Front-End Engineering Design Study for Retrofit Post-Combustion Carbon Capture on a Natural Gas Combined Cycle Power Plant

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PROJECT SUMMARY

Project Objective

The objective of the project is to conduct a Front-End Engineering Design (FEED) study to determine the technical and economic feasibility of installing a retrofit, post-combustion, carbon capture facility on a commercially operating, natural gas-fired, combined cycle (NGCC) power plant. The Electric Power Research Institute (EPRI), California Resources Corporation (CRC), and Fluor Corporation used Fluor's Econamine FG Plus℠ (EFG+) conducted the FEED study for capturing CO_2 produced by CRC's 550 MWe Elk Hills Power Plant (EHPP), located in the Elk Hills Oil Field near Tupman, Kern County, California. The EHPP was commissioned in 2003 and is powered by two General Electric 7FA gas turbines (GTs), with two heat recovery steam generators (HRSGs) providing steam to a General Electric D11 steam turbine (ST).

The target capture amount is 4,000 tonnes CO_2/day for use in either enhanced oil recovery (EOR) or dedicated geological saline storage located on CRC property at or nearby EHPP. This CO_2 is captured from a combination of the CO_2 emitted from the flue gas from EHPP and the flue gas generated from a natural gas-fired auxiliary boiler that supplies steam to the EFG+ process.

Project Scope

This FEED study incorporates and evaluates all aspects of the EFG+ process including all necessary utility systems that are not preexisting at the site. EFG+ uses a proprietary aqueous amine in an absorber-stripper configuration shown schematically in Figure 1. For the FEED study, steam needed for EFG+ is supplied by an auxilliary boiler (not shown) and the inlet flue gas is a mixture of flue gas from EHPP and the auxillary boiler. The CO_2 product specification is shown in Table 1.

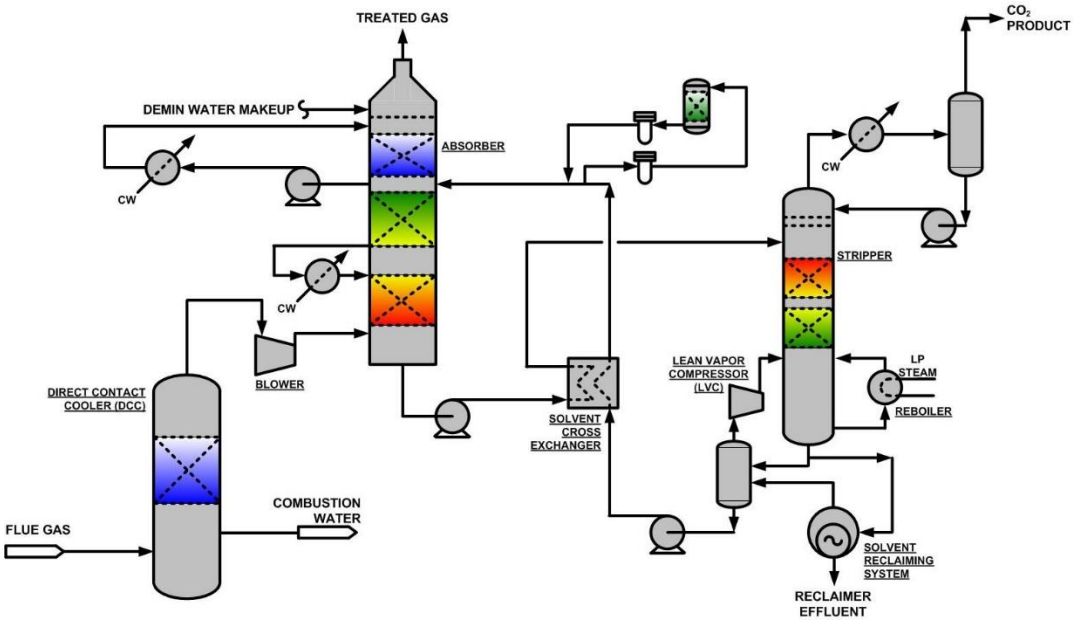


Figure 1. Schematic of Fluor Corporations Econamine FG Plus^{TM} CO_2 Capture Process

Table 1. CO_2 Product Specification

Parameter	Value	
CO_2 Production Pressure	2,300 psig	159.6 bar (abs)
CO_2 Production Temperature	<130 °F	<54.4 °C
CO_2 Production Purity	97+ vol%	
Nitrogen	<1 ppmv	
Oxygen	<10 ppmv	
Ammonia	<1 ppmv	
Particulate Matter	<1 ppmw	
Water	<25 lb/MMscf	<0.4 g/m^3
Water Dew Point	-13.6 °F	-25.3 °C

Project Design Basis

The project location is the Elk Hills Power Plant in the Southwestern edge of the San Joaquin Valley in Kern County, California. This location is atop the Elk Hills Oil Field which is the proposed CO_2 injection and storage location. The CO_2 can be used for enhanced oil recovery or

CO_2 storage or a combination of both, topics that are being pursued outside of the scope of this FEED project. As shown in Figure 2, the carbon capture process is to be located immediately south of EHPP in a space measuring over 24,000 square meters (250,000 square feet).

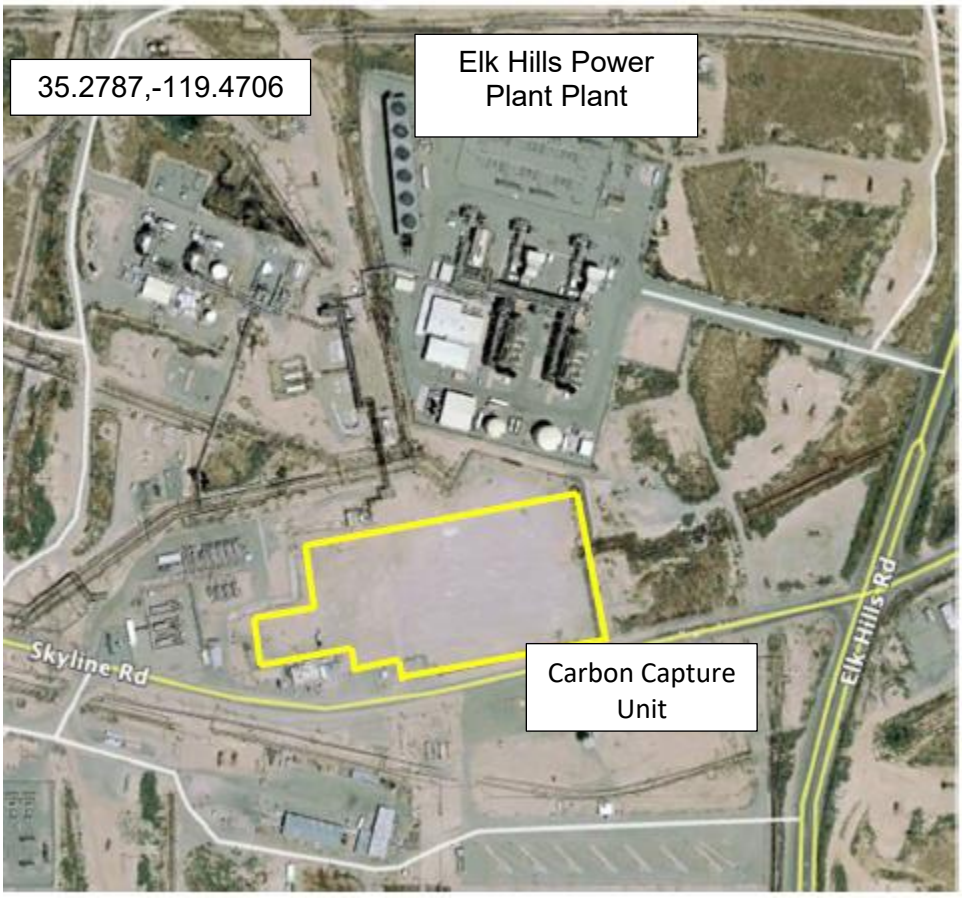


Figure 2. Site Location

Specifics about the site climate design data are shown in Table 2. The fuel gas to the GTs is a blend of the Elk Hills fuel gas system and purchased Kern-Mojave gas. This blend varies both seasonally and operationally. After a review of this variability, the design fuel gas supplied to the GTs was defined as shown in Table 3.

The flue gas being processed in the carbon capture unit is a combination of exhaust gas from the EHPP as well as the flue gas from the boiler within the scope of the carbon capture unit.

Table 2. Site Data

Parameter	Value	
Plant Elevation	1,380 feet	420.6 m
Barometric Pressure	14.0 psia	0.965 bar (abs)
Ambient Dry Bulb Temperature		
Design	92°F	33.3 °C
Maximum	115°F	46.1 °C
Minimum	20°F	-6.7 °C
Design Wet Bulb Temperature	66°F	18.9 °C
Annual Average Temperature	65°F	18.3 °C
Annual Average Humidity	49.6%	
Average annual rainfall	6.49”	16.5 cm
25 year maximum 24-hour rainfall	2.29”	5.82 cm

Table 3. Design Fuel Gas Composition

Component	Concentration (Mol%)
Methane (CH_4)	83.3
Ethane (C_2H_6)	8.9
Propane (C_3H_8)	0.2
i-Butane (i-C_4H_{10})	0.0
C_4	0.0
iC_5	0.0
C_5	0.0
C_{6+}	0.0
Carbon Dioxide (CO_2)	7.0
Nitrogen (N_2)	0.5

The maximum flow rate drawn from each of the flue gas streams is limited by design to 95% of the total available flow to ensure no air ingress into the system. The boiler flue gas is taken preferentially due to its higher CO_2 concentration. The remainder of the required flue gas to achieve the capture plant capacity is drawn from the GTs. The design parameters and compositions of the individual flue gas flow streams and the combined composition feeding the carbon capture unit can be found in Table 4 and Figure 3.

Table 4. Design Flue Gas

Parameter	CTG1		CTG2		Boiler		Combine	
Flue Gas Available Flow Rate	574,000* scfm	16,300 m^3/min	574,000* scfm	16,300 m^3/min	111,000 scfm	3,140 m^3/min	1,260,000 * scfm	35,700 m^3/min
Flue Gas Draw	545,000 scfm	15,400 m^3/min	545,000 scfm	15,400 m^3/min	109,000 scfm	3,090 m^3/min	1,200,000 scfm	33,900 m^3/min
Percent Flue Gas Draw	95% Max		95% Max		95%		-	
Temperature	210 °F	98.9 °C	210 °F	98.9 °C	298 °F	148 °C	214 °F	101 °C
Pressure	0.0 psig	0.0 barg	0.0 psig	0.0 barg	0.0 psig	0.0 barg	0.0 psig	0.0 barg
Composition (%v/v)								
N_2	72.81		72.81		68.84		72.45	
O_2	11.59		11.59		2.5		10.76	
H_2O	10.31		10.31		17.46		10.96	
CO_2	4.35		4.35		10.25		4.89	
Ar	0.94		0.94		0.94		0.94	
CO (ppmv dry)	< 0.1		< 0.1		< 61		< 5.7	
NOx (ppmv dry)	< 1.9		< 1.9		< 2.5		< 1.8	
THC (ppmv dry)	< 1.0		< 1.0		Nil		< 1.0	
NH3 (ppmv dry)	< 5.9		< 5.9		Nil		< 5.9	
SO2 (gr/100 ft3)	< 0.06		< 0.06		Nil		< 0.06	
Total Particulate Emissions (gr/dscf)	0.002		0.002		Nil		< 0.002	

**Minimum*

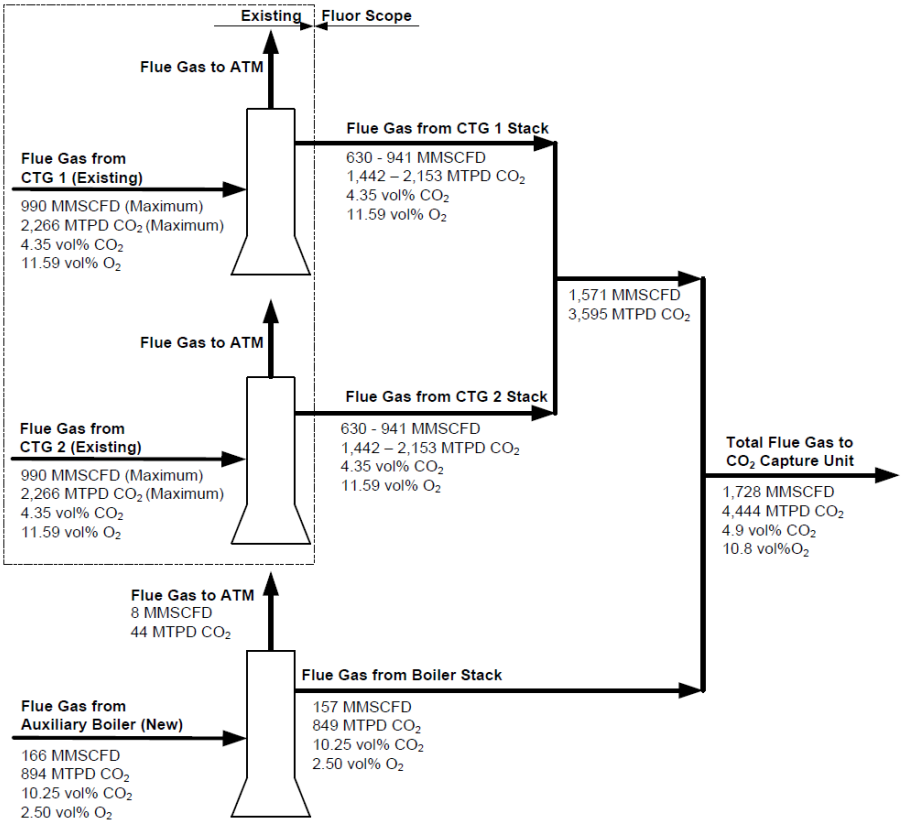


Figure 3. Process Flow Diagram

The EFG+ plant is designed to capture 90% of the CO_2 from the total flue gas feed to the unit. The treated flue gas is vented to atmosphere directly from the EFG+ plant absorber. The on-stream factor for the plant is 95% with a turndown of 40%. The solvent make-up storage capacity is a minimum of 30 days. Figure 4 shows a simplified Block Flow Diagram (BFD) for the overall EFG+-based CCU.

Excluding CRC's owners' costs, the capital cost for the EFG+ carbon capture process is estimated to be $748M, with accuracy range of plus or minus fifteen percent (15%). Major estimate clarifications are provided below:

- Project execution basis is assumed to be on a lump sum engineering, procurement and construction basis with performance guarantees and liquidated damages.
- Forward escalation of $39.0 M has been included from 2020 to project completion.

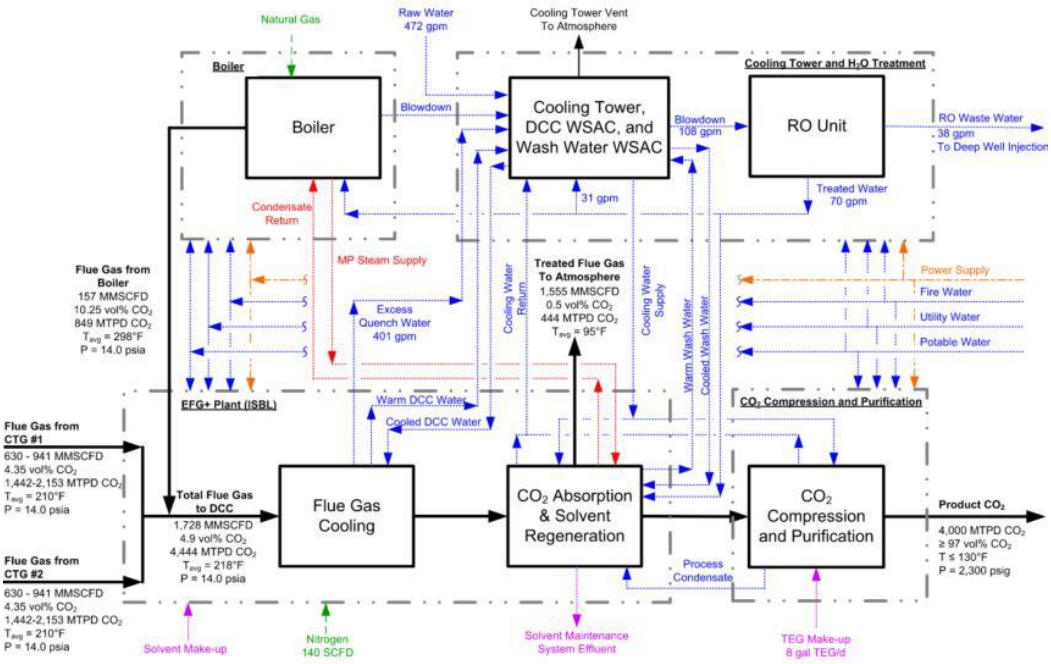


Figure 4. Block Flow Diagram

- The project construction execution is based on the use of Union labor. Per diem and incentives for labor attraction and retention are included.
- Sales Tax is included. This is valued at $8.5 M.
- The plant design is based on Seismic Zone 3.
- Pre-commissioning, Commissioning, Start-up and the Performance Testing were included.
- Contingency has been included at $57.0 M.
- Licensor Fee is excluded.
- Mass excavation of the site is excluded (Owner's cost due to pre-existing conditions).
- The $748 M installed cost estimate has been broken into equipment systems consisting of CO_2 Capture Plant - $387 M, Utility Systems - $267 M, CO_2 Compression - $61 M, Balance of Plant - $33 M

There are some unique aspects of the project which should be noted. Water minimization is an important component of the design. This involved the inclusion of hybrid cooling systems (Wet Surface Air Coolers (WSAC), Air Coolers, Secondary Glycol Cooling and Water Cooling) in the scope. While the incorporation of these systems increased the Capital Cost of the project, they significantly reduced the amount of water usage. Additionally, a Water Reverse Osmosis System is included within the project scope. Since steam extraction was not initially incorporated for the CO_2 recovery process, package boilers have been included within the project scope. The combined total installed cost for these utility systems is $267 M.

Though many cost-cutting measures have been incorporated into the final design and cost estimate, one key measure for which an evaluation outside the FEED project is a re-consideration of steam extraction from the power plant. Steam extraction was considered at the early stages of the FEED, but CRC decided to proceed without steam extraction to avoid major modifications to the existing steam turbine that could lead to infeasible power plant operation with the carbon capture unit offline. Additionally, steam extraction will reduce the power plant output by an estimated 30-35 MW at design capacity. Fluor proceeded with a FEED design that included package boilers dedicated to producing all the steam required for the carbon capture unit.

As part of the cost-cutting measures identified, it was decided to re-consider extraction of steam from the existing steam turbine. Not only does steam extraction eliminate the need for the carbon capture unit package boilers, but since the extracted steam is fully condensed within the carbon capture unit, a significant portion of the existing power plant cooling load is freed up. This freed up cooling can be utilized within the carbon capture unit to eliminate up to five of the eight WSACs. Fluor has roughly estimated a potential capital savings of up to $35-45 M associated with

implementing the steam extraction / integration. However, a complete evaluation was outside the scope of the current FEED.

The project requested a single connection to the CRC Power System. CRC evaluated interconnecting to CRC's 115 kV line. The project will require a transmission tie line to interconnect the Project switching station to the existing CRC transmission line. The Project switching station must use redundant line current differential protection over fiber with Direct Transfer Trip per CRC requirements. The provided costs are based on preliminary engineering and design.

The area surrounding the project is highly congested which will require the use of self-supporting dead-end structures. Approximately ½ mile of single conduction 115 kV transmission tie line is expected to be built using tubular steel poles with anchor bolt foundation designs at a cost of approximately $1.3 M. The switching station is expected to utilize a single bus, single breaker configuration at a cost of approximately $1 M. Redundant fiber optics paths will be required a cost of approximately $0.3 M. The estimated total Project interconnection cost is $2.6 M and is in addition to the estimate discussed above.

The project generated a Level 1 (Management Summary) Engineering, Procurement, Construction and Commissioning (EPCC) schedule to support the execution of the project proceeding. For the phases mentioned (EPCC) the total duration is 41 months. Based upon the current execution approach, time has been allowed prior to the start of Detailed Engineering, for Fluor to improve the Capital Cost Estimate accuracy, and for CRC to obtain project financing. Procurement of all equipment and materials including long lead and critical equipment, occurs after project award. There has also been time allotted after the commissioning of the facility, to startup the plant and conduct the performance testing of the facility.

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ACRONYMS AND ABBREVIATIONS

BACT	Best Available Control Technology
BFD	Block Flow Diagram
CEMS	Continuous Emissions Monitoring System
CCC	Contractors Cargo Company
CCS	Carbon Capture and Sequestration
CCU	CO_2 Capture Unit
CRC	California Resources Corporation
CTG	Combustion Turbine Generator
DCC	Direct Contact Cooler
EFG+	Econamine FG Plus^{SM}
EOR	Enhanced Oil Recovery
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
FEED	Front End Engineering and Design
HRSG	Heat Recovery Steam Generator
KO	Knock Out
MMSCF	Million Standard Cubic Feet
MMSCFD	Million Standard Cubic Feet per Day
MTPD	Metric Tons per Day
NGCC	Natural Gas Combined Cycle
PFD	Process Flow Diagram
RO	Reverse Osmosis
SJVAPCD	San Joaquin Valley Air Pollution Control District (SJVAPCD)
SMS	Solvent Maintenance System
STLC	Soluble Threshold Limit Concentration
TEG	Tri-ethylene glycol
TTLC	Total Threshold Limit Concentration
UFD	Utility Flow Diagram
UIC	Underground Injection Control
US EPA	United States Environmental Protection Agency
VOC	Volatile Organic Compounds
WSAC	Wet Surface Air Cooler

Front-End Engineering Design Study for Retrofit Post-Combustion Carbon Capture on a Natural Gas Combined Cycle Power Plant

Basis of Design – FEED Scope

1.0 Executive Summary

Electric Power Research Institute (EPRI) has been awarded funding from the U.S. DOE (with California Resources Corporation (CRC) and Fluor as sub-recipients) aimed to execute a Front End Engineering and Design (FEED) study. The objective of the FEED study is to determine the technical and economic feasibility to retrofit a post-combustion carbon capture unit on a 550 MW commercially operating Natural Gas Combined Cycle (NGCC) power plant located at CRC's Elk Hills Power Plant located near Tupman, California. The CO_2 Capture Unit (CCU) is based on Fluor's proprietary Econamine FG Plus^{SM} (EFG+) technology and is designed to recover a combined 4,000 metric tons per day (MTPD) of CO_2 from the flue gas streams produced by two existing power plant Combustion Turbine Generators (CTGs) along with a flue gas stream produced by a new boiler package.

The selected EFG+ process configuration has been set to minimize the cost for the EFG+ carbon capture application. A new boiler package is included in the scope to meet all the CCU's steam demands. This new boiler package is designed to produce medium pressure steam by combusting a new mixed fuel gas blend provided by CRC. Combustion of the new fuel gas produces a flue gas that is more concentrated in CO_2, and less concentrated in oxygen than either of the CTG flue gas streams. It is therefore preferential to recover the maximum amount of CO_2 from the new boiler package flue gas over the CTG flue gases. Fluor limits the draw from any one of the sources to 95% to ensure 5% of the flue gas is continuously vented from each of the source stacks to mitigate against drawing air into the stack and diluting the flue gas. This results in approximately 19% of the CO_2 recovered (765 MTPD of CO_2), to be from the new boiler package

flue gas. The remaining 81% of CO_2 is recovered from the CTG flue gas streams (3,235 MTPD of CO_2). Up to 95% of the flue gas can be drawn from either of the two existing CTG stacks. To meet the 4,000 MTPD CO_2 capture capacity, the EFG+ plant is designed to capture 90% of the CO_2 from a mixed flue gas consisting of:

- 95% of the total flue gas available from the new Boiler Package
- 95% of the total normal flue gas available from either of the two CTGs
- 64% of the total normal flue gas available from the remaining CTG

Based on a 90% CO_2 capture rate from the combined flue gases indicated above, the resulting overall net CO_2 capture rate is 74% of the total CO_2 available in all three flue gas streams, or 71% of the total CO_2 available from the two CTG flue gas streams, assuming full load power plant operation.

Figure 1 provides a Process Block Flow Sketch indicating the final high-level configuration.

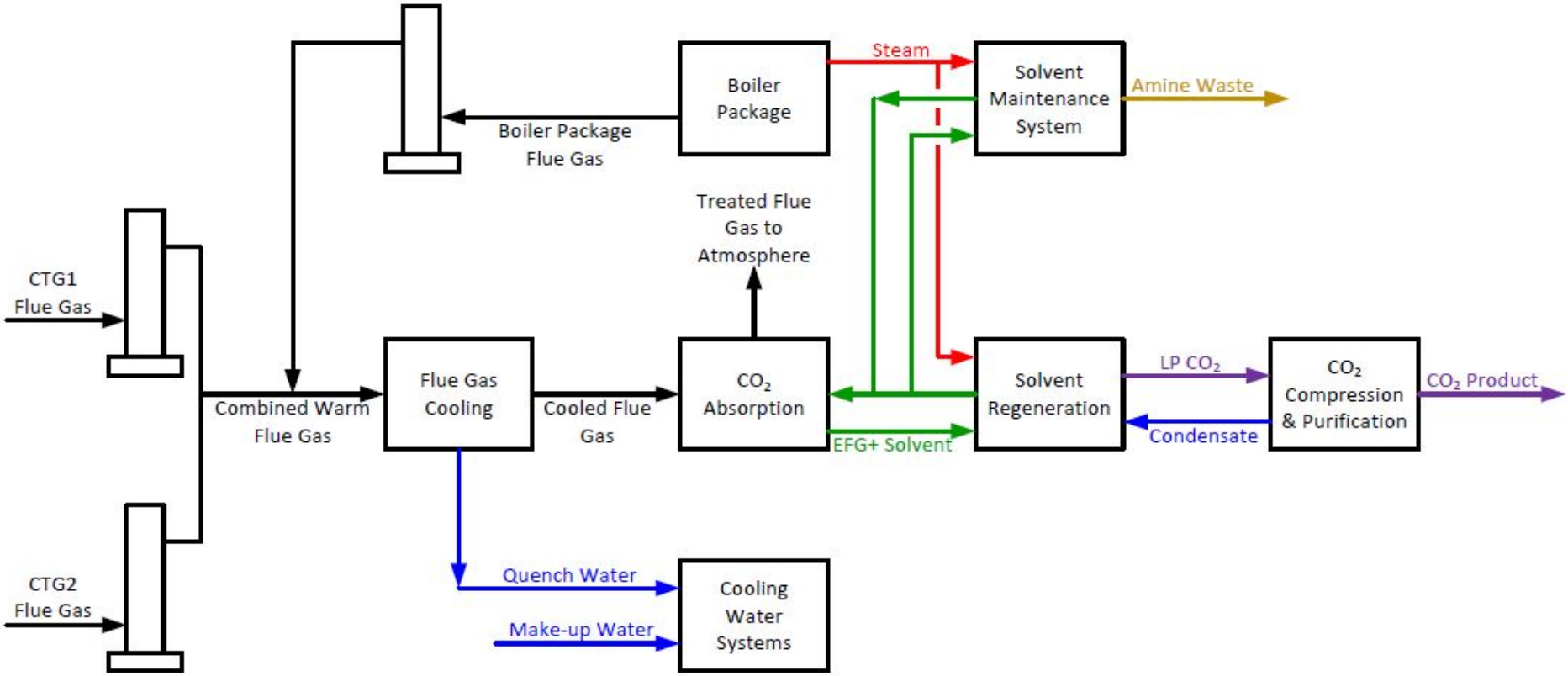


Figure 1: Block Flow Process Sketch

A controlled portion of flue gas from each of the three source stacks are routed via ducting to a larger common duct, from which the mixed flue gas is first routed to the flue gas cooling system. Within the flue gas cooling system, the mixed flue gas is cooled from 218°F to 92°F. Cooling of the flue gas serves to condense out approximately 400 gpm of water vapor. The condensed water is harvested from the Flue Gas Cooling system and is routed as make-up water to the CCU cooling water system to reduce the overall CCU make-up water requirement by about 46%. This water recovery is a key element of the CCU design to be water conscious in the drought prone state of California where water may not be readily available, making water minimization a key Project charter.

Cooled flue gas from the Flue Gas Cooling system is then routed to the CO_2 Absorption system. Within the CO_2 Absorption system, the flue gas is contacted against the EFG+ solvent, an aqueous amine solution that chemically absorbs 90% of the CO_2 from the flue gas. The treated flue gas is then washed to remove vapor phase and entrained amine before being vented to atmosphere from the top of the CO_2 Absorption system. CO_2-rich amine solution from the bottom of the CO_2 Absorption system is pumped to the Solvent Regeneration system. In the solvent regeneration system, the loaded solvent is first heated, then contacted against stripping steam to free the chemically bound CO_2 from the solvent to produce a low-pressure CO_2 product. The stripping steam is produced by condensing low-pressure steam that is provided by the new Boiler Package.

Hot lean solvent from the bottom of the Solvent Regeneration system is pumped through a series of heat exchangers to cool the solvent before returning it to the CO_2 Absorption system. A slip stream of the solvent is diverted to the Solvent Maintenance System (SMS), a proprietary system designed to remove contaminants from the circulating solvent as to maintain the solvent to a high

quality. These contaminants are collected in a storage tank and periodically (monthly) hauled off-site for disposal. The SMS utilizes medium pressure steam, also provided by the new Boiler Package.

The water-saturated low-pressure CO_2 produced in the Solvent Regeneration system is routed to the CO_2 Compression system. Key equipment included in the CO_2 Compression system are a 7-stage CO_2 Compressor and a glycol-based Dehydration Package. Between each stage of compression, the partially compressed CO_2 is cooled against a closed-loop aqueous glycol solution. Any water that is condensed in these intercooling stages is separated from the CO_2 in knock-out pots that are integral to the intercoolers. The condensed water is combined and returned to the Solvent Regeneration system. Routing the collected condensate back to the Solvent Regeneration system serves to recover any amine that may carry over to the CO_2 Compression system. A closed-loop aqueous glycol secondary cooling loop is implemented for the CO_2 Compression intercoolers to:

1. Limit cooling with the open-loop cooling water system, thereby satisfying the Project charter to minimize make-up water consumption as much as reasonably possible
2. Avoid air-cooled intercoolers, which significantly increases the interconnecting piping volume and pressure drop in the system, and hinders the response time by the compressor control system

An aqueous glycol system is provided over a straight water-cooled system for two reasons:

1. Glycol provides inherent protections against freezing that satisfy winterization requirements for handling the 20°F minimum ambient temperature.
2. A glycol system avoids the need for an additional chemical injection system that would be otherwise be required to maintain a 100% closed water loop system.

Heat is removed from the circulating glycol loop via an air cooler. Based on a 92°F design dry bulb temperature for air cooling, the circulating glycol is designed to supply cooling at 112°F. A 9°F approach temperature allows for cooling the process fluid to 121°F in the compression intercoolers. After the 5th stage of compression, the partially compressed CO_2 is extracted, cooled against cooling water and routed to a Tri-Ethylene Glycol (TEG) Dehydration Package. Cooling water is used in lieu of aqueous glycol to cool the partially compressed CO_2 before it is fed to the Dehydration Package as a means to provide deeper cooling (110°F vs. 121°F) to maximize the quantity of water condensed out, thereby reducing the load on the Dehydration Package. The dehydration step is necessary to meet the CO_2 product specification of 25 lb H_2O per million standard cubic feet (MMSCF) (527 ppmv) of CO_2 product.

Partially compressed and dehydrated CO_2 from the TEG Dehydration Package is further compressed in the final two compression stages, cooled against air to meet CRC's 130°F maximum temperature specification for the CO_2 product, and routed to the CCU battery limits at 2,300 psig.

Also included in the CCU scope are all the needed chemical storage tanks, drain collection tanks, and make-up pumps. This includes storage and drain tanks for the EFG+ amine solvent and TEG. The drain tanks are designed to recover their respective chemicals through a closed drain system for each chemical.

Three independent cooling water systems are included in the CCU scope:

1. Direct Contact Cooler (DCC) Wet Surface Air Cooler (WSAC)
2. Wash Water WSAC
3. Dedicated Cooling Tower

As mentioned previously, a key project charter is to minimize the CCU water consumption due to lack of water availability at the Elk Hills site located in the drought prone state of California. Consideration was initially given to designing the CCU as a 100% air-cooled plant. However, it was quickly realized that due to the hot ambient conditions and large cooling loads required, a 100% air-cooled plant would require a significantly large number of air cooler bays that would increase the cost of the CCU. Furthermore, the hot ambient conditions during the summer would result in inefficient plant operation that would increase the operating cost. Instead, the design solution incorporates a hybrid air and water-cooled solution.

The hybrid air-water cooled system first consists of using dedicated WSACs for each of the two largest cooling loads; the DCC as part of the Flue Gas Cooling system, and the Wash Water as part of the CO_2 Absorption system. These two cooling services comprise over 70% of the overall CCU cooling load. WSACs serve to perform a maximum reasonable amount of cooling using air to cool the process fluid over dry coils, followed by deeper cooling of the process fluid by spraying a circulating cooling water stream over wet coils. Utilization of WSACs for these two services provides for a lower cost solution compared to air cooling only, while also reducing the CCU net make-up water requirement by approximately 40% compared to a system utilizing equivalent air cooler and water-cooled trim coolers.

A dedicated Boiler Package is provided to meet all the CCU steam demands, including that of the Solvent Regeneration system and the SMS. The Boiler Package produces the steam in a water-tube boiler by burning a nominal 550 MMBtu/hr of a mixed fuel gas blend provided by CRC. Make-up water to the Boiler Package is provided from a Reverse Osmosis (RO) Unit, also included in the CCU scope. The RO Unit treats blowdown from the three cooling water systems to recover about 65% of the water. By including a boiler to meet the CCU steam demands, CRC

does not expect any material change in the performance of the Elk Hills Power Plant. There may be preferential dispatching priority with capture in place, which could lead to an increase in the annual capacity factor of the plant. An additional future potential upside not currently modeled is an increase in electrical sales realizations to the grid based on a "clean power" designation. Although the marketable capacity will be reduced by the 35 MW electrical power supplied to the CCU.

Other utilities required by the CCU include instrument air, plant air, nitrogen, potable water, raw water, natural gas, and electrical power. The CCU is equipped with a dedicated instrument and plant air package to meet the unit plant and instrument air requirements. Raw water, potable water, nitrogen, and natural gas are provided by CRC at the CCU battery limits. Electrical power is provided through the existing CRC Elk Hills transmission system. This electrical power will provide the approximate 35 MW load required by the CCU process equipment users. There will be a new 115 kV line brought from an existing CRC substation to the new CCU substation where it will be stepped down to 13.8 kV / 4160 V / 480 V for the major plant loads.

Towards the end of the FEED effort, the CRC and Fluor teams engaged in a brainstorming session aimed to identify potential cost-cutting items. These items were then evaluated and those that yielded a positive outcome have been incorporated into the final FEED design. After incorporating these items, the total installed cost of the CO_2 capture island is $387 MM with the following additional capital costs; CO_2 compression ($61 MM), utility systems ($267 MM) and Balance of Plant ($33 MM). Therefore, the estimated total installed cost is $748 MM. For greater insight into the makeup of this estimate please refer to Section 16 of this report.

One additional item identified during the cost-cutting brainstorming workshop that is still under evaluation is to reconsider extracting steam from the existing power plant steam turbine and

eliminate the new boiler package that produces steam for the CCU. Steam extraction was considered at the early stages of the FEED, but CRC elected to go with package boilers to avoid major modifications to the existing steam turbine that could potentially lead to infeasible power plant operation with the CCU offline. Furthermore, utilizing steam extraction would reduce the power output of the power plant by an estimated 35 MW. However, further consideration revealed that not only does steam extraction eliminate the need for the CCU package boilers, but since the extracted steam is fully condensed within the CCU, a significant portion of the existing power plant cooling load is freed up. This freed up cooling can be utilized within the CCU to eliminate up to five of the eight WSACs resulting in significant cost savings. Integrating the CCU steam and cooling water systems with the CCU not only impacts the utility systems; but eliminating the package boilers from which the flue gas is being treated in the CCU requires a much more extensive evaluation compared to other cost-cutting items identified. Since the evaluation is on-going, the FEED design remains with package boilers incorporated, and no steam extraction from the power plant. Once the evaluation is complete, the final design can be updated based on the evaluation outcome.

2.0 Project Scope

The U.S DOE has awarded EPRI funding to manage a FEED study for retrofitting a post-combustion carbon capture unit on a NGCC power plant at CRC's 550 megawatt Elk Hills Power Plant located near Tupman, California. CRC has selected Fluor's proprietary EFG+ licensed technology for the FEED with the unit designed to capture a combined 4,000 MTPD of CO_2 from the flue gases produced by the existing power plant CTGs along with flue gas produced by the new boiler package within the CCU. The 4,000 MTPD CO_2 capture is achieved by normally processing about 79% of the total available CTG flue gas (considering full load operation) and

95% of the boiler package flue gas, then removing 90% of the CO_2 available from the processed flue gas streams. This results in an overall net CO_2 capture rate of 71% of the total CO_2 available from the CTG flue gases (considering full load operation) and 86% of the total CO_2 available from the new boiler package flue gas, thereby netting an overall normal CO_2 capture of about 74%.

There is an on-going evaluation to consider eliminating the new boiler package within the CCU as a cost saving measure. Since the purpose of the boiler package is to produce the steam needed for the CCU solvent regeneration system, elimination of the boiler will require modifications to the existing steam turbine to allow for extraction of the steam at turbine IP/LP crossover. If the boiler is eliminated, the CCU will still target a 4,000 MTPD design CO_2 capture capacity with all the CO_2 capture from the CTG flue gas streams.

Both Fluor and CRC are sub-recipients of the DOE award. The Carbon Capture and Sequestration (CCS) project will compress and utilize the captured CO_2 for Enhanced Oil Recovery (EOR) at CRC's Elk Hills reservoirs. The project scope includes the CO_2 capture plant, compression and treating of the CO_2, and the required utility systems to support the new facility.

2.1 System Boundaries

The Block Flow Diagram depicted in Section 5.1 not only describes the interfaces between the various Process Blocks, it also defines the process and utility streams which originate outside the CCS plant. The utility inputs include; high voltage electrical power, fire water, utility water, raw water, nitrogen, and natural gas. The flue gas process stream originates at the tie-in point to the power plant exhaust stacks.

3.0 Project Design Basis

3.1 Site Characteristics

The project site, as indicated in the yellow outline of Figure 2, previously was a location of a different process unit which has been demolished with the existing equipment and foundations being removed to below grade. Due to the potential for underground obstructions the Owner will bathtub the site to specified elevations and then transition it to the EPC contractor. There is an existing road that borders the south side of the unit and provides multiple access points into the unit during construction. There is also site access from an existing road on the northwest corner of the unit.

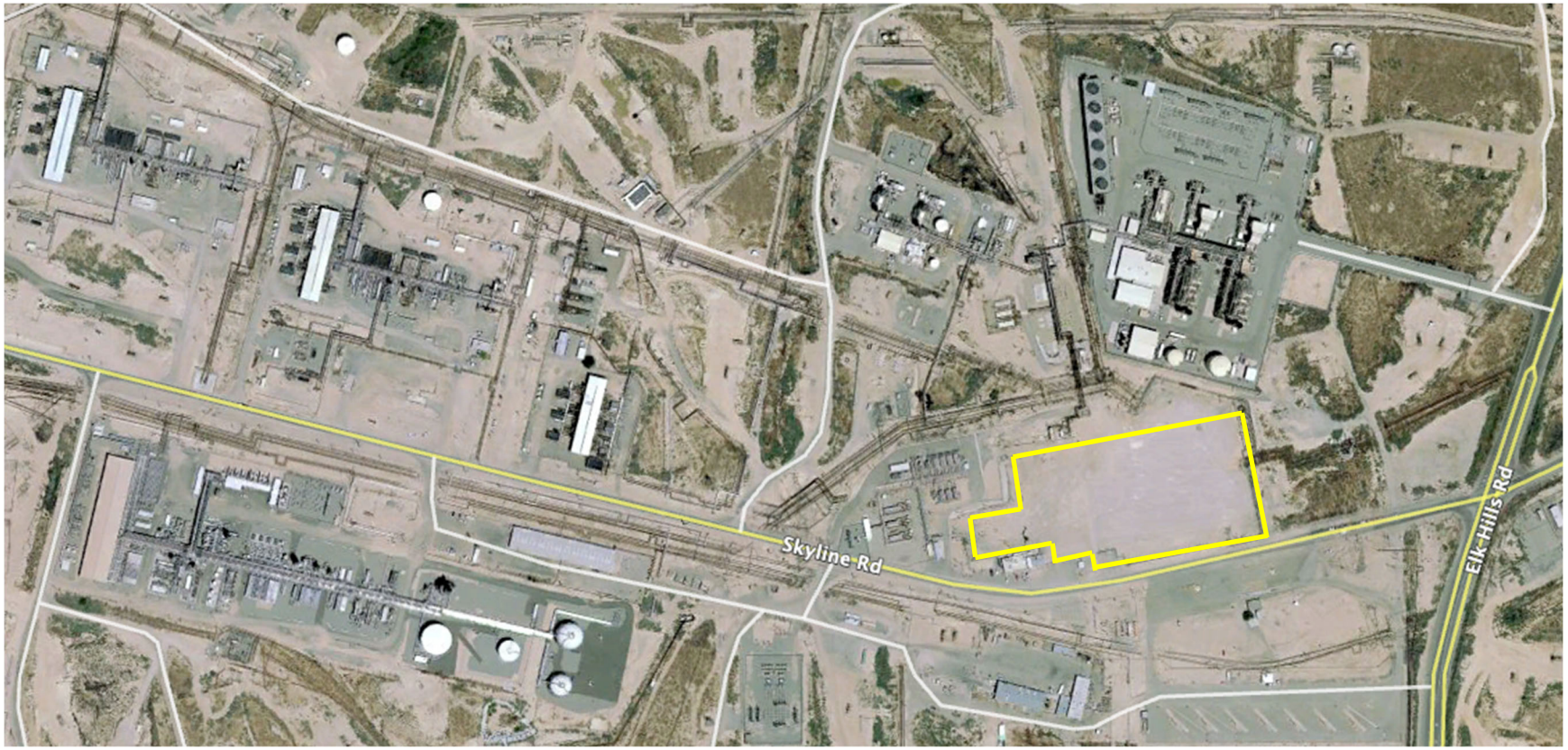


Figure 2: Project Site

3.2 Site Ambient Conditions

Table 1 gives the relevant site data for the study.

Table 1: Site Data

Parameter	Value
Ambient Dry Bulb Temperature	
Maximum (°F)	115
Minimum (°F)	20
Design (°F)	92 (Note 1)
Design Wet Bulb Temperature	66
Design Relative Humidity (%)	49.6
Site Elevation (ft)	1,340 (HPFS)
Atmospheric Pressure (psia)	14.0
Annual Mean Rainfall (in)	6.49
Mean Wind Velocity - Summer (mph)	6.0
Mean Wind Velocity - Winter (mph)	5.4
Design Wind Velocity (mph)	85
Notes: 1) Air coolers shall be designed for a 20°F approach to the design dry bulb temperature.	

3.3 Fuel Feedstock and Flue Gas Characteristics

Fuel gas is required in the CO_2 capture unit for firing the new auxiliary boiler to produce steam for solvent regeneration and reclaiming. The auxiliary boiler shall be designed to normally burn a primary fuel gas. Additionally, the auxiliary boiler shall be capable of burning the Kern-Mojave fuel gas as an alternate. Both fuel gas compositions are indicated in Table 2. As mentioned in Section 2.0, there is an ongoing evaluation to consider eliminating the new auxiliary boiler, which would eliminate the need for any fuel gas within the CCU.

Table 2: Fuel Gas Composition

Component	Primary Fuel Gas Concentration (mol%)	Alternate Kern-Mojave Fuel Gas Concentration (mol%)
C1	56.11	93.26
C2	22.00	5.12
C3	0.06	0.34
iC4	0.00	0.03
nC4	0.01	0.03
iC5	0.00	0.01
nC5	0.00	0.01
C6+	0.00	0.00
CO2	21.27	0.88
N2	0.55	0.32
LHV (Btu/lbmol)	329,390	357,240
HHV (Btu/lbmol)	360,864	393,148

The overall flue gas feed to the carbon capture unit will be a combination of flue gases produced from the two existing CTGs; along with flue gas produced by a new auxiliary boiler that has been included as part of the project to supply steam for the capture plant. Preferential CO_2 recovery shall be performed on the auxiliary boiler flue gas because it has a higher CO_2 concentration compared to the CTG flue gas streams. A higher CO_2 concentration means processing less flue gas per ton of CO_2 recovered, resulting in a more energy efficient and less capital-intensive process. However, to avoid air ingress through the auxiliary boiler stack, the flue gas draw shall be limited to 95% of the total available flue gas, while maintaining 5% of the total available flow through the stack.

Louver dampers shall be installed in the flue gas duct lines from each of the CTGs. These louver dampers will provide CRC with the ability to modulate the flue gas flow from either of the CTGs. Flue gas will be preferentially drawn from only one of the two CTGs up to a maximum of 95% of the total available flue gas from that CTG. The draw rate from the second CTG is then set to achieve a total desired CO_2 production rate of 4,000 MTPD based on 90% CO_2 recovery efficiency in the CO_2 capture unit.

Figure 3 shows the flow scheme of the combined flue gas from each of these sources.

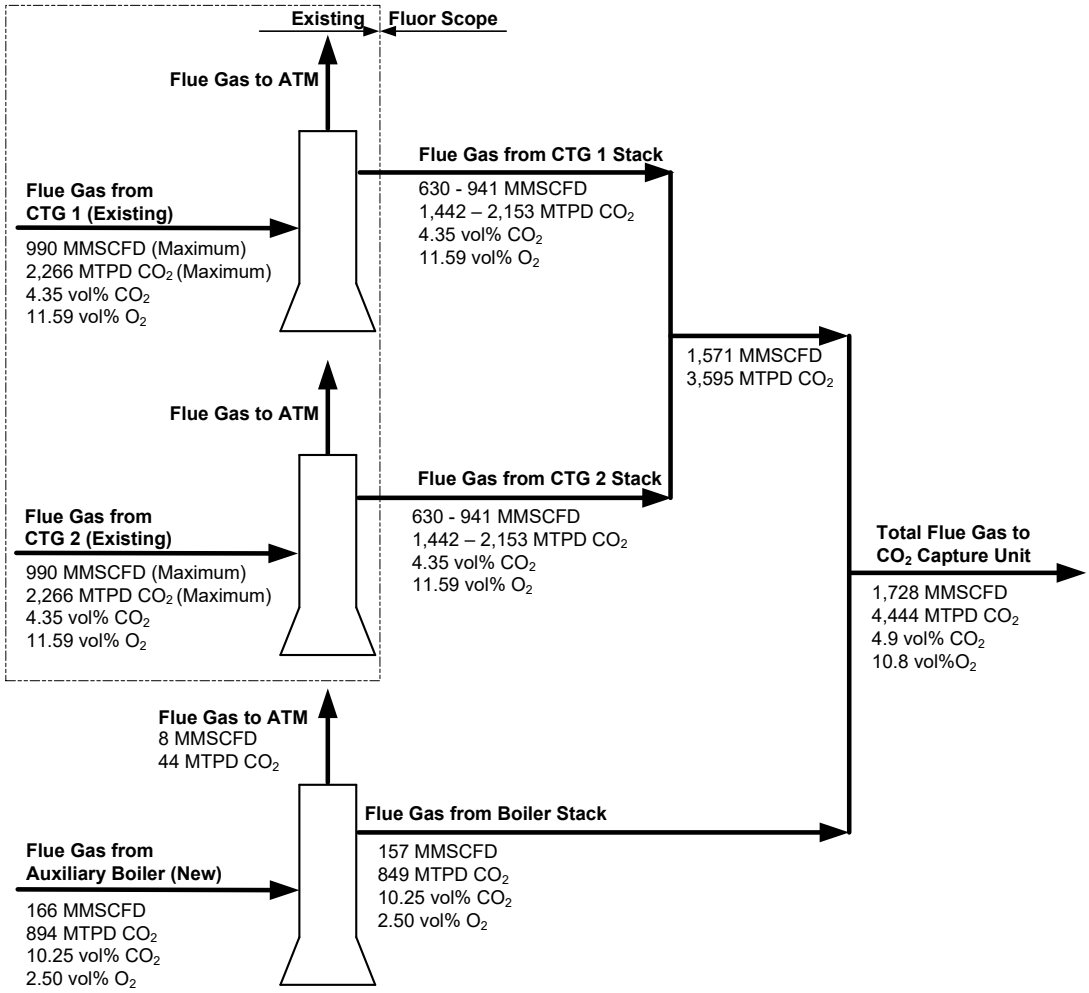


Figure 3: Flow Scheme for Flue Gas Feed to the CO_2 Capture Unit

Table 3 gives the properties of the flue gas feeds to the carbon capture plant.

Table 3: Flue Gas Feed Design Characteristics

Parameter	Value			
	CTG1	CTG2	New Boiler	TOTAL
Total Flue Gas Available Flow Rate (MMSCFD)	990 (Maximum)	990 (Maximum)	166	2,146 (Maximum)
Total Flue Gas Draw (MMSCFD)	630 – 941 (Note 1)	630 – 941 (Note 1)	157	1,728
Percent Flue Gas Draw	63% - 95% (Note 1)	63% - 95% (Note 1)	95.0% (Note 2)	-
Temperature (°F)	210	210	298	218
Pressure (psig)	0.0	0.0	0.0	0.0
Composition (%v/v)				
N2	72.81	72.81	68.84	72.45
O2	11.59	11.59	2.5	10.76
H2O	10.31	10.31	17.46	10.96
CO2	4.35	4.35	10.25	4.89
Ar	0.94	0.94	0.94	0.94
CO (ppmv dry)	< 0.1	< 0.1	< 61	< 5.7
NOx (ppmv dry)	< 1.9	< 1.9	< 2.5	< 1.8
THC (ppmv dry)	< 1.0	< 1.0	Nil	< 1.0
NH3 (ppmv dry)	< 5.9	< 5.9	<6.1	< 5.9
SO2 (gr/100 ft3)	< 0.06	< 0.06	Nil	< 0.06
Total Particulate Emissions (gr/dscf)	0.002	0.002	0.0014	0.002

Notes:
1) The combined flue gas draw rate from the CTGs is specified to achieve a total CO_2 production rate 4,000 MTPD at 90% recovery efficiency in the CO_2 capture unit. Flue gas draw from the individual CTGs shall be set such that flue gas can be taken from either of the CTGs up to a maximum 95% of the total available flue gas, with the balance taken from the second CTG. As such, the percent flue gas draw will vary depending on total flue gas available from the CTGs along with which CTG the preferential draw is taken from.
2) Draw rate from new auxiliary boiler set at 95% maximum to avoid air ingress by maintaining 5% flow through the stack.
3) An ongoing evaluation is being performed that considers eliminating the new auxiliary boiler dedicated to producing steam for the CCU. If the boiler is eliminated, not only would the total combined flue gas flow rate and composition change due to removal of the boiler portion of the flue gas feed to the CCU, but the CTG flue gas conditions are likely to change depending on CRC's selected fuel gas feed to the CTGs.

3.4 Environmental Requirements

Air Emissions

The below is an assessment of the air permit limitations and required control technologies for the proposed equipment.

Flue gas From Boiler Package – permit required

Per the San Joaquin Valley Air Pollution Control District (SJVAPCD) any boiler rated higher than 5 MMBTU/HR will be require to meet Best Available Control Technology (BACT) with low NO_X burners, Rule 4306 NO_X and CO limits, and meet Rule 4320 enhanced limits or pay emissions fees.

Table 4: SJVAPCD NO_x and CO_2 Limits

Unit Rating	Rule 4306	4320 Enhanced NOx Limit
5 MMBTU/HR up to 20 MMBTU/HR	9 ppm NOX and 400 ppm CO at 3% O2	5 ppm NOX at 3% O2
>20 MMBTU/HR up <75 MMBTU/HR	7 ppm NOX and 400 ppm CO at 3% O2	2.5 ppm NOX at 3% O2
>75 MMBTU/HR	5 ppm NOX and 400 ppm CO at 3% O2	2.5 ppm NOX at 3% O2

Fugitive emissions for Methane losses will need to be performed on hydrocarbon bearing fuel system components.

Absorber Treated Flue Gas Vent (Normal Operations and Start-up) – permit required

Given that the treated flue gas does not control any of the criteria pollutants from the generation units (Power Plant Turbines, CCU Boiler) the SJVAPCD may request that vent gas monitoring is performed at the exhaust location, possibly a Continuous Emissions Monitoring System

(CEMS) given the volume of the flue gas. The SJVAPCD may also require a flow volume totalizer at the exhaust. Given that ammonia and aldehydes are formed as a byproduct of solvent oxidation, the SJVAPCD will perform a health risk assessment to confirm volumes are within cancer risk acceptable thresholds. In addition, the SJVAPCD may request third party source testing of both start up and normal operations on a given frequency. There is a possibility that the SJVAPCD may require a costs analysis as to why VOCs cannot be feasibly controlled with an additional measure such as a carbon adsorber. Fugitive emissions for Methane and VOC losses will need to be performed on hydrocarbon bearing components.

Blowoff from CO_2 Compressor - permit required

Operations will be required to monitor, and survey planned blow-down events, including calculating or measuring blow down volume via flow meter. In addition, the compressor may require annual surveys for emissions losses due to leak-by on isolation valves. If the compressor is of the reciprocating or centrifugal type, the seal vents will be recommended to be under control or perform annual emissions and repair surveys.

Fugitive emissions for Methane and VOC losses will need to be performed on hydrocarbon bearing components during normal operations.

Compressor Start-up and Discharge Venting

Operations will be required to monitor planned venting events, including calculating or measuring vent volume via flow meter.

RO Unit Waste Water

No significant air contaminants are expected in the RO unit.

Solvent Maintenance System Effluent – permit required

APCD will require the system to be of closed piping with no solvent emission losses. Fugitive emissions for VOC losses will need to be performed on the system. System will need to purged to control system prior to opening. Any solvent removal will be done with receiving vessel under vapor control (carbon system or portable permitted combustion device).

Solvent Recovery Tank Vent – permit required

APCD will require the system to be of closed piping with no solvent emission losses. Vent should routed to vapor control system, including routing vapors to fuel system or the installation of low NOx burner, or storing solvent in pressurized vessel. Fugitive emissions for VOC losses will need to be performed on the system.

Vent on Glycol Tanks – permits required

For tanks 1,100 up to 19,800 gallons with a True Vapor Pressure of 11 psia, the tank will need to be equipped with a pressure-vacuum relief valve, or internal floating roof, or external floating roof, or vapor recovery system. Fugitive emissions for VOC losses will need to be performed on the tank.

Relief Valve Emissions

Some relief valves may be required to be routed to a control system, such as a flare or thermal oxidizer, specifically from the solvent system if the risk for accumulation of flammable or toxic vapors is present. Fugitive emissions for VOC losses will need to be performed on the system.

Water Discharge

An Underground Injection Control (UIC) Class I permit will be required to properly dispose of nonhazardous effluent as required by Title 40 of the Code of Federal Regulations (CFR) Parts

124, 144, 146, and 147. Class I wells are used to inject effluent into deep, confined rock formations. Class I wells are required to be drilled below the lowermost underground source of drinking water (USDW). Approximately 800 operational Class I wells exist in the United States.

The effluent will be injected into the Lower Tulare Formation near the plant. The injection fluid is expected to consist of cooling tower blowdown, plant area wash down, reverse osmosis reject water, plant and equipment drains, and non-oil-contaminated storm runoff.

The United States Environmental Protection Agency (US EPA) will be the lead agency for the permitting and regulation of the disposal wells. The US EPA will obtain input from the Central Valley Regional Water Quality Control Board, the State Water Resources Control Board, the California Geologic Energy Management Division, other stakeholder agencies, and the public during the permitting process. The permit application preparation, stakeholder agency consultations, and public comment period will take approximately two years to complete.

Waste Disposal

The below is an assessment of the waste handling requirements of the waste stream(s) generated by the proposed EFG+ CCU designed for CRC's CO_2 Capture from Elk Hills Power Plant Project.

Waste Stream(s)

The SMS effluent is comprised of heat stable salts, non-volatile solvent degradation products, unrecovered solvent, and a small amount of water. The SMS effluent will be stored in the Spent Solvent Tank which is sized to hold 30 days of continuous SMS operation effluent with the SMS operating at design capacity. The waste will be removed and disposed off-site via a third-party waste disposal contractor. The exact composition of the waste stream is highly dependent on

plant operation. Fluctuations in flue gas conditions along with how well the solvent hygiene is maintained by plant personnel can have a significant impact on both the waste production rate and composition.

Waste Characterization

The management of hazardous and non-hazardous waste at CRC facilities involves a cohesive effort on the part of CRC operations and contractor staff. The responsibilities of CRC personnel regarding waste management operations include, but are not limited to, the following:

1. Review and approve the project design, scope of work, and funding for waste management facilities, remediation and disposal projects;
2. Provide guidance on waste management issues and activities; and
3. Provide oversight of waste management activities to ensure compliance with Federal, State and Local waste management laws and regulations.

CRC personnel are responsible for conducting routine daily waste management activities that include, performing waste sampling and characterization of new waste streams.

EPA and the Cal-EPA require that all generators of waste, must initially determine if the waste is hazardous by first checking if the waste is excluded or exempted from regulation under Title 22 Section 66261.4 or 25143.2 of the Health & Safety Code. If not excluded or exempted, then the generator can determine the hazardous classification by using one of three methods: 1) Listing, 2) Characteristic Identification, or 3) Generator Knowledge.

1. **Listed Waste:** The US and Cal-EPA have established hazardous wastes lists, which are found in Title 22, Chapter 11 and 40 CFR Part 261. Since the RCRA wastes are

also included in the State listing (Title 22), this Title 22 list will be used as reference for this plan: a) Articles 4, b) Article 4.1 and c) Appendix X of Chapter 11, Title 22.

a. Title 22, Article 4 (RCRA Hazardous Waste List from 40 CFR Sections 261.31 through 261.33) lists three sources: (1) F waste from non-specific sources, (2) K waste from specific sources and (3) P & U waste – discarded, off spec and spill residues.

b. Article 4.1 (Additional Lists of Hazardous Wastes) includes California M-listed waste (mercury-containing products that are hazardous when discarded).

c. Appendix X List – if a waste is listed in Appendix X, the waste is presumed hazardous unless proven otherwise by testing or applying knowledge of hazardous characteristics. The generator is responsible for getting the waste tested, as applicable, using approved testing methods.

2. **Characteristic Identification:** In order to determine if a waste exhibits hazardous characteristics, the generator shall have the waste tested for the four hazardous waste characteristic criteria, except where generator knowledge is applied. These criteria are:

a. **Ignitability**: liquid with low flash point (<140° F), oxidizers

b. **Corrosivity**: pH ≤ 2, or ≥ 12.5, for solids a metal EPA Method 1110A can be used

c. **Reactivity**: very unstable, even under normal operating conditions; reacts violently with water

d. **Toxicity**: exceed the TCLP limits or Total Threshold Limit Concentration (TTLC) or Soluble Threshold Limit Concentration (STLC), or acute aquatic 96-hour LC_{50} criteria.

3. **Generator Knowledge:** A generator's material knowledge may be employed to determine the characterization of the waste including the origin of material, process generating the material, whether the material is used or unused, constituents or ingredients present, and known physical properties (e.g. flash point, pH, liquid/solid content, color, odor).

The generator is required to keep records of any test results, waste analyses, or other determinations made in accordance with 22 CCR 66262.11 for at least three years from the date the waste was last sent to off-site treatment, storage or disposal.

The TTLC and STLC values are used for California wastes such as certain inorganic persistent and bio-accumulative substances, mainly heavy metals. A complete listing of these metals and their TTLC and STLC values are presented in Table 5 (below). Selected organic compounds (mostly pesticides) also have TTLC and STLC values specified in the regulations to determine their hazardous waste characteristics. These organic compounds are not routinely generated at CRC. In addition, wastes generated in California must be able to pass the 96-hour aquatic toxicity test. If the LD_{50} of the fish test is less than 500 mg/l, then the waste is considered as California hazardous waste.

Table 5: TTLC & STLC Values

TTLC AND STLC VALUES FOR INORGANIC SUBSTANCES		
Substance	STLC [a] (mg/l)	TTLC [a] (mg/kg)
Antimony and/or antimony compounds	15	500
Arsenic and/or arsenic compounds	5	500
Asbestos [b]		1%

TTLC AND STLC VALUES FOR INORGANIC SUBSTANCES		
Barium and /or barium compounds (excluding barite)	100	10,000 [c]
Beryllium and/or beryllium compounds	0.75	75
Cadmium and/or cadmium compounds	1.0	100
Chromium (VI) compounds	5	500
Chromium and/or chromium (III) compounds	5[d]	2,500
Cobalt and/or cobalt compounds	80	8,000
Copper and/or copper compounds	25	2,500
Fluoride salts	180	18,000
Lead and/or lead compounds	5.0	1,000
Mercury and/or mercury compounds	0.2	20
Molybdenum and/or molybdenum compounds	350	3,500[e]
Nickel and/or nickel compounds	20	2,000
Selenium and/or selenium compounds	1.0	100
Silver and/or silver compounds	5	500
Thallium and/or thallium compounds	7.0	700
Vanadium and/or vanadium compounds	24	2,400
Zinc and/or zinc compounds	250	5,000

[a] STLC and TTLC values are calculated on the concentration of the elements, not the compounds
[b] Apply only to friable, powdered or finely divided material; includes chrysotile, amosite, crocidolite, tremolite, anthrophylite and actinolite.
[c] Excluding barium sulfate
[d] If the soluble chromium, as determined by the TCLP testing is less than 5 mg/l, and the soluble chromium equals or exceeds 500 mg/l and the waste is not otherwise identified as a RCRA hazardous waste pursuant to Section 66261.100, then the waste is a non-RCRA hazardous waste.
[e] Excluding molybdenum disulfide
Source: Title 22 Section 66261.24

The TCLP is used for RCRA waste determination only. The TCLP has resulted in the addition of 26 more compounds on the "D" listing that are now considered hazardous if their

concentrations equal or exceed the regulatory limits. A complete listing of these compounds and their limits are presented in Table 6.

Table 6: Toxicity Characteristic Contaminants and Regulatory Levels

Toxicity Characteristic Contaminants and Regulatory Levels					
EPA hazardous waste number	**Contaminant**	**Regulatory Level (mg/L)**	**EPA Hazardous Waste Number**	**Contaminant**	**Regulatory Level (mg/L)**
D004	Arsenic	5.0	D032	Hexachlorobenzene	0.13
D005	Barium	100.0	D033	Hexachloro-1,3-butadiene	0.5
D018	Benzene*	0.5			
D006	Cadmium	1.0	D034	Hexachloroethane	3.0
D019	Carbon tetrachloride*	0.5	D008	Lead	5.0
D020		0.03	D013	Lindane	0.4
D021	Chlordane	100.0	D009	Mercury	0.2
D022	Chlorobenzene*	6.0	D014	Methoxychlor	10.0
D007	Chloroform*	5.0	D035	Methyl ethyl ketone*	200.0
D023	Chromium	200.0[a]	D036	Nitrobenzene	2.0
D024	o-Cresol	200.0[a]	D037	Pentachlorophenol	100.0
D025	m-Cresol	200.0[a]	D038	Pyridine	5.0
D026	p-Cresol	200.0[a]	D010	Selenium	1.0[b]
D016	Cresol	10.0	D011	Silver	5.0
D027	2,4-D	7.5	D039	Tetrachloroethylene*	0.7
D028	1,4-Dichlorobenzene	0.5	D015	Toxaphene	0.5
D029		0.7	D040	Trichloroethylene*	0.5
D030	1,2-Dichloroethane*	0.13	D041	2,4,5-Trichlorophenol	400.0
D012		0.02	D042		2.0
D031	1,1-Dichloroethylene*	0.008	D017	2,4,6-Trichlorophenol	1.0
	2,4-Dinitrotoluene		D043	2,4,5-TP (Silvex)	0.2
	Endrin			Vinyl chloride*	
	Heptachlor (and its epoxide)				

Toxicity Characteristic Contaminants and Regulatory Levels
*This waste is listed as a volatile organic compound (VOC) in the TCLP test method; therefore, the zero-headspace extractor must be used when performing the TCLP on wastes containing this compound. [a]if o-, m-, and p-cresol concentrations cannot be differentiated, the total cresol (D026) concentration is used. The regulatory level of cresol is 200 mg/l. [b]Quantitation limit is greater than the calculated regulatory level. The quantitation limit therefore becomes the regulatory level. Source: Title 22 Section 66261.24

3.5 Site Specific Design Considerations

The EFG+ plant is designed to capture 90% of the CO_2 from the total flue gas feed to the unit.

The treated flue gas will be vented to atmosphere directly from the EFG+ Plant Absorber.

The on-stream factor for the plant will be 95% with a turndown of 40%.

The solvent make-up storage capacity will be a minimum of 30 days.

Water minimization is required for this project. Plant's cooling strategy is centered around reducing water make-up requirement.

As mentioned in Section 2.1, the project site was previously occupied by a processing plant which has since been demolished. It is expected that subsurface interferences will be present. Owner will bathtub the site to specified elevations and then transition it to the EPC contractor.

As the site is remote in nature, it is not expected to have any requirements for plume abatement as there is existing water vapor plumes from existing cooling towers and other equipment on the site. Similarly, noise abatement beyond those outlined by CalOSHA are not expected give the distance to the closest public roadway and background noise levels.

3.6 Modularization Design Requirements

Modularization of the project was highly investigated in an effort to reduce site construction hours and place craft labor in as controlled environment as possible. The nearest viable port is the Port of Stockton which is located approximately 225 miles from the project site. Due to limitations in the proximity of water access, the available road system and obstructions associated with road transport the module envelop was limited to 120 ft (L) x 20 ft (W) x 18 ft (H) at 250,000 lbs.

4.0 Basic contracting and purchasing strategy

The purchasing strategy for the project would be to open major equipment supply to the world market for such materials. Due to size and transportation constraints the columns would need to be field fabricated and thus be installed as part of a subcontract package. The basis of Fluor's execution would be to utilize local and regional union subcontractors for the installation of all facilities. The subcontractor selection would be based upon the availability of local subcontractors with current execution experience for the planned work. Prior to commencing the execution of Detailed Engineering, Procurement and Construction this strategy will have to be reviewed to determine if market conditions have changed, requiring modifications to the execution and durations currently envisioned for the project.

5.0 Process Engineering / Plant Configuration

This section describes the final CCU Process configuration that is selected to adhere to the key project charter of minimizing water usage while maintaining a low overall CO_2 capture cost.

5.1 Block Flow Diagram

Figure 4 shows a simplified Block Flow Diagram (BFD) for the overall EFG+-based CCU.

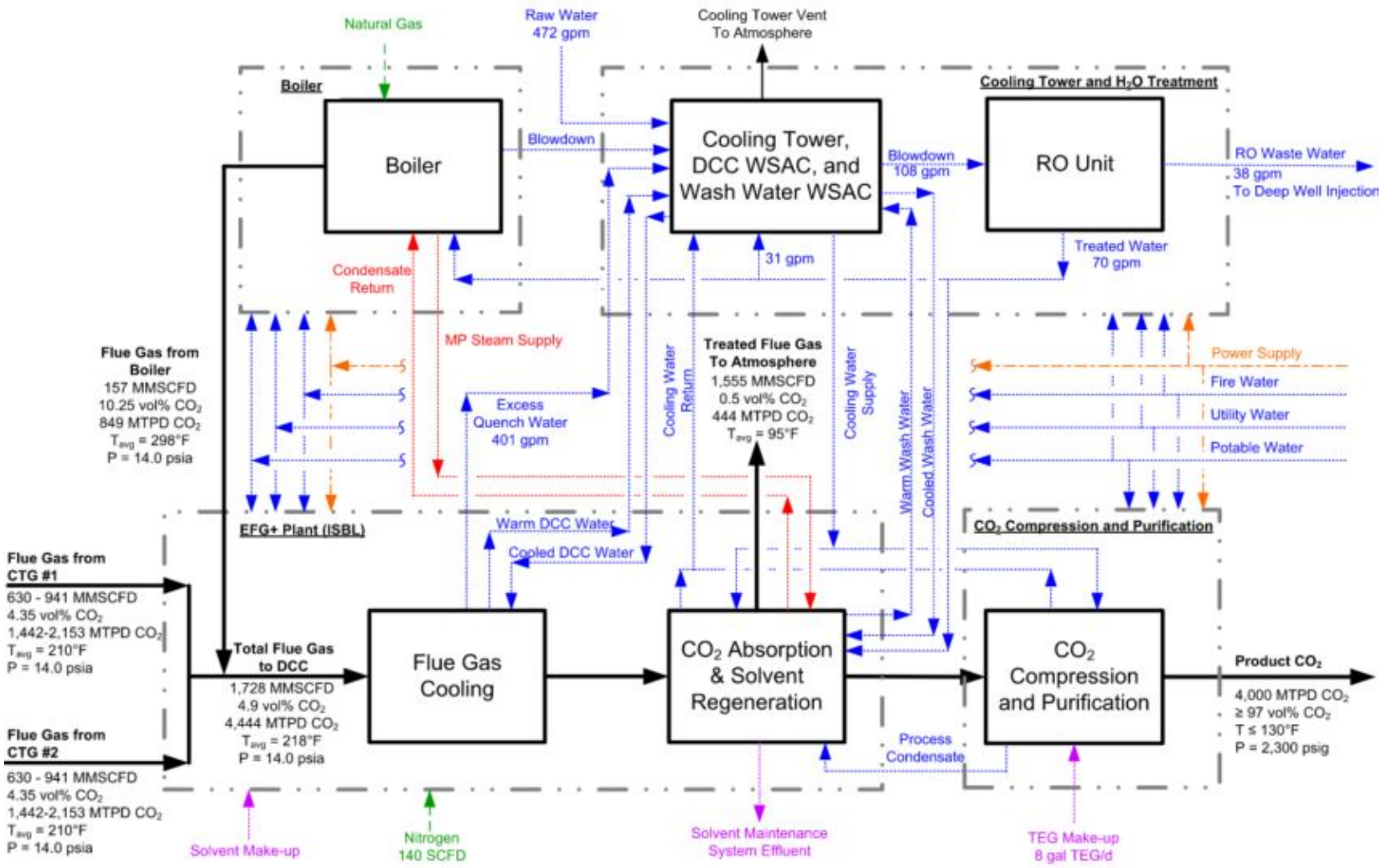


Figure 4: Block Flow Diagram

Within the BFD, the unit is divided into six (6) equipment subsystems:

- Flue Gas Cooling
- CO_2 Absorption & Solvent Regeneration
- CO_2 Compression and Purification
- Boiler
- Cooling Tower, DCC WSAC, and Wash Water WSAC
- RO Unit

The EFG+-based CCU is designed to recover 4,000 MTPD of CO_2 from flue gas streams produced by two existing CTGs, along with a third flue gas stream produced by a new Boiler Package. The Boiler Package produces flue gas at 298°F containing 10.25 vol% CO_2 while each of the CTGs produce flue gas at 210°F containing 4.35 vol% CO_2. It is preferential to recover as much CO_2 as feasible from the Boiler Package flue gas since treating this gas stream requires the unit to process only about 42% of the equivalent quantity of CTG flue gas per ton of CO_2 recovered.

If the on-going cost-cutting evaluation results in elimination of the Boiler Package, it is intended to keep the design capacity of the CCU at 4,000 MTPD CO_2 capture capacity, with all the CO_2 recovered from the CTG flue gas streams. Depending on which fuel gas CRC elects to feed to the CTGs, it is expected that the CTG flue gas CO_2 concentration will increase to above 4.5 vol% CO_2. With the current configuration, approximately 95% of the total Boiler Package flue gas, or 157 MMSCFD, is combined with 1,571 MMSCFD of flue gas from the CTGs to produce 1,728 MMSCFD total flue gas at 218°F and containing 4.9 vol% CO_2. The combined flue gas is routed to the Flue Gas Cooling system where it is cooled to near ambient conditions against a circulating DCC water stream. Within the Flue Gas Cooling system, cooled DCC water provided by the

DCC WSAC is contacted directly against the combined flue gas to cool the flue gas below its dew point. This cooling results in 401 gpm of water condensing out of the combined flue gas, with the condensed water being utilized to supplement the make-up water requirements associated with the Cooling Tower, DCC WSAC, and Wash Water WSAC. Warm DCC water from the Flue Gas Cooling system is pumped back to the DCC WSAC where heat is removed from the circulating water stream against air and cooling water.

Cooled flue gas from the Flue Gas Cooling system is routed to the CO_2 Absorption & Solvent Regeneration system. Within the CO_2 Absorption section, the cooled flue gas is contacted against the EFG+ solvent that serves to chemically absorb 90% of the total CO_2 present in the flue gas. The CO_2-lean flue gas is then washed and cooled against a circulating wash water stream as a means to minimize amine emissions. Cold wash water from the Wash Water WSAC is routed to the top of the CO_2 Absorption section where it is contacted directly against the CO_2-lean flue gas both as a means to scrub any entrained amine from the flue gas, and to cool the CO_2-lean flue gas before it is vented to atmosphere. Cooling the treated flue gas prior to venting is beneficial since it reduces the amine solvent vapor pressure and therefore, the vapor phase amine emissions. Approximately 1,555 MMSCFD of treated flue gas, containing only 0.5 vol% CO_2 and less than 0.1 ppmv amines, is vented from the CO_2 Absorption section to the atmosphere at 95°F. Warm wash water is pumped from the CO_2 Absorption section back to the Wash Water WSAC where heat is removed from the circulating water stream against air and water.

The CO_2-rich amine solvent from the Absorption section is pumped to the Regeneration section. Within the Regeneration section, the amine solvent is heated and contacted against stripping steam that serves to liberate the chemically bound CO_2 from the solvent. This produces a water-saturated CO_2 vapor stream that is routed to the CO_2 Compression and Purification system. Heat

is provided to the Solvent Regeneration system in the form of medium pressure steam provided by the Boiler Package. The steam is condensed against process fluids as a means to perform both regeneration and reclamation of the amine solvent. Hot CO_2-lean amine solvent from the regeneration system is cooled against cooling water, provided by a stand-alone packaged cooling tower system, before the pumped lean solvent is sent back to the Absorption section.

Water-saturated low-pressure CO_2 from the Solvent Regeneration system is routed to the CO_2 Compression and Purification system where it is compressed to 2,300 psig, and purified to greater than 97 vol% CO_2, less than 25 lb/MMSCF water vapor, and less than 50 ppmv oxygen. The compression occurs over a multi-stage integrally geared compressor with interstage cooling. Interstage cooling is achieved using a combination of both air (air-cooled glycol loop for interstage cooling, air cooler for aftercooler) and cooling water provided by the Cooling Tower system. The hybrid air-water cooling approach is taken as a means to minimize the unit's overall net water consumption.

As an additional means to minimize the unit's net make-up water consumption, a RO Unit is included to treat blowdown water produced by the Cooling Tower, DCC WSAC, and Wash Water WSAC. The RO Unit recovers about 65%, or 70 gpm, of the 108 gpm total blowdown water. The remaining 38 gpm is collected and routed to the unit battery limits for deep well injection.

5.2 Process Flow Diagrams

Process Flow Diagrams (PFDs) associated with the EFG+-based CCU are provided as Attachment 1. There are six (6) PFD drawings covering the following process equipment systems:

- Flue Gas Cooling (Drawing No. EH-35R-CCU1-D006)
- CO_2 Absorption (Drawing No. EH-35R-CCU1-D007)
- Solvent Regeneration (Drawing No. EH-35R-CCU1-D008)
- Solvent Maintenance (Drawing No. EH-35R-CCU1-D009)
- Chemical Storage and Supply (Drawing No. EH-35R-CCU1-D010)
- CO_2 Compression (Drawing No. EH-35R-CCU1-D011)

The EFG+ CCU is designed to recover 4,000 MTPD of CO_2 from the flue gases produced by the two existing GE CTGs, along with flue gas produced by a new Boiler Package that is required to produce the necessary regeneration steam for the EFG+ unit. Flue gases from the three source streams are combined and routed to the Flue Gas Cooling system.

Flue Gas Cooling

Reference Drawing No. EH-35R-CCU1-D006

It is necessary to cool the combined flue gas streams to near ambient conditions prior to contacting the solvent to allow the chemical CO_2 absorption process to occur. The combined flue gases are cooled against a circulating water stream in a DCC column. Warm water from the bottom of the DCC column is pumped over to a WSAC where heat is removed from the circulating water stream, before returning the cooled water back to the top of the DCC column. Since the combined flue gas is cooled to near ambient temperature, below the dew point of the gas stream, a portion of the water vapor contained in the gas stream will condense out. This condensed water is removed from the circulating water loop as needed to maintain the system water balance and is then utilized to supplement a portion of the make-up water to the EFG+ CCU cooling water systems.

CO_2 Absorption

Reference Drawing No EH- 35R-CCU1-D007

Cooled flue gas leaving the top of the DCC column is pulled into the CO_2 Absorption system by a Blower, which is required to overcome the pressure drop through the Flue Gas Cooling and CO_2 Absorption systems. From the Blower, the flue gas is discharged into the bottom of the Absorber where it is contacted with the EFG+ solvent. The EFG+ solvent flows down the Absorber while chemically removing CO_2 from the flue gas. In the top section of the Absorber, the CO_2-lean flue gas is washed against a circulating water stream that serves to reduce EFG+ solvent emissions by cooling and scrubbing the flue gas before the treated gas is vented to atmosphere. Similar to the DCC circulating water loop, heat is removed from the Absorber circulating wash water loop by pumping the warm water over to a dedicated WSAC, with the cooled wash water being returned back to the top of the CO_2 Absorber wash section. The CO_2-rich solvent is pumped to the Solvent Regeneration system.

Solvent Regeneration

Reference Drawing No EH- 35R-CCU1-D008

Rich solvent entering the Solvent Regeneration system is first heated with hot lean solvent before being fed to the Stripper column. Within the Stripper column, the rich solvent flows down the packing where it is contacted against stripping steam that serves to liberate the chemically bound CO_2 from the solvent. Stripping steam is produced in the reboilers using part of the steam produced by the Boiler Package to heat and vaporize a portion of the water from the hot lean solvent. Vapor leaving the top of the Stripper, consisting of CO_2 saturated with water vapor, is cooled against air in the Condenser where most of the water vapor is condensed. Condensed

water is separated from the CO_2 / remaining water vapor, and the bulk of the condensed water is returned to the top of the Stripper column where it is used as reflux. The remaining saturated low-pressure CO_2 is routed to the CO_2 compression system. Hot lean solvent from the bottom of the Stripper is pumped back through a cross exchanger, where it is partially cooled against rich solvent, and further cooled against cooling water, before being returned to the top portion of the Absorber.

Solvent Maintenance

Reference Drawing No EH- 35R-CCU1-D0009

The SMS is a proprietary equipment system designed to maintain the solvent quality. It is designed to remove heat stable salts and other soluble contaminants / degradations products from the circulating amine solvent loop while using part of the 165 psig MP steam produced by the Boiler Package. The SMS concentrates these undesirable products into a single concentrated waste stream that is collected, stored, and periodically hauled off for disposal. Fluctuations in flue gas conditions along with how well the solvent hygiene is maintained by plant personnel can have a significant impact on both the waste production rate and composition.

If it is decided to eliminate the Boiler Package and extract LP steam from the power plant for solvent regeneration, heating in the SMS can be achieved using electric heaters.

Chemical Storage and Supply

Reference Drawing No EH- 35R-CCU1-D0010

The Chemical Storage and Supply system consists of:

- Two (2) chemical storage tanks designed to store fresh EFG+ solvent and TEG

- Two (2) chemical pumps for pumping the make-up chemicals from the storage tanks to their destination users
- Two (2) drain collection tanks designed to collect EFG+ solvent and TEG through their respective closed-drain systems
- One (1) recovery pump to transfer EFG+ solvent from the EFG+ solvent collection tank back to the circulating solvent loop.
- One (1) filter designed to filter the recovered EFG+ solvent as it is pumped back into the main circulating solvent loop.

CO_2 Compression

Reference Drawing No EH- 35R-CCU1-D0011

Water-saturated low-pressure CO_2 from the Solvent Regeneration system is routed to the CO_2 Compression system where it is compressed, cooled (glycol/water cooled intercoolers and air cooled aftercooler) and treated to meet the final product specifications as specified in Table 7.

Table 7: CO_2 Product Specifications

Parameter	Value
End Use	Enhanced Oil Recovery
CO_2 Capture Capacity (MTPD)	4,000
Temperature (°F)	≤ 130
Pressure (psig)	2,300
Composition (%v/v)	
Carbon Dioxide (CO_2)	≥ 97%
Water Vapor (H_2O)	≤ 25 lb/MMSCF (Note 1)
Oxygen (O_2)	≤ 50 ppmv
Nitrogen (N_2)	≤ 1%
Ammonia (NH_3)	≤ 1 ppmv
Particulate Matter	≤ 1 ppmw
Notes: 1) Water content of 25 lb/MMSCF corresponds to a water drop out temperature in the dense phase CO_2 product of -13.6°F.	

The compression is achieved in a 7-stage compressor. Partially compressed CO_2 is extracted after the 5th compression stage and is routed to the TEG CO_2 Dehydration Unit for water removal. Molecular sieves can also be used to achieve the required dehydration. Molecular sieves are capable of reducing the water content to much lower levels than TEG systems. However, molecular sieves are generally much more expensive than TEG systems and are therefore used only when a more stringent water content is specified in the CO_2 product, such as for cryogenic applications. For this CO_2 pipeline application, a TEG system is easily capable of meeting the project 25 lb per MMSCF maximum H_2O water content specification. As such, the lower cost TEG system has been selected for this dehydration application.

Compressed CO_2 discharged from the final compression stage is then cooled against air and routed to the EFG+ CCU battery limits.

5.3 Utility Flow Diagrams

Utility Flow Diagrams (UFDs) associated with the EFG+-based CCU are provided as Attachment 2. There are six (6) UFD frames covering the following utility equipment systems:

- Cooling Water System (Drawing No. EH-35R-CCU1-D012)
- Boiler and RO Unit (Drawing No. EH-35R-CCU1-D013)
- Plant and Instrument Air (Drawing No. EH-35R-CCU1-D014)
- Glycol System (Drawing No. EH-35R-CCU1-D015)
- Potable and Raw Water (Drawing No. EH-35R-CCU1-D016)
- Wet Surface Air Coolers (Drawing No. EH-35R-CCU1-D017)

Cooling Water System

Reference Drawing No EH- 35R-CCU1-D0012

A circulating cooling water loop is provided as a utility system for the EFG+ CCU to meet a portion of the unit's cooling demands. Included in the Cooling Water system are: a dedicated single-cell cooling tower, basin, circulation pumps, and a chemical injection package. Cooled water is drawn from the basin and pumped to the various EFG+ CCU users. Warm water is returned from the various users and routed to the top of the Cooling Tower, where heat is removed from the water through induced draft fans. A Cooling Water Chemical Injection Package is provided to inject various chemicals into both the circulating cooling water loop and the RO Unit as a means to maintain the quality of the water.

Boiler and RO Unit

Reference Drawing No EH- 35R-CCU1-D0013

A dedicated Boiler Package is provided to meet the EFG+ CCU steam demands. The Boiler Package fires fuel gas provided by CRC at the plant battery limits to produce medium pressure steam utilized in the EFG+ CCU Solvent Regeneration System. Boiler feed water make-up is provided to the Boiler Package via a RO Unit that is included within the EFG+ CCU scope. The RO Unit is designed to recover water from the Cooling Water system blowdown as a means to minimize overall make-up water requirements due to lack of available water at the Elk Hills Power Plant site. In addition to providing make-up water to the Boiler Package, the RO Unit provides make-up water to the CO_2 Absorption system and Wet Surface Air Cooler basins. Reject water from the RO Unit is collected in a sump, from which it is pumped to the EFG+ CCU battery limits.

Plant and Instrument Air

Reference Drawing No EH- 35R-CCU1-D0014

Instrument and plant air requirements for the EFG+ CCU are met by a dedicated Plant and Instrument Air system. The Plant and Instrument Air system provide dry instrument and plant air to the various EFG+ CCU users.

Glycol System

Reference Drawing No EH- 35R-CCU1-D0015

A circulating glycol system is included as a closed-loop secondary cooling water system to provide cooling to the CO_2 Compression system. Heat is removed from the closed-loop system via air coolers. Although a direct water-cooled system using an open cooling tower can provide

deeper cooling than an air-cooled closed loop system, the air-cooled closed loop system was implemented to:

- Satisfy the project charter to minimize make-up water requirements, and therefore cooling load on the open-loop cooling tower system
- Avoid using air coolers directly in the CO_2 Compression system which would otherwise result in:
  - higher inter-stage pressure drops resulting in reduced compression efficiency
  - longer interconnecting piping distances between the compressor stages and intercoolers, resulting in increased inventory and decreased response time by the compressor control system

The Glycol system consists of an expansion tank, circulation pumps, and an air cooler for removing heat from the circulating glycol loop.

Potable and Raw Water

Reference Drawing No EH- 35R-CCU1-D0016

Potable and raw water are provided by CRC to the EFG+ CCU battery limits, from which they are distributed to the various utility stations and users within the EFG+ CCU.

Wet Surface Air Coolers (WSACs)

Reference Drawing No EH- 35R-CCU1-D0017

WSACs are provided to handle the two largest cooling loads within the EFG+ CCU: cooling of large circulating water stream associated with both the DCC circulating water and the CO_2 Absorption circulating wash water. WSACs achieve the cooling in two steps: initial cooling is performed against air using dry coils, while deeper cooling is achieved with internal circulating

water streams using wet coils. This hybrid air / water cooling approach is advantageous in that it allows for:

- reduced water make-up requirements when compared to 100% water cooling since air cooling is utilized to the maximum reasonable extent
- better overall process efficiency compared to 100% air cooling since deeper and tighter temperature approaches are achieved with water cooling.

Each WSAC service is equipped with wet and dry coils, basins, circulating spray water pumps, and cooling cell fans. Circulating spray water pumps draw cooled water from the basins and pumps the water through nozzles that spray the water over the wet coils. Water from the wet coils is collected in each of the DCC and wash water dedicated basins.

There is currently an on-going cost-cutting evaluation that is considering elimination of the Boiler Package that is dedicated to producing the steam needed for the CCU. If the Boiler Package is removed, steam will be extracted from the IP/LP crossover in the existing steam turbine generator. By extracting the steam at the IP/LP crossover and condensing the steam within the CCU, a significant portion of cooling capacity within the existing CRC cooling water system would be freed up. This freed up cooling capacity could be utilized within the CCU, thereby eliminating the need for perhaps five of the eight WSACs.

5.4 Overall Heat and Material Balance

Figure 5 is an Overall Heat and Material Balance providing flow rates, temperatures, pressures, and compositions for all the process streams to and from the overall EFG+ CCU process unit. Stream numbers correspond to the stream diamonds on the PFDs that are provided as Attachment 1.

Figure 5: Overall Heat and Material Balances

Stream Description		Flue Gas from CTG 1		Flue Gas from CTG 2		Flue Gas from Boiler Package		Combined Flue Gas to DCC		DCC Excess Water to WSAC / Cooling Tower Basins		Treated Flue Gas Vent to Atmosphere	
Stream Number		101A		101B		102		103		107		202	
Temperature, °F		210		210		298		218		123		95	
Pressure, psia		14.0		14.0		14.0		13.8		60.0		14.0	
Vapor Fraction		1.0		1.0		1.0		1.0		0.0		1.0	
Component Flows	MW	lbmol/hr	mol%	lbmol/hr	mol%	lbmol/hr	mol%	lbmol/hr	mol%	lbmol/hr	mol%	lbmol/hr	mol%
H_2O	18.02	10,646	10.3%	7,133	10.3%	3,020	17.5%	20,799	11.0%	11,014	100.0%	10,098	5.9%
CO_2	44.01	4,493	4.3%	3,010	4.3%	1,773	10.2%	9,276	4.9%	0	0.0%	927	0.5%
N_2	28.01	75,206	72.8%	50,388	72.8%	11,909	68.8%	137,503	72.5%	0	0.0%	137,502	80.5%
Ar	39.95	971	0.9%	650	0.9%	163	0.9%	1,784	0.9%	0	0.0%	1,784	1.0%
O_2	32.00	11,972	11.6%	8,021	11.6%	432	2.5%	20,425	10.8%	0	0.0%	20,425	12.0%
CO	28.01	0.01	0.1 ppmv	0.01	0.1 ppmv	0.87	50.3 ppmv	0.89	4.7 ppmv	0.00	0.0%	0.89	5.2 ppmv
NO_X (as NO_2)	46.01	0.18	1.7 ppmv	0.12	1.7 ppmv	0.04	2.3 ppmv	0.34	1.8 ppmv	0.00	0.0%	0.33	1.9 ppmv
SO_2	64.06	0.07	0.7 ppmv	0.05	0.7 ppmv	0.00	0.0 ppmv	0.12	0.6 ppmv	0.00	0.0%	0.00	0.0 ppmv
Total Flow, lbmol/hr		103,289		69,203		17,298		189,789		11,015		170,737	
Total Flow, lb/hr		2,918,190		1,955,220		486,410		5,359,820		198,450		4,799,460	
Molecular Weight		28.3		28.3		28.1		28.2		18.0		28.1	
Density, lb/ft³		0.055		0.055		0.048		0.054		61.7		0.066	
Liquid Flow, gpm (Actual)		-		-		-		-		401		-	
Actual Vapor Flow, acfm		883,233		591,776		167,342		1,662,945		-		1,209,392	
Vapor Flow, scfm		653,130		437,591		109,381		1,200,101		-		1,079,627	

Stream Description		Treated RO Water to Absorber		Compressed CO_2 Product to Battery Limits	
Stream Number		207		609	
Temperature, °F		105		130	
Pressure, psia		14.2		2,314	
Vapor Fraction		0.0		Supercritical	
Component Flows	MW	lbmol/hr	mol%	lbmol/hr	mol%
H_2O	18.02	276	100.0%	4	526 ppmv
CO_2	44.01	0	0.0%	8,349	99.9%
N_2	28.01	0	0.0%	1.50	180 ppmv
Ar	39.95	0	0.0%	0.04	5 ppmv
O_2	32.00	0	0.0%	0.09	<10 ppmv
CO	28.01	0.00	0.0%	0.00	0.0%
NO	30.00	0.00	0.0%	0.00	0.0%
NO_X (as NO_2)	46.01	0.00	0.0%	0.00	0.0%
SO_2	64.06	0.00	0.0%	0.00	0.0%
Total Flow, lbmol/hr		276		8,355	
Total Flow, lb/hr		4,970		367,510	
Molecular Weight		18.0		44.0	
Density, lb/ft³		61.9		42.7	
Liquid Flow, gpm (Actual)		10		-	
Actual Vapor Flow, acfm		-		-	
Vapor Flow, scfm		-		-	

5.5 Process Description

This section provides simplified descriptions of each part of the EFG+ CCU process designed for the CRC carbon capture project. In reading this section, it is recommended to refer to the PFDs and UFDs, provided as Attachment 1 and 2, respectively. The unit is designed to recover 4,000 MTPD of CO_2 from the flue gas streams produced by the two existing GE CTGs, along with flue gas produced by the new Boiler Package (CCU1-M-710), which is required to produce necessary regeneration steam for the EFG+ CCU.1

Fluor's scope begins at two new tie-ins to the existing CTG Heat Recovery Steam Generator (HRSG) stacks and ends with compressed carbon dioxide production. Excluded from Fluor's scope are the following equipment systems:

1. CO_2 pipeline
2. All EOR facilities
3. Deep well injection of RO Unit concentrate

The EFG+ CCU can be divided into seven primary subsystems or sections:

1. Flue Gas Cooling
2. CO_2 Absorption
3. Solvent Regeneration
4. Solvent Maintenance
5. Chemical Storage and Supply
6. CO_2 Compression
7. Utility Support Systems

Flue Gas Cooling

Refer to drawing number EH-35R-CCU1-D006 for the PFD showing the Flue Gas Cooling system.

Flue Gas Inlet Ducting System (CCU1-M-101) consists of a ducting network designed to transfer flue gas from each of the three atmospheric source stacks into a common duct, with the common duct then routed to the Flue Gas Cooling system. The draw from any one of the sources is limited to 95% to ensure at least 5% of the flue gas is continuously vented from each of the source stacks. This is done as a means to mitigate against drawing air down the stack, which would dilute the flue gas CO_2 concentration and increase the O_2 concentration, both of which are detrimental to the CO_2 recovery process. A lower CO_2 concentration reduces the CO_2 recovery efficiency since it requires a larger volume of gas to be treated per ton of CO_2 recovered. Higher oxygen content in the flue gas will lead to increased degradation of the amine solvent.

The Boiler Package produces flue gas containing over 10 vol% CO_2 and only 2.5 vol% O_2 compared to the CTGs that produce flue gas containing 4 vol% CO_2 and over 11 vol% O_2. As such, it is always preferential to take the maximum 95% draw rate from the Boiler Package stack. Processing 95% of the Boiler Package flue gas with the Boiler Package operating at full load and a 90% CO_2 absorption efficiency, produces 765 MTPD, or 19% of the overall 4,000 MTPD CCU design capacity. The remaining 81%, or 3,235 MTPD CO_2 is recovered from the CTG flue gases.

Each CTG produces 990 million standard cubic feet per day (MMSCFD) of flue gas at full operating load, containing 2,266 MTPD of CO_2. It is therefore necessary to draw from both CTGs to produce the remaining 3,235 MTPD CO_2 required to meet the overall 4,000 MTPD CCU design capacity. The CCU is designed to be able to process up to 95% of the flue gas from either of the two CTGs. A maximum 95% draw from one of the CTGs would result in a required flue

gas draw rate of 64% from the 2nd CTG to meet the 4,000 MTPD CO_2 recovery rate based on the CCU design 90% removal efficiency.

CTG flue gases are available at 210°F while the Boiler Package flue gas is available at 298°F. Combining the three flue gas streams in the Flue Gas Inlet Ducting System results in a mixed temperature of 218°F. The total combined flue gas flow rate is controlled by the Blower (CCU1-K-201), while the specific flow rate from each source is controlled by the following modulating louver dampers:

- CTG Flue Gas Louver Damper (CCU1-M-102 A/B)
- Boiler Flue Gas Louver Damper (CCU1-M-103)

Any of the three flue gas sources can be isolated from the CCU via the following guillotine dampers:

- Boiler Flue Gas Isolation Damper (CCU1-M-107)
- CTG Flue Gas Isolation Damper (CCU1-M-106A/B)

The combined flue gas is routed to the DCC (CCU1-C-101) column where the flue gas is contacted against a circulating water stream that serves to sub-cool the flue gas to 92°F. By cooling the flue gas to 92°F, water vapor is condensed out, resulting in a reduced mass and volumetric flue gas flow to be treated in the CO_2 Absorption system. This condensed water, consisting of approximately 400 gpm, is removed from the Flue Gas Cooling system as a means to maintain the system water balance. Since the condensed water is relatively clean, it is used to supplement a significant portion of the overall make-up water to the EFG+ CCU cooling water systems.

Warm water from the bottom of the DCC is pumped from the column by the DCC Water Pump (CCU1-P-101 A/B), and through the DCC WSAC (CCU1-M-704), a hybrid air / water cooler. The DCC WSAC cools the warm water from about 120°F to 83°F, with the cooled water returned to the top of the DCC column.

Due to inherent pressure drop in the flue gas ducting and DCC column, the cooled flue gas leaves the top of the DCC column under slight vacuum from which it is pulled into the CO_2 Absorption system by the Blower.

CO_2 Absorption

Refer to drawing number EH-35R-CCU1-D007 for the PFD showing the CO_2 Absorption system.

Cooled flue gas from the Flue Gas Cooling system is routed to the Blower via the DCC Flue Gas Outlet Duct (CCU1-M-105). The Blower, located in the flue gas path between the DCC and Absorber (CCU1-C-201) columns, is used to overcome the pressure drop through the DCC, Absorber, and associated ducting. Flue gas from the Blower is then routed to the Absorber via the Absorber Flue Gas Inlet Duct (CCU1-M-201). Within the Absorber, the flue gas flow up the column is counter-current to EFG+ solvent that flows down the column while chemically absorbing CO_2 from the flue gas. From the absorption section, the CO_2-lean flue gas continues to flow up the Absorber column into a wash section. In the wash section of the Absorber, the flue gas is contacted against a circulating water stream that serves to cool and scrub the flue gas as a means to minimize EFG+ solvent emissions by reducing both vapor phase and mechanical carryover of amine. Treated flue gas leaving the Absorber wash system is then vented directly from the top of the Absorber at 95°F. Absorber Stack Damper (CCU1-M-202) is provided at the top of the Absorber stack to prevent ingress of rain into the solvent system when the CCU is shut

down. The damper is fully open when the CCU is in operation and fully closed when the CCU is shut down.

Since the flue gas is chemically treated against an aqueous amine solution in the Absorber, the flue gas enters the wash section at the top of the Absorber saturated with water vapor. Cooling of the flue gas in the wash system will therefore lead to additional water vapor condensing out of the flue gas. To enhance the performance of the wash system, RO water is continuously fed to the top Absorber wash section. This water, along with any water vapor that is condensed out of the flue gas in the Absorber wash system, is removed from the wash system and diverted to the Absorber amine system as needed to maintain the wash system water balance.

Warm wash water collected at the bottom of the Absorber wash water system is pumped via the Wash Water Pump (CCU1-P-201 A/B), through the Wash Water Wet Surface Air Cooler (WSAC) (CCU1-M-705), where it is cooled against air and water to 83°F, and returned to the top of the Absorber wash system.

CO_2-rich solvent from the bottom of the Absorber is pumped over to the Solvent Regeneration system by the Rich Solvent Pump (CCU1-P-202 A/B).

Solvent Regeneration

Refer to drawing number EH-35R-CCU1-D008 for the PFD showing the Solvent Regeneration system.

Rich solvent entering the Solvent Regeneration system is first heated against lean solvent in the Solvent Cross Exchanger (CCU1-E-301), before being fed to the top of the Stripper (CCU1-C-301) below the wash section of the column. Solvent flows down the Stripper counter-current to stripping steam which provides the energy for breaking the bond between the EFG+ solvent and

the CO_2, thereby liberating the CO_2 from the solvent. CO_2 and steam travel upward in the column to the wash section of the Stripper located above the rich solvent feed nozzle. In the wash section, condensed water from the Overhead Accumulator (CCU1-V-302) contacts the gas over trays. The reflux water partially cools the gas and scrubs entrained solvent and much of the vapor phase solvent out of the overhead gas.

Vapor from the top of the Stripper contains CO_2 saturated with water. The vapor is cooled to 112°F and most of the water is condensed against air in the Condenser (CCU1-FF-301). The two-phase mixture from the Condenser enters the Overhead Accumulator where the CO_2 and condensed water are separated. The low-pressure CO_2 product is routed to the CO_2 Compression system.

Stripping steam is provided from the Reboiler (CCU1-E-302) by condensing steam provided by the Boiler Package. CO_2-lean solvent collected near the bottom of the Stripper is routed to the Reboiler, where the EFG+ solution is heated to produce a two-phase mixture, with the vapor phase consisting mostly of steam. The two-phase mixture is returned to the bottom of the Stripper to provide the bulk stripping steam for solvent regeneration. Since the Reboiler is a thermosyphon configuration, the solvent-side circulation occurs naturally without pumps.

Steam condensate from the Reboiler is collected in the Reboiler Condensate Drum (CCU1-V-303). From the Reboiler Condensate Drum, most of the condensate is pumped back to the Boiler Package via the Reboiler Condensate Pump (CCU1-P-303 A/B). A slip stream of the pumped condensate is diverted and used to desuperheat steam feeding the Reboiler in the Reboiler Steam Desuperheater (CCU1-M-301).

Lean solvent from the bottom of the Stripper is pumped via the Lean Solvent Pump (CCU1-P-301 A/B) through the Solvent Cross Exchanger, where it is initially cooled against rich solvent.

The cooled lean solvent from the Solvent Cross Exchanger is then further cooled against cooling water in the Lean Solvent Cooler (CCU1-E-202) before being routed back to the Absorber. A slipstream of the cooled lean solvent is diverted to the Lean Solvent Filter (CCU1-V-201) that serves to remove any particulates from the circulating solvent stream. The filtered slipstream is returned to the cooled lean solvent stream feeding the Absorber.

Solvent Maintenance

Refer to drawing number EH-35R-CCU1-D009 for the PFD showing the Solvent Maintenance System.

The Solvent Maintenance System (SMS) is a proprietary equipment system for maintaining a high solvent quality. It is designed to remove heat stable salts and other soluble contaminants degradation products from the circulating solvent loop. The SMS concentrates these undesirable products into a single concentrated waste stream and routes the waste stream to the Spent Solvent Tank (CCU1-T-401)

Chemical Storage and Supply

Refer to drawing number EH-35R-CCU1-D010 for the PFD showing the Chemical Storage and Supply system.

Make-up solvent is stored in the Solvent Storage Tank (CCU1-T-501) and is added to the bottom of the Absorber as needed using the Solvent Make-up Pump (CCU1-P-501). The amount of solvent make-up per day depends on the plant operating conditions and is determined by regular monitoring of the solvent concentration. The difference between the measured and desired solvent concentration is used to determine how much make-up solvent must be added. The amount of make-up is controlled by the run time of the Solvent Make-up Pump.

Nitrogen provided via cylinders is required to blanket the Solvent Storage Tank in order to protect the solvent against oxidative degradation.

All drains in the solvent system are routed to the Solvent Recovery Tank (CCU1-T-502) through a closed drain system. The recovered solvent is ultimately pumped back to the Absorber boot via the Solvent Recovery Pump (CCU1-P-502). The Solvent Recovery Filter (CCU1-V-501) is provided to filter particulates out of the solvent before being sent to the Absorber.

Make-up triethylene glycol (TEG) is stored in the TEG Storage Tank (CCU1-T-503) and is added to the CO_2 Dehydration Package (CCU1-M-602) as needed using the TEG Make-up Pump (CCU1-P-503).

CO_2 Compression

Refer to drawing number EH-35R-CCU1-D011 for the PFD showing the CO_2 Compression system.

Following CO_2 recovery, the captured CO_2 is compressed and purified to meet the desired product specifications.

Low-pressure CO_2 product from the Solvent Regeneration system is routed to the CO_2 Product Compressor Suction Knock Out (KO) Drum (CCU1-V-603), which is provided as a final protection to prevent any liquids from carrying over to the suction of the CO_2 Product Compressor. In addition to low-pressure CO_2 from the Overhead Accumulator, the CO_2 Product Compressor Suction KO Drum is also fed with: the compressor anti-surge recycle line, the TEG offgas from the CO_2 Dehydration Package, and the collected condensate stream from the downstream compressor intercooling stages. Within the CO_2 Product Compressor Suction KO

Drum, any condensed water is separated from the predominantly CO_2 vapor streams and pumped back to the Solvent Regeneration system via the Process Condensate Pump (CCU1-P-601 A/B).

Overhead vapor from the CO_2 Product Compressor Suction KO Drum is routed to the CO_2 Product Compressor, a 7-stage compressor that consists of a wet section and a dry section. The wet section of the compressor includes aqueous glycol-cooled intercoolers with integrated moisture separators. Between each of the stages, the partially compressed CO_2 is cooled against aqueous glycol that is provided as a secondary cooling loop. The dry section also includes an aqueous glycol cooled intercooler between stages 6 and 7.

Between the wet and dry sections, the partially compressed CO_2 product is treated to remove water vapor as a means to satisfy the 25 lb H_2O per MMSCF CO_2 product maximum allowable water content specification. Partially compressed CO_2 is extracted from a compressor inter-stage, cooled against cooling water in the CO_2 Product Compressor Intercooler (CCU1-E-601), and any water vapor that is condensed is removed in the CO_2 Product Compressor Intercooler KO Drum (CCU1-V-602). Cooling water is used in lieu of aqueous glycol for this service to provide for deeper cooling and maximum water knock-out as to reduce the load on the CO_2 Dehydration Package. Condensate collected in the CO_2 Product Compressor Intercooler KO Drum is combined with condensate collected in the upstream CO_2 Product Compressor wet section moisture separators. The combined condensates are then routed to the CO_2 Product Compressor Suction KO Drum.

Overhead gas from the CO_2 Product Compressor Intercooler KO Drum is routed to the CO_2 Dehydration Package, a vendor supplied triethylene glycol (TEG) skidded unit that serves to further reduce the water content in the CO_2 product gas as needed to meet the product

specification. Water vapor that is removed from the CO_2 product in the CO_2 Dehydration Package is recycled back to the CO_2 Product Compressor Suction KO Drum as TEG offgas.

The dehydrated gas from the CO_2 Dehydration Package is returned to the dry section of the CO_2 Product Compressor where it is further compressed to the meet the desired product pressure of 2,300 psig. Following the final compression stage, the compressed CO_2 is cooled against air in the CO_2 Product Compressor Aftercooler (CCU1-FF-601) to meet the maximum desired temperature of 130 °F, before being routed to the plant battery limits.

During start-up, the product CO_2 is initially recycled through the anti-surge line while a portion can be vented to atmosphere through the CO_2 Vent Stack (CCU1-VS-601) to ensure the product specifications are met before sending the CO_2 to the plant battery limits. Upon a trip or shutdown of the CO_2 Product Compressor, the compression system will be automatically depressurized/de-inventoried through blow-off valves (provided by the compressor vendor) with the CO_2 routed to the CO_2 Vent Stack. The CO_2 Vent Stack serves to provide a single emission point for all depressurization and relief lines from the CO_2 compression system.

Supporting Utility Systems

Refer to the Utility Flow Diagrams provided as Attachment 2.

Utilities required by the EFG+ CCU include: cooling water, steam, water treatment, instrument air, plant air, secondary aqueous glycol cooling, nitrogen, raw water, and potable water.

Cooling Water System

The overall CCU cooling water system is designed to meet the unit's cooling water demands with three cooling subsystems:

- DCC WSAC system (Drawing No. EH-35R-CCU1-D017)

- Wash Water WSAC system (Drawing No. EH-35R-CCU1-D017)
- Dedicated cooling tower system (Drawing No. EH-35R-CCU1-D012)

Descriptions of the DCC and Wash Water WSAC systems are provided in the previous sections.

A new dedicated cooling tower system is provided to meet the remaining cooling water demands associated with the EFG+ CCU. The system is equipped with a single cell Cooling Tower (CCU1-M-701), Cooling Tower Basin (CCU1-M-702), Cooling Water Pumps (CCU1-P-701 A/B), and Cooling Water System Chemical Injection Package (CCU1-M-703).

The Cooling Water Pumps draw the cold cooling water from the Cooling Tower Basin and route the cooling water through the various EFG+ CCU users. From the users, the warm cooling water is returned to the top of the Cooling Tower, an induced draft tower designed to cool the cooling water from 104°F to 74°F. A continuous blowdown is taken from the discharge of the Cooling Water Pumps to prevent build-up of contaminants in the circulating cooling water loop.

A Cooling Tower Chemical Injection Package (CCU1-M-703) is provided to maintain the quality of the circulating cooling water. This package includes a dosing facility for the following cooling water treatment chemicals:

- Sulfuric acid
- Corrosion inhibitor
- Scale inhibitor
- Silica Dispersant
- Chlorine Dioxide
- Bio-dispersant

In addition, the Cooling Water Chemical Injection Package will serve to store and dose chemicals to the RO Unit. The RO Unit chemicals foreseen to be required include:

- Membrane biocide
- Membrane scale inhibitor
- Sodium metabisulfite dechlorination

A portion of the make-up water to the cooling tower system is supplied by the excess DCC quench water and RO water. The balance of make-up water is provided by CRC at the unit battery limits as raw water make-up.

Steam System

To meet the EFG+ plant steam demands, a dedicated fuel gas fired Boiler Package is provided to produce medium pressure saturated steam. The Boiler Package burns a nominal 550 MMBtu/hr of fuel gas at full load and includes boiler drums with convection tubes, boiler furnace, burner and windbox assembly, burner throat, air blower, economizer, blowdown drum, feed water pumps, deaerator, ammonia injection / SCR catalyst system, and stack. Saturated steam produced at 165 psig from the Boiler Package is routed to the various EFG+ CCU users and is returned to the Boiler Package deaerator as steam condensate. Blowdown water is routed to the Cooling Tower Basin, DCC WSAC Basin, and Wash Water WSAC Basin. Make-up water is provided from the RO Unit (CCU1-M-711).

Water Treatment System

Due to the lack of water available at the Elk Hills Power Plant site, the EFG+ CCU is equipped with a water treatment system, consisting of a RO Unit that is designed to recover at least 65% of the Cooling Tower blowdown. The recovered water is utilized as make-up to the CO_2

Absorption system, Boiler Package, DCC WSAC Basin, Wash Water WSAC Basin, and the Cooling Tower Basin. RO Water Pump (CCU1-P-710 A/B) is used to route RO water to the CO_2 Absorption system and the Boiler Package. The remaining reject water is collected in the Reject Water Sump (CCU1-M-712) from which it is pumped to the EFG+ CCU battery limits via the Reject Water Pump (CCU1-P-711 A/B) where it will ultimately be disposed via deep well injection.

Plant and Instrument Air System

Instrument and plant air requirements for the EFG+ CCU are met by a dedicated Plant and Instrument Air Package (CCU1-M-720). The Plant and Instrument Air Package consists of 2 x 100% air compressors with intercoolers and knockout pots, wet air receiver, a dual-bed desiccant dryer, dry air receiver, and associated filters.

Secondary Aqueous Glycol Cooling System (Glycol System)

Water-cooled intercoolers are preferred over air coolers in the CO_2 compression system for the following reasons:

- Significantly reduced pressure drop compared to air coolers, resulting in reduced compression power requirements, especially at the front end of the compression train
- Shorter interconnecting piping distances between the compressor stages and intercoolers, providing for reduced inventory and better response time by the compressor control system
- Allows the compressor vendor to integrate the knock-out drum and intercooler for each intercooling stage

However, the draw-back to using water-cooled intercoolers is that they add to the overall cooling water load and therefore the overall EFG+ CCU make-up water requirements, thus contradicting the project charter of water minimization. As an alternative, the unit is designed with an aqueous glycol secondary cooling loop. Implementing a secondary cooling loop allows for all the advantages associated with water-cooled intercoolers without adding to the plant water consumption. The heated aqueous glycol solution can be cooled in a single air cooling service, rather than having a separate air cooling service for each intercooling stage.

The secondary glycol cooling system consists of a Glycol Solution Expansion Tank (CCU1-T-730), Glycol Solution Pump (CCU1-P-730 A/B), and a Glycol Solution Cooler (CCU1-FF-730). Cooled aqueous glycol solution from the Glycol Solution Expansion Tank is pumped by the Glycol Solution Pump through the various CO_2 compression intercoolers, where the solution absorbs the compression heat from each of the CO_2 Product Compressor stage discharge streams. The heated glycol solution is then routed through the Glycol Cooler where the solution is cooled against air before being returned to the Glycol Expansion Tank.

Electrical Power

Electrical power is supplied to the CCU from a new 115 kV line that will run from an existing CRC substation to the new CCU substation. The CCU substation provides power that will be stepped down to 13.8 kV / 4160 V / 480 V for major plant loads that will be fed from a Main and an Auxiliary Power Center. Due to the large inductive loads at the facility, an automated power factor correction capacitor bank will be applied within the CCU electrical system at the 15 kV level. CCU process equipment users will consume a nominal 35 MW of electrical power at full operating load. This includes all process equipment users within the carbon capture unit, CO_2 compression / dehydration, and utility support equipment such as boilers and cooling towers.

Excluded from this value are loads associated with auxiliaries such as analyzer shelters, lube oil systems, lighting, electrical heat tracing, seal air systems, HVAC, transformers and UPS.

5.6 List of Major Equipment and Overall Dimensions

A Process Sized Equipment List is included as Attachment 3.

5.7 Plot Plan

A Plot Plan is provided as Attachment 4 to indicate how the major equipment in the EFG+ CCU has been arranged. The following narrative is a high-level description outlining the strategy for the plot layout.

Flue gas ducting ties into the existing CTG stacks (not pictured on the Plot Plan) located to the North of the EFG+ CCU plot. To minimize the length and pressure drop associated with the large flue gas duct network, the Direct Contact Cooler (DCC) (C-101) is located on the north side of the plot. Boiler Package (M-710) is located adjacent to and east of the DCC column with its stack on the north side of the packaged unit. A smaller flue gas duct transfers flue gas from the Boiler Package stack, north to the larger common CTG flue gas duct. Tie-in to the larger common flue gas duct is to the north of the EFG+ CCU plot to ensure adequate straight run is provided to allow for sufficient mixing and distribution into the DCC.

Cooled overhead flue gas from the top of the DCC is routed to the Blower (K-201), located adjacent and to the west of the DCC. The DCC, Blower, and Absorber (C-201) are placed in-line from east to west, respectively, to avoid horizontal turns in the large flue gas ducting. Turns in the ducting can result in misdistribution and inaccurate flow measurement if inadequate straight run is provided to allow the flue gas flow profile to even out. Avoiding such turns, and therefore excessive straight runs not only minimizes ducting material cost, but also pressure drop along the

flue gas path. This in-turn minimizes the differential head and therefore electrical power associated with the Blower.

The following large circulation pumps are located underneath a structure just to the south of the DCC and Absorber columns:

- DCC Water Pump (P-101 A/B)
- Wash Water Pump (P-201 A/B)
- Rich Solvent Pump (P-202 A/B)
- Lean Solvent Pump (P-301 A/B)

This location and arrangement provides for minimum lengths associated with the large suction lines. Additionally, both the Rich and Lean Solvent Pumps discharge to the Solvent Cross Exchanger (E-301) which is located on the structure deck directly above the pumps. The other plate exchanger, Lean Solvent Cooler (E-202), is located on the same structure deck as the Solvent Cross Exchanger to keep the like equipment and services together.

The DCC and Wash Water Pumps circulate process water through the DCC and Wash Water WSACs (M-704 and M-705, respectively), located in the southeastern corner of the plot. Locating the WSACs and Cooling Tower (M-701) in the southeastern corner of the plot is done as a means to minimize drift and hot air recirculation based on the prevailing wind direction out of the northwest.

South of the large circulation pumps and plate exchanger structure is the main pipe rack running in the east-west direction across a middle section of the plot that carries the bulk of the large piping. A finger rack is provided off the main pipe rack serving to support the process water lines to/from the main pipe rack to/from the WSACs, and the smaller make-up and drain lines to/from

the chemical storage and supply area located in the southwestern area of the plot. A truck loading/unloading area is provided in the southwestern corner of the plot to provide access to the chemical storage and supply area.

The Stripper (C-301), Reboiler (E-302), Reboiler Condensate Drum (V-303), and Reboiler Condensate Pump (P-303 A/B) all work together and are therefore close-coupled to the west of the finger rack take-off from the main pipe rack. This provides for a centralized location for large amine, steam, and condensate lines with close access to the main pipe rack. The large low-pressure CO_2 overhead line from the Stripper is routed to the Condenser (FF-301) that consists of multiple air cooler bays located on top of the main pipe rack next to the Stripper. The two-phase CO_2-water mixture from the Condenser is routed to the Overhead Accumulator (V-302) located in the central area of the plot just south of the main pipe rack. Reflux Pump (P-302 A/B) is located next to the Overhead Accumulator to minimize the pump suction line run.

All equipment associated with the CO_2 Compression system including the CO_2 Product Compressor (K-601), CO_2 Product Compressor Intercooler (E-601), CO_2 Product Compressor Intercooler KO Drum (V-602) and CO_2 Dehydration Package (M-602) are located in the remaining area in the west end of the plot, on the north side of the main pipe rack. Equipment associated with the secondary glycol aqueous cooling system, including the Glycol Expansion Tank (T-730) and Glycol Solution Pump (P-730 A/B) are also located in the west side of the plot, on the south side of the main pipe rack since this system provides cooling for the CO_2 Product Compressor. Similar to the Condenser, both the CO_2 Product Aftercooler (FF-601) and Glycol Solution Cooler (FF-730) consist of multiple air cooler bays that reside on top of the main pipe rack.

5.8 Operating and Maintenance Costs

The major operating and maintenance costs associated with the CCU include:

- Utility requirements – for this project, the two major utility requirements are fuel gas for generating steam in the new boiler package, and electrical power.
- Consumables – EFG+ solvent, raw water make-up, TEG, cooling water treatment chemicals, and RO system treatment chemicals.
- Waste Haul-off – SMS waste effluent removal
- Plant personnel
- Maintenance costs

The EFG+ CCU requires one control room operator and one field operator per shift. Assuming a four shift schedule, a total of 4 control room operators and 4 field operators will be required. It is possible that the control room operators be shared with the power plant. Two laboratory technicians are required for the EFG+ CCU. Several maintenance personnel are required for the EFG+ CCU, which can possibly be shared with the power plant. Overall personnel requirements for the CCU are summarized in Table 8.

Table 8: Personnel Requirements

Staff Position	Positions Required
Control Room Operator	4
Field Operator	4
Laboratory Technician	2
Maintenance Supervisor (Note 1)	1
Electrical Technician (Note 1)	1
Mechanical Technician (Note 1)	2
Instrumentation Technician (Note 1)	2
Notes: 1) Maintenance Supervisor and Technicians can be shared with power plant.	

6.0 Civil Engineering

This section describes the Civil Engineering conceptual design, which include the following:

- Site grading and earthwork volume calculations
- Conceptual site preparation including the mass excavation plan for foundation and utilities installation
- Conceptual site storm water runoff drainage system
- Conceptual plant roads and access
- Conceptual spill containment assessment and plan
- Conceptual plant finished grading and paving plan

6.1 Soil Load Analysis

A Site Specific Geo-technical Investigation, which included field investigation, laboratory testing and engineering analysis, was conducted for the project which provided a report with recommendations for design of foundations and piles along with recommendations for site preparation and grading. Based upon the findings of the soil investigation, the upper three to ten (3'-10') feet of existing soils at the project site are soft and compressible; therefore the report provided recommended depths for soil-removal and compaction requirements that correspond to expected bearing pressures. In addition, the geo-technical investigation report provided criteria for supporting lightly loaded structures on shallow foundations (spread footings and structural mats) and supporting heavy loaded structures on deep foundations (piles). It also provided dynamic soil properties for designing of vibrating equipment foundations. For more information, refer to the Geotechnical Investigation Report provided as Attachment 5.

6.2 Storm Water Runoff Plan

Storm water runoff and firewater discharge from all areas of the plant are collected through swales and a series of catch basins connected by an underground piping system and conveys the flow to a detention basin.

The storm water runoff system has been sized to accommodate the largest runoff generated from the following:

- Design rainfall event, 10-year 24-hour storm
- Fire water discharge, estimated to be 1,500 gpm for the plant

Due to the presence of Amine and Glycol in the plant, the storm water sewer system is considered to be potentially contaminated and therefore the detention basin has been lined with a geotextile

preventing any seepage and ground water contamination. The water collected in the basin will be removed by vacuum truck, as required.

The detention basin has been sized per Kern County Development Standards Engineering Bulletin 11-02. The rainfall event for sizing the basin was the data for a 10-year 5-day storm obtained from the NOAA Atlas 14, Vol 6, Ver. 2.0.

6.3 Geologic Assessment

The Geologic Hazard Study and Seismic Design Information are based on the Site Specific Geo-technical Investigation report. The Geological Hazards Assessments indicates that there is a low probability for liquefaction to occur during a major earthquake at the site. The site-specific seismic design acceleration values to be utilized for the proposed facilities should be 0.94g for short periods (SDS) and 0.465g for the 1 second period (SD1). Based on the seismic shear wave survey conducted, Site Class of "C" (very dense soil and soft rock) can be utilized and the seismic design category is D per 2019 CBC (California Building Code). In the event of major earthquake, there is a low potential for rock falls or landslides to impact the site. Minor settlements (< 1") may occur at the site during a major earthquake. Based on the lithology encountered in the top 10ft of soil borings, it appears that low to moderately expansive surface soils are present at the site. Tests done indicate that no mitigation measures will be necessary for expansive soil or hydro-compaction. For more information on the Geological Hazard Study, refer to Appendix D of the Geo-technical Investigation Report, provided as Attachment 5.

6.4 Spill Containment Assessment

To minimize the potential for contaminating plant storm water runoff, secondary containment in the form of concrete curbing has been provided for areas where equipment containing Amine and Glycol are located.

Each curbed area will have at least one sump with a drain pipe connected to the storm water drainage system via a normally closed valve. In curbed areas with multiple equipment items; to prevent the spread of a spill from a single equipment item to the entire curbed area, multiple sumps in opposite corners have been placed with a ridge in between them dividing the curbed area into smaller subareas.

Each valve will be placed in a concrete box with a checkered plate cover equipped with a locking mechanism outside and adjacent to the curb.

After a rain event, the water collected within the curb will be tested for contaminants and if clean, the normally closed valve will be opened releasing the water to the underground storm sewer system. If water collected within the curb is contaminated, or in the event of a spill, the contents will be removed via vacuum truck.

Curbs have been sized to accommodate the largest possible spill, which is the working capacity of the equipment plus a 10 year-24 hour storm event.

Where practical, several equipment items with the same service have been placed inside a single curb. The combined curb has been sized to accommodate a spill from the largest equipment item within that curb plus the rainfall noted above.

7.0 Structural Engineering

This section summarizes the Structural Engineering effort for the project, highlighted by the Foundation Design Drawings, Structural and Architectural Drawings, along with a summary as to how the Material take-off were developed.

7.1 Foundation Design Drawings

Select Preliminary Foundation and Piling Design Drawings developed for the FEED effort are provided as Attachment 6. Included in Attachment 6 are sketches for:

- Main Air Cooler Pipe Rack Foundation and Piling Sketches (EH-35R-CCU1-SKT-00100 THRU 00103)
- Plate and Frame Exchangers Structure Foundation and Piling Sketches (EH-35R-CCU1-SKT-00104 THRU 00105)
- Foundation and Pile Sketches for Compressors (EH-35R-CCU1-SKT-00107 THRU 00109)
- North-South and East-West Finger Pipe Rack Foundation and Pile Sketches (EH-35R-CCU1-SKT-00110 THRU 00113)
- Auxiliary and Main Power Centers Foundations and Piling Sketches (EH-35R-CCU1-SKT-00120 THRU 00127)
- Blower Concrete Structure, Foundation and Piling Sketches (EH-35R-CCU1-SKT-00128 THRU 00129)

- Foundation and Piling Sketches for Vertical Vessels, Horizontal Vessels, Tanks, Pumps, Vendor Packaged equipment, Retaining Wall, Cooling Towers and Duct Supports (EH-35R-CCU1-SKT-00130 THRU 00165)

7.2 Structural and Architectural Design Drawings

Select Preliminary Structural Drawings that were developed for the FEED effort are provided as Attachment 7. Included in Attachment 7 are sketches for:

- Main Air Cooler Pipe Rack Steel Sketches (EH-35R-CCU1-SKT-00200 THRU 00210)
- Plate and Frame Exchangers Steel Structure Sketches (EH-35R-CCU1-SKT-00211 THRU 00217)
- Compressor Shelter and Platforms Steel Sketches (EH-35R-CCU1-SKT-00231 THRU 00238)
- North-South and East-West Finger Pipe Rack Steel Sketches (EH-35R-CCU1-SKT-00239 THRU 00246)
- DCC and Absorber Access Steel Sketches (EH-35R-CCU1-SKT-00247 THRU 00252)
- Auxiliary and Main Power Centers Steel Sketches (EH-35R-CCU1-SKT-00253 THRU 00254)
- Blower access platform and Duct Support & Access Steel Sketches (EH-35R-CCU1-SKT-00255 THRU 00265)
- Duct Support Steel Sketches (EH-35R-CCU1-SKT-00266 THRU 00285)

7.3 Material Take-Offs

Structural Material Take-offs were generated from a combination of extraction from the 3D model and derived manually from the preliminary sketches developed for Structures, Foundations and Pilings.

Pipe sizes 3" and larger were modeled utilizing S3D software. Material quantities for pipe sizes 3"and larger were extracted from the S3D model. Material quantities for pipe sizes less than 2" were derived manually.

8.0 Mechanical Engineering

Mechanical Engineering developed equipment specifications for various types of equipment utilized in the CCU design, along with data sheets for each equipment item identified in the Process Size Equipment List (Attachment 4). Attachment 8 is a compilation of all the following equipment specifications developed during the FEED effort.

- EH-35R-CCU1-SPC-255-56001 Axial And Centrifugal Compressors - API 617
- EH-35R-CCU1-SPC-255-56016 Axial Fans
- EH-35R-CCU1-SPC-255-56028 ASME Horizontal, End Suction Centrifugal Pumps
- EH-35R-CCU1-SPC-255-56029 General Purpose Horizontal Centrifugal Pumps
- EH-35R-CCU1-SPC-255-56032 General Purpose Vertical Centrifugal Pumps
- EH-35R-CCU1-SPC-255-56066 Special Purpose Gear Units - API 613
- EH-35R-CCU1-SPC-255-56070 General Purpose Induction Motors – ½ HP Through 200 HP – IEEE 841
- EH-35R-CCU1-SPC-255-56071 Special Purpose Induction Motors - API 541

- EH-35R-CCU1-SPC-255-56073 General Purpose Induction Motors – API 547
- EH-35R-CCU1-SPC-255-56074 Synchronous Motors and Generators – API 546
- EH-35R-CCU1-SPC-255-56084 Lubrication, Shaft-Sealing and Oil-Control Systems and Auxiliaries - API 614
- EH-35R-CCU1-SPC-255-57020 API 660 ISO 16812 - Shell Tube Heat Exchangers
- EH-35R-CCU1-SPC-255-57030 Air-Cooled Heat Exchangers
- EH-35R-CCU1-SPC-255-57035 Plate Heat Exchangers
- EH-35R-CCU1-SPC-255-57040 Cooling Towers
- EH-35R-CCU1-SPC-255-57110 Watertube Boilers
- EH-35R-CCU1-SPC-255-58001 Design and Fabrication Specification for Vessels ASME Cosde Section VIII, Division 1
- EH-35R-CCU1-SPC-255-58005 Design of Lifting Components for Mechanical Equipment
- EH-35R-CCU1-SPC-255-58040 Design and Fabrication Specification for Pressure Vessel Internals
- EH-35R-CCU1-SPC-255-59010 Packaged Mechanical Equipment
- EH-35R-CCU1-SPC-255-85002 Welding and NDE Requirements for Shop or Field Fabricated Piping
- EH-35R-CCU1-SPC-255-85012 Positive Material Identification (PMI)
- EH-35R-CCU1-SPC-255-85050 Welding/NDE Requirements for Equipment

- EH-35R-CCU1-SPC-255-85110 Hot Insulation
- EH-35R-CCU1-SPC-255-85210 Aboveground Coatings
- EH-35R-CCU1-SPC-255-85400 Galvanizing
- EH-35R-CCU1-SPC-255-85530 Materials and Fabrication Requirements for Duplex Stainless Steel

9.0 Electrical Engineering

The electrical distribution system is supported by two Power Centers. The Main Power Center is located at the northwest end of the plot and provides power for loads serviced at 13.8kV and below including the Auxiliary Power Center. The Auxiliary Power Center is located more centrally on the plot and provides power for the loads at the east end of the site at 4160V and below.

Electrical heat tracing is provided for freeze protection through two controllers located at opposing ends of the CCU.

9.1 Electrical Equipment

An Electrical Equipment List, developed to document the major electrical equipment parameters, is included as Attachment 9. Electrical equipment is located in electrically unclassified areas (either inside the Power Center Buildings or outside any Class I, Division 2 electrically hazardous areas).

9.2 Cable Schedule / Aboveground Power Drawings

An Electrical Cable Schedule, indicating power and control cables, is provided as Attachment 10.

Select Aboveground Power drawings showing cable tray information for the CCU distribution system are provided as Attachment 11.

10.0 Instrumentation & Controls Engineering

The basic philosophy of the facility is to provide control of the process from the existing GTU2 hunter building control room. A new operator work station will be provided for that purpose. Another new operator workstation will be located at the Central Control Facility (CCF) that will also have the ability to control the CO_2 plant. Two Local Operator Interface (LOI) will be located in the field, one each at the West and East ends of the plant.

Components for the new control system such as controllers, power supplies, network cards will be housed in the Project Power Center Equipment Room. Also located within the Power Center will be an engineering work station interface for the new control system.

Remote I/O boxes strategically located within the facility will be the interface point for field instruments to the control system. Remote I/O boxes will have a fiber optic link back to the Power Center equipment room.

10.1 Network Architecture Drawing

The conceptual Network Architecture Drawing is provided as Attachment 12.

The DCS I/O will utilize an “electronic marshalling” concept in which the field signals are landed directly on the I/O chassis within the field Remote IO box. The IO device for each signal type will be selectable on a point by point basis thus eliminating the requirement for intermediate marshalling for signal segregation.

10.2 Subsystem Interfaces

All subsystems will communicate bi-directionally with the DCS to facilitate the maximum use of the DCS for historization, alarming, and display of information to operators. Subsystem interface to DCS will be Ethernet. Communication protocol will be EtherNet/IP (preferred) or Modbus TCP.

10.3 Instrumentation Cables

Instrumentation cables will be installed in conduit and overhead tray systems. Cable specifications and installation details shall be prepared during detailed design.

Fiber optic cables used between the local areas and the Power Center will be routed in overhead tray.

10.4 Communications Infrastructure

The project is to be part of an existing plant site which has an established and adequate communication infrastructure system with sufficient integrity and security to accommodate the needs of the project. No system design changes are envisioned for the site due to the demands of the project. Interfaces will be provided to the existing fiber optic network.

11.0 Fire Protection Engineering

The CCU shall be equipped with a Fire Protection System such that in the event of a major fire, the Fire Protection System will serve to:

- Minimize personnel injury
- Minimize equipment damage
- Avoid escalation of the fire

The Fire Protection System shall protect all structures and equipment that are critical to life safety, as well as enclosures housing critical systems, equipment, or services. A Fire Protection Design Basis has been developed for the Project and is provided as Attachment 13.

11.1 Fire Protection System

The fire risk in this new unit is low due to no known flammable hydrocarbons being processed. The remaining fire hazards are:

- A presence of combustibles with high flash points such as lube oil for the CO_2 Product Compressors.
- Natural gas is used as fuel in the steam boiler package.

The facility will be equipped with an underground firewater ring main around the perimeter. The ring main will be connected on two sides to the existing site firewater distribution system. Hydrants along all four sides of the plant are fed from this ring main. Post indicator valves (PIV) will be provided to isolated no more than five hydrants to allow for maintenance and repair while continue to provide firewater to the remaining hydrants.

An addressable fire alarm panel shall be installed in the Main Power Center protected with smoke detection and manual fire alarm system designed and installed in accordance with NFPA 72. The building shall be equipped with dry chemical and carbon dioxide fire extinguishers.

A total of four (4) CO_2 infrared gas detectors will be located around the new K-601 CO_2 Compressor and will be tied into the plant fire and gas detection system. An audible horn and visual strobe unit will be located near the compressor mounted in an unobstructed visible location operated by the fire and gas detection panel.

A complete Firefighting Equipment Specification developed for the Project is provided as Attachment 14.

12.0 Facilities Engineering

The FEED phase of this Project did not require any scope for Facilities Engineering. Existing buildings with HVAC (Control Room, Maintenance Shop, etc) are adequate to meet additional requirements associated with this Project. No new HVAC buildings are required.

13.0 Site Security

The site will be secured with fencing and controlled access for vehicles, construction personnel, equipment and deliveries, as well as removal of trash and construction debris.

14.0 Logistics

This section describes the Logistics effort for the Project, which was limited to a route study that considered the transportation of equipment approximately 225 miles from the Port of Stockton to Elk Hills Power LLC, near Tupman, CA. The route study was performed by a third party contractor, Contractors Cargo Company (CCC).

CCC concluded that the transportation of equipment was feasible. The Port of Stockton is well equipped to do projects of this magnitude and works well within the industry. A review of the recommended route between the Port of Stockton and the Elk Hills Project site indicates that there are no permanent overhead obstructions. There are hundreds of obstructions such as wires, signal, etc. along the route, but all of these obstructions can be moved. It is recommended to perform a follow-up verification of the route study within 3 months of the actual start of equipment transportation to ensure that there are no new obstructions or changes to road conditions.

The major grade encountered on the route will begin at CA-269 and I-5 (Outside of Avenal, CA) and will end on CA-269 entering Avenal. A few minor grades occur over the remainder to the route. No civil/road work will need to be done due to the inclines or declines.

To help reduce travel time between the Port of Stockton and the Elk Hills Project site, the maximum recommended item to be transported shall be no greater than 120 ft (L) x 20 ft (W) x 18 ft (H) at 250,000 lbs. The maximum recommended module size for travel between PCL Industries (Bakersfield) and the Elk Hills Project site is 80 ft (L) x 20 ft (W) x 18 ft (H) at 200,000 lbs.

15.0 Constructability

Construction will be performed in a green-field environment, without the restrictions of working in an operating facility, such as requiring daily work permits from plant operations or the use of fire-retardant clothing. Work within the existing facility will require work permits and fire retardant clothing.

15.1 Construction Access

The proposed site is on a 17.7 acre parcel in the Elk Hills, CA oilfield at the intersection of Elk Hills Rd and Skyline Rd. The nearest major city is Bakersfield, CA, which is approximately 34 miles to the east, via Stockdale Highway. The site is accessed via Skyline Rd, from Elk Hills Rd. Roads to the site are paved. The site is bordered on the west by an existing oilfield processing facility, on the north by the Elk Hills Power Plant, on the east by oilfield pipelines and on the south by Skyline Rd. There is limited area available around the site for temporary construction facilities and equipment/material laydown.

15.2 Laydown Areas

The Lay-down area that was identified is approximately 4 miles south of the project site, as indicated in Attachment 15.

15.3 Sequencing of Construction Work

The sequence will begin with installation of piling, underground piping, electrical duct banks (minimal) and foundations. Some foundations may be put on hold, temporarily, to facilitate crane access and field assembly of the four field fabricated vessels previously mentioned. The area paving or finished surfaces should follow in order to provide a stable and flat working surface from which to proceed with the structural, mechanical, electrical and instrumentation work.

Equipment should be received and taken directly to foundations and set, where feasible, in order to avoid double-handling. Pipe racks should be fully loaded, except for cabling, prior to placement of air coolers in order to allow crane access for loading of piping and cable tray installation. This construction sequence will be further defined as additional information becomes available and based on comments from the selected construction contractors

16.0 Project Cost Estimate (~ +/- 15%)

16.1 Overview

After the development of the scope of facilities was completed, a Capital Cost Estimate was performed. This estimate has an accuracy range of plus or minus fifteen percent (15%). A Basis of Estimate was developed to provide definition around the content of the estimate and is included as Attachment 16. Major estimate clarifications are provided below.

General Clarifications:

- Project execution basis is assumed to be on a lump sum engineering, procurement and construction basis with performance guarantees and liquidated damages.
- Forward escalation has been included from 2020 to project completion. This is valued at $39.0 MM.
- The project construction execution is based on the use of Union labor. Per diem and incentives for labor attraction and retention are included.
- Sales Tax is included. This is valued at $8.5 MM.
- The plant design is based on Seismic Zone 3.
- Pre-commissioning, Commissioning, Start-up and the Performance Testing were included.
- Contingency has been included at $57.0 MM.
- Licensor Fee is excluded.
- Mass excavation of the site is excluded (Owner's cost due to pre-existing conditions).

The estimate has been broken into three equipment systems with the total installed costs of each system as follows:

- CO_2 Capture Plant - $387 MM
- Utility Systems - $267 MM
- CO_2 Compression - $61 MM
- Balance of Plant - $33 MM

Summing all cost components results in a combined total installed cost of $748 MM. Further details on the scope breakdown of each of the systems are described in sections 16.2 thru 16.5. Please also see the Basis of Estimate and the Estimate Summaries provided as Attachments 16 and 17.

16.2 Utility Systems

Due to the lack of excess utility capacity within the existing facility, all the required utilities to support the CO_2 Capture Plant are included as part of the project. These include the following:

- Cooling Tower and Wet Surface Air Coolers
- Boilers for steam production
- Power Infrastructure including modifications and improvements to the existing plant electrical infrastructure
- Flue Gas Duct and Dampers
- Plant and Instrument Air
- Reverse Osmosis Unit

There are some unique aspects of the project which should be noted to provide the reader with a more in depth understanding of the project. Water minimization is an important component of the design. This involved the inclusion of hybrid cooling systems (Wet Surface Air Coolers, Air Coolers, Secondary Glycol Cooling and Water Cooling) in the scope. While the incorporation of these systems increased the Capital Cost of the project they significantly reduced the amount of water usage. Additionally, a Water Reverse Osmosis System is included within the project scope.

Since steam extraction was not available for the CO_2 recovery process, package boilers have been included within the project scope. The combined total installed cost for these utility systems is $267 MM.

Though many cost-cutting measures have been incorporated into the final design and cost estimate, one key measure for which an evaluation is on-going is a re-consideration for steam extraction from the power plant. Steam extraction was considered at the early stages of the FEED, but CRC instructed Fluor to proceed without steam extraction to avoid major modifications to the existing steam turbine that could lead to infeasible power plant operation with the CCU offline. Additionally, steam extraction will reduce the power plant output by an estimated 35 MW. Fluor proceeded with a FEED design that included package boilers dedicated to producing all the steam required for the CCU.

As part of the cost-cutting measures identified, it was decided to re-consider extraction of steam from the existing steam turbine. Not only does steam extraction eliminate the need for the CCU package boilers, but since the extracted steam is fully condensed within the CCU, a significant portion of the existing power plant cooling load is freed up. This freed up cooling can be utilized within the CCU to eliminate up to five of the eight WSACs. Fluor has roughly estimated a potential savings of up to $35-45 MM associated with implementing the steam extraction / integration. However, the complete evaluation is still ongoing.

16.3 CO_2 Compression

The combined total installed cost for CO_2 compression and dehydration systems is $61 MM.

16.4 CO_2 Capture Plant

For an in-depth description of the facilities included within this portion of the Capital Cost Estimate please refer to the Process Description provided in Section 5.2 of this report. The estimated total plant capital cost (excluding Owner's costs) for the CO_2 Capture facility is approximately $387 MM.

16.5 Balance of Plant

This cost collect area is utilized to capture costs which are not directly attributable to the other cost areas. The estimated value for these costs are $33 MM.

16.6 Electrical Portion of the OSBL

The project has requested a single connection to the CRC Power System. CRC evaluated interconnecting the Project to CRC's 26R – 35R CGP 115 kV line. The project will require a transmission tie line to interconnect the Project switching station to the existing CRC transmission line. The Project switching station must utilize redundant line current differential protection over fiber with Direct Transfer Trip per CRC requirements. The provided costs are base on preliminary engineering and design.

The area surrounding the project is highly congested which will require the use of self-supporting dead-end structures. Approximately ½ mile of single conduction 115 kV transmission tie line is expected to be built using tubular steel poles with anchor bolt foundation designs at a cost of approximately $1.3 MM. The switching station is expected to utilize a single bus, single breaker configuration at a cost of approximately $1 MM. Redundant fiber optics paths will be required to connect 26R, 35R CGP, and the Project Switching stations at a cost of approximately $0.3

MM. The estimated total Project interconnection cost is $2.6 MM, and is in addition to the estimate discussed above.

17.0 Estimated Project Schedule

The project generated a Level 1 (Management Summary) Engineering, Procurement, Construction and Commissioning (EPCC) schedule to support the execution of the project going forward. For the phases mentioned (EPCC) the total duration is 41 months. Based upon the current execution approach, time has been allowed prior to the start of Detailed Engineering, for Fluor to improve the Capital Cost Estimate accuracy, and for CRC to obtain project financing. Procurement of all equipment and materials including long lead and critical equipment, occurs after project award. There has also been time allotted after the commissioning of the facility, to startup the plant and conduct the performance testing of the facility. This entire sequence of activities is depicted in Attachment 18.

Attachments

Attachment 1 - Process Flow Diagrams

CCU1-M-102A/B
CTG FLUE GAS
LOUVER DAMPER

CCU1-M-103
BOILER FLUE GAS
LOUVER DAMPER

CCU1-M-101
FLUE GAS
INLET DUCTING SYSTEM

CCU1-M-106A/B
CTG FLUE GAS ISOLATION
DAMPER

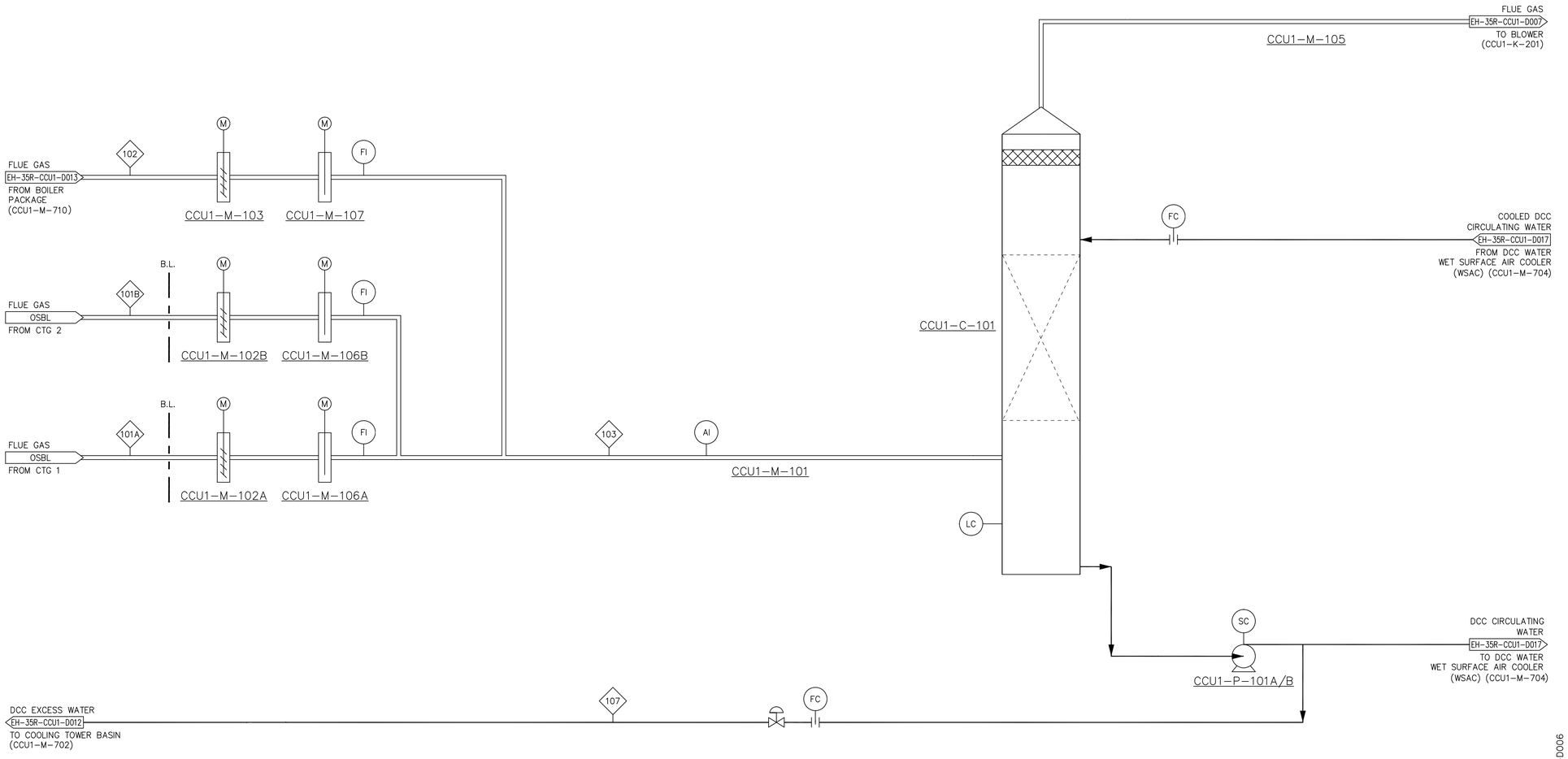
CCU1-M-107
BOILER FLUE GAS
ISOLATION DAMPER

CCU1-C-101
DIRECT CONTACT
COOLER

CCU1-M-105
DCC FLUE GAS
OUTLET DUCT

CCU1-P-101A/B
DCC WATER
PUMP

NOTES:



LEGEND:

◇ STREAM NUMBER

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ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT NO.1
FLUE GAS COOLING
PROCESS FLOW DIAGRAM

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-D006	1 OF 1	1	NONE

EH-35R-CCU1-D006
08/27/2020 11:47

CCU1-K-201
BLOWER

CCU1-M-201
ABSORBER FLUE GAS INLET DUCT

CCU1-P-201A/B
WASH WATER PUMP

CCU1-M-202
ABSORBER STACK DAMPER

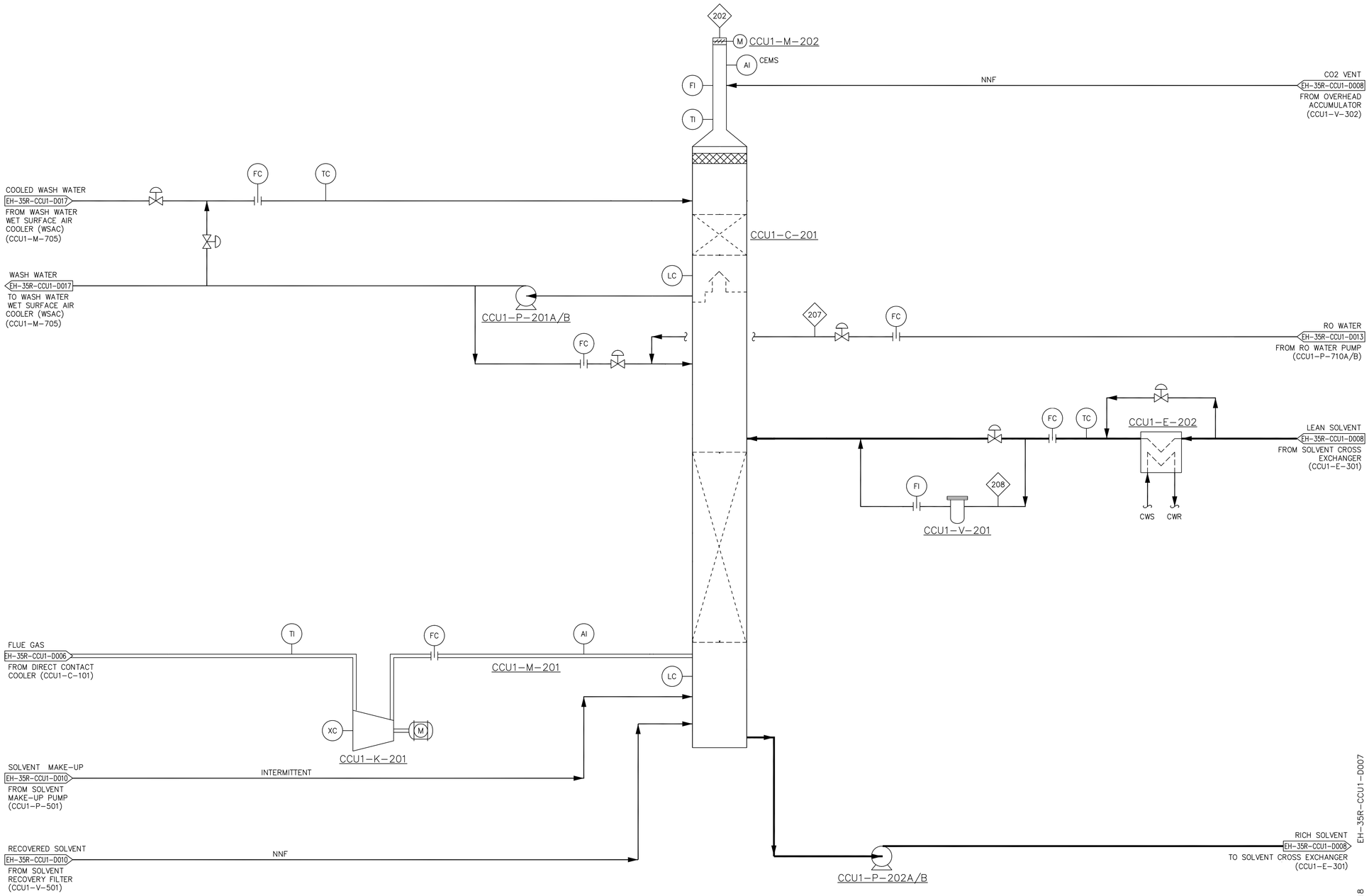
CCU1-C-201
ABSORBER

CCU1-P-202A/B
RICH SOLVENT PUMP

CCU1-V-201
LEAN SOLVENT FILTER

CCU1-E-202
LEAN SOLVENT COOLER

NOTES:



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08/27/2020

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CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT NO.1
CO_2 ABSORPTION
PROCESS FLOW DIAGRAM

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-D007	1 OF 1	1	NONE

CCU1-E-301 SOLVENT CROSS EXCHANGER

CCU1-P-301A/B LEAN SOLVENT PUMP

CCU1-C-301 STRIPPER

CCU1-FF-301 CONDENSER

CCU1-P-302A/B REFLUX PUMP

CCU1-V-302 OVERHEAD ACCUMULATOR

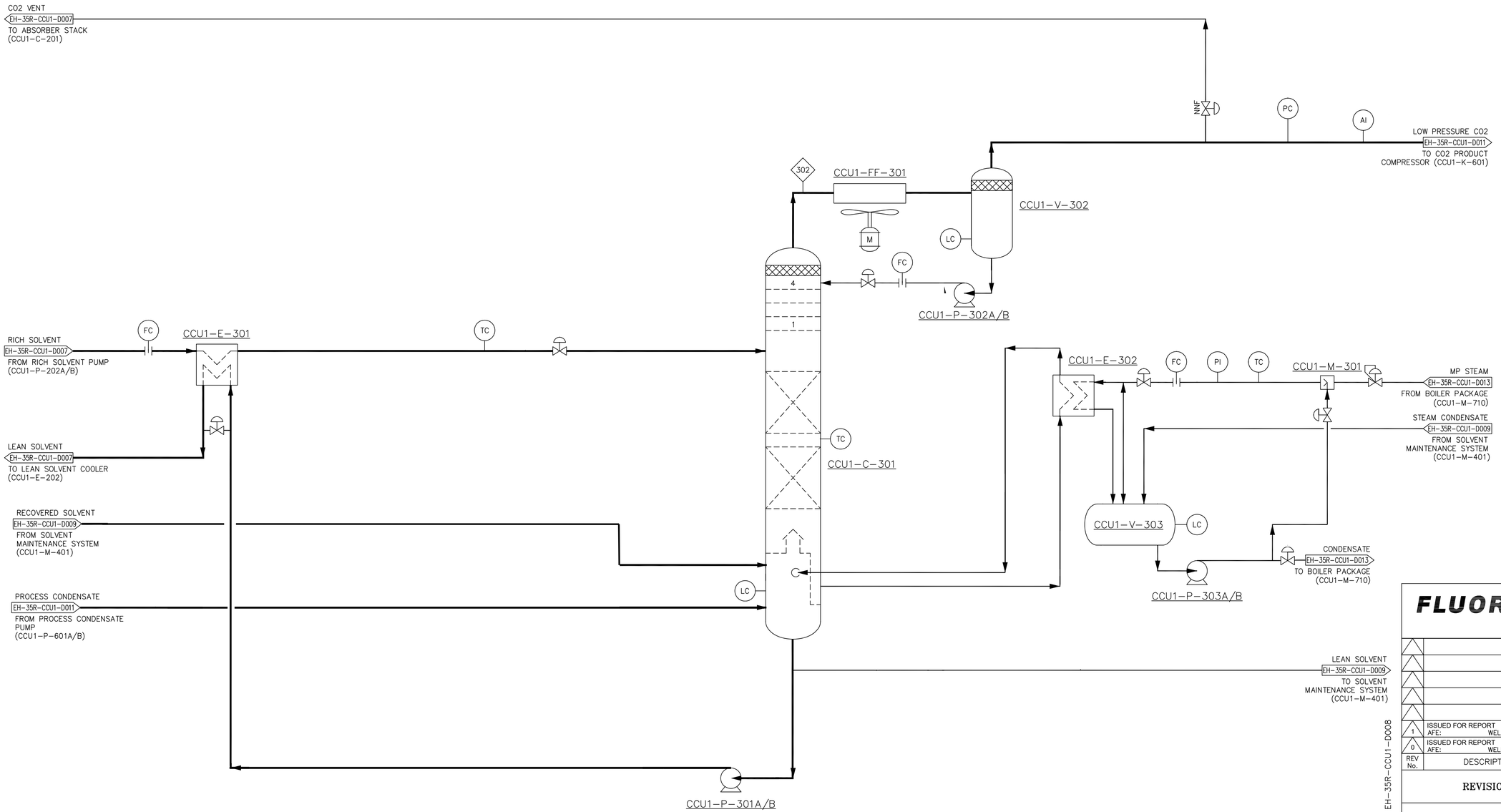
CCU1-E-302 REBOILER

CCU1-V-303 REBOILER CONDENSATE DRUM

CCU1-P-303A/B REBOILER CONDENSATE PUMP

CCU1-M-301 REBOILER STEAM DESUPERHEATER

NOTES:



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09:58

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SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT NO.1
SOLVENT REGENERATION
PROCESS FLOW DIAGRAM

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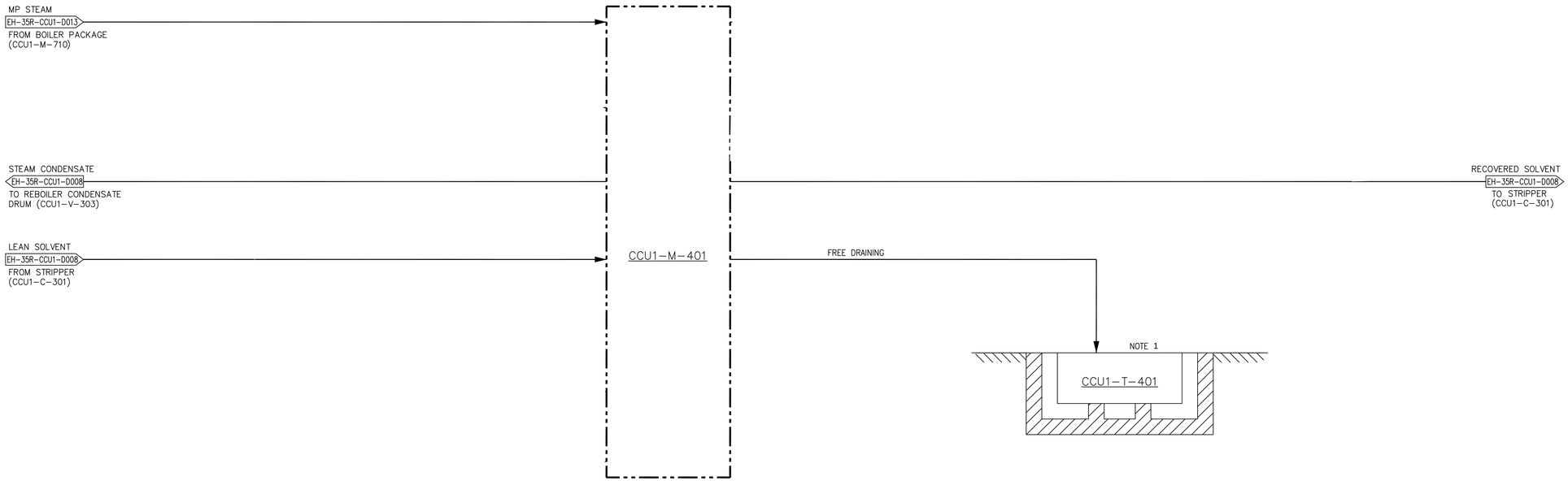
CRC

CCU1–M–401
SOLVENT MAINTENANCE
SYSTEM

CCU1–T–401
SPENT SOLVENT TANK

NOTES:

1. SPENT SOLVENT TANK CONTENTS TO BE REMOVED AND HAULED OFF VIA VACUUM TRUCK.



LEGEND:

◇ STREAM NUMBER

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CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT NO.1
SOLVENT MAINTENANCE
PROCESS FLOW DIAGRAM

DRAWING No.	SHEET	REV.	SCALE
EH–35R–CCU1–D009	1 OF 1	1	NONE

EH–35R–CCU1–D009
08/27/2020 10:04

CCU1–T–504
GLYCOL DRAIN SUMP

CCU1–P–501
SOLVENT MAKE–UP
PUMP

CCU1–T–501
SOLVENT STORAGE
TANK

CCU1–T–503
TEG STORAGE
TANK

CCU1–P–503
TEG MAKE–UP
PUMP

CCU1–V–501
SOLVENT RECOVERY
FILTER

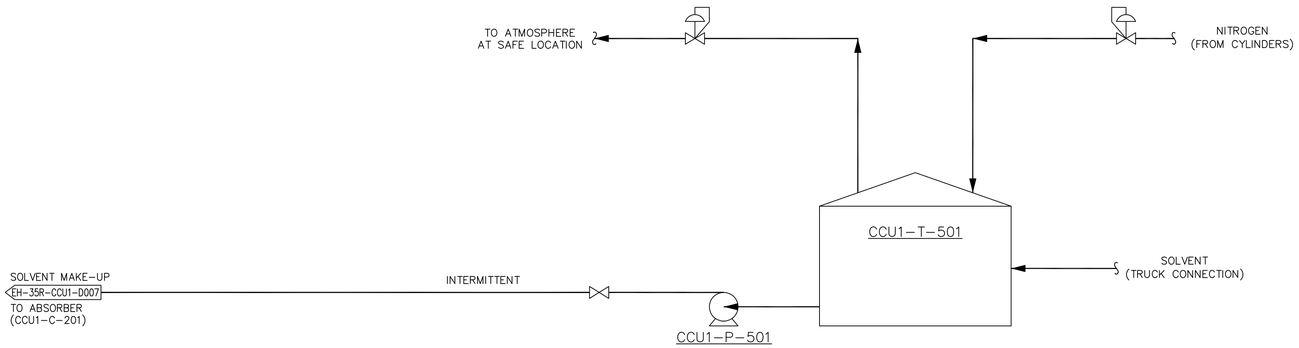
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SOLVENT RECOVERY
PUMP

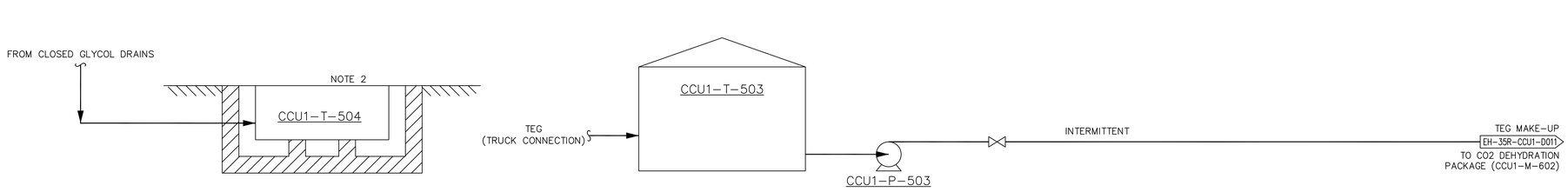
CCU1–T–502
SOLVENT RECOVERY
TANK

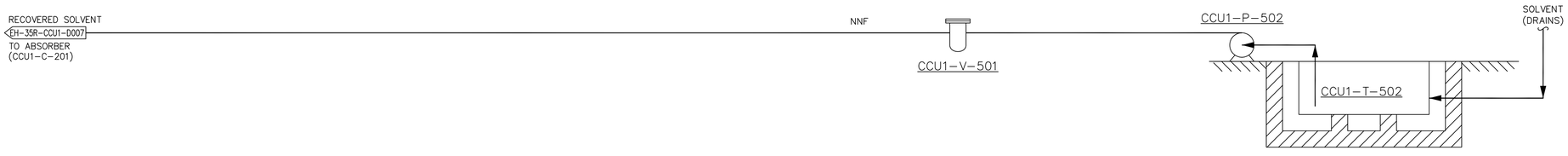
NOTES:

1. ABBREVIATIONS :
   TEG : TRIETHYLENE GLYCOL

2. GLYCOL DRAIN SUMP CONTENTS TO BE REMOVED AND HAULED OFF VIA VACUUM TRUCK.







LEGEND:

◇ STREAM NUMBER

FLUOR®

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SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT NO.1
CHEMICAL STORAGE AND SUPPLY
PROCESS FLOW DIAGRAM

DRAWING No.	SHEET	REV.	SCALE
EH–35R–CCU1–D010	1 OF 1	1	NONE

CCU1−V−603
CO_2 PRODUCT COMPRESSOR
SUCTION KO DRUM

CCU1−P−601A/B
PROCESS CONDENSATE PUMP

CCU1−VS−601
CO_2 VENT STACK

CCU1−K−601
CO_2 PRODUCT
COMPRESSOR

CCU1-E-601
CO2 DEHYDRATION PACKAGE
PRE-COOLER

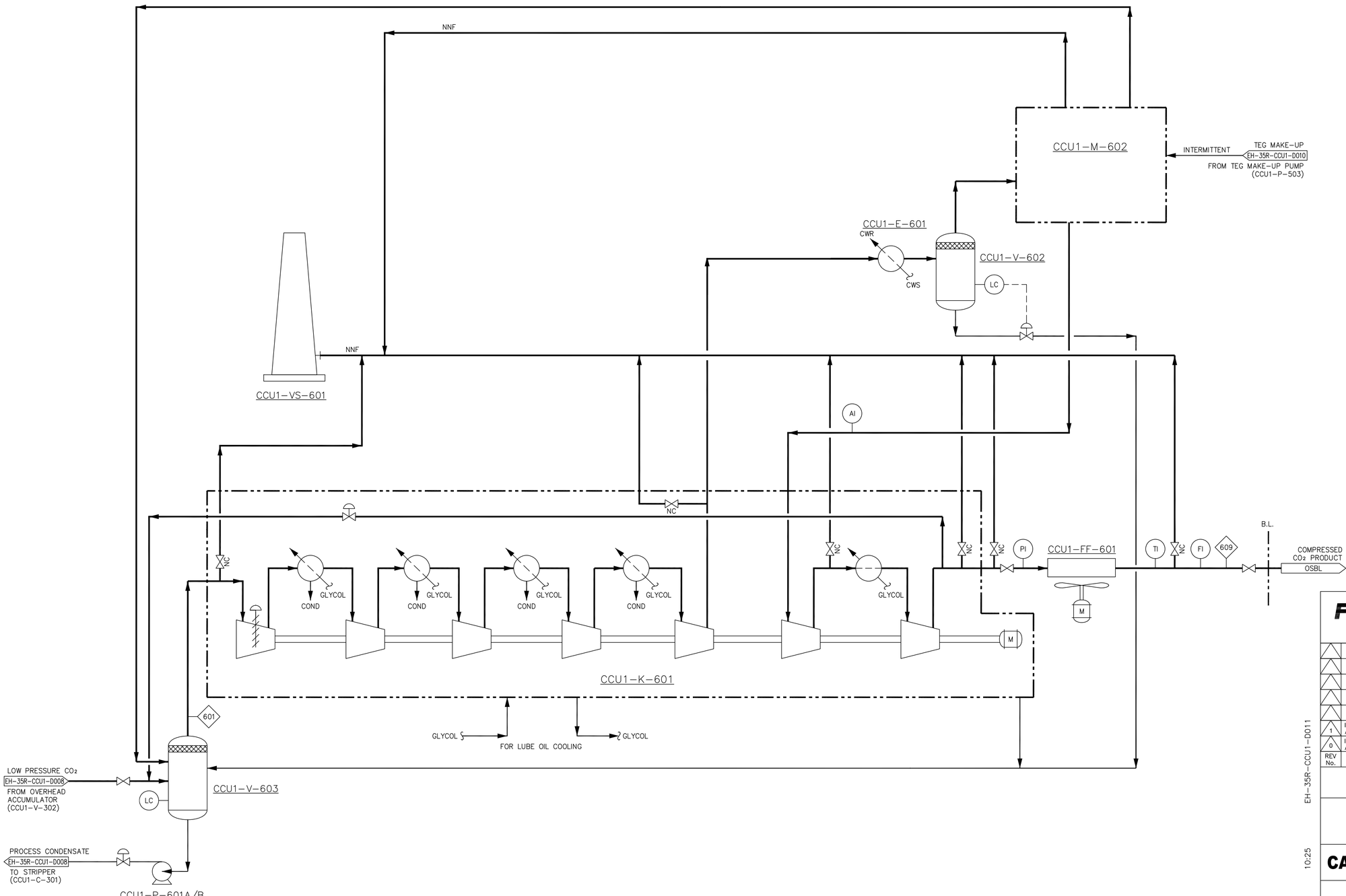
CCU1-V-602
CO2 DEHYDRATION PACKAGE
PRE-COOLER KO DRUM

CCU1−M−602
CO_2 DEHYDRATION
PACKAGE

CCU1−FF−601
CO_2 PRODUCT COMPRESSOR
AFTERCOOLER

NOTES:

1. ABBREVIATIONS:
   TEG : TRIETHYLENE GLYCOL



LEGEND:

◇ STREAM NUMBER

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
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10:25

08/27/2020

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT NO.1
CO2 COMPRESSION
PROCESS FLOW DIAGRAM

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CRC

Attachment 2 – Utility Flow Diagrams

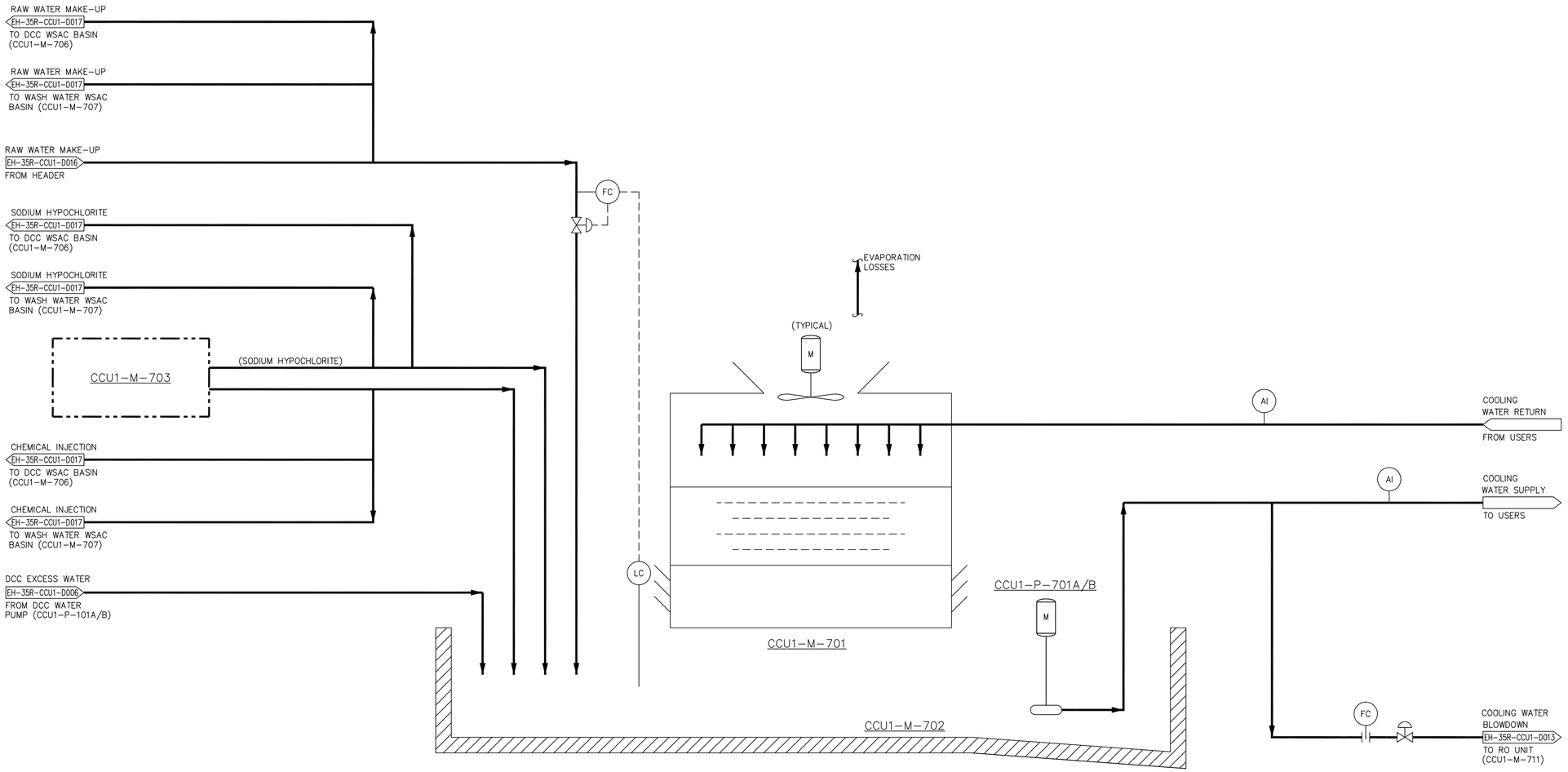
CCU1-M-703
COOLING WATER SYSTEM
CHEMICAL INJECTION PACKAGE

CCU1-M-701
COOLING TOWER

CCU1-M-702
COOLING TOWER BASIN

CCU1-P-701A/B
COOLING WATER PUMPS

NOTES:



LEGEND:

◇ STREAM NUMBER

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ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT NO.1
COOLING WATER SYSTEM
UTILITY FLOW DIAGRAM

DRAWING No.	SHEET	REV.	SCALE
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EH-35R-CCU1-D012
08/27/2020 11:19

CCU1-M-710
BOILER PACKAGE

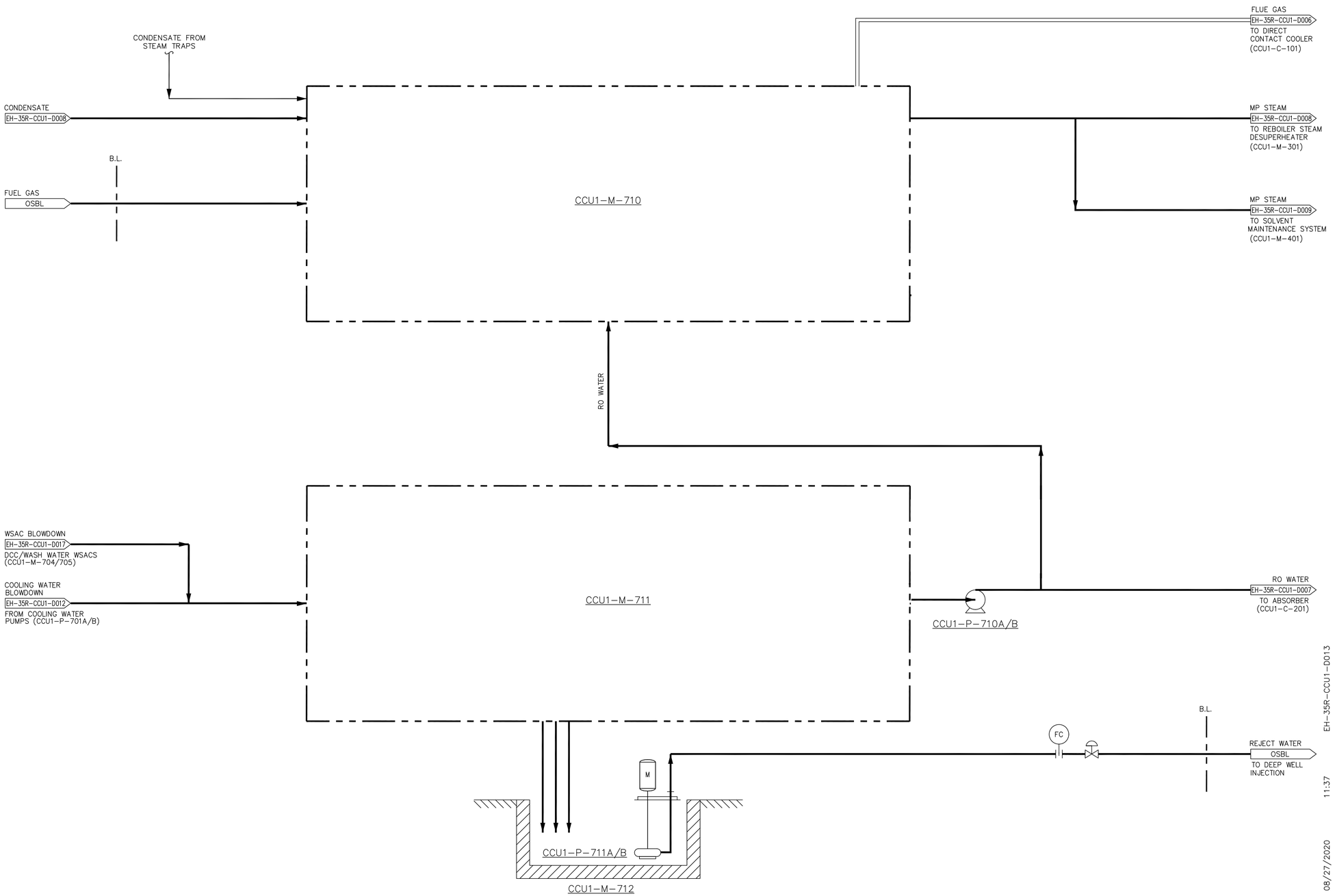
CCU1-M-711
RO UNIT

CCU1-P-711A/B
REJECT WATER PUMP

CCU1-M-712
REJECT WATER SUMP

CCU1-P-710A/B
RO WATER PUMP

NOTES:



LEGEND:

◇ STREAM NUMBER

FLUOR

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EH-35R-CCU1-D013

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08/27/2020

ELK HILLS OPERATION

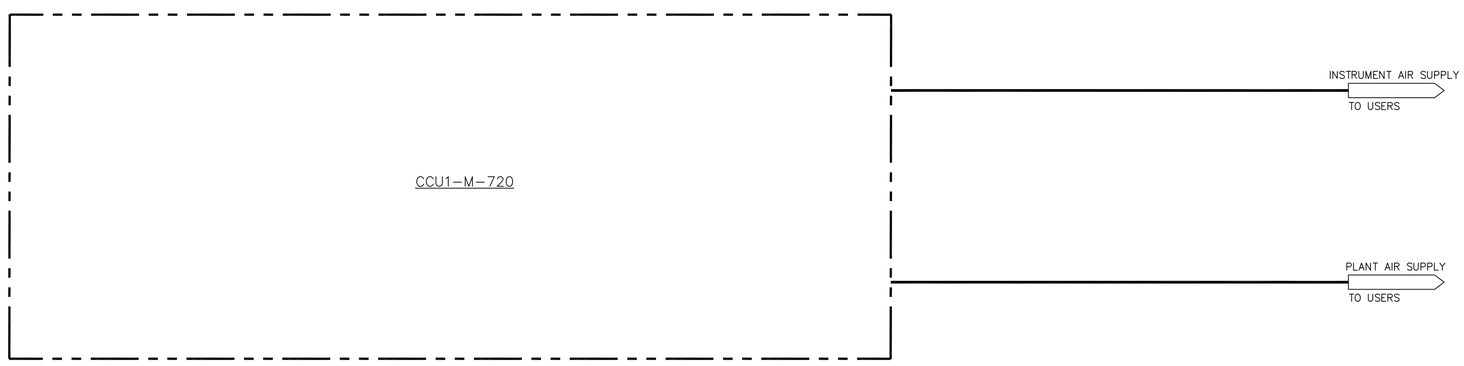
CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT NO.1
BOILER AND RO UNIT
UTILITY FLOW DIAGRAM

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-D013	1 OF 1	1	NONE

CCU1–M–720
PLANT AND INSTRUMENT AIR PACKAGE

NOTES:



LEGEND:

◇ STREAM NUMBER

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
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0	ISSUED FOR REPORT AFE: WELL:	N/A	IW	IW	ADA	NP	JPG/SR

REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT NO.1
PLANT AND INSTRUMENT AIR
UTILITY FLOW DIAGRAM

DRAWING No.	SHEET	REV.	SCALE
EH–35R–CCU1–D014	1 OF 1	1	NONE

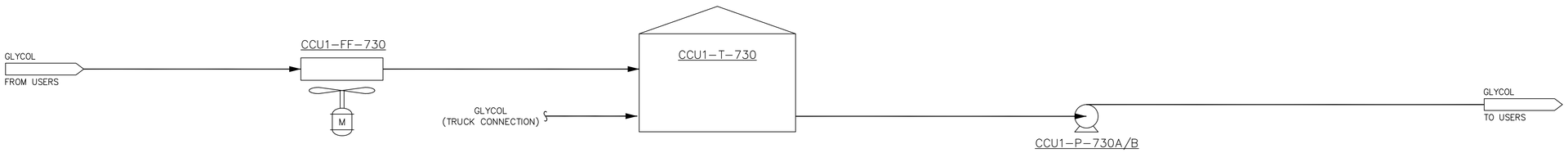
EH–35R–CCU1–D014
08/27/2020 11:40

CCU1–FF–730
GLYCOL SOLUTION COOLER

CCU1–T–730
GLYCOL SOLUTION
EXPANSION TANK

CCU1–P–730A/B
GLYCOL SOLUTION PUMP

NOTES:



LEGEND:

◇ STREAM NUMBER

FLUOR®

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REVISIONS | APPROVALS

EH–35R–CCU1–D015
08/27/2020 11:42

ELK HILLS OPERATION

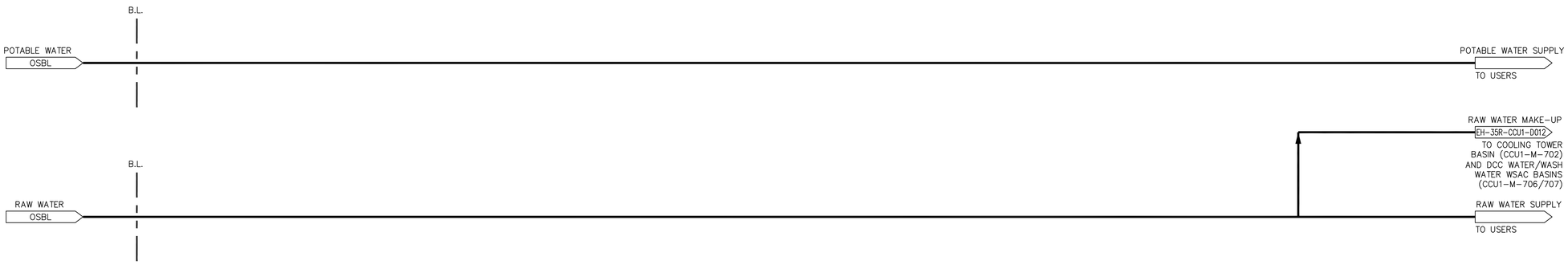
CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT NO.1
GLYCOL SYSTEM
UTILITY FLOW DIAGRAM

DRAWING No.	SHEET	REV.	SCALE
EH–35R–CCU1–D015	1 OF 1	1	NONE

CRC

NOTES:



LEGEND:

◇ STREAM NUMBER

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
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REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT NO.1
POTABLE AND RAW WATER
UTILITY FLOW DIAGRAM

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-D016	1 OF 1	1	NONE

CRC

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08/27/2020

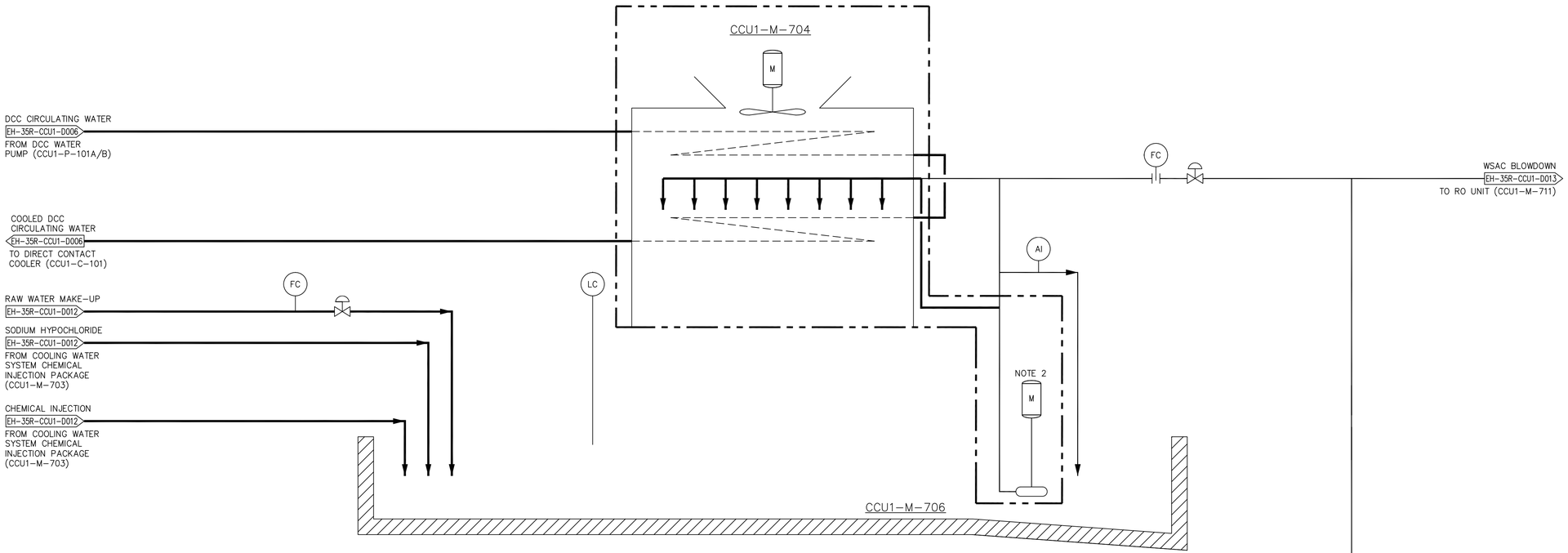
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DCC WATER WET SURFACE
AIR COOLER (WSAC)

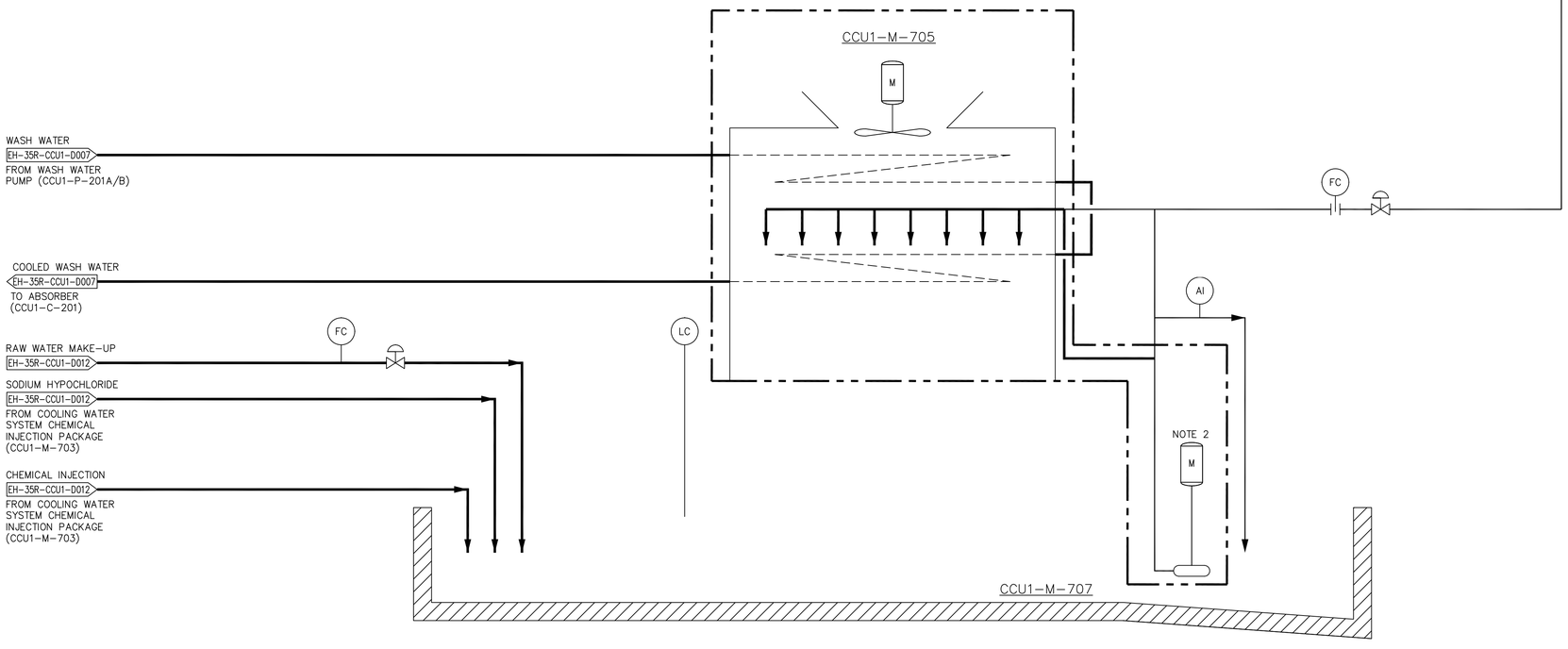
CCU1–M–705
WASH WATER WET SURFACE
AIR COOLER (WSAC)

CCU1–M–706
DCC WATER WSAC BASIN

CCU1–M–707
WASH WATER WSAC BASIN

NOTES:





LEGEND:

◇ STREAM NUMBER

FLUOR

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
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REVISIONS | APPROVALS

EH–35R–CCU1–D017

08/27/2020 13:59

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT NO.1
WET SURFACE AIR COOLERS
UTILITY FLOW DIAGRAM

DRAWING No.	SHEET	REV.	SCALE
EH–35R–CCU1–D017	1 OF 1	1	NONE

CRC

Attachment 3 – Process Sized Equipment List

FLUOR

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

PROCESS SIZED EQUIPMENT LIST - AIR COOLERS

CONTRACT:	C1RC		
DATE:	N/A	REV.:	1
BY:	CHK'D:	APP'D:	
IW	JPG	JPG	

SRV. NO.	Item No.	Description	Design Conditions		Materials of Construction		Remarks
			Press	Temp			
			psig	°F	Header	Tubes	
1	CCU1-FF-301	Condenser	50 / FV	250	304L SS	304L SS	
2	CCU1-FF-601	CO_2 Product Compressor Aftercooler	2,450	310	304L SS	304L SS	
3	CCU1-FF-730	Glycol Solution Cooler	90	250	CS	CS	

FLUOR

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

PROCESS SIZED EQUIPMENT LIST - COMPRESSORS

CONTRACT:	C1RC		
DATE:	N/A	REV.:	1
BY:	CHK'D:	APP'D:	
IW	JPG	JPG	

SRV. NO.	Item No.	Description	Materials of Construction	Comp. Type	Driver Type	Remarks
1	CCU1-K-201	Blower	Housing: 304L SS Impeller: 304L SS Seals: Carb. Ring	Axial Fan	Electric Motor	
2	CCU1-K-601	CO_2 Product Compressor	Manufacturer's Standard (304L SS equivalent or better)	Integrally Geared Centrifugal	Electric Motor	

FLUOR

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

PROCESS SIZED EQUIPMENT LIST - COLUMNS

CONTRACT:	C1RC		
DATE:	N/A	REV.:	1
BY:	CHK'D:	APP'D:	
IW	JPG	JPG	

SRV. NO.	Item No.	Description	Design		Materials of Construction	Insulation	Remarks
			Press	Temp			
			psig	°F			
1	CCU1-C-101	Direct Contact Cooler (DCC)	+2 / -3	300	304L SS / 316L SS	PP (partial)	
2	CCU1-C-201	Absorber	2.0	250	304L SS / 316L SS	None	
3	CCU1-C-301	Stripper	50 / FV	310	316L SS	Hot	

FLUOR

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

PROCESS SIZED EQUIPMENT LIST - HEAT EXCHANGERS

CONTRACT:	C1RC		
DATE:	N/A	REV.:	1
BY:	CHK'D:	APP'D:	
IW	JPG	JPG	

SRV. NO.	Item No.	Description	Design Conditions				Materials of Construction		Remarks
			Shell / Hot Side		Tube / Cold Side				
			Press	Temp	Press	Temp			
			psig	°F	psig	°F	Shell/Frame	Tubes/Plates	
1	CCU1-E-202	Lean Solvent Cooler	180	250	180	250	CS	316 SS	
2	CCU1-E-301	Solvent Cross Exchanger	210	310	210	310	CS	316 SS	
3	CCU1-E-302	Reboiler	75 / FV	350	50 / FV	310	CS	Duplex SS 2205	
4	CCU1-E-601	CO_2 Dehydration Package Pre-Cooler	750 / FV	300	580	250	304L SS	304L SS	

FLUOR

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

PROCESS SIZED EQUIPMENT LIST - FILTERS

CONTRACT:	C1RC		
DATE:	N/A	REV.:	1
BY:	CHK'D:	APP'D:	
IW	JPG	JPG	

SRV. NO.	Item No.	Description	Design Conditions		Materials of Construction	Remarks
			Temp	Press		
			°F	psig		
1	CCU1-V-201	Lean Solvent Filter	180	180	Shell: 304L SS Internals: 304L SS	Cartridge type filter.
2	CCU1-V-501	Solvent Recovery Filter	180	70	Shell: 304L SS Internals: 304L SS	Cartridge type filter.

FLUOR

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

PROCESS SIZED EQUIPMENT LIST - PUMPS

CONTRACT:	C1RC		
DATE:	N/A	REV.:	1
BY:	CHK'D:	APP'D:	
IW	JPG	JPG	

SRV. NO.	Item No.	Description	Design Conditions		Materials		Pump Type	Driver Type	Remarks
			Temp	Press					
			°F	psig	Casing	Impeller			
1	CCU1-P-101 A/B	DCC Water Pump	185	70	304L SS	304L SS	Vertical Can	Electric Motor	One operating pump with one installed spare.
2	CCU1-P-201 A/B	Wash Water Pump	185	140	304L SS	304L SS	Centrifugal	Electric Motor	One operating pump with one installed spare.
3	CCU1-P-202 A/B	Rich Solvent Pump	160	210	316L SS	316L SS	Vertical Can	Electric Motor	One operating pump with one installed spare.
4	CCU1-P-301 A/B	Lean Solvent Pump	310	180	316L SS	316L SS	Vertical Can	Electric Motor	One operating pump with one installed spare.
5	CCU1-P-302 A/B	Reflux Pump	250	140	304L SS	304L SS	Centrifugal	Electric Motor	One operating pump with one installed spare.
6	CCU1-P-303 A/B	Reboiler Condensate Pump	350	120	CS	12% Cr	Centrifugal	Electric Motor	One operating pump with one installed spare.
7	CCU1-P-501	Solvent Make-Up Pump	250	50	304L SS	304L SS	Centrifugal	Electric Motor	Normally not running.

FLUOR

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

PROCESS SIZED EQUIPMENT LIST - PUMPS

CONTRACT:	C1RC		
DATE:	N/A	REV.:	1
BY:	CHK'D:	APP'D:	
IW	JPG	JPG	

SRV. NO.	Item No.	Description	Design Conditions		Materials		Pump Type	Driver Type	Remarks
			Temp	Press					
			°F	psig	Casing	Impeller			
8	CCU1-P-502	Solvent Recovery Pump	310	70	304L SS	304L SS	Vertical	Electric Motor	Normally not running. Mounted on top of sump flange.
9	CCU1-P-503	TEG Make-up Pump	250	20	CS	12% Cr	Positive Displacement	Electric Motor	Normally not running.
10	CCU1-P-601 A/B	Process Condensate Pump	250	100	304L SS	304L SS	Centrifugal	Electric Motor	One operating pump with one installed spare.
11	CCU1-P-701 A/B	Cooling Water Pump	150	100	CS or DI (if PIP)	12% Cr or DI (if PIP)	Centrifugal	Electric Motor	One operating pump with one installed spare.
12	CCU1-P-710 A/B	RO Water Pump	150	110	304L SS	304L SS	Centrifugal	Electric Motor	One operating pump with one installed spare.
13	CCU1-P-711 A/B	Reject Water Pump	150	150	Duplex SS 2205	Duplex SS 2205	Vertical	Electric Motor	One operating pump with one installed spare.
14	CCU1-P-730 A/B	Glycol Solution Pump	250	90	CS	12% Cr	Centrifugal	Electric Motor	One operating pump with one installed spare.

FLUOR

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

PROCESS SIZED EQUIPMENT LIST - VESSELS

CONTRACT:	C1RC		
DATE:	N/A	REV.:	1
BY:	CHK'D:	APP'D:	
IW	JPG	JPG	

SRV. NO.	Item No.	Description	Design		Materials of Construction	Insulation	Remarks
			Press	Temp			
			psig	°F			
1	CCU1-V-302	Overhead Accumulator	50 / FV	250	304L SS / 316L SS	None	Equipped with inlet box and demister.
2	CCU1-V-303	Reboiler Condensate Drum	75 / FV	350	CS	Hot	
3	CCU1-V-602	CO_2 Dehydration Package Pre-Cooler KO Drum	750 / FV	250	304L SS / 316L SS	None	Equipped with inlet box and demister.
4	CCU1-V-603	CO_2 Product Compressor Suction KO Drum	50/ FV	250	304L SS / 316L SS	None	Equipped with inlet box and demister.

FLUOR

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

PROCESS SIZED EQUIPMENT LIST - TANKS

CONTRACT:	C1RC		
DATE:	N/A	REV.:	1
BY:	CHK'D:	APP'D:	
IW	JPG	JPG	

SRV. NO.	Item No.	Description	Tank Type	Design		Materials of Construction	Remarks
				Press	Temp		
				inH2O	°F		
1	CCU1-T-401	Spent Solvent Tank	Rectangular	+8 / -4	350	Duplex SS 2304 or 316L SS	
2	CCU1-T-501	Solvent Storage Tank	Cone Roof	+15 / -8	200	Duplex SS 2304 or 304L SS	
3	CCU1-T-502	Solvent Recovery Tank	Rectangular	+8 / -4	310	Duplex SS 2304 or 304L SS	
4	CCU1-T-503	TEG Storage Tank	Flat Roof	+8 / -4	200	CS	
5	CCU1-T-504	Glycol Drain Sump	Flat Roof	+8 / -4	200	CS	
6	CCU1-T-730	Glycol Solution Expansion Tank	Cone Roof	+8 / -4	200	CS	

FLUOR

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

PROCESS SIZED EQUIPMENT LIST - MISCELLANEOUS

CONTRACT:	C1RC		
DATE:	N/A	REV.:	1
BY:	CHK'D:	APP'D:	
IW	JPG	JPG	

SRV. NO.	Item No.	Description	Specifications	Remarks
1	CCU1-M-101	Flue Gas Inlet Ducting System	MOC: 316L SS (lean duplex or standard 2205 can be used if more economical) Design Temperature: 350°F Design Pressure: ±25 in H2O	
2	CCU1-M-102 A/B	CTG Flue Gas Louver Damper	MOC: Manufacturer's Standard (304L SS minimum) Design Temperature: 350°F Design Pressure: ±25 in H2O	
3	CCU1-M-103	Boiler Flue Gas Louver Damper	MOC: Manufacturer's Standard (304L SS minimum) Design Temperature: 350°F Design Pressure: ±25 in H2O	
4	CCU1-M-105	DCC Flue Gas Outlet Duct	316L SS (lean duplex or standard 2205 can be used if more economical) Design Temperature: 250°F Design Pressure: ±25 in H2O	
5	CCU1-M-106 A/B	CTG Flue Gas Isolation Damper	MOC: Manufacturer's Standard (304L SS minimum) Design Temperature: 350°F Design Pressure: ±25 in H2O	
6	CCU1-M-107	Boiler Flue Gas Isolation Damper	MOC: Manufacturer's Standard (304L SS minimum) Design Temperature: 350°F Design Pressure: ±25 in H2O	
7	CCU1-M-201	Absorber Flue Gas Inlet Duct	316L SS (lean duplex or standard 2205 can be used if more economical) Design Temperature: 250°F Design Pressure: ±25 in H2O	

SRV. NO.	Item No.	Description	Specifications	Remarks
8	CCU1-M-202	Absorber Stack Damper	304L SS Design Temperature: 250°F Design Pressure: 2 psig	
9	CCU1-M-301	Reboiler Steam Desuperheater	Design Pressure: 75 psig / FV Design Temperature: 425°F	
10	CCU1-M-401	Solvent Maintenance System	Proprietary equipment system to maintain solvent hygiene.	
11	CCU1-M-602	CO_2 Dehydration Package	TEG type dryer. 1 x 100% trains. Vendor supplied package. Unit processes 76.4 MMSCFD of wet CO2 gas. Outlet water content < 25 lb/MMscf in the product CO_2. Design Pressure: 750 psig (TEG Contactor) MOC: Manufacturer Standard (TEG Contactor to be 304L SS at a minimum)	
12	CCU1-M-701	Cooling Tower	Single Cell Tower CW Supply Temperature: 74 °F, CW Return Temperature: 104 °F	
13	CCU1-M-702	Cooling Tower Basin		
14	CCU1-M-703	Cooling Water System Chemical Injection Package	Package to include storage tanks / totes and dosing pumps for three cooling water systems and an RO membrane system. Dosing chemicals foreseen for the cooling water system include: sulfuric acid, corrosion inhibitor, scale inhibitor, silica dispersant, chlorine dioxide (including generation system), bio dispesant, and algacide. RO system chemicals foreseen include: membrane biocide, membrane scale inhibitor, and sodium metabisulfite dechlorination. System shall be designed to dose into three separate cooling water systems and the RO membrane system. Each of the systems shall have a 1x100% operating dosing pump for each chemical with a common warehouse spare for each chemical.	

FLUOR

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

PROCESS SIZED EQUIPMENT LIST - MISCELLANEOUS

CONTRACT:	C1RC		
DATE:	N/A	REV.:	1
BY:	CHK'D:	APP'D:	
IW	JPG	JPG	

SRV. NO.	Item No.	Description	Specifications	Remarks
15	CCU1-M-704	DCC Water Wet Surface Air Cooler (WSAC)	WSACs to consist of tower cells, fan deck, corrugated FRP partitions, PVC drift eliminators, fans, FRP fan cylinders, drive shafts, gear drives, 316L SS wet and dry coils, spray arms, spray nozzles, and coil adapter base. Spray pumps (3x50%) shall also be provided in a common basin in this service along with all interconnecting piping between spray pumps and spray nozzles. Minimum design conditions for process piping are 70 psig and 250F.	
16	CCU1-M-705	Wash Water Wet Surface Air Cooler (WSAC)	WSACs to consist oftower cells, fan deck, corrugated FRP partitions, PVC drift eliminators, fans, FRP fan cylinders, drive shafts, gear drives, 316L SS wet and dry coils, spray arms, spray nozzles, and coil adapter base. Spray pumps (3x50%) shall also be provided in a common basin in this service along with all interconnecting piping between spray pumps and spray nozzles. Minimum design conditions for process piping are 140 psig and 250F.	
17	CCU1-M-706	DCC Wet Surface Air Cooler (WSAC) Basin	One common basin for the DCC WSACs.	
18	CCU1-M-707	Wash Water Wet Surface Air Cooler (WSAC) Basin	One common basin for the Wash Water WSACs.	
19	CCU1-M-710	Boiler Package	Packaged system to include boiler drums & convection tubes, boiler furnace, burner & windbox assembly, burner throat, air blower, economizer, blowdown drum, feed water pumps, deaerator, ammonia injection / SCR catalyst system, and stack. Boiler is designed to produce medium pressure saturated steam. MOC: CS with 1/16" corrosion allowance	
20	CCU1-M-711	RO Unit	Treats cooling tower blowdown water to recover a 65% (minimum) as permeate. Unit includes Ultrafilter pre-treatment and RO water system including all tanks, pumps, filters, chemical storage / injection equipment, and interconnecting piping.	
21	CCU1-M-712	Reject Water Sump		

FLUOR

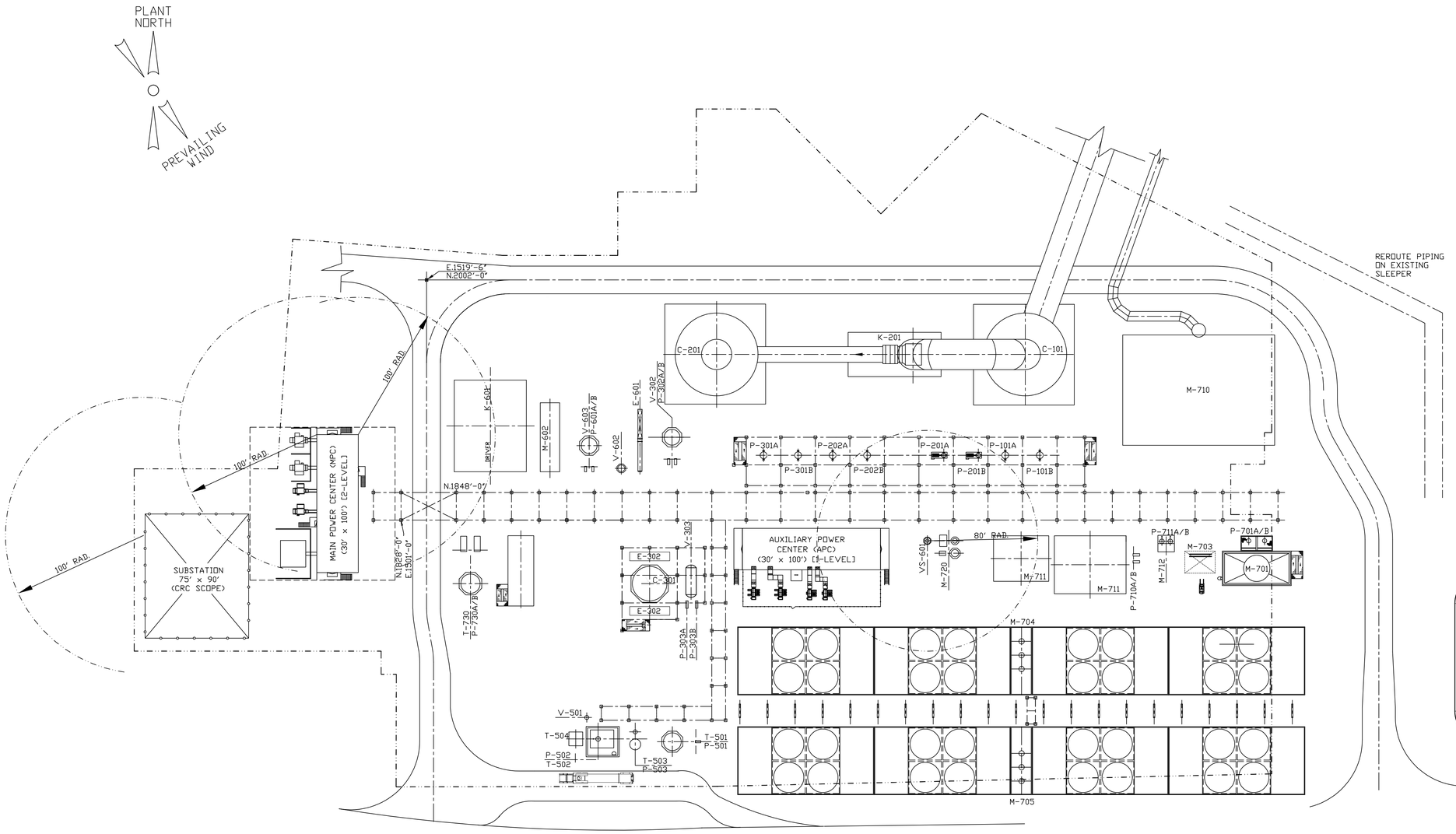
CO_2 CAPTURE FROM ELK HILLS POWER PLANT

PROCESS SIZED EQUIPMENT LIST - MISCELLANEOUS

CONTRACT:	C1RC		
DATE:	N/A	REV.:	1
BY:	CHK'D:	APP'D:	
IW	JPG	JPG	

SRV. NO.	Item No.	Description	Specifications	Remarks
22	CCU1-M-720	Plant and Instrument Air Package	Package to incude two (2) 100% compressors (one operating / one spare), one (1) wet air receiver, two (2) 100% air dryers (for instrument air) with a common pre-filter and aafter filter, and one (1) dry air receiver.	
22	CCU1-VS-601	CO_2 Vent Stack	Design Pressure: 2 psig Design Temperature: -20 / 250°F MOC: CS with 1/8" corrosion allowance	

Attachment 4 – Plot Plan



EQUIPMENT LIST

C-101	DIRECT CONTACT COOLER (DCC)
C-201	ABSORBER
C-301	STRIPPER
E-202	LEAN SOLVENT COOLER
E-301	SOLVENT CROSS EXCHANGER
E-302	REBOILER
E-601	CO2 DEHYDRATION PACKAGE PRECOOLER
FF-301	CONDENSER
FF-601	CO2 PRODUCT COMPRESSOR AFTERCOOLER
FF-730	GLYCOL SOLUTION COOLER
K-201	BLOWER
K-601	CO2 PRODUCT COMPRESSOR
M-401	SOLVENT MAINTENANCE SYSTEM
M-602	CO2 DEHYDRATION PACKAGE
M-701	COOLING TOWER
M-702	COOLING TOWER BASIN
M-703	COOLING WATER SYSTEM CHEMICAL INJECTION PKG.
M-704	DCC WATER WET SURFACE AIR COOLER (WSAC)
M-705	WASH WATER WET SURFACE AIR COOLER (WSAC)
M-706	DCC WET SURFACE AIR COOLER BASIN
M-707	WASH WATER WET SURFACE AIR COOLER BASIN
M-710	BOILER PACKAGE
M-711	RO WATER PACKAGE
M-712	REJECT WATER SUMP
M-720	PLANT AND INSTRUMENT AIR PACKAGE
P-101A/B	DCC WATER PUMP
P-201A/B	WASH WATER PUMP
P-202A/B	RICH SOLVENT PUMP
P-301A/B	LEAN SOLVENT PUMP
P-302A/B	REFLUX PUMP
P-303A/B	REBOILER CONDENSATE PUMP
P-501	SOLVENT MAKE-UP PUMP
P-502	SOLVENT RECOVERY PUMP
P-503	TEG MAKE-UP PUMP
P-601A/B	PROCESS CONDENSATE PUMP
P-701A/B	COOLING WATER PUMP
P-710A/B	RO WATER PUMP
P-711A/B	REJECT WATER PUMP
P-730A/B	GLYCOL SOLUTION PUMP
T-401	SPENT SOLVENT TANK
T-501	SOLVENT STORAGE TANK
T-502	SOLVENT RECOVERY TANK
T-503	TEG STORAGE TANK
T-504	GLYCOL DRAIN SUMP
T-730	GLYCOL SOLUTION EXPANSION TANK
V-201	LEAN SOLVENT FILTER
V-302	OVERHEAD ACCUMULATOR
V-303	REBOILER CONDENSATE DRUM
V-501	SOLVENT RECOVERY FILTER
V-602	CO2 DEHYDRATION PACKAGE PRECOOLER KO DRUM
V-603	CO2 PRODUCT COMPRESSOR SUCTION KO DRUM
VS-601	CO2 VENT STACK

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
1	ISSUED FOR REPORT AFE: WELL:	8/31/21	MM	FP		NP	TS
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REVISIONS | APPROVALS

CAD NO.

PLOT TIME

PLOT DATE

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
PLOT PLAN
GRADE

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-P001	1 OF 1	1	

Attachment 5 – Geotechnical Investigation Report

SOILS ENGINEERING, INC.

REVISED
09-04-20

GEOTECHNICAL INVESTIGATION

FOR THE

CO2 CAPTURE PROJECT

FROM ELK HILLS POWER PLANT (EH-35R/C1RC)

APN: 158-090-19 | 4026 SKYLINE ROAD

TUPMAN, KERN COUNTY, CA

Prepared for:
Fluor Federal Services, Inc.
100 Fluor Daniel Drive
Greenville, South Carolina 29607

By:

SOILS ENGINEERING, INC.
SEI File No. 20-17662
August 6, 2020

REGISTERED PROFESSIONAL ENGINEER
LOUIS THOMAS BAYNE
No. 000125
GEOTECHNICAL
STATE OF CALIFORNIA

L. Thomas Bayne, G.E.

CERTIFIED ENGINEERING GEOLOGIST
ROBERT J. BECKER
No. 2238
REN 2/28/21
STATE OF CALIFORNIA

Robert Becker, C.E.G.

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GEOTECHNICAL INVESTIGATION

FOR THE

CO2 CAPTURE PROJECT

FROM ELK HILLS POWER PLANT (EH-35R/C1RC)

APN: 158-090-19 | 4026 SKYLINE ROAD

TUPMAN, KERN COUNTY, CA

SOILS ENGINEERING, INC.
SEI File No. 20-17662
September 4, 2020

INTRODUCTION

Purpose and Scope of Investigation – This investigation was prepared to provide recommendations for site preparation and grading for a proposed **CO_2** Capture Project to be located near the intersection of Elk Hills Road and Skyline Road. The proposed plant is designed to capture **CO_2** generated by operations conducted at the Elk Hills Power Plant located just north of the proposed capture project site.

This investigation was conducted to study the physical properties of soil: geologic origin; mode of deposition; grain-size; shear strength, compressibility, thermal-conductivity, electrical resistivity, and seismic characteristics – all of which influence the proposed tank foundations, piping supports, and machinery pads. This investigation was also prepared to assess subsurface conditions for their ability to provide foundation-support; to evaluate existing and native soils characteristics for use as structure backfill for underground electrical transmission lines, oil and gas pipelines; and for their adequacy for support of proposed continuous foundations, small to large structural-mats, and cast-in-drilled-hole (CIDH) as well as driven pile-foundations.

This investigation includes not only surface exploration consisting of test-borings, drive-sampling, and bulk samples obtained by hand but also downhole-measurements to determine geophysical properties such as Poisson's Ratio, Shear-Wave-Velocity as well as soil-electrical-resistivity used to obtain data about sites.

Subsurface exploration involved drilling soil test borings to a minimum depth of 37 feet and to a maximum depth of 101 feet; drive-sampling and performing penetration-tests; and obtaining soil samples using a Three (3") – inch outside-diameter by two-and-one-half inch (2.5") or a California-Modified Sampler. Samples recovered were transported to our laboratory for classification and testing.

Based on our engineering analyses which included settlement analyses, determination of maximum and allowable bearing capacity recommendations are provided herein for the site

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preparation, grading, and drainage; foundation selection and design; pile-foundations, and structural mat foundations.

Appendix A, "Guide Specifications for Earthwork," is provided as supplement to Section I, "Earthwork," in the recommendations of the report.

Appendix B, "Field Investigation," contains a boring location map, Figure 1, and Logs of Test Borings, Figures 2 through 17.

Appendix C, "Soils Test Data," contains tabulations of laboratory test data.

Appendix D, "Geologic Hazard Study," contains information provided by EQFAULT, Subsurface Surveys – Summary Report, LiquefyPro, CGS and the SEAOC.

Appendix E, various Foundation Figures and Calculation Tables.

Executive Summary - Existing soils within the upper three to ten (3'-10') feet are compressible and should be compacted to provide adequate support for small, lightly loaded structures and machinery foundations. Large-diameter tanks, and heavy machinery imposing relatively large bearing pressures will require soil-removal and compaction to a depth of ten (10'). Site soils are acceptable for use as engineered fill. After loose, compressible surface materials are excavated and compacted, balanced cuts and fills should be feasible, reducing the need for importing soils to the site. The depth of excavation required for each of the proposed structures should be determined by the Geotechnical Engineer (GE) or the GE's designated representative on the site. During earthwork operations, when the excavation depths have reached the planned elevations, the GE shall review and test the excavation bottom to verify that firm, unyielding material has been exposed and relative compaction tests indicate a minimum relative compaction of 82 percent. If excavations expose earth materials not meeting these requirements, the excavation shall be deepened, reviewed, and retested until firm, unyielding, soils are exposed on the excavation bottom. Procedures described above are more fully described in Section II, Earthwork, subsection C review of excavation bottoms.

Foundation subgrade for most of the proposed units will consist of a layer of Class 2 or Class 3 Base. For equipment, machinery, or structures which have moisture-sensitive flooring, a thin layer of sand, SP or SW, will be needed to protect moisture-proofing membranes from puncture and to absorb excess moisture from concrete

Foundations - Most of the equipment and machinery proposed can be adequately supported on mat foundations designed for maximum allowable bearing pressures of 1000 pounds per square foot. Heavier equipment imposing bearing pressures exceeding 2000 pounds per square foot should be supported on large structural-mats or on foundations consisting of cast-in-drilled-hole piles or driven steel piles.

We hope this provides the information you require. If you have any questions regarding the contents of our report, or if we can be of further assistance, please contact us.

Respectfully submitted,
SOILS ENGINEERING, INC.

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SITE INFORMATION

A. GENERAL SITE LOCATION AND CONDITIONS

The project site is located just south of the existing Elk Hills Power Plant, north of Skyline Road and west of Elk Hills Road in Tupman, Kern County, California. This is within the northeast ¼ of Section 35 of Township 30 South and Range 23 East in Kern County, California.

The project area has been cleared of former structures and has a dirt and gravel surface with no major surface obstructions. The far eastern portion of the site is slightly lower and has some scrub vegetation. The majority of the site area has a slight slope toward the northwest. The approximate central site coordinates are 35.278489 North Latitude and -119.470834 West Longitude.

At the time of our investigation a remedial project was being implemented in the southern portion of the site utilizing an excavator and loader to excavate mix and place petroleum impacted soil back into the subsurface. The backfilled area was then tested for vapor levels and this activity was repeated. SEI was told that Ahtna was complete with the phase of remediation they were conducting while we were on-site. No report of their activities was made available to SEI.

In 2013 and 2014 the previously existing 35R Lean Oil Absorption Plant (35R LOAP) within the current project area was demolished and the equipment, aboveground storage tanks, buildings and resulting debris were hauled off-site for disposal/recycling. The known asbestos containing materials (ACMs) were properly removed and disposed of prior to the demolition occurring. Approximately 110 cubic yards of petroleum contaminated soil was hauled off-site for appropriate disposal at the Clean Harbors facility in Buttonwillow, CA. Another 1383 cubic yards of waste generated was taken to the 10G waste disposal facility for permitted land farming. The excavations for the removal of the contaminated soil and underground piping etc. was approximately 1 foot to 2 feet according to the 35R Closure Report prepared by Four Peaks Environmental & Engineering LLC dated November 6, 2014. The excavation areas were backfilled and the site was graded to match existing topography and to promote drainage. No mention of compaction testing during the backfilling was found in the Closure Report.

North of the project area is the Elk Hills Power Plant with two (2) large generator cooling stacks and associated equipment. To the west is the older 35R Gas Plant with pipelines, compressor units etc. and to the south is Skyline Road. Approximately 1100’ to the southwest is the newer 35R Gas Plant.

B. STRUCTURAL CONSIDERATIONS

Following is a list of the proposed structures that are anticipated for the project:

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Equipment Number or Structure	Equipment or Structure Description	Dimensions	Empty Weight[2] kips	Operating Weight[2] Kips (Bearing Pressure KSF)
FF-101	DCC WATER AIR COOLER			
FF-201	WASH WATER AIR COOLER			
FF-301	CONDENSER			
FF-601	CO2 PRODUCT COMPRESSOR AFTERCOOLER			
FF-730	GLYCOL SOULTION COOLER			
K-201	BLOWER			
	K-201 SUPPORT STRUCTURE FOUNDATION LOADING			
K-601	CO2 PRODUCT COMPRESSOR			
C-101	DIRECT CONTACT COOLER			
	C-101 SUPPORT STRUCTURE FOUNDATION LOADS			
C-201	ABSORBER			
	C-201 SUPPORT STRUCTURE FOUNDATION LOADS			
C-301	STRIPPER			
E-101	DCC WATER TRIM COOLER			
E-201	WASH WATER TRIM COOLER			
E-202	LEAN SOLVENT COOLER			
E-301	SOLVENT CROSS EXCHANGER			

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E-201	REBOILER			
E-601	CO2 PRODUCE COMPRESSOR INTERCOOLER			
P-101 A/B	DCC WATER PUMP			
P-201 A/B	WASH WATER PUMP			
P-202 A/B	RICH SOLVENT PUMP			

[1] The information in Table 1 is preliminary and subject to change.
[2] Weights and vertical reactions are displayed in Allowable Stress Design (ASD) level forces and have no applied load combination factor.

The heavily loaded structures consist of units C-101 (cooler), C-201(absorber) & C-301 (stripper) with operating weights ranging from 1700 kips to 8100 kips.

C. GEOLOGIC SETTING

According to the 2010 Geologic Map of California, the zone of influence for the proposed construction is located wholly within Quaternary Pliocene-Pleistocene non-marine sedimentary rocks (QPc) consisting of sandstone, shale, and gravel deposits; mostly loosely consolidated within the Elk Hills Oil and Gas Field.

The Elk Hills Oil and Gas Field is located about 25 miles southwest of the City of Bakersfield, within the San Joaquin Valley in Kern County, California. The San Joaquin Valley is a large alluvial plain bordered by the Sierra Nevada Mountains on the east, the Diablo and Temblor Ranges on the west, the Tehachapi Mountains on the south, and the San Joaquin River on the north. The San Joaquin Valley is filled with alluvial sediments generally thousands of feet thick eroded from the mountains on all sides. The Elk Hills Oil and Gas Field is an anticline, composed of stratified alluvial soils that have been uplifted (SCS, 1986). The Elk Hills are a spur of the Temblor Range that extend southeastward approximately 16 miles and are 6 miles wide, reaching a maximum elevation of 1,551 feet. This is 1,000 to 1,200 feet above the main floor of the San Joaquin Valley.

The Tertiary and Quaternary deposits underlying Elk Hills and nearby areas are up to 24,000 feet thick. The Tulare formation lies at the surface of the Elk Hills and consists of alternating beds of non-marine sand, gravel, silt and clay (most noticeably the Amnicola, Tulare and Corcoran clay units). The Tulare formation consists of both unsaturated and saturated zones. The upper units of the Tulare formation are mostly unsaturated, while the lower units can be saturated with both water and oil. A geologic cross section of the southern San Joaquin Valley and the Elk Hills Oil and Gas Field is provided as Plate 3 (Department of Conservation, 1986 in DOE, 1993) in Appendix D.

The Tulare formation has been folded into a large compound anticline consisting of two

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subsidiary anticlines commonly referred to as the 29R and the 31S structures (DOE, 1997). The 29R structure is tightly folded, asymmetrical and faulted. The 31S structure is cut by numerous minor faults, four of which reach the surface in the northeast flank of the structure. Other faults in the shallow out-bearing beds do not reach the surface. Woodring et al. (1932) described smaller "earthquake cracks" along and parallel to the extreme north flank. Their trend is approximately perpendicular to the surface faults.

Most noticeable among these cracks or small faults is the Tupman fault, which is a fracture cutting post-Tulare fan deposits with strike-slip and vertical displacement in the northeast flank of Elk Hills. A geologic cross section beneath the Elk Hills area, showing the 29R and 31S structures, is provided as Plate 4 (DOE, 1993) in Appendix D. The site is not located in an Alquist-Priolo (earthquake fault) Special Study Zone, however there are numerous earthquake faults in the vicinity. The nearby faults, with distances from the site, are tabulated below.

SAN ANDREAS (Multiple Segments)	15.0	miles/	24.2	kilometers
KERN FRONT	22.5	miles/	36.2	kilometers
WHITE WOLF.....	25.0	miles/	40.2	kilometers
PLEITO THRUST	25.3	miles/	40.7	kilometers
SAN JUAN.....	29.1	miles/	46.8	kilometers
BIG PINE	40.8	miles/	65.6	kilometers
GARLOCK (West)	44.2	miles/	71.2	kilometers
SAN LUIS RANGE (S. Margin)	46.9	miles/	75.5	kilometers
NORTH CHANNEL SLOPE	49.0	miles/	78.8	kilometers
SAN GABRIEL.....	51.4	miles/	82.8	kilometers

The largest estimated maximum site acceleration, based on deterministic methods, is 0.249g from an 8.0 magnitude earthquake on the San Andreas Fault approximately 24.2 kilometers away. The information above is from the program EQFault (vers.3.0) and a complete listing of faults within 100-miles is presented in Appendix D along with a more detailed Geologic Hazard Study.

D. SUBSURFACE CONDITIONS

Earth materials identified in the sixteen (16) onsite soil borings (B-1 to B-16) conducted in June 2020 located in the proposed building areas consisted generally of intervals of interbedded silty and sandy clay, sandy silt, silty sand, clayey sand, poorly graded sand and well-graded gravelly sand/sandy gravel layers along with some cobbles in the top 100 feet below ground surface (bgs) (see Plate 2 for boring locations). These soils are described as CL, ML, SM, SC, SP, SW and GW, respectively, in the Unified Soils Classification System (USCS).

The subsurface soils were described as medium dense to very dense for the cohesionless material (sands), and firm too hard for the cohesive soils (silts and clays). The majority of the soil borings encountered sandy silt (ML), silty clay (CL) or clayey sand (SC) in the top 2' to 10' below ground surface (bgs). Beneath this surface material was a fine to very coarse-grained gravelly sand (SW) with cobbles up to 4" in diameter to an approximate elevation of 1305' asl. Layers of sandy silt (ML) and silty clay (CL & CH) are predominate from approximately 1305' to 1275' asl with a sand lense between 1292' to 1300' asl. Below this clay and sandy silt layer is predominately sand (SM and SP) with occasional layers of Sandy Silt (ML) and Clayey Sand (SC) to the depth explored (101' or an approximate elevation of 1238' asl. Blowcounts for the

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bottom 12" of each soil sample collected during this investigation were normally greater than 50, but less than 100. The 16 soil borings conducted by SEI did not encounter any significant underground obstructions. Borings B-9 and B-11 did encounter some minor debris (plastic, etc.) in the top ~4 feet at these locations. See Appendix B for the boring logs.

Five (5) Test Pits (TP-1 to TP-5) were dug to a depth of 12' bgs at proposed building locations spread across the site and the lithology was observed and described by a Professional Geologist (PG). In the western portion of the site (TP-3, TP-4) the majority of the surface material was a silty sand (SM) to a depth of 2' which was underlain by a gravelly sand/sandy gravel (SW/GW) with cobbles up to 4" in diameter present. In TP-4 abandoned electrical conduit (3 pipes) was encountered at a depth of 3' bgs and the test pit was continued further to the south to avoid these conduits. Test Pit TP-2 encountered some minor hydrocarbon impacted soil in the top 6' before encountering a clay drainage pipe. The TP-2 location was moved approximately 15' further to the east and was then advanced to a depth of 12'. TP-2 had sandy silt (ML) in the top 7 feet and was underlain by silty sand (SM) to a depth of 11' and then a gravelly sand (SW) was encountered. TP-1 had sandy clayey silt (ML) in the top 2 feet and was underlain by sandy silt/silty sand (ML/SM) to a depth of 6' and then a gravelly sand (SW) was encountered. TP-5 had some silty sand in the top 2 feet with a thin layer of hydrocarbon impacted soil from 2' to 2.5' and was underlain by gravelly sand (SW) with cobbles up to 4 inches in diameter. All of the test pits were backfilled with excavated native soil which was placed and compacted by the excavator bucket in 6" lifts up to match the existing surfaces. See attached Test Pit logs in Appendix B for more detail.

A seismic shear wave survey was conducted by Subsurface Surveys at boring locations B-2 and B-12 with a geophone surface line length of 345'. The reported shear wave velocities ranged from 827 to 1390 ft/sec to a depth of 65' bgs. Significant noise from the adjacent Power Plant to the north made interpretation of the seismic date difficult below a depth of 65 feet. Shear wave velocities increased steadily to the total depth of good data and interpolated Vs100 feet velocities ranged from 1050 ft/s to 1155 ft/s. P wave velocities ranged from 1384 ft/sec to 2686 ft/sec in the top 56 feet and were increasing with depth. Subsurface Surveys states "This suggests the true Vs100 ft values at this site will, most likely, be significantly higher than the extrapolated data." See Appendix D for more detail.

Three (3) abandoned electrical conduits were encountered along the west wall of Test Pit #4. CRC Safety personnel were contacted, and Test Pit #4 was moved approximately 5' further south and no subsurface obstacles were encountered at the new location. In Test Pit #2 a clay drain line was encountered along the southern wall of the test pit. Water with some oil blebs came out of the clay pipe. CRC Safety personnel were contacted, and Test Pit #2 was moved approximately 15' further east and no subsurface obstacles were encountered at the new location.

Expansion Index (EI) testing performed in our laboratory on the cohesive surface soils encountered in our field exploration ranged from 3 to 28, which indicates a low expansion potential. Expansive soils are defined in the 2019 California Building Code (CBC), Section 1803A.5.3. Soils are considered to be expansive when the EI result is greater than 20, per ASTM D4829, Expansion Index of Soils. Design of foundations for structures shall be designed in accordance with the 2019 CBC, Sections 1808A.6.1, & 1808A.6.2.

Cohesionless materials below three to ten feet are in a medium dense to very dense; fine-

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grained soils are stiff to hard. They should provide adequate support for the proposed structures and machinery provided that a portion of the surface soils are excavated and compacted as outlined in the earthwork recommendations of this report.

The soil at the project site is classified as type C per OSHA regulations.

Detailed descriptions of the various soils encountered during our field investigation are shown on Figures 2 through 17 in Appendix B, "Field Investigation." A "Key to Symbols" legend describing the symbols in the boring logs is also attached.

E. HYDROLOGY

No groundwater was encountered in any of the soil borings to the total depth explored (101 feet). A groundwater assessment conducted by the Mark Group within 27R approximately 1 mile to the northwest of the subject site encountered no groundwater to a depth of 420' in 1987. Depth to groundwater is estimated at over 500 feet below ground surface (bgs.) in this area. It is expected that groundwater will be deep enough to not be an issue at this site.

Constant head permeability (ASTM D-2434) tests were performed on different types of surface soils.

Test results ranged from 9.73×10^{-3} cm/sec for the Silty sand to 1.42×10^{-7} cm/sec for the Sandy Silt. See test data on table 1(Laboratory Test Data).

The erosion potential for the site appears to be low to moderate. The Rainfall Erosivity Factor (R Factor) according to the National Pollutant Discharge Elimination System (NPDES) webpage is 18.14 and will require an NPDES and seek the Construction General Permit with the State Water Resources Board.

The surface runoff coefficients for the site area appear to currently be in the range of 0.1 to 0.3 since it is now an unimproved area. Once the area is developed this will rise to 0.6 to 0.9 depending on the surface improvements. These values are from the State Water Resources Control Board.

The RULSE soil edibility Factor K appears to 0.24 for this area of Kern County according to the State RUSLE K Values Map prepared by the State Water Resources Board.

F. SEISMIC DESIGN VALUES

Per the 2019 California Building Code (CBC), the American Society of Civil Engineers (ASCE) 7-16 Section 20.3, and a seismic survey, the site is classified as a Site Class "C". Utilizing the USGS and ASCE 7-16 seismic design methodologies the following seismic design values were determined. The table presented on page 11 outlines the seismic design criteria.

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SEISMIC DESIGN CRITERIA		VALUE	SOURCE
Risk Category		**III**	2019 CBC Table 1604.5 or 1604*A*.5
Site Class		**C**	2019 CBC § 1613.2.2 or 1613*A*.2.2; ASCE 7-16 Table. 20.3-1; Site Specific Soils Report, & Seismic Survey
Mapped MCE_R Spectral Response Acceleration, short period	S_S	**1.175g**	SEAOC-OSHPD software; 2019 CBC Figure 1613.2.1(1)
Mapped MCE_R Spectral Response Acceleration, at 1-sec. Period	S_1	**0.465g**	SEAOC-OSHPD software; 2019 CBC Figure 1613.2.1(2)
Site Coefficient	F_a	**1.2**	SEAOC- OSHPD software; 2019 CBC Table 1613.2.3(1) or 1613*A*.2.3(1)
Site Coefficient	F_v*	**1.5**	2019 CBC Table 1613.2.3(2) or 1613*A*.2.3(2)
Adjusted MCE_R Spectral Response Acceleration, short period, $F_a * S_s$	S_{MS}	**1.41**	SEAOC- OSHPD software; 2019 CBC § 1613.2.3 or 1613*A*.2.3
Adjusted MCE_R Spectral Response Acceleration, 1-sec. period, $F_v * S_1$	S_{M1}	**0.697**	2019 CBC § 1613.2.3 or 1613*A*.2.3
Design Spectral Response Acceleration, short period, 2/3 S_{MS}	S_{DS}	**0.94**	SEAOC- OSHPD software; 2019 CBC § 1613.2.4 or 1613*A*.2.4
Design Spectral Response Acceleration, 1-sec. period, 2/3 S_{MI}	S_{D1}	**0.465**	2019 CBC § 1613.2.4 or 1613*A*.2.4
Peak Ground Acceleration for Max. Considered Earthquake (MCE_G)	PGA	**0.500g**	SEAOC- OSHPD software; ASCE 7-16 Fig 22-9
Site Coefficient, F_{PGA} = 1.2, F_{PGA}* PGA	PGA_M	**0.600g**	SEAOC- OSHPD software; ASCE 7-16 § 11.8.3.2
Mapped Risk Coefficient at 0.2 second Spectral Response Period	C_{RS}	**0.902**	SEAOC- OSHPD software; ASCE 7-16 Figure 22-18A
Mapped Risk Coefficient at 1 second Spectral Response Period	C_{R1}	**0.891**	SEAOC- OSHPD software; ASCE 7-16 Figure 22-19A
Seismic Design Category, short period		**D**	2019 CBC § 1613.2.5
Seismic Design Category, 1second period		**D**	2019 CBC § 1613.2.5
MCE_R = Maximum Considered Earthquake (risk targeted) MCE_G = Maximum Considered Earthquake (geometric mean)			

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EARTHWORK RECOMMENDATIONS

A. COMPACTION AND OPTIMUM MOISTURE

Unless otherwise specified herein, the terms "compaction" or "compacted", wherever used or implied in this report, should be interpreted as compaction to ninety percent (90%), or greater, of the laboratory maximum density (as determined in accordance with ASTM Test Method D1557). The term, “Optimum Moisture,” wherever use or implied within this report, should be interpreted as that obtained by the above described test method.

B. STRIPPING

Prior to soil compaction, existing ground surfaces should be stripped of surface vegetation. A stripping depth of one in should be adequate. The geotechnical engineer shall review the stripped surface to verify that the stripping depth is sufficient to remove the bulk of organic growth. In no instance should material which has been stripped be used as engineered fill or blended with and compacted in original ground.

C. GROUND SURFACE PREPARATION

Proposed Structure Areas:

Ground surfaces in the proposed building areas shall be compacted in accordance with the following procedures:

1. Heavily loaded structures: Excavate earth material to a minimum depth of five (5) below bottom of proposed foundations or ten (10) feet below bottom of existing grade, whichever is deeper.

2. Lightly loaded structures: Excavate earth material to a minimum depth of three (3) below bottom of proposed foundations. or five (5) feet below bottom of existing grade, whichever is deeper.

3. The bottom of the excavation shall be reviewed by the soil engineer or his or her representative prior to any backfill operations. The top foot (1) of materials exposed at the bottom of the excavation shall be scarified and compacted to a minimum of 90 percent of ASTM D1557.

4. Moisten excavated and imported soils to near optimum moisture consistent with effective compaction and soil stability. Compact moistened soils to a minimum of 90 percent of the maximum density obtained by ASTM Test Method D1557.

5. Work to lines at least ten (10) feet for the heavily loaded structures and five (5) feet for the lightly loaded structures beyond the outside edges of exterior footings and two feet beyond pavement edges. Where existing improvements may be affected by the excavation and/or compaction activities, the geotechnical engineer, the civil engineer, and the architect shall be notified as quickly as possible so that specific recommendations may be formulated. In no case shall the contractor proceed if there is the potential to undermine or damage adjacent structures, improvements, or utilities.

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Review of Excavation Bottoms:

Due to the demolition operation performed at the subject site, it is very critical that prior to placement of backfill, excavation bottoms shall be reviewed for indications of loose-fill, discoloration, loose, compressible materials or debris from previous operations . Where these are encountered, they should be excavated and removed, or excavated and compacted as directed by the geotechnical engineer.

Excavation of native soils shall continue in vertical increments of one foot until relative compaction tests taken at the bottom of the working surface (excavation bottom) equal or exceed 80% relative compaction.

Fill placement in excavations shall not proceed until the geotechnical engineer or his or her representative on the site has reviewed, tested as described above and accepted materials exposed at the bottom of the excavation.

Pavement Areas:

Ground surfaces to receive concrete driveways or bituminous pavements should be scarified and compacted to a minimum depth of 12 inches below the grading plane in cut areas or to 12 inches in areas to receive fill. Engineered fill placed in proposed pavement areas should conform to the requirements of Section 5.4, "Placing, Spreading and Compacting Fill Materials," of Appendix A.

Compaction in proposed pavement areas should be a minimum of 90 percent of the maximum density as obtained by ASTM Test Method D1557 and should extend to a minimum of two feet beyond the outside edges of pavements. *The top eight (8) inches of subgrade below the grading plane in pavement areas shall be compacted to a minimum of 95%.*

Utility Lines:

Backfill for utility lines traversing areas proposed for facilities, pavements, concrete slabs-on-grade, or areas to receive engineered fill for future construction should be compacted in accordance with the same requirements for adjacent and/or overlying fill materials. Compaction should include haunch area, spring line, and from top of pipe to finished subgrade. The haunch area up to one foot above the top of the pipe should be backfilled with "cohesionless" material.

Cohesionless native materials may be used for trench and pipe or conduit backfill. The term "cohesionless," as used herein, is defined as material which when dry, will flow readily in the haunch areas of the pipe trench. Pipe backfill materials should not contain rocks larger than two inches in maximum dimension. Where adjacent native materials exposed on the trench bottoms contain protruding rock fragments larger than two inches in maximum dimension, conduits and pipelines should be laid on bedding consisting of clean, cohesionless sand (SP), in the Unified Soils Classification System.

Compaction Requirements - where not otherwise specified in our plans or in these recommendations, the following compaction requirements are applicable to all electrical, gas or water conduits:

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TABLE A COMPACTION DEPTH			
Area	**Haunch to 1 ft. Above Top of Pipe**	**1 ft. Above Top of Pipe to 2'6" Below Finished Grade**	**2'6" Below Finished Grade to Finished Subgrade**
Structures	90%	90%	90%
Pavements	90%	90%	90%
Non-Structural	90%	90%	90%

D. ENGINEERED FILL

Earth materials obtained on-site are acceptable for use as engineered fill provided that all grasses, weeds and other deleterious debris are first removed. Engineered fill materials should be placed in thin layers (less than ten inches uncompacted thickness), brought to near the optimum moisture content or to a moisture content commensurate with effective compaction and soil stability, and compacted to a minimum of 90 percent of the maximum density obtainable by ASTM Test Method D1557, "Placing, Spreading and Compacting Fill Materials," in Appendix A.

E. IMPORTED FILL

The table shown below provides general guidelines for acceptance of import engineered fill. Materials of equal or better quality than on-site material could be reviewed by the Geotechnical Engineer of Record (GEOR) on a case-by-case basis. No soil materials shall be imported onto the project site without prior approval by the GEOR. Any deviation from the specifications given below shall be approved by the GEOR prior to import operations.

Maximum Percent Passing #200 Sieve 40
Maximum Percent Retained 3" Sieve 0
Maximum Percent Retained 1½" Sieve for *Building Areas* 15
Maximum Percent Retained ¾" Sieve for *Landscape Areas* 5
Maximum Percent Retained ½" Sieve for *Play Fields* 0
Maximum Liquid Limit 40
Maximum Plasticity Index 14
Minimum R-Value for *Pavement Areas* 50

Furthermore, the soils proposed for import shall be generally homogenous and shall not contain cemented and/or clayey and/or silty lumps larger than one inch. When such lumps are present, they shall not represent more than ten percent (10%) of the material by dry weight. Where a proposed import source contains obviously variable soils, such as clay and/or silt layers, the soils which do not meet the above requirements shall be segregated and not used for this project or the various layers shall be thoroughly mixed prior to sampling and testing by the Geotechnical Engineer. The contractor shall provide sufficient notice, prior to import operations, to allow sampling, testing, and evaluation of the proposed import material(s). Because of the time needed to perform the above tests, the contractor shall provide a means by which the Geotechnical Engineer, or others, can verify that the material which was sampled and tested is the same material which is being imported to the project.

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F. DRAINAGE

Finished ground grades adjacent to the proposed building areas should be sloped to provide positive free drainage away from the foundations. No areas should be constructed that would allow drainage generated on the site, or water impinging upon the site from outside sources, to pond near footings and slabs or behind curbs. Where ground surfaces adjacent to subsurface walls are to be landscaped, walls should be waterproofed. Installation of gravel-filled drains to route subsurface drainage away from walls will reduce the thickness of damp-proofing resulting in a considerable savings.

G. SLOPES

Both fill and cut slopes should be constructed at 2:1 (horizontal to vertical) in accordance with the 2019 California Building Code. Finished slopes nearer than five feet from building foundations should be graded no steeper than five horizontals to one vertical (5:1). A slope ratio of two horizontal to one vertical (2:1) should provide adequate stability for slopes farther than five feet from footing lines.

The fill slopes shall be compacted to a minimum of 90% of ASTM D-1557 and in accordance with the Guide specifications for Earthwork, Appendix A. This may be achieved by overfilling the constructed slope and trimming to a compacted finished surface, rolling the slope face with a sheepsfoot as the level of the fill is raised, or any method that achieves the desired product. The cut portion of the slope should be constructed first. Prior to construction of the fill slope, incompetent surface soils should be removed from the top of the cut.

Areas to receive fill or to support structures, slabs or pavements should be removed of all vegetation, debris and disturbed soils. All existing uncertified fill soils should be excavated to expose competent native soils. Existing underground pipelines, private sewage disposal systems and any water or oil wells, if encountered during grading, should be removed or capped in accordance with procedures considered acceptable by the appropriate governing agency. Tree roots to 2 inches in diameter should be removed.

Both fill and cut slopes will be subject to erosion immediately after grading and should be designed to reduce surficial sloughing by implementing a permanent slope maintenance program as soon as practical after completion of slope construction. Slope maintenance should include proper care of erosion and drainage control devices, rodent control, and immediate planting with deep-rooting, lightweight, drought-resistant vegetation. An erosion control geotextile may also be used in combination with vegetation to control erosion.

Experience has shown that slope performance is largely dependent upon proper slope maintenance (i.e., planting, proper watering, clearing of drainage devices, etc.). Slopes properly placed and conscientiously maintained are not expected to display excessive raveling or sloughing.

FOUNDATIONS

Foundations are recommended to provide stable, non-yielding, support for proposed Tanks, Pipelines, Equipment and Machinery, and Buildings. Criteria for selecting the most adequate foundations are settlement and bearing-capacity. Most often, settlement controls. Tolerances of proposed improvements to total and differential settlements control selection of the most cost-effective foundations. Appurtenant pipelines and conduits entering processing-units from

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outside locations are most subject to bending and shear forces caused by total settlements. The amount of shear and bending that these pipelines and conduits can sustain will determine the most cost-effective foundation support. For instance, isolated columns that are not structurally connected are more prone to differential movement than their counterparts resting on structural mats.

Following is listed three foundation options, the use of which can be decided based upon design requirements, between shallow foundations (spread footings and structural mats) and deep foundations (drilled piers, driven precast, pre-stressed piles and driven steel piles).The soil strength design parameters are shown on our laboratory test data, Figure 1.

A. SPREAD FOOTINGS & STRUCTURAL MATS

The heavily loaded structures consist of units C-101 (cooler), C-201(absorber) & C-301 (stripper) with operating weights ranging from 1700 kips to 8100 kips.

The proposed structures including the cooling tower basins can be best supported on spread footings or structural-mat having the minimum depths and widths shown in and in accordance with the following Table B. No shape restrictions shall be applied to these foundations.

TABLE B
FOUNDATION DESIGN CRITERIA – *LIGHTLY* LOADED STRUCTURES

Footing Type	Minimum Width (ft.)	Minimum Depth Below Lowest Adjacent Subgrade (ft.)	Maximum Allowable (Net) Soil Bearing Pressure (lbs. / sq. ft.)
Continuous	2	3	2500
Isolated	2	3	2500
Structural Mat	5	3	1000

TABLE B
FOUNDATION DESIGN CRITERIA – *HEAVILY* LOADED STRUCTURES

Footing Type	Minimum Width (ft.)	Minimum Depth Below Lowest Adjacent Subgrade (ft.)	Maximum Allowable (Net) Soil Bearing Pressure (lbs. / sq. ft.)
Continuous	5	3	3500
Isolated	5	3	3500
Structural Mat	10	5	2000

Bearing pressures given are for the minimum widths and depths shown above. Bearing pressures given above are for dead and sustained (loads acting most of the time) live loads; they may be increase by one-third for wind and/or seismic loading conditions. The proposed foundations shall be reinforced in accordance with the structural engineer's recommendations.

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Tanks:

Tank foundations need more rigidity where they are supporting the shell but can tolerate more movement between the perimeter and center. The rigidity provided by a structural mat may not be necessary where a ring wall confining crushed rock may serve the same purpose with less cost.

It is recommended that tank-settlement be measured during the water-test. This allows, soil-compressibility, coefficient-of-consolidation, compression-coefficient, and time-settlement parameters to be estimated and used to predict long-term tank movements. Time permitting, considerations should be given to allowing the tank to stand full until primary consolidation is complete. This will reduce settlements that occur during the filling and emptying process during normal tank use.

Settlement:

Provided maximum allowable soil bearing pressures given above are not exceeded, total settlement should not exceed one inch. A major portion, two-thirds to one-half, of total settlement should occur before the end of construction. Differential settlements should occur before the end of construction. Differential settlements should, accordingly, be less than one-half of an inch for a horizontal span of twenty feet.

B. DRILLED PIERS

Graphs providing Ultimate and Allowable capacity in compression and in tension for values of Skin-Friction, End-Bearing, and Total Capacity expressed in tons / ft2, tons, and tons, respectively, are given in Appendix E. A Safety Factor of 2.5 was applied for the Skin-Friction and a Safety Factor of 3 was utilized for the End-Bearing in these charts. These values are plotted versus depth below the pile-head. Values given for Ultimate and Allowable Capacity in compression and tension may be increased by 1/3 for Wind and Seismic loading conditions. Loads given are ultimate loads.

Estimated Settlement for Drilled Piers with Matt Foundation:

Settlement of Piles/Pier Groups will depend on the Pile size and spacing of the Piles. The analysis conducted for Pile Groups 9 x 9 spaced at 3 diameters showed an anticipated immediate settlement ranging from 1 to 2 inches based on the loads and pile group configurations provided to us. Anticipated differential settlement should range from 0.5 to 1 inch. No long-term settlement is anticipated for the piles embedded in the sandy subsurface material.

Following are the criteria of the proposed drilled Cast-In Place Piers:

- Casing of the shaft may be needed, especially in sandy soil layers.
- Dewatering of the shaft prior to concrete placement (if encountered) will be required during the construction of the foundations.
- Deflection, Moment, and Shear for free-headed and fixed-headed piles are plotted against distance from the top-of-pile for 24 inch and 36 inch free-headed

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and fixed-headed piles. Graphs are shown on Figures in Appendix E. Graphs representing Pile-Head Deflection vs. Pile Length and Pile Buckling Analyses are shown on the figures in Appendix E.

- Curves are provided in Appendix E and were estimated by the computer program LPile v2019 based on cohesion, angle of internal friction and e50. Friction Angles were estimated by the program LPILE using correlations between penetration resistance (SPT) and angles of internal friction. Pushover analyses for lateral load and moment are provided on Figures in Appendix E.

- It is recommended that piles be spaced three (3) diameters apart. Group-Efficiency Factors for piles for 3 x 3, 5 x 5, and 10 x 10 piles groups were equal to **0.991**.

- *Pile Group Efficiency:* For pile groups having less spacing than 3 pile diameters, the following formula by Converse-Labarre (1980) shall be used[1]:

$$\eta = 1 - \left[\frac{(n_1 - 1)n_2 + (n_2 - 1)n_1}{90 n_1 n_2}\right]\theta$$

Where: $\theta = \tan^{-1}(D/s)$ in degrees
n_1 = number of columns of piles in the group
n_2 = number of rows of piles in the group
D = diameter of the pile; s=spacing of the piles in the group.

With respect to axial loads, for pile groups, of six to sixteen piles with a spacing of three pile diameters, a 20% reduction in allowable uplift loads and no reduction in allowable download loads are recommended. For pile groups greater than sixteen, we recommend a 35% reduction in allowable uplift loads and no reduction in allowable download loads.

- Down-drag is not anticipated. Subsurface soils at the site are dry to moist and pre-consolidated. Soil settlement caused by saturation and hydro-consolidation owing to poor site drainage conditions, if it occurred, would cause down-drag. However, down-drag forces caused by friction would not exceed end-bearing resistance afforded at pile-tips. Piles are expected to be installed in earth materials that are not moisture-sensitive and not prone to settle due to hydro-consolidation.

- Verticality: Drilled holes shall be drilled vertically (90° from horizontal or 0° from vertical). The amount of deviation from vertical shall not exceed 2 degrees from vertical.

[1] Tuan, PHAM Anh. (2016). A Simplified Formular For Analysis Group Efficiency of Piles in Granular Soil. *International Journal of Scientific & Engineering Research*, *Vol. 7 (ISSN 2229-5518)*, p. 18.

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- Concrete Placement: All concrete should be placed in one continuous operation. Vibration to consolidate concrete should be provided. Casing will be required to stabilize the shaft. An adequate height of concrete should be maintained above the bottom of the casing while it is gradually raised.

- If water is encountered, it shall be evacuated from the drilled-hole prior to placing concrete with a submersible pump capable of evacuating the cased-hole during concrete placement operations. The pump shall be adequate to evacuate the drilled-and-cased-hole in less than one minute. For purposes of determining the proper pump size, permeability for porous, water-bearing strata should be taken as 0.10 centimeters per second.

- Concrete should be placed immediately following completion of drilling and review of completed shaft. The Geotechnical Engineer or his or her representative shall review and approve the drilled hole prior to placing concrete. The excavation should not be permitted to remain open overnight.

- Adequate devices should be used to guide the fall of concrete in the pier and prevent it from striking the shaft walls, entraining soil or promoting sloughing during placement.

- Construction Review and Observations: The Soils Engineer should provide continuous review of pier drilling and concrete placement. He should also retain the option of reviewing individual piers and requesting minor depth variations when warranted by changes in soil conditions from those assumed during the preparation of the Soil Investigation.

C. DRIVEN PRECAST PRESTRESSED PILES

The proposed structures can be supported on precast, pre-stressed concrete piles driven to refusal or to an elevation sufficient to provide the required lateral resistance.

DYNAMIC DESIGN PARAMETERS

Based on the shear wave velocities (Vs) and p-wave velocities (Vp) reported by Subsurface Surveys in the on-site seismic survey conducted in the area of soil borings B-2 and B-12 along with measured soil densities the following dynamic soil properties were calculated.

Dynamic Shear Modulus
The dynamic shear modulus (**G**) was calculated in 10’ intervals based on the shear wave velocity (Vs) and the measured wet density (**d**) of the soil within that depth interval at borings B-2 and B-12. At boring B-2 the shear modulus (**G**) ranged from 2374074 lbs/ft2 (psf) at 10’ to 5465198 psf at 90’ with an average G of 4277700 psf for the top 100’. At boring B-12 the shear modulus (**G**) ranged from 2610204 psf at 10’ to 9116132 psf at 100’ with an average **G** of 5703780 psf for the top 100’. The average **G** for the top 100’ was 4990741 psf. See Table in Appendix E for all results.

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Poisson's Ratio

The Poisson's Ratio (***u***) was calculated in 10' intervals based on the ratio of Vs and Vp at borings B-2 and B-12. The Poisons Ratio (***u***) ranged from 0.2223 (10') to 0.3626 (60') at boring B-2 with an average ***u*** of 0.316969 in the top 100'. The Poisons Ratio (***u***) ranged from 0.1102 (50') to 0.33309 (20') at boring B-12 with an average ***u*** of 0.26348 in the top 100'. The average ***u*** for the top 100' was 0.29022. See Table in Appendix E for all results.

Bulk Modulus

The Bulk Modulus (**K**) was calculated in 10' intervals based on the shear wave velocity (Vs), p-wave velocity (Vp) and the measured wet density (**d**) of the soil within that depth interval at borings B-2 and B-12. At boring B-2 that bulk modulus (**K**) ranged from 3483553 lbs/ft2 (psf) at 10' to 17083428 psf at 90' with an average **K** of 11393339 psf for the top 100'. At boring B-12 the bulk modulus (**K**) ranged from 4161188 psf at 10' to 16613778 psf at 100' with an average **K** of 10725291 psf for the top 100'. The average **K** for the top 100' was 11059315 psf. See Table in Appendix E for all results.

Youngs Modulus

The Youngs Modulus (**E**) was calculated in 10' intervals based on the shear wave velocity (Vs), the Poisson's Ratio (***u***) and the measured wet density (**d**) of the soil within that depth interval at borings B-2 and B-12. At boring B-2 that Youngs modulus (**E**) ranged from 5803778 lbs/ft2 (psf) at 10' to 14815689 psf at 90' with an average **E** of 11308654 psf for the top 100'. At boring B-12 the Youngs modulus (**E**) ranged from 6140112 psf at 10' to 23119728 psf at 100' with an average **E** of 14389902 psf for the top 100'. The average **E** for the top 100' was 12849278 psf. See Table in Appendix E for all results.

MODULUS OF SUBGRADE REACTION

Modulus of subgrade reaction for use in design of foundations is based on ranges of values for soil types provided by Foundation Analysis and Design by Joseph E Bowles.[2] Equation 1 should be used for footings on sandy soils. Foundations on clay soils should employ Equation 2. Equation 3 is for rectangular footings having dimensions w= **b** (width) and l = **mb** (length) the variable "m" being the ratio of the length to the width of the foundation**.** **K_s1** is the modulus of subgrade reaction from the source referenced above based on a 1-foot x 1-foot square plate. For general guidance K_s1 *of 225 kcf* may be used for the subsurface soils.

Equation (1) $$k_{sf} = K_{s1} \times \left(\frac{B+1}{2B}\right)^2$$

Equation (2) $$k_{sf} = K_{s1} \times B$$

Equation (3) $$k_{sf} = K_{s1} \times \frac{m+.5}{1.5 \times m}$$

Values given above should be used for guidance. Local values may be higher or lower and should be based on results of in-situ plate bearing tests performed in accordance with ASTM Test Method D1194.

[2] Bowles, Joseph E; FOUNDATION ANALYSIS AND DESIGN; McGraw-Hill Book Company (1977); Table 9-1 pg. 269

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LATERAL EARTH PRESSURES

Lateral earth pressures and friction coefficients for determining the passive lateral resistance of foundations against lateral movement and the active lateral forces against retaining walls and subsurface walls, expressed as equivalent fluid pressures, are given below in Table C. Lateral earth pressures were computed assuming that backfill materials are essentially free draining and level; and that no surcharge loads, or sloping backfills are present within a distance from the wall equal to or less than the height (H)* of the wall.

(H)* = the height of backfill above the lowest adjacent ground surface.

TABLE C
LATERAL EARTH PRESSURE

Case	Lateral Earth Pressures
Active	30 P.C.F
Passive	380 P.C.F.
At-Rest	45 P.C.F.

Active Case: Active lateral earth pressures should be used when computing forces against free standing retaining walls, unrestrained at the tops. Active pressures should not be used where tilting outward of the walls is greater than .002H would not be desirable.

Passive Case: Passive lateral earth pressures should be used when computing the lateral resistance provided by undisturbed or compacted native soils against the movement of footing. When computing passive resistance, the upper one foot of embedment depth should be discounted.

At-Rest Case: At-rest pressures should be used for subsurface walls restrained at their tops by floor diaphragms or tie-backs and for retaining walls where tilting outward greater than .002 H would not be desirable.

Frictional Resistance: A friction coefficient of **0.45** may be used when computing the frictional resistance to sliding of footings, grade beams, and slabs-on-grade. Frictional resistance and passive lateral soil resistance may be combined without reduction.

SLABS-ON-GROUND

Slabs-on-ground may be supported on earth materials prepared in accordance with the recommendations of the Geotechnical Investigation.

We recommend that moisture protection be provided for interior concrete slabs-on-ground that will receive moisture-sensitive floor coverings, or where moisture-sensitive equipment, products, or environments may be present. For exceptions to slab moisture protection, refer to the 2019 California Building Code, Section 1907.1. The project designer should provide specific details regarding construction of the concrete slab-on-ground, including the moisture barrier or vapor retarder/barrier, capillary break (if included), and blotter material (if included). The American Concrete Institute recommends a minimum moisture vapor retarder of 10 mil thick polyethylene. The vapor retarder should be protected from damage. Punctures and tears should be repaired

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prior to concrete placement. If there are any rooms in which the temperature will be lower than 45°F, the use of a capillary break on the soil subgrade should be considered.

It has been common local practice to use a sandy material as a blotter layer between the moisture barrier and the concrete to absorb some of the bleed water and to potentially reduce slab curling. However, a blotter layer may act as a moisture reservoir and all apparent advantages of its use are then negated. Therefore, it should not be incorporated into the section design for moisture-sensitive slabs if it cannot be kept dry prior to concrete placement or if water may migrate into the layer after slab construction (eg. wet curing, rainfall). If the slab-on-ground section is to include a blotter layer between the moisture barrier and the concrete, it is our recommendation that the blotter material consist of crusher fines (rock dust) or sand with angular, interlocking grains. The material should be easily compacted and should be screened so that 100% of the material is finer than ¼". Do not use blotter material which may be potentially reactive with the alkalis in the concrete or which has high sulfate content. At the time of concrete placement, the blotter material should be dry to damp, compact, and smooth. For slabs which are to be water-cured, a blotter layer should not be used. For further consideration, refer to the American Concrete Institute *Manual of Concrete Practice 302.1R and 360.*

Slab thicknesses, reinforcing, and the concrete characteristics should be in accordance with the project designer's recommendations. The 2019 California Building Code, Section 1907.1 requires that the slab thickness be not less than 3½".

Pressurized water lines should not be installed beneath slabs-on-ground. Where pressurized water lines must be routed beneath the slab, they should be routed entirely inside continuous sleeves with both ends open to the atmosphere above the slab surface. Gravity flow sewer lines may underlie slabs-on-ground, but they should be routed to the point of connection by the shortest feasible path.

PAVEMENT

Following are our recommendations for Hot Mix Asphalt and Portland Cement Concrete Pavement:

Hot mix asphalt should meet the requirements of the California Department of Transportation *Standard Specifications Section 39* (2010 or newer). Aggregate base should meet the Class 2 requirements in the *Standard Specifications Section 26*.

Portland cement concrete should meet the recommendations of the American Concrete Institute *Guide for the Design and Construction of Concrete Parking Lots* (ACI 330R).

Ground surfaces to receive pavement should be moisture conditioned as needed and compacted. For areas which are cut to grade and for the existing grade in fill areas, scarify the top one foot (1.0') of soil, moisture condition it to approximately optimum moisture (as determined in accordance with ASTM D1557), and compact it. Engineered fill in pavement areas should be placed, spread, moisture conditioned, and compacted in accordance with the recommendations of the geotechnical investigation or as described herein. Compaction for pavement areas should extend at least two feet beyond the edges of the pavement(s). The uppermost one foot (1.0') of pavement subgrade (cut or fill) should be compacted to not less than ninety-five percent (95%) of the laboratory maximum density (as determined in accordance with ASTM D1557). Engineered fill below the uppermost one foot of pavement subgrade should be compacted to not less than ninety percent (90%) of the laboratory maximum density (as

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determined in accordance with ASTM D1557). As an alternative to scarifying one foot of the soil, the contractor may choose to excavate that material, moisture condition it, and replace it in uniform lifts prior to compaction.

Pavement section design options, based on the "R" Value test results by Soils Engineering, Inc. are tabulated below.

Flexible Pavement with Hot Mix Asphalt for Traffic Index* = 5					
Subgrade "R" Value	Aggregate Base Min. "R" Value (Class 2)	Traffic Index	Thickness Options		Minimum Subgrade Compaction** Thickness
			Hot Mix Asphalt Thickness	Class 2 Aggregate Base** Thickness	
35	78	5	0.20'	0.60'	1.0'

* California Department of Transportation *Highway Design Manual, Chapter 610*.
**Compaction of Class 2 Aggregate Base and of the uppermost one foot (1.0') of soil subgrade should be not less than 95% of ASTM D1557 laboratory maximum density.

Flexible Pavement with Hot Mix Asphalt for Traffic Index* = 7					
Subgrade "R" Value	Aggregate Base Min. "R" Value (Class 2)	Traffic Index	Thickness Options		Minimum Subgrade Compaction** Thickness
			Hot Mix Asphalt Thickness	Class 2 Aggregate Base** Thickness	
35	78	7	0.25'	1.00'	1.0'

* California Department of Transportation *Highway Design Manual, Chapter 610*.
**Compaction of Class 2 Aggregate Base and of the uppermost one foot (1.0') of soil subgrade should be not less than 95% of ASTM D1557 laboratory maximum density.

Portland Cement Concrete Pavement					
Subgrade "R" Value	Traffic Category	Concrete Minimum Flexural Strength	Portland Cement Concrete Thickness	Class 2 Aggregate Base** Thickness	Minimum Subgrade Compaction** Thickness
35	"A" with ADDT=1 (autos only)	MOR 550 psi	4.5"	0"	1.0'
	"D" with ADDT=700 (heavy trucks)	MOR 550 psi	7.5"	6"	1.0'

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**Compaction of Class 2 Aggregate Base and Subgrade to be not less than 95% of ASTM D1557 laboratory maximum density.

Native soils are adequate as a subgrade for the proposed pavement options.

These recommendations are valid only if the pavement is properly drained and shoulder areas are graded to prevent water ponding at pavement edges. All construction should be subject to adequate tests and observations to verify conformance with these recommendations.

SOIL CORROSIVITY

Laboratory Tests

- Soluble Sulfates (SO_4): The highest Sulfate (SO_4) concentration measured was 3.6 ppm. Generally, sulfate concentrations greater than 1,500 ppm are considered to be corrosive to foundation elements. (Ref: ACI 318, Section 4.3, Table 4.3.1)

- Chlorides (Cl): The highest Chloride (Cl) concentration measured was 0.86 ppm. Generally, chloride concentrations greater than 500 ppm are considered to be corrosive to foundation elements. (Ref: Caltrans Corrosion Guidelines / Version 1.0)
- pH: The soil pH result was 7.73. Generally, a pH level less than 5.5 are considered to be corrosive to foundation elements. (Ref: Caltrans Corrosion Guidelines / Version 1.0).

- Electrical Conductivity (EC): The soil EC @ 25^0 Celsius was measured at 11 µS/cm. EC, the reciprocal of resistivity, is a measure of the soil's electrical resistance and is considered to be a significant indicator of the potential for corrosion of buried metals. Other factors, including soil pH, soluble salts (type and concentration), soil types, and aerobic versus anaerobic conditions are expected to affect buried metals. Soils Engineering, Inc. does not practice in the specific field of corrosion engineering or electrical engineering. For specific recommendations regarding corrosion and/or earth grounding, it is recommended that an engineer practicing in the field for which there is concern be consulted.

- Thermal Conductivity: Thermal characteristics were determined in accordance with ASTM D-5334 (Determination of Thermal Conductivity of Soil and Soft Rock by Thermal Needle Probe). Laboratory test results are shown on Table 1, attached in Appendix C.

Field Electrical Resistivity

The field soil resistivity test results for subject site are tabulated below.

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Soil Resistivity

Surface Soils: Dry, loose, gravelly silty sand, soil temperature at 6"=97° F. Weather: Clear, warm, dry, 80° F

Wenner Four-Point Method

June 17, 2020		"A" Spacing		Electrode Depth (inches)	Reading (Ω)	**Calculated Resistivity (Ω-cm)**	Notes
Equipment: AEMC 4620		**feet**	cm				
R-1	Between Borings B-2 and B-3; north to south	**5'**	152.5	3	1.69	**1,619**	
		10'	305	6	1.36	**2,606**	
		15'	457.5	9	1.08	**3,105**	
R-1	Between Borings B-2 and B-3; west to east	**5'**	152.5	3	1.26	**1,207**	
		10'	305	6	0.93	**1,782**	
		15'	457.5	9	0.82	**2,357**	
R-2	Near Boring B-6; south to north	**5'**	152.5	3	5.07	**4,858**	
		10'	305	6	3.13	**5,998**	
		15'	457.5	9	2.09	**6,008**	
R-2	Near Boring B-6; west to east	**5'**	152.5	3	1.65	**1,581**	
		10'	305	6	2.56	**4,906**	
		15'	457.5	9	1.70	**4,887**	
R-3	Near Boring B-8; north to south	**5'**	152.5	3	2.08	**1,993**	
		10'	305	6	1.31	**2,510**	
		15'	457.5	9	1.24	**3,564**	
R-3	Near Boring B-8; east to west	**5'**	152.5	3	1.80	**1,725**	
		10'	305	6	1.59	**3,047**	
		15'	457.5	9	1.47	**4,226**	
R-4	Between Borings B-11 and B-12; south to north	**5'**	152.5	3	1.72	**1,648**	
		10'	305	6	1.45	**2,779**	
		15'	457.5	9	1.38	**3,967**	
R-4	Between Borings B-11 and B-12; east to west	**5'**	152.5	3	1.98	**1,897**	
		10'	305	6	1.33	**2,549**	
		15'	457.5	9	1.21	**3,478**	

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LIMITATIONS, OBSERVATION, AND TESTING

Conclusions and recommendations in this report are given for the CO2 Capture Project, within APN: 158-090-19, located on 4026 Skyline Road in Tupman, Kern County, California below.

a. The information retrieved from sixteen (16) exploratory borings drilled at the subject site to a maximum depth of 101.5 feet below the existing ground surface;
b. Our laboratory testing program results;
c. Our engineering analysis based on the information defined in this report;
d. Our experience in the Kern County area.

Variations in soil type, strength and consistency may exist between specific boring locations. These variations may not become evident until after the start of construction.

If such variations appear, a re-evaluation of the soils test data and recommendations may be necessary. Unless a Geotechnical Engineer of this firm is afforded the opportunity to review plans and specifications, we accept no responsibility for compliance with design concepts or interpretations made by others about foundation support, fill selection, fill placement or other recommendations presented in this report. Changes in conditions of the subject property can occur with time because of natural processes or the works of man on the subject site or on adjacent properties. Changes in applicable engineering and construction standards can also occur as the result of legislation or from the broadening of knowledge. Accordingly, the finding of this report may be invalidated, wholly or in part, by changes beyond our control. Therefore, this report is subject to review and should not be relied upon without review after a period of two years or after any modifications to the site.

REVIEW OF EARTHWORK OPERATIONS

Review of earthwork operations relating to site clearing, ground stabilization, placement and compaction of fill materials, and finished grading is critical to the structural integrity of building foundation and floor systems. While the preliminary Geotechnical investigation and report provide guidelines, which are used by the design team, i.e., architects, grading engineers, structural engineers, landscape engineers, etc., in completing their respective tasks, review of plans and site review and testing during earthwork operations are vital adjuncts to the completion of the Geotechnical engineer's tasks.

The most prevalent cause of failure of a structure foundation system is lack of adequate review and testing during the earthwork phase of the project. Projects rarely reach completion without some alteration being required such as may result from a change in subsurface conditions, an amendment in the size and scope of the project, a revision of the grading plans or a variation in structural details. Occasionally, even minor changes can significantly affect the performance of foundations. The most prevalent secondary cause for foundation failure is inadequate implementation of Geotechnical recommendations during the formulation of foundation designs and grading plans. The error in a foundation design or an omission of a key element from a grading plan occurs most often as a result of inadequate communication between the various project consultants and -- when a change in consultants occurs -- improper transfer of authority and responsibility.

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It is imperative, therefore, that any revisions to the project scope, any change in structural detail, or change in consultant, be brought to the attention of Soils Engineering, Inc. to allow for timely review and revision of recommendations and for an orderly transfer of responsibility and approval. It is the responsibility of the owner or his or her representative to ensure that a representative of our firm is present at all times during earthwork operations relating to site preparation and grading, so that relative compaction tests can be performed, earthwork operations can be observed and compliance with the recommendations provided herein can be established.

This engineering report has been prepared within the limits prescribed to us by the client or his or her representative, in accordance with the generally accepted principles and practices of Geotechnical engineering. No other warranty, expressed or implied, is included or intended in this report.

Respectfully submitted,
SOILS ENGINEERING, INC.

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APPENDIX A

GENERAL GUIDE SPECIFICATIONS FOR EARTHWORK

1. GENERAL

1.1 Scope

These specifications and plans include all earthwork pertaining to site rough grading including, but not limited to, furnishing all labor and equipment necessary for clearing and grubbing; stripping; preparation of ground surfaces to receive fill; excavation; placement and compaction of structural and non-structural fill; disposal of excess materials and products of clearing, grubbing, and stripping; and any other work necessary to bring ground elevations to the lines and grades shown on the project plans. Wherever exists discrepancies between these guide-specifications and the earthwork recommendations in Section I of the above geotechnical report, the most stringent recommendations shall supersede.

1.2 Performance:

It shall be the responsibility of the contractor to complete all earthwork in accordance with project plans and specifications. No variance from plans and specifications shall be permitted without written approval of the Engineer-of-Record, hereinafter referred to as the "Engineer" or his or her designated representative, hereinafter referred to as the "Soils Engineer." Earthwork shall not be considered complete until the "engineer" has issued a written statement confirming substantial compliance of earthwork operations to these specifications and to the project plans. The contractor shall assume sole responsibility for job site conditions during earthwork operations on the project, including safety of all persons and preservation of all property. This requirement shall apply continuously and not be limited to normal working hours. The contractor shall defend, indemnify, and hold harmless the owners, engineer, and soils engineer from all liability and claims, real or alleged, arising out of performance of earthwork on this project, except from liability incurred through sole negligence of the owner, engineers, or soils engineers.

2. DEFINITIONS

2.1 Excavations:

Excavation shall be defined within the content of these specifications as earth material excavated for constructing fill embankment; grading the site to elevations shown on project plans; or placing underground pipelines, conduits, or other subsurface utilities or minor structures. Excavations shall be made true to the lines shown on project plans and to within plus or minus one-tenth (0.1) of a foot, of grades shown on the accepted site grading plans.

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2.2 Engineered Fill:

Engineered fill shall be construed within the body of these specifications as earth materials conforming to specifications provided in the soils or geotechnical report placed to raise the grade of the site, to backfill excavations, or to construct asphaltic concrete or Portland cement concrete pavement; and upon which the soils engineer has performed sufficient tests and has made sufficient observation during placement and compaction to enable him to issue a written statement confirming substantial conformance of the work to project earthwork specifications.

2.3 On-Site Material:

On-site material is earth material obtained in excavation made on the project site.

2.4 Imported Material:

Imported materials are earth materials obtained off the site, hauled in, and placed as fill.

2.5 "Compaction" or "Compacted:"

Wherever expressed or implied within the context of these specifications shall be interpreted as compaction to ninety (90) percent of the maximum density obtainable by ASTM Test Method D1557.

2.6 Grading Plane:

The grading Plane is the surface of the basement material upon which the lowest layer of subbase, base, asphaltic or Portland cement concrete, surfacing, or another specified layer is placed.

3. SITE CONDITIONS

The contractor shall visit the site, prior to bid submittal, to explore existing subsurface conditions; to survey site topographic, and to define the nature of materials that may be encountered while performing its work under this contract. Moreover, the contractor shall make his or her own interpretation of the contents of the Geotechnical Report, as they pertain to said conditions. The contractor shall assume all liability under the contract for any loss sustained as a result of variations which may exist between specific soil boring locations or changed conditions resulting from natural or man-made circumstances occurring after the date of the Preliminary Field Investigations.

4. CLEARING AND GRUBBING

4.1 Clearing and Grubbing

Clearing and grubbing shall consist of removing all debris such as metal, broken concrete, trash, vegetation growth and other biodegradable substances, from all areas to be graded. Existing obstructions below shall be removed in accordance with the following procedures:

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4.1.1 Slabs and Pavements - Shall be completely removed. Asphaltic or Portland Cement, concrete fragments may be used in engineered fills provided they are broken down to a maximum dimension of six (6.0) inches and thoroughly dispersed within a friable soil matrix. Engineered fill containing said fragments should not be placed above the elevation of the bottom of the lowest structure footing.

4.1.2 Foundations - Existing at the time of grading shall be removed to a depth not less than two (2.0) feet below the bottom of the lowest structure footing.

4.1.3 Basements, Septic Tanks – Buried concrete containers of similar construction located within areas destined to receive pavements, structures, or engineered fills should be completely removed and disposed of off the site. Basements, septic tanks, etc., situated outside structures, or structural fill areas shall be disposed of by breaking an opening in bottoms to permit drainage, and by breaking walls down to not less than two (2.0) feet below finished subgrade.

4.1.4 Buried Utilities – Such as sewer, water and gas lines or electrical conduits to remain in service shall be re-routed to pass no closer than four (4.0) feet to the outside edge of proposed exterior footings of structures. Lines to be abandoned shall be completely removed to a minimum depth of two (2.0) feet below finished building pad grade. Concrete lines deeper than two (2.0) feet below finished building pad grade and having diameters less than six (6.0) inches can be crushed in place.

4.1.5 Root Systems – Shall be completely removed to a minimum depth of two (2.0) feet below the bottom of the lowest proposed structure footing or to two (2.0) feet below finished subgrade, whichever depth is lower. Root systems deeper than the elevation indicated above shall be excavated to allow no roots larger than two (2.0) inches in diameter.

4.1.6 Cavities – Resulting from clearing and grubbing or cavities existing on the site because of man-made or natural activity shall be backfilled with earth materials placed and compacted in accordance with Sections 5.3 and 5.4 of these specifications.

4.1.7 Preservation or Monuments, Construction Stakes, Property Corner Stakes, or other temporary or permanent horizontal or vertical control reference points shall be the responsibility of the contractor. Where these markers are disturbed, they shall be replaced at the contractor's expense.

5. SITE GRADING

Site grading shall consist of excavation and placement of fills to lines and grades shown on the project plans and in accordance with project specifications and recommendations of the Preliminary Soils Report, whichever is more stringent. The following are recommendations issued in this report:

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5.1 Areas to Receive Fill:

5.1.1 Surfaces to receive fill shall be scarified to a depth of at least six (6.0) inches, or as recommended in this report, whichever is greater, until the surface is free from ruts, hummocks or other uneven features which would tend to prevent uniform compaction by the equipment to be used.

5.1.2 After the area to receive fill has been cleared and scarified, it shall be moistened and compacted to a depth of at least six (6.0) inches in accordance with specifications for compacting fill material in paragraph 5.4, below.

5.2 Excavation:

5.2.1 Excavations shall be cut to elevations plus or minus 0.1 foot of the grades shown on the accepted plans.

5.2.2 When excavated materials are to be used in engineered fill, the excavation shall be made in a manner to produce as much mixing of the excavated materials as practicable.

5.2.3 When excavations are to be backfilled, and where surfaces exposed by excavation are to support structures or concrete floor slabs, the exposed surfaces shall be scarified, moistened and compacted, as stated above, for areas to receive fill. Over excavation below specified depths will not eliminate the requirement for exposed surface compaction.

5.3 Fill Materials:

5.3.1 Materials obtained from on-site excavations will be considered satisfactory for construction of on-site engineered fills, unless otherwise stated in the Soils Report or Foundation Investigation. If unexpected pockets of poor or weak materials are encountered in excavations, and they cannot be upgraded by mixing with other materials or by other means, they may be rejected by the soils engineer for use in engineered fill. Rocks larger than 12 inches in size in any dimension shall not be allowed in the proposed building area. If a large amount of rocks greater than 12 inches in size in any dimension is encountered, a rock disposal area shall be located on the grading plan. Rocks shall be mixed with well-graded soils to assure that the voids in these areas will fill properly.

5.3.2 When imported fill materials are necessary to bring the site up to planned grades, no material shall be imported prior to its approval and acceptance by the soils engineer.

5.3.2 The soils engineer shall be given notice of the proposed source of imported materials with adequate time allowance for his or her testing of the proposed materials. The time required for testing will vary with different types of materials, job conditions, and ultimate function of filled areas. Under best conditions the time requirement will not be less than 48 hours.

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5.4 Placing, Spreading, and Compacting Fill Material:

5.4.1 The fill materials shall be placed in layers which, when compacted, shall not exceed six (6.0) inches in thickness. Each layer shall be spread evenly and shall be thoroughly mixed during the spreading to insure uniformity of material in each layer. Increased thickness of layers may be approved by the soils engineer when conditions warrant.

5.4.2 All fills shall be placed in level layers; layers shall be continuous over the area of any structural unit, and all portions of the fill shall be brought up simultaneously within the area of any structural unit. When imported material is used, it must be placed so that its thickness is as uniform as possible within the area of any structural unit.

5.4.3 When materials are to be excavated and replaced in a compacted condition, segmented, or leap-frogging of cut-fill operations within the area of any structural unit will not be permitted unless the method is specifically described by the soils engineer.

5.4.4 When the moisture content of fill material is below the lower limit specified by the Soils Engineer, water shall be added until the moisture content is as specified; and when it is above the upper limit specified, the material shall be aerated by blading or other satisfactory methods until the moisture content is as specified.

5.4.5 After each layer has been placed, mixed, and spread evenly, it shall be thoroughly compacted to not less than ninety (90) percent of maximum density in accordance with ASTM Density Test Method D1557. Compaction shall be by equipment of such design that it will be able to compact the fill to specified density. When the soils engineer specifies a specific type of compaction equipment to be used, such equipment shall be used as specified.

5.4.6 Compaction of each layer shall be continuous over its entire area and the equipment shall make sufficient trips to ensure that the desired density has been obtained.

5.4.7 Field density tests shall be made by the soils engineer. The compaction of each layer of fill shall be subject to testing. Where sheepsfoot rollers are used, the soil may be disturbed to a depth of several inches.
Density tests shall be taken in the compacted material below the disturbed surface. When tests indicate the density of any layer of fill or portion thereof is below the required ninety (90) percent density, the layer or portion shall be re-worked until the required density has been obtained.

5.4.8 When the soils engineer specifies compaction to other standards or to percentages other than ninety (90) percent, such specification, with respect to the items, shall supersede these specifications.

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5.4.9 The fill operation shall be continued in six (6) inch compacted layers, as specified above, until the fill has been brought to within 0.1 foot, plus or minus, of the finished slopes and grades, as shown on the accepted plans. The finished surface of fill areas shall be graded or bladed to a smooth and uniform surface and no loose material shall be left on the surface.

5.4.10 No fill materials shall be placed, spread, or compacted while it is frozen or thawing or during unfavorable weather conditions. When work is interrupted by weather conditions, fill operations shall not be resumed until the soils engineer indicates that moisture content and density of previously placed fill are satisfactory.

5.5 Observations and Testing:

The soils engineer shall be provided with a 48-hour notice, in order that he may be present at the site during all earthwork activities related to excavation, tree root removal, stripping, backfill, and compaction and filling of the site and to perform periodic compaction tests so that substantial conformance to these recommendations can be established.

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APPENDIX B

FIELD INVESTIGATION

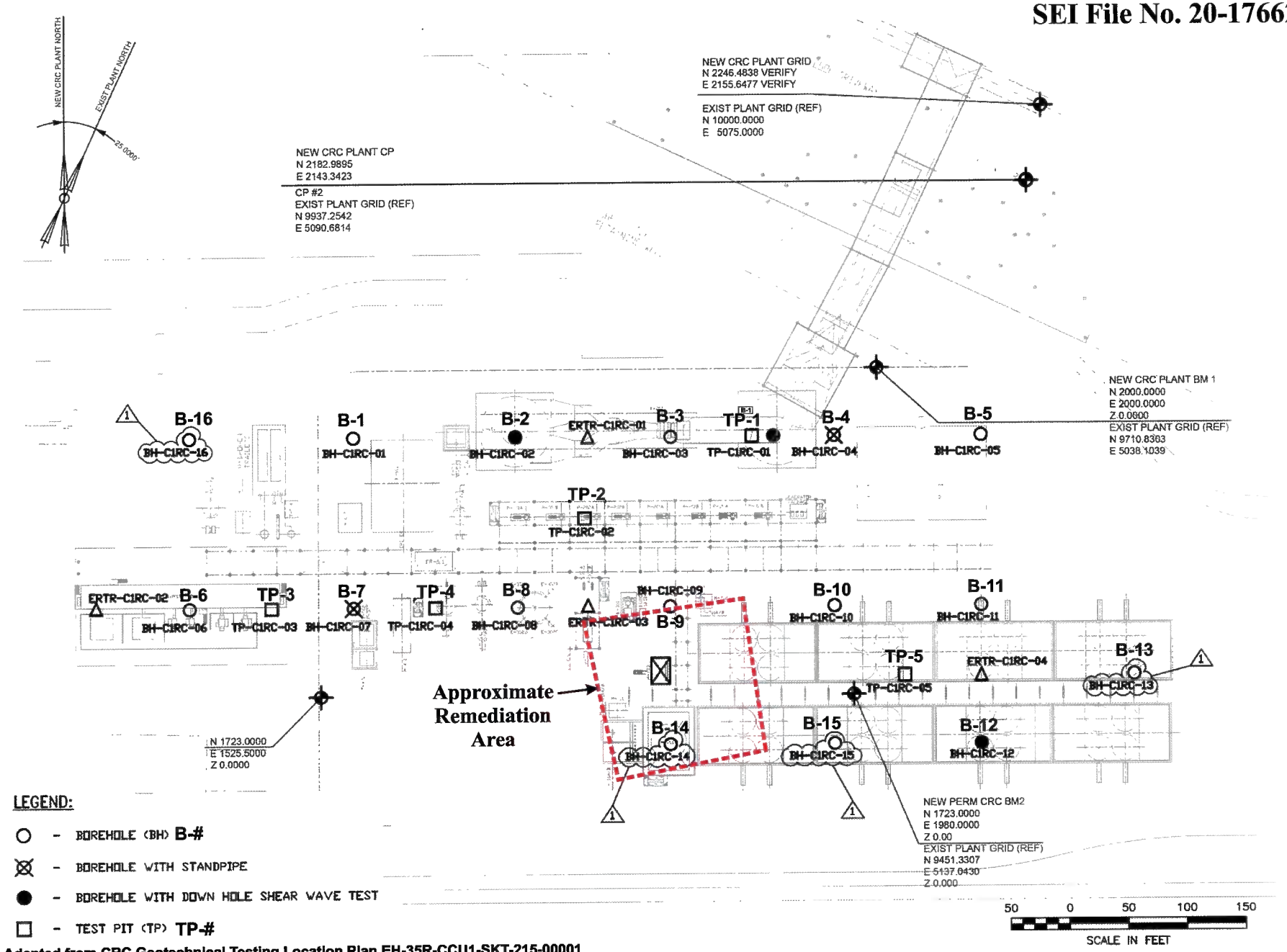
Sixteen (16) test borings were drilled at the subject site and terminated at a maximum depth of 101.5 feet below the existing ground surface. Borings were advanced using an eight (8.0) inch hollow-stem auger. Test data and descriptions from these holes form the basis of the conclusions and recommendations contained in this report.

Undisturbed samples and disturbed bulk samples were obtained. Undisturbed samples were taken using either a 2-3/8” (inside diameter) split-barrel sampler or a 1-3/8” (inside diameter), 2” (outside diameter) Standard Penetration Sampler (SPT). Penetration resistance of undisturbed soils was obtained by driving the above described sampler using a one-hundred-forty-pound hammer falling thirty inches (30"). Blow counts for each six inch (6") driven increment was recorded and are reported on the Test Borings Logs. In addition, bulk soil samples, selected as most representative of near surface soils encountered, were taken for laboratory testing.

As drilling progressed, earth materials encountered were logged and classified in accordance with the Unified Soils Classification System and presented graphically on Logs of Test Borings, Figures 2 and 17, along with the Legend. Approximate locations of test borings are shown on the Boring Location Map, Figure 1.

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SEI File No. 20-17662



LEGEND:

- ○ - BOREHOLE (BH) B-#
- ⊠ - BOREHOLE WITH STANDPIPE
- ● - BOREHOLE WITH DOWN HOLE SHEAR WAVE TEST
- □ - TEST PIT (TP) TP-#

Adapted from CRC Geotechnical Testing Location Plan EH-35R-CCU1-SKT-215-00001

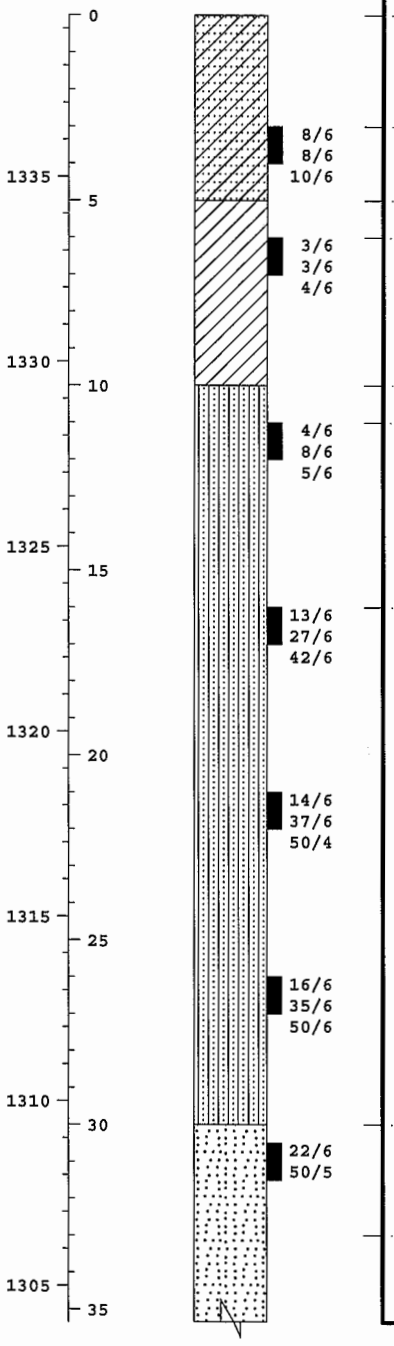
Soil Boring Location Map

FIGURE 1

LOG OF TEST BORING
BORING B-1

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/12/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▽ **:** *N/A* **CAVING -** ▶ **:** *N/A*

FILE NO: *17662*
ELEV.: *1339.36'*
START: *6/12/20*
FINISH: *6/12/20*
LOGGER: *M. WATTS*



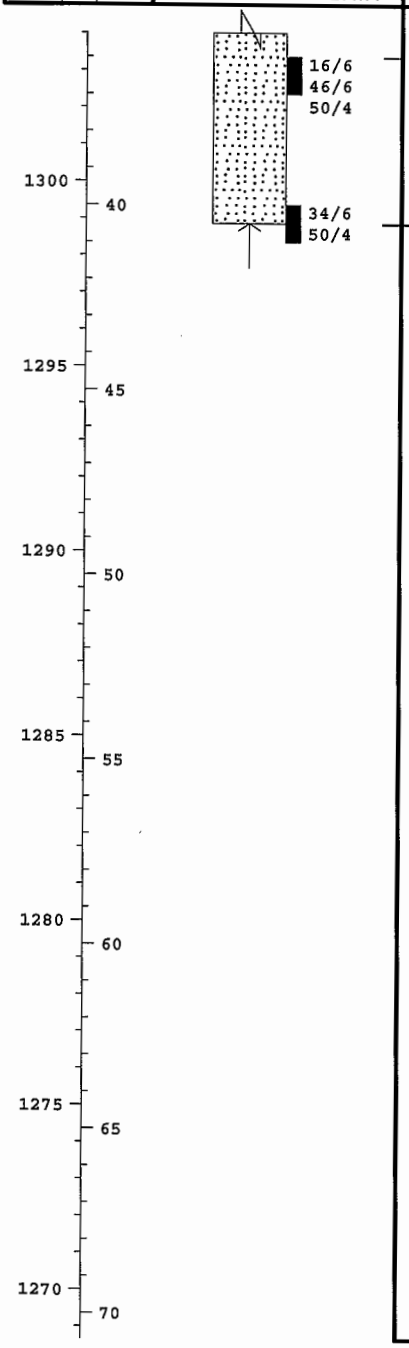
ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
		SC	CLAYEY SAND; yellowish brown, dry to damp, fine, gravel.			
			Medium dense, gravel.		111.1	16.3
		CL	SANDY CLAY; yellowish brown, damp, low plasticity.		112.8	13.7
			Medium stiff.			
		SM	SILTY SAND; yellowish brown, damp, fine, trace of gravel.		101.8	10.2
			Medium dense.			
			Very dense, gravel.		116.6	3.7
					120.0	3.4
					94.9	8.0
		SP	POORLY GRADED SAND; light yellowish brown, dry, fine.		104.5	4.1
			Hard/tight drilling.			

Figure Number 2

LOG OF TEST BORING
BORING B-1

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/12/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▽ **:** *N/A* **CAVING -** ▶ **:** *N/A*

FILE NO: *17662*
ELEV.: *1339.36'*
START: *6/12/20*
FINISH: *6/12/20*
LOGGER: *M. WATTS*

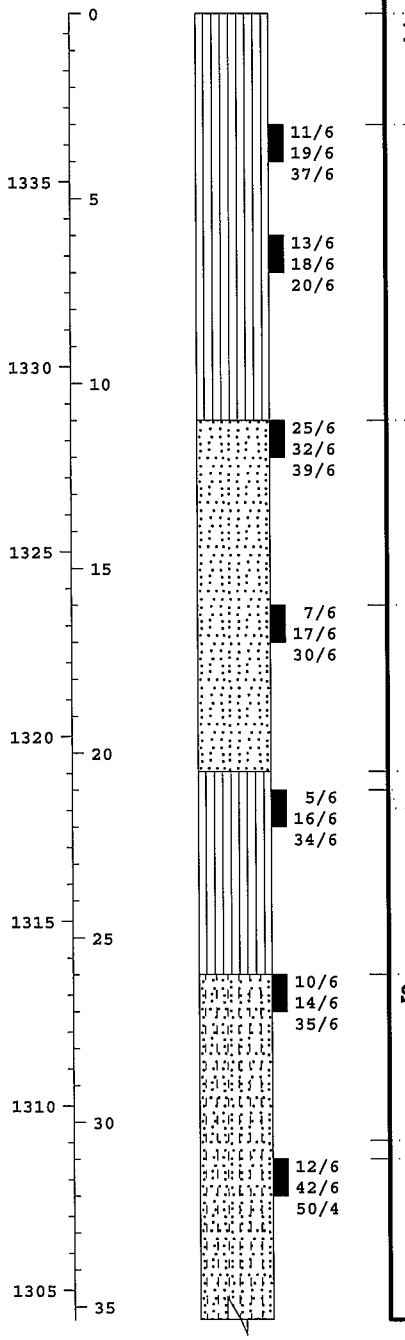


ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
			Gravel.		97.7	16.3
			BOTTOM. Refusal.		100.2	3.7

Figure Number 2

LOG OF TEST BORING
BORING B-2

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
FILE NO: *17662*
BORING DATE: *6/8/20*
ELEV.: *1339.55'*
BORING LOCATION: *See Boring Location Map, Figure 1*
START: *6/8/20*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
FINISH: *6/8/20*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▽ : *N/A* **CAVING - ▶ :** *N/A*
LOGGER: *M. WATTS*

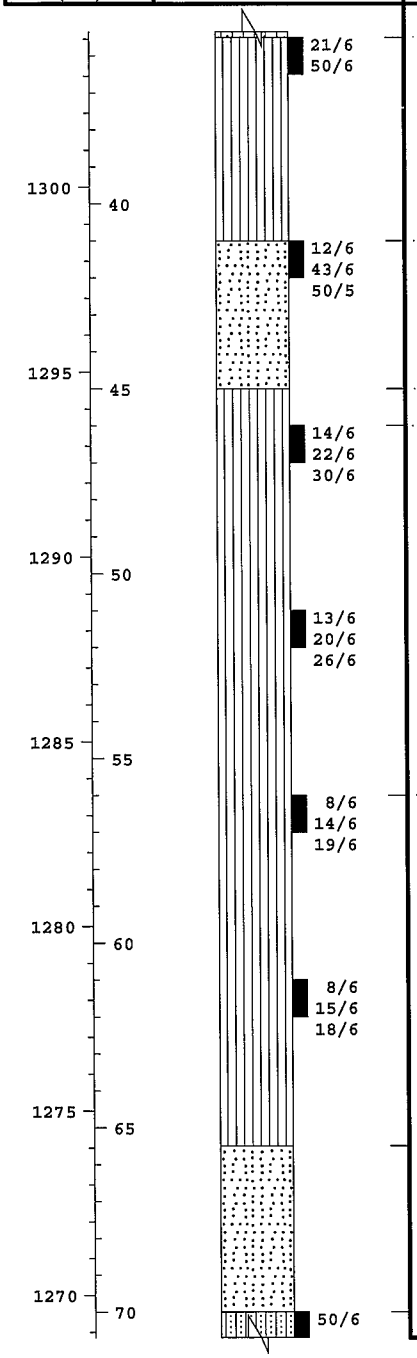


ELEVATION/ DEPTH (feet)	USCS	Description	Remarks	Density pcf	Moisture %
	ML	SANDY SILT WITH CLAY; light yellowish brown, dry, high plasticity, rock.			
		Hard, rock.		109.3	8.6
				105.6	11.8
	SP	POORLY GRADED SAND; light yellowish brown, dry, very dense, fine, rock.		111.6	6.0
		Very dense.		119.3	3.7
	ML	SANDY SILT; brown, damp, trace of clay, low plasticity.		119.3	3.7
		Hard.			
	SP-SM	POORLY GRADED SANAD with low fine content; light yellowish brown, dry to damp, dense.		107.2	5.3
		Dry.			
		Very dense.		107.0	2.6

Figure Number 3

LOG OF TEST BORING
BORING B-2

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
FILE NO: *17662*
BORING DATE: *6/8/20*
ELEV.: *1339.55'*
BORING LOCATION: *See Boring Location Map, Figure 1*
START: *6/8/20*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
FINISH: *6/8/20*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ▶ :** *N/A* **LOGGER:** *M. WATTS*

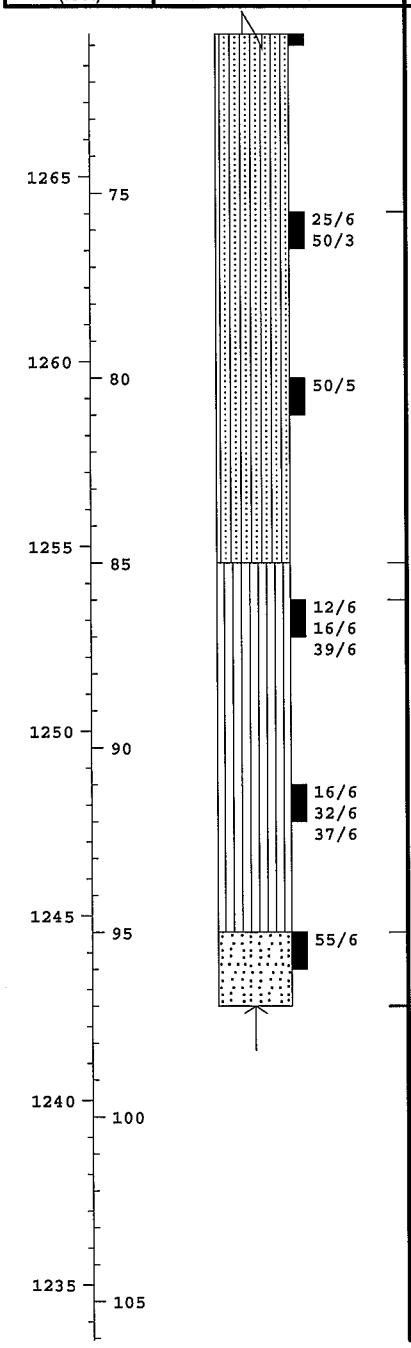


ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
		ML	SANDY SILT; light yellowish brown, fine, very dense, low to medium plasticity.		109.5	4.2
		SP	POORLY GRADED SAND; light yellowish brown, very dense, gravel.		104.1	8.5
		ML	SANDY SILT WITH CLAY; yellowish brown, damp, low to medium plasticity. Hard.		105.8	23.0
					107.9	21.8
			Medium to high plasticity.		96.1	28.1
					95.1	26.9
		SP	POORLY GRADED SAND; yellowish brown, dry to damp, very dense, fine, rock with traces of clay.		110.5	7.0
					82.8	28.4

Figure Number 3

LOG OF TEST BORING
BORING B-2

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
FILE NO: *17662*
BORING DATE: *6/8/20*
ELEV.: *1339.55'*
BORING LOCATION: *See Boring Location Map, Figure 1*
START: *6/8/20*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
FINISH: *6/8/20*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ▶ :** *N/A*
LOGGER: *M. WATTS*



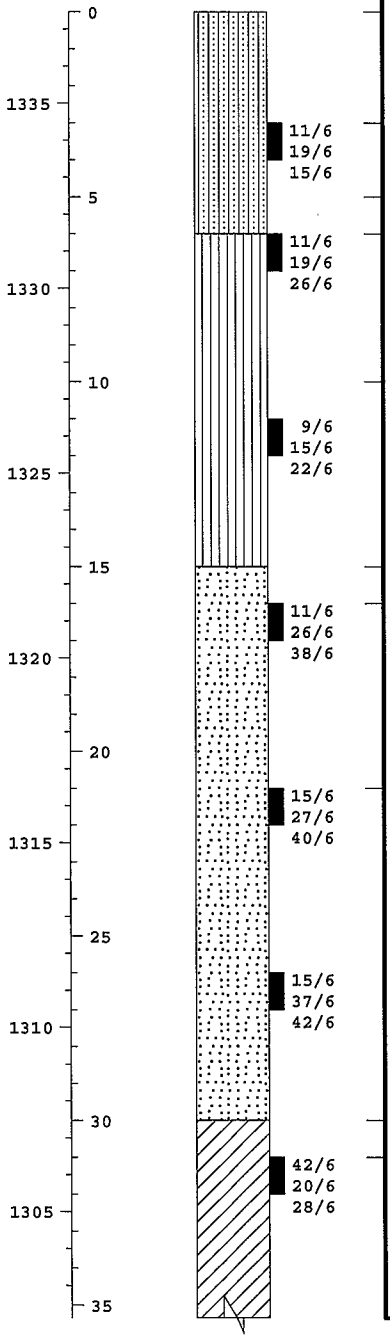
ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
		SM	SILTY SAND; yellowish brown, fine, traces of clay and gravel.			
			Very dense.		102.9	5.4
					112.8	3.8
		ML	SANDY SILT WITH CLAY; yellowish brown, damp, medium to high plasticity. Hard.		104.3	23.9
					109.2	16.9
		SP	POORLY GRADED SAND; light yellowish brown, dry to damp, very dense, fine.		94.3	8.0
			BOTTOM. Refusal due to hard drilling.			

Figure Number 3

LOG OF TEST BORING
BORING B-3

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/8/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ▶ :** *N/A*

FILE NO: *17662*
ELEV.: *1337.47'*
START: *6/8/20*
FINISH: *6/8/20*
LOGGER: *M. WATTS*

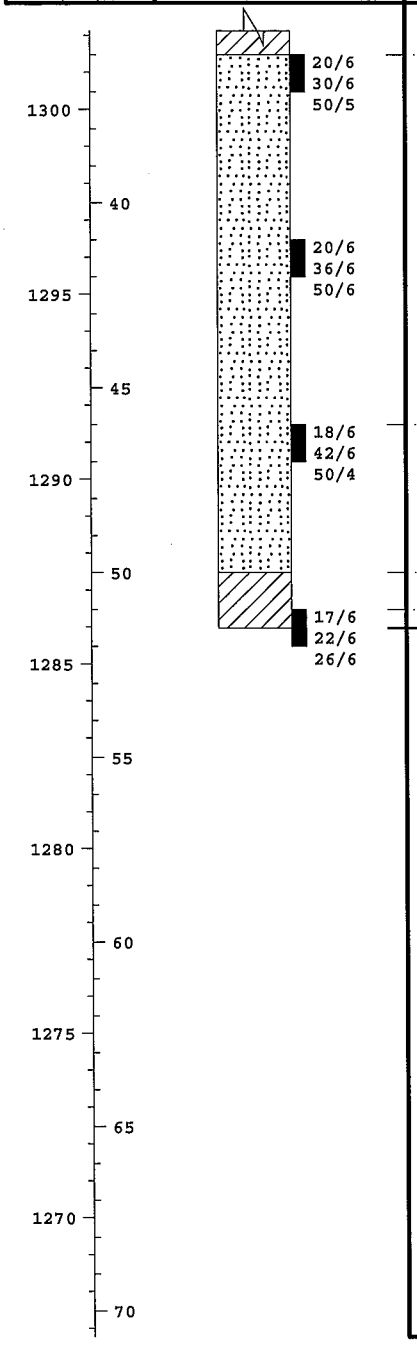


ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
		SM	SILTY SAND; yellowish brown, dry, trace of clay, low plasticity, gravel.			
			Dense, slight odor.		112.3	7.9
			Odor, gray in color,			
		ML	stained.		119.5	15.3
			SANDY SILT; brown, fine, low plasticity, trace of clay, trace of gravel.			
			Yellowish brown, no odor.		111.8	16.6
		SP	POORLY GRADED SAND; light yellowish brown, dry, fine to medium, gravel.		112.9	3.8
			Very dense.			
			Gravel.		111.1	2.7
					116.9	2.0
		CL	CLAY; yellowish brown, damp, medium plasticity.		97.9	28.4
			Hard.			

Figure Number 4

LOG OF TEST BORING
BORING B-3

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
FILE NO: *17662*
BORING DATE: *6/8/20*
ELEV.: *1337.47'*
BORING LOCATION: *See Boring Location Map, Figure 1*
START: *6/8/20*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
FINISH: *6/8/20*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ▶ :** *N/A*
LOGGER: *M. WATTS*

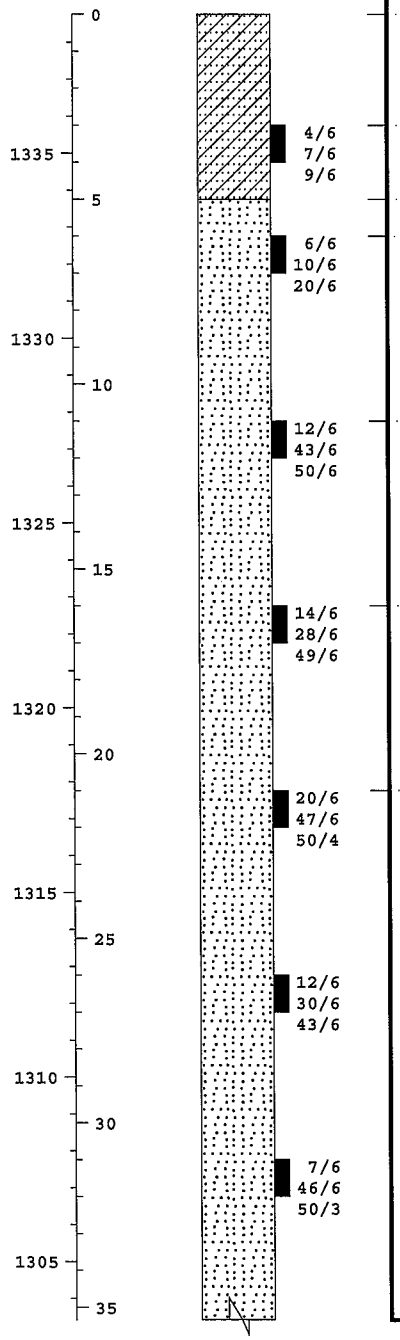


ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
		SP	POORLY GRADED SAND; light yellowish brown, dry to damp, very dense, fine, gravel.		105.4	9.2
					101.0	2.9
			Very dense, rock.		103.8	17.8
		CL	SANDY CLAY; yellowish brown, damp, medium plasticity. Hard.		98.9	27.1
			BOTTOM.			

Figure Number 4

LOG OF TEST BORING
BORING B-4

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
FILE NO: *17662*
BORING DATE: *6/12/20*
ELEV.: *1338.76'*
BORING LOCATION: *See Boring Location Map, Figure 1*
START: *6/12/20*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
FINISH: *6/12/20*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ **:** *N/A* **CAVING -** ▶ **:** *N/A*
LOGGER: *M. WATTS*



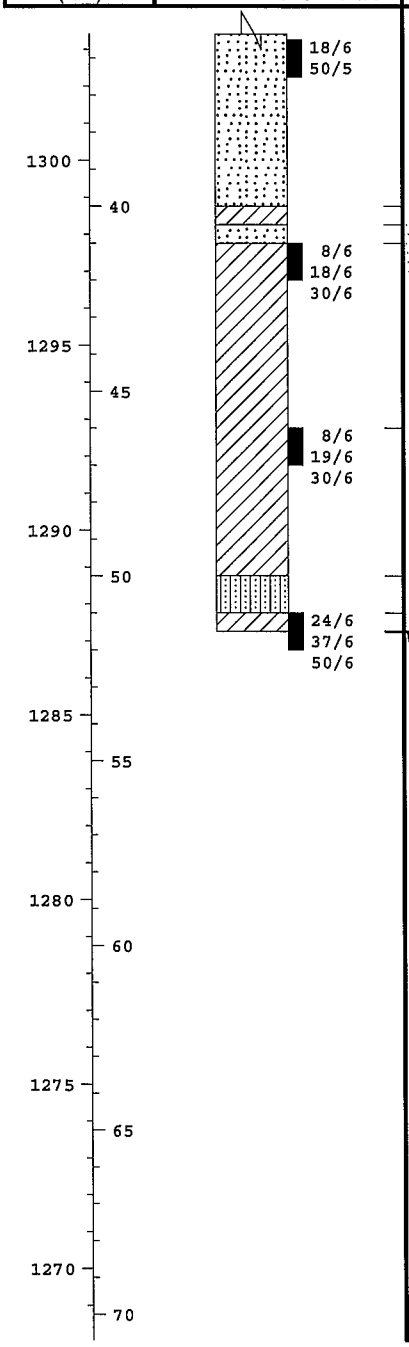
ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
		SC	CLAYEY SAND; light yellowish brown, dry to damp, fine, gravel.			
			Medium dense.		81.6	16.0
		SP	POORLY GRADED SAND; light yellowish brown, dry to damp, fine, gravel.		103.8	8.3
			Dense.			
			Very dense, gravel.		113.4	3.3
			Rock.		111.6	3.0
			Very dense, fine to medium, rock and gravel.		114.8	1.6
					101.2	2.5
					94.9	2.1

Figure Number 5

LOG OF TEST BORING
BORING B-4

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/12/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ▶ :** *N/A*

FILE NO: *17662*
ELEV.: *1338.76'*
START: *6/12/20*
FINISH: *6/12/20*
LOGGER: *M. WATTS*



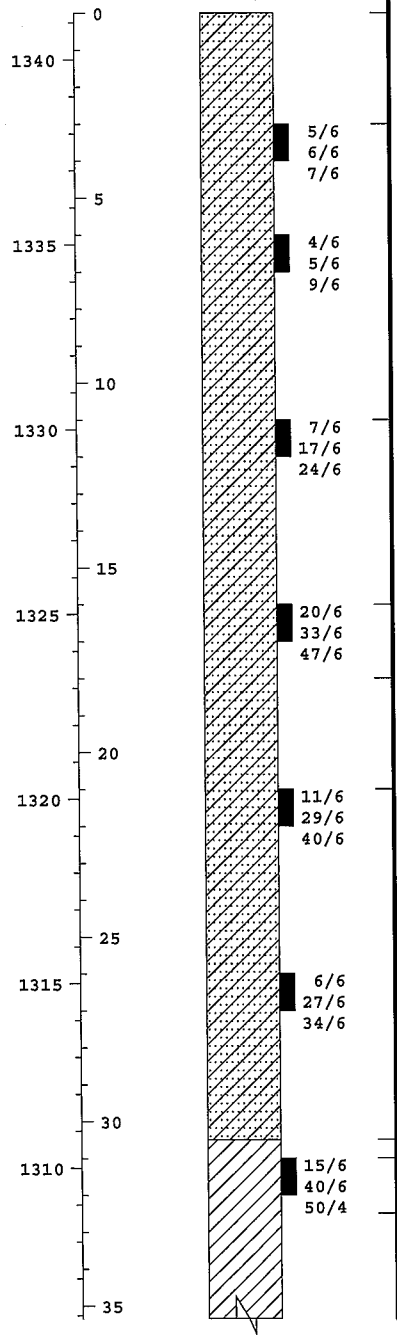
ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
					84.3	3.1
		CL	SANDY CLAY; brown, damp,			
		SP	medium plasticity.		120.6	8.5
		CL	POORLY GRADED SAND; light yellowish brown, dry, fine.			
			SANDY CLAY; light brown, dry, hard, low plasticity, rock.		101.3	20.0
			brown, damp, medium plasticity.			
		SM	SILTY SAND; yellowish brown,			
		CL	dry to damp, fine.		109.3	6.6
			SANDY CLAY; yellowish brown, dry to damp, hard, medium plasticity.			
			BOTTOM.			

Figure Number 5

LOG OF TEST BORING
BORING B-5

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/10/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ▶ :** *N/A*

FILE NO: *17662*
ELEV.: *1341.26'*
START: *6/10/20*
FINISH: *6/10/20*
LOGGER: *M. WATTS*



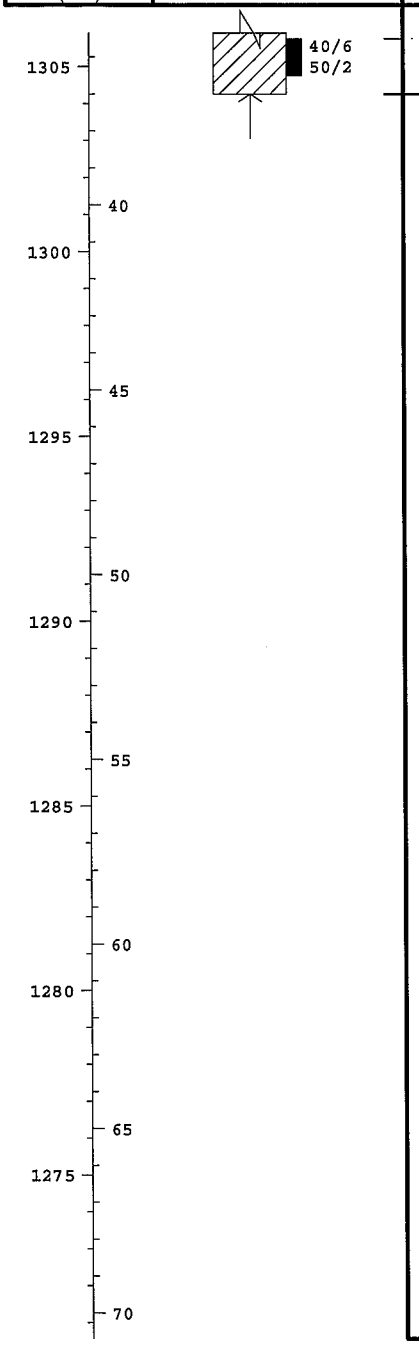
ELEVATION/ DEPTH (feet)	USCS	Description	Remarks	Density pcf	Moisture %
	SC	CLAYEY SAND; light yellowish brown, dry, low plasticity, gravel.			
		Medium dense.		93.5	11.8
				94.6	9.9
		Dense, gravel.		111.8	2.4
		Very dense.		109.9	1.5
		Rock.			
		Very dense, fine to medium, gravel.		100.9	8.9
				105.4	1.7
	CL	SANDY CLAY; yellowish brown, dry to damp, medium to high plasticity.		116.7	14.8
		Hard.			
		Hard/tight drilling.			

Figure Number 6

LOG OF TEST BORING
BORING B-5

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/10/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ▶ :** *N/A*

FILE NO: *17662*
ELEV.: *1341.26'*
START: *6/10/20*
FINISH: *6/10/20*
LOGGER: *M. WATTS*

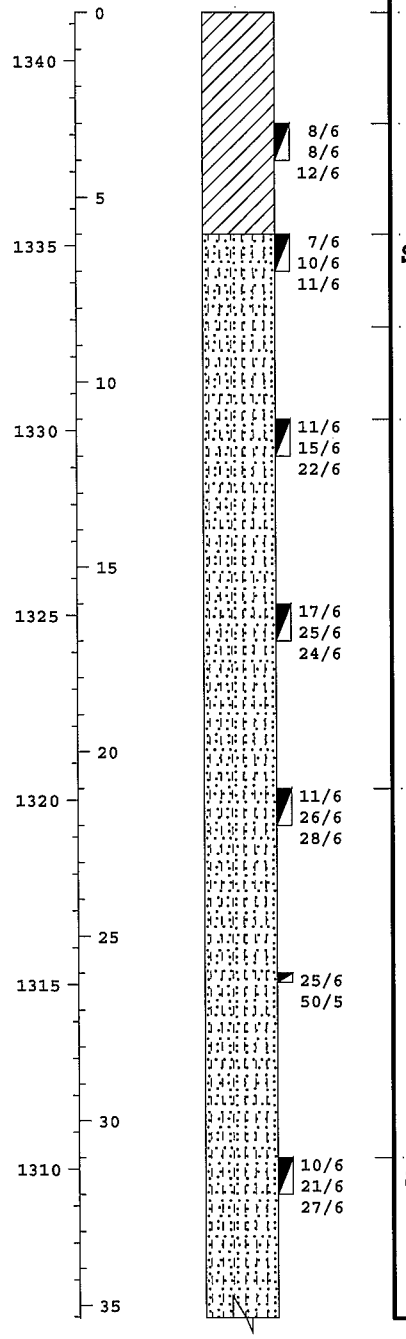


ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
			Dry, light yellowish brown, hard, with silt.		109.1	6.8
			BOTTOM. Refusal due to tight drilling.			

Figure Number 6

LOG OF TEST BORING
BORING B-6

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
FILE NO: *17662*
BORING DATE: *6/10/20*
ELEV.: *1341.31'*
BORING LOCATION: *See Boring Location Map, Figure 1*
START: *6/10/20*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
FINISH: *6/10/20*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ▶ :** *N/A*
LOGGER: *M. WATTS*



ELEVATION/ DEPTH (feet)	USCS	Description	Remarks	Density pcf	Moisture %
	CL	SANDY CLAY; light yellowish brown, dry to damp, low plasticity, gravel.			
		Very stiff, gravel.			8.3
	SP-SM	POORLY GRADED SAND with low fine content; yellowish brown, dry to damp, fine, medium dense, gravel.			13.1
		Slow drilling due to rock.			
		Dense, rock.			8.3
					3.8
		Very dense, rock.			5.4
					3.7
	SP-SM	Dense.			4.4

Figure Number 7

LOG OF TEST BORING
BORING B-6

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/10/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ **:** *N/A* **CAVING -** ▶ **:** *N/A*

FILE NO: *17662*
ELEV.: *1341.31'*
START: *6/10/20*
FINISH: *6/10/20*
LOGGER: *M. WATTS*

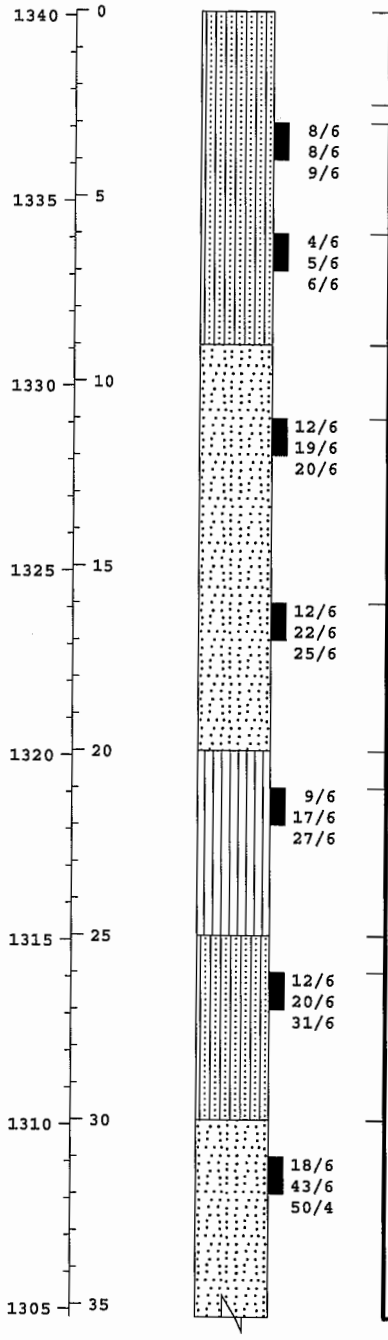
ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
1305	14/6 26/6 32/6		Very dense, gravel.			3.5
40						
1300	16/6 27/6 29/6					2.7
45						
1295	12/6 20/6 30/6					11.9
		ML	SANDY SILT; yellowish brown, damp, low plasticity.			
50						
1290	6/6 18/6 23/6		Hard.			16.2
			BOTTOM.			
55						
1285						
60						
1280						
65						
1275						
70						

Figure Number 7

LOG OF TEST BORING
BORING B-7

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/5/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ **:** *N/A* **CAVING -** ▶ **:** *N/A*

FILE NO: *17662*
ELEV.: *1340.14'*
START: *6/5/20*
FINISH: *6/5/20*
LOGGER: *M. WATTS*



ELEVATION/ DEPTH (feet)	USCS	Description	Remarks	Density pcf	Moisture %
	SM	SILTY SAND; light yellowish brown, dry, trace of clay, low plasticity, gravel.			
		Staining gray with odor. Medium dense, gravel.	VOCS 20-30 PPM	114.3	15.0
		Staining and odor throughout entire samples. Bag sample taken for observation.	VOCS 200-300 PPM	101.5	9.7
	SP	POORLY GRADED SAND; gray, dry to damp, fine, gravel, staining and odor cont. Dense.	VOCS 500-600 PPM	103.2	9.6
		Gravel.		107.0	7.5
	ML	CLAYEY SILT; olive, dry to damp, low plasticity, oily saturation with odor.	VOCS 500-600 PPM	105.0 112.9 112.6	16.9 16.9 16.9
		Hard. Oily saturation with odor, all tubes were taken for observation.			
	SM	SILTY SAND; light yellowish brown, dry, fine, no staining but odor is present.		97.9	4.8
		Very dense.			
	SP	POORLY GRADED SAND; light yellowish brown, dry, fine, odor cont.	VOCS 600-700 PPM	98.6	3.0

Figure Number 8

LOG OF TEST BORING
BORING B-7

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/5/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ **:** *N/A* **CAVING -** ▶ **:** *N/A*

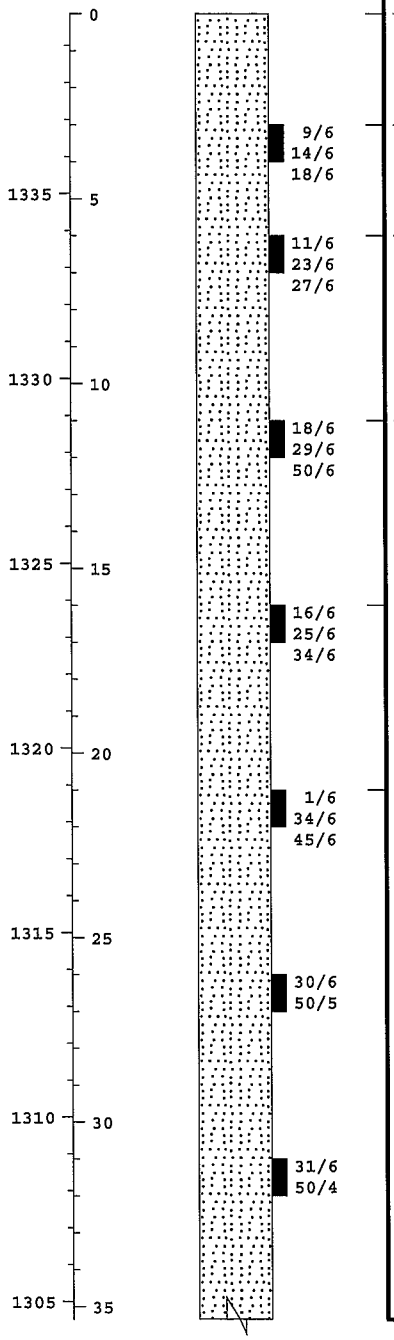
FILE NO: *17662*
ELEV.: *1340.14'*
START: *6/5/20*
FINISH: *6/5/20*
LOGGER: *M. WATTS*

ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
	17/6 39/6 50/4		Odor cont.	VOCS 80-90 PPM	101.6	4.6
1300 — 40	11/6 42/6 50/4			VOCS 80-90 PPM	105.1	5.3
1295 — 45	7/6 16/6 27/6	CL	SANDY CLAY; yellowish brown, damp, low to medium plasticity. Hard. Odor not detected		109.5	22.2
1290 — 50	24/6 38/6 50/5	SM	SILTY SAND; light yellowish brown, dry to damp, fine. Very dense. BOTTOM.		98.0	9.6
1285 — 55						
1280 — 60						
1275 — 65						
1270 — 70						

Figure Number 8

LOG OF TEST BORING
BORING B-8

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
FILE NO: *17662*
BORING DATE: *6/16/20*
ELEV.: *1339.86'*
BORING LOCATION: *See Boring Location Map, Figure 1*
START: *6/16/20*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
FINISH: *6/16/20*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ▶ :** *N/A*
LOGGER: *M. WATTS*



ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
		SP	POORLY GRADED SAND; dry, fine, gravel.			
			Dense, gravel.		107.1	12.5
			Very dense, gravel.		89.9	27.1
			Fine to medium.		110.1	6.5
			Fine.		107.4	3.7
			Fine to medium.		114.5	3.6
					94.0	3.4
					99.6	4.1

Figure Number 9

LOG OF TEST BORING
BORING B-8

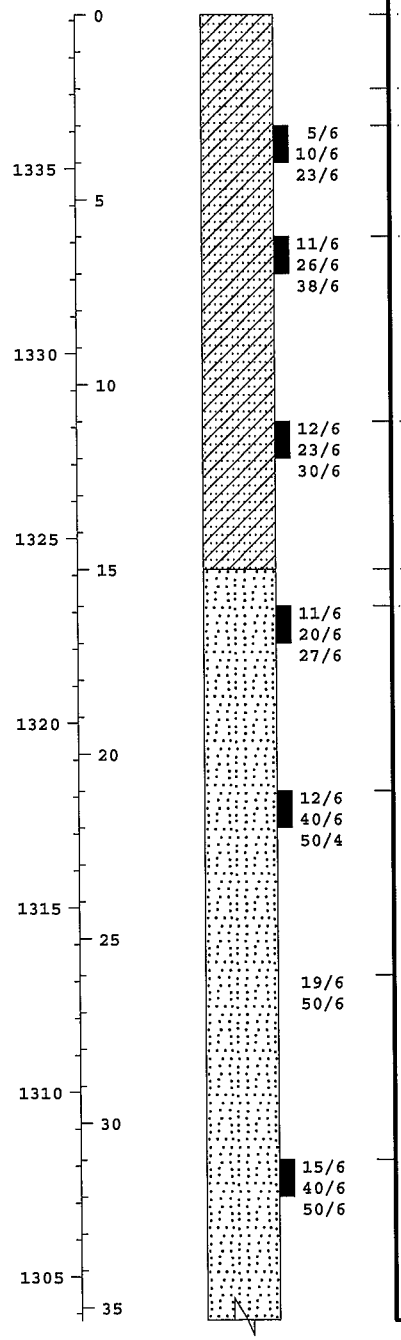
PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
FILE NO: *17662*
BORING DATE: *6/16/20*
ELEV.: *1339.86'*
BORING LOCATION: *See Boring Location Map, Figure 1*
START: *6/16/20*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
FINISH: *6/16/20*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ▶ :** *N/A* **LOGGER:** *M. WATTS*

ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
	30/6 50/4		No recovery.	Moisture can is from sampler.		3.9
1300 — 40	17/6 25/6 41/6		Very dense.		102.3	4.0
1295 — 45	9/6 28/6 39/6	SM	SILTY SAND; yellowish brown, dry to damp, fine, traces of clay.		110.6	17.0
1290 — 50	7/6 23/6 40/6		Very dense.		112.0	16.5
			BOTTOM.			
1285 — 55						
1280 — 60						
1275 — 65						
1270 — 70						

Figure Number 9

LOG OF TEST BORING
BORING B-9

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
FILE NO: *17662*
BORING DATE: *6/5/20*
ELEV.: *1339.16'*
BORING LOCATION: *See Boring Location Map, Figure 1*
START: *6/5/20*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
FINISH: *6/5/20*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▽ : *N/A* **CAVING - ▶ :** *N/A* **LOGGER:** *M. WATTS*

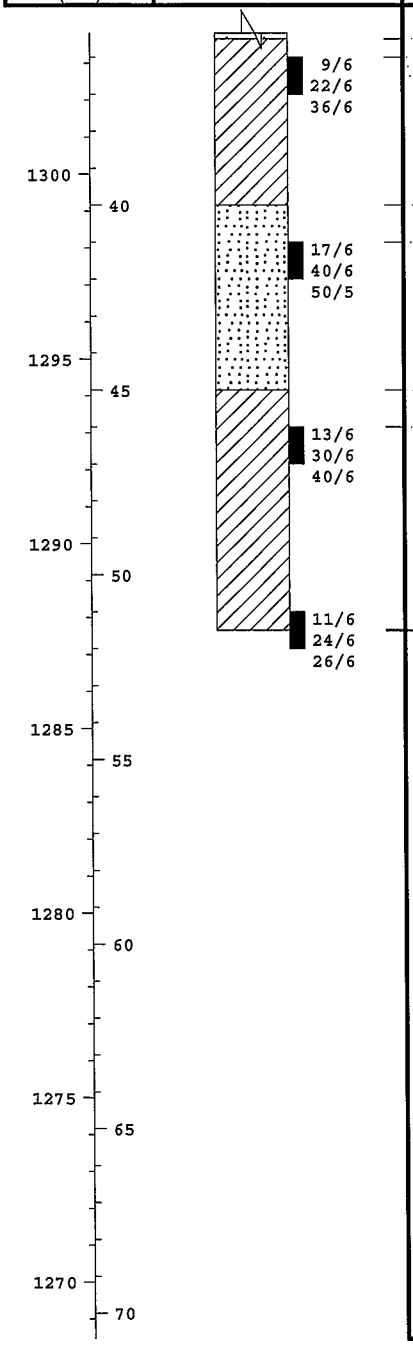


ELEVATION/ DEPTH (feet)	USCS	Description	Remarks	Density pcf	Moisture %
	SC	CLAYEY SAND; light yellowish brown, dry to damp, fine, gravel.			
		Trash, plastic.		115.3	11.5
		Dense, rock.			
		Very dense, rock.		126.3	9.9
		Gray in color with slight odor. No reading detected with meter.		120.6	14.4
	SP	POORLY GRADED SAND; light yellowish brown, dry, fine, gravel.		99.6	7.9
		Dense.			
		Very dense, gravel.		117.5	3.3
		No recovery.			
		Very dense.		125.3	2.4

Figure Number 10

LOG OF TEST BORING
BORING B-9

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
FILE NO: *17662*
BORING DATE: *6/5/20*
ELEV.: *1339.16'*
BORING LOCATION: *See Boring Location Map, Figure 1*
START: *6/5/20*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
FINISH: *6/5/20*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ⬢ :** *N/A* **LOGGER:** *M. WATTS*

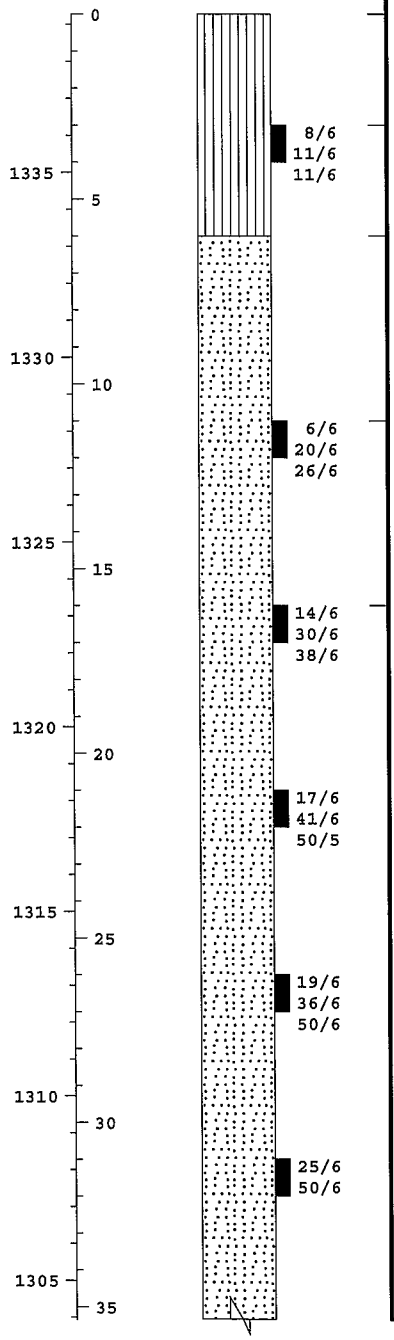


ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
		CL	SANDY CLAY; yellowish brown, damp, low to medium plasticity. Hard.		93.3	25.6
		SP	POORLY GRADED SAND; light yellowish brown, dry, fine, gravel. Very dense.		96.4	1.9
		CL	SANDY CLAY; yellowish brown, damp, with silt, low to medium plasticity. Hard.		122.5	12.6
			BOTTOM.		109.4	17.5

Figure Number 10

LOG OF TEST BORING
BORING B-10

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
FILE NO: *17662*
BORING DATE: *6/15/20*
ELEV.: *1339.28'*
BORING LOCATION: *See Boring Location Map, Figure 1*
START: *6/15/20*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
FINISH: *6/15/20*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ **:** *N/A* **CAVING -** ▶ **:** *N/A*
LOGGER: *M. WATTS*

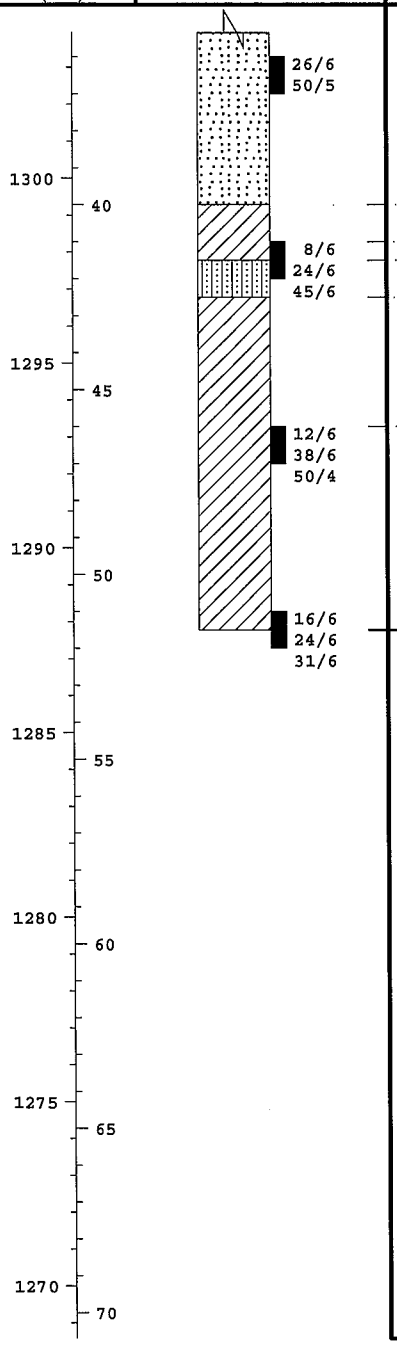


ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
		ML	SANDY SILT; yellowish brown, dry to damp, with clay, low plasticity.			
			Very stiff.		116.1	11.4
		SP	POORLY GRADED SAND; yellowish brown, dry to damp, dense, fine, gravel.		115.0	5.9
			Dense, gravel.		110.4	3.5
			Very dense, gravel.		114.0	6.9
					101.1	3.7
					105.0	4.5
					74.2	1.8

Figure Number 11

LOG OF TEST BORING
BORING B-10

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
FILE NO: *17662*
BORING DATE: *6/15/20*
ELEV.: *1339.28'*
BORING LOCATION: *See Boring Location Map, Figure 1*
START: *6/15/20*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
FINISH: *6/15/20*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ▶ :** *N/A* **LOGGER:** *M. WATTS*



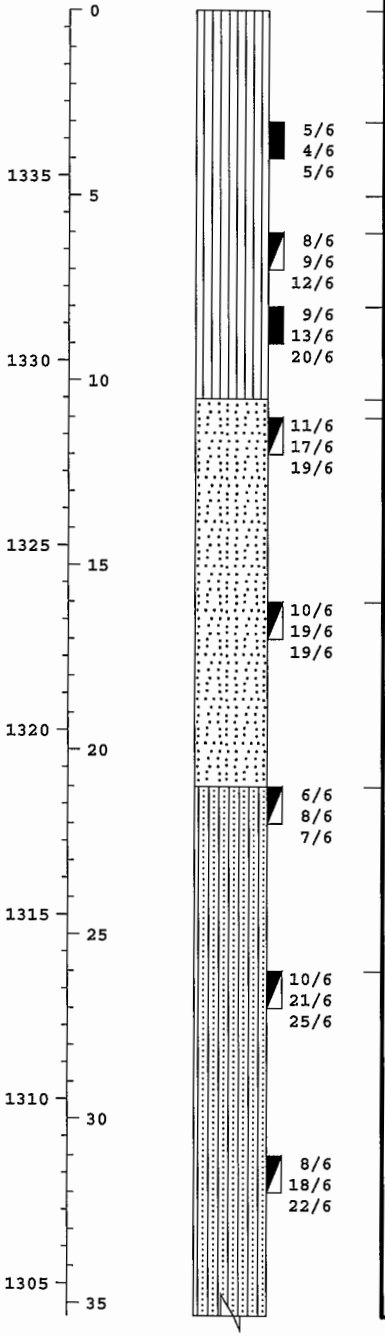
ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
					90.5	19.7
		CL	SANDY CLAY; yellowish brown, damp, low plasticity,		125.4	10.5
		SM	gravel.			
		CL	Hard.			
			SILTY SAND; yellowish brown, damp, fine, traces of clay.			
			SANDY CLAY; yellowish brown, dry to damp, low plasticity.		120.4	13.7
			Hard.			
			BOTTOM.		107.9	22.7

Figure Number 11

LOG OF TEST BORING
BORING B-11

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/11/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ **:** *N/A* **CAVING -** ▶ **:** *N/A*

FILE NO: *17662*
ELEV.: *1339.47'*
START: *6/11/20*
FINISH: *6/11/20*
LOGGER: *M. WATTS*



ELEVATION/ DEPTH (feet)	USCS	Description	Remarks	Density pcf	Moisture %
	ML	SANDY SILT; brown, dry to damp, with clay, low plasticity, gravel.			
		Stiff, gravel (trash, plastic pieces)			11.0
		Odor and staining.	VOC 3ppm out of bag.		
		Very stiff with sand and gravel.			10.7
		Drove tube to review if staining was present and to test VOCs.	VOC 20ppm.		
	SP	POORLY GRADED SAND; light yellowish brown, dry to damp, fine, odor/staining.	No VOC reading.		8.5 8.0
		Dense (no staining or odor from 10.5'-11.5')			
		Dense, gravel.			7.8
	SM	SILTY SAND; light brown poorly graded, medium dense.			5.8
		Dense.		105.0	4.5
				74.2	1.8

Figure Number 12

LOG OF TEST BORING
BORING B-11

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/11/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ▶ :** *N/A*

FILE NO: *17662*
ELEV.: *1339.47'*
START: *6/11/20*
FINISH: *6/11/20*
LOGGER: *M. WATTS*

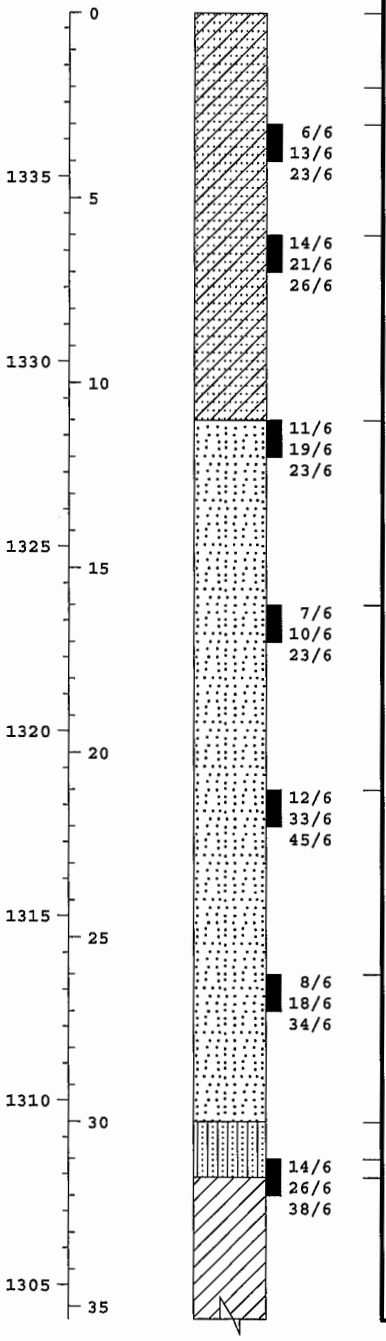
ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
1300 / 40	11/6 27/6 35/6		Very dense.		90.5	19.7
				No sample due to error.		
1295 / 45	6/6 14/6 19/6	SM	Dense.			7.0
1290 / 50		CL	SANDY CLAY; brown, damp, low to medium plasticity.			
1285 / 55	5/6 9/6 11/6		Very stiff. BOTTOM.			25.9
1280 / 60						
1275 / 65						
1270 / 70						

Figure Number 12

LOG OF TEST BORING
BORING B-12

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/9/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▽ **:** *N/A* **CAVING -** ▶ **:** *N/A*

FILE NO: *17662*
ELEV.: *1339.42'*
START: *6/9/20*
FINISH: *6/9/20*
LOGGER: *M. WATTS*



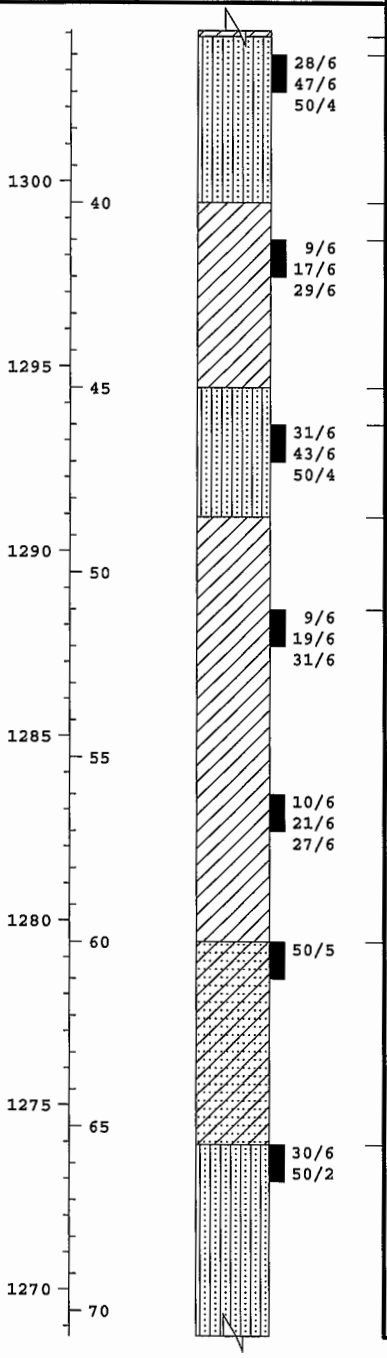
ELEVATION/ DEPTH (feet)	USCS	Description	Remarks	Density pcf	Moisture %
	SC	CLAYEY SAND; light yellowish brown, dry, low plasticity.			
		Damp, yellowish brown, gravel.		115.9	12.1
		Dense.			
		Gravel, shale.		117.1	12.6
	SP	POORLY GRADED SAND; yellowish brown, dry to damp, dense, fine, gravel.		116.5	5.3
		Dense, rock, gravel.		91.4	2.8
		Very dense, fine to medium.		107.1	2.3
		Very dense, fine.		104.3	1.8
	SM	SILTY SAND; light brown, dry to damp, low plasticity.		94.4	28.2
	CL	Hard. SANDY CLAY; brown, damp, medium plasticity.			

Figure Number 13

LOG OF TEST BORING
BORING B-12

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/9/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ⬟ :** *N/A*

FILE NO: *17662*
ELEV.: *1339.42'*
START: *6/9/20*
FINISH: *6/9/20*
LOGGER: *M. WATTS*



ELEVATION/ DEPTH (feet)	USCS	Description	Remarks	Density pcf	Moisture %
	SM	SILTY SAND; light yellowish brown, dry, fine. Very dense.		91.3	10.2
	CL	SANDY CLAY; yellowish brown, dry to damp, medium plasticity. Hard.		117.5	15.8
	SM	SILTY SAND; light yellowish brown, dry, fine, traces of clay. Very dense.		103.5	6.0
	CL	SILTY CLAY; brown, damp, medium plasticity. Hard.		107.2	21.5
				108.7	21.6
	SC	CLAYEY SAND; light yellowish brown, dry, very dense, fine.		88.9	4.9
	SM	SILTY SAND; light yellowish brown, dry, very dense, fine.		88.1	4.4

Figure Number 13

LOG OF TEST BORING
BORING B-12

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/9/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ▶ :** *N/A*

FILE NO: *17662*
ELEV.: *1339.42'*
START: *6/9/20*
FINISH: *6/9/20*
LOGGER: *M. WATTS*

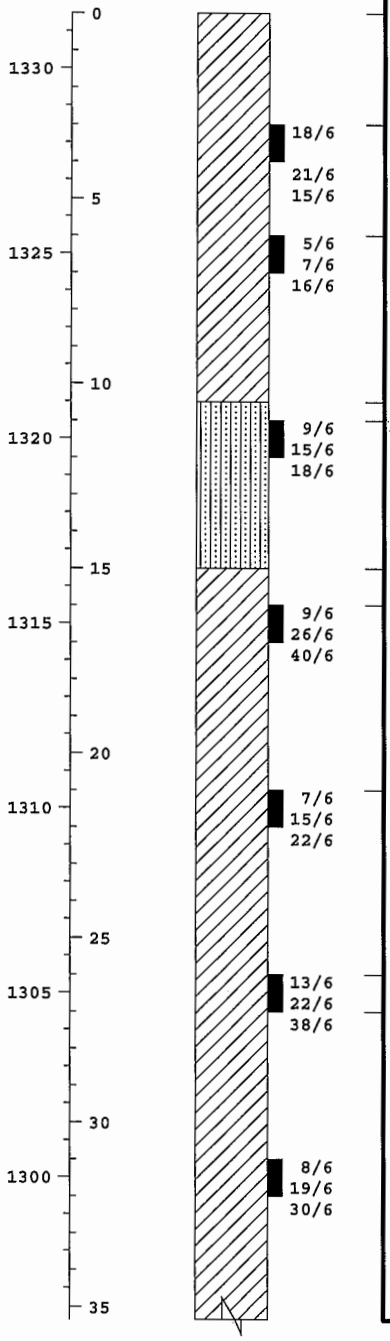
ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
1265 / 75	10/6 50/4					2.8
	28/6 50/4		Fine to medium.		107.4	4.1
1260 / 80	34/6 50/3				95.5	2.9
1255 / 85	16/6 50/3	SC	CLAYEY SAND; light yellowish brown, dry, very dense, fine.		110.7	2.2
1250 / 90	38/6 50/2	SM	SILTY SAND; light yellowish brown, dry, very dense, fine.		107.3	3.3
1245 / 95	25/6 50/3				96.0	3.2
1240 / 100	15/6 28/6 50/5	CL	SILTY CLAY; brown, damp, medium plasticity. Hard.		110.4	16.2
1235 / 105			BOTTOM.			

Figure Number 13

LOG OF TEST BORING
BORING B-13

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/18/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ▶ :** *N/A*

FILE NO: *17662*
ELEV.: *1331.48'*
START: *6/18/20*
FINISH: *6/18/20*
LOGGER: *M. WATTS*



ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
		CL	SILTY CLAY; yellowish brown, dry to damp, low plasticity.			
			Hard.		120.6	9.1
			Very stiff.		97.6	14.8
		SM	SILTY SAND; light yellowish brown, dry, fine.		119.9	8.1
			Dense.			
		CL	SANDY CLAY; light yellowish brown, dry, low to medium plasticity.		116.0	13.8
			Hard.			
			Dry to damp.		112.7	18.3
			Hard, with traces of silt.		117.5	13.9
			Tight, hard drilling.			
					116.8	15.0

Figure Number 14

LOG OF TEST BORING
BORING B-13

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/18/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ▶ :** *N/A*

FILE NO: *17662*
ELEV.: *1331.48'*
START: *6/18/20*
FINISH: *6/18/20*
LOGGER: *M. WATTS*

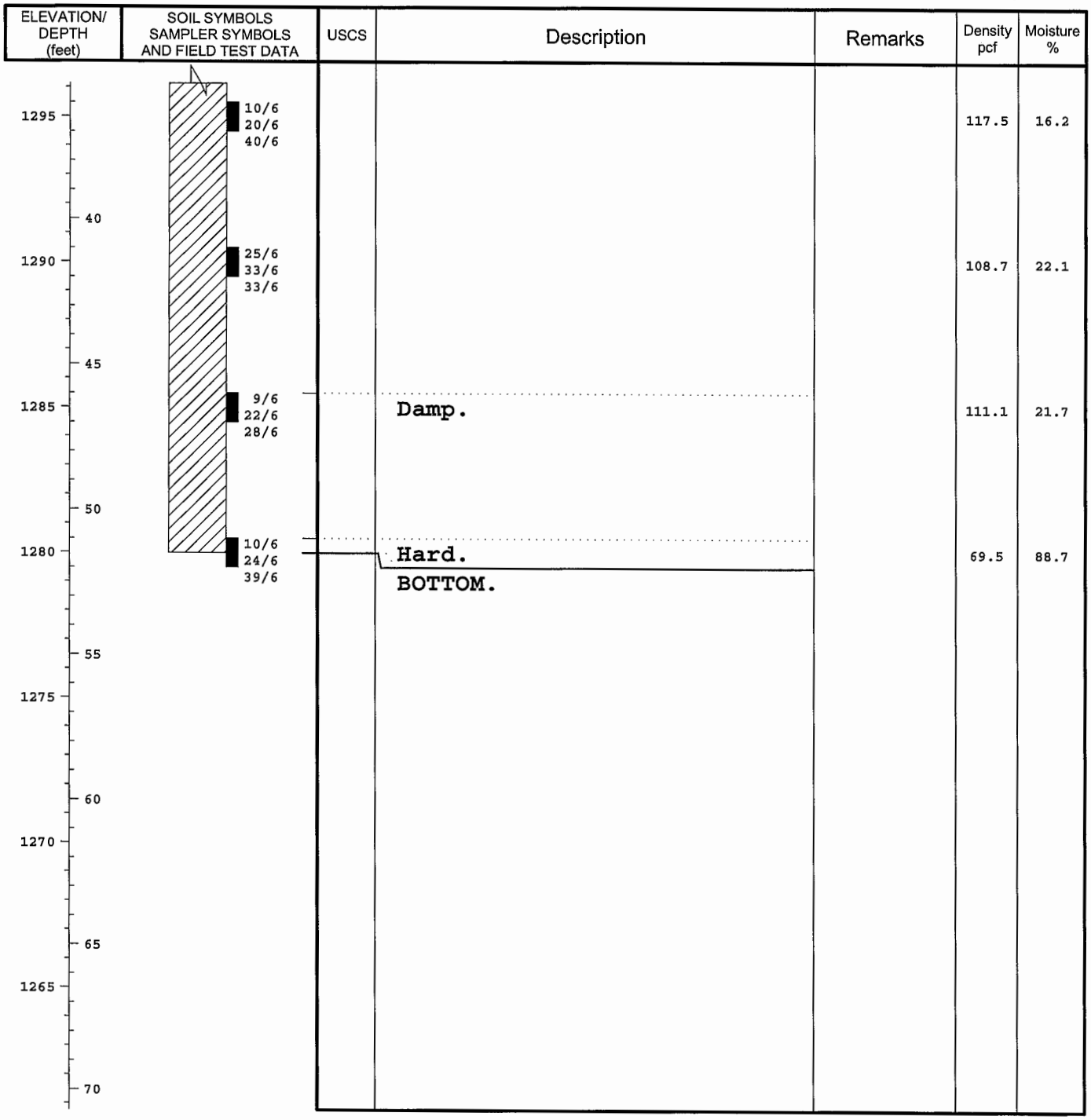
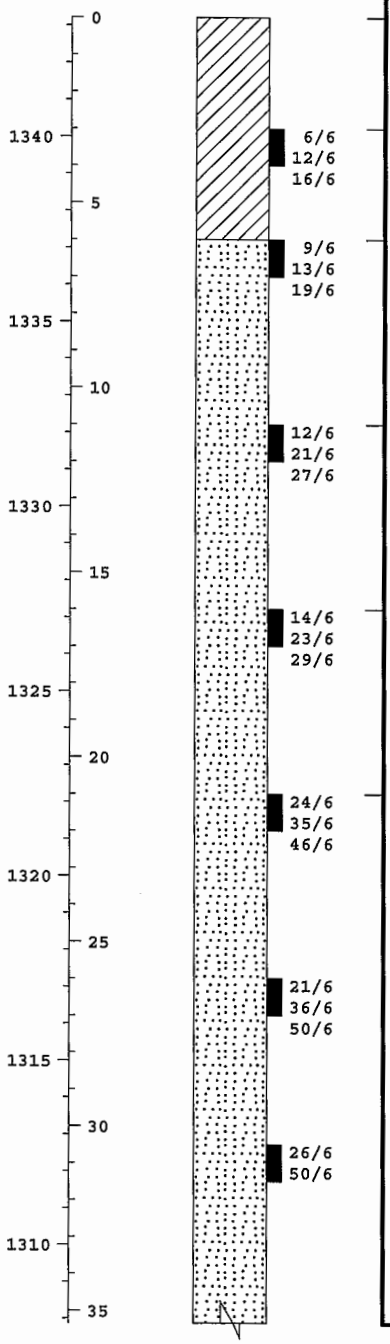


Figure Number 14

LOG OF TEST BORING
BORING B-14

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/15/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ▶ :** *N/A*

FILE NO: *17662*
ELEV.: *1343.22'*
START: *6/15/20*
FINISH: *6/15/20*
LOGGER: *M. WATTS*



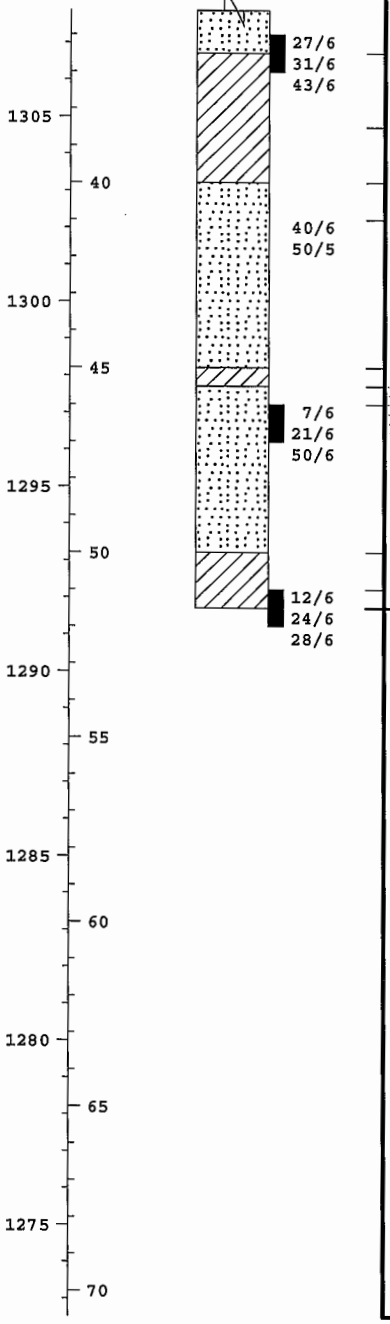
ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
		CL	SILTY CLAY; light yellowish brown, dry, low plasticity.			
			Very stiff.		100.5	15.0
		SP	POORLY GRADED SAND; light yellowish brown, dry, dense, fine, gravel.		112.7	10.8
			Dense, gravel.		111.7	5.7
			Very dense, gravel.		110.0	3.1
			Fine to medium.		100.7	11.0
					100.0	11.4
					91.7	4.3

Figure Number 15

LOG OF TEST BORING
BORING B-14

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/15/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ▶ :** *N/A*

FILE NO: *17662*
ELEV.: *1343.22'*
START: *6/15/20*
FINISH: *6/15/20*
LOGGER: *M. WATTS*



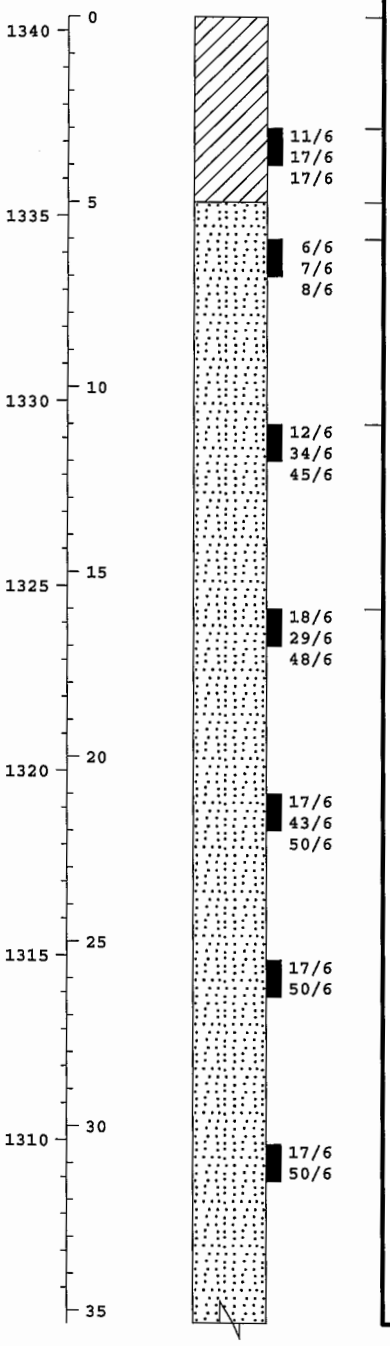
USCS	Description	Remarks	Density pcf	Moisture %
CL	SANDY CLAY; yellowish brown, dry to damp, low plasticity, gravel (nose cone).		119.5	10.0
	Tight/hard drilling.			
SP	POORLY GRADED SAND; light yellowish brown, dry, fine to medium.			3.4
	No recovery.			
CL	SANDY CLAY; brown, damp, low			
SP	plasticity.		120.5	6.4
	POORLY GRADED SAND; light yellowish brown, dry to damp, fine, gravel.			
CL	Very dense, traces of clay.			
	SILTY CLAY; yellowish brown, damp, low plasticity.		116.2	17.3
	Hard.			
	BOTTOM.			

Figure Number 15

LOG OF TEST BORING
BORING B-15

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/18/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ **:** *N/A* **CAVING -** ▶ **:** *N/A*

FILE NO: *17662*
ELEV.: *1340.38'*
START: *6/18/20*
FINISH: *6/18/20*
LOGGER: *M. WATTS*



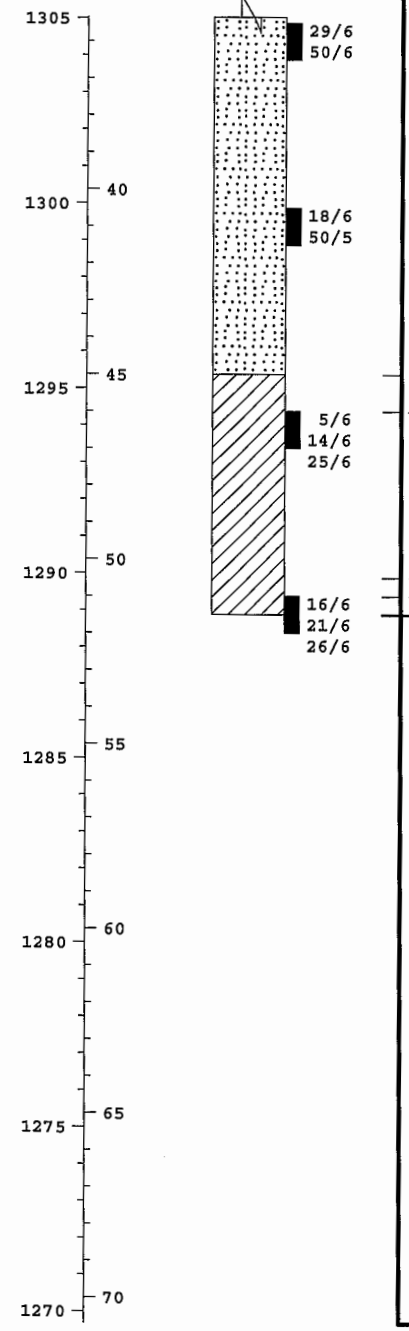
ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
		CL	SANDY CLAY; light yellowish brown, dry, low plasticity.			
			Hard.		112.0	10.3
		SP	POORLY GRADED SAND; light yellowish brown, dry to damp, fine, rock.		100.7	3.9
			Medium dense.			
			Very dense.		105.7	11.5
			Gravel.		127.8	3.0
					106.7	2.0
					87.1	24.9
					96.1	2.8

Figure Number 16

LOG OF TEST BORING
BORING B-15

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/18/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▽ : *N/A* **CAVING - ▶ :** *N/A*

FILE NO: *17662*
ELEV.: *1340.38'*
START: *6/18/20*
FINISH: *6/18/20*
LOGGER: *M. WATTS*



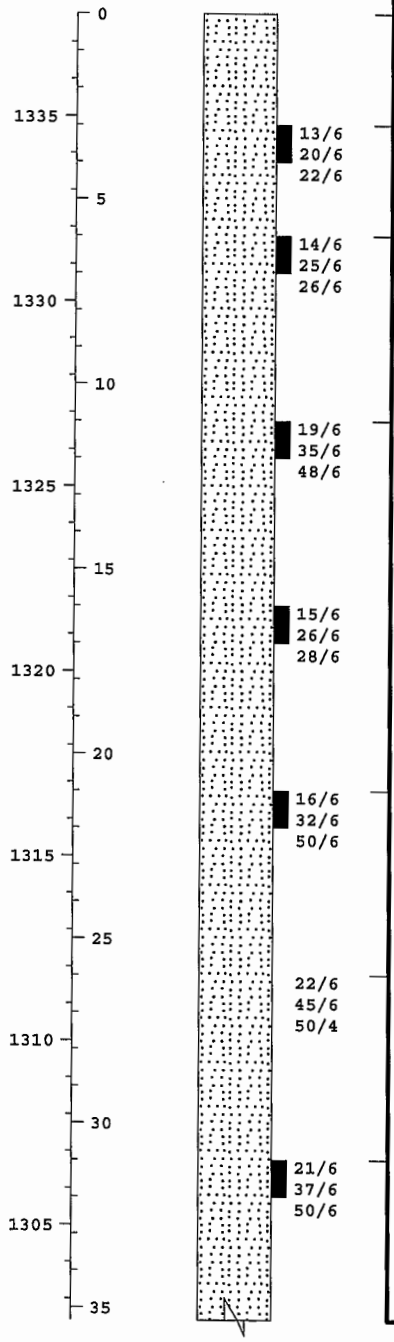
ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
	29/6 50/6				78.2	5.0
	18/6 50/5				92.2	7.7
	5/6 14/6 25/6	CL	SANDY CLAY WITH SILT; yellowish brown, damp, low plasticity. Hard.		110.7	16.4
	16/6 21/6 26/6		SANDY CLAY; yellowish brown, damp, low plasticity. Hard.		107.1	21.8
			BOTTOM.			

Figure Number 16

LOG OF TEST BORING
BORING B-16

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/16/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ⯈ :** *N/A*

FILE NO: *17662*
ELEV.: *1337.77'*
START: *6/16/20*
FINISH: *6/16/20*
LOGGER: *M. WATTS*



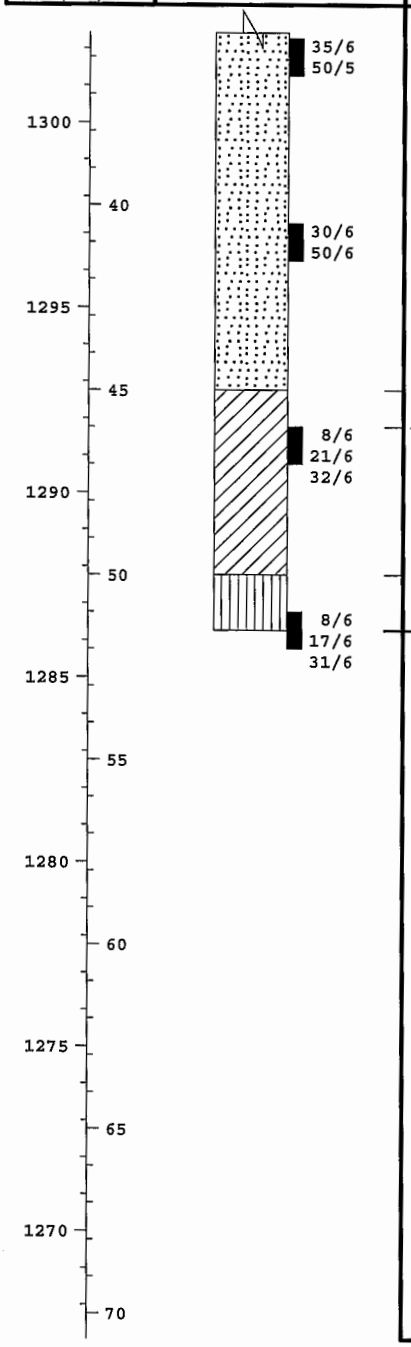
ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
		SP	POORLY GRADED SAND; light yellowish brown, dry, fine to medium, gravel.			
	13/6 20/6 22/6		Dense, gravel.		109.5	3.8
	14/6 25/6 26/6		Very dense, gravel.		110.5	3.2
	19/6 35/6 48/6		Gravel/rock.		92.5	22.2
	15/6 26/6 28/6				100.2	6.0
	16/6 32/6 50/6		Fine.		109.4	2.1
	22/6 45/6 50/4		No recovery.	Moisture can from sampler.		1.5
	21/6 37/6 50/6		Very dense.		106.0	3.2

Figure Number 17

LOG OF TEST BORING
BORING B-16

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/16/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ▶ :** *N/A*

FILE NO: *17662*
ELEV.: *1337.77'*
START: *6/16/20*
FINISH: *6/16/20*
LOGGER: *M. WATTS*



USCS	Description	Remarks	Density pcf	Moisture %
			78.0	8.5
			71.1	14.3
CL	SILTY CLAY; yellowish brown, damp, low to medium plasticity. Hard.		116.0	15.2
ML	SANDY SILT; yellowish brown, dry to damp, low plasticity, traces of clay. BOTTOM.		115.9	14.8

Figure Number 17

KEY TO SYMBOLS

Symbol Description

Strata symbols

 Clayey sand

 Low plasticity clay

 Silty sand

 Poorly graded sand

 Silt

 Poorly graded sand with silt

Misc. Symbols

 Drill rejection

 Boring continues

Soil Samplers

 California sampler

 Standard penetration test

Notes:

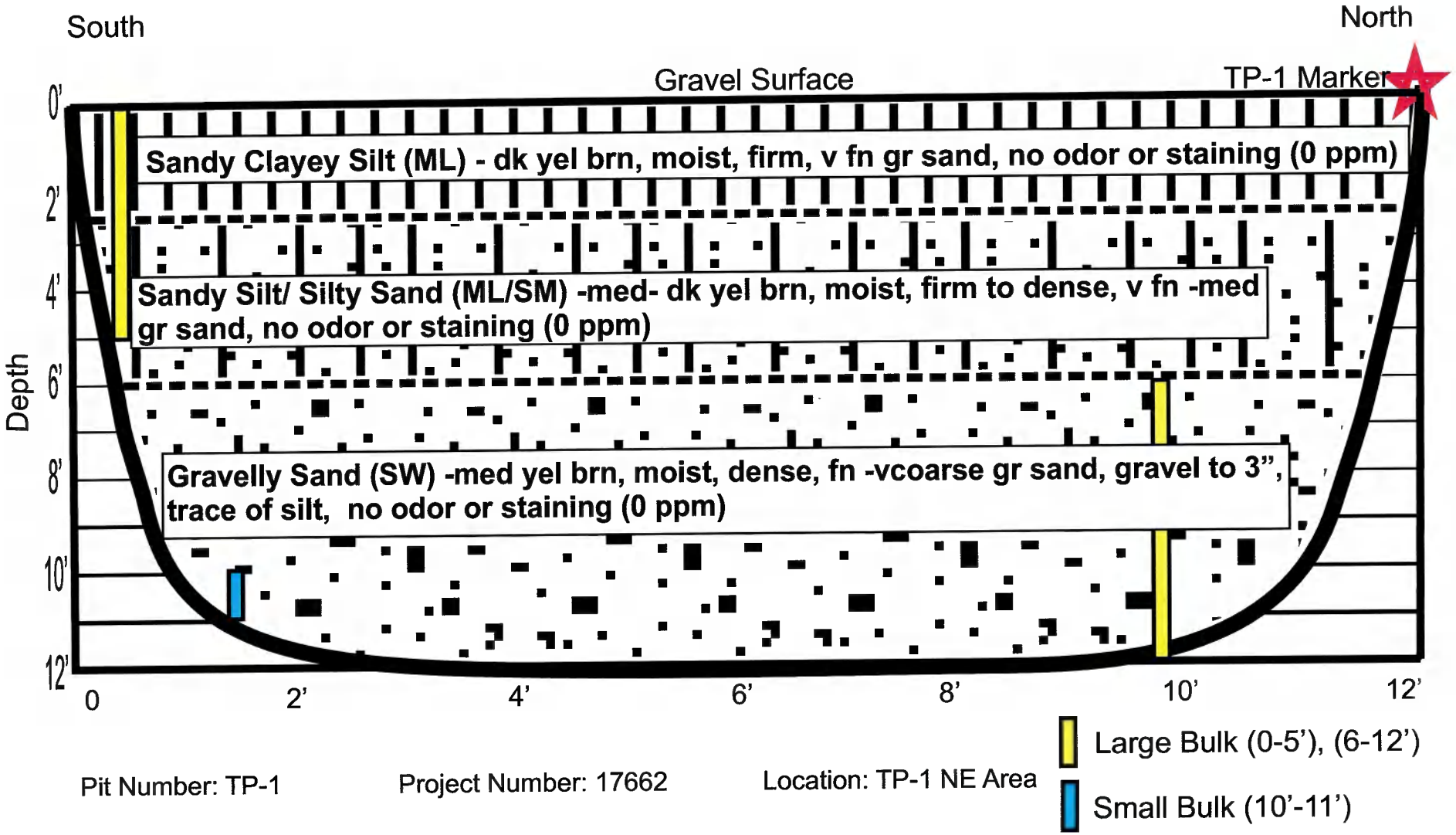
1. Sixteen (16) exploratory borings were drilled between 06/05/2020 and 06/18/2020 using an 8-inch outside diameter hollow-stem auger.

2. No free groundwater was encountered to the maximum depth drilled of 101.5'.

3. Boring locations are shown on the Boring Location Map, Figure 1.

4. These logs are subject to the limitations, conclusions, and recommendations in this report.

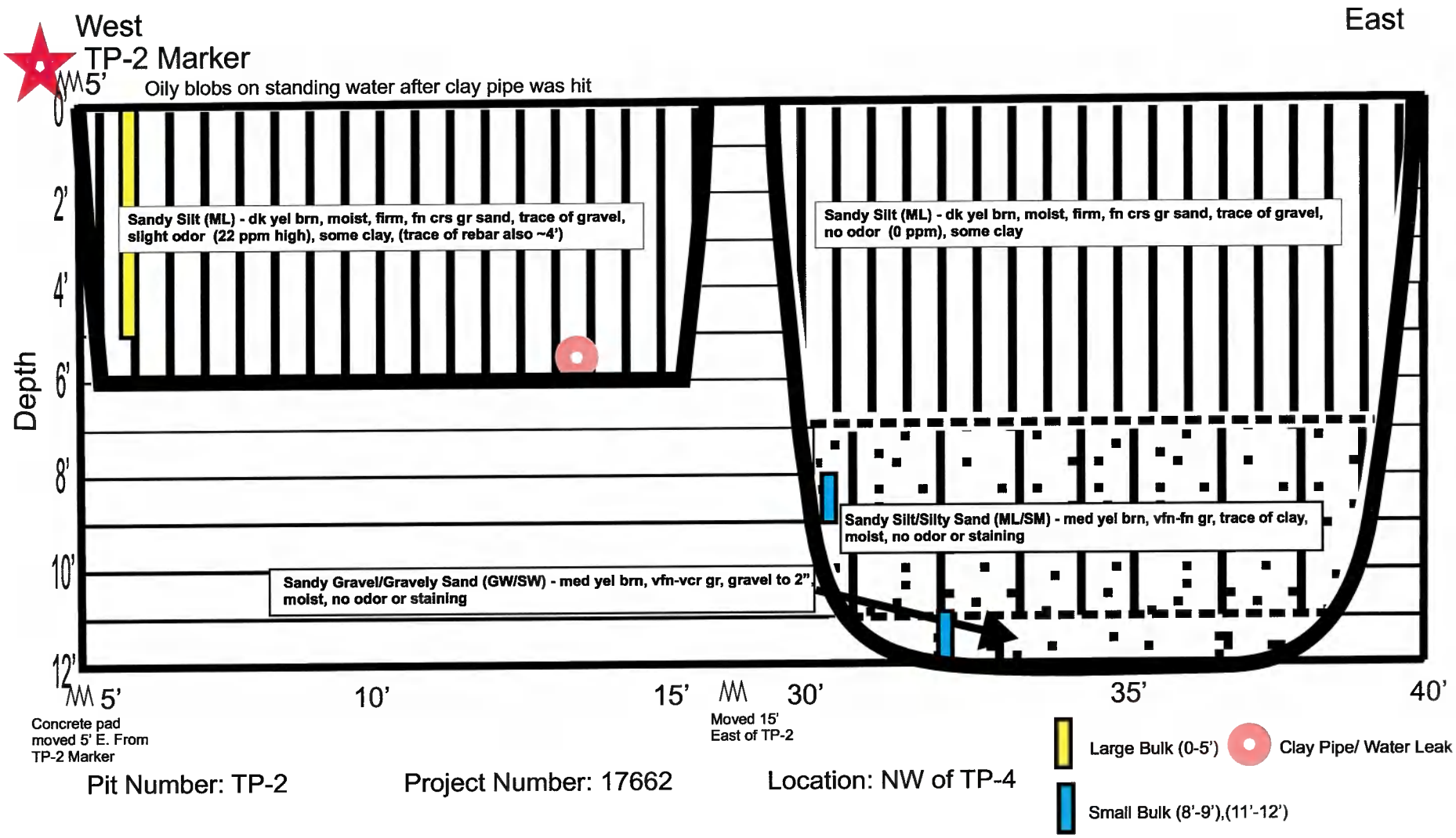
5. Results of tests conducted on samples recovered are reported on the logs.



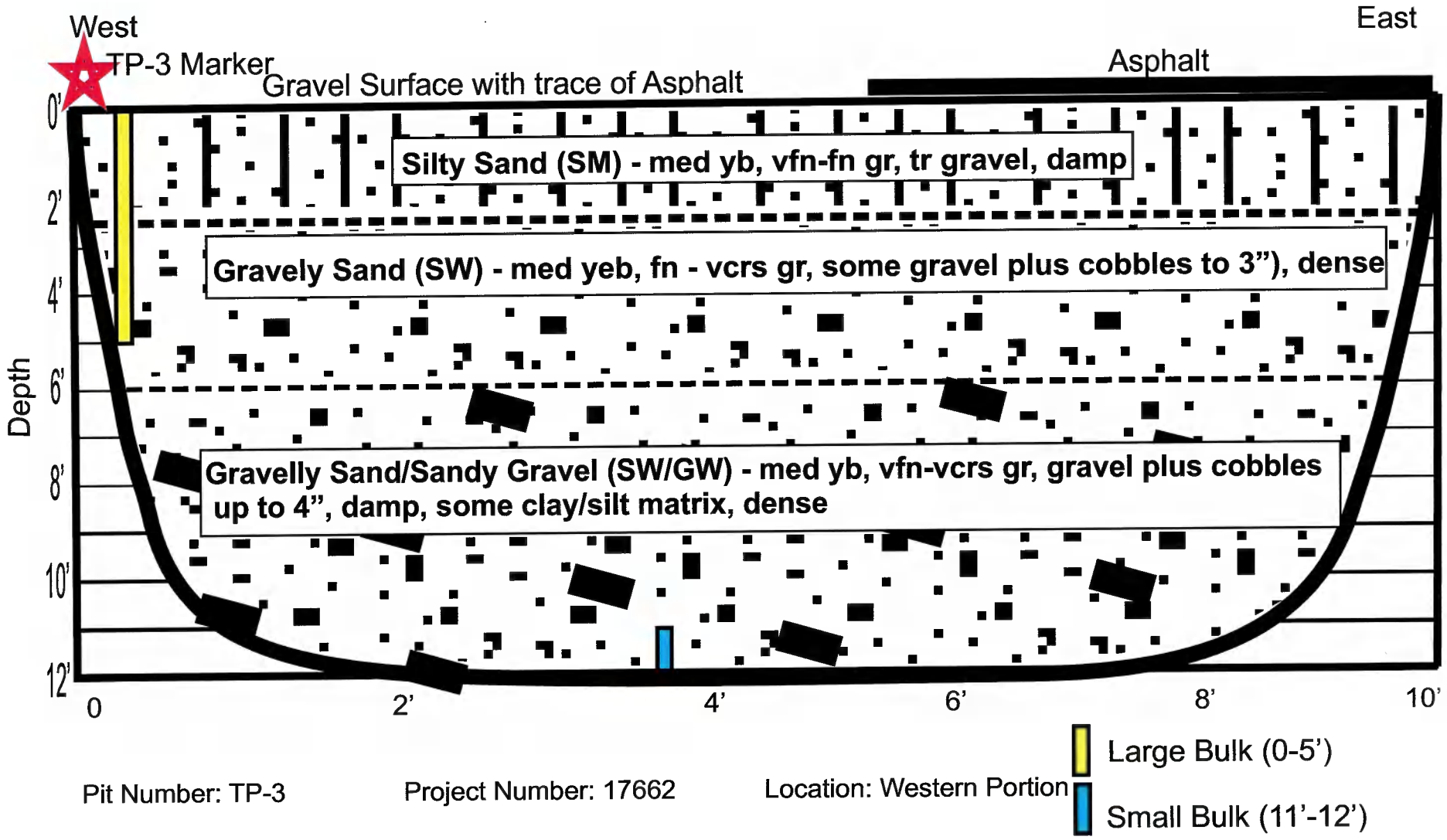
Pit Number: TP-1

Project Number: 17662

Location: TP-1 NE Area



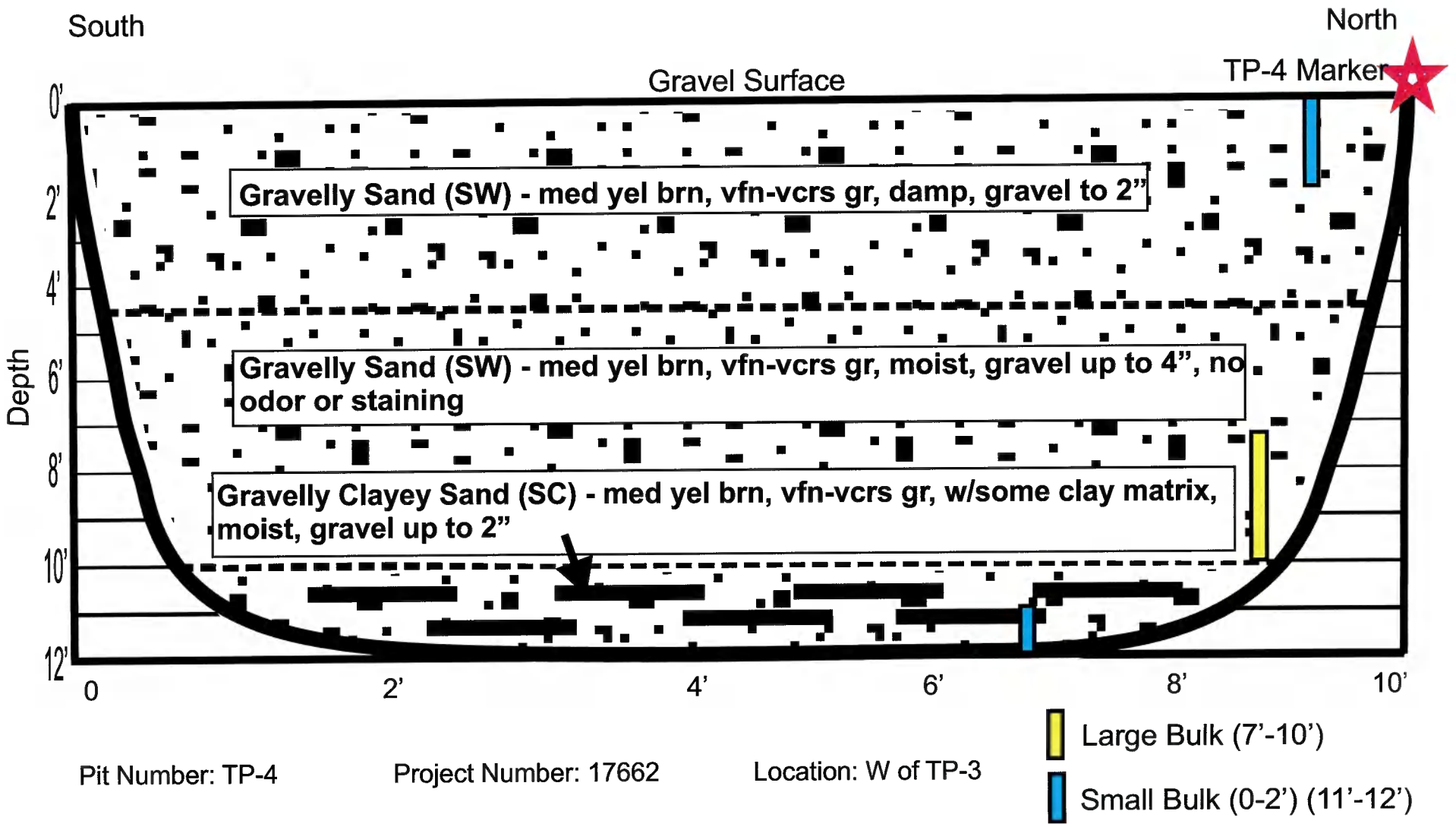
Pit Number: TP-2 Project Number: 17662 Location: NW of TP-4



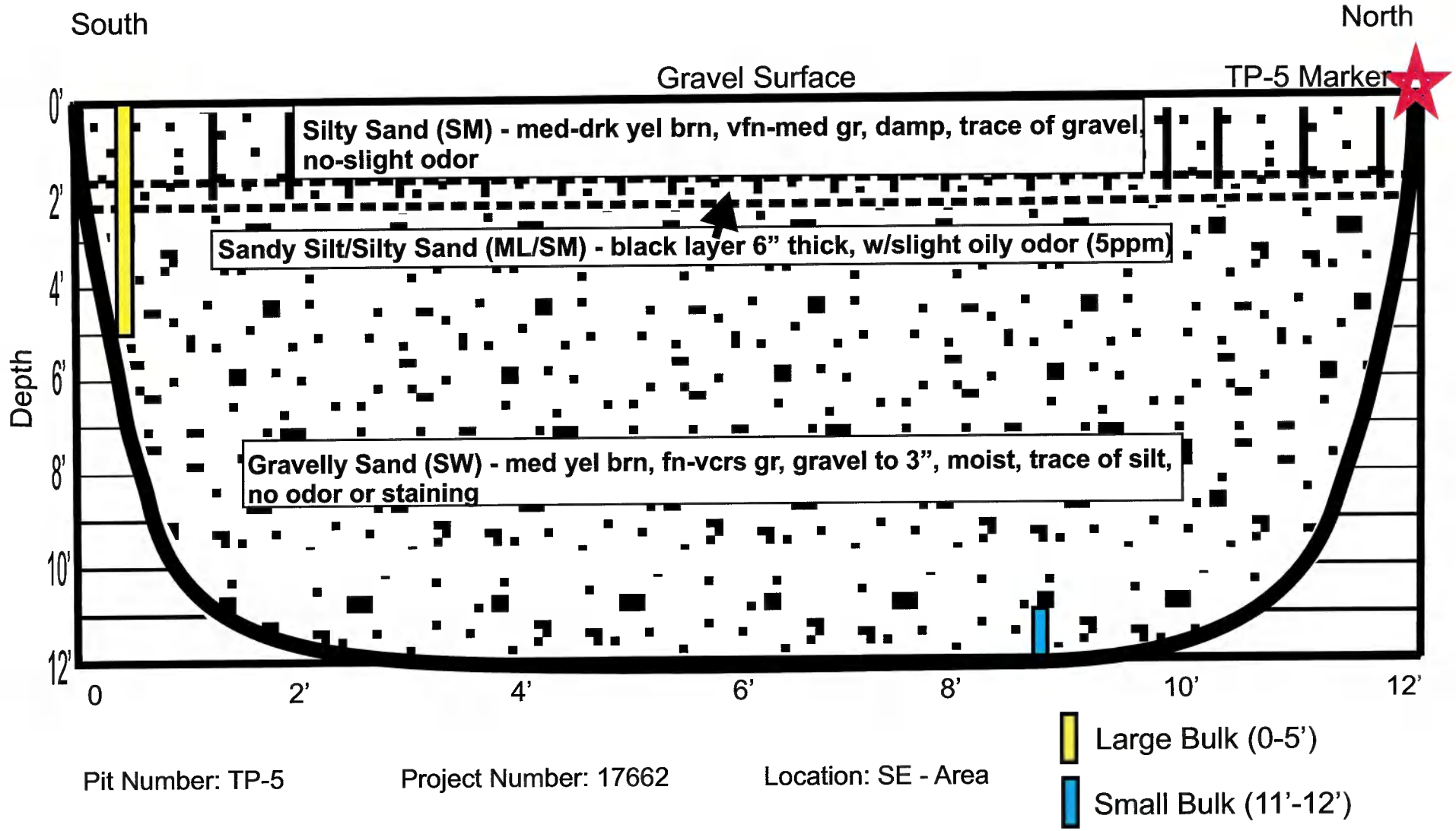
Pit Number: TP-3

Project Number: 17662

Location: Western Portion



Pit Number: TP-4 Project Number: 17662 Location: W of TP-3



Pit Number: TP-5 Project Number: 17662 Location: SE - Area

APPENDIX C

SOIL TEST DATA

SIEVE ANALYSES (ASTM D422 and/or ASTM D1140)

Grain size distributions for specimens retrieved from various subsurface elevations were tested to classify the materials. Test results are presented on Figures A-1 through A-18.

IN-SITU DENSITY & MOISTURE RELATIONSHIPS (ASTM D2216 & D2937)

Moisture & density data for undisturbed native soils was obtained by use of a 2-3/8-inch (inside diameter) split-barrel sampler. Test results are given on the Logs of Test Borings, Figures 2 and through 17.

CONSOLIDATION TESTS (ASTM D2435)

Compressibility of soils was determined on saturated, undisturbed samples of native materials. Consolidation Test Diagrams, Figures B-1 through B-17, graphically express the relationship of vertical strain vs. applied vertical (normal) load for earth materials selected as most representative of the soil strata within the anticipated zone of influence of foundation loads.

DIRECT SHEAR TESTS (ASTM D3080)

A quick-consolidated direct shear test was performed on an undisturbed, saturated sample of native earth materials. This test provides information on soil shear strength vs. normal load and is used to determine the angle of internal friction and cohesion of earth materials under essentially drained conditions. Test results are presented on Figures C-1 through C-18.

EXPANSION INDEX (ASTM D4829)

The Expansion Index test is designed to measure a basic index property of soil and in this respect is comparable to other index tests such as the Atterberg Limits. In formulating the test procedures, no attempt has been made to duplicate any particular moisture or loading conditions which may occur in the field. Rather, an attempt has been made to control all variables which influence the expansive characteristics of a particular soil and still retain a practical test for general engineering usage. Near surface soils were obtained and tested for expansiveness. Test results are presented on the Laboratory Testing Recap Table 2.

UNCONFINED COMPRESSIVE STRENGTH (ASTM D2166)

Tests were performed to determine the unconfined compressive strength of cohesive soil in the undisturbed, remolded, or compacted condition, using strain-controlled application of the axial load. Test results are presented on Figure D-1.

MAXIMUM DENSITY - OPTIMUM MOISTURE RELATIONSHIPS (ASTM D1557)

Maximum density - optimum moisture test results provide a relationship between soil moisture content at compaction vs. dry density for a fixed compactive effort. Test results are presented on Figures E-1 though E-5.

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PERMEABILITY TESTS (ASTM D2434)

Permeability of in-situ soil specimens were determined by the Constant Head Method. Test results are shown on the Laboratory Testing Recap Table 1.

SOIL CORROSIVITY (SO_4 / pH / Chlorides)

Tests for Soluble Sulfates (SO_4), Soluble Chlorides (Cl), pH, and Electrical Conductivity (EC) values were performed on one (1) composite sample retrieved from the upper 3 feet to determine the corrosion potential of the soils. Corrosion prevention measures and the extent to which measures should be taken (if any) should be addressed with the corrosion engineer. Soluble Sulfates and Soluble Chlorides values were determined according to EPA 300.0M. The pH values were determined according to EPA Method 9045C. The Electrical Conductivity values were determined according to EPA Method 120.1. Results of all the constituents are discussed in the Soil Corrosivity section.

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Fluor Federal Services, Inc.

Geotechnical Engineering Services
CO2 Capture Project from Elk Hills Power Plant Project (EH-35R/C1RC)
APN: 158-090-19 | 4026 Skyline Rd, Tupman, CA 93276

SEI File No. 20-17662
June 30, 2020

TABLE 1

TEST LOCATION	USCS	% < # 200	CONSOLIDATION				DIRECT SHEAR		UNCONFINED COMPRESSION		E.I.	ATTERBERG LIMITS			THERMAL CONDUCTIVITY & RESISTIVITY					R-VALUE @ 300 psi		PERM.	MAXIMUM DENSITY	
			C_C	C_S	S.P. (psf)	HV %	C, (ksf)	F.A.	Q_U, (psi)	C, (ksf)		LL	PL	PI	K W/(m·K)	RHO °C·cm/W	Temp °C	Density	Moisture	R.V.	E.P. (psi)	K	MDD (pcf)	O.M.
B-1 @ 6'	CL	55	0.12	0.01	0	-1.2					28													
B-1 @ 11'	SM						0	39.2																
B-2 @ 6'	ML	52	0.08	0.01	0	-0.9																		
B-2 @ 11'	SP						0	40.3																
B-2 @ 21'	ML						0.31	32.8																
B-2 @ 26'	SP-SM						0	35.9																
B-2 @ 31'	SP-SM	7.7	0.03	0	0	-0.5																		
B-3 @ 3'	SM	41	0.10	0	0	-0.4																		
B-3 @ 6'	ML						0.37	33.8																
B-3 @ 16'	SP						0	43.6																
B-4 @ 3'	SM																					9.73×10^{-3}		
B-4 @ 6'	SP	4.4	0.02	0	0	-0.1																		
B-5 @ 3'	SC	41	0.14	0	0	-2.9																		
B-5 @ 6'	SC	24	0.10	0.01	0	-0.6	0.28	31.9																

CONSOLIDATION
Cc - Compression Index
Cs - Swell Index
S.P. (psf) - Swell Pressure
HV % - Heave Precentage / Collapase

UNCONFINED COMPRESSION
Q_U (psi) - Unconfined Compression Strength
C, (ksf) - Cohesion

DIRECT SHEAR
C (ksf) - Cohesion
F.A. - Friction Angle

E.I. - EXPANSION INDEX
ATTERBERG LIMITS
LL - Liquid Limit
PL - Plastic Limit
PI - Plasticity Index

(R)ESISTANCE VALUE
RV - R-Value @ 300 psi
EP - Expansion Press @ 300 psi

THERMAL CONDUCTIVITY & RESISTIVITY
K - Thermal Conductivity in Watts per Meter Kelvin
RHO - Centimeter - Degree C per Watt
Temp oC - Temperature of Specimen in Celcius
Density - Remolded Specimen Density
Moisture - Remolded Specimen Moisture

MAXIMUM DENSITY
MDD (pcf) - Max Dry Density
O.M. - Optimum Moisture

CONSTANT HEAD PERMEABILITY
K - Coefficient of Permeability (cm/sec)

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Fluor Federal Services, Inc.

Geotechnical Engineering Services
CO2 Capture Project from Elk Hills Power Plant Project (EH-35R/C1RC)
APN: 158-090-19 | 4026 Skyline Rd, Tupman, CA 93276

SEI File No. 20-17662
June 30, 2020

TABLE 2

TEST LOCATION	USCS	% < # 200	CONSOLIDATION				DIRECT SHEAR		UNCONFINED COMPRESSION		E.I.	ATTERBERG LIMITS			THERMAL CONDUCTIVITY & RESISTIVITY					R-VALUE @ 300 psi		PERM.	MAXIMUM DENSITY	
			C_C	C_S	S.P. (psf)	HV %	C, (ksf)	F.A.	Q_U, (psi)	C, (ksf)		LL	PL	PI	K W/(m·K)	RHO °C·cm/W	Temp °C	Density	Moisture	R.V.	E.P. (psi)	K	MDD (pcf)	O.M.
B-5 @ 16'	CL																							
B-6 @ 6'	SP-SM	11																						
B-6 @ 31'	SP-SM	8.2																						
B-6 @ 51'	ML	74																						
B-7 @ 3'	SM	38	0.09	0.01	0	-0.4																		
B-7 @ 6'	SM						0.06	34.2																
B-8 @ 3'	SC																					9.73×10^{-5}		
B-9 @ 3'	SC	46	0.12	0.01	0	-0.9																		
B-9 @ 6'	SC	34	0.04	0.01	0	-0.1																		
B-9 @ 16'	SP						0	40.8																
B-8 @ 3'	ML																					1.42×10^{-7}		
B-10 @ 6'	SP						0	41.3																
B-11 @ 11'	SP-SM	7.8																						
B-11 @ 21'	SM	13																						
B-11 @ 46'	SM	18																						

CONSOLIDATION
Cc - Compression Index
Cs - Swell Index
S.P. (psf) - Swell Pressure
HV % - Heave Precentage / Collapase

UNCONFINED COMPRESSION
Q_U (psi) - Unconfined Compression Strength
C, (ksf) - Cohesion

DIRECT SHEAR
C (ksf) - Cohesion
F.A. - Friction Angle

E.I. - EXPANSION INDEX

ATTERBERG LIMITS
LL - Liquid Limit
PL - Plastic Limit
PI - Plasticity Index

(R)ESISTANCE VALUE
RV - R-Value @ 300 psi
EP - Expansion Press @ 300 psi

THERMAL CONDUCTIVITY & RESISTIVITY
K - Thermal Conductivity in Watts per Meter Kelvin
RHO - Centimeter - Degree C per Watt
Temp oC - Temperature of Specimen in Celcius
Density - Remolded Specimen Density
Moisture - Remolded Specimen Moisture

MAXIMUM DENSITY
MDD (pcf) - Max Dry Density
O.M. - Optimum Moisture

CONSTANT HEAD PERMEABILITY
K - Coefficient of Permeability (cm/sec)

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Geotechnical Engineering Services
CO2 Capture Project from Elk Hills Power Plant Project (EH-35R/C1RC)
APN: 158-090-19 | 4026 Skyline Rd, Tupman, CA 93276

SEI File No. 20-17662
June 30, 2020

TABLE 3

TEST LOCATION	USCS	% < # 200	CONSOLIDATION				DIRECT SHEAR		UNCONFINED COMPRESSION		E.I.	ATTERBERG LIMITS			THERMAL CONDUCTIVITY & RESISTIVITY					R-VALUE @ 300 psi		PERM.	MAXIMUM DENSITY	
			C_C	C_S	S.P. (psf)	HV %	C, (ksf)	F.A.	Q_U, (psi)	C, (ksf)		LL	PL	PI	K W/(m·K)	RHO °C·cm/W	Temp °C	Density	Moisture	R.V.	E.P. (psi)	K	MDD (pcf)	O.M.
B-12 @ 3'	SC	44	0.11	0.01	0	-1																		
B-12 @ 6'	SC						0.31	35.6			3													
B-12 @ 16'	SP						0	42.5																
B-12 @ 26'	SP						0	36.2																
B-13 @ 31'	ML								90	6.51														
B-14 @ 6'	SP						0.06	41.4																
B-14 @ 11'	SP		0.07	0.01	0	-1.1																		
B-14 @ 16'	SP						0	44.3																
TP-1 @ 0-5'	SC	46	0.15	0.01	0	-1.3					22	28	22	6	1.223	0.817	25.7	106.6	12.5%	35	0.01		118.4	12.5%
TP-1 @ 6-12'	SP-SM		0.03	0	0	-0.3	0	41.3															127.6	8.7%
TP-3 @ 0-5'	SP-SM		0.03	0	0	-0.2	0	44															123.5	9.5%
TP-4 @ 7-10'	SP-SM		0.04	0.01	0	-0.1																	124.2	9.5%
TP-5 @ 0-5'	SM	17	0.10	0.01	0	-1.6	0	44.1							1.423	0.702	25.6	114.2	7.5%	57	0		127.4	7.5%

CONSOLIDATION
Cc - Compression Index
Cs - Swell Index
S.P. (psf) - Swell Pressure
HV % - Heave Precentage / Collapase

UNCONFINED COMPRESSION
Q_U (psi) - Unconfined Compression Strength
C, (ksf) - Cohesion

DIRECT SHEAR
C (ksf) - Cohesion
F.A. - Friction Angle

E.I. - EXPANSION INDEX
ATTERBERG LIMITS
LL - Liquid Limit
PL - Plastic Limit
PI - Plasticity Index

(R)ESISTANCE VALUE
RV - R-Value @ 300 psi
EP - Expansion Press @ 300 psi

THERMAL CONDUCTIVITY & RESISTIVITY
K - Thermal Conductivity in Watts per Meter Kelvin
RHO - Centimeter - Degree C per Watt
Temp oC - Temperature of Specimen in Celcius
Density - Remolded Specimen Density
Moisture - Remolded Specimen Moisture

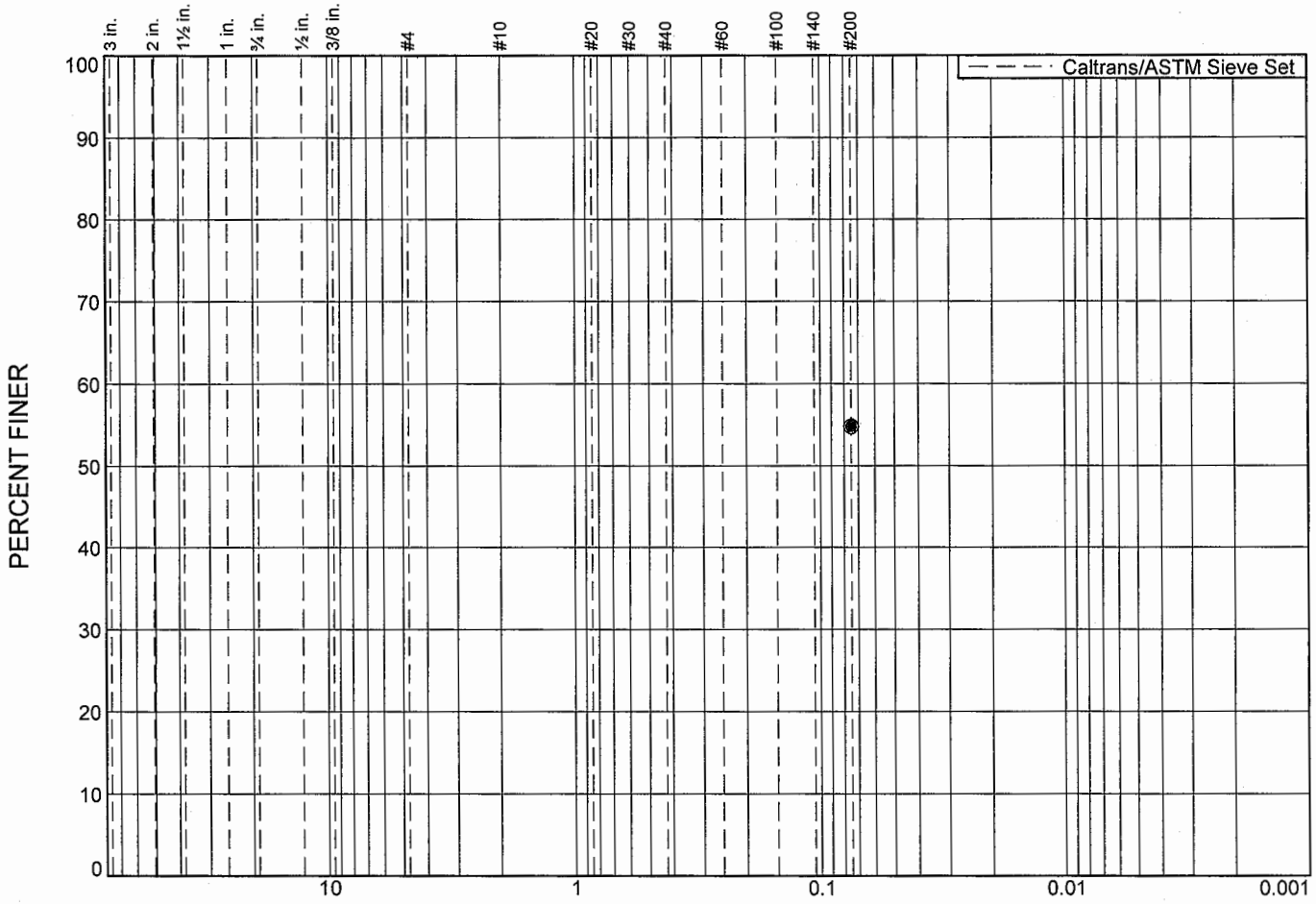
MAXIMUM DENSITY
MDD (pcf) - Max Dry Density
O.M. - Optimum Moisture

CONSTANT HEAD PERMEABILITY
K - Coefficient of Permeability (cm/sec)

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Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○							55	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-1		6'	SANDY CLAY	CL

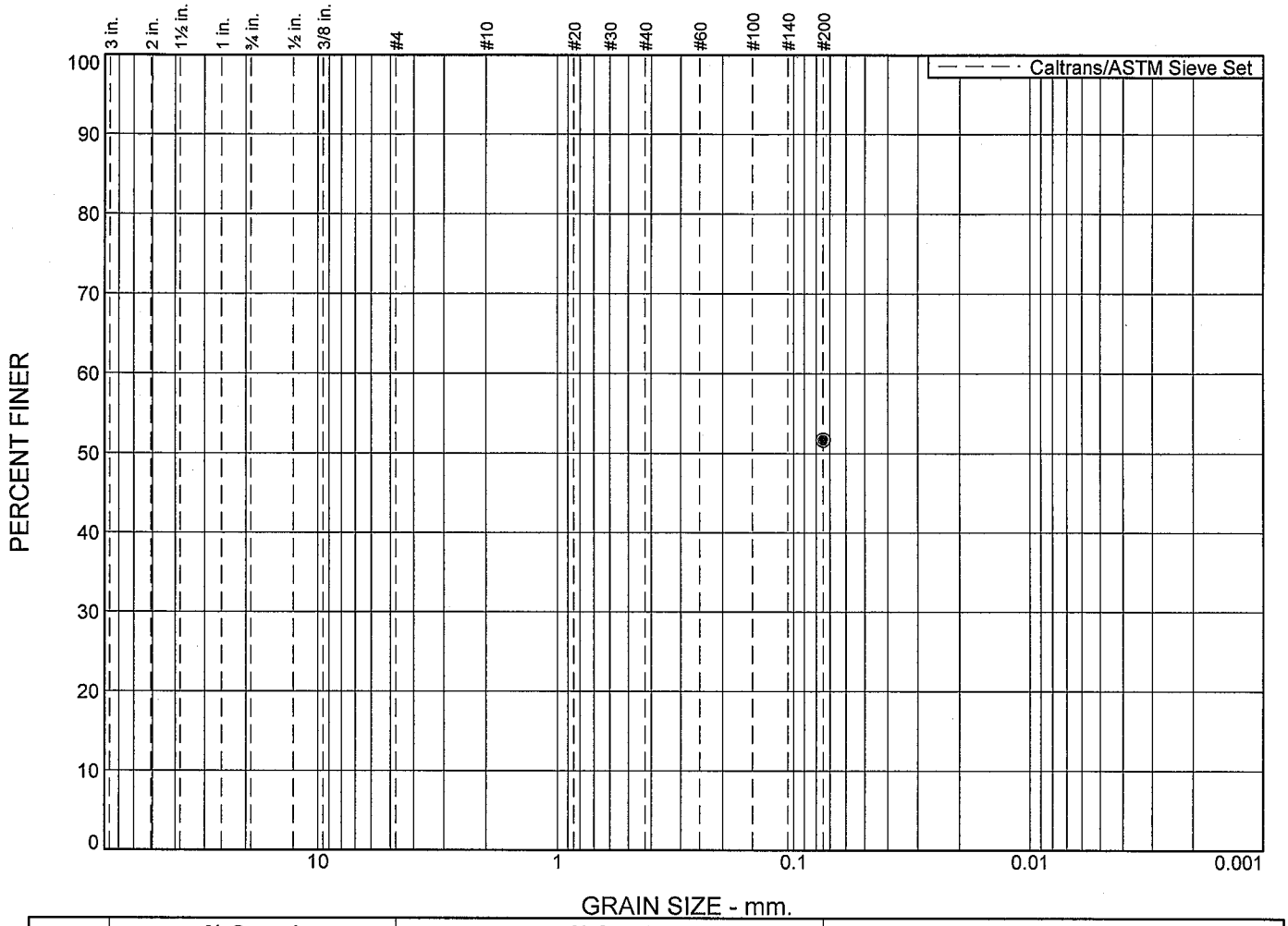
SOILS ENGINEERING, INC.

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Project No.: 17662 **Figure** A-1

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○							52	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-2		6'	SANDY SILT	ML

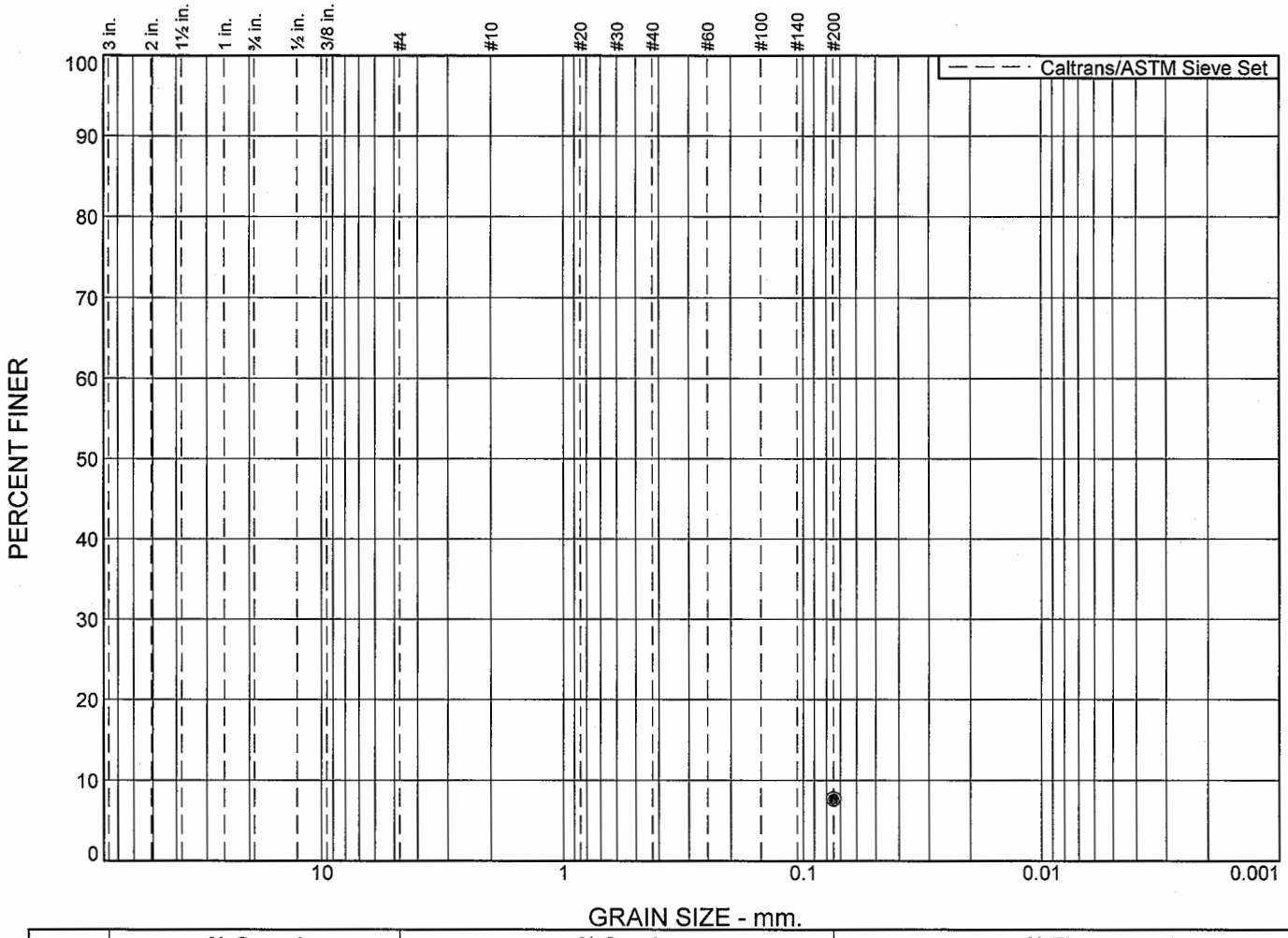
SOILS ENGINEERING, INC.

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Project No.: 17662 **Figure** A-2

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○							7.7	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-2		31'	POORLY GRADED SANAD with low fine content	SP-SM

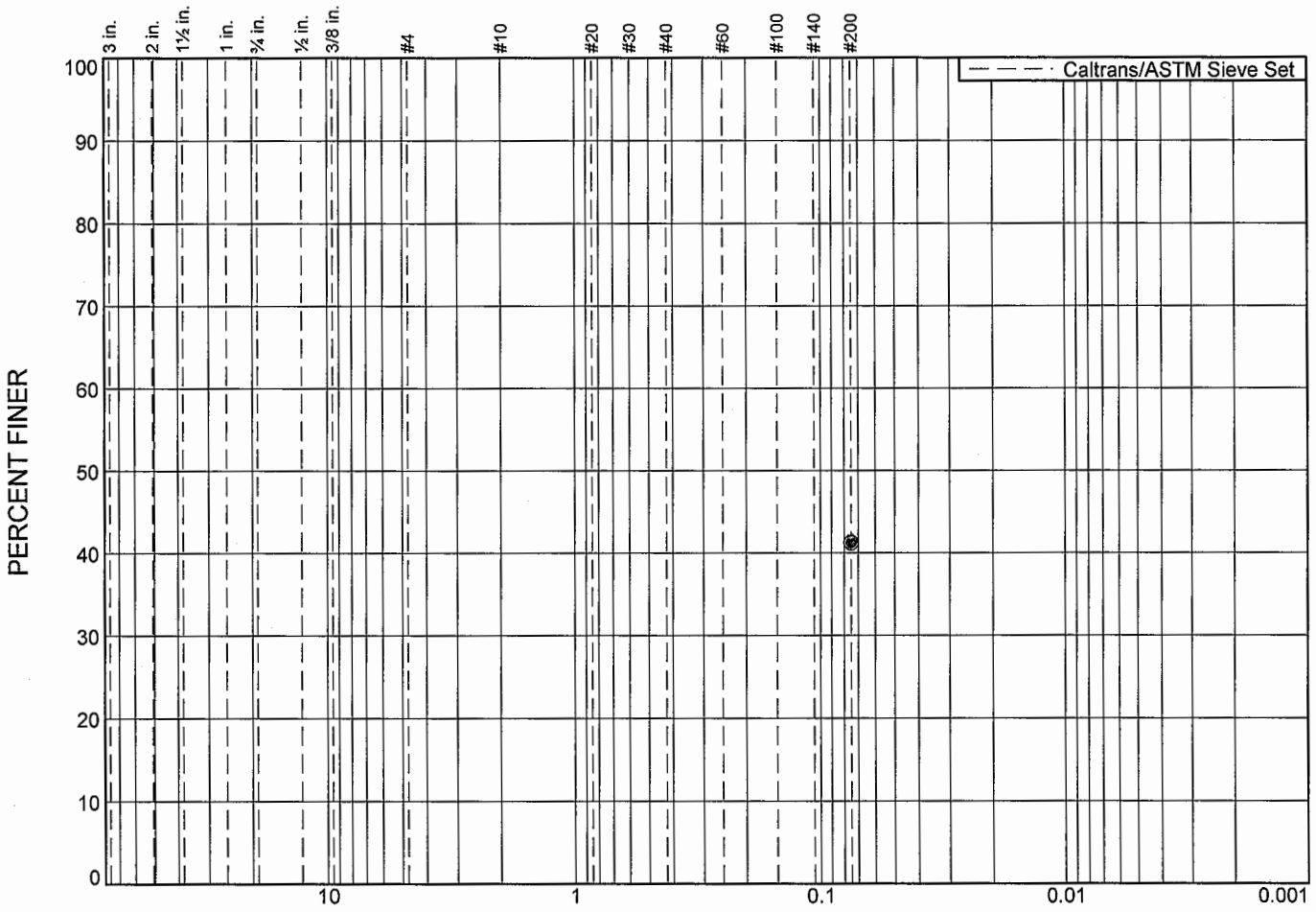
SOILS ENGINEERING, INC.

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Project No.: 17662 **Figure** A-3

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○							41	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-3		3'	SILTY SAND	SM

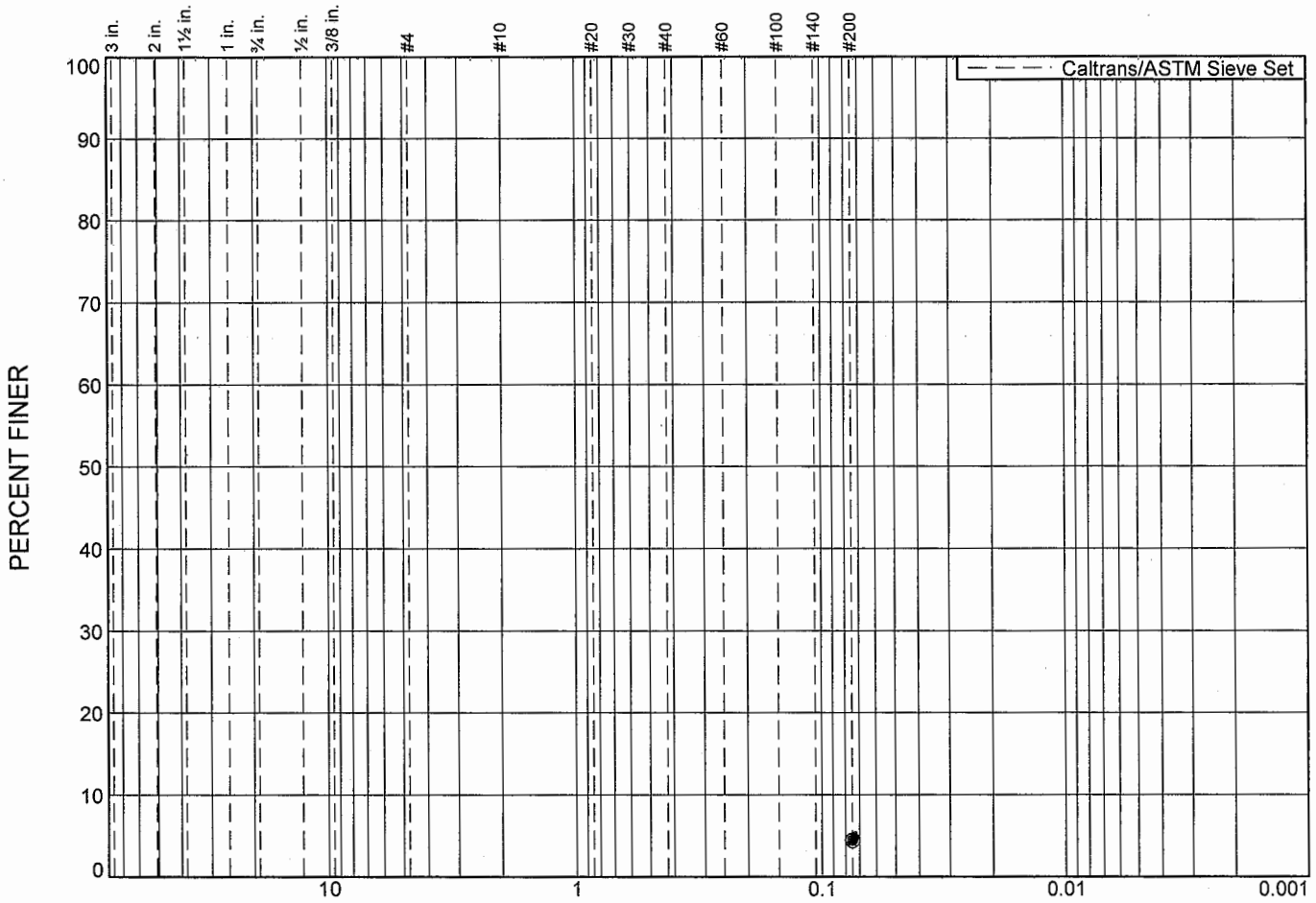
SOILS ENGINEERING, INC.

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Project No.: 17662 **Figure** A-4

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○							4.4	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-4		6'	POORLY GRADED SAND	SP

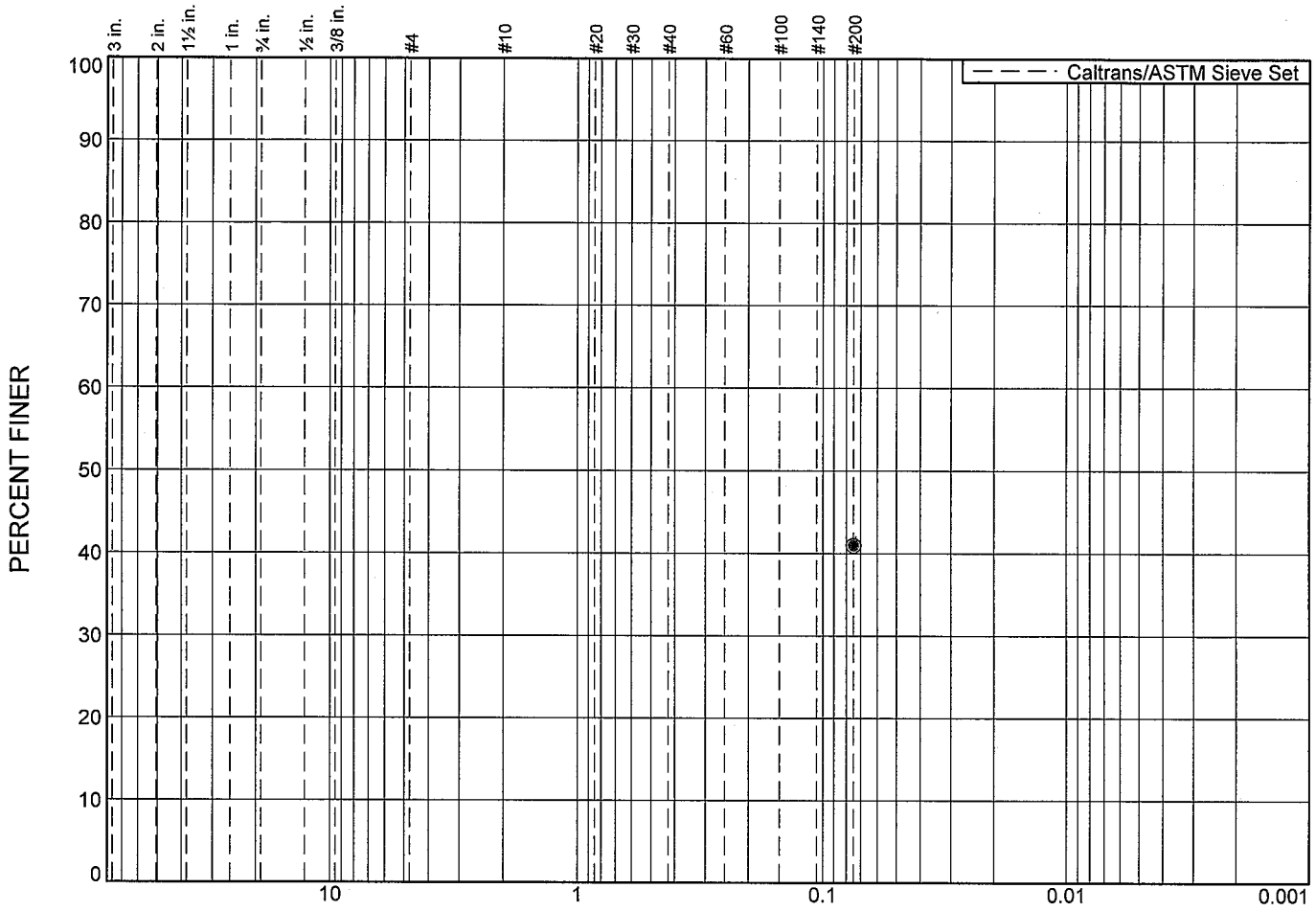
SOILS ENGINEERING, INC.

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Project No.: 17662 **Figure** A-5

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○							41	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-5		3'	CLAYEY SAND	SC

SOILS ENGINEERING, INC.

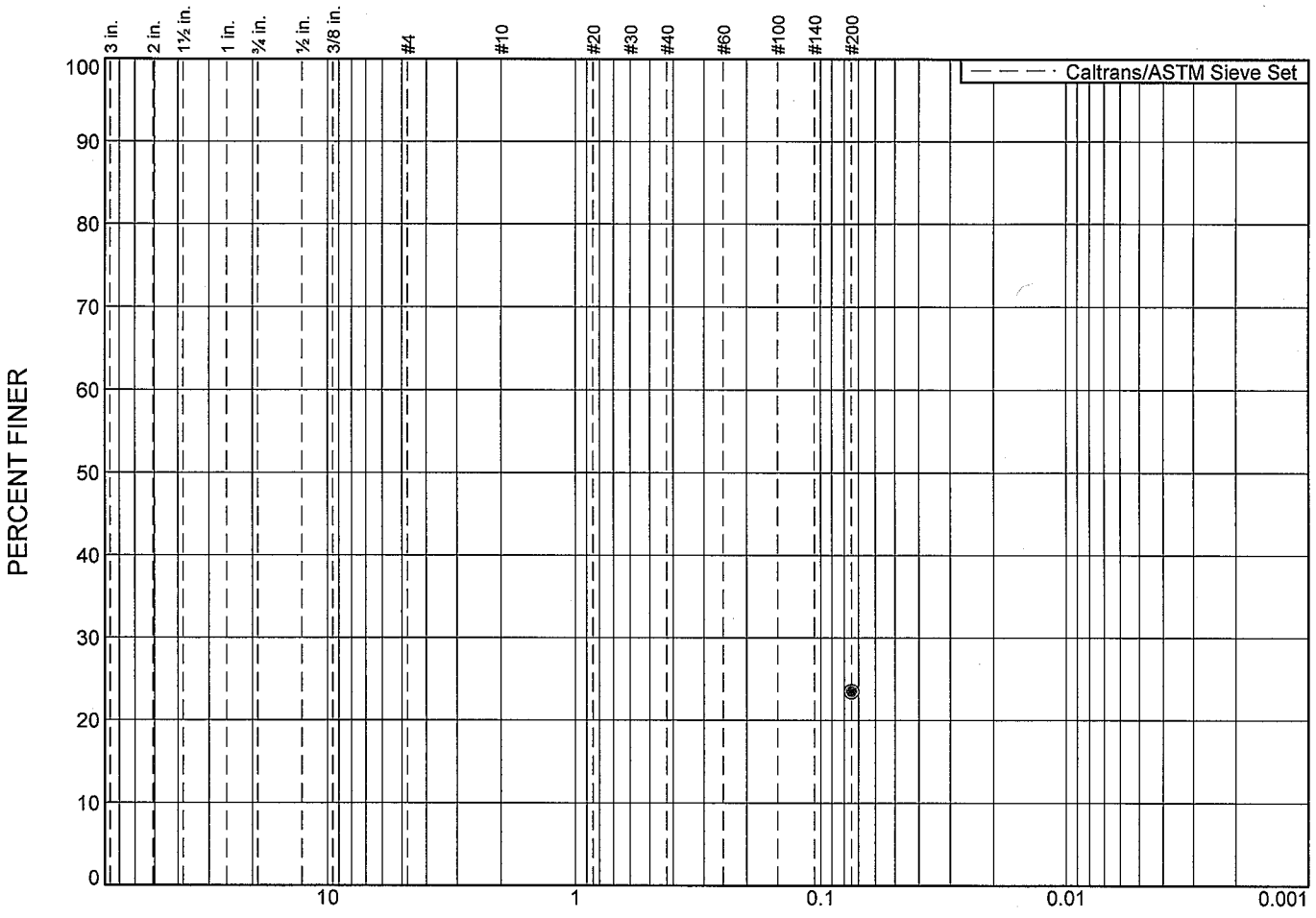
Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Project No.: 17662

Figure A-6

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○							24	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-5		6'	CLAYEY SAND	SC

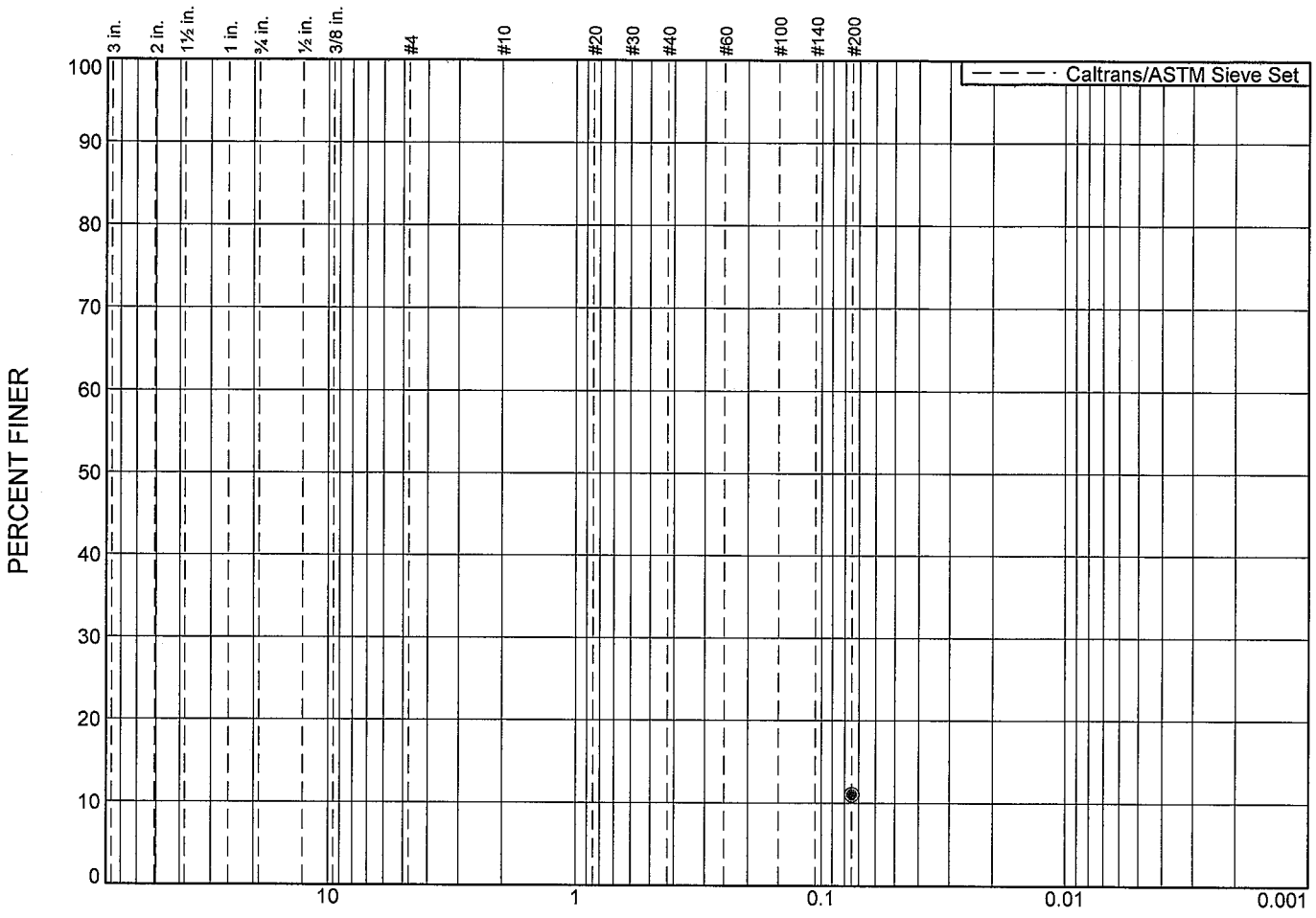
SOILS ENGINEERING, INC.

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Project No.: 17662 **Figure** A-7

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○							11	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-6		6'	POORLY GRADED SAND with low fine content	SP-SM

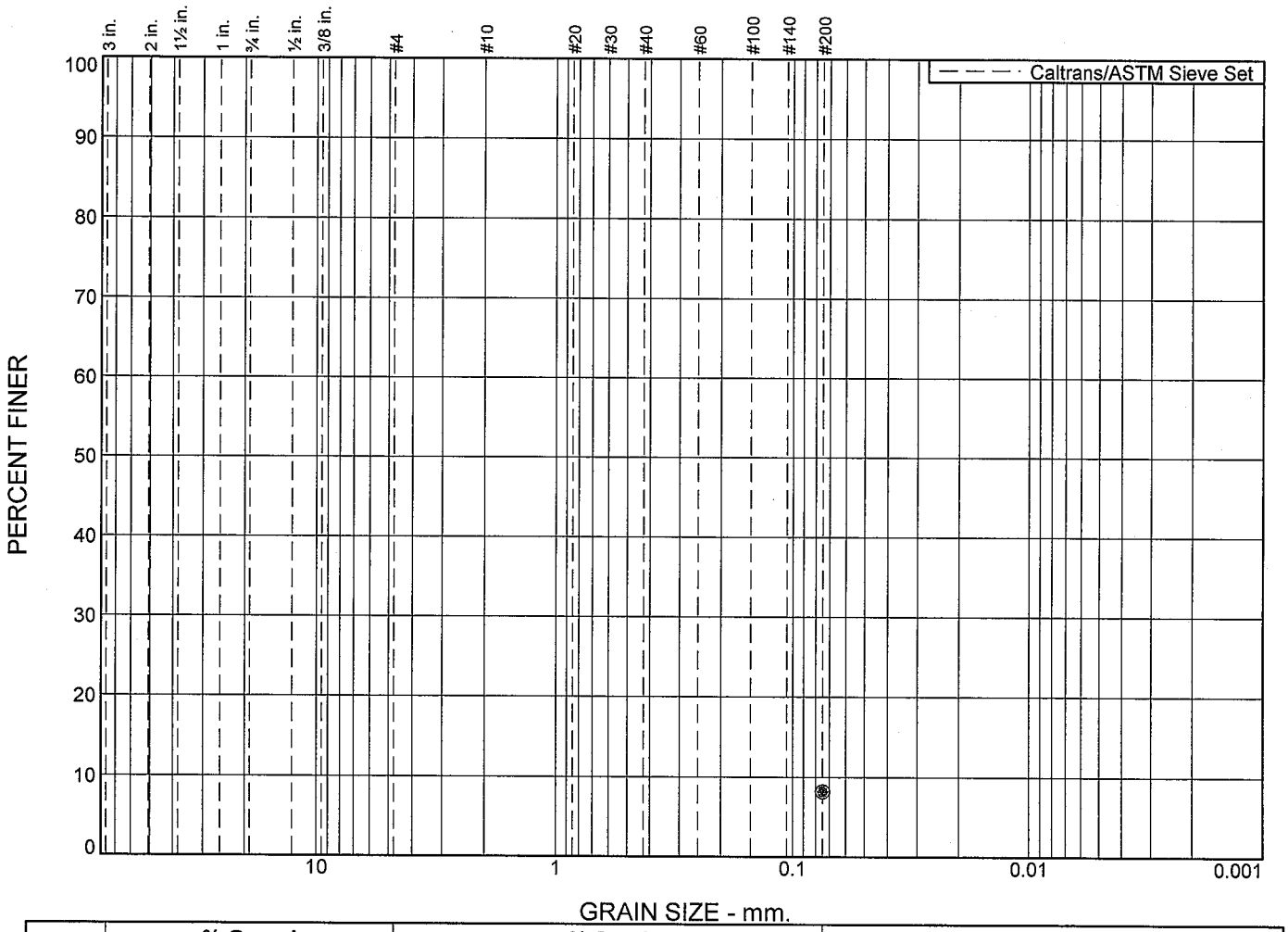
SOILS ENGINEERING, INC.

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Project No.: 17662 **Figure** A-8

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○							8.2	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-6		31'	POORLY GRADED SAND with low fine content	SP-SM

SOILS ENGINEERING, INC.

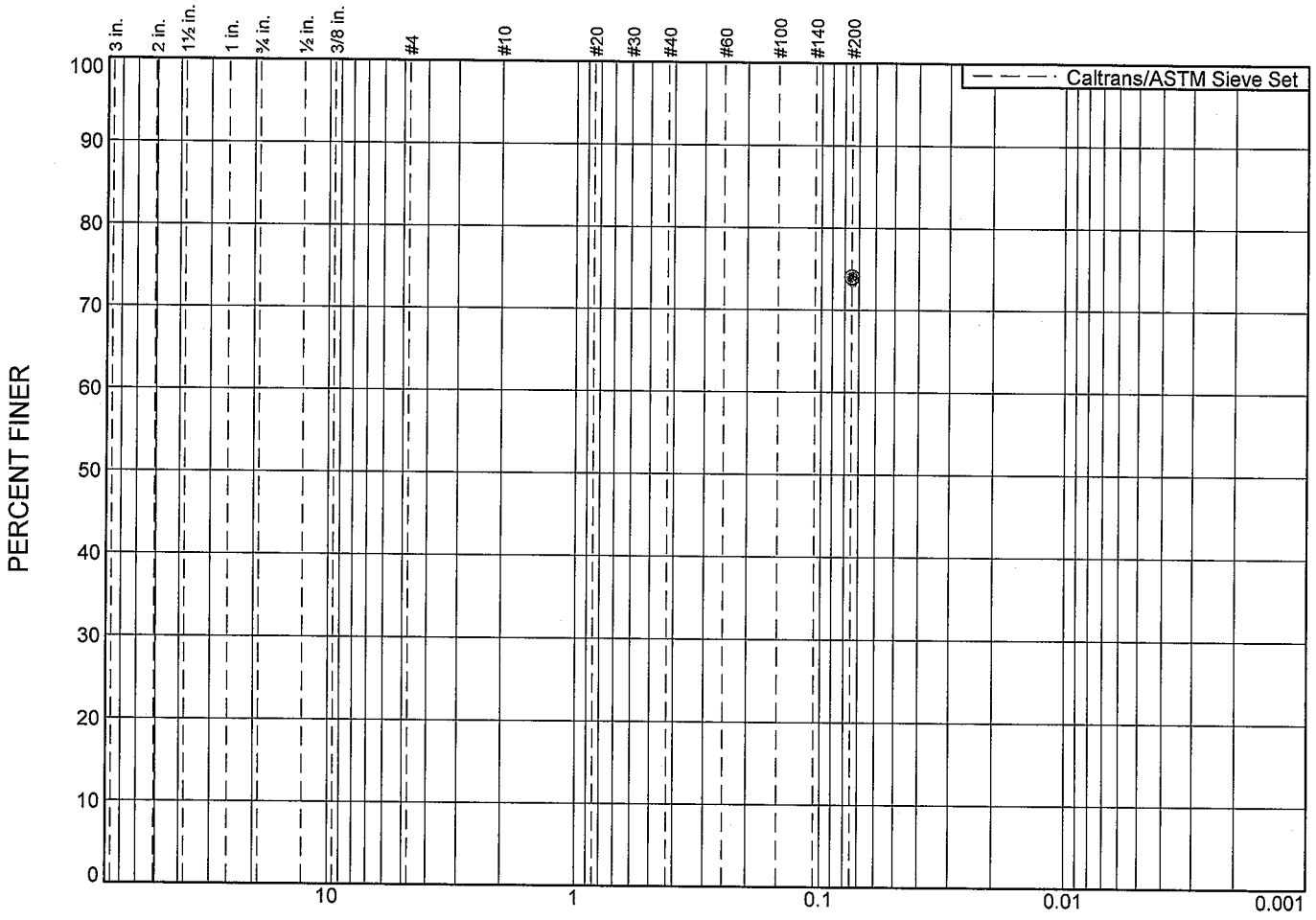
Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Project No.: 17662

Figure A-9

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○							74	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-6		51'	SANDY SILT	ML

SOILS ENGINEERING, INC.

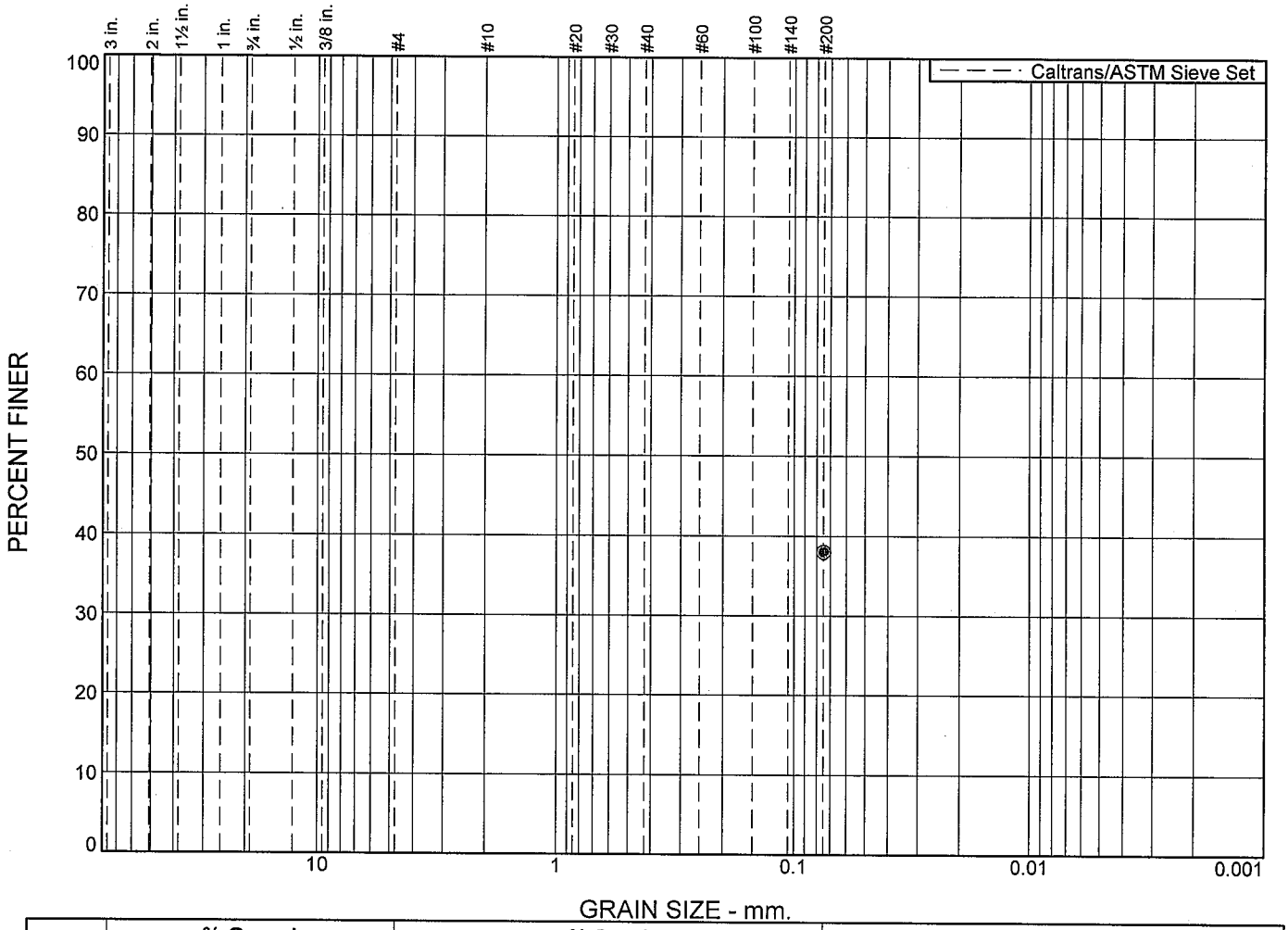
Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Project No.: 17662

Figure A-10

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○							38	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-7		3'	SILTY SAND	SM

SOILS ENGINEERING, INC.

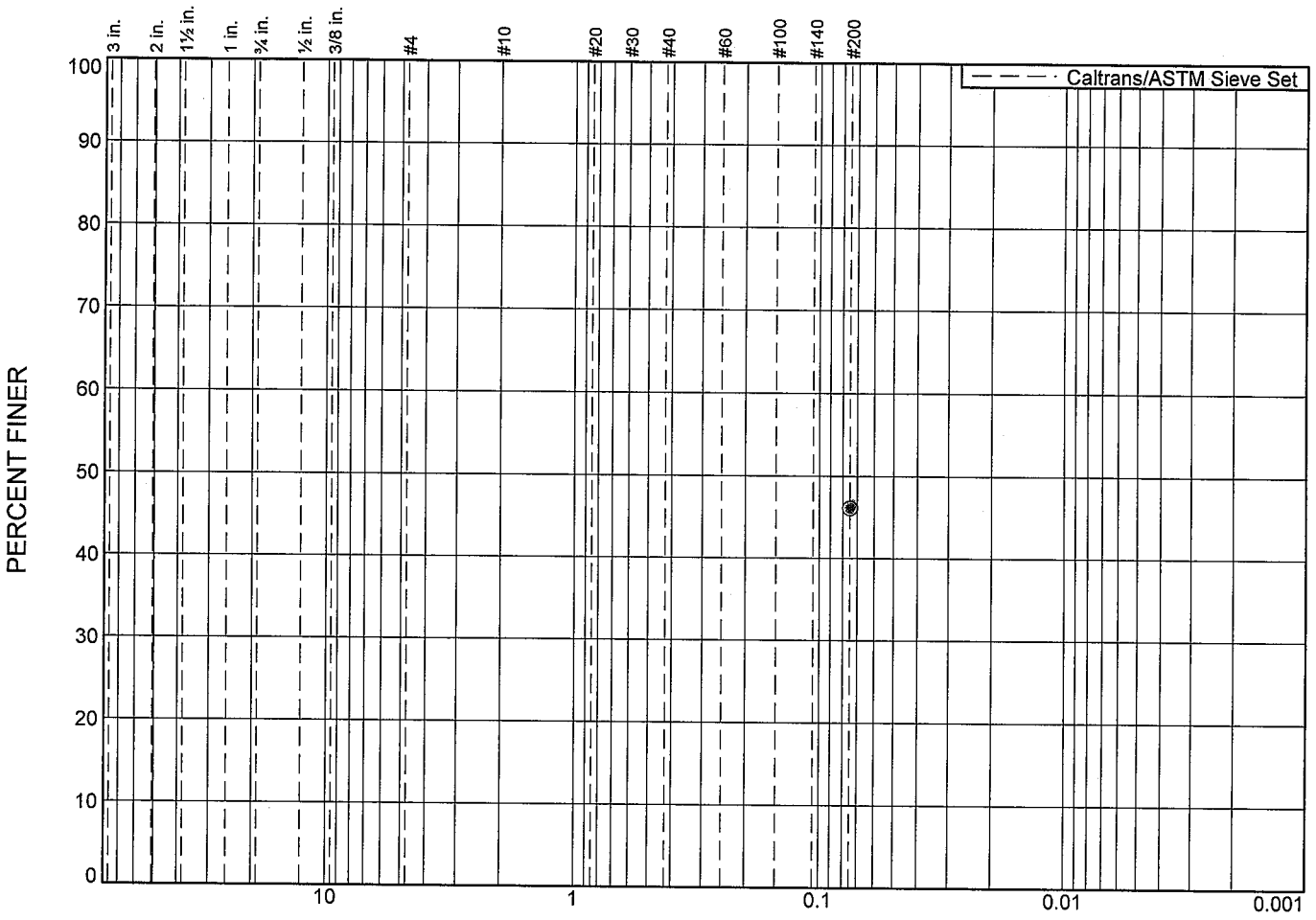
Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Project No.: 17662

Figure A-11

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○							46	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-9		3'	CLAYEY SAND	SC

SOILS ENGINEERING, INC.

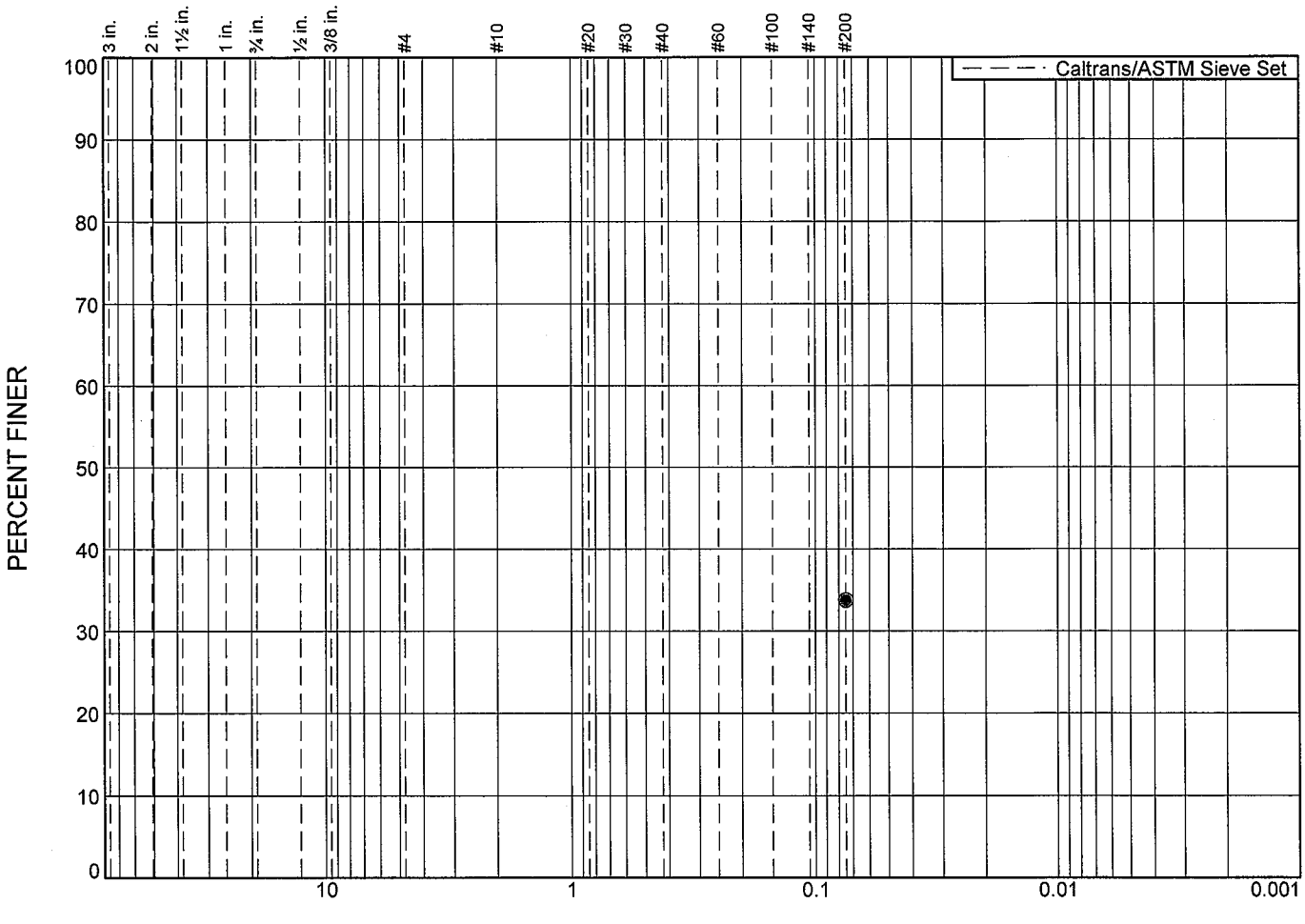
Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Project No.: 17662

Figure A-12

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○							34	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-9		6'	CLAYEY SAND	SC

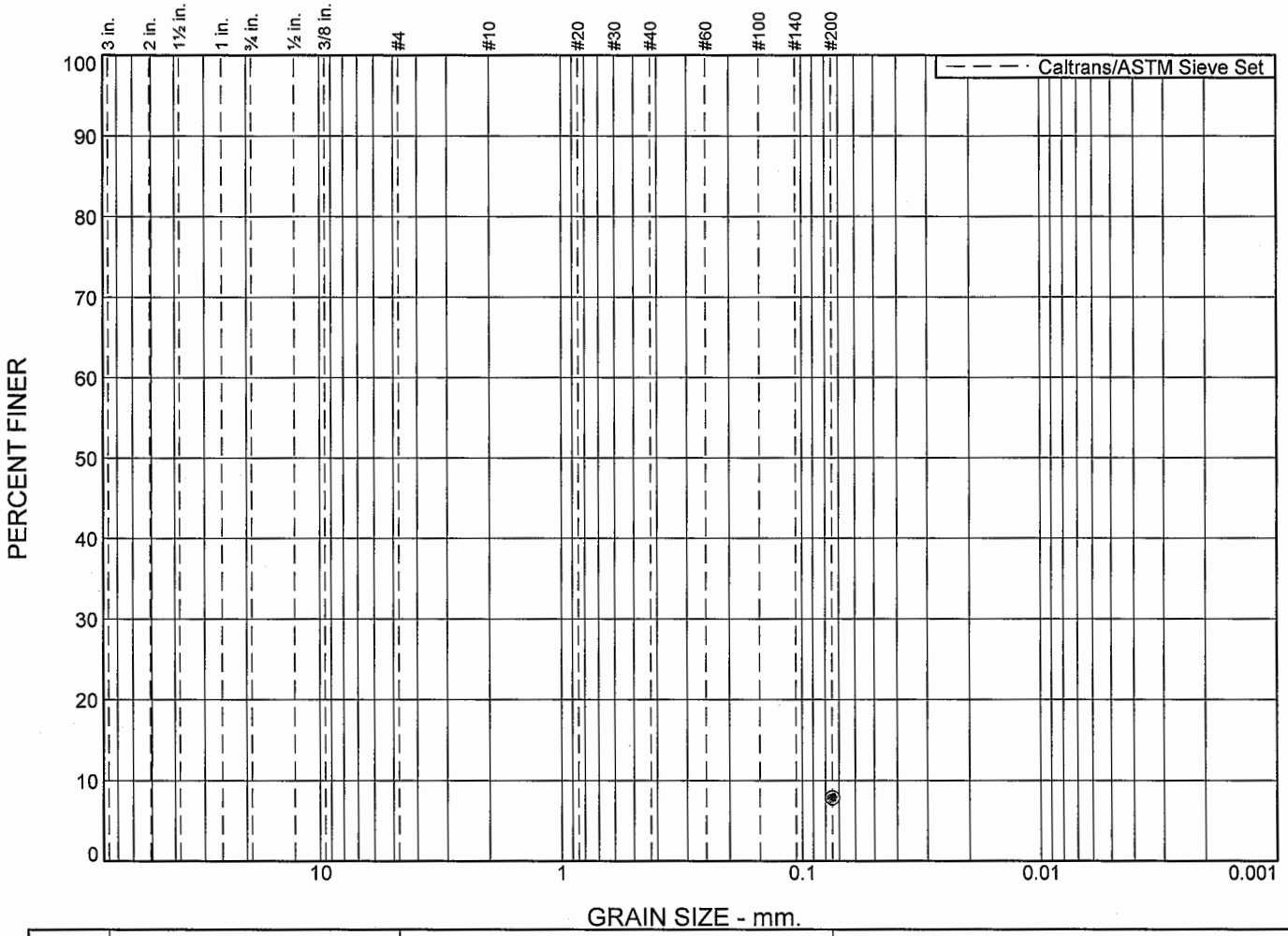
SOILS ENGINEERING, INC.

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Project No.: 17662 **Figure** A-13

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○							7.8	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-11		11'	POORLY GRADED SAND with low fine content	SP-SM

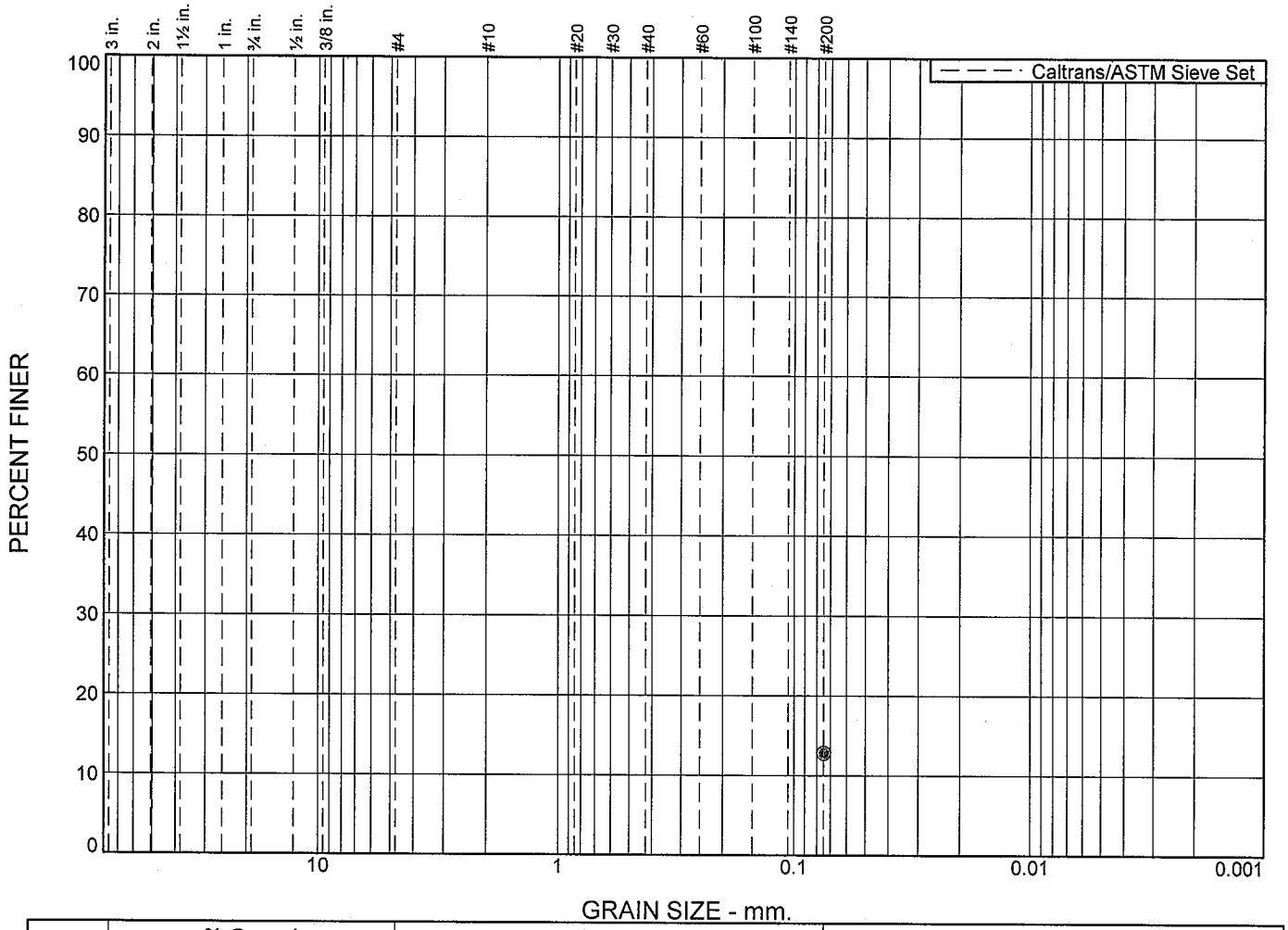
SOILS ENGINEERING, INC.

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Project No.: 17662 **Figure** A-14

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○							13	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-11		21'	SILTY SAND	SM

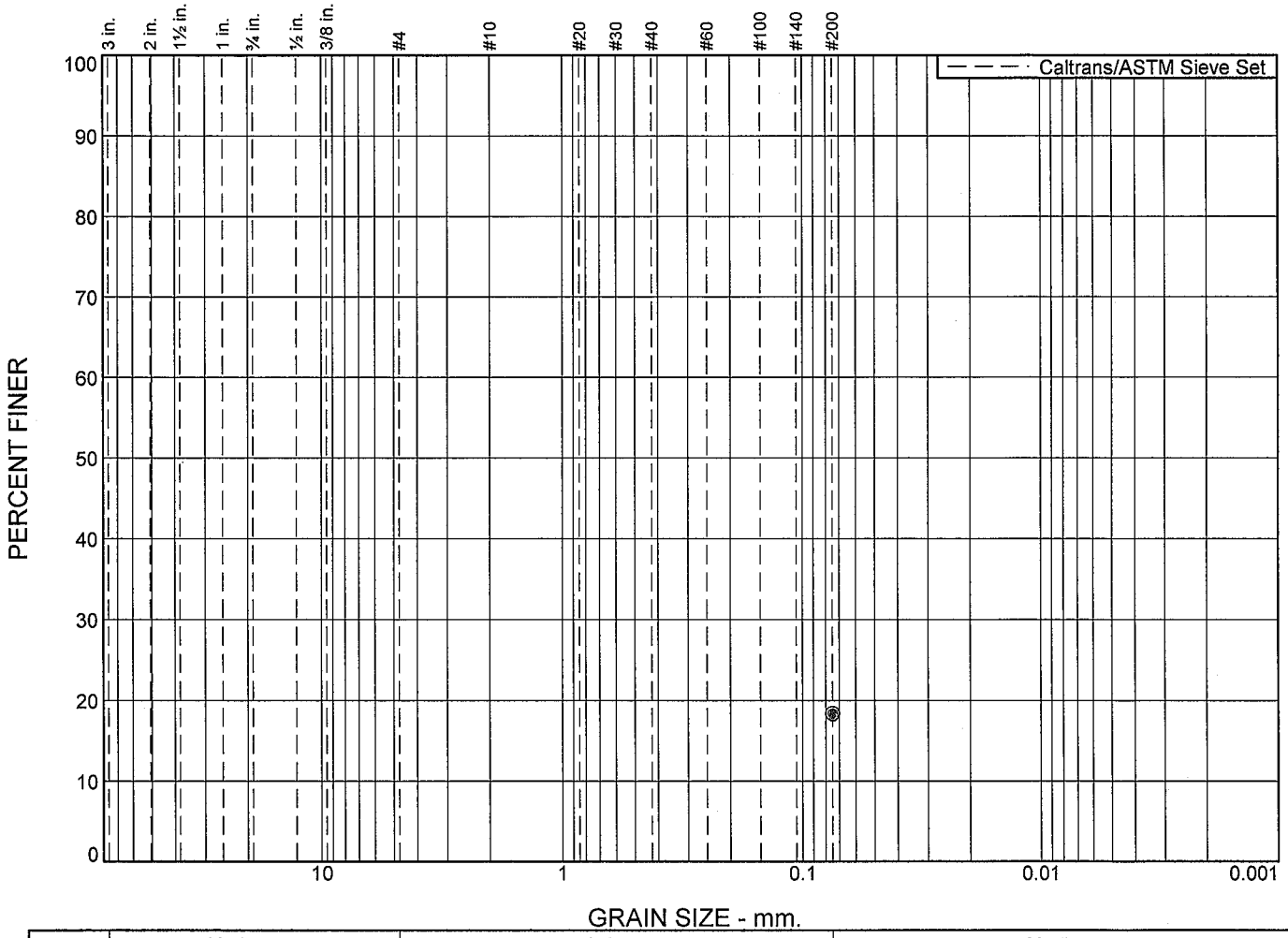
SOILS ENGINEERING, INC.

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Project No.: 17662 **Figure** A-15

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○							18	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-11		46'	SILTY SAND	SM

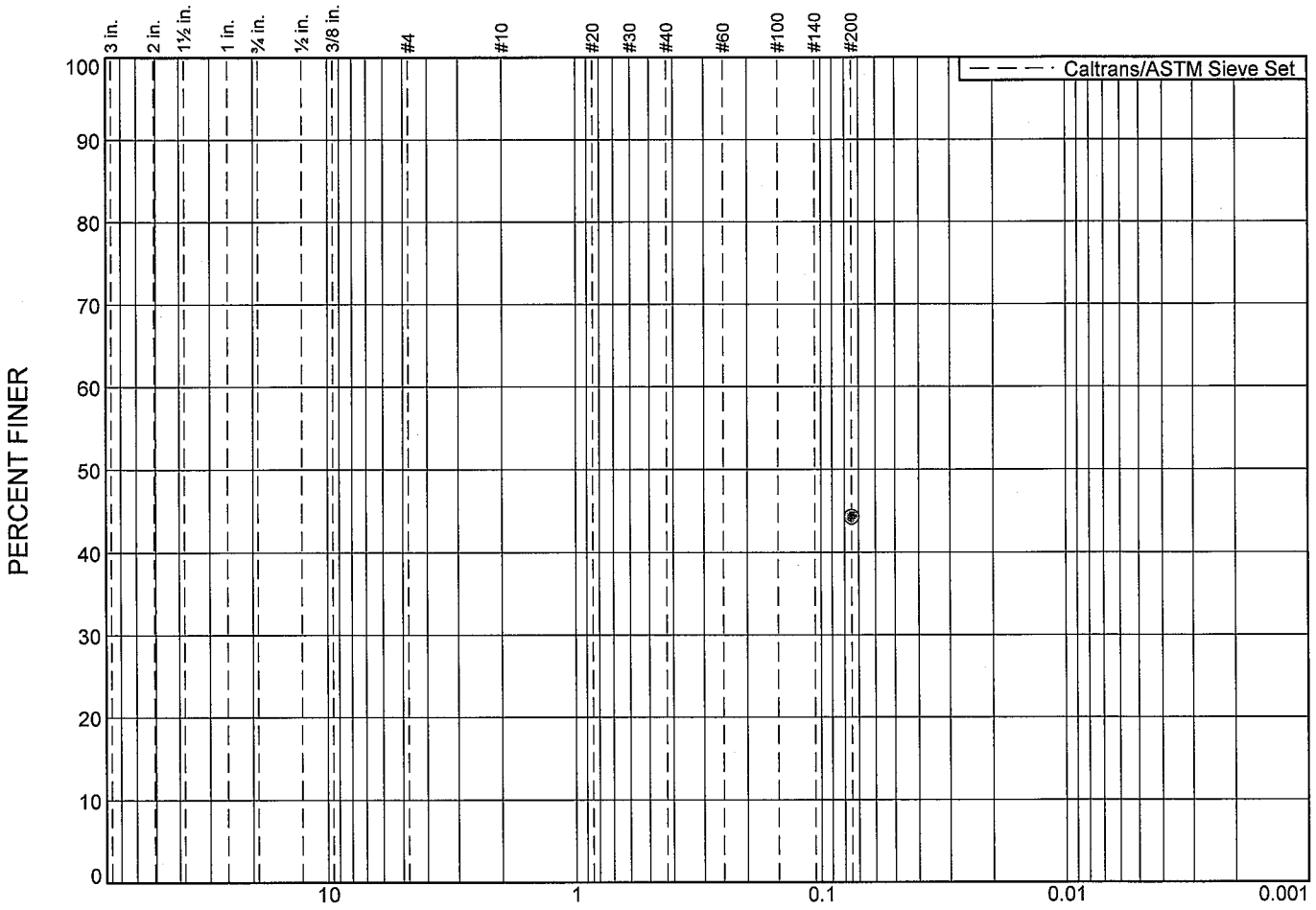
SOILS ENGINEERING, INC.

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Project No.: 17662 **Figure** A-16

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○							44	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-12		3'	CLAYEY SAND	SC

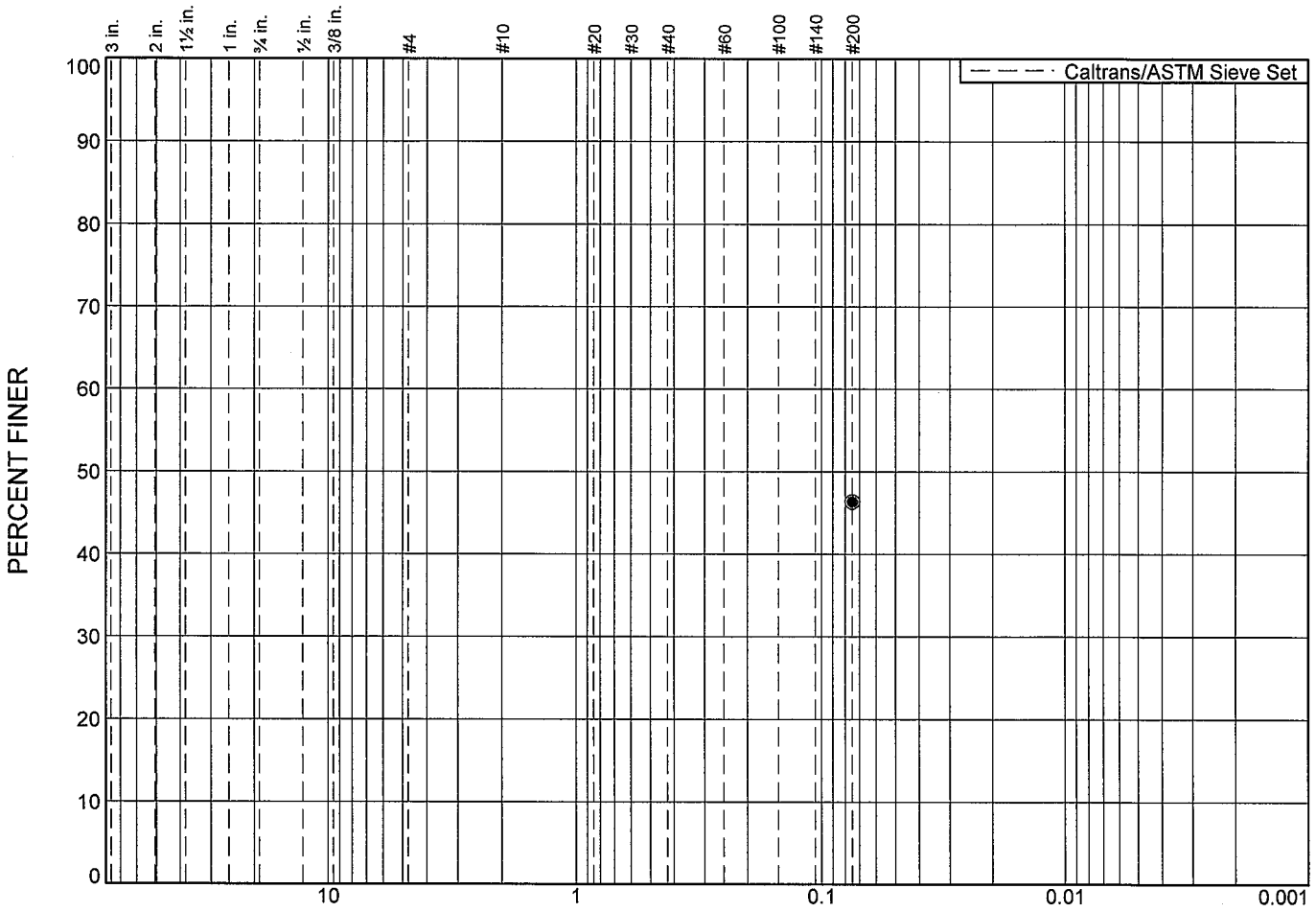
SOILS ENGINEERING, INC.

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Project No.: 17662 **Figure** A-17

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○							46	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○		74622	0-5'	CLAYEY SAND	SC
				Location: TP-1 @ 0-5'	
				Large Bulk Sample	

SOILS ENGINEERING, INC.

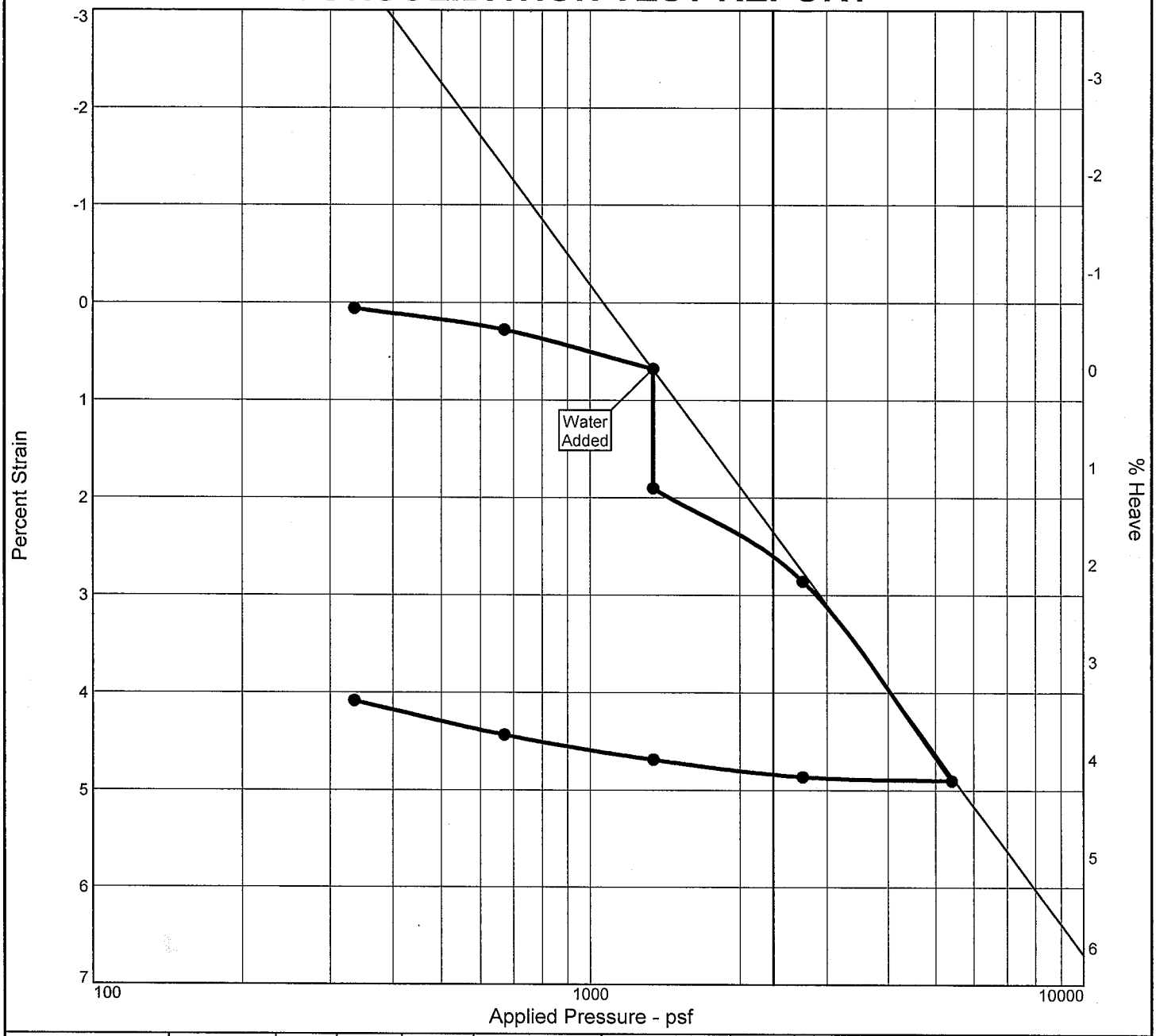
Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Project No.: 17662

Figure A-18

CONSOLIDATION TEST REPORT



Natural		Dry Dens.	LL	PI	Sp.	Overburden	P_c	C_c	C_s	Swell Press.	Heave	e_o
Sat.	Moist.	(pcf)			Gr.	(psf)	(psf)			(psf)	%	
63.3 %	16.9 %	96.8	N/A	N/A	2.65	336	2615	0.12	0.01		-1.2	0.710

MATERIAL DESCRIPTION	USCS	AASHTO
SANDY CLAY	CL	N/A

Project No. 17662 **Client:** Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-1 **Depth:** 6'

Remarks:
Test Date: 06/12/20

SOILS ENGINEERING, INC.

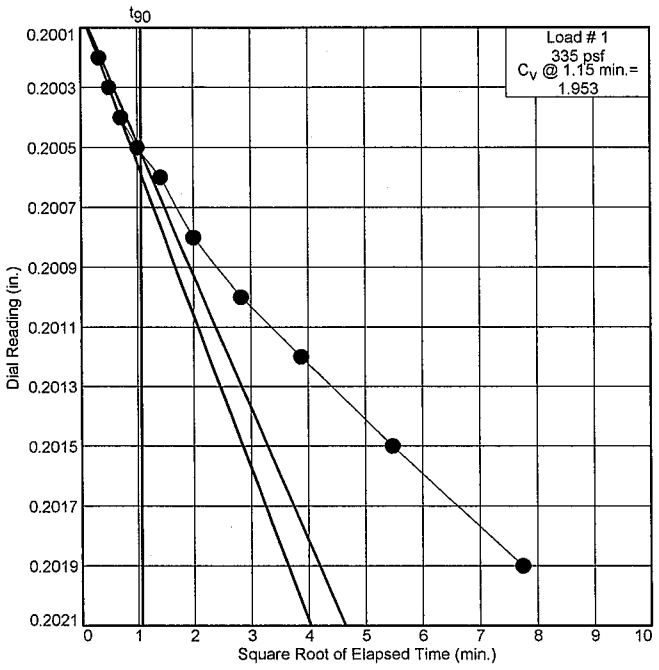
Figure B-1

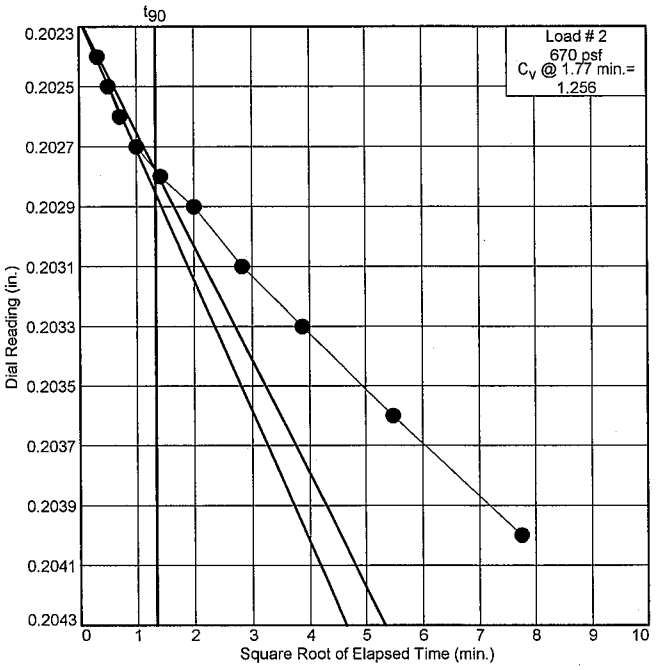
Tested By: DM **Checked By:** AL

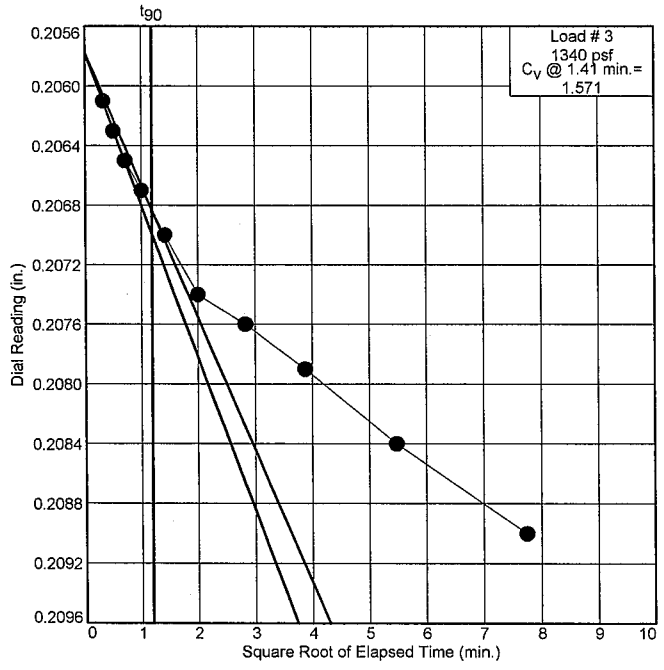
Dial Reading vs. Time

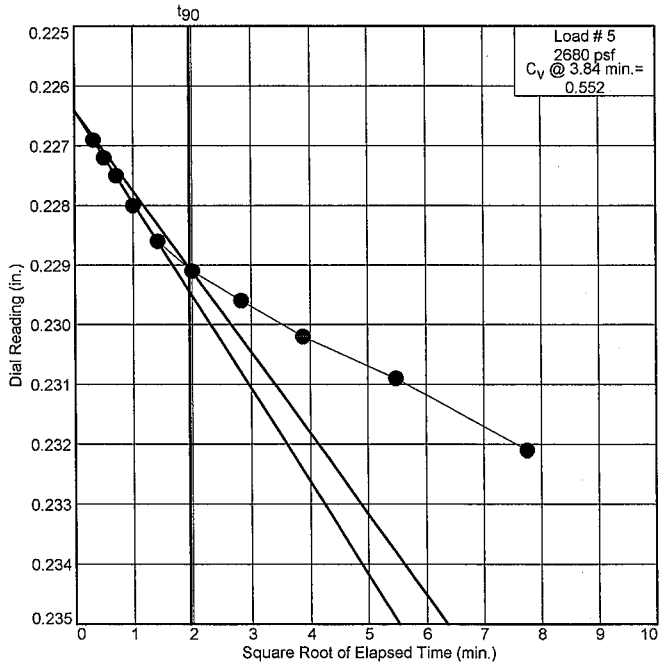
Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-1 Depth: 6'









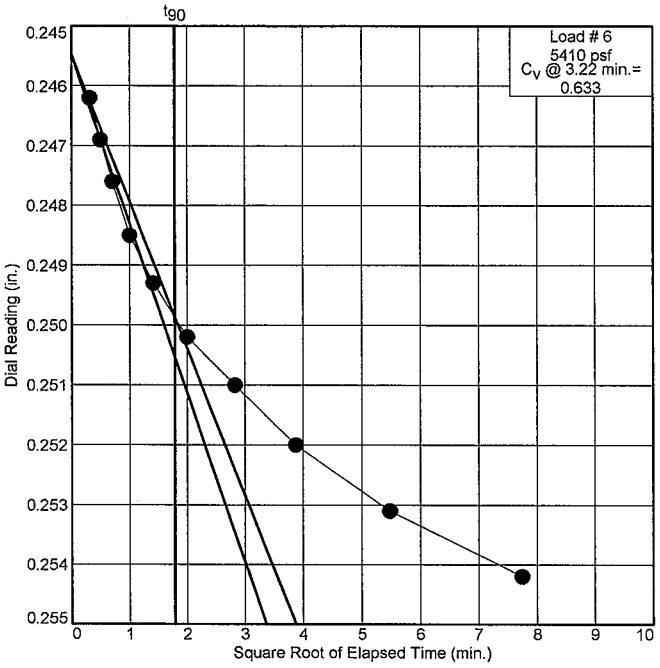
SOILS ENGINEERING, INC.

Figure B-1

Dial Reading vs. Time

Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

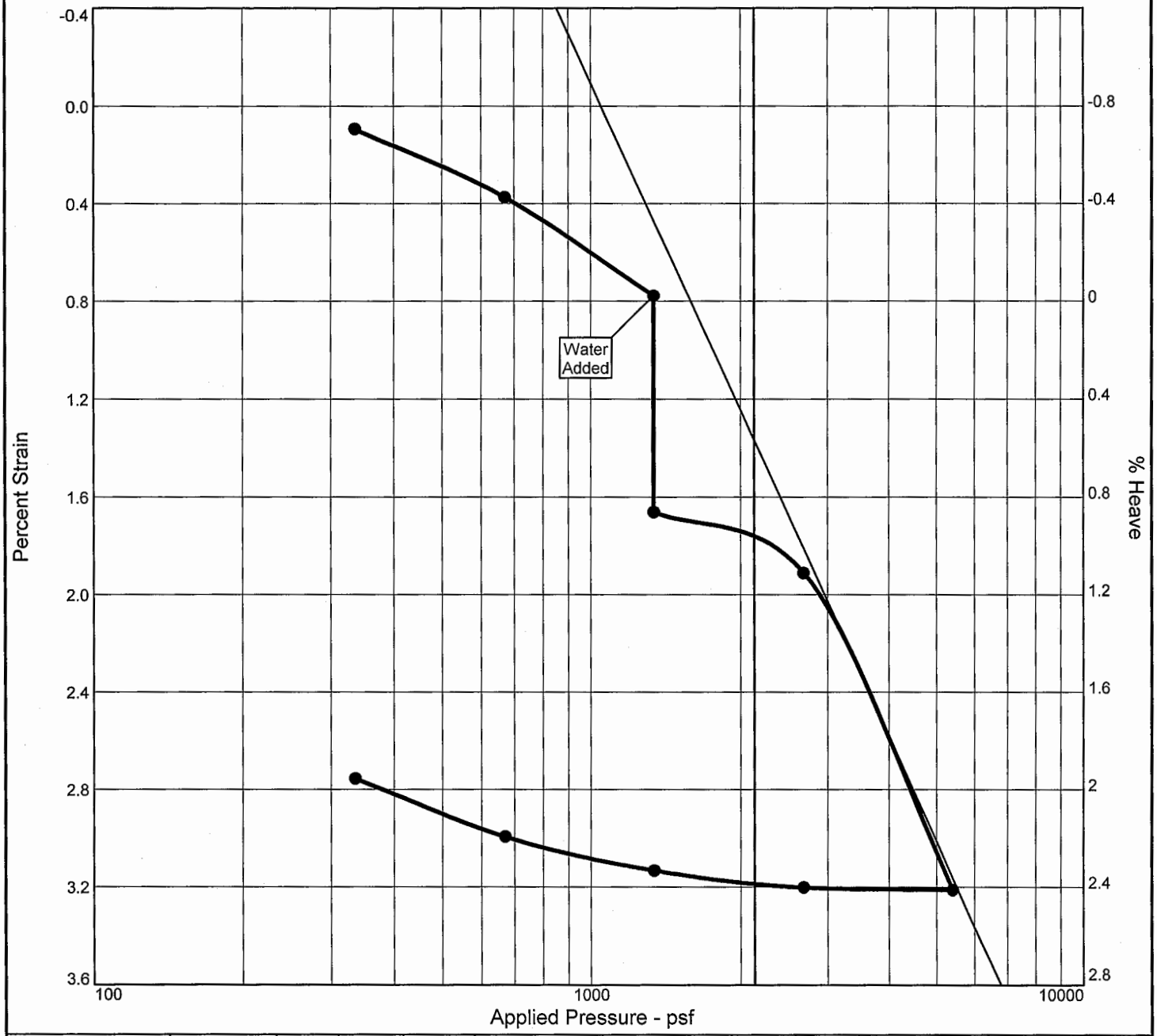
Source of Sample: B-1 Depth: 6'



SOILS ENGINEERING, INC.

Figure B-1

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_s	Swell Press. (psf)	Heave %	e_o
62.6 %	17.5 %	95.1	N/A	N/A	2.65	336	2646	0.08	0.01		-0.9	0.740

MATERIAL DESCRIPTION	USCS	AASHTO
SANDY SILT	ML	N/A

Project No. 17662 **Client:** Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-2 **Depth:** 6'

Remarks:
Test Date: 06/11/20

SOILS ENGINEERING, INC.

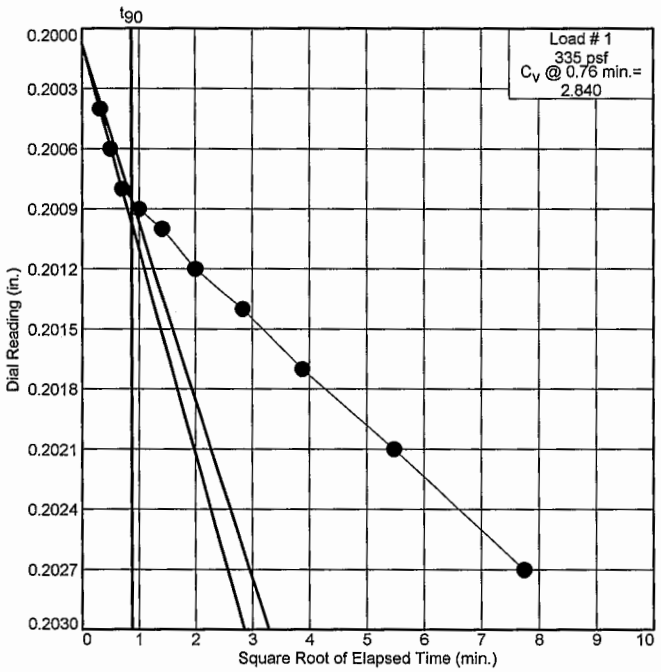
Figure B-2

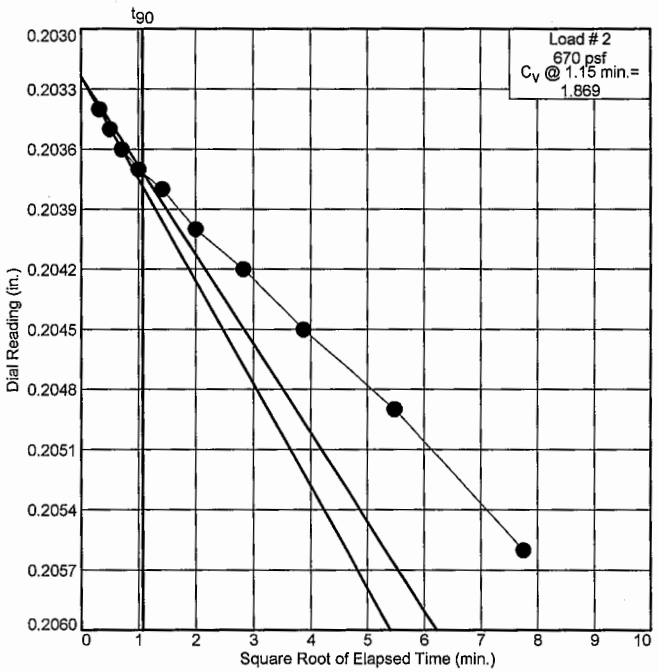
Tested By: DM **Checked By:** AL

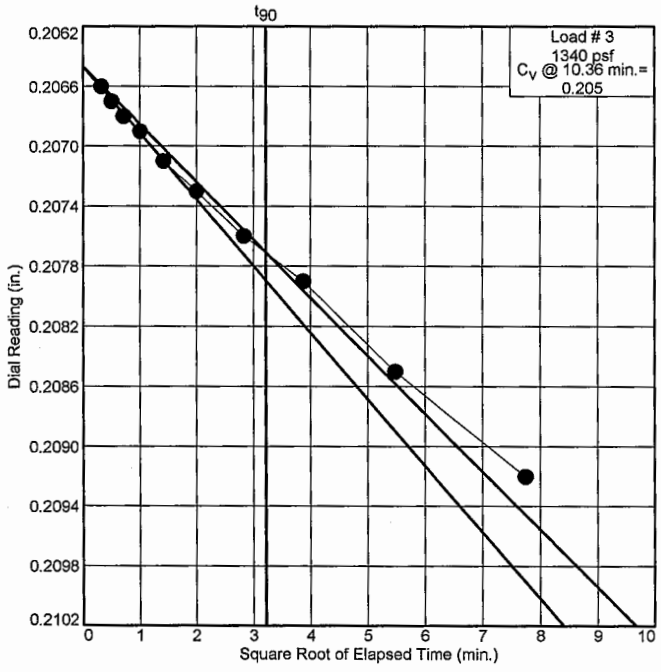
Dial Reading vs. Time

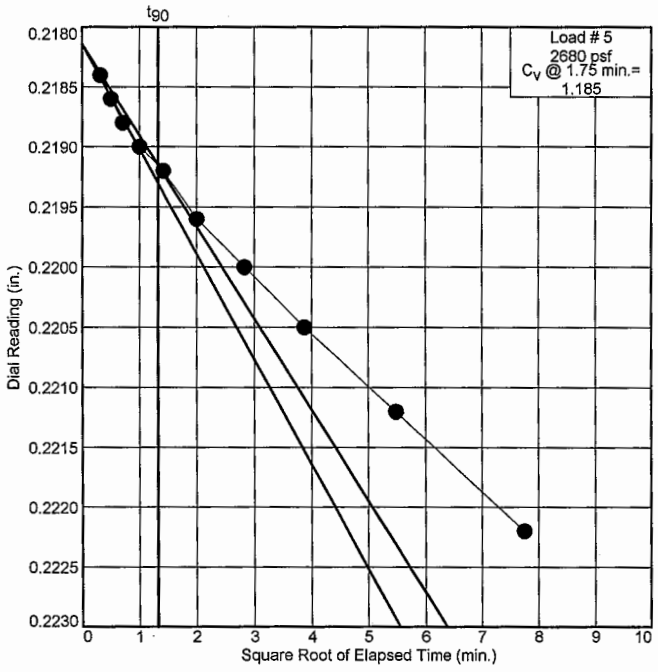
Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-2 Depth: 6'









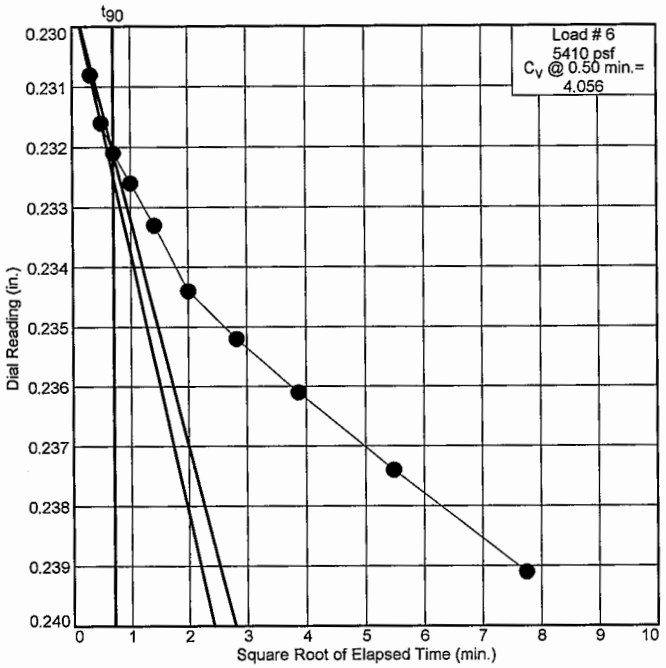
SOILS ENGINEERING, INC.

Figure B-2

Dial Reading vs. Time

Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

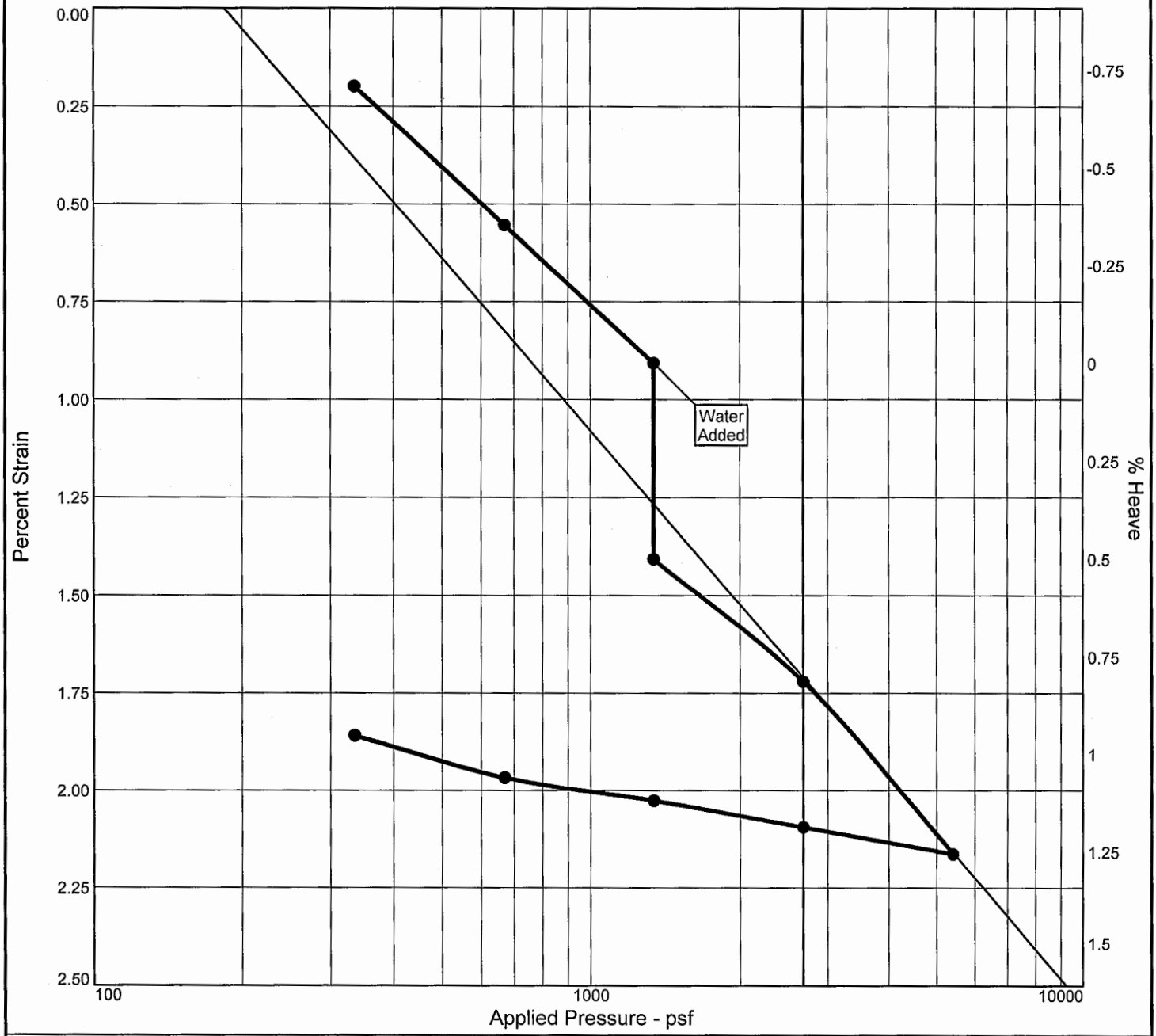
Source of Sample: B-2 Depth: 6'



SOILS ENGINEERING, INC.

Figure B-2

CONSOLIDATION TEST REPORT



Natural		Dry Dens.	LL	PI	Sp.	Overburden	P_c	C_c	C_s	Swell Press.	Heave	e_o
Sat.	Moist.	(pcf)			Gr.	(psf)	(psf)			(psf)	%	
22.9 %	6.5 %	94.4	N/A	N/A	2.65	336	2757	0.03	0.00		-0.5	0.753

MATERIAL DESCRIPTION	USCS	AASHTO
POORLY GRADED SAND with low fine content	SP-SM	N/A

Project No. 17662 **Client:** Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-2 **Depth:** 31'

Remarks:
Test Date: 06/08/20

SOILS ENGINEERING, INC.

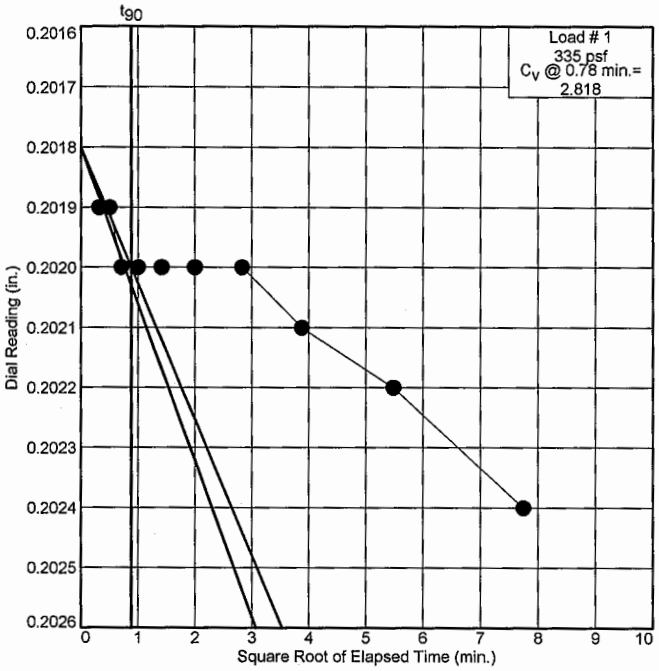
Figure B-3

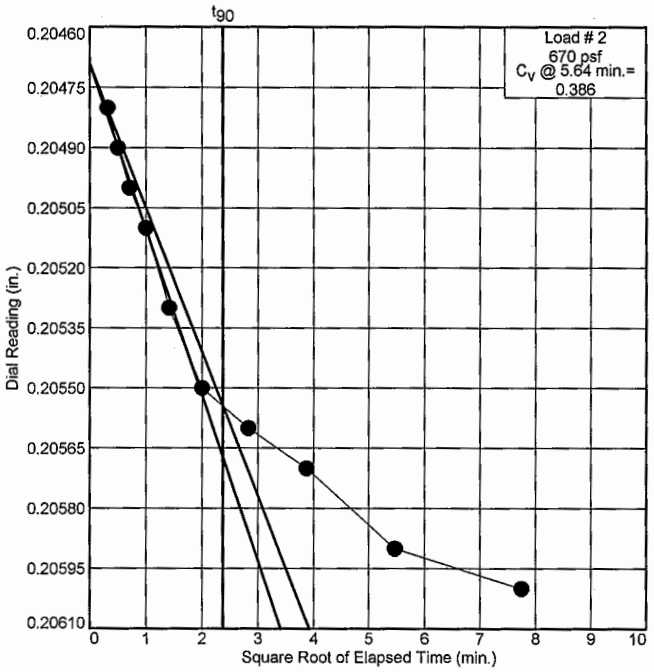
Tested By: DM **Checked By:** AL

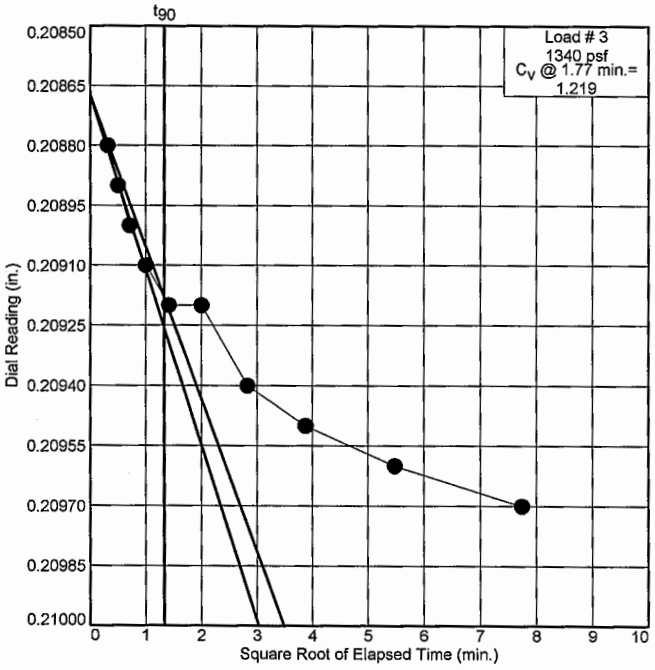
Dial Reading vs. Time

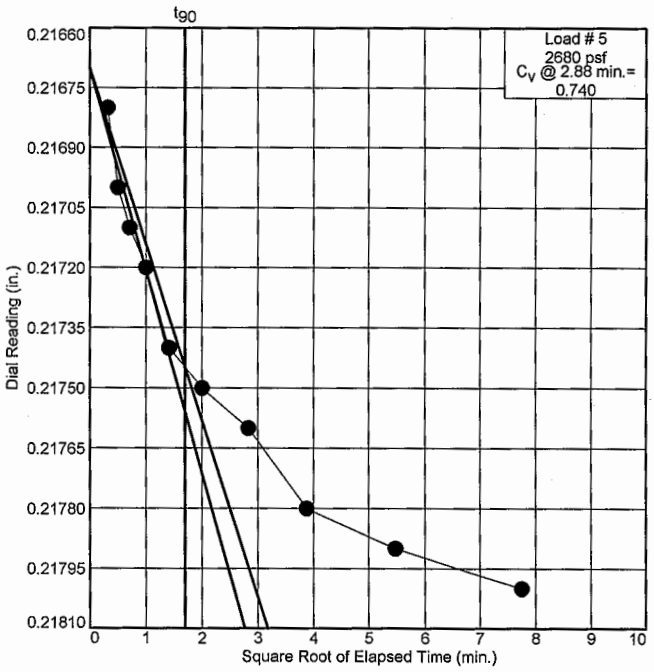
Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-2 Depth: 31'









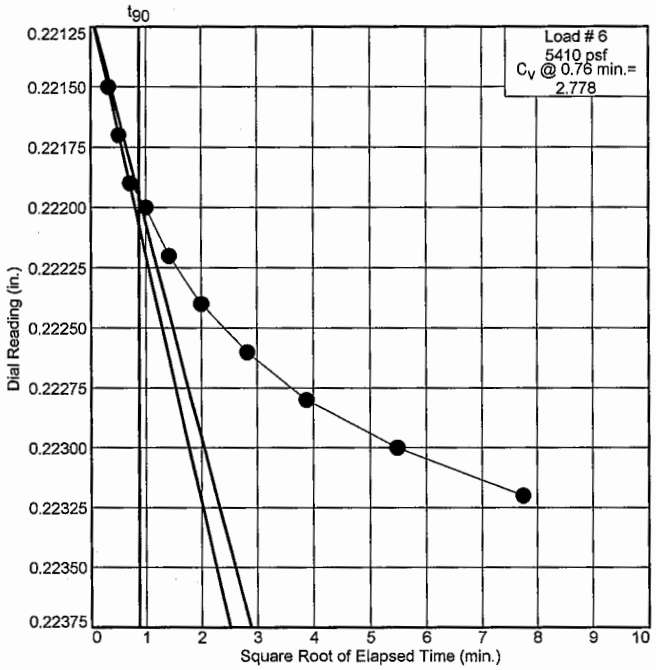
SOILS ENGINEERING, INC.

Figure B-3

Dial Reading vs. Time

Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

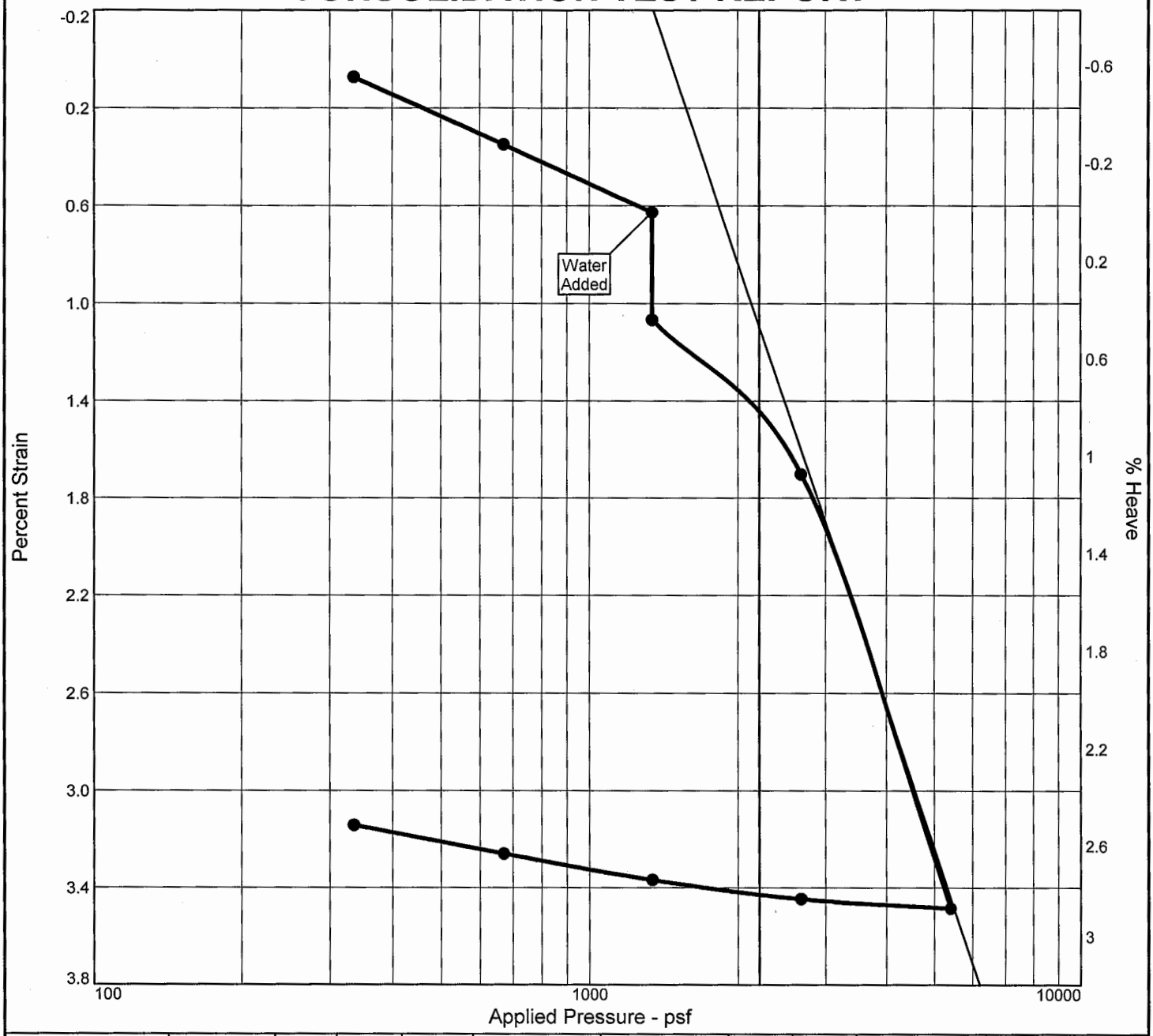
Source of Sample: B-2 Depth: 31'



SOILS ENGINEERING, INC.

Figure B-3

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_s	Swell Press. (psf)	Heave %	e_o
Sat.	Moist.											
52.9 %	14.8 %	95.1	N/A	N/A	2.65	336	2598	0.10	0.00		-0.4	0.740

MATERIAL DESCRIPTION	USCS	AASHTO
SILTY SAND	SM	N/A

Project No. 17662 **Client:** Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-3 **Depth:** 3'

Remarks:

Test Date: 06/11/20

SOILS ENGINEERING, INC.

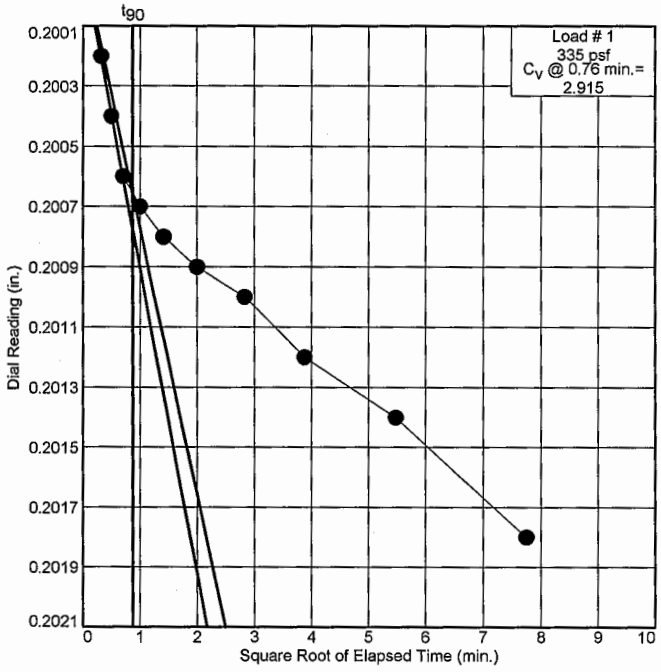
Figure B-4

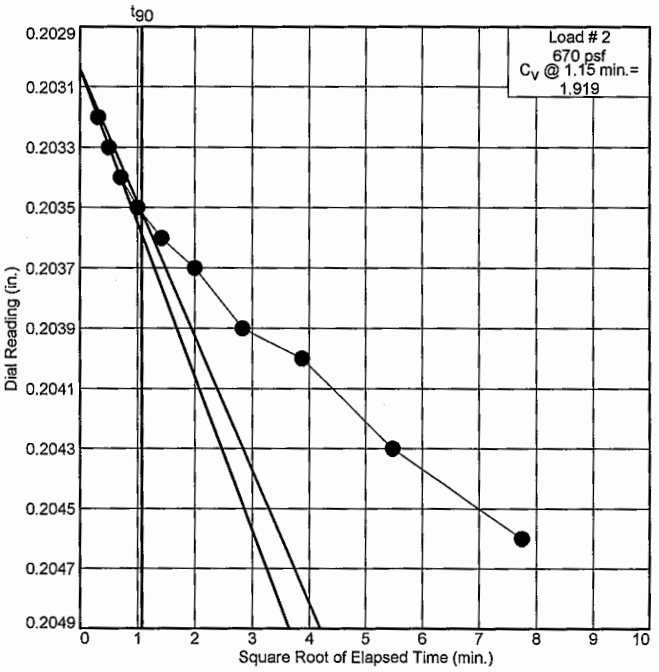
Tested By: DM **Checked By:** AL

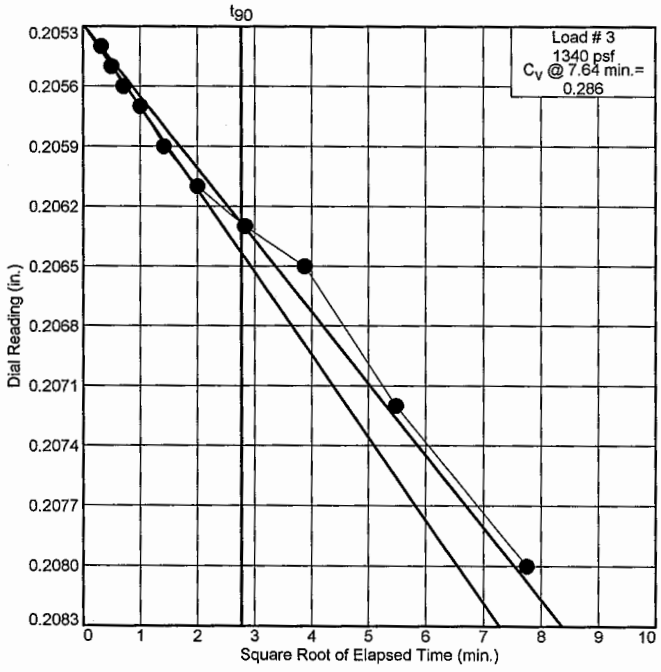
Dial Reading vs. Time

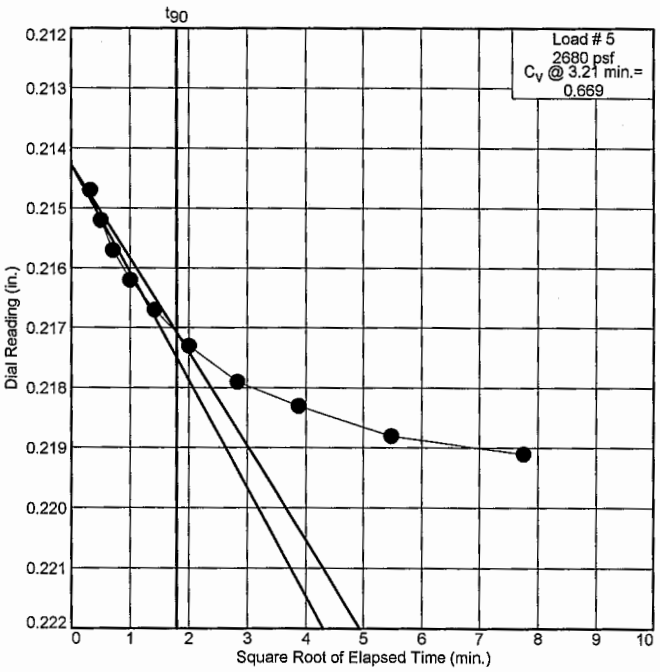
Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-3 Depth: 3'









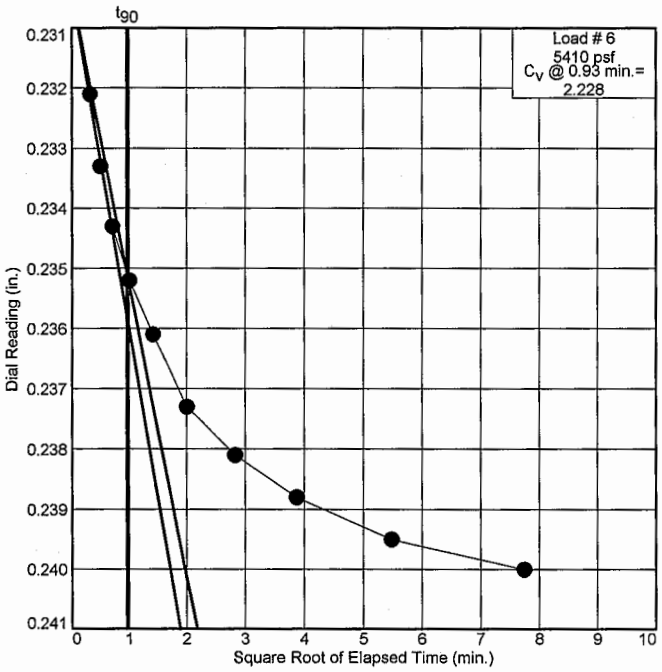
SOILS ENGINEERING, INC.

Figure B-4

Dial Reading vs. Time

Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

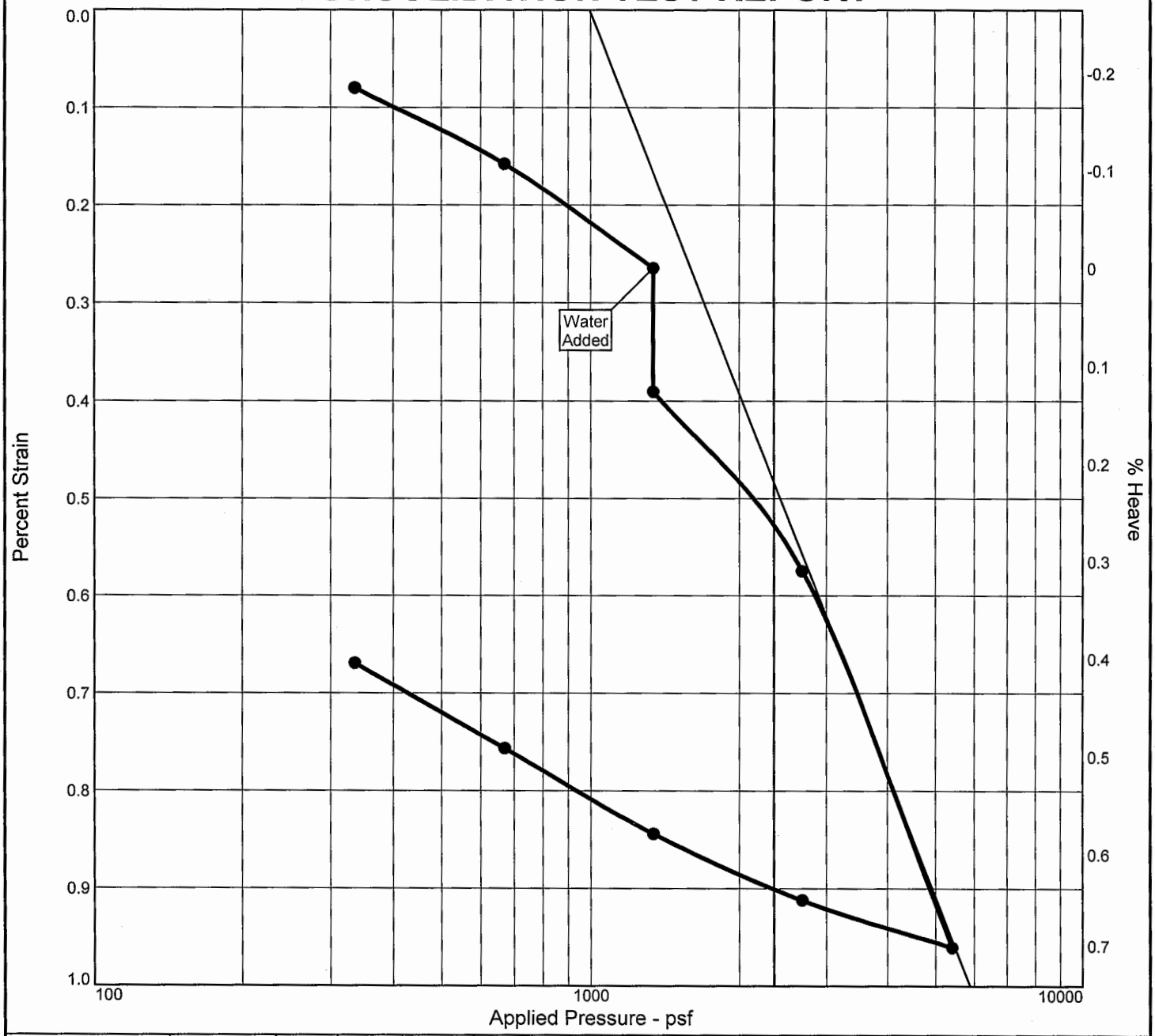
Source of Sample: B-3 Depth: 3'



SOILS ENGINEERING, INC.

Figure B-4

CONSOLIDATION TEST REPORT



Natural		Dry Dens.	LL	PI	Sp.	Overburden	P_c	C_c	C_s	Swell Press.	Heave	e_o
Sat.	Moist.	(pcf)			Gr.	(psf)	(psf)			(psf)	%	
27.9 %	6.8 %	100.4	N/A	N/A	2.65	336	2620	0.02	0.00		-0.1	0.647

MATERIAL DESCRIPTION	USCS	AASHTO
POORLY GRADED SAND	SP	N/A

Project No. 17662 **Client:** Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-4 **Depth:** 6'

Remarks:
Test Date: 06/12/20

SOILS ENGINEERING, INC.

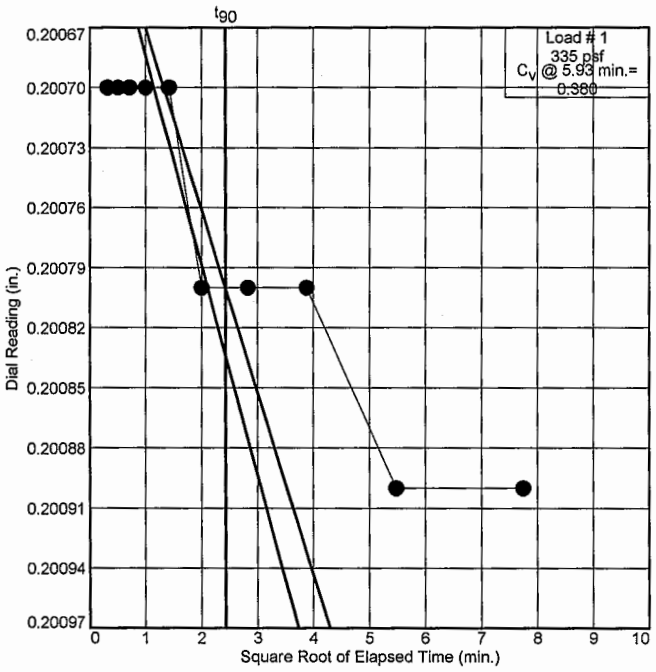
Figure B-5

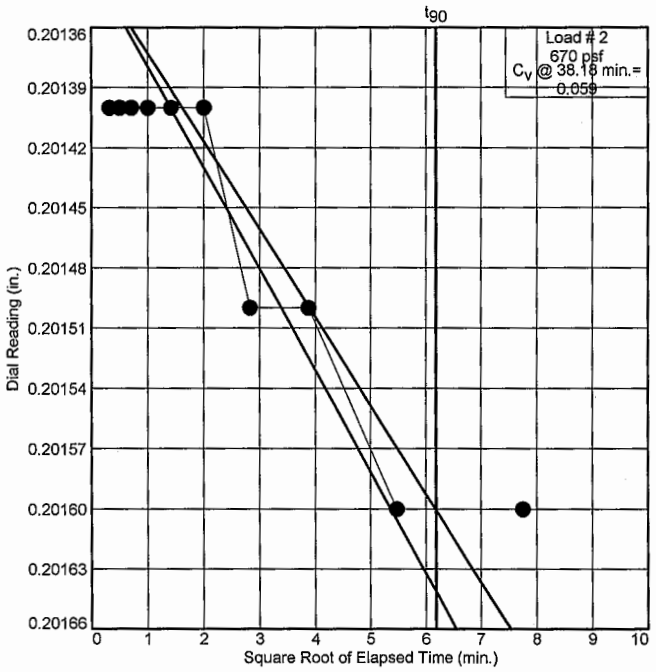
Tested By: DM **Checked By:** AL

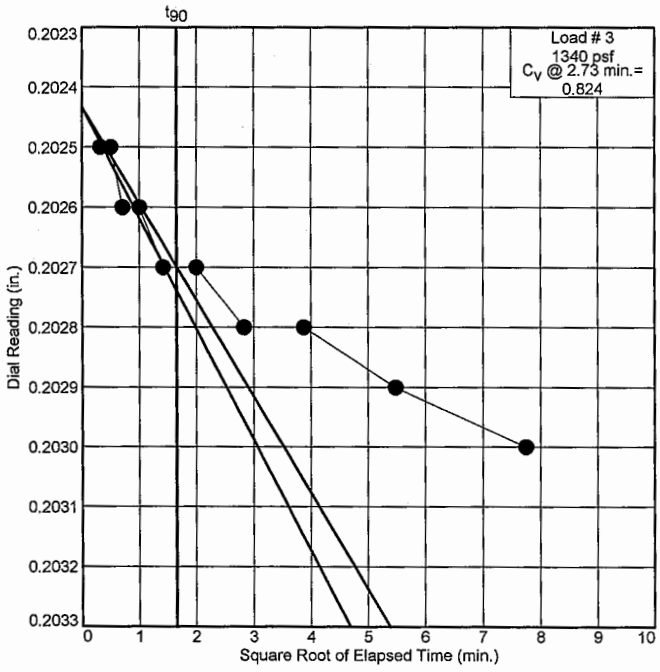
Dial Reading vs. Time

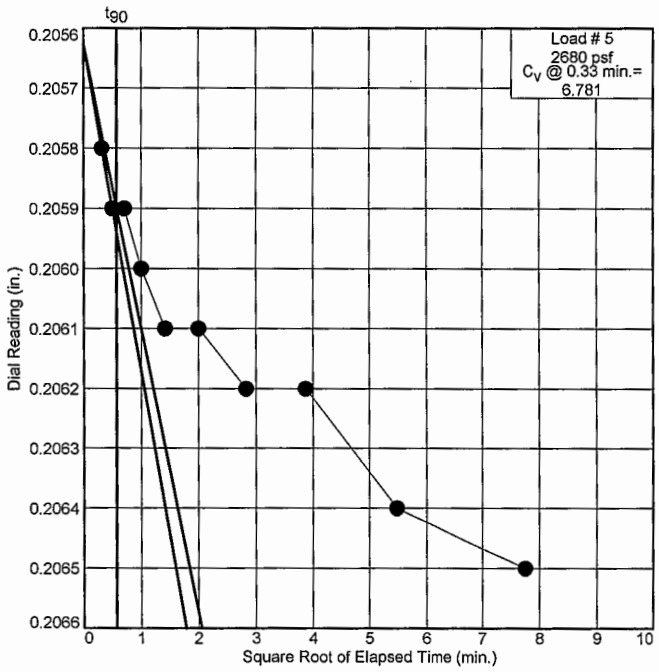
Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-4 Depth: 6'









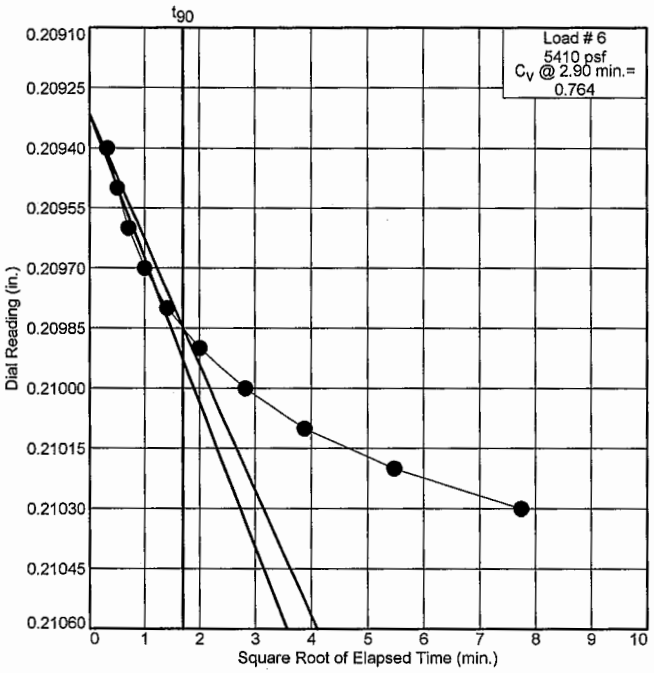
SOILS ENGINEERING, INC.

Figure B-5

Dial Reading vs. Time

Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

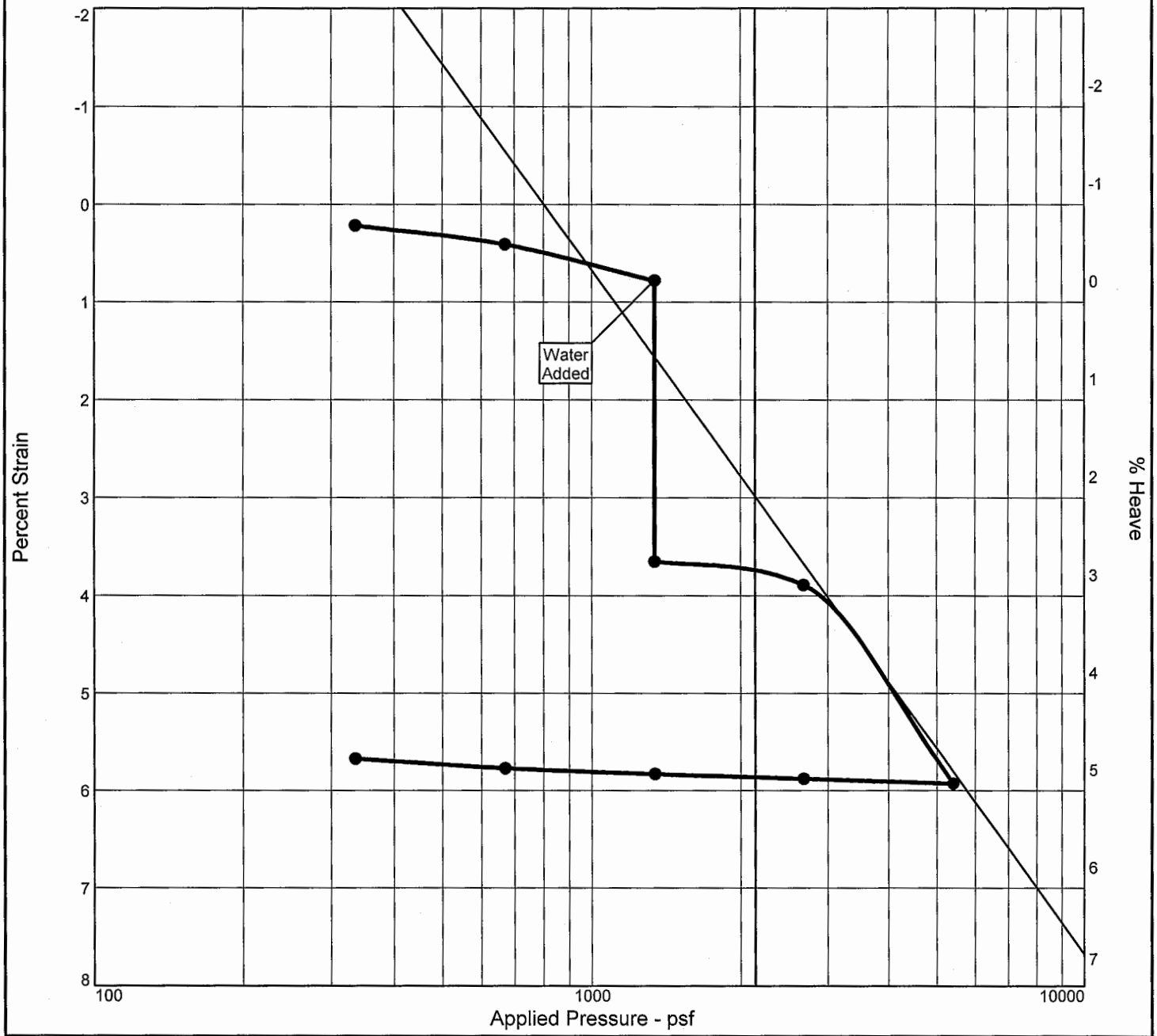
Source of Sample: B-4 Depth: 6'



SOILS ENGINEERING, INC.

Figure B-5

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_s	Swell Press. (psf)	Heave %	e_o
34.2 %	12.2 %	85.0	N/A	N/A	2.65	336	2719	0.14	0.00		-2.9	0.946

MATERIAL DESCRIPTION	USCS	AASHTO
CLAYEY SAND	SC	N/A

Project No. 17662 **Client:** Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-5 **Depth:** 3'

Remarks:
Test Date: 06/16/20

SOILS ENGINEERING, INC.

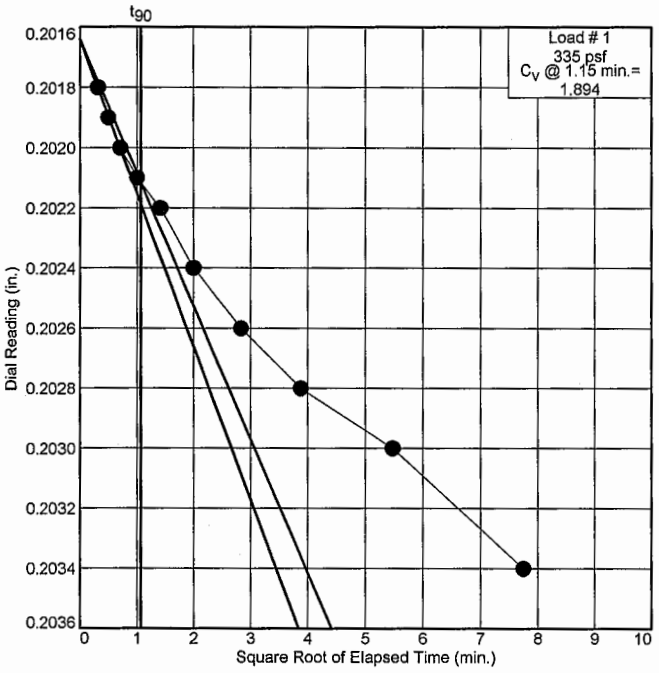
Figure B-6

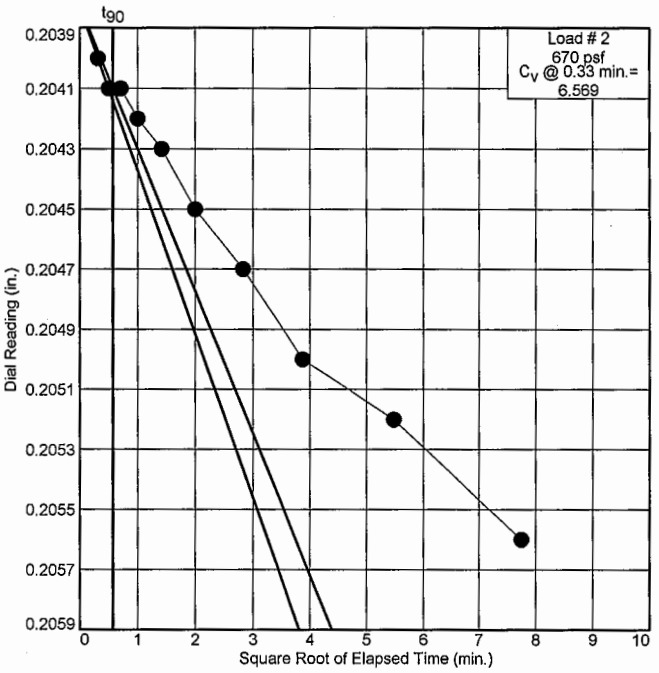
Tested By: DM **Checked By:** AL

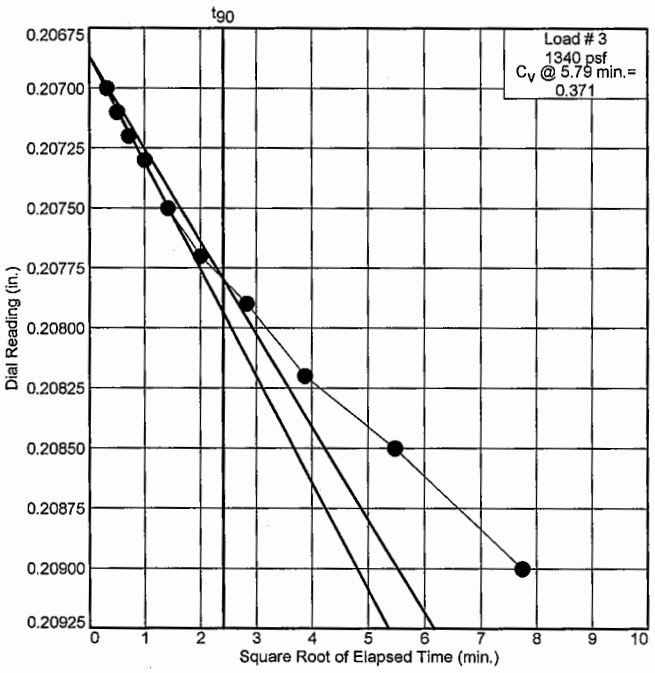
Dial Reading vs. Time

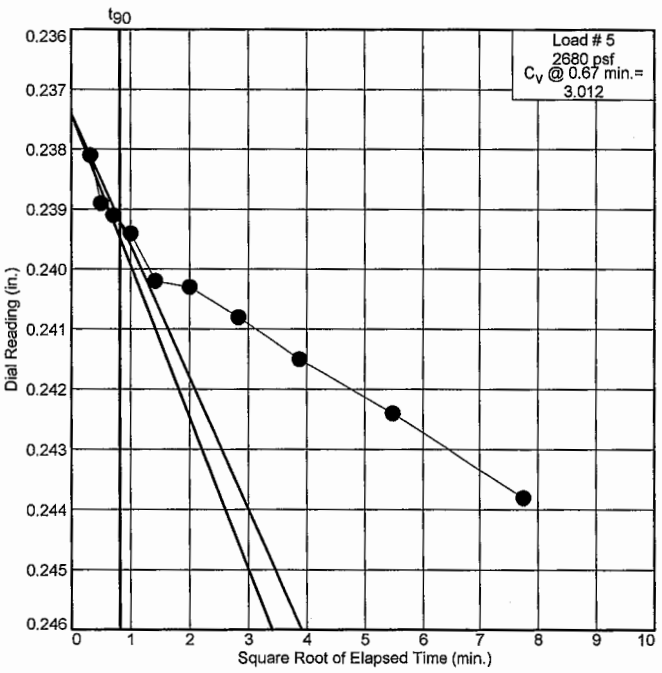
Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-5 Depth: 3'









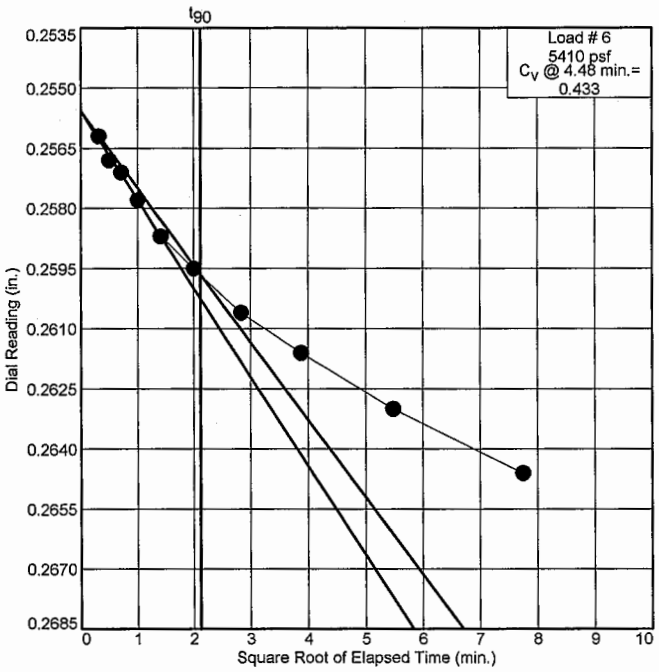
SOILS ENGINEERING, INC.

Figure B-6

Dial Reading vs. Time

Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

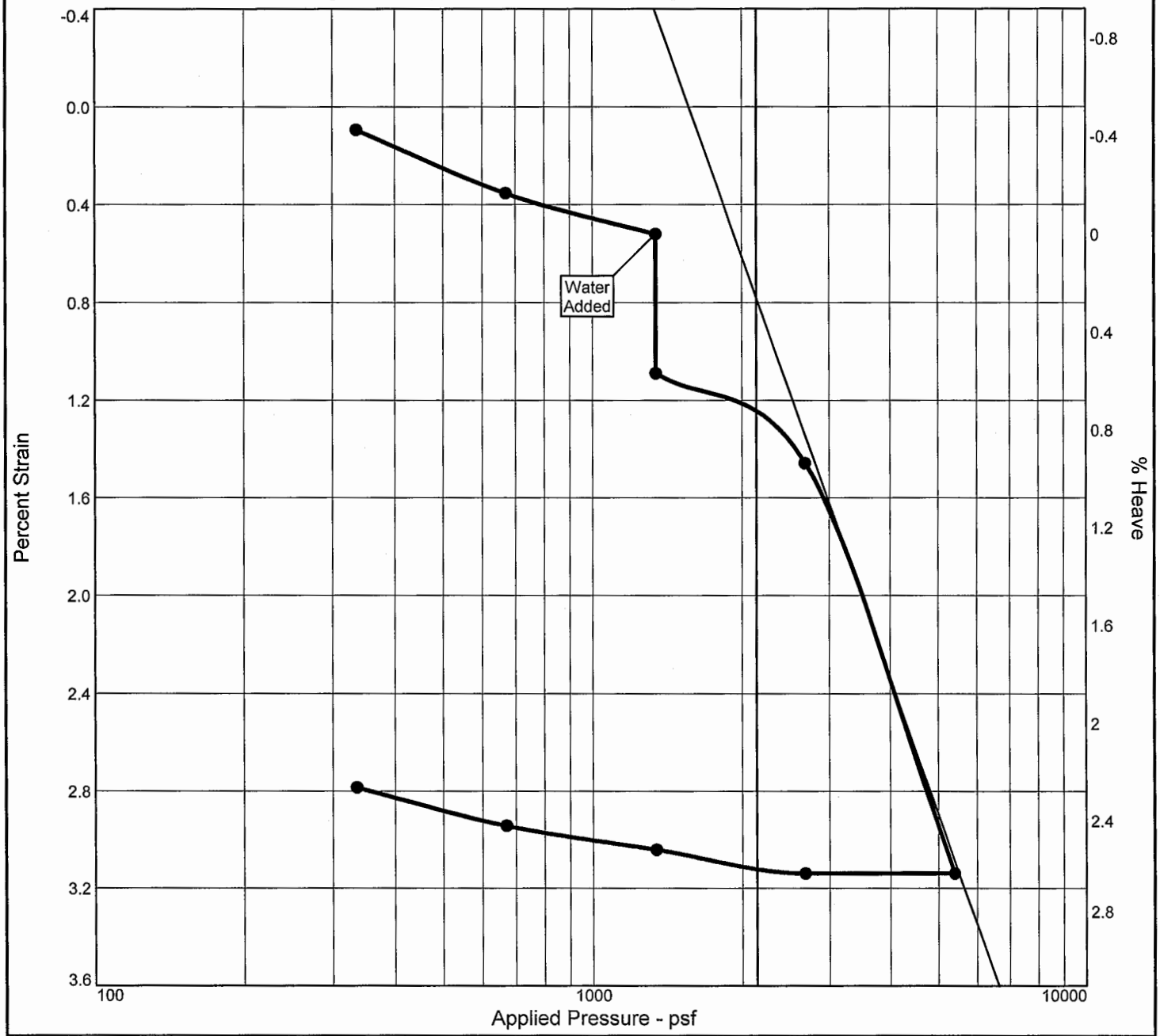
Source of Sample: B-5 Depth: 3'



SOILS ENGINEERING, INC.

Figure B-6

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_s	Swell Press. (psf)	Heave %	e_o
40.8 %	11.8 %	93.8	N/A	N/A	2.65	336	2627	0.10	0.01		-0.6	0.763

MATERIAL DESCRIPTION	USCS	AASHTO
CLAYEY SAND	SC	N/A

Project No. 17662 **Client:** Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-5 **Depth:** 6'

Remarks:
Test Date: 06/16/20

SOILS ENGINEERING, INC.

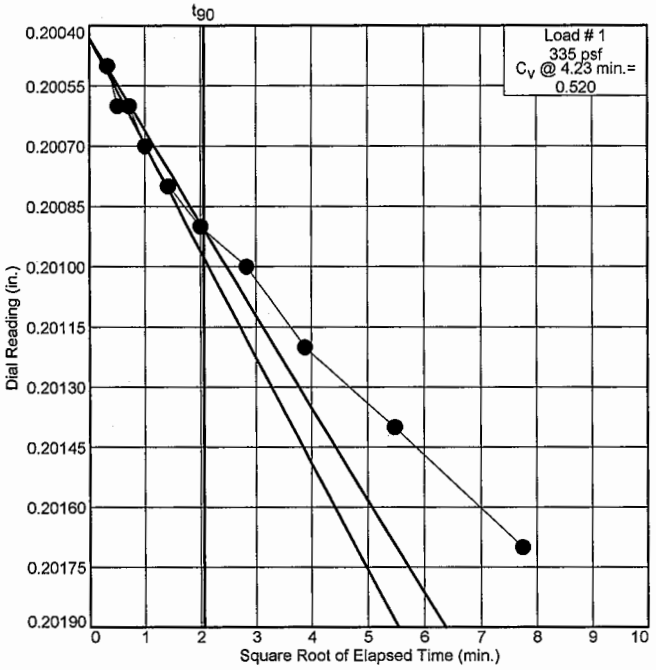
Figure B-7

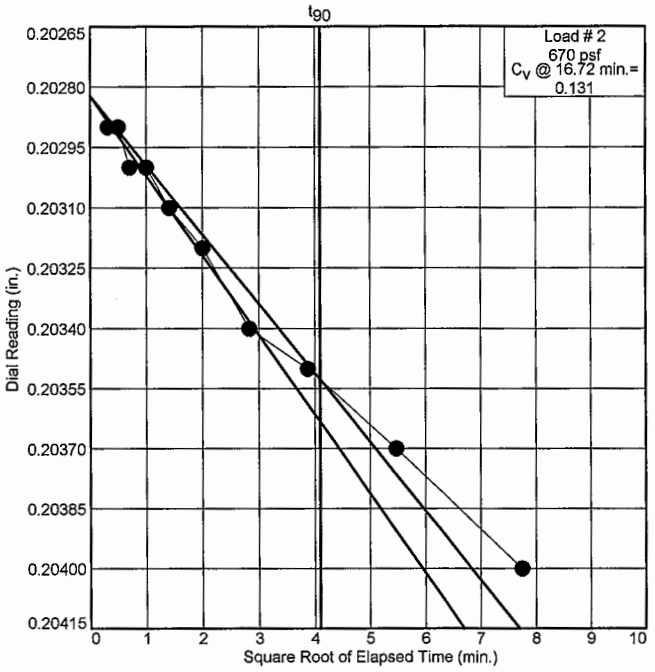
Tested By: DM **Checked By:** AL

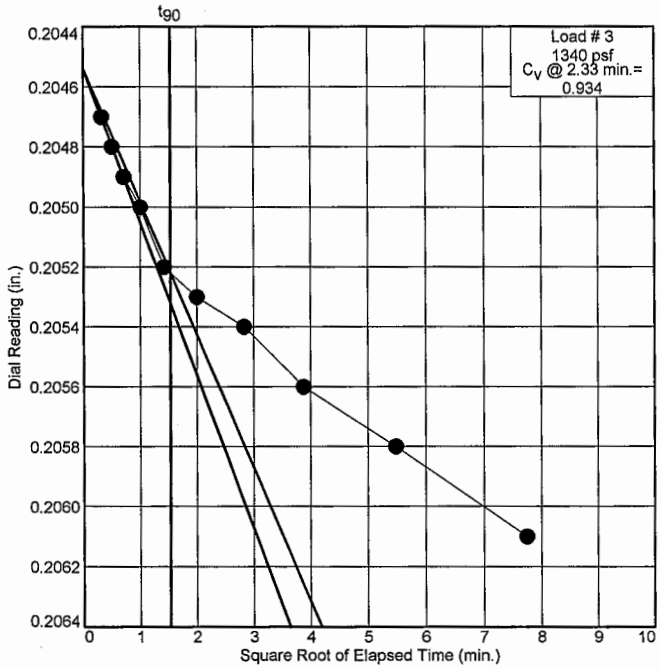
Dial Reading vs. Time

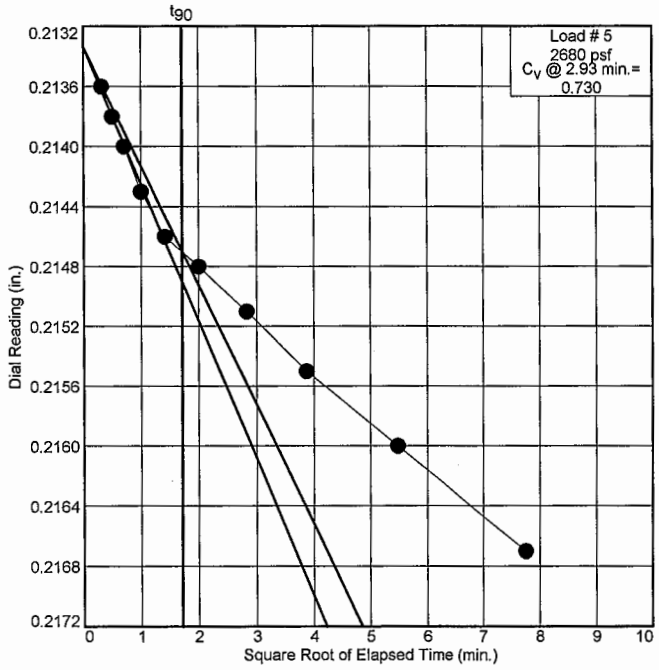
Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-5 Depth: 6'









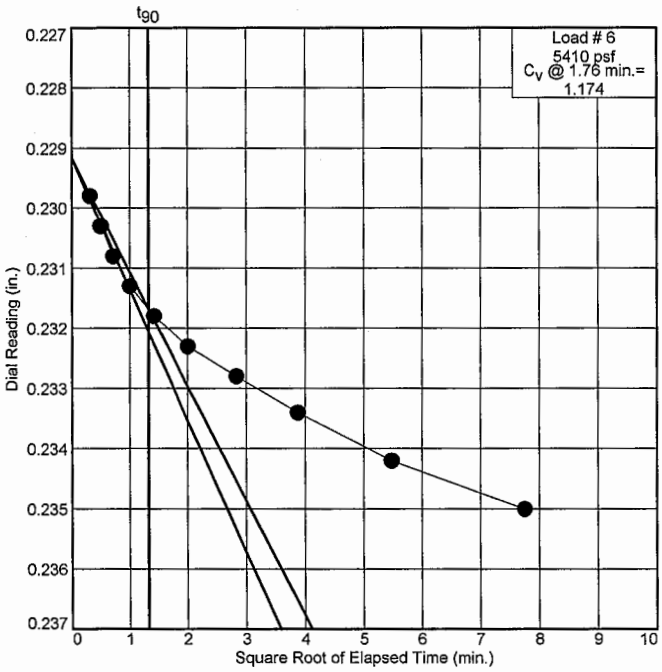
SOILS ENGINEERING, INC.

Figure B-7

Dial Reading vs. Time

Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

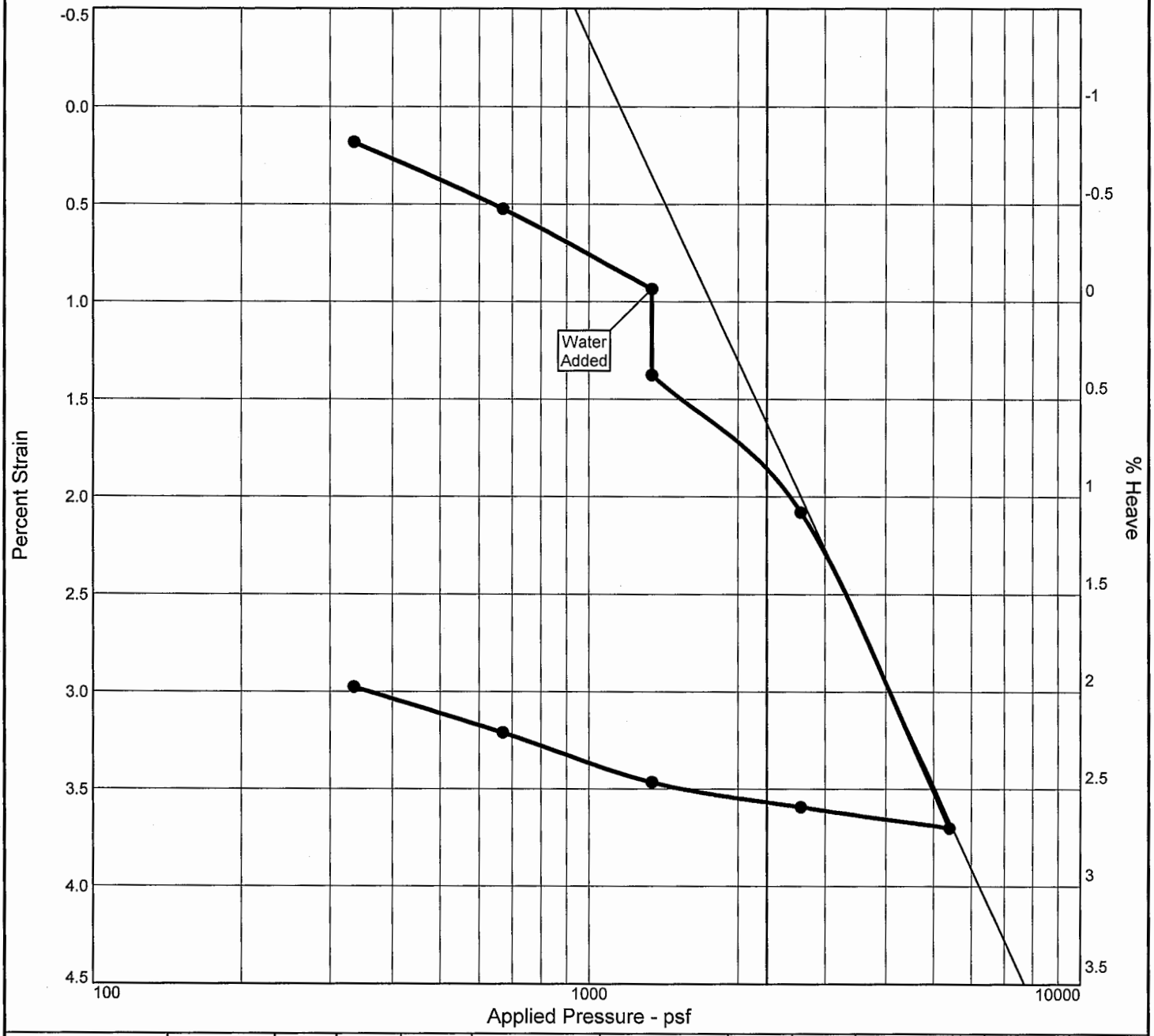
Source of Sample: B-5 Depth: 6'



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Figure B-7

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_s	Swell Press. (psf)	Heave %	e_o
51.5 %	11.4 %	104.3	N/A	N/A	2.65	336	2605	0.09	0.01		-0.4	0.585

MATERIAL DESCRIPTION	USCS	AASHTO
SILTY SAND	SM	N/A

Project No. 17662 **Client:** Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-7 **Depth:** 3'

Remarks:
Test Date: 06/11/20

SOILS ENGINEERING, INC.

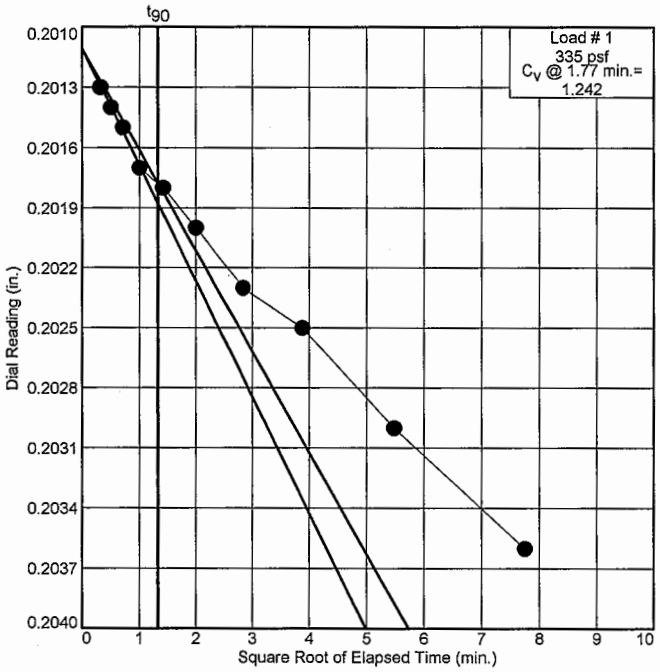
Figure B-8

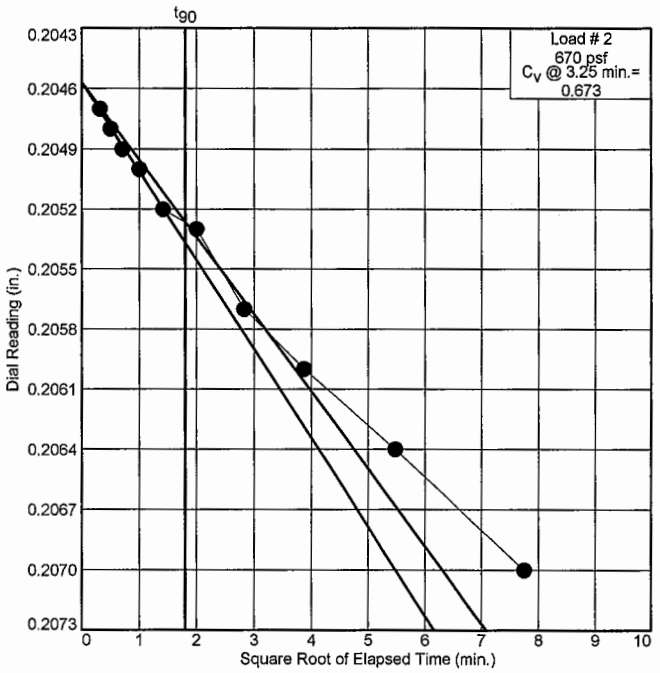
Tested By: DM **Checked By:** AL

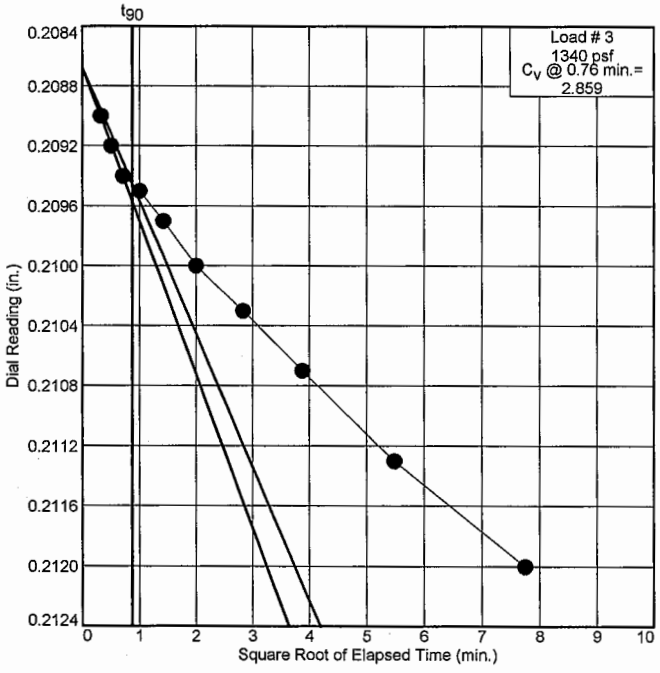
Dial Reading vs. Time

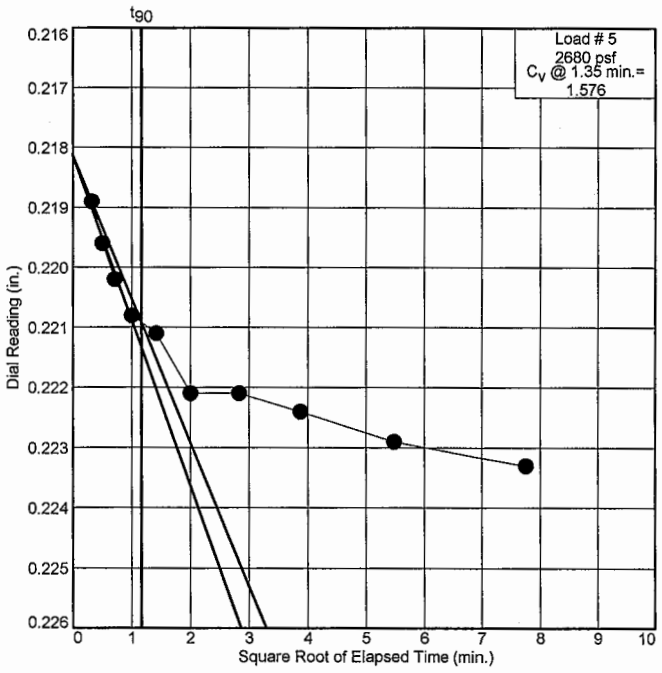
Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-7 Depth: 3'









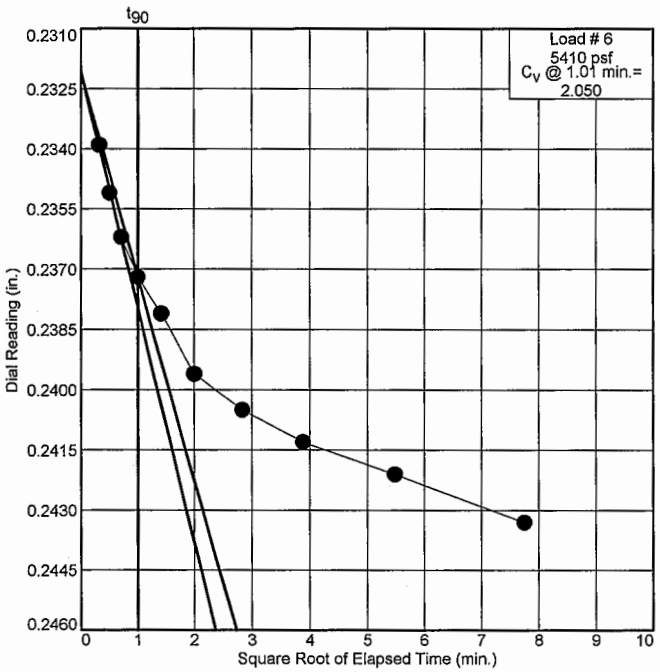
SOILS ENGINEERING, INC.

Figure B-8

Dial Reading vs. Time

Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

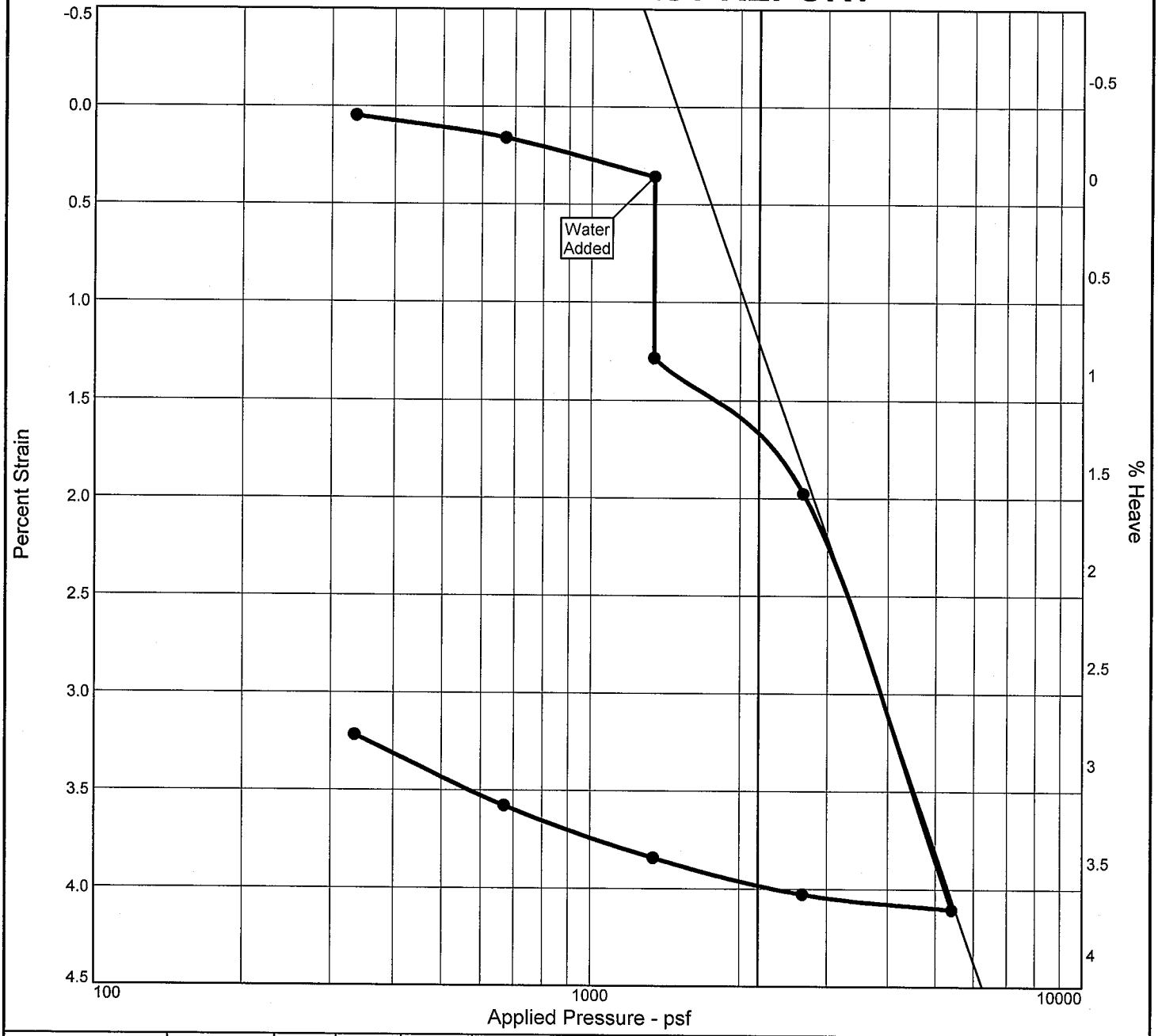
Source of Sample: B-7 Depth: 3'



SOILS ENGINEERING, INC.

Figure B-8

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_s	Swell Press. (psf)	Heave %	e_o
58.5 %	14.5 %	99.8	N/A	N/A	2.65	336	2601	0.12	0.01		-0.9	0.658

MATERIAL DESCRIPTION	USCS	AASHTO
CLAYEY SAND	SC	N/A

Project No. 17662 **Client:** Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-9 **Depth:** 3'

Remarks:
Test Date: 06/11/20

SOILS ENGINEERING, INC.

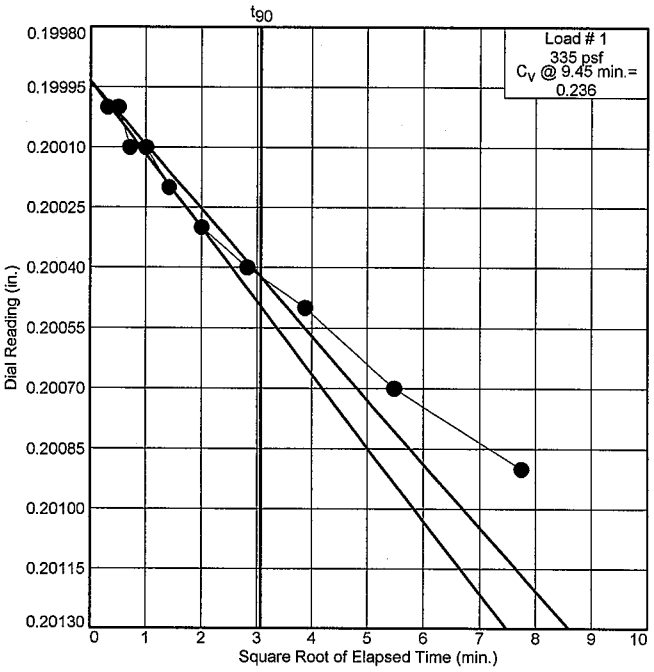
Figure B-9

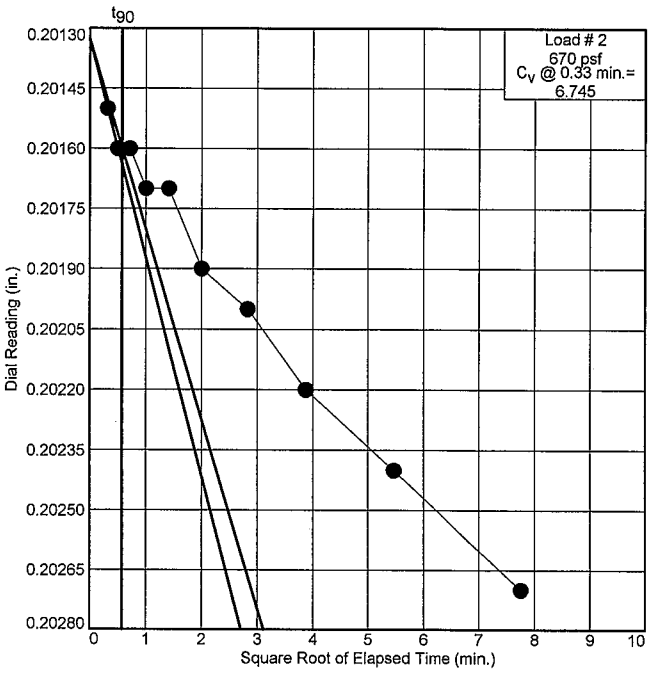
Tested By: DM **Checked By:** AL

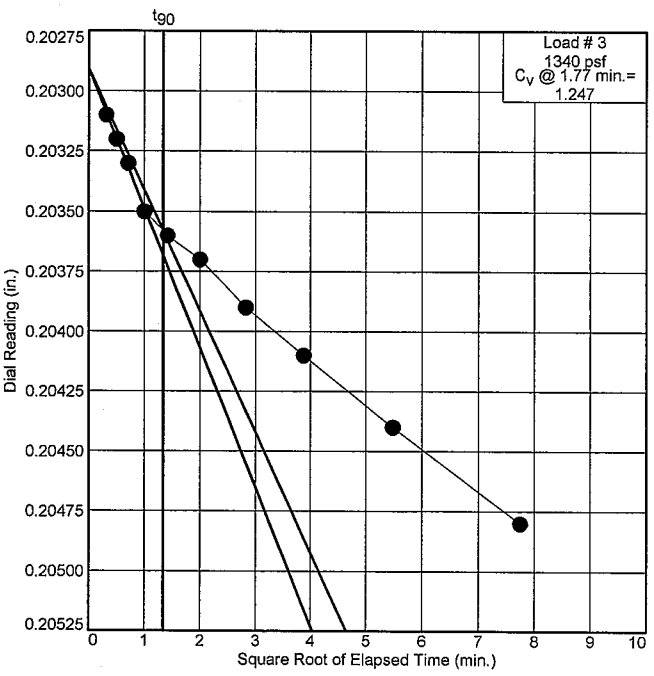
Dial Reading vs. Time

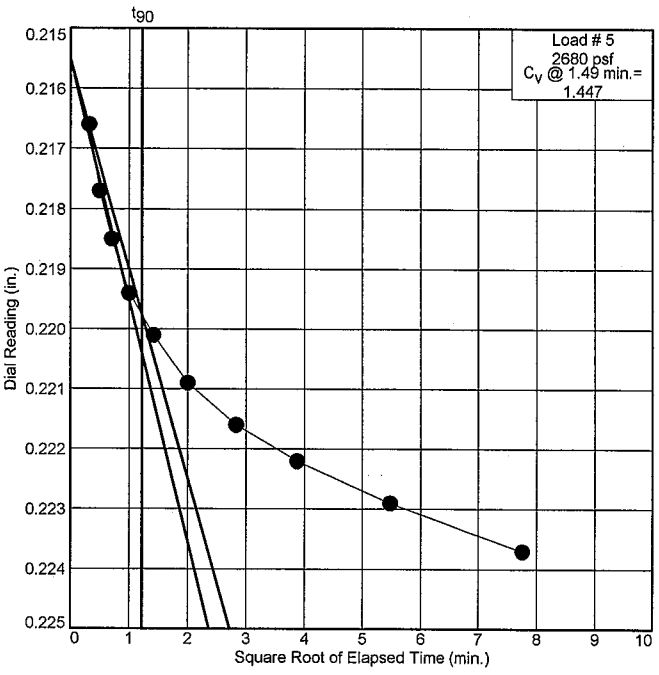
Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-9 Depth: 3'









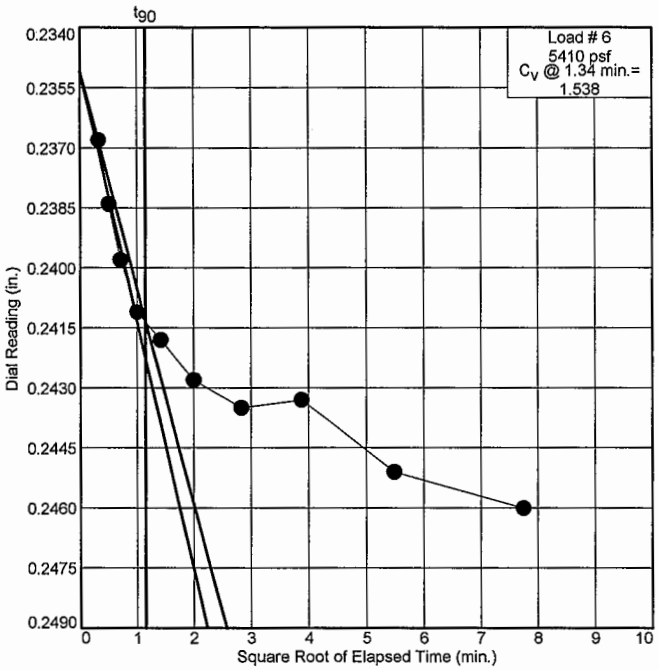
SOILS ENGINEERING, INC.

Figure B-9

Dial Reading vs. Time

Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

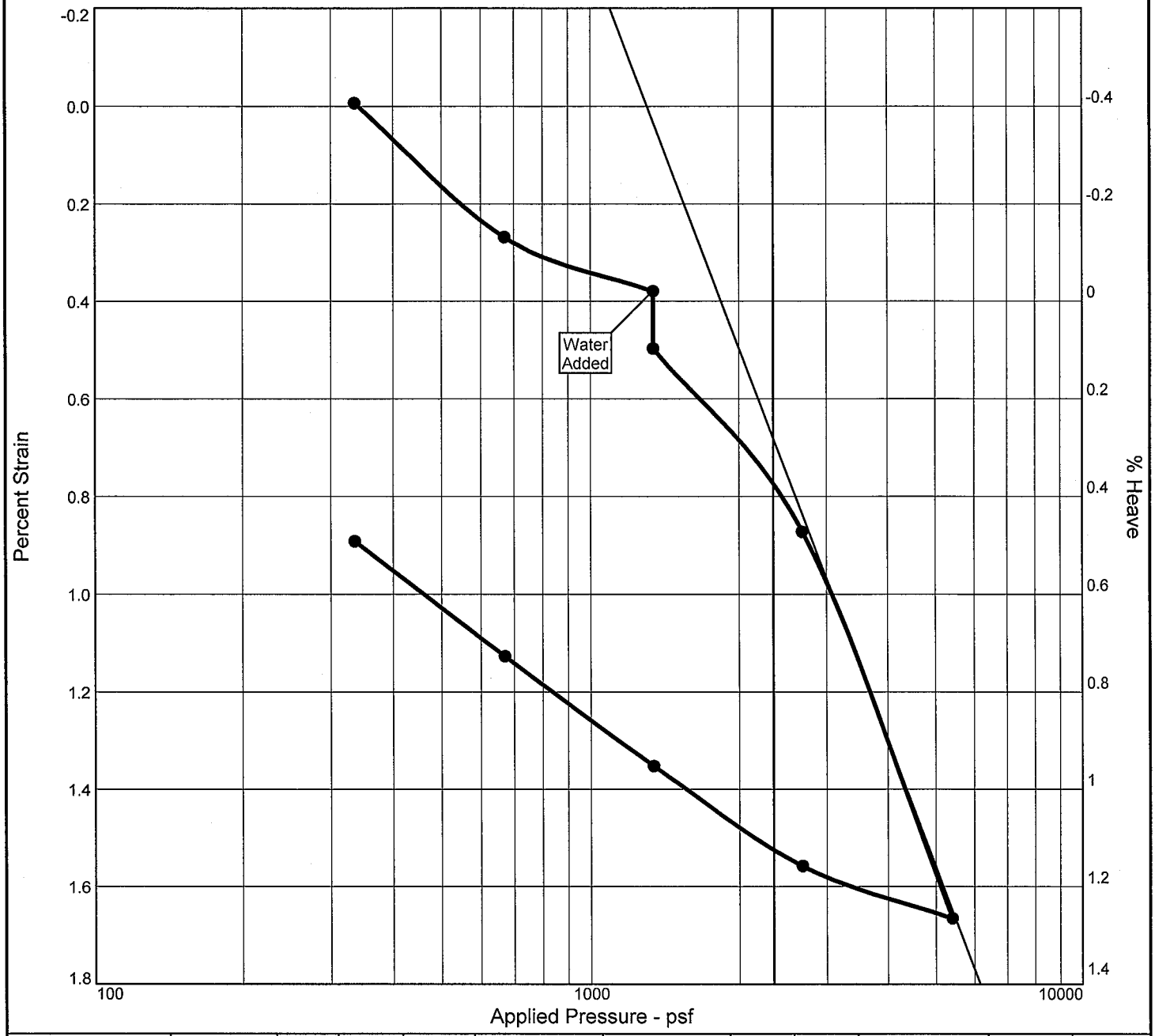
Source of Sample: B-9 Depth: 3'



SOILS ENGINEERING, INC.

Figure B-9

CONSOLIDATION TEST REPORT



Natural		Dry Dens.	LL	PI	Sp.	Overburden	P_c	C_c	C_s	Swell Press.	Heave	e_o
Sat.	Moist.	(pcf)			Gr.	(psf)	(psf)			(psf)	%	
75.3 %	14.3 %	110.0	N/A	N/A	2.65	336	2618	0.04	0.01		-0.1	0.503

MATERIAL DESCRIPTION	USCS	AASHTO
CLAYEY SAND	SC	N/A

Project No. 17662 **Client:** Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-9 **Depth:** 6'

Remarks:

Test Date: 07/07/20

SOILS ENGINEERING, INC.

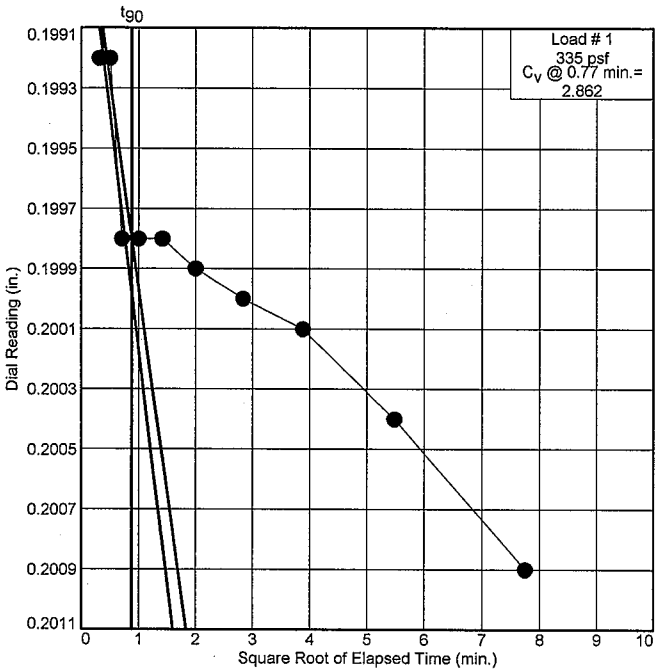
Figure B-10

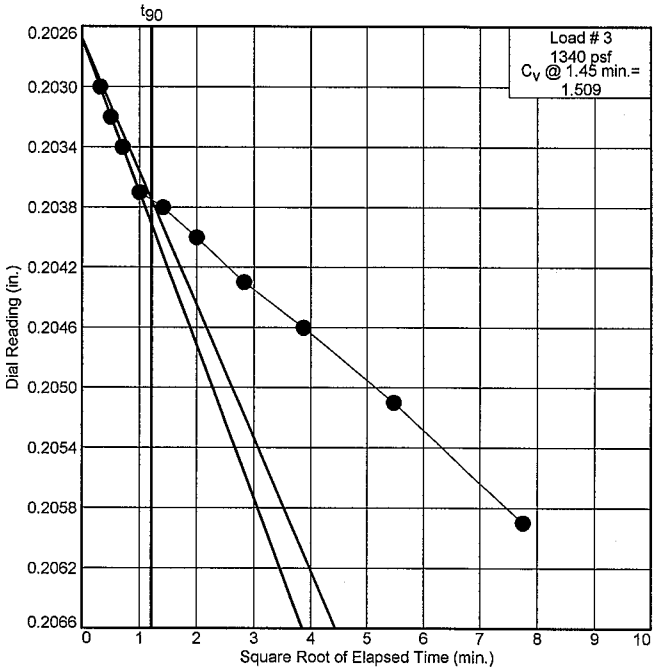
Tested By: EV **Checked By:** RG

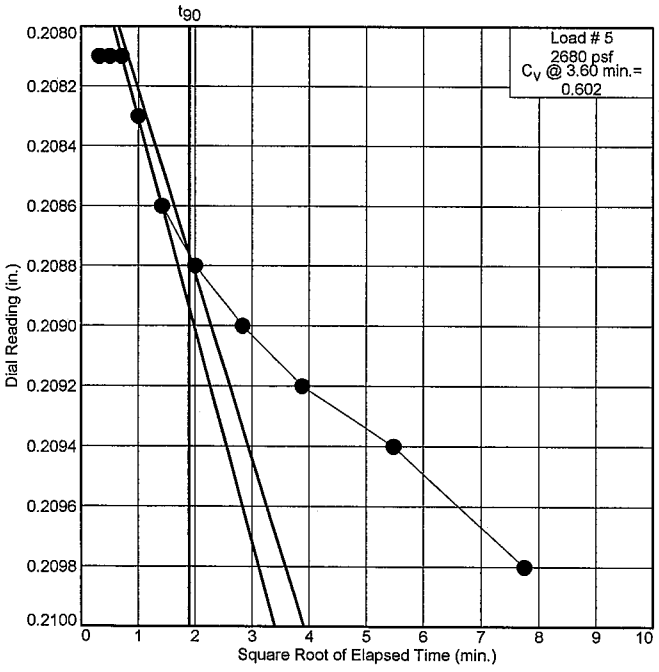
Dial Reading vs. Time

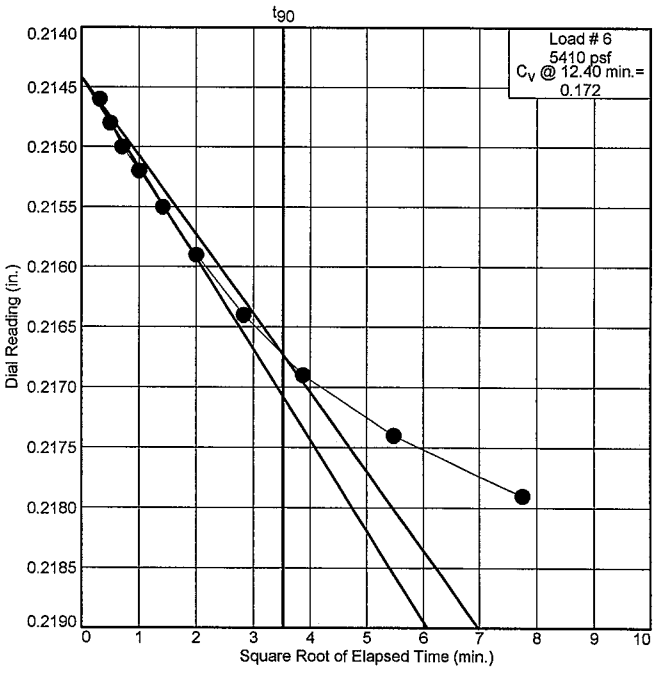
Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-9 Depth: 6'





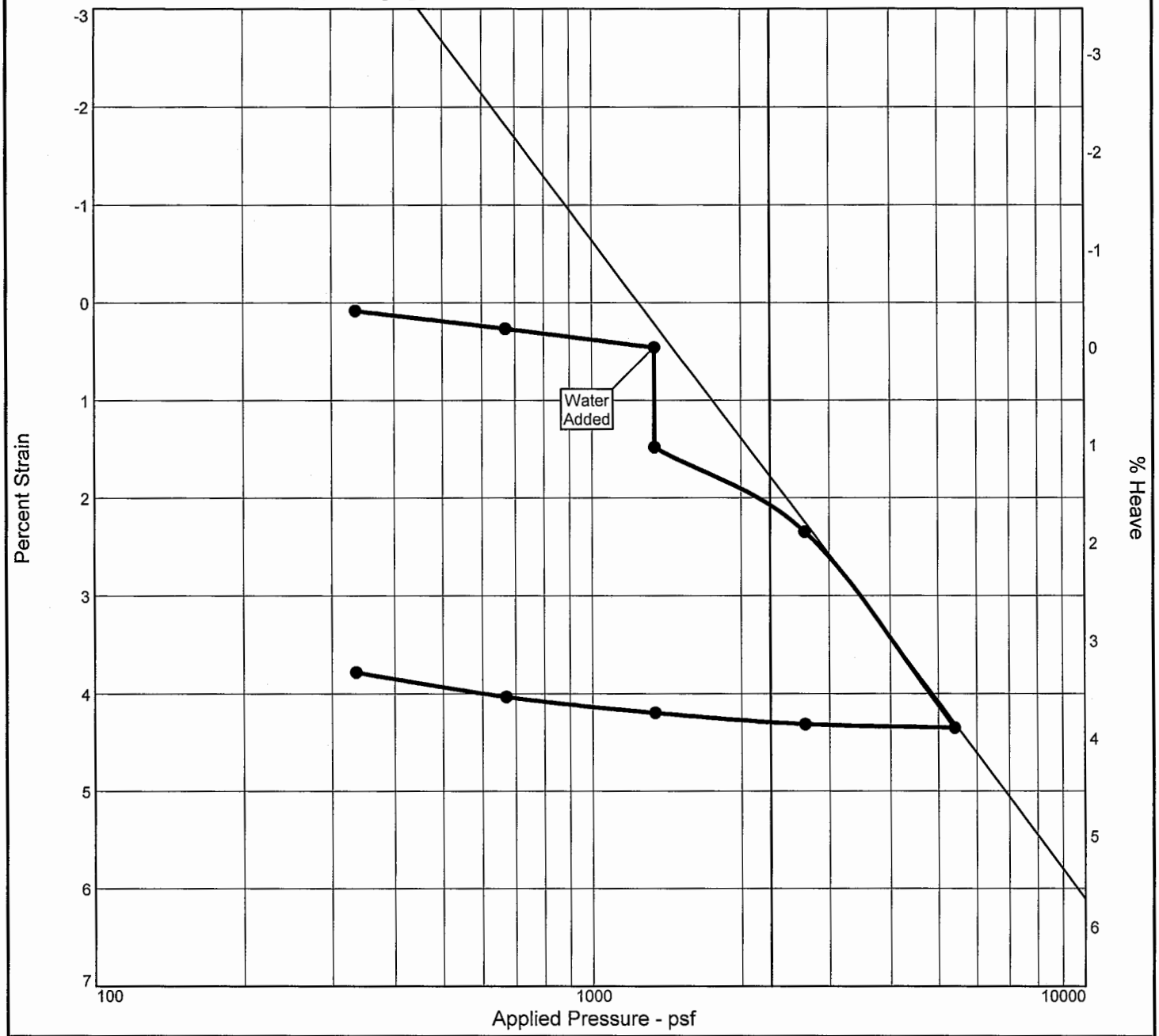




SOILS ENGINEERING, INC.

Figure B-10

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_s	Swell Press. (psf)	Heave %	e_o
55.7 %	12.8 %	102.8	N/A	N/A	2.65	336	2604	0.11	0.01		-1.0	0.610

MATERIAL DESCRIPTION	USCS	AASHTO
CLAYEY SAND	SC	N/A

Project No. 17662 **Client:** Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-12 **Depth:** 3'

Remarks:
Test Date: 06/11/20

SOILS ENGINEERING, INC.

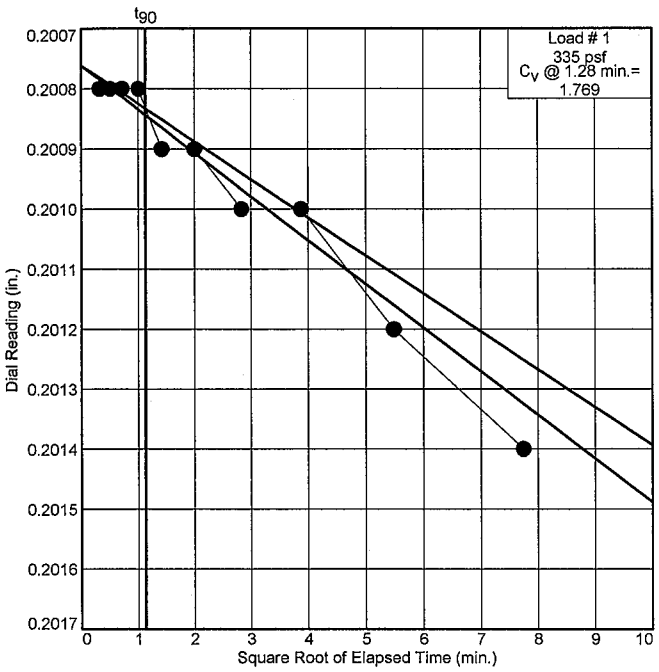
Figure B-11

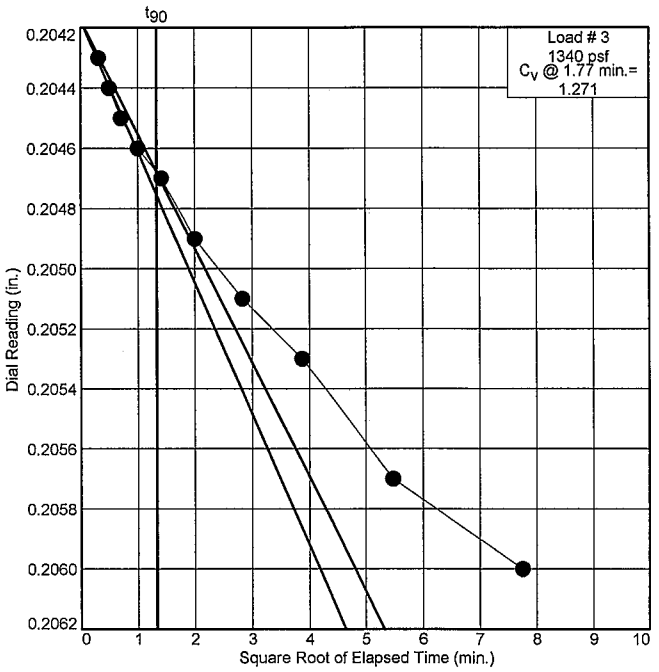
Tested By: DM **Checked By:** AL

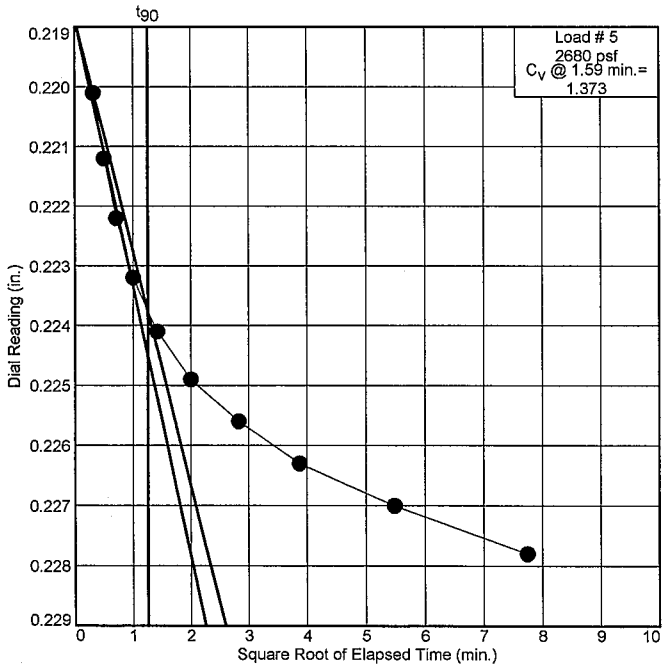
Dial Reading vs. Time

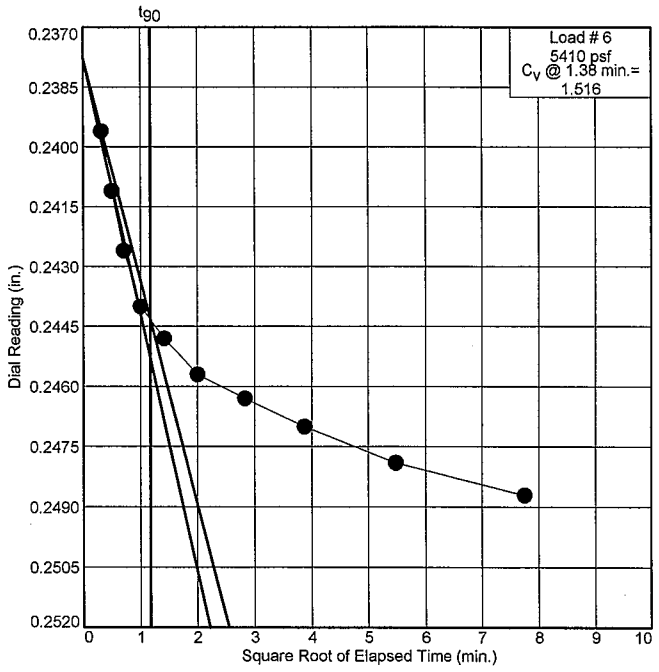
Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-12 Depth: 3'





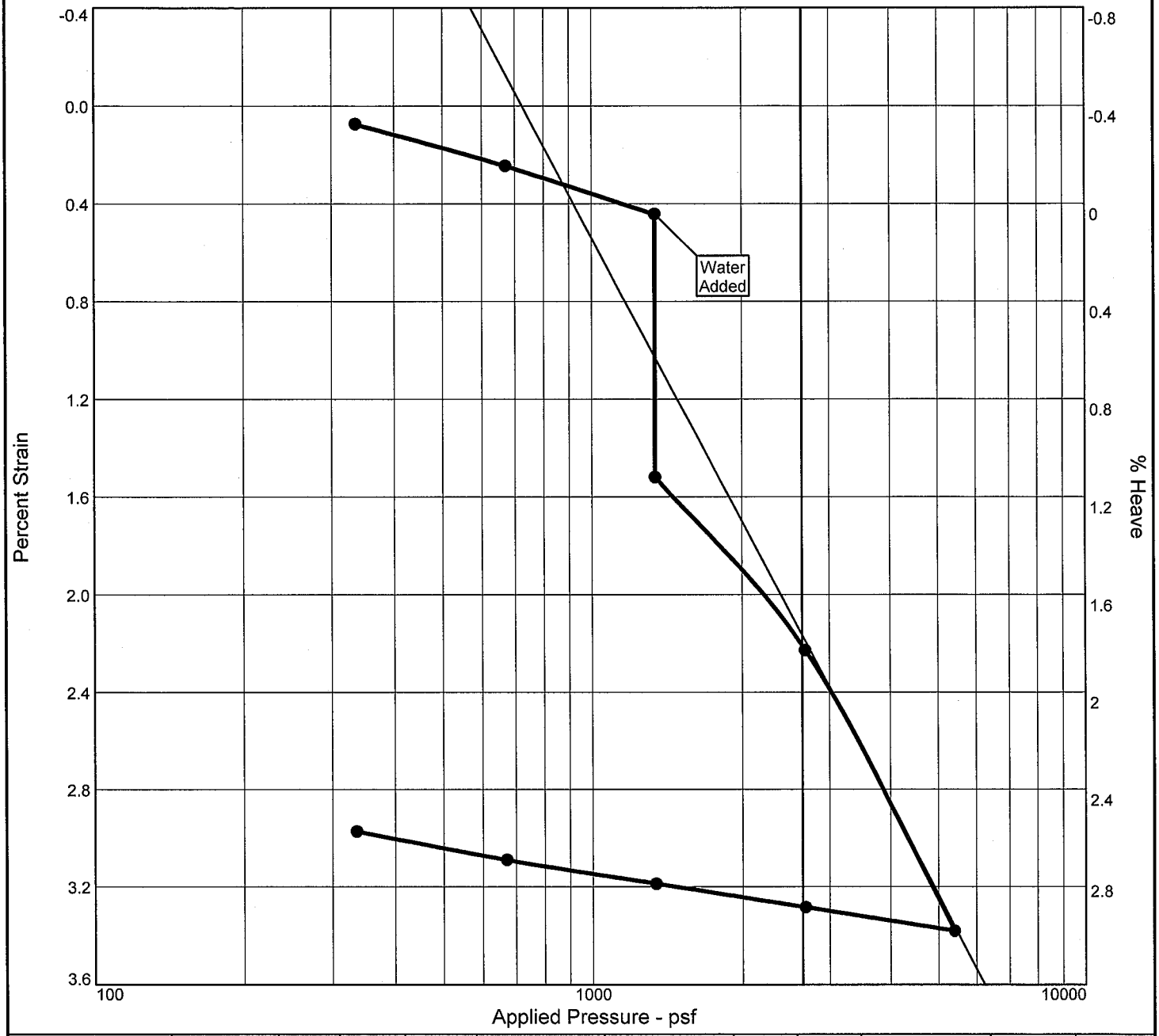




SOILS ENGINEERING, INC.

Figure B-11

CONSOLIDATION TEST REPORT



Natural		Dry Dens.	LL	PI	Sp.	Overburden	P_c	C_c	C_s	Swell Press.	Heave	e_o
Sat.	Moist.	(pcf)			Gr.	(psf)	(psf)			(psf)	%	
25.5 %	7.6 %	92.6	N/A	N/A	2.65	336	2757	0.07	0.01		-1.1	0.787

MATERIAL DESCRIPTION	USCS	AASHTO
POORLY GRADED SAND	SP	N/A

Project No. 17662 **Client:** Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-14 **Depth:** 11'

Remarks:

Test Date: 07/07/20

SOILS ENGINEERING, INC.

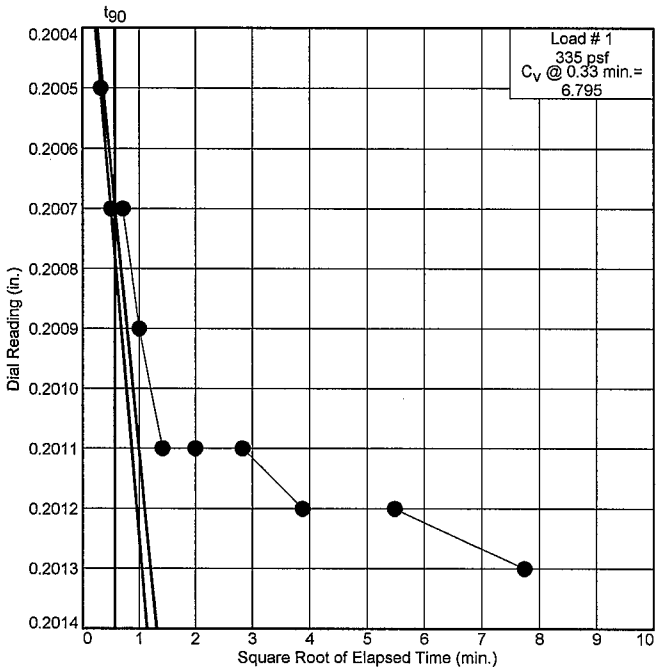
Figure B-12

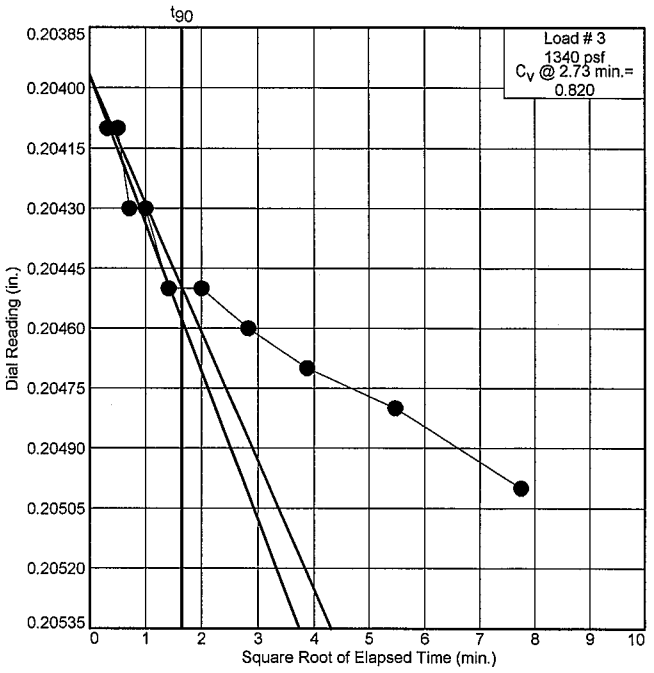
Tested By: EV **Checked By:** AL

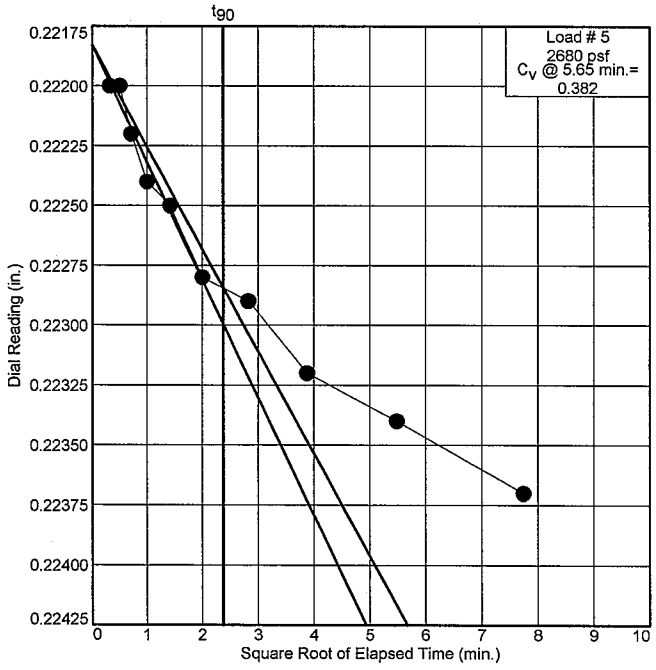
Dial Reading vs. Time

Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-14 Depth: 11'



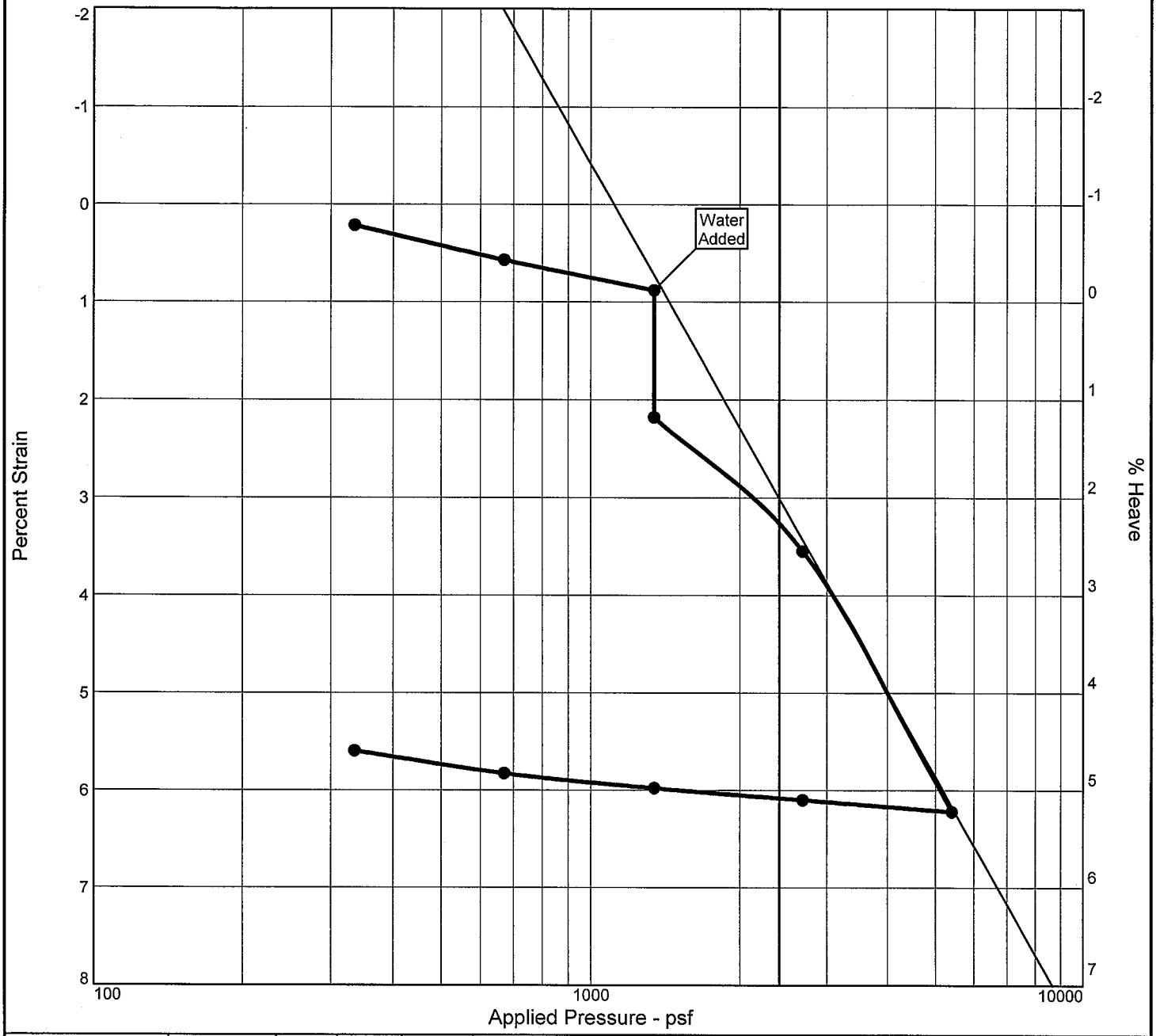




SOILS ENGINEERING, INC.

Figure B-12

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_s	Swell Press. (psf)	Heave %	e_o
52.6 %	13.9 %	97.3	N/A	N/A	2.65	336	2637	0.15	0.01		-1.3	0.701

MATERIAL DESCRIPTION	USCS	AASHTO
CLAYEY SAND	SC	N/A

Project No. 17662 **Client:** Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Location: TP-1 @ 0-5' **Depth:** 0-5' **Sample Number:** 74622

Remarks:
Test Date: 07/07/20

SOILS ENGINEERING, INC.

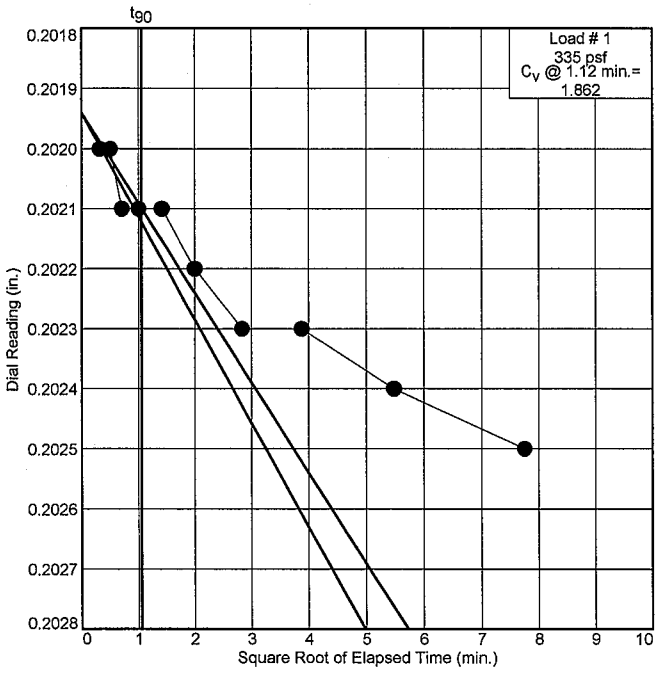
Figure B-13

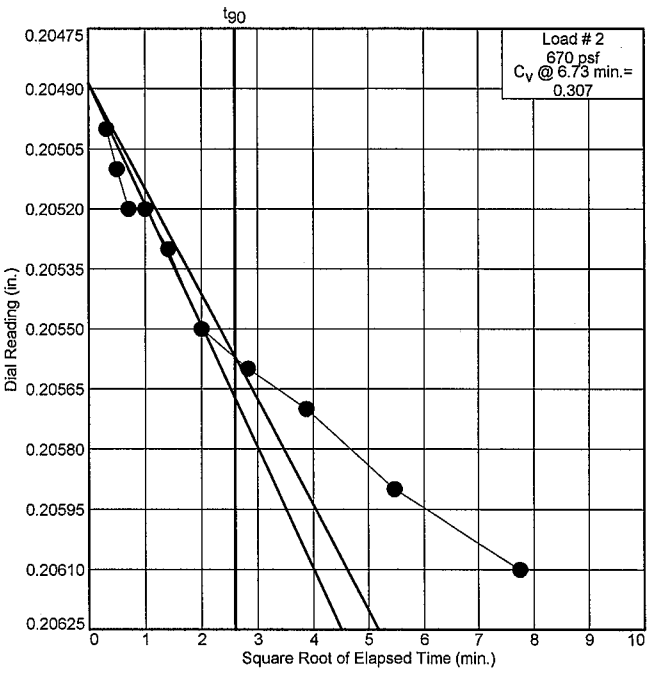
Tested By: EV **Checked By:** AL

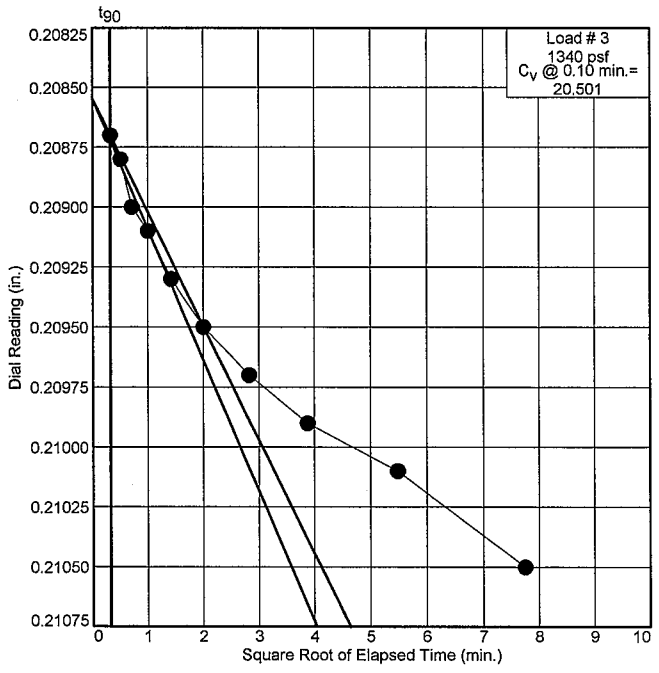
Dial Reading vs. Time

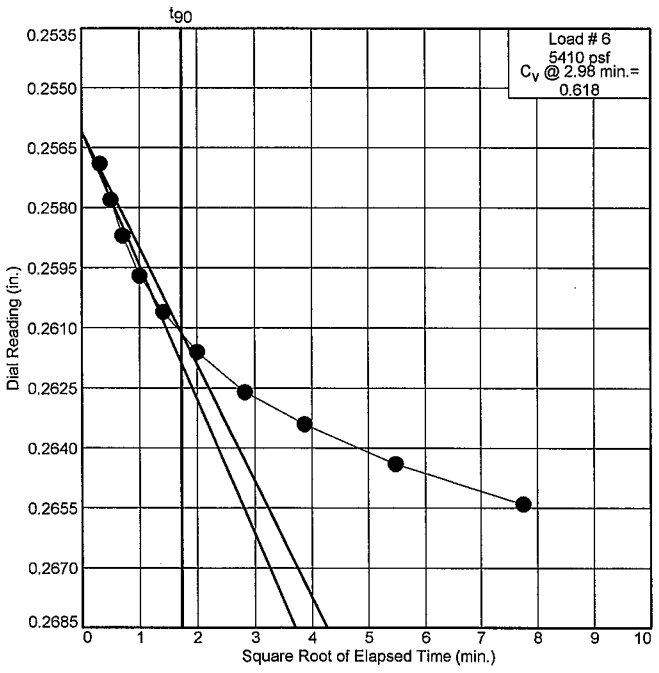
Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Location: TP-1 @ 0-5' Depth: 0-5' Sample Number: 74622





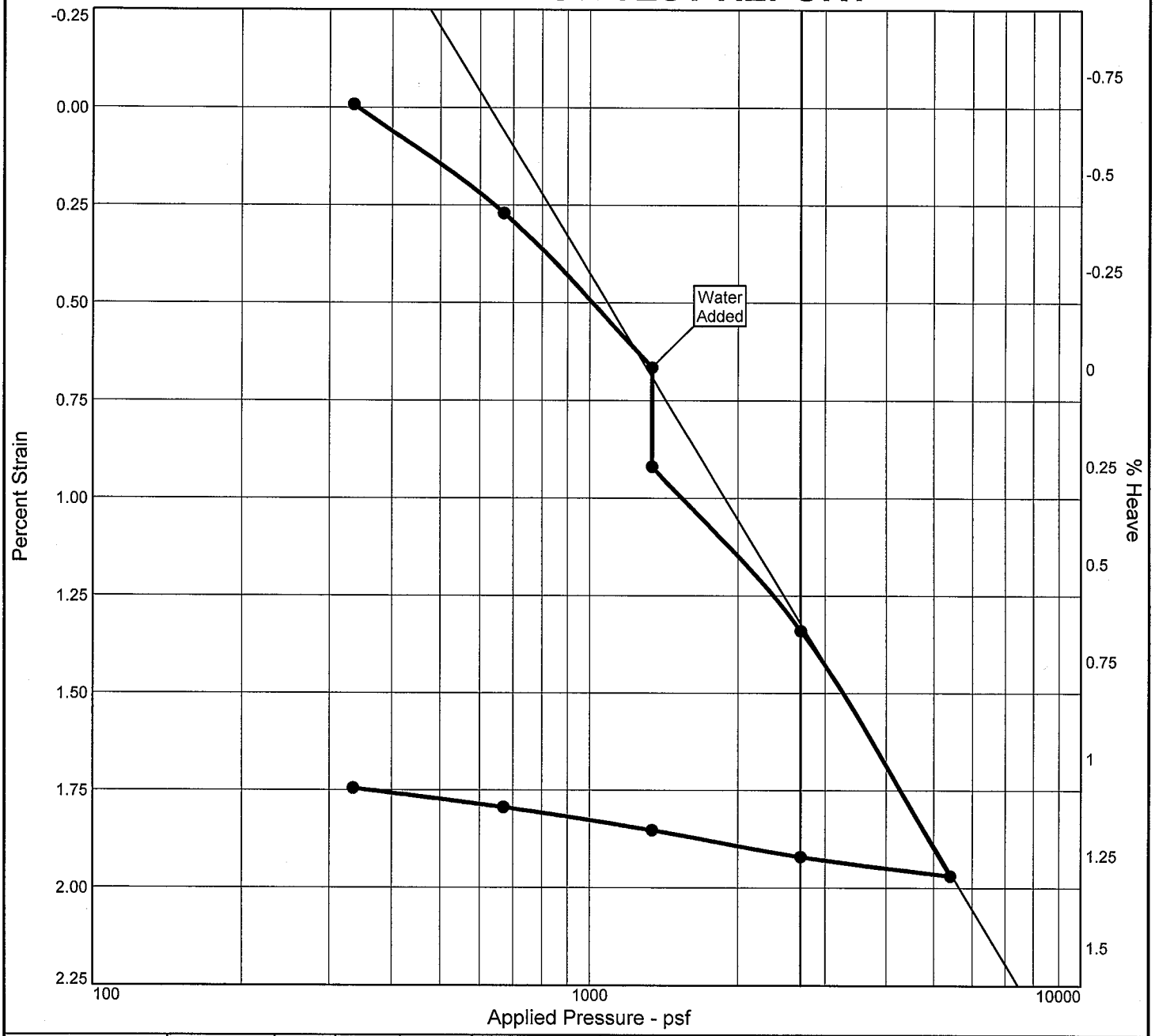




SOILS ENGINEERING, INC.

Figure B-13

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_s	Swell Press. (psf)	Heave %	e_o
Sat.	Moist.											
43.7 %	9.0 %	106.9	N/A	N/A	2.65	336	2767	0.03	0.00		-0.3	0.547

MATERIAL DESCRIPTION	USCS	AASHTO
POORLY GRADED SAND with silt/low fine content	SP-SM	N/A

Project No. 17662 **Client:** Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Location: TP-1 @ 6-12' **Depth:** 6-12' **Sample Number:** 74624

Remarks:
Test Date: 07/07/20

SOILS ENGINEERING, INC.

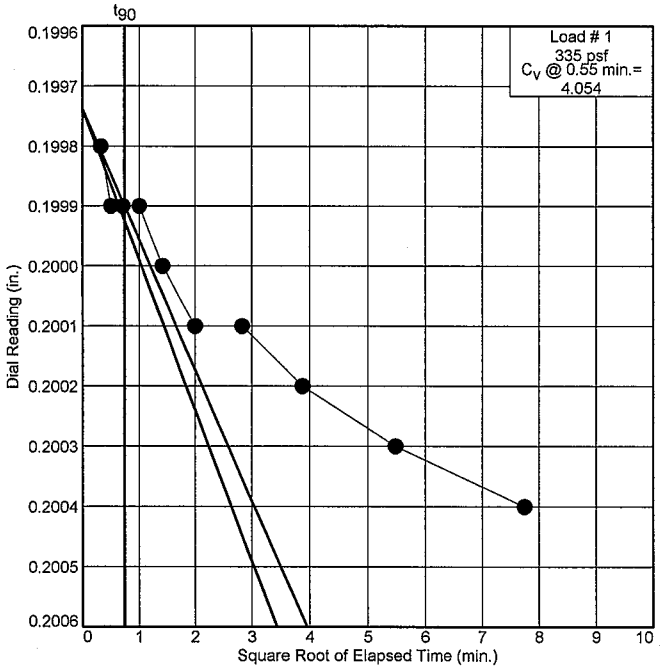
Figure B-14

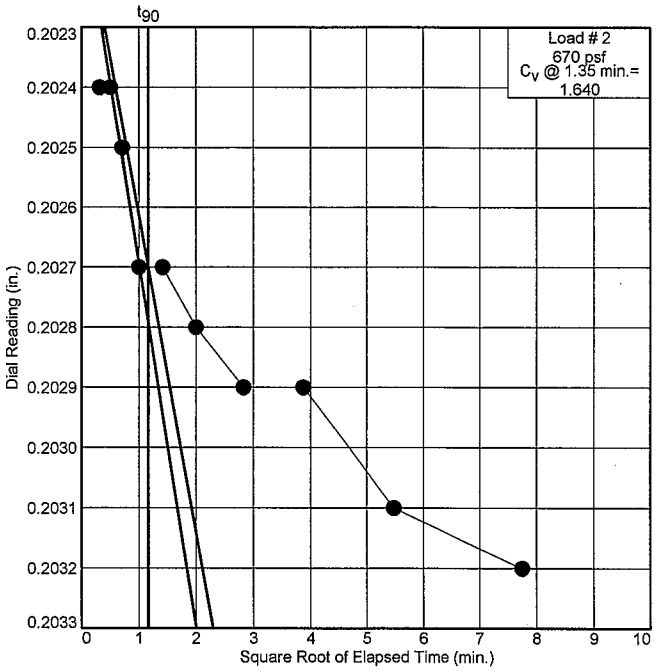
Tested By: EV **Checked By:** AL

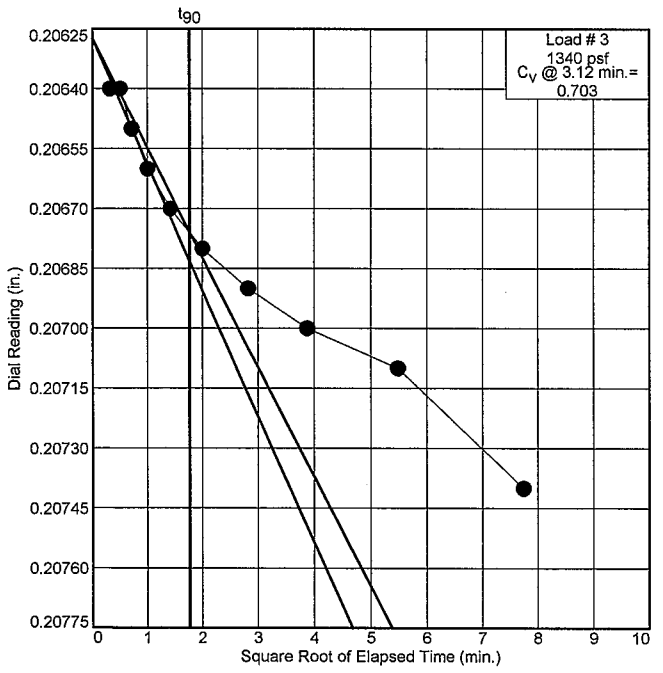
Dial Reading vs. Time

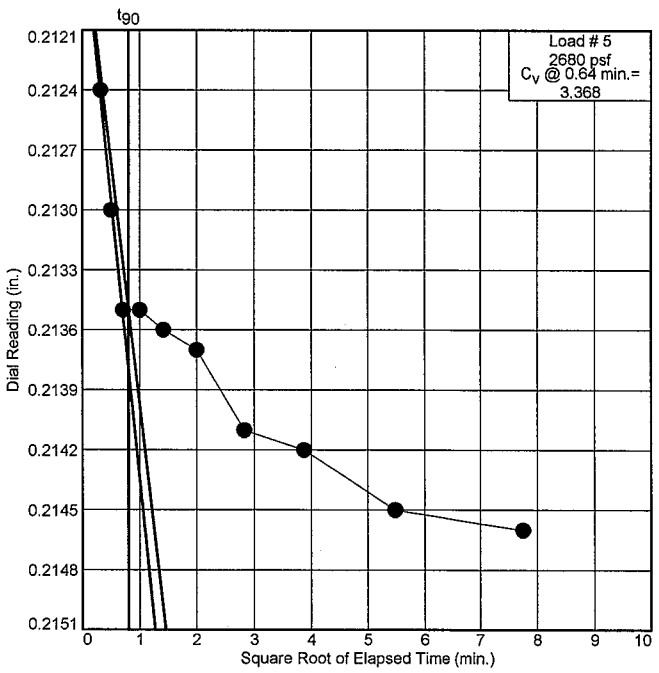
Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Location: TP-1 @ 6-12' Depth: 6-12' Sample Number: 74624









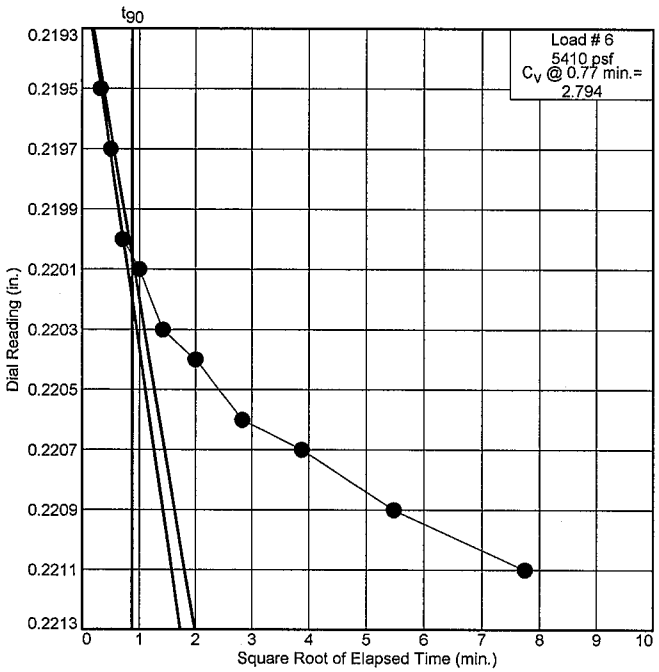
SOILS ENGINEERING, INC.

Figure B-14

Dial Reading vs. Time

Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

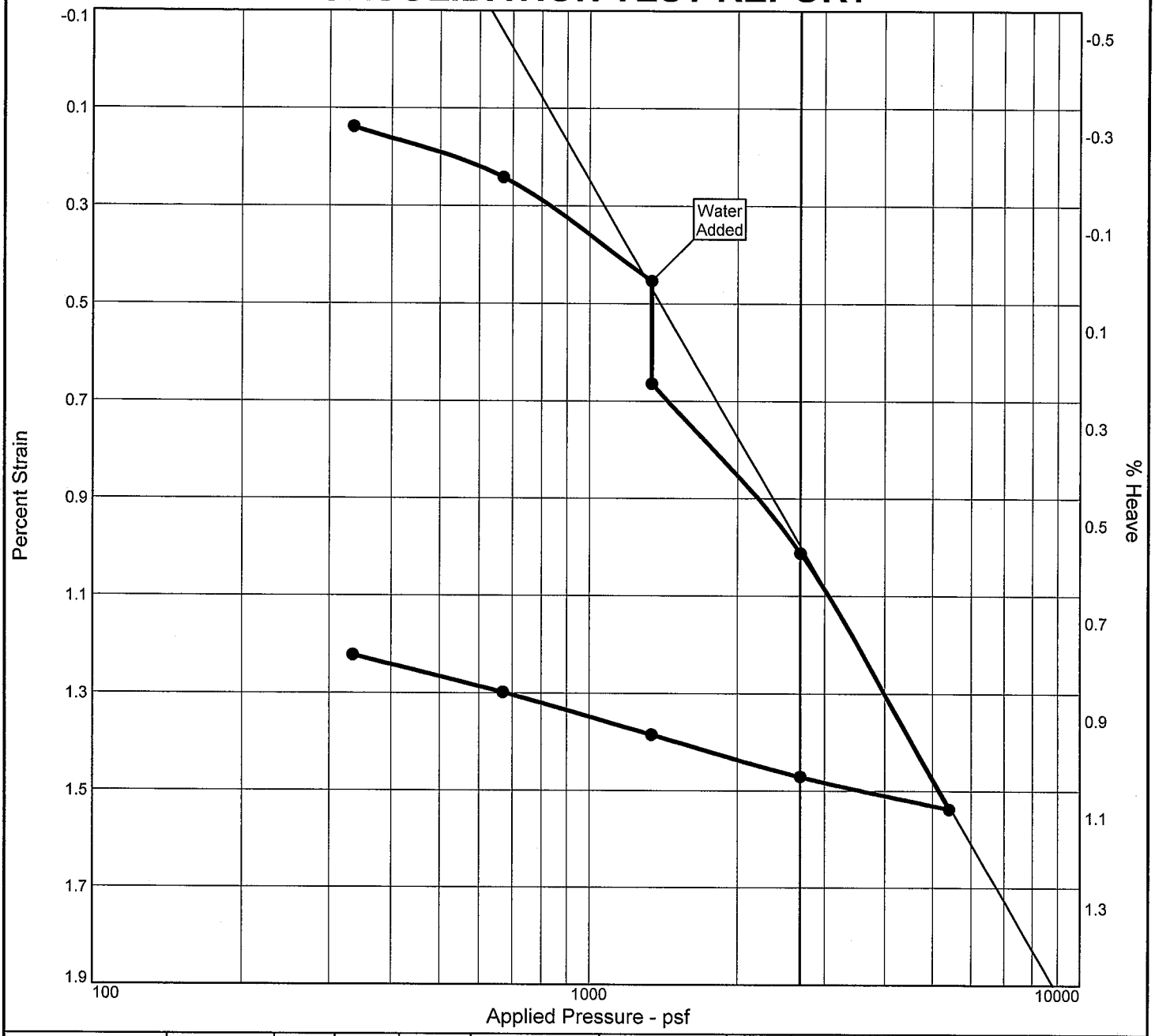
Location: TP-1 @ 6-12' Depth: 6-12' Sample Number: 74624



SOILS ENGINEERING, INC.

Figure B-14

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_s	Swell Press. (psf)	Heave %	e_o
Sat.	Moist.											
35.3 %	7.7 %	104.7	N/A	N/A	2.65	336	2769	0.03	0.00		-0.2	0.580

MATERIAL DESCRIPTION	USCS	AASHTO
POORLY GRADED SAND with silt/low fine content	SP-SM	N/A

Project No. 17662 **Client:** Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Location: TP-3 @ 0-5' **Depth:** 0-5' **Sample Number:** 74631

Remarks:

Test Date: 07/07/20

SOILS ENGINEERING, INC.

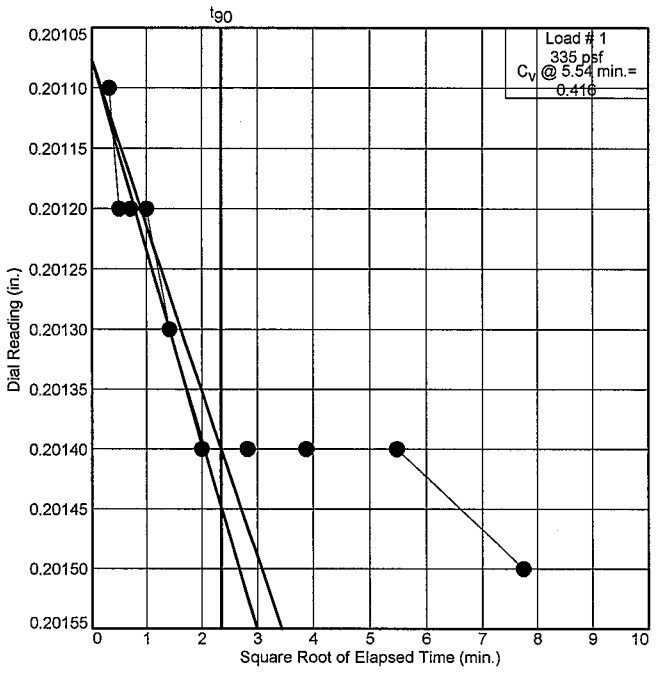
Figure B-15

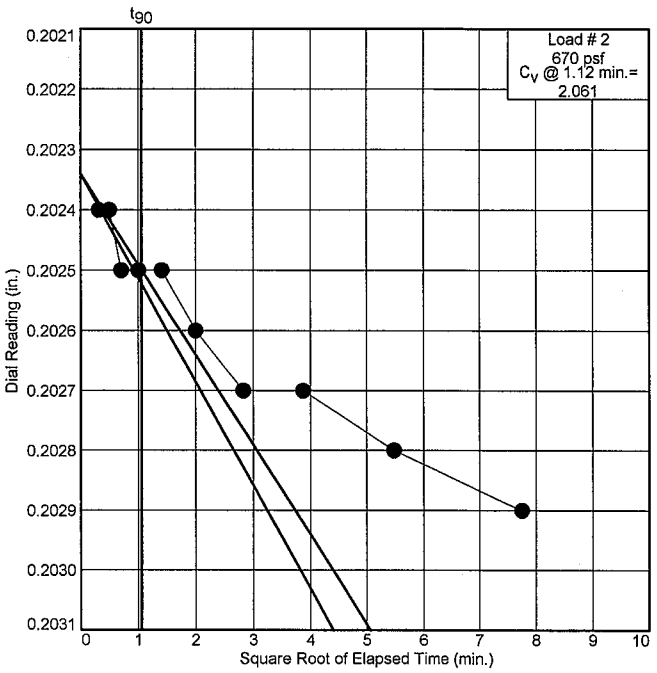
Tested By: EV **Checked By:** AL

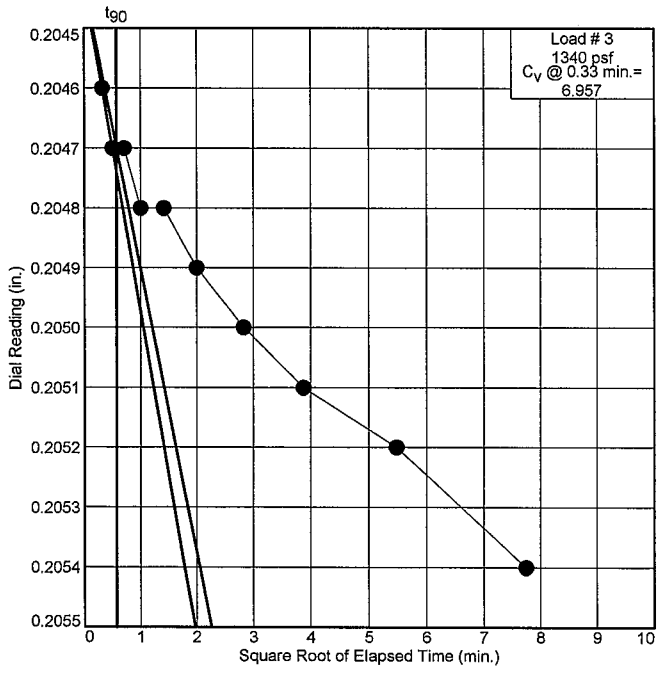
Dial Reading vs. Time

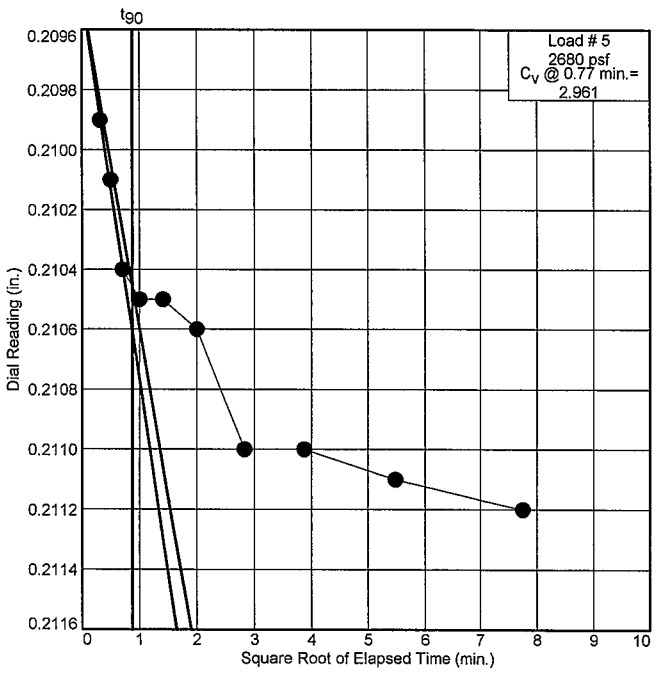
Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Location: TP-3 @ 0-5' Depth: 0-5' Sample Number: 74631









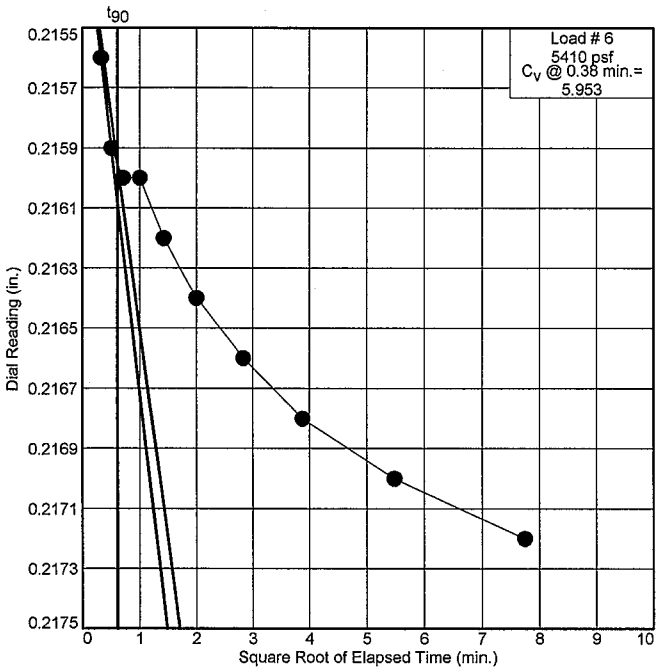
SOILS ENGINEERING, INC.

Figure B-15

Dial Reading vs. Time

Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

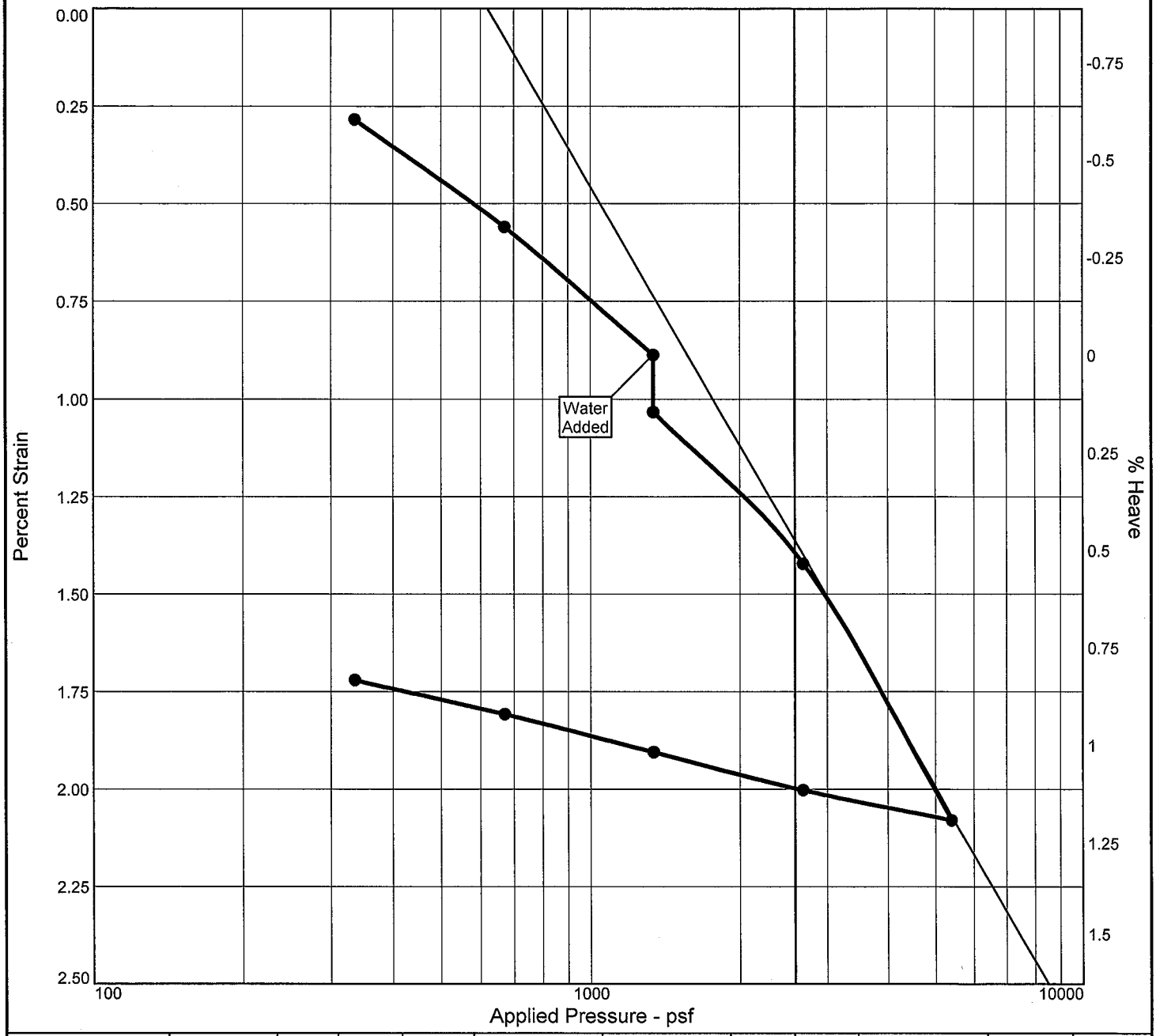
Location: TP-3 @ 0-5' Depth: 0-5' Sample Number: 74631



SOILS ENGINEERING, INC.

Figure B-15

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_s	Swell Press. (psf)	Heave %	e_o
54.5 %	14.4 %	97.2	N/A	N/A	2.65	336	2721	0.04	0.01		-0.1	0.702

MATERIAL DESCRIPTION	USCS	AASHTO
POORLY GRADED SAND with silt/low fine content	SP-SM	N/A

Project No. 17662 **Client:** Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Location: TP-4 @ 7-10' **Depth:** 7-10' **Sample Number:** 74637

Remarks:
Test Date: 07/09/20

SOILS ENGINEERING, INC.

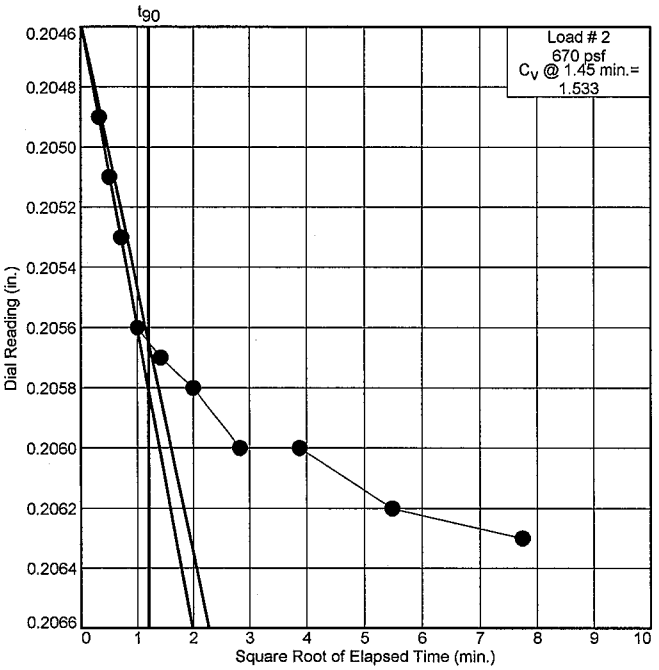
Figure B-16

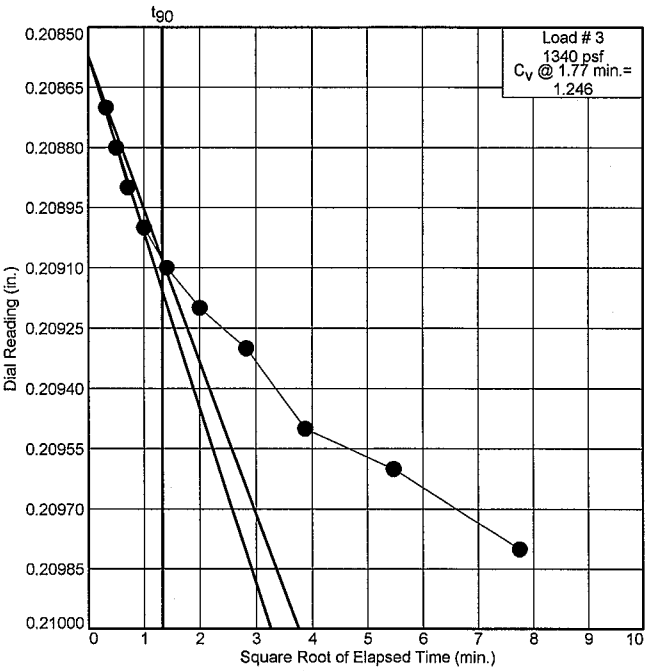
Tested By: DM **Checked By:** AL

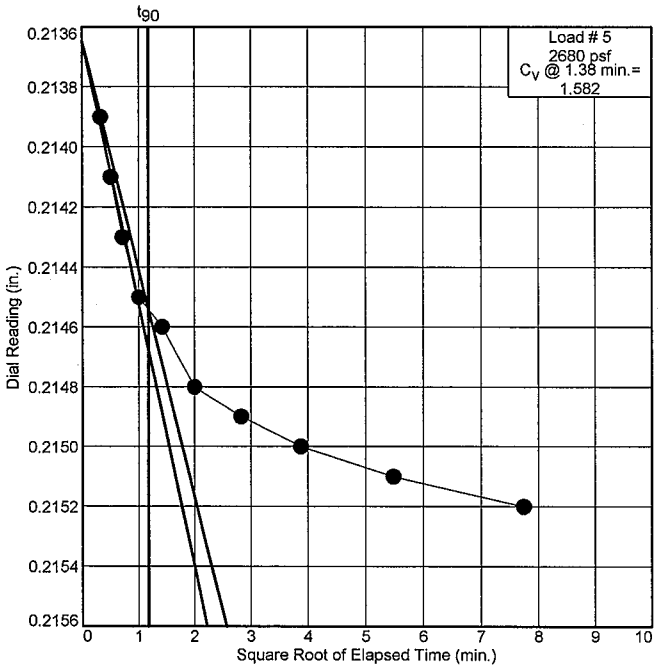
Dial Reading vs. Time

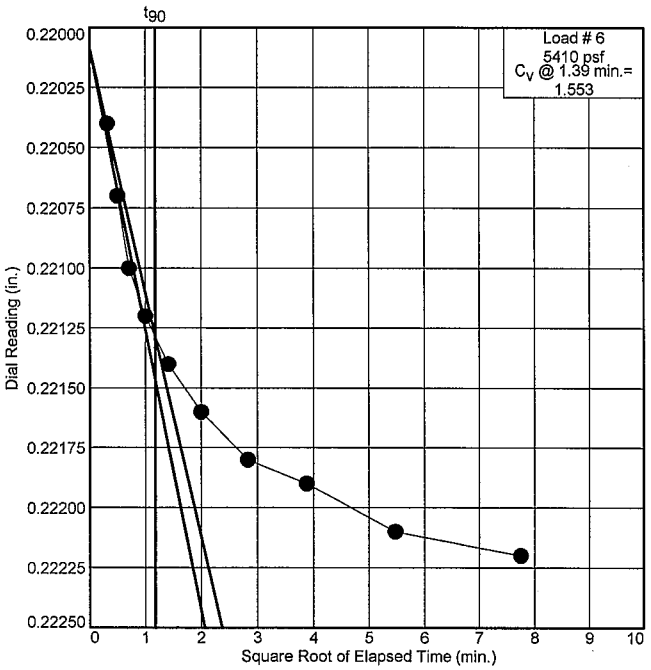
Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Location: TP-4 @ 7-10' Depth: 7-10' Sample Number: 74637





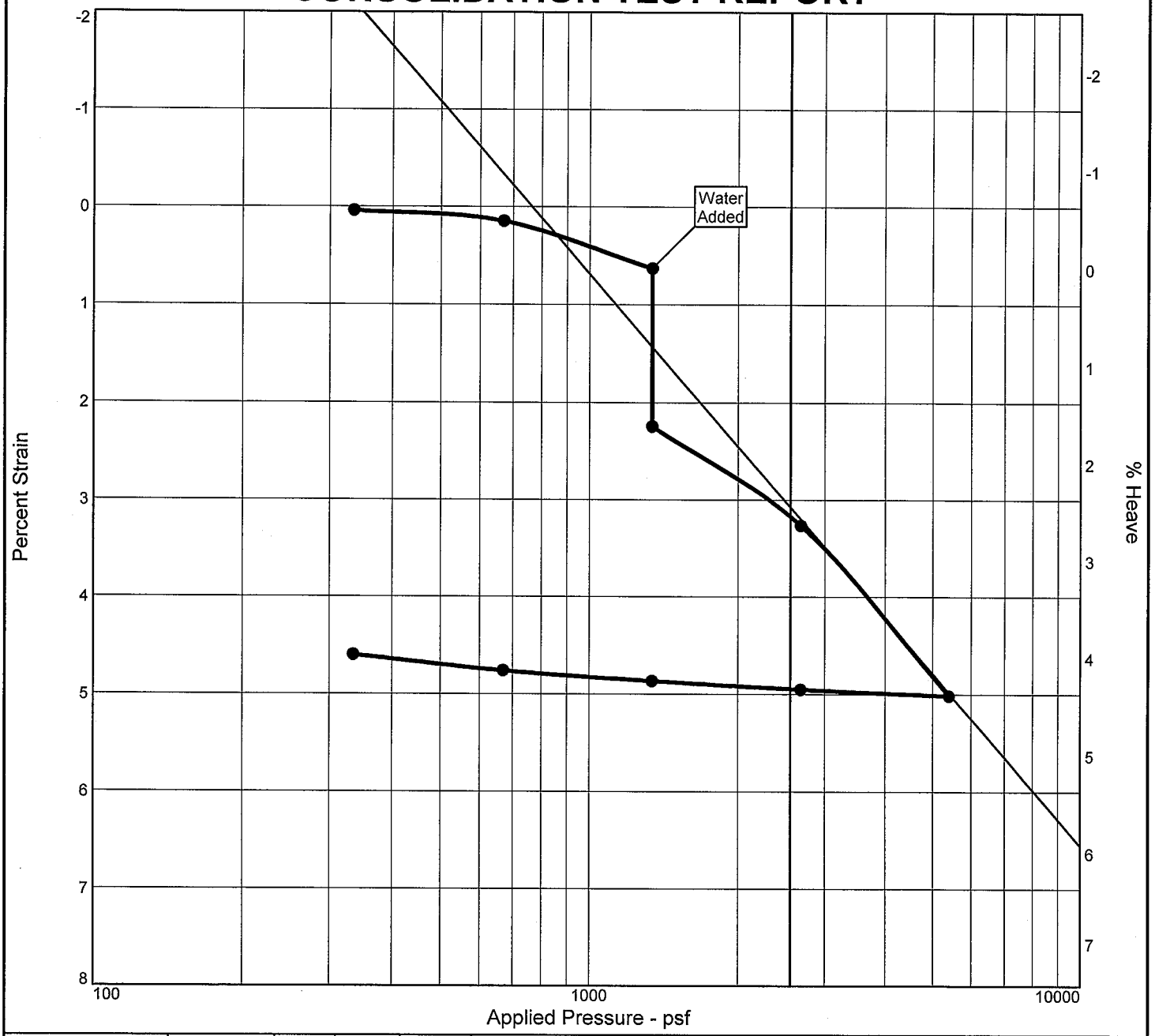




SOILS ENGINEERING, INC.

Figure B-16

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_s	Swell Press. (psf)	Heave %	e_o
38.1 %	9.6 %	99.1	N/A	N/A	2.65	336	2705	0.10	0.01		-1.6	0.670

MATERIAL DESCRIPTION	USCS	AASHTO
POORLY GRADED SAND with silt/low fine content	SP-SM	N/A

Project No. 17662 **Client:** Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Location: TP-5 @ 0-5' **Depth:** 0-5' **Sample Number:** 74639

Remarks:
Test Date: 07/09/20

SOILS ENGINEERING, INC.

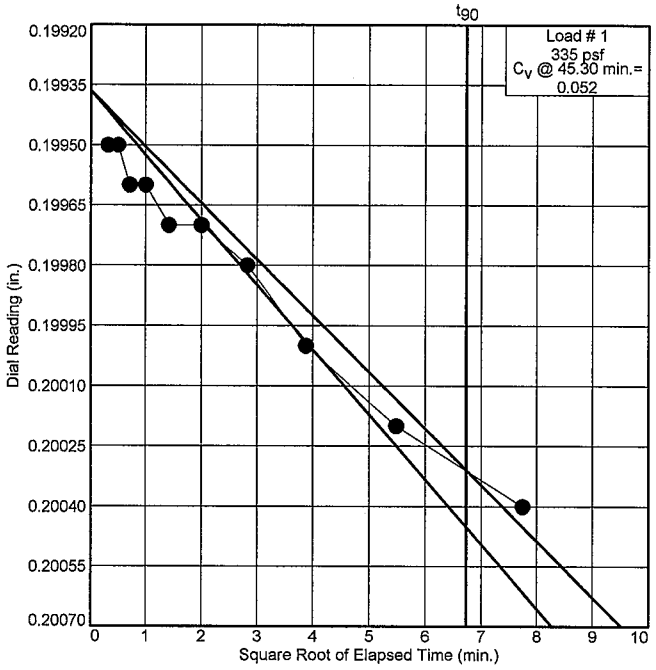
Figure B-17

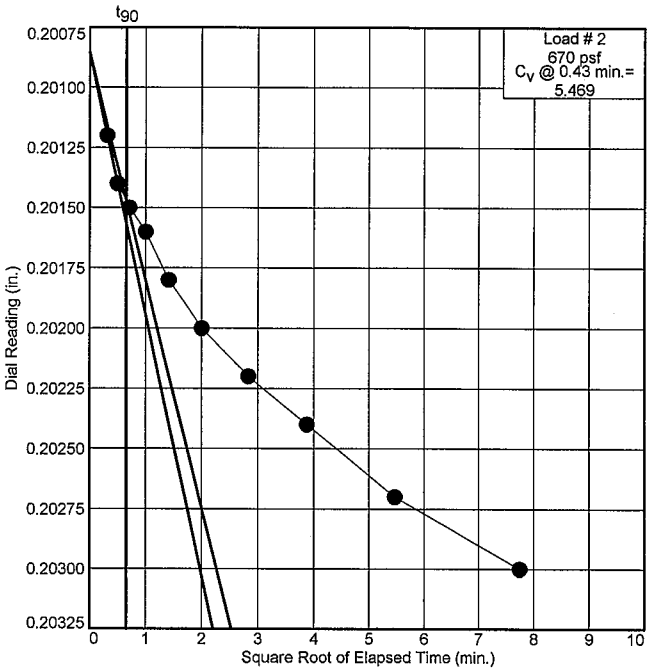
Tested By: EV **Checked By:** AL

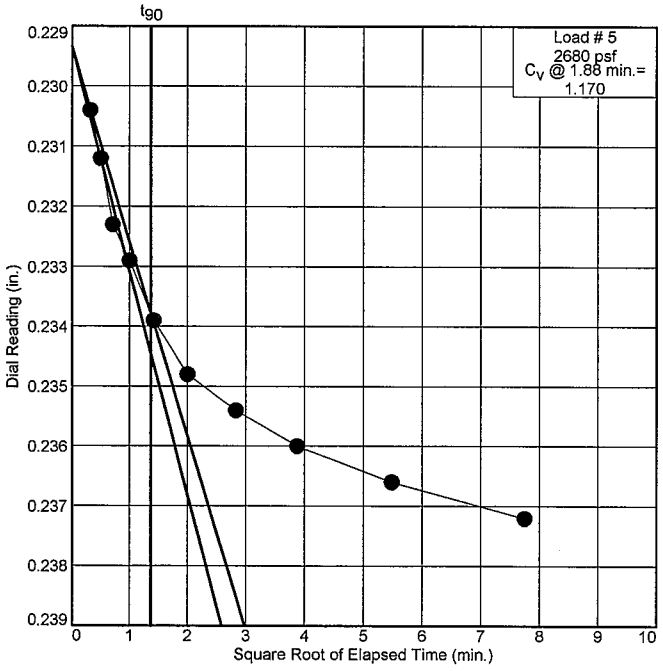
Dial Reading vs. Time

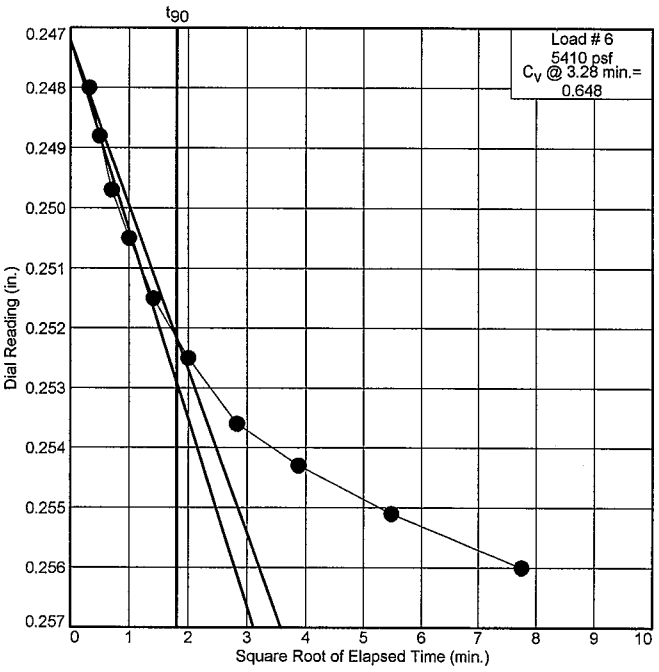
Project No.: 17662
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Location: TP-5 @ 0-5' Depth: 0-5' Sample Number: 74639



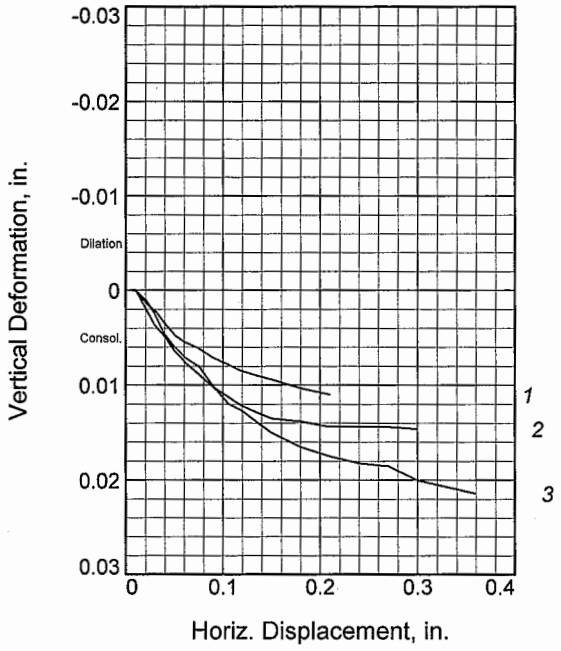


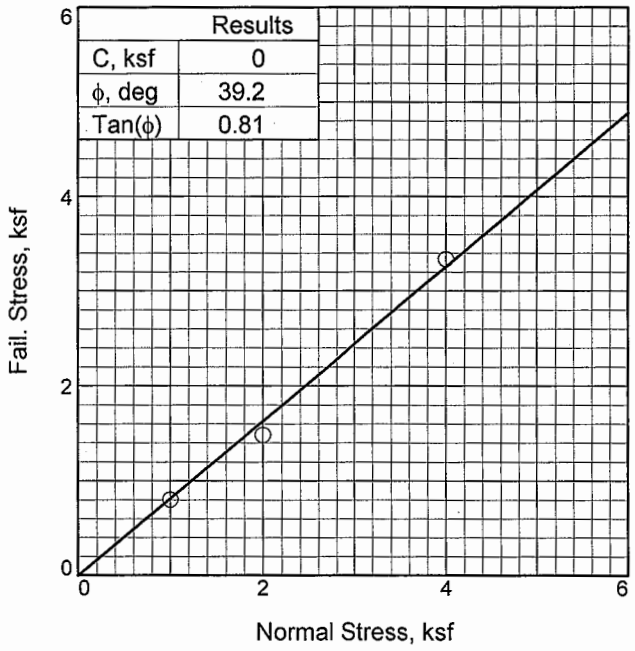


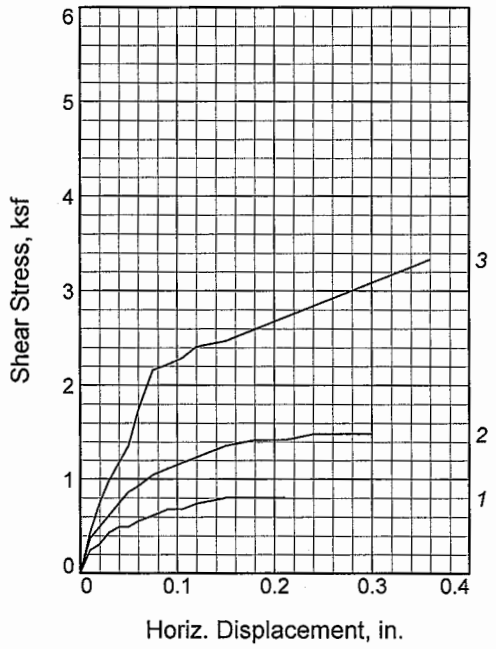


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Figure B-17







Sample No.		1	2	3
Initial	Water Content, %	10.3	11.0	10.8
	Dry Density, pcf	95.0	96.0	97.3
	Saturation, %	36.9	40.3	40.8
	Void Ratio	0.7410	0.7239	0.6995
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	20.9	20.8	20.0
	Dry Density, pcf	95.0	96.0	97.3
	Saturation, %	74.8	76.1	75.6
	Void Ratio	0.7410	0.7239	0.6995
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
Normal Stress, ksf		1.00	2.00	4.00
Fail. Stress, ksf		0.80	1.48	3.33
Displacement, in.		0.15	0.24	0.36
Ult. Stress, ksf				
Displacement, in.				
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: 2.50 x 6" TUBE
Description: SILTY SAND; yellowish brown, damp, fine, trace of gravel, medium dense.
LL= N/A **PI=** N/A
Assumed Specific Gravity= 2.65
Remarks: Test Date: 06/23/20

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-1 **Depth:** 11'

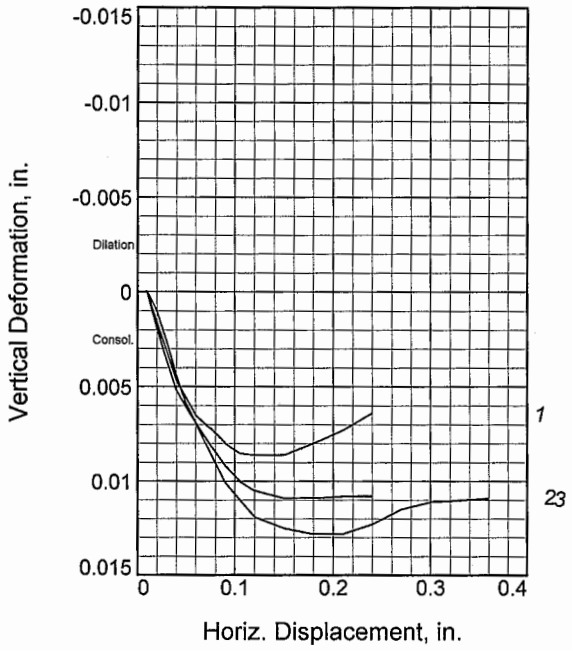
Proj. No.: 17662 **Date Sampled:** 06/12/20

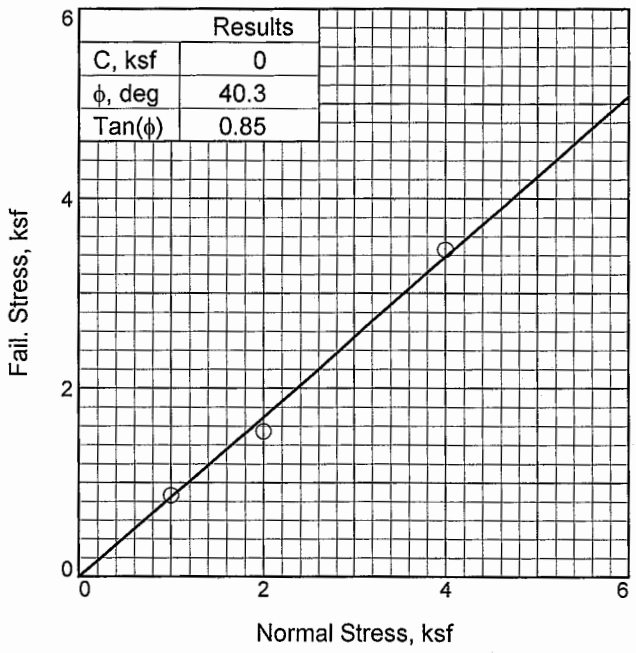
DIRECT SHEAR TEST REPORT

SOILS ENGINEERING, INC.

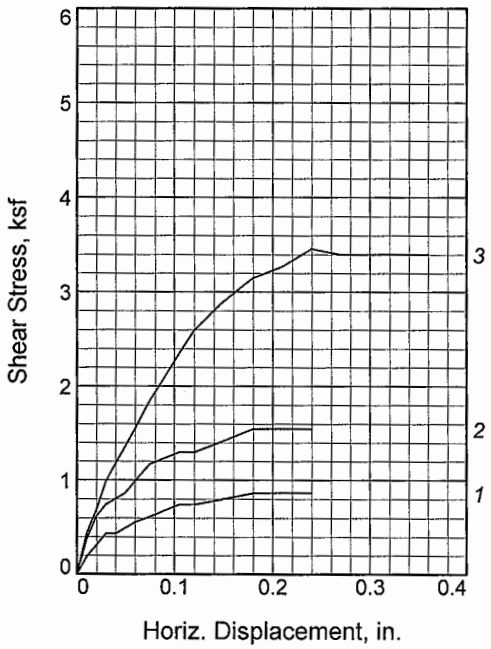
Figure C-1

Tested By: EV





Results	
C, ksf	0
ϕ, deg	40.3
Tan(ϕ)	0.85



Sample No.		1	2	3
Initial	Water Content, %	5.0	4.4	4.7
	Dry Density, pcf	101.9	100.5	103.5
	Saturation, %	21.2	17.9	20.6
	Void Ratio	0.6235	0.6457	0.5979
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	16.3	16.8	17.1
	Dry Density, pcf	101.9	100.5	103.5
	Saturation, %	69.2	68.8	75.8
	Void Ratio	0.6235	0.6457	0.5979
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
Normal Stress, ksf		1.00	2.00	4.00
Fail. Stress, ksf		0.86	1.54	3.46
Displacement, in.		0.18	0.18	0.24
Ult. Stress, ksf				
Displacement, in.				
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: 2.50" x 6" TUBE
Description: POORLY GRADED SAND; light yellowish brown, dry, very dense, fine, rock.
LL= N/A **PI=** N/A
Assumed Specific Gravity= 2.65
Remarks: Test Date: 06/10/20

Figure C-2

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

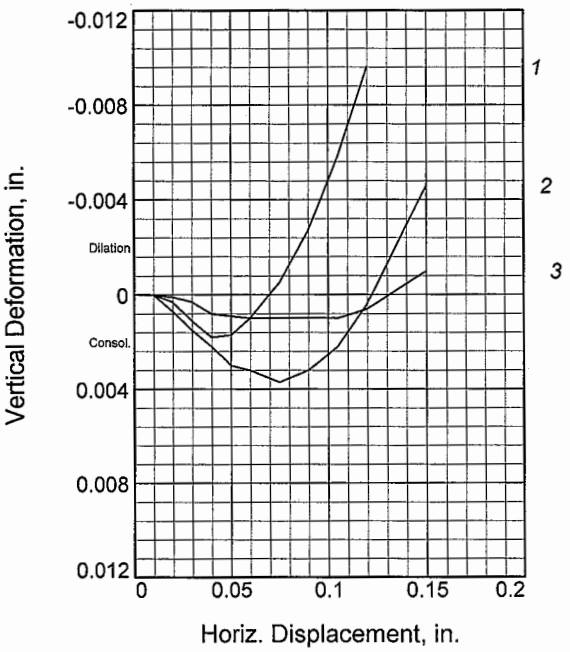
Source of Sample: B-2 **Depth:** 11'

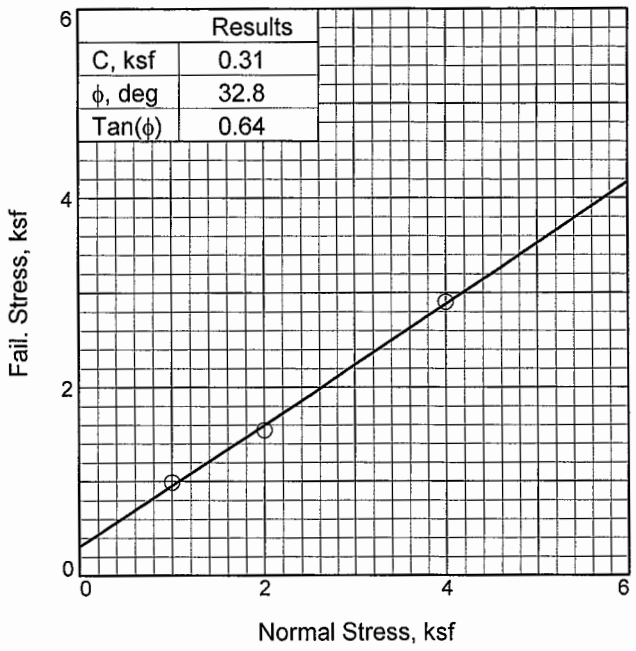
Proj. No.: 17662 **Date Sampled:** 06/08/20

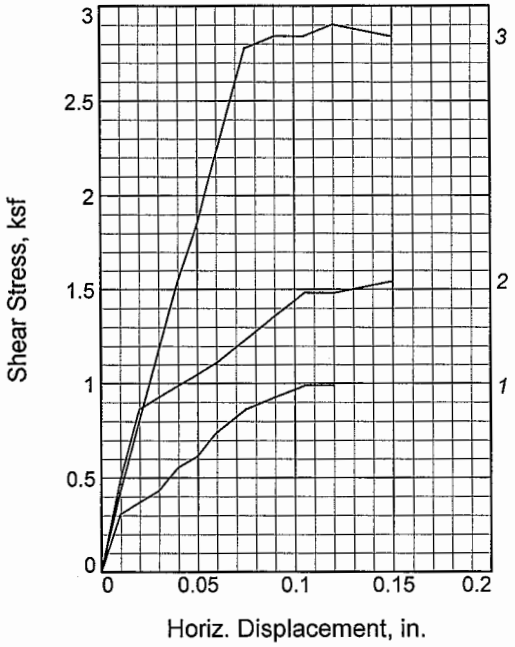
DIRECT SHEAR TEST REPORT

SOILS ENGINEERING, INC.

Tested By: EV **Checked By:** AL







Sample No.		1	2	3
Initial	Water Content, %	15.6	15.7	13.0
	Dry Density, pcf	107.8	110.4	117.7
	Saturation, %	77.5	83.7	85.0
	Void Ratio	0.5341	0.4983	0.4053
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	19.9	18.7	15.0
	Dry Density, pcf	107.8	110.4	117.7
	Saturation, %	98.9	99.4	97.9
	Void Ratio	0.5341	0.4983	0.4053
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
Normal Stress, ksf		1.00	2.00	4.00
Fail. Stress, ksf		0.99	1.54	2.90
Displacement, in.		0.11	0.15	0.12
Ult. Stress, ksf				
Displacement, in.				
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: 2.50" x 6" TUBE
Description: SANDY SILT; brown, damp, trace of clay, low plasticity, hard.
LL= N/A **PI=** N/A
Assumed Specific Gravity= 2.65
Remarks: Test Date: 06/11/20

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-2 **Depth:** 21'

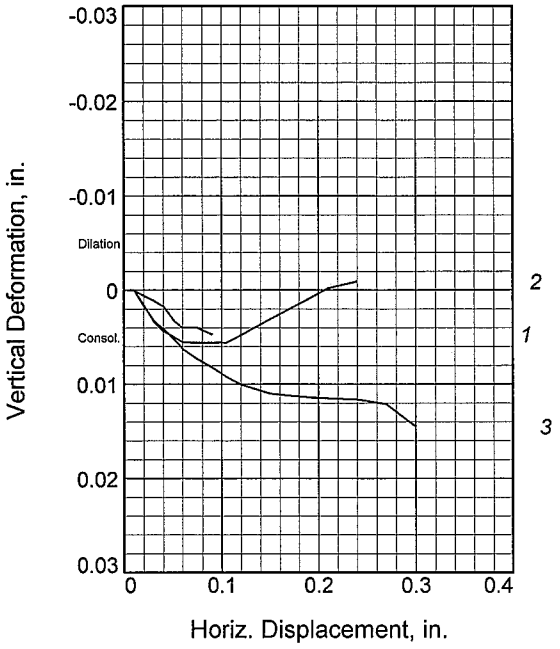
Proj. No.: 17662 **Date Sampled:** 06/08/20

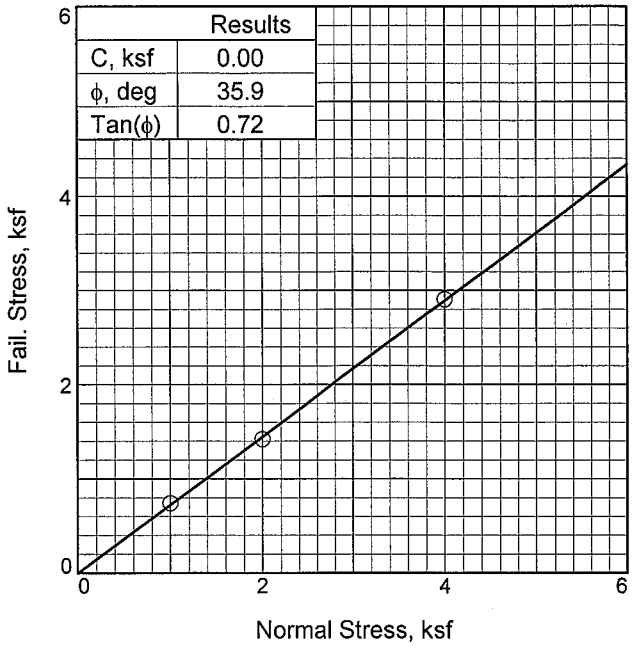
DIRECT SHEAR TEST REPORT

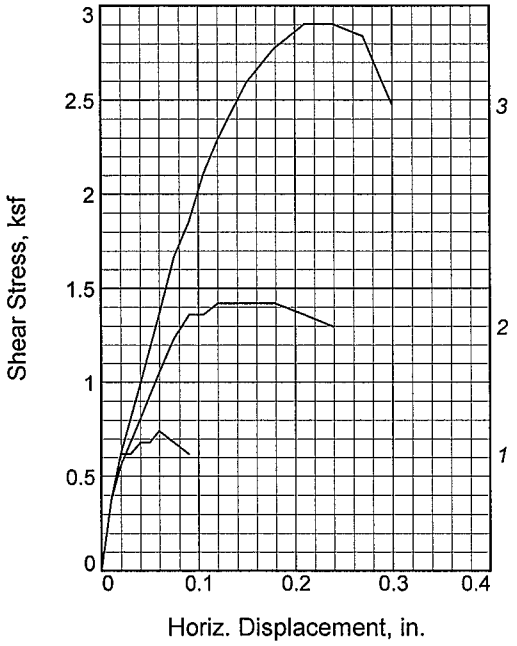
SOILS ENGINEERING, INC.

Figure C-3

Tested By: EV **Checked By:** AL







Sample No.		1	2	3
Initial	Water Content, %	12.2	12.0	8.9
	Dry Density, pcf	106.6	99.1	85.0
	Saturation, %	58.5	47.4	24.9
	Void Ratio	0.5515	0.6700	0.9452
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	14.1	21.4	25.1
	Dry Density, pcf	106.6	99.1	85.0
	Saturation, %	67.8	84.5	70.3
	Void Ratio	0.5515	0.6700	0.9452
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
Normal Stress, ksf		1.00	2.00	4.00
Fail. Stress, ksf		0.74	1.42	2.90
Displacement, in.		0.06	0.12	0.21
Ult. Stress, ksf				
Displacement, in.				
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: 2.50" x 6" TUBE
Description: POORLY GRADED SANAD with low fine content; light yellowish brown, dry to
LL= N/A **PI=** N/A
Assumed Specific Gravity= 2.65
Remarks: Test Date: 06/24/20

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-2 **Depth:** 26'

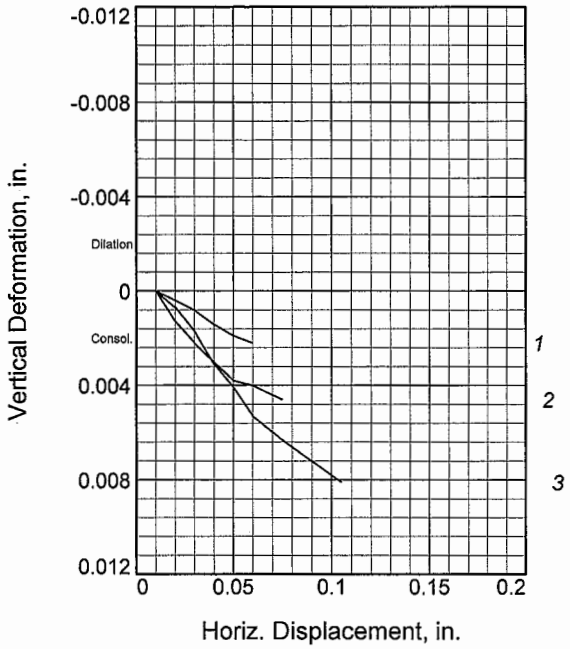
Proj. No.: 17662 **Date Sampled:** 06/08/20

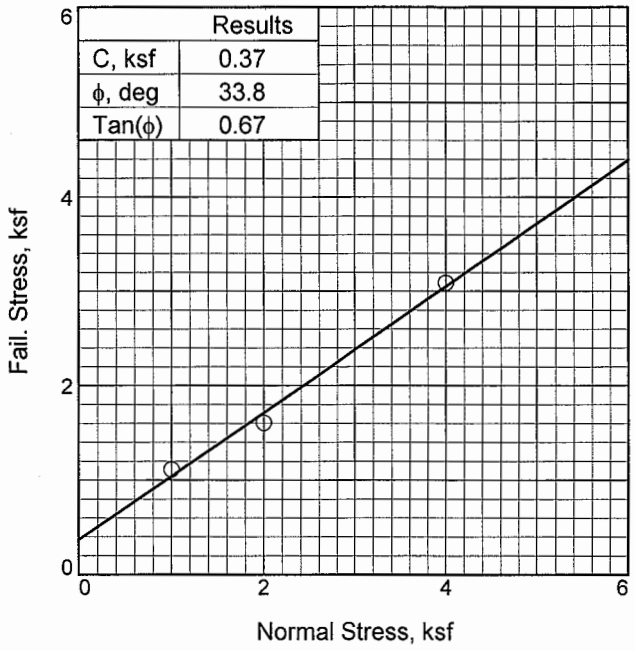
DIRECT SHEAR TEST REPORT

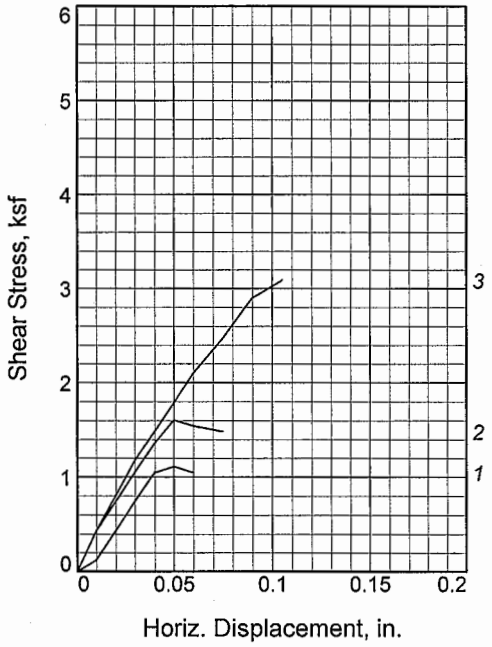
SOILS ENGINEERING, INC.

Figure C-4

Tested By: EV







Sample No.		1	2	3
Initial	Water Content, %	14.8	14.8	16.5
	Dry Density, pcf	108.9	108.5	107.0
	Saturation, %	75.7	74.9	79.9
	Void Ratio	0.5196	0.5244	0.5465
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	18.7	18.8	19.5
	Dry Density, pcf	108.9	108.5	107.0
	Saturation, %	95.5	94.9	94.7
	Void Ratio	0.5196	0.5244	0.5465
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
Normal Stress, ksf		1.00	2.00	4.00
Fail. Stress, ksf		1.11	1.61	3.09
Displacement, in.		0.05	0.05	0.11
Ult. Stress, ksf				
Displacement, in.				
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: 2.50" x 6" TUBE
Description: SANDY SILT; brown, fine, low plasticity, trace of clay, trace of gravel.
LL= N/A **PI=** N/A
Assumed Specific Gravity= 2.65
Remarks: Test Date: 06/29/20

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-3 **Depth:** 6'

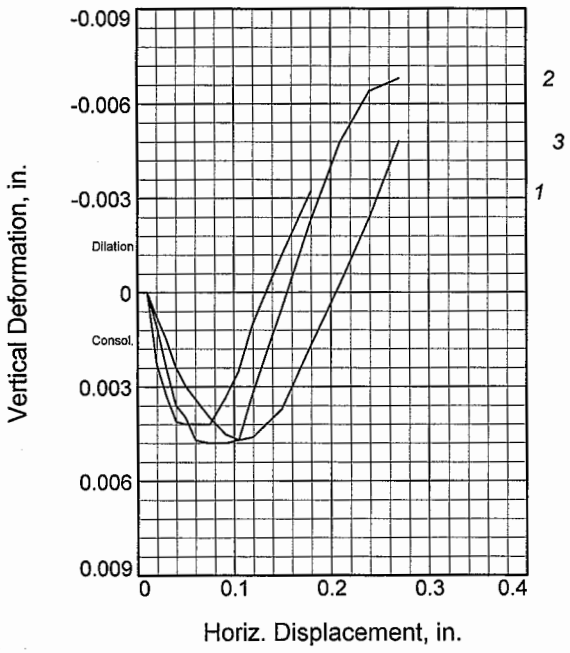
Proj. No.: 17662 **Date Sampled:** 06/08/20

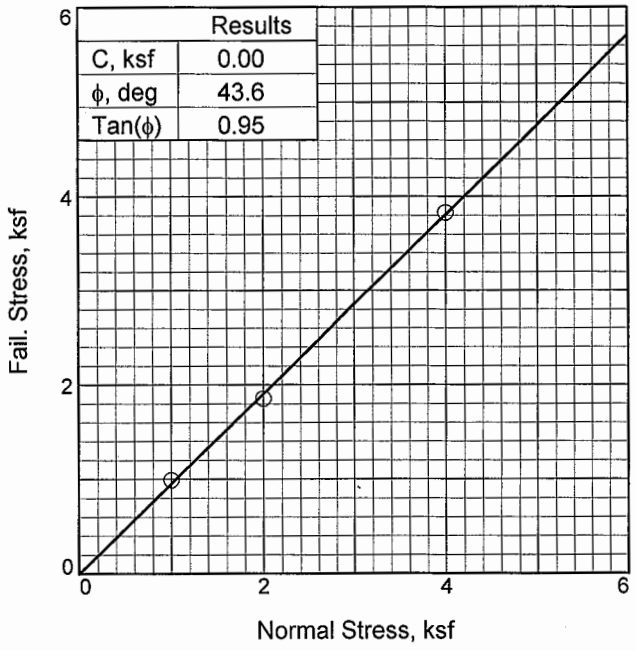
DIRECT SHEAR TEST REPORT

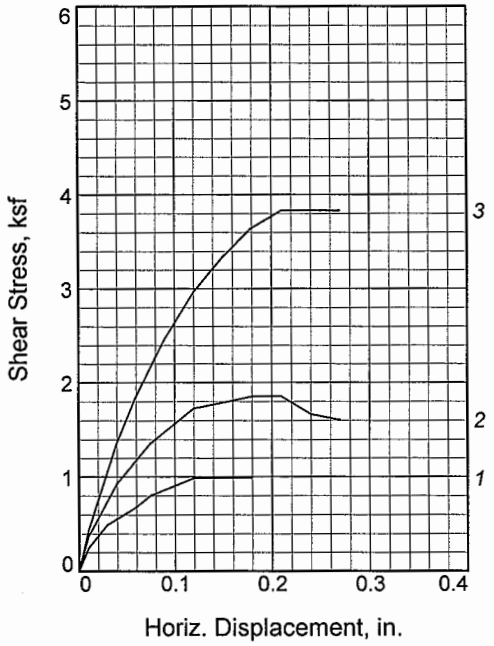
SOILS ENGINEERING, INC.

Figure C-5

Tested By: EV **Checked By:** AL







Sample No.		1	2	3
Initial	Water Content, %	4.8	4.4	4.3
	Dry Density, pcf	105.8	108.0	107.2
	Saturation, %	22.5	21.8	21.1
	Void Ratio	0.5641	0.5317	0.5428
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	14.7	15.5	15.7
	Dry Density, pcf	105.8	108.0	107.2
	Saturation, %	69.1	77.4	76.7
	Void Ratio	0.5641	0.5317	0.5428
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
Normal Stress, ksf		1.00	2.00	4.00
Fail. Stress, ksf		0.99	1.85	3.83
Displacement, in.		0.12	0.18	0.21
Ult. Stress, ksf				
Displacement, in.				
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: 2.50" x 6" TUBE
Description: POORLY GRADED SAND; light yellowish brown, dry, fine to medium, gravel, very
LL= N/A **PI=** N/A
Assumed Specific Gravity= 2.65
Remarks: Test Date: 07/01/20

Figure C-6

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

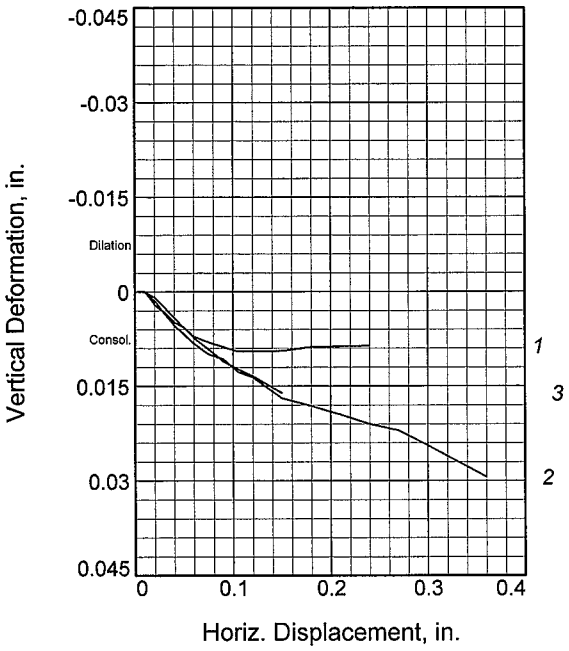
Source of Sample: B-3 **Depth:** 16'

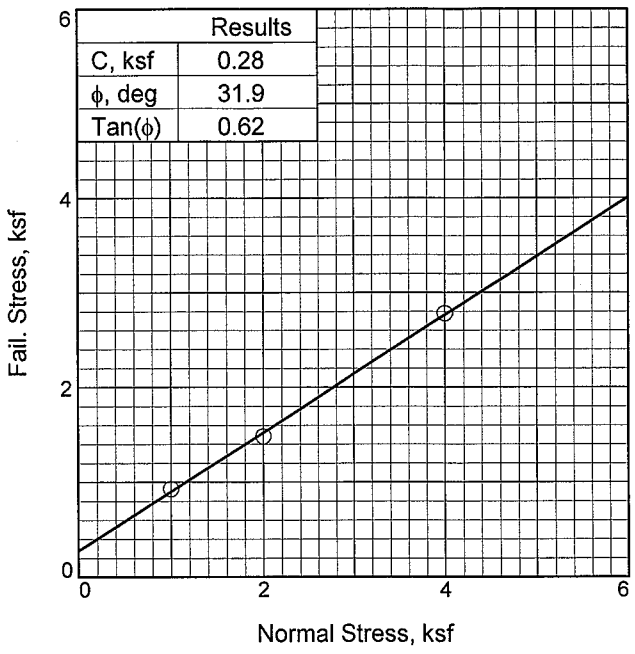
Proj. No.: 17662 **Date Sampled:** 06/08/20

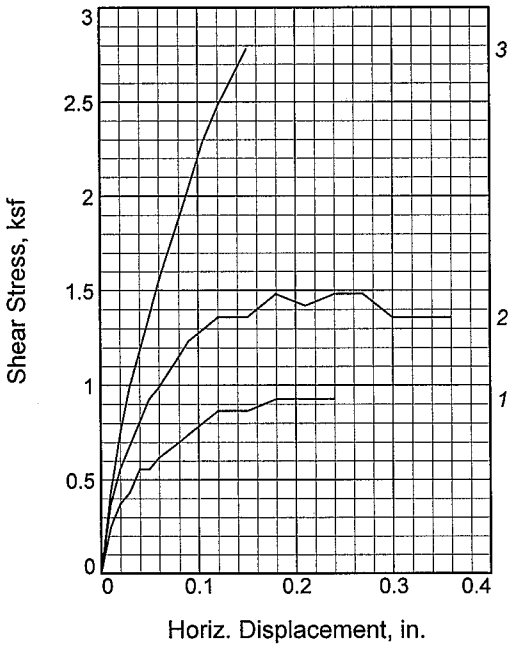
DIRECT SHEAR TEST REPORT

SOILS ENGINEERING, INC.

Tested By: EV **Checked By:** AL







Sample No.		1	2	3
Initial	Water Content, %	9.9	7.7	15.0
	Dry Density, pcf	87.9	92.0	88.6
	Saturation, %	29.7	25.5	45.7
	Void Ratio	0.8824	0.7980	0.8678
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	22.8	22.1	20.8
	Dry Density, pcf	87.9	92.0	88.6
	Saturation, %	68.5	73.6	63.4
	Void Ratio	0.8824	0.7980	0.8678
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
Normal Stress, ksf		1.00	2.00	4.00
Fail. Stress, ksf		0.93	1.48	2.78
Displacement, in.		0.18	0.18	0.15
Ult. Stress, ksf				
Displacement, in.				
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: 2.50" x 6" TUBE
Description: CLAYEY SAND; light yellowish brown, dry, low plasticity, gravel.
LL= N/A **PI=** N/A
Assumed Specific Gravity= 2.65
Remarks: Test Date: 06/15/20

Figure C-7

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

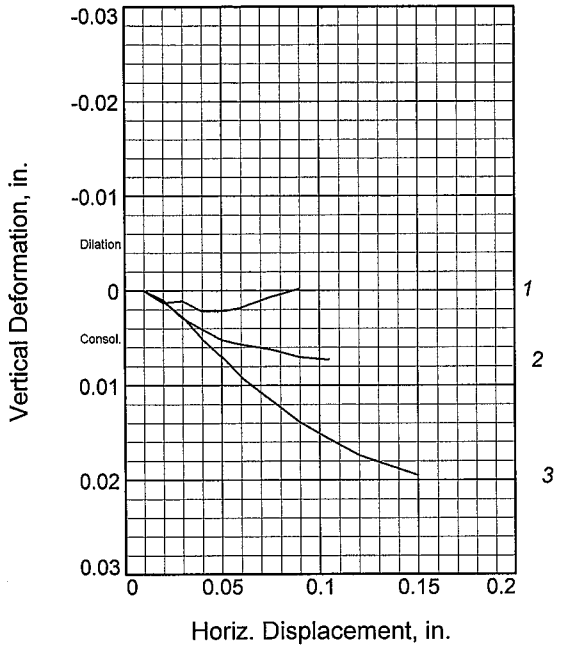
Source of Sample: B-5 **Depth:** 6'

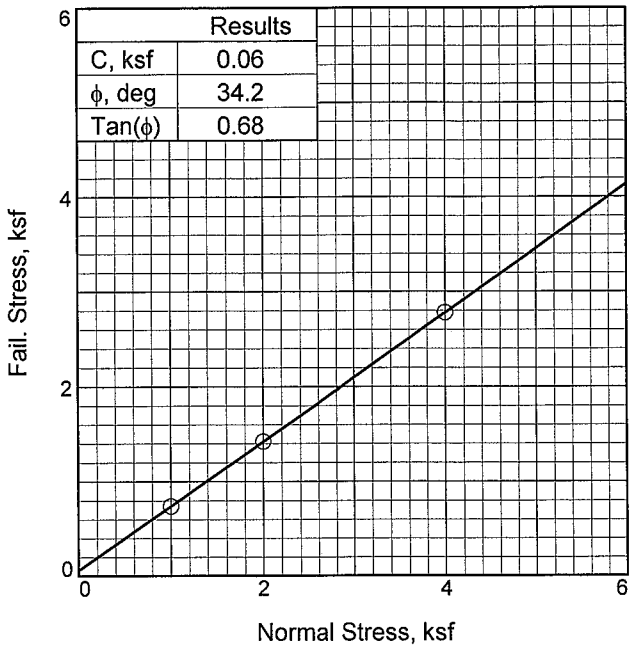
Proj. No.: 17662 **Date Sampled:** 06/10/20

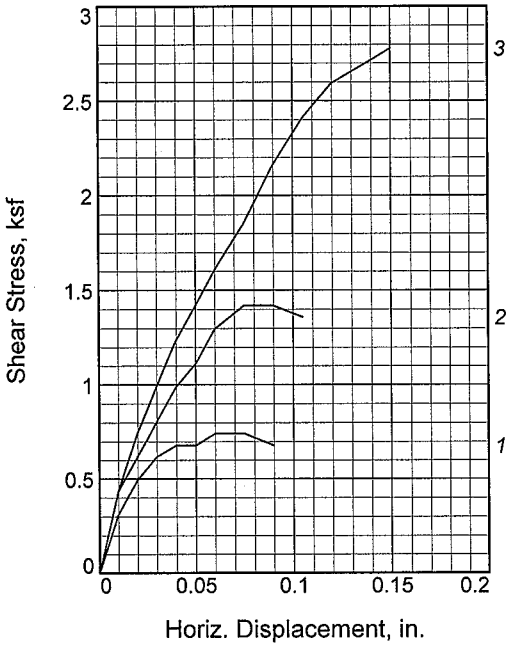
DIRECT SHEAR TEST REPORT

SOILS ENGINEERING, INC.

Tested By: EV







Sample No.		1	2	3
Initial	Water Content, %	10.3	10.9	12.1
	Dry Density, pcf	109.9	107.2	105.9
	Saturation, %	54.2	53.2	57.1
	Void Ratio	0.5053	0.5428	0.5615
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	14.9	14.8	14.6
	Dry Density, pcf	109.9	107.2	105.9
	Saturation, %	78.4	72.0	68.9
	Void Ratio	0.5053	0.5428	0.5615
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
Normal Stress, ksf		1.00	2.00	4.00
Fail. Stress, ksf		0.74	1.42	2.78
Displacement, in.		0.06	0.08	0.15
Ult. Stress, ksf				
Displacement, in.				
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: 2.50" x 6" TUBE
Description: SILTY SAND; light yellowish brown, dry, cohesive, gravel.
LL= N/A **PI=** N/A
Assumed Specific Gravity= 2.65
Remarks: 06/15/20

Figure C-8

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

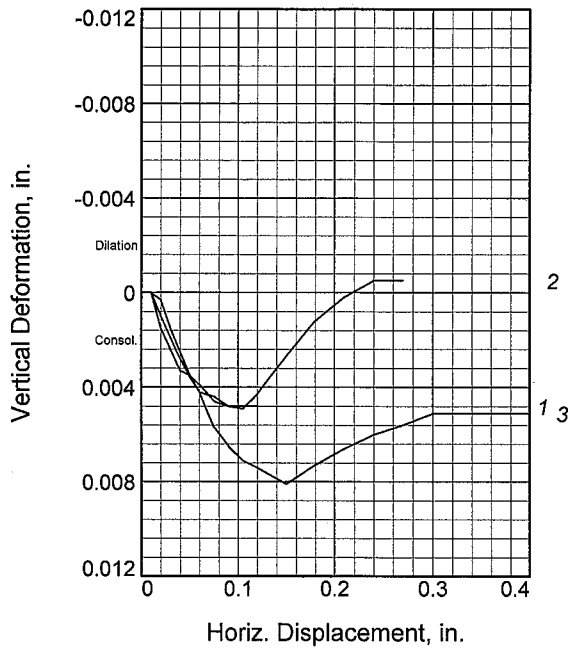
Source of Sample: B-7 **Depth:** 6'

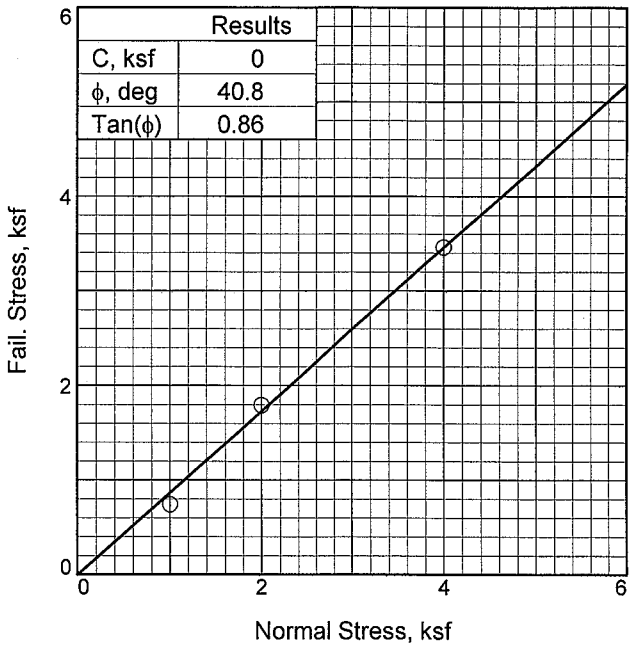
Proj. No.: 17662 **Date Sampled:** 06/05/20

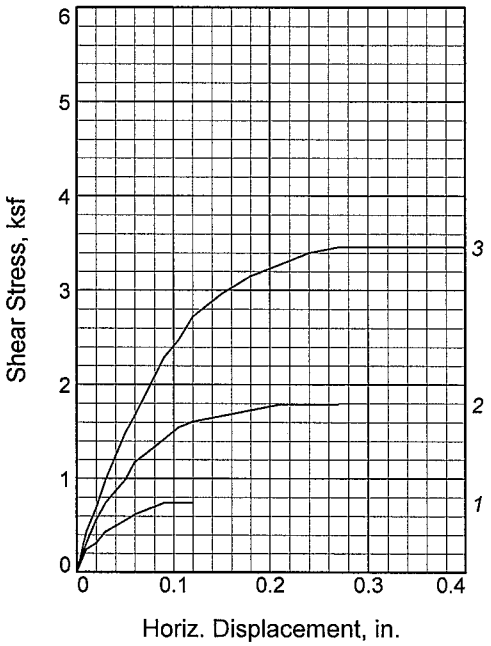
DIRECT SHEAR TEST REPORT

SOILS ENGINEERING, INC.

Tested By: EV







Sample No.		1	2	3
Initial	Water Content, %	6.6	6.6	7.9
	Dry Density, pcf	92.5	93.1	92.1
	Saturation, %	22.2	22.4	26.4
	Void Ratio	0.7879	0.7764	0.7963
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	21.4	21.1	22.5
	Dry Density, pcf	92.5	93.1	92.1
	Saturation, %	71.9	71.9	74.9
	Void Ratio	0.7879	0.7764	0.7963
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
Normal Stress, ksf		1.00	2.00	4.00
Fail. Stress, ksf		0.74	1.79	3.46
Displacement, in.		0.09	0.21	0.27
Ult. Stress, ksf				
Displacement, in.				
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: 2.5" x 6" TUBE
Description: POORLY GRADED SAND; light yellowish brown, non cohesive trace of fine
LL= N/A **PI=** N/A
Assumed Specific Gravity= 2.65
Remarks: Test Date: 07/01/20

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-9 **Depth:** 16'

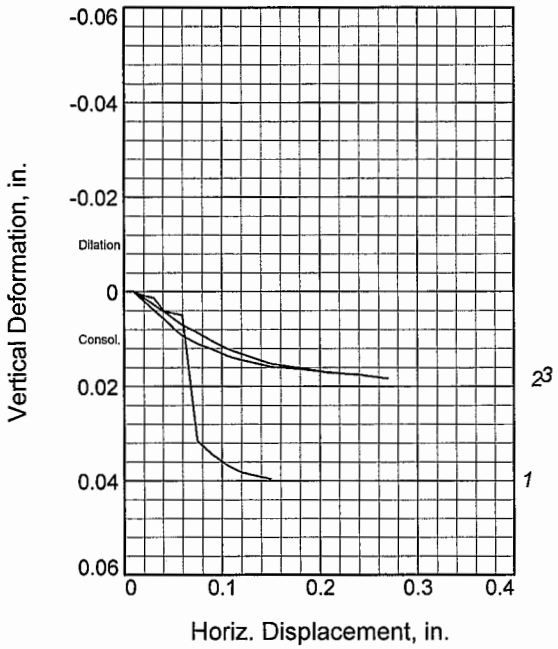
Proj. No.: 17662 **Date Sampled:** 06/05/20

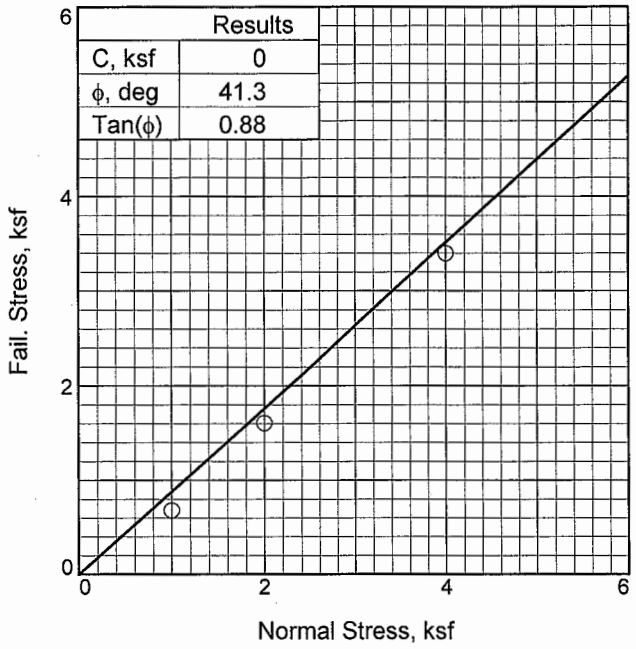
DIRECT SHEAR TEST REPORT

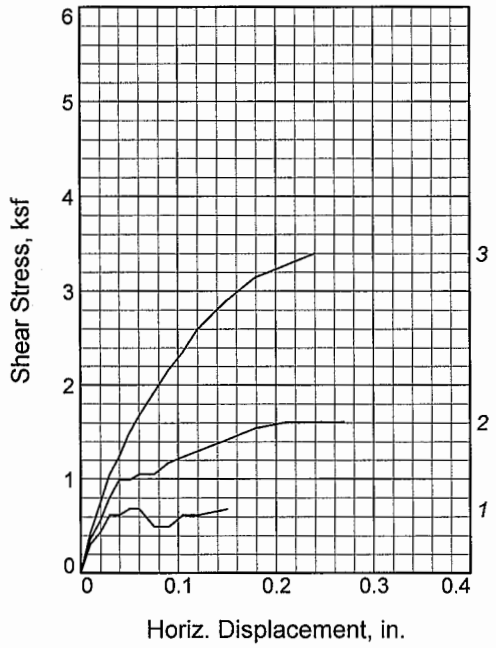
SOILS ENGINEERING, INC.

Figure C-9

Tested By: EV **Checked By:** AL







Sample No.		1	2	3
Initial	Water Content, %	6.7	5.8	5.4
	Dry Density, pcf	99.5	98.4	100.7
	Saturation, %	26.6	22.4	22.2
	Void Ratio	0.6628	0.6817	0.6429
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	17.4	16.1	16.8
	Dry Density, pcf	99.5	98.4	100.7
	Saturation, %	69.5	62.5	69.3
	Void Ratio	0.6628	0.6817	0.6429
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
Normal Stress, ksf		1.00	2.00	4.00
Fail. Stress, ksf		0.68	1.61	3.40
Displacement, in.		0.05	0.21	0.24
Ult. Stress, ksf				
Displacement, in.				
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: 2.50" x 6" TUBE
Description: POORLY GRADED SAND; yellowish brown, dry to damp, dense, fine, gravel.
LL= N/A **PI=** N/A
Assumed Specific Gravity= 2.65
Remarks: Test Date: 06/23/20

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-10 **Depth:** 6'

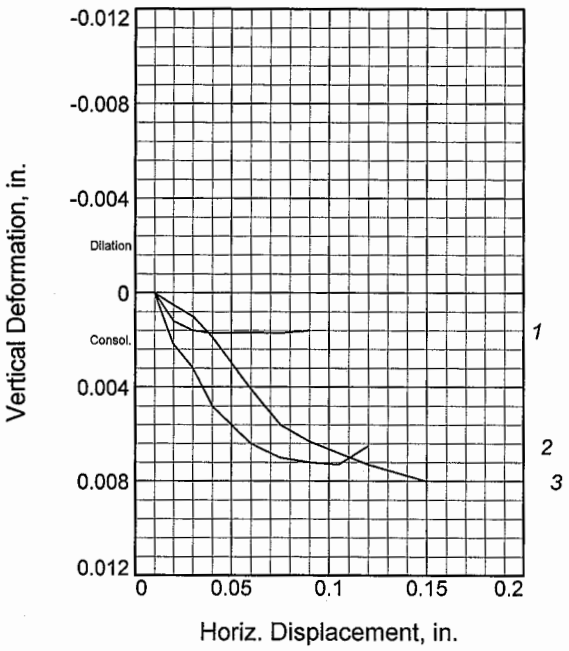
Proj. No.: 17662 **Date Sampled:** 06/15/20

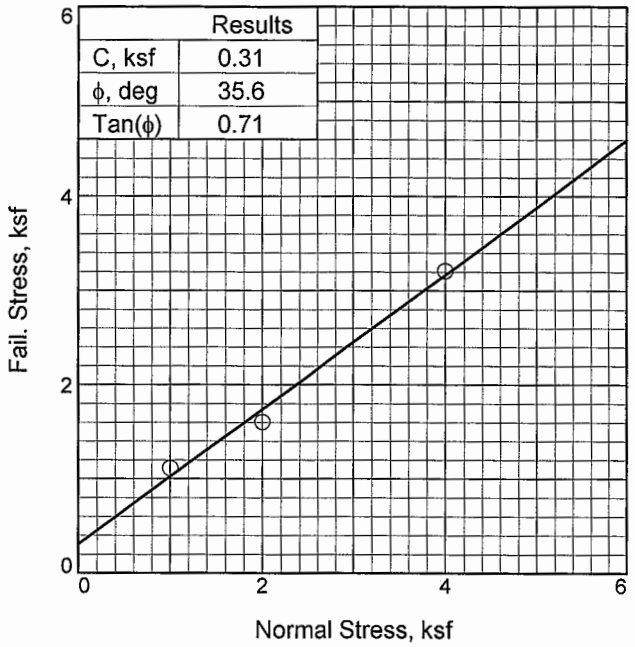
DIRECT SHEAR TEST REPORT

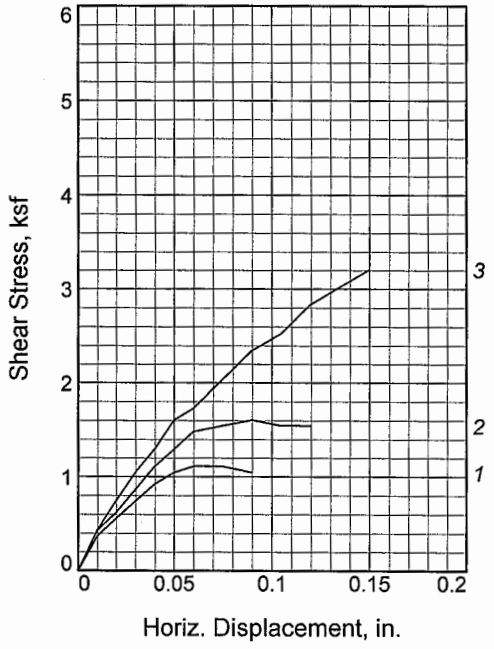
SOILS ENGINEERING, INC.

Figure C-10

Tested By: EV **Checked By:** AL







Sample No.		1	2	3
Initial	Water Content, %	12.7	12.3	8.9
	Dry Density, pcf	110.7	111.8	114.1
	Saturation, %	67.8	68.0	52.4
	Void Ratio	0.4948	0.4799	0.4498
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	17.0	16.4	15.1
	Dry Density, pcf	110.7	111.8	114.1
	Saturation, %	91.1	90.5	89.2
	Void Ratio	0.4948	0.4799	0.4498
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
Normal Stress, ksf		1.00	2.00	4.00
Fail. Stress, ksf		1.11	1.61	3.21
Displacement, in.		0.06	0.09	0.15
Ult. Stress, ksf				
Displacement, in.				
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: 2.50" x 6" TUBE
Description: CLAYEY SAND; light yellowish brown, dry, low plasticity.
LL= N/A **PI=** N/A
Assumed Specific Gravity= 2.65
Remarks: Test Date: 06/17/20

Figure C-11

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

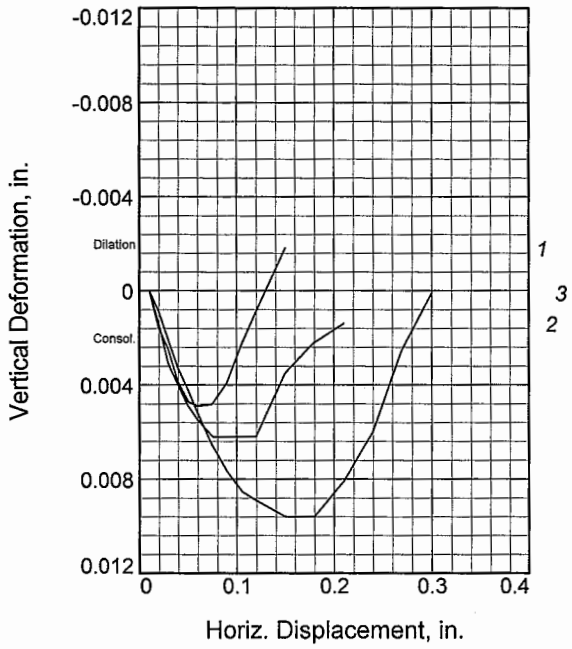
Source of Sample: B-12 **Depth:** 6'

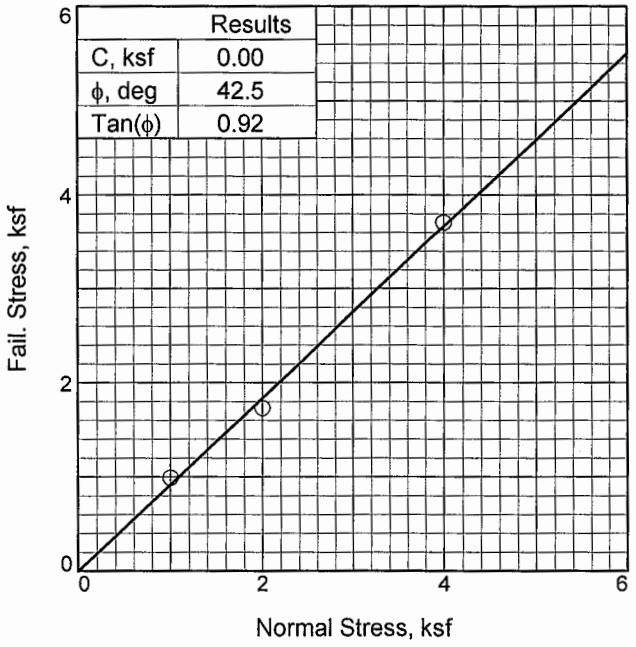
Proj. No.: 17662 **Date Sampled:** 06/09/20

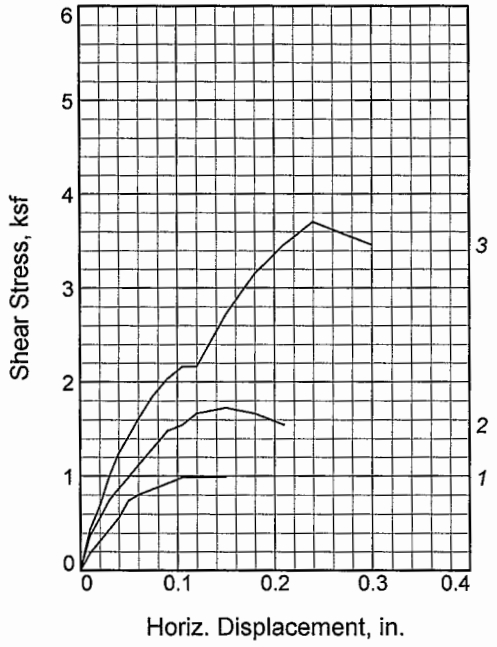
DIRECT SHEAR TEST REPORT

SOILS ENGINEERING, INC.

Tested By: EV **Checked By:** AL







Sample No.		1	2	3
Initial	Water Content, %	3.8	4.0	4.1
	Dry Density, pcf	99.5	102.8	102.0
	Saturation, %	15.2	17.5	17.6
	Void Ratio	0.6628	0.6099	0.6221
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	18.1	17.6	16.7
	Dry Density, pcf	99.5	102.8	102.0
	Saturation, %	72.2	76.4	71.1
	Void Ratio	0.6628	0.6099	0.6221
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
Normal Stress, ksf		1.00	2.00	4.00
Fail. Stress, ksf		0.99	1.73	3.71
Displacement, in.		0.11	0.15	0.24
Ult. Stress, ksf				
Displacement, in.				
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: 2.50" x 6" TUBE
Description: POORLY GRADED SAND; yellowish brown, dry to damp, dense, fine, gravel.
LL= N/A **PI=** N/A
Assumed Specific Gravity= 2.65
Remarks: Test Date: 06/23/20

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-12 **Depth:** 16'

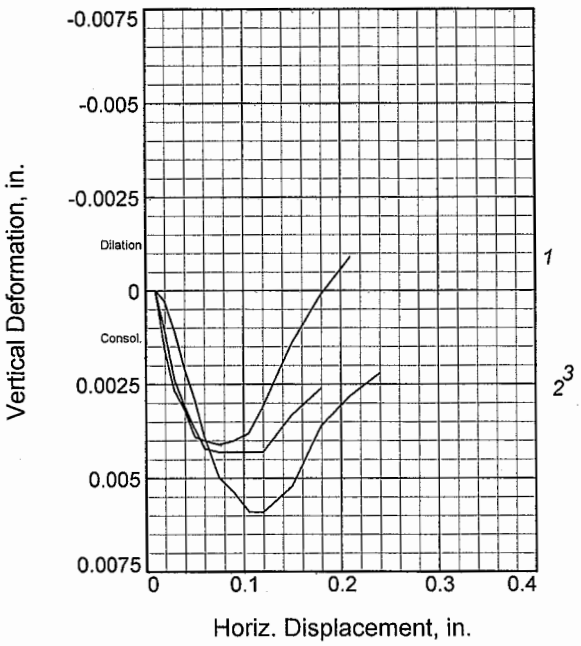
Proj. No.: 17662 **Date Sampled:** 06/09/20

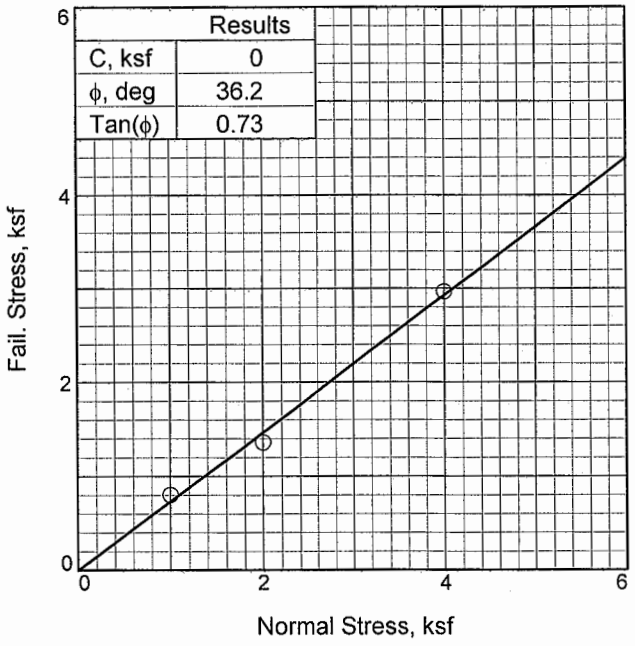
DIRECT SHEAR TEST REPORT

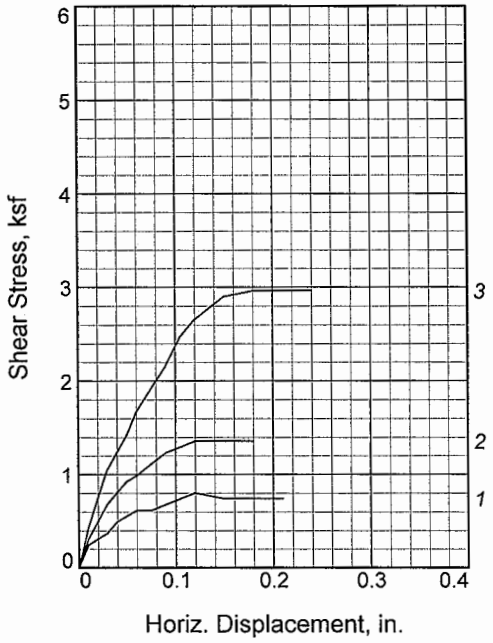
SOILS ENGINEERING, INC.

Figure C-12

Tested By: EV **Checked By:** AL







Sample No.		1	2	3
Initial	Water Content, %	4.0	4.9	5.7
	Dry Density, pcf	91.7	91.3	92.1
	Saturation, %	13.3	16.0	19.0
	Void Ratio	0.8047	0.8115	0.7963
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	24.5	24.3	23.5
	Dry Density, pcf	91.7	91.3	92.1
	Saturation, %	80.6	79.3	78.3
	Void Ratio	0.8047	0.8115	0.7963
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
Normal Stress, ksf		1.00	2.00	4.00
Fail. Stress, ksf		0.80	1.36	2.96
Displacement, in.		0.12	0.12	0.18
Ult. Stress, ksf				
Displacement, in.				
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: 2.5" x 6" TUBE
Description: POORLY GRADED SAND; light yellowish brown, fine, non cohesive, Very dense.
LL= N/A **PI=** N/A
Assumed Specific Gravity= 2.65
Remarks: Test Date: 07/01/20

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Source of Sample: B-12 **Depth:** 26'

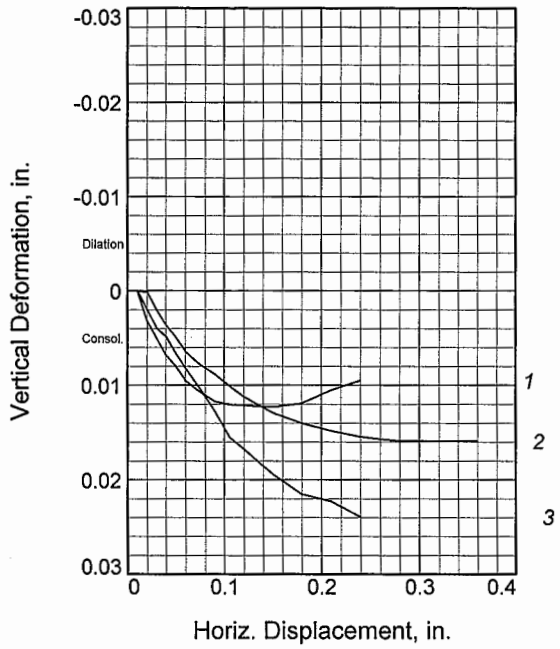
Proj. No.: 17662 **Date Sampled:** 06/09/20

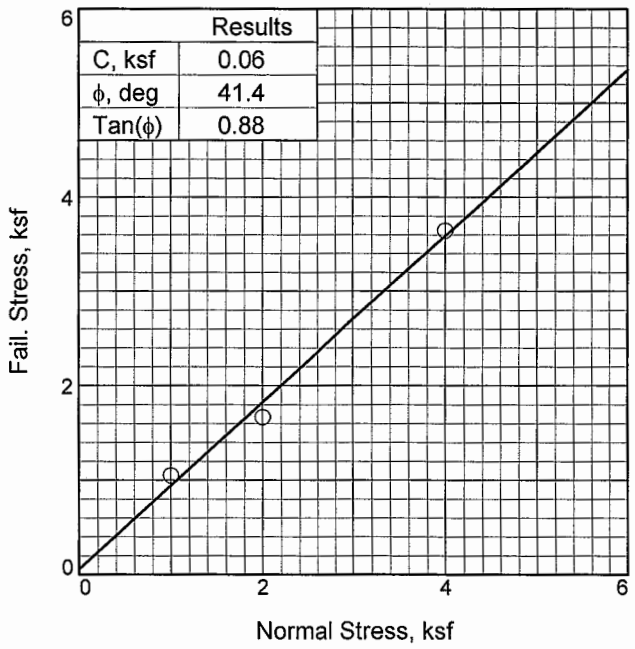
DIRECT SHEAR TEST REPORT

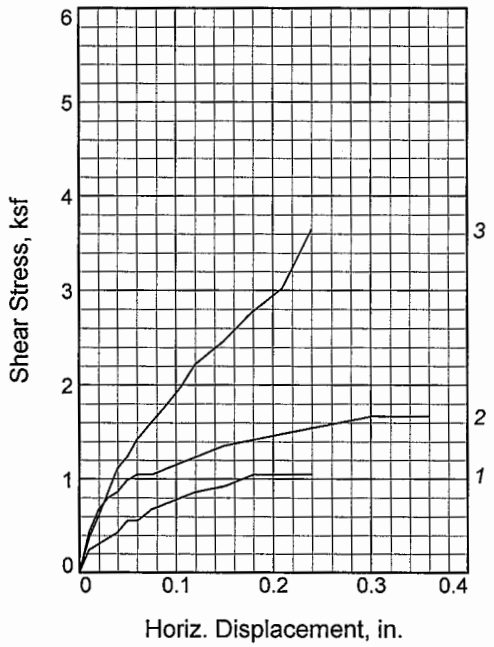
SOILS ENGINEERING, INC.

Figure C-13

Tested By: EV **Checked By:** AL







Sample No.		1	2	3
Initial	Water Content, %	14.7	14.2	13.9
	Dry Density, pcf	95.3	85.6	99.9
	Saturation, %	52.9	40.2	56.4
	Void Ratio	0.7363	0.9335	0.6556
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	25.3	25.6	21.3
	Dry Density, pcf	95.3	85.6	99.9
	Saturation, %	91.0	72.8	85.9
	Void Ratio	0.7363	0.9335	0.6556
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
Normal Stress, ksf		1.00	2.00	4.00
Fail. Stress, ksf		1.05	1.67	3.64
Displacement, in.		0.18	0.30	0.24
Ult. Stress, ksf				
Displacement, in.				
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: 2.50" x 6" TUBE
Description: POORLY GRADED SAND; light yellowish brown, dry, dense, fine, gravel.
LL= N/A **PI=** N/A
Assumed Specific Gravity= 2.65
Remarks: Test Date: 06/23/20

Figure C-14

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

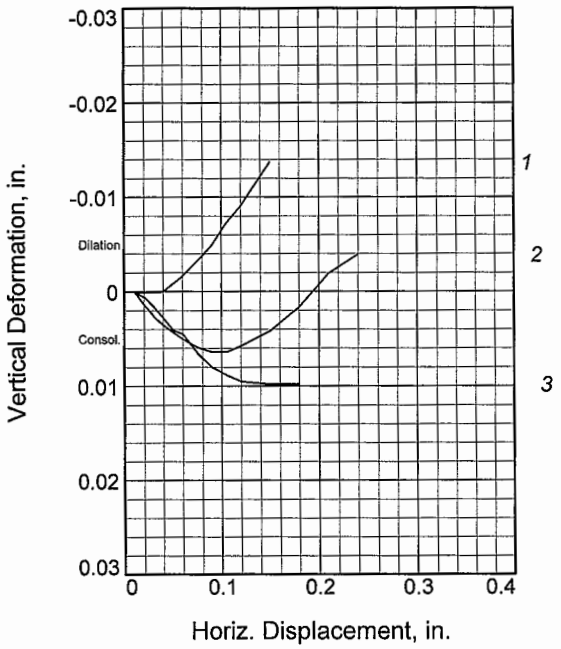
Source of Sample: B-14 **Depth:** 6'

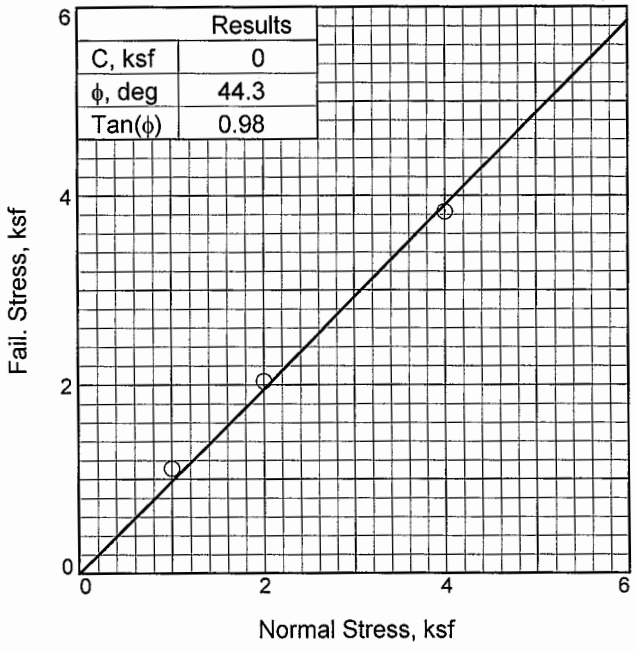
Proj. No.: 17662 **Date Sampled:** 06/15/20

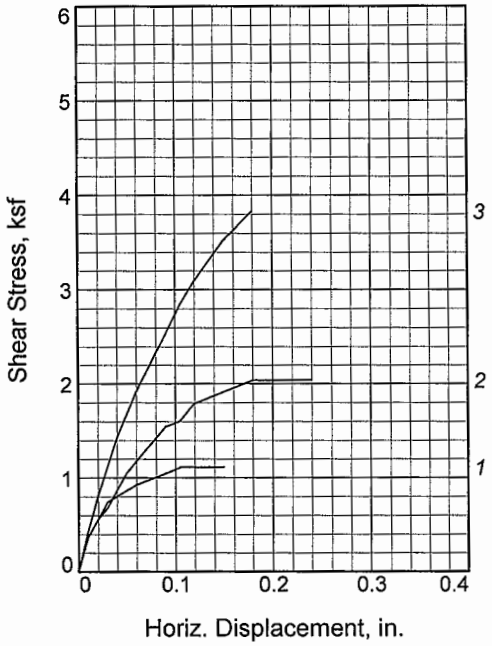
DIRECT SHEAR TEST REPORT

SOILS ENGINEERING, INC.

Tested By: EV







Sample No.		1	2	3
Initial	Water Content, %	6.5	5.8	7.2
	Dry Density, pcf	96.7	96.4	97.5
	Saturation, %	24.2	21.5	27.5
	Void Ratio	0.7116	0.7162	0.6965
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	17.9	17.6	17.5
	Dry Density, pcf	96.7	96.4	97.5
	Saturation, %	66.6	65.0	66.8
	Void Ratio	0.7116	0.7162	0.6965
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
Normal Stress, ksf		1.00	2.00	4.00
Fail. Stress, ksf		1.11	2.04	3.83
Displacement, in.		0.11	0.18	0.18
Ult. Stress, ksf				
Displacement, in.				
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: 2.50" x 6" TUBE
Description: POORLY GRADED SAND; light yellowish brown, dry, dense, fine, gravel.
LL= N/A **PI=** N/A
Assumed Specific Gravity= 2.65
Remarks: Test Date: 06/24/20

Figure C-15

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

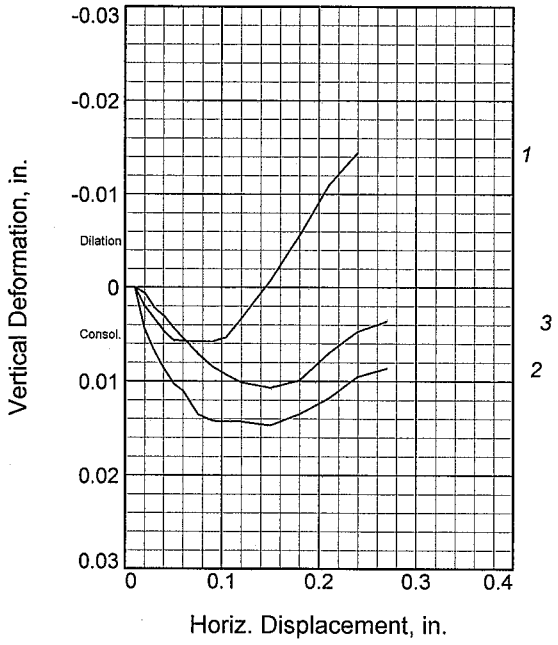
Source of Sample: B-14 **Depth:** 16'

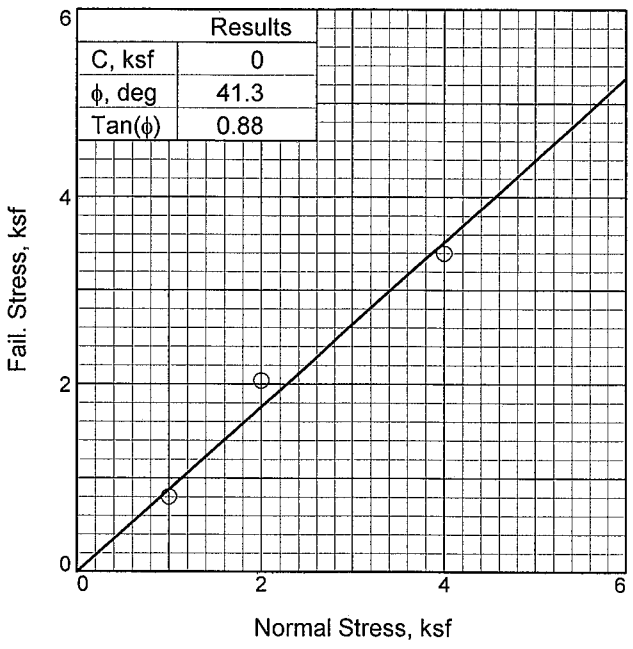
Proj. No.: 17662 **Date Sampled:** 06/15/20

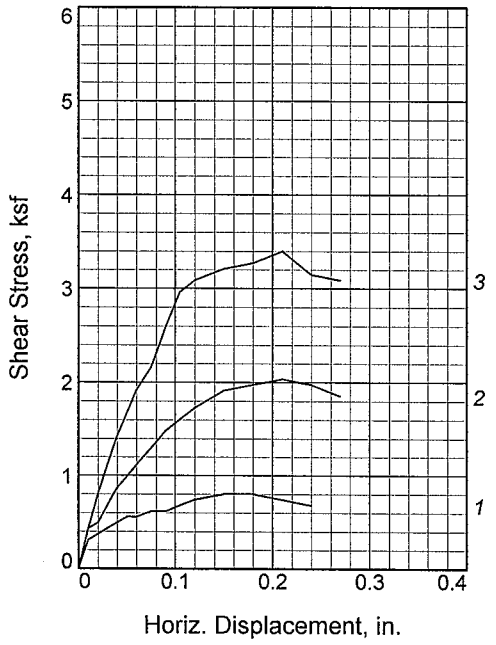
DIRECT SHEAR TEST REPORT

SOILS ENGINEERING, INC.

Tested By: EV







Sample No.		1	2	3
Initial	Water Content, %	18.9	21.5	16.6
	Dry Density, pcf	96.2	92.4	101.8
	Saturation, %	69.8	72.1	70.2
	Void Ratio	0.7192	0.7896	0.6248
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	26.7	29.6	23.1
	Dry Density, pcf	96.2	92.4	101.8
	Saturation, %	98.5	99.3	97.8
	Void Ratio	0.7192	0.7896	0.6248
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
Normal Stress, ksf		1.00	2.00	4.00
Fail. Stress, ksf		0.80	2.04	3.40
Displacement, in.		0.15	0.21	0.21
Ult. Stress, ksf				
Displacement, in.				
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: REMOLDED
Description: POORLY GRADED SAND with silt/ low fine content; yellowish brown, non-cohesive,
LL= N/A **PI=** N/A
Assumed Specific Gravity= 2.65
Remarks: Test Date: 07/02/20

Figure C-16

Client: Fluor Federal Services, Inc.

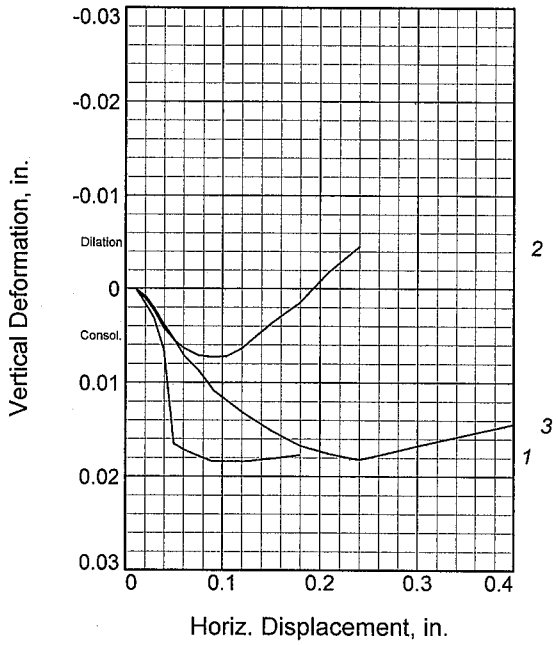
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

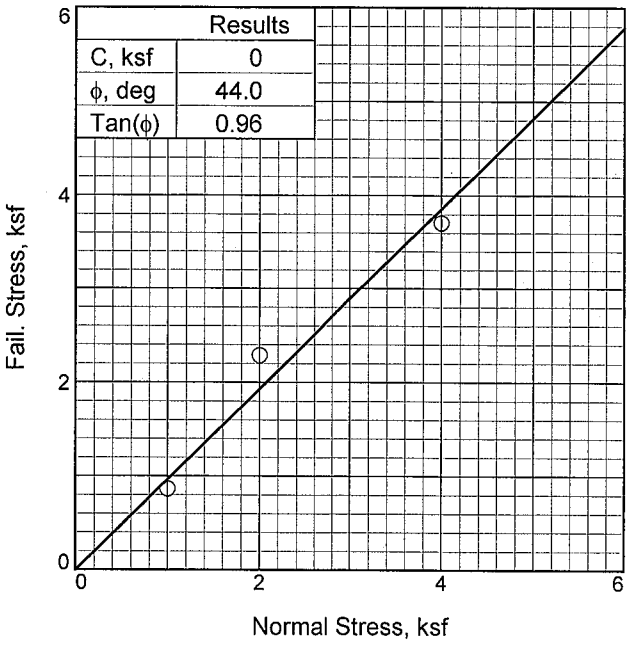
Location: TP-1 @ 6-12'
Sample Number: 74624 **Depth:** 6-12'
Proj. No.: 17662 **Date Sampled:** 06/19/20

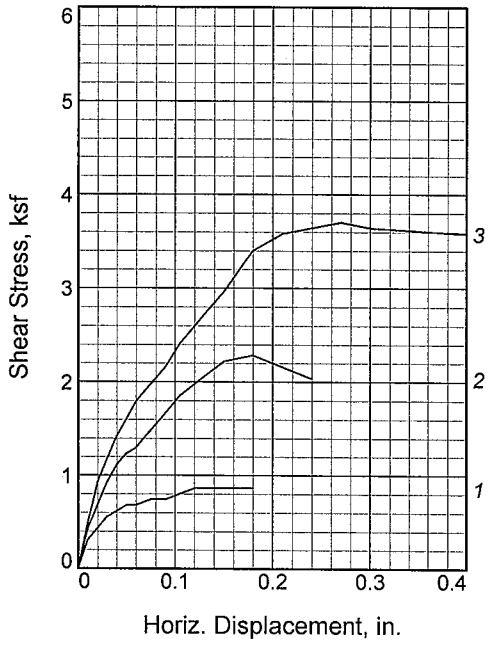
DIRECT SHEAR TEST REPORT

SOILS ENGINEERING, INC.

Tested By: EV







Sample No.		1	2	3
Initial	Water Content, %	8.2	7.9	9.3
	Dry Density, pcf	99.8	104.6	99.7
	Saturation, %	33.0	35.9	37.4
	Void Ratio	0.6585	0.5821	0.6599
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	18.9	16.9	18.6
	Dry Density, pcf	99.8	104.6	99.7
	Saturation, %	76.0	77.1	74.8
	Void Ratio	0.6585	0.5821	0.6599
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
Normal Stress, ksf		1.00	2.00	4.00
Fail. Stress, ksf		0.86	2.29	3.71
Displacement, in.		0.12	0.18	0.27
Ult. Stress, ksf				
Displacement, in.				
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: REMOLDED
Description: POORLY GRADED SAND with silt/ low fine content; yellowish brown, non-cohesive,
LL= N/A **PI=** N/A
Assumed Specific Gravity= 2.65
Remarks: Test Date: 07/02/20

Figure C-17

Client: Fluor Federal Services, Inc.

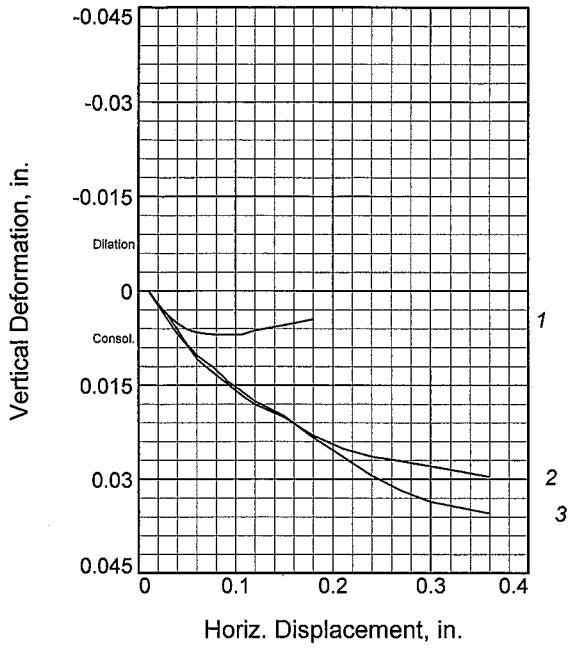
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

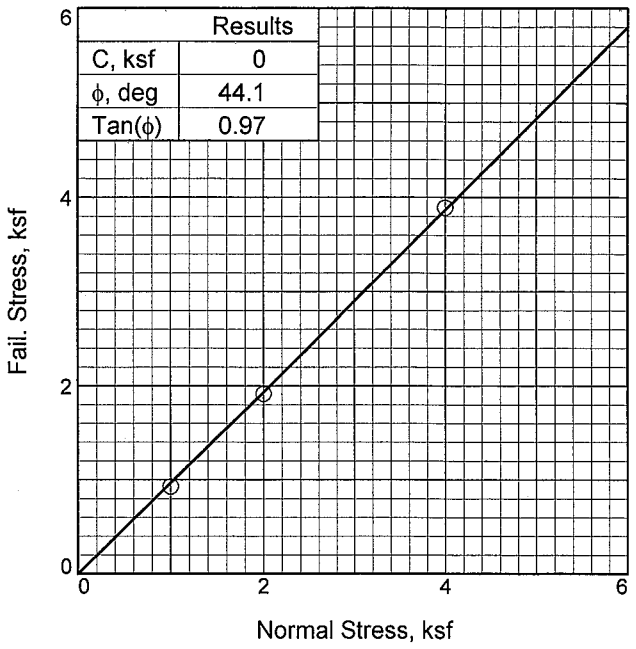
Location: TP-3 @ 0-5'
Sample Number: 74631 **Depth:** 0-5'
Proj. No.: 17662 **Date Sampled:** 06/19/20

DIRECT SHEAR TEST REPORT

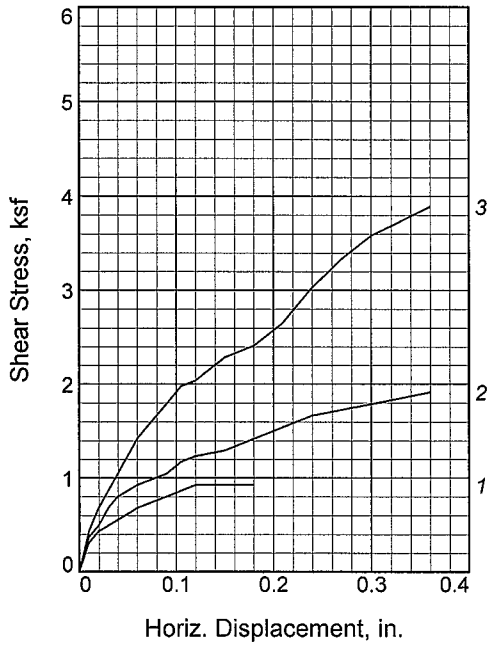
SOILS ENGINEERING, INC.

Tested By: EV **Checked By:** AL





Results	
C, ksf	0
ϕ, deg	44.1
Tan(ϕ)	0.97



Sample No.		1	2	3
Initial	Water Content, %	9.8	9.2	10.1
	Dry Density, pcf	107.2	106.7	105.2
	Saturation, %	47.8	44.2	46.5
	Void Ratio	0.5428	0.5502	0.5730
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	16.7	16.4	16.0
	Dry Density, pcf	107.2	106.7	105.2
	Saturation, %	81.4	79.2	74.1
	Void Ratio	0.5428	0.5502	0.5730
	Diameter, in.	2.38	2.38	2.38
	Height, in.	1.00	1.00	1.00
Normal Stress, ksf		1.00	2.00	4.00
Fail. Stress, ksf		0.93	1.91	3.89
Displacement, in.		0.12	0.36	0.36
Ult. Stress, ksf				
Displacement, in.				
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: 2.50" x 6" TUBE
Description: POORLY GRADED SAND WITH SILT/LOW FINE CONTENT, yellowish brown,
LL= N/A **PI=** N/A
Assumed Specific Gravity= 2.65
Remarks: Test Date: 06/30/20

Figure C-18

Client: Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

Location: TP-5 @ 0-5' Large Bulk
Sample Number: 74639 **Depth:** 0-5'
Proj. No.: 17662 **Date Sampled:** 06/12/20

DIRECT SHEAR TEST REPORT

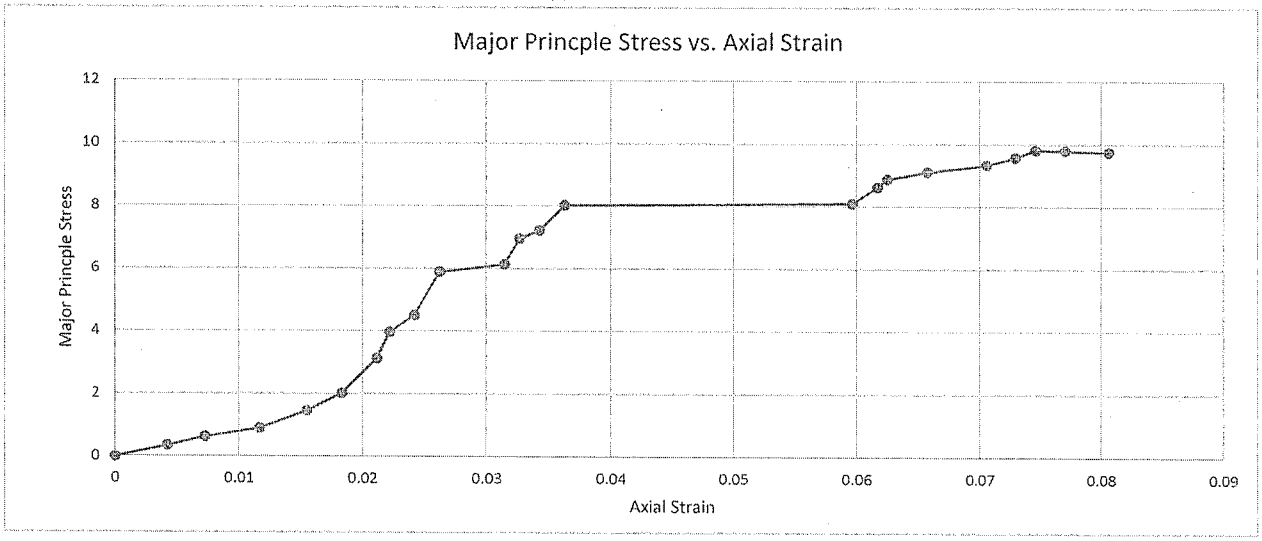
SOILS ENGINEERING, INC.

Tested By: EV **Checked By:** AL

Unconfined Compression Report

Initial Average Diameter D_0(in.)=	2.41	should be close to 2.375 which is the inside diameter of boring tube
Initial Average Height H_0(in.)=	4.96	shoot for 5.5", acceptable range is 4.75"-5.90" based on boring tube diameter
Initial Area A_0(in^2)=	4.56	
Initial Volume V_0(in^3)=	22.62	
Height to Diameter ratio=	2.06	ASTM specifies 2-2.5 ratio
Strain rate (%/min)=	1.25	strain rate must be between .5-2(%/min)
rate of hand crank (seconds/turn)=	4.84	

	elapsed time	load dial	axial load	strain dial	total strain	unit strain	corrected area	stress	stress
Units	(sec)	(.001")	(lbs)	(.01")	(.001")		(in^2)	(lbs/in^2)	(ksf)
	0	0	2.06	0	0	0	0.00	0.00	0
	15	10	11.09	21	0.021	0.00423387	4.58	2.42	0.35
	30	20	20.12	36	0.036	0.00725806	4.59	4.38	0.63
	45	30	29.15	58	0.058	0.01169355	4.61	6.32	0.91
	60	50	47.21	77	0.077	0.01552419	4.63	10.19	1.47
	75	70	65.27	91	0.091	0.01834677	4.65	14.05	2.02
	90	110	101.39	105	0.105	0.02116935	4.66	21.76	3.13
	105	140	128.48	110	0.11	0.02217742	4.66	27.55	3.97
	120	160	146.54	120	0.12	0.02419355	4.67	31.35	4.51
	135	210	191.70	130	0.13	0.02620968	4.68	40.93	5.89
	150	220	200.73	156	0.156	0.03145161	4.71	42.63	6.14
	165	250	227.82	162	0.162	0.03266129	4.71	48.32	6.96
	180	260	236.85	170	0.17	0.03427419	4.72	50.15	7.22
	195	290	263.94	180	0.18	0.03629032	4.73	55.77	8.03
	210	300	272.97	296	0.296	0.05967742	4.85	56.28	8.10
	225	320	291.03	306	0.306	0.06169355	4.86	59.87	8.62
	240	330	300.06	310	0.31	0.0625	4.86	61.68	8.88
	255	340	309.09	326	0.326	0.06572581	4.88	63.32	9.12
	270	350	318.12	350	0.35	0.07056452	4.91	64.83	9.34
	285	360	327.15	362	0.362	0.07298387	4.92	66.50	9.58
	300	370	336.18	370	0.37	0.07459677	4.93	68.21	9.82
	315	370	336.18	382	0.382	0.07701613	4.94	68.03	9.80
	330	370	336.18	400	0.4	0.08064516	4.96	67.77	9.76



Unconfined Compressive strength Q_u=	9.82	(ksf)
Unconfined Compressive strength Q_u=	68	(psi)
Cohesion C =	4.91	(ksf)

SOILS ENGINEERING, INC.

Client: Fluor Federal Services, Inc.

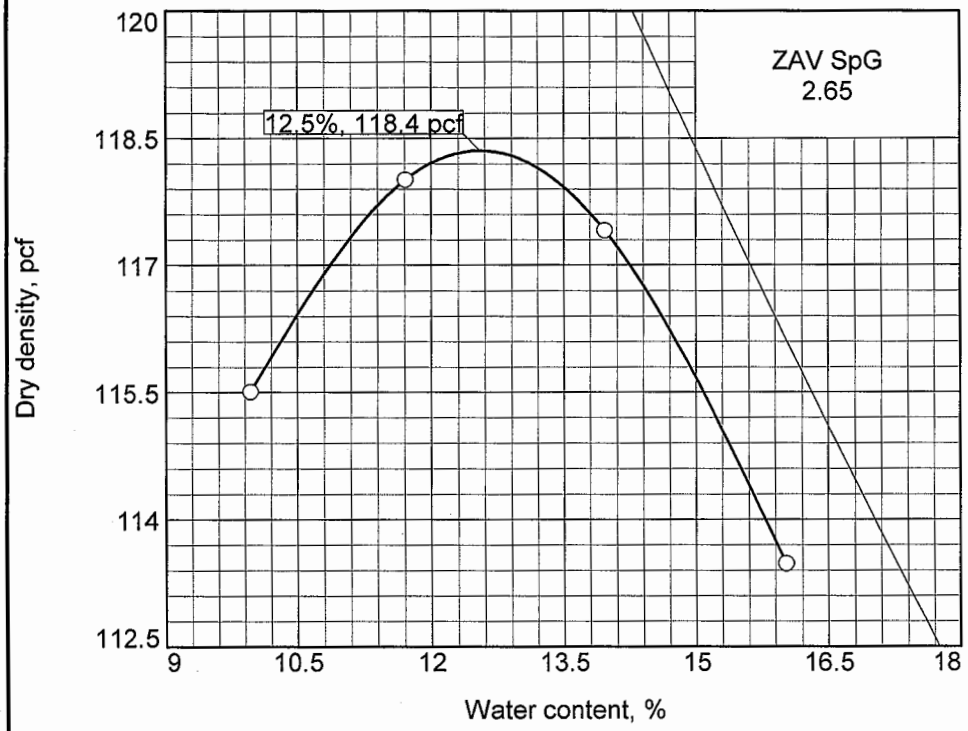
Project: CO2 Capture Project from Elk Hills Power Plant Project (EH-35R/C1RC)

Location: B-5 **Depth:** 16'

Material Description: SILTY CLAY; light yellowish brown, fine, low plasticity.

Project No.: 20-17662 **Figure** D-1

Maximum Density / Optimum Moisture Report



Curve No.
01

Test Specification:
ASTM D 1557 Method B Modified

Hammer Wt.: 10 lb.
Hammer Drop: 18 in.
Number of Layers: five
Blows per Layer: 25
Mold Size: 0.03333 cu. ft.

Test Performed on Material Passing 3/4 in. **Sieve**

Soil Data

NM N/A **Sp.G.** EST. 2.65
LL N/A **PI** N/A
%>3/4 in. N/A **%<#200** 46
USCS SC **AASHTO** N/A

TESTING DATA

	1	2	3	4	5	6
WM + WS	3971.1	4000.9	3898.3	3968.5		
WM	1978.0	1978.0	1978.0	1978.0		
WW + T #1	514.0	493.9	493.7	506.9		
WD + T #1	501.9	482.1	484.9	491.6		
TARE #1	398.6	397.6	396.6	396.1		
WW + T #2						
WD + T #2						
TARE #2						
MOISTURE	11.7	14.0	10.0	16.0		
DRY DENSITY	118.0	117.4	115.5	113.5		

TEST RESULTS

Maximum dry density = 118.4 pcf

Optimum moisture = 12.5 %

Material Description

CLAYEY SAND; light yellowish brown, PG, cohesive, low plasticity clay, trace of fine gravel

Project No. 17662 **Client:** Fluor Federal Services, Inc.
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

○ **Location:** TP-1 @ 0-5' **Depth:** 0-5' **Sample Number:** 74622

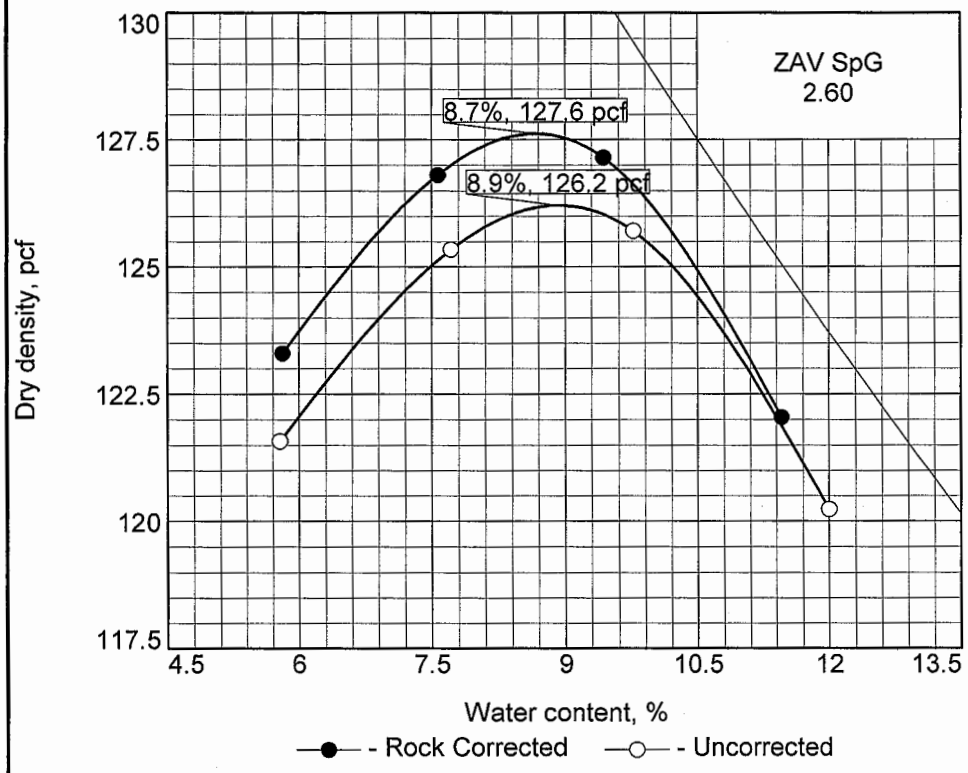
Remarks:
Sample No: 74622
Sampled By: MW/LG
Date Tested: 06/25/20

SOILS ENGINEERING, INC.

Figure E-1

Tested By: DM **Checked By:** AL

Maximum Density / Optimum Moisture Report



Curve No.
02

Test Specification:
ASTM D 1557 Method B Modified
ASTM D4718-15 Oversize Corr. Applied to

Hammer Wt.: 10 lb.
Hammer Drop: 18 in.
Number of Layers: five
Blows per Layer: 25
Mold Size: 0.03333 cu. ft.

Test Performed on Material Passing 3/4 in. **Sieve**

Soil Data

NM N/A **Sp.G.** EST. 2.65
LL N/A **PI** N/A
%>3/4 in. 9.11 **%<#200** N/A
USCS SP-SM **AASHTO** N/A

TESTING DATA

	1	2	3	4	5	6
WM + WS	4019.2	4064.1	4013.9	3922.3		
WM	1978.0	1978.0	1978.0	1978.0		
WW + T #1	492.4	494.3	203.9	501.3		
WD + T #1	485.6	485.8	193.7	495.5		
TARE #1	397.5	398.8	108.7	395.2		
WW + T #2						
WD + T #2						
TARE #2						
MOISTURE	7.6	9.4	11.5	5.8		
DRY DENSITY	126.8	127.1	122.0	123.3		

ROCK CORRECTED TEST RESULTS	UNCORRECTED	Material Description
Maximum dry density = 127.6 pcf	126.2 pcf	POORLY GRADED SAND with silt/low fine content; yellowish brown, non-cohesive, trace of fine gravel, trace of gravel
Optimum moisture = 8.7 %	8.9 %	

Project No. 17662 **Client:** Fluor Federal Services, Inc.
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

○ **Location:** TP-1 @ 6-12' **Depth:** 6-12' **Sample Number:** 74624

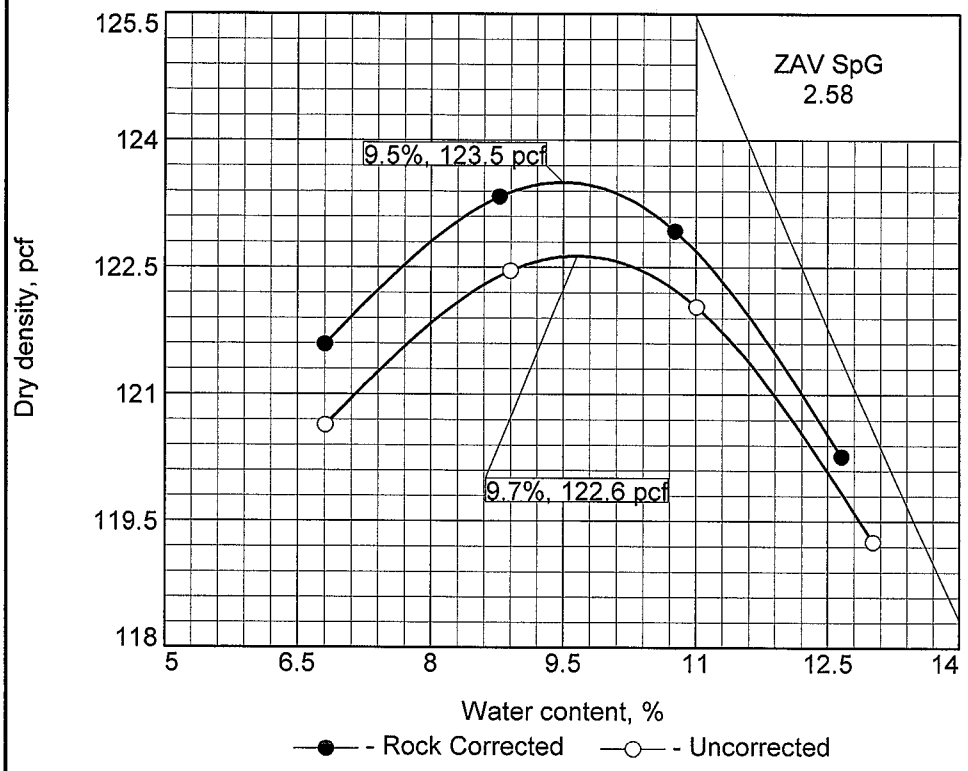
Remarks:
Sample No: 74624
Sampled By: MW/LG
Date Tested: 07/01/20
Oversize Specific Gravity 2.3

SOILS ENGINEERING, INC.

Figure E-2

Tested By: DM **Checked By:** AL

Maximum Density / Optimum Moisture Report



Curve No.
03

Test Specification:
ASTM D 1557 Method B Modified
ASTM D4718-15 Oversize Corr. Applied to

Hammer Wt.: 10 lb.
Hammer Drop: 18 in.
Number of Layers: five
Blows per Layer: 25
Mold Size: 0.03333 cu. ft.

Test Performed on Material Passing 3/4 in. **Sieve**

Soil Data

NM N/A **Sp.G.** EST. 2.65
LL N/A **PI** N/A
%>3/4 in. 5.71 **%<#200** N/A
USCS SP-SM **AASHTO** N/A

TESTING DATA

	1	2	3	4	5	6
WM + WS	3926.0	3994.1	4026.0	4015.6		
WM	1978.0	1978.0	1978.0	1978.0		
WW + T #1	202.8	491.7	492.3	504.2		
WD + T #1	196.8	484.1	482.9	491.6		
TARE #1	108.7	398.7	397.5	394.8		
WW + T #2						
WD + T #2						
TARE #2						
MOISTURE	6.8	8.8	10.8	12.7		
DRY DENSITY	121.6	123.3	122.9	120.3		

ROCK CORRECTED TEST RESULTS	UNCORRECTED
Maximum dry density = 123.5 pcf	122.6 pcf
Optimum moisture = 9.5 %	9.7 %

Material Description
POORLY GRADED SAND with silt/low fine content; yellowish brown, non-cohesive, trace of fine gravel, trace of gravel

Project No. 17662 **Client:** Fluor Federal Services, Inc.
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

○ **Location:** TP-3 @ 0-5' **Depth:** 0-5' **Sample Number:** 74631

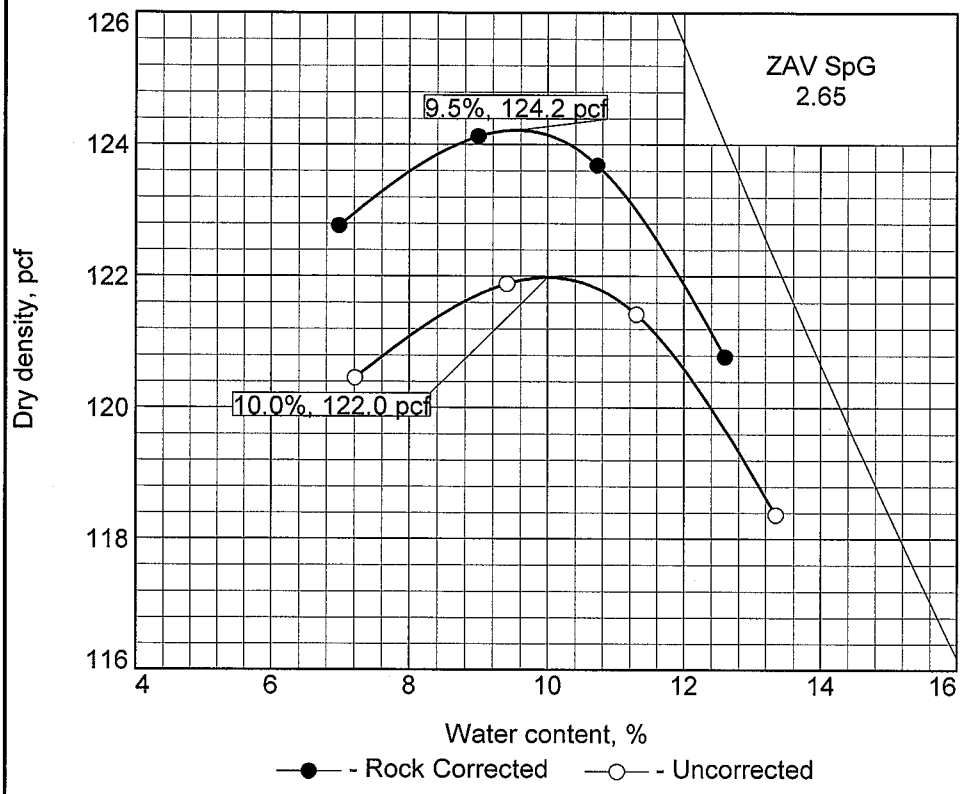
Remarks:
Sample No: 74631
Sampled By: MW/LG
Date Tested: 07/01/20
Oversize Specific Gravity 2.24

SOILS ENGINEERING, INC.

Figure E-3

Tested By: DM **Checked By:** AL

Maximum Density / Optimum Moisture Report



Curve No.
04

Test Specification:
ASTM D 1557 Method B Modified
ASTM D4718-15 Oversize Corr. Applied to

Hammer Wt.: 10 lb.
Hammer Drop: 18 in.
Number of Layers: five
Blows per Layer: 25
Mold Size: 0.03333 cu. ft.

Test Performed on Material Passing 3/4 in. **Sieve**

Soil Data

NM N/A **Sp.G.** EST. 2.65
LL N/A **PI** N/A
%>3/4 in. 8.36 **%<#200** N/A
USCS SP-SM **AASHTO** N/A

TESTING DATA

	1	2	3	4	5	6
WM + WS	3930.4	3994.0	4021.1	4006.3		
WM	1978.0	1978.0	1978.0	1978.0		
WW + T #1	496.9	494.6	493.9	506.4		
WD + T #1	490.2	486.2	484.0	493.2		
TARE #1	397.3	396.9	396.4	394.3		
WW + T #2						
WD + T #2						
TARE #2						
MOISTURE	7.0	9.0	10.7	12.6		
DRY DENSITY	122.8	124.1	123.7	120.8		

ROCK CORRECTED TEST RESULTS	UNCORRECTED
Maximum dry density = 124.2 pcf	122.0 pcf
Optimum moisture = 9.5 %	10.0 %

Material Description
POORLY GRADED SAND with silt/low fine content; yellowish brown, non-cohesive, trace of fine gravel, trace of gravel

Project No. 17662 **Client:** Fluor Federal Services, Inc.
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

○ **Location:** TP-4 @ 7-10' **Depth:** 7-10' **Sample Number:** 74637

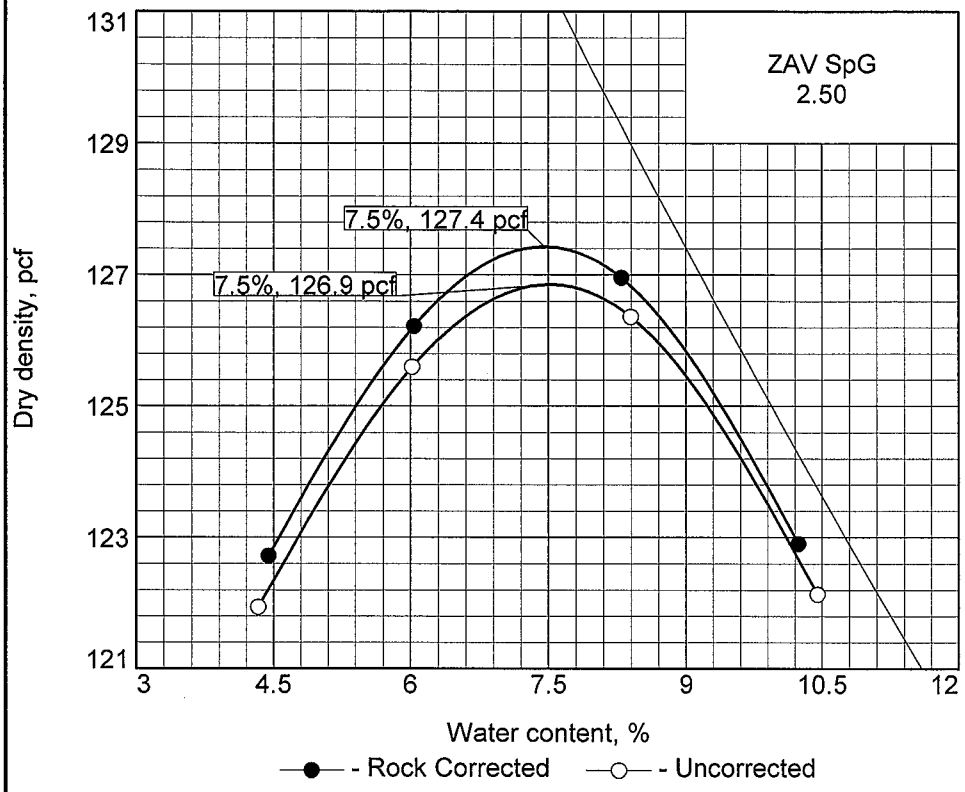
Remarks:
Sample No: 74637
Sampled By: MW/LG
Date Tested: 07/06/20
Oversize Specific Gravity 2.49

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Figure E-4

Tested By: DM **Checked By:** AL

Maximum Density / Optimum Moisture Report



Curve No.
05

Test Specification:
ASTM D 1557 Method B Modified
ASTM D4718-15 Oversize Corr. Applied to

Hammer Wt.: 10 lb.
Hammer Drop: 18 in.
Number of Layers: five
Blows per Layer: 25
Mold Size: 0.03333 cu. ft.

Test Performed on Material Passing 3/4 in. **Sieve**

Soil Data

NM N/A **Sp.G.** EST. 2.65
LL N/A **PI** N/A
%>3/4 in. 5.3 **%<#200**
USCS SP-SM **AASHTO** N/A

TESTING DATA

	1	2	3	4	5	6
WM + WS	4048.8	4017.4	3991.0	3901.3		
WM	1978.0	1978.0	1978.0	1978.0		
WW + T #1	496.9	501.0	502.6	502.6		
WD + T #1	489.3	491.3	496.6	498.1		
TARE #1	398.8	398.5	396.9	394.2		
WW + T #2						
WD + T #2						
TARE #2						
MOISTURE	8.3	10.2	6.0	4.4		
DRY DENSITY	127.0	122.9	126.2	122.7		

ROCK CORRECTED TEST RESULTS	UNCORRECTED	Material Description
Maximum dry density = 127.4 pcf	126.9 pcf	POORLY GRADED SAND WITH SILT/ LOW FINE CONTENT, yellowish brown, cohesive, trace of fine gravel, trace of gravel
Optimum moisture = 7.5 %	7.5 %	

Project No. 17662 **Client:** Fluor Federal Services, Inc.
Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

○ **Location:** TP-5 @ 0-5' **Depth:** 0-5' **Sample Number:** 74639

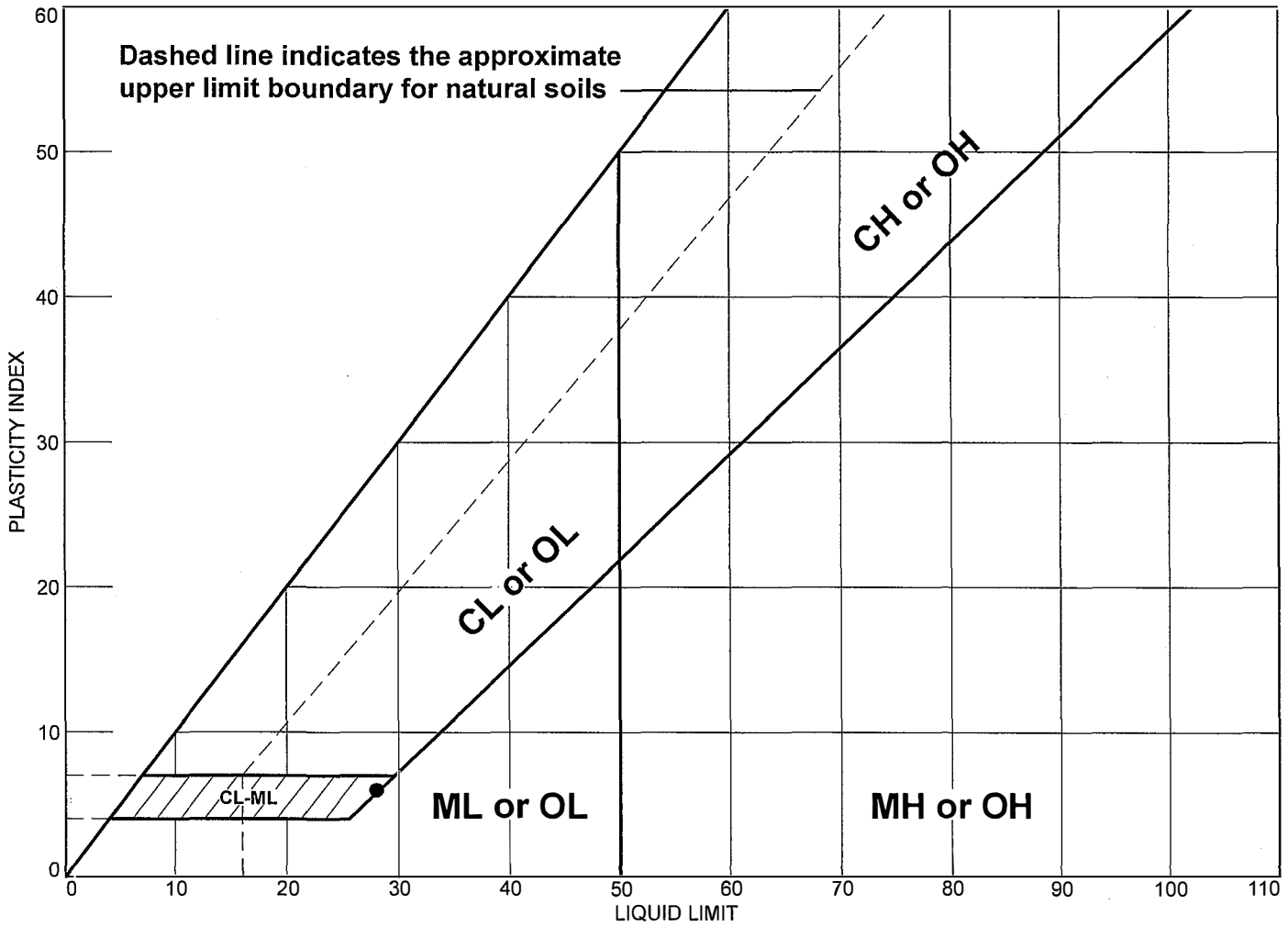
Remarks:
Sample No: 74639
Sampled By: MW/LG
Date Tested: 06/26/20

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Figure E-5

Tested By: DM **Checked By:** AL

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	CLAYEY SAND; light yellowish brown, PG, cohesive, low plasticity clay, trace of fine gravel	28	22	6		46.3	SC

Project No. 17662 **Client:** Fluor Federal Services, Inc.

Project: CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)

● **Location:** TP-1 @ 0-5' **Depth:** 0-5' **Sample Number:** 74622

Remarks:

● Test Date: 07/13/20

SOILS ENGINEERING, INC.

Figure F-1

Tested By: RG **Checked By:** AL

APPENDIX D

GEOLOGIC HAZAZRD STUDY

SEISMIC DESIGN INFORMATION

SEAOC Design Map Summary and Detail Report

EQFAULT

Version 3.00

California Fault Map

Subsurface Surveys – Seismic Survey Summary Report

LiquefyPro Data & Results

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SOILS ENGINEERING, INC.

GEOLOGIC HAZARD STUDY

FOR THE

CO2 CAPTURE PROJECT

FROM ELK HILLS POWER PLANT (EH-35R/C1RC)

APN: 158-090-19 | 4026 SKYLINE ROAD

TUPMAN, KERN COUNTY, CA

Prepared for:
Fluor Federal Services, Inc.
100 Fluor Daniel Drive
Greenville, South Carolina 29607

By:

SOILS ENGINEERING, INC.
SEI File No.20-17662

July 2020

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Appendix A: Deterministic Site Parameters, EQFault listing, EQSEARCHWIN, data, Seismic Design Data. USGS Unified Hazard Tool – Deaggregation data.

Appendix B: Selected Boring Logs, Test Pit Logs, Subsurface Surveys – Seismic Survey Summary Report, Table 1 – Blowcount Comparison for Deepest Borings and LiquefyPro Data

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SOILS ENGINEERING, INC.

July 13, 2020

File No. 20-17662

Fluor Federal Services, Inc.
100 Fluor Daniel Drive
Greenville, South Carolina 29607

Subject: Geological Hazard Study
For the CO2 Capture Project
From Elk Hills Power Plant (EH-35R/C1RC)
APN: 158-090-19 | 4026 Skyline Road
Tupman, Kern County, Ca

In accordance with your request and authorization, Soils Engineering, Inc. (SEI) has performed a Geological Hazards Study for the above described subject property within the Elk Hills Oil Field, Tupman, California (site). This study was conducted in compliance with the California Code of Regulations, Title 24, Chapters 16, 18 and 33 of the 2019 California Building Code.

Our Geological Hazards Assessment indicates that there is a low probability for liquefaction to occur during a major earthquake at the site and that the maximum peak ground acceleration at the site would be 0.249g, as a result of a maximum earthquake of magnitude 8.0 on the San Andreas Fault, approximately 24 kilometers away. The computer-modeling program EQSearchwin estimated that a ground motion of 0.141g from a 5.0 magnitude earthquake on June 1, 1893. The proposed structures should be built to withstand this magnitude of an earthquake and ground motions.

The site-specific design acceleration values to be utilized for the proposed improvements should be 0.94g for short periods (S_{Ds}) and 0.465g for the 1 second period (S_{D1}). Site Class C can be utilized for this site area based on a seismic survey conducted on-site and blowcount per foot analyses and the seismic design category is a D for both short and 1-second periods per the 2019 CBC.

In the event of a major earthquake, there is a very low potential for rock falls or landslides to impact the site. Minor settlement (<1") may occur at this site during a major earthquake.

Based on the lithology encountered in the top 10 feet in the soil borings, it appears that low to moderately expansive surface soils are present at this site. Expansive index testing and consolidation tests indicate that no mitigation measures will be necessary for expansive soils or hydrocompaction.

No additional geologic assessment is recommended at this time.

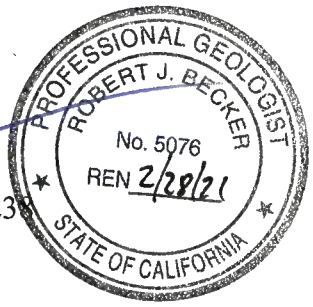
The accompanying report is an instrument of service of ***Soils Engineering, Inc.*** The report summarizes our findings and relates our opinions with respect to the potential for geological hazards to affect the site. Note that our findings and opinions are based on information that we obtained on

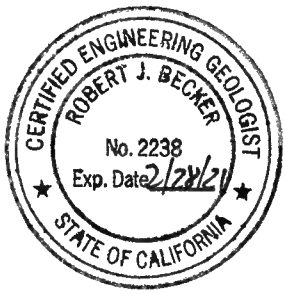
given dates, through records review, site review, and related activities. It is possible that other information exists or subsequently has become known, just as it is possible for conditions, we observed to have changed after our observation.

Soils Engineering, Inc. will be pleased to provide more information in this regard. Please call us for assistance at (661) 831-5100.

Sincerely,
SOILS ENGINEERING, INC.

Robert J. Becker, P.G. 5076, C.E.G. 2238
Expires 2/28/21





SOILS ENGINEERING, INC.

GEOLOGICAL HAZARDS STUDY

For
Proposed CO2 Recovery Facility
NW of Skyline Road and Elk Hills Road
In the
Elk Hills Oil & Gas Field, Tupman, California

July 2020

1.0 Introduction

Soils Engineering, Inc. (SEI) has conducted a Geological Hazards Study for the proposed development of a CO2 Recovery Facility, located northwest of Skyline Road and Elk Hills Road (site) within the Elk Hills Oil & Gas Field in Tupman, California (see Location Map, Plate 1). The site location coordinates are approximately 35.278489° north, latitude, and -119.470834° west, longitude. The following is an Executive Summary of the investigation conducted between June 5, 2020, and July 13, 2020.

A site reconnaissance, which consisted of walking the property and evaluating the surrounding geological features, was conducted by SEI personnel in June 2020. The project site covers approximately 8 acres, as shown on Plate 2, and consists of vacant land with mainly a dirt and gravel surface. Some scrub vegetation is present in the far eastern portion of the site area and has a slightly lower elevation. Adjacent off-site properties include Skyline Road to the south, the older 35R Gas Plant to the west, the Elk Hills Power Plant to the north, and vacant land with some pipelines to the east.

2.0 Geology and Hydrology

2.1 Geologic Setting

According to the 2010 Geologic Map of California the zone of influence for the proposed construction is located wholly within Quaternary Pliocene-Pleistocene non-marine sedimentary rocks (QPc) consisting of sandstone, shale, and gravel deposits; mostly loosely consolidated within the Elk Hills Oil and Gas Field. The Elk Hills Oil and Gas Field is located about 25 miles southwest of the City of Bakersfield, within the San Joaquin Valley in Kern County, California. The San Joaquin Valley is a large alluvial plain bordered by the Sierra Nevada Mountains on the east, the Diablo and Temblor Ranges on the west, the Tehachapi Mountains on the south, and the San Joaquin River on the north. The San Joaquin Valley is filled with alluvial sediments generally thousands of feet thick eroded from the mountains on all sides. The Elk Hills Oil and Gas Field is an anticline, composed of stratified alluvial soils that have been uplifted (SCS, 1986). The Elk Hills are a spur of the Temblor Range that extend southeastward approximately 16 miles and are 6 miles wide, reaching a maximum elevation of 1,551 feet. This is 1,000 to 1,200 feet above the main floor of the San

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Joaquin Valley.

The Tertiary and Quaternary deposits underlying Elk Hills and nearby areas are up to 24,000 feet thick. The Tulare formation lies at the surface of the Elk Hills and consists of alternating beds of non-marine sand, gravel, silt and clay (most noticeably the Amnicola, Tulare and Corcoran clay units). The Tulare formation consists of both unsaturated and saturated zones. The upper units of the Tulare formation are mostly unsaturated, while the lower units can be saturated with both water and oil. A geologic cross section of the southern San Joaquin Valley and the Elk Hills Oil and Gas Field is provided as Plate 3 (Department of Conservation, 1986 in DOE, 1993).

The Tulare formation has been folded into a large compound anticline consisting of two subsidiary anticlines commonly referred to as the 29R and the 31S structures (DOE, 1997). The 29R structure is tightly folded, asymmetrical and faulted. The 31S structure is cut by numerous minor faults, four of which reach the surface in the northeast flank of the structure. Other faults in the shallow out-bearing beds do not reach the surface. Woodring et al. (1932) described smaller "earthquake cracks" along and parallel to the extreme north flank. Their trend is approximately perpendicular to the surface faults. Most noticeable among these cracks or small faults is the Tupman fault, which is a fracture cutting post-Tulare fan deposits with strike-slip and vertical displacement in the northeast flank of Elk Hills. A geologic cross section beneath the Elk Hills area, showing the 29R and 31S structures, is provided as Plate 4 (DOE, 1993). The site is not located in an Alquist-Priolo (earthquake fault) Special Study Zone, however there are numerous earthquake faults in the vicinity. The nearby faults, with distances from the site, are tabulated below.

SAN ANDREAS (Multiple Segments)	15	miles/	24.2	kilometers
Kern Front	22.5	miles/	36.2	kilometers
WHITE WOLF	25	miles/	40.2	kilometers
PLEITO THRUST	25.3	miles/	40.7	kilometers
SAN JUAN	29.1	miles/	46.8	kilometers
BIG PINE	40.8	miles/	65.6	kilometers
GARLOCK (West)	44.2	miles/	71.2	kilometers
SAN LUIS RANGE (S. Margin)	46.9	miles/	75.5	kilometers
NORTH CHANNEL SLOPE	49	miles/	78.8	kilometers
SAN GABRIEL	51.4	miles/	82.8	kilometers

2.2 Surface Lithology

Earth materials identified in the 16 onsite soil borings (B-1 to B-16) conducted in June 2020 located in the proposed building areas consisted generally of intervals of interbedded silty and sandy clay, sandy silt, silty sand, clayey sand, poorly graded sand and well-graded gravelly sand/sandy gravel layers along with some cobbles in the top 100 feet below ground surface (bgs). See Plate 2 for boring locations. These soils are described as CL, ML, SM, SC, SP, SW and GW, respectively, in

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the Unified Soils Classification System (USCS). The subsurface soils were described as medium dense to very dense for the cohesionless material (sands), and firm to hard for the cohesive soils (silts and clays). The majority of the soil borings encountered sandy silt (ML), silty clay (CL) or clayey sand (SC) in the top 2' to 10' below ground surface (bgs). Beneath this surface material was a fine to very coarse-grained gravelly sand (SW) with cobbles up to 4" in diameter to an approximate elevation of 1305' above sea level (asl). Layers of sandy silt (ML) and silty clay (CL & CH) are predominate from approximately 1305' to 1275' asl with a sand lense between 1292' to 1300' asl. Below this clay and sandy silt layer is predominately sand (SM and SP) with occasional layers of Sandy Silt (ML) and Clayey Sand (SC) to the depth explored (101' or an approximate elevation of 1238' asl. Blowcounts for the bottom 12" of each soil sample collected during this investigation were normally greater than 50, but less than 100. See Attachment B for selected boring logs and Appendix B of the Geotechnical Report for all of the soil boring logs.

Five (5) Test Pits (TP-1 to TP-5) were dug to a depth of 12' bgs at proposed building locations spread across the site and the lithology was observed and described by a Professional Geologist (PG). In the western portion of the site (TP-3, TP-4) the majority of the surface material was a silty sand (SM) to a depth of 2' which was underlain by a gravelly sand/sandy gravel (SW/GW) with cobbles up to 4" in diameter present. In TP-4 abandoned electrical conduit (3 pipes) was encountered at a depth of 3' bgs and the test pit was continued further to the south to avoid these conduits. Test Pit TP-2 encountered some minor hydrocarbon impacted soil in the top 6' before encountering a clay drainage pipe. The TP-2 location was moved approximately 15' further to the east and was then advanced to a depth of 12'. TP-2 had sandy silt (ML) in the top 7 feet and was underlain by silty sand (SM) to a depth of 11' and then a gravelly sand (SW) was encountered. TP-1 had sandy clayey silt (ML) in the top 2 feet and was underlain by sandy silt/silty sand (ML/SM) to a depth of 6' and then a gravelly sand (SW) was encountered. TP-5 had some silty sand in the top 2 feet with a thin layer of hydrocarbon impacted soil from 2' to 2.5' and was underlain by gravelly sand (SW) with cobbles up to 4 inches in diameter. All of the test pits were backfilled with excavated native soil which was placed and compacted by the excavator bucket in 6" lifts up to match the existing surfaces. See attached Test Pit logs in Attachment B for more detail.

A seismic shear wave survey was conducted by Subsurface Surveys at boring locations B-2 and B-12 with a geophone surface line length of 345'. The reported shear wave velocities ranged from 827 to 1390 ft/sec to a depth of 65' bgs. Significant noise from the adjacent Power Plant to the north made interpretation of the seismic date difficult below a depth of 65 feet. Shear wave velocities increased steadily to the total depth of good data and interpolated Vs100 feet velocities ranged from 1050 ft/s to 1155 ft/s. P wave velocities ranged from 1384 ft/sec to 2686 ft/sec in the top 56 feet and were increasing with depth. Subsurface Surveys states "This suggests the true Vs100 ft values at this site will, most likely, be significantly higher than the extrapolated data." See attachment B for more detail.

To further evaluate the appropriate Soil Class type for the site, blowcounts for the deeper borings were reviewed. This included borings B-2 and B-12 which were advanced to depths of 97' and 101'

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bgs to approximate elevations of 1243' and 1238' asl, respectively. Soil samples were collected at 5' intervals utilizing a California modified split-spoon sampler. The blowcounts for the CA modified samples were adjusted by a factor of 0.65 to reflect equivalent SPT values as determined by comparing blowcounts from adjacent borings B-6 and B-11 utilizing the standard penetration split-spoon sampler (SPT) sampling method. The mean standard penetration resistance for these soil borings (B-2 and B-12) ranged from 52.01 (B-2 to 97') to 64 (B-12 to 101') as shown on the Table 1 included in Attachment B. Based on this information the site area soil conditions are most consistent with the "C" Site Class (very dense soil and soft rock) for average soil properties in the top 100' at the site.

SEI has prepared two (2) cross-sections running NW to SE (Plate 6, A-A') and east-west (Plate 7, B-B'), which show the general site geology encountered in the soil borings conducted at this site. The line of these two (2) cross-sections are shown on Plate 2.

No shallow groundwater was encountered in the soil borings advanced up to a depth of 100'. See selected soil boring logs included in Attachment B for more detail.

2.3 Hydrology

Unconfined Aquifer - Depth to groundwater is estimated at over 500 feet below ground surface (bgs.) in this area of Kern County. A groundwater assessment conducted by the Mark Group within 27R approximately 1 mile to the northwest of the subject site encountered no groundwater to a depth of 420' in 1987. In addition, a 1000-foot soil boring was drilled in 1991 at the nearby 27R facility and did not encounter water.

Perched Water, Ground Water or Seepage - No shallow ground water beneath the site is known and no groundwater was encountered in any of the soil borings at the site to a depth of 100'.

3.0 Seismic and Fault Hazards

3.1 Seismic History

From 1852 through 2020, southern California has experienced at least 20 major earthquakes with estimated Richter scale magnitudes ranging from 5.9 to 8.0. The largest recorded earthquake in the region of Elk Hills occurred in 1952 with an estimated Richter scale magnitude of 7.7 on the White Wolf Fault (referred to as the Kern County Earthquake). Prior to Richter scale usage, the historical Fort Tejon earthquake of 1857 occurred along the San Andreas Fault (23.6 kilometers away) with an estimated magnitude of at least 7.9.

In addition to the two (2) major earthquakes mentioned above, many earthquakes have occurred in the Kern County area, but only a few have had a magnitude greater than five on the Richter scale. Some of these include; the Wheeler Ridge earthquake (5.2 magnitude) and the Bakersfield Quake (5.8 magnitude, an aftershock of the Kern County Earthquake).

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The Wheeler Ridge earthquake occurred on May 27, 1993, 15 miles southwest of the city of Bakersfield; although noticed over a wide area of southern and central California, it caused little damage.

The Bakersfield Quake occurred on August 22, 1952 approximately 6 miles east southeast of Bakersfield. This Kern County Earthquake aftershock was the closest to Bakersfield and caused extensive damage to downtown Bakersfield and killed 2 people.

The Kern County Earthquake (magnitude 7.7), which occurred on July 21, 1952, claimed 12 lives and caused at least $50 million in damage.

The Fort Tejon earthquake (estimated magnitude 7.9), which occurred in January 1857 caused 2 deaths and severe damage to Fort Tejon and other small communities in the area. Since this was a sparsely populated area in 1857 the damage was not as much as it would be today. The severe shaking from this earthquake lasted for more than a minute and reportedly caused the Kern River to turn upstream, the waters of Tulare Lake to be thrown up onto it's shore stranding fish miles from the original Lake bed, and causing cracks in the ground as far away as San Bernardino, CA. The surface rupture along the San Andreas Fault was at least 220 miles, with an average slip of 15 feet and a maximum displacement of 30 feet (SCEDC, 2001).

Though the Elk Hills Oil and Gas Field is in a seismically active region, no historically active faults have been identified by the State Geologist of the California Division of Mines and Geology (CDMG) at Elk Hills (DOE 1993). Only minor in-active faults have been mapped in the Elk Hills Oil and Gas Field. The closest major active fault near Elk Hills is the San Andreas fault, located approximately 15 miles west of Elk Hills on the west side of the Temblor Range. Other major faults near Elk Hills are the White Wolf fault (25 miles southeast from Elk Hills), the Kern front fault (27 miles northeast from Elk Hills), and the Pleito Thrust fault (25 miles southeast from Elk Hills). The closest minor active fault is the Buena Vista Fault approximately 5 miles away.

The major quaternary faulting in the project vicinity is shown on Plate 5. Characteristics of major faults within 25 miles of the site are discussed in the following subsections and are shown on Table A.

San Andreas Fault

The Carrizo segment of the San Andreas fault is located approximately 15 miles west of the site (Plate 5). Movement along the San Andreas in this area is almost pure strike-slip at an average rate of 20 mm to 35 mm per year. The maximum moment magnitude (Mo) of this fault is reported as 7.8 to 8.0 by the California Division of Mines and Geology (CDMG). This segment of the San Andreas last ruptured in the 1857 Fort Tejon earthquake with displacements of 5-10 meters along a 220-mile surface rupture. An earthquake magnitude of 8.0 has been estimated by the U.S. Geological Survey

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for this segment and a conditional probability of occurrence of such an event of 0.1 over the 30 year period of 1988 to 2018 (USGS, 1988). Other segments of the San Andreas fault include the Cholame (north) and Mojave (south) segments; their respective distances from the site and characteristic magnitudes are 58 miles and magnitude 7.3 (Cholame) and 78 miles and magnitude 7.8 (Mojave). The associated conditional probabilities of occurrence, for the 30-year period of 1988 to 2018, estimated by the U. S. Geological Survey (1988), were 0.3 for both segments.

Boundary Zone Blind Thrusts

The Coast Ranges-Sierran Block boundary zone is a newly recognized 375-mile long zone of thrust and reverse faulting located along the western side of the Central Valley (Woodward-Clyde, 1991). The zone forms the tectonic boundary between the Coast Ranges and the Sierran crustal block. It is characterized by a series of anticlinal folds. The southernmost segment of the fault extends northward from the southwest corner of the San Joaquin Valley to north of Coalinga. Several recent earthquakes, including the Coalinga in 1983, North Kettleman Hills in 1985, Whittier Narrows in 1987, and Northridge in 1994 have occurred along the southern portion of this boundary zone. Several investigators have suggested that anticlinal folds along the west margin of the San Joaquin basin (including Elk Hills) can be related to blind thrusts. Three (3) potentially active thrust faults have been identified just south of Elk Hills approximately 1.0 mile northwest of Ford City (DOE, 1994). Two of the faults have been accurately located and trend northwest to southwest. The third fault is inferred to trend in the same direction and may be associated with the active Buena Vista Thrust fault (5 miles away). Displacement along each fault caused by creep has been identified (DOE, 1994). Fault creep was first reported in 1993 after causing several oil well casings to collapse (DOE, 1994). This fault creep may be associated with the withdrawal of oil in this area (SCECDC, 2001).

White Wolf Fault

The White Wolf and Pleito thrust faults are located near the junction of the Sierra Nevada -Great Valley and Mojave tectonic blocks with the San Andreas Fault to the west (Plate 7). Movement along the White Wolf has been reported at an average rate of 2 mm per year. The maximum moment magnitude of this fault is reported as 7.3 by the CDMG. The White Wolf fault is a northeast-trending reverse fault that ruptured during the magnitude 7.7 Kern County earthquake of July 21, 1952. The White Wolf fault is approximately 25 miles southeast of the site. Two (2) associated aftershocks occurring on July 29, and August 22, 1952 (referred to as the Bakersfield Quake) with magnitudes 6.1, and 5.8, respectively, occurred some distance (approximately 12 miles) northwest of the White Wolf fault and caused increased damage to downtown Bakersfield.

Pleito Thrust Fault

The Pleito thrust fault lies to the west of the White Wolf fault. It is an accurate, generally east-west trending, south dipping thrust fault along the southern margin of the San Joaquin Valley.

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The fault is approximately 25 miles from the site. Movement along the Pleito Thrust has been reported at an average rate of 2 mm per year. The maximum moment magnitude of this fault is reported as 7.3 by the CDMG. The latest movement is Holocene so the fault is classified as active, although there are no confirmed associations with historical seismicity. Wesnousky (1986) assessed a characteristic magnitude of 7.0 and return period of 1470 years for the fault.

SEI utilized the software program EQSEARCHWIN version 3.0 (Thomas F. Blake) to evaluate historical earthquakes in the area of the site over the last 200 years. The Earthquake Epicenter Map (Plate 5C) shows earthquake magnitudes and the epicentral distance from the site. The majority of the seismic activity in the area of the site has been along the White Wolf Fault and the San Andreas Fault. The closest earthquake of at least 5.0 magnitude to the site was 3.8 kilometers away, at a magnitude of 5.0 in June 1893. The largest magnitude earthquake within 100 miles was 7.9 on the San Andreas Fault in 1857. The largest estimated site acceleration is 0.141 g from a 5.0 magnitude earthquake on June 1, 1893. The EQSEARCHWIN estimation of Peak Acceleration from California Earthquake Catalogs Table, Earthquake Recurrence Curve, Earthquake Epicenter Map and a graph of the Number of Earthquakes (N) above Magnitude (M) are presented in Attachment A.

3.2 Seismic Evaluation

The site is located within the East Elk Hills Quadrangle in the northeast ¼ of Section 35, Township 30 South, Range 23 East and is not located in an Alquist-Priolo special studies zone (California Fault Zone). Local faults and general geology are also shown on the East Elk Hills Quadrangle, Seismic Hazard Atlas Maps prepared for the Kern County Council of Governments (Plate 5B).

According to the East Elk Hills Quadrangle Seismic Hazard Atlas Map, no active faults are present within 2 miles of the site. The nearest major active fault, as indicated by the computer-modeling program EQFault version 2.01, is the San Andreas Fault, which is approximately 24.2 kilometers to the southwest. The Kern Front Fault is approximately 36.2 kilometers to the northeast. The White Wolf Fault is approximately 40.2 kilometers to the southeast. The Pleito Fault is located approximately 40.7 kilometers southwest of the site. The closest minor active fault is the Buena Vista Fault approximately 5 miles away. Regional faults in relation to the site location are presented on Plate 5A and are from the Fault Activity Map of California (CDMG, 2010).

3.3 Seismic Design

The seismic design values are presented in the table below based on the 2019 California Building Code (CBC). The Site Class for the proposed improvements located northwest of Skyline Road and Elk Hills Road in Tupman, Kern County, California, were determined by a seismic shear wave survey and evaluating the standard penetration test data obtained at the site which are provided in the attached Boring Logs.

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SEISMIC DESIGN CRITERIA		VALUE	SOURCE
Risk Category		II	2019 CBC Table 1604.5 or 1604*A*.5
Site Class		C	2019 CBC § 1613.2.2 or 1613*A*.2.2; ASCE 7-16 Table. 20.3-1; Site Specific Soils Report, & Seismic Survey
Mapped MCE_R Spectral Response Acceleration, short period	S_S	1.175g	SEAOC-OSHPD software; 2019 CBC Figure 1613.2.1(1)
Mapped MCE_R Spectral Response Acceleration, at 1-sec. Period	S_1	0.465g	SEAOC-OSHPD software; 2019 CBC Figure 1613.2.1(2)
Site Coefficient	F_a	1.2	SEAOC- OSHPD software; 2019 CBC Table 1613.2.3(1) or 1613*A*.2.3(1)
Site Coefficient	F_v	1.5	2019 CBC Table 1613.2.3(2) or 1613*A*.2.3(2)
Adjusted MCE_R Spectral Response Acceleration, short period, $F_a * S_s$	S_{MS}	1.41	SEAOC- OSHPD software; 2019 CBC § 1613.2.3 or 1613*A*.2.3
Adjusted MCE_R Spectral Response Acceleration, 1-sec. period, $F_v * S_1$	S_{M1}	0.697	2019 CBC § 1613.2.3 or 1613*A*.2.3
Design Spectral Response Acceleration, short period, 2/3 S_{MS}	S_{DS}	0.94	SEAOC- OSHPD software; 2019 CBC § 1613.2.4 or 1613*A*.2.4
Design Spectral Response Acceleration, 1-sec. period, 2/3 S_{MI}	S_{D1}	0.465	2019 CBC § 1613.2.4 or 1613*A*.2.4
Peak Ground Acceleration for Max. Considered Earthquake (MCE_G)	PGA	0.500g	SEAOC- OSHPD software; ASCE 7-16 Fig 22-9
Site Coefficient, F_{PGA} = 1.2, F_{PGA}* PGA	PGA_M	0.600g	SEAOC- OSHPD software; ASCE 7-16 § 11.8.3.2
Mapped Risk Coefficient at 0.2 second Spectral Response Period	C_{RS}	0.902	SEAOC- OSHPD software; ASCE 7-16 Figure 22-18A
Mapped Risk Coefficient at 1 second Spectral Response Period	C_{R1}	0.891	SEAOC- OSHPD software; ASCE 7-16 Figure 22-19A
Seismic Design Category, short period		D	2019 CBC § 1613.2.5
Seismic Design Category, 1second period		D	2019 CBC § 1613.2.5
MCE_R = Maximum Considered Earthquake (risk targeted) MCE_G = Maximum Considered Earthquake (geometric mean)			

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3.4 Seismology & Calculation of Earthquake Ground Motion

Because the site is not located within or directly adjacent to a mapped Alquist-Priolo (AP) Earthquake Zone, is not a Seismic Design Category E or F and is not required by ASCE 7 §11.4.7, a site-specific ground motion analysis was not conducted for this site. The above seismic design information in Section 3.3 will be utilized for this project.

3.5 Possible Earthquake Effects

A number of active faults are located within a 50-mile radius of the subject site. To evaluate the affect a major earthquake might have on the site, the computer modeling program EQFaultwin vers. 3.0 (Thomas Blake) was utilized. Site-specific parameters were inputted and the programs computed the maximum peak site ground accelerations resulting from an earthquake. Because ground accelerations are based largely on fault distance and magnitude, we have focused our analysis on those faults which are close to the site, or that have large maximum credible magnitudes, or a combination of the two. The result of this analysis is presented below in Table A.

TABLE A

FAULT	Approximate Distance (Km)	Maximum Earthquake Magnitude (Mw)	Maximum Peak Ground Acceleration (g)	Estimated Site Intensity (MM)
San Andreas (1857 Rupture, Carrizo M-1c-2, Whole M-la, Cho-Moj M-1b-1, Cholame M-1c-1)	**24.2** to 36.1	7.3 to **8**	0.127 to **0.249**	VIII to **IX**
Kern Front	36.2	6.3	0.091	VII
White Wolf	40.2	7.3	0.143	VIII
Pleito Thrust	40.7	7.0	0.121	VII
San Juan	46.8	7.1	0.94	VII
Big Pine	65.6	6.9	0.065	VI
Garlock (West)	71.2	7.3	0.076	VII

This analysis estimates that a maximum peak ground acceleration of 0.249g would be felt at the site as a result of a maximum earthquake of magnitude 8.0 on the San Andreas Fault, approximately 24.2 kilometers away. See attached Deterministic Site Parameters for a full listing of computed values for faults within a 100-mile radius of the site in Attachment A. Also attached is a California Fault Map showing nearby faults in relationship to the site (Plate 5).

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Utilizing the USGS Unified Tool Box program the Probabilistic Seismic Hazard Deaggregation for the Site was calculated to be 0.432g for a 5% chance every 50 years of exceedance based on a 7.33 magnitude earthquake occurring 20.47 kilometers away. See Attachment A for this calculation results page.

3.6 Potential for Ground Rupture, Ground Shaking, Ground Failure

Ground rupture may occur along a fault trace in a major earthquake. Since this site is not located within 500 feet of a suspected active fault, it is unlikely that ground rupture would occur here. Moderate to strong ground shaking is likely at this site, in the event of a major earthquake on one of the nearby faults. Based on the predicted maximum horizontal accelerations at the site and the soil types identified in this investigation, ground failure is highly unlikely at this site.

3.7 Potential for Earthquake-Induced Flooding and Flood Zone

The site is located in an area with only a limited amount of surface water sources. It is very unlikely that earthquake-induced flooding would occur at this site.

3.8 Liquefaction Potential

No shallow groundwater was encountered in any of the soil borings (B-1 to B-16) to a maximum depth explored of 101 feet below ground surface (bgs). Historic depth to water has been well over 100' bgs in this area of Kern County. Therefore, liquefaction potential is minimal at this site.

3.9 Slope Stability

The site is located in an area with minimal slope to the west. No evidence of historic landslides or creep was observed in this area. There is a very low potential for rockfalls or landslides to impact the site in the event of a major earthquake. Overall, the site appears to be very stable.

3.10 Settlement

The estimated amount of dynamic settlement that would occur at this site during a major earthquake is approximately 0.37" (B-6) to 0.56" (B-11) based on the lithology encountered, the SPT blow counts recorded during sampling and the settlement analysis conducted on borings B-6 and B-11 sample data utilizing the program LiquefyPro. The estimated amount of differential settlement is 0.185" (B-6) to 0.281" (B-11) according to the program LiquefyPro. See attached Liquefaction Analysis Calculation Sheets and graphs in Attachment B for more detail.

3.11 Expansive Soil and Hydrocollapse Potential

Based on the lithology encountered in the top 10 feet in the soil borings, it appears that low to moderately expansive surface soils are present at this site. Three (3) expansive index tests were conducted on soil samples including B-1 @ 6', B12 @ 6', and TP-1 0 to 5' with an EI's of 3 to 28 reported which is low. Multiple consolidation tests were also conducted on the top 6' of samples with the results ranging from -0.1 to -2.9% indicating a low to moderate consolidation potential.

The City of Bakersfield Safety Element includes a discussion on land subsidence potential in the

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Bakersfield area. The main causes of land subsidence are Tectonic Subsidence, Oil & Gas Fluid Extraction, Groundwater Withdrawal and Hydrocompaction of Moisture Deficient Alluvial Deposits. Figure 15 in the Safety Element shows the areas of significant subsidence within the Bakersfield area. The proposed project is located within the area where no historic land subsidence has occurred and is outside of the area of hydrocompaction as shown on attached Plate 8. There is an area of hydrocompaction shown a few miles west of the site area. Based on this information it appears that regional subsidence should not be an issue at this site requiring any special mitigation or requirements.

4.0 Conclusions & Recommendations

Our Geological Hazards Assessment indicates that there is a low probability for liquefaction to occur during a major earthquake at the site and that the maximum peak ground acceleration at the site would be 0.249g, as a result of a maximum earthquake of magnitude 8.0 on the San Andreas Fault, approximately 24 kilometers away. The computer-modeling program EQSearchwin estimated that a ground motion of 0.141g from a 5.0 magnitude earthquake on June 1, 1893. The proposed structures should be built to withstand this magnitude of an earthquake and ground motions.

The site-specific design acceleration values to be utilized for the proposed improvements should be 0.94g for short periods (S_{Ds}) and 0.465g for the 1 second period (S_{D1}). Site Class C can be utilized for this site area based on a seismic survey conducted on-site and blowcount per foot analyses and the seismic design category is a D for both short and 1-second periods per the 2019 CBC.

In the event of a major earthquake, there is a very low potential for rock falls or landslides to impact the site. Minor settlement (<1") may occur at this site during a major earthquake.

Based on the lithology encountered in the top 10 feet in the soil borings, it appears that low to moderately expansive surface soils are present at this site. Expansive index testing and consolidation tests indicate that no mitigation measures will be necessary for expansive soils or hydrocompaction.

No additional geologic assessment is recommended at this time.

5.0 Attachments

- ***5.1*** Location Map- Plate 1, "Location Map" shows the location of the site with relationship to roads and land features.
- ***5.2*** Plot Plan - Plate 2, "PLOT PLAN" shows the location and configuration of the Site area.
- ***5.3*** Plate 3, Regional Geologic Cross-section - shows the regional geology of the Elk Hills Oil & Gas Field.
- ***5.4*** Plate 4, Cross-section Elk Hills - shows the regional subsurface geology of the Elk Hills Oil & Gas Field.
- 5.5 Plate 5, Fault Location Map- shows the site in relation to the nearest active faults within 100 miles based on the EQFault program.

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5.5.1 Plate 5A, shows the Regional Faults based on the Fault Activity Map of California 2010.

5.5.2 Plate 5B, Seismic Hazard Atlas Map, shows local geology and faults within the East Elk Hills Quadrangle near the site.

5.5.3 Plate 5C, Earthquake Epicenter Map, shows the site location on an earthquake epicenter map of historical earthquakes with magnitudes >5.0, from the Eqsearchwin computer modeling program

5.6 Plate 6, Geologic Cross-Section A to A', shows the subsurface lithology encountered in some of the soil borings at the site from Northwest to Southeast.

5.7 Plate 7, Geologic Cross-Section B to B', shows the subsurface lithology encountered in some of the soil borings at the site from West to East.

5.8 Regional Land Subsidence Map, Plate 8, shows the regional area of land subsidence and hydrocompaction.

5.9 Attachment A - Deterministic Site Parameters - EQFAULTWIN data determined for the site for faults within 100 miles. EQSEARCHWIN data concerning the distance and magnitude of earthquakes within 100 miles of the site is attached. Seismic Design Data from SEAOC- OSHPD. USGS Unified Hazard Tool – Deaggregation data.

5.10 Attachment B - Presents selected Boring Logs, Test Pit Logs, Subsurface Surveys - Seismic Survey Summary Report, Table 1 - Blowcount Comparison for Deepest Borings and LiquefyPro data.

6.0 References

- Water Supply Reports, Report on Water Conditions ID4, Kern County Water Agency, Bakersfield, California, 1983 to 2017.
- USGS Quadrangle Map, East Elk Hills Quadrangle, Sheet, 1968.
- Smith, Arthur, California Division of Mines and Geology - Geologic Map of California-Bakersfield Sheet, 1964, Olaf P. Jennings Edition.
- Jennings, Charles and Bryant, William, 2010 Geologic Map of California, CDMG, 2010.
- Jennings, Charles and Bryant, William, Fault Activity Map of California, CDMG, 2010.
- U.S. Dept. of Agricultural Soil Surveys, 1942, 1945, 1946.
- EQFaultwin, ver. 3.0, Thomas F. Blake;
- EQSEARCHWIN, ver. 3.0, Thomas F. Blake
- Blake, Thomas, Empirical Prediction of Earthquake Induced Liquefaction Potential.
- Seismic Hazard Atlas Map, East Elk Hills Quadrangle, Kern County.
- California Fault Parameters, 1996 Draft, California Department of Conservation, Division of Mines and Geology.
- N. Bolton Seed, Kotiji Tokimatsu, A.M., A.S.C.E, Evaluation of Settlement in Sands Due to Earthquake Shaking; Journal of Geotechnical Engineering A.S.C.E. Vol. 113, No. 8, August, 1987.
- Department of Water Resources, Groundwater Data Module, web page: http://wdl.water.ca.gov/gw/admin/main_menu_gw.asp

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- USGS, Design Maps, http://geohazards.usgs.gov/designmaps/us
- LiquefyPro (version 5.9b), CivilTech Software.
- Soils Engineering, Inc. – Preliminary Geotechnical Investigation, File No. 98-8810, December 28, 1998.
- Soils Engineering, Inc. – Final Engineering Geology Report for Elk Hills Power Plant, File No. 01-9542, January 25, 2002.
- Bid Documents for Geotechnical Investigation, LLC RFQ 537 197 – 591002, including Geologic Resources and Hazards section 5.5 of Power Plant Application.
- Southern California Earthquake Data Center (SCEDC), Internet Information Site.
- Microgeophysics Corp. (MGC), Geophysical Investigation Final Report-Downhole Survey, Elk Hills Power Plant Project, February 22, 2001.
- Soils Engineering, Inc. –Engineering Geology Report for Proposed 35R Gas Processing Facility, Section 35, T30S, R23E, Elk Hills in Kern County, California, File No. 13370, September 2010.
- Subsurface Surveys, Elk Hills Seismic Survey Report, August 18, 2010.
- Subsurface Surveys, Seismic Survey Summary Report, CRC – CO2 Capture Project, Elk Hills Property, Bakersfield, June 19, 2020.
- Mark Group, Vertical and Lateral Extent of Waste Constituents, 27R Waste Management Facility, Naval Petroleum Reserve-1, Elk Hills, CA, December 1987.

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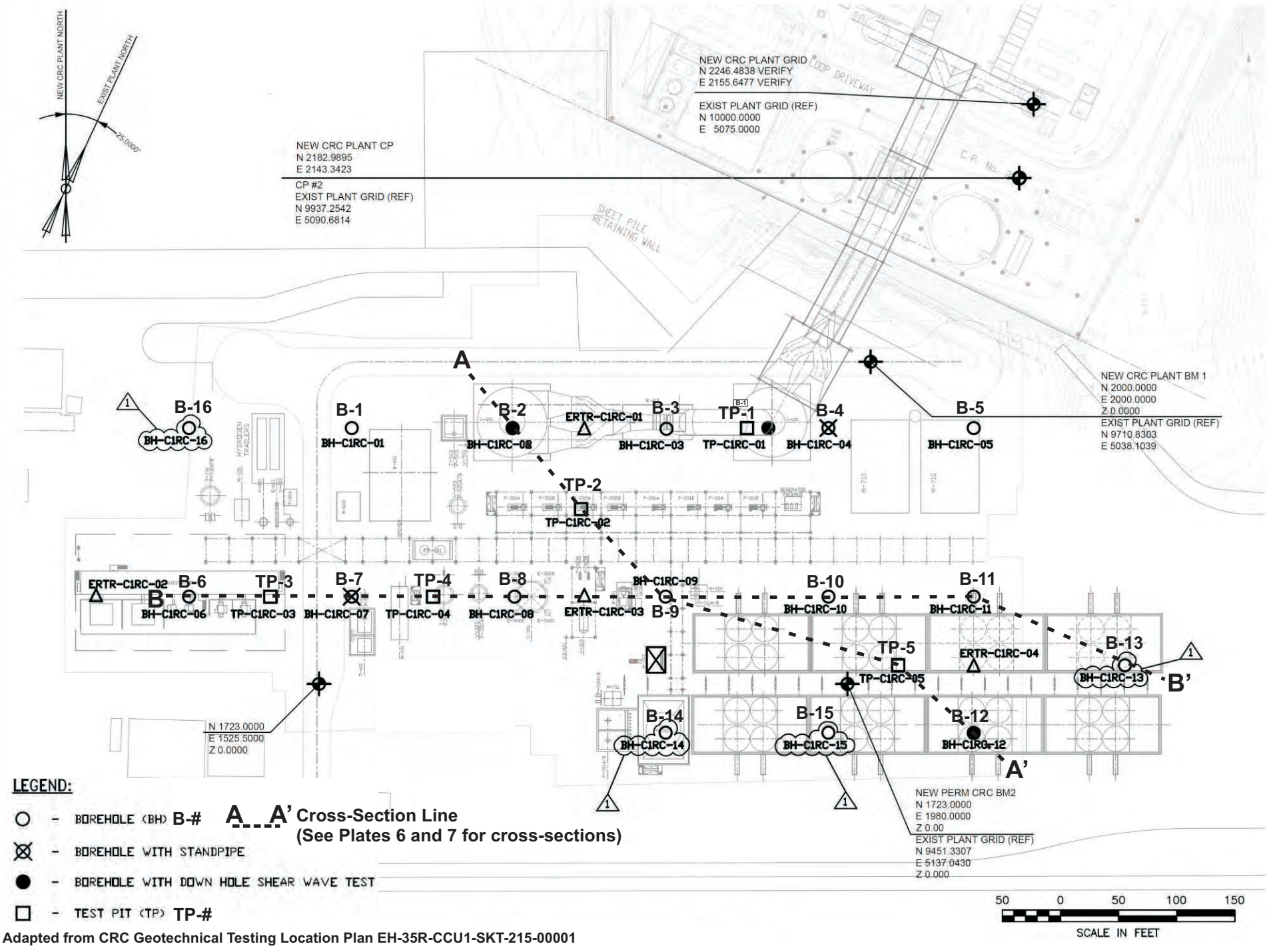
DATE: 6/2020
PROJECT: 20-19662

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Bakersfield, CA 93313
(661) 831 - 5100

Proposed CO 2 Recovery Plant
Sec. 35, T30S, R23R,Kern County, CA.

Location Map

PLATE
1



Adapted from CRC Geotechnical Testing Location Plan EH-35R-CCU1-SKT-215-00001

PLOT PLAN With Soil Borings & Cross-Section Lines

PLATE 2

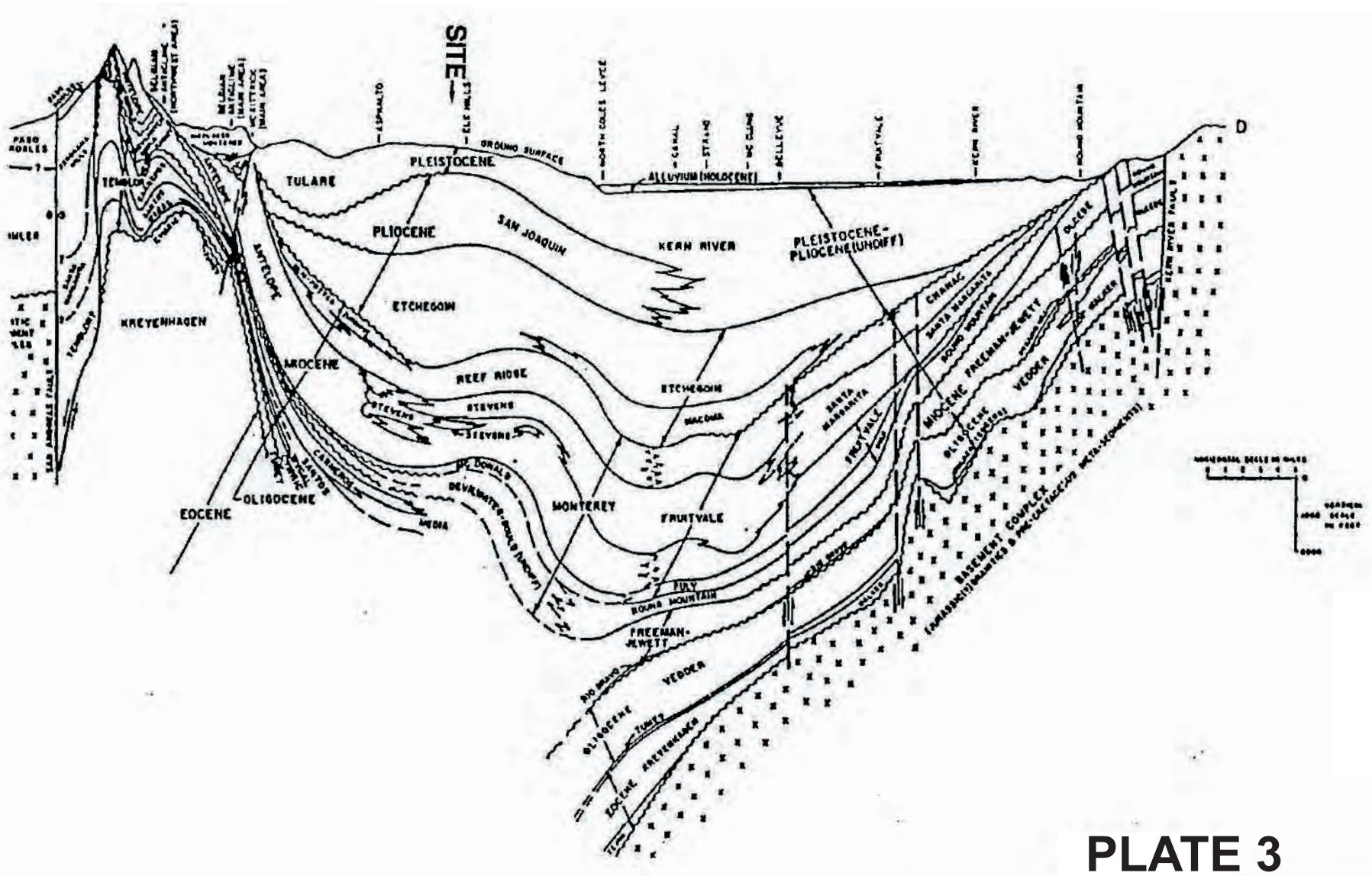
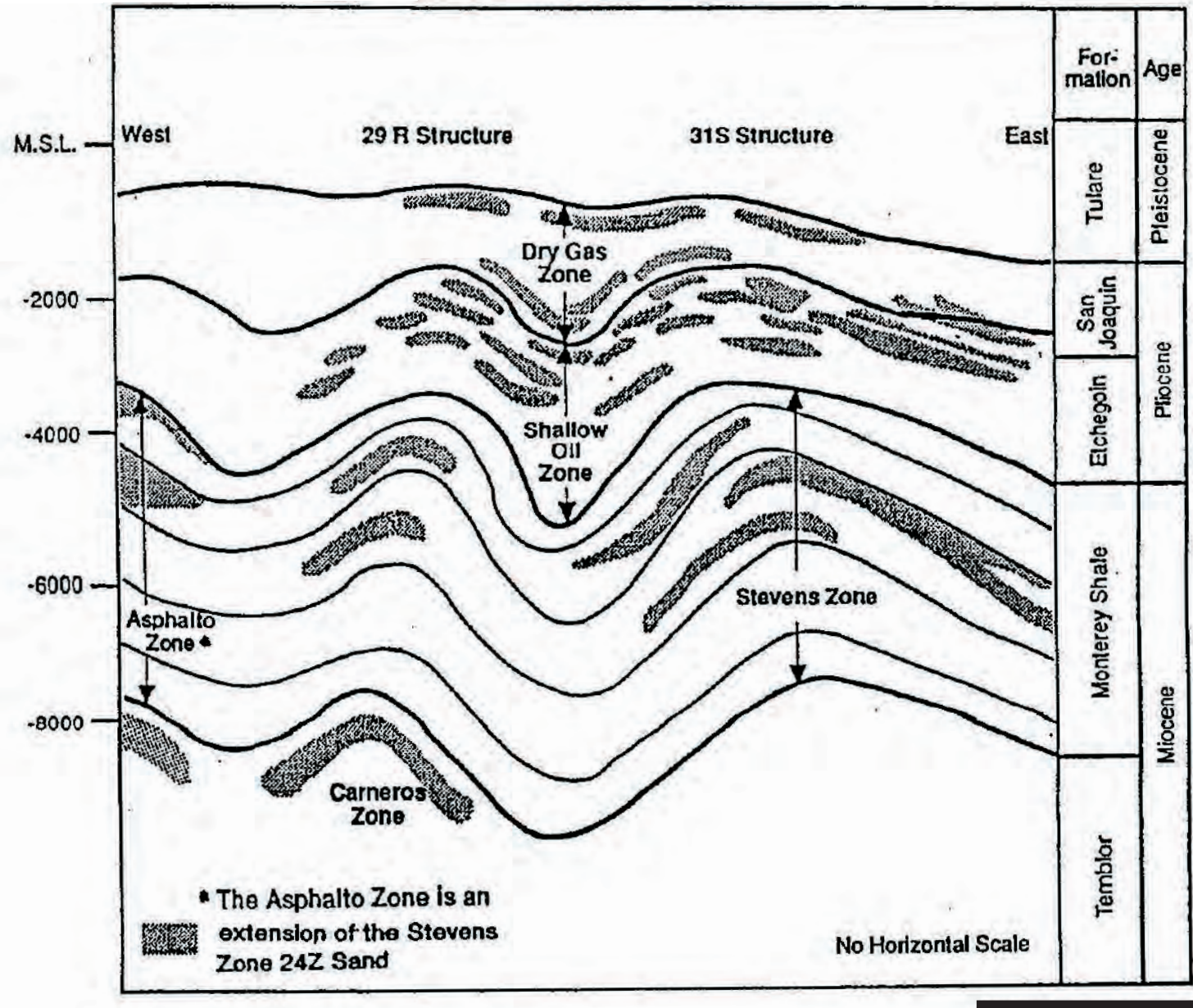


PLATE 3

Proposed CO 2 Recovery Plant

Geologic Cross Section of the Elk Hills Area

Source: DOE, 1993

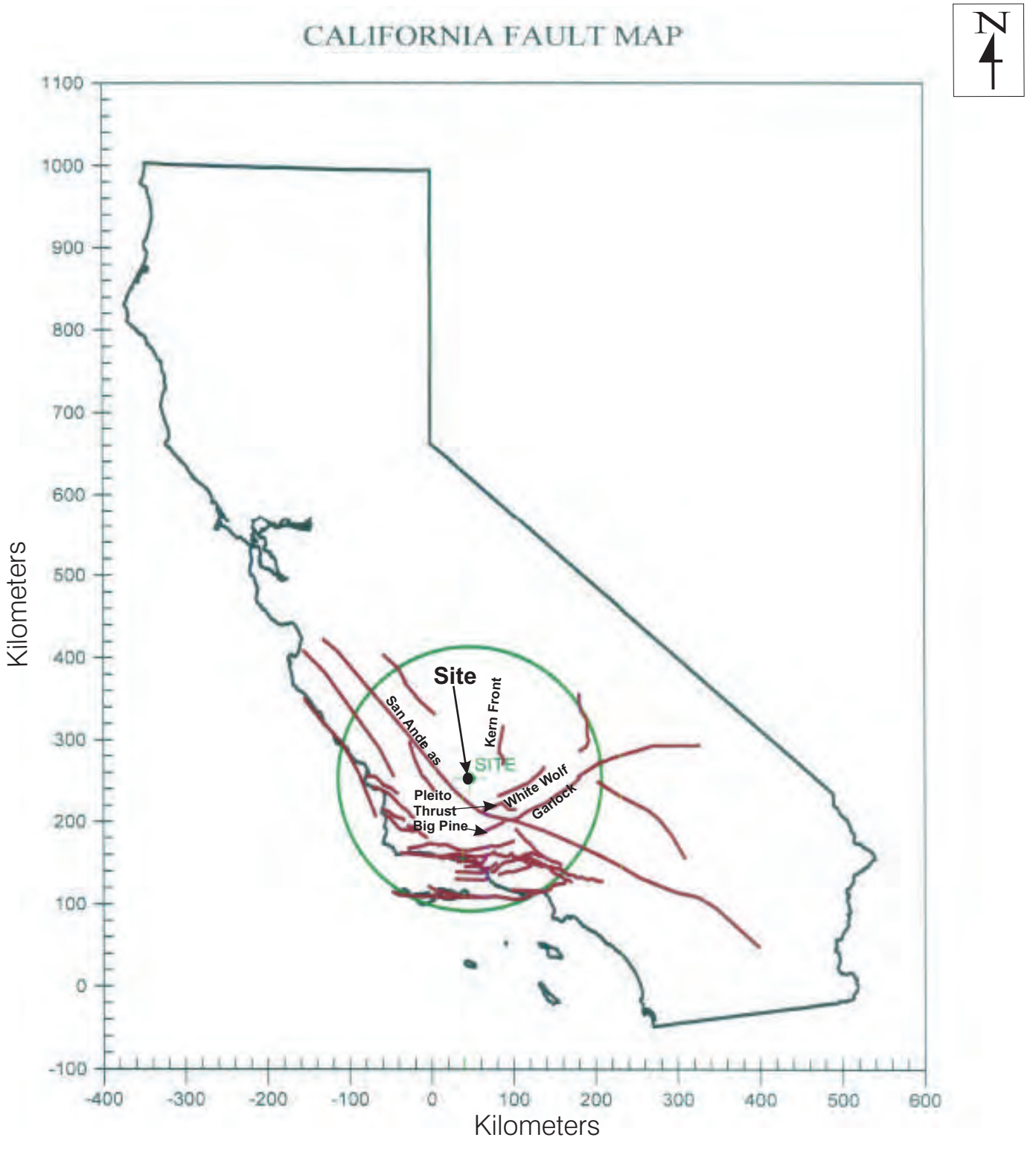


Source: DOE, 1993

PLATE 4

Proposed CO 2 Recovery Plant

Schematic Cross Section of the Elk Hills



SOILS ENGINEERING, INC. 4400 Yeager Way BAKERSFIELD, CA 93313 DATE: 6/20 PROJECT: #17662	**Proposed 35R CO2 Capture Project** **Sec 35, T30S, R23E** **Kern County, CA** Fault Location Map	**PLATE** **5**

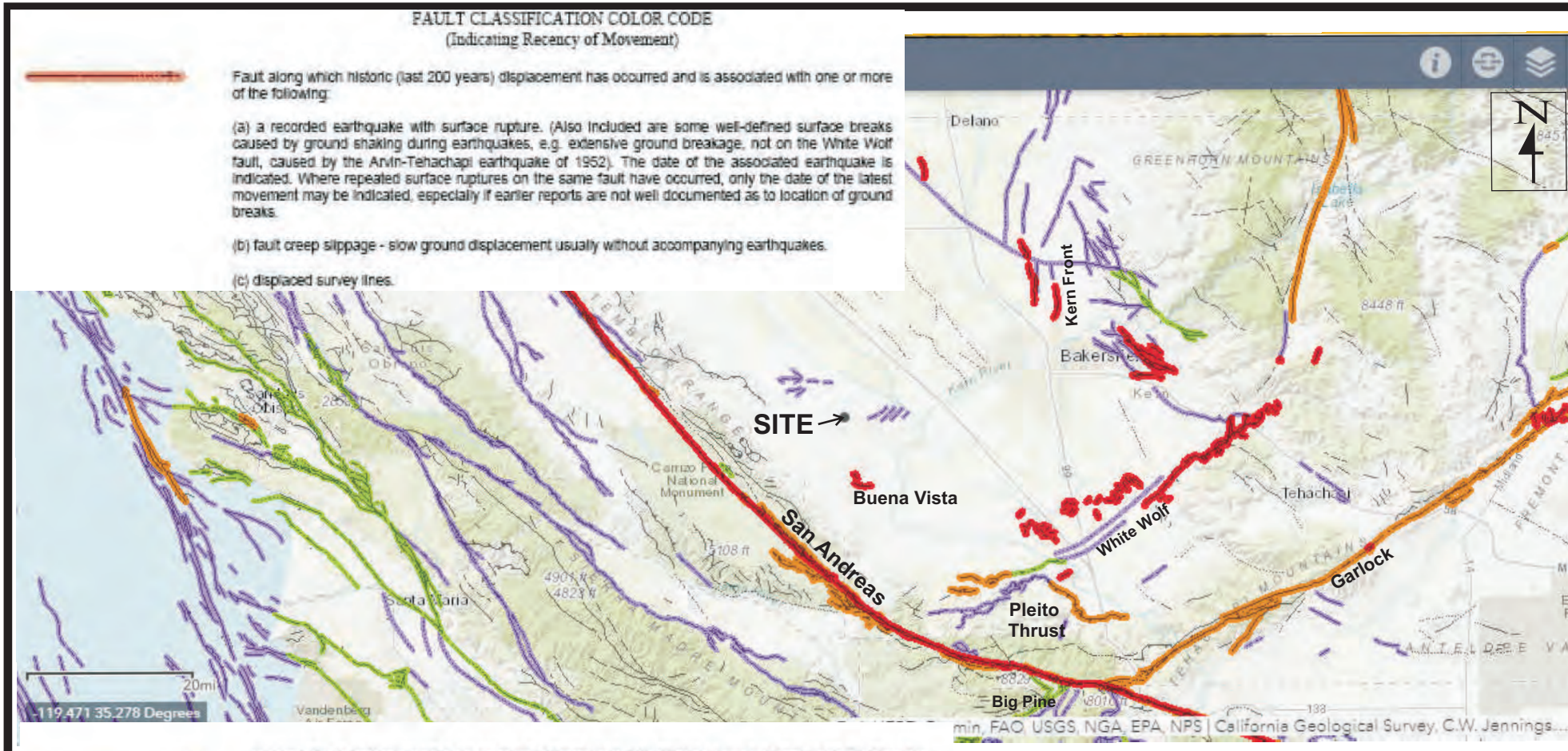
FAULT CLASSIFICATION COLOR CODE
(Indicating Recency of Movement)

Fault along which historic (last 200 years) displacement has occurred and is associated with one or more of the following:

(a) a recorded earthquake with surface rupture. (Also included are some well-defined surface breaks caused by ground shaking during earthquakes, e.g. extensive ground breakage, not on the White Wolf fault, caused by the Arvin-Tehachapi earthquake of 1952). The date of the associated earthquake is indicated. Where repeated surface ruptures on the same fault have occurred, only the date of the latest movement may be indicated, especially if earlier reports are not well documented as to location of ground breaks.

(b) fault creep slippage - slow ground displacement usually without accompanying earthquakes.

(c) displaced survey lines.



Holocene fault displacement (during past 11,700 years) without historic record. Geomorphic evidence for Holocene faulting includes sag ponds, scarps showing little erosion, or the following features in Holocene age deposits: offset stream courses, linear scarps, shutter ridges, and triangular faceted spurs. Recency of faulting offshore is based on the interpreted age of the youngest strata displaced by faulting.

Late Quaternary fault displacement (during past 700,000 years). Geomorphic evidence similar to that described for Holocene faults except features are less distinct. Faulting may be younger, but lack of younger overlying deposits precludes more accurate age classification.

Quaternary fault (age undifferentiated). Most faults of this category show evidence of displacement sometime during the past 1.6 million years; possible exceptions are faults which displace rocks of undifferentiated Plio-Pleistocene age. Unnumbered Quaternary faults were based on Fault Map of California, 1975. See Bulletin 201, Appendix D for source data.

Pre-Quaternary fault (older that 1.6 million years) or fault without recognized Quaternary displacement. Some faults are shown in this category because the source of mapping used was of reconnaissnce nature, or was not done with the object of dating fault displacements. Faults in this category are not necessarily inactive.

From 2010 Fault Activity Map of California, CDMG

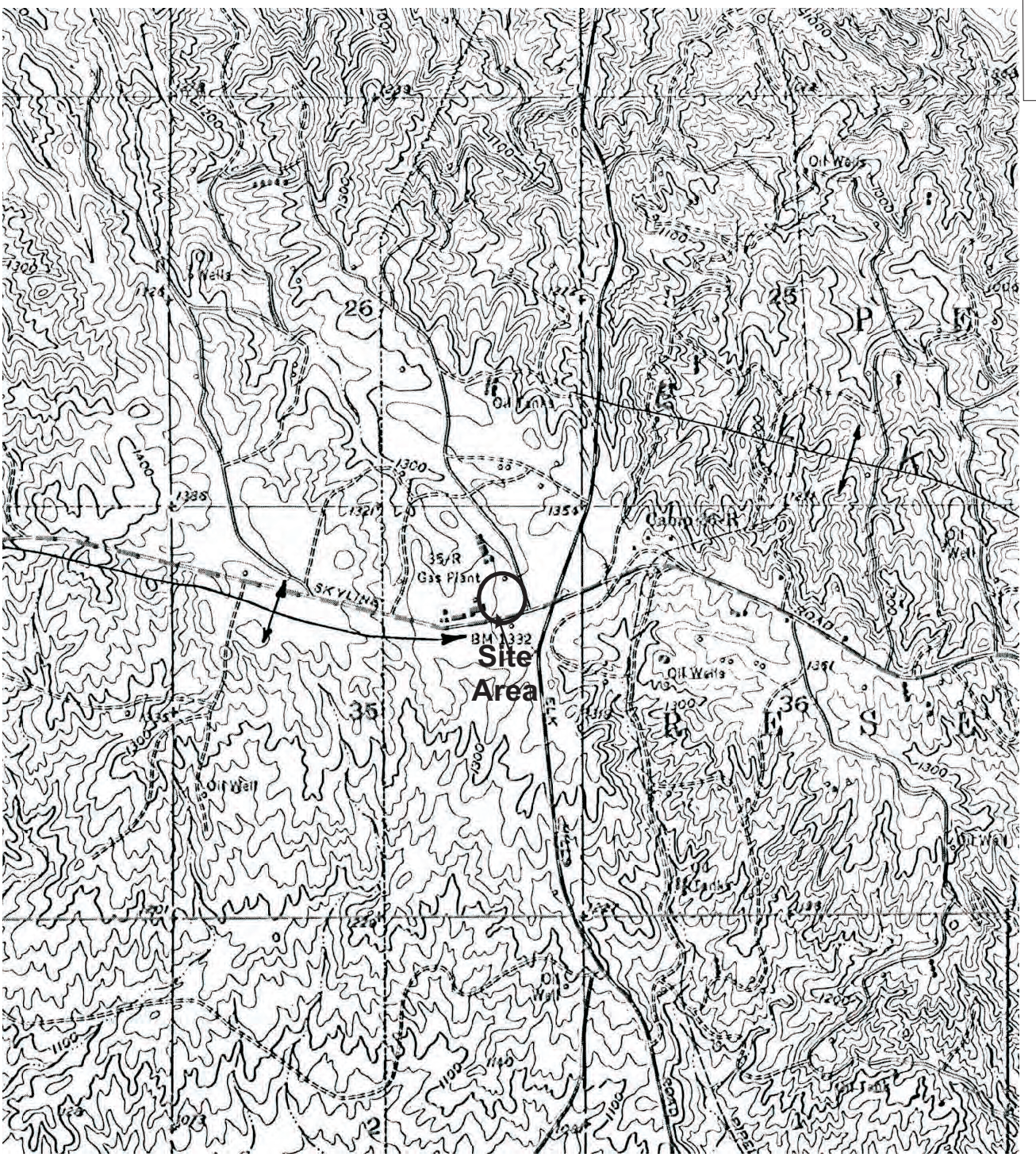
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BAKERSFIELD, CA 93313

DATE: 6/20
PROJECT: #17662

Proposed 35R CO2 Capture Project
Elk Hills Oil Field, Kern County, CA

Regional Fault Map

PLATE
5A



Ys = Young Sediments (Pleistocene and younger) Os = Older Sediments (Pliocene and Older)

Earthquake Epicenters (richter magnitude)
- 2.9 or less
- <3.0-3.9
- 4.0-4.9

Faults
- Surface Faulting
- Subsurface Faulting

Shallow Water Zone (<20')

SOURCE: East Elk Hills Quadrangle, Seismic Hazard Atlas Map, Kern County Council of Govt.

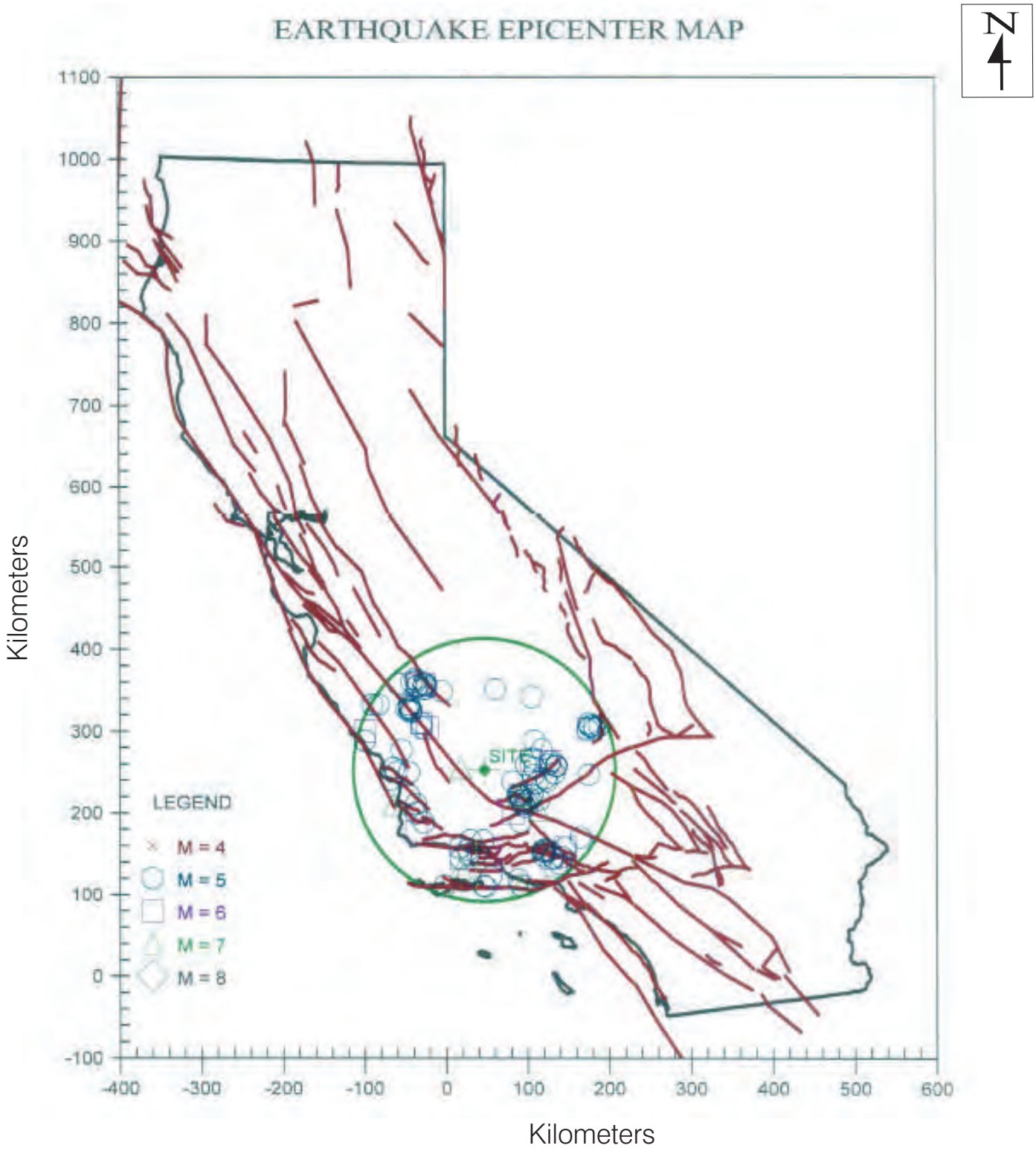
SOILS ENGINEERING, INC
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BAKERSFIELD, CA 93313

DATE: 6/20
PROJECT: #17662

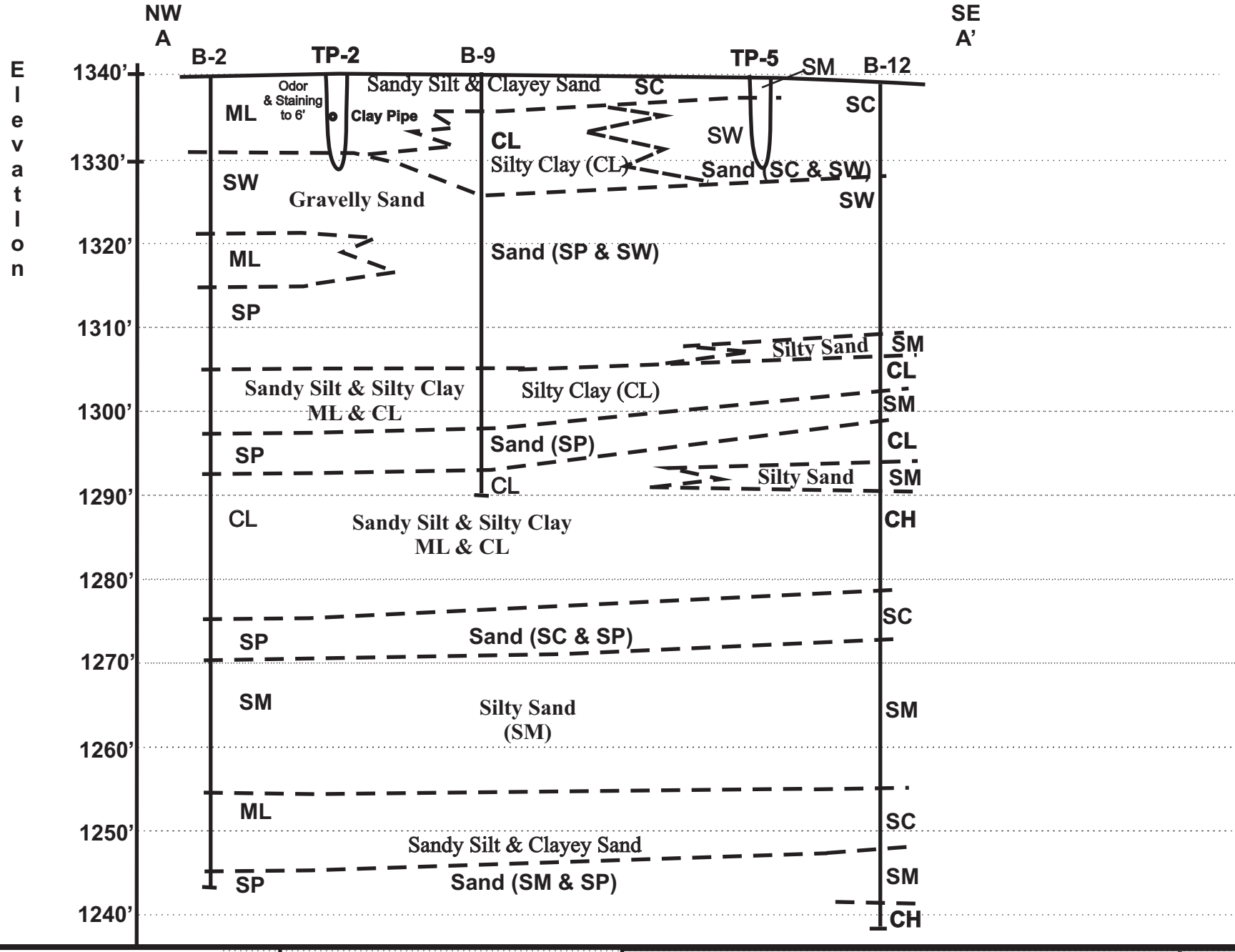
Proposed 35R CO2 Capture Project
Sec 35, T30S, R23E
Kern County, CA

Seismic Hazard Zone Atlas Map

PLATE 5B



SOILS ENGINEERING, INC. 4400 Yeager Way BAKERSFIELD, CA 93313 DATE: 6/20 PROJECT: #17662	**Proposed 35R CO2 Capture Project** **Sec 35, T30S, R23E** **Kern County, CA** Earthquake Epicenter Map	**PLATE** **5C**



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Bakersfield, California 93313

Project Number: 20-17662
Date: 6/2020

LEGEND

Test Pit

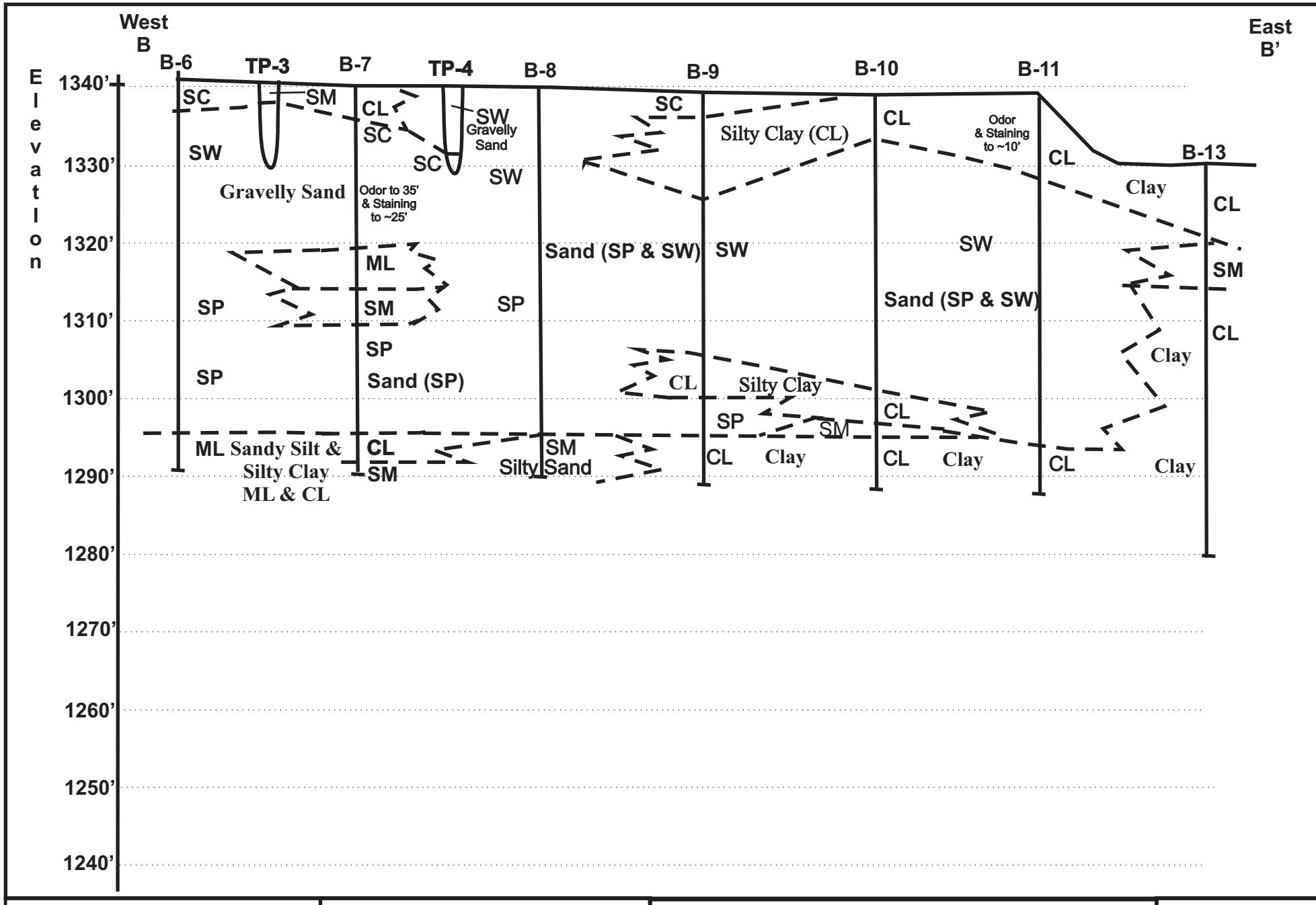
Boring Location

Approx. Horizontal Scale
0 100'

35R CO 2 Recovery Plant
Section 35, T30S, R23E
Kern County, CA.

NW-SE Cross-Section A to A'

PLATE 6

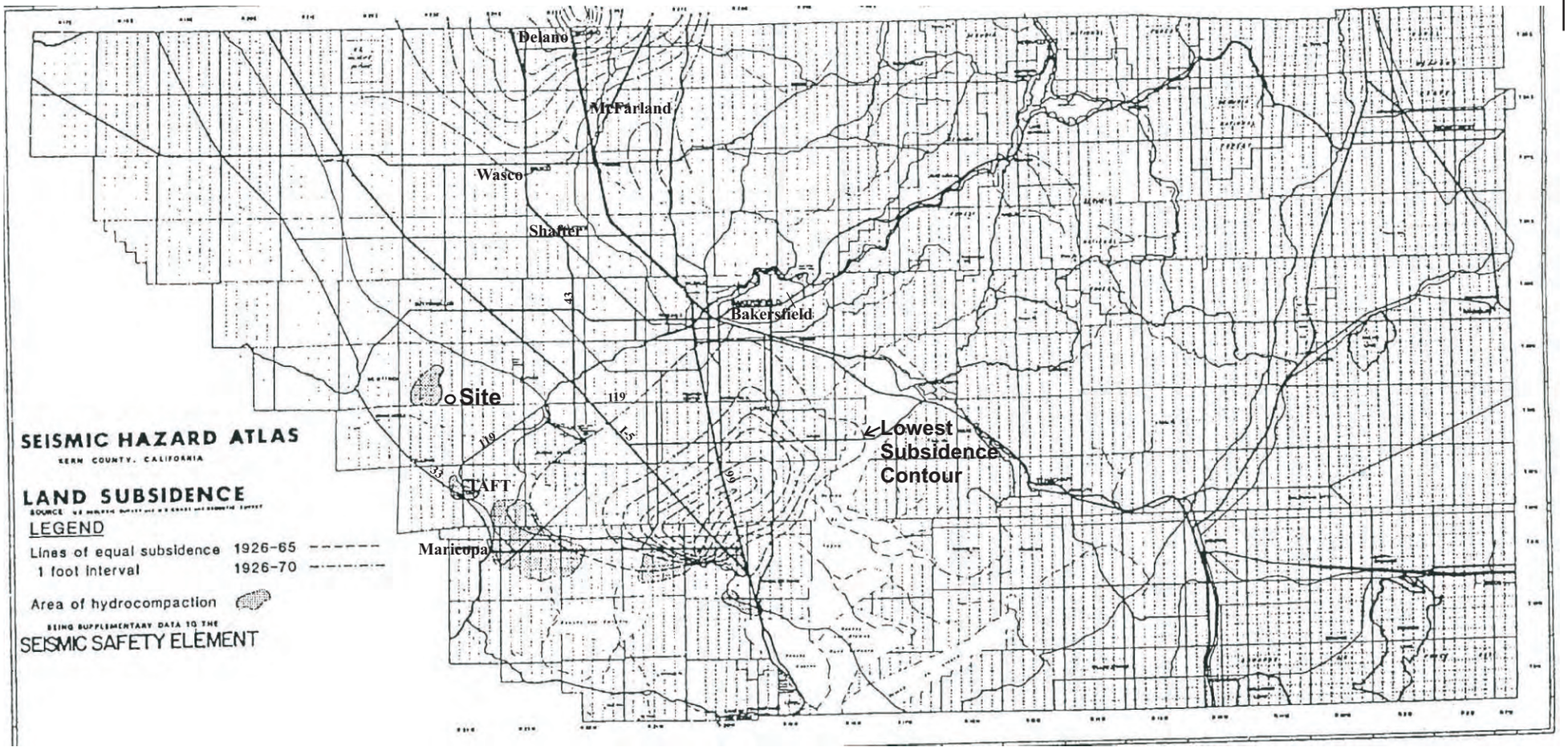


SOILS ENGINEERING, INC.
4400 Yeager Way
Bakersfield, California 93313
Project Number: 20-17662
Date: 6/2020

LEGEND
Test Pit
Boring Location
Approx. Horizontal Scale
0 100'

35R CO 2 Recovery Plant
Section 35, T30S, R23E
Kern County, CA.
W-E Cross-Section B to B'

PLATE 7



Regional Land Subsidence Map

From City of Bakersfield Safety Element (Figure 15)

Plate 8

Attachment A

Deterministic Site Parameters - EQFault, EQSEARCHWIN Data, Seismic Design Data, and Unified Hazard Tool – Deaggregation Data.

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*    E Q F A U L T   *
*                    *
*    Version 3.00    *
*                    *
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DETERMINISTIC ESTIMATION OF
PEAK ACCELERATION FROM DIGITIZED FAULTS

JOB NUMBER: 17662

DATE: 06-24-2020

JOB NAME: 17662 Fluor CO2 Recovery

CALCULATION NAME: Test Run Analysis

FAULT-DATA-FILE NAME: CGSFLTE.DAT

SITE COORDINATES:
SITE LATITUDE: 35.2785
SITE LONGITUDE: 119.4708

SEARCH RADIUS: 100 mi

ATTENUATION RELATION: 2) Boore et al. (1997) Horiz. - NEHRP C (520)
UNCERTAINTY (M=Median, S=Sigma): M Number of Sigmas: 0.0
DISTANCE MEASURE: cd_2drp
SCOND: 0
Basement Depth: 5.00 km Campbell SSR: Campbell SHR:
COMPUTE PEAK HORIZONTAL ACCELERATION

FAULT-DATA FILE USED: CGSFLTE.DAT

MINIMUM DEPTH VALUE (km): 0.0

EQFAULT SUMMARY

DETERMINISTIC SITE PARAMETERS

ABBREVIATED FAULT NAME	APPROXIMATE DISTANCE mi (km)	ESTIMATED MAX. EARTHQUAKE EVENT: MAXIMUM EARTHQUAKE MAG.(Mw)	PEAK SITE ACCEL. g	EST. SITE INTENSITY MOD.MERC.
SAN ANDREAS - 1857 Rupture M-2a	15.0(24.2)	7.8	0.224	IX
SAN ANDREAS - Whole M-1a	15.0(24.2)	8.0	0.249	IX
SAN ANDREAS - Cho-Moj M-1b-1	15.0(24.2)	7.8	0.224	IX
SAN ANDREAS - Carrizo M-1c-2	15.0(24.2)	7.4	0.181	VIII
SAN ANDREAS - Cholame M-1c-1	22.4(36.1)	7.3	0.127	VIII
Kern Front	22.5(36.2)	6.3	0.091	VII
WHITE WOLF	25.0(40.2)	7.3	0.143	VIII
PLEITO THRUST	25.3(40.7)	7.0	0.121	VII
SAN JUAN	29.1(46.8)	7.1	0.094	VII
BIG PINE	40.8(65.6)	6.9	0.065	VI
GARLOCK (West)	44.2(71.2)	7.3	0.076	VII
SAN LUIS RANGE (S. Margin)	46.9(75.5)	7.2	0.083	VII
NORTH CHANNEL SLOPE	49.0(78.8)	7.4	0.090	VII
SAN GABRIEL	51.4(82.8)	7.2	0.064	VI
SANTA YNEZ (West)	52.1(83.8)	7.1	0.060	VI
SANTA YNEZ (East)	53.3(85.8)	7.1	0.059	VI
M.RIDGE-ARROYO PARIDA-SANTA ANA	53.7(86.5)	7.2	0.075	VII
GREAT VALLEY 14	54.7(88.0)	6.4	0.049	VI
LOS ALAMOS-W. BASELINE	55.9(89.9)	6.9	0.062	VI
SAN CAYETANO	56.3(90.6)	7.0	0.065	VI
LOS OSOS	56.7(91.2)	7.0	0.065	VI
SAN ANDREAS - Parkfield	57.1(91.9)	6.5	0.041	V
LIONS HEAD	57.5(92.6)	6.6	0.052	VI
RED MOUNTAIN	57.9(93.2)	7.0	0.064	VI
RINCONADA	58.7(94.4)	7.5	0.068	VI
CASMALIA (Orcutt Frontal Fault)	59.7(96.1)	6.5	0.048	VI
VENTURA - PITAS POINT	64.4(103.6)	6.9	0.056	VI
OAK RIDGE MID-CHANNEL STRUCTURE	65.5(105.4)	6.6	0.047	VI
SAN ANDREAS - Mojave M-1c-3	67.5(108.6)	7.4	0.057	VI
OAK RIDGE (Onshore)	68.5(110.2)	7.0	0.056	VI
CHANNEL IS. THRUST (Eastern)	69.6(112.0)	7.5	0.072	VI
GREAT VALLEY 13	70.2(113.0)	6.5	0.042	VI
HOLSER	70.8(113.9)	6.5	0.042	VI
SANTA SUSANA	70.8(114.0)	6.7	0.047	VI
SIMI-SANTA ROSA	71.1(114.5)	7.0	0.054	VI
NORTHRIDGE (E. Oak Ridge)	74.3(119.5)	7.0	0.053	VI
ANACAPA-DUME	76.7(123.5)	7.5	0.067	VI
OAK RIDGE(Blind Thrust Offshore)	76.7(123.5)	7.1	0.054	VI
HOSGRI	77.5(124.8)	7.5	0.054	VI
SAN ANDREAS (Creeping)	79.2(127.5)	6.2	0.027	V

DETERMINISTIC SITE PARAMETERS

ABBREVIATED FAULT NAME	APPROXIMATE DISTANCE mi (km)	ESTIMATED MAX. EARTHQUAKE EVENT: MAXIMUM EARTHQUAKE MAG.(Mw)	PEAK SITE ACCEL. g	EST. SITE INTENSITY MOD.MERC.
SIERRA MADRE (San Fernando)	81.5(131.1)	6.7	0.042	VI
GARLOCK (East)	81.6(131.3)	7.5	0.052	VI
So. SIERRA NEVADA	85.7(137.9)	7.3	0.055	VI
SANTA CRUZ ISLAND	87.7(141.2)	7.0	0.046	VI
MALIBU COAST	88.0(141.7)	6.7	0.039	V
GREAT VALLEY 12	88.5(142.4)	6.3	0.032	V
SANTA ROSA ISLAND	90.1(145.0)	7.1	0.048	VI
VERDUGO	90.2(145.2)	6.9	0.043	VI
SIERRA MADRE	95.3(153.3)	7.2	0.048	VI
SANTA MONICA	95.6(153.9)	6.6	0.035	V
LENWOOD-LOCKHART-OLD WOMAN SPRGS	96.5(155.3)	7.5	0.046	VI
GREAT VALLEY 11	99.0(159.4)	6.4	0.031	V
HOLLYWOOD	99.2(159.6)	6.4	0.031	V
LITTLE LAKE	99.7 (160.5)	6.9	0.033	V

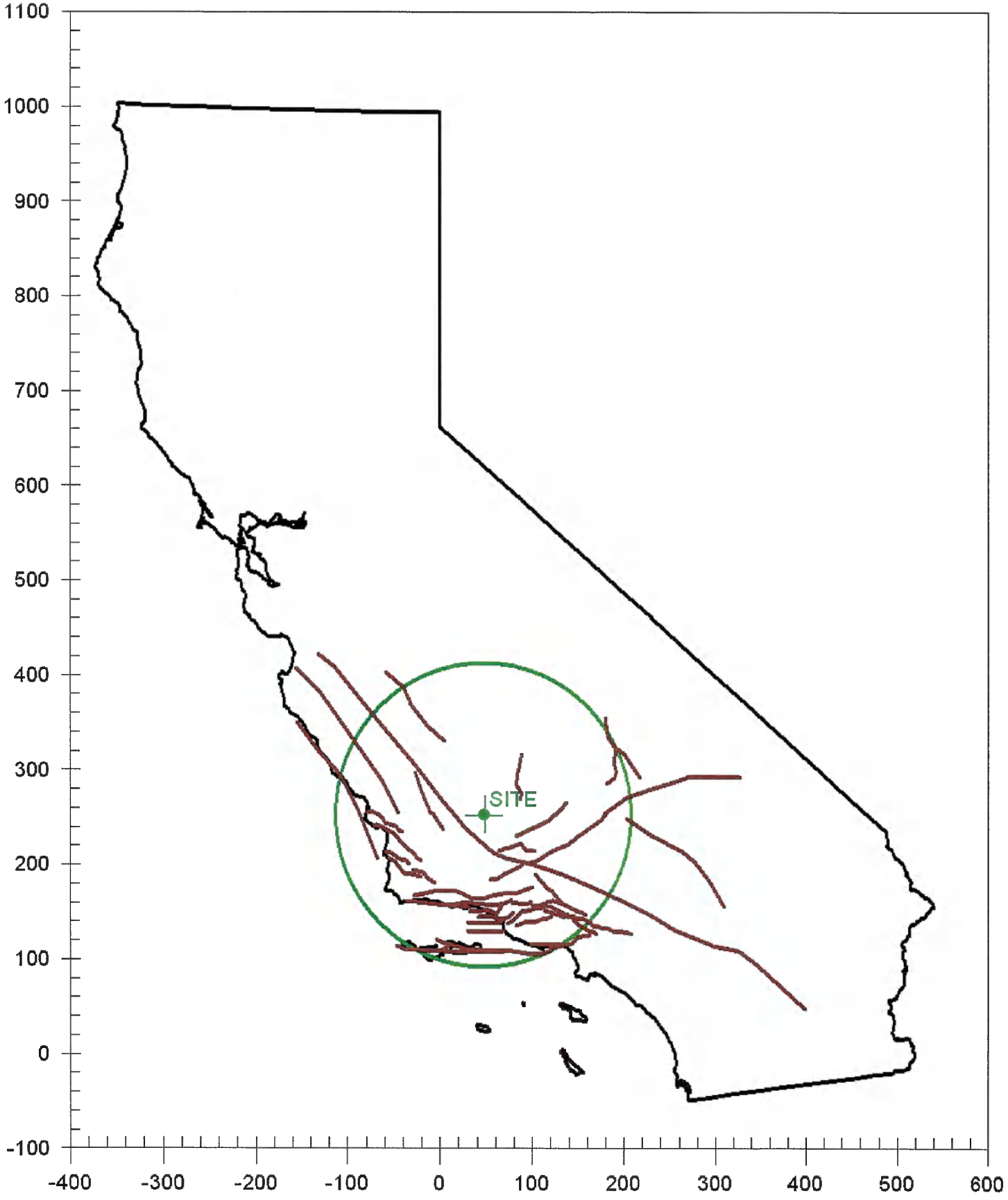
-END OF SEARCH- 54 FAULTS FOUND WITHIN THE SPECIFIED SEARCH RADIUS.

THE SAN ANDREAS - Whole M-1a FAULT IS CLOSEST TO THE SITE.
IT IS ABOUT 15.0 MILES (24.2 km) AWAY.

LARGEST MAXIMUM-EARTHQUAKE SITE ACCELERATION: 0.2487 g

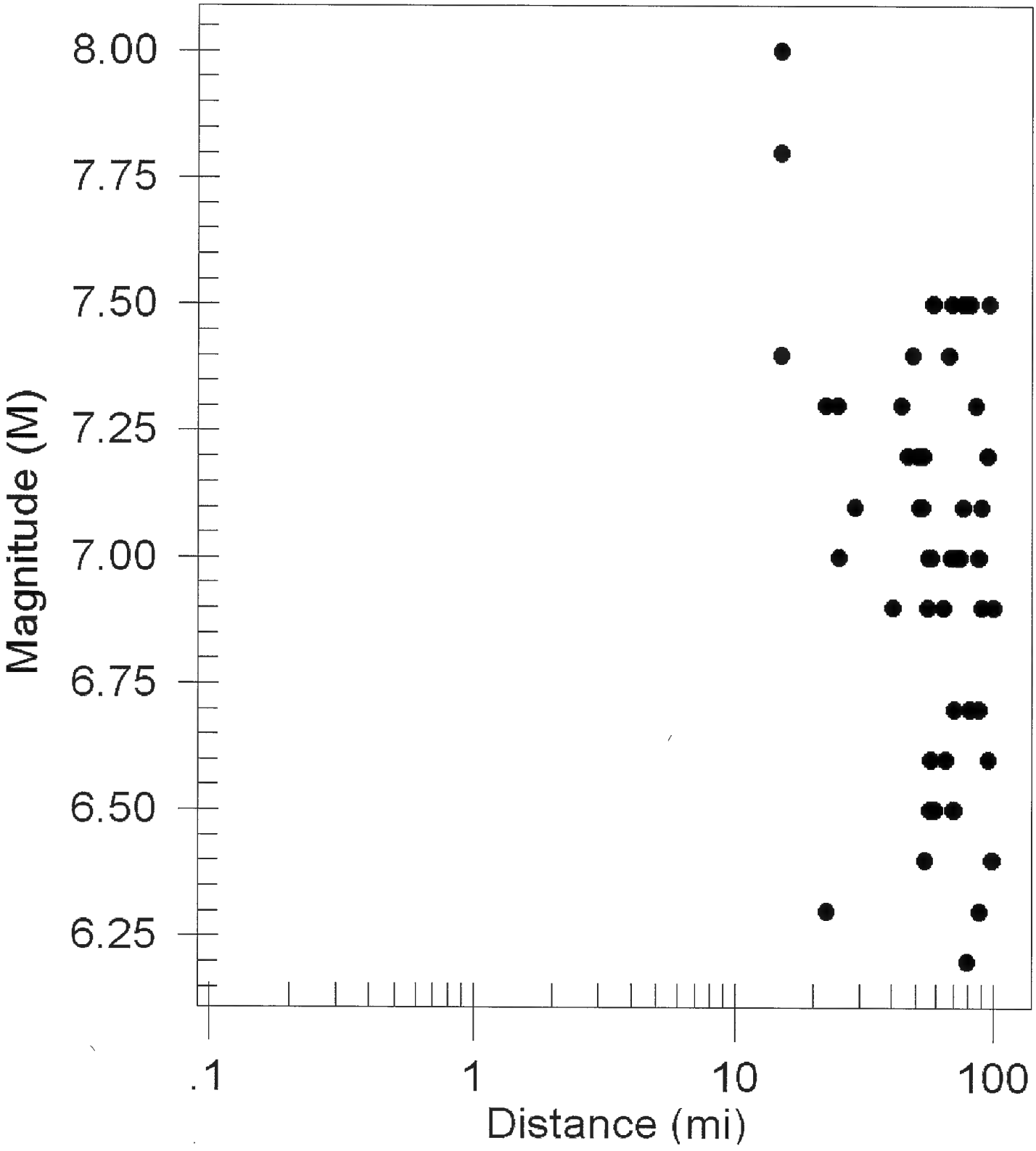
CALIFORNIA FAULT MAP

17662 Fluor CO2 Recovery



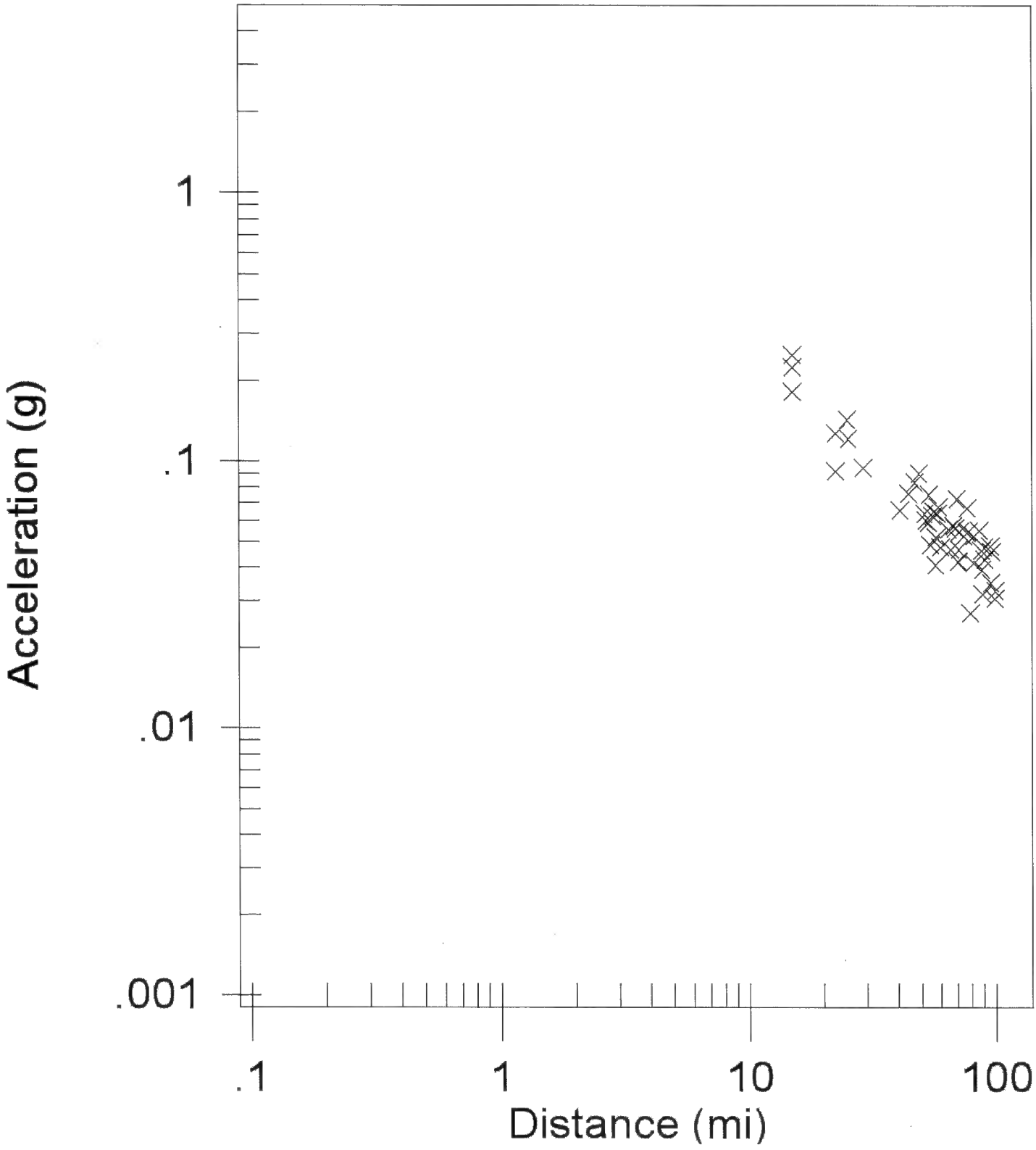
EARTHQUAKE MAGNITUDES & DISTANCES

17662 Fluor CO2 Recovery



MAXIMUM EARTHQUAKES

17662 Fluor CO2 Recovery



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*                       *
*    E Q S E A R C H    *
*                       *
*     Version 3.00      *
*                       *
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ESTIMATION OF
PEAK ACCELERATION FROM
CALIFORNIA EARTHQUAKE CATALOGS

JOB NUMBER: 17662

DATE: 06-24-2020

JOB NAME: 17662 Fluor CO2 Recov

EARTHQUAKE-CATALOG-FILE NAME: ALLQUAKE.DAT

SITE COORDINATES:
SITE LATITUDE: 34.4708
SITE LONGITUDE: 119.6917

SEARCH DATES:
START DATE: 1800
END DATE: 2010

SEARCH RADIUS:
100.0 mi
160.9 km

ATTENUATION RELATION: 2) Boore et al. (1997) Horiz. - NEHRP C (520)
UNCERTAINTY (M=Median, S=Sigma): M Number of Sigmas: 0.0
ASSUMED SOURCE TYPE: SS [SS=Strike-slip, DS=Reverse-slip, BT=Blind-thrust]
SCOND: 0 Depth Source: A
Basement Depth: 5.00 km Campbell SSR: Campbell SHR:
COMPUTE PEAK HORIZONTAL ACCELERATION

MINIMUM DEPTH VALUE (km): 0.0

EARTHQUAKE SEARCH RESULTS

Page 1

FILE CODE	LAT. NORTH	LONG. WEST	DATE	TIME (UTC) H M Sec	DEPTH (km)	QUAKE MAG.	SITE ACC. g	SITE MM INT.	APPROX. DISTANCE mi [km]
T-A	34.5000	119.6700	06/01/1893	12 0 0.0	0.0	5.00	0.141	VIII	2.4(3.8)
MGI	34.4000	119.7000	03/25/1806	8 0 0.0	0.0	5.00	0.107	VII	4.9(7.9)
T-A	34.4200	119.8200	00/00/1862	0 0 0.0	0.0	5.70	0.114	VII	8.1(13.0)
PAS	34.3470	119.6960	08/13/1978	225453.4	12.8	5.10	0.081	VII	8.5(13.8)
DMG	34.3670	119.5830	07/01/1941	75054.8	0.0	5.90	0.115	VII	9.5(15.2)
DMG	34.5000	119.5000	06/29/1926	2321 0.0	0.0	5.50	0.083	VII	11.1(17.8)
DMG	34.5000	119.5000	08/05/1930	1125 0.0	0.0	5.00	0.064	VI	11.1(17.8)
MGI	34.3000	119.8000	07/03/1925	1638 0.0	0.0	5.30	0.066	VI	13.3(21.4)
MGI	34.3000	119.8000	07/03/1925	1821 0.0	0.0	5.30	0.066	VI	13.3(21.4)
DMG	34.3000	119.8000	06/29/1925	144216.0	0.0	6.25	0.108	VII	13.3(21.4)
DMG	34.2000	119.8000	12/21/1812	19 0 0.0	0.0	7.00	0.120	VII	19.7(31.7)
DMG	34.1180	119.7020	07/05/1968	04517.2	5.9	5.20	0.040	V	24.4(39.2)
DMG	34.1000	119.4000	05/19/1893	035 0.0	0.0	5.50	0.039	V	30.5(49.1)
DMG	34.0000	119.5000	02/18/1926	1818 0.0	0.0	5.00	0.027	V	34.3(55.2)
DMG	33.9860	119.4750	08/06/1973	232917.0	16.9	5.00	0.027	V	35.7(57.4)
DMG	34.0000	120.0170	04/01/1945	234342.0	0.0	5.40	0.032	V	37.4(60.2)
DMG	34.7000	120.3000	01/12/1915	431 0.0	0.0	5.50	0.033	V	38.0(61.2)
DMG	34.7000	120.3000	07/31/1902	920 0.0	0.0	5.50	0.033	V	38.0(61.2)
DMG	34.8000	119.1000	09/05/1883	1230 0.0	0.0	6.00	0.041	V	40.6(65.3)
MGI	34.6000	120.4000	07/28/1902	657 0.0	0.0	6.30	0.047	VI	41.3(66.4)
MGI	34.6000	120.4000	08/01/1902	330 0.0	0.0	6.30	0.047	VI	41.3(66.4)
DMG	34.7000	119.0000	10/23/1916	254 0.0	0.0	5.50	0.030	V	42.4(68.2)
MGI	34.8000	120.4000	12/12/1902	0 0 0.0	0.0	5.70	0.031	V	46.2(74.4)
DMG	34.0650	119.0350	02/21/1973	144557.3	8.0	5.90	0.035	V	46.8(75.3)
MGI	34.9000	120.4000	03/29/1928	625 0.0	0.0	5.30	0.024	V	49.9(80.4)
DMG	34.8670	118.9330	09/21/1941	1953 7.2	0.0	5.20	0.022	IV	51.0(82.1)
DMG	34.0000	119.0000	09/24/1827	4 0 0.0	0.0	7.00	0.058	VI	51.1(82.3)
MGI	34.0000	119.0000	12/14/1912	0 0 0.0	0.0	5.70	0.029	V	51.1(82.3)
DMG	34.9000	118.9500	08/01/1952	13 430.0	0.0	5.10	0.021	IV	51.5(82.9)
DMG	34.9410	118.9870	11/15/1961	53855.5	10.7	5.00	0.020	IV	51.5(82.9)
DMG	34.9320	118.9760	03/01/1963	02557.9	13.9	5.00	0.020	IV	51.6(83.1)
DMG	35.0000	119.0330	07/21/1952	12 2 0.0	0.0	5.60	0.027	V	52.3(84.1)
DMG	35.0000	119.0170	01/12/1954	233349.0	0.0	5.90	0.031	V	52.9(85.2)
DMG	35.0000	119.0170	07/21/1952	115214.0	0.0	7.70	0.081	VII	52.9(85.2)
DMG	34.9830	118.9830	05/23/1954	235243.0	0.0	5.10	0.020	IV	53.5(86.2)
DMG	35.0000	119.0000	02/16/1919	1557 0.0	0.0	5.00	0.019	IV	53.6(86.3)
DMG	35.0000	119.0000	07/21/1952	12 531.0	0.0	6.40	0.041	V	53.6(86.3)
T-A	34.9200	118.9200	05/23/1857	0 0 0.0	0.0	5.00	0.019	IV	53.7(86.4)
T-A	34.9200	118.9200	01/20/1857	0 0 0.0	0.0	5.00	0.019	IV	53.7(86.4)
DMG	34.9000	118.9000	10/23/1916	244 0.0	0.0	6.00	0.033	V	53.8(86.6)
GSB	34.3790	118.7110	01/19/1994	210928.6	14.0	5.50	0.024	V	56.2(90.5)
GSP	34.3770	118.6980	01/18/1994	004308.9	11.0	5.20	0.021	IV	57.0(91.7)
DMG	34.9500	118.8670	07/21/1952	121936.0	0.0	5.30	0.022	IV	57.3(92.2)
GSP	35.1490	119.1040	05/28/1993	044740.6	21.0	5.20	0.020	IV	57.5(92.5)
GSP	34.3260	118.6980	01/17/1994	233330.7	9.0	5.60	0.025	V	57.5(92.5)
DMG	35.3000	119.8000	01/09/1857	16 0 0.0	0.0	7.90	0.085	VII	57.6(92.7)
GSP	34.3940	118.6690	06/26/1995	084028.9	13.0	5.00	0.018	IV	58.5(94.1)
GSP	34.3690	118.6720	04/26/1997	103730.7	16.0	5.10	0.019	IV	58.5(94.1)
MGI	35.0000	120.5000	11/19/1927	332 0.0	0.0	5.00	0.018	IV	58.6(94.4)
T-A	34.8300	118.7500	11/27/1852	0 0 0.0	0.0	7.00	0.052	VI	59.0(94.9)
DMG	35.0000	118.8330	07/23/1952	181351.0	0.0	5.20	0.020	IV	60.9(98.0)
DMG	35.0000	118.8330	07/23/1952	75319.0	0.0	5.40	0.022	IV	60.9(98.0)
GSP	34.3780	118.6180	01/19/1994	211144.9	11.0	5.10	0.018	IV	61.5(98.9)

EARTHQUAKE SEARCH RESULTS

FILE CODE	LAT. NORTH	LONG. WEST	DATE	TIME (UTC) H M Sec	DEPTH (km)	QUAKE MAG.	SITE ACC. g	SITE MM INT.	APPROX. DISTANCE mi [km]
PAS	34.9430	118.7430	06/10/1988	23 643.0	6.8	5.40	0.021	IV	62.9(101.3)
DMG	34.3000	118.6000	04/04/1893	1940 0.0	0.0	6.00	0.029	V	63.3(101.9)
GSP	34.3050	118.5790	01/29/1994	112036.0	1.0	5.10	0.018	IV	64.4(103.7)
PAS	33.6710	119.1110	09/04/1981	155050.3	5.0	5.30	0.020	IV	64.4(103.7)
DMG	34.9000	120.7000	11/04/1927	135053.0	0.0	7.50	0.063	VI	64.5(103.7)
GSB	34.3010	118.5650	01/17/1994	204602.4	9.0	5.20	0.018	IV	65.3(105.0)
GSP	34.2130	118.5370	01/17/1994	123055.4	18.0	6.70	0.039	V	68.2(109.7)
PAS	33.9440	118.6810	01/01/1979	231438.9	11.3	5.00	0.016	IV	68.2(109.8)
DMG	35.1330	118.7670	07/21/1952	194122.0	0.0	5.50	0.021	IV	69.6(111.9)
DMG	33.9500	118.6320	08/31/1930	04036.0	0.0	5.20	0.017	IV	70.4(113.3)
MGI	35.2500	120.5000	07/10/1917	045 0.0	0.0	5.30	0.018	IV	70.6(113.7)
MGI	35.2500	120.5000	07/10/1917	043 0.0	0.0	5.30	0.018	IV	70.6(113.7)
MGI	35.2500	120.5000	07/09/1917	2222 0.0	0.0	5.00	0.016	IV	70.6(113.7)
MGI	35.2500	120.5000	07/09/1917	2238 0.0	0.0	5.30	0.018	IV	70.6(113.7)
GSP	34.2310	118.4750	03/20/1994	212012.3	13.0	5.30	0.018	IV	71.3(114.7)
DMG	34.3080	118.4540	02/09/1971	144346.7	6.2	5.20	0.017	IV	71.4(114.9)
DMG	35.2170	118.8170	07/23/1952	1317 5.0	0.0	5.70	0.022	IV	71.5(115.0)
PAS	33.9190	118.6270	01/19/1989	65328.8	11.9	5.00	0.015	IV	71.8(115.5)
DMG	34.4110	118.4010	02/09/1971	14 041.8	8.4	6.40	0.032	V	73.6(118.5)
DMG	34.4110	118.4010	02/09/1971	14 1 8.0	8.0	5.80	0.023	IV	73.6(118.5)
DMG	34.4110	118.4010	02/09/1971	141028.0	8.0	5.30	0.018	IV	73.6(118.5)
DMG	34.4110	118.4010	02/09/1971	14 244.0	8.0	5.80	0.023	IV	73.6(118.5)
DMG	35.3330	118.9170	08/22/1952	224124.0	0.0	5.80	0.023	IV	73.9(119.0)
MGI	34.0000	118.5000	11/19/1918	2018 0.0	0.0	5.00	0.015	IV	75.4(121.3)
DMG	34.0000	118.5000	08/04/1927	1224 0.0	0.0	5.00	0.015	IV	75.4(121.3)
DMG	35.1500	118.6330	01/27/1954	141948.0	0.0	5.00	0.015	IV	76.2(122.6)
DMG	35.3000	118.8000	12/23/1905	2223 0.0	0.0	5.00	0.015	IV	76.3(122.9)
DMG	35.1830	118.6500	07/21/1952	151358.0	0.0	5.10	0.015	IV	76.8(123.6)
MGI	35.1700	120.7500	12/01/1916	2253 0.0	0.0	5.70	0.021	IV	77.0(123.9)
T-A	35.2500	120.6700	00/00/1830	0 0 0.0	0.0	5.70	0.021	IV	77.2(124.3)
T-A	35.2500	120.6700	12/17/1852	0 0 0.0	0.0	5.70	0.021	IV	77.2(124.3)
DMG	35.3830	118.8500	07/29/1952	7 347.0	0.0	6.10	0.026	V	79.0(127.1)
MGI	35.3000	120.7000	12/07/1906	640 0.0	0.0	5.90	0.023	IV	80.9(130.1)
DMG	35.4000	118.8170	07/29/1952	8 146.0	0.0	5.10	0.015	IV	81.0(130.4)
DMG	35.2330	118.5330	07/21/1952	174244.0	0.0	5.10	0.014	IV	84.1(135.4)
DMG	33.2670	119.4500	11/18/1947	2159 3.0	0.0	5.00	0.014	III	84.3(135.6)
DMG	34.5190	118.1980	08/23/1952	10 9 7.1	13.1	5.00	0.014	III	85.1(136.9)
DMG	35.3330	118.6000	07/31/1952	12 9 9.0	0.0	5.80	0.021	IV	85.8(138.1)
MGI	34.0000	118.3000	09/03/1905	540 0.0	0.0	5.30	0.016	IV	85.8(138.1)
MGI	34.0800	118.2600	07/16/1920	18 8 0.0	0.0	5.00	0.013	III	86.0(138.4)
DMG	33.2910	119.1930	10/24/1969	82912.1	10.0	5.10	0.014	IV	86.3(138.9)
MGI	35.5000	120.6000	01/01/1830	0 0 0.0	0.0	5.00	0.013	III	87.7(141.1)
DMG	35.3670	118.5830	07/23/1952	03832.0	0.0	6.10	0.024	IV	88.1(141.8)
DMG	35.3670	118.5830	07/23/1952	31923.0	0.0	5.00	0.013	III	88.1(141.8)
T-A	34.0000	118.2500	01/10/1856	0 0 0.0	0.0	5.00	0.013	III	88.5(142.4)
T-A	34.0000	118.2500	03/26/1860	0 0 0.0	0.0	5.00	0.013	III	88.5(142.4)
T-A	34.0000	118.2500	09/23/1827	0 0 0.0	0.0	5.00	0.013	III	88.5(142.4)
DMG	35.3150	118.5160	07/25/1952	194323.7	11.2	5.70	0.019	IV	88.5(142.4)
DMG	35.3110	118.4990	07/25/1952	1313 8.2	2.8	5.00	0.013	III	89.0(143.3)
DMG	35.3170	118.4940	07/25/1952	19 944.6	5.5	5.70	0.019	IV	89.5(144.1)
DMG	35.5000	118.7000	01/06/1905	1430 0.0	0.0	5.00	0.013	III	90.5(145.7)
DMG	33.8500	118.2670	03/11/1933	1425 0.0	0.0	5.00	0.013	III	92.0(148.0)
DMG	35.6000	118.8000	06/30/1926	1331 0.0	0.0	5.00	0.013	III	92.8(149.4)

EARTHQUAKE SEARCH RESULTS

FILE CODE	LAT. NORTH	LONG. WEST	DATE	TIME (UTC) H M Sec	DEPTH (km)	QUAKE MAG.	SITE ACC. g	SITE MM INT.	APPROX. DISTANCE mi [km]
DMG	35.7500	120.2500	03/10/1922	112120.0	0.0	6.50	0.028	V	93.8(150.9)
MGI	34.1000	118.1000	07/11/1855	415 0.0	0.0	6.30	0.025	V	94.3(151.8)
PAS	34.0730	118.0980	10/04/1987	105938.2	8.2	5.30	0.015	IV	95.0(152.9)
DMG	33.7830	118.2500	11/14/1941	84136.3	0.0	5.40	0.015	IV	95.1(153.0)
DMG	35.7500	120.3300	08/18/1922	512 0.0	0.0	5.00	0.012	III	95.4(153.5)
PAS	34.0610	118.0790	10/01/1987	144220.0	9.5	5.90	0.020	IV	96.3(154.9)
GSP	34.2620	118.0020	06/28/1991	144354.5	11.0	5.40	0.015	IV	97.4(156.7)
DMG	35.8000	120.3300	06/08/1934	447 0.0	0.0	6.00	0.020	IV	98.6(158.7)
DMG	35.8000	120.3300	06/05/1934	2148 0.0	0.0	5.00	0.012	III	98.6(158.7)
DMG	35.8000	120.3300	12/28/1939	121538.0	0.0	5.00	0.012	III	98.6(158.7)
DMG	35.8000	120.3300	06/08/1934	430 0.0	0.0	5.00	0.012	III	98.6(158.7)
DMG	34.6090	121.4350	11/05/1969	1754 7.9	10.0	5.60	0.016	IV	99.6(160.3)

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-END OF SEARCH- 118 EARTHQUAKES FOUND WITHIN THE SPECIFIED SEARCH AREA.

TIME PERIOD OF SEARCH: 1800 TO 1999

LENGTH OF SEARCH TIME: 200 years

THE EARTHQUAKE CLOSEST TO THE SITE IS ABOUT 2.4 MILES (3.8 km) AWAY.

LARGEST EARTHQUAKE MAGNITUDE FOUND IN THE SEARCH RADIUS: 7.9

LARGEST EARTHQUAKE SITE ACCELERATION FROM THIS SEARCH: 0.141 g

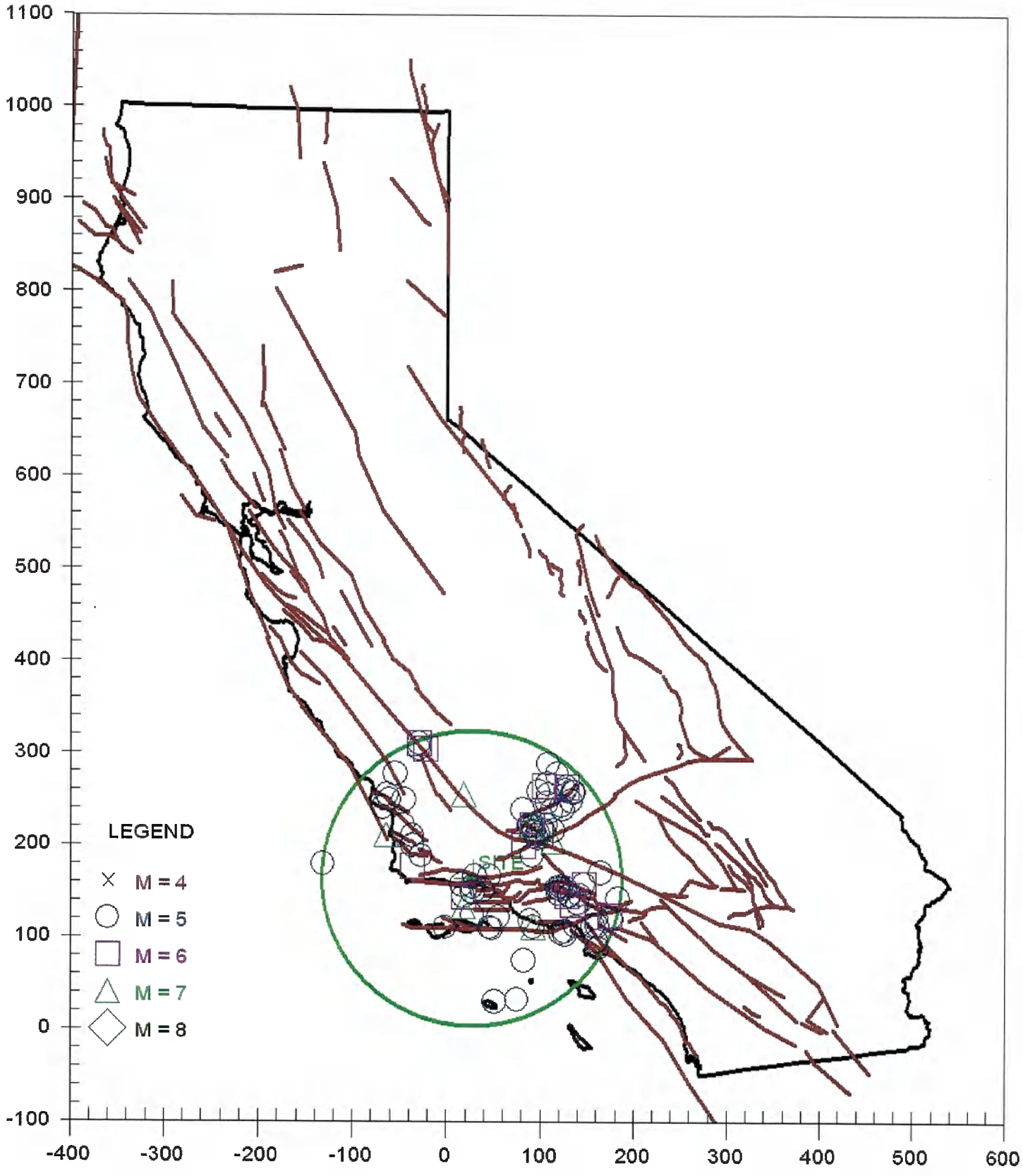
COEFFICIENTS FOR GUTENBERG & RICHTER RECURRENCE RELATION:
a-value= 1.471
b-value= 0.386
beta-value= 0.890

TABLE OF MAGNITUDES AND EXCEEDANCES:

Earthquake Magnitude	Number of Times Exceeded	Cumulative No. / Year
4.0	118	0.59296
4.5	118	0.59296
5.0	118	0.59296
5.5	48	0.24121
6.0	20	0.10050
6.5	8	0.04020
7.0	6	0.03015
7.5	3	0.01508

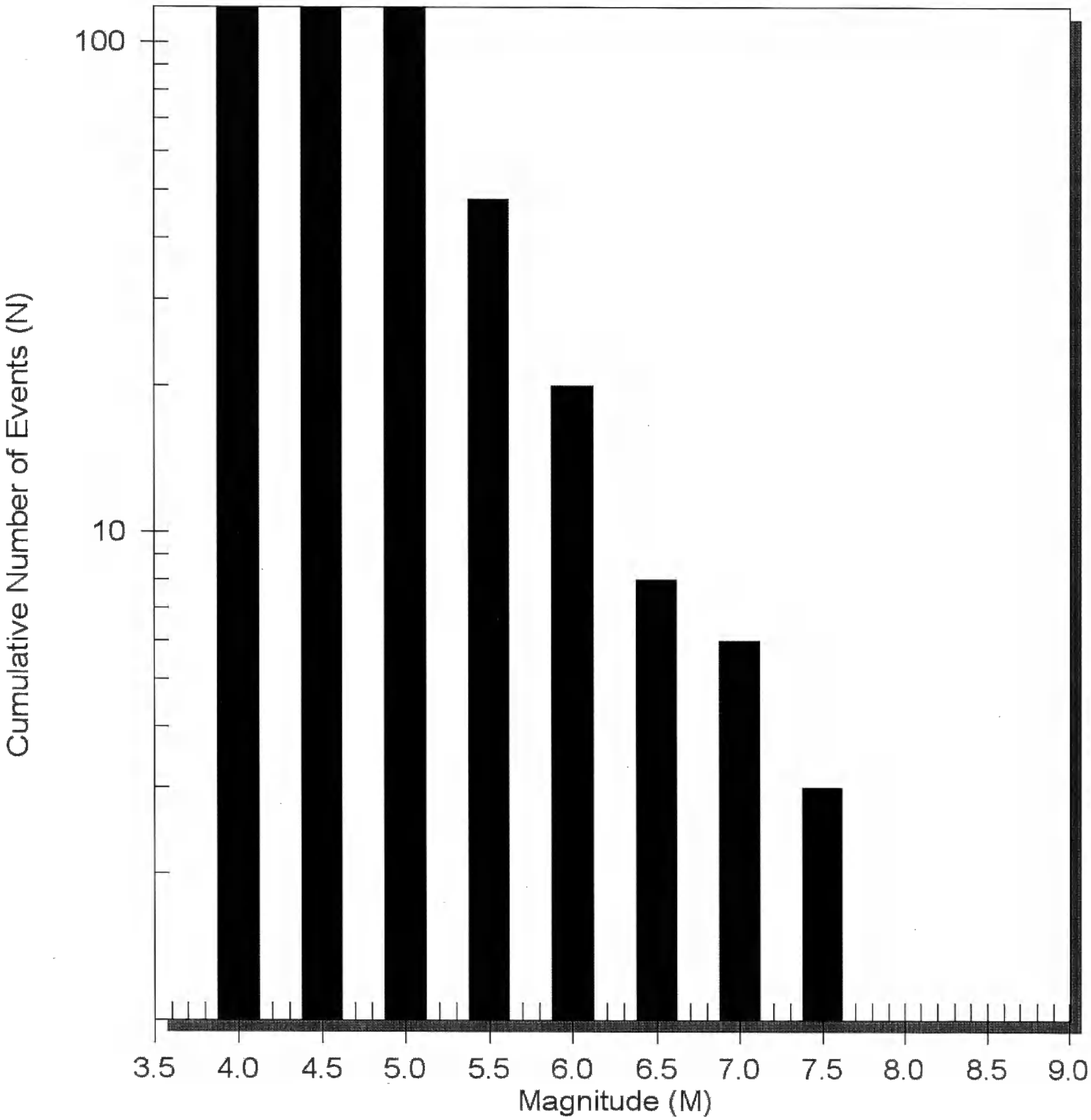
EARTHQUAKE EPICENTER MAP

17662 Fluor CO2 Recov



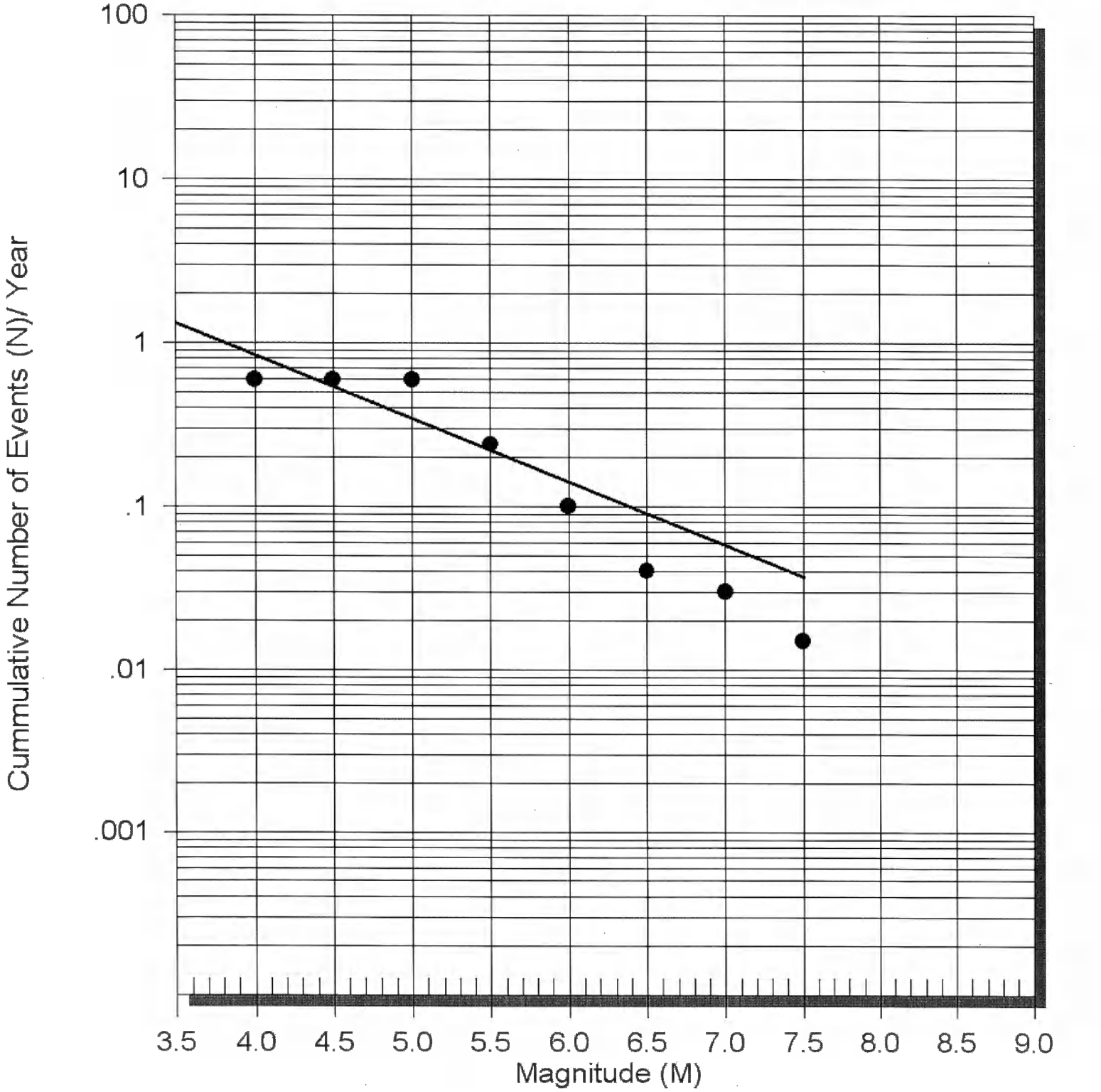
Number of Earthquakes (N) Above Magnitude (M)

17662 Fluor CO2 Recov



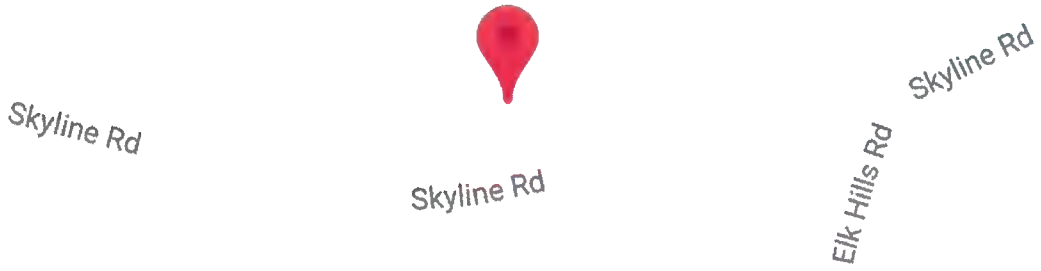
EARTHQUAKE RECURRENCE CURVE

17662 Fluor CO2 Recov



17662 Fluor CO2 Recovery Facility

Latitude, Longitude: 35.278489, -119.470834



Date	6/24/2020, 7:45:46 AM
Design Code Reference Document	ASCE7-16
Risk Category	II
Site Class	C - Very Dense Soil and Soft Rock

Type	Value	Description
S_S	1.175	MCE_R ground motion. (for 0.2 second period)
S_1	0.465	MCE_R ground motion. (for 1.0s period)
S_{MS}	1.41	Site-modified spectral acceleration value
S_{M1}	0.697	Site-modified spectral acceleration value
S_{DS}	0.94	Numeric seismic design value at 0.2 second SA
S_{D1}	0.465	Numeric seismic design value at 1.0 second SA

Type	Value	Description
SDC	D	Seismic design category
F_a	1.2	Site amplification factor at 0.2 second
F_v	1.5	Site amplification factor at 1.0 second
PGA	0.5	MCE_G peak ground acceleration
F_{PGA}	1.2	Site amplification factor at PGA
PGA_M	0.6	Site modified peak ground acceleration
T_L	12	Long-period transition period in seconds
SsRT	1.175	Probabilistic risk-targeted ground motion. (0.2 second)
SsUH	1.302	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration
SsD	1.5	Factored deterministic acceleration value. (0.2 second)
S1RT	0.465	Probabilistic risk-targeted ground motion. (1.0 second)
S1UH	0.521	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration.
S1D	0.6	Factored deterministic acceleration value. (1.0 second)
PGAd	0.5	Factored deterministic acceleration value. (Peak Ground Acceleration)
C_{RS}	0.902	Mapped value of the risk coefficient at short periods
C_{R1}	0.891	Mapped value of the risk coefficient at a period of 1 s

DISCLAIMER

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U.S. Geological Survey - Earthquake Hazards Program

Unified Hazard Tool

Please do not use this tool to obtain ground motion parameter values for the design code reference documents covered by the U.S. Seismic Design Maps web tools (e.g., the International Building Code and the ASCE 7 or 41 Standard). The values returned by the two applications are not identical.

Input

Edition

Dynamic: Conterminous U.S. 2014 (update) (v4.2.0)

Spectral Period

Peak Ground Acceleration

Latitude

Decimal degrees

35.278489

Time Horizon

Return period in years

975

Longitude

Decimal degrees, negative values for western longitudes

-119.470834

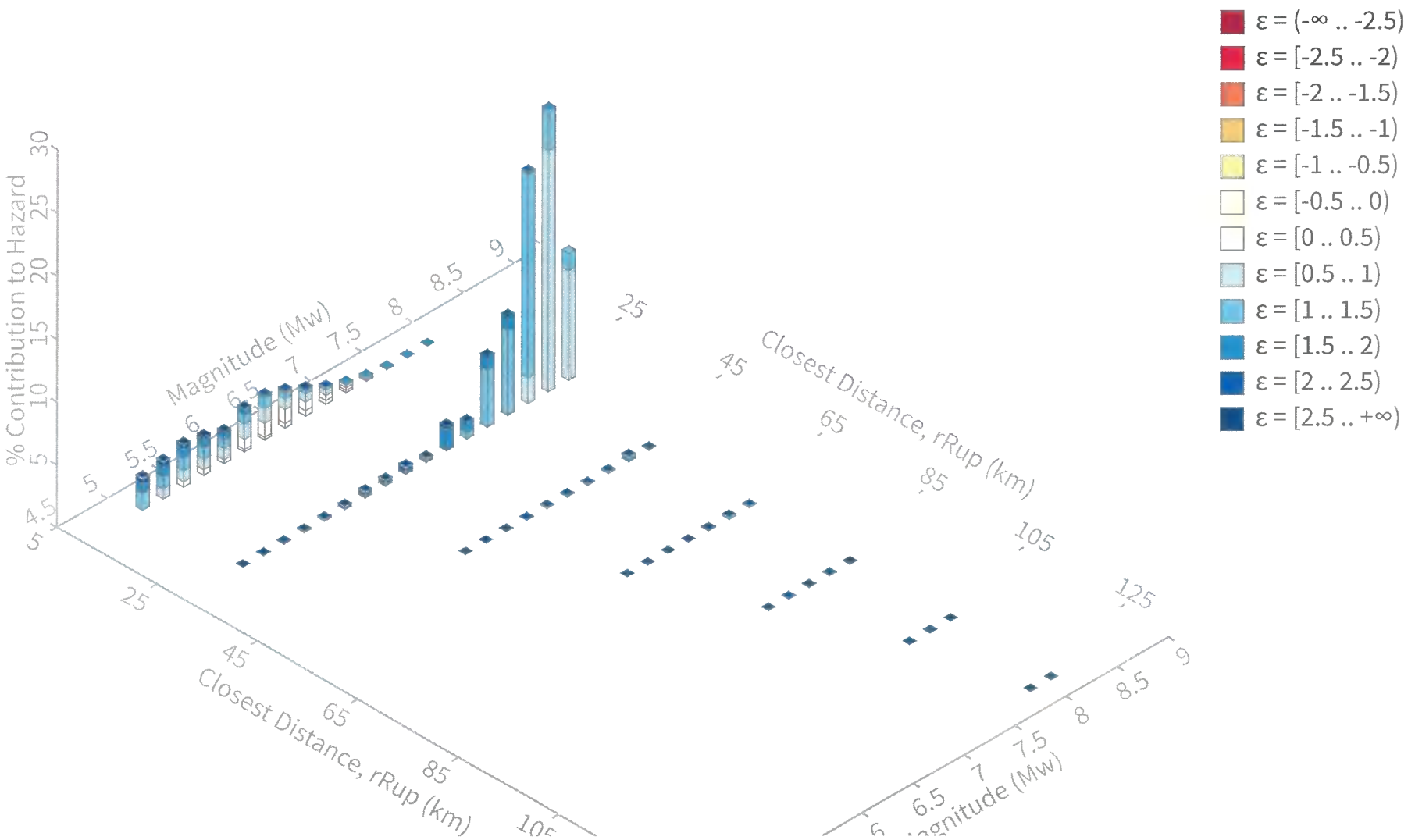
Site Class

537 m/s (Site class C)

Deaggregation

Component

Total



Summary statistics for, Deaggregation: Total

Deaggregation targets

Return period: 975 yrs
Exceedance rate: 0.001025641 yr^{-1}
PGA ground motion: 0.43259434 g

Recovered targets

Return period: 1088.283 yrs
Exceedance rate: 0.00091887867 yr^{-1}

Totals

Binned: 100 %
Residual: 0 %
Trace: 0.12 %

Mean (over all sources)

m: 7.33
r: 20.47 km
ε_0: 1.1 σ

Mode (largest m-r bin)

m: 8.1
r: 24.22 km
ε_0: 0.96 σ
Contribution: 22.32 %

Mode (largest m-r-ε_0 bin)

m: 8.1
r: 24.2 km
ε_0: 0.9 σ
Contribution: 19.1 %

Discretization

r: min = 0.0, max = 1000.0, Δ = 20.0 km
m: min = 4.4, max = 9.4, Δ = 0.2
ε: min = -3.0, max = 3.0, Δ = 0.5 σ

Epsilon keys

ε0: [-∞ .. -2.5)
ε1: [-2.5 .. -2.0)
ε2: [-2.0 .. -1.5)
ε3: [-1.5 .. -1.0)
ε4: [-1.0 .. -0.5)
ε5: [-0.5 .. 0.0)
ε6: [0.0 .. 0.5)
ε7: [0.5 .. 1.0)
ε8: [1.0 .. 1.5)
ε9: [1.5 .. 2.0)
ε10: [2.0 .. 2.5)

Deaggregation Contributors

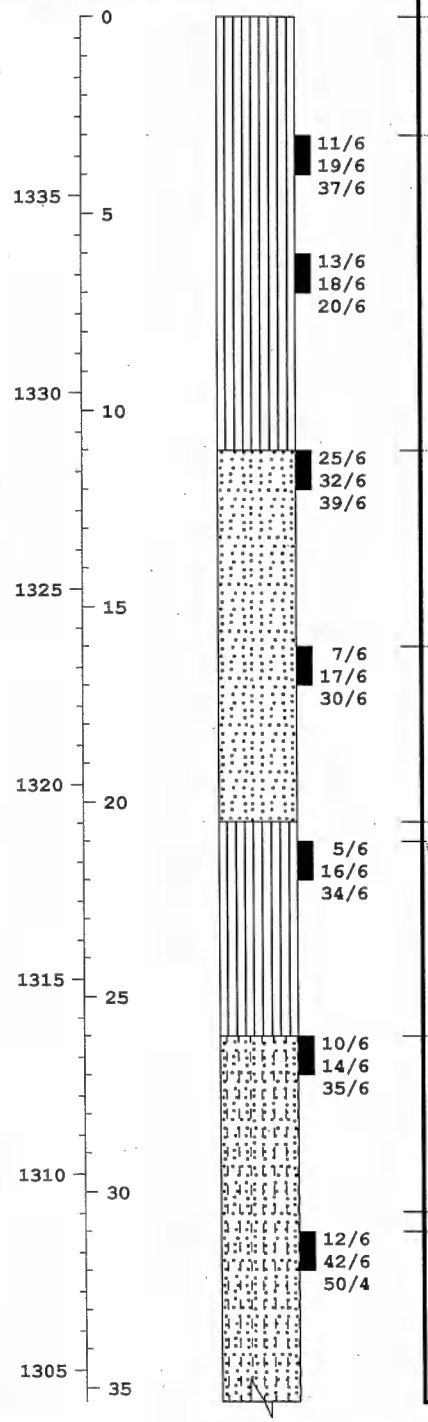
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UC33brAvg_FM31	System							34.56
San Andreas (Carrizo) rev [4]		24.20	7.94	1.08	119.649°W	35.117°N	222.06	32.61
UC33brAvg_FM32	System							34.41
San Andreas (Carrizo) rev [4]		24.20	7.94	1.08	119.649°W	35.117°N	222.06	32.52
UC33brAvg_FM31 (opt)	Grid							15.53
PointSourceFinite: -119.471, 35.310		6.05	5.75	0.61	119.471°W	35.310°N	0.00	2.03
PointSourceFinite: -119.471, 35.310		6.05	5.75	0.61	119.471°W	35.310°N	0.00	2.03
PointSourceFinite: -119.471, 35.337		7.72	5.87	0.84	119.471°W	35.337°N	0.00	1.43
PointSourceFinite: -119.471, 35.337		7.72	5.87	0.84	119.471°W	35.337°N	0.00	1.43
UC33brAvg_FM32 (opt)	Grid							15.51
PointSourceFinite: -119.471, 35.310		6.05	5.75	0.61	119.471°W	35.310°N	0.00	2.03
PointSourceFinite: -119.471, 35.310		6.05	5.75	0.61	119.471°W	35.310°N	0.00	2.03
PointSourceFinite: -119.471, 35.337		7.72	5.86	0.84	119.471°W	35.337°N	0.00	1.43
PointSourceFinite: -119.471, 35.337		7.72	5.86	0.84	119.471°W	35.337°N	0.00	1.43

Attachment B

Selected Boring Logs, Test Pit Logs, Subsurface Surveys - Seismic Survey Summary Report, Table 1 - Blowcount Comparison for Deepest Borings and LiquefyPro data.

LOG OF TEST BORING
BORING B-2

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
FILE NO: *17662*
BORING DATE: *6/8/20*
ELEV.: *1339.55'*
BORING LOCATION: *See Boring Location Map, Figure 1*
START: *6/8/20*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
FINISH: *6/8/20*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ➡ :** *N/A*
LOGGER: *M. WATTS*



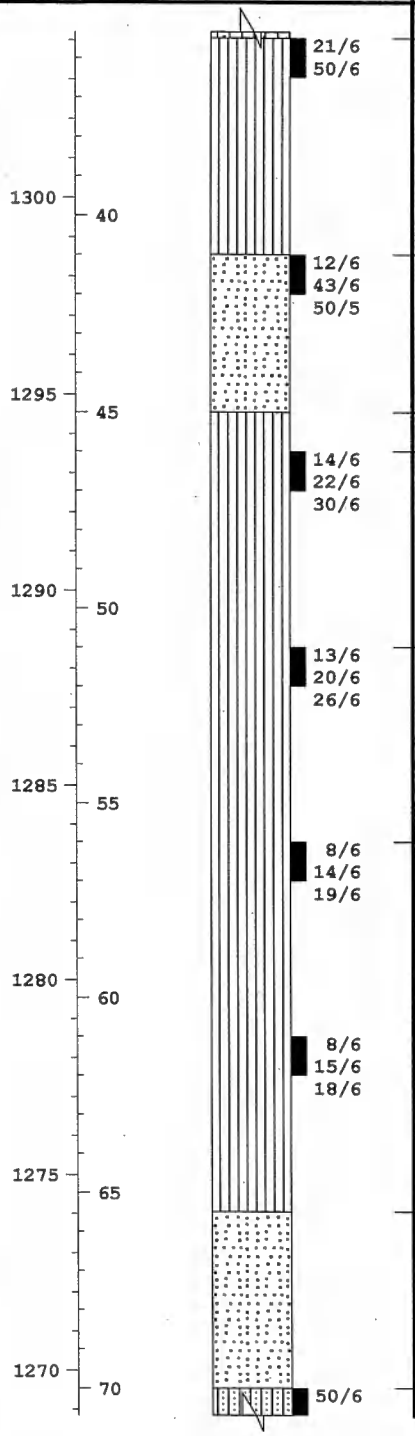
ELEVATION/ DEPTH (feet)	USCS	Description	Remarks	Density pcf	Moisture %
	ML	SANDY SILT WITH CLAY; light yellowish brown, dry, high plasticity, rock.			
		Hard, rock.		109.3	8.6
				105.6	11.8
	SP	POORLY GRADED SAND; light yellowish brown, dry, very dense, fine, rock.		111.6	6.0
		Very dense.		119.3	3.7
	ML	SANDY SILT; brown, damp, trace of clay, low plasticity.		119.3	3.7
		Hard.			
	SP-SM	POORLY GRADED SANAD with low fine content; light yellowish brown, dry to damp, dense.		107.2	5.3
		Dry.			
	SP-SM	Very dense.		107.0	2.6

Figure Number 3

LOG OF TEST BORING
BORING B-2

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/8/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▽ : *N/A* **CAVING - ▶ :** *N/A*

FILE NO: *17662*
ELEV.: *1339.55'*
START: *6/8/20*
FINISH: *6/8/20*
LOGGER: *M. WATTS*

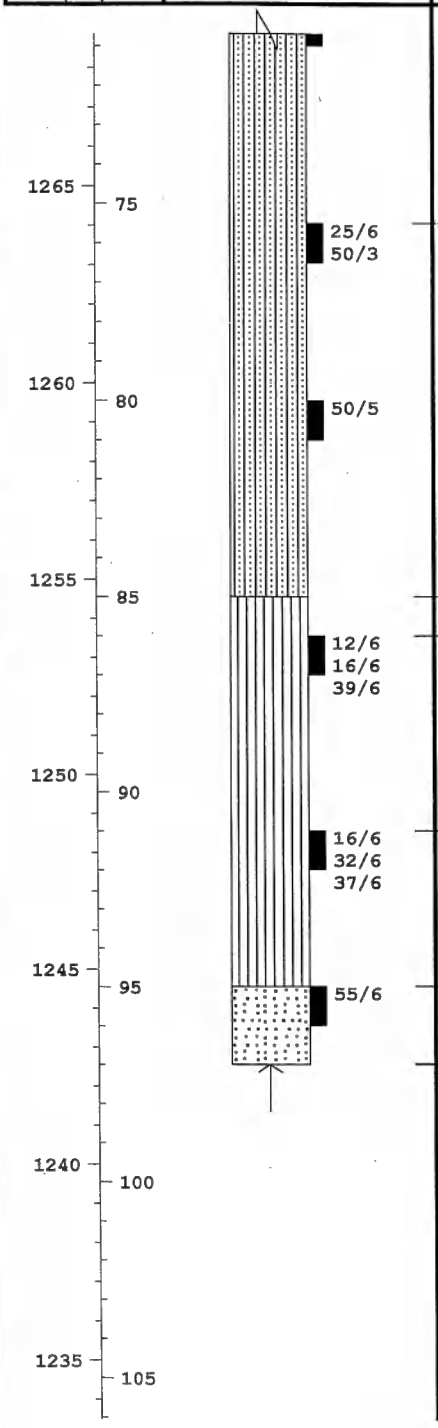


ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
		ML	SANDY SILT; light yellowish brown, fine, very dense, low to medium plasticity.		109.5	4.2
		SP	POORLY GRADED SAND; light yellowish brown, very dense, gravel.		104.1	8.5
		ML	SANDY SILT WITH CLAY; yellowish brown, damp, low to medium plasticity. Hard.		105.8	23.0
			With silt.		107.9	21.8
			Medium to high plasticity.		96.1	28.1
					95.1	26.9
		SP	POORLY GRADED SAND; yellowish brown, dry to damp, very dense, fine, rock with traces of clay.		110.5	7.0
					82.8	28.4

Figure Number 3

LOG OF TEST BORING
BORING B-2

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
FILE NO: *17662*
BORING DATE: *6/8/20*
ELEV.: *1339.55'*
BORING LOCATION: *See Boring Location Map, Figure 1*
START: *6/8/20*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
FINISH: *6/8/20*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ➧ :** *N/A* **LOGGER:** *M. WATTS*



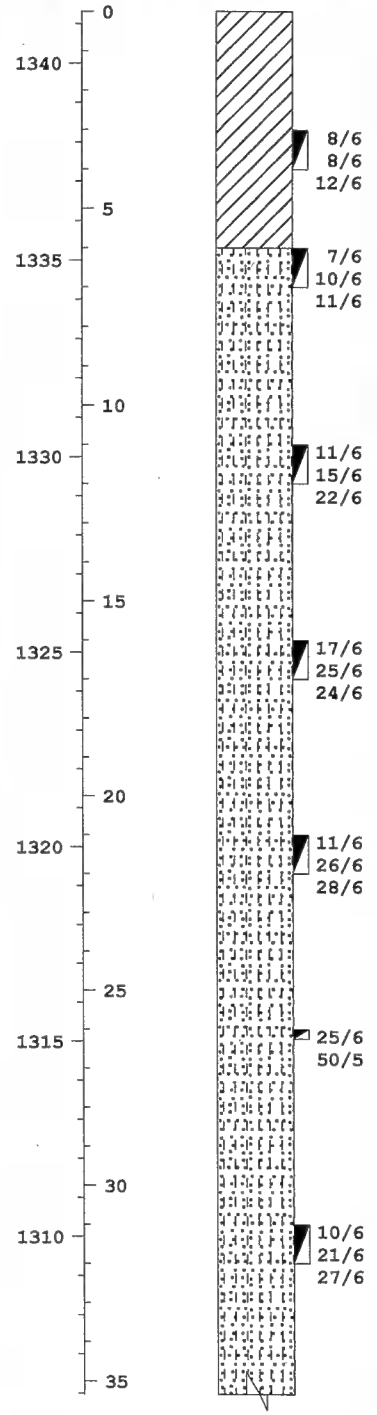
ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
		SM	SILTY SAND; yellowish brown, fine, traces of clay and gravel.			
			Very dense.		102.9	5.4
					112.8	3.8
		ML	SANDY SILT WITH CLAY; yellowish brown, damp, medium to high plasticity.		104.3	23.9
			Hard.			
			Hard.		109.2	16.9
		SP	POORLY GRADED SAND; light yellowish brown, dry to damp, very dense, fine.		94.3	8.0
			BOTTOM. Refusal due to hard drilling.			

Figure Number 3

LOG OF TEST BORING
BORING B-6

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/10/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▽ : *N/A* **CAVING - ▶ :** *N/A*

FILE NO: *17662*
ELEV.: *1341.31'*
START: *6/10/20*
FINISH: *6/10/20*
LOGGER: *M. WATTS*



ELEVATION/ DEPTH (feet)	USCS	Description	Remarks	Density pcf	Moisture %
	CL	SANDY CLAY; light yellowish brown, dry to damp, low plasticity, gravel.			
		Very stiff, gravel.			8.3
	SP-SM	POORLY GRADED SAND with low fine content; yellowish brown, dry to damp, fine, medium dense, gravel.			13.1
		Slow drilling due to rock.			
		Dense, rock.			8.3
					3.8
		Very dense, rock.			5.4
					3.7
	SP-SM	Dense.			4.4

Figure Number 7

LOG OF TEST BORING
BORING B-6

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/10/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ▶ :** *N/A*

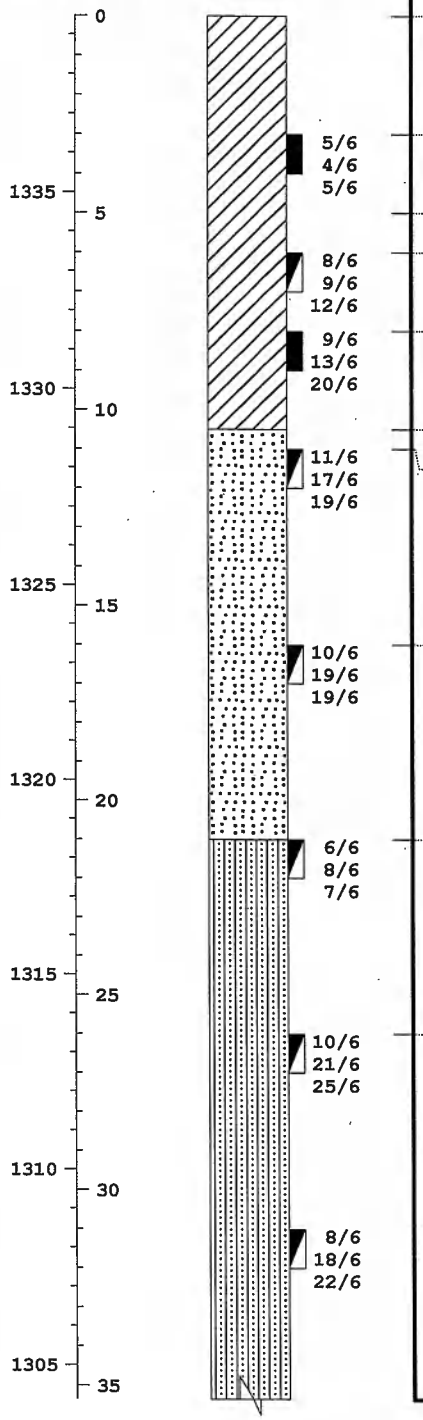
FILE NO: *17662*
ELEV.: *1341.31'*
START: *6/10/20*
FINISH: *6/10/20*
LOGGER: *M. WATTS*

ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
1305	14/6 26/6 32/6		Very dense, gravel.			3.5
40						
1300	16/6 27/6 29/6					2.7
45						
1295	12/6 20/6 30/6					11.9
		ML	SANDY SILT; yellowish brown, damp, low plasticity.			
50						
1290	6/6 18/6 23/6		Hard. BOTTOM.			16.2
55						
1285						
60						
1280						
65						
1275						
70						

Figure Number 7

LOG OF TEST BORING
BORING B-11

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
FILE NO: *17662*
BORING DATE: *6/11/20*
ELEV.: *1339.47'*
BORING LOCATION: *See Boring Location Map, Figure 1*
START: *6/11/20*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
FINISH: *6/11/20*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ⏚ : *N/A* **CAVING - ➧ :** *N/A* **LOGGER:** *M. WATTS*



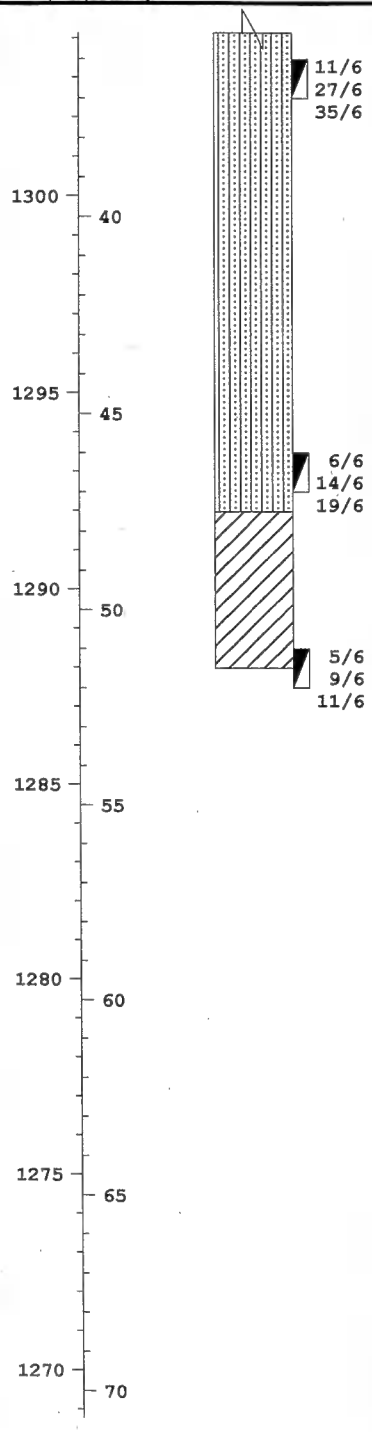
ELEVATION/ DEPTH (feet)	USCS	Description	Remarks	Density pcf	Moisture %
0	CL	CLAY; brown, dry to damp, low plasticity, gravel.			
1335 5		Stiff, gravel (trash, plastic pieces)			11.0
		Odor and staining.	VOC 3ppm out of bag.		
		Very stiff with sand and gravel.			10.7
1330 10		Drove tube to review if staining was present and to test VOCs.	VOC 20ppm.		
	SP	POORLY GRADED SAND; light yellowish brown, dry to damp, fine, odor/staining.	No VOC reading.		8.5 8.0
1325 15		Dense (no staining or odor from 10.5'-11.5')			
		Dense, gravel.			7.8
1320 20					
	SM	SILTY SAND; light brown poorly graded, medium dense.			5.8
1315 25					
		Dense.		105.0	4.5
1310 30					
				74.2	1.8
1305 35					

Figure Number 12

LOG OF TEST BORING
BORING B-11

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/11/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▽ : *N/A* **CAVING - ▶ :** *N/A*

FILE NO: *17662*
ELEV.: *1339.47'*
START: *6/11/20*
FINISH: *6/11/20*
LOGGER: *M. WATTS*



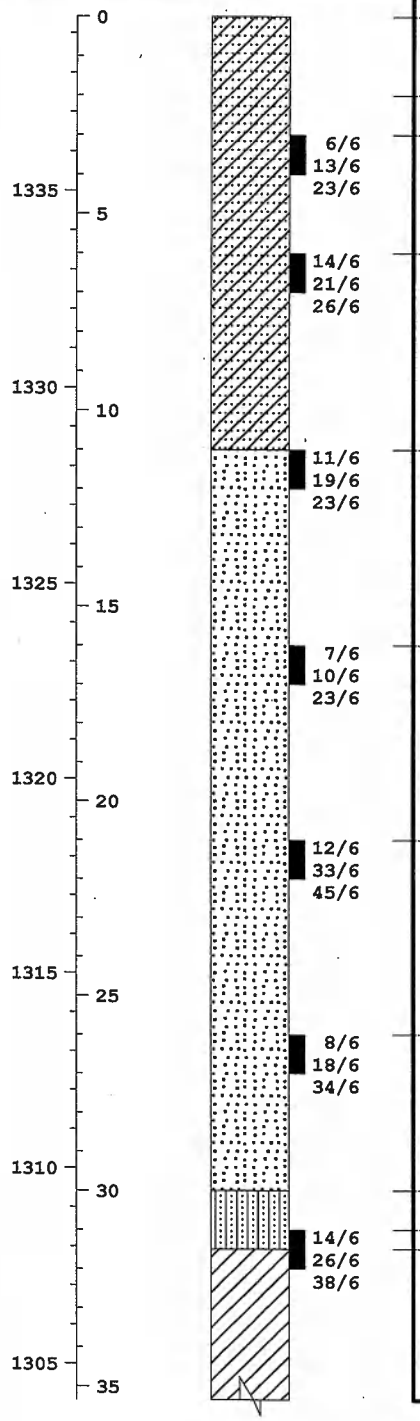
ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
			Very dense.		90.5	19.7
				No sample due to error.		
		SM	Dense.			7.0
		CL	CLAY; brown, damp, low to medium plasticity.			
			Very stiff.			25.9
			BOTTOM.			

Figure Number 12

LOG OF TEST BORING
BORING B-12

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/9/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▽ : *N/A* **CAVING - ➡ :** *N/A*

FILE NO: *17662*
ELEV.: *1339.42'*
START: *6/9/20*
FINISH: *6/9/20*
LOGGER: *M. WATTS*



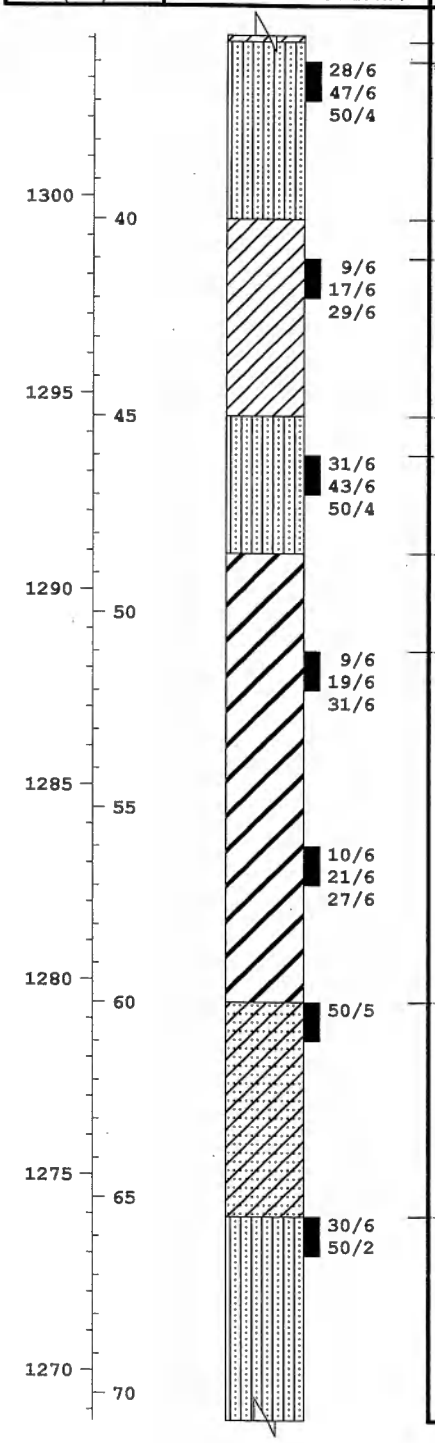
ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
		SC	CLAYEY SAND; light yellowish brown, dry, low plasticity.			
			Damp, yellowish brown, gravel.		115.9	12.1
			Dense.			
			Gravel, shale.		117.1	12.6
		SP	POORLY GRADED SAND; yellowish brown, dry to damp, dense, fine, gravel.		116.5	5.3
			Dense, rock, gravel.		91.4	2.8
			Very dense, fine to medium.		107.1	2.3
			Very dense, fine.		104.3	1.8
		SM	SILTY SAND; light brown, dry to damp, low plasticity.		94.4	28.2
		CL	Hard.			
			CLAY; brown, damp, high plasticity, nose cone			

Figure Number 13

LOG OF TEST BORING
BORING B-12

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/9/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ▶ :** *N/A*

FILE NO: *17662*
ELEV.: *1339.42'*
START: *6/9/20*
FINISH: *6/9/20*
LOGGER: *M. WATTS*



ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
		SM	material.			
			SILTY SAND; light yellowish brown, dry, fine.		91.3	10.2
			Very dense.			
		CL	SANDY CLAY; yellowish brown, dry to damp, medium plasticity.		117.5	15.8
			Hard.			
		SM	SILTY SAND; light yellowish brown, dry, fine, traces of clay.		103.5	6.0
			Very dense.			
		CH	SILTY CLAY; brown, damp, high plasticity.			
			Hard.		107.2	21.5
					108.7	21.6
		SC	CLAYEY SAND; light yellowish brown, dry, very dense, fine.		88.9	4.9
		SM	SILTY SAND.		88.1	4.4

Figure Number 13

LOG OF TEST BORING
BORING B-12

PROJECT: *CO2 Capture Project Elk Hills Power Plant (EH-35R/C1RC)*
BORING DATE: *6/9/20*
BORING LOCATION: *See Boring Location Map, Figure 1*
DRILL METHOD: *4.25" I.D. Hollow-Stem Auger*
DESCRIPTION: *Geotechnical Engineering Services*
DEPTH TO WATER - ▼ : *N/A* **CAVING - ➧ :** *N/A*

FILE NO: *17662*
ELEV.: *1339.42'*
START: *6/9/20*
FINISH: *6/9/20*
LOGGER: *M. WATTS*

ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Remarks	Density pcf	Moisture %
	10/6 50/4					2.8
1265 – 75	28/6 50/4		Fine to medium.		107.4	4.1
1260 – 80	34/6 50/3				95.5	2.9
1255 – 85	16/6 50/3	SC	CLAYEY SAND.		110.7	2.2
1250 – 90	38/6 50/2	SM	SILTY SAND.		107.3	3.3
1245 – 95	25/6 50/3				96.0	3.2
1240 – 100	15/6 28/6 50/5	CH	SILTY CLAY; brown, damp, medium to high plasticity. Hard.		110.4	16.2
1235 – 105			BOTTOM.			

Figure Number 13

KEY TO SYMBOLS

Symbol Description

Strata symbols


Silt


Poorly graded sand


Poorly graded sand with silt


Silty sand


Low plasticity clay


Clayey sand


High plasticity clay

Misc. Symbols


Drill rejection


Boring continues

Soil Samplers

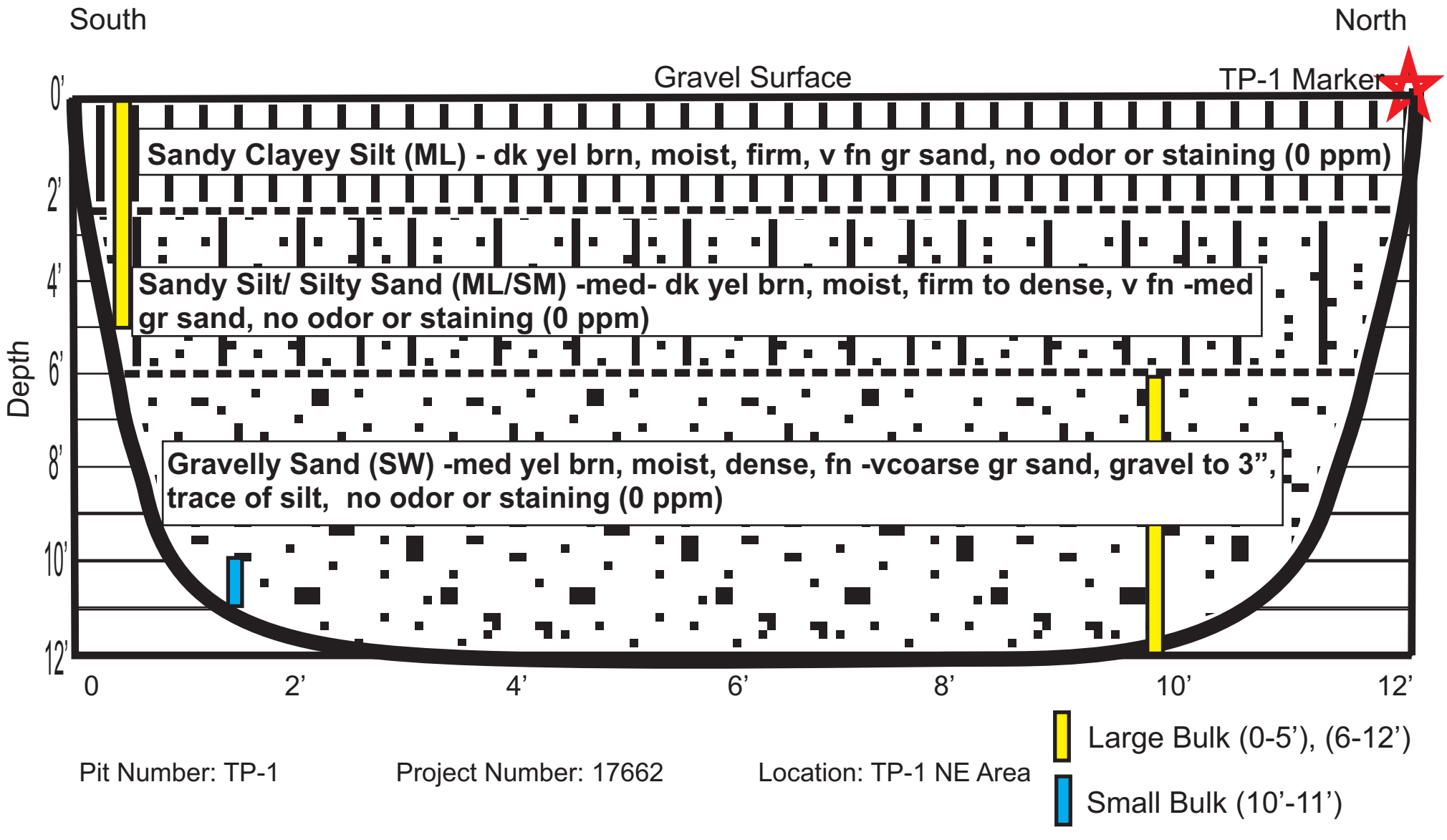

California sampler


Standard penetration test

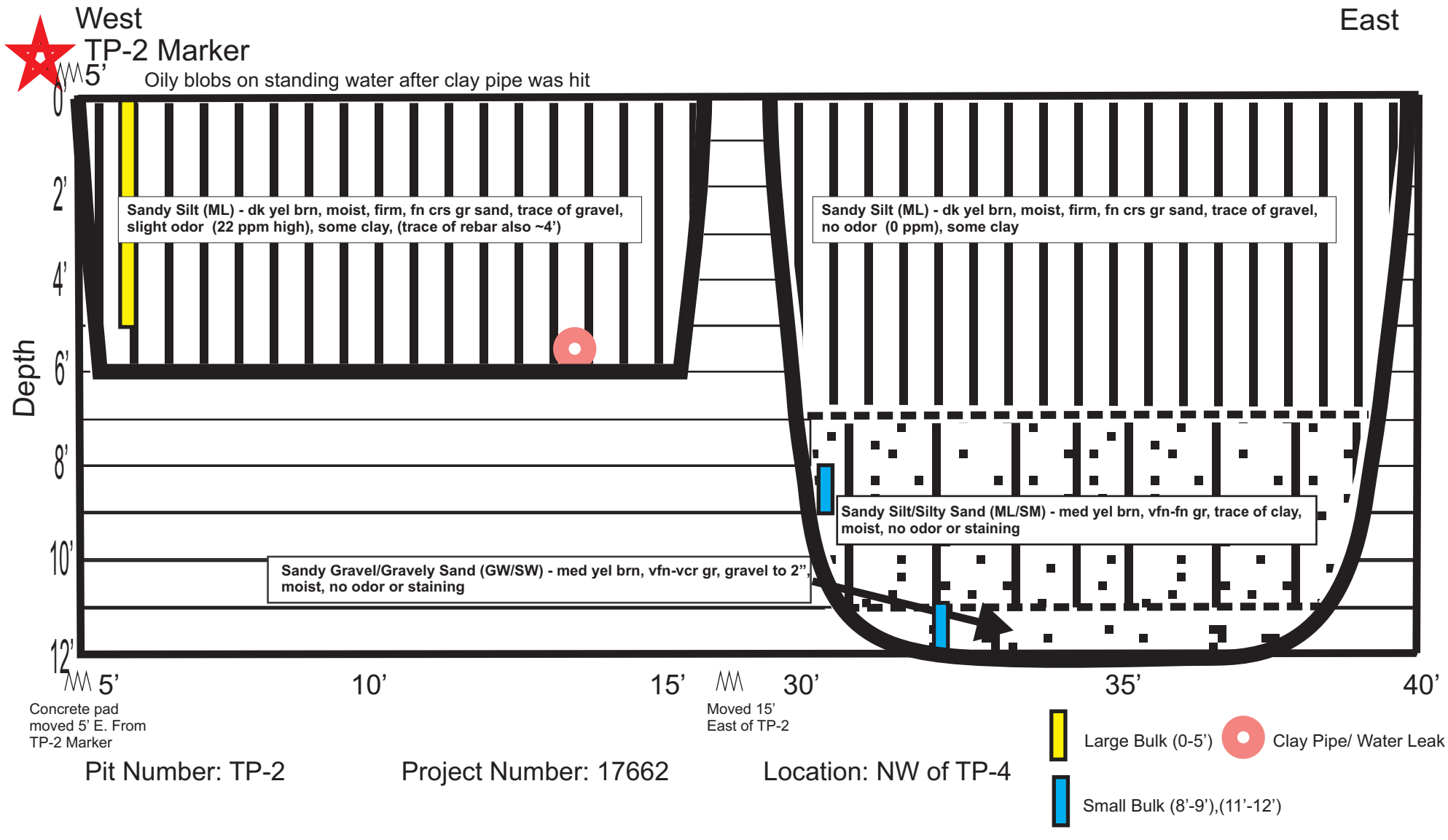
Notes:

1. Seven (7) exploratory borings were drilled between 06/05/2020 and using an 8-inch outside diameter hollow-stem auger.
2. No free groundwater was encountered to the maximum depth drilled of 101.5'.
3. Boring locations are shown on the Boring Location Map, Figure 1.
4. These logs are subject to the limitations, conclusions, and recommendations in this report.
5. Results of tests conducted on samples recovered are reported on the logs.

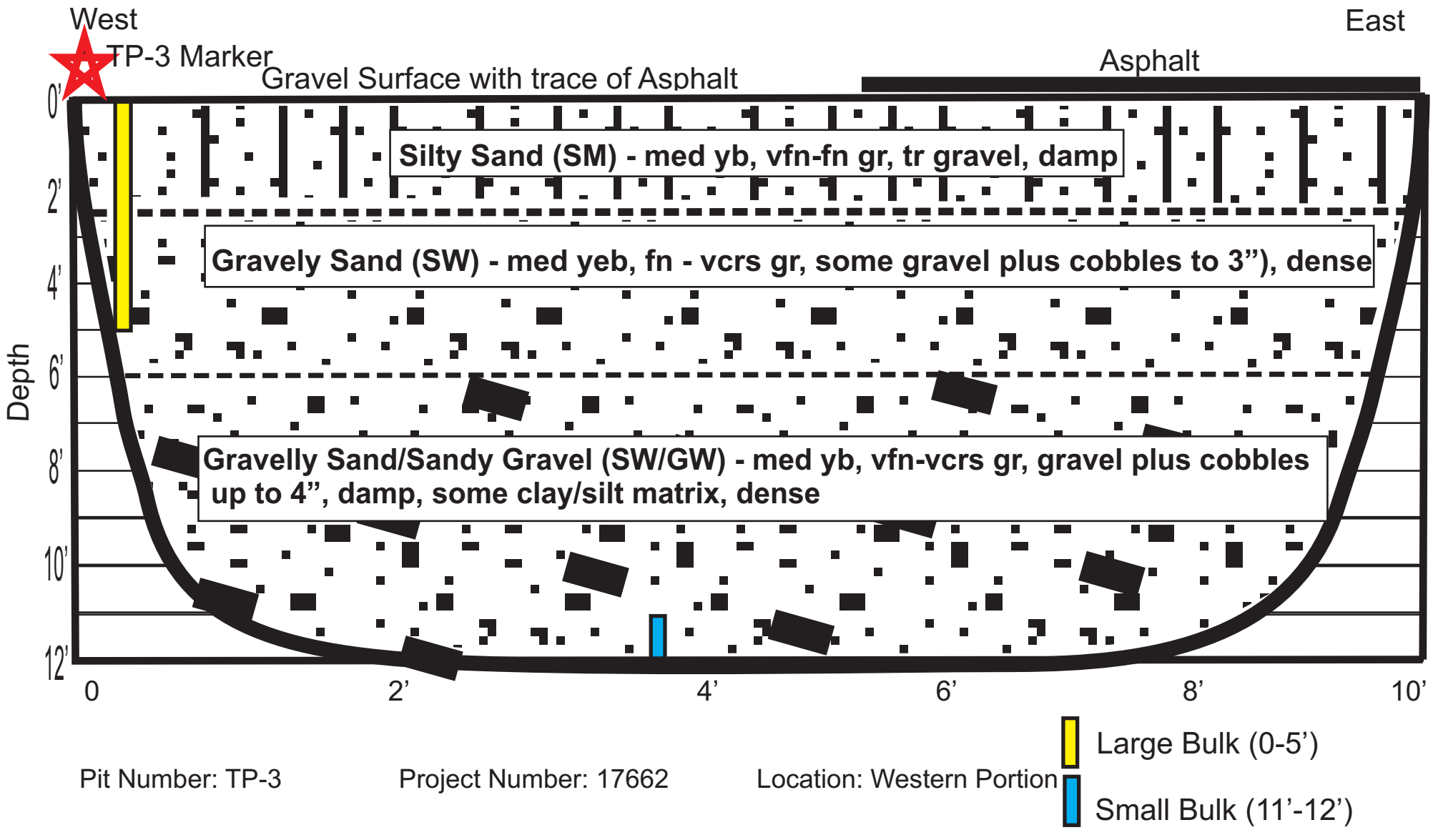
TABLE 1 - BLOWCOUNT COMPARISON FOR DEEPEST BORINGS												
Western Portion							Eastern Portion					
Depth	B6 (spt)	USCS	B2 (CM)	USCS	SPT/CM Ratio (same USCS)	Converted B2 to SPT	Depth	B11 (spt)	USCS	B12 (CM)	Converted B12 to SPT	USCS	SPT/CM Ratio (same USCS)
3	20	CL	46	CL	0.434782609	29.9	3	6	CL	36	23.4	SC	
6	21	SW	38	CL		24.7	6	21	CL	47	30.55	SC	
11	37	SW	72	SW	0.513888889	46.8	11	36	SW	39	25.35	SW	0.923076923
16	49	SW	47	SW	1.042553191	30.55	16	38	SW	33	21.45	SW	1.151515152
21	54	SW	50	ML		32.5	21	15	SW	78	50.7	SW	0.192307692
26	75	SW	49	SP	1.530612245	31.85	26	46	SW	52	33.8	SW	0.884615385
31	48	SW	92	SP	0.52173913	59.8	31	40	SW	64	41.6	SM	0.625
36	58	SW	71	ML		46.15	36	52	SW	97	63.05	CL	
41	56	SW	93	SP	0.602150538	60.45	41	56	SW	46	29.9	SM	
46	50	SW	52	ML		33.8	46	33	SW	93	60.45	CL	
51	41	ML	46	ML	0.891304348	29.9	51	20	CL	50	32.5	SM	
56			33	ML	**Average**	21.45	56			48	31.2	CH	**Average**
61			33	ML	**0.791004421**	21.45	61			100	100	CH	**0.75530303**
66			65	SP		42.25	66			100	100	SC	
71			100	SM		100	71			100	100	SM	
76			100	SM		100	76			100	100	SM	
81			100	SM		100	81			100	100	SM	
86			55	ML		35.75	86			100	100	SC	
91			69	ML		44.85	91			100	100	SM	
96			100	SW		100	96			100	100	SM	
101			100	SW		100	101			100	100	CH	
46.3 top 50'			**70.55**		**Avg BC/100' =**	**52.01**	**33 top 50'**			**Avg BC/100' =**	**64.00**	**Using 0.65 conversion factor**	



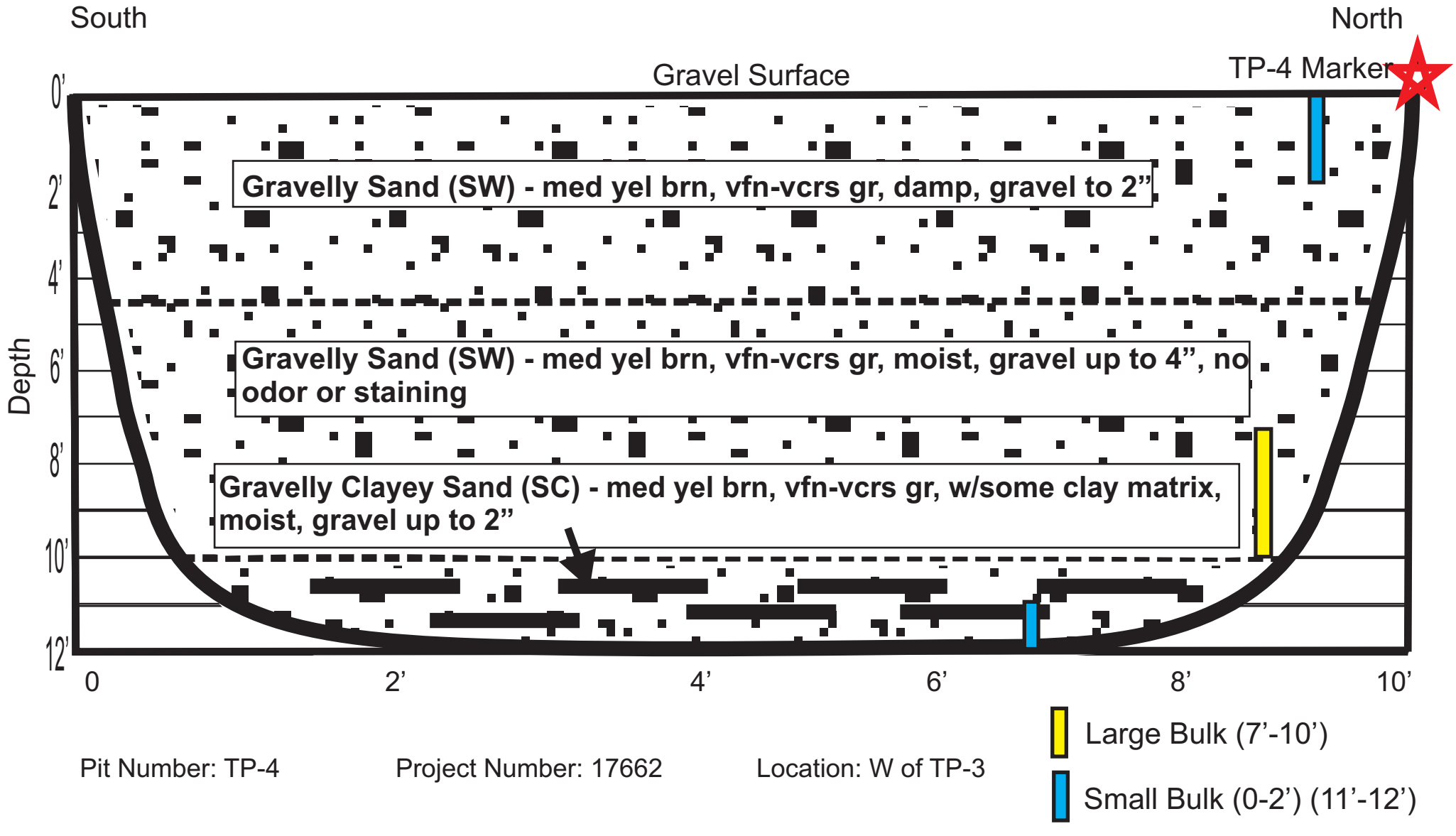
Pit Number: TP-1 Project Number: 17662 Location: TP-1 NE Area



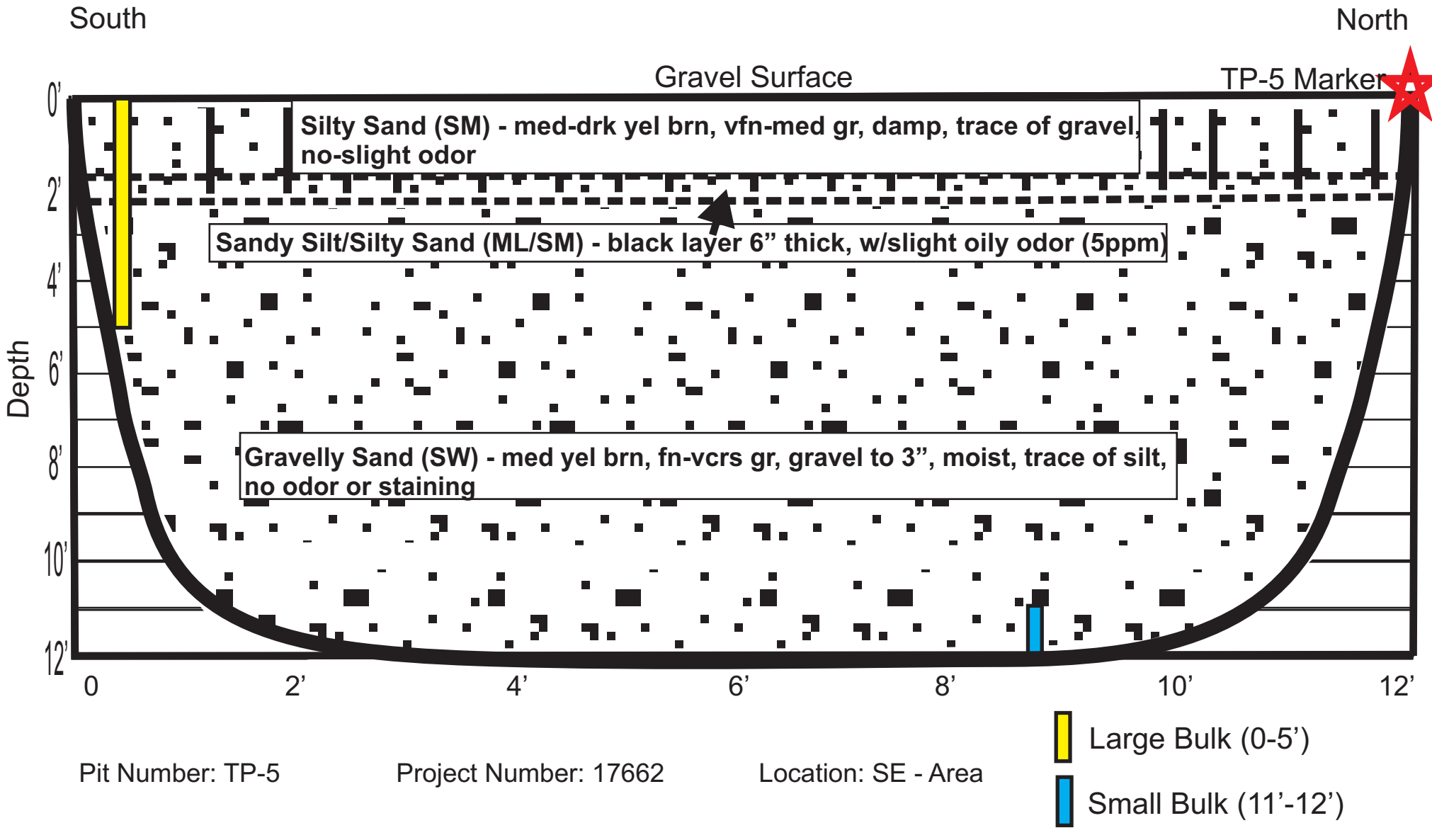
Pit Number: TP-2 Project Number: 17662 Location: NW of TP-4



Pit Number: TP-3 Project Number: 17662 Location: Western Portion



Pit Number: TP-4 Project Number: 17662 Location: W of TP-3



Pit Number: TP-5 Project Number: 17662 Location: SE - Area

Subsurface Surveys & Associates, Inc.
2075 Corte Del Nogal, Suite W Carlsbad, CA 92011
Phone: (760) 476-0492 Fax: (760) 476-0493

Soils Engineering, Inc.
4400 Yeager Way
Bakersfield, CA

June 19, 2020

Attn: Robert Becker

Re: Seismic Survey Summary Report
CRC - CO2 Capture Project
Elk Hills Property, Bakersfield

This report covers the results of a seismic shear wave survey performed near the intersection of Elk Hills Rd and Skyline Rd, in the Elk Hills west of Bakersfield, California. The main objective was to record low frequency surface wave data to determine shear wave velocity (Vs) to a depth of 100 feet. A secondary objective was to measure the compressional wave velocity (Vp) of the alluvium and provide cross sections showing the thickness and lateral extent of the alluvial layers. This information should be useful for foundation design and for planning excavations, grading, and other earthwork.

The field work was conducted on June 20, 2020. Two seismic lines were recorded at locations selected by SEI. A survey location map is provided on Figure 1 that shows the position and orientation of the traverses.

GEOLOGIC SETTING

A review of the Geologic Map of California, Bakersfield Sheet, (California Division of Mines and Geology, 1975) indicates the Elk Hills area is underlain by Plio-Pleistocene non-marine sediments. Boring logs from B-2 and B-12, provided by SEI, show the alluvial deposits are composed of alternating sequences of sand, sandy silt, clayey sand, and gravel.

DATA ACQUISITION AND FIELD METHODS

Surface wave data were recorded with a Bison 9024 signal enhancement seismograph and 4.5 Hz geophones. The standard spread layout used 24 geophones with a 15-foot spacing which provided a line length of 345 feet.. Each spread used three shotpoints, one off each end (5-foot offset) and one at the center of the spread.

Seismic energy was generated by sledge hammer impacts on a metal plate. The sample rate was 0.5 milliseconds (msec) and a record length of 750 msec was used to completely envelop the surface waves. Example shear wave records are displayed on Figure 2.

Compressional wave energy, also created with the sledge hammer, was recorded with 28 Hz geophones. Five shotpoints were used for refraction recording. The signal enhancement feature

of the seismograph allowed returns from repeated hits to be stacked, thus improving the signal. Each record was stored digitally on an internal hard disk and printed copies of each seismogram were made in the field on thermal paper.

Relative elevations of all shotpoints and geophones were determined by differential leveling with a hand level. Geophone 1 (distance = 0 ft.) at the beginning of each line was assigned a elevation value of 0.0 feet. This datum point served as the reference elevation for all other measurements.

Labeled wooden stakes were placed at the beginning and end of each spread and a Garmin handheld GPS receiver was used to record the latitude and longitude coordinates of the stakes. The coordinates were used to make the location map shown on Figure 1.

SEISMIC METHODS

MASW – The Multi-channel Analysis of Surface Waves method uses low frequency surface waves, commonly referred to as “ground roll”, to extract shear wave (S-wave) velocity data. This information is commonly used for soil classification, tower and foundation design, and seismic response spectra calculations.

This method does not measure shear wave velocity directly. Rather, dispersion curves are extracted from the raw multi-channel field records and inverted to produce a plot of velocity verses depth.

Refraction Method - involves measuring the total time for compressional waves to travel from a shotpoint through the subsurface to a set of geophones placed linearly along the ground. Based on Snell's Law, when two or more layers are present with increasingly higher acoustic velocity, waves become critically refracted across the layer boundaries and begin traveling at the speed of the underlying layer. The advancing waves then generate new wavefronts back to the ground surface. The first surge of energy hitting the geophone is termed the "first arrival" and is depicted on the seismogram as a high angle deflection along each trace.

Recognition of direct wave arrivals (non-refracted) verses refracted waves is a key element of refraction interpretation. To assist this process, the first arrival times measured from the seismic records are plotted on graphs of time verses distance called Time-Distance graphs. An example T-D graph from Line 2 is shown on Figure 3. Based on changes in slope on the graphs, a preliminary layer number (i.e. 1, 2, 3) is assigned to each segment of the graph. The layer assignments together with time, distance and elevation data are input to a computer for additional processing.

DATA REDUCTION AND VELOCITY DETERMINATION

MASW - Surface wave records were processed with SeisImager/SW software from Geometrics Inc. The software calculates shear wave velocity by mathematical inversion of the dispersive phase velocity of surface waves. In this application, Raleigh waves (also referred to as “ground roll”) are the main surface waves of interest. A summary of the steps involved is provided below.

Standard time-distance field records are converted from time domain to frequency domain using a phase velocity- frequency transformation. This yields dispersion curve plots of frequency (Hz) verses phase velocity in (ft/sec). A wave equation module then performs inversion modeling to produce the graphics.

Refraction -Processing and interpretation of this data set was accomplished with “SIPT2", an interactive inversion modeling program developed by James Scott for the U.S. Bureau of Mines. The inversion algorithm uses the delay time method to construct a first pass depth model. The model is then adjusted by an iterative ray tracing process that attempts to minimize the discrepancies between the total travel times calculated along ray paths and the observed travel times measured in the field.

This program calculates refractor velocity in two ways. First, apparent velocities from each shot are determined by the inverse slope of a best fit (least squares) line through datum-corrected travel times. True velocity is estimated from the apparent velocities by using the following equation:

$$Vt = 2(Vu \times Vd)/(Vu + Vd)$$

where Vt = true velocity
Vu = apparent up dip velocity
Vd = apparent down dip velocity

The second method uses a more sophisticated set of equations (the Hobson-Overton formula) developed by the Canadian Geological Survey. The final velocity assigned to the refractor is a weighted average of the results of the two methods. The weighting is based on the number of arrival times used in the computations.

SUMMARY OF RESULTS

Shear Wave Analysis - High amplitude noise from the adjacent power plant had a significant impact on the shear wave recording. Noise levels were 2-3 times higher than the signal being generated by the shear wave source. Consequently, the deeper surface wave dispersion patterns were masked by the noise. As a result, the modeling results are limited to depths of 40-65 feet.

Inversion modeling results are displayed on Figures 4 and 5. The curves show a fairly constant increase in velocity with increasing depth. This is typical of alluvial deposits. The curve below

the posted data points is based on extrapolation to 100 feet.

The extrapolated Vs100 ft value is 1050 ft/s below Line 1 and 1155 ft/s below Line 2. The P-wave velocity cross sections discussed below, show a significant velocity increase below depths of 50 feet. This suggests the true Vs100 ft values at this site will, most likely, be significantly higher than the extrapolated data.

Refraction Data - Results from refraction analysis show a three layer solution beneath both lines (see Figures 6-7). Velocities posted on the cross sections represent averages as described in the previous section. Therefore, minor localized changes in velocity may occur along any profile. A description of the layers is provided below and a cross section summary is shown in Table 1.

Layer 1 - is mostly loose recent alluvium. Thickness is generally less than 15 feet.

Layer 2 - is interpreted to be older alluvium. The velocity range is 1869-1928 ft/sec.

Layer 3 - represents consolidated older alluvial deposits with average velocity between 2477-2686 ft/sec.

Table 1. Cross Section Summary Velocity in (ft/sec), Depth in (feet)

Line	Velocity Layer 1	Velocity Layer 2	Velocity Layer 3	Depth Range Layer 2/3 Interface
1	1415	1869	2477	32 - 56
2	1384	1928	2686	40 - 54

Velocity tends to be gradational in most alluvial deposits and usually produces a gradual increase in velocity with depth. Consequently, variation of ± 10% from the posted averages may occur between the top and bottom of the layers.

All data acquired during this survey is considered confidential and is available for review by your staff at any time. We appreciate the opportunity to participate in this project.

Please call if there are any questions.



Phillip A. Walen
Senior Geophysicist
CA Registration No. GP917

Seismic Survey Location Map

CRC Elk Hills Project Site -- Bakersfield, CA

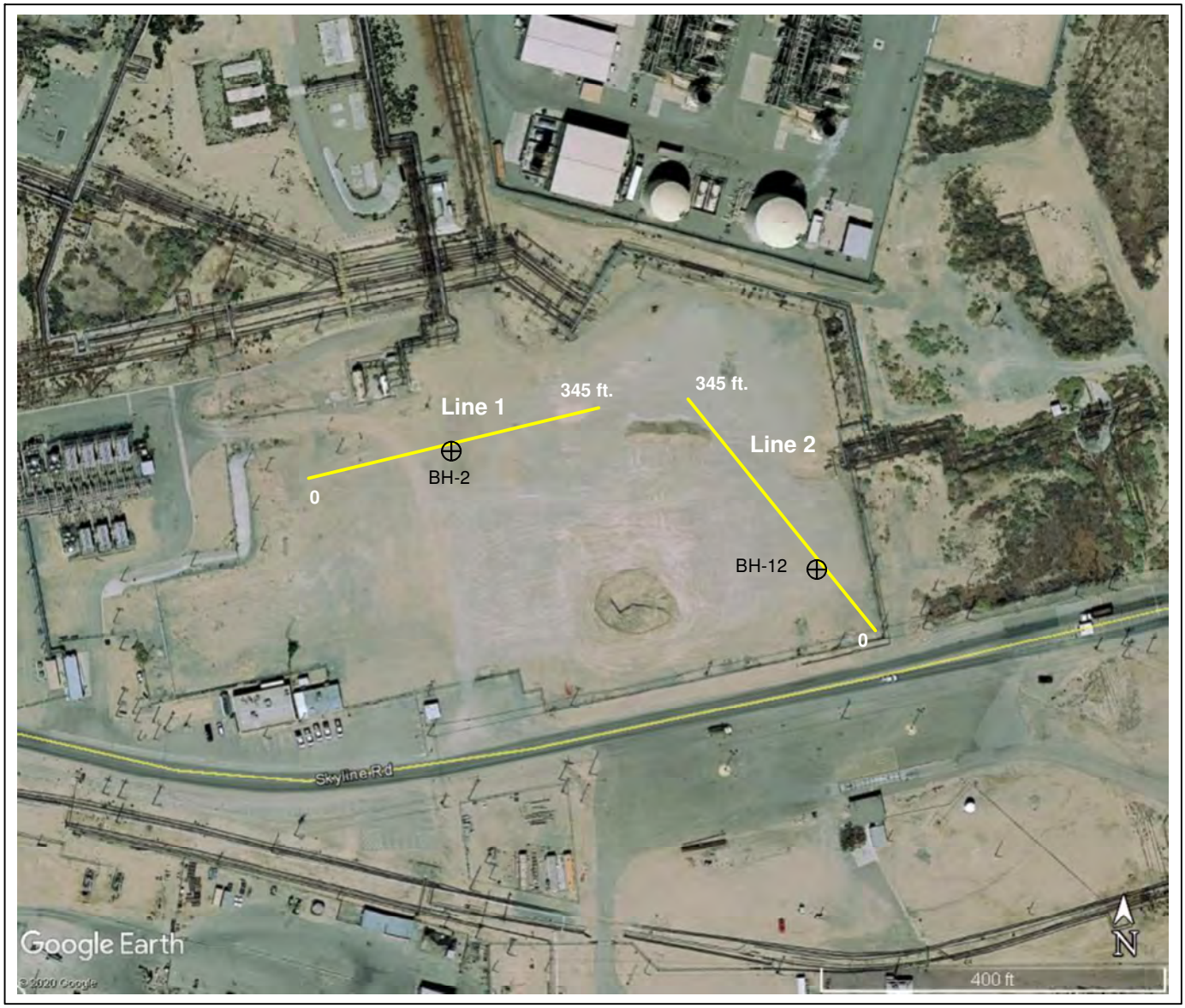


Figure 1

Example shear wave records

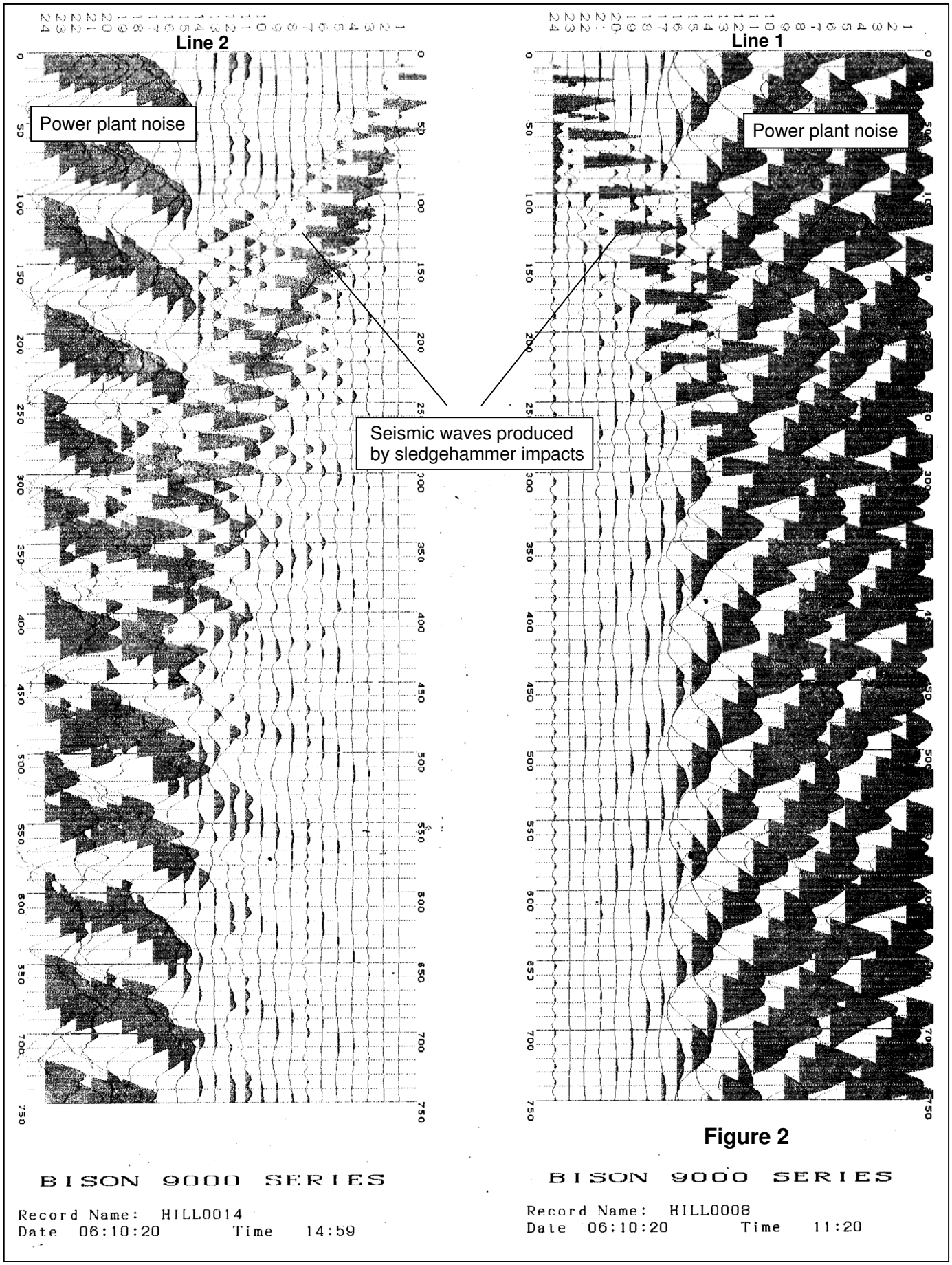
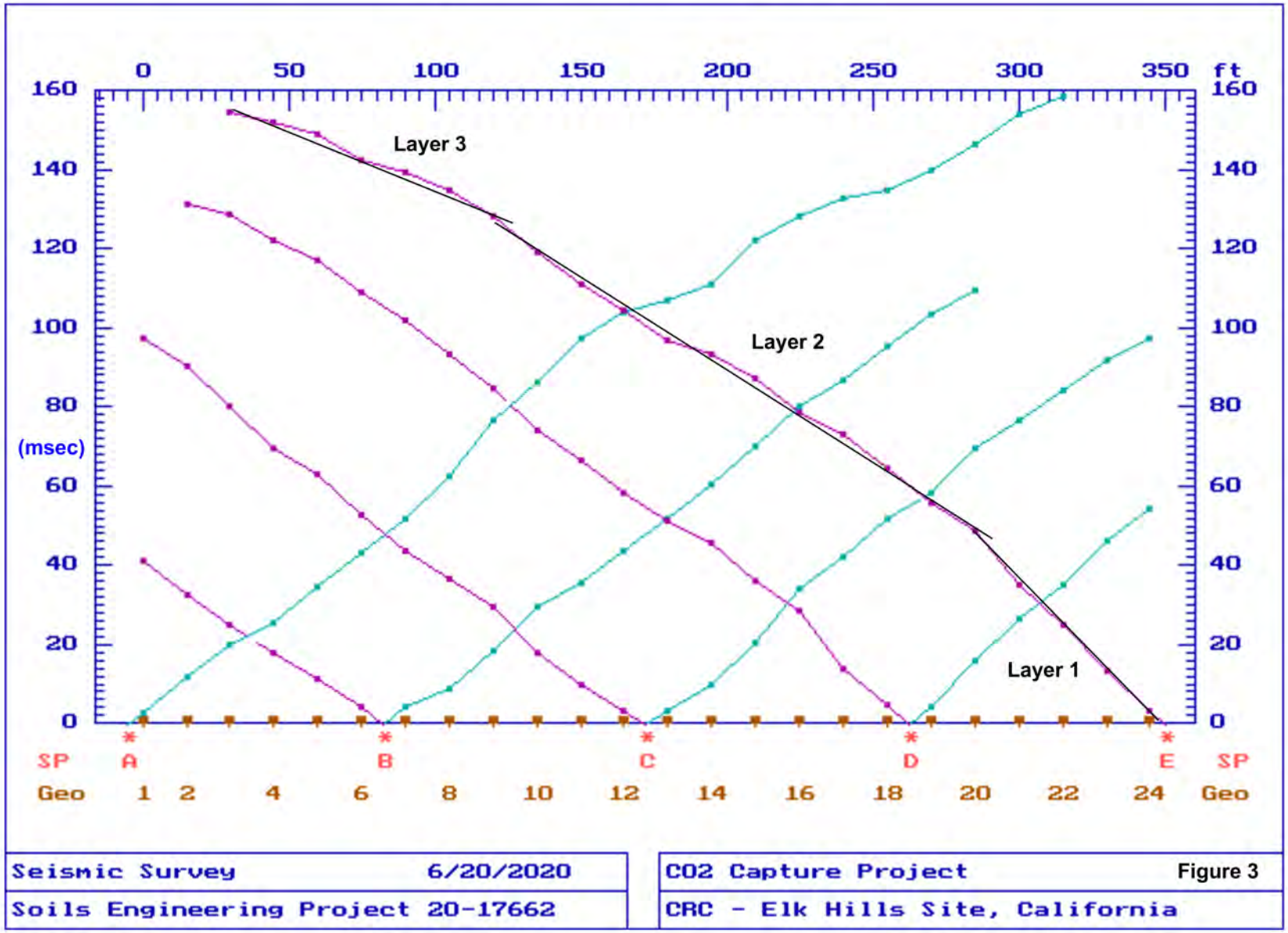


Figure 2

Example Time-Distance Graph -- Line 2



Seismic Survey 6/20/2020	CO2 Capture Project Figure 3
Soils Engineering Project 20-17662	CRC - Elk Hills Site, California

Inversion Model: S-wave Velocity verses Depth -- Line 1

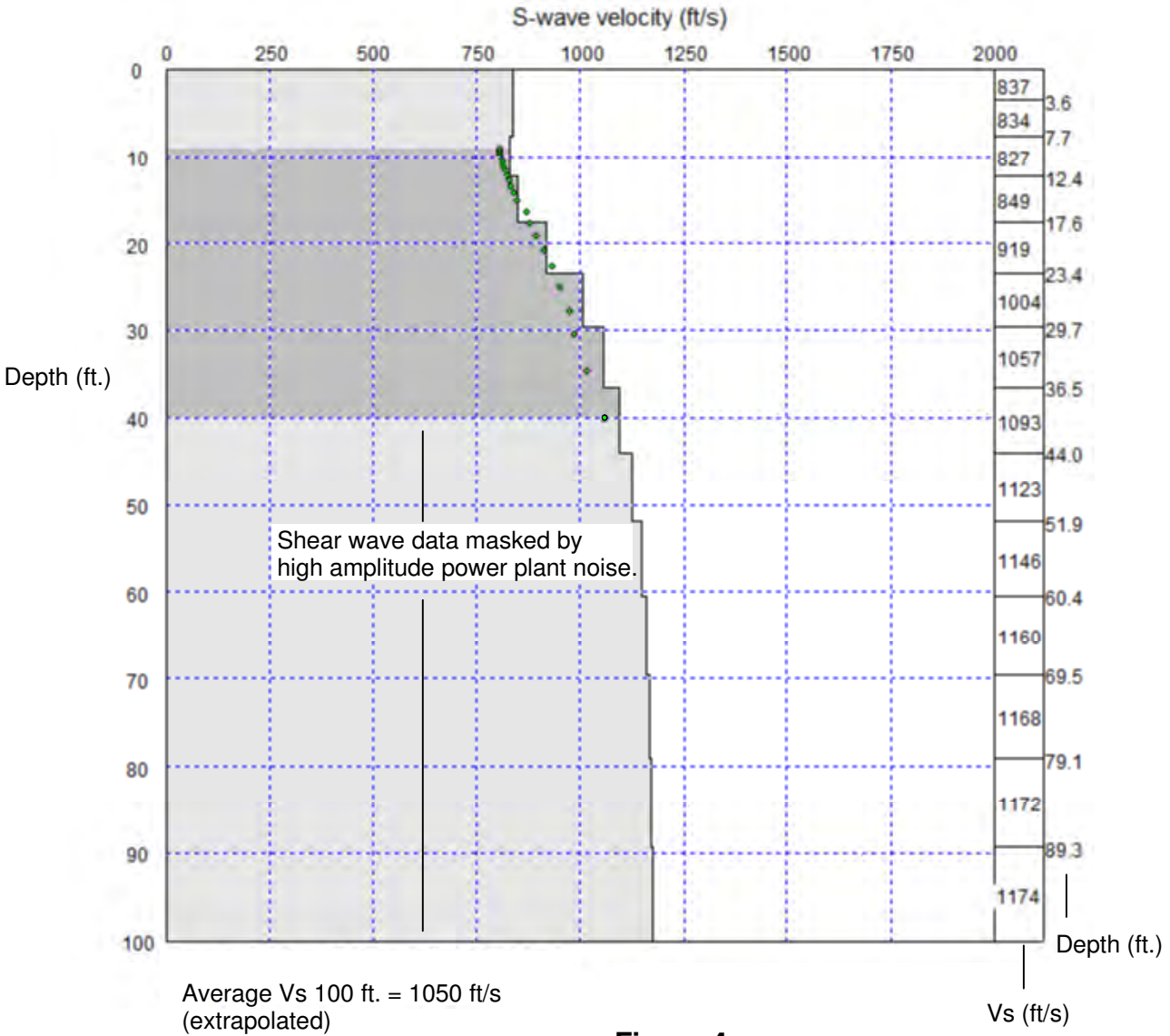


Figure 4

Inversion Model: S-wave Velocity verses Depth -- Line 2

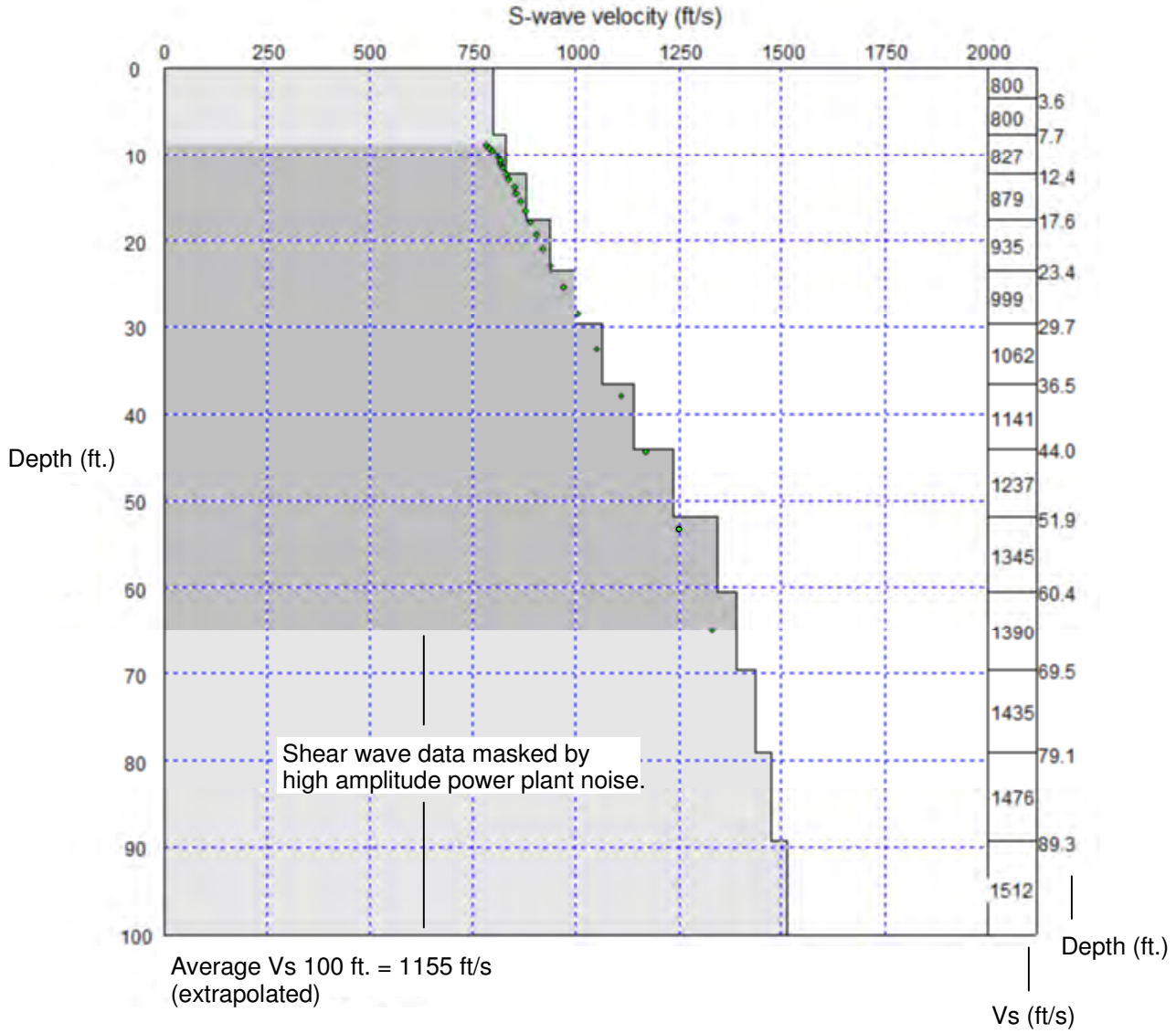
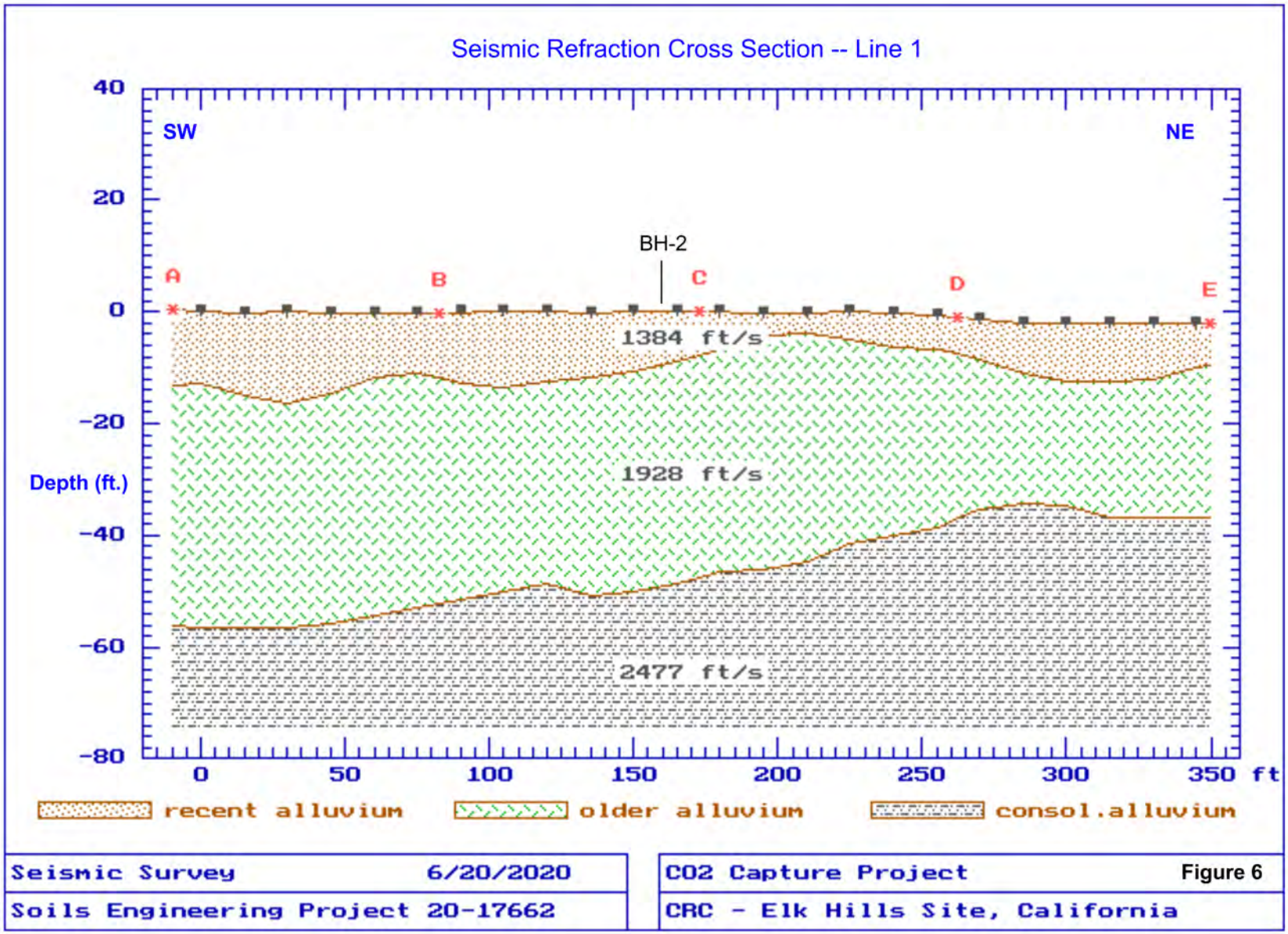
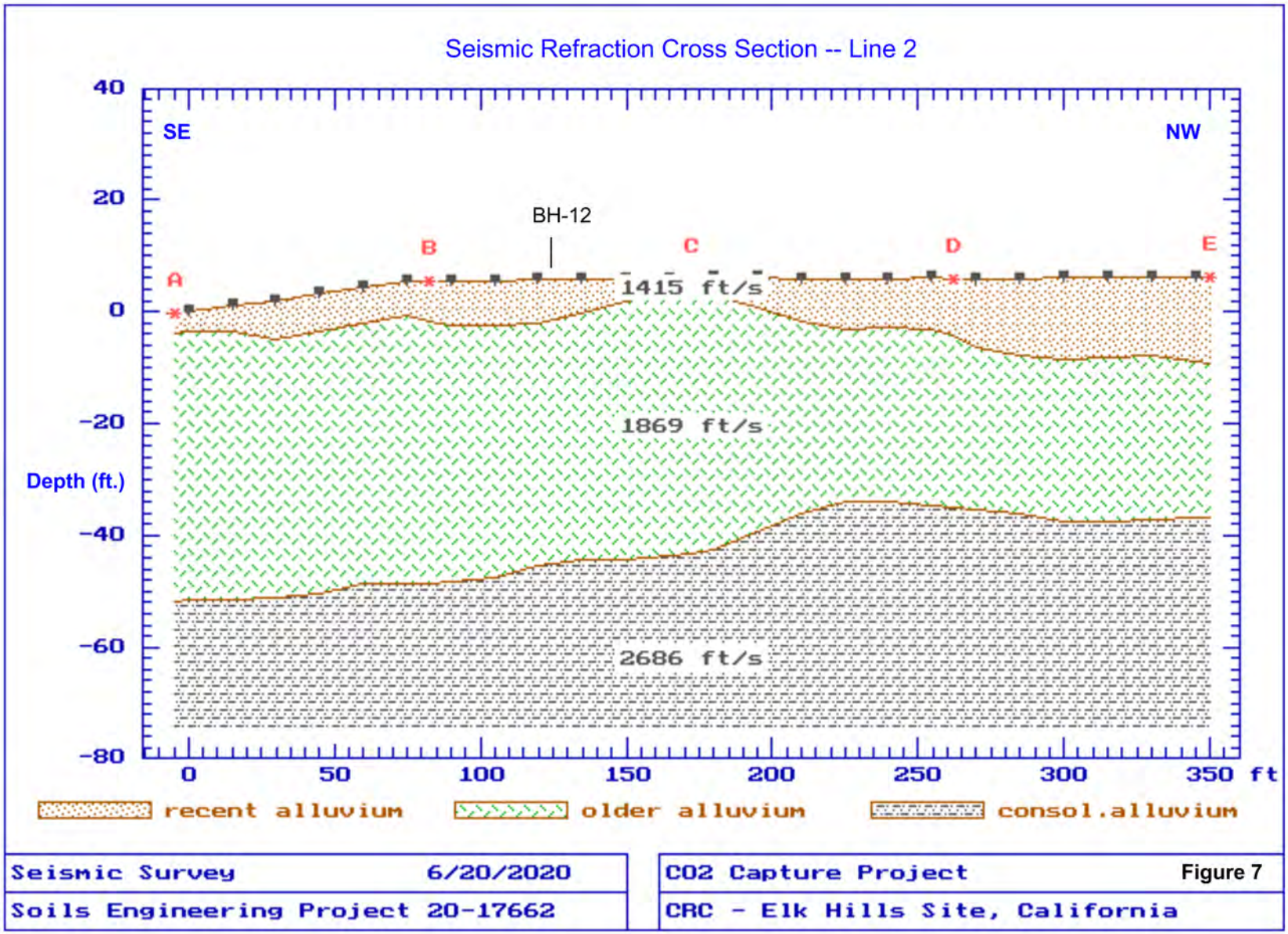


Figure 5



Seismic Survey 6/20/2020	CO2 Capture Project
Soils Engineering Project 20-17662	CRC - Elk Hills Site, California

Figure 6



Seismic Survey 6/20/2020	CO2 Capture Project
Soils Engineering Project 20-17662	CRC - Elk Hills Site, California

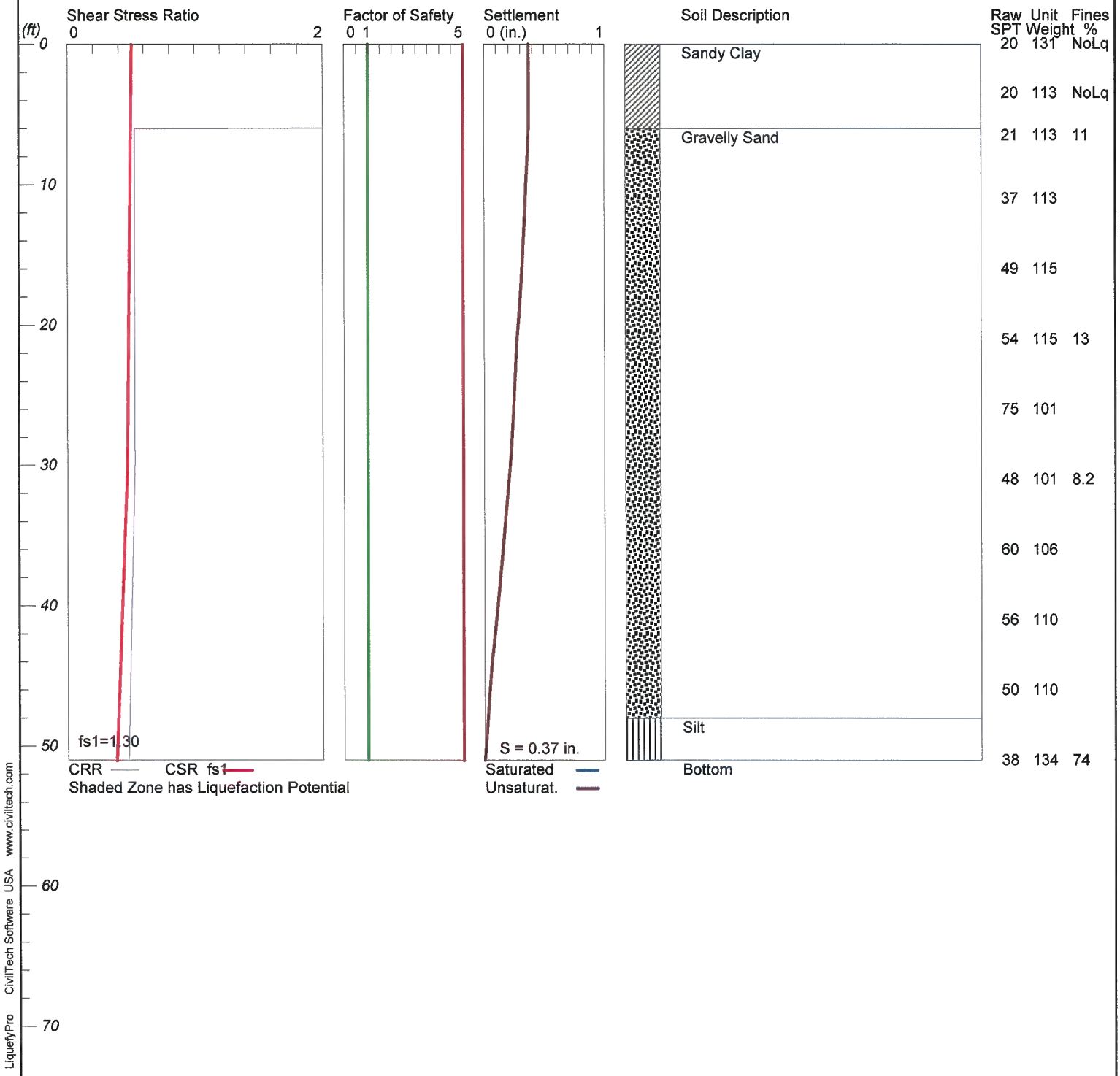
Figure 7

LIQUEFACTION ANALYSIS

CRC CO2 Capture Project

Hole No.=B-6 Water Depth=100+ ft Surface Elev.=1341

Magnitude=7.33
Acceleration=0.6g



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LIQUEFACTION ANALYSIS SUMMARY
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Font: Courier New, Regular, Size 8 is recommended for this report.
Licensed to Robert Becker, Soils Engineering 7/2/2020 8:15:35 AM

Input File Name: O:\b. PROJECT FILES (ACTIVE)\17600-17699\17662 Fluor, CO2 Capture Project from Elk Hills Power Plant Project (EH-35RC1RC)\OFFICE REPORTS\17662 Geohaz\LiquefyPro Files\17662 B-6.liq
Title: CRC CO2 Capture Project
Subtitle: 17662

Surface Elev.=1341
Hole No.=B-6
Depth of Hole= 51.00 ft
Water Table during Earthquake= 999.00 ft
Water Table during In-Situ Testing= 999.00 ft
Max. Acceleration= 0.6 g
Earthquake Magnitude= 7.33

Input Data:
Surface Elev.=1341
Hole No.=B-6
Depth of Hole=51.00 ft
Water Table during Earthquake= 999.00 ft
Water Table during In-Situ Testing= 999.00 ft
Max. Acceleration=0.6 g
Earthquake Magnitude=7.33
No-Liquefiable Soils: CL, OL are Non-Liq. Soil

1. SPT or BPT Calculation.
2. Settlement Analysis Method: Tokimatsu, M-correction
3. Fines Correction for Liquefaction: Idriss/Seed
4. Fine Correction for Settlement: During Liquefaction*
5. Settlement Calculation in: All zones*
6. Hammer Energy Ratio, Ce = 1.25
7. Borehole Diameter, Cb= 1
8. Sampling Method, Cs= 1.2
9. User request factor of safety (apply to CSR) , User= 1.3
   Plot one CSR curve (fs1=User)
10. Use Curve Smoothing: Yes*

* Recommended Options

In-Situ Test Data:

Depth ft	SPT	gamma pcf	Fines %
0.00	20.00	131.00	NoLiq
3.50	20.00	113.00	NoLiq
6.50	21.00	113.00	11.00
11.00	37.00	113.00	11.00
16.00	49.00	115.00	11.00
21.00	54.00	115.00	13.00
26.00	75.00	101.00	13.00
31.00	48.00	101.00	8.20
36.00	60.00	106.00	8.20
41.00	56.00	110.00	8.20
46.00	50.00	110.00	8.20
51.00	38.00	134.00	74.00

Output Results:

Settlement of Saturated Sands=0.00 in.
Settlement of Unsaturated Sands=0.37 in.
Total Settlement of Saturated and Unsaturated Sands=0.37 in.
Differential Settlement=0.185 to 0.244 in.

Depth ft	CRRm	CSRfs	F.S.	S_sat. in.	S_dry in.	S_all in.
0.00	2.00	0.51	5.00	0.00	0.37	0.37
0.05	2.00	0.51	5.00	0.00	0.37	0.37
0.10	2.00	0.51	5.00	0.00	0.37	0.37
0.15	2.00	0.51	5.00	0.00	0.37	0.37
0.20	2.00	0.51	5.00	0.00	0.37	0.37
0.25	2.00	0.51	5.00	0.00	0.37	0.37
0.30	2.00	0.51	5.00	0.00	0.37	0.37
0.35	2.00	0.51	5.00	0.00	0.37	0.37
0.40	2.00	0.51	5.00	0.00	0.37	0.37
0.45	2.00	0.51	5.00	0.00	0.37	0.37
0.50	2.00	0.51	5.00	0.00	0.37	0.37
0.55	2.00	0.51	5.00	0.00	0.37	0.37
0.60	2.00	0.51	5.00	0.00	0.37	0.37
0.65	2.00	0.51	5.00	0.00	0.37	0.37
0.70	2.00	0.51	5.00	0.00	0.37	0.37
0.75	2.00	0.51	5.00	0.00	0.37	0.37
0.80	2.00	0.51	5.00	0.00	0.37	0.37
0.85	2.00	0.51	5.00	0.00	0.37	0.37
0.90	2.00	0.51	5.00	0.00	0.37	0.37
0.95	2.00	0.51	5.00	0.00	0.37	0.37
1.00	2.00	0.51	5.00	0.00	0.37	0.37
1.05	2.00	0.51	5.00	0.00	0.37	0.37
1.10	2.00	0.51	5.00	0.00	0.37	0.37
1.15	2.00	0.51	5.00	0.00	0.37	0.37
1.20	2.00	0.51	5.00	0.00	0.37	0.37
1.25	2.00	0.51	5.00	0.00	0.37	0.37
1.30	2.00	0.51	5.00	0.00	0.37	0.37
1.35	2.00	0.51	5.00	0.00	0.37	0.37
1.40	2.00	0.51	5.00	0.00	0.37	0.37
1.45	2.00	0.51	5.00	0.00	0.37	0.37
1.50	2.00	0.51	5.00	0.00	0.37	0.37
1.55	2.00	0.51	5.00	0.00	0.37	0.37
1.60	2.00	0.51	5.00	0.00	0.37	0.37
1.65	2.00	0.51	5.00	0.00	0.37	0.37
1.70	2.00	0.50	5.00	0.00	0.37	0.37
1.75	2.00	0.50	5.00	0.00	0.37	0.37
1.80	2.00	0.50	5.00	0.00	0.37	0.37
1.85	2.00	0.50	5.00	0.00	0.37	0.37

1.90	2.00	0.50	5.00	0.00	0.37	0.37
1.95	2.00	0.50	5.00	0.00	0.37	0.37
2.00	2.00	0.50	5.00	0.00	0.37	0.37
2.05	2.00	0.50	5.00	0.00	0.37	0.37
2.10	2.00	0.50	5.00	0.00	0.37	0.37
2.15	2.00	0.50	5.00	0.00	0.37	0.37
2.20	2.00	0.50	5.00	0.00	0.37	0.37
2.25	2.00	0.50	5.00	0.00	0.37	0.37
2.30	2.00	0.50	5.00	0.00	0.37	0.37
2.35	2.00	0.50	5.00	0.00	0.37	0.37
2.40	2.00	0.50	5.00	0.00	0.37	0.37
2.45	2.00	0.50	5.00	0.00	0.37	0.37
2.50	2.00	0.50	5.00	0.00	0.37	0.37
2.55	2.00	0.50	5.00	0.00	0.37	0.37
2.60	2.00	0.50	5.00	0.00	0.37	0.37
2.65	2.00	0.50	5.00	0.00	0.37	0.37
2.70	2.00	0.50	5.00	0.00	0.37	0.37
2.75	2.00	0.50	5.00	0.00	0.37	0.37
2.80	2.00	0.50	5.00	0.00	0.37	0.37
2.85	2.00	0.50	5.00	0.00	0.37	0.37
2.90	2.00	0.50	5.00	0.00	0.37	0.37
2.95	2.00	0.50	5.00	0.00	0.37	0.37
3.00	2.00	0.50	5.00	0.00	0.37	0.37
3.05	2.00	0.50	5.00	0.00	0.37	0.37
3.10	2.00	0.50	5.00	0.00	0.37	0.37
3.15	2.00	0.50	5.00	0.00	0.37	0.37
3.20	2.00	0.50	5.00	0.00	0.37	0.37
3.25	2.00	0.50	5.00	0.00	0.37	0.37
3.30	2.00	0.50	5.00	0.00	0.37	0.37
3.35	2.00	0.50	5.00	0.00	0.37	0.37
3.40	2.00	0.50	5.00	0.00	0.37	0.37
3.45	2.00	0.50	5.00	0.00	0.37	0.37
3.50	2.00	0.50	5.00	0.00	0.37	0.37
3.55	2.00	0.50	5.00	0.00	0.37	0.37
3.60	2.00	0.50	5.00	0.00	0.37	0.37
3.65	2.00	0.50	5.00	0.00	0.37	0.37
3.70	2.00	0.50	5.00	0.00	0.37	0.37
3.75	2.00	0.50	5.00	0.00	0.37	0.37
3.80	2.00	0.50	5.00	0.00	0.37	0.37
3.85	2.00	0.50	5.00	0.00	0.37	0.37
3.90	2.00	0.50	5.00	0.00	0.37	0.37
3.95	2.00	0.50	5.00	0.00	0.37	0.37
4.00	2.00	0.50	5.00	0.00	0.37	0.37
4.05	2.00	0.50	5.00	0.00	0.37	0.37
4.10	2.00	0.50	5.00	0.00	0.37	0.37
4.15	2.00	0.50	5.00	0.00	0.37	0.37
4.20	2.00	0.50	5.00	0.00	0.37	0.37
4.25	2.00	0.50	5.00	0.00	0.37	0.37
4.30	2.00	0.50	5.00	0.00	0.37	0.37
4.35	2.00	0.50	5.00	0.00	0.37	0.37
4.40	2.00	0.50	5.00	0.00	0.37	0.37
4.45	2.00	0.50	5.00	0.00	0.37	0.37
4.50	2.00	0.50	5.00	0.00	0.37	0.37
4.55	2.00	0.50	5.00	0.00	0.37	0.37
4.60	2.00	0.50	5.00	0.00	0.37	0.37
4.65	2.00	0.50	5.00	0.00	0.37	0.37
4.70	2.00	0.50	5.00	0.00	0.37	0.37
4.75	2.00	0.50	5.00	0.00	0.37	0.37
4.80	2.00	0.50	5.00	0.00	0.37	0.37
4.85	2.00	0.50	5.00	0.00	0.37	0.37
4.90	2.00	0.50	5.00	0.00	0.37	0.37
4.95	2.00	0.50	5.00	0.00	0.37	0.37
5.00	2.00	0.50	5.00	0.00	0.37	0.37
5.05	2.00	0.50	5.00	0.00	0.37	0.37
5.10	2.00	0.50	5.00	0.00	0.37	0.37
5.15	2.00	0.50	5.00	0.00	0.37	0.37
5.20	2.00	0.50	5.00	0.00	0.37	0.37
5.25	2.00	0.50	5.00	0.00	0.37	0.37
5.30	2.00	0.50	5.00	0.00	0.37	0.37

5.35	2.00	0.50	5.00	0.00	0.37	0.37
5.40	2.00	0.50	5.00	0.00	0.37	0.37
5.45	2.00	0.50	5.00	0.00	0.37	0.37
5.50	2.00	0.50	5.00	0.00	0.37	0.37
5.55	2.00	0.50	5.00	0.00	0.37	0.37
5.60	2.00	0.50	5.00	0.00	0.37	0.37
5.65	2.00	0.50	5.00	0.00	0.37	0.37
5.70	2.00	0.50	5.00	0.00	0.37	0.37
5.75	2.00	0.50	5.00	0.00	0.37	0.37
5.80	2.00	0.50	5.00	0.00	0.37	0.37
5.85	2.00	0.50	5.00	0.00	0.37	0.37
5.90	2.00	0.50	5.00	0.00	0.37	0.37
5.95	2.00	0.50	5.00	0.00	0.37	0.37
6.00	0.53	0.50	5.00	0.00	0.37	0.37
6.05	0.53	0.50	5.00	0.00	0.37	0.37
6.10	0.53	0.50	5.00	0.00	0.37	0.37
6.15	0.53	0.50	5.00	0.00	0.37	0.37
6.20	0.53	0.50	5.00	0.00	0.37	0.37
6.25	0.53	0.50	5.00	0.00	0.37	0.37
6.30	0.53	0.50	5.00	0.00	0.37	0.37
6.35	0.53	0.50	5.00	0.00	0.37	0.37
6.40	0.53	0.50	5.00	0.00	0.37	0.37
6.45	0.53	0.50	5.00	0.00	0.37	0.37
6.50	0.53	0.50	5.00	0.00	0.37	0.37
6.55	0.53	0.50	5.00	0.00	0.37	0.37
6.60	0.53	0.50	5.00	0.00	0.37	0.37
6.65	0.53	0.50	5.00	0.00	0.37	0.37
6.70	0.53	0.50	5.00	0.00	0.37	0.37
6.75	0.53	0.50	5.00	0.00	0.37	0.37
6.80	0.53	0.50	5.00	0.00	0.37	0.37
6.85	0.53	0.50	5.00	0.00	0.37	0.37
6.90	0.53	0.50	5.00	0.00	0.37	0.37
6.95	0.53	0.50	5.00	0.00	0.37	0.37
7.00	0.53	0.50	5.00	0.00	0.37	0.37
7.05	0.53	0.50	5.00	0.00	0.37	0.37
7.10	0.53	0.50	5.00	0.00	0.36	0.36
7.15	0.53	0.50	5.00	0.00	0.36	0.36
7.20	0.53	0.50	5.00	0.00	0.36	0.36
7.25	0.53	0.50	5.00	0.00	0.36	0.36
7.30	0.53	0.50	5.00	0.00	0.36	0.36
7.35	0.53	0.50	5.00	0.00	0.36	0.36
7.40	0.53	0.50	5.00	0.00	0.36	0.36
7.45	0.53	0.50	5.00	0.00	0.36	0.36
7.50	0.53	0.50	5.00	0.00	0.36	0.36
7.55	0.53	0.50	5.00	0.00	0.36	0.36
7.60	0.53	0.50	5.00	0.00	0.36	0.36
7.65	0.53	0.50	5.00	0.00	0.36	0.36
7.70	0.53	0.50	5.00	0.00	0.36	0.36
7.75	0.53	0.50	5.00	0.00	0.36	0.36
7.80	0.53	0.50	5.00	0.00	0.36	0.36
7.85	0.53	0.50	5.00	0.00	0.36	0.36
7.90	0.53	0.50	5.00	0.00	0.36	0.36
7.95	0.53	0.50	5.00	0.00	0.36	0.36
8.00	0.53	0.50	5.00	0.00	0.36	0.36
8.05	0.53	0.50	5.00	0.00	0.36	0.36
8.10	0.53	0.50	5.00	0.00	0.36	0.36
8.15	0.53	0.50	5.00	0.00	0.36	0.36
8.20	0.53	0.50	5.00	0.00	0.36	0.36
8.25	0.53	0.50	5.00	0.00	0.36	0.36
8.30	0.53	0.50	5.00	0.00	0.36	0.36
8.35	0.53	0.50	5.00	0.00	0.36	0.36
8.40	0.53	0.50	5.00	0.00	0.36	0.36
8.45	0.53	0.50	5.00	0.00	0.36	0.36
8.50	0.53	0.50	5.00	0.00	0.36	0.36
8.55	0.53	0.50	5.00	0.00	0.36	0.36
8.60	0.53	0.50	5.00	0.00	0.36	0.36
8.65	0.53	0.50	5.00	0.00	0.36	0.36
8.70	0.53	0.50	5.00	0.00	0.36	0.36
8.75	0.53	0.50	5.00	0.00	0.36	0.36

8.80	0.53	0.50	5.00	0.00	0.35	0.35
8.85	0.53	0.50	5.00	0.00	0.35	0.35
8.90	0.53	0.50	5.00	0.00	0.35	0.35
8.95	0.53	0.50	5.00	0.00	0.35	0.35
9.00	0.53	0.50	5.00	0.00	0.35	0.35
9.05	0.53	0.50	5.00	0.00	0.35	0.35
9.10	0.53	0.50	5.00	0.00	0.35	0.35
9.15	0.53	0.50	5.00	0.00	0.35	0.35
9.20	0.53	0.50	5.00	0.00	0.35	0.35
9.25	0.53	0.50	5.00	0.00	0.35	0.35
9.30	0.53	0.50	5.00	0.00	0.35	0.35
9.35	0.53	0.50	5.00	0.00	0.35	0.35
9.40	0.53	0.50	5.00	0.00	0.35	0.35
9.45	0.53	0.50	5.00	0.00	0.35	0.35
9.50	0.53	0.50	5.00	0.00	0.35	0.35
9.55	0.53	0.50	5.00	0.00	0.35	0.35
9.60	0.53	0.50	5.00	0.00	0.35	0.35
9.65	0.53	0.50	5.00	0.00	0.35	0.35
9.70	0.53	0.50	5.00	0.00	0.35	0.35
9.75	0.53	0.50	5.00	0.00	0.35	0.35
9.80	0.53	0.50	5.00	0.00	0.35	0.35
9.85	0.53	0.50	5.00	0.00	0.35	0.35
9.90	0.53	0.50	5.00	0.00	0.35	0.35
9.95	0.53	0.50	5.00	0.00	0.35	0.35
10.00	0.53	0.50	5.00	0.00	0.35	0.35
10.05	0.53	0.50	5.00	0.00	0.35	0.35
10.10	0.53	0.50	5.00	0.00	0.35	0.35
10.15	0.53	0.50	5.00	0.00	0.35	0.35
10.20	0.53	0.49	5.00	0.00	0.35	0.35
10.25	0.53	0.49	5.00	0.00	0.35	0.35
10.30	0.53	0.49	5.00	0.00	0.35	0.35
10.35	0.53	0.49	5.00	0.00	0.35	0.35
10.40	0.53	0.49	5.00	0.00	0.35	0.35
10.45	0.53	0.49	5.00	0.00	0.35	0.35
10.50	0.53	0.49	5.00	0.00	0.35	0.35
10.55	0.53	0.49	5.00	0.00	0.34	0.34
10.60	0.53	0.49	5.00	0.00	0.34	0.34
10.65	0.53	0.49	5.00	0.00	0.34	0.34
10.70	0.53	0.49	5.00	0.00	0.34	0.34
10.75	0.53	0.49	5.00	0.00	0.34	0.34
10.80	0.53	0.49	5.00	0.00	0.34	0.34
10.85	0.53	0.49	5.00	0.00	0.34	0.34
10.90	0.53	0.49	5.00	0.00	0.34	0.34
10.95	0.53	0.49	5.00	0.00	0.34	0.34
11.00	0.53	0.49	5.00	0.00	0.34	0.34
11.05	0.53	0.49	5.00	0.00	0.34	0.34
11.10	0.53	0.49	5.00	0.00	0.34	0.34
11.15	0.53	0.49	5.00	0.00	0.34	0.34
11.20	0.53	0.49	5.00	0.00	0.34	0.34
11.25	0.53	0.49	5.00	0.00	0.34	0.34
11.30	0.53	0.49	5.00	0.00	0.34	0.34
11.35	0.53	0.49	5.00	0.00	0.34	0.34
11.40	0.53	0.49	5.00	0.00	0.34	0.34
11.45	0.53	0.49	5.00	0.00	0.34	0.34
11.50	0.53	0.49	5.00	0.00	0.34	0.34
11.55	0.53	0.49	5.00	0.00	0.34	0.34
11.60	0.53	0.49	5.00	0.00	0.34	0.34
11.65	0.53	0.49	5.00	0.00	0.34	0.34
11.70	0.53	0.49	5.00	0.00	0.34	0.34
11.75	0.53	0.49	5.00	0.00	0.34	0.34
11.80	0.53	0.49	5.00	0.00	0.34	0.34
11.85	0.53	0.49	5.00	0.00	0.34	0.34
11.90	0.53	0.49	5.00	0.00	0.34	0.34
11.95	0.53	0.49	5.00	0.00	0.34	0.34
12.00	0.53	0.49	5.00	0.00	0.34	0.34
12.05	0.53	0.49	5.00	0.00	0.34	0.34
12.10	0.53	0.49	5.00	0.00	0.34	0.34
12.15	0.53	0.49	5.00	0.00	0.34	0.34
12.20	0.53	0.49	5.00	0.00	0.34	0.34

12.25	0.53	0.49	5.00	0.00	0.34	0.34
12.30	0.53	0.49	5.00	0.00	0.34	0.34
12.35	0.53	0.49	5.00	0.00	0.34	0.34
12.40	0.53	0.49	5.00	0.00	0.34	0.34
12.45	0.53	0.49	5.00	0.00	0.34	0.34
12.50	0.53	0.49	5.00	0.00	0.34	0.34
12.55	0.53	0.49	5.00	0.00	0.33	0.33
12.60	0.53	0.49	5.00	0.00	0.33	0.33
12.65	0.53	0.49	5.00	0.00	0.33	0.33
12.70	0.53	0.49	5.00	0.00	0.33	0.33
12.75	0.53	0.49	5.00	0.00	0.33	0.33
12.80	0.53	0.49	5.00	0.00	0.33	0.33
12.85	0.53	0.49	5.00	0.00	0.33	0.33
12.90	0.53	0.49	5.00	0.00	0.33	0.33
12.95	0.53	0.49	5.00	0.00	0.33	0.33
13.00	0.53	0.49	5.00	0.00	0.33	0.33
13.05	0.53	0.49	5.00	0.00	0.33	0.33
13.10	0.53	0.49	5.00	0.00	0.33	0.33
13.15	0.53	0.49	5.00	0.00	0.33	0.33
13.20	0.53	0.49	5.00	0.00	0.33	0.33
13.25	0.53	0.49	5.00	0.00	0.33	0.33
13.30	0.53	0.49	5.00	0.00	0.33	0.33
13.35	0.53	0.49	5.00	0.00	0.33	0.33
13.40	0.53	0.49	5.00	0.00	0.33	0.33
13.45	0.53	0.49	5.00	0.00	0.33	0.33
13.50	0.53	0.49	5.00	0.00	0.33	0.33
13.55	0.53	0.49	5.00	0.00	0.33	0.33
13.60	0.53	0.49	5.00	0.00	0.33	0.33
13.65	0.53	0.49	5.00	0.00	0.33	0.33
13.70	0.53	0.49	5.00	0.00	0.33	0.33
13.75	0.53	0.49	5.00	0.00	0.33	0.33
13.80	0.53	0.49	5.00	0.00	0.33	0.33
13.85	0.53	0.49	5.00	0.00	0.33	0.33
13.90	0.53	0.49	5.00	0.00	0.33	0.33
13.95	0.53	0.49	5.00	0.00	0.33	0.33
14.00	0.53	0.49	5.00	0.00	0.33	0.33
14.05	0.53	0.49	5.00	0.00	0.33	0.33
14.10	0.53	0.49	5.00	0.00	0.33	0.33
14.15	0.53	0.49	5.00	0.00	0.33	0.33
14.20	0.53	0.49	5.00	0.00	0.33	0.33
14.25	0.53	0.49	5.00	0.00	0.32	0.32
14.30	0.53	0.49	5.00	0.00	0.32	0.32
14.35	0.53	0.49	5.00	0.00	0.32	0.32
14.40	0.53	0.49	5.00	0.00	0.32	0.32
14.45	0.53	0.49	5.00	0.00	0.32	0.32
14.50	0.53	0.49	5.00	0.00	0.32	0.32
14.55	0.53	0.49	5.00	0.00	0.32	0.32
14.60	0.53	0.49	5.00	0.00	0.32	0.32
14.65	0.53	0.49	5.00	0.00	0.32	0.32
14.70	0.53	0.49	5.00	0.00	0.32	0.32
14.75	0.53	0.49	5.00	0.00	0.32	0.32
14.80	0.53	0.49	5.00	0.00	0.32	0.32
14.85	0.53	0.49	5.00	0.00	0.32	0.32
14.90	0.53	0.49	5.00	0.00	0.32	0.32
14.95	0.53	0.49	5.00	0.00	0.32	0.32
15.00	0.53	0.49	5.00	0.00	0.32	0.32
15.05	0.53	0.49	5.00	0.00	0.32	0.32
15.10	0.53	0.49	5.00	0.00	0.32	0.32
15.15	0.53	0.49	5.00	0.00	0.32	0.32
15.20	0.53	0.49	5.00	0.00	0.32	0.32
15.25	0.53	0.49	5.00	0.00	0.32	0.32
15.30	0.53	0.49	5.00	0.00	0.32	0.32
15.35	0.53	0.49	5.00	0.00	0.32	0.32
15.40	0.53	0.49	5.00	0.00	0.32	0.32
15.45	0.53	0.49	5.00	0.00	0.32	0.32
15.50	0.53	0.49	5.00	0.00	0.32	0.32
15.55	0.53	0.49	5.00	0.00	0.32	0.32
15.60	0.53	0.49	5.00	0.00	0.32	0.32
15.65	0.53	0.49	5.00	0.00	0.32	0.32

15.70	0.53	0.49	5.00	0.00	0.32	0.32
15.75	0.53	0.49	5.00	0.00	0.32	0.32
15.80	0.53	0.49	5.00	0.00	0.32	0.32
15.85	0.53	0.49	5.00	0.00	0.31	0.31
15.90	0.53	0.49	5.00	0.00	0.31	0.31
15.95	0.53	0.49	5.00	0.00	0.31	0.31
16.00	0.53	0.49	5.00	0.00	0.31	0.31
16.05	0.53	0.49	5.00	0.00	0.31	0.31
16.10	0.53	0.49	5.00	0.00	0.31	0.31
16.15	0.53	0.49	5.00	0.00	0.31	0.31
16.20	0.53	0.49	5.00	0.00	0.31	0.31
16.25	0.53	0.49	5.00	0.00	0.31	0.31
16.30	0.53	0.49	5.00	0.00	0.31	0.31
16.35	0.53	0.49	5.00	0.00	0.31	0.31
16.40	0.53	0.49	5.00	0.00	0.31	0.31
16.45	0.53	0.49	5.00	0.00	0.31	0.31
16.50	0.53	0.49	5.00	0.00	0.31	0.31
16.55	0.53	0.49	5.00	0.00	0.31	0.31
16.60	0.53	0.49	5.00	0.00	0.31	0.31
16.65	0.53	0.49	5.00	0.00	0.31	0.31
16.70	0.53	0.49	5.00	0.00	0.31	0.31
16.75	0.53	0.49	5.00	0.00	0.31	0.31
16.80	0.53	0.49	5.00	0.00	0.31	0.31
16.85	0.53	0.49	5.00	0.00	0.31	0.31
16.90	0.53	0.49	5.00	0.00	0.31	0.31
16.95	0.53	0.49	5.00	0.00	0.31	0.31
17.00	0.53	0.49	5.00	0.00	0.31	0.31
17.05	0.53	0.49	5.00	0.00	0.31	0.31
17.10	0.53	0.49	5.00	0.00	0.31	0.31
17.15	0.53	0.49	5.00	0.00	0.31	0.31
17.20	0.53	0.49	5.00	0.00	0.31	0.31
17.25	0.53	0.49	5.00	0.00	0.31	0.31
17.30	0.53	0.49	5.00	0.00	0.30	0.30
17.35	0.53	0.49	5.00	0.00	0.30	0.30
17.40	0.53	0.49	5.00	0.00	0.30	0.30
17.45	0.53	0.49	5.00	0.00	0.30	0.30
17.50	0.53	0.49	5.00	0.00	0.30	0.30
17.55	0.53	0.49	5.00	0.00	0.30	0.30
17.60	0.53	0.49	5.00	0.00	0.30	0.30
17.65	0.53	0.49	5.00	0.00	0.30	0.30
17.70	0.53	0.49	5.00	0.00	0.30	0.30
17.75	0.53	0.49	5.00	0.00	0.30	0.30
17.80	0.53	0.49	5.00	0.00	0.30	0.30
17.85	0.53	0.49	5.00	0.00	0.30	0.30
17.90	0.53	0.49	5.00	0.00	0.30	0.30
17.95	0.53	0.49	5.00	0.00	0.30	0.30
18.00	0.53	0.49	5.00	0.00	0.30	0.30
18.05	0.53	0.49	5.00	0.00	0.30	0.30
18.10	0.53	0.49	5.00	0.00	0.30	0.30
18.15	0.53	0.49	5.00	0.00	0.30	0.30
18.20	0.53	0.49	5.00	0.00	0.30	0.30
18.25	0.53	0.49	5.00	0.00	0.30	0.30
18.30	0.53	0.49	5.00	0.00	0.30	0.30
18.35	0.53	0.49	5.00	0.00	0.30	0.30
18.40	0.53	0.49	5.00	0.00	0.30	0.30
18.45	0.53	0.49	5.00	0.00	0.30	0.30
18.50	0.53	0.49	5.00	0.00	0.30	0.30
18.55	0.53	0.49	5.00	0.00	0.30	0.30
18.60	0.53	0.49	5.00	0.00	0.29	0.29
18.65	0.53	0.48	5.00	0.00	0.29	0.29
18.70	0.53	0.48	5.00	0.00	0.29	0.29
18.75	0.53	0.48	5.00	0.00	0.29	0.29
18.80	0.53	0.48	5.00	0.00	0.29	0.29
18.85	0.53	0.48	5.00	0.00	0.29	0.29
18.90	0.53	0.48	5.00	0.00	0.29	0.29
18.95	0.53	0.48	5.00	0.00	0.29	0.29
19.00	0.53	0.48	5.00	0.00	0.29	0.29
19.05	0.53	0.48	5.00	0.00	0.29	0.29
19.10	0.53	0.48	5.00	0.00	0.29	0.29

19.15	0.53	0.48	5.00	0.00	0.29	0.29
19.20	0.53	0.48	5.00	0.00	0.29	0.29
19.25	0.53	0.48	5.00	0.00	0.29	0.29
19.30	0.53	0.48	5.00	0.00	0.29	0.29
19.35	0.53	0.48	5.00	0.00	0.29	0.29
19.40	0.53	0.48	5.00	0.00	0.29	0.29
19.45	0.53	0.48	5.00	0.00	0.29	0.29
19.50	0.53	0.48	5.00	0.00	0.29	0.29
19.55	0.53	0.48	5.00	0.00	0.29	0.29
19.60	0.53	0.48	5.00	0.00	0.29	0.29
19.65	0.53	0.48	5.00	0.00	0.29	0.29
19.70	0.53	0.48	5.00	0.00	0.29	0.29
19.75	0.53	0.48	5.00	0.00	0.28	0.28
19.80	0.53	0.48	5.00	0.00	0.28	0.28
19.85	0.53	0.48	5.00	0.00	0.28	0.28
19.90	0.53	0.48	5.00	0.00	0.28	0.28
19.95	0.53	0.48	5.00	0.00	0.28	0.28
20.00	0.53	0.48	5.00	0.00	0.28	0.28
20.05	0.53	0.48	5.00	0.00	0.28	0.28
20.10	0.53	0.48	5.00	0.00	0.28	0.28
20.15	0.53	0.48	5.00	0.00	0.28	0.28
20.20	0.53	0.48	5.00	0.00	0.28	0.28
20.25	0.53	0.48	5.00	0.00	0.28	0.28
20.30	0.53	0.48	5.00	0.00	0.28	0.28
20.35	0.53	0.48	5.00	0.00	0.28	0.28
20.40	0.53	0.48	5.00	0.00	0.28	0.28
20.45	0.53	0.48	5.00	0.00	0.28	0.28
20.50	0.53	0.48	5.00	0.00	0.28	0.28
20.55	0.53	0.48	5.00	0.00	0.28	0.28
20.60	0.53	0.48	5.00	0.00	0.28	0.28
20.65	0.53	0.48	5.00	0.00	0.28	0.28
20.70	0.53	0.48	5.00	0.00	0.28	0.28
20.75	0.53	0.48	5.00	0.00	0.27	0.27
20.80	0.53	0.48	5.00	0.00	0.27	0.27
20.85	0.53	0.48	5.00	0.00	0.27	0.27
20.90	0.53	0.48	5.00	0.00	0.27	0.27
20.95	0.53	0.48	5.00	0.00	0.27	0.27
21.00	0.53	0.48	5.00	0.00	0.27	0.27
21.05	0.53	0.48	5.00	0.00	0.27	0.27
21.10	0.53	0.48	5.00	0.00	0.27	0.27
21.15	0.53	0.48	5.00	0.00	0.27	0.27
21.20	0.53	0.48	5.00	0.00	0.27	0.27
21.25	0.53	0.48	5.00	0.00	0.27	0.27
21.30	0.53	0.48	5.00	0.00	0.27	0.27
21.35	0.53	0.48	5.00	0.00	0.27	0.27
21.40	0.53	0.48	5.00	0.00	0.27	0.27
21.45	0.53	0.48	5.00	0.00	0.27	0.27
21.50	0.53	0.48	5.00	0.00	0.27	0.27
21.55	0.53	0.48	5.00	0.00	0.27	0.27
21.60	0.53	0.48	5.00	0.00	0.27	0.27
21.65	0.53	0.48	5.00	0.00	0.27	0.27
21.70	0.53	0.48	5.00	0.00	0.27	0.27
21.75	0.53	0.48	5.00	0.00	0.27	0.27
21.80	0.53	0.48	5.00	0.00	0.27	0.27
21.85	0.53	0.48	5.00	0.00	0.27	0.27
21.90	0.53	0.48	5.00	0.00	0.27	0.27
21.95	0.53	0.48	5.00	0.00	0.27	0.27
22.00	0.53	0.48	5.00	0.00	0.27	0.27
22.05	0.53	0.48	5.00	0.00	0.27	0.27
22.10	0.53	0.48	5.00	0.00	0.27	0.27
22.15	0.53	0.48	5.00	0.00	0.26	0.26
22.20	0.53	0.48	5.00	0.00	0.26	0.26
22.25	0.53	0.48	5.00	0.00	0.26	0.26
22.30	0.53	0.48	5.00	0.00	0.26	0.26
22.35	0.53	0.48	5.00	0.00	0.26	0.26
22.40	0.53	0.48	5.00	0.00	0.26	0.26
22.45	0.53	0.48	5.00	0.00	0.26	0.26
22.50	0.53	0.48	5.00	0.00	0.26	0.26
22.55	0.53	0.48	5.00	0.00	0.26	0.26

22.60	0.53	0.48	5.00	0.00	0.26	0.26
22.65	0.53	0.48	5.00	0.00	0.26	0.26
22.70	0.53	0.48	5.00	0.00	0.26	0.26
22.75	0.53	0.48	5.00	0.00	0.26	0.26
22.80	0.53	0.48	5.00	0.00	0.26	0.26
22.85	0.53	0.48	5.00	0.00	0.26	0.26
22.90	0.53	0.48	5.00	0.00	0.26	0.26
22.95	0.53	0.48	5.00	0.00	0.26	0.26
23.00	0.53	0.48	5.00	0.00	0.26	0.26
23.05	0.53	0.48	5.00	0.00	0.26	0.26
23.10	0.53	0.48	5.00	0.00	0.26	0.26
23.15	0.53	0.48	5.00	0.00	0.26	0.26
23.20	0.53	0.48	5.00	0.00	0.26	0.26
23.25	0.53	0.48	5.00	0.00	0.26	0.26
23.30	0.53	0.48	5.00	0.00	0.26	0.26
23.35	0.53	0.48	5.00	0.00	0.26	0.26
23.40	0.53	0.48	5.00	0.00	0.26	0.26
23.45	0.53	0.48	5.00	0.00	0.26	0.26
23.50	0.53	0.48	5.00	0.00	0.26	0.26
23.55	0.53	0.48	5.00	0.00	0.26	0.26
23.60	0.53	0.48	5.00	0.00	0.26	0.26
23.65	0.53	0.48	5.00	0.00	0.26	0.26
23.70	0.53	0.48	5.00	0.00	0.26	0.26
23.75	0.53	0.48	5.00	0.00	0.26	0.26
23.80	0.53	0.48	5.00	0.00	0.26	0.26
23.85	0.53	0.48	5.00	0.00	0.25	0.25
23.90	0.53	0.48	5.00	0.00	0.25	0.25
23.95	0.53	0.48	5.00	0.00	0.25	0.25
24.00	0.53	0.48	5.00	0.00	0.25	0.25
24.05	0.53	0.48	5.00	0.00	0.25	0.25
24.10	0.53	0.48	5.00	0.00	0.25	0.25
24.15	0.53	0.48	5.00	0.00	0.25	0.25
24.20	0.53	0.48	5.00	0.00	0.25	0.25
24.25	0.53	0.48	5.00	0.00	0.25	0.25
24.30	0.53	0.48	5.00	0.00	0.25	0.25
24.35	0.53	0.48	5.00	0.00	0.25	0.25
24.40	0.53	0.48	5.00	0.00	0.25	0.25
24.45	0.53	0.48	5.00	0.00	0.25	0.25
24.50	0.53	0.48	5.00	0.00	0.25	0.25
24.55	0.53	0.48	5.00	0.00	0.25	0.25
24.60	0.53	0.48	5.00	0.00	0.25	0.25
24.65	0.53	0.48	5.00	0.00	0.25	0.25
24.70	0.53	0.48	5.00	0.00	0.25	0.25
24.75	0.53	0.48	5.00	0.00	0.25	0.25
24.80	0.53	0.48	5.00	0.00	0.25	0.25
24.85	0.53	0.48	5.00	0.00	0.25	0.25
24.90	0.53	0.48	5.00	0.00	0.25	0.25
24.95	0.53	0.48	5.00	0.00	0.25	0.25
25.00	0.53	0.48	5.00	0.00	0.25	0.25
25.05	0.53	0.48	5.00	0.00	0.25	0.25
25.10	0.53	0.48	5.00	0.00	0.25	0.25
25.15	0.53	0.48	5.00	0.00	0.25	0.25
25.20	0.53	0.48	5.00	0.00	0.25	0.25
25.25	0.53	0.48	5.00	0.00	0.25	0.25
25.30	0.53	0.48	5.00	0.00	0.25	0.25
25.35	0.53	0.48	5.00	0.00	0.25	0.25
25.40	0.53	0.48	5.00	0.00	0.25	0.25
25.45	0.53	0.48	5.00	0.00	0.25	0.25
25.50	0.53	0.48	5.00	0.00	0.25	0.25
25.55	0.53	0.48	5.00	0.00	0.24	0.24
25.60	0.53	0.48	5.00	0.00	0.24	0.24
25.65	0.53	0.48	5.00	0.00	0.24	0.24
25.70	0.53	0.48	5.00	0.00	0.24	0.24
25.75	0.53	0.48	5.00	0.00	0.24	0.24
25.80	0.53	0.48	5.00	0.00	0.24	0.24
25.85	0.53	0.48	5.00	0.00	0.24	0.24
25.90	0.53	0.48	5.00	0.00	0.24	0.24
25.95	0.53	0.48	5.00	0.00	0.24	0.24
26.00	0.53	0.48	5.00	0.00	0.24	0.24

26.05	0.53	0.48	5.00	0.00	0.24	0.24
26.10	0.53	0.48	5.00	0.00	0.24	0.24
26.15	0.53	0.48	5.00	0.00	0.24	0.24
26.20	0.53	0.48	5.00	0.00	0.24	0.24
26.25	0.53	0.48	5.00	0.00	0.24	0.24
26.30	0.53	0.48	5.00	0.00	0.24	0.24
26.35	0.53	0.48	5.00	0.00	0.24	0.24
26.40	0.53	0.48	5.00	0.00	0.24	0.24
26.45	0.53	0.48	5.00	0.00	0.24	0.24
26.50	0.53	0.48	5.00	0.00	0.24	0.24
26.55	0.53	0.48	5.00	0.00	0.24	0.24
26.60	0.53	0.48	5.00	0.00	0.24	0.24
26.65	0.53	0.48	5.00	0.00	0.24	0.24
26.70	0.53	0.48	5.00	0.00	0.24	0.24
26.75	0.53	0.48	5.00	0.00	0.24	0.24
26.80	0.53	0.48	5.00	0.00	0.24	0.24
26.85	0.53	0.48	5.00	0.00	0.24	0.24
26.90	0.53	0.48	5.00	0.00	0.24	0.24
26.95	0.53	0.48	5.00	0.00	0.24	0.24
27.00	0.53	0.48	5.00	0.00	0.24	0.24
27.05	0.53	0.48	5.00	0.00	0.24	0.24
27.10	0.53	0.47	5.00	0.00	0.24	0.24
27.15	0.53	0.47	5.00	0.00	0.24	0.24
27.20	0.53	0.47	5.00	0.00	0.23	0.23
27.25	0.53	0.47	5.00	0.00	0.23	0.23
27.30	0.53	0.47	5.00	0.00	0.23	0.23
27.35	0.53	0.47	5.00	0.00	0.23	0.23
27.40	0.53	0.47	5.00	0.00	0.23	0.23
27.45	0.53	0.47	5.00	0.00	0.23	0.23
27.50	0.53	0.47	5.00	0.00	0.23	0.23
27.55	0.53	0.47	5.00	0.00	0.23	0.23
27.60	0.53	0.47	5.00	0.00	0.23	0.23
27.65	0.53	0.47	5.00	0.00	0.23	0.23
27.70	0.53	0.47	5.00	0.00	0.23	0.23
27.75	0.53	0.47	5.00	0.00	0.23	0.23
27.80	0.53	0.47	5.00	0.00	0.23	0.23
27.85	0.53	0.47	5.00	0.00	0.23	0.23
27.90	0.53	0.47	5.00	0.00	0.23	0.23
27.95	0.53	0.47	5.00	0.00	0.23	0.23
28.00	0.53	0.47	5.00	0.00	0.23	0.23
28.05	0.53	0.47	5.00	0.00	0.23	0.23
28.10	0.53	0.47	5.00	0.00	0.23	0.23
28.15	0.53	0.47	5.00	0.00	0.23	0.23
28.20	0.53	0.47	5.00	0.00	0.23	0.23
28.25	0.53	0.47	5.00	0.00	0.23	0.23
28.30	0.53	0.47	5.00	0.00	0.23	0.23
28.35	0.53	0.47	5.00	0.00	0.23	0.23
28.40	0.53	0.47	5.00	0.00	0.23	0.23
28.45	0.53	0.47	5.00	0.00	0.23	0.23
28.50	0.53	0.47	5.00	0.00	0.23	0.23
28.55	0.53	0.47	5.00	0.00	0.23	0.23
28.60	0.53	0.47	5.00	0.00	0.22	0.22
28.65	0.53	0.47	5.00	0.00	0.22	0.22
28.70	0.53	0.47	5.00	0.00	0.22	0.22
28.75	0.53	0.47	5.00	0.00	0.22	0.22
28.80	0.53	0.47	5.00	0.00	0.22	0.22
28.85	0.53	0.47	5.00	0.00	0.22	0.22
28.90	0.53	0.47	5.00	0.00	0.22	0.22
28.95	0.53	0.47	5.00	0.00	0.22	0.22
29.00	0.53	0.47	5.00	0.00	0.22	0.22
29.05	0.53	0.47	5.00	0.00	0.22	0.22
29.10	0.53	0.47	5.00	0.00	0.22	0.22
29.15	0.53	0.47	5.00	0.00	0.22	0.22
29.20	0.53	0.47	5.00	0.00	0.22	0.22
29.25	0.53	0.47	5.00	0.00	0.22	0.22
29.30	0.53	0.47	5.00	0.00	0.22	0.22
29.35	0.53	0.47	5.00	0.00	0.22	0.22
29.40	0.53	0.47	5.00	0.00	0.22	0.22
29.45	0.53	0.47	5.00	0.00	0.22	0.22

29.50	0.53	0.47	5.00	0.00	0.22	0.22
29.55	0.53	0.47	5.00	0.00	0.22	0.22
29.60	0.53	0.47	5.00	0.00	0.22	0.22
29.65	0.53	0.47	5.00	0.00	0.22	0.22
29.70	0.53	0.47	5.00	0.00	0.22	0.22
29.75	0.53	0.47	5.00	0.00	0.22	0.22
29.80	0.53	0.47	5.00	0.00	0.21	0.21
29.85	0.53	0.47	5.00	0.00	0.21	0.21
29.90	0.53	0.47	5.00	0.00	0.21	0.21
29.95	0.53	0.47	5.00	0.00	0.21	0.21
30.00	0.53	0.47	5.00	0.00	0.21	0.21
30.05	0.53	0.47	5.00	0.00	0.21	0.21
30.10	0.53	0.47	5.00	0.00	0.21	0.21
30.15	0.53	0.47	5.00	0.00	0.21	0.21
30.20	0.53	0.47	5.00	0.00	0.21	0.21
30.25	0.53	0.47	5.00	0.00	0.21	0.21
30.30	0.53	0.47	5.00	0.00	0.21	0.21
30.35	0.53	0.47	5.00	0.00	0.21	0.21
30.40	0.53	0.47	5.00	0.00	0.21	0.21
30.45	0.53	0.47	5.00	0.00	0.21	0.21
30.50	0.53	0.47	5.00	0.00	0.21	0.21
30.55	0.53	0.47	5.00	0.00	0.21	0.21
30.60	0.53	0.47	5.00	0.00	0.21	0.21
30.65	0.53	0.47	5.00	0.00	0.21	0.21
30.70	0.53	0.47	5.00	0.00	0.21	0.21
30.75	0.53	0.47	5.00	0.00	0.21	0.21
30.80	0.53	0.47	5.00	0.00	0.21	0.21
30.85	0.53	0.47	5.00	0.00	0.20	0.20
30.90	0.53	0.47	5.00	0.00	0.20	0.20
30.95	0.53	0.47	5.00	0.00	0.20	0.20
31.00	0.53	0.47	5.00	0.00	0.20	0.20
31.05	0.53	0.47	5.00	0.00	0.20	0.20
31.10	0.53	0.47	5.00	0.00	0.20	0.20
31.15	0.53	0.47	5.00	0.00	0.20	0.20
31.20	0.53	0.47	5.00	0.00	0.20	0.20
31.25	0.53	0.47	5.00	0.00	0.20	0.20
31.30	0.53	0.47	5.00	0.00	0.20	0.20
31.35	0.53	0.47	5.00	0.00	0.20	0.20
31.40	0.53	0.47	5.00	0.00	0.20	0.20
31.45	0.53	0.47	5.00	0.00	0.20	0.20
31.50	0.53	0.47	5.00	0.00	0.20	0.20
31.55	0.53	0.47	5.00	0.00	0.20	0.20
31.60	0.53	0.46	5.00	0.00	0.20	0.20
31.65	0.53	0.46	5.00	0.00	0.20	0.20
31.70	0.53	0.46	5.00	0.00	0.20	0.20
31.75	0.53	0.46	5.00	0.00	0.20	0.20
31.80	0.53	0.46	5.00	0.00	0.19	0.19
31.85	0.53	0.46	5.00	0.00	0.19	0.19
31.90	0.53	0.46	5.00	0.00	0.19	0.19
31.95	0.53	0.46	5.00	0.00	0.19	0.19
32.00	0.53	0.46	5.00	0.00	0.19	0.19
32.05	0.53	0.46	5.00	0.00	0.19	0.19
32.10	0.53	0.46	5.00	0.00	0.19	0.19
32.15	0.52	0.46	5.00	0.00	0.19	0.19
32.20	0.52	0.46	5.00	0.00	0.19	0.19
32.25	0.52	0.46	5.00	0.00	0.19	0.19
32.30	0.52	0.46	5.00	0.00	0.19	0.19
32.35	0.52	0.46	5.00	0.00	0.19	0.19
32.40	0.52	0.46	5.00	0.00	0.19	0.19
32.45	0.52	0.46	5.00	0.00	0.19	0.19
32.50	0.52	0.46	5.00	0.00	0.19	0.19
32.55	0.52	0.46	5.00	0.00	0.19	0.19
32.60	0.52	0.46	5.00	0.00	0.19	0.19
32.65	0.52	0.46	5.00	0.00	0.19	0.19
32.70	0.52	0.46	5.00	0.00	0.19	0.19
32.75	0.52	0.46	5.00	0.00	0.18	0.18
32.80	0.52	0.46	5.00	0.00	0.18	0.18
32.85	0.52	0.46	5.00	0.00	0.18	0.18
32.90	0.52	0.46	5.00	0.00	0.18	0.18

32.95	0.52	0.46	5.00	0.00	0.18	0.18
33.00	0.52	0.46	5.00	0.00	0.18	0.18
33.05	0.52	0.46	5.00	0.00	0.18	0.18
33.10	0.52	0.46	5.00	0.00	0.18	0.18
33.15	0.52	0.46	5.00	0.00	0.18	0.18
33.20	0.52	0.46	5.00	0.00	0.18	0.18
33.25	0.52	0.46	5.00	0.00	0.18	0.18
33.30	0.52	0.46	5.00	0.00	0.18	0.18
33.35	0.52	0.46	5.00	0.00	0.18	0.18
33.40	0.52	0.46	5.00	0.00	0.18	0.18
33.45	0.52	0.46	5.00	0.00	0.18	0.18
33.50	0.52	0.46	5.00	0.00	0.18	0.18
33.55	0.52	0.46	5.00	0.00	0.18	0.18
33.60	0.52	0.46	5.00	0.00	0.18	0.18
33.65	0.52	0.46	5.00	0.00	0.18	0.18
33.70	0.52	0.46	5.00	0.00	0.17	0.17
33.75	0.52	0.46	5.00	0.00	0.17	0.17
33.80	0.52	0.46	5.00	0.00	0.17	0.17
33.85	0.52	0.46	5.00	0.00	0.17	0.17
33.90	0.52	0.46	5.00	0.00	0.17	0.17
33.95	0.52	0.46	5.00	0.00	0.17	0.17
34.00	0.52	0.45	5.00	0.00	0.17	0.17
34.05	0.52	0.45	5.00	0.00	0.17	0.17
34.10	0.52	0.45	5.00	0.00	0.17	0.17
34.15	0.52	0.45	5.00	0.00	0.17	0.17
34.20	0.52	0.45	5.00	0.00	0.17	0.17
34.25	0.52	0.45	5.00	0.00	0.17	0.17
34.30	0.52	0.45	5.00	0.00	0.17	0.17
34.35	0.52	0.45	5.00	0.00	0.17	0.17
34.40	0.52	0.45	5.00	0.00	0.17	0.17
34.45	0.52	0.45	5.00	0.00	0.17	0.17
34.50	0.52	0.45	5.00	0.00	0.17	0.17
34.55	0.52	0.45	5.00	0.00	0.17	0.17
34.60	0.52	0.45	5.00	0.00	0.17	0.17
34.65	0.52	0.45	5.00	0.00	0.17	0.17
34.70	0.52	0.45	5.00	0.00	0.16	0.16
34.75	0.52	0.45	5.00	0.00	0.16	0.16
34.80	0.52	0.45	5.00	0.00	0.16	0.16
34.85	0.52	0.45	5.00	0.00	0.16	0.16
34.90	0.52	0.45	5.00	0.00	0.16	0.16
34.95	0.52	0.45	5.00	0.00	0.16	0.16
35.00	0.52	0.45	5.00	0.00	0.16	0.16
35.05	0.52	0.45	5.00	0.00	0.16	0.16
35.10	0.52	0.45	5.00	0.00	0.16	0.16
35.15	0.52	0.45	5.00	0.00	0.16	0.16
35.20	0.52	0.45	5.00	0.00	0.16	0.16
35.25	0.52	0.45	5.00	0.00	0.16	0.16
35.30	0.52	0.45	5.00	0.00	0.16	0.16
35.35	0.52	0.45	5.00	0.00	0.16	0.16
35.40	0.52	0.45	5.00	0.00	0.16	0.16
35.45	0.52	0.45	5.00	0.00	0.16	0.16
35.50	0.52	0.45	5.00	0.00	0.16	0.16
35.55	0.52	0.45	5.00	0.00	0.16	0.16
35.60	0.52	0.45	5.00	0.00	0.16	0.16
35.65	0.52	0.45	5.00	0.00	0.16	0.16
35.70	0.52	0.45	5.00	0.00	0.15	0.15
35.75	0.52	0.45	5.00	0.00	0.15	0.15
35.80	0.52	0.45	5.00	0.00	0.15	0.15
35.85	0.52	0.45	5.00	0.00	0.15	0.15
35.90	0.52	0.45	5.00	0.00	0.15	0.15
35.95	0.52	0.45	5.00	0.00	0.15	0.15
36.00	0.52	0.45	5.00	0.00	0.15	0.15
36.05	0.51	0.45	5.00	0.00	0.15	0.15
36.10	0.51	0.45	5.00	0.00	0.15	0.15
36.15	0.51	0.45	5.00	0.00	0.15	0.15
36.20	0.51	0.45	5.00	0.00	0.15	0.15
36.25	0.51	0.45	5.00	0.00	0.15	0.15
36.30	0.51	0.45	5.00	0.00	0.15	0.15
36.35	0.51	0.45	5.00	0.00	0.15	0.15

36.40	0.51	0.45	5.00	0.00	0.15	0.15
36.45	0.51	0.44	5.00	0.00	0.15	0.15
36.50	0.51	0.44	5.00	0.00	0.15	0.15
36.55	0.51	0.44	5.00	0.00	0.15	0.15
36.60	0.51	0.44	5.00	0.00	0.15	0.15
36.65	0.51	0.44	5.00	0.00	0.15	0.15
36.70	0.51	0.44	5.00	0.00	0.14	0.14
36.75	0.51	0.44	5.00	0.00	0.14	0.14
36.80	0.51	0.44	5.00	0.00	0.14	0.14
36.85	0.51	0.44	5.00	0.00	0.14	0.14
36.90	0.51	0.44	5.00	0.00	0.14	0.14
36.95	0.51	0.44	5.00	0.00	0.14	0.14
37.00	0.51	0.44	5.00	0.00	0.14	0.14
37.05	0.51	0.44	5.00	0.00	0.14	0.14
37.10	0.51	0.44	5.00	0.00	0.14	0.14
37.15	0.51	0.44	5.00	0.00	0.14	0.14
37.20	0.51	0.44	5.00	0.00	0.14	0.14
37.25	0.51	0.44	5.00	0.00	0.14	0.14
37.30	0.51	0.44	5.00	0.00	0.14	0.14
37.35	0.51	0.44	5.00	0.00	0.14	0.14
37.40	0.51	0.44	5.00	0.00	0.14	0.14
37.45	0.51	0.44	5.00	0.00	0.14	0.14
37.50	0.51	0.44	5.00	0.00	0.14	0.14
37.55	0.51	0.44	5.00	0.00	0.14	0.14
37.60	0.51	0.44	5.00	0.00	0.14	0.14
37.65	0.51	0.44	5.00	0.00	0.14	0.14
37.70	0.51	0.44	5.00	0.00	0.13	0.13
37.75	0.51	0.44	5.00	0.00	0.13	0.13
37.80	0.51	0.44	5.00	0.00	0.13	0.13
37.85	0.51	0.44	5.00	0.00	0.13	0.13
37.90	0.51	0.44	5.00	0.00	0.13	0.13
37.95	0.51	0.44	5.00	0.00	0.13	0.13
38.00	0.51	0.44	5.00	0.00	0.13	0.13
38.05	0.51	0.44	5.00	0.00	0.13	0.13
38.10	0.51	0.44	5.00	0.00	0.13	0.13
38.15	0.51	0.44	5.00	0.00	0.13	0.13
38.20	0.51	0.44	5.00	0.00	0.13	0.13
38.25	0.51	0.44	5.00	0.00	0.13	0.13
38.30	0.51	0.44	5.00	0.00	0.13	0.13
38.35	0.51	0.44	5.00	0.00	0.13	0.13
38.40	0.51	0.44	5.00	0.00	0.13	0.13
38.45	0.51	0.44	5.00	0.00	0.13	0.13
38.50	0.51	0.44	5.00	0.00	0.13	0.13
38.55	0.51	0.44	5.00	0.00	0.13	0.13
38.60	0.51	0.44	5.00	0.00	0.13	0.13
38.65	0.51	0.44	5.00	0.00	0.12	0.12
38.70	0.51	0.44	5.00	0.00	0.12	0.12
38.75	0.51	0.44	5.00	0.00	0.12	0.12
38.80	0.51	0.44	5.00	0.00	0.12	0.12
38.85	0.51	0.43	5.00	0.00	0.12	0.12
38.90	0.51	0.43	5.00	0.00	0.12	0.12
38.95	0.51	0.43	5.00	0.00	0.12	0.12
39.00	0.51	0.43	5.00	0.00	0.12	0.12
39.05	0.51	0.43	5.00	0.00	0.12	0.12
39.10	0.51	0.43	5.00	0.00	0.12	0.12
39.15	0.51	0.43	5.00	0.00	0.12	0.12
39.20	0.51	0.43	5.00	0.00	0.12	0.12
39.25	0.51	0.43	5.00	0.00	0.12	0.12
39.30	0.51	0.43	5.00	0.00	0.12	0.12
39.35	0.51	0.43	5.00	0.00	0.12	0.12
39.40	0.51	0.43	5.00	0.00	0.12	0.12
39.45	0.51	0.43	5.00	0.00	0.12	0.12
39.50	0.51	0.43	5.00	0.00	0.12	0.12
39.55	0.51	0.43	5.00	0.00	0.11	0.11
39.60	0.51	0.43	5.00	0.00	0.11	0.11
39.65	0.51	0.43	5.00	0.00	0.11	0.11
39.70	0.51	0.43	5.00	0.00	0.11	0.11
39.75	0.51	0.43	5.00	0.00	0.11	0.11
39.80	0.51	0.43	5.00	0.00	0.11	0.11

39.85	0.51	0.43	5.00	0.00	0.11	0.11
39.90	0.51	0.43	5.00	0.00	0.11	0.11
39.95	0.51	0.43	5.00	0.00	0.11	0.11
40.00	0.50	0.43	5.00	0.00	0.11	0.11
40.05	0.50	0.43	5.00	0.00	0.11	0.11
40.10	0.50	0.43	5.00	0.00	0.11	0.11
40.15	0.50	0.43	5.00	0.00	0.11	0.11
40.20	0.50	0.43	5.00	0.00	0.11	0.11
40.25	0.50	0.43	5.00	0.00	0.11	0.11
40.30	0.50	0.43	5.00	0.00	0.11	0.11
40.35	0.50	0.43	5.00	0.00	0.11	0.11
40.40	0.50	0.43	5.00	0.00	0.11	0.11
40.45	0.50	0.43	5.00	0.00	0.10	0.10
40.50	0.50	0.43	5.00	0.00	0.10	0.10
40.55	0.50	0.43	5.00	0.00	0.10	0.10
40.60	0.50	0.43	5.00	0.00	0.10	0.10
40.65	0.50	0.43	5.00	0.00	0.10	0.10
40.70	0.50	0.43	5.00	0.00	0.10	0.10
40.75	0.50	0.43	5.00	0.00	0.10	0.10
40.80	0.50	0.43	5.00	0.00	0.10	0.10
40.85	0.50	0.43	5.00	0.00	0.10	0.10
40.90	0.50	0.43	5.00	0.00	0.10	0.10
40.95	0.50	0.43	5.00	0.00	0.10	0.10
41.00	0.50	0.43	5.00	0.00	0.10	0.10
41.05	0.50	0.43	5.00	0.00	0.10	0.10
41.10	0.50	0.43	5.00	0.00	0.10	0.10
41.15	0.50	0.43	5.00	0.00	0.10	0.10
41.20	0.50	0.43	5.00	0.00	0.10	0.10
41.25	0.50	0.43	5.00	0.00	0.10	0.10
41.30	0.50	0.42	5.00	0.00	0.09	0.09
41.35	0.50	0.42	5.00	0.00	0.09	0.09
41.40	0.50	0.42	5.00	0.00	0.09	0.09
41.45	0.50	0.42	5.00	0.00	0.09	0.09
41.50	0.50	0.42	5.00	0.00	0.09	0.09
41.55	0.50	0.42	5.00	0.00	0.09	0.09
41.60	0.50	0.42	5.00	0.00	0.09	0.09
41.65	0.50	0.42	5.00	0.00	0.09	0.09
41.70	0.50	0.42	5.00	0.00	0.09	0.09
41.75	0.50	0.42	5.00	0.00	0.09	0.09
41.80	0.50	0.42	5.00	0.00	0.09	0.09
41.85	0.50	0.42	5.00	0.00	0.09	0.09
41.90	0.50	0.42	5.00	0.00	0.09	0.09
41.95	0.50	0.42	5.00	0.00	0.09	0.09
42.00	0.50	0.42	5.00	0.00	0.09	0.09
42.05	0.50	0.42	5.00	0.00	0.09	0.09
42.10	0.50	0.42	5.00	0.00	0.08	0.08
42.15	0.50	0.42	5.00	0.00	0.08	0.08
42.20	0.50	0.42	5.00	0.00	0.08	0.08
42.25	0.50	0.42	5.00	0.00	0.08	0.08
42.30	0.50	0.42	5.00	0.00	0.08	0.08
42.35	0.50	0.42	5.00	0.00	0.08	0.08
42.40	0.50	0.42	5.00	0.00	0.08	0.08
42.45	0.50	0.42	5.00	0.00	0.08	0.08
42.50	0.50	0.42	5.00	0.00	0.08	0.08
42.55	0.50	0.42	5.00	0.00	0.08	0.08
42.60	0.50	0.42	5.00	0.00	0.08	0.08
42.65	0.50	0.42	5.00	0.00	0.08	0.08
42.70	0.50	0.42	5.00	0.00	0.08	0.08
42.75	0.50	0.42	5.00	0.00	0.08	0.08
42.80	0.50	0.42	5.00	0.00	0.08	0.08
42.85	0.50	0.42	5.00	0.00	0.08	0.08
42.90	0.50	0.42	5.00	0.00	0.08	0.08
42.95	0.50	0.42	5.00	0.00	0.07	0.07
43.00	0.50	0.42	5.00	0.00	0.07	0.07
43.05	0.50	0.42	5.00	0.00	0.07	0.07
43.10	0.50	0.42	5.00	0.00	0.07	0.07
43.15	0.50	0.42	5.00	0.00	0.07	0.07
43.20	0.50	0.42	5.00	0.00	0.07	0.07
43.25	0.50	0.42	5.00	0.00	0.07	0.07

43.30	0.50	0.42	5.00	0.00	0.07	0.07
43.35	0.50	0.42	5.00	0.00	0.07	0.07
43.40	0.50	0.42	5.00	0.00	0.07	0.07
43.45	0.50	0.42	5.00	0.00	0.07	0.07
43.50	0.50	0.42	5.00	0.00	0.07	0.07
43.55	0.50	0.42	5.00	0.00	0.07	0.07
43.60	0.50	0.42	5.00	0.00	0.07	0.07
43.65	0.50	0.42	5.00	0.00	0.07	0.07
43.70	0.50	0.41	5.00	0.00	0.06	0.06
43.75	0.50	0.41	5.00	0.00	0.06	0.06
43.80	0.50	0.41	5.00	0.00	0.06	0.06
43.85	0.50	0.41	5.00	0.00	0.06	0.06
43.90	0.50	0.41	5.00	0.00	0.06	0.06
43.95	0.50	0.41	5.00	0.00	0.06	0.06
44.00	0.50	0.41	5.00	0.00	0.06	0.06
44.05	0.49	0.41	5.00	0.00	0.06	0.06
44.10	0.49	0.41	5.00	0.00	0.06	0.06
44.15	0.49	0.41	5.00	0.00	0.06	0.06
44.20	0.49	0.41	5.00	0.00	0.06	0.06
44.25	0.49	0.41	5.00	0.00	0.06	0.06
44.30	0.49	0.41	5.00	0.00	0.06	0.06
44.35	0.49	0.41	5.00	0.00	0.06	0.06
44.40	0.49	0.41	5.00	0.00	0.06	0.06
44.45	0.49	0.41	5.00	0.00	0.06	0.06
44.50	0.49	0.41	5.00	0.00	0.06	0.06
44.55	0.49	0.41	5.00	0.00	0.05	0.05
44.60	0.49	0.41	5.00	0.00	0.05	0.05
44.65	0.49	0.41	5.00	0.00	0.05	0.05
44.70	0.49	0.41	5.00	0.00	0.05	0.05
44.75	0.49	0.41	5.00	0.00	0.05	0.05
44.80	0.49	0.41	5.00	0.00	0.05	0.05
44.85	0.49	0.41	5.00	0.00	0.05	0.05
44.90	0.49	0.41	5.00	0.00	0.05	0.05
44.95	0.49	0.41	5.00	0.00	0.05	0.05
45.00	0.49	0.41	5.00	0.00	0.05	0.05
45.05	0.49	0.41	5.00	0.00	0.05	0.05
45.10	0.49	0.41	5.00	0.00	0.05	0.05
45.15	0.49	0.41	5.00	0.00	0.05	0.05
45.20	0.49	0.41	5.00	0.00	0.05	0.05
45.25	0.49	0.41	5.00	0.00	0.05	0.05
45.30	0.49	0.41	5.00	0.00	0.05	0.05
45.35	0.49	0.41	5.00	0.00	0.05	0.05
45.40	0.49	0.41	5.00	0.00	0.05	0.05
45.45	0.49	0.41	5.00	0.00	0.05	0.05
45.50	0.49	0.41	5.00	0.00	0.05	0.05
45.55	0.49	0.41	5.00	0.00	0.05	0.05
45.60	0.49	0.41	5.00	0.00	0.05	0.05
45.65	0.49	0.41	5.00	0.00	0.05	0.05
45.70	0.49	0.41	5.00	0.00	0.04	0.04
45.75	0.49	0.41	5.00	0.00	0.04	0.04
45.80	0.49	0.41	5.00	0.00	0.04	0.04
45.85	0.49	0.41	5.00	0.00	0.04	0.04
45.90	0.49	0.41	5.00	0.00	0.04	0.04
45.95	0.49	0.41	5.00	0.00	0.04	0.04
46.00	0.49	0.41	5.00	0.00	0.04	0.04
46.05	0.49	0.41	5.00	0.00	0.04	0.04
46.10	0.49	0.41	5.00	0.00	0.04	0.04
46.15	0.49	0.40	5.00	0.00	0.04	0.04
46.20	0.49	0.40	5.00	0.00	0.04	0.04
46.25	0.49	0.40	5.00	0.00	0.04	0.04
46.30	0.49	0.40	5.00	0.00	0.04	0.04
46.35	0.49	0.40	5.00	0.00	0.04	0.04
46.40	0.49	0.40	5.00	0.00	0.04	0.04
46.45	0.49	0.40	5.00	0.00	0.04	0.04
46.50	0.49	0.40	5.00	0.00	0.04	0.04
46.55	0.49	0.40	5.00	0.00	0.04	0.04
46.60	0.49	0.40	5.00	0.00	0.04	0.04
46.65	0.49	0.40	5.00	0.00	0.04	0.04
46.70	0.49	0.40	5.00	0.00	0.04	0.04

46.75	0.49	0.40	5.00	0.00	0.04	0.04
46.80	0.49	0.40	5.00	0.00	0.04	0.04
46.85	0.49	0.40	5.00	0.00	0.04	0.04
46.90	0.49	0.40	5.00	0.00	0.03	0.03
46.95	0.49	0.40	5.00	0.00	0.03	0.03
47.00	0.49	0.40	5.00	0.00	0.03	0.03
47.05	0.49	0.40	5.00	0.00	0.03	0.03
47.10	0.49	0.40	5.00	0.00	0.03	0.03
47.15	0.49	0.40	5.00	0.00	0.03	0.03
47.20	0.49	0.40	5.00	0.00	0.03	0.03
47.25	0.49	0.40	5.00	0.00	0.03	0.03
47.30	0.49	0.40	5.00	0.00	0.03	0.03
47.35	0.49	0.40	5.00	0.00	0.03	0.03
47.40	0.49	0.40	5.00	0.00	0.03	0.03
47.45	0.49	0.40	5.00	0.00	0.03	0.03
47.50	0.49	0.40	5.00	0.00	0.03	0.03
47.55	0.49	0.40	5.00	0.00	0.03	0.03
47.60	0.49	0.40	5.00	0.00	0.03	0.03
47.65	0.49	0.40	5.00	0.00	0.03	0.03
47.70	0.49	0.40	5.00	0.00	0.03	0.03
47.75	0.49	0.40	5.00	0.00	0.03	0.03
47.80	0.49	0.40	5.00	0.00	0.03	0.03
47.85	0.49	0.40	5.00	0.00	0.03	0.03
47.90	0.49	0.40	5.00	0.00	0.03	0.03
47.95	0.49	0.40	5.00	0.00	0.03	0.03
48.00	0.49	0.40	5.00	0.00	0.03	0.03
48.05	0.49	0.40	5.00	0.00	0.03	0.03
48.10	0.49	0.40	5.00	0.00	0.02	0.02
48.15	0.49	0.40	5.00	0.00	0.02	0.02
48.20	0.49	0.40	5.00	0.00	0.02	0.02
48.25	0.48	0.40	5.00	0.00	0.02	0.02
48.30	0.48	0.40	5.00	0.00	0.02	0.02
48.35	0.48	0.40	5.00	0.00	0.02	0.02
48.40	0.48	0.40	5.00	0.00	0.02	0.02
48.45	0.48	0.40	5.00	0.00	0.02	0.02
48.50	0.48	0.40	5.00	0.00	0.02	0.02
48.55	0.48	0.39	5.00	0.00	0.02	0.02
48.60	0.48	0.39	5.00	0.00	0.02	0.02
48.65	0.48	0.39	5.00	0.00	0.02	0.02
48.70	0.48	0.39	5.00	0.00	0.02	0.02
48.75	0.48	0.39	5.00	0.00	0.02	0.02
48.80	0.48	0.39	5.00	0.00	0.02	0.02
48.85	0.48	0.39	5.00	0.00	0.02	0.02
48.90	0.48	0.39	5.00	0.00	0.02	0.02
48.95	0.48	0.39	5.00	0.00	0.02	0.02
49.00	0.48	0.39	5.00	0.00	0.02	0.02
49.05	0.48	0.39	5.00	0.00	0.02	0.02
49.10	0.48	0.39	5.00	0.00	0.02	0.02
49.15	0.48	0.39	5.00	0.00	0.02	0.02
49.20	0.48	0.39	5.00	0.00	0.02	0.02
49.25	0.48	0.39	5.00	0.00	0.02	0.02
49.30	0.48	0.39	5.00	0.00	0.02	0.02
49.35	0.48	0.39	5.00	0.00	0.01	0.01
49.40	0.48	0.39	5.00	0.00	0.01	0.01
49.45	0.48	0.39	5.00	0.00	0.01	0.01
49.50	0.48	0.39	5.00	0.00	0.01	0.01
49.55	0.48	0.39	5.00	0.00	0.01	0.01
49.60	0.48	0.39	5.00	0.00	0.01	0.01
49.65	0.48	0.39	5.00	0.00	0.01	0.01
49.70	0.48	0.39	5.00	0.00	0.01	0.01
49.75	0.48	0.39	5.00	0.00	0.01	0.01
49.80	0.48	0.39	5.00	0.00	0.01	0.01
49.85	0.48	0.39	5.00	0.00	0.01	0.01
49.90	0.48	0.39	5.00	0.00	0.01	0.01
49.95	0.48	0.39	5.00	0.00	0.01	0.01
50.00	0.48	0.39	5.00	0.00	0.01	0.01
50.05	0.48	0.39	5.00	0.00	0.01	0.01
50.10	0.48	0.39	5.00	0.00	0.01	0.01
50.15	0.48	0.39	5.00	0.00	0.01	0.01

50.20	0.48	0.39	5.00	0.00	0.01	0.01
50.25	0.48	0.39	5.00	0.00	0.01	0.01
50.30	0.48	0.39	5.00	0.00	0.01	0.01
50.35	0.48	0.39	5.00	0.00	0.01	0.01
50.40	0.48	0.39	5.00	0.00	0.01	0.01
50.45	0.48	0.39	5.00	0.00	0.01	0.01
50.50	0.48	0.39	5.00	0.00	0.00	0.00
50.55	0.48	0.39	5.00	0.00	0.00	0.00
50.60	0.48	0.39	5.00	0.00	0.00	0.00
50.65	0.48	0.39	5.00	0.00	0.00	0.00
50.70	0.48	0.39	5.00	0.00	0.00	0.00
50.75	0.48	0.39	5.00	0.00	0.00	0.00
50.80	0.48	0.39	5.00	0.00	0.00	0.00
50.85	0.48	0.39	5.00	0.00	0.00	0.00
50.90	0.48	0.39	5.00	0.00	0.00	0.00
50.95	0.48	0.39	5.00	0.00	0.00	0.00
51.00	0.48	0.38	5.00	0.00	0.00	0.00

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* F.S.<1, Liquefaction Potential Zone
(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

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1 atm (atmosphere) = 1 tsf (ton/ft2)

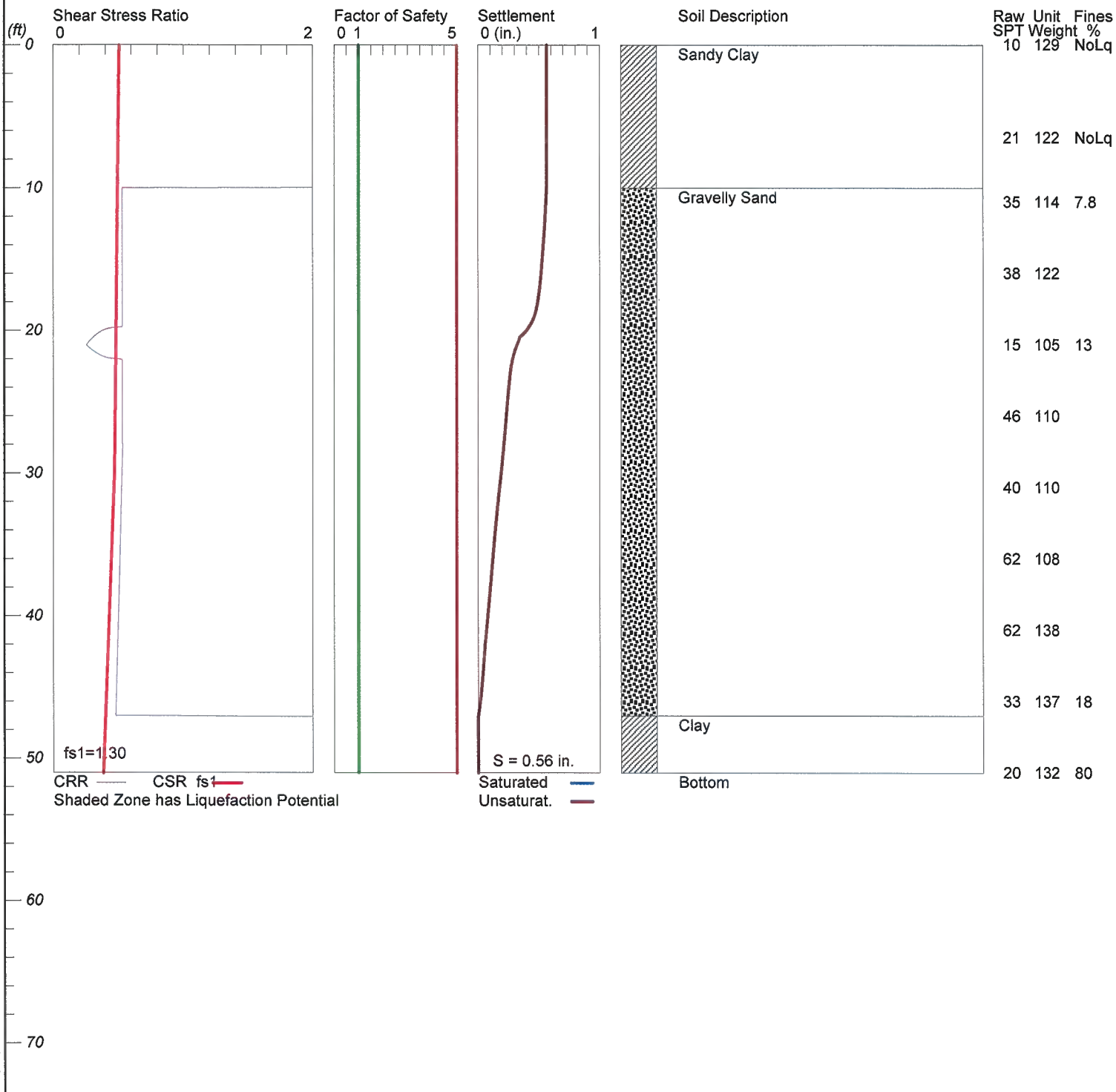
CRRm	Cyclic resistance ratio from soils
CSRsf	Cyclic stress ratio induced by a given earthquake (with user request factor of safety)
F.S.	Factor of Safety against liquefaction, F.S.=CRRm/CSRsf
S_sat	Settlement from saturated sands
S_dry	Settlement from Unsaturated Sands
S_all	Total Settlement from Saturated and Unsaturated Sands
NoLiq	No-Liquefy Soils

LIQUEFACTION ANALYSIS

CRC CO2 Capture Project

Hole No.=B-11 Water Depth=100+ ft Surface Elev.=1339

Magnitude=7.33
Acceleration=0.6g



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LIQUEFACTION ANALYSIS SUMMARY
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Font: Courier New, Regular, Size 8 is recommended for this report.
Licensed to Robert Becker, Soils Engineering 7/2/2020 8:17:43 AM

Input File Name: O:\b. PROJECT FILES (ACTIVE)\17600-17699\17662 Fluor, CO2 Capture Project from Elk Hills Power Plant Project (EH-35RC1RC)\OFFICE REPORTS\17662 Geohaz\LiquefyPro Files\17662 B-11.liq
Title: CRC CO2 Capture Project
Subtitle: 17662

Surface Elev.=1339
Hole No.=B-11
Depth of Hole= 51.00 ft
Water Table during Earthquake= 999.00 ft
Water Table during In-Situ Testing= 999.00 ft
Max. Acceleration= 0.6 g
Earthquake Magnitude= 7.33

Input Data:
Surface Elev.=1339
Hole No.=B-11
Depth of Hole=51.00 ft
Water Table during Earthquake= 999.00 ft
Water Table during In-Situ Testing= 999.00 ft
Max. Acceleration=0.6 g
Earthquake Magnitude=7.33
No-Liquefiable Soils: CL, OL are Non-Liq. Soil

1. SPT or BPT Calculation.
2. Settlement Analysis Method: Tokimatsu, M-correction
3. Fines Correction for Liquefaction: Idriss/Seed
4. Fine Correction for Settlement: During Liquefaction*
5. Settlement Calculation in: All zones*
6. Hammer Energy Ratio, Ce = 1.25
7. Borehole Diameter, Cb= 1
8. Sampling Method, Cs= 1.2
9. User request factor of safety (apply to CSR) , User= 1.3
   Plot one CSR curve (fs1=User)
10. Use Curve Smoothing: Yes*

* Recommended Options

In-Situ Test Data:

Depth ft	SPT	gamma pcf	Fines %
0.00	10.00	129.00	NoLiq
6.50	21.00	122.00	NoLiq
11.00	35.00	114.00	7.80
16.00	38.00	122.00	7.80
21.00	15.00	105.00	13.00
26.00	46.00	110.00	13.00
31.00	40.00	110.00	13.00
36.00	62.00	108.00	13.00
41.00	62.00	138.00	13.00
46.00	33.00	137.00	18.00
51.00	20.00	132.00	80.00

Output Results:

Settlement of Saturated Sands=0.00 in.
Settlement of Unsaturated Sands=0.56 in.
Total Settlement of Saturated and Unsaturated Sands=0.56 in.
Differential Settlement=0.281 to 0.371 in.

Depth ft	CRRm	CSRfs	F.S.	S_sat. in.	S_dry in.	S_all in.
0.00	2.00	0.51	5.00	0.00	0.56	0.56
0.05	2.00	0.51	5.00	0.00	0.56	0.56
0.10	2.00	0.51	5.00	0.00	0.56	0.56
0.15	2.00	0.51	5.00	0.00	0.56	0.56
0.20	2.00	0.51	5.00	0.00	0.56	0.56
0.25	2.00	0.51	5.00	0.00	0.56	0.56
0.30	2.00	0.51	5.00	0.00	0.56	0.56
0.35	2.00	0.51	5.00	0.00	0.56	0.56
0.40	2.00	0.51	5.00	0.00	0.56	0.56
0.45	2.00	0.51	5.00	0.00	0.56	0.56
0.50	2.00	0.51	5.00	0.00	0.56	0.56
0.55	2.00	0.51	5.00	0.00	0.56	0.56
0.60	2.00	0.51	5.00	0.00	0.56	0.56
0.65	2.00	0.51	5.00	0.00	0.56	0.56
0.70	2.00	0.51	5.00	0.00	0.56	0.56
0.75	2.00	0.51	5.00	0.00	0.56	0.56
0.80	2.00	0.51	5.00	0.00	0.56	0.56
0.85	2.00	0.51	5.00	0.00	0.56	0.56
0.90	2.00	0.51	5.00	0.00	0.56	0.56
0.95	2.00	0.51	5.00	0.00	0.56	0.56
1.00	2.00	0.51	5.00	0.00	0.56	0.56
1.05	2.00	0.51	5.00	0.00	0.56	0.56
1.10	2.00	0.51	5.00	0.00	0.56	0.56
1.15	2.00	0.51	5.00	0.00	0.56	0.56
1.20	2.00	0.51	5.00	0.00	0.56	0.56
1.25	2.00	0.51	5.00	0.00	0.56	0.56
1.30	2.00	0.51	5.00	0.00	0.56	0.56
1.35	2.00	0.51	5.00	0.00	0.56	0.56
1.40	2.00	0.51	5.00	0.00	0.56	0.56
1.45	2.00	0.51	5.00	0.00	0.56	0.56
1.50	2.00	0.51	5.00	0.00	0.56	0.56
1.55	2.00	0.51	5.00	0.00	0.56	0.56
1.60	2.00	0.51	5.00	0.00	0.56	0.56
1.65	2.00	0.51	5.00	0.00	0.56	0.56
1.70	2.00	0.50	5.00	0.00	0.56	0.56
1.75	2.00	0.50	5.00	0.00	0.56	0.56
1.80	2.00	0.50	5.00	0.00	0.56	0.56
1.85	2.00	0.50	5.00	0.00	0.56	0.56
1.90	2.00	0.50	5.00	0.00	0.56	0.56

1.95	2.00	0.50	5.00	0.00	0.56	0.56
2.00	2.00	0.50	5.00	0.00	0.56	0.56
2.05	2.00	0.50	5.00	0.00	0.56	0.56
2.10	2.00	0.50	5.00	0.00	0.56	0.56
2.15	2.00	0.50	5.00	0.00	0.56	0.56
2.20	2.00	0.50	5.00	0.00	0.56	0.56
2.25	2.00	0.50	5.00	0.00	0.56	0.56
2.30	2.00	0.50	5.00	0.00	0.56	0.56
2.35	2.00	0.50	5.00	0.00	0.56	0.56
2.40	2.00	0.50	5.00	0.00	0.56	0.56
2.45	2.00	0.50	5.00	0.00	0.56	0.56
2.50	2.00	0.50	5.00	0.00	0.56	0.56
2.55	2.00	0.50	5.00	0.00	0.56	0.56
2.60	2.00	0.50	5.00	0.00	0.56	0.56
2.65	2.00	0.50	5.00	0.00	0.56	0.56
2.70	2.00	0.50	5.00	0.00	0.56	0.56
2.75	2.00	0.50	5.00	0.00	0.56	0.56
2.80	2.00	0.50	5.00	0.00	0.56	0.56
2.85	2.00	0.50	5.00	0.00	0.56	0.56
2.90	2.00	0.50	5.00	0.00	0.56	0.56
2.95	2.00	0.50	5.00	0.00	0.56	0.56
3.00	2.00	0.50	5.00	0.00	0.56	0.56
3.05	2.00	0.50	5.00	0.00	0.56	0.56
3.10	2.00	0.50	5.00	0.00	0.56	0.56
3.15	2.00	0.50	5.00	0.00	0.56	0.56
3.20	2.00	0.50	5.00	0.00	0.56	0.56
3.25	2.00	0.50	5.00	0.00	0.56	0.56
3.30	2.00	0.50	5.00	0.00	0.56	0.56
3.35	2.00	0.50	5.00	0.00	0.56	0.56
3.40	2.00	0.50	5.00	0.00	0.56	0.56
3.45	2.00	0.50	5.00	0.00	0.56	0.56
3.50	2.00	0.50	5.00	0.00	0.56	0.56
3.55	2.00	0.50	5.00	0.00	0.56	0.56
3.60	2.00	0.50	5.00	0.00	0.56	0.56
3.65	2.00	0.50	5.00	0.00	0.56	0.56
3.70	2.00	0.50	5.00	0.00	0.56	0.56
3.75	2.00	0.50	5.00	0.00	0.56	0.56
3.80	2.00	0.50	5.00	0.00	0.56	0.56
3.85	2.00	0.50	5.00	0.00	0.56	0.56
3.90	2.00	0.50	5.00	0.00	0.56	0.56
3.95	2.00	0.50	5.00	0.00	0.56	0.56
4.00	2.00	0.50	5.00	0.00	0.56	0.56
4.05	2.00	0.50	5.00	0.00	0.56	0.56
4.10	2.00	0.50	5.00	0.00	0.56	0.56
4.15	2.00	0.50	5.00	0.00	0.56	0.56
4.20	2.00	0.50	5.00	0.00	0.56	0.56
4.25	2.00	0.50	5.00	0.00	0.56	0.56
4.30	2.00	0.50	5.00	0.00	0.56	0.56
4.35	2.00	0.50	5.00	0.00	0.56	0.56
4.40	2.00	0.50	5.00	0.00	0.56	0.56
4.45	2.00	0.50	5.00	0.00	0.56	0.56
4.50	2.00	0.50	5.00	0.00	0.56	0.56
4.55	2.00	0.50	5.00	0.00	0.56	0.56
4.60	2.00	0.50	5.00	0.00	0.56	0.56
4.65	2.00	0.50	5.00	0.00	0.56	0.56
4.70	2.00	0.50	5.00	0.00	0.56	0.56
4.75	2.00	0.50	5.00	0.00	0.56	0.56
4.80	2.00	0.50	5.00	0.00	0.56	0.56
4.85	2.00	0.50	5.00	0.00	0.56	0.56
4.90	2.00	0.50	5.00	0.00	0.56	0.56
4.95	2.00	0.50	5.00	0.00	0.56	0.56
5.00	2.00	0.50	5.00	0.00	0.56	0.56
5.05	2.00	0.50	5.00	0.00	0.56	0.56
5.10	2.00	0.50	5.00	0.00	0.56	0.56
5.15	2.00	0.50	5.00	0.00	0.56	0.56
5.20	2.00	0.50	5.00	0.00	0.56	0.56
5.25	2.00	0.50	5.00	0.00	0.56	0.56
5.30	2.00	0.50	5.00	0.00	0.56	0.56
5.35	2.00	0.50	5.00	0.00	0.56	0.56

5.40	2.00	0.50	5.00	0.00	0.56	0.56
5.45	2.00	0.50	5.00	0.00	0.56	0.56
5.50	2.00	0.50	5.00	0.00	0.56	0.56
5.55	2.00	0.50	5.00	0.00	0.56	0.56
5.60	2.00	0.50	5.00	0.00	0.56	0.56
5.65	2.00	0.50	5.00	0.00	0.56	0.56
5.70	2.00	0.50	5.00	0.00	0.56	0.56
5.75	2.00	0.50	5.00	0.00	0.56	0.56
5.80	2.00	0.50	5.00	0.00	0.56	0.56
5.85	2.00	0.50	5.00	0.00	0.56	0.56
5.90	2.00	0.50	5.00	0.00	0.56	0.56
5.95	2.00	0.50	5.00	0.00	0.56	0.56
6.00	2.00	0.50	5.00	0.00	0.56	0.56
6.05	2.00	0.50	5.00	0.00	0.56	0.56
6.10	2.00	0.50	5.00	0.00	0.56	0.56
6.15	2.00	0.50	5.00	0.00	0.56	0.56
6.20	2.00	0.50	5.00	0.00	0.56	0.56
6.25	2.00	0.50	5.00	0.00	0.56	0.56
6.30	2.00	0.50	5.00	0.00	0.56	0.56
6.35	2.00	0.50	5.00	0.00	0.56	0.56
6.40	2.00	0.50	5.00	0.00	0.56	0.56
6.45	2.00	0.50	5.00	0.00	0.56	0.56
6.50	2.00	0.50	5.00	0.00	0.56	0.56
6.55	2.00	0.50	5.00	0.00	0.56	0.56
6.60	2.00	0.50	5.00	0.00	0.56	0.56
6.65	2.00	0.50	5.00	0.00	0.56	0.56
6.70	2.00	0.50	5.00	0.00	0.56	0.56
6.75	2.00	0.50	5.00	0.00	0.56	0.56
6.80	2.00	0.50	5.00	0.00	0.56	0.56
6.85	2.00	0.50	5.00	0.00	0.56	0.56
6.90	2.00	0.50	5.00	0.00	0.56	0.56
6.95	2.00	0.50	5.00	0.00	0.56	0.56
7.00	2.00	0.50	5.00	0.00	0.56	0.56
7.05	2.00	0.50	5.00	0.00	0.56	0.56
7.10	2.00	0.50	5.00	0.00	0.56	0.56
7.15	2.00	0.50	5.00	0.00	0.56	0.56
7.20	2.00	0.50	5.00	0.00	0.56	0.56
7.25	2.00	0.50	5.00	0.00	0.56	0.56
7.30	2.00	0.50	5.00	0.00	0.56	0.56
7.35	2.00	0.50	5.00	0.00	0.56	0.56
7.40	2.00	0.50	5.00	0.00	0.56	0.56
7.45	2.00	0.50	5.00	0.00	0.56	0.56
7.50	2.00	0.50	5.00	0.00	0.56	0.56
7.55	2.00	0.50	5.00	0.00	0.56	0.56
7.60	2.00	0.50	5.00	0.00	0.56	0.56
7.65	2.00	0.50	5.00	0.00	0.56	0.56
7.70	2.00	0.50	5.00	0.00	0.56	0.56
7.75	2.00	0.50	5.00	0.00	0.56	0.56
7.80	2.00	0.50	5.00	0.00	0.56	0.56
7.85	2.00	0.50	5.00	0.00	0.56	0.56
7.90	2.00	0.50	5.00	0.00	0.56	0.56
7.95	2.00	0.50	5.00	0.00	0.56	0.56
8.00	2.00	0.50	5.00	0.00	0.56	0.56
8.05	2.00	0.50	5.00	0.00	0.56	0.56
8.10	2.00	0.50	5.00	0.00	0.56	0.56
8.15	2.00	0.50	5.00	0.00	0.56	0.56
8.20	2.00	0.50	5.00	0.00	0.56	0.56
8.25	2.00	0.50	5.00	0.00	0.56	0.56
8.30	2.00	0.50	5.00	0.00	0.56	0.56
8.35	2.00	0.50	5.00	0.00	0.56	0.56
8.40	2.00	0.50	5.00	0.00	0.56	0.56
8.45	2.00	0.50	5.00	0.00	0.56	0.56
8.50	2.00	0.50	5.00	0.00	0.56	0.56
8.55	2.00	0.50	5.00	0.00	0.56	0.56
8.60	2.00	0.50	5.00	0.00	0.56	0.56
8.65	2.00	0.50	5.00	0.00	0.56	0.56
8.70	2.00	0.50	5.00	0.00	0.56	0.56
8.75	2.00	0.50	5.00	0.00	0.56	0.56
8.80	2.00	0.50	5.00	0.00	0.56	0.56

8.85	2.00	0.50	5.00	0.00	0.56	0.56
8.90	2.00	0.50	5.00	0.00	0.56	0.56
8.95	2.00	0.50	5.00	0.00	0.56	0.56
9.00	2.00	0.50	5.00	0.00	0.56	0.56
9.05	2.00	0.50	5.00	0.00	0.56	0.56
9.10	2.00	0.50	5.00	0.00	0.56	0.56
9.15	2.00	0.50	5.00	0.00	0.56	0.56
9.20	2.00	0.50	5.00	0.00	0.56	0.56
9.25	2.00	0.50	5.00	0.00	0.56	0.56
9.30	2.00	0.50	5.00	0.00	0.56	0.56
9.35	2.00	0.50	5.00	0.00	0.56	0.56
9.40	2.00	0.50	5.00	0.00	0.56	0.56
9.45	2.00	0.50	5.00	0.00	0.56	0.56
9.50	2.00	0.50	5.00	0.00	0.56	0.56
9.55	2.00	0.50	5.00	0.00	0.56	0.56
9.60	2.00	0.50	5.00	0.00	0.56	0.56
9.65	2.00	0.50	5.00	0.00	0.56	0.56
9.70	2.00	0.50	5.00	0.00	0.56	0.56
9.75	2.00	0.50	5.00	0.00	0.56	0.56
9.80	2.00	0.50	5.00	0.00	0.56	0.56
9.85	2.00	0.50	5.00	0.00	0.56	0.56
9.90	2.00	0.50	5.00	0.00	0.56	0.56
9.95	2.00	0.50	5.00	0.00	0.56	0.56
10.00	0.53	0.50	5.00	0.00	0.56	0.56
10.05	0.53	0.50	5.00	0.00	0.56	0.56
10.10	0.53	0.50	5.00	0.00	0.56	0.56
10.15	0.53	0.50	5.00	0.00	0.56	0.56
10.20	0.53	0.49	5.00	0.00	0.56	0.56
10.25	0.53	0.49	5.00	0.00	0.56	0.56
10.30	0.53	0.49	5.00	0.00	0.56	0.56
10.35	0.53	0.49	5.00	0.00	0.56	0.56
10.40	0.53	0.49	5.00	0.00	0.56	0.56
10.45	0.53	0.49	5.00	0.00	0.56	0.56
10.50	0.53	0.49	5.00	0.00	0.56	0.56
10.55	0.53	0.49	5.00	0.00	0.56	0.56
10.60	0.53	0.49	5.00	0.00	0.56	0.56
10.65	0.53	0.49	5.00	0.00	0.56	0.56
10.70	0.53	0.49	5.00	0.00	0.56	0.56
10.75	0.53	0.49	5.00	0.00	0.56	0.56
10.80	0.53	0.49	5.00	0.00	0.56	0.56
10.85	0.53	0.49	5.00	0.00	0.56	0.56
10.90	0.53	0.49	5.00	0.00	0.56	0.56
10.95	0.53	0.49	5.00	0.00	0.56	0.56
11.00	0.53	0.49	5.00	0.00	0.56	0.56
11.05	0.53	0.49	5.00	0.00	0.56	0.56
11.10	0.53	0.49	5.00	0.00	0.56	0.56
11.15	0.53	0.49	5.00	0.00	0.56	0.56
11.20	0.53	0.49	5.00	0.00	0.56	0.56
11.25	0.53	0.49	5.00	0.00	0.56	0.56
11.30	0.53	0.49	5.00	0.00	0.56	0.56
11.35	0.53	0.49	5.00	0.00	0.55	0.55
11.40	0.53	0.49	5.00	0.00	0.55	0.55
11.45	0.53	0.49	5.00	0.00	0.55	0.55
11.50	0.53	0.49	5.00	0.00	0.55	0.55
11.55	0.53	0.49	5.00	0.00	0.55	0.55
11.60	0.53	0.49	5.00	0.00	0.55	0.55
11.65	0.53	0.49	5.00	0.00	0.55	0.55
11.70	0.53	0.49	5.00	0.00	0.55	0.55
11.75	0.53	0.49	5.00	0.00	0.55	0.55
11.80	0.53	0.49	5.00	0.00	0.55	0.55
11.85	0.53	0.49	5.00	0.00	0.55	0.55
11.90	0.53	0.49	5.00	0.00	0.55	0.55
11.95	0.53	0.49	5.00	0.00	0.55	0.55
12.00	0.53	0.49	5.00	0.00	0.55	0.55
12.05	0.53	0.49	5.00	0.00	0.55	0.55
12.10	0.53	0.49	5.00	0.00	0.55	0.55
12.15	0.53	0.49	5.00	0.00	0.55	0.55
12.20	0.53	0.49	5.00	0.00	0.55	0.55
12.25	0.53	0.49	5.00	0.00	0.55	0.55

12.30	0.53	0.49	5.00	0.00	0.55	0.55
12.35	0.53	0.49	5.00	0.00	0.55	0.55
12.40	0.53	0.49	5.00	0.00	0.55	0.55
12.45	0.53	0.49	5.00	0.00	0.55	0.55
12.50	0.53	0.49	5.00	0.00	0.55	0.55
12.55	0.53	0.49	5.00	0.00	0.55	0.55
12.60	0.53	0.49	5.00	0.00	0.55	0.55
12.65	0.53	0.49	5.00	0.00	0.55	0.55
12.70	0.53	0.49	5.00	0.00	0.55	0.55
12.75	0.53	0.49	5.00	0.00	0.55	0.55
12.80	0.53	0.49	5.00	0.00	0.55	0.55
12.85	0.53	0.49	5.00	0.00	0.54	0.54
12.90	0.53	0.49	5.00	0.00	0.54	0.54
12.95	0.53	0.49	5.00	0.00	0.54	0.54
13.00	0.53	0.49	5.00	0.00	0.54	0.54
13.05	0.53	0.49	5.00	0.00	0.54	0.54
13.10	0.53	0.49	5.00	0.00	0.54	0.54
13.15	0.53	0.49	5.00	0.00	0.54	0.54
13.20	0.53	0.49	5.00	0.00	0.54	0.54
13.25	0.53	0.49	5.00	0.00	0.54	0.54
13.30	0.53	0.49	5.00	0.00	0.54	0.54
13.35	0.53	0.49	5.00	0.00	0.54	0.54
13.40	0.53	0.49	5.00	0.00	0.54	0.54
13.45	0.53	0.49	5.00	0.00	0.54	0.54
13.50	0.53	0.49	5.00	0.00	0.54	0.54
13.55	0.53	0.49	5.00	0.00	0.54	0.54
13.60	0.53	0.49	5.00	0.00	0.54	0.54
13.65	0.53	0.49	5.00	0.00	0.54	0.54
13.70	0.53	0.49	5.00	0.00	0.54	0.54
13.75	0.53	0.49	5.00	0.00	0.54	0.54
13.80	0.53	0.49	5.00	0.00	0.54	0.54
13.85	0.53	0.49	5.00	0.00	0.54	0.54
13.90	0.53	0.49	5.00	0.00	0.54	0.54
13.95	0.53	0.49	5.00	0.00	0.54	0.54
14.00	0.53	0.49	5.00	0.00	0.54	0.54
14.05	0.53	0.49	5.00	0.00	0.53	0.53
14.10	0.53	0.49	5.00	0.00	0.53	0.53
14.15	0.53	0.49	5.00	0.00	0.53	0.53
14.20	0.53	0.49	5.00	0.00	0.53	0.53
14.25	0.53	0.49	5.00	0.00	0.53	0.53
14.30	0.53	0.49	5.00	0.00	0.53	0.53
14.35	0.53	0.49	5.00	0.00	0.53	0.53
14.40	0.53	0.49	5.00	0.00	0.53	0.53
14.45	0.53	0.49	5.00	0.00	0.53	0.53
14.50	0.53	0.49	5.00	0.00	0.53	0.53
14.55	0.53	0.49	5.00	0.00	0.53	0.53
14.60	0.53	0.49	5.00	0.00	0.53	0.53
14.65	0.53	0.49	5.00	0.00	0.53	0.53
14.70	0.53	0.49	5.00	0.00	0.53	0.53
14.75	0.53	0.49	5.00	0.00	0.53	0.53
14.80	0.53	0.49	5.00	0.00	0.53	0.53
14.85	0.53	0.49	5.00	0.00	0.53	0.53
14.90	0.53	0.49	5.00	0.00	0.53	0.53
14.95	0.53	0.49	5.00	0.00	0.53	0.53
15.00	0.53	0.49	5.00	0.00	0.53	0.53
15.05	0.53	0.49	5.00	0.00	0.53	0.53
15.10	0.53	0.49	5.00	0.00	0.53	0.53
15.15	0.53	0.49	5.00	0.00	0.52	0.52
15.20	0.53	0.49	5.00	0.00	0.52	0.52
15.25	0.53	0.49	5.00	0.00	0.52	0.52
15.30	0.53	0.49	5.00	0.00	0.52	0.52
15.35	0.53	0.49	5.00	0.00	0.52	0.52
15.40	0.53	0.49	5.00	0.00	0.52	0.52
15.45	0.53	0.49	5.00	0.00	0.52	0.52
15.50	0.53	0.49	5.00	0.00	0.52	0.52
15.55	0.53	0.49	5.00	0.00	0.52	0.52
15.60	0.53	0.49	5.00	0.00	0.52	0.52
15.65	0.53	0.49	5.00	0.00	0.52	0.52
15.70	0.53	0.49	5.00	0.00	0.52	0.52

15.75	0.53	0.49	5.00	0.00	0.52	0.52
15.80	0.53	0.49	5.00	0.00	0.52	0.52
15.85	0.53	0.49	5.00	0.00	0.52	0.52
15.90	0.53	0.49	5.00	0.00	0.52	0.52
15.95	0.53	0.49	5.00	0.00	0.52	0.52
16.00	0.53	0.49	5.00	0.00	0.52	0.52
16.05	0.53	0.49	5.00	0.00	0.52	0.52
16.10	0.53	0.49	5.00	0.00	0.52	0.52
16.15	0.53	0.49	5.00	0.00	0.52	0.52
16.20	0.53	0.49	5.00	0.00	0.51	0.51
16.25	0.53	0.49	5.00	0.00	0.51	0.51
16.30	0.53	0.49	5.00	0.00	0.51	0.51
16.35	0.53	0.49	5.00	0.00	0.51	0.51
16.40	0.53	0.49	5.00	0.00	0.51	0.51
16.45	0.53	0.49	5.00	0.00	0.51	0.51
16.50	0.53	0.49	5.00	0.00	0.51	0.51
16.55	0.53	0.49	5.00	0.00	0.51	0.51
16.60	0.53	0.49	5.00	0.00	0.51	0.51
16.65	0.53	0.49	5.00	0.00	0.51	0.51
16.70	0.53	0.49	5.00	0.00	0.51	0.51
16.75	0.53	0.49	5.00	0.00	0.51	0.51
16.80	0.53	0.49	5.00	0.00	0.51	0.51
16.85	0.53	0.49	5.00	0.00	0.51	0.51
16.90	0.53	0.49	5.00	0.00	0.51	0.51
16.95	0.53	0.49	5.00	0.00	0.51	0.51
17.00	0.53	0.49	5.00	0.00	0.50	0.50
17.05	0.53	0.49	5.00	0.00	0.50	0.50
17.10	0.53	0.49	5.00	0.00	0.50	0.50
17.15	0.53	0.49	5.00	0.00	0.50	0.50
17.20	0.53	0.49	5.00	0.00	0.50	0.50
17.25	0.53	0.49	5.00	0.00	0.50	0.50
17.30	0.53	0.49	5.00	0.00	0.50	0.50
17.35	0.53	0.49	5.00	0.00	0.50	0.50
17.40	0.53	0.49	5.00	0.00	0.50	0.50
17.45	0.53	0.49	5.00	0.00	0.50	0.50
17.50	0.53	0.49	5.00	0.00	0.50	0.50
17.55	0.53	0.49	5.00	0.00	0.50	0.50
17.60	0.53	0.49	5.00	0.00	0.50	0.50
17.65	0.53	0.49	5.00	0.00	0.49	0.49
17.70	0.53	0.49	5.00	0.00	0.49	0.49
17.75	0.53	0.49	5.00	0.00	0.49	0.49
17.80	0.53	0.49	5.00	0.00	0.49	0.49
17.85	0.53	0.49	5.00	0.00	0.49	0.49
17.90	0.53	0.49	5.00	0.00	0.49	0.49
17.95	0.53	0.49	5.00	0.00	0.49	0.49
18.00	0.53	0.49	5.00	0.00	0.49	0.49
18.05	0.53	0.49	5.00	0.00	0.49	0.49
18.10	0.53	0.49	5.00	0.00	0.49	0.49
18.15	0.53	0.49	5.00	0.00	0.49	0.49
18.20	0.53	0.49	5.00	0.00	0.48	0.48
18.25	0.53	0.49	5.00	0.00	0.48	0.48
18.30	0.53	0.49	5.00	0.00	0.48	0.48
18.35	0.53	0.49	5.00	0.00	0.48	0.48
18.40	0.53	0.49	5.00	0.00	0.48	0.48
18.45	0.53	0.49	5.00	0.00	0.48	0.48
18.50	0.53	0.49	5.00	0.00	0.48	0.48
18.55	0.53	0.49	5.00	0.00	0.48	0.48
18.60	0.53	0.49	5.00	0.00	0.47	0.47
18.65	0.53	0.48	5.00	0.00	0.47	0.47
18.70	0.53	0.48	5.00	0.00	0.47	0.47
18.75	0.53	0.48	5.00	0.00	0.47	0.47
18.80	0.53	0.48	5.00	0.00	0.47	0.47
18.85	0.53	0.48	5.00	0.00	0.47	0.47
18.90	0.53	0.48	5.00	0.00	0.46	0.46
18.95	0.53	0.48	5.00	0.00	0.46	0.46
19.00	0.53	0.48	5.00	0.00	0.46	0.46
19.05	0.53	0.48	5.00	0.00	0.46	0.46
19.10	0.53	0.48	5.00	0.00	0.46	0.46
19.15	0.53	0.48	5.00	0.00	0.45	0.45

19.20	0.53	0.48	5.00	0.00	0.45	0.45
19.25	0.53	0.48	5.00	0.00	0.45	0.45
19.30	0.53	0.48	5.00	0.00	0.45	0.45
19.35	0.53	0.48	5.00	0.00	0.44	0.44
19.40	0.53	0.48	5.00	0.00	0.44	0.44
19.45	0.53	0.48	5.00	0.00	0.44	0.44
19.50	0.53	0.48	5.00	0.00	0.44	0.44
19.55	0.53	0.48	5.00	0.00	0.43	0.43
19.60	0.53	0.48	5.00	0.00	0.43	0.43
19.65	0.53	0.48	5.00	0.00	0.43	0.43
19.70	0.53	0.48	5.00	0.00	0.42	0.42
19.75	0.53	0.48	5.00	0.00	0.42	0.42
19.80	0.47	0.48	5.00	0.00	0.41	0.41
19.85	0.43	0.48	5.00	0.00	0.41	0.41
19.90	0.41	0.48	5.00	0.00	0.41	0.41
19.95	0.39	0.48	5.00	0.00	0.40	0.40
20.00	0.38	0.48	5.00	0.00	0.40	0.40
20.05	0.37	0.48	5.00	0.00	0.39	0.39
20.10	0.36	0.48	5.00	0.00	0.39	0.39
20.15	0.35	0.48	5.00	0.00	0.38	0.38
20.20	0.35	0.48	5.00	0.00	0.38	0.38
20.25	0.34	0.48	5.00	0.00	0.37	0.37
20.30	0.33	0.48	5.00	0.00	0.36	0.36
20.35	0.32	0.48	5.00	0.00	0.36	0.36
20.40	0.32	0.48	5.00	0.00	0.35	0.35
20.45	0.31	0.48	5.00	0.00	0.34	0.34
20.50	0.31	0.48	5.00	0.00	0.34	0.34
20.55	0.30	0.48	5.00	0.00	0.34	0.34
20.60	0.30	0.48	5.00	0.00	0.34	0.34
20.65	0.29	0.48	5.00	0.00	0.33	0.33
20.70	0.29	0.48	5.00	0.00	0.33	0.33
20.75	0.28	0.48	5.00	0.00	0.33	0.33
20.80	0.28	0.48	5.00	0.00	0.33	0.33
20.85	0.27	0.48	5.00	0.00	0.33	0.33
20.90	0.27	0.48	5.00	0.00	0.32	0.32
20.95	0.26	0.48	5.00	0.00	0.32	0.32
21.00	0.26	0.48	5.00	0.00	0.32	0.32
21.05	0.26	0.48	5.00	0.00	0.32	0.32
21.10	0.27	0.48	5.00	0.00	0.31	0.31
21.15	0.27	0.48	5.00	0.00	0.31	0.31
21.20	0.28	0.48	5.00	0.00	0.31	0.31
21.25	0.29	0.48	5.00	0.00	0.31	0.31
21.30	0.29	0.48	5.00	0.00	0.30	0.30
21.35	0.30	0.48	5.00	0.00	0.30	0.30
21.40	0.31	0.48	5.00	0.00	0.30	0.30
21.45	0.31	0.48	5.00	0.00	0.30	0.30
21.50	0.32	0.48	5.00	0.00	0.30	0.30
21.55	0.33	0.48	5.00	0.00	0.30	0.30
21.60	0.34	0.48	5.00	0.00	0.29	0.29
21.65	0.35	0.48	5.00	0.00	0.29	0.29
21.70	0.36	0.48	5.00	0.00	0.29	0.29
21.75	0.37	0.48	5.00	0.00	0.29	0.29
21.80	0.38	0.48	5.00	0.00	0.29	0.29
21.85	0.39	0.48	5.00	0.00	0.29	0.29
21.90	0.41	0.48	5.00	0.00	0.28	0.28
21.95	0.44	0.48	5.00	0.00	0.28	0.28
22.00	0.51	0.48	5.00	0.00	0.28	0.28
22.05	0.53	0.48	5.00	0.00	0.28	0.28
22.10	0.53	0.48	5.00	0.00	0.28	0.28
22.15	0.53	0.48	5.00	0.00	0.28	0.28
22.20	0.53	0.48	5.00	0.00	0.28	0.28
22.25	0.53	0.48	5.00	0.00	0.28	0.28
22.30	0.53	0.48	5.00	0.00	0.27	0.27
22.35	0.53	0.48	5.00	0.00	0.27	0.27
22.40	0.53	0.48	5.00	0.00	0.27	0.27
22.45	0.53	0.48	5.00	0.00	0.27	0.27
22.50	0.53	0.48	5.00	0.00	0.27	0.27
22.55	0.53	0.48	5.00	0.00	0.27	0.27
22.60	0.53	0.48	5.00	0.00	0.27	0.27

22.65	0.53	0.48	5.00	0.00	0.27	0.27
22.70	0.53	0.48	5.00	0.00	0.27	0.27
22.75	0.53	0.48	5.00	0.00	0.27	0.27
22.80	0.53	0.48	5.00	0.00	0.26	0.26
22.85	0.53	0.48	5.00	0.00	0.26	0.26
22.90	0.53	0.48	5.00	0.00	0.26	0.26
22.95	0.53	0.48	5.00	0.00	0.26	0.26
23.00	0.53	0.48	5.00	0.00	0.26	0.26
23.05	0.53	0.48	5.00	0.00	0.26	0.26
23.10	0.53	0.48	5.00	0.00	0.26	0.26
23.15	0.53	0.48	5.00	0.00	0.26	0.26
23.20	0.53	0.48	5.00	0.00	0.26	0.26
23.25	0.53	0.48	5.00	0.00	0.26	0.26
23.30	0.53	0.48	5.00	0.00	0.26	0.26
23.35	0.53	0.48	5.00	0.00	0.26	0.26
23.40	0.53	0.48	5.00	0.00	0.26	0.26
23.45	0.53	0.48	5.00	0.00	0.26	0.26
23.50	0.53	0.48	5.00	0.00	0.26	0.26
23.55	0.53	0.48	5.00	0.00	0.26	0.26
23.60	0.53	0.48	5.00	0.00	0.25	0.25
23.65	0.53	0.48	5.00	0.00	0.25	0.25
23.70	0.53	0.48	5.00	0.00	0.25	0.25
23.75	0.53	0.48	5.00	0.00	0.25	0.25
23.80	0.53	0.48	5.00	0.00	0.25	0.25
23.85	0.53	0.48	5.00	0.00	0.25	0.25
23.90	0.53	0.48	5.00	0.00	0.25	0.25
23.95	0.53	0.48	5.00	0.00	0.25	0.25
24.00	0.53	0.48	5.00	0.00	0.25	0.25
24.05	0.53	0.48	5.00	0.00	0.25	0.25
24.10	0.53	0.48	5.00	0.00	0.25	0.25
24.15	0.53	0.48	5.00	0.00	0.25	0.25
24.20	0.53	0.48	5.00	0.00	0.25	0.25
24.25	0.53	0.48	5.00	0.00	0.25	0.25
24.30	0.53	0.48	5.00	0.00	0.25	0.25
24.35	0.53	0.48	5.00	0.00	0.25	0.25
24.40	0.53	0.48	5.00	0.00	0.25	0.25
24.45	0.53	0.48	5.00	0.00	0.25	0.25
24.50	0.53	0.48	5.00	0.00	0.24	0.24
24.55	0.53	0.48	5.00	0.00	0.24	0.24
24.60	0.53	0.48	5.00	0.00	0.24	0.24
24.65	0.53	0.48	5.00	0.00	0.24	0.24
24.70	0.53	0.48	5.00	0.00	0.24	0.24
24.75	0.53	0.48	5.00	0.00	0.24	0.24
24.80	0.53	0.48	5.00	0.00	0.24	0.24
24.85	0.53	0.48	5.00	0.00	0.24	0.24
24.90	0.53	0.48	5.00	0.00	0.24	0.24
24.95	0.53	0.48	5.00	0.00	0.24	0.24
25.00	0.53	0.48	5.00	0.00	0.24	0.24
25.05	0.53	0.48	5.00	0.00	0.24	0.24
25.10	0.53	0.48	5.00	0.00	0.24	0.24
25.15	0.53	0.48	5.00	0.00	0.24	0.24
25.20	0.53	0.48	5.00	0.00	0.24	0.24
25.25	0.53	0.48	5.00	0.00	0.24	0.24
25.30	0.53	0.48	5.00	0.00	0.24	0.24
25.35	0.53	0.48	5.00	0.00	0.24	0.24
25.40	0.53	0.48	5.00	0.00	0.24	0.24
25.45	0.53	0.48	5.00	0.00	0.24	0.24
25.50	0.53	0.48	5.00	0.00	0.24	0.24
25.55	0.53	0.48	5.00	0.00	0.23	0.23
25.60	0.53	0.48	5.00	0.00	0.23	0.23
25.65	0.53	0.48	5.00	0.00	0.23	0.23
25.70	0.53	0.48	5.00	0.00	0.23	0.23
25.75	0.53	0.48	5.00	0.00	0.23	0.23
25.80	0.53	0.48	5.00	0.00	0.23	0.23
25.85	0.53	0.48	5.00	0.00	0.23	0.23
25.90	0.53	0.48	5.00	0.00	0.23	0.23
25.95	0.53	0.48	5.00	0.00	0.23	0.23
26.00	0.53	0.48	5.00	0.00	0.23	0.23
26.05	0.53	0.48	5.00	0.00	0.23	0.23

26.10	0.53	0.48	5.00	0.00	0.23	0.23
26.15	0.53	0.48	5.00	0.00	0.23	0.23
26.20	0.53	0.48	5.00	0.00	0.23	0.23
26.25	0.53	0.48	5.00	0.00	0.23	0.23
26.30	0.53	0.48	5.00	0.00	0.23	0.23
26.35	0.53	0.48	5.00	0.00	0.23	0.23
26.40	0.53	0.48	5.00	0.00	0.23	0.23
26.45	0.53	0.48	5.00	0.00	0.23	0.23
26.50	0.53	0.48	5.00	0.00	0.23	0.23
26.55	0.53	0.48	5.00	0.00	0.23	0.23
26.60	0.53	0.48	5.00	0.00	0.22	0.22
26.65	0.53	0.48	5.00	0.00	0.22	0.22
26.70	0.53	0.48	5.00	0.00	0.22	0.22
26.75	0.53	0.48	5.00	0.00	0.22	0.22
26.80	0.53	0.48	5.00	0.00	0.22	0.22
26.85	0.53	0.48	5.00	0.00	0.22	0.22
26.90	0.53	0.48	5.00	0.00	0.22	0.22
26.95	0.53	0.48	5.00	0.00	0.22	0.22
27.00	0.53	0.48	5.00	0.00	0.22	0.22
27.05	0.53	0.48	5.00	0.00	0.22	0.22
27.10	0.53	0.47	5.00	0.00	0.22	0.22
27.15	0.53	0.47	5.00	0.00	0.22	0.22
27.20	0.53	0.47	5.00	0.00	0.22	0.22
27.25	0.53	0.47	5.00	0.00	0.22	0.22
27.30	0.53	0.47	5.00	0.00	0.22	0.22
27.35	0.53	0.47	5.00	0.00	0.22	0.22
27.40	0.53	0.47	5.00	0.00	0.22	0.22
27.45	0.53	0.47	5.00	0.00	0.22	0.22
27.50	0.53	0.47	5.00	0.00	0.22	0.22
27.55	0.53	0.47	5.00	0.00	0.22	0.22
27.60	0.53	0.47	5.00	0.00	0.21	0.21
27.65	0.53	0.47	5.00	0.00	0.21	0.21
27.70	0.53	0.47	5.00	0.00	0.21	0.21
27.75	0.53	0.47	5.00	0.00	0.21	0.21
27.80	0.53	0.47	5.00	0.00	0.21	0.21
27.85	0.53	0.47	5.00	0.00	0.21	0.21
27.90	0.53	0.47	5.00	0.00	0.21	0.21
27.95	0.53	0.47	5.00	0.00	0.21	0.21
28.00	0.53	0.47	5.00	0.00	0.21	0.21
28.05	0.53	0.47	5.00	0.00	0.21	0.21
28.10	0.53	0.47	5.00	0.00	0.21	0.21
28.15	0.53	0.47	5.00	0.00	0.21	0.21
28.20	0.53	0.47	5.00	0.00	0.21	0.21
28.25	0.53	0.47	5.00	0.00	0.21	0.21
28.30	0.53	0.47	5.00	0.00	0.21	0.21
28.35	0.53	0.47	5.00	0.00	0.21	0.21
28.40	0.53	0.47	5.00	0.00	0.21	0.21
28.45	0.53	0.47	5.00	0.00	0.21	0.21
28.50	0.53	0.47	5.00	0.00	0.21	0.21
28.55	0.53	0.47	5.00	0.00	0.20	0.20
28.60	0.53	0.47	5.00	0.00	0.20	0.20
28.65	0.53	0.47	5.00	0.00	0.20	0.20
28.70	0.53	0.47	5.00	0.00	0.20	0.20
28.75	0.53	0.47	5.00	0.00	0.20	0.20
28.80	0.53	0.47	5.00	0.00	0.20	0.20
28.85	0.53	0.47	5.00	0.00	0.20	0.20
28.90	0.53	0.47	5.00	0.00	0.20	0.20
28.95	0.53	0.47	5.00	0.00	0.20	0.20
29.00	0.53	0.47	5.00	0.00	0.20	0.20
29.05	0.53	0.47	5.00	0.00	0.20	0.20
29.10	0.53	0.47	5.00	0.00	0.20	0.20
29.15	0.53	0.47	5.00	0.00	0.20	0.20
29.20	0.53	0.47	5.00	0.00	0.20	0.20
29.25	0.53	0.47	5.00	0.00	0.20	0.20
29.30	0.53	0.47	5.00	0.00	0.20	0.20
29.35	0.53	0.47	5.00	0.00	0.20	0.20
29.40	0.53	0.47	5.00	0.00	0.20	0.20
29.45	0.53	0.47	5.00	0.00	0.19	0.19
29.50	0.53	0.47	5.00	0.00	0.19	0.19

29.55	0.53	0.47	5.00	0.00	0.19	0.19
29.60	0.53	0.47	5.00	0.00	0.19	0.19
29.65	0.53	0.47	5.00	0.00	0.19	0.19
29.70	0.53	0.47	5.00	0.00	0.19	0.19
29.75	0.53	0.47	5.00	0.00	0.19	0.19
29.80	0.53	0.47	5.00	0.00	0.19	0.19
29.85	0.53	0.47	5.00	0.00	0.19	0.19
29.90	0.53	0.47	5.00	0.00	0.19	0.19
29.95	0.53	0.47	5.00	0.00	0.19	0.19
30.00	0.53	0.47	5.00	0.00	0.19	0.19
30.05	0.53	0.47	5.00	0.00	0.19	0.19
30.10	0.53	0.47	5.00	0.00	0.19	0.19
30.15	0.53	0.47	5.00	0.00	0.19	0.19
30.20	0.53	0.47	5.00	0.00	0.19	0.19
30.25	0.53	0.47	5.00	0.00	0.19	0.19
30.30	0.53	0.47	5.00	0.00	0.18	0.18
30.35	0.53	0.47	5.00	0.00	0.18	0.18
30.40	0.53	0.47	5.00	0.00	0.18	0.18
30.45	0.53	0.47	5.00	0.00	0.18	0.18
30.50	0.53	0.47	5.00	0.00	0.18	0.18
30.55	0.53	0.47	5.00	0.00	0.18	0.18
30.60	0.53	0.47	5.00	0.00	0.18	0.18
30.65	0.53	0.47	5.00	0.00	0.18	0.18
30.70	0.53	0.47	5.00	0.00	0.18	0.18
30.75	0.53	0.47	5.00	0.00	0.18	0.18
30.80	0.53	0.47	5.00	0.00	0.18	0.18
30.85	0.53	0.47	5.00	0.00	0.18	0.18
30.90	0.52	0.47	5.00	0.00	0.18	0.18
30.95	0.52	0.47	5.00	0.00	0.18	0.18
31.00	0.52	0.47	5.00	0.00	0.18	0.18
31.05	0.52	0.47	5.00	0.00	0.18	0.18
31.10	0.52	0.47	5.00	0.00	0.17	0.17
31.15	0.52	0.47	5.00	0.00	0.17	0.17
31.20	0.52	0.47	5.00	0.00	0.17	0.17
31.25	0.52	0.47	5.00	0.00	0.17	0.17
31.30	0.52	0.47	5.00	0.00	0.17	0.17
31.35	0.52	0.47	5.00	0.00	0.17	0.17
31.40	0.52	0.47	5.00	0.00	0.17	0.17
31.45	0.52	0.47	5.00	0.00	0.17	0.17
31.50	0.52	0.47	5.00	0.00	0.17	0.17
31.55	0.52	0.47	5.00	0.00	0.17	0.17
31.60	0.52	0.46	5.00	0.00	0.17	0.17
31.65	0.52	0.46	5.00	0.00	0.17	0.17
31.70	0.52	0.46	5.00	0.00	0.17	0.17
31.75	0.52	0.46	5.00	0.00	0.17	0.17
31.80	0.52	0.46	5.00	0.00	0.17	0.17
31.85	0.52	0.46	5.00	0.00	0.17	0.17
31.90	0.52	0.46	5.00	0.00	0.16	0.16
31.95	0.52	0.46	5.00	0.00	0.16	0.16
32.00	0.52	0.46	5.00	0.00	0.16	0.16
32.05	0.52	0.46	5.00	0.00	0.16	0.16
32.10	0.52	0.46	5.00	0.00	0.16	0.16
32.15	0.52	0.46	5.00	0.00	0.16	0.16
32.20	0.52	0.46	5.00	0.00	0.16	0.16
32.25	0.52	0.46	5.00	0.00	0.16	0.16
32.30	0.52	0.46	5.00	0.00	0.16	0.16
32.35	0.52	0.46	5.00	0.00	0.16	0.16
32.40	0.52	0.46	5.00	0.00	0.16	0.16
32.45	0.52	0.46	5.00	0.00	0.16	0.16
32.50	0.52	0.46	5.00	0.00	0.16	0.16
32.55	0.52	0.46	5.00	0.00	0.16	0.16
32.60	0.52	0.46	5.00	0.00	0.16	0.16
32.65	0.52	0.46	5.00	0.00	0.16	0.16
32.70	0.52	0.46	5.00	0.00	0.16	0.16
32.75	0.52	0.46	5.00	0.00	0.15	0.15
32.80	0.52	0.46	5.00	0.00	0.15	0.15
32.85	0.52	0.46	5.00	0.00	0.15	0.15
32.90	0.52	0.46	5.00	0.00	0.15	0.15
32.95	0.52	0.46	5.00	0.00	0.15	0.15

33.00	0.52	0.46	5.00	0.00	0.15	0.15
33.05	0.52	0.46	5.00	0.00	0.15	0.15
33.10	0.52	0.46	5.00	0.00	0.15	0.15
33.15	0.52	0.46	5.00	0.00	0.15	0.15
33.20	0.52	0.46	5.00	0.00	0.15	0.15
33.25	0.52	0.46	5.00	0.00	0.15	0.15
33.30	0.52	0.46	5.00	0.00	0.15	0.15
33.35	0.52	0.46	5.00	0.00	0.15	0.15
33.40	0.52	0.46	5.00	0.00	0.15	0.15
33.45	0.52	0.46	5.00	0.00	0.15	0.15
33.50	0.52	0.46	5.00	0.00	0.15	0.15
33.55	0.52	0.46	5.00	0.00	0.15	0.15
33.60	0.52	0.46	5.00	0.00	0.14	0.14
33.65	0.52	0.46	5.00	0.00	0.14	0.14
33.70	0.52	0.46	5.00	0.00	0.14	0.14
33.75	0.52	0.46	5.00	0.00	0.14	0.14
33.80	0.52	0.46	5.00	0.00	0.14	0.14
33.85	0.52	0.46	5.00	0.00	0.14	0.14
33.90	0.52	0.46	5.00	0.00	0.14	0.14
33.95	0.52	0.46	5.00	0.00	0.14	0.14
34.00	0.52	0.45	5.00	0.00	0.14	0.14
34.05	0.52	0.45	5.00	0.00	0.14	0.14
34.10	0.52	0.45	5.00	0.00	0.14	0.14
34.15	0.52	0.45	5.00	0.00	0,14	0.14
34.20	0.52	0.45	5.00	0.00	0.14	0.14
34.25	0.52	0.45	5.00	0.00	0.14	0.14
34.30	0.52	0.45	5.00	0.00	0.14	0.14
34.35	0.52	0.45	5.00	0.00	0.14	0.14
34.40	0.52	0.45	5.00	0.00	0.14	0.14
34.45	0.52	0.45	5.00	0.00	0.14	0.14
34.50	0.52	0.45	5.00	0.00	0.14	0.14
34.55	0.52	0.45	5.00	0.00	0.13	0.13
34.60	0.52	0.45	5.00	0.00	0.13	0.13
34.65	0.51	0.45	5.00	0.00	0.13	0.13
34.70	0.51	0.45	5.00	0.00	0.13	0.13
34.75	0.51	0.45	5.00	0.00	0.13	0.13
34.80	0.51	0.45	5.00	0.00	0.13	0.13
34.85	0.51	0.45	5.00	0.00	0.13	0.13
34.90	0.51	0.45	5.00	0.00	0.13	0.13
34.95	0.51	0.45	5.00	0.00	0.13	0.13
35.00	0.51	0.45	5.00	0.00	0.13	0.13
35.05	0.51	0.45	5.00	0.00	0.13	0.13
35.10	0.51	0.45	5.00	0.00	0.13	0.13
35.15	0.51	0.45	5.00	0.00	0.13	0.13
35.20	0.51	0.45	5.00	0.00	0.13	0.13
35.25	0.51	0.45	5.00	0.00	0.13	0.13
35.30	0.51	0.45	5.00	0.00	0.13	0.13
35.35	0.51	0.45	5.00	0.00	0.13	0.13
35.40	0.51	0.45	5.00	0.00	0.13	0.13
35.45	0.51	0.45	5.00	0.00	0.13	0.13
35.50	0.51	0.45	5.00	0.00	0.12	0.12
35.55	0.51	0.45	5.00	0.00	0.12	0.12
35.60	0.51	0.45	5.00	0.00	0.12	0.12
35.65	0.51	0.45	5.00	0.00	0.12	0.12
35.70	0.51	0.45	5.00	0.00	0.12	0.12
35.75	0.51	0.45	5.00	0.00	0.12	0.12
35.80	0.51	0.45	5.00	0.00	0.12	0.12
35.85	0.51	0.45	5.00	0.00	0.12	0.12
35.90	0.51	0.45	5.00	0.00	0.12	0.12
35.95	0.51	0.45	5.00	0.00	0.12	0.12
36.00	0.51	0.45	5.00	0.00	0.12	0.12
36.05	0.51	0.45	5.00	0.00	0.12	0.12
36.10	0.51	0.45	5.00	0.00	0.12	0.12
36.15	0.51	0.45	5.00	0.00	0.12	0.12
36.20	0.51	0.45	5.00	0.00	0.12	0.12
36.25	0.51	0.45	5.00	0.00	0.12	0.12
36.30	0.51	0.45	5.00	0.00	0.12	0.12
36.35	0.51	0.45	5.00	0.00	0.12	0.12
36.40	0.51	0.45	5.00	0.00	0.12	0.12

36.45	0.51	0.44	5.00	0.00	0.12	0.12
36.50	0.51	0.44	5.00	0.00	0.11	0.11
36.55	0.51	0.44	5.00	0.00	0.11	0.11
36.60	0.51	0.44	5.00	0.00	0.11	0.11
36.65	0.51	0.44	5.00	0.00	0.11	0.11
36.70	0.51	0.44	5.00	0.00	0.11	0.11
36.75	0.51	0.44	5.00	0.00	0.11	0.11
36.80	0.51	0.44	5.00	0.00	0.11	0.11
36.85	0.51	0.44	5.00	0.00	0.11	0.11
36.90	0.51	0.44	5.00	0.00	0.11	0.11
36.95	0.51	0.44	5.00	0.00	0.11	0.11
37.00	0.51	0.44	5.00	0.00	0.11	0.11
37.05	0.51	0.44	5.00	0.00	0.11	0.11
37.10	0.51	0.44	5.00	0.00	0.11	0.11
37.15	0.51	0.44	5.00	0.00	0.11	0.11
37.20	0.51	0.44	5.00	0.00	0.11	0.11
37.25	0.51	0.44	5.00	0.00	0.11	0.11
37.30	0.51	0.44	5.00	0.00	0.11	0.11
37.35	0.51	0.44	5.00	0.00	0.11	0.11
37.40	0.51	0.44	5.00	0.00	0.11	0.11
37.45	0.51	0.44	5.00	0.00	0.11	0.11
37.50	0.51	0.44	5.00	0.00	0.10	0.10
37.55	0.51	0.44	5.00	0.00	0.10	0.10
37.60	0.51	0.44	5.00	0.00	0.10	0.10
37.65	0.51	0.44	5.00	0.00	0.10	0.10
37.70	0.51	0.44	5.00	0.00	0.10	0.10
37.75	0.51	0.44	5.00	0.00	0.10	0.10
37.80	0.51	0.44	5.00	0.00	0.10	0.10
37.85	0.51	0.44	5.00	0.00	0.10	0.10
37.90	0.51	0.44	5.00	0.00	0.10	0.10
37.95	0.51	0.44	5.00	0.00	0.10	0.10
38.00	0.51	0.44	5.00	0.00	0.10	0.10
38.05	0.51	0.44	5.00	0.00	0.10	0.10
38.10	0.51	0.44	5.00	0.00	0.10	0.10
38.15	0.51	0.44	5.00	0.00	0.10	0.10
38.20	0.51	0.44	5.00	0.00	0.10	0.10
38.25	0.51	0.44	5.00	0.00	0.10	0.10
38.30	0.51	0.44	5.00	0.00	0.10	0.10
38.35	0.51	0.44	5.00	0.00	0.10	0.10
38.40	0.50	0.44	5.00	0.00	0.10	0.10
38.45	0.50	0.44	5.00	0.00	0.10	0.10
38.50	0.50	0.44	5.00	0.00	0.09	0.09
38.55	0.50	0.44	5.00	0.00	0.09	0.09
38.60	0.50	0.44	5.00	0.00	0.09	0.09
38.65	0.50	0.44	5.00	0.00	0.09	0.09
38.70	0.50	0.44	5.00	0.00	0.09	0.09
38.75	0.50	0.44	5.00	0.00	0.09	0.09
38.80	0.50	0.44	5.00	0.00	0.09	0.09
38.85	0.50	0.43	5.00	0.00	0.09	0.09
38.90	0.50	0.43	5.00	0.00	0.09	0.09
38.95	0.50	0.43	5.00	0.00	0.09	0.09
39.00	0.50	0.43	5.00	0.00	0.09	0.09
39.05	0.50	0.43	5.00	0.00	0.09	0.09
39.10	0.50	0.43	5.00	0.00	0.09	0.09
39.15	0.50	0.43	5.00	0.00	0.09	0.09
39.20	0.50	0.43	5.00	0.00	0.09	0.09
39.25	0.50	0.43	5.00	0.00	0.09	0.09
39.30	0.50	0.43	5.00	0.00	0.09	0.09
39.35	0.50	0.43	5.00	0.00	0.09	0.09
39.40	0.50	0.43	5.00	0.00	0.09	0.09
39.45	0.50	0.43	5.00	0.00	0.08	0.08
39.50	0.50	0.43	5.00	0.00	0.08	0.08
39.55	0.50	0.43	5.00	0.00	0.08	0.08
39.60	0.50	0.43	5.00	0.00	0.08	0.08
39.65	0.50	0.43	5.00	0.00	0.08	0.08
39.70	0.50	0.43	5.00	0.00	0.08	0.08
39.75	0.50	0.43	5.00	0.00	0.08	0.08
39.80	0.50	0.43	5.00	0.00	0.08	0.08
39.85	0.50	0.43	5.00	0.00	0.08	0.08

39.90	0.50	0.43	5.00	0.00	0.08	0.08
39.95	0.50	0.43	5.00	0.00	0.08	0.08
40.00	0.50	0.43	5.00	0.00	0.08	0.08
40.05	0.50	0.43	5.00	0.00	0.08	0.08
40.10	0.50	0.43	5.00	0.00	0.08	0.08
40.15	0.50	0.43	5.00	0.00	0.08	0.08
40.20	0.50	0.43	5.00	0.00	0.08	0.08
40.25	0.50	0.43	5.00	0.00	0.08	0.08
40.30	0.50	0.43	5.00	0.00	0.08	0.08
40.35	0.50	0.43	5.00	0.00	0.07	0.07
40.40	0.50	0.43	5.00	0.00	0.07	0.07
40.45	0.50	0.43	5.00	0.00	0.07	0.07
40.50	0.50	0.43	5.00	0.00	0.07	0.07
40.55	0.50	0.43	5.00	0.00	0.07	0.07
40.60	0.50	0.43	5.00	0.00	0.07	0.07
40.65	0.50	0.43	5.00	0.00	0.07	0.07
40.70	0.50	0.43	5.00	0.00	0.07	0.07
40.75	0.50	0.43	5.00	0.00	0.07	0.07
40.80	0.50	0.43	5.00	0.00	0.07	0.07
40.85	0.50	0.43	5.00	0.00	0.07	0.07
40.90	0.50	0.43	5.00	0.00	0.07	0.07
40.95	0.50	0.43	5.00	0.00	0.07	0.07
41.00	0.50	0.43	5.00	0.00	0.07	0.07
41.05	0.50	0.43	5.00	0.00	0.07	0.07
41.10	0.50	0.43	5.00	0.00	0.07	0.07
41.15	0.50	0.43	5.00	0.00	0.07	0.07
41.20	0.50	0.43	5.00	0.00	0.07	0.07
41.25	0.50	0.43	5.00	0.00	0.06	0.06
41.30	0.50	0.42	5.00	0.00	0.06	0.06
41.35	0.50	0.42	5.00	0.00	0.06	0.06
41.40	0.50	0.42	5.00	0.00	0.06	0.06
41.45	0.50	0.42	5.00	0.00	0.06	0.06
41.50	0.50	0.42	5.00	0.00	0.06	0.06
41.55	0.50	0.42	5.00	0.00	0.06	0.06
41.60	0.50	0.42	5.00	0.00	0.06	0.06
41.65	0.50	0.42	5.00	0.00	0.06	0.06
41.70	0.50	0.42	5.00	0.00	0.06	0.06
41.75	0.50	0.42	5.00	0.00	0.06	0.06
41.80	0.49	0.42	5.00	0.00	0.06	0.06
41.85	0.49	0.42	5.00	0.00	0.06	0.06
41.90	0.49	0.42	5.00	0.00	0.06	0.06
41.95	0.49	0.42	5.00	0.00	0.06	0.06
42.00	0.49	0.42	5.00	0.00	0.06	0.06
42.05	0.49	0.42	5.00	0.00	0.06	0.06
42.10	0.49	0.42	5.00	0.00	0.06	0.06
42.15	0.49	0.42	5.00	0.00	0.05	0.05
42.20	0.49	0.42	5.00	0.00	0.05	0.05
42.25	0.49	0.42	5.00	0.00	0.05	0.05
42.30	0.49	0.42	5.00	0.00	0.05	0.05
42.35	0.49	0.42	5.00	0.00	0.05	0.05
42.40	0.49	0.42	5.00	0.00	0.05	0.05
42.45	0.49	0.42	5.00	0.00	0.05	0.05
42.50	0.49	0.42	5.00	0.00	0.05	0.05
42.55	0.49	0.42	5.00	0.00	0.05	0.05
42.60	0.49	0.42	5.00	0.00	0.05	0.05
42.65	0.49	0.42	5.00	0.00	0.05	0.05
42.70	0.49	0.42	5.00	0.00	0.05	0.05
42.75	0.49	0.42	5.00	0.00	0.05	0.05
42.80	0.49	0.42	5.00	0.00	0.05	0.05
42.85	0.49	0.42	5.00	0.00	0.05	0.05
42.90	0.49	0.42	5.00	0.00	0.05	0.05
42.95	0.49	0.42	5.00	0.00	0.05	0.05
43.00	0.49	0.42	5.00	0.00	0.05	0.05
43.05	0.49	0.42	5.00	0.00	0.05	0.05
43.10	0.49	0.42	5.00	0.00	0.05	0.05
43.15	0.49	0.42	5.00	0.00	0.05	0.05
43.20	0.49	0.42	5.00	0.00	0.05	0.05
43.25	0.49	0.42	5.00	0.00	0.05	0.05
43.30	0.49	0.42	5.00	0.00	0.04	0.04

43.35	0.49	0.42	5.00	0.00	0.04	0.04
43.40	0.49	0.42	5.00	0.00	0.04	0.04
43.45	0.49	0.42	5.00	0.00	0.04	0.04
43.50	0.49	0.42	5.00	0.00	0.04	0.04
43.55	0.49	0.42	5.00	0.00	0.04	0.04
43.60	0.49	0.42	5.00	0.00	0.04	0.04
43.65	0.49	0.42	5.00	0.00	0.04	0.04
43.70	0.49	0.41	5.00	0.00	0.04	0.04
43.75	0.49	0.41	5.00	0.00	0.04	0.04
43.80	0.49	0.41	5.00	0.00	0.04	0.04
43.85	0.49	0.41	5.00	0.00	0.04	0.04
43.90	0.49	0.41	5.00	0.00	0.04	0.04
43.95	0.49	0.41	5.00	0.00	0.04	0.04
44.00	0.49	0.41	5.00	0.00	0.04	0.04
44.05	0.49	0.41	5.00	0.00	0.04	0.04
44.10	0.49	0.41	5.00	0.00	0.04	0.04
44.15	0.49	0.41	5.00	0.00	0.04	0.04
44.20	0.49	0.41	5.00	0.00	0.04	0.04
44.25	0.49	0.41	5.00	0.00	0.04	0.04
44.30	0.49	0.41	5.00	0.00	0.04	0.04
44.35	0.49	0.41	5.00	0.00	0.04	0.04
44.40	0.49	0.41	5.00	0.00	0.03	0.03
44.45	0.49	0.41	5.00	0.00	0.03	0.03
44.50	0.49	0.41	5.00	0.00	0.03	0.03
44.55	0.49	0.41	5.00	0.00	0.03	0.03
44.60	0.49	0.41	5.00	0.00	0.03	0.03
44.65	0.49	0.41	5.00	0.00	0.03	0.03
44.70	0.49	0.41	5.00	0.00	0.03	0.03
44.75	0.49	0.41	5.00	0.00	0.03	0.03
44.80	0.49	0.41	5.00	0.00	0.03	0.03
44.85	0.49	0.41	5.00	0.00	0.03	0.03
44.90	0.49	0.41	5.00	0.00	0.03	0.03
44.95	0.49	0.41	5.00	0.00	0.03	0.03
45.00	0.49	0.41	5.00	0.00	0.03	0.03
45.05	0.49	0.41	5.00	0.00	0.03	0.03
45.10	0.49	0.41	5.00	0.00	0.03	0.03
45.15	0.49	0.41	5.00	0.00	0.03	0.03
45.20	0.48	0.41	5.00	0.00	0.03	0.03
45.25	0.48	0.41	5.00	0.00	0.03	0.03
45.30	0.48	0.41	5.00	0.00	0.03	0.03
45.35	0.48	0.41	5.00	0.00	0.02	0.02
45.40	0.48	0.41	5.00	0.00	0.02	0.02
45.45	0.48	0.41	5.00	0.00	0.02	0.02
45.50	0.48	0.41	5.00	0.00	0.02	0.02
45.55	0.48	0.41	5.00	0.00	0.02	0.02
45.60	0.48	0.41	5.00	0.00	0.02	0.02
45.65	0.48	0.41	5.00	0.00	0.02	0.02
45.70	0.48	0.41	5.00	0.00	0.02	0.02
45.75	0.48	0.41	5.00	0.00	0.02	0.02
45.80	0.48	0.41	5.00	0.00	0.02	0.02
45.85	0.48	0.41	5.00	0.00	0.02	0.02
45.90	0.48	0.41	5.00	0.00	0.02	0.02
45.95	0.48	0.41	5.00	0.00	0.02	0.02
46.00	0.48	0.41	5.00	0.00	0.02	0.02
46.05	0.48	0.41	5.00	0.00	0.01	0.01
46.10	0.48	0.41	5.00	0.00	0.01	0.01
46.15	0.48	0.40	5.00	0.00	0.01	0.01
46.20	0.48	0.40	5.00	0.00	0.01	0.01
46.25	0.48	0.40	5.00	0.00	0.01	0.01
46.30	0.48	0.40	5.00	0.00	0.01	0.01
46.35	0.48	0.40	5.00	0.00	0.01	0.01
46.40	0.48	0.40	5.00	0.00	0.01	0.01
46.45	0.48	0.40	5.00	0.00	0.01	0.01
46.50	0.48	0.40	5.00	0.00	0.01	0.01
46.55	0.48	0.40	5.00	0.00	0.01	0.01
46.60	0.48	0.40	5.00	0.00	0.01	0.01
46.65	0.48	0.40	5.00	0.00	0.01	0.01
46.70	0.48	0.40	5.00	0.00	0.01	0.01
46.75	0.48	0.40	5.00	0.00	0.00	0.00

46.80	0.48	0.40	5.00	0.00	0.00	0.00
46.85	0.48	0.40	5.00	0.00	0.00	0.00
46.90	0.48	0.40	5.00	0.00	0.00	0.00
46.95	0.48	0.40	5.00	0.00	0.00	0.00
47.00	0.48	0.40	5.00	0.00	0.00	0.00
47.05	2.00	0.40	5.00	0.00	0.00	0.00
47.10	2.00	0.40	5.00	0.00	0.00	0.00
47.15	2.00	0.40	5.00	0.00	0.00	0.00
47.20	2.00	0.40	5.00	0.00	0.00	0.00
47.25	2.00	0.40	5.00	0.00	0.00	0.00
47.30	2.00	0.40	5.00	0.00	0.00	0.00
47.35	2.00	0.40	5.00	0.00	0.00	0.00
47.40	2.00	0.40	5.00	0.00	0.00	0.00
47.45	2.00	0.40	5.00	0.00	0.00	0.00
47.50	2.00	0.40	5.00	0.00	0.00	0.00
47.55	2.00	0.40	5.00	0.00	0.00	0.00
47.60	2.00	0.40	5.00	0.00	0.00	0.00
47.65	2.00	0.40	5.00	0.00	0.00	0.00
47.70	2.00	0.40	5.00	0.00	0.00	0.00
47.75	2.00	0.40	5.00	0.00	0.00	0.00
47.80	2.00	0.40	5.00	0.00	0.00	0.00
47.85	2.00	0.40	5.00	0.00	0.00	0.00
47.90	2.00	0.40	5.00	0.00	0.00	0.00
47.95	2.00	0.40	5.00	0.00	0.00	0.00
48.00	2.00	0.40	5.00	0.00	0.00	0.00
48.05	2.00	0.40	5.00	0.00	0.00	0.00
48.10	2.00	0.40	5.00	0.00	0.00	0.00
48.15	2.00	0.40	5.00	0.00	0.00	0.00
48.20	2.00	0.40	5.00	0.00	0.00	0.00
48.25	2.00	0.40	5.00	0.00	0.00	0.00
48.30	2.00	0.40	5.00	0.00	0.00	0.00
48.35	2.00	0.40	5.00	0.00	0.00	0.00
48.40	2.00	0.40	5.00	0.00	0.00	0.00
48.45	2.00	0.40	5.00	0.00	0.00	0.00
48.50	2.00	0.40	5.00	0.00	0.00	0.00
48.55	2.00	0.39	5.00	0.00	0.00	0.00
48.60	2.00	0.39	5.00	0.00	0.00	0.00
48.65	2.00	0.39	5.00	0.00	0.00	0.00
48.70	2.00	0.39	5.00	0.00	0.00	0.00
48.75	2.00	0.39	5.00	0.00	0.00	0.00
48.80	2.00	0.39	5.00	0.00	0.00	0.00
48.85	2.00	0.39	5.00	0.00	0.00	0.00
48.90	2.00	0.39	5.00	0.00	0.00	0.00
48.95	2.00	0.39	5.00	0.00	0.00	0.00
49.00	2.00	0.39	5.00	0.00	0.00	0.00
49.05	2.00	0.39	5.00	0.00	0.00	0.00
49.10	2.00	0.39	5.00	0.00	0.00	0.00
49.15	2.00	0.39	5.00	0.00	0.00	0.00
49.20	2.00	0.39	5.00	0.00	0.00	0.00
49.25	2.00	0.39	5.00	0.00	0.00	0.00
49.30	2.00	0.39	5.00	0.00	0.00	0.00
49.35	2.00	0.39	5.00	0.00	0.00	0.00
49.40	2.00	0.39	5.00	0.00	0.00	0.00
49.45	2.00	0.39	5.00	0.00	0.00	0.00
49.50	2.00	0.39	5.00	0.00	0.00	0.00
49.55	2.00	0.39	5.00	0.00	0.00	0.00
49.60	2.00	0.39	5.00	0.00	0.00	0.00
49.65	2.00	0.39	5.00	0.00	0.00	0.00
49.70	2.00	0.39	5.00	0.00	0.00	0.00
49.75	2.00	0.39	5.00	0.00	0.00	0.00
49.80	2.00	0.39	5.00	0.00	0.00	0.00
49.85	2.00	0.39	5.00	0.00	0.00	0.00
49.90	2.00	0.39	5.00	0.00	0.00	0.00
49.95	2.00	0.39	5.00	0.00	0.00	0.00
50.00	2.00	0.39	5.00	0.00	0.00	0.00
50.05	2.00	0.39	5.00	0.00	0.00	0.00
50.10	2.00	0.39	5.00	0.00	0.00	0.00
50.15	2.00	0.39	5.00	0.00	0.00	0.00
50.20	2.00	0.39	5.00	0.00	0.00	0.00

50.25	2.00	0.39	5.00	0.00	0.00	0.00
50.30	2.00	0.39	5.00	0.00	0.00	0.00
50.35	2.00	0.39	5.00	0.00	0.00	0.00
50.40	2.00	0.39	5.00	0.00	0.00	0.00
50.45	2.00	0.39	5.00	0.00	0.00	0.00
50.50	2.00	0.39	5.00	0.00	0.00	0.00
50.55	2.00	0.39	5.00	0.00	0.00	0.00
50.60	2.00	0.39	5.00	0.00	0.00	0.00
50.65	2.00	0.39	5.00	0.00	0.00	0.00
50.70	2.00	0.39	5.00	0.00	0.00	0.00
50.75	2.00	0.39	5.00	0.00	0.00	0.00
50.80	2.00	0.39	5.00	0.00	0.00	0.00
50.85	2.00	0.39	5.00	0.00	0.00	0.00
50.90	2.00	0.39	5.00	0.00	0.00	0.00
50.95	2.00	0.39	5.00	0.00	0.00	0.00
51.00	2.00	0.38	5.00	0.00	0.00	0.00

* F.S.<1, Liquefaction Potential Zone
(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

1 atm (atmosphere) = 1 tsf (ton/ft2)

CRRm	Cyclic resistance ratio from soils
CSRsf	Cyclic stress ratio induced by a given earthquake (with user request factor of safety)
F.S.	Factor of Safety against liquefaction, F.S.=CRRm/CSRsf
S_sat	Settlement from saturated sands
S_dry	Settlement from Unsaturated Sands
S_all	Total Settlement from Saturated and Unsaturated Sands
NoLiq	No-Liquefy Soils

APPENDIX E

FIGURES & TABLES

- **ALLOWABLE COMPRESSIVE RESISTANCE VS PILE EMBEDMENT FOR A 24 INCH CIDH PILE, Figure A**
- **AXIAL LOAD VS SETTLEMENT (AVERAGED)FOR 24 INCH DIA CIDH, Figure B**
- **LATERAL LOAD VS TOP DEFLECTION FOR A 24 INCH DIAMETER FIXED-HEADED CIDH PILE, Figure C**
- **LATERAL LOAD VS TOP DEFLECTION FOR A 24 INCH DIAMETER FREE-HEADED CIDH PILE, Figure D**
- **LATERAL PILE DEFLECTION, BENDING-MOMENT, AND SHEAR-FORCE VS DISTANCE 24 INCH FIXED HEADED, Figure E**
- **LATERAL PILE DEFLECTION, BENDING-MOMENT, AND SHEAR-FORCE VS DISTANCE 24 INCH FREE HEADED, Figure F**
- **MAXIMUM MOMENT VS LATERAL LOAD FOR A 24 INCH DIAMETER FIXED-HEADED CIDH PILE, Figure G**
- **MAXIMUM MOMENT VS LATERAL LOAD FOR A 24 INCH DIAMETER FREE-HEADED CIDH PILE, Figure H**
- **MOMENT PUSHOVER ANALYSIS FOR FIXED HEADED AND FREE HEADED 24 INCH DIAMETER CIDH PILE, Figure I**
- **PILE DEFLECTION, CURVATURE, AND BENDING-MOMENT VS DISTANCE OF 24 INCH FIXED, Figure J**
- **PILE DEFLECTION, CURVATURE, MOMENT VS. DEPTH FOR 24 INCH FREE HEADED, Figure K**
- **SHEAR PUSHOVER ANALYSIS FOR FIXED HEADED AND FREE HEADED 24 INCH DIAMETER CIDH PILE, Figure L**
- **ALLOWABLE COMPRESSIVE RESISTANCE VS PILE EMBEDMENT LENTH FOR A 36 INCH, Figure M**
- **AXIAL LOAD VS SETTLEMENT FOR A 36 INCH DIAMETER PILE, Figure N**
- **DEFLECTION, CURVATURE, MOMENT VS. DEPTH 36 INCH FREE HEADED, Figure O**
- **DEFLECTION, CURVATURE, MOMENT VS. DEPTH FOR A 36 INCH DIA. FIXED HEADED, Figure P**
- **LOAD VS. TOP DEFLECTION 36 INCH FIXED HEADED CIDH PILE, Figure Q**
- **LOAD VS. TOP DEFLECTION 36 INCH FREE HEADED, Figure R**
- **MAXIMUM MOMENT VS LATERAL LOAD FOR A 36 INCH DIAMETER FREE-HEADED CIDH PILE, Figure S**
- **MAXIMUM MOMENT VS. LATERAL LOAD FOR A 36 INCH DIA. FIXED-HEADED CIDH PILE, Figure T**
- **MOMENT PUSHOVER ANALYSIS FOR A 36 INCH DIAMETER PILE, Figure U**
- **PILE DEFLECTION BENDING MOMENT AND SHEAR FORCE VS DISTANCE 36 INCH FIXED HEADED, Figure V**
- **PILE DEFLECTION BENDING MOMENT AND SHEAR FORCE VS DISTANCE 36 INCH FREE HEADED, Figure W**
- **SHEAR PUSHOVER ANALYSES FOR FIXED AND FREE HEADED 36 INCH DIAMETER PILES, Figure X**

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ALLOWABLE COMPRESSIVE RESISTANCE VS PILE EMBEDMENT LENTH FOR A 24 INCH DIAMETER CIDH PILE

Resistance/F.S. (tons)

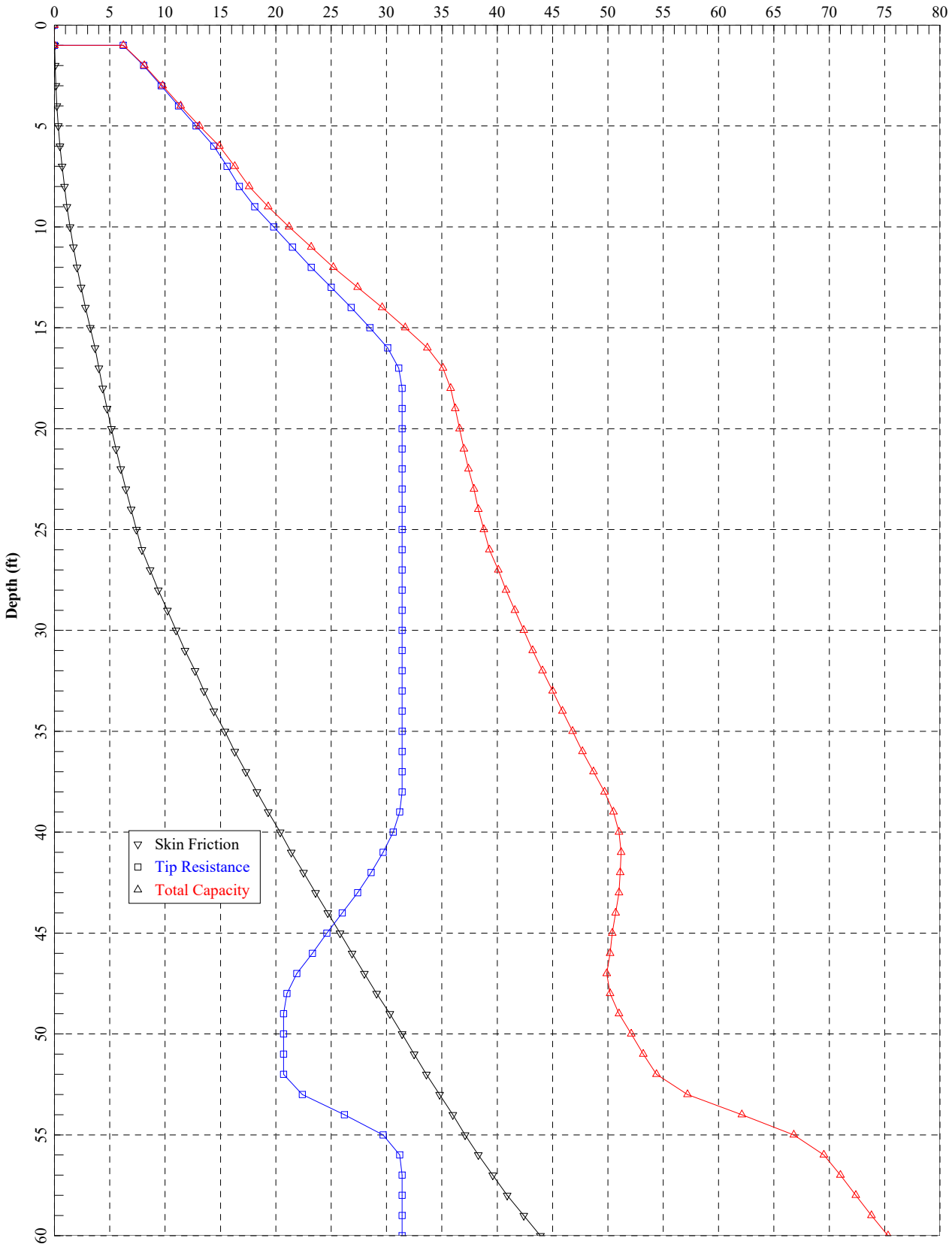


Figure A

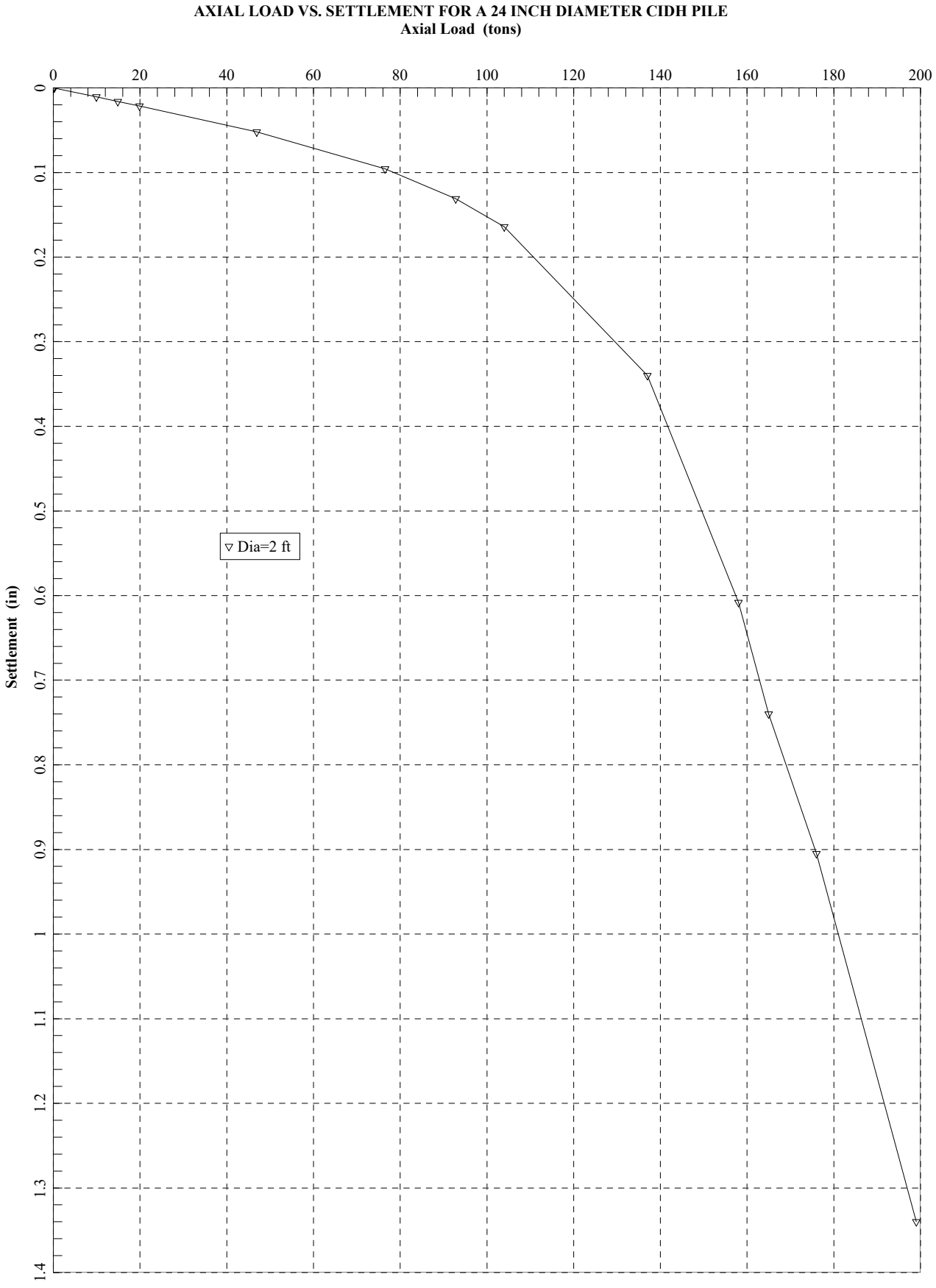

AXIAL LOAD VS. SETTLEMENT FOR A 24 INCH DIAMETER CIDH PILE
Axial Load (tons)
0
20
40
60
80
100
120
140
160
180
200
Settlement (in)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
▽ Dia=2 ft

Figure B

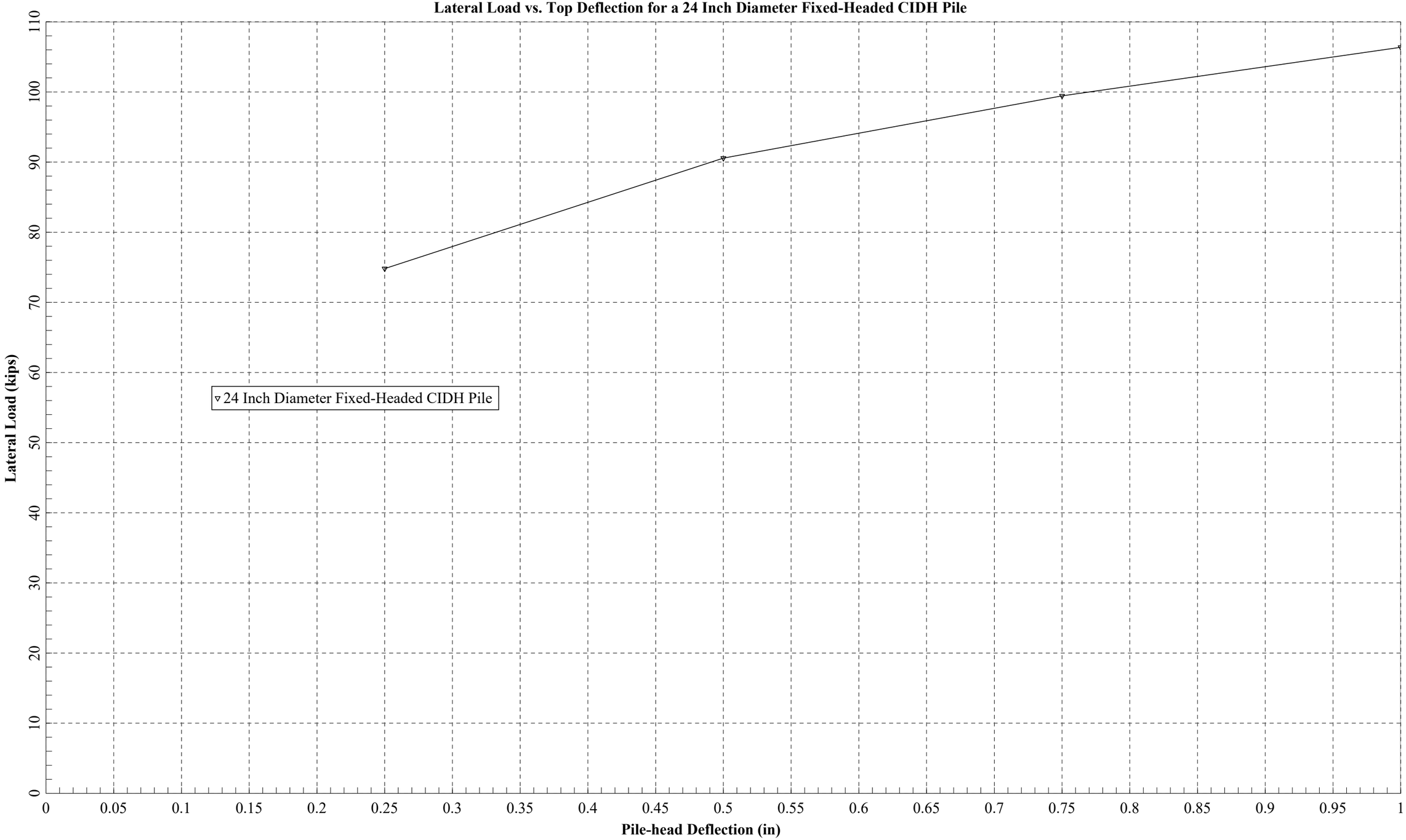

Lateral Load vs. Top Deflection for a 24 Inch Diameter Fixed-Headed CIDH Pile
Lateral Load (kips)
Pile-head Deflection (in)
24 Inch Diameter Fixed-Headed CIDH Pile
0
10
20
30
40
50
60
70
80
90
100
110
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1

Figure C

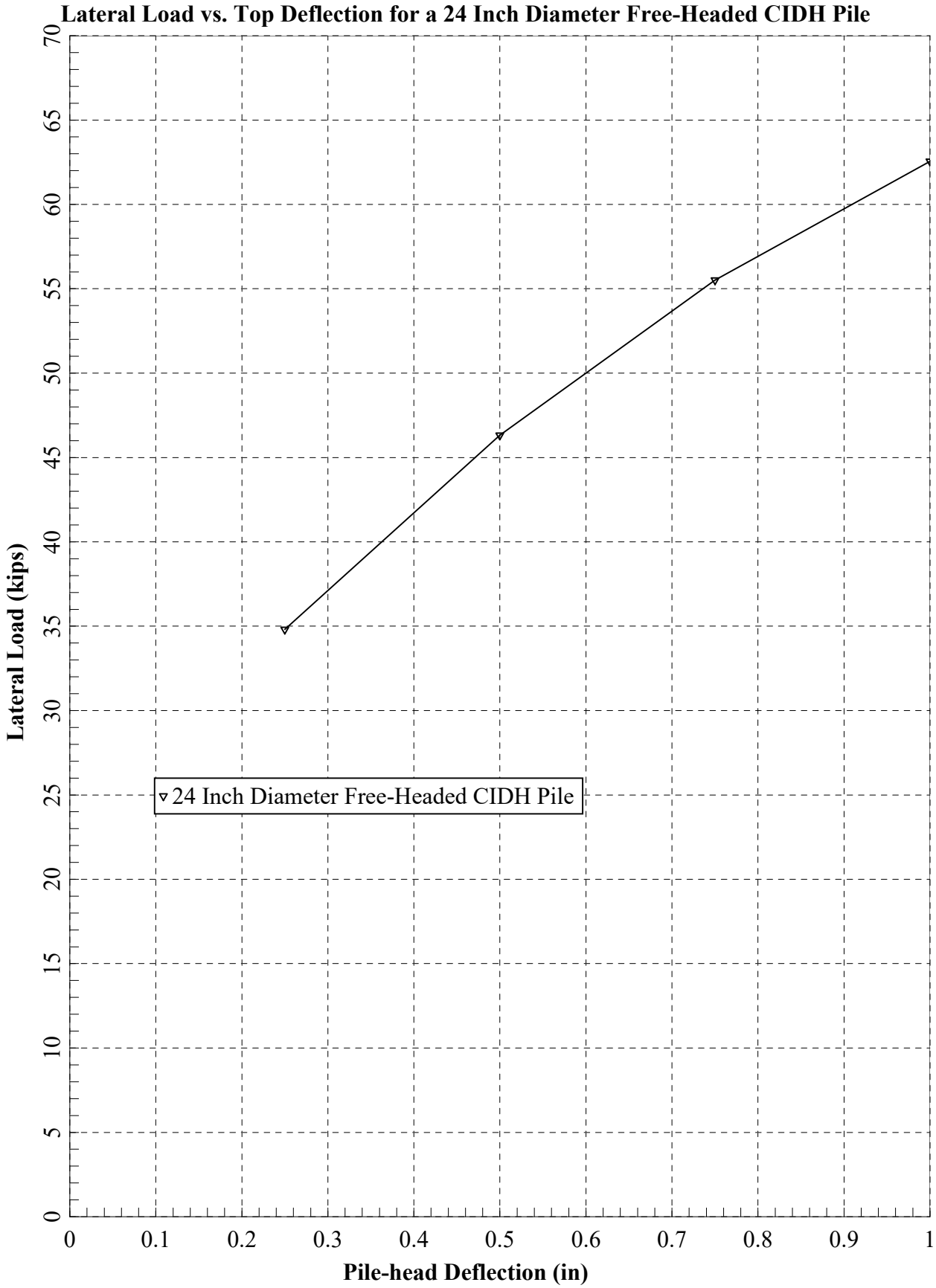

Lateral Load vs. Top Deflection for a 24 Inch Diameter Free-Headed CIDH Pile
Lateral Load (kips)
Pile-head Deflection (in)
24 Inch Diameter Free-Headed CIDH Pile
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

Figure D

LATERAL PILE DEFLECTION, BENDING-MOMENT, AND SHEAR-FORCE VS DISTANCE FROM TOP OF A 24 INCH DIAMETER FIXED-HEADED PILE

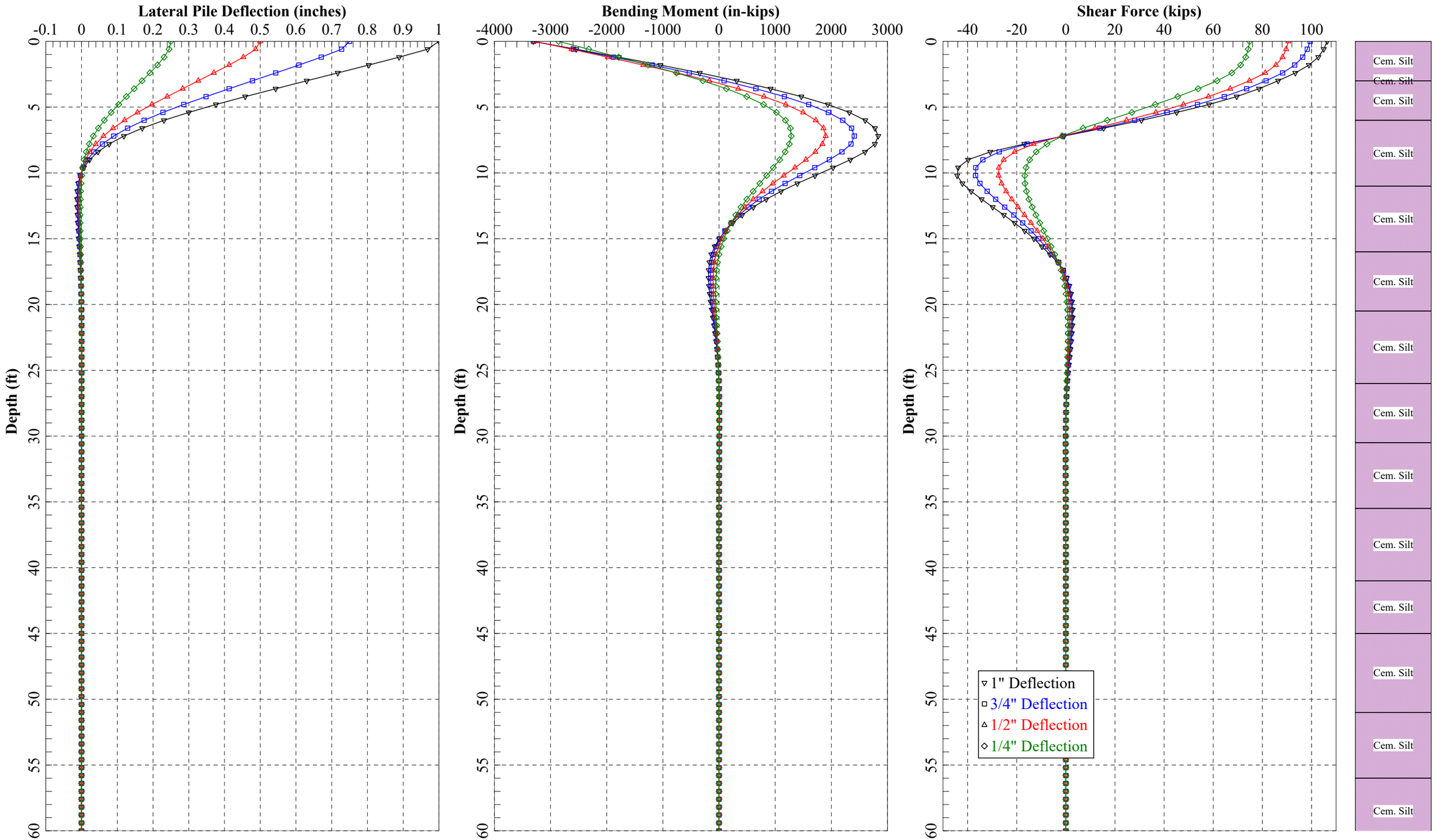


Figure E

LATERAL PILE DEFLECTION, BENDING-MOMENT, AND SHEAR-FORCE VS DISTANCE FROM TOP OF A 24 INCH DIAMETER FREE-HEADED CIDH PILE

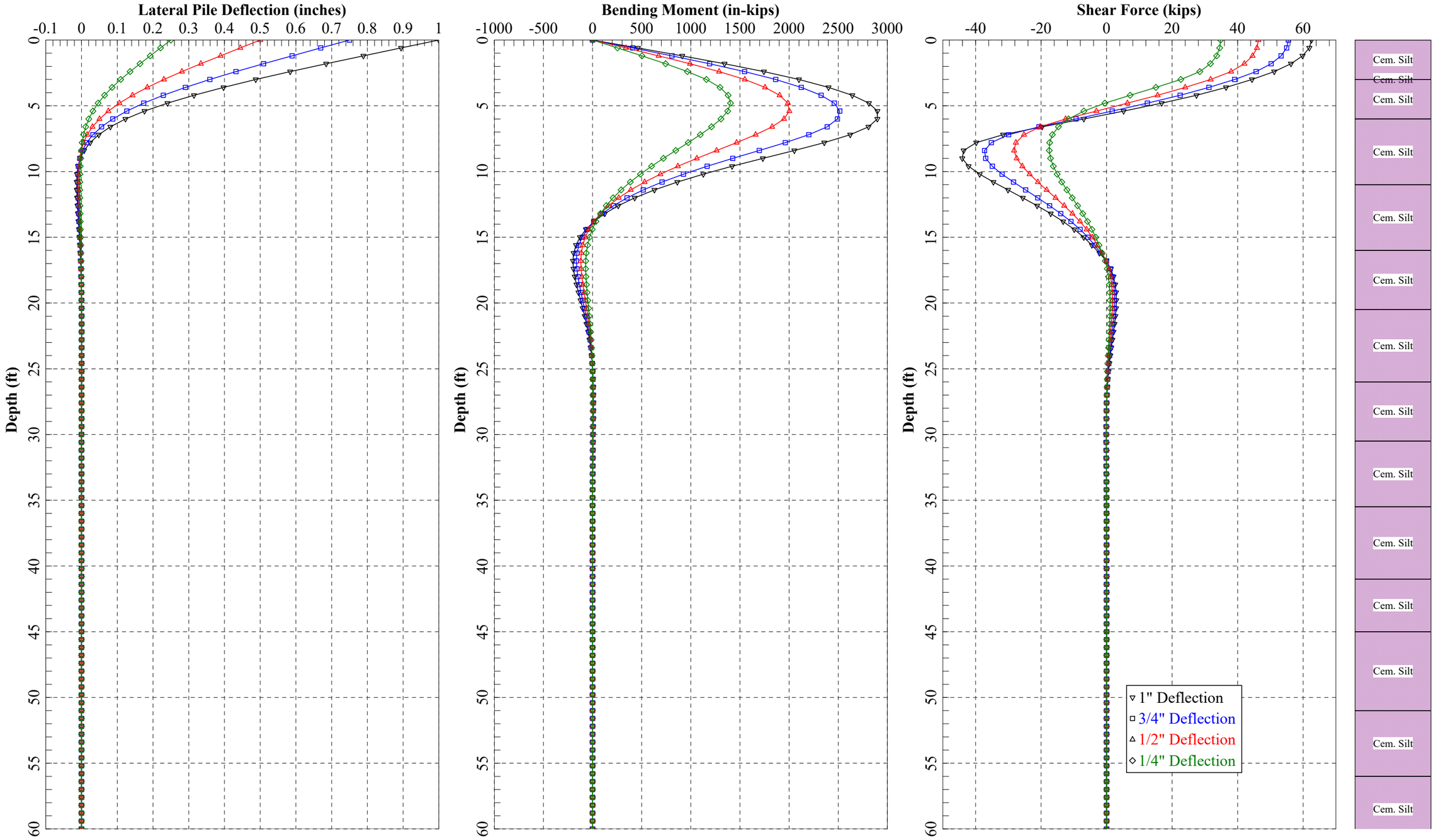


Figure F

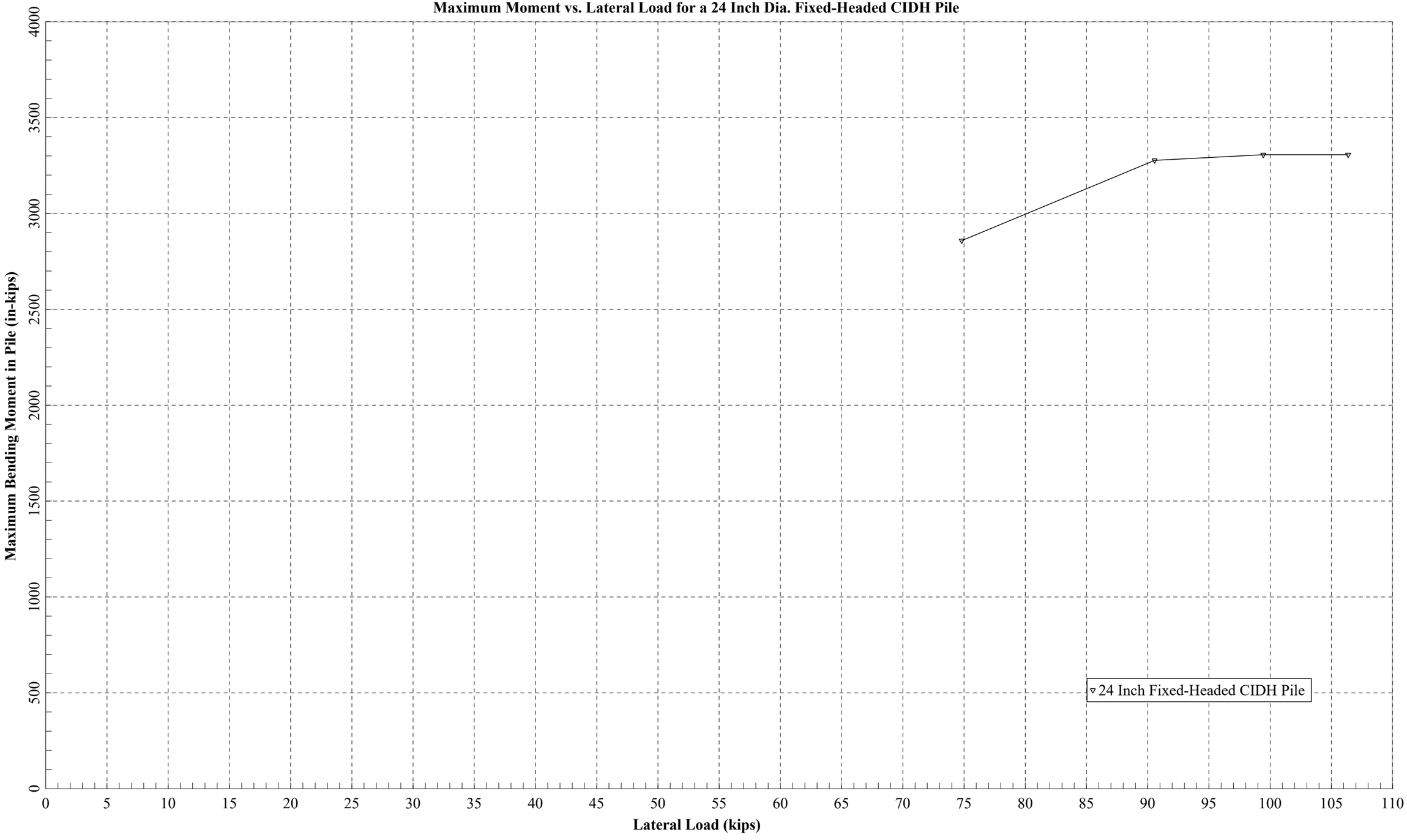

Maximum Moment vs. Lateral Load for a 24 Inch Dia. Fixed-Headed CIDH Pile
Maximum Bending Moment in Pile (in-kips)
0
500
1000
1500
2000
2500
3000
3500
4000
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
Lateral Load (kips)
24 Inch Fixed-Headed CIDH Pile

Figure G

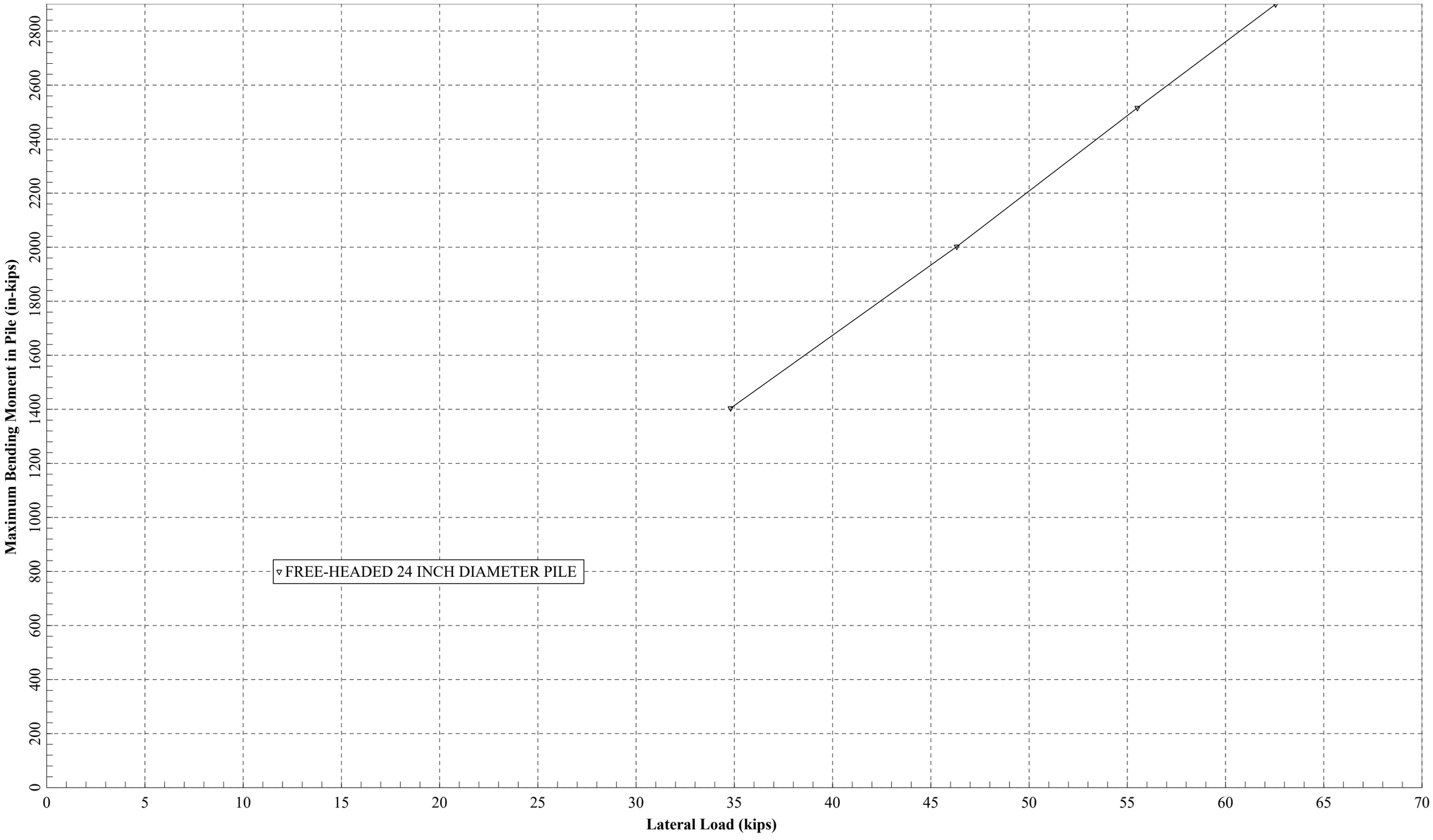

Maximum Moment vs. Lateral Load for a 24 Inch Dia. Free-Headed CIDH Pile
Maximum Bending Moment in Pile (in-kips)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
FREE-HEADED 24 INCH DIAMETER PILE
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
Lateral Load (kips)

Figure H

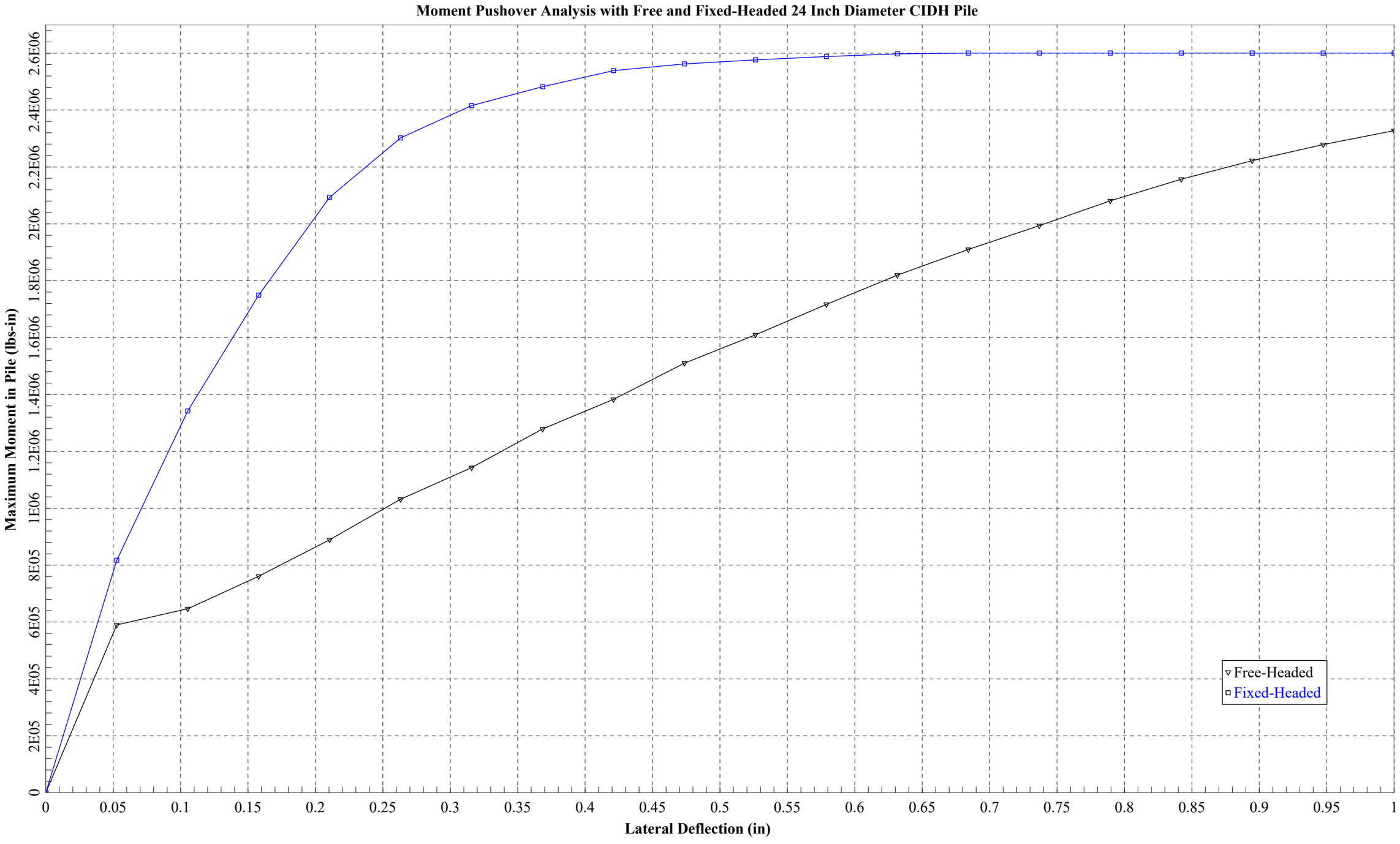

Moment Pushover Analysis with Free and Fixed-Headed 24 Inch Diameter CIDH Pile
Maximum Moment in Pile (lbs-in)
0
2E05
4E05
6E05
8E05
1E06
1.2E06
1.4E06
1.6E06
1.8E06
2E06
2.2E06
2.4E06
2.6E06
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1
Lateral Deflection (in)
Free-Headed
Fixed-Headed

Figure I

LATERAL PILE DEFLECTION, CURVATURE, AND BENDING-MOMENT VS DISTANCE FROM TOP OF A 24 INCH DIAMETER FIXED-HEADED CIDH PILE

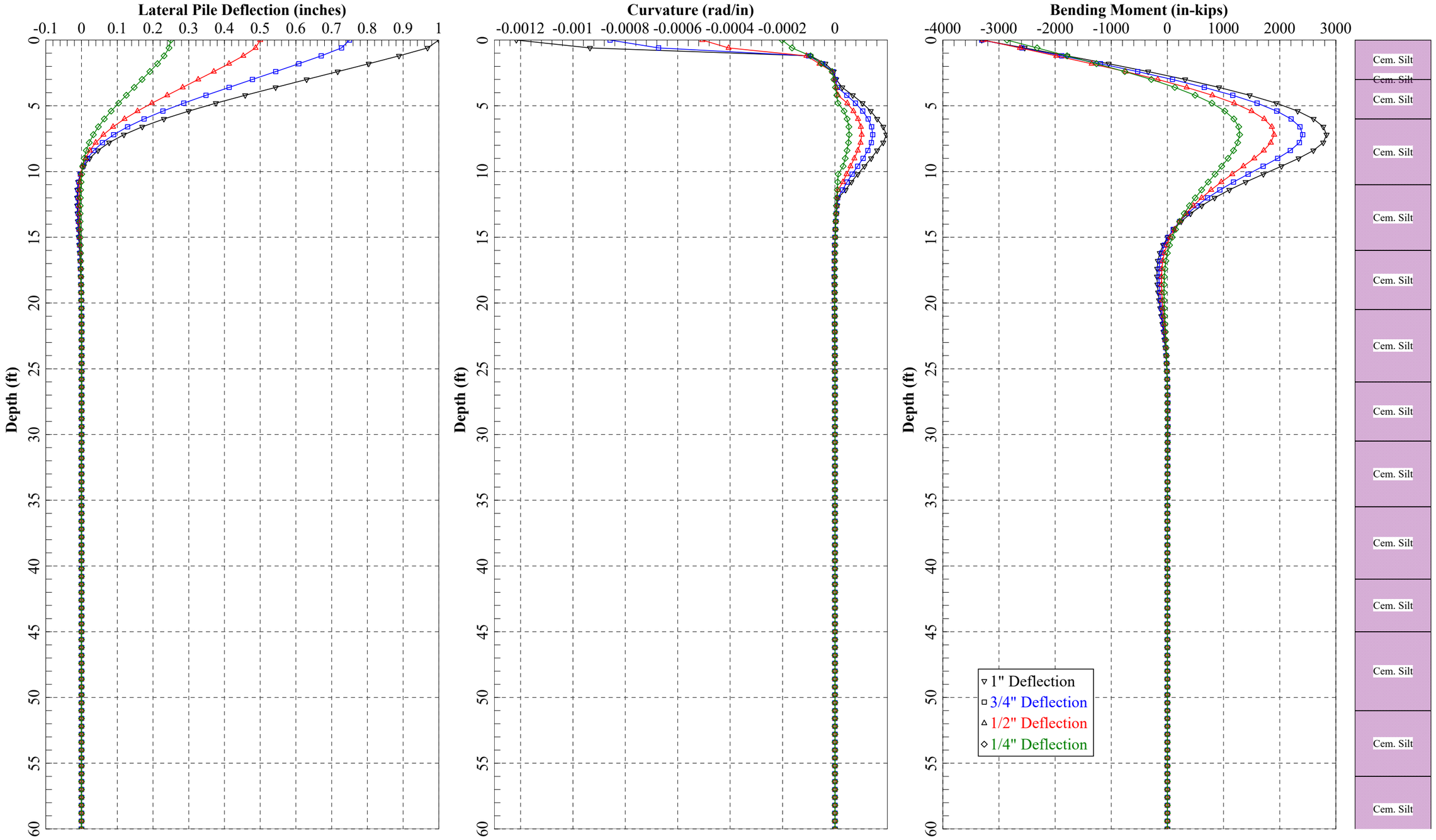


Figure J

LATERAL PILE-DEFLECTION, CURVATURE, AND MOMENT VS.
DISTANCE FROM TOP OF 24-INCH FREE-HEADED CIDH PILE

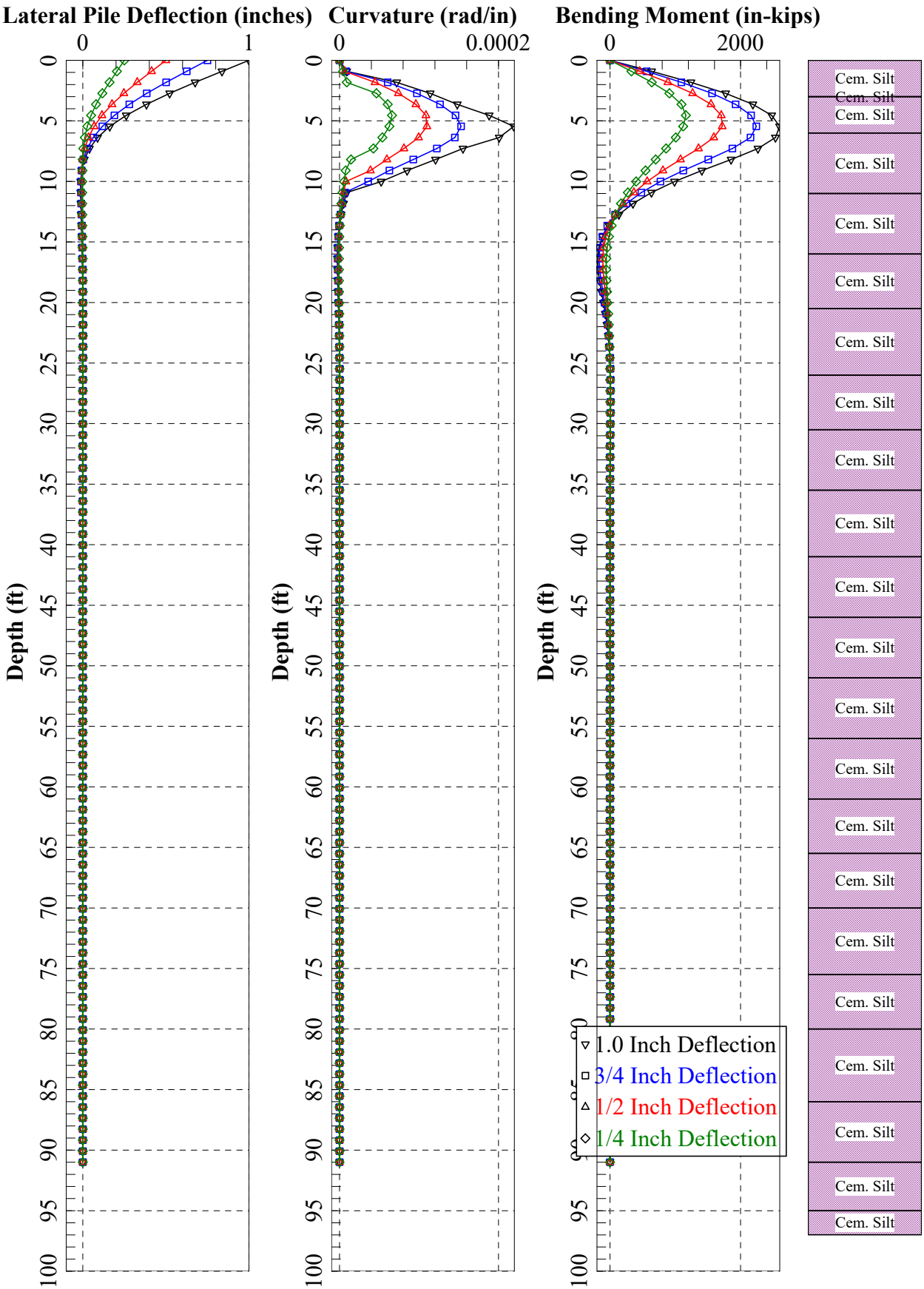


Figure K

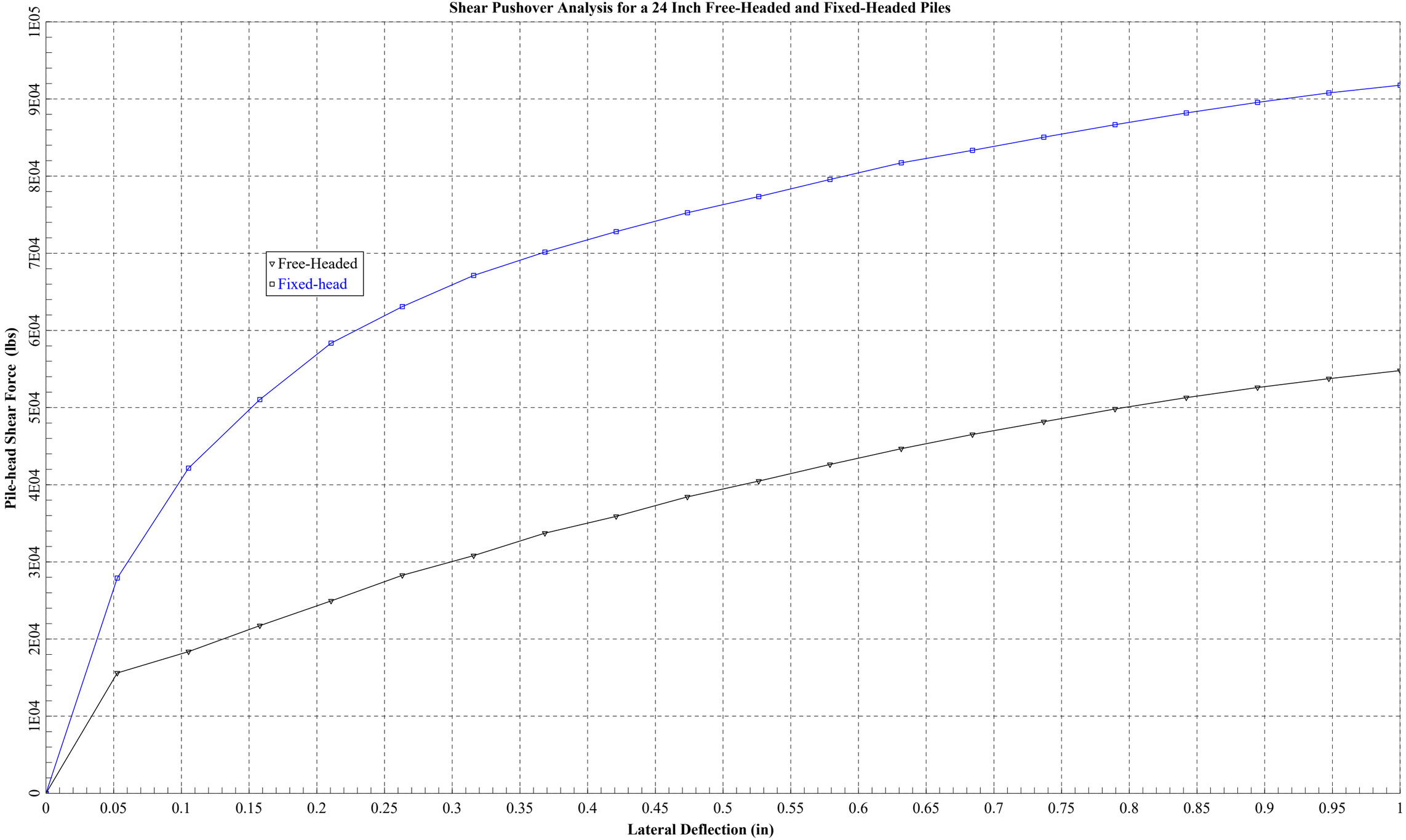

Shear Pushover Analysis for a 24 Inch Free-Headed and Fixed-Headed Piles
Free-Headed
Fixed-head
Pile-head Shear Force (lbs)
0
1E04
2E04
3E04
4E04
5E04
6E04
7E04
8E04
9E04
1E05
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1
Lateral Deflection (in)

Figure L

ALLOWABLE COMPRESSIVE RESISTANCE VS PILE EMBEDMENT LENTH FOR A 36 INCH DIAMETER CIDH PILE

Resistance/F.S. (tons)

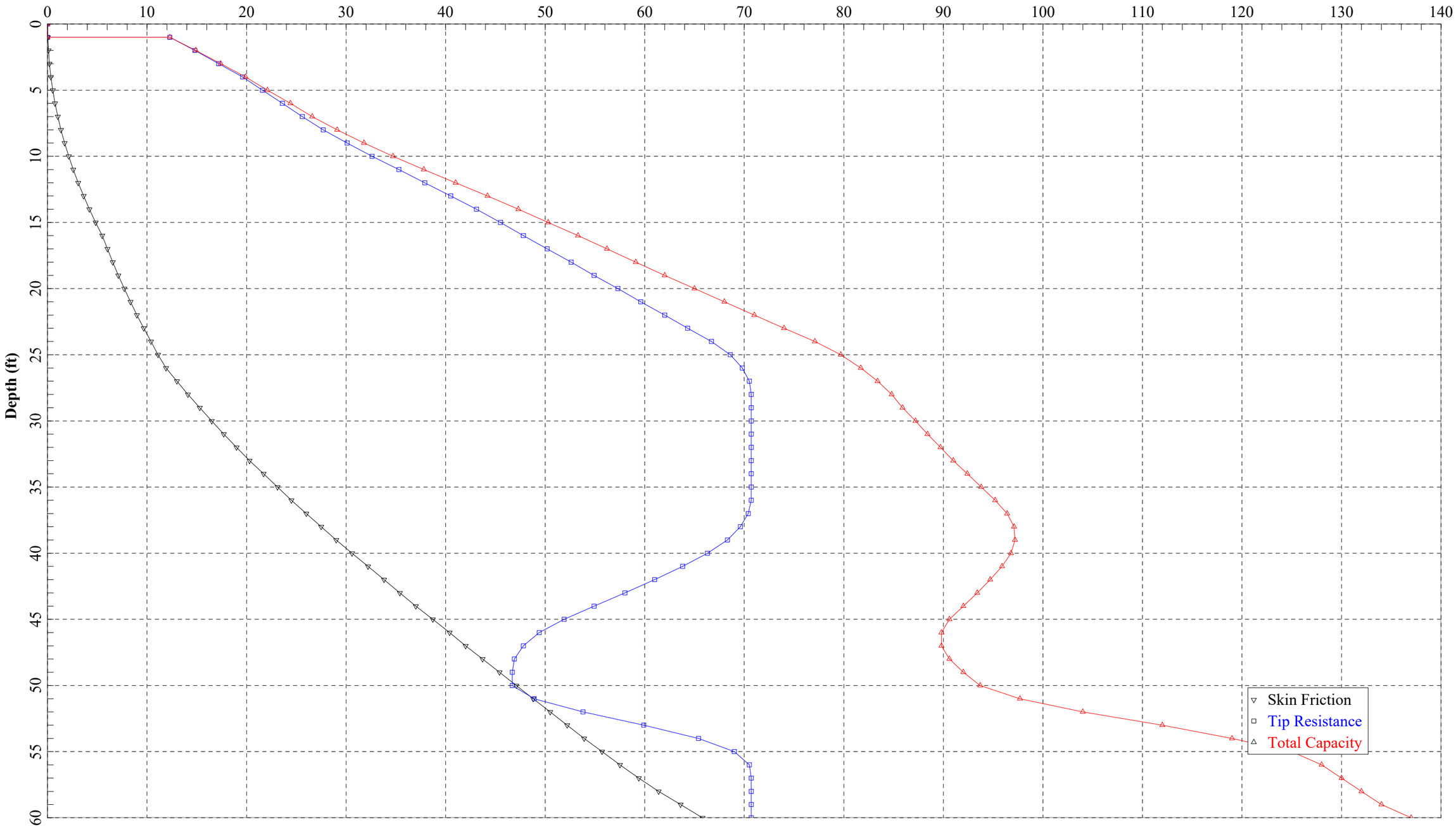


Figure M

AXIAL LOAD VS. SETTLEMENT FOR A 36 INCH DIAMETER CIDH PILE

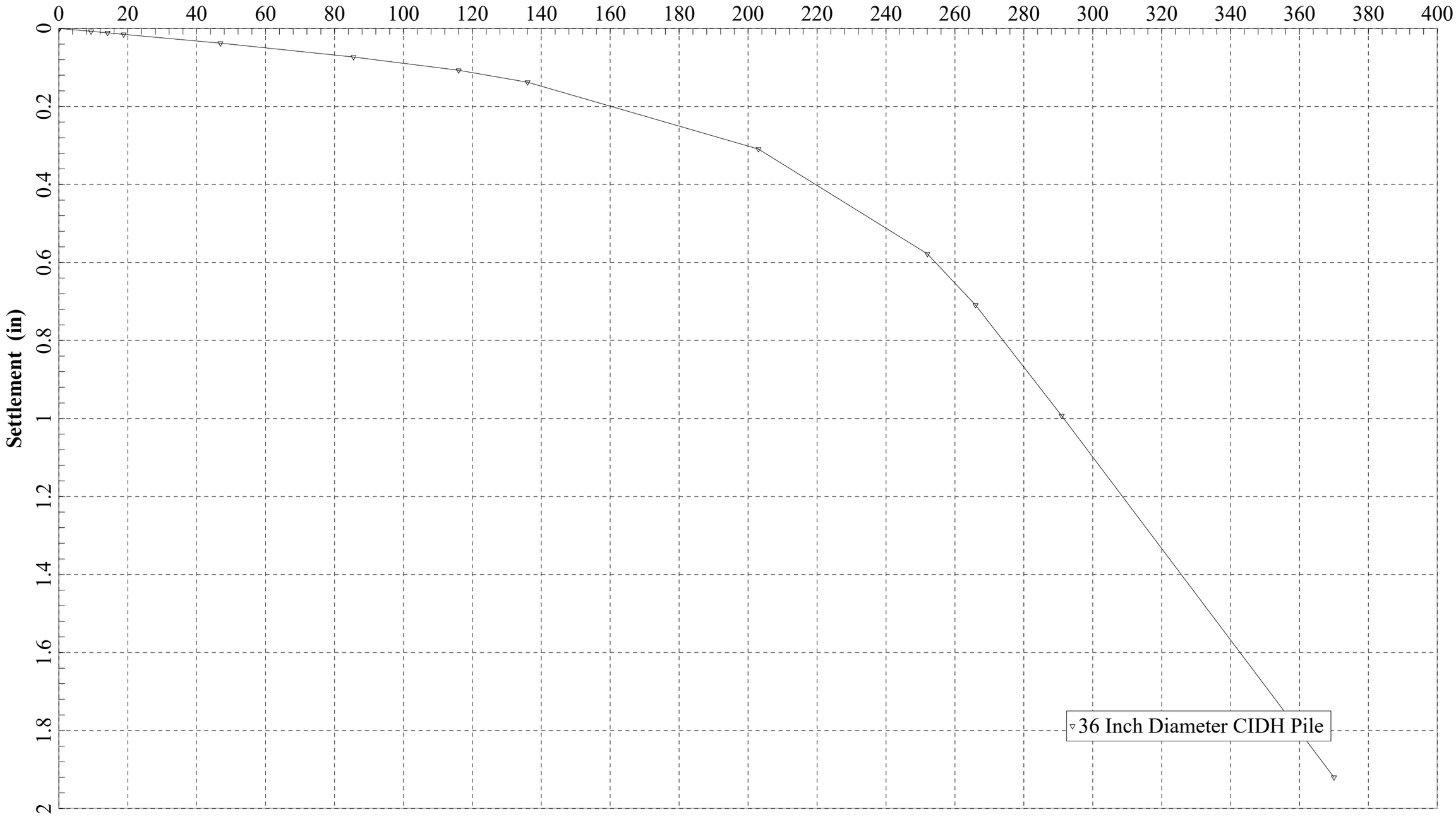


Figure N

DEFLECTION, CURVATURE, AND BENDING-MOMENT VS DISTANCE FROM TOP OF A 36" DIA. FREE-HEADED CIDH PILE

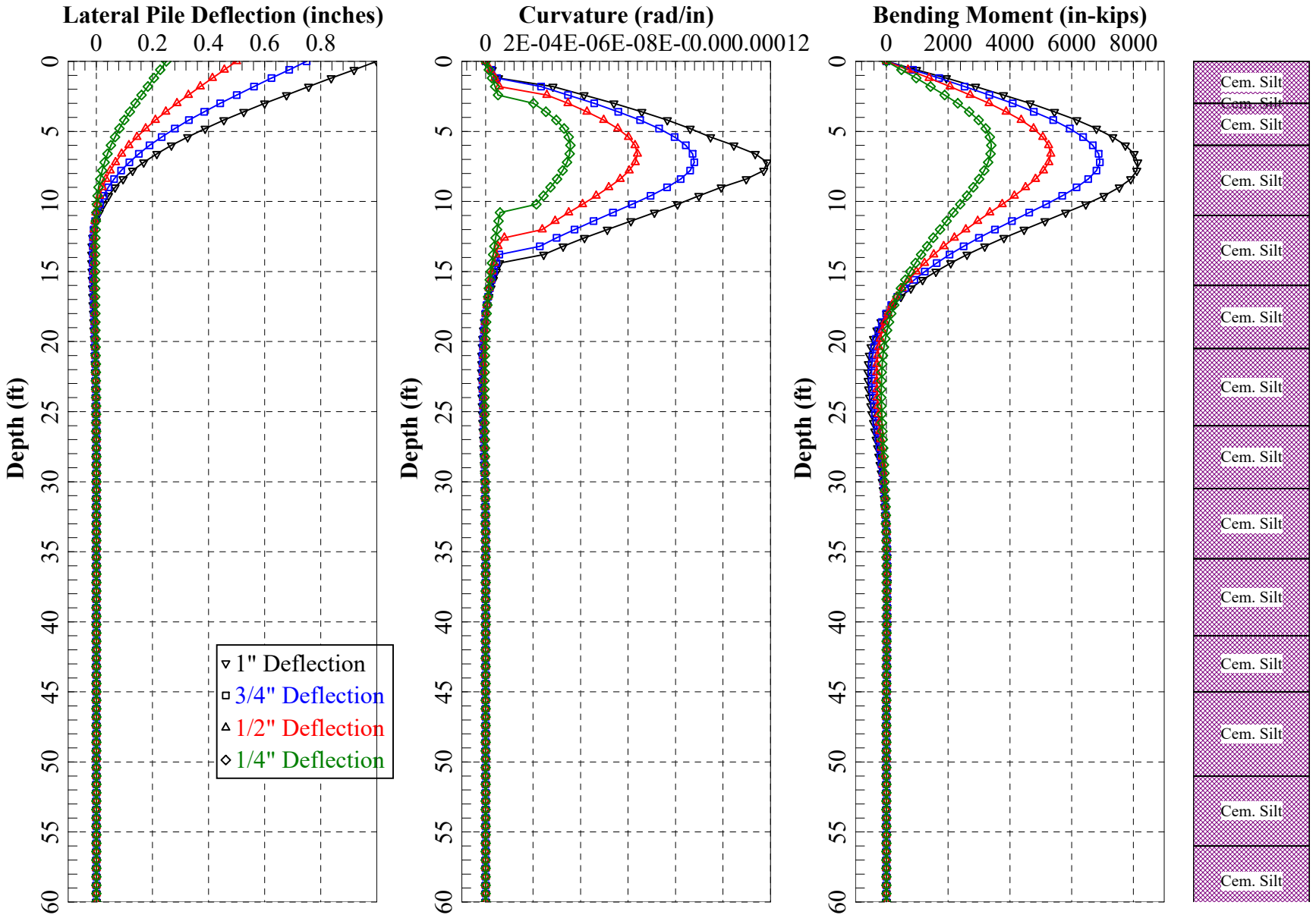


Figure O

DEFLECTION, CURVATURE, AND BENDING-MOMENT VS DISTANCE FROM TOP OF A 36" DIA. FIXED-HEADED CIDH PILE

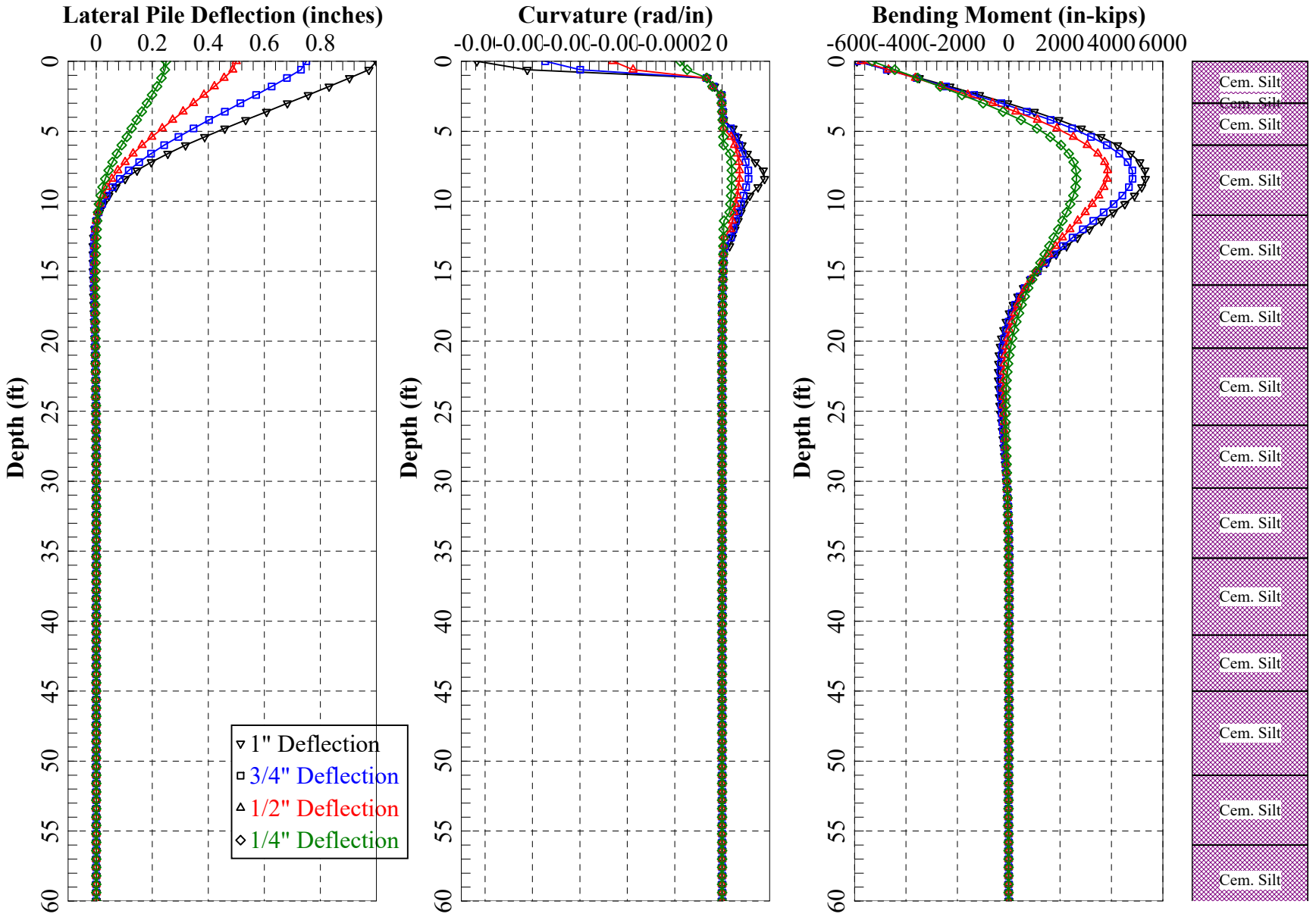


Figure P

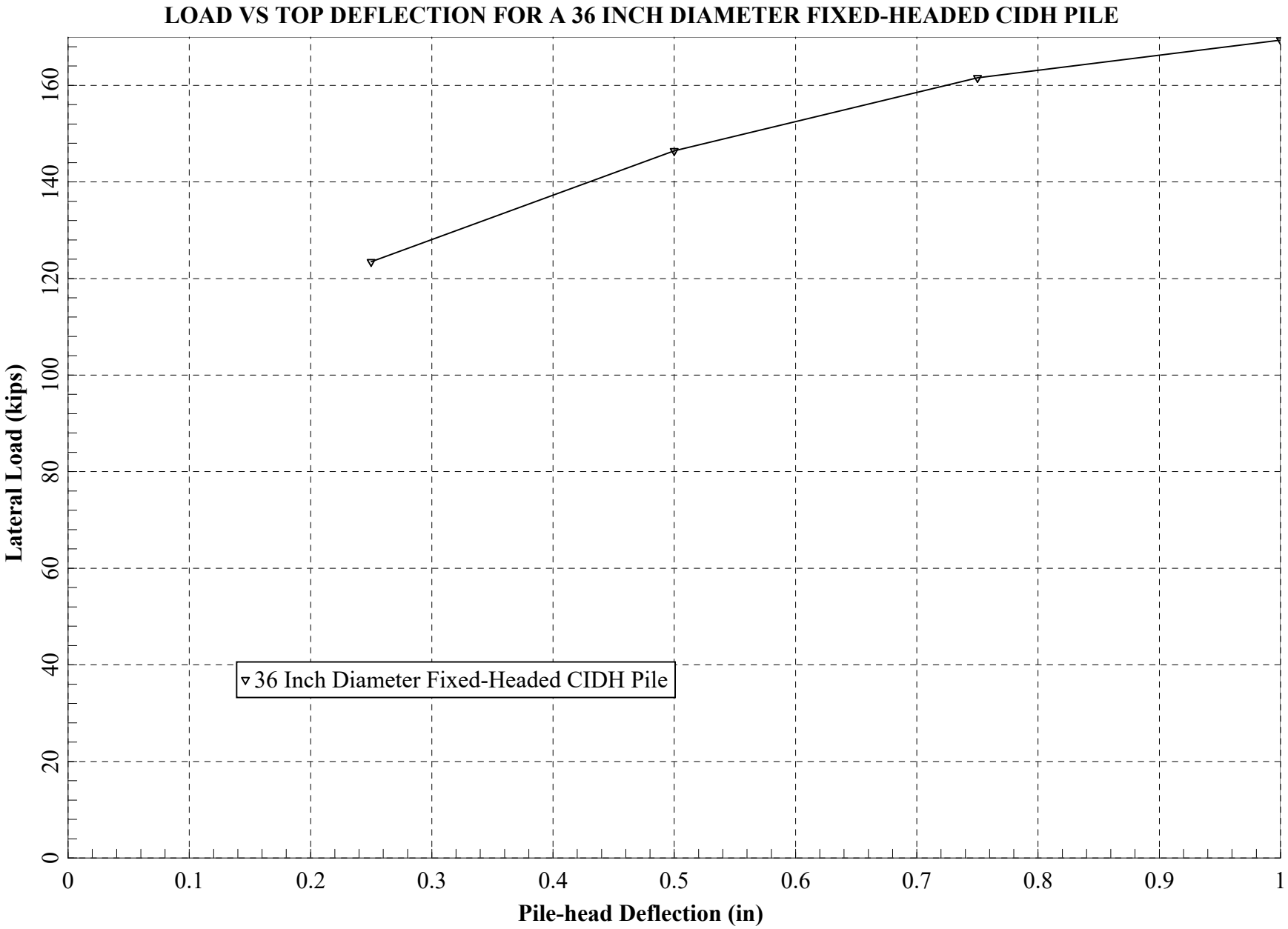

LOAD VS TOP DEFLECTION FOR A 36 INCH DIAMETER FIXED-HEADED CIDH PILE
Lateral Load (kips)
0
20
40
60
80
100
120
140
160
Pile-head Deflection (in)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
36 Inch Diameter Fixed-Headed CIDH Pile

Figure Q

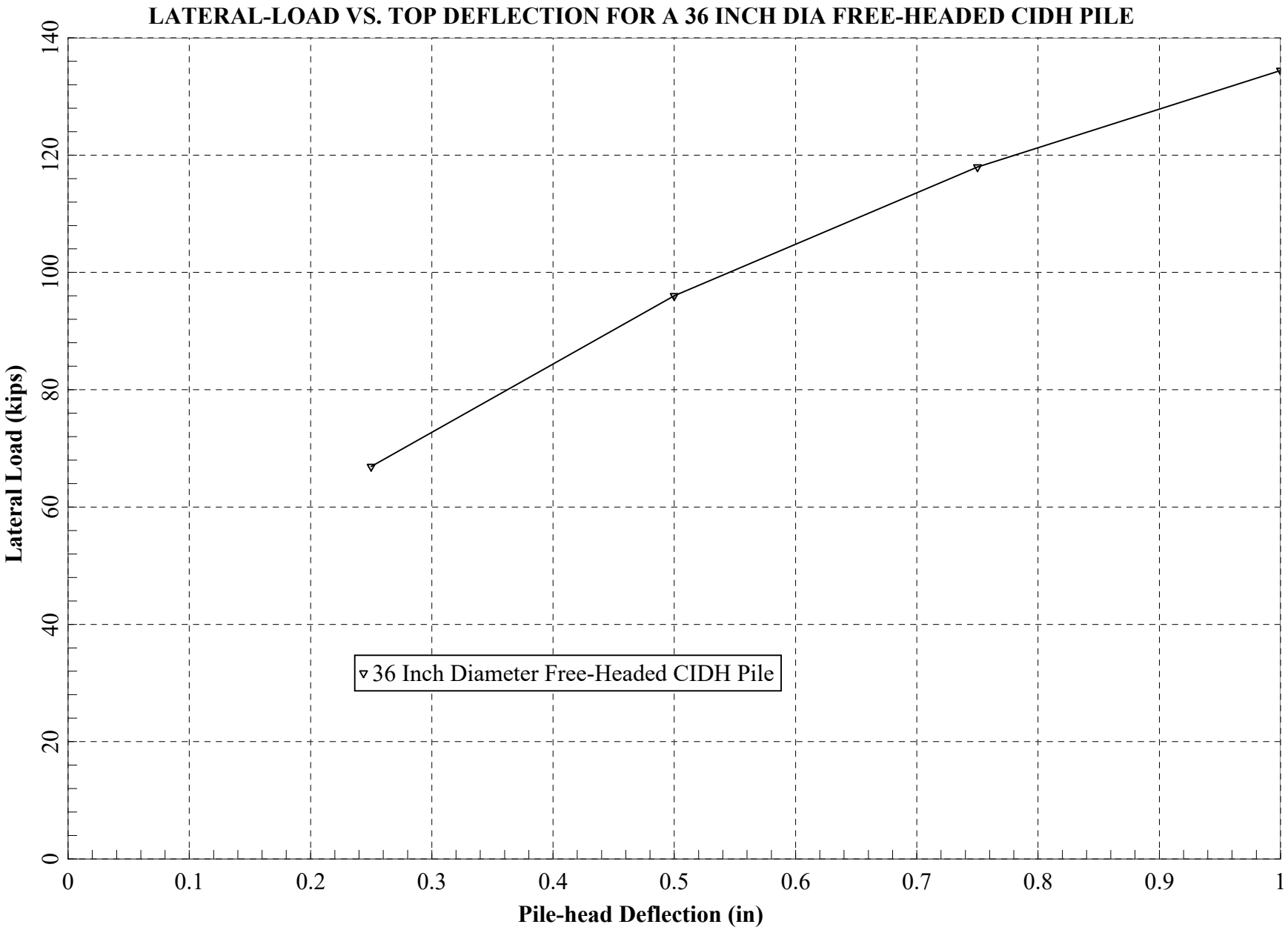

LATERAL-LOAD VS. TOP DEFLECTION FOR A 36 INCH DIA FREE-HEADED CIDH PILE
Lateral Load (kips)
0
20
40
60
80
100
120
140
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Pile-head Deflection (in)
36 Inch Diameter Free-Headed CIDH Pile

Figure R

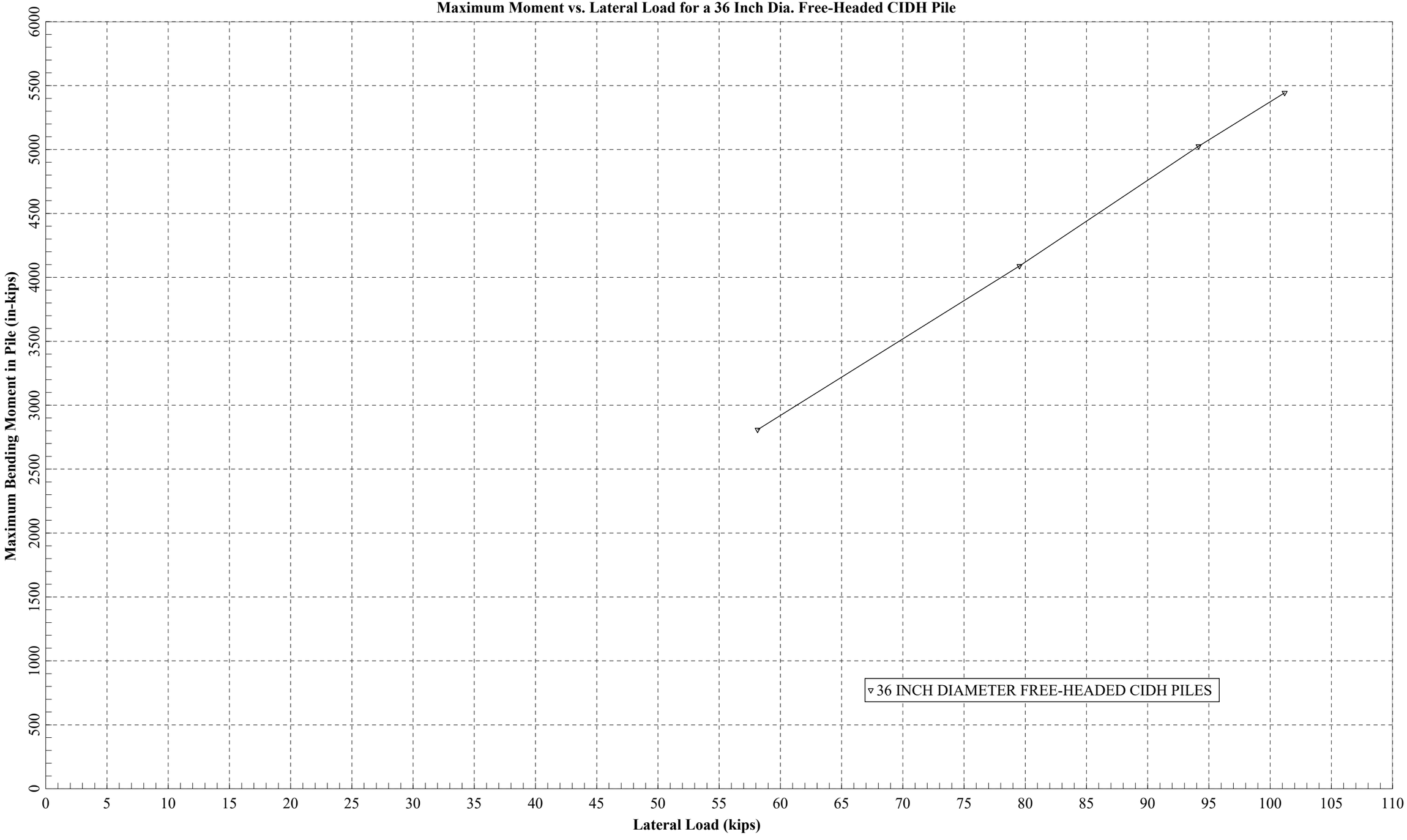

Maximum Moment vs. Lateral Load for a 36 Inch Dia. Free-Headed CIDH Pile
Maximum Bending Moment in Pile (in-kips)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
Lateral Load (kips)
36 INCH DIAMETER FREE-HEADED CIDH PILES

Figure S

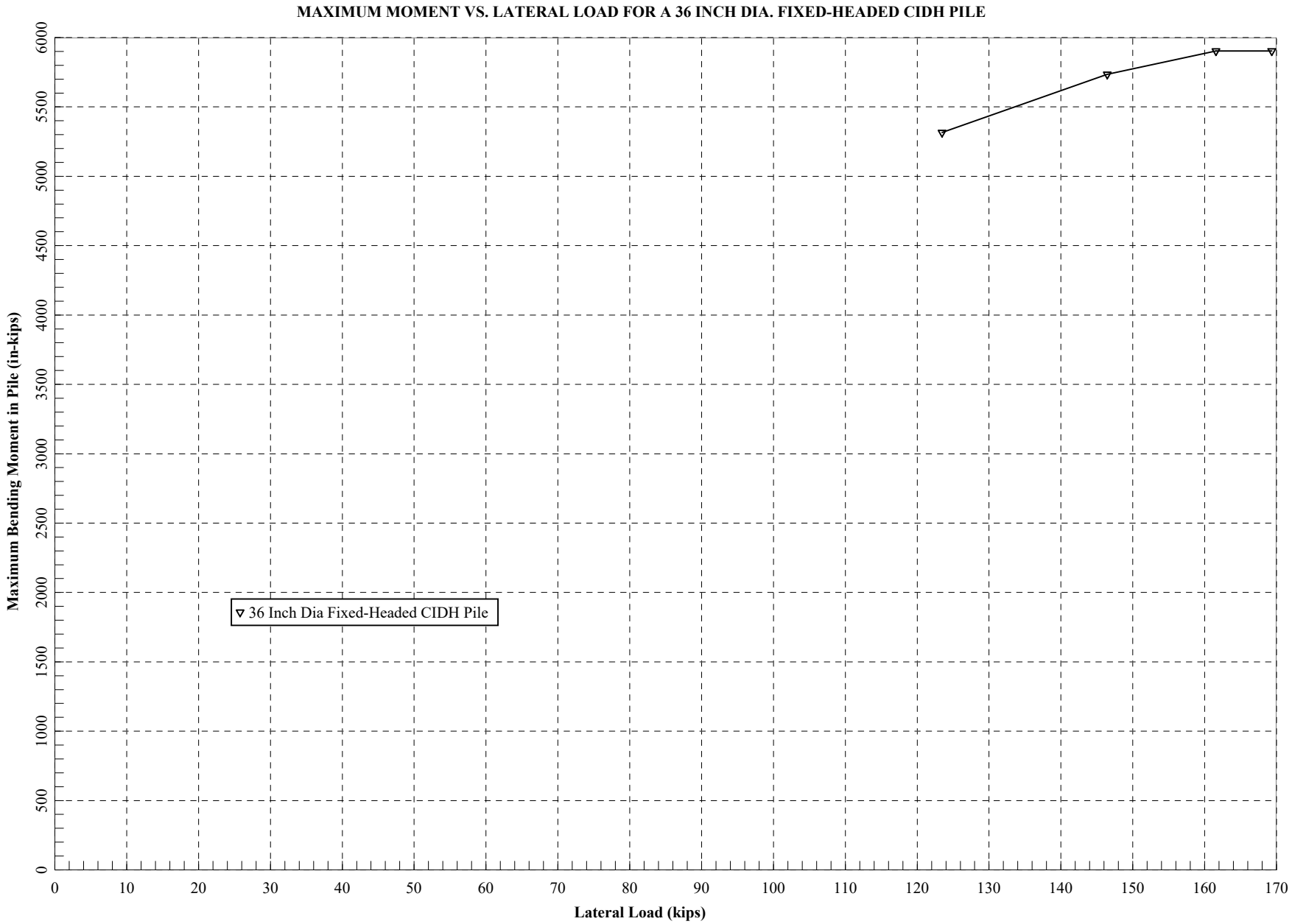

MAXIMUM MOMENT VS. LATERAL LOAD FOR A 36 INCH DIA. FIXED-HEADED CIDH PILE
Maximum Bending Moment in Pile (in-kips)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
Lateral Load (kips)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
36 Inch Dia Fixed-Headed CIDH Pile

Figure T

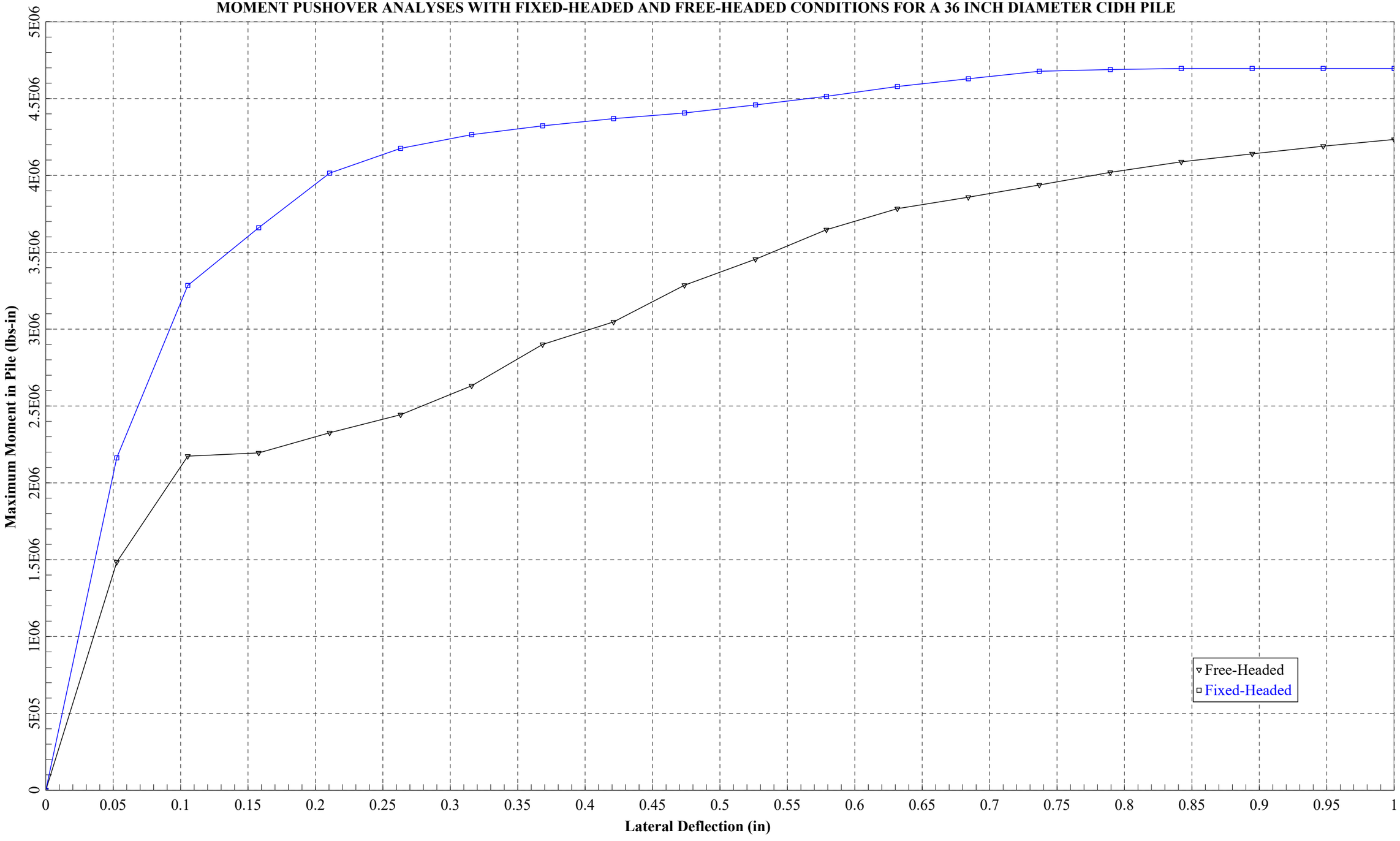

MOMENT PUSHOVER ANALYSES WITH FIXED-HEADED AND FREE-HEADED CONDITIONS FOR A 36 INCH DIAMETER CIDH PILE
Maximum Moment in Pile (lbs-in)
0
5E05
1E06
1.5E06
2E06
2.5E06
3E06
3.5E06
4E06
4.5E06
5E06
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1
Lateral Deflection (in)
Free-Headed
Fixed-Headed

Figure U

LATERAL PILE DEFLECTION, BENDING-MOMENT, AND SHEAR FORCE VS. DISTANCE FROM TOP OF A 36 INCH DIAMETER FIXED-HEADED PILE

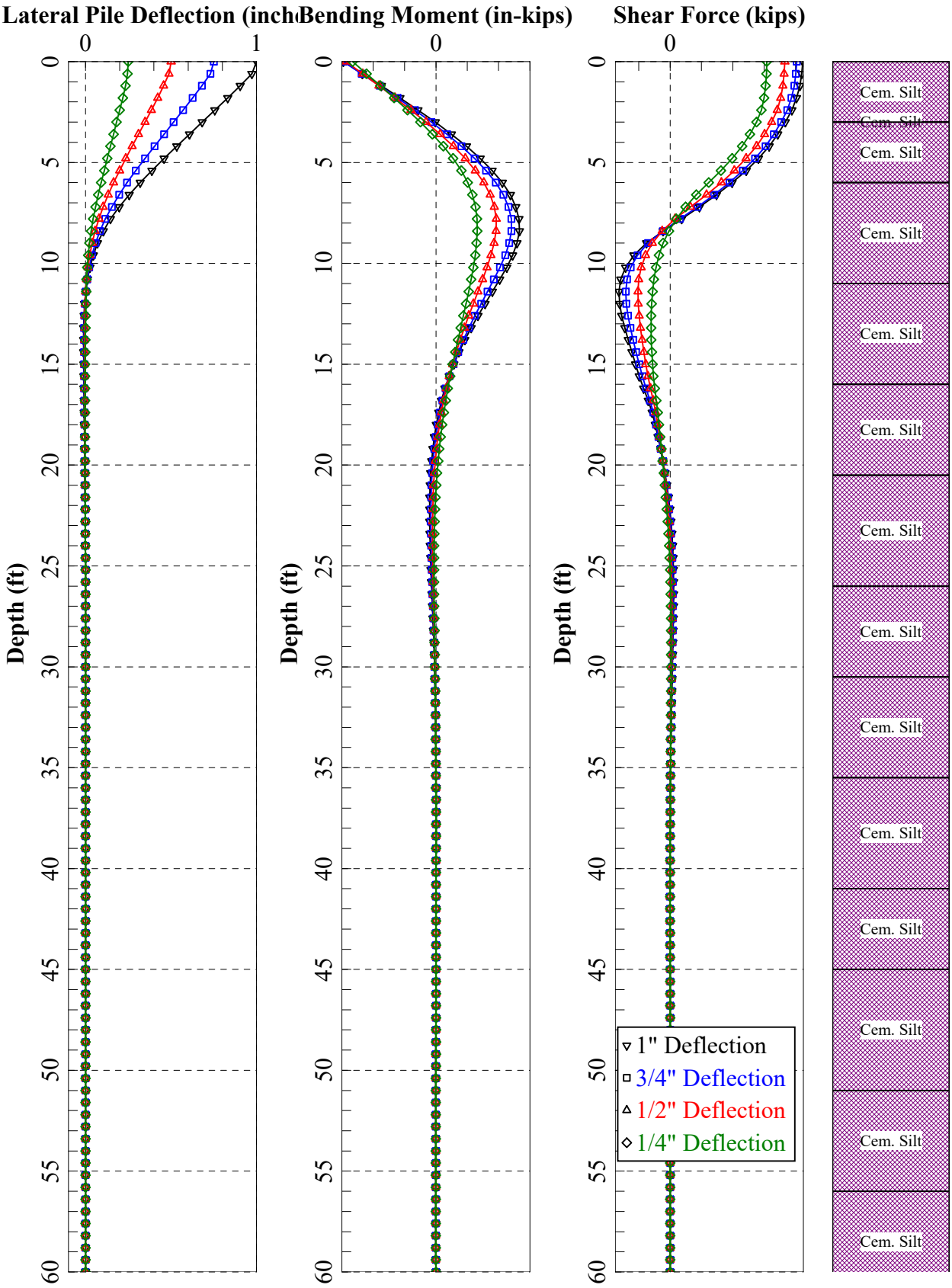


Figure V

LATERAL PILE DEFLECTION, BENDING-MOMENT, AND SHEAR-FORCE VS DISTANCE FROM TOP OF A 36 INCH DIAMETER FREE-HEADED PILE

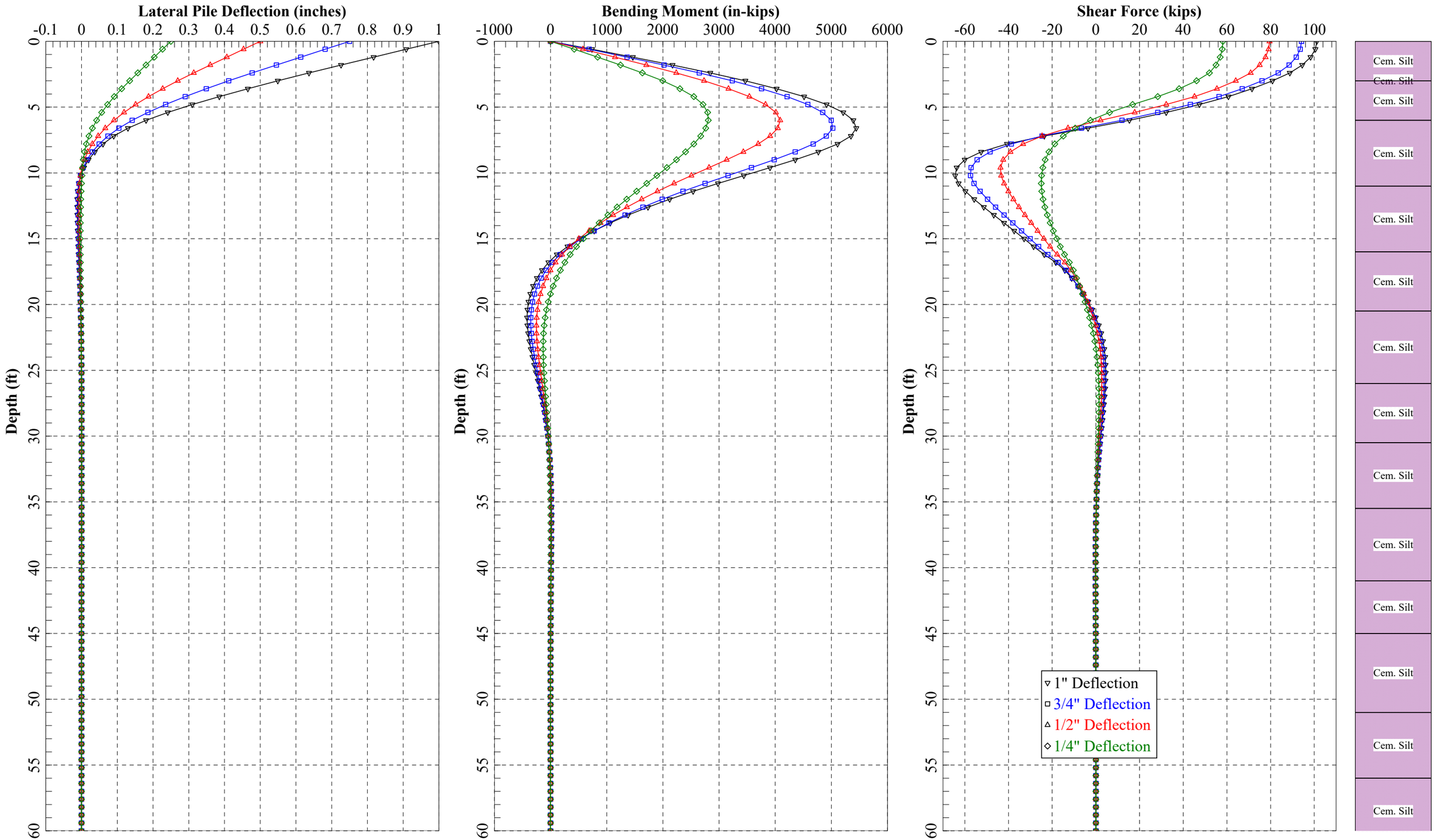


Figure W

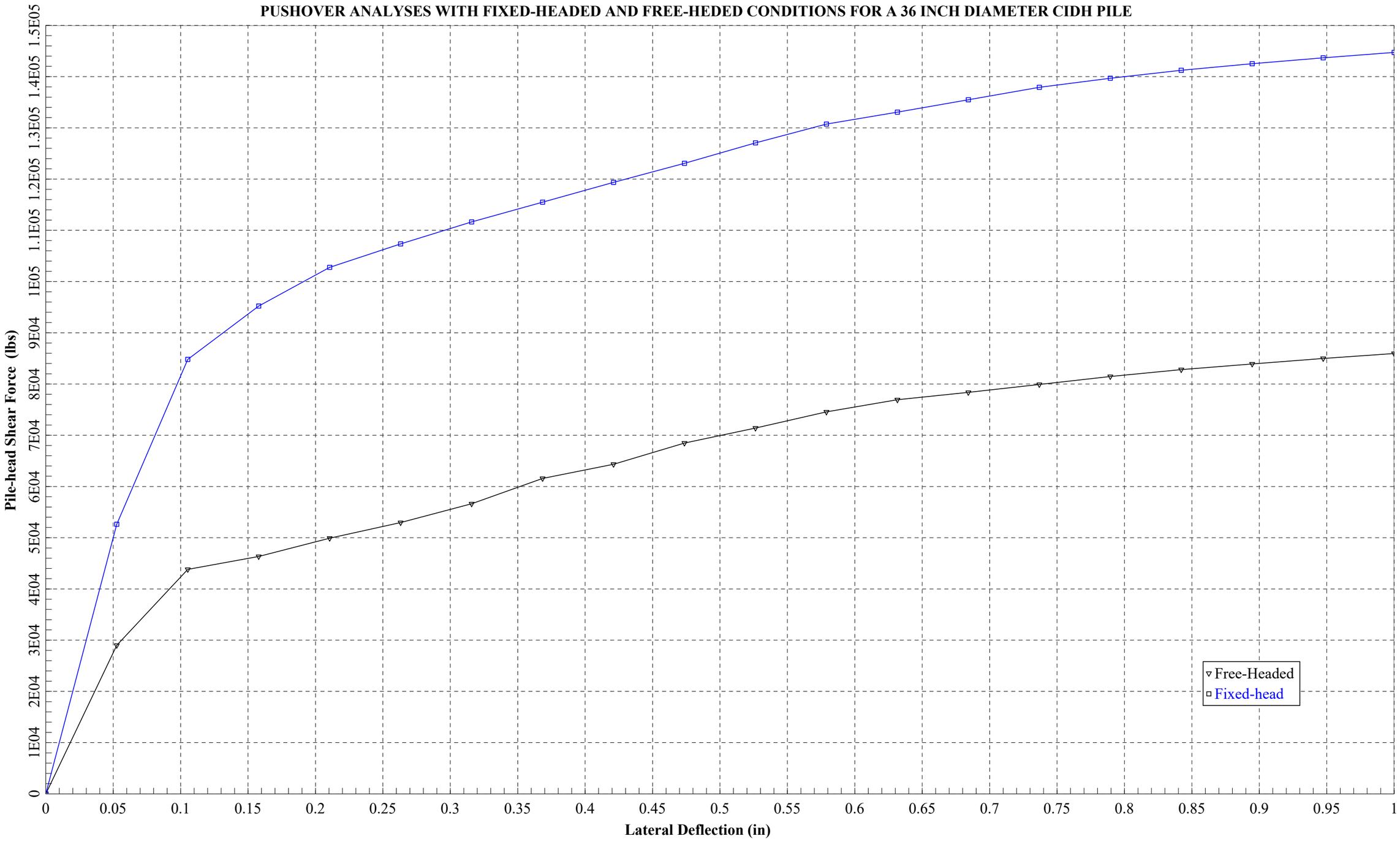

PUSHOVER ANALYSES WITH FIXED-HEADED AND FREE-HEDED CONDITIONS FOR A 36 INCH DIAMETER CIDH PILE
Pile-head Shear Force (lbs)
0
1E04
2E04
3E04
4E04
5E04
6E04
7E04
8E04
9E04
1E05
1.1E05
1.2E05
1.3E05
1.4E05
1.5E05
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1
Lateral Deflection (in)
Free-Headed
Fixed-head

Figure X

SEISMIC SURVEY DATA & CALCULATED DYNAMIC SOIL PROPERTIES

SEISMIC SURVEY DATA							Poisson's Ratio u =(Vp²-2Vs²)/2(Vp²-Vs²)			Shear Modulus = G = d * Vs², d = mass density of soil = WT density/32.15						
	Line 1 BH-2		Line 2 - BH-12		AVGs.		Poisson's Ratio's			BH-2			BH-12			AVG/Depth
DEPTH	Vs	Vp	Vs	Vp	Vs	Vp	BH-2	BH-12	AVG/Depth	WT. Density	d	G lbs/ft2	WT. Density	d	G in lbs/ft2	G lbs/ft2
10	827	1384	827	1415	827	1399.5	0.222324805	0.24060112	0.231462965	111.6	3.47122862	2374073.92	122.7	3.816485	2610204.924	2492139.42
20	919	1928	935	1869	927	1898.5	0.352998288	0.33309539	0.343046837	120.4	3.74494557	3162834.97	109.5	3.40591	2977531.493	3070183.233
30	1030	1928	1030	1869	1030	1898.5	0.300303733	0.28191074	0.291107237	109.8	3.41524106	3623229.24	120.9	3.760498	3989511.975	3806370.607
40	1093	1928	1141	1869	1117	1898.5	0.263204673	0.20294052	0.233072596	113	3.51477449	4198921.84	136	4.230171	5507179.347	4853050.591
50	1123	1928	1237	1869	1180	1898.5	0.243261246	0.11024574	0.176753492	131.4	4.08709176	5154349.94	130.3	4.052877	6201586.958	5677968.449
60	1150	2477	1370	2686	1260	2581.5	0.362612505	0.32418444	0.343398473	120.7	3.75427683	4965031.1	93.2	2.898911	5440966.719	5202998.911
70	1165	2477	1420	2686	1292.5	2581.5	0.357980468	0.3060481	0.332014283	106.3	3.30637636	4487496.66	111.8	3.477449	7011929.082	5749712.869
80	1170	2477	1450	2686	1310	2581.5	0.356407956	0.29436028	0.325384117	117	3.63919129	4981688.96	98.3	3.057543	6428483.67	5705086.314
90	1173	2477	1500	2686	1336.5	2581.5	0.355457496	0.27339546	0.314426477	127.7	3.97200622	5465198.55	110.8	3.446345	7754276.827	6609737.687
100	1174	2477	1512	2686	1343	2581.5	0.35513951	0.26806673	0.311603119	101.8	3.16640747	4364183.42	128.2	3.987558	9116132.529	6740157.972
50'-100' interpolated			65'-100' interpolated		**1162.3**	**2190.1**	**0.316969068**	**0.26348485**	**0.29022696**	**115.97**	**3.60715397**	**4277700.86**	**116.17**	**3.613375**	**5703780.352**	**4990740.605**

Vs = Shear Wave Velocity in Ft/Sec, Vp = P-Wave Velocity in Ft/sec

Bulk Modulus K =d(Vp²-(4Vs²/3))			
	K in lbs/ft2		AVG/Depth
DEPTH	BH-2	BH-12	K in lbs/ft2
10	3483553.8	4161188.9	3822371.35
20	9703538.4	7927349.28	8815443.87
30	7864107.1	7816674.49	7840390.79
40	7466501.1	7433762.82	7450131.94
50	8320005.5	5888569.75	7104287.62
60	16414433	13659852	15037142.4
70	14303039	15739154.2	15021096.7
80	15686112	13487624.3	14586868
90	17083428	14524952.9	15804190.4
100	13608674	16613778.9	15111226.3
AVG.	**11393339**	**10725291**	**11059315**

Youngs Modulus E = 2 d Vs² (1 +u)			
	E in lbs/ft2		AVG/Depth
DEPTH	BH-2	BH-12	E in lbs/ft2
10	5803778.9	6476446.3	6140112.6
20	8558620.6	7938667.0	8248643.8
30	9422597	10228396.5	9825496.75
40	10608195	13249618.4	11928906.9
50	12816407	13770571.0	13293489
60	13530827	14409687.0	13970256.9
70	12187866	18315833.3	15251849.5
80	13514405	16641547.8	15077976.4
90	14815689	19748521.8	17282105.2
100	11828155	23119728.7	17473941.7
AVG.	**11308654**	**14389902**	**12849278**

Poisson's ratio $\mu = (Vp^2 - 2Vs^2) \ / \ 2(Vp^2 - Vs^2)$

shear modulus $G = d\ Vs^2$ where d = mass density*

bulk modulus $K = d\ (Vp^2 - (4\ Vs^2 / 3))$

Young's modulus $E = 2\ d\ Vs^2\ (1 + \mu)$

* Note: in the above equations, in situ mass density (d) is expressed in lbs per cubic foot divided by g (32.15 ft/sec², the acceleration of gravity) to produce results in English units. For example, if the in situ density of a soil is 128 lbs/ft³, the value of d to use in the formulas is

$$d = \frac{128\ lb}{ft^3} \times \frac{1}{32.15\ ft/sec^2} = \frac{4\ lb\ sec^2}{ft^4} \quad \text{mass density}$$

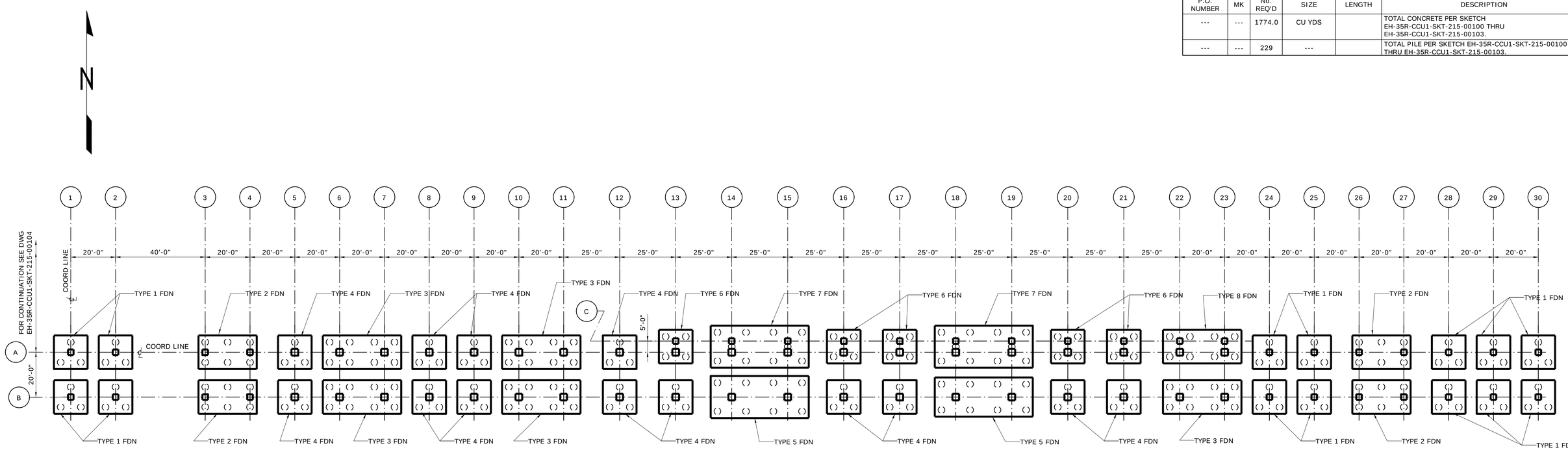
Values of G, K, and E will then be expressed in lbs/ft² , μ is dimensionless

Attachment 6 – Foundation Design Drawings

* QUANTITIES LISTED ARE NET

BILL OF MATERIAL

P.O. NUMBER	MK	No. REQ'D	SIZE	LENGTH	DESCRIPTION
---	---	1774.0	CU YDS		TOTAL CONCRETE PER SKETCH EH-35R-CCU1-SKT-215-00100 THRU EH-35R-CCU1-SKT-215-00103.
---	---	229	---		TOTAL PILE PER SKETCH EH-35R-CCU1-SKT-215-00100 THRU EH-35R-CCU1-SKT-215-00103.



KEY PLAN
SCALE: Fit To Scale

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

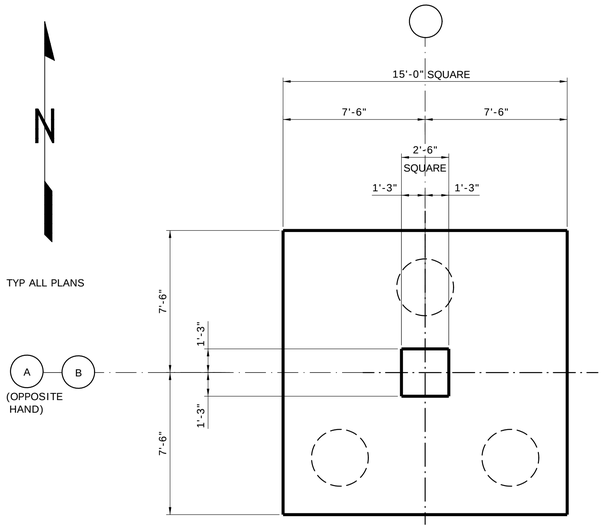
REVISIONS | APPROVALS

ELK HILLS OPERATION

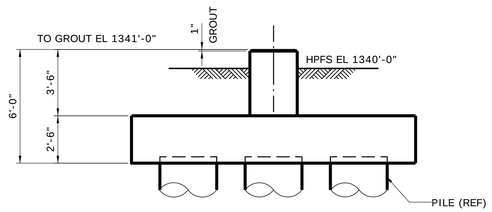
CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
AIR COOLER PIPERACK FOUNDATIONS
PLAN

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00100	1 OF 1	C	NTS



PLAN



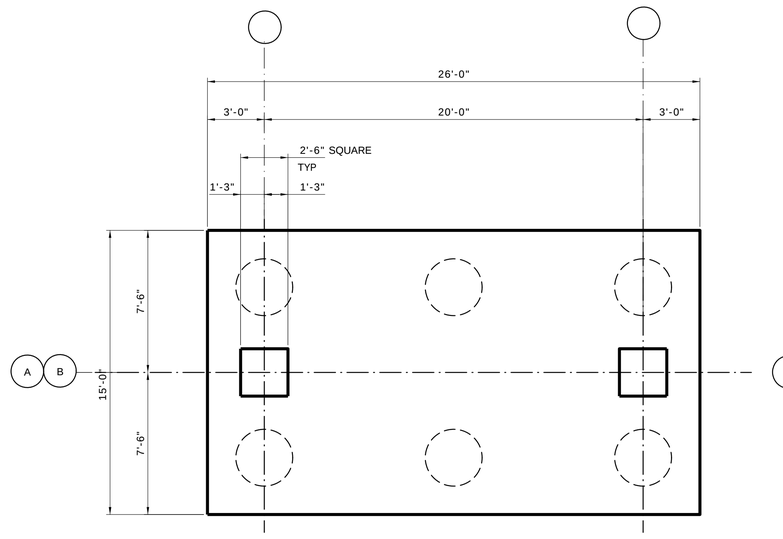
SOUTH ELEVATION

LOOKING NORTH

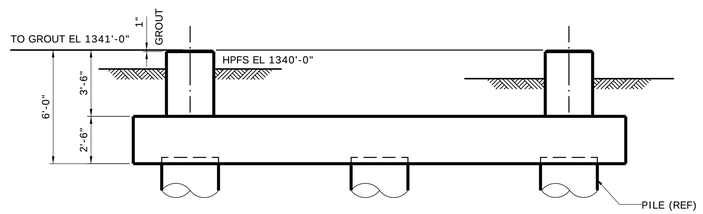
TYPE 1 FOUNDATION

14-FDNS REQUIRED AT 21.6 CU. YDS. EACH = 302.4 CY. YDS. TOTAL

SCALE: 1/4" = 1'-0"



PLAN



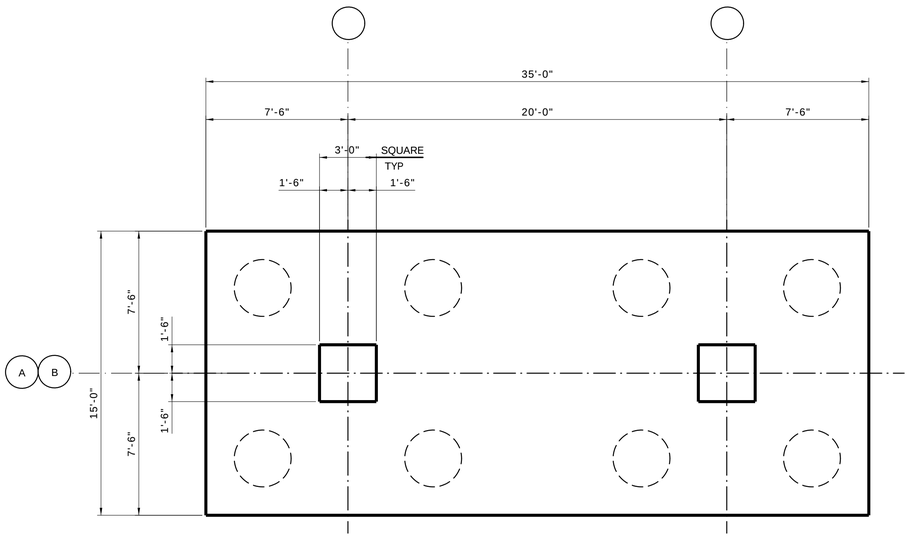
SOUTH ELEVATION

LOOKING NORTH

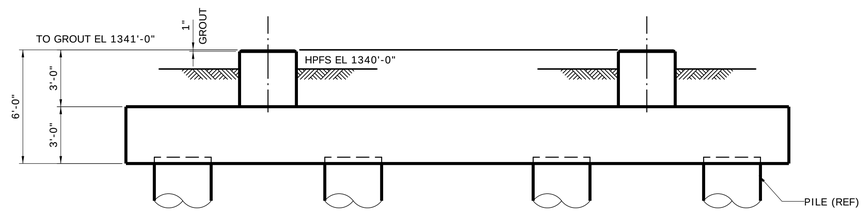
TYPE 2 FOUNDATION

4-FDNS REQUIRED AT 37.7 CU. YDS. EACH = 150.8 CY. YDS. TOTAL

SCALE: 1/4" = 1'-0"



PLAN



SOUTH ELEVATION

LOOKING NORTH

TYPE 3 FOUNDATION

5-FDNS REQUIRED AT 60.4 CU. YDS. EACH = 302.0 CY. YDS. TOTAL

SCALE: 1/4" = 1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

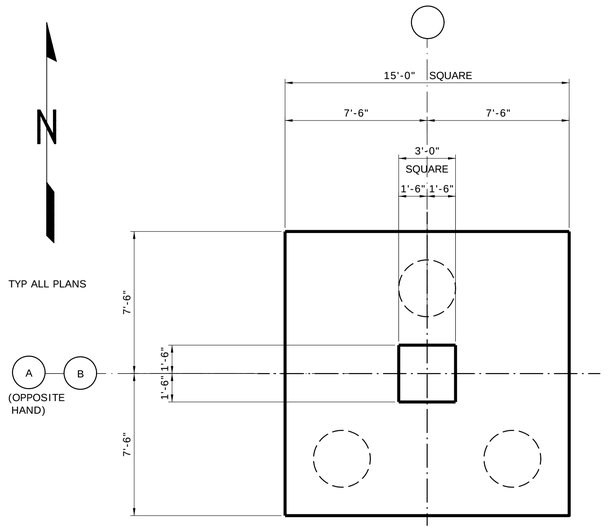
REVISIONS | APPROVALS

ELK HILLS OPERATION

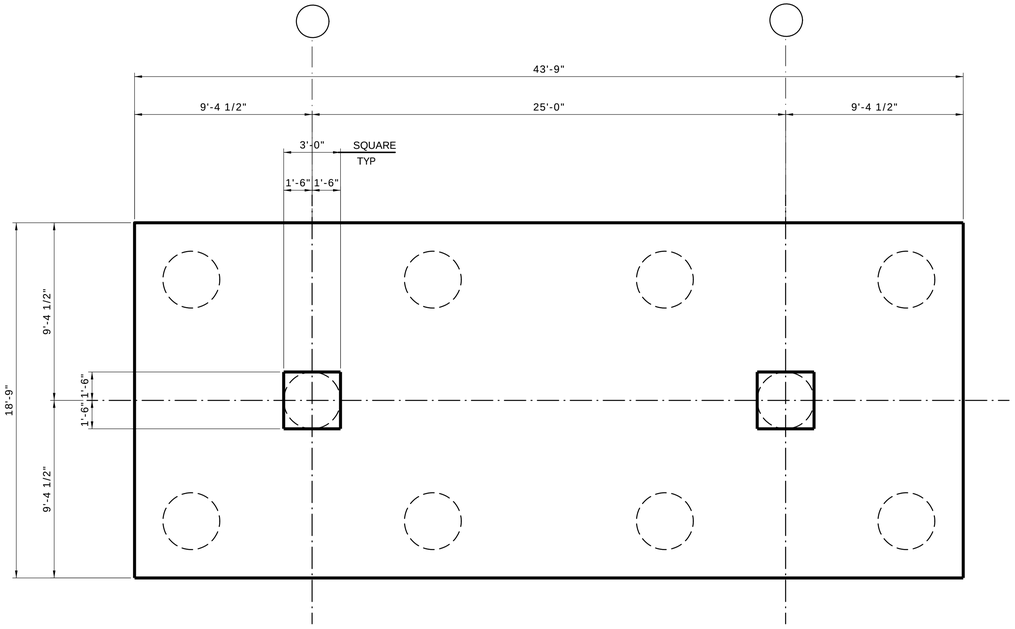
CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
AIR COOLER PIPERACK FOUNDATIONS
PLANS & ELEVATIONS

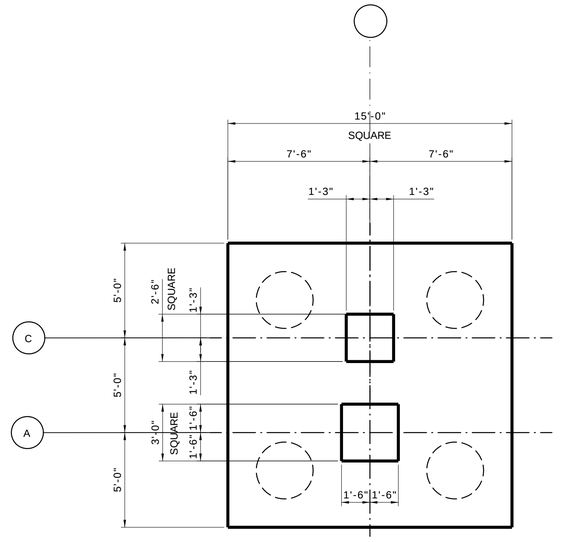
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00101	1 OF 1	C	1/4"=1'-0"



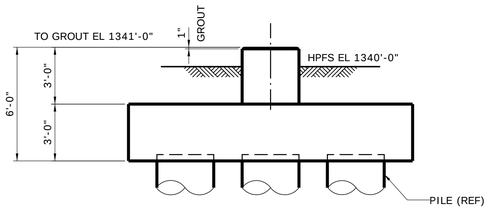
PLAN



PLAN



PLAN



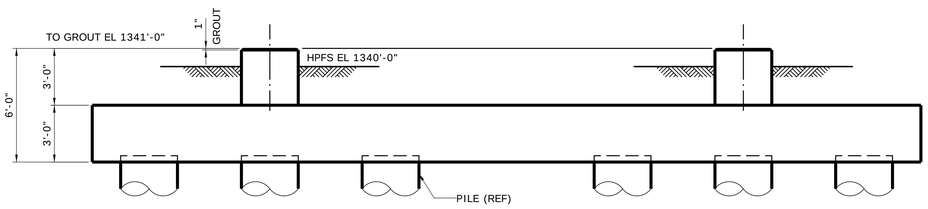
SOUTH ELEVATION

LOOKING NORTH

TYPE 4 FOUNDATION

13-FDNS REQUIRED AT 26.0 CU. YDS. EACH = 338.0 CY. YDS. TOTAL

SCALE: 1/4" = 1'-0"



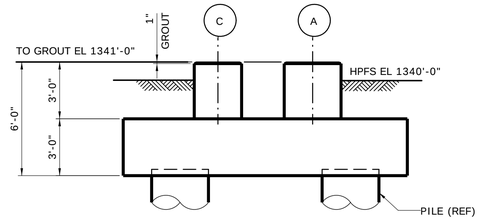
SOUTH ELEVATION

LOOKING NORTH

TYPE 5 FOUNDATION

2-FDNS REQUIRED AT 93.2 CU. YDS. EACH = 186.4 CY. YDS. TOTAL

SCALE: 1/4" = 1'-0"



WEST ELEVATION

LOOKING EAST

TYPE 6 FOUNDATION

6-FDNS REQUIRED AT 26.6 CU. YDS. EACH = 159.6 CY. YDS. TOTAL

SCALE: 1/4" = 1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

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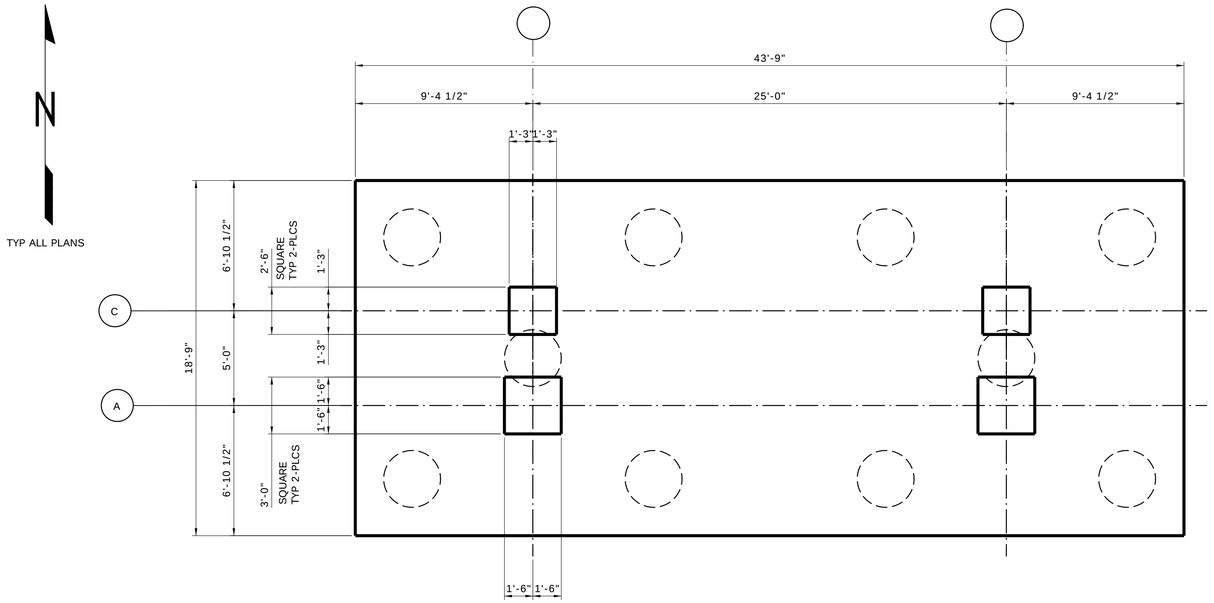
ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

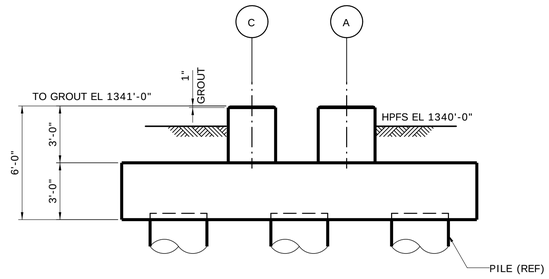
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
AIR COOLER PIPERACK FOUNDATIONS
PLANS & ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00102	1 OF 1	C	1/4"=1'-0"

CRC



PLAN



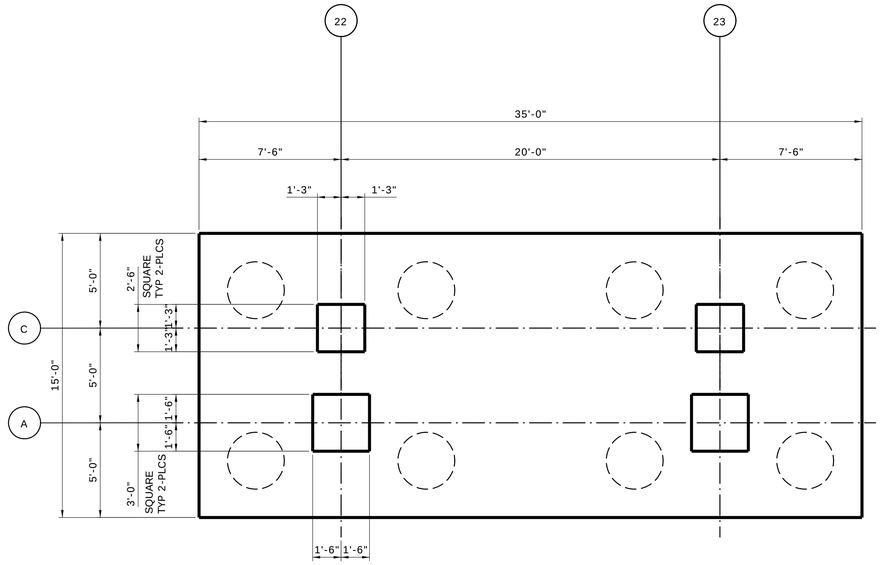
WEST ELEVATION

LOOKING EAST

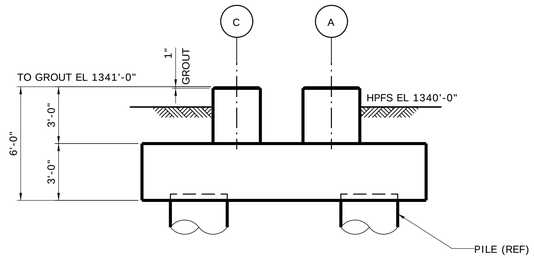
TYPE 7 FOUNDATION

2-FDNS REQUIRED AT 94.5 CU. YDS. EACH = 189.0 CY. YDS. TOTAL

SCALE: 1/4" = 1'-0"



PLAN



WEST ELEVATION

LOOKING EAST

TYPE 8 FOUNDATION

1-FDN REQUIRED AT 61.9 CU. YDS. TOTAL

SCALE: 1/4" = 1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

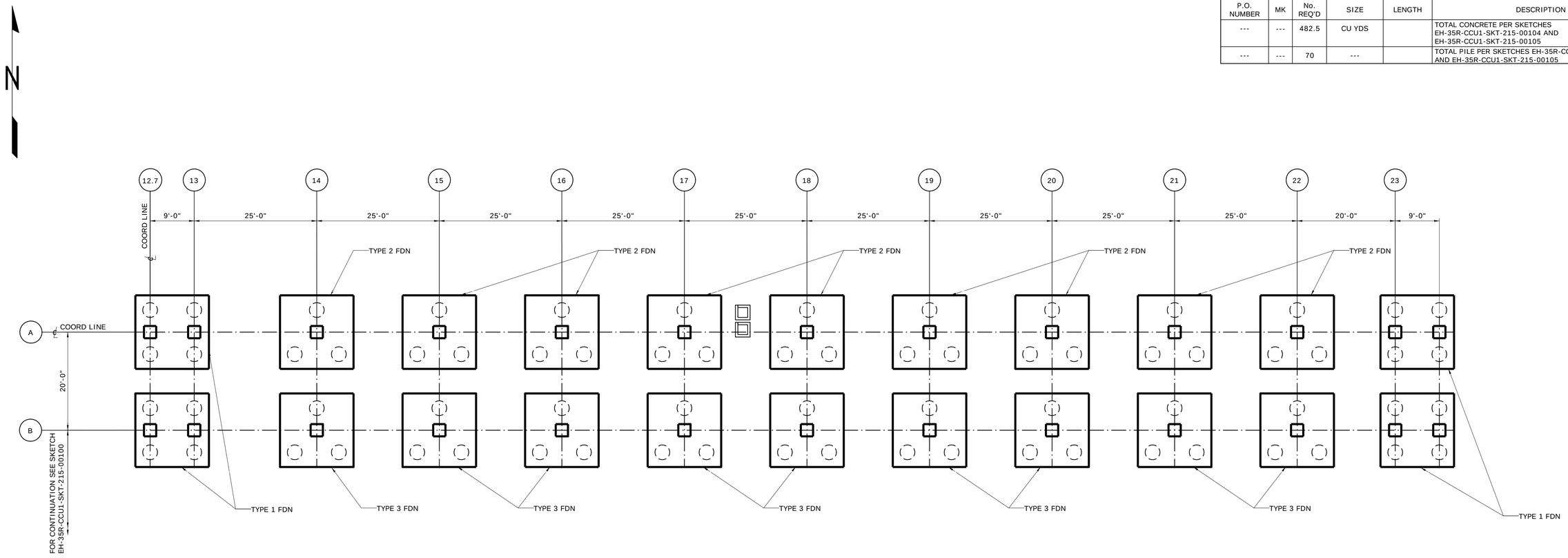
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
AIR COOLER PIPERACK FOUNDATIONS
PLANS & ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00103	1 OF 1	C	1/4"=1'-0"

* QUANTITIES LISTED ARE NET

BILL OF MATERIAL

P.O. NUMBER	MK	No. REQ'D	SIZE	LENGTH	DESCRIPTION
---	---	482.5	CU YDS		TOTAL CONCRETE PER SKETCHES EH-35R-CCU1-SKT-215-00104 AND EH-35R-CCU1-SKT-215-00105
---	---	70	---		TOTAL PILE PER SKETCHES EH-35R-CCU1-SKT-215-00104 AND EH-35R-CCU1-SKT-215-00105



KEY PLAN
SCALE: 3/32 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

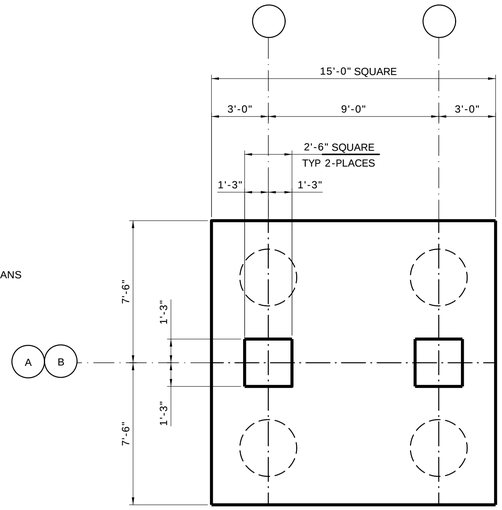
CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
PLATE & FRAME EXCHANGERS STRUCTURAL FDNS
KEY PLAN

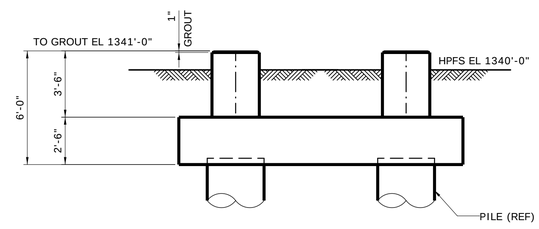
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00104	1 OF 1	C	3/32"=1'-0"

CRC

TYP ALL PLANS



PLAN



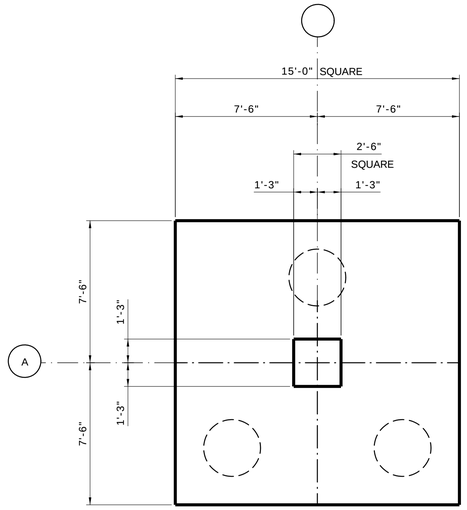
SOUTH ELEVATION

LOOKING NORTH

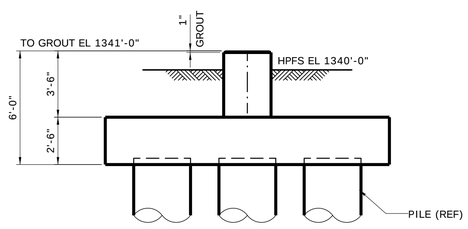
TYPE 1 FOUNDATION

4-FDNS REQUIRED AT 22.4 CU. YDS. EACH = 89.6 CY. YDS. TOTAL

SCALE: 1/4" = 1'-0"



PLAN



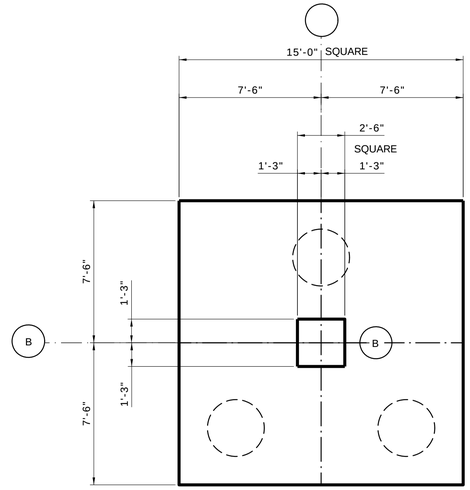
SOUTH ELEVATION

LOOKING NORTH

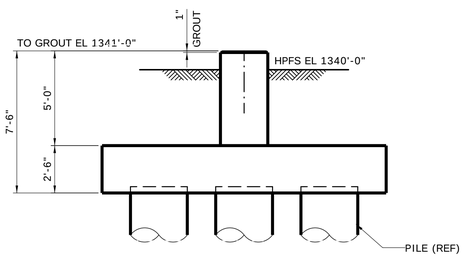
TYPE 2 FOUNDATION

9-FDNS REQUIRED AT 21.6 CU. YDS. EACH = 194.4 CY. YDS. TOTAL

SCALE: 1/4" = 1'-0"



PLAN



SOUTH ELEVATION

LOOKING NORTH

TYPE 3 FOUNDATION

9-FDNS REQUIRED AT 22.0 CU. YDS. EACH = 198.0 CY. YDS. TOTAL

SCALE: 1/4" = 1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

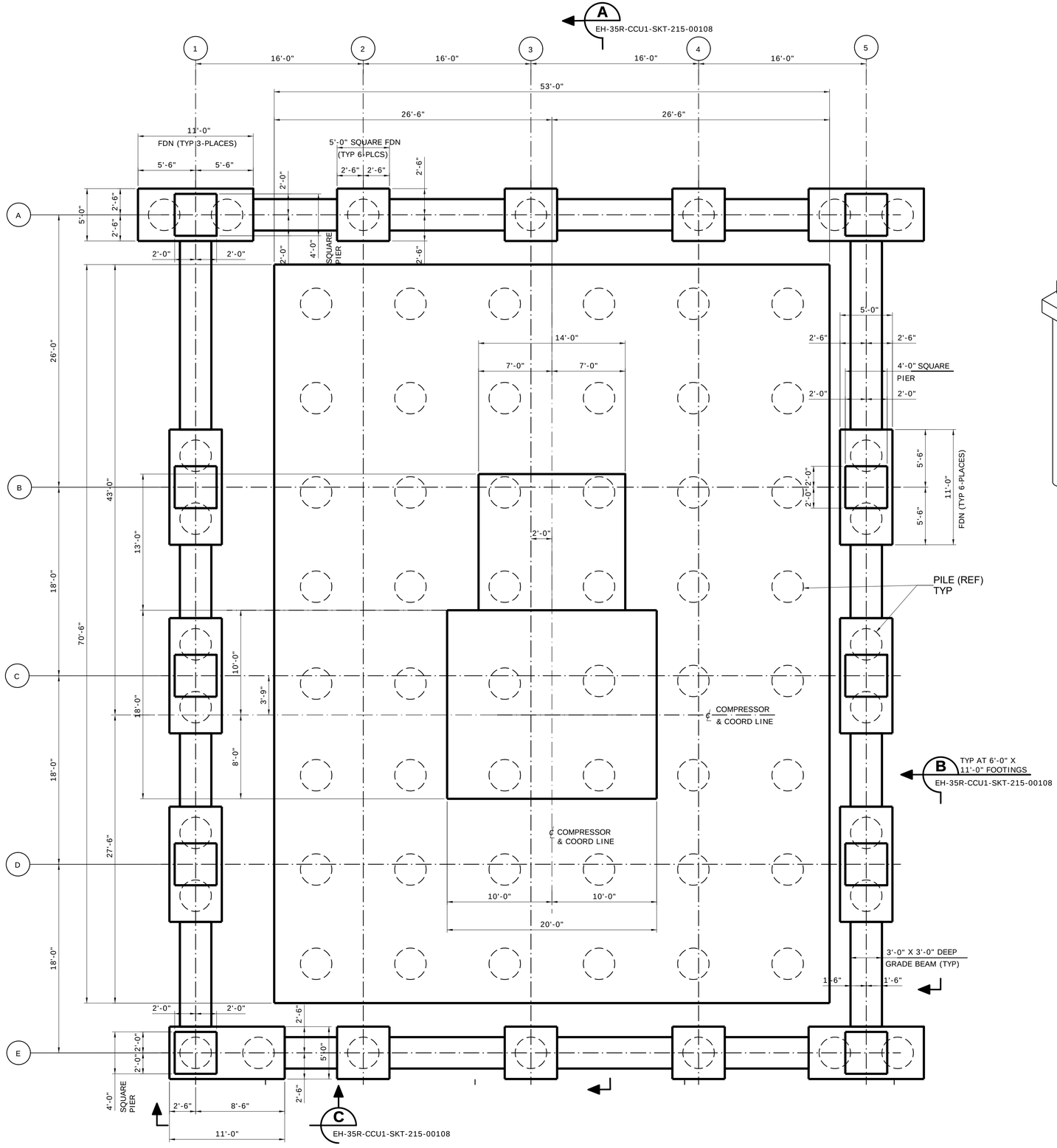
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
PLATE & FRAME EXCHANGERS STRUCTURAL FDNS
PLANS & ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00105	1 OF 1	C	1/4"=1'-0"



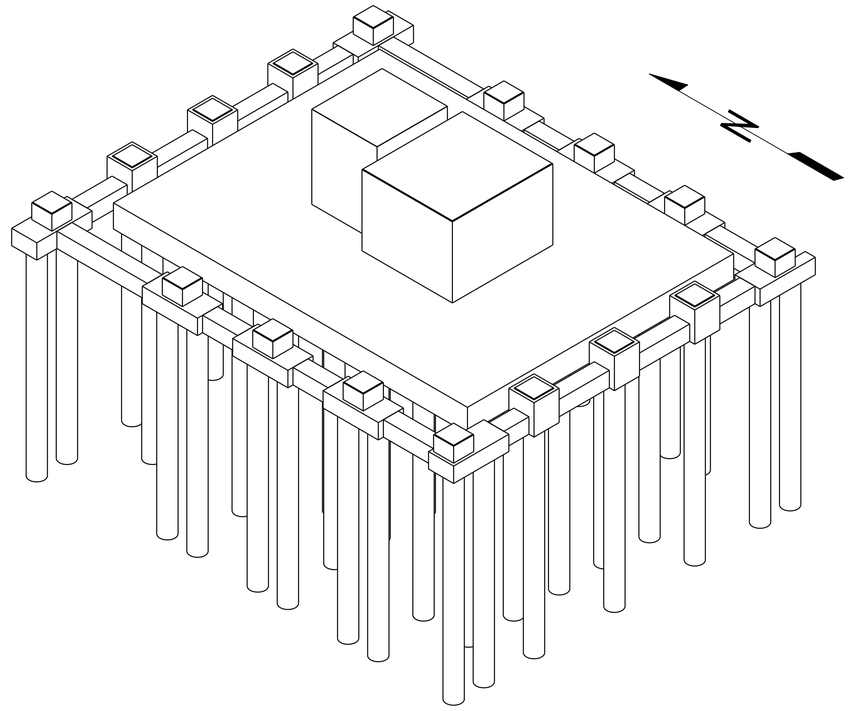
FOUNDATION AT COMPRESSOR K-601

SCALE: 3/16 in: 1 ft

* QUANTITIES LISTED ARE NET

BILL OF MATERIAL

P.O. NUMBER	MK	No. REQ'D	SIZE	LENGTH	DESCRIPTION
---	---	1050.0	CU YDS		TOTAL CONCRETE PER SKETCHES EH-35R-CCU1-SKT-215-00107 AND EH-35R-CCU1-SKT-215-00108
---	---	74	---		TOTAL CONCRETE PER SKETCHES EH-35R-CCU1-SKT-215-00107 AND EH-35R-CCU1-SKT-215-00108



ISOMETRIC

LOOKING NORTHEAST (DOWN)
SCALE: 3/32 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

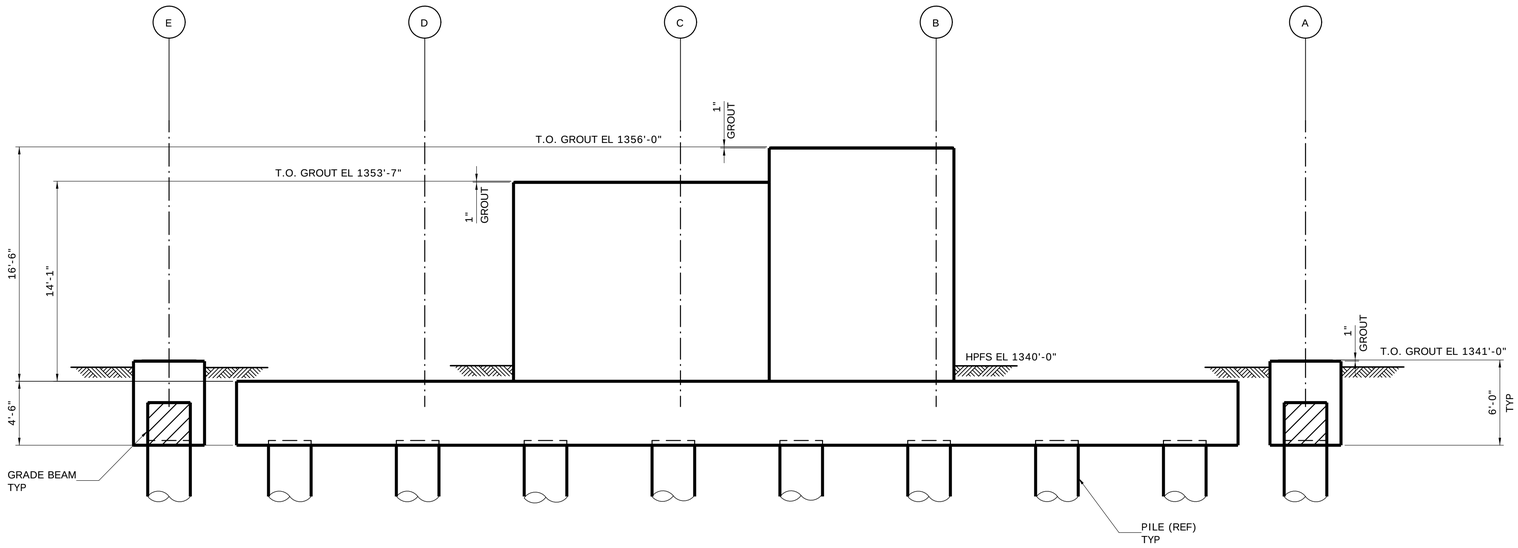
REVISIONS | APPROVALS

ELK HILLS OPERATION

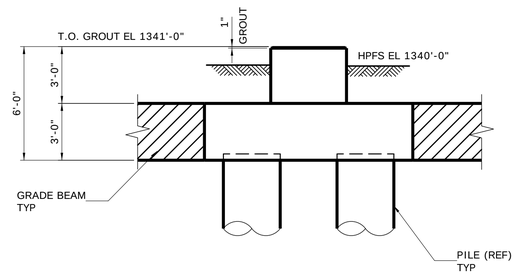
CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
K-601 COMPRESSOR PLATFORM & SHELTER FDNS
ISOEMETRIC & PLAN

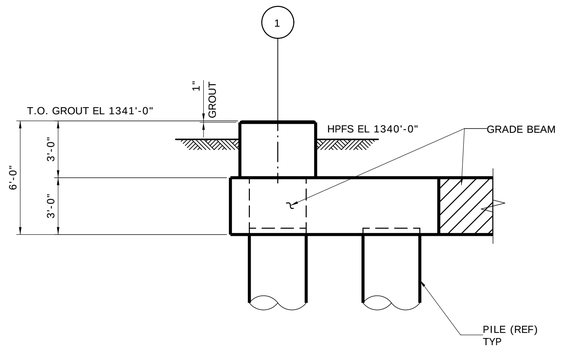
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00107	1 OF 1	C	AS NOTED



SECTION A
SCALE : 3/16" = 1'-0"
EH-35R-CCU1-SKT-215-00107



SECTION B
SCALE : 1/4" = 1'-0"
EH-35R-CCU1-SKT-215-00107



SECTION C
SCALE : 1/4" = 1'-0"
EH-35R-CCU1-SKT-215-00107

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
K-601 COMPRESSOR PLATFORM & SHELTER FDNS
SECTIONS

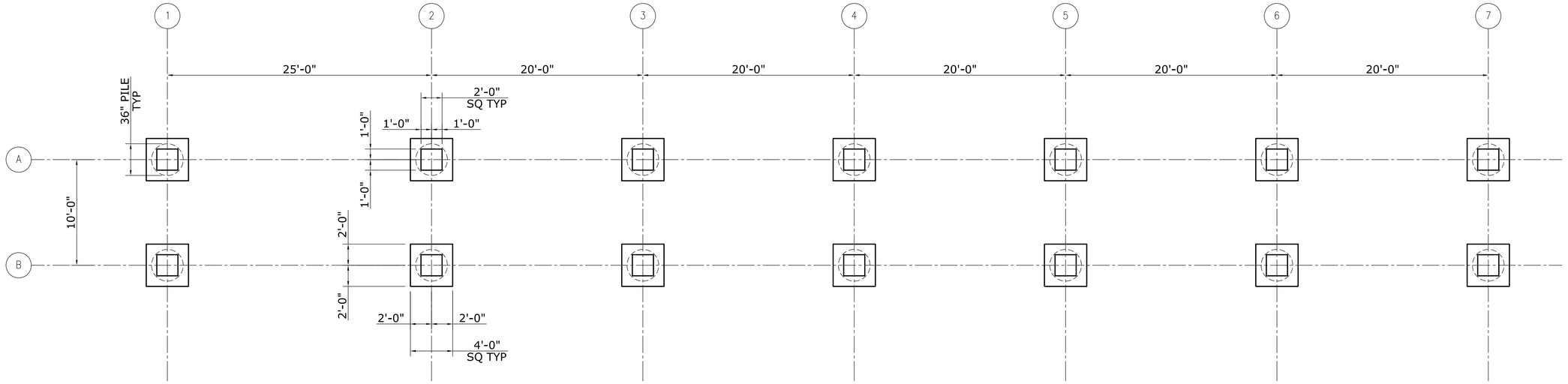
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00108	1 OF 1	C	AS NOTED

BILL OF MATERIAL

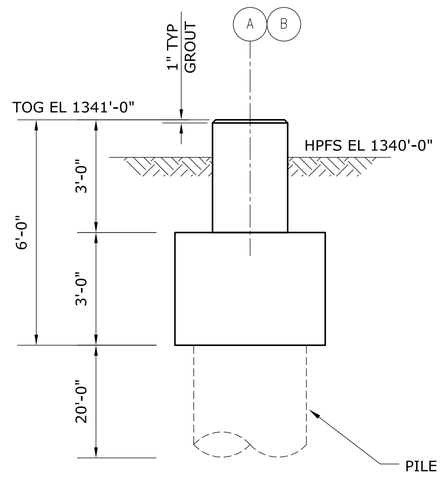
*SEE SPECIFICATIONS

QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO REQD	SIZE	LENGTH	DESCRIPTION
——	——	31.3	CU YDS	——	TOTAL CONCRETE PER THIS SKETCH
——	——	14	PILE	——	36" PILES X 20' LONG



PLAN VIEW
SCALE: 3/16"=1'-0"



ELEVATION
SCALE: 1/2"=1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	TY	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
NORTH–SOUTH FINGER PIPERACK FOUNDATION
PLAN & ELEVATION

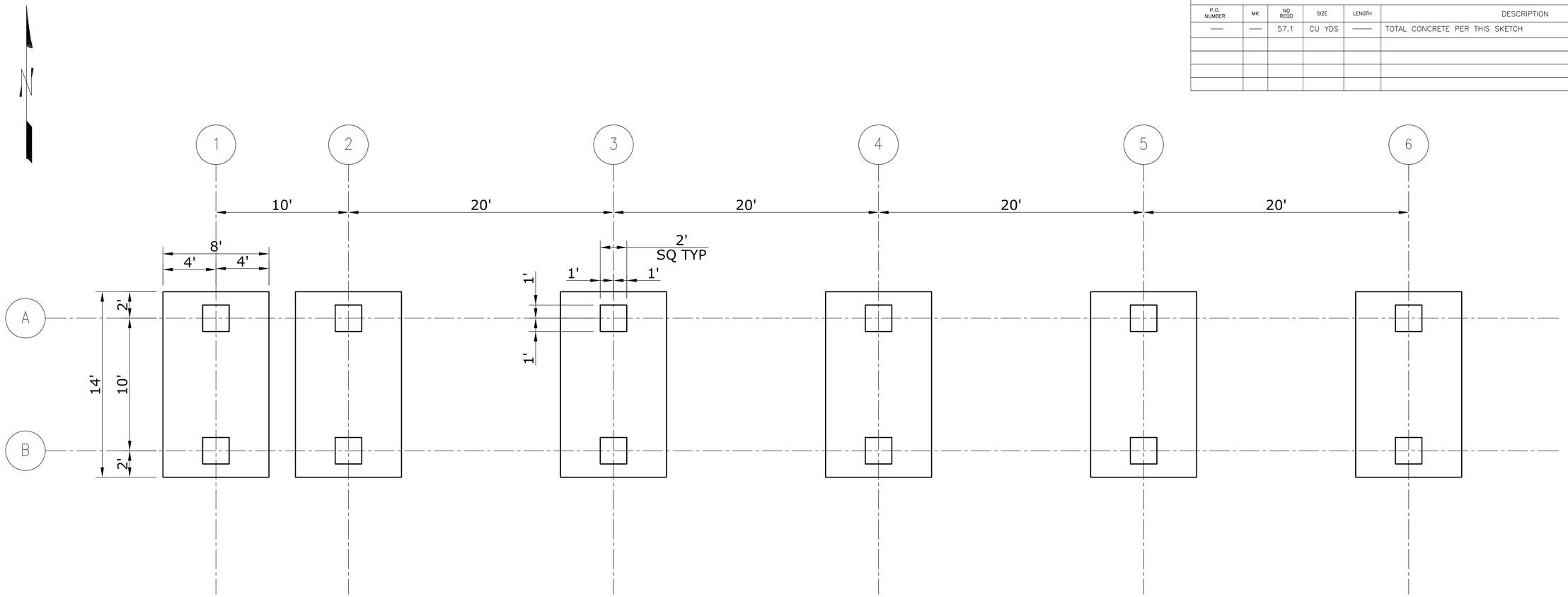
DRAWING No.	SHEET	REV.	SCALE
EH–35R–CCU1–SKT–215–00110	1 OF 1	C	AS NOTED

BILL OF MATERIAL

*SEE SPECIFICATIONS

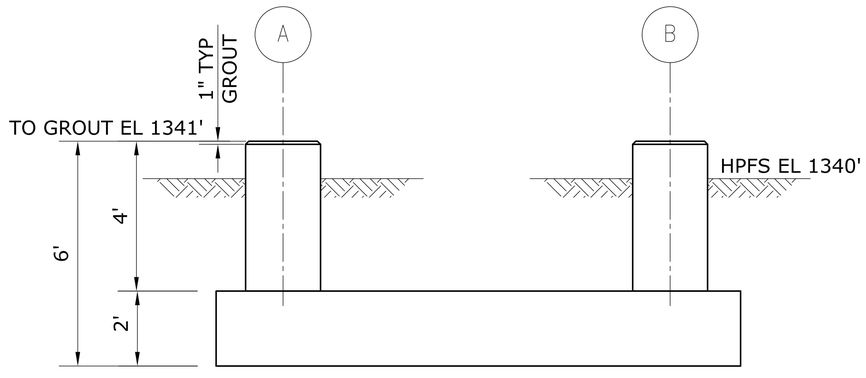
QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO REQD	SIZE	LENGTH	DESCRIPTION
——	——	57.1	CU YDS	——	TOTAL CONCRETE PER THIS SKETCH



PLAN

SCALE: 1/4" = 1'-0"



EAST ELEVATION (LOOKING WEST)

SCALE: 1/2" = 1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	TY	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

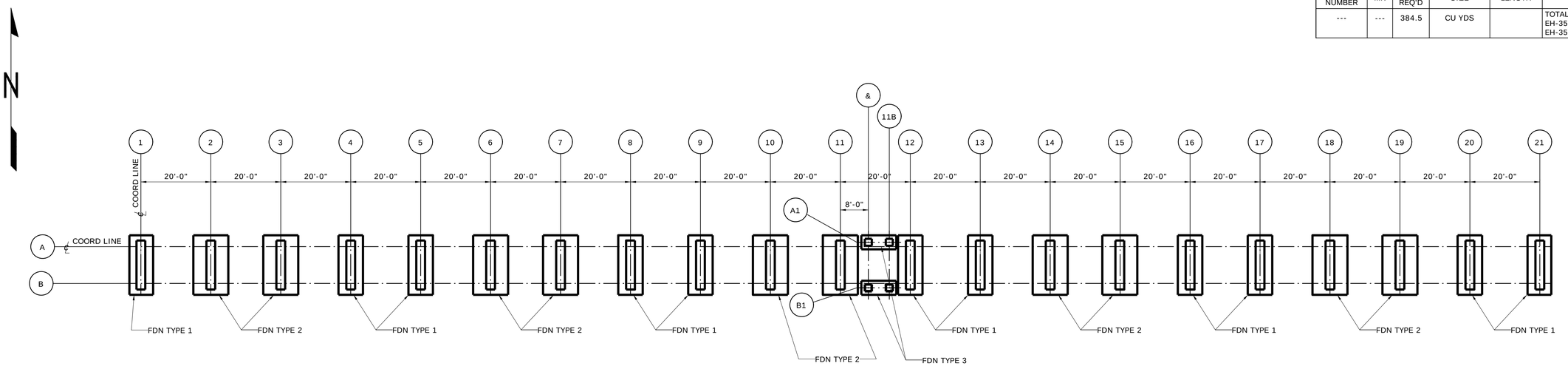
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
EAST–WEST FINGER PIPERACK FDOUNDATION
PLAN & ELEVATION

DRAWING No.	SHEET	REV.	SCALE
EH–35R–CCU1–SKT–215–00111	1 OF 1	C	AS NOTED

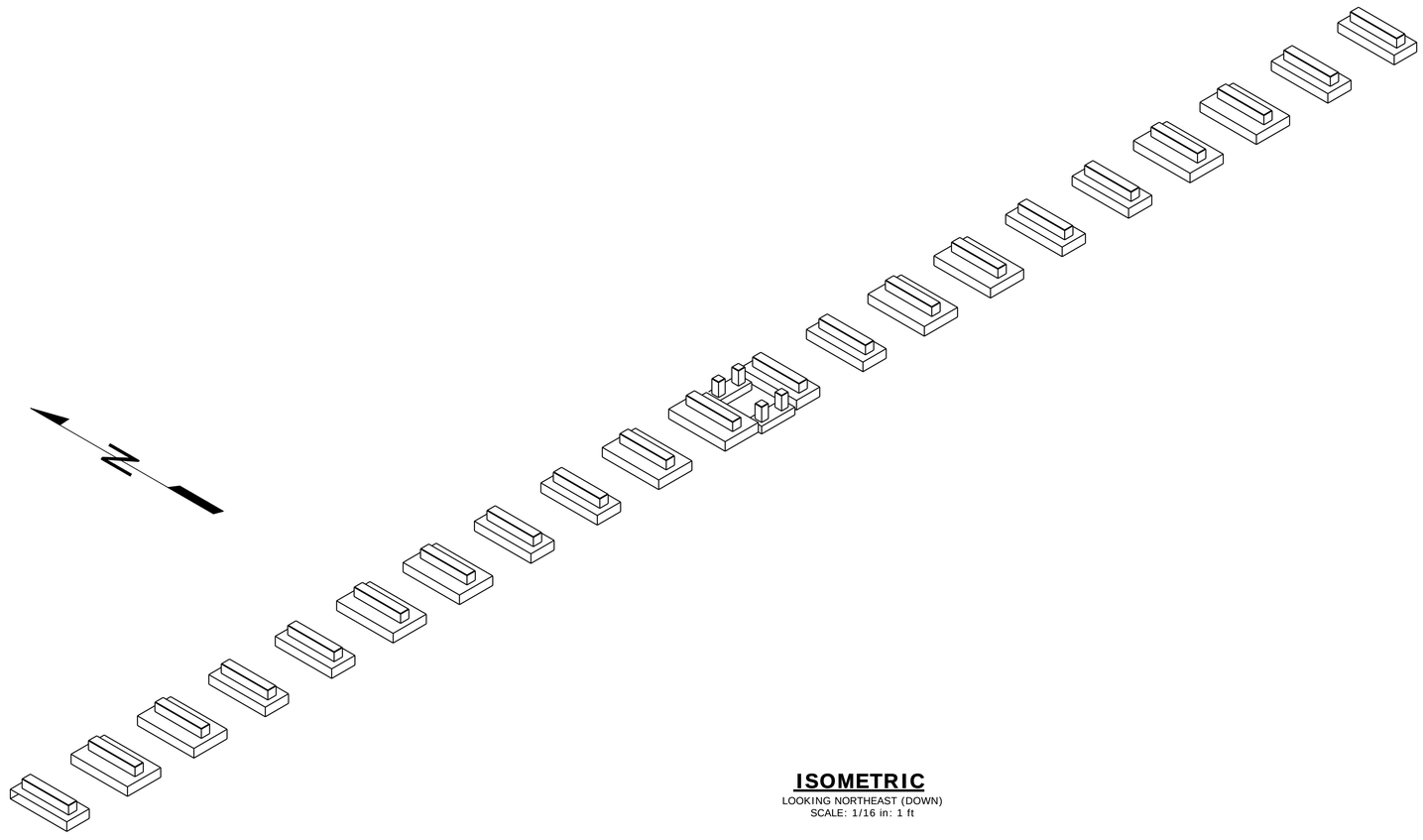
* QUANTITIES LISTED ARE NET

BILL OF MATERIAL

P.O. NUMBER	MK	No. REQ'D	SIZE	LENGTH	DESCRIPTION
---	---	384.5	CU YDS		TOTAL CONCRETE PER SKETCHES EH-35R-CCU1-SKT-215-00112 AND EH-35R-CCU1-SKT-215-00113



KEY PLAN
SCALE: 1/16 in: 1 ft



ISOMETRIC
LOOKING NORTHEAST (DOWN)
SCALE: 1/16 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

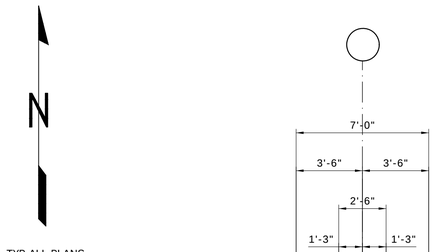
REVISIONS | APPROVALS

ELK HILLS OPERATION

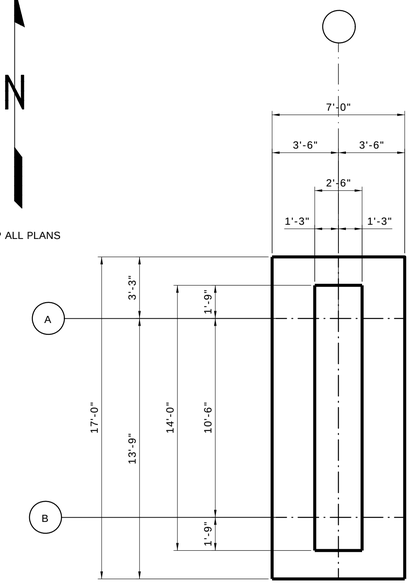
CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
WSAC SLEEPERWAY & PLATFORM FOUNDATIONS
ISOEMETRIC & PLAN

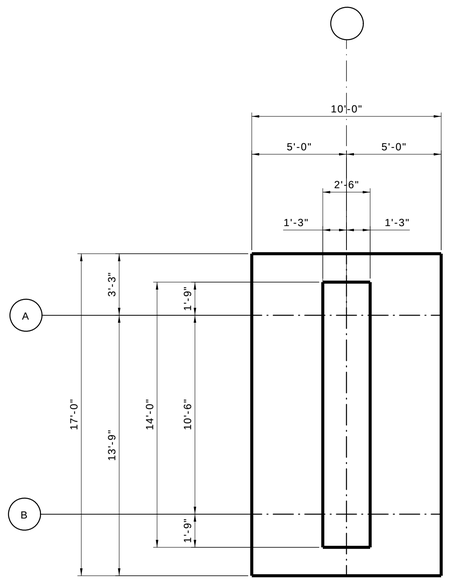
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00112	1 OF 1	C	1/16"=1'-0"



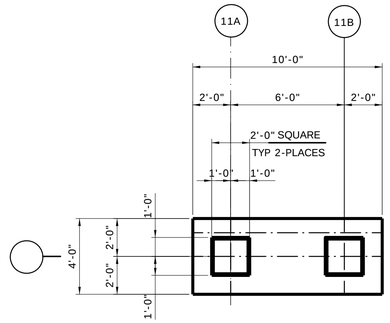
TYP ALL PLANS



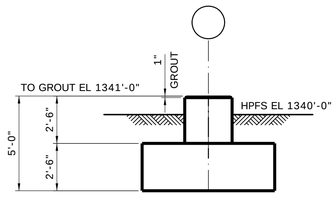
PLAN



PLAN



PLAN



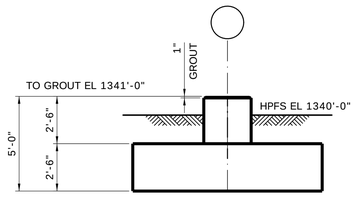
SOUTH ELEVATION

LOOKING NORTH

TYPE 1 FOUNDATION

11-FDNS REQUIRED AT 14.3 CU. YDS. EACH = 157.3 CY. YDS. TOTAL

SCALE: 1/4" = 1'-0"



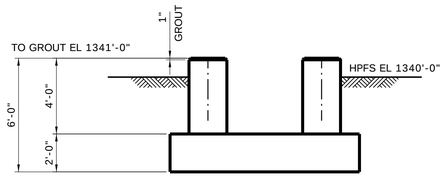
SOUTH ELEVATION

LOOKING NORTH

TYPE 2 FOUNDATION

10-FDNS REQUIRED AT 19.0 CU. YDS. EACH = 190.0 CY. YDS. TOTAL

SCALE: 1/4" = 1'-0"



SOUTH ELEVATION

LOOKING NORTH

TYPE 3 FOUNDATION

2-FDNS REQUIRED AT 4.1 CU. YDS. EACH = 8.2 CY. YDS. TOTAL

SCALE: 1/4" = 1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KB	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
WSAC SLEEPERWAY & PLATFORM FOUNDATIONS
PLANS & ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00113	1 OF 1	C	1/4"=1'-0"

CRC

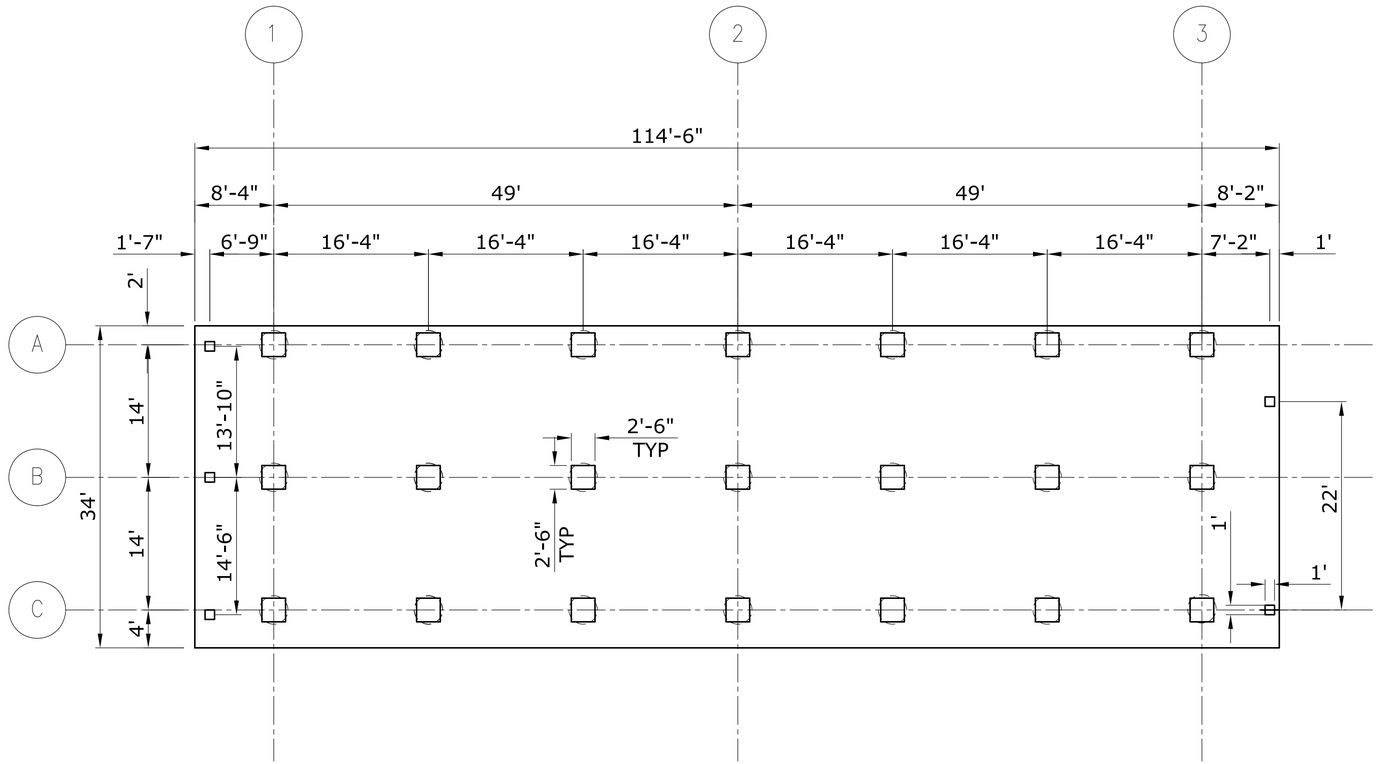
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BILL OF MATERIAL

*SEE SPECIFICATIONS

QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO REQD	SIZE	LENGTH	DESCRIPTION
—	—	581.3	CU YDS	—	TOTAL CONCRETE PER SKETCHES EH-35R-CCU1-SKT-215-00120 AND EH-35R-CCU1-SKT-215-00121
—	—	21	36" DIA	40'-0"	TOTAL PILE PER SKETCHES EH-35R-CCU1-SKT-215-00120 AND EH-35R-CCU1-SKT-215-00121



FOUNDATION PLAN

SCALE: 1/8" = 1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/01/20	TY	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

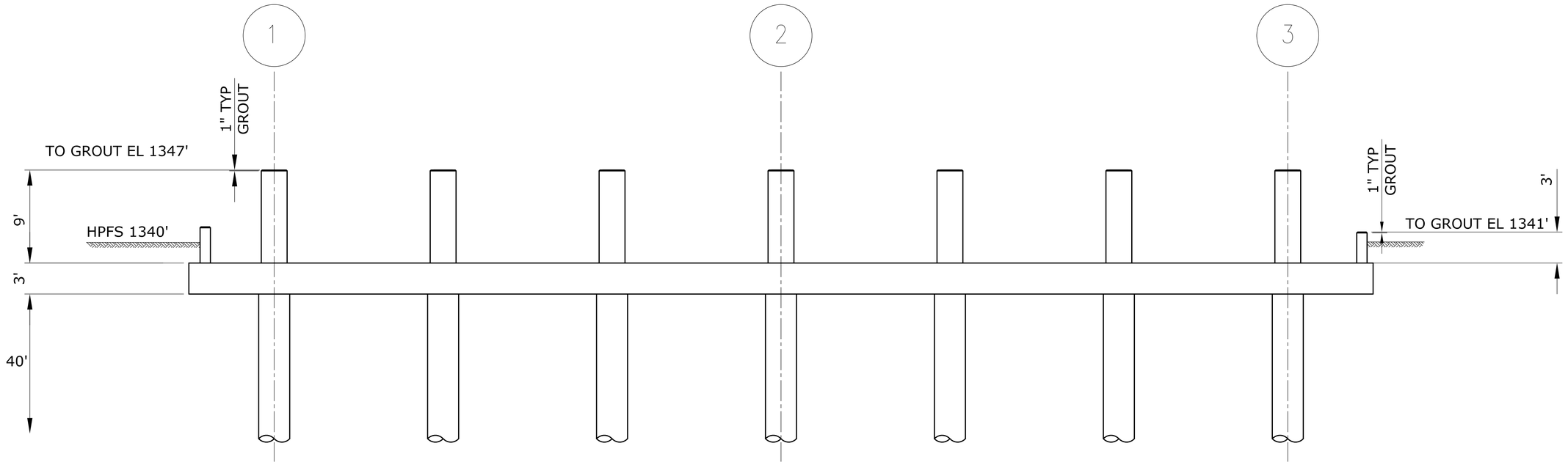
ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
AUXILIARY POWER CENTER (APC) FOUNDATION PLAN

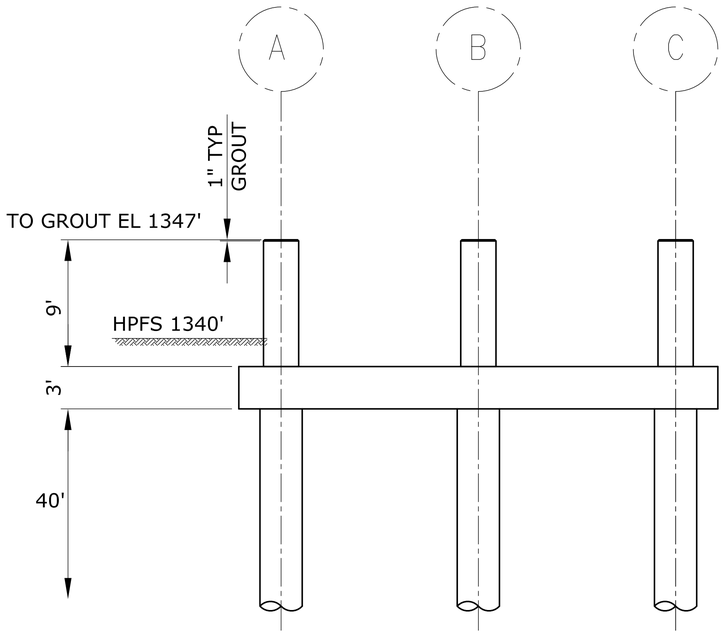
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00120	1 OF 1	C	1/8"=1'-0"

CRC



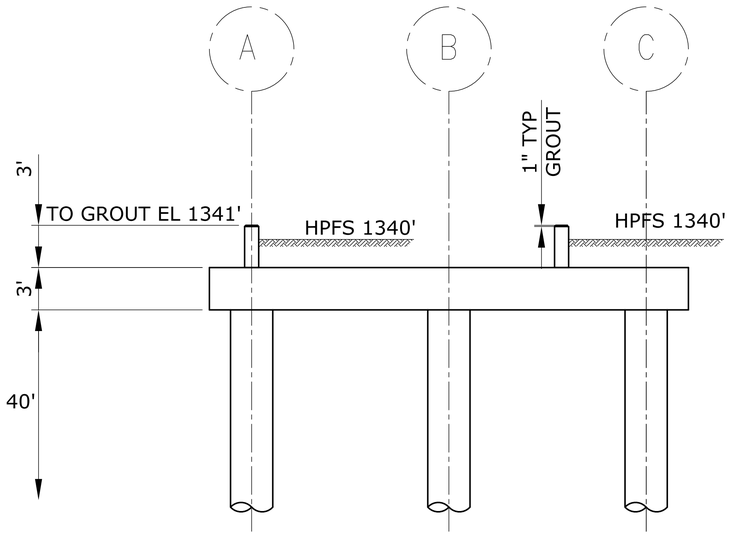
SOUTH ELEVATION (LOOKING NORTH)

SCALE: 3/16" = 1'-0"



COLUMN LINE 3 ELEVATION

SCALE: 3/16" = 1'-0"



EAST ELEVATION (LOOKING WEST)

SCALE: 3/16" = 1'-0"

FLUOR.

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	9/30/20	TY	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

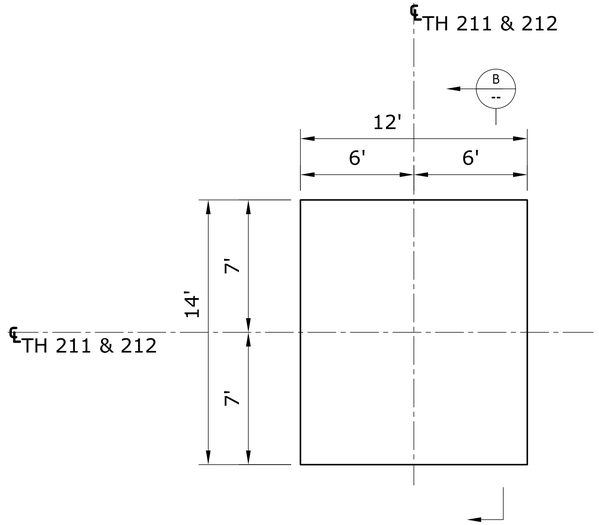
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

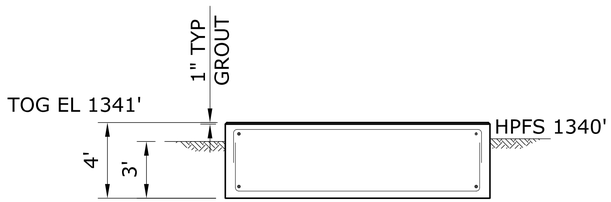
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
AUXILIARY POWER CENTER (APC) FOUNDATION ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00121	1 OF 1	C	3/16"=1'-0"



TH 211 & 212 FOUNDATION PLAN

SCALE: 1/4" = 1'-0"



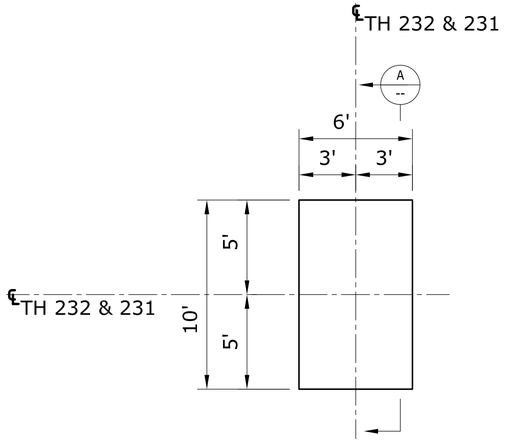
SECTION B

SCALE: 1/4" = 1'-0"

BILL OF MATERIAL

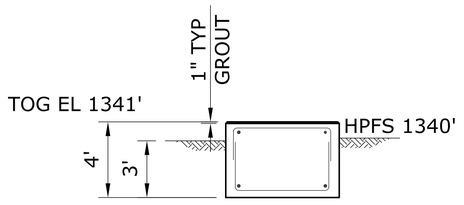
*SEE SPECIFICATIONS — QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO. REQD	SIZE	LENGTH	DESCRIPTION
——	——	69.0	CU YDS	——	TOTAL CONCRETE PER THIS SKETCH



TH 231 & 231 FOUNDATION PLAN

SCALE: 1/4" = 1'-0"



SECTION A

SCALE: 1/4" = 1'-0"

FLUOR

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	TY	TY	WA WA	NP MP	WA WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

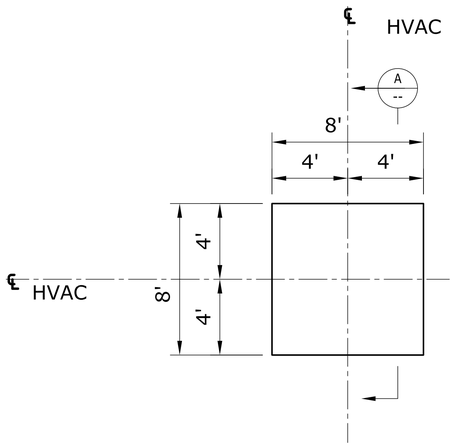
REVISIONS — APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

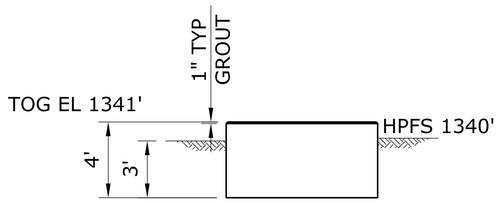
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
AUXILIARY POWER CENTER (APC) FOUNDATION
TRANSFORMERS FOUNDATION PLANS & SECTIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00122	1 OF 1	C	1/4"=1'-0"



PLAN

SCALE: 1/4" = 1'-0"



SECTION A

SCALE: 1/4" = 1'-0"

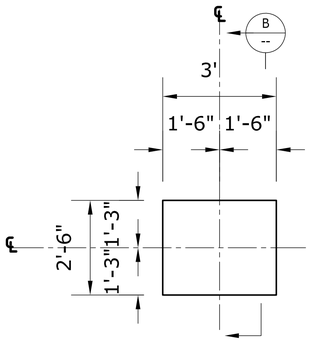
BILL OF MATERIAL

*SEE SPECIFICATIONS

QUANTITIES LISTED ARE NET

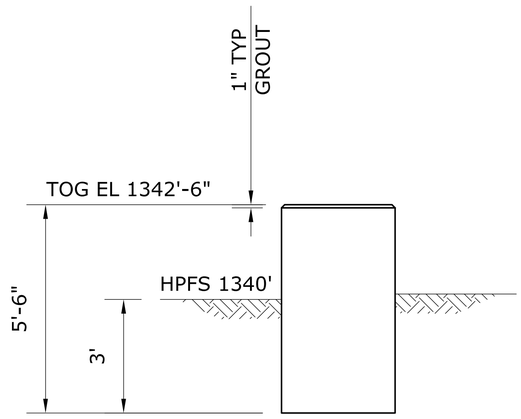
P.O. NUMBER	MK	NO. REQD	SIZE	LENGTH	DESCRIPTION
——	——	34.63	CU YDS	——	TOTAL CONCRETE PER THIS SKETCH

HVAC FOUNDATION



PLAN

SCALE: 1/2" = 1'-0"



SECTION B

SCALE: 1/2" = 1'-0"

BUS DUCT SUPPORT

FLUOR

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	TY	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
AUXILIARY POWER CENTER (APC) FOUNDATION
HVAD FDN & BUS DUCT: PLANS & SECTIONS

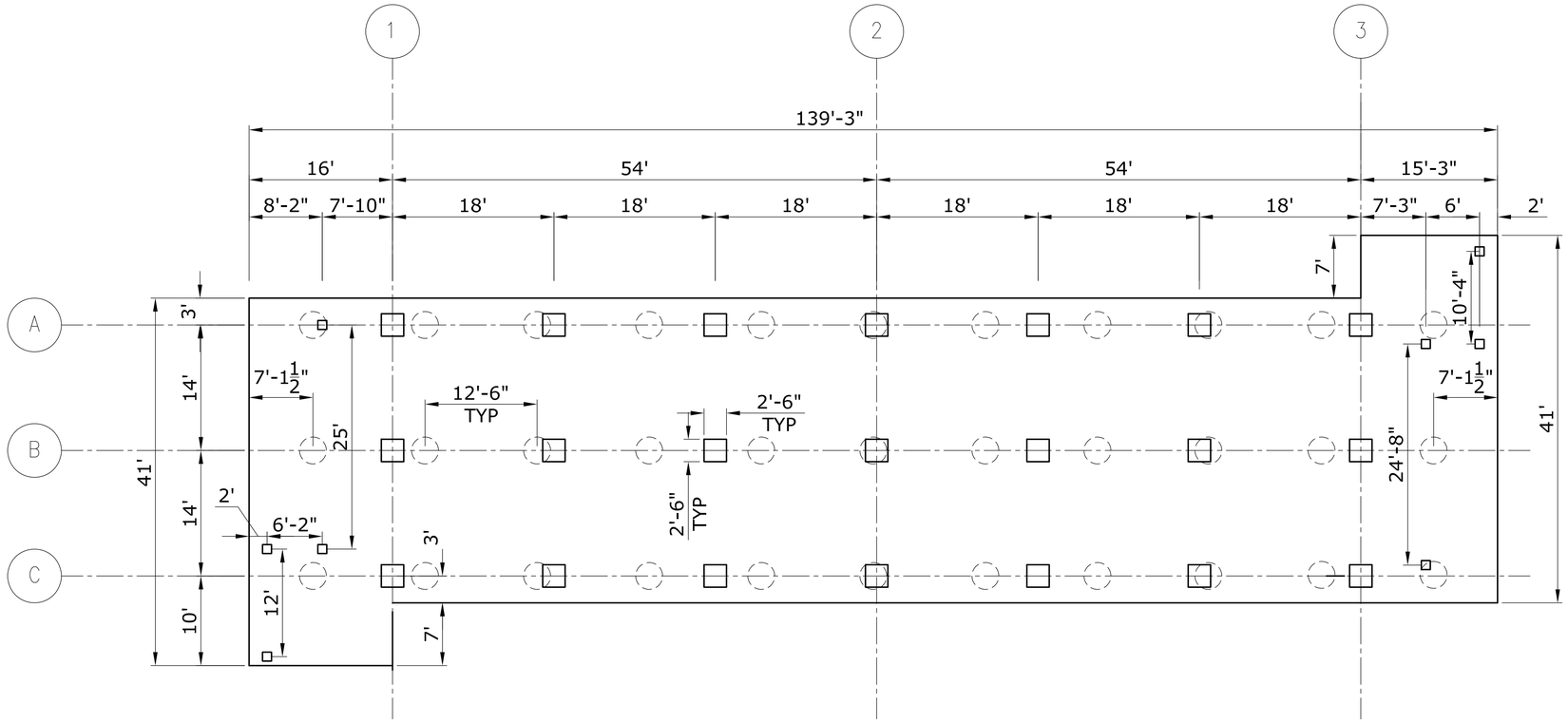
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00123	1 OF 1	C	1/4"=1'-0"

BILL OF MATERIAL

*SEE SPECIFICATIONS

QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO. REQD	SIZE	LENGTH	DESCRIPTION
—	—	844.9	CU YDS	—	TOTAL CONCRETE PER SKETCHES EH-35R-CCU1-SKT-215-00124 AND EH-35R-CCU1-SKT-215-00125
—	—	33	36" DIA	40'-0"	TOTAL PILE PER SKETCHES EH-35R-CCU1-SKT-215-00124 AND EH-35R-CCU1-SKT-215-00125



FOUNDATION PLAN

SCALE: 1/8" = 1'-0"

FLUOR.

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	TY	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

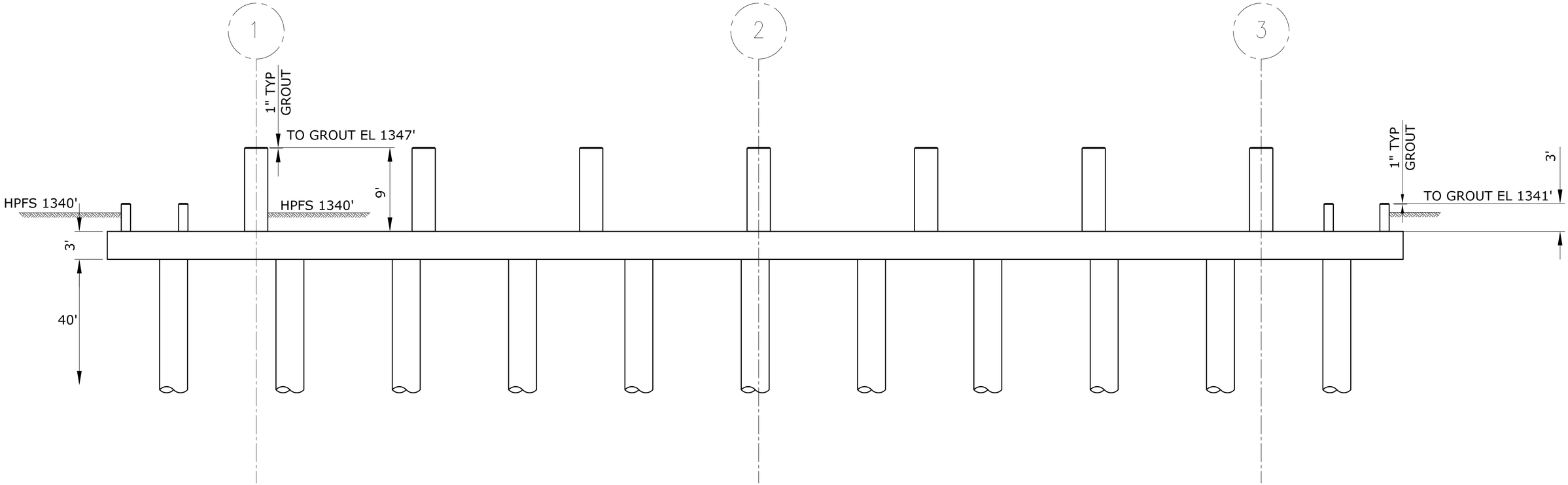
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

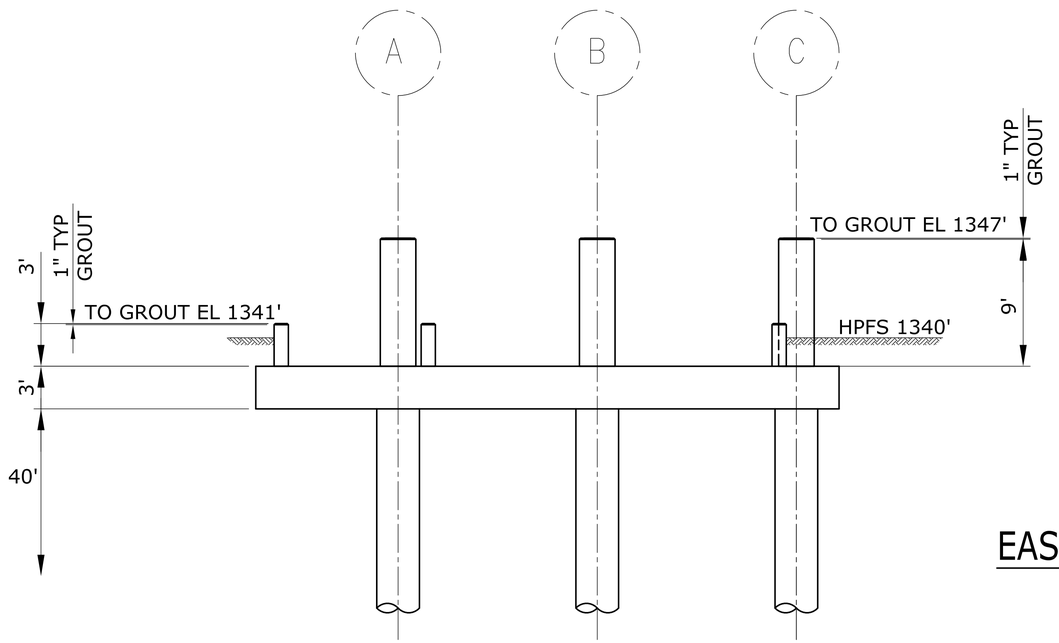
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
MAIN POWER CENTER (MPC) FOUNDATION PLAN

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00124	1 OF 1	C	1/8"=1'-0"



SOUTH ELEVATION (LOOKING NORTH)

SCALE: 3/16" = 1'-0"



EAST ELEVATION (LOOKING WEST)

SCALE: 3/16" = 1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	TY	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

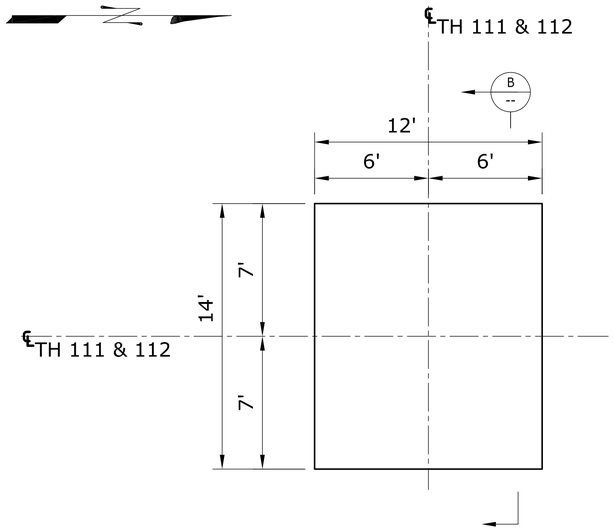
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
MAIN POWER CENTER (MPC) FOUNDATION ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00125	1 OF 1	C	3/16"=1'-0"



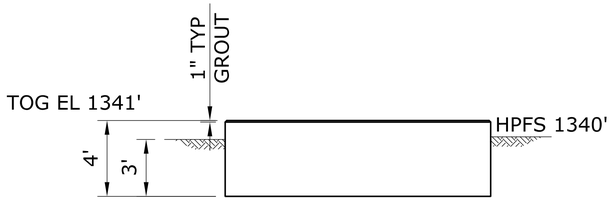
TH 111 & 112 FOUNDATION PLAN

SCALE: 1/4" = 1'-0"

BILL OF MATERIAL

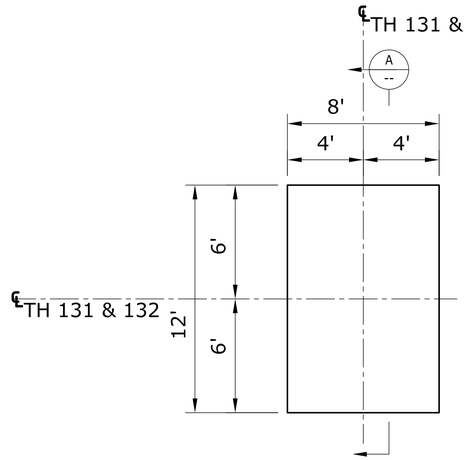
*SEE SPECIFICATIONS — QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO REQD	SIZE	LENGTH	DESCRIPTION
—	—	166.3	CU YDS	—	TOTAL CONCRETE PER THIS SKETCH



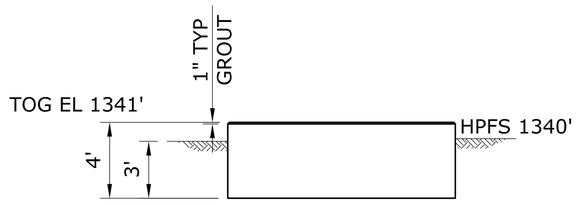
SECTION B

SCALE: 1/4" = 1'-0"



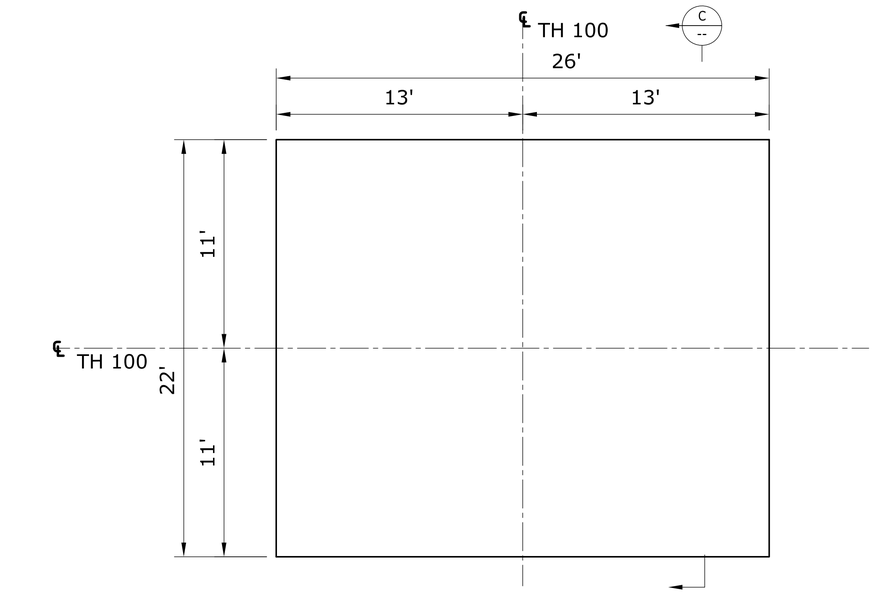
TH 131 & 132 FOUNDATION PLAN

SCALE: 1/4" = 1'-0"



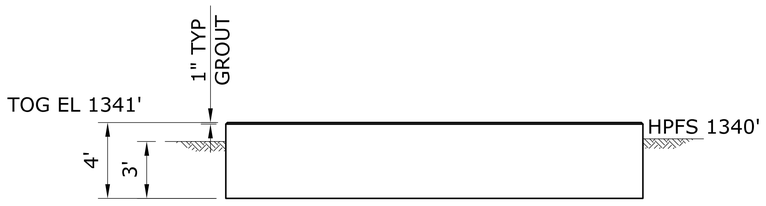
SECTION A

SCALE: 1/4" = 1'-0"



TH 100 FOUNDATION PLAN

SCALE: 1/4" = 1'-0"



SECTION C

SCALE: 1/4" = 1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	TY	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS — APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

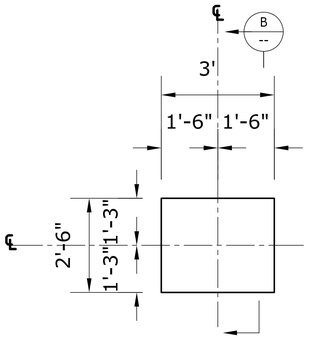
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
MAIN POWER CENTER (MPC) FOUNDATION
TRANSFORMER FDN: PLANS AND SECTIOND

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00126	1 OF 1	C	1/4"=1'-0"

BILL OF MATERIAL

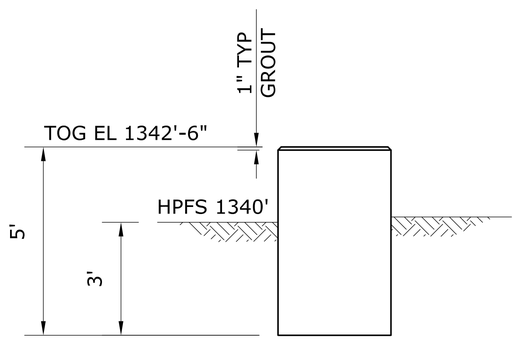
*SEE SPECIFICATIONS — QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO. REQD	SIZE	LENGTH	DESCRIPTION
—	—	83.02	CU YDS	—	TOTAL CONCRETE PER THIS SKETCH



PLAN

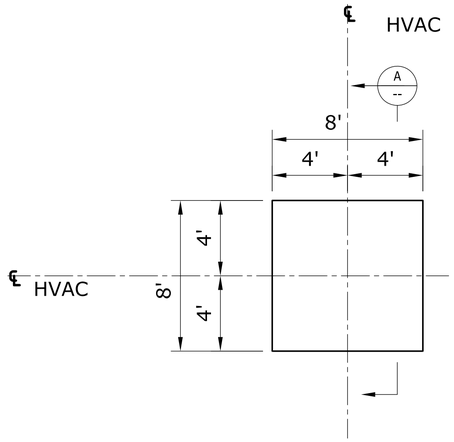
SCALE: 1/2" = 1'-0"



SECTION B

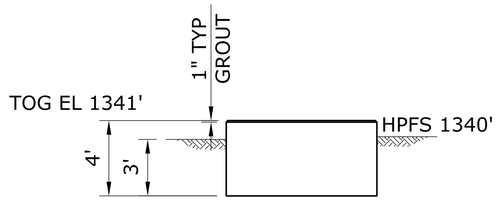
SCALE: 1/2" = 1'-0"

BUS DUCT SUPPORT



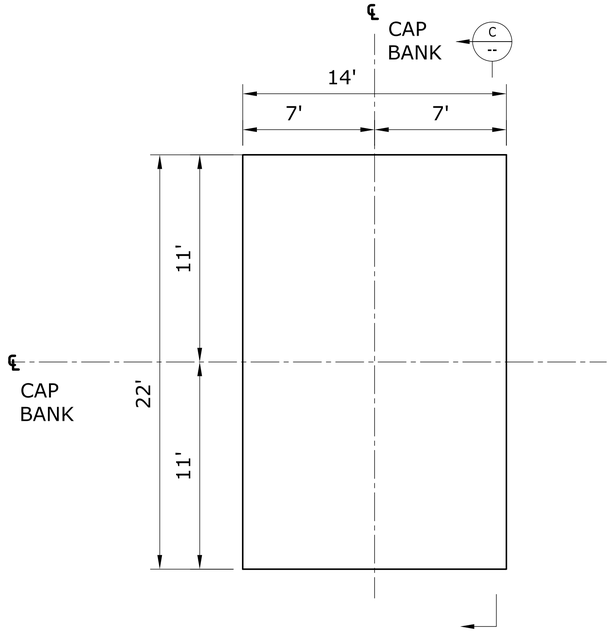
PLAN

SCALE: 1/4" = 1'-0"



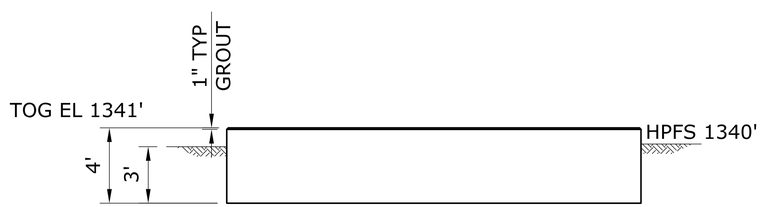
SECTION A

SCALE: 1/4" = 1'-0"



PLAN

SCALE: 1/4" = 1'-0"



SECTION C

SCALE: 1/4" = 1'-0"

CAPACITOR BANK FOUNDATION

HVAC FOUNDATION

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	TY	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

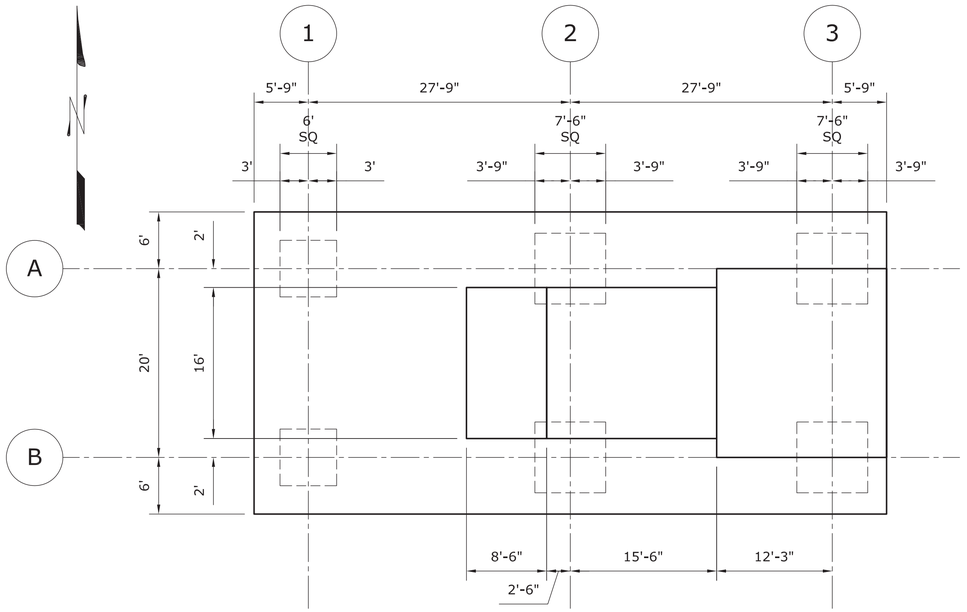
REVISIONS — APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

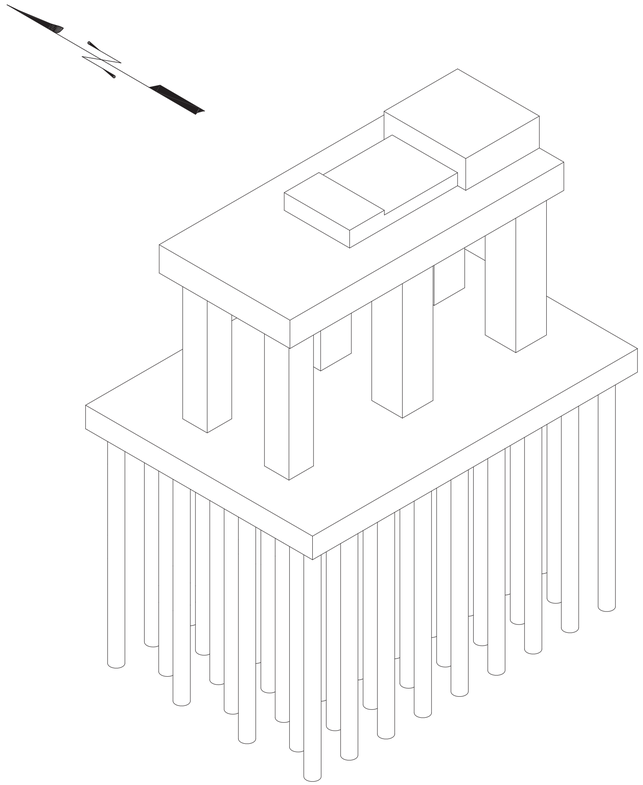
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
MAIN POWER CENTER (MPC) FOUNDATION
PLANS AND SECTIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00127	1 OF 1	C	AS NOTED



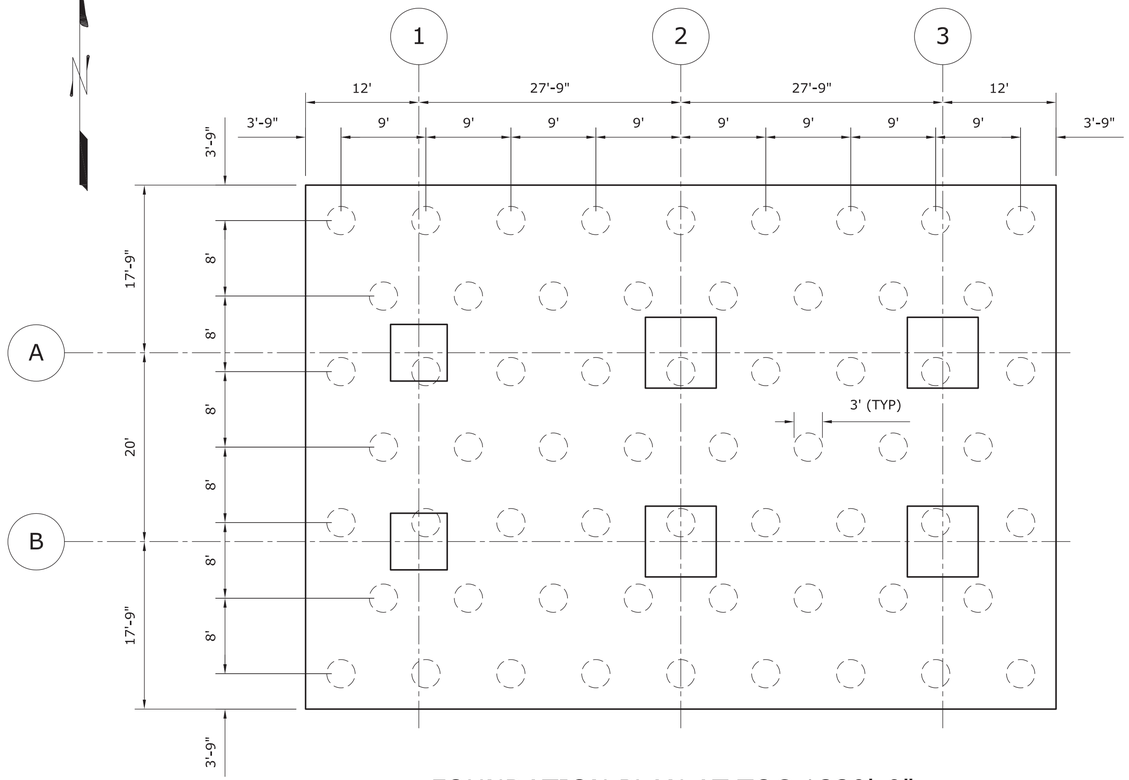
PLAN AT TOC 1382'-1"

SCALE: 1/8" = 1'-0"



ISOMETRIC

LOOKING NORTHEAST (DOWN)
SCALE: 1/16" = 1'-0"



FOUNDATION PLAN AT TOC 1339'-0"

SCALE: 1/8" = 1'-0"

BILL OF MATERIAL

*SEE SPECIFICATIONS

QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO. REQD	SIZE	LENGTH	DESCRIPTION
—	—	2889.5	CU YDS	—	TOTAL CONCRETE PER SKETCHES EH-35R-CCU1-SKT-215-00128 AND EH-35R-CCU1-SKT-215-00129
—	—	60	36" DIA	60'-0"	TOTAL PILE PER SKETCHES EH-35R-CCU1-SKT-215-00128 AND EH-35R-CCU1-SKT-215-00129

FLUOR

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	JT	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

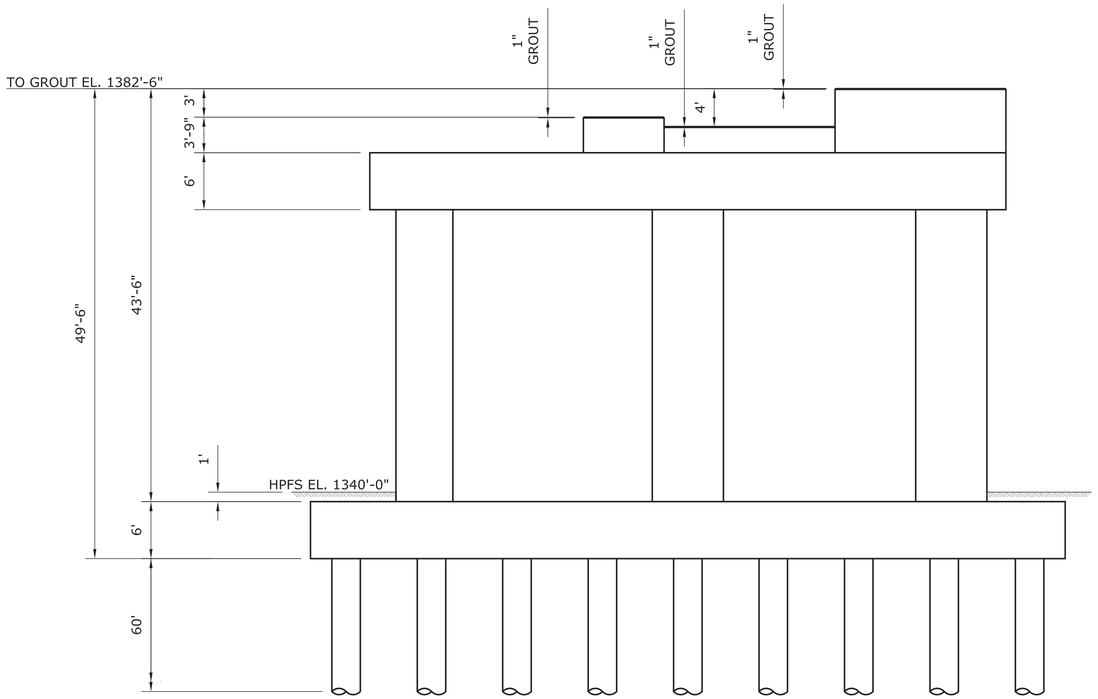
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

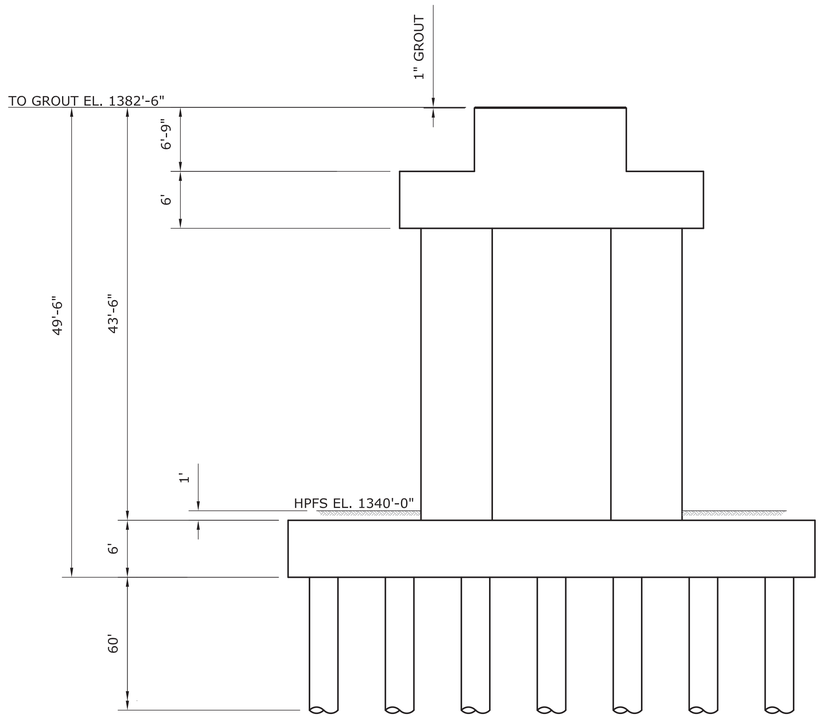
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
K-201 BLOWER FOUNDATION
ISOMETRIC AND PLANS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00128	1 OF 1	C	AS NOTED



SOUTH ELEVATION (LOOKING NORTH)

SCALE: 1/8" = 1'-0"



EAST ELEVATION (LOOKING WEST)

SCALE: 1/8" = 1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	JT	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

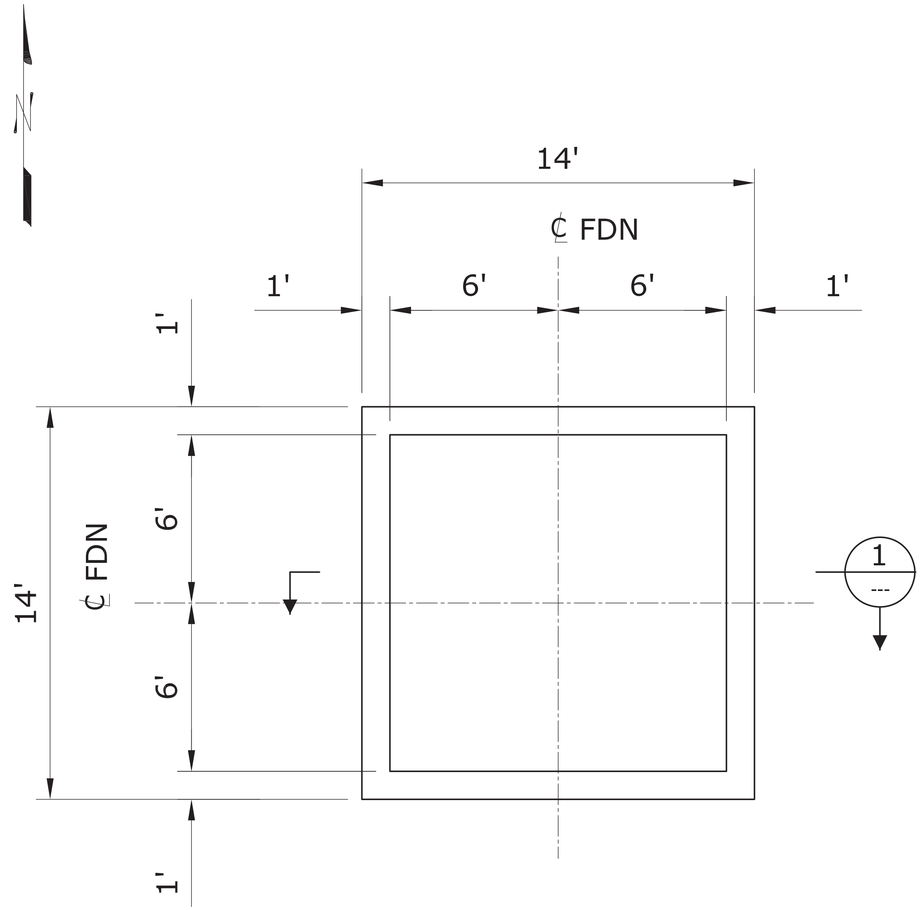
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

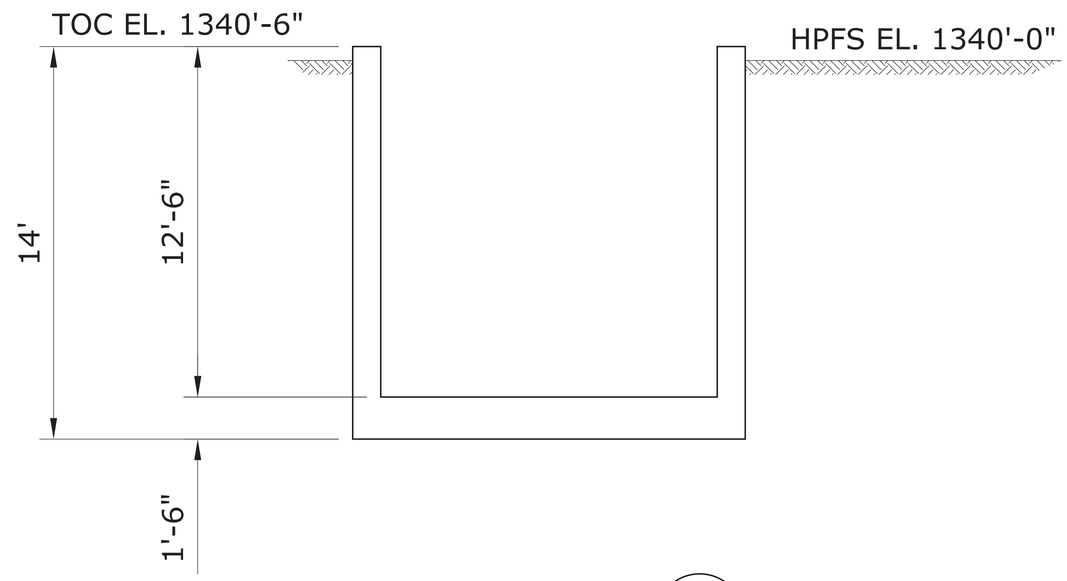
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
K-201 BLOWER FOUNDATION
ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00129	1 OF 1	C	1/8"=1'-0"



FOUNDATION PLAN AT TOC 1340'-6"

SCALE: 3/8" = 1'-0"



SECTION 1 / ---

SCALE: 3/8" = 1'-0"

BILL OF MATERIAL

*SEE SPECIFICATIONS — QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO REQD	SIZE	LENGTH	DESCRIPTION
——	——	30	CU YDS	——	TOTAL CONCRETE PER THIS SKETCH

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	JT	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS — APPROVALS

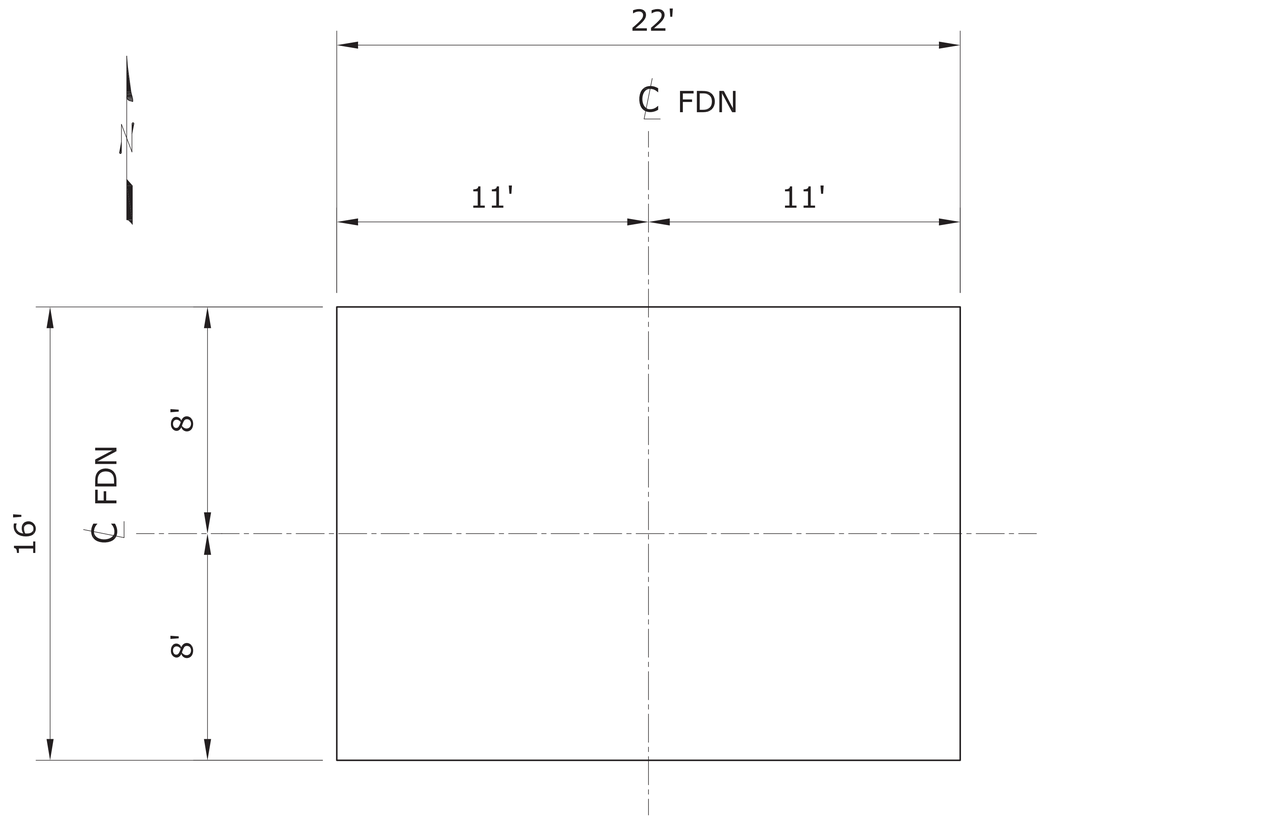
ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
M-712 FOUNDATION
PLAN & SECTION

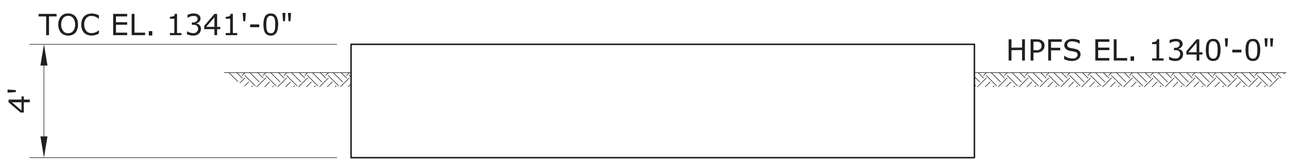
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00130	1 OF 1	C	3/8"=1'-0"

CRC



FOUNDATION PLAN AT TOC 1341'-0"

SCALE: 3/8" = 1'-0"



SOUTH ELEVATION

LOOKING NORTH

SCALE: 3/8" = 1'-0"

*SEE SPECIFICATIONS

BILL OF MATERIAL

QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO. REQD	SIZE	LENGTH	DESCRIPTION
——	——	60.0	CU YDS	——	TOTAL CONCRETE PER THIS SKETCH

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	JT	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

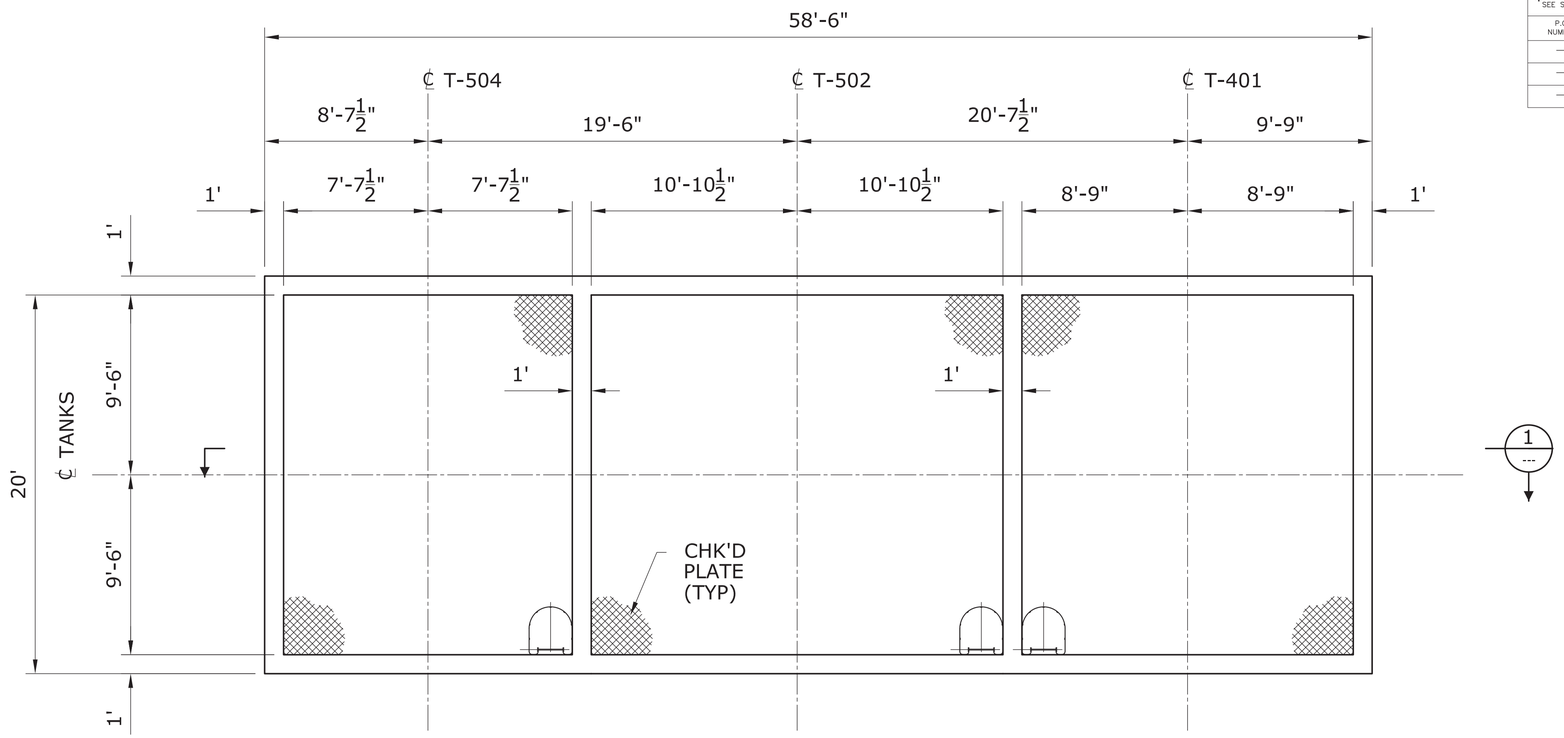
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
M.703 FOUNDATION
PLAN & ELEVATION

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00131	1 OF 1	C	3/8"=1'-0"



FOUNDATION PLAN AT TOC 1340'-6"

SCALE: 1/4" = 1'-0"



SECTION 1

SCALE: 1/4" = 1'-0"

BILL OF MATERIAL

*SEE SPECIFICATIONS

QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO REQD	SIZE	LENGTH	DESCRIPTION
—	—	251.2	CU YDS	—	TOTAL CONCRETE PER THIS SKETCH
—	—	6.5	TONS	—	TOTAL 1/4" CHECKERED PLATE PER THIS SKETCH
—	—	0.5	TONS	—	TOTAL LADDER PER THIS SKETCH

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/01/20	JT	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
T-401, T-502 AND T-504 FOUNDATION PLAN AND ELEVATION

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00132	1 OF 1	C	1/4"=1'-0"

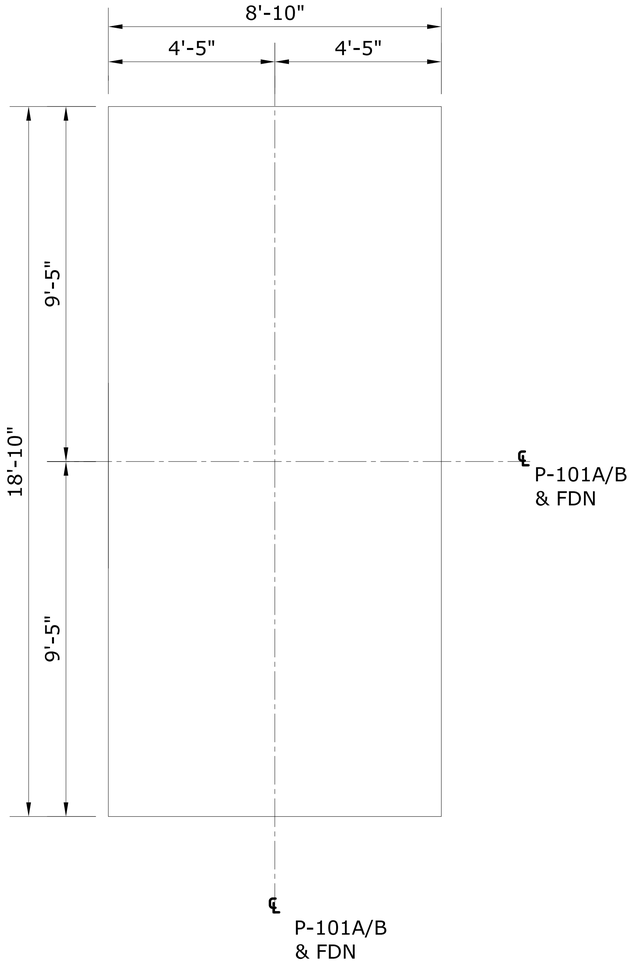
CRC

BILL OF MATERIAL

*SEE SPECIFICATIONS

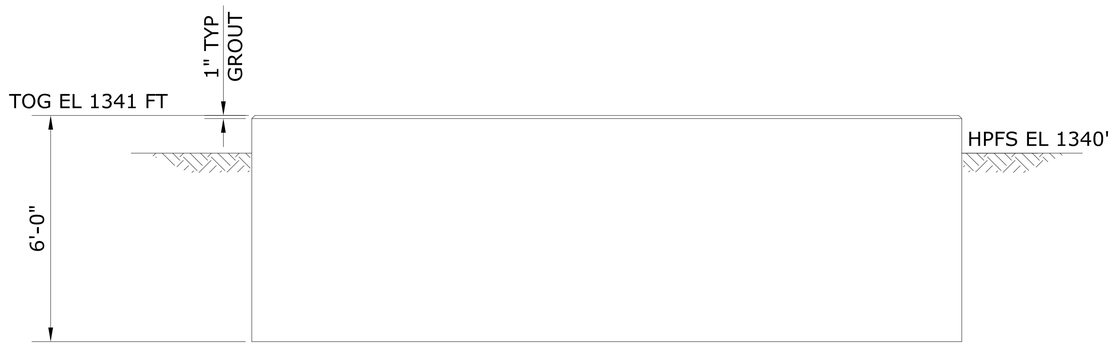
QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO REQD	SIZE	LENGTH	DESCRIPTION
——	——	83.4	CU YDS	——	TOTAL CONCRETE PER THIS SKETCH



PLAN

SCALE: 1/2" = 1'-0"



SOUTH ELEVATION (LOOKING NORTH)

SCALE: 1/2" = 1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	TY	BT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
P-101 A/B FOUNDATIONS
PLAN & ELEVATION

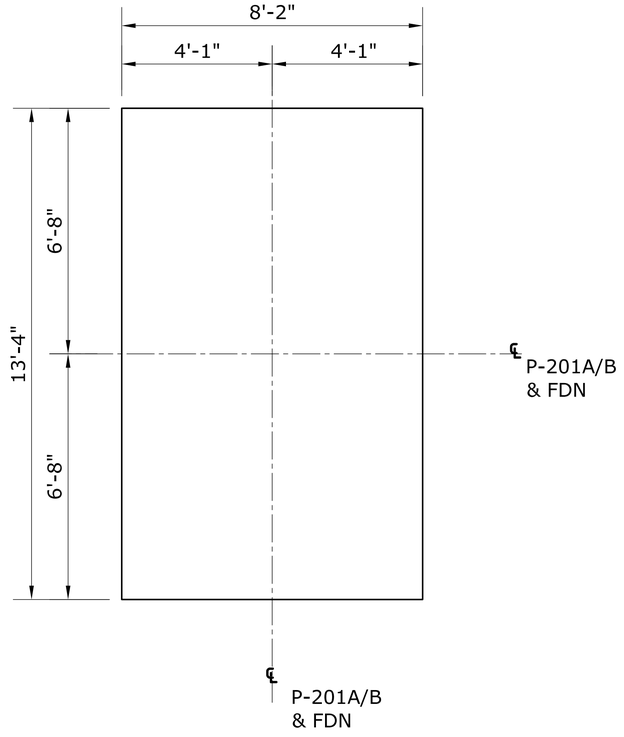
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00133	1 OF 1	C	1/2"=1'-0"

BILL OF MATERIAL

*SEE SPECIFICATIONS

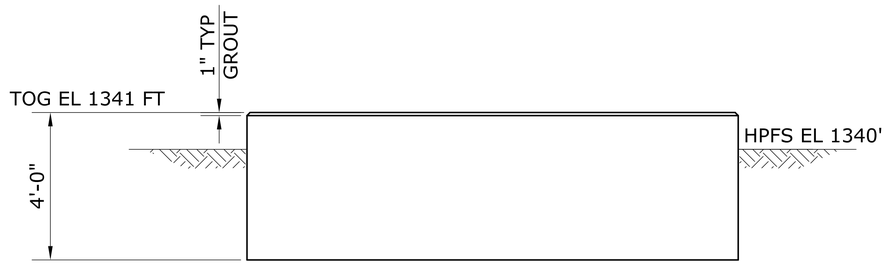
QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO REQD	SIZE	LENGTH	DESCRIPTION
——	——	39.0	CU YDS	——	TOTAL CONCRETE PER THIS SKETCH



PLAN

SCALE: 1/2" = 1'-0"



SOUTH ELEVATION (LOOKING NORTH)

SCALE: 1/2" = 1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	TY	BT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
P–201 A/B FOUNDATIONS
PLAN & ELEVATION

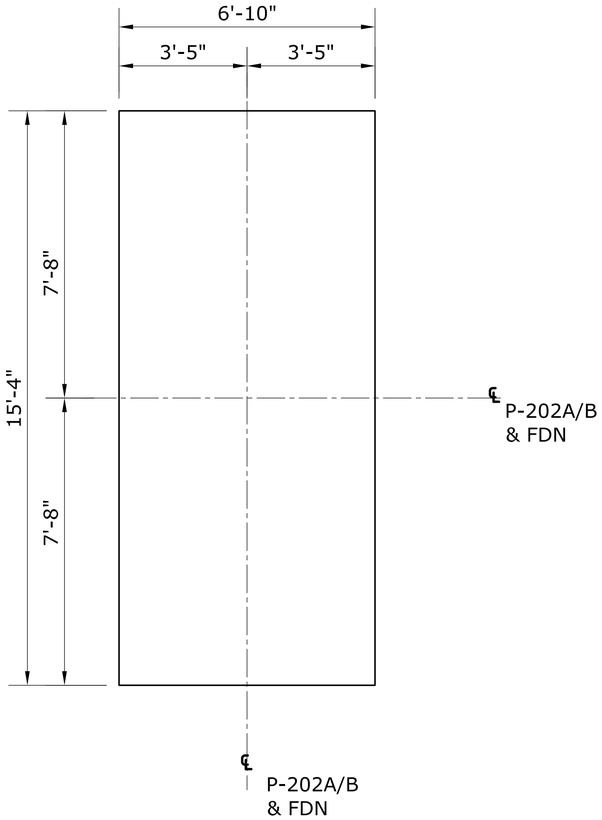
DRAWING No.	SHEET	REV.	SCALE
EH–35R–CCU1–SKT–215–00134	1 OF 1	C	1/2"=1'-0"

BILL OF MATERIAL

*SEE SPECIFICATIONS

QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO REQD	SIZE	LENGTH	DESCRIPTION
—	—	40.0	CU YDS	—	TOTAL CONCRETE PER THIS SKETCH



PLAN

SCALE: 1/2" = 1'-0"



SOUTH ELEVATION (LOOKING NORTH)

SCALE: 1/2" = 1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	TY	BT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
P-202 A/B FOUNDATIONS
PLAN & ELEVATION

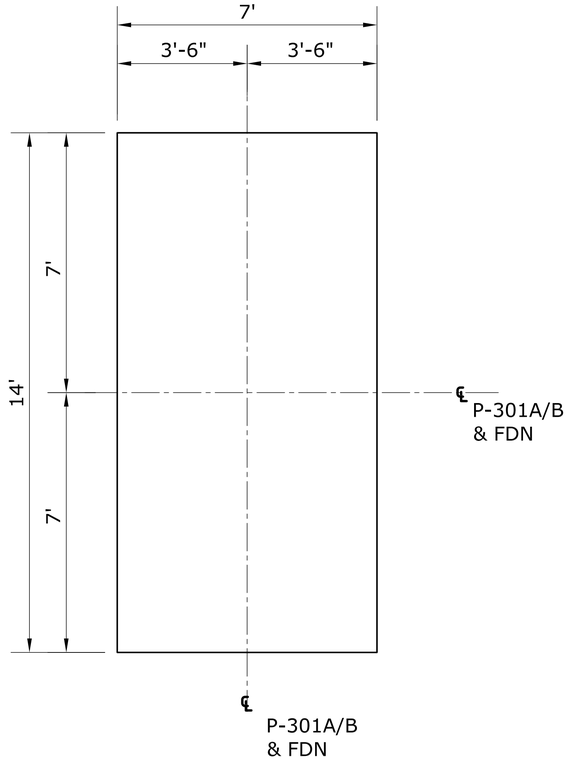
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00135	1 OF 1	C	1/2"=1'-0"

BILL OF MATERIAL

*SEE SPECIFICATIONS

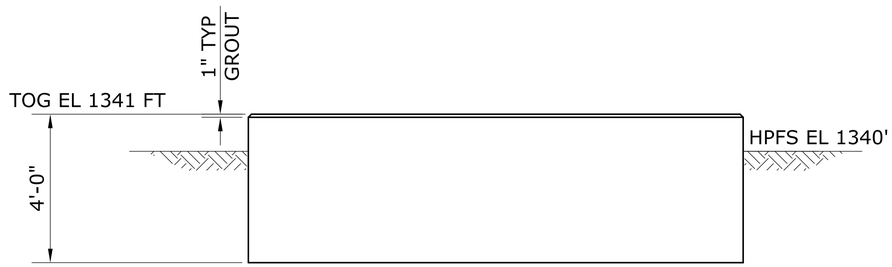
QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO. REQD	SIZE	LENGTH	DESCRIPTION
—	—	36.9	CU YDS	—	TOTAL CONCRETE PER THIS SKETCH



PLAN

SCALE: 1/2" = 1'-0"



SOUTH ELEVATION (LOOKING NORTH)

SCALE: 1/2" = 1'-0"

FLUOR.

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	TPJ	BT BT	WA WA	NP NP	WA WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

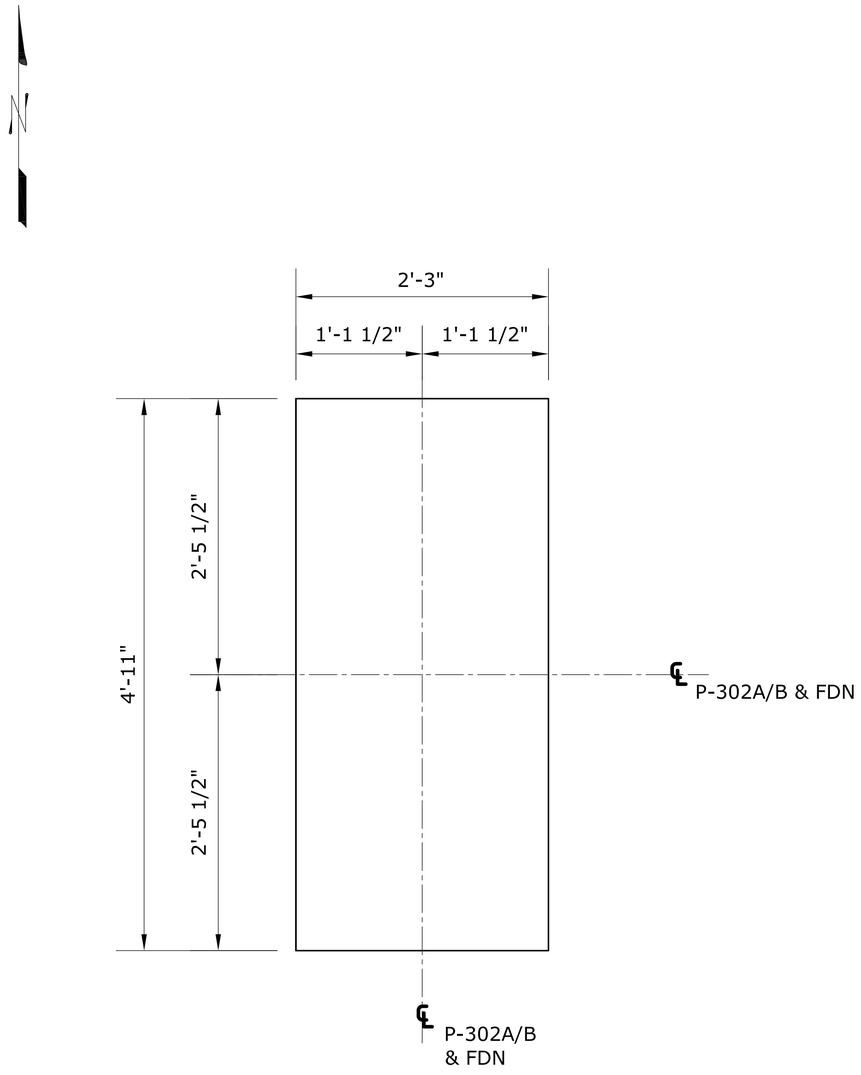
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

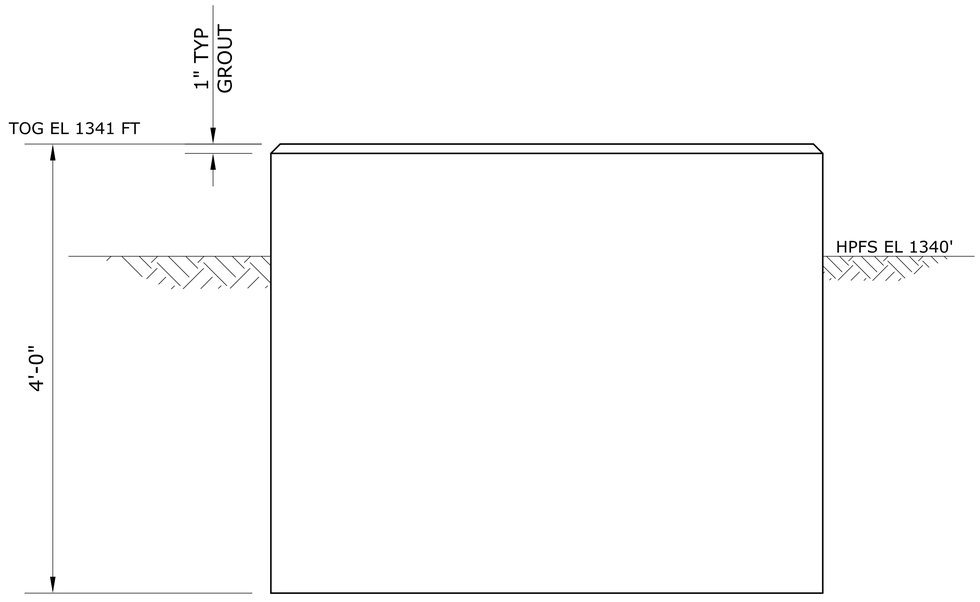
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
P-301 A/B FOUNDATIONS
PLAN & ELEVATION

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00136	1 OF 1	C	1/2"=1'-0"



PLAN

SCALE: 1 1/2" = 1'-0"



EAST ELEVATION (LOOKING WEST)

SCALE: 1 1/2" = 1'-0"

BILL OF MATERIAL

*SEE SPECIFICATIONS — QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO REQD	SIZE	LENGTH	DESCRIPTION
—	—	5.5	CU YDS	—	TOTAL CONCRETE PER THIS SKETCH

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	TY	BT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS — APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
P–302 A/B FOUNDATIONS
PLAN & ELEVATION

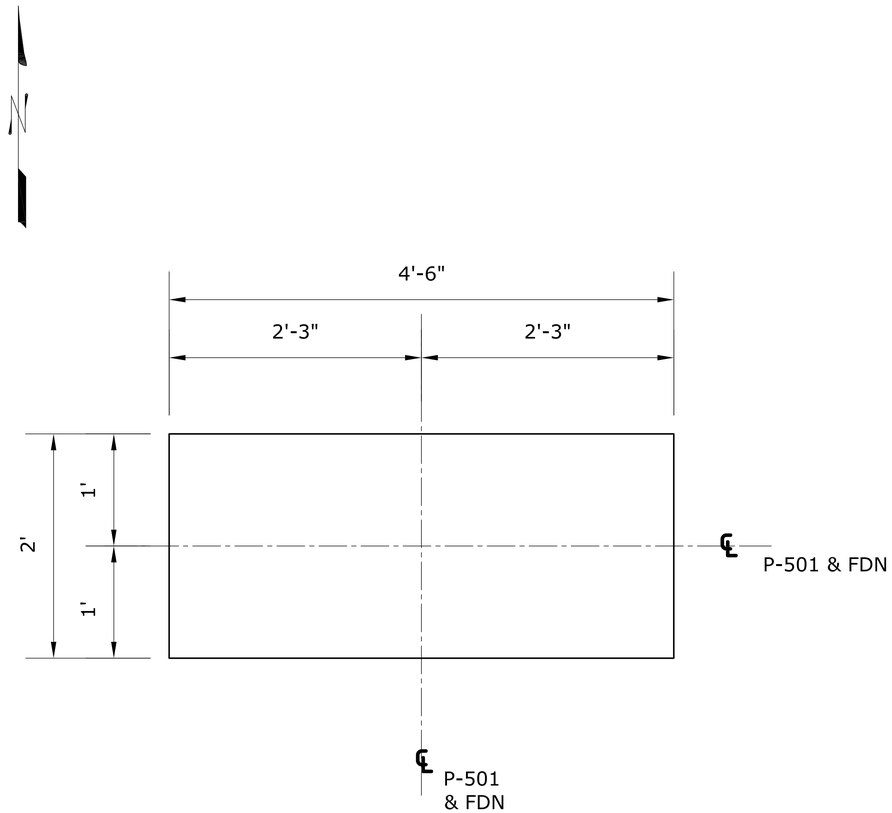
DRAWING No.	SHEET	REV.	SCALE
EH–35R–CCU1–SKT–215–00137	1 OF 1	C	1 1/2"=1'-0"

BILL OF MATERIAL

*SEE SPECIFICATIONS

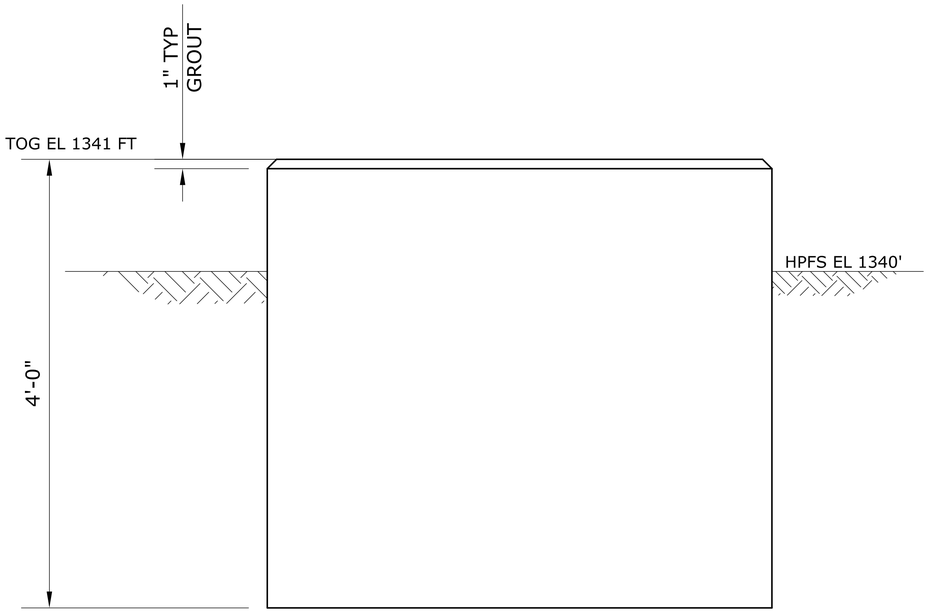
QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO REQD	SIZE	LENGTH	DESCRIPTION
——	——	1.47	CU YDS	——	TOTAL CONCRETE PER THIS SKETCH



PLAN

SCALE: 1 1/2" = 1'-0"



SOUTH ELEVATION (LOOKING NORTH)

SCALE: 1 1/2" = 1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	TY TY	BT BT	WA WA	NP NP	WA WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
P-501 FOUNDATION
PLAN & ELEVATION

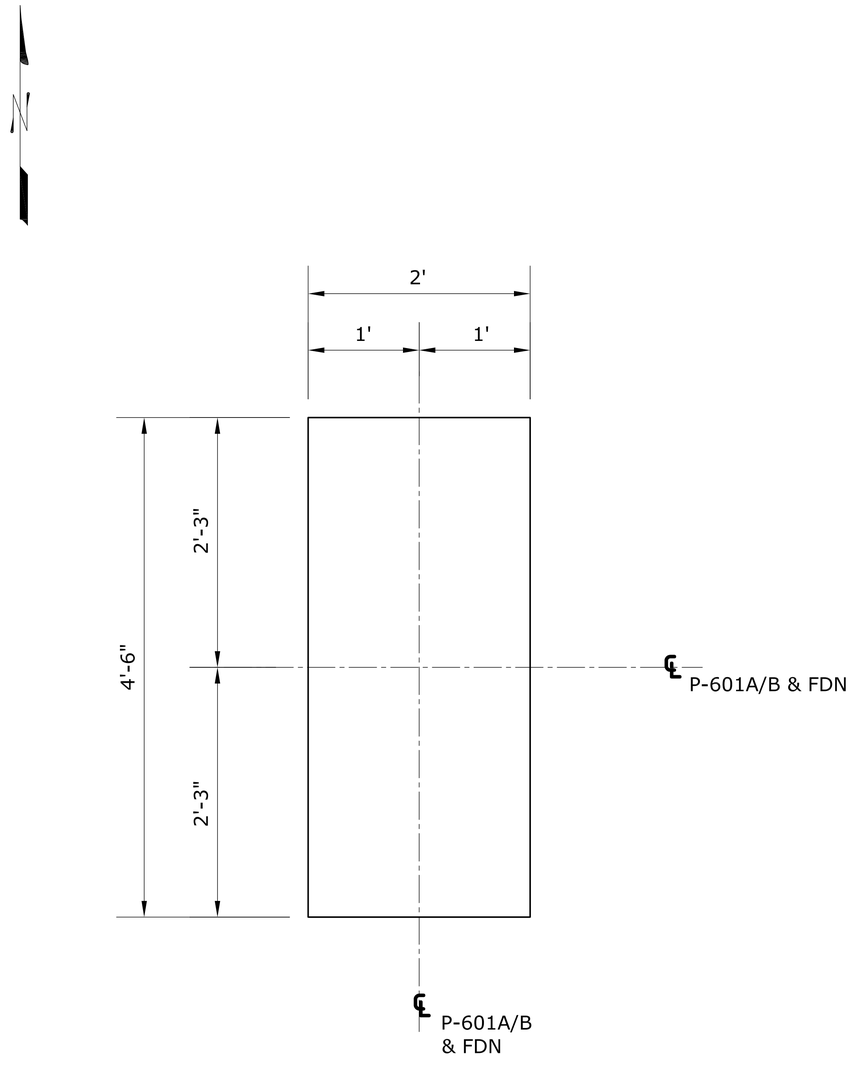
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00138	1 OF 1	C	1 1/2"=1'-0"

BILL OF MATERIAL

*SEE SPECIFICATIONS

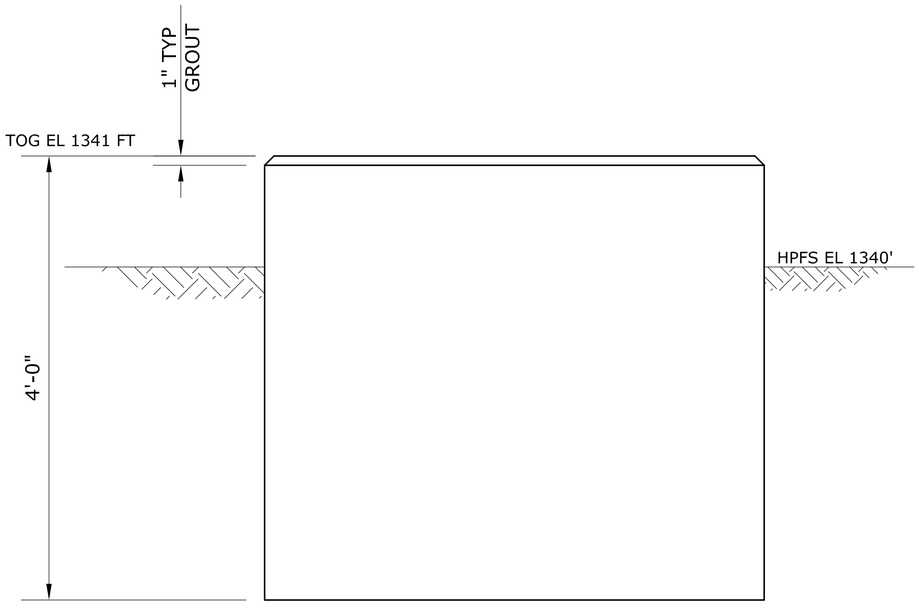
QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO. REQD	SIZE	LENGTH	DESCRIPTION
—	—	4.0	CU YDS	—	TOTAL CONCRETE PER this SKETCH



PLAN

SCALE: 1 1/2" = 1'-0"



EAST ELEVATION (LOOKING WEST)

SCALE: 1 1/2" = 1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	TY	BT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
P-601 A/B FOUNDATIONS
PLAN & ELEVATION

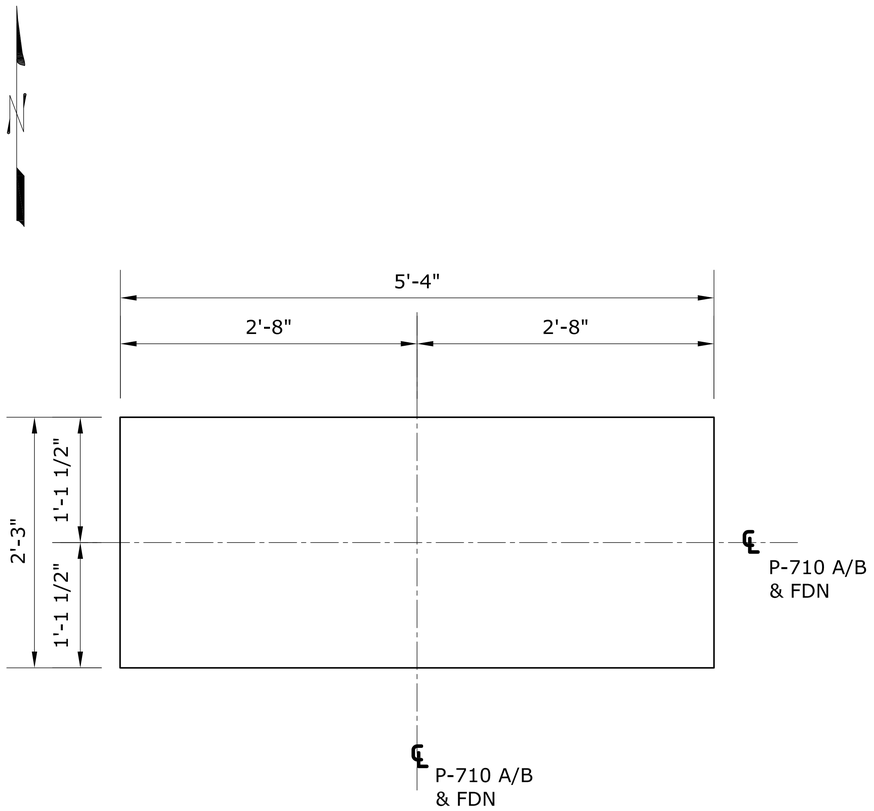
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00139	1 OF 1	C	1 1/2"=1'-0"

BILL OF MATERIAL

*SEE SPECIFICATIONS

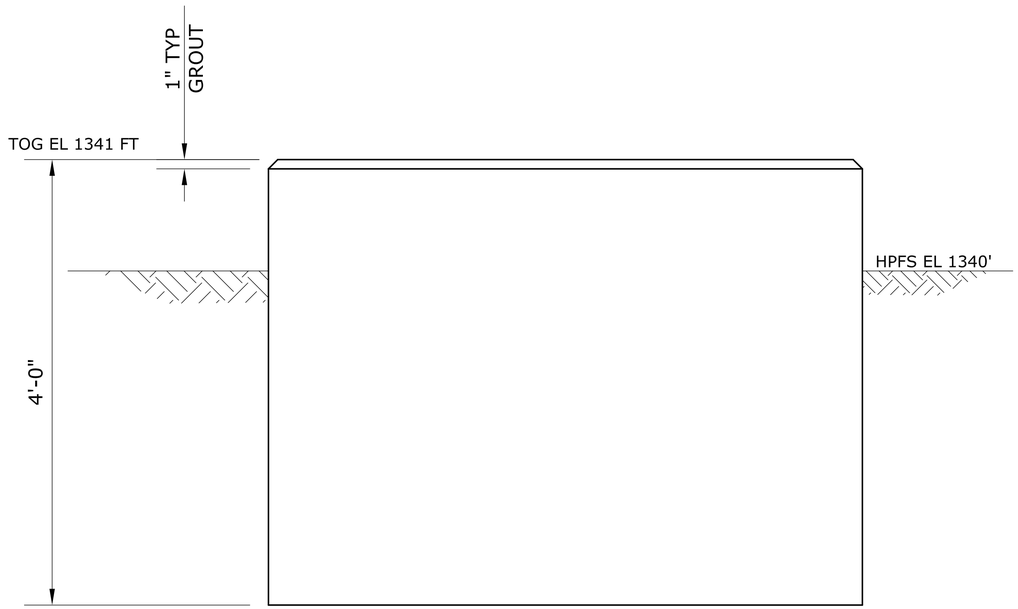
QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO REQD	SIZE	LENGTH	DESCRIPTION
—	—	5.5	CU YDS	—	TOTAL CONCRETE PER THIS SKETCH



PLAN

SCALE: 1 1/2" = 1'-0"



SOUTH ELEVATION (LOOKING NORTH)

SCALE: 1 1/2" = 1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	TY	BT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
P-710 A/B FOUNDATIONS
PLAN & ELEVATION

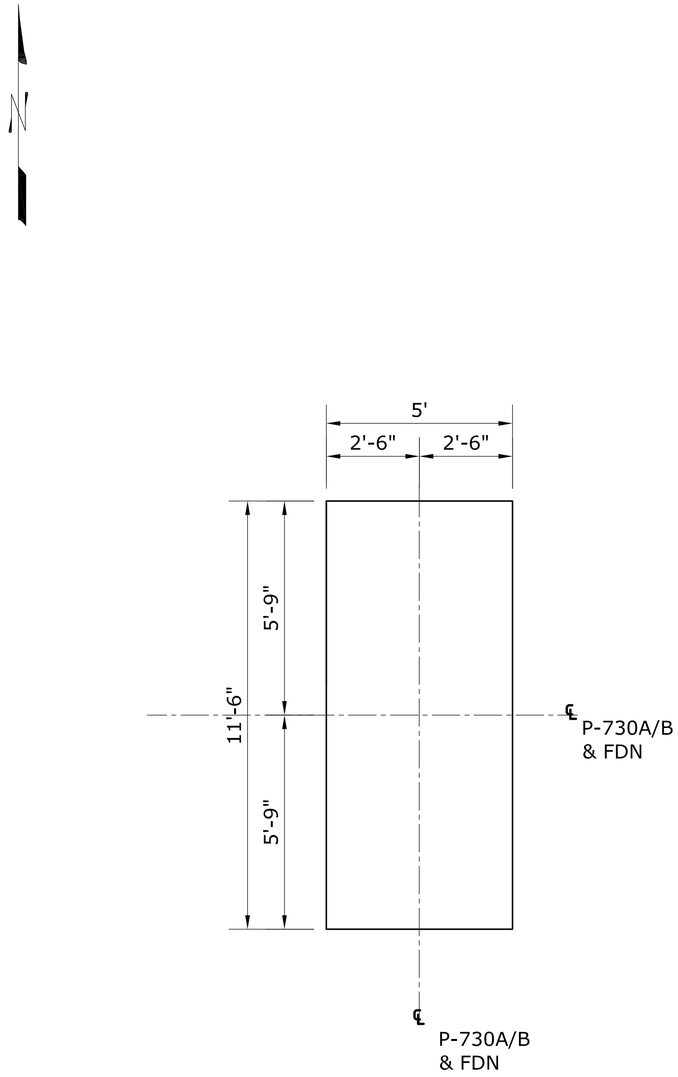
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00140	1 OF 1	C	1 1/2"=1'-0"

BILL OF MATERIAL

*SEE SPECIFICATIONS

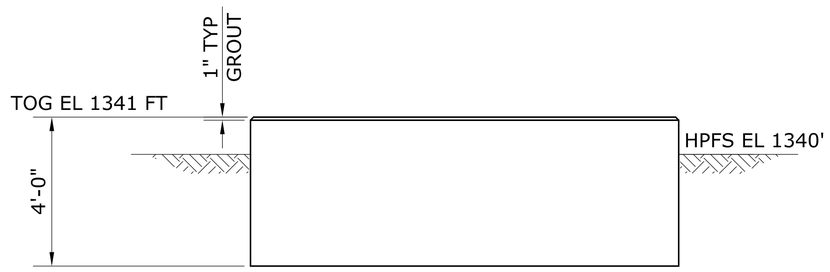
QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO REQD	SIZE	LENGTH	DESCRIPTION
——	——	24.1	CU YDS	——	TOTAL CONCRETE PER THIS SKETCH



PLAN

SCALE: 1/2" = 1'-0"



EAST ELEVATION (LOOKING WEST)

SCALE: 1/2" = 1'-0"

FLUOR

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/01/20	TY TJ	BT BT	WA WA	NP MP	WA WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

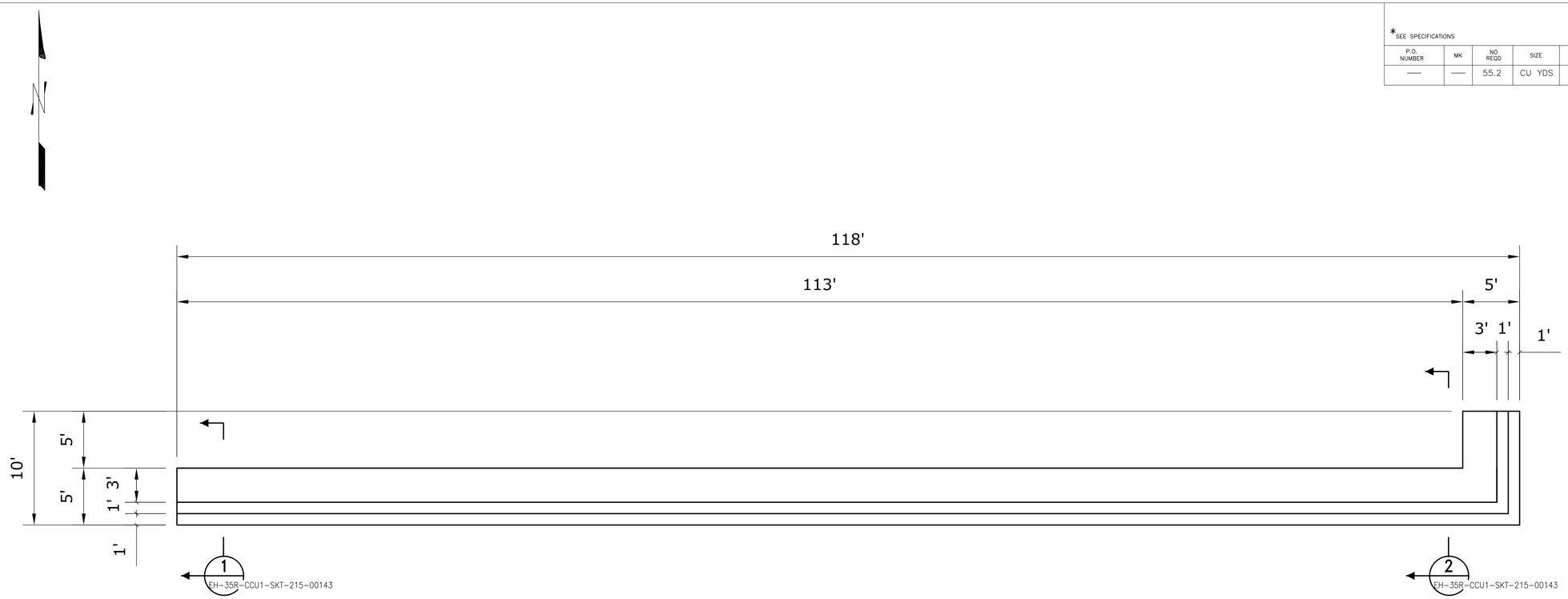
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
P-730 A/B FOUNDATIONS
PLAN & ELEVATION

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00141	1 OF 1	C	1/2"=1'-0"



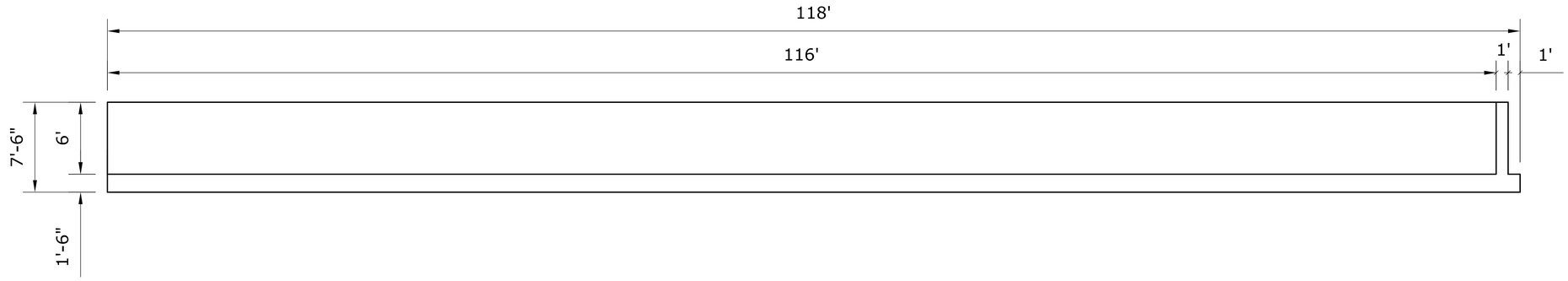
PLAN AT TOC 1344'-0"

SCALE: 3/16" = 1'-0"

BILL OF MATERIAL

*SEE SPECIFICATIONS — QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO REQD	SIZE	LENGTH	DESCRIPTION
—	—	55.2	CU YDS	—	TOTAL CONCRETE PER SKETCHES EH-35R-CCU1-SKT-215-00142 AND EH-35R-CCU1-SKT-215-00143



SOUTH ELEVATION (LOOKING NORTH)

SCALE: 3/16" = 1'-0"

FLUOR

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/01/20	JT	JT	WAVA	NP,MP	WAVA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

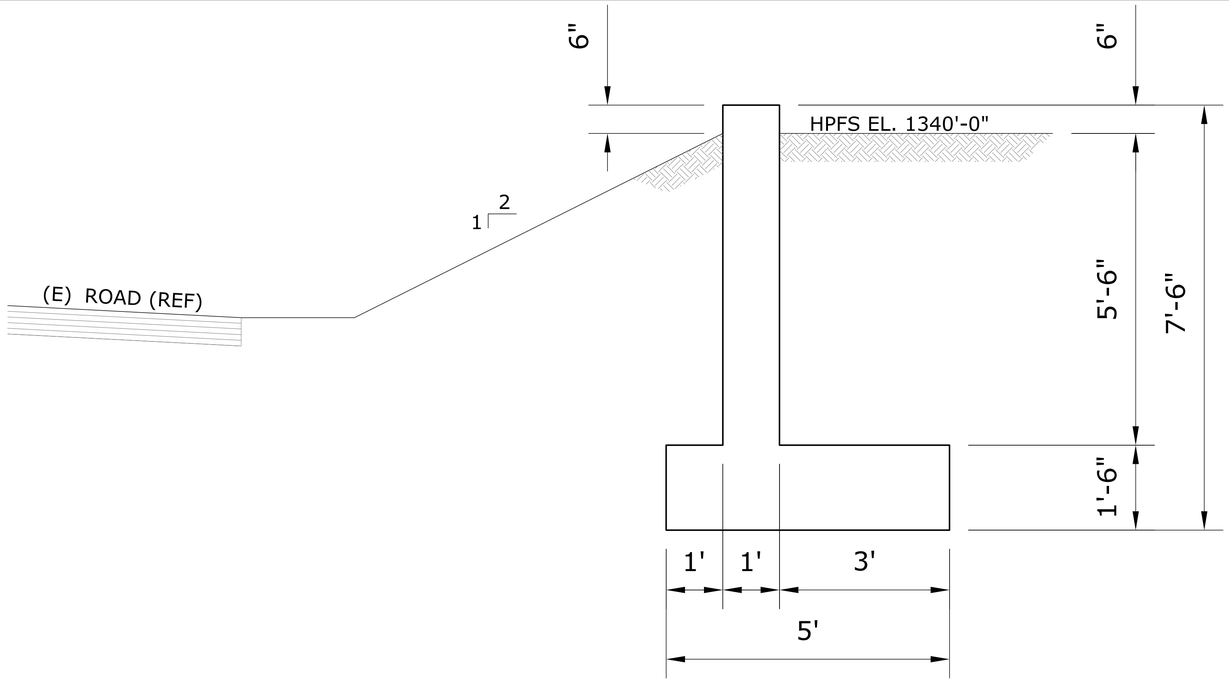
REVISIONS — APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

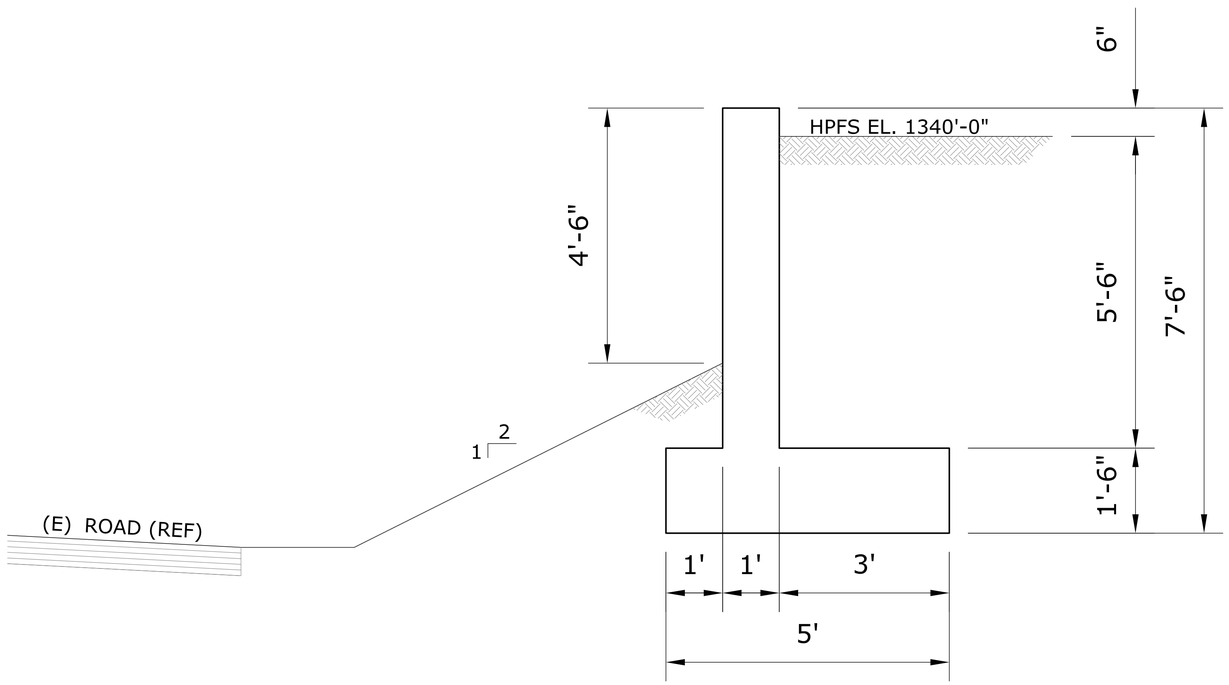
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
RETAINING WALL
PLAN & ELEVATION

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00142	1 OF 1	C	3/16"=1'-0"



SECTION 1

SCALE: 3/4" = 1'-0"



SECTION 2

SCALE: 3/4" = 1'-0"

FLUOR

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/01/20	JT	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

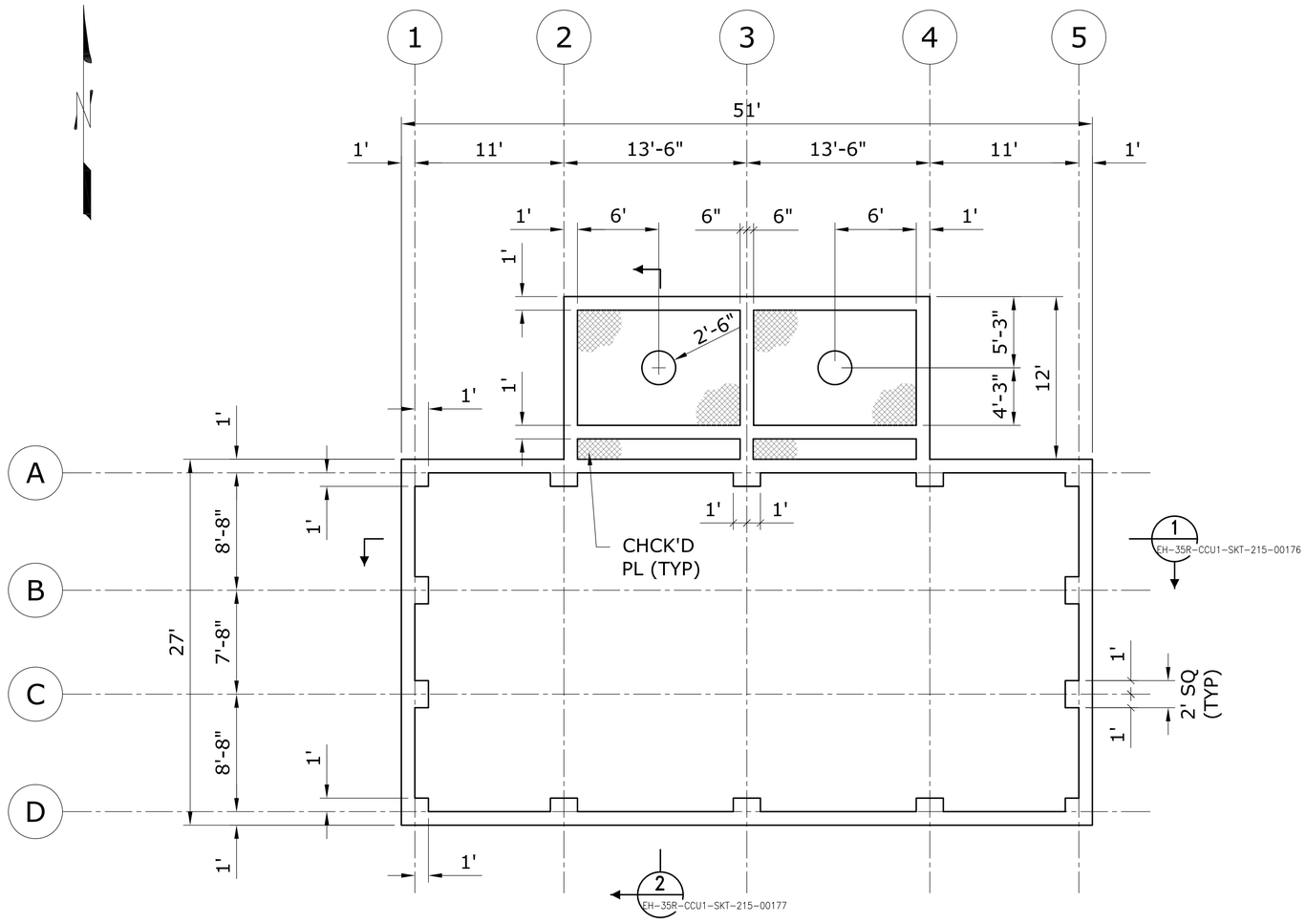
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

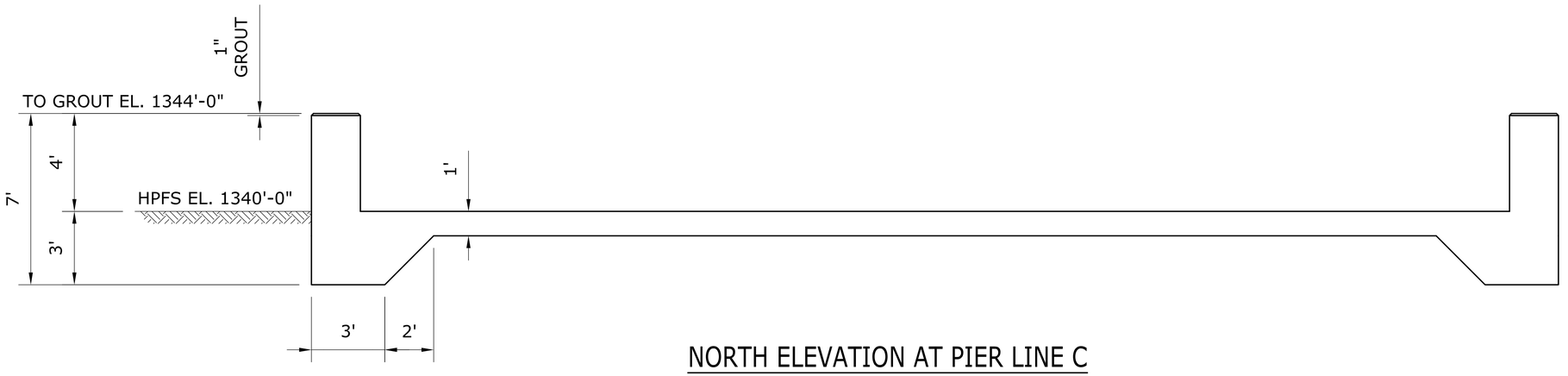
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
RETAINING WALL
SECTIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00143	1 OF 1	C	3/4"=1'-0"



FOUNDATION PLAN AT TOC 1343'-0"

SCALE: 3/16" = 1'-0"



NORTH ELEVATION AT PIER LINE C

LOOKING SOUTH

SCALE: 3/8" = 1'-0"

* SEE SPECIFICATIONS

BILL OF MATERIAL

QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO. REQD	SIZE	LENGTH	DESCRIPTION
—	—	255.0	CU YDS	——	TOTAL CONCRETE PER SKETCHES EH-35R-CCU1-SKT-215-00144 THRU EH-35R-CCU1-SKT-215-00146
—	—	2.58	TONS	——	1/2" CHECKERED FLOOR PLATE

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/01/20	JT	JT	WA WA	NP AVP	WA WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

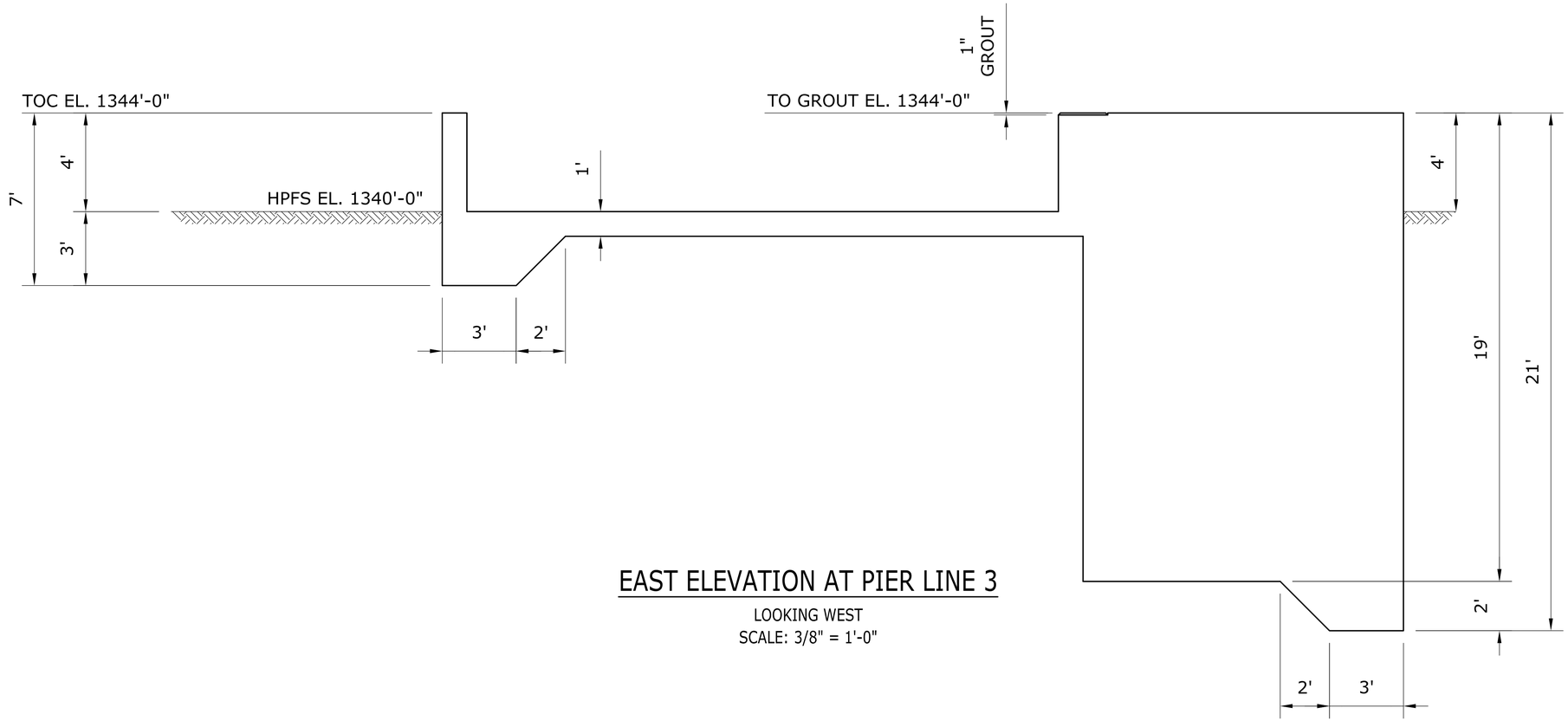
ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
M-701 COOLING TOWER CONCRETE
PLAN & ELEVATION

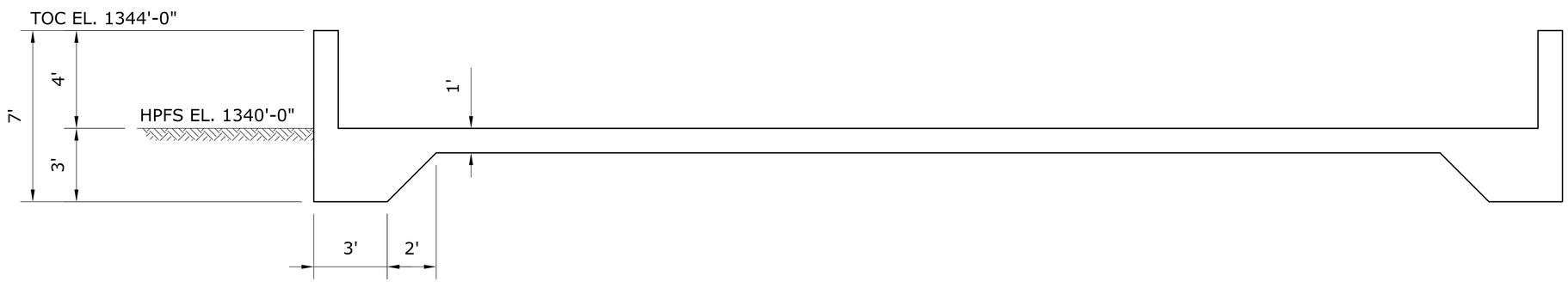
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00144	1 OF 1	C	AS NOTED

CRC



EAST ELEVATION AT PIER LINE 3

LOOKING WEST
SCALE: 3/8" = 1'-0"



SECTION 1

SCALE: 3/8" = 1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	JT	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

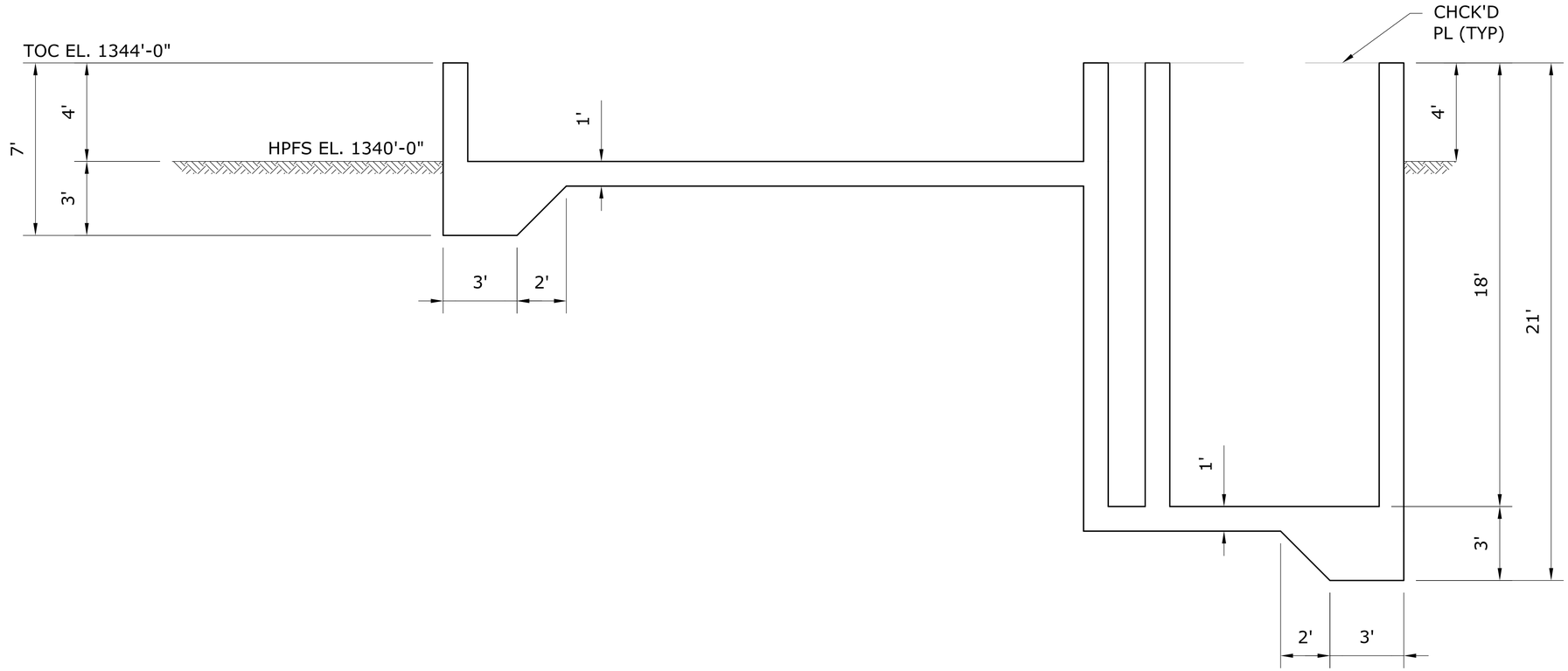
ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
M-701 COOLING TOWER CONCRETE
ELEVATION & SECTION

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00145	1 OF 1	C	3/8"=1'-0"

CRC



SECTION 2

SCALE: 3/8" = 1'-0"

FLUOR

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	JT	JT	WMA	NP	WMA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
M-701 COOLING TOWER CONCRETE SECTION

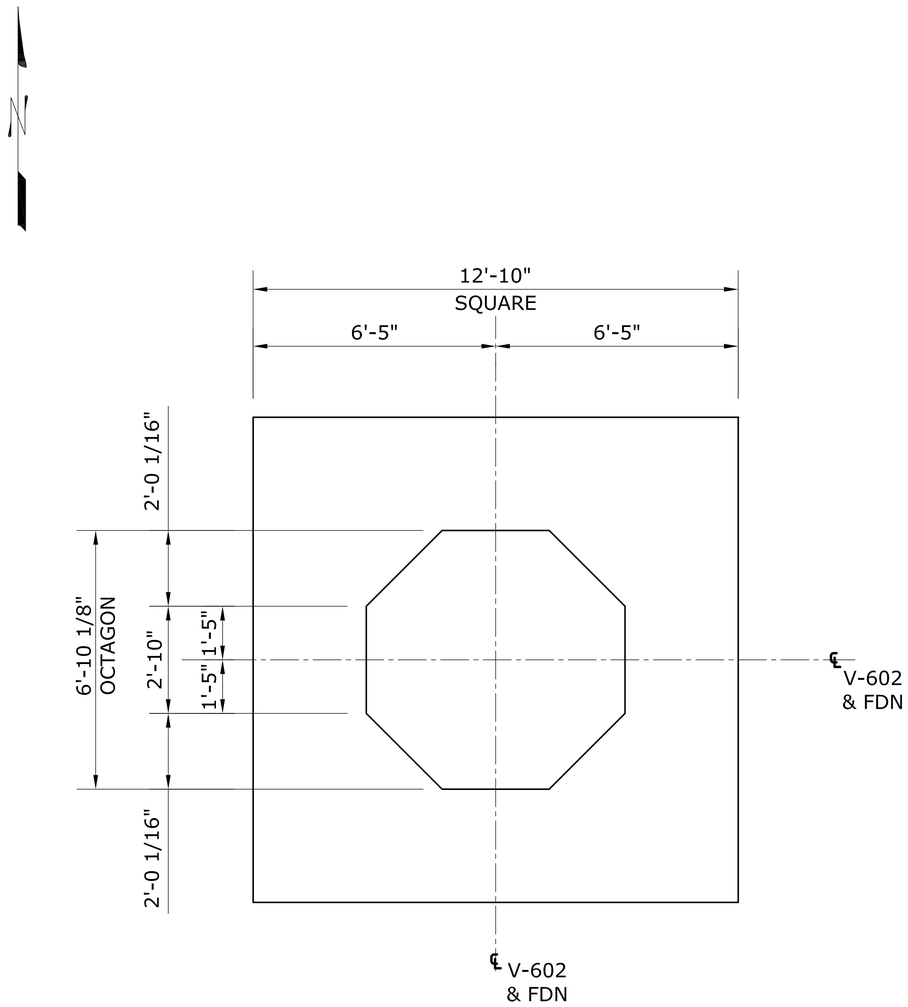
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00146	1 OF 1	C	3/8"=1'-0"

BILL OF MATERIAL

*SEE SPECIFICATIONS

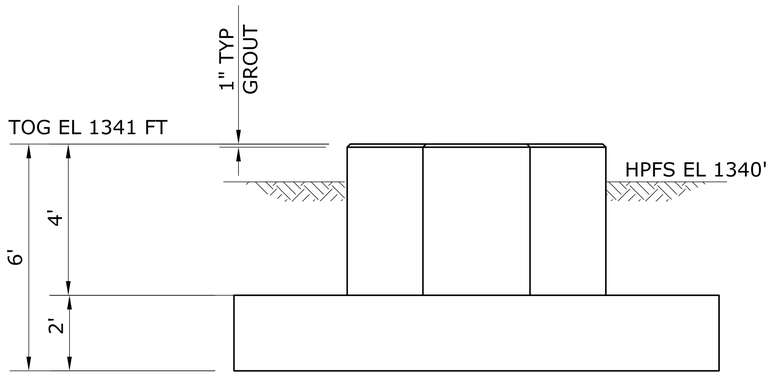
QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO. REQD	SIZE	LENGTH	DESCRIPTION
——	——	18.0	CU YDS	——	TOTAL CONCRETE PER THIS SKETCH



PLAN

SCALE: 1/2" = 1'-0"



ELEVATION

SCALE: 1/2" = 1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	TY	BT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

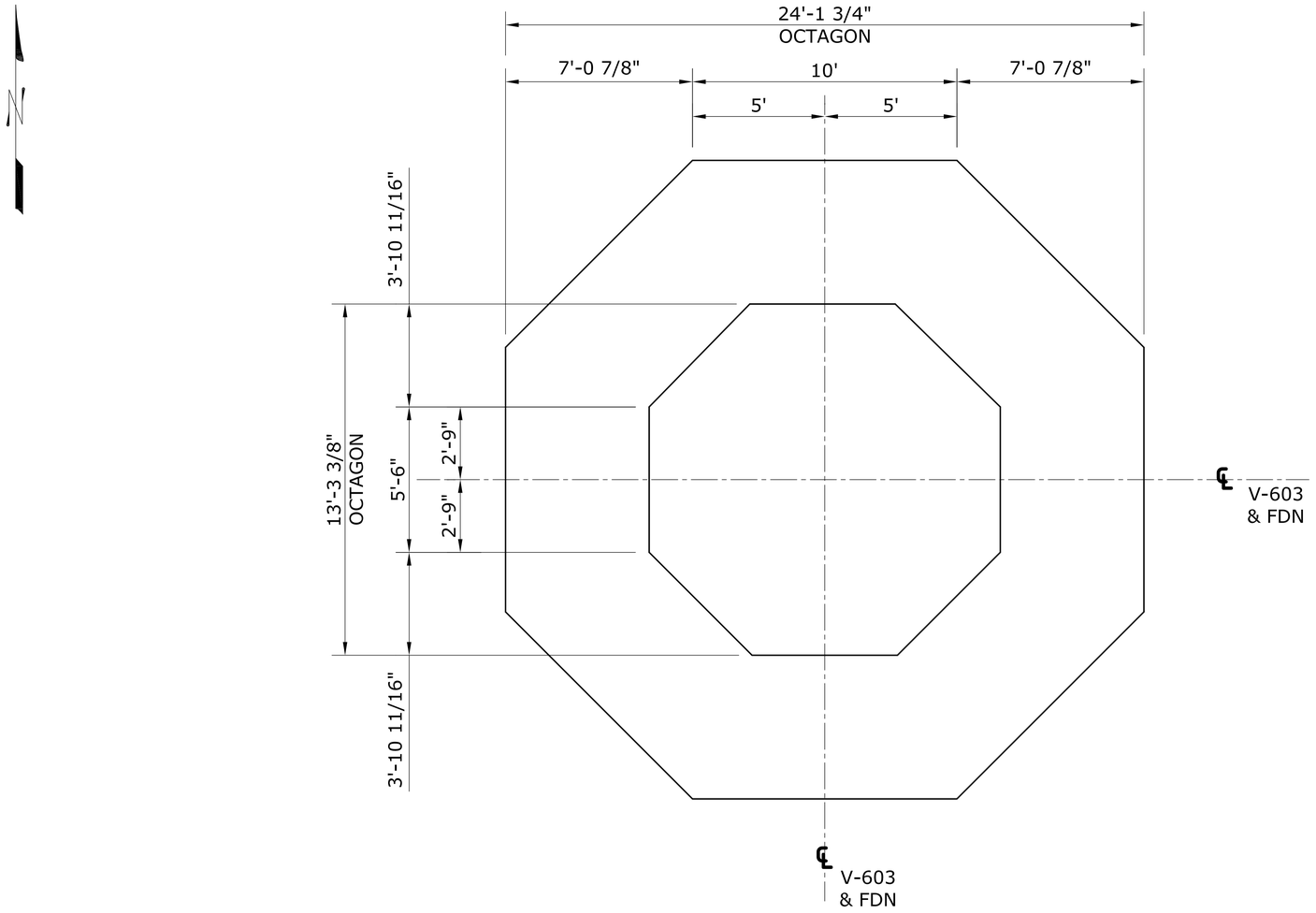
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

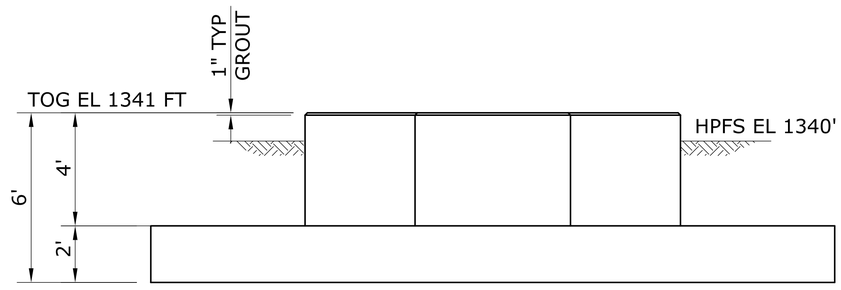
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
V-602 FOUNDATION
PLAN & ELEVATION

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00149	1 OF 1	C	1/2"=1'-0"



PLAN

SCALE: 3/8" = 1'-0"



ELEVATION

SCALE: 3/8" = 1'-0"

BILL OF MATERIAL

*SEE SPECIFICATIONS

QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO REQD	SIZE	LENGTH	DESCRIPTION
——	——	57.6	CU YDS	——	TOTAL CONCRETE PER THIS SKETCH

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	TY	BT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

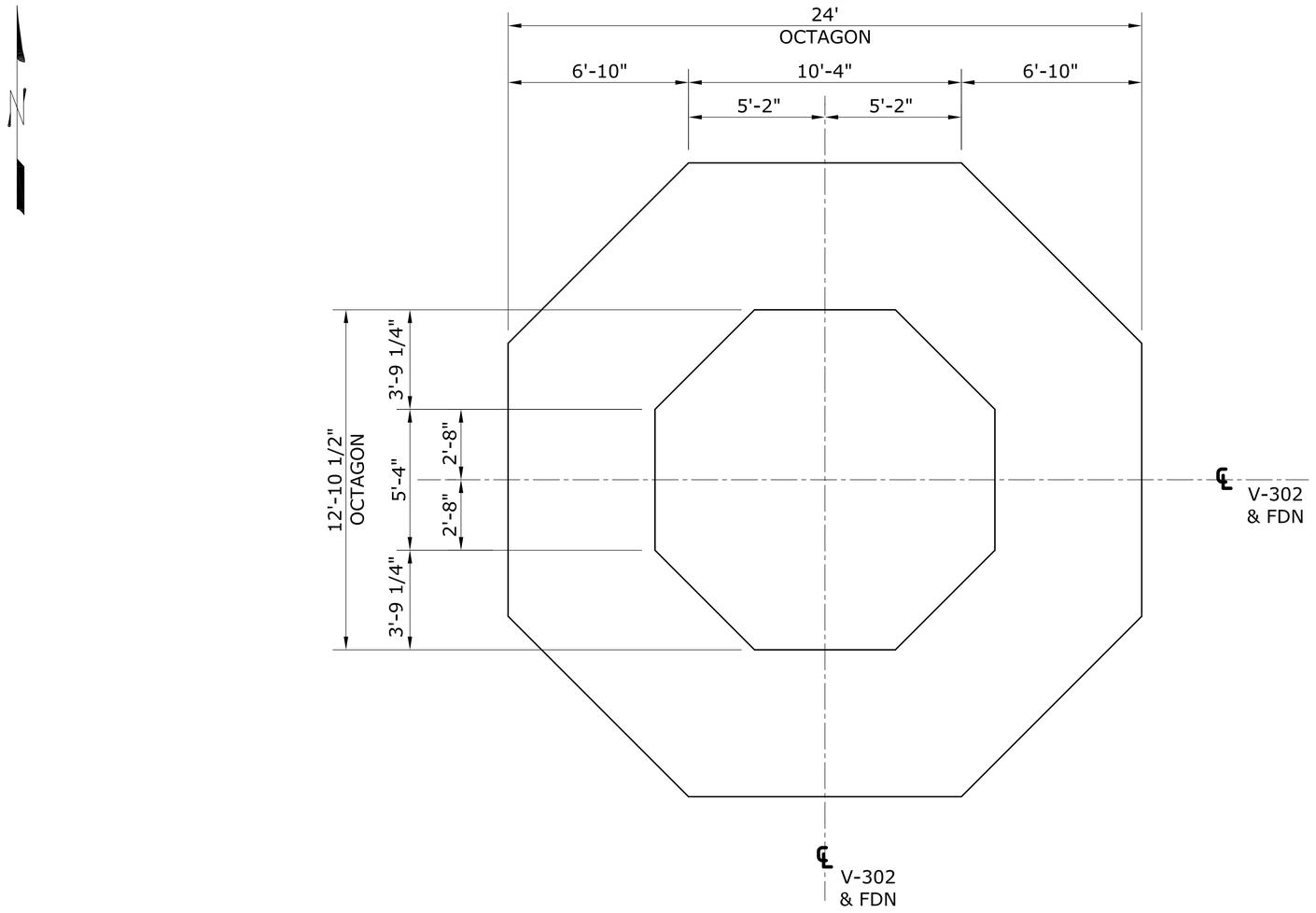
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

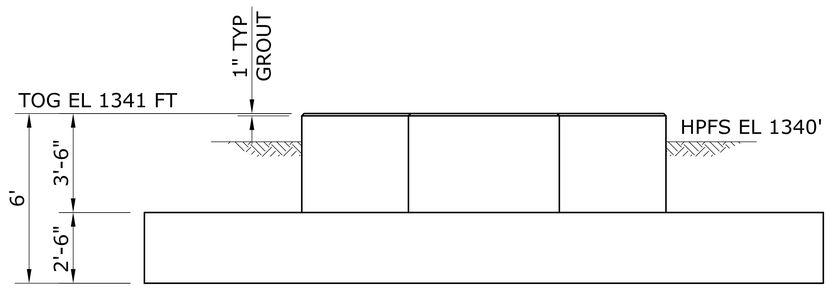
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
V-603 FOUNDATION
PLAN & ELEVATION

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00150	1 OF 1	C	3/8"=1'-0"



PLAN

SCALE: 3/8" = 1'-0"



ELEVATION

SCALE: 3/8" = 1'-0"

BILL OF MATERIAL

*SEE SPECIFICATIONS

QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO REQD		LENGTH	DESCRIPTION
—	—	62.5	CU YDS	——	TOTAL CONCRETE PER THIS SKETCH

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	TY	BT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

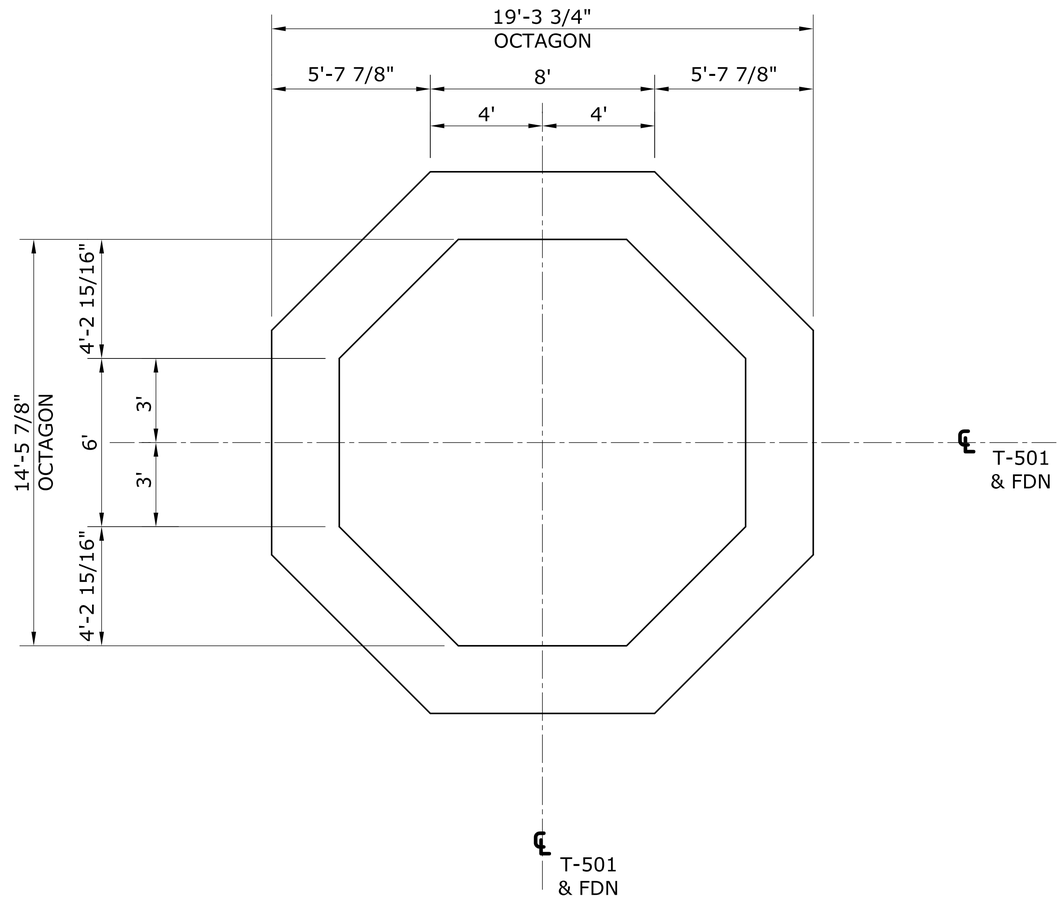
ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
V-302 FOUNDATION
PLAN & ELEVATION

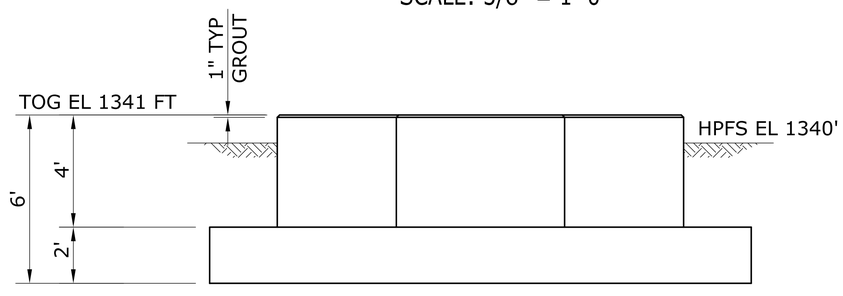
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00151	1 OF 1	C	3/8"=1'-0"

N



PLAN

SCALE: 3/8" = 1'-0"



ELEVATION

SCALE: 3/8" = 1'-0"

*SEE SPECIFICATIONS

BILL OF MATERIAL

QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO REQD	SIZE	LENGTH	DESCRIPTION
——	——	48.7	CU YDS	——	TOTAL CONCRETE PER THIS SKETCH

FLUOR.

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	TY	BT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
T-501 FOUNDATION
PLAN & ELEVATION

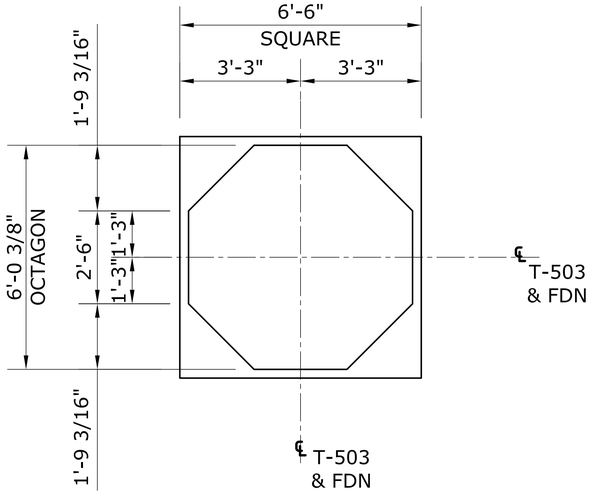
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00152	1 OF 1	C	3/8"=1'-0"

BILL OF MATERIAL

*SEE SPECIFICATIONS

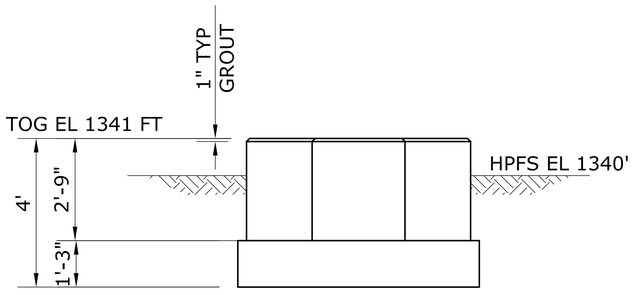
QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO. REQD	SIZE	LENGTH	DESCRIPTION
——	——	6.4	CU YDS	——	TOTAL CONCRETE PER THIS SKETCH



PLAN

SCALE: 1/2" = 1'-0"



ELEVATION

SCALE: 1/2" = 1'-0"

FLUOR.

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/01/20	TY	BT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

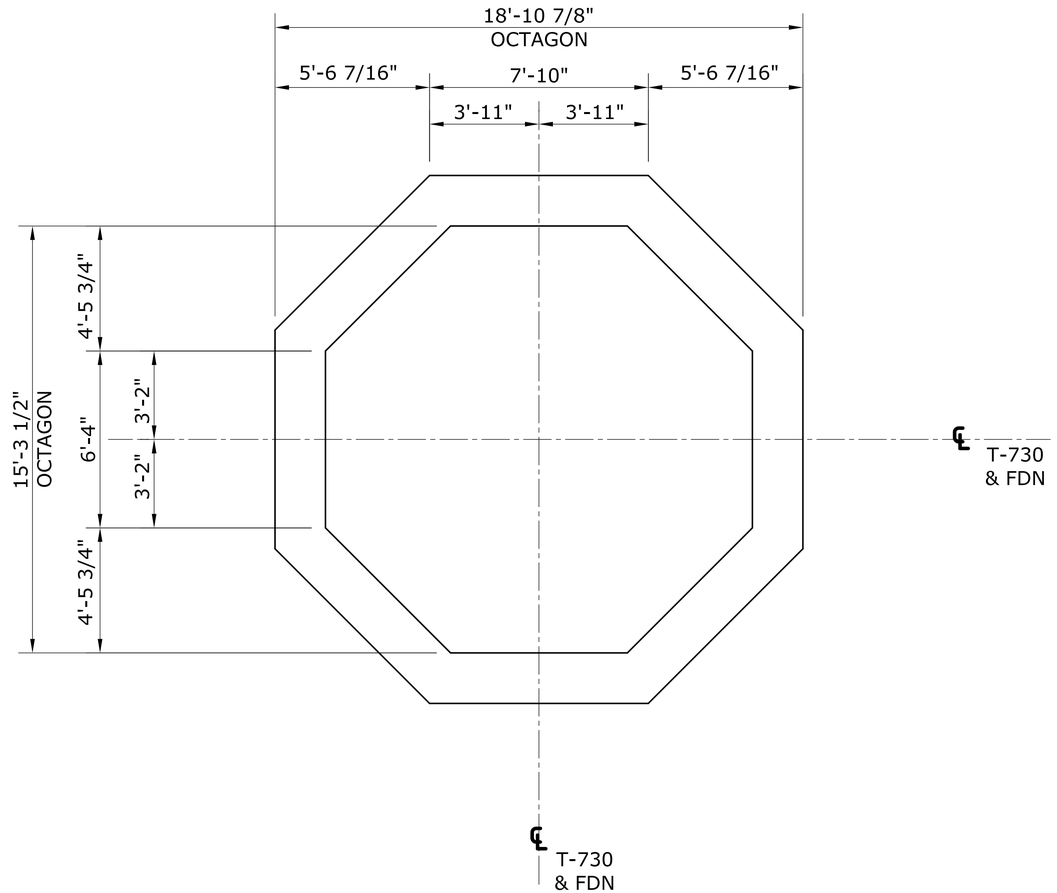
ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
T-503 FOUNDATION
PLAN & ELEVATION

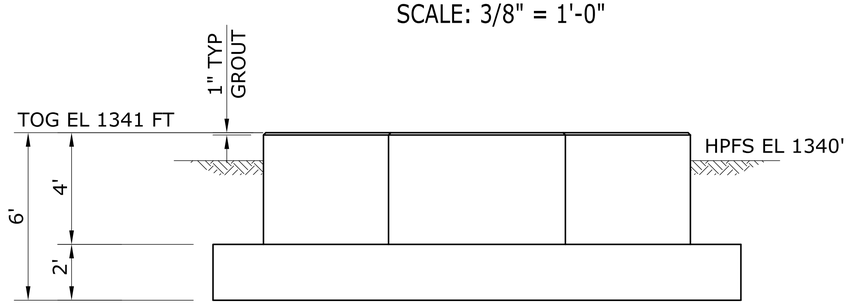
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00153	1 OF 1	C	1/2"=1'-0"





PLAN

SCALE: 3/8" = 1'-0"



ELEVATION

SCALE: 3/8" = 1'-0"

BILL OF MATERIAL

*SEE SPECIFICATIONS

QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO REQD	SIZE	LENGTH	DESCRIPTION
——	——	51.0	CU YDS	——	TOTAL CONCRETE PER THIS SKETCH

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	TY	BT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

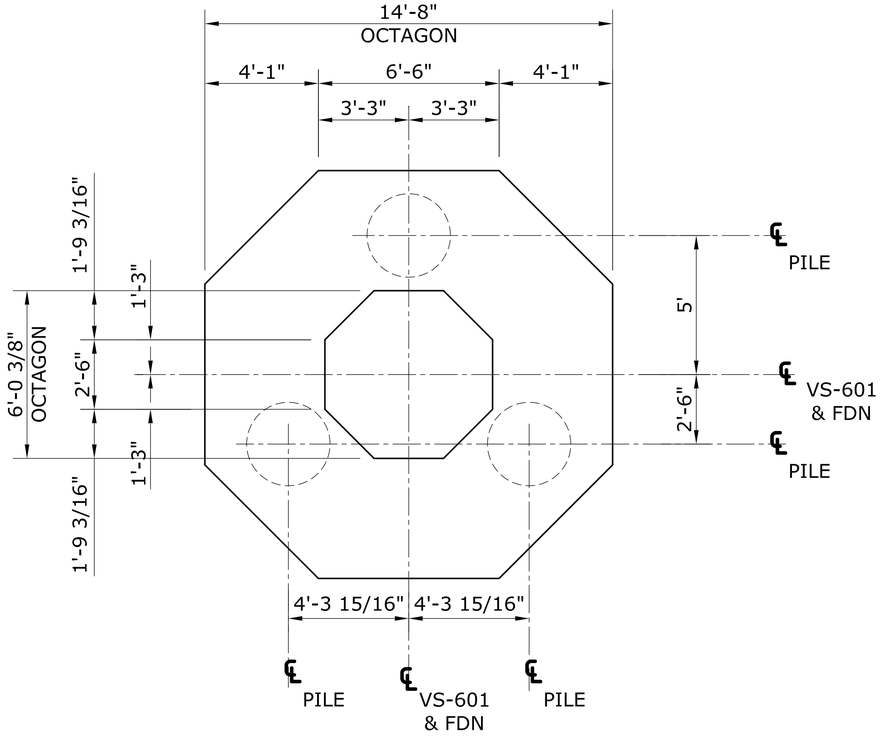
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

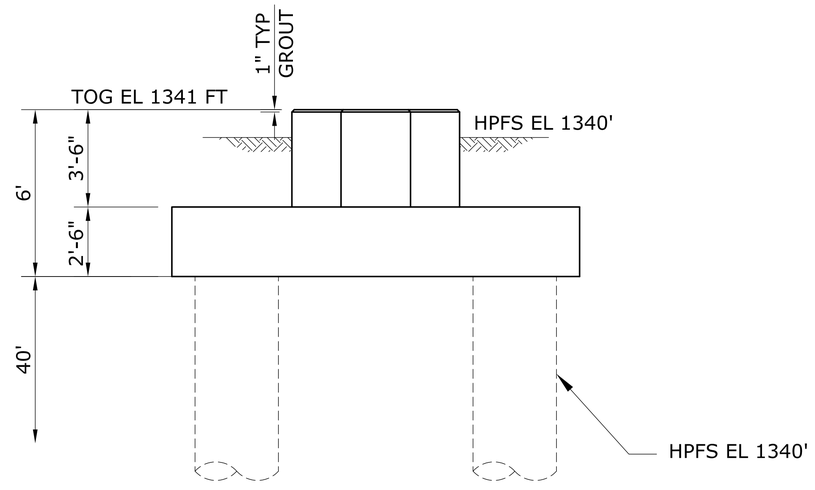
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
T-730 FOUNDATION
PLAN & ELEVATION

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00154	1 OF 1	C	3/8"=1'-0"



PLAN

SCALE: 3/8" = 1'-0"



ELEVATION

SCALE: 3/8" = 1'-0"

BILL OF MATERIAL

*SEE SPECIFICATIONS

QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO. REQD	SIZE	LENGTH	DESCRIPTION
—	—	20.8	CU YDS	——	TOTAL CONCRETE PER THIS SKETCH
—	—	3	36" DIA	40'-0"	TOTAL PILES PER THIS SKETCH

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/01/20	TY	BT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

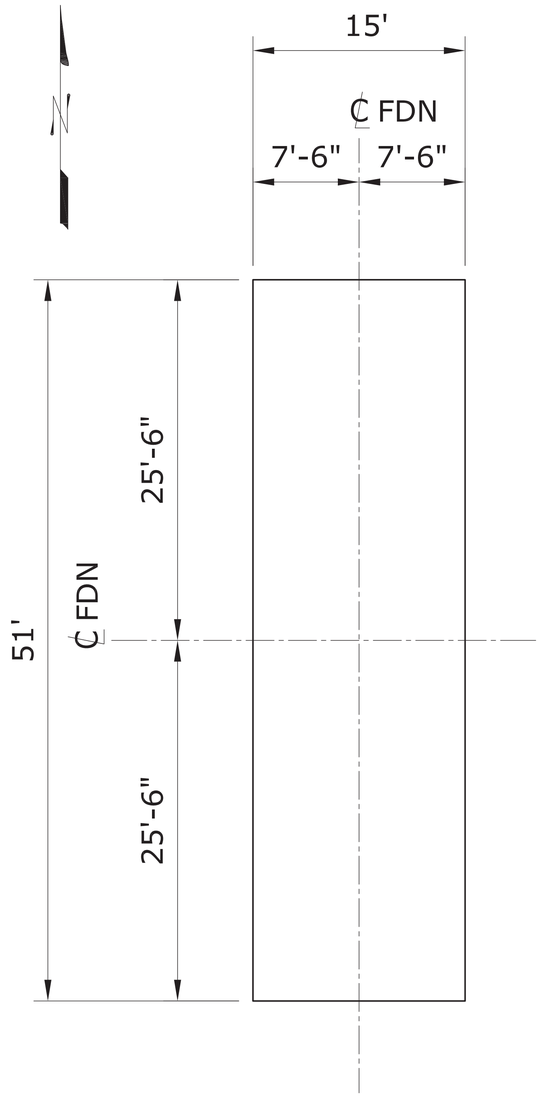
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

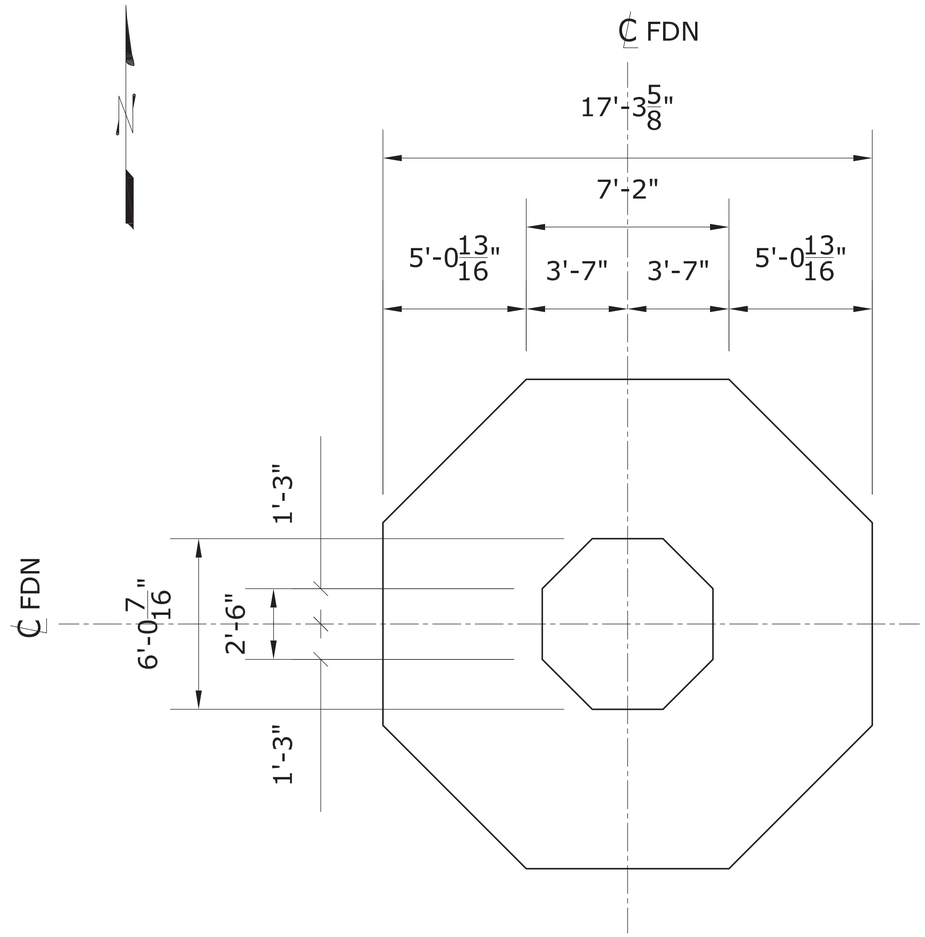
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
VS-601 FOUNDATION
PLAN & ELEVATION

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00155	1 OF 1	C	3/8"=1'-0"



TEG REGENERATION MODULE
FOUNDATION PLAN AT TOC 1341'-0"

SCALE: 3/16" = 1'-0"



GLYCOL CONTACTOR
FOUNDATION PLAN AT TOC 1337'-0"

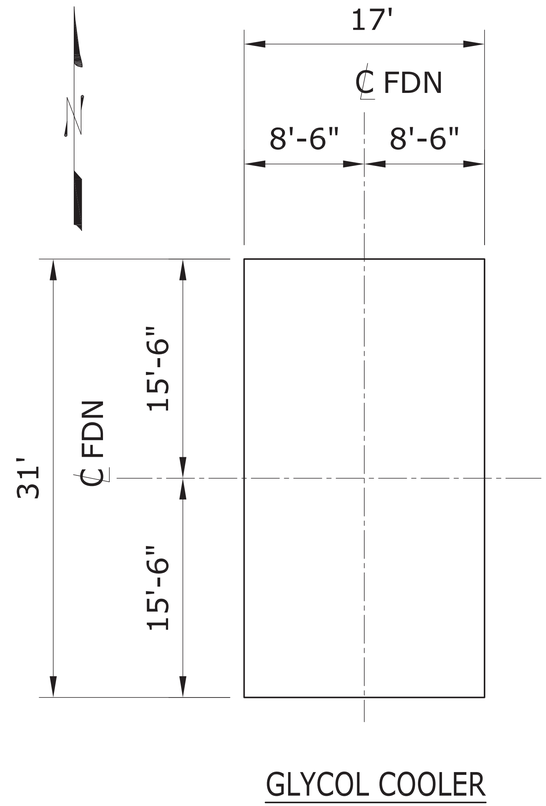
SCALE: 3/8" = 1'-0"

* SEE SPECIFICATIONS

BILL OF MATERIAL

QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO. REQD	SIZE	LENGTH	DESCRIPTION
—	—	214.4	CU YDS	—	TOTAL CONCRETE PER SKETCHES EH-35R-CCU1-SKT-215-00156 & EH-35R-CCU1-SKT-215-00157



GLYCOL COOLER
FOUNDATION PLAN AT TOC 1341'-0"

SCALE: 3/16" = 1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	JT	JT	WVA	NP AMP	WVA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

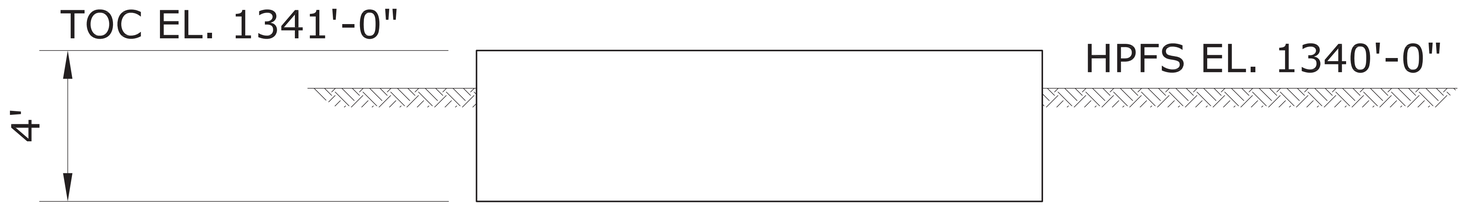
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

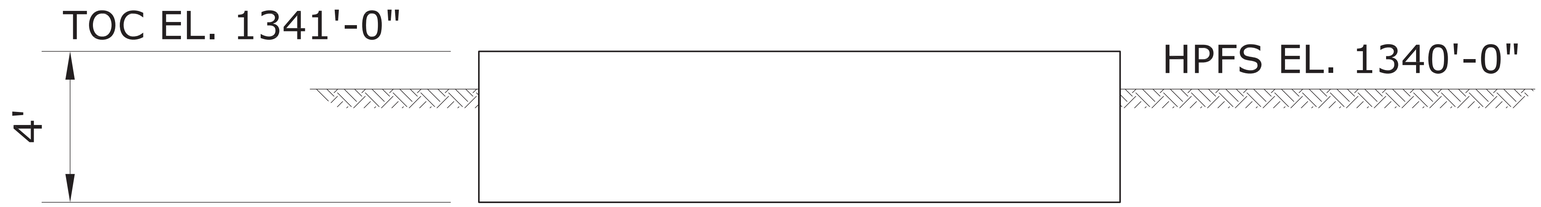
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
M-602 FOUNDATIONS
PLANS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00156	1 OF 1	C	AS NOTED



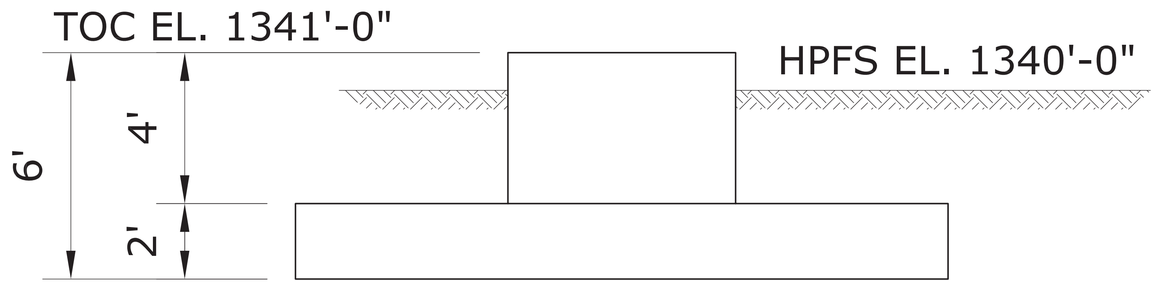
TEG REGENERATION MODULE
SOUTH ELEVATION

LOOKING NORTH
SCALE: 1/2" = 1'-0"



GLYCOL COOLER
SOUTH ELEVATION

LOOKING NORTH
SCALE: 1/2" = 1'-0"



GLYCOL CONTACTOR
SOUTH ELEVATION

LOOKING NORTH
SCALE: 1/2" = 1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	JT	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

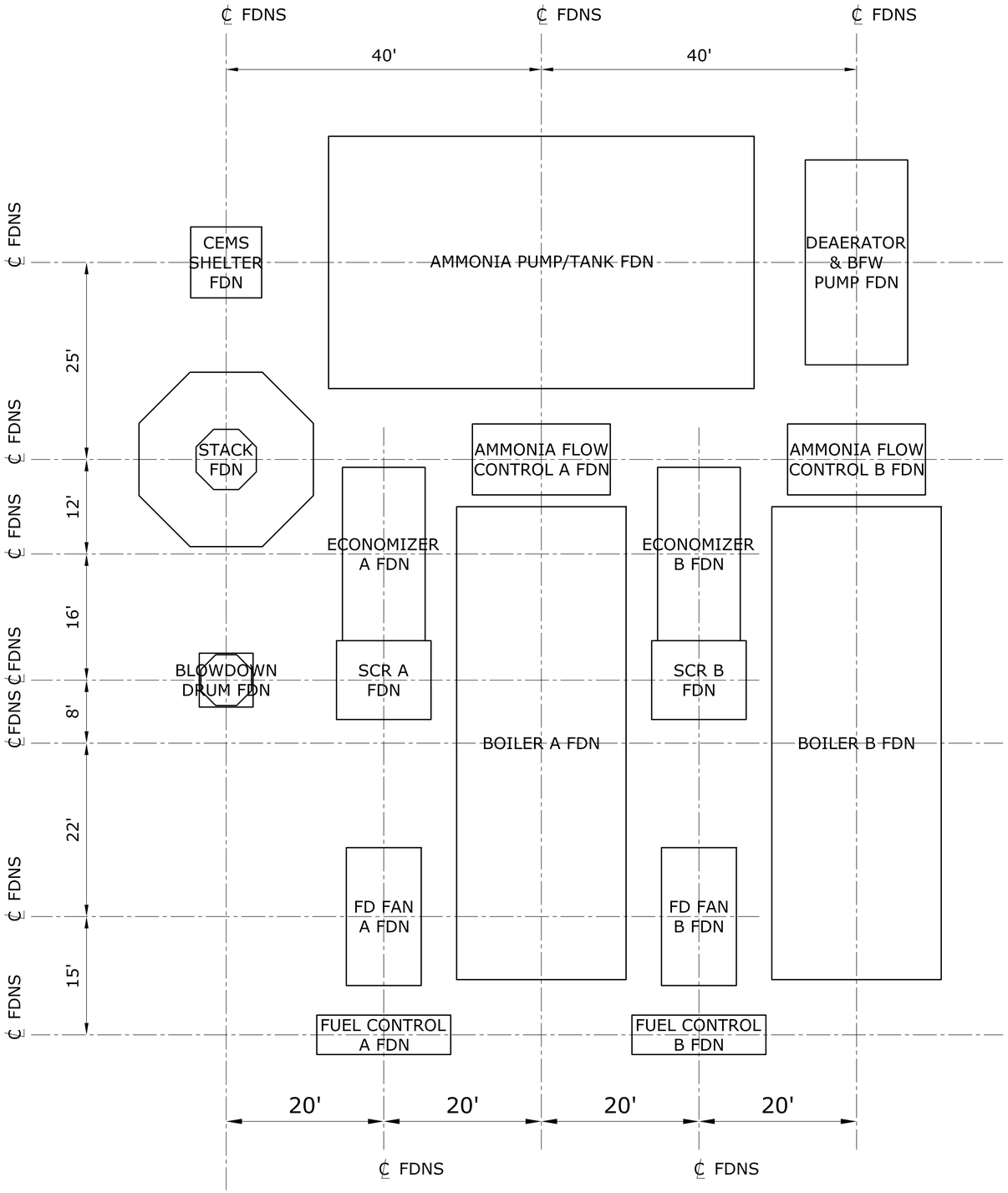
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
M-602 FOUNDATIONS
ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00157	1 OF 1	C	1/2"=1'-0"



M-710 A/B BOILER PACKAGE FOUNDATION KEY PLAN

SCALE: 1/8" = 1'-0"

* SEE SPECIFICATIONS

BILL OF MATERIAL

QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO. REQD	SIZE	LENGTH	DESCRIPTION
—	—	890.1	CU YDS	—	TOTAL CONCRETE PER SKETCHES EH-35R-CCU1-SKT-215-00159 THRU EH-35R-CCU1-SKT-215-00162

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	JT	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

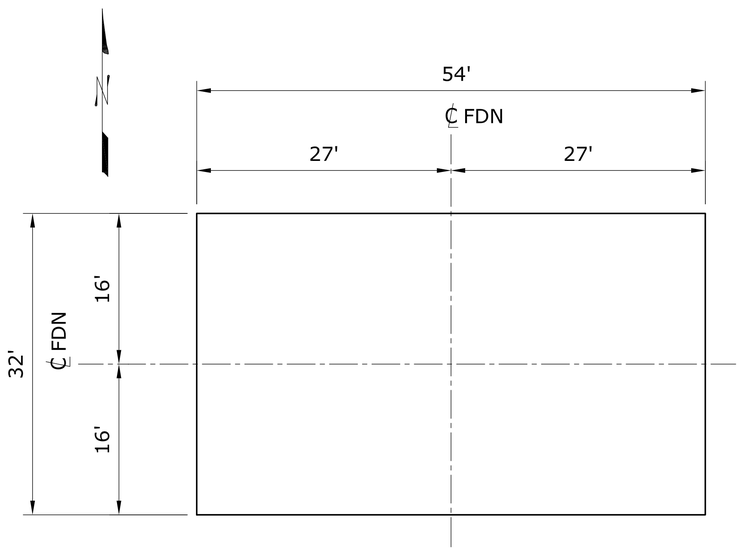
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

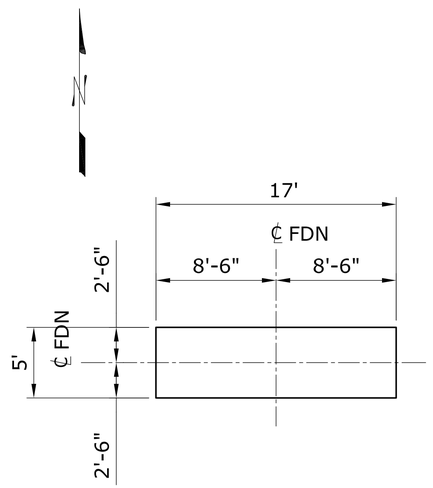
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
M-710 A/B FOUNDATIONS
KEY PLAN

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00159	1 OF 1	C	1/8"=1'-0"



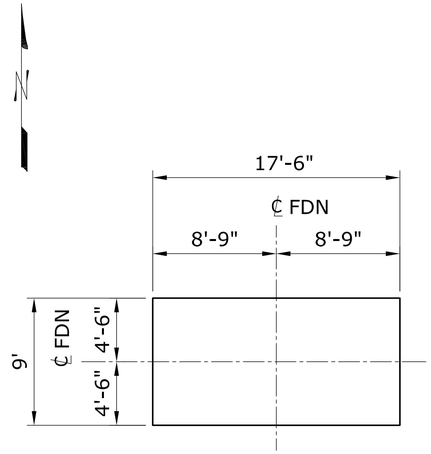
AMMONIA PUMP/TANK
FOUNDATION PLAN AT TOC 1341'-0"

SCALE: 1/8" = 1'-0"



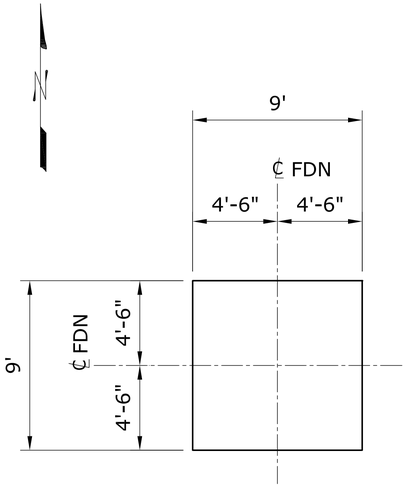
FUEL CONTROL A & B
FOUNDATION PLAN AT TOC 1341'-0"

SCALE: 3/16" = 1'-0"



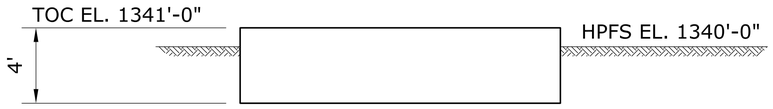
AMMONIA FLOW CONTROL A & B
FOUNDATION PLAN AT TOC 1341'-0"

SCALE: 3/16" = 1'-0"



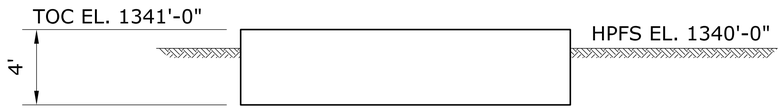
CEMS SHELTER
FOUNDATION PLAN AT TOC 1341'-0"

SCALE: 1/4" = 1'-0"



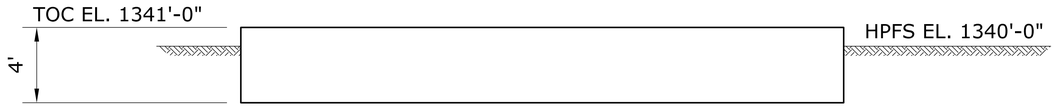
FUEL CONTROL A & B
SOUTH ELEVATION

LOOKING NORTH
SCALE: 1/4" = 1'-0"



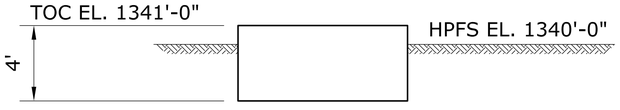
AMMONIA FLOW CONTROL A & B
SOUTH ELEVATION

LOOKING NORTH
SCALE: 1/4" = 1'-0"



AMMONIA PUMP/TANK
SOUTH ELEVATION

LOOKING NORTH
SCALE: 1/4" = 1'-0"



CEMS SHELTER
SOUTH ELEVATION

LOOKING NORTH
SCALE: 1/4" = 1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	JT	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

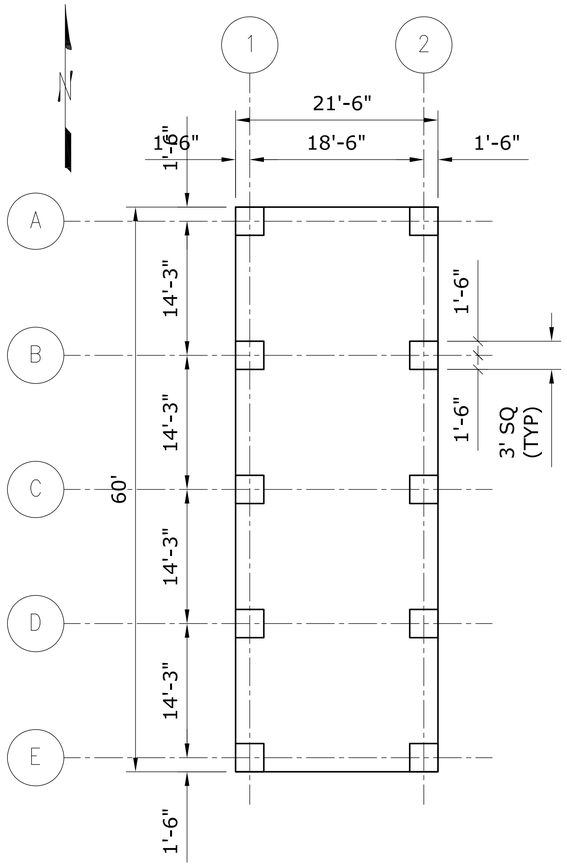
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

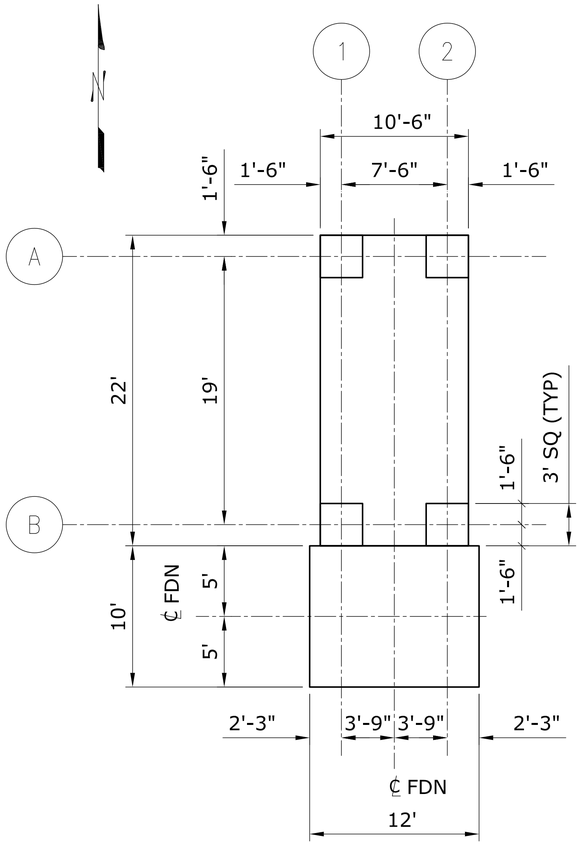
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
M-710 A/B FOUNDATIONS
PLANS & ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00160	1 OF 1	C	AS NOTED



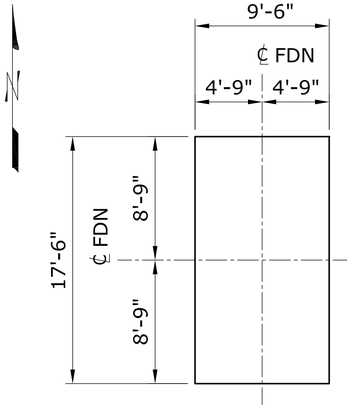
BOILER A & B
FOUNDATION PLAN AT TOC 1338'-0"

SCALE: 1/8" = 1'-0"



ECONOMIZER A & B AND SCR A & B
FOUNDATION PLAN AT TOC 1338'-0"

SCALE: 3/16" = 1'-0"



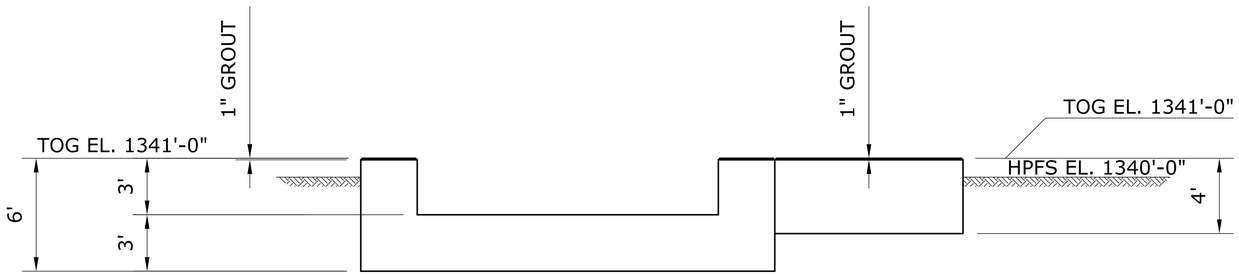
FD FAN A & B
FOUNDATION PLAN AT TOC 1341'-0"

SCALE: 3/16" = 1'-0"



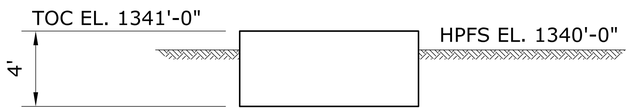
BOILER A & B
SOUTH ELEVATION

LOOKING NORTH
SCALE: 1/4" = 1'-0"



ECONOMIZER A & B AND SCR A & B
EAST ELEVATION

LOOKING WEST
SCALE: 1/4" = 1'-0"



FD FAN A & B
SOUTH ELEVATION

LOOKING NORTH
SCALE: 1/4" = 1'-0"

FLUOR.

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	JT	JT	WA	NP AMP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

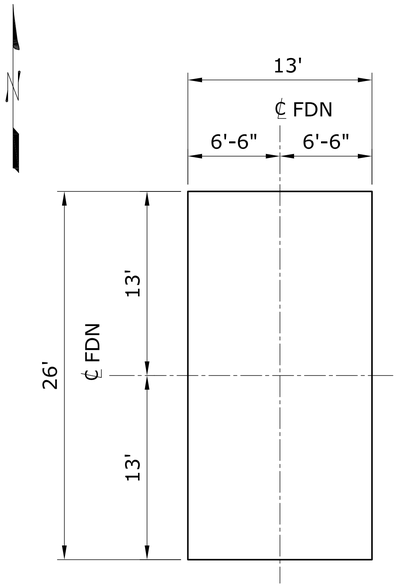
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

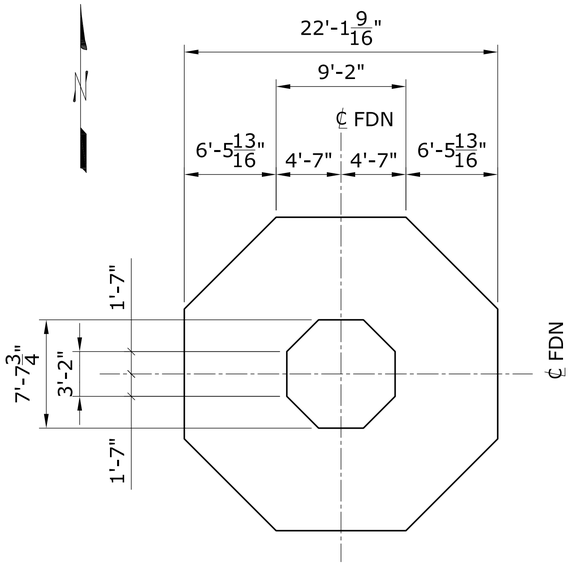
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
M-710 A/B FOUNDATIONS
PLANS & ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00161	1 OF 1	C	AS NOTED



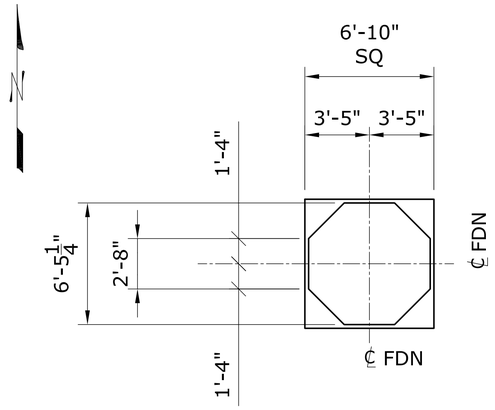
DEAERATOR AND BFW PUMP
FOUNDATION PLAN AT TOC 1341'-0"

SCALE: 3/16" = 1'-0"



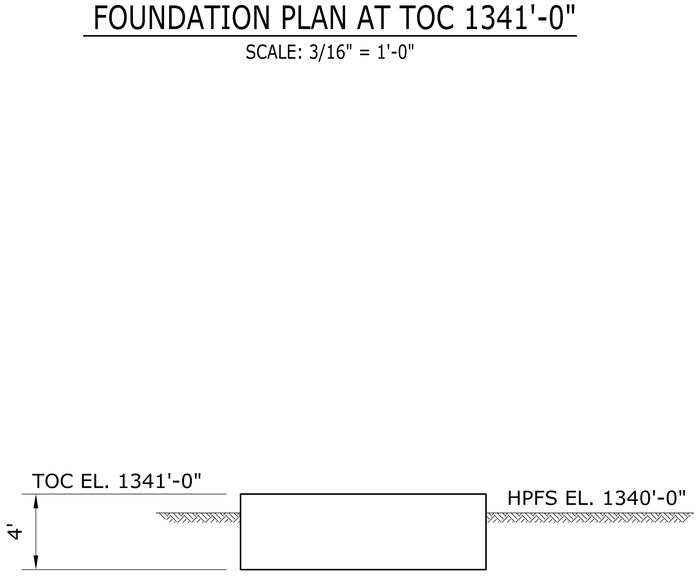
STACK
FOUNDATION PLAN AT TOC 1338'-0"

SCALE: 3/16" = 1'-0"



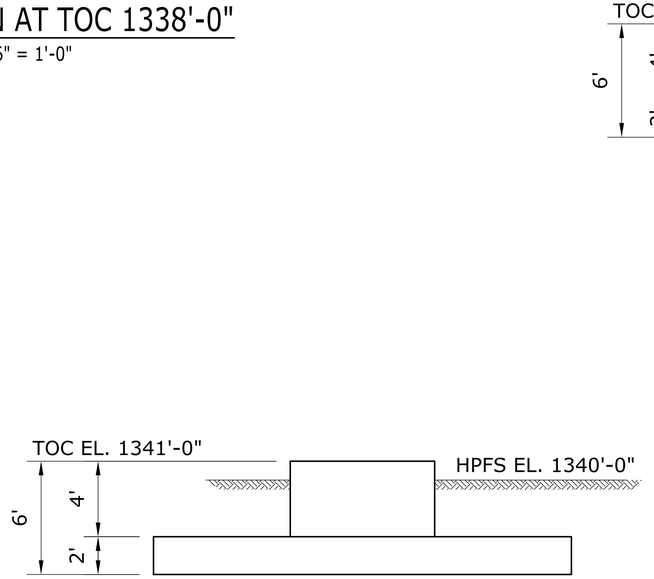
BLOWDOWN DRUM
FOUNDATION PLAN AT TOC 1338'-0"

SCALE: 1/4" = 1'-0"



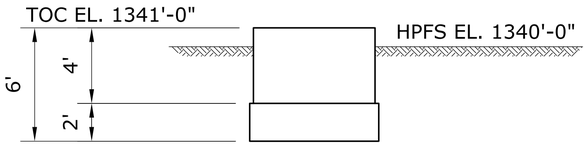
DEARATOR & BFW PUMP
SOUTH ELEVATION

LOOKING NORTH
SCALE: 1/4" = 1'-0"



STACK
SOUTH ELEVATION

LOOKING NORTH
SCALE: 1/4" = 1'-0"



BLOWDOWN DRUM
SOUTH ELEVATION

LOOKING NORTH
SCALE: 1/4" = 1'-0"

FLUOR.

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	JT	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

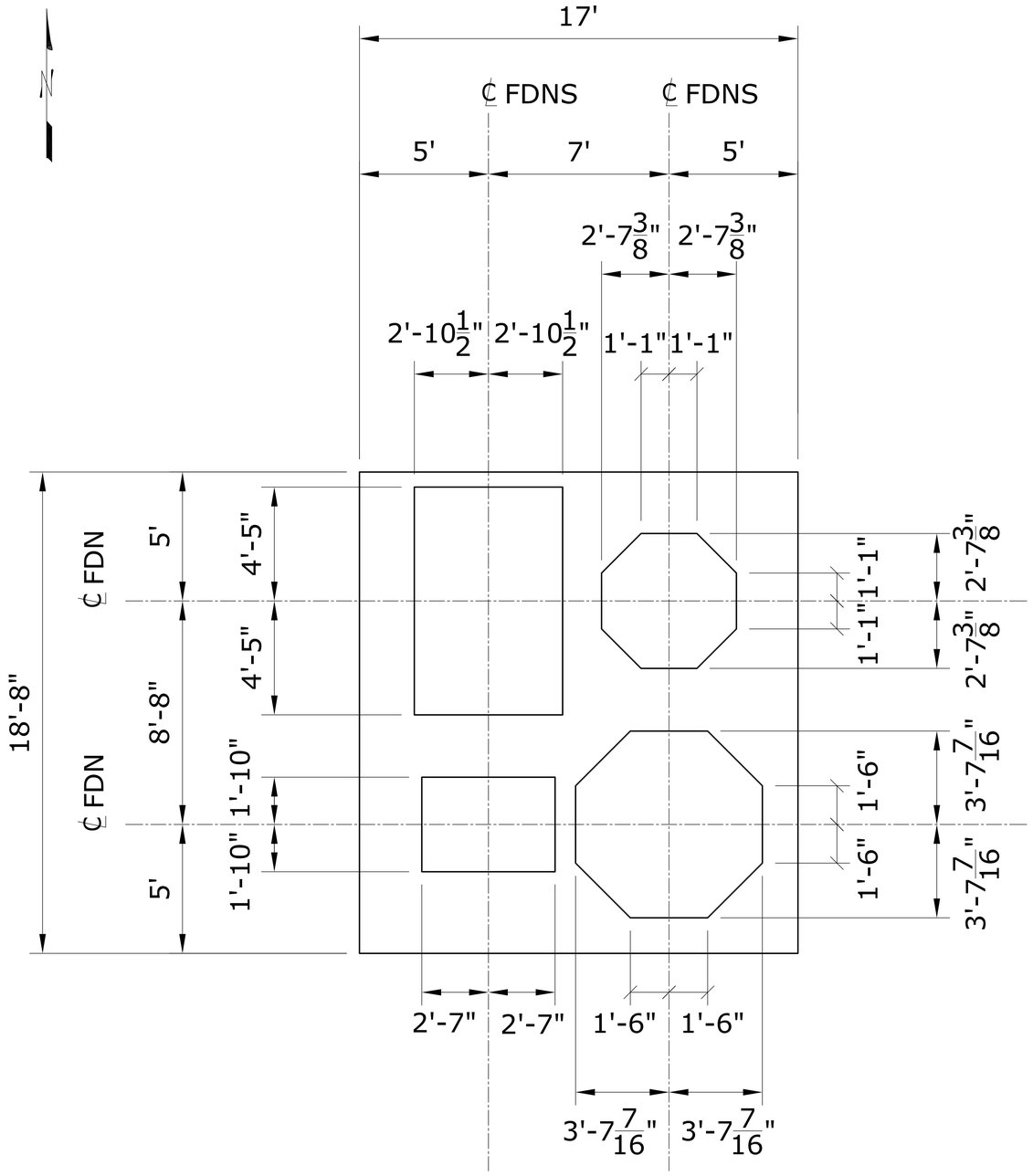
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

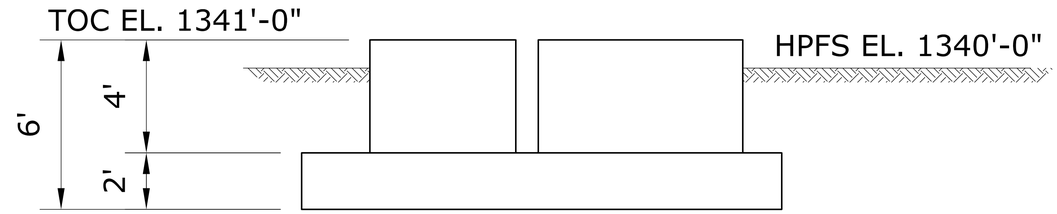
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
M-710 A/B FOUNDATIONS
PLANS & ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00162	1 OF 1	C	AS NOTED



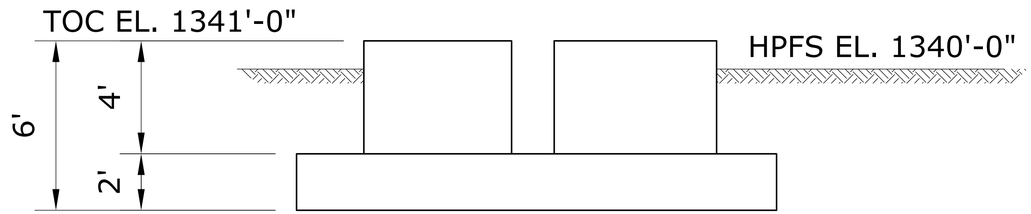
FOUNDATION PLAN AT TOC 1341'-0"

SCALE: 3/8" = 1'-0"



SOUTH ELEVATION

LOOKING NORTH
SCALE: 3/8" = 1'-0"



NORTH ELEVATION

LOOKING SOUTH
SCALE: 3/8" = 1'-0"

*SEE SPECIFICATIONS

BILL OF MATERIAL

QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO. REQD	SIZE	LENGTH	DESCRIPTION
—	—	39.0	CU YDS	—	TOTAL CONCRETE PER THIS SKETCH

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
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B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

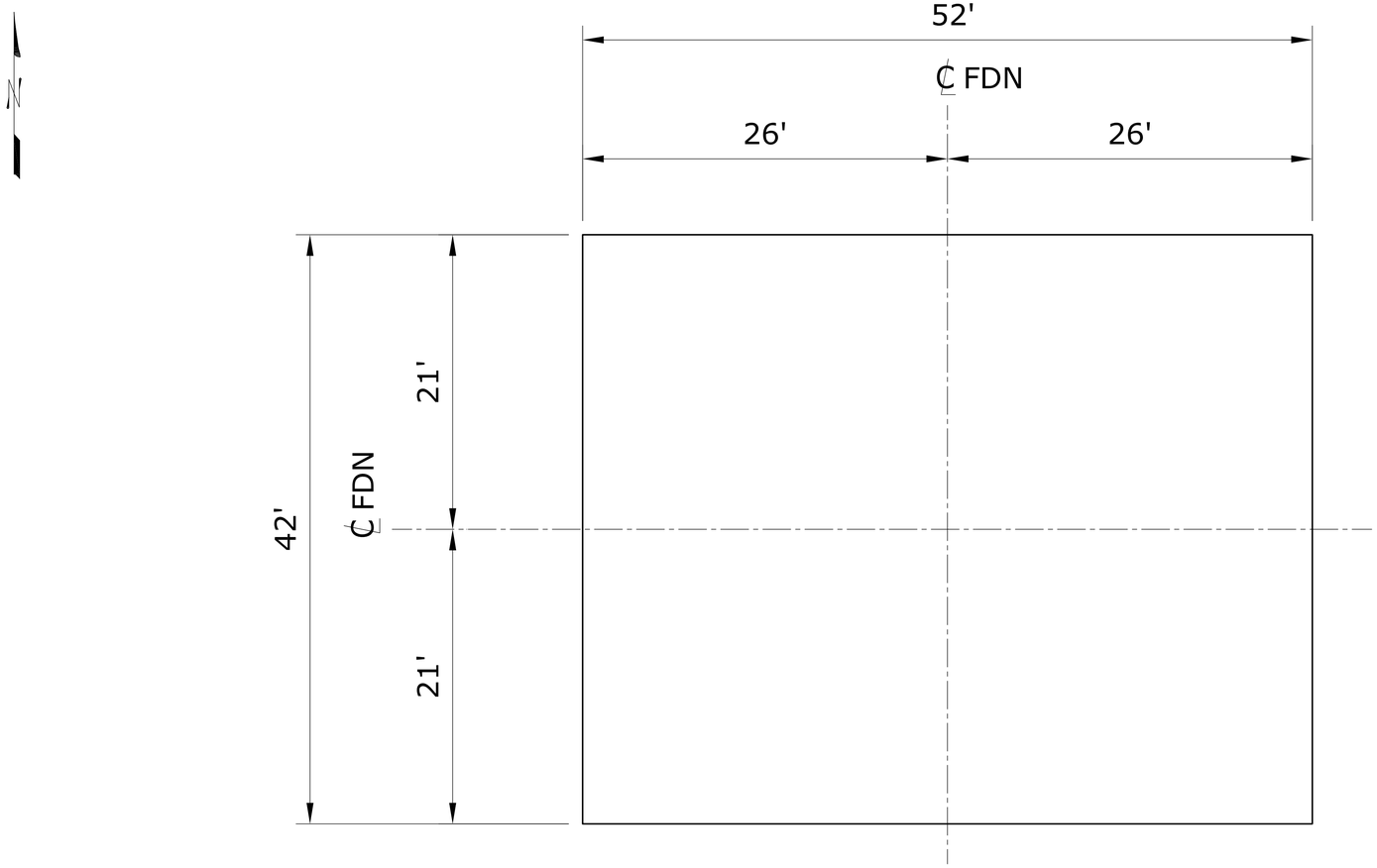
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

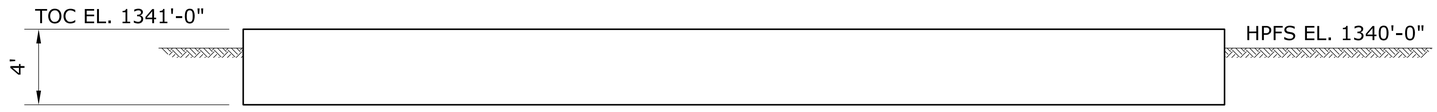
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
M-720 FOUNDATION
PLAN & ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00163	1 OF 1	C	3/8"=1'-0"



FOUNDATION PLAN AT TOC 1341'-0"

SCALE: 3/16" = 1'-0"



SOUTH ELEVATION

LOOKING NORTH
SCALE: 1/4" = 1'-0"

BILL OF MATERIAL

*SEE SPECIFICATIONS — QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO. REQD	SIZE	LENGTH	DESCRIPTION
—	—	330.3	CU YDS	—	TOTAL CONCRETE PER THIS SKETCH

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
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B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS — APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
M-711 FOUNDATION
PLAN & ELEVATION

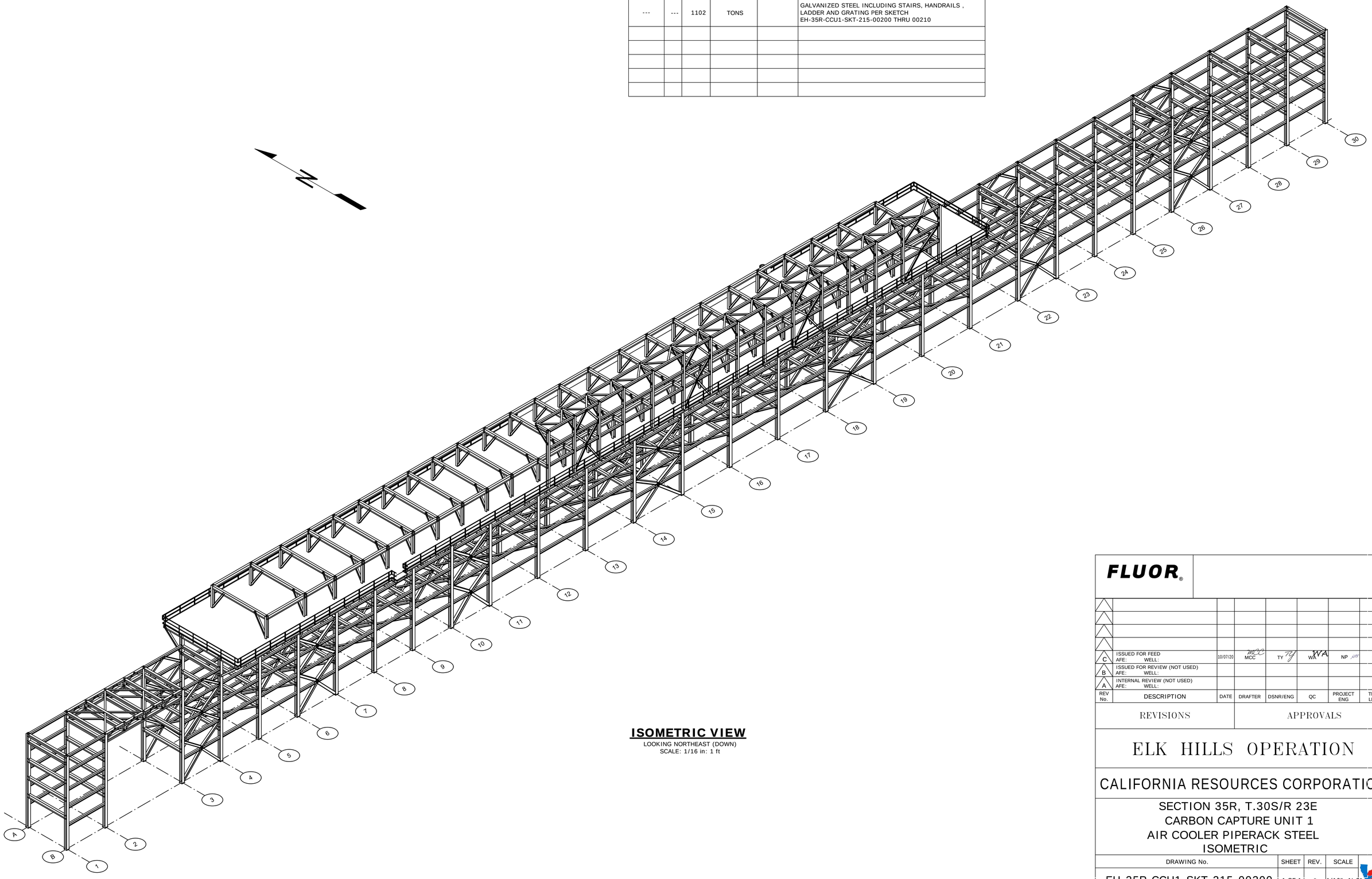
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00164	1 OF 1	C	AS NOTED

Attachment 7 – Structural and Architectural Drawings

BILL OF MATERIAL

* SEE SPECIFICATION

TYPE	MK	No. REQ'D	SIZE	LENGTH	DESCRIPTION
---	---	1102	TONS		GALVANIZED STEEL INCLUDING STAIRS, HANDRAILS , LADDER AND GRATING PER SKETCH EH-35R-CCU1-SKT-215-00200 THRU 00210



ISOMETRIC VIEW
LOOKING NORTHEAST (DOWN)
SCALE: 1/16 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	MCC	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

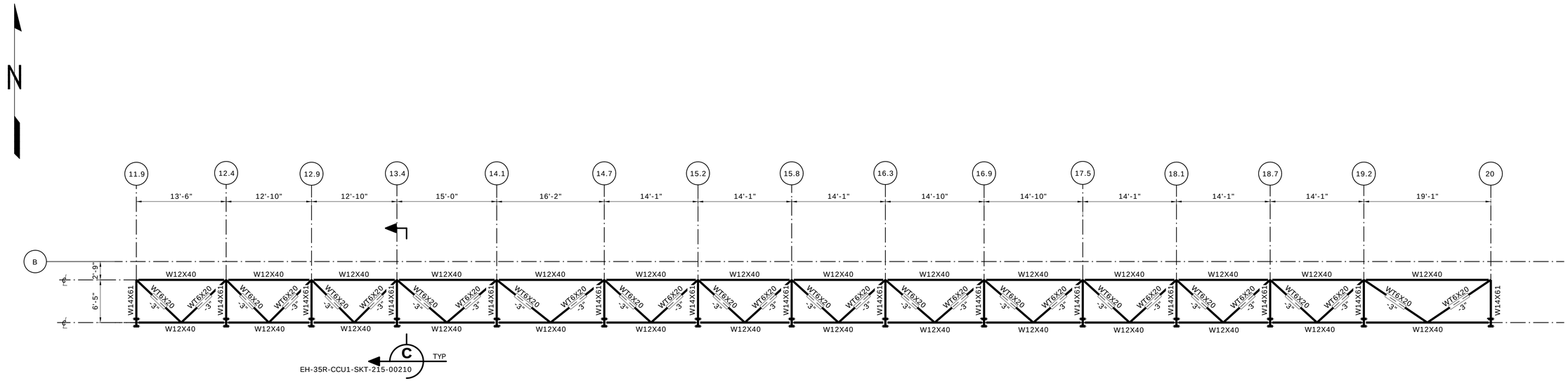
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
AIR COOLER PIPERACK STEEL
ISOMETRIC

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00200	1 OF 1	C	1/16"=1'-0"



PLAN @ TOS 1413' 6"

SCALE: 1/8 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	MCC	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

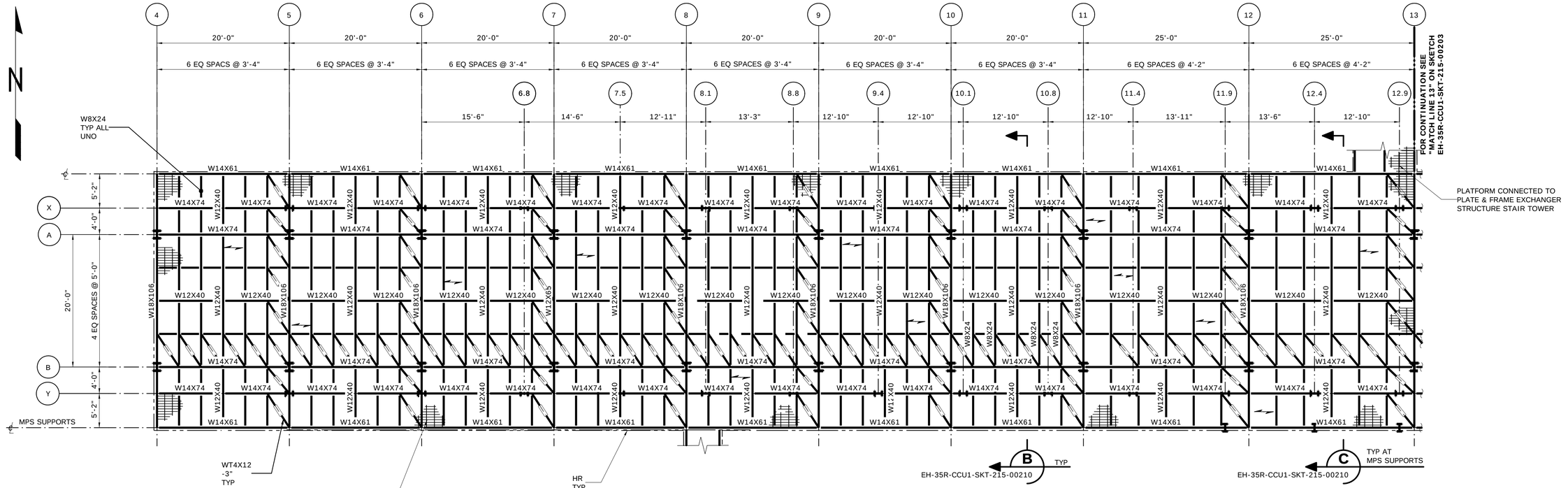
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
AIR COOLER PIPERACK STEEL
PLAN @ TOS EL 1413'-6"

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00201	1 OF 1	C	1/8"=1'-0"



PARTIAL PLAN 1 @ TOS 1388' 0"

SCALE: 1/8 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	MCC	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

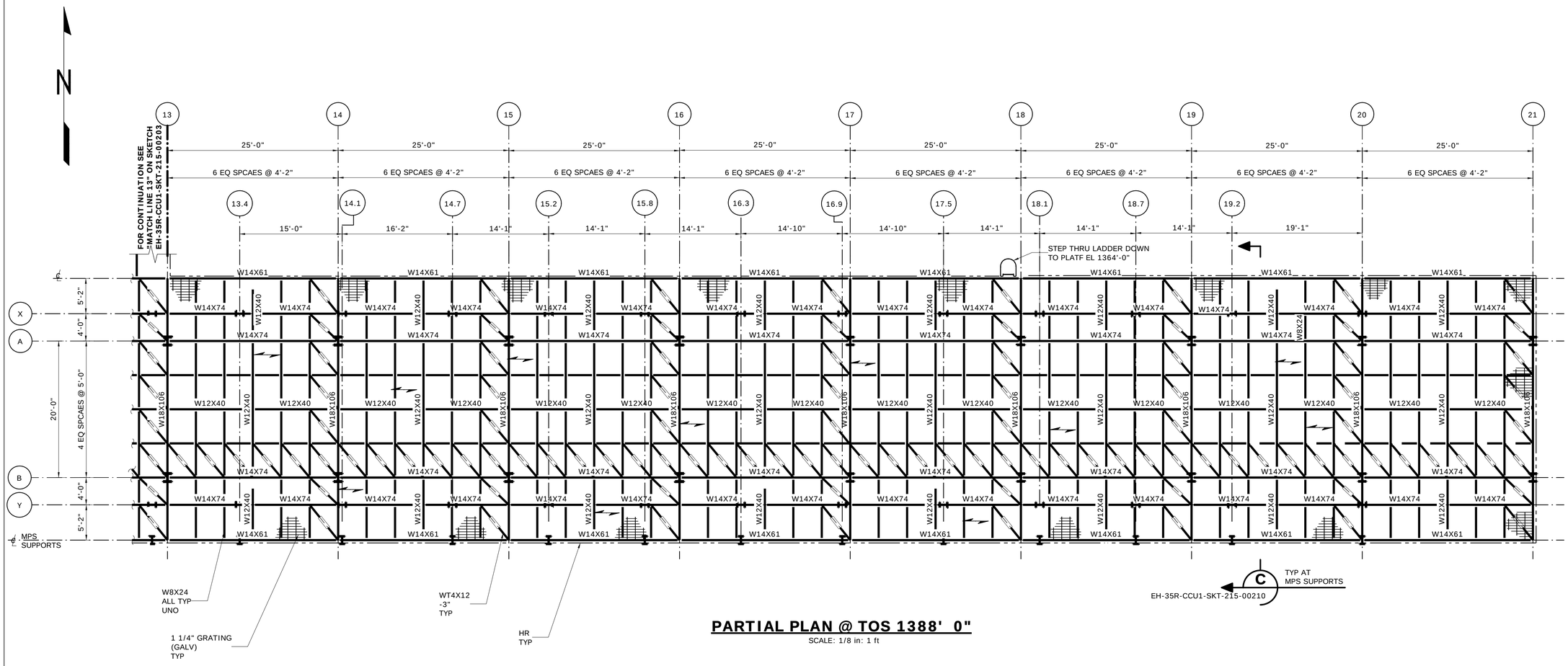
ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
AIR COOLER PIPERACK STEEL
PARTIAL PLAN @ TOS EL 1388'-0"

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00202	1 OF 1	C	1/8"=1'-0"

CRC



PARTIAL PLAN @ TOS 1388' 0"

SCALE: 1/8 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	MCC	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

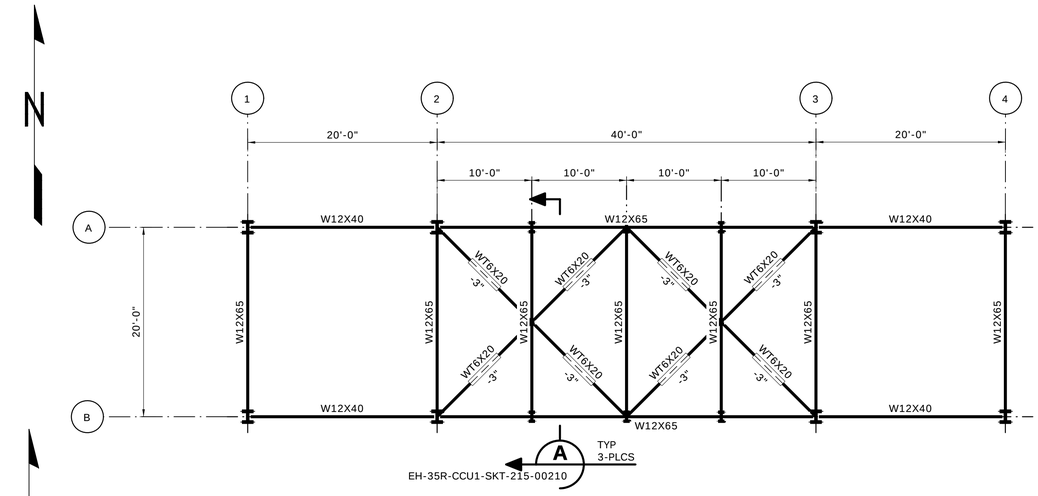
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

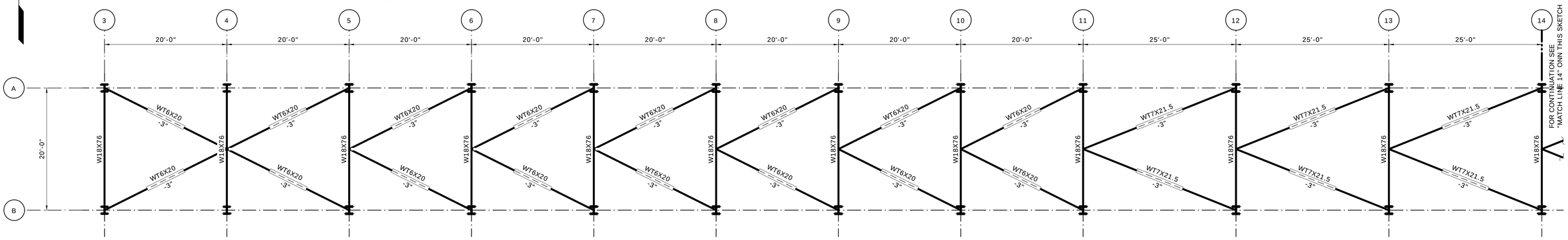
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
AIR COOLER PIPERACK STEEL
PARTIAL PLAN @ TOS EL 1388'-0"

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00203	1 OF 1	C	1/8"=1'-0"



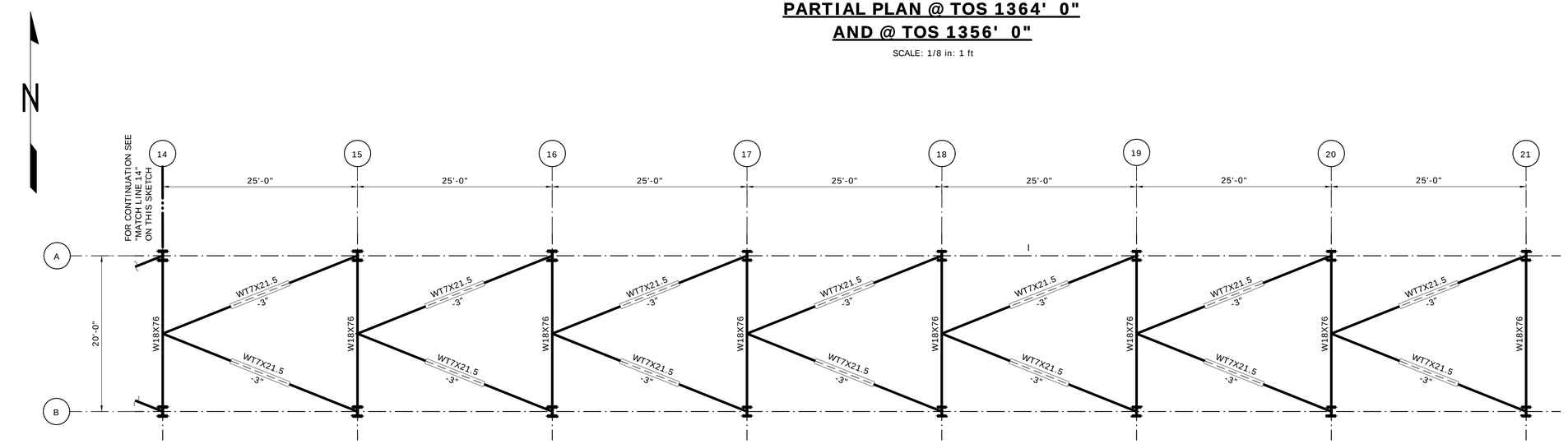
PARTIAL PLAN @ TOS 1383' 0" AND @ TOS 1380' 0"

SCALE: 1/8 in: 1 ft



PARTIAL PLAN @ TOS 1364' 0" AND @ TOS 1356' 0"

SCALE: 1/8 in: 1 ft



PARTIAL PLAN @ TOS 1364' 0" AND @ TOS 1356' 0"

SCALE: 1/8 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	MCC	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

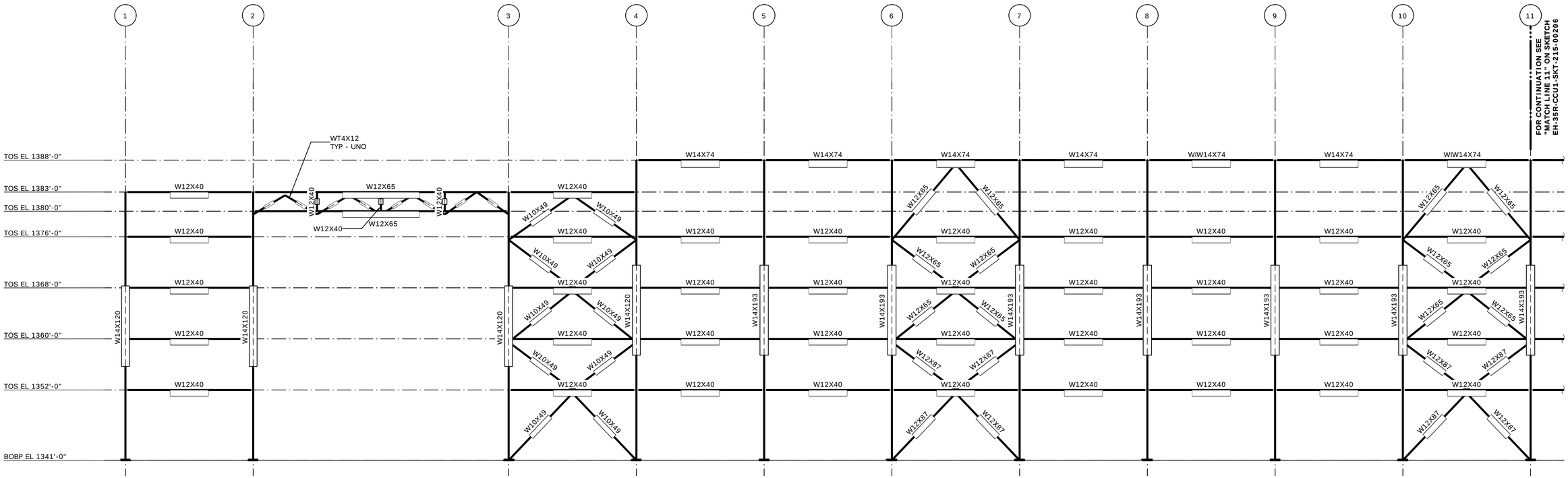
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
AIR COOLER PIPERACK STEEL
PLANS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00204	1 OF 1	C	1/8"=1'-0"



PARTIAL SOUTH ELEVATION @ COL LINES A & B

LOOKING NORTH
SCALE: 1/8 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	MCC	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

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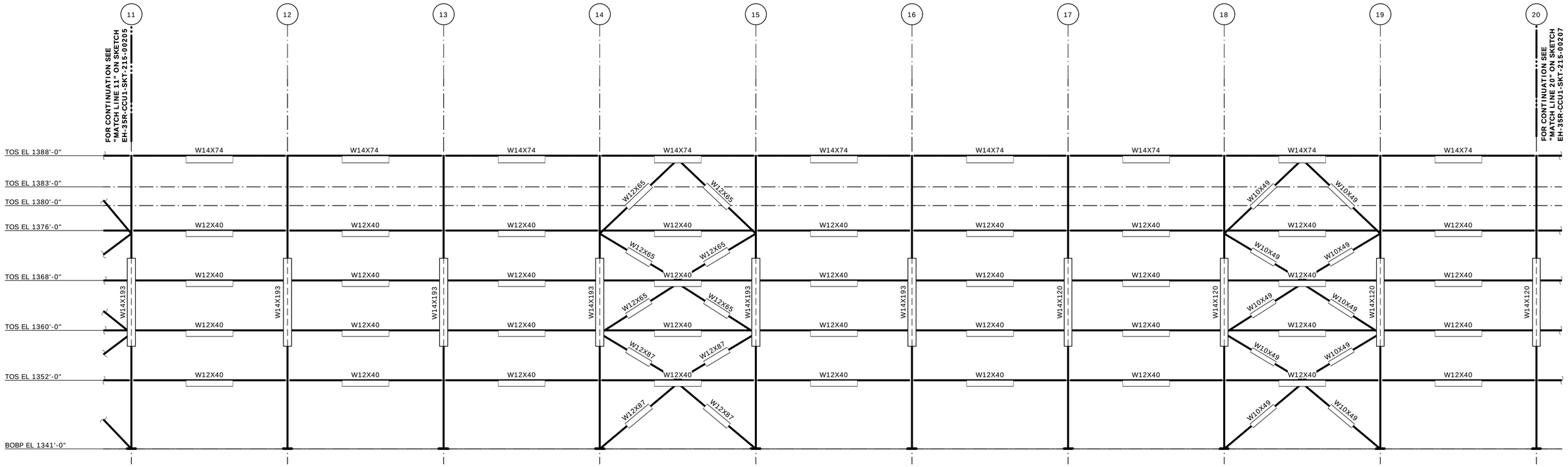
ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
AIR COOLER PIPERACK STEEL
PARTIAL SOUTH ELEVATION @ COL LINES A & B

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00205	1 OF 1	C	1/8"=1'-0"

CRC



PARTIAL SOUTH ELEVATION @ COL LINES A & B

LOOKING NORTH
SCALE: 1/8 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	MCC	TY	WAWA	NP	WAWA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

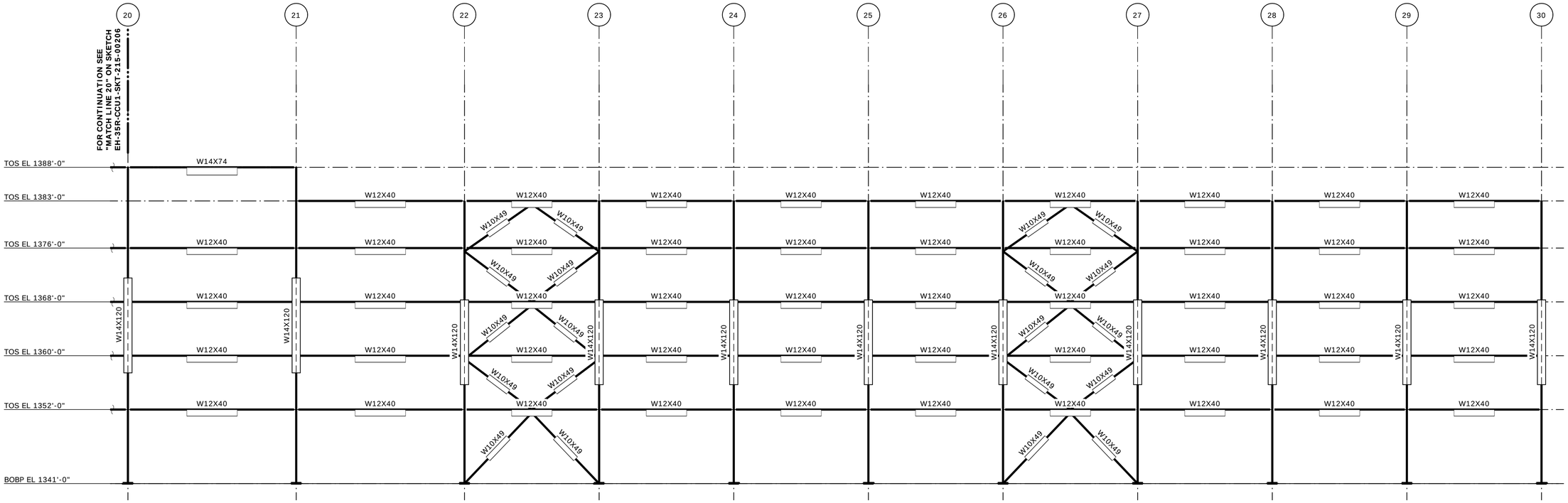
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
AIR COOLER PIPERACK STEEL
PARTIAL SOUTH ELEVATION @ COL LINES A & B

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00206	1 OF 1	C	1/8"=1'-0"



PARTIAL SOUTH ELEVATION @ COL LINES A & B

LOOKING NORTH
SCALE: 1/8 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	MCC	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
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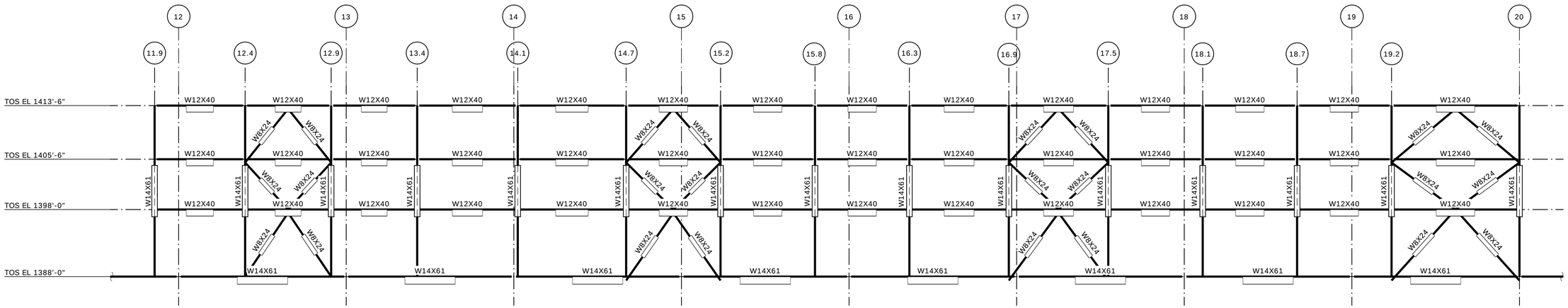
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
AIR COOLER PIPERACK STEEL
PARTIAL SOUTH ELEVATION @ COL LINES A & B

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00207	1 OF 1	C	1/8"=1'-0"



SOUTH ELEVATION @ MPS SUPPORTS

LOOKING NORTH
SCALE: 1/8 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	MCC	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

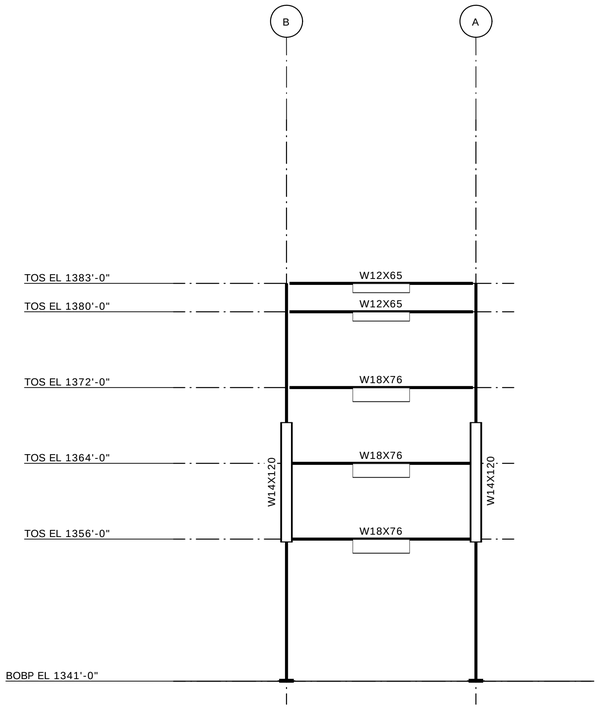
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ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

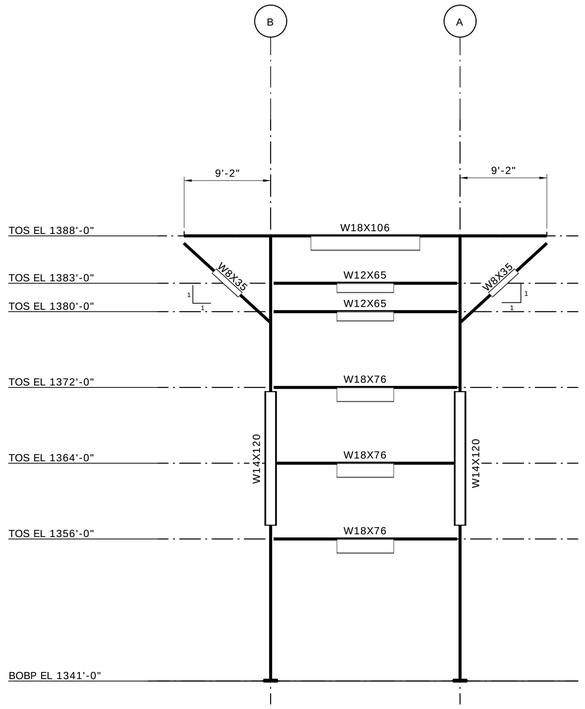
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
AIR COOLER PIPERACK STEEL
SOUTH ELEVATION AT MPS SUPPORTS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00208	1 OF 1	C	1/8"=1'-0"



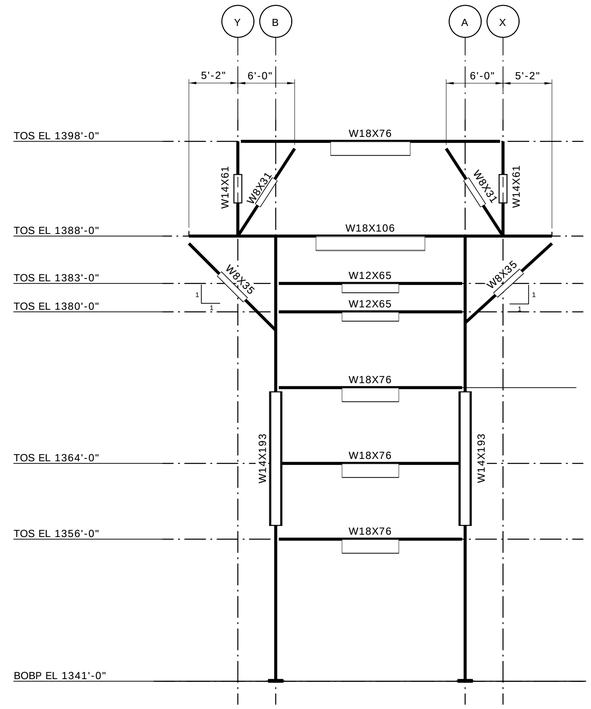
EAST ELEVATION @ COL LINES 1 THRU 3 AND COL LINES 22 THRU 30

LOOKING WEST
SCALE: 1/8 in: 1 ft



EAST ELEVATION @ COL LINES 4 , 7 & 8 THRU 19

LOOKING WEST
SCALE: 1/8 in: 1 ft



EAST ELEVATION @ COL LINES 5, 6 & 21

LOOKING WEST
SCALE: 1/8 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	MCC	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

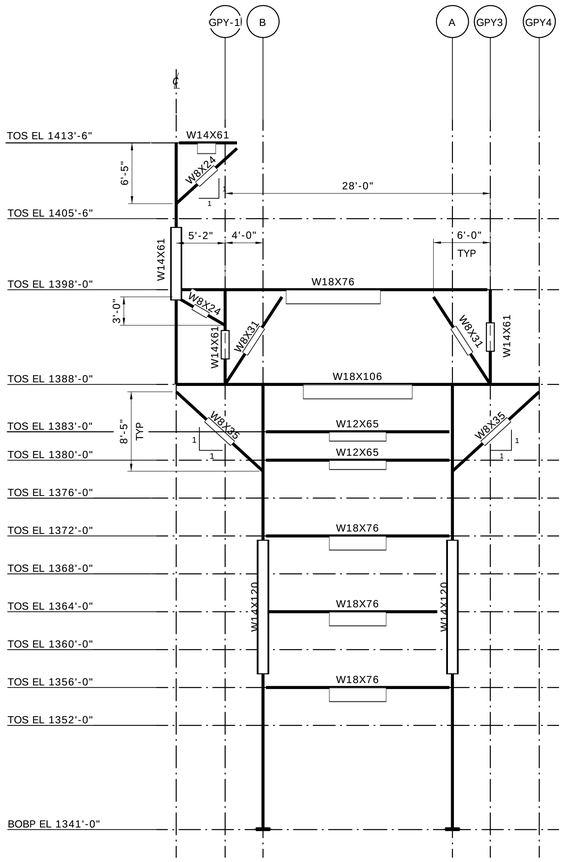
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

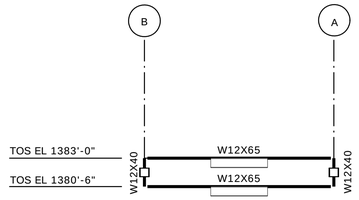
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
AIR COOLER PIPERACK STEEL
EAST ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00209	1 OF 1	C	1/8"=1'-0"



EAST ELEVATION @ COL LINE 20

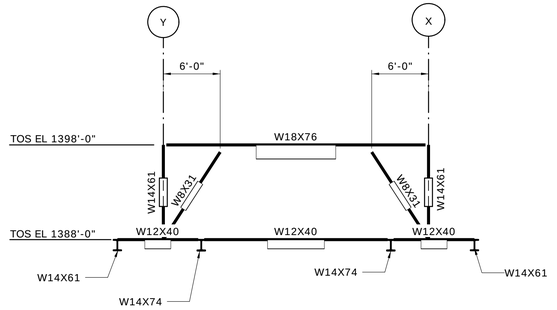
LOOKING WEST
SCALE: 1/8 in: 1 ft



SECTION A

SCALE: 1/8 in: 1 ft

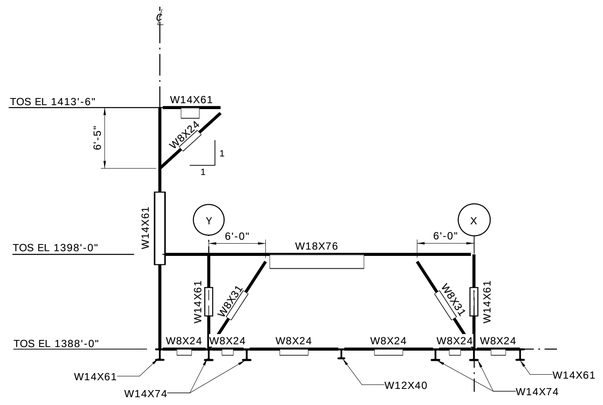
EH-35R-CCU1-SKT-215-00204



SECTION B

SCALE: 1/8 in: 1 ft

EH-35R-CCU1-SKT-215-00202



SECTION C

SCALE: 1/8 in: 1 ft

EH-35R-CCU1-SKT-215-00201
EH-35R-CCU1-SKT-215-00202
EH-35R-CCU1-SKT-215-00203

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	MCC	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

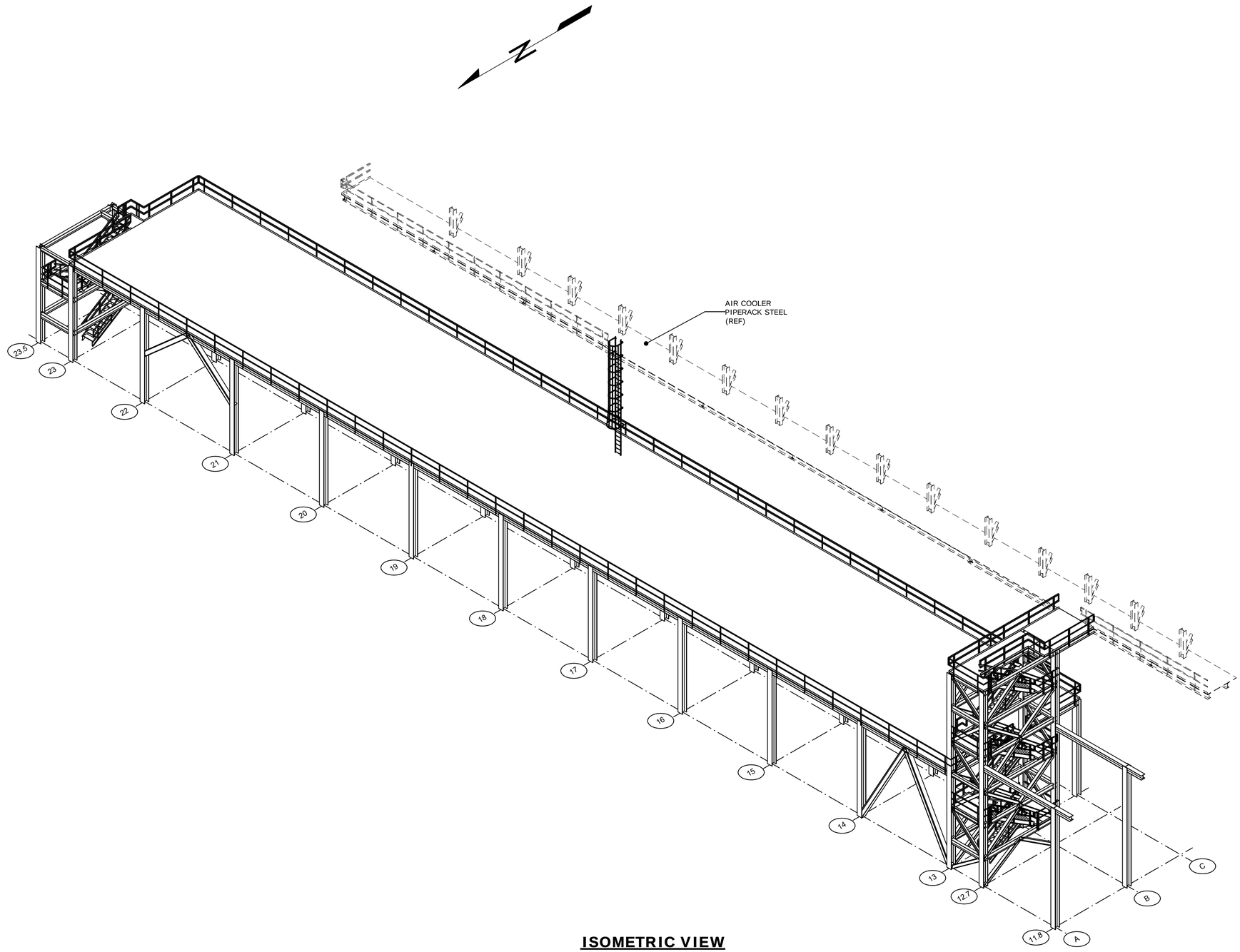
ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
AIR COOLER PIPERACK STEEL
EAST ELEVATION & SECTIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00210	1 OF 1	C	1/8"=1'-0"

CRC



ISOMETRIC VIEW
LOOKING SOUTHEAST (DOWN)
SCALE: 3/32 in: 1 ft

* SEE SPECIFICATION

BILL OF MATERIAL

TYPE	MK	No. REQ'D	SIZE	LENGTH	DESCRIPTION
---	---	294	TONS		GALVANIZED STEEL INCLUDING STAIRS, HANDRAILS , LADDER AND GRATING PER SKETCH EH-35R-CCU1-SKT-215-00211 THRU 00217

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	09/30/20	MCC	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

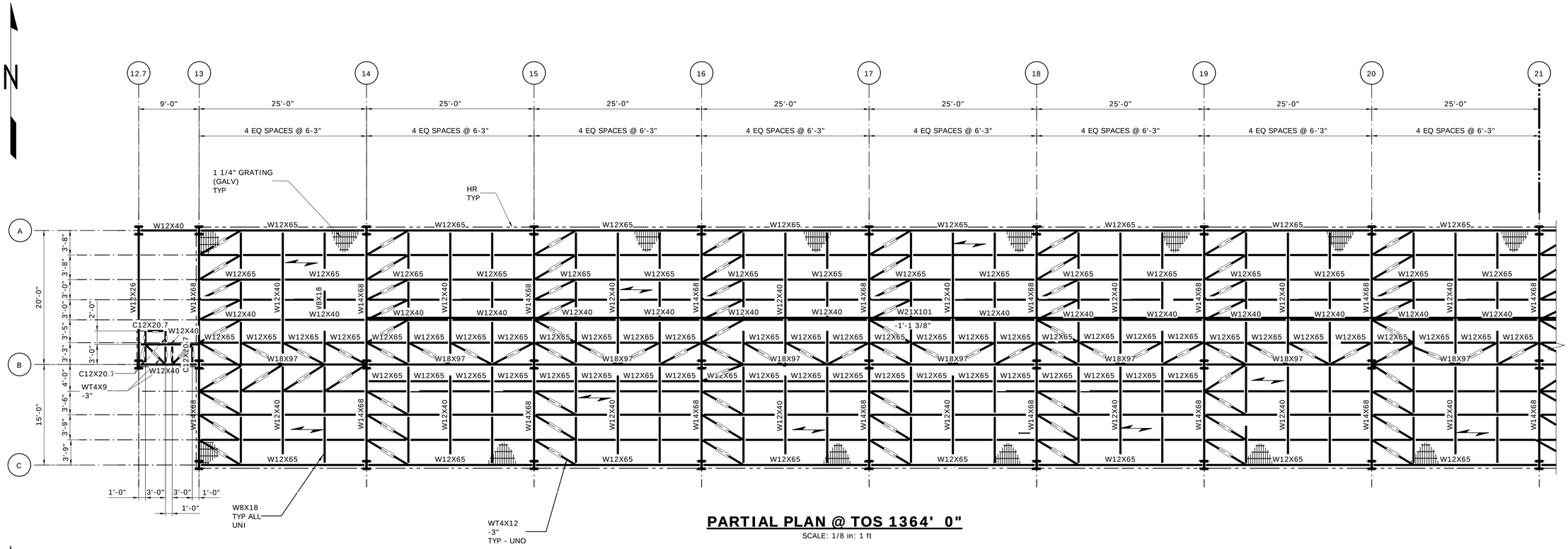
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

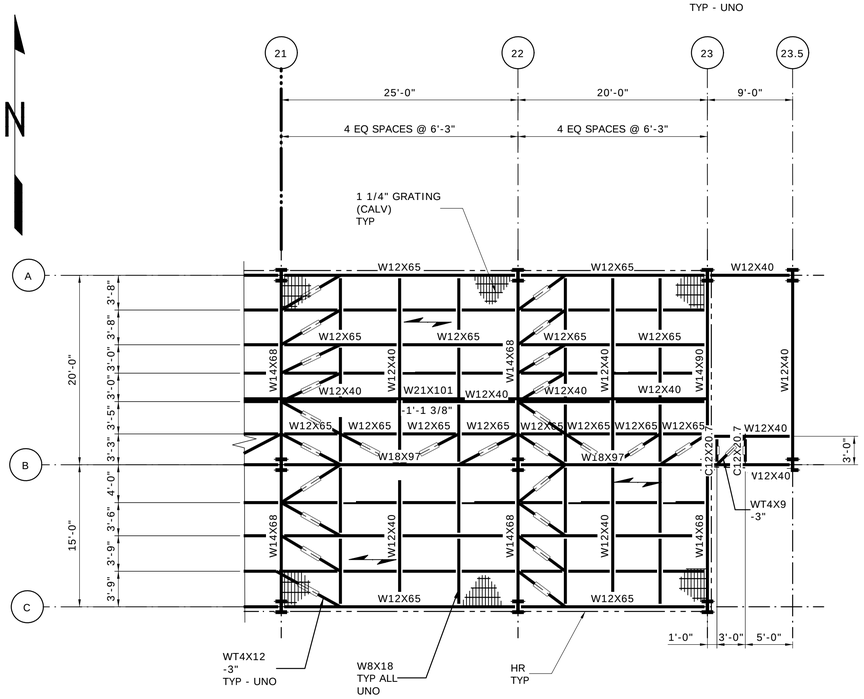
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
PLATE & FRAME EXCHANGERS STRUCTURE STEEL
ISOMETRIC

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00211	1 OF 1	C	3/32"=1'-0"



PARTIAL PLAN @ TOS 1364' 0"

SCALE: 1/8 in: 1 ft



PARTIAL PLAN @ TOS 1364' 0"

SCALE: 1/8 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	MCC	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

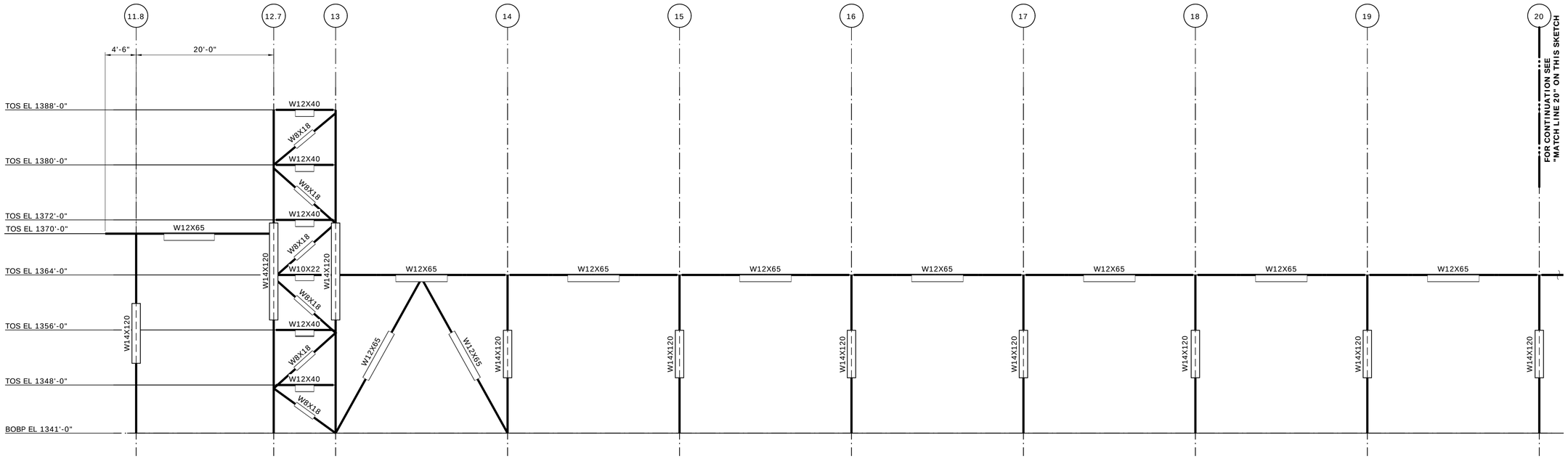
ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
PLATE & FRAME EXCHANGERS STRUCTURE STEEL
PLAN @ TOS EL 1364'-0"

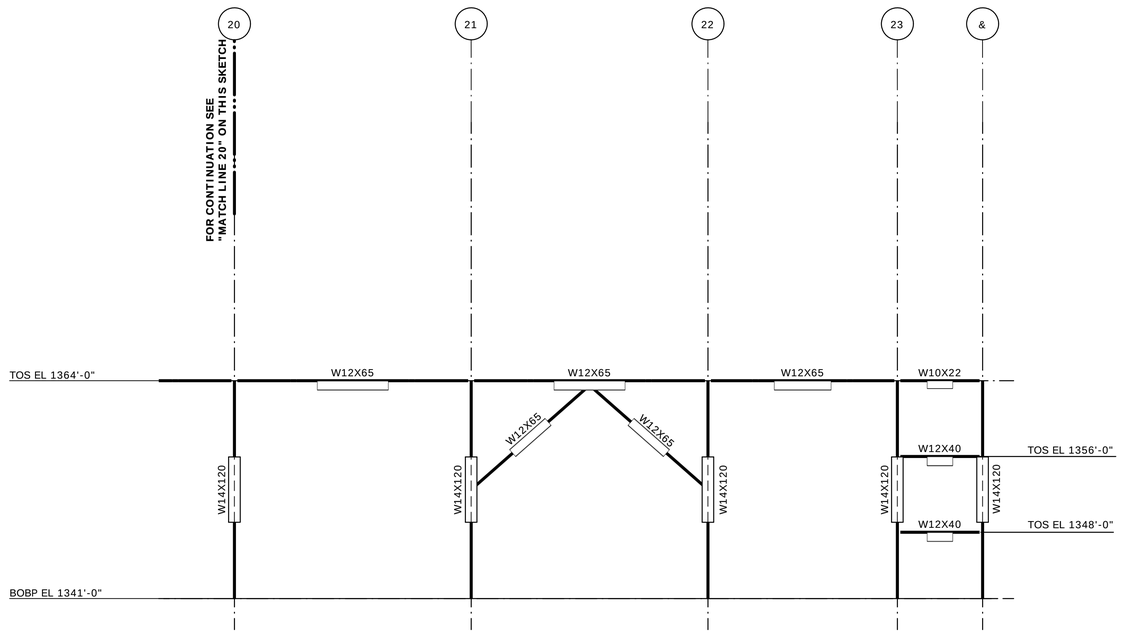
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00212	1 OF 1	C	1/8"=1'-0"

CRC



PARTIAL SOUTH ELEVATION @ COL LINE A

LOOKING NORTH
SCALE: 1/8 in: 1 ft



PARTIAL SOUTH ELEVATION @ COL LINE A

LOOKING NORTH
SCALE: 1/8 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	MCC	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

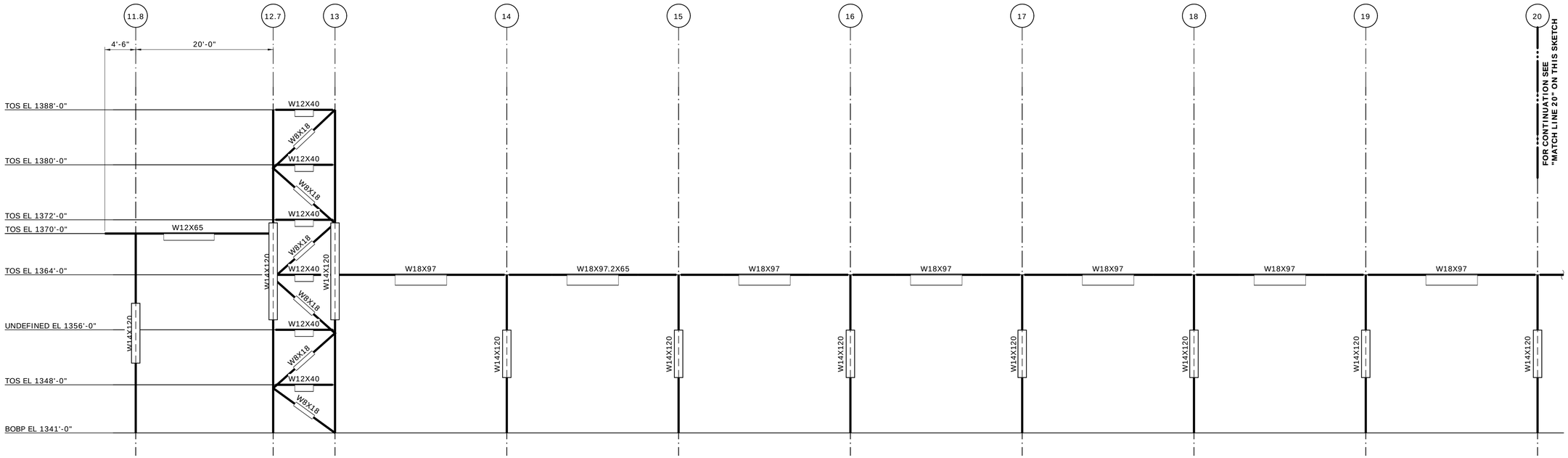
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

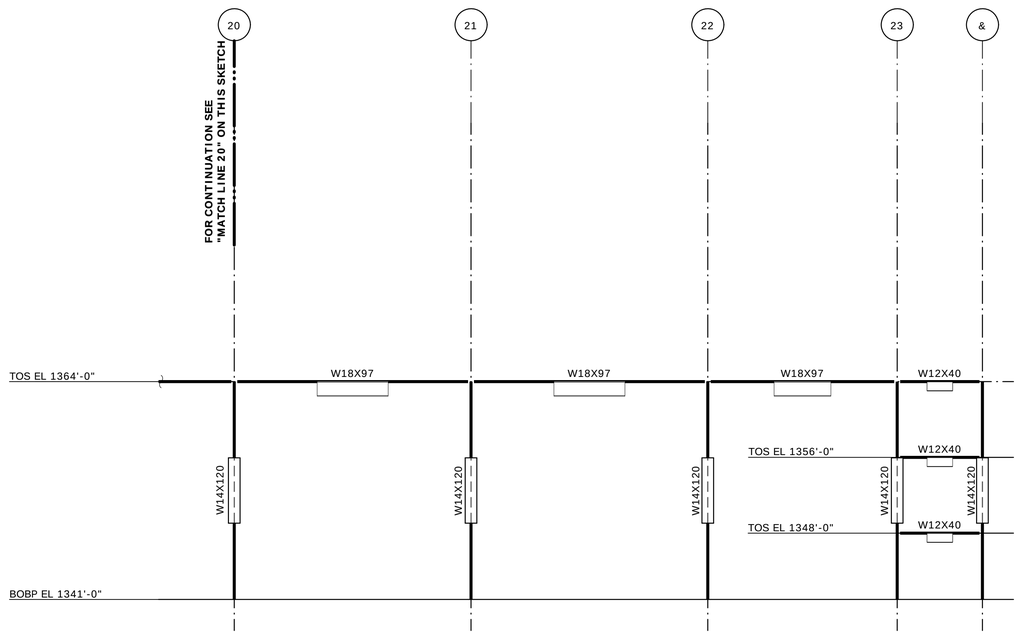
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
PLATE & FRAME EXCHANGERS STRUCTURE STEEL
SOUTH ELEVATION @ COL LINE A

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00213	1 OF 1	C	1/8"=1'-0"



PARTIAL SOUTH ELEVATION @ COL LINE B

LOOKING NORTH
SCALE: 1/8 in: 1 ft



PARTIAL SOUTH ELEVATION @ COL LINE B

LOOKING NORTH
SCALE: 1/8 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	MCC	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

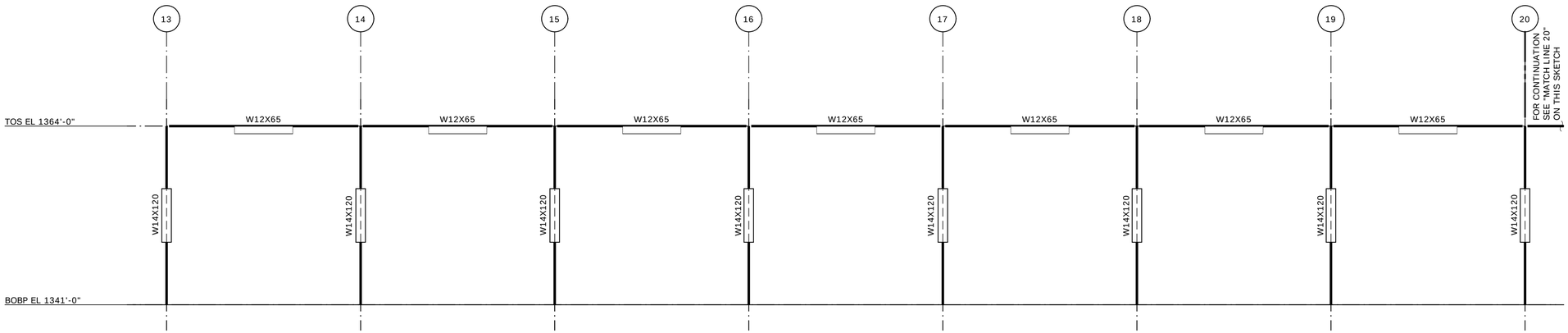
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

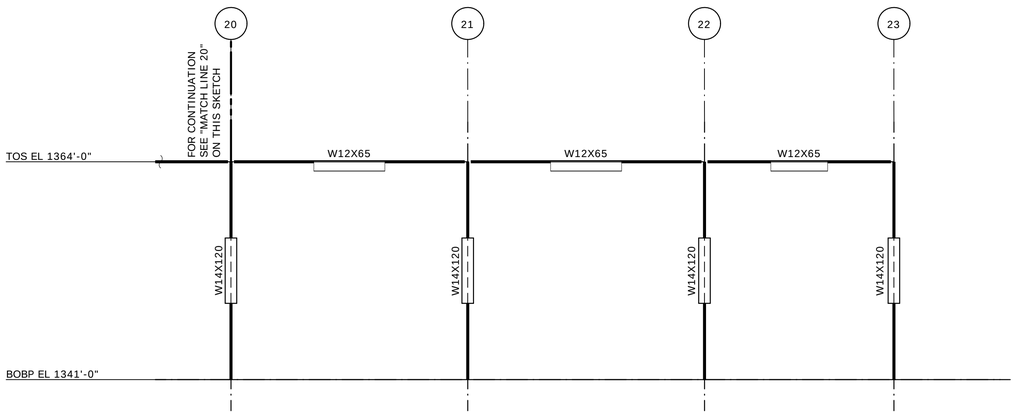
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
PLATE & FRAME EXCHANGERS STRUCTURE STEEL
SOUTH ELEVATION @ COL LINE B

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00214	1 OF 1	C	1/8"=1'-0"



SOUTH ELEVATION @ COL LINE C

LOOKING NORTH
SCALE: 1/8 in: 1 ft



PARTIAL SOUTH ELEVATION @ COL LINE C

LOOKING NORTH
SCALE: 1/8 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	MCC	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

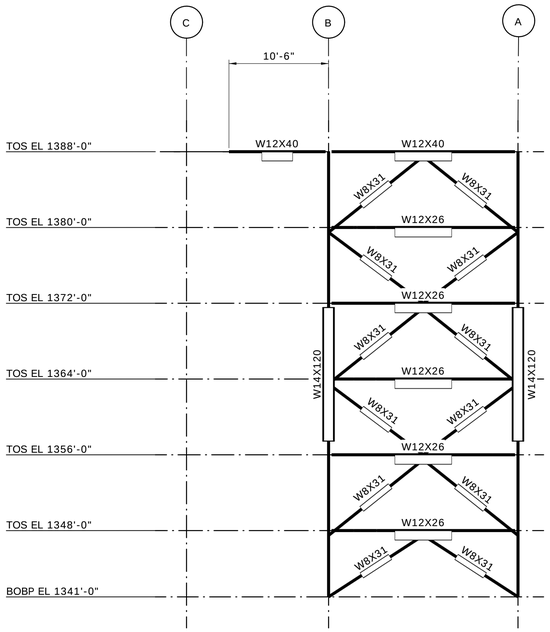
ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
PLATE & FRAME EXCHANGERS STRUCTURE STEEL
SOUTH ELEVATION @ COL LINE C

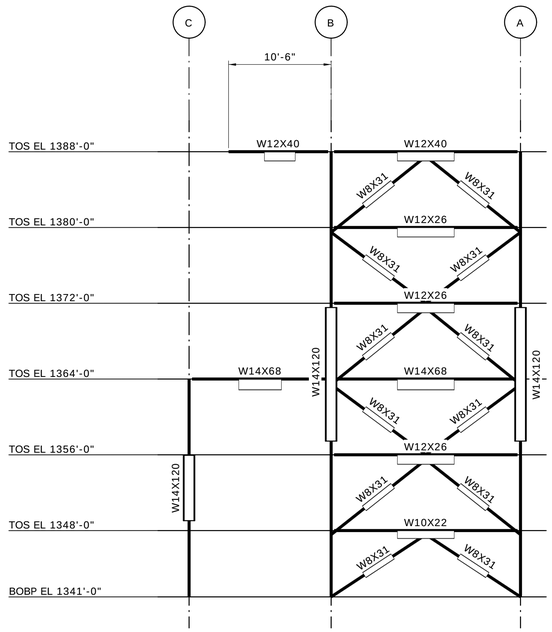
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00215	1 OF 1	C	1/8"=1'-0"

CRC



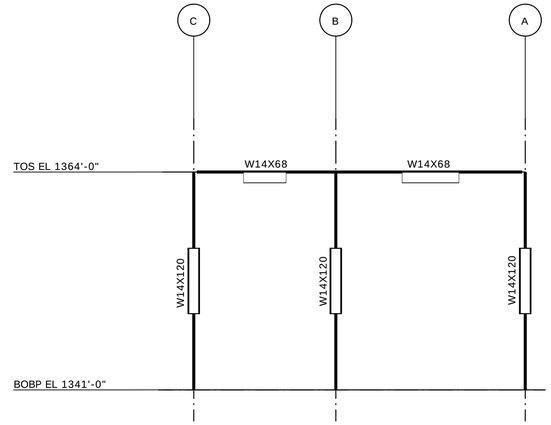
EAST ELEVATION @ COL LINE 12.7

LOOKING WEST
SCALE: 1/8 in: 1 ft



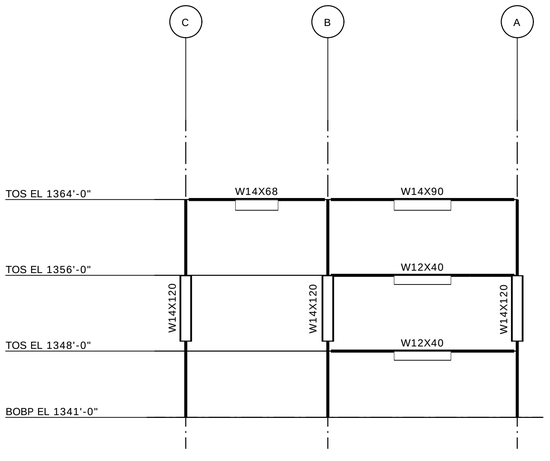
EAST ELEVATION @ COL LINE 13

LOOKING WEST
SCALE: 1/8 in: 1 ft



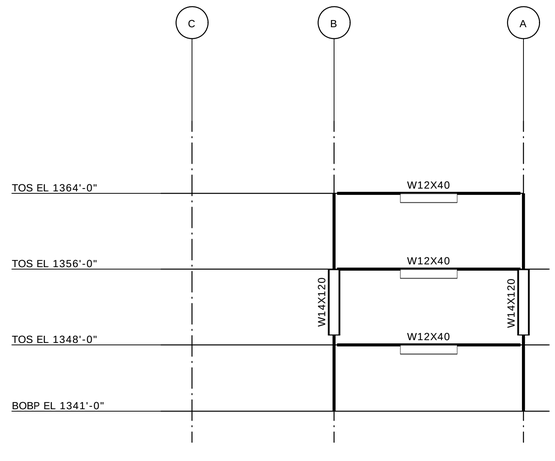
EAST ELEVATION @ COL LINE 14 THRU 22

LOOKING WEST
SCALE: 1/8 in: 1 ft



EAST ELEVATION @ COL LINE 23

LOOKING WEST
SCALE: 1/8 in: 1 ft



EAST ELEVATION @ COL LINE 23.5

LOOKING WEST
SCALE: 1/8 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	MCC	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

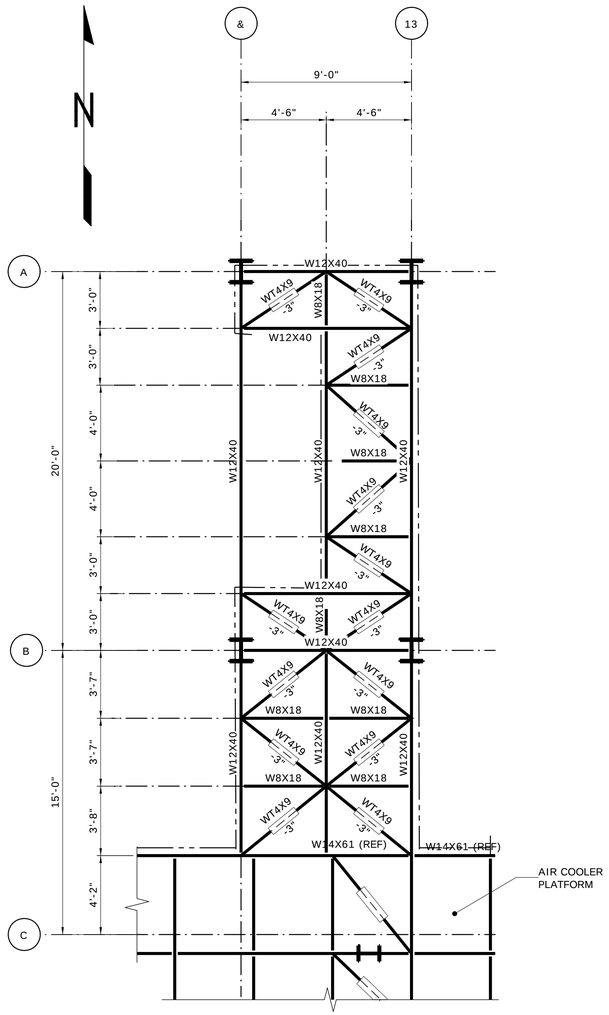
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

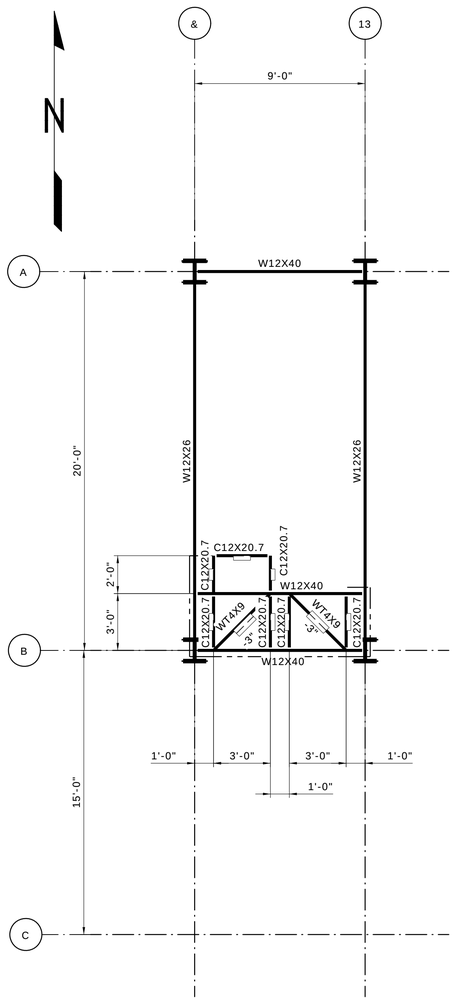
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
PLATE & FRAME EXCHANGERS STRUCTURE STEEL
EAST ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00216	1 OF 1	C	1/8"=1'-0"



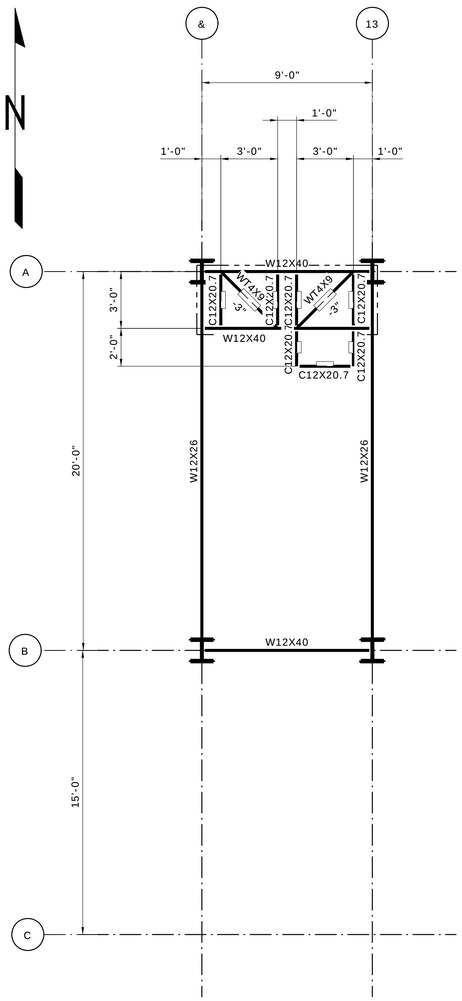
STAIR LANDING @ TOS EL 1388'-0"

SCALE: 1/4 in: 1 ft



STAIR LANDING @ TOS EL 1380'-0", TOS EL 1364'-0" & TOS EL 1348'-0"

SCALE: 1/4 in: 1 ft



STAIR LANDING @ TOS EL 1372'-0" & TOS EL 1356'-0"

SCALE: 1/4 in: 1 ft

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	MCC	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

REVISIONS

APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

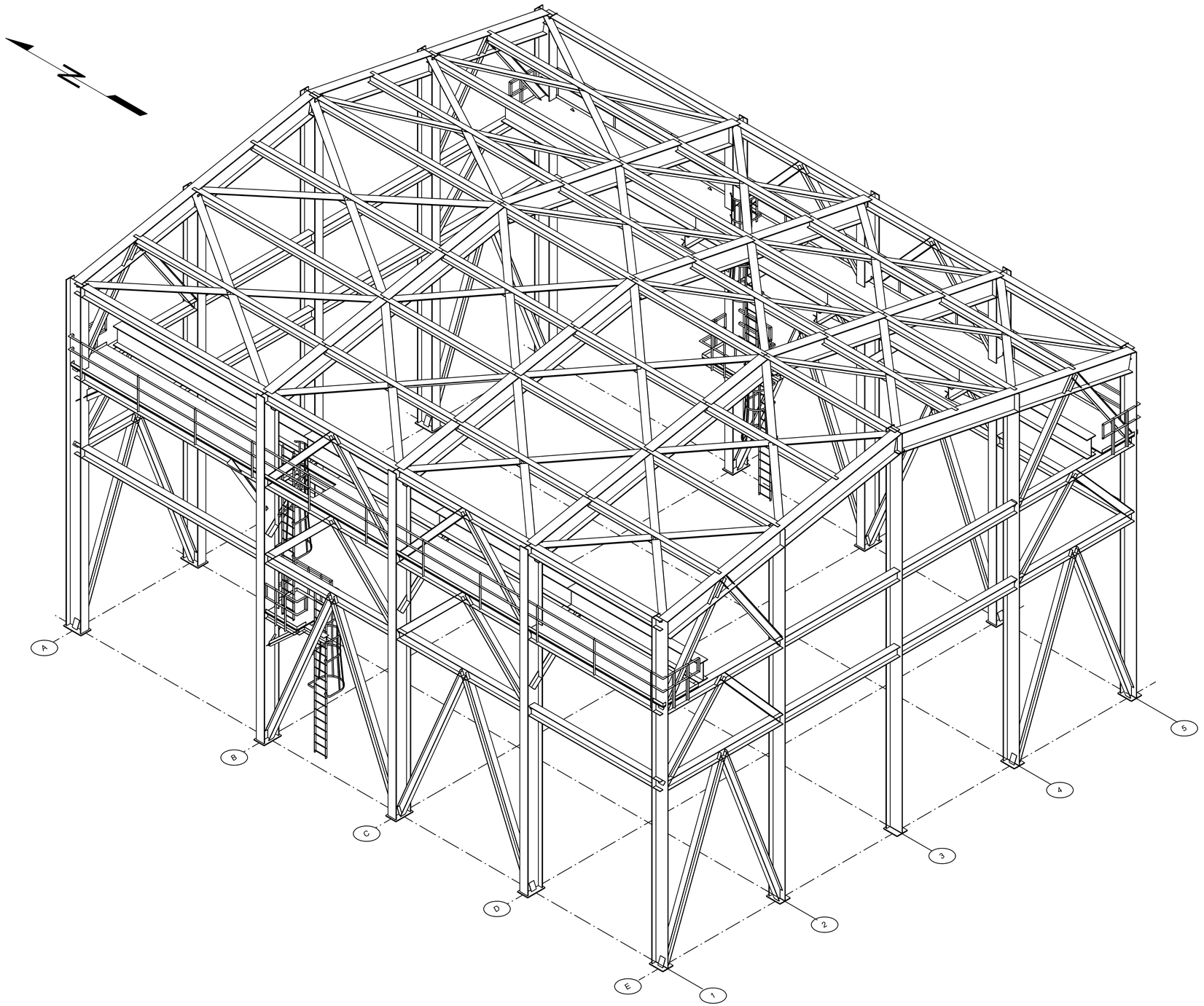
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
PLATE & FRAME EXCHANGERS STRUCTURE STEEL PLANS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00217	1 OF 1	C	1/4"=1'-0"

* QUANTITIES LISTED ARE NET

BILL OF MATERIAL

P.O. NUMBER	MK	No. REQ'D	SIZE	LENGTH	DESCRIPTION
---	---	219	TONS	---	GALVANIZED STRUCTURAL STEEL INCLUDING GUARD RAILS, LADDER AND GRATING PER SKETCH EH-35R-CCU1-SKT-215-00231 THRU 00236.



ISOMETRIC
LOOKING NORTHEAST (DOWN)
SCALE: 3/16 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

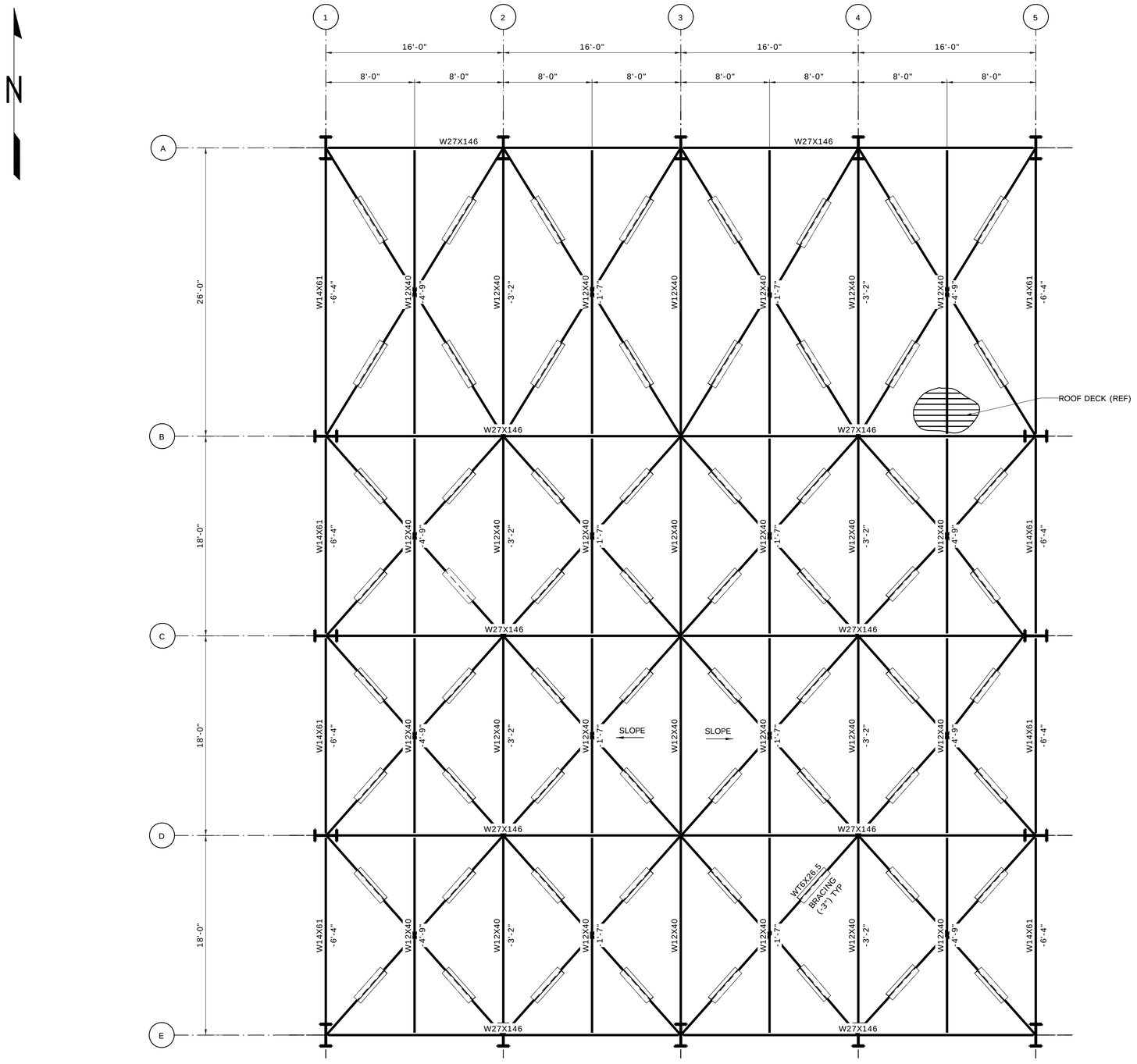
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
K-601 COMPRESSOR PLATFORM & SHELTER STEEL
ISOMETRIC

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00231	1 OF 1	C	3/16"=1'-0"



ROOF PLAN @ TOS 1388' 4" UNO

SCALE: 3/16 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

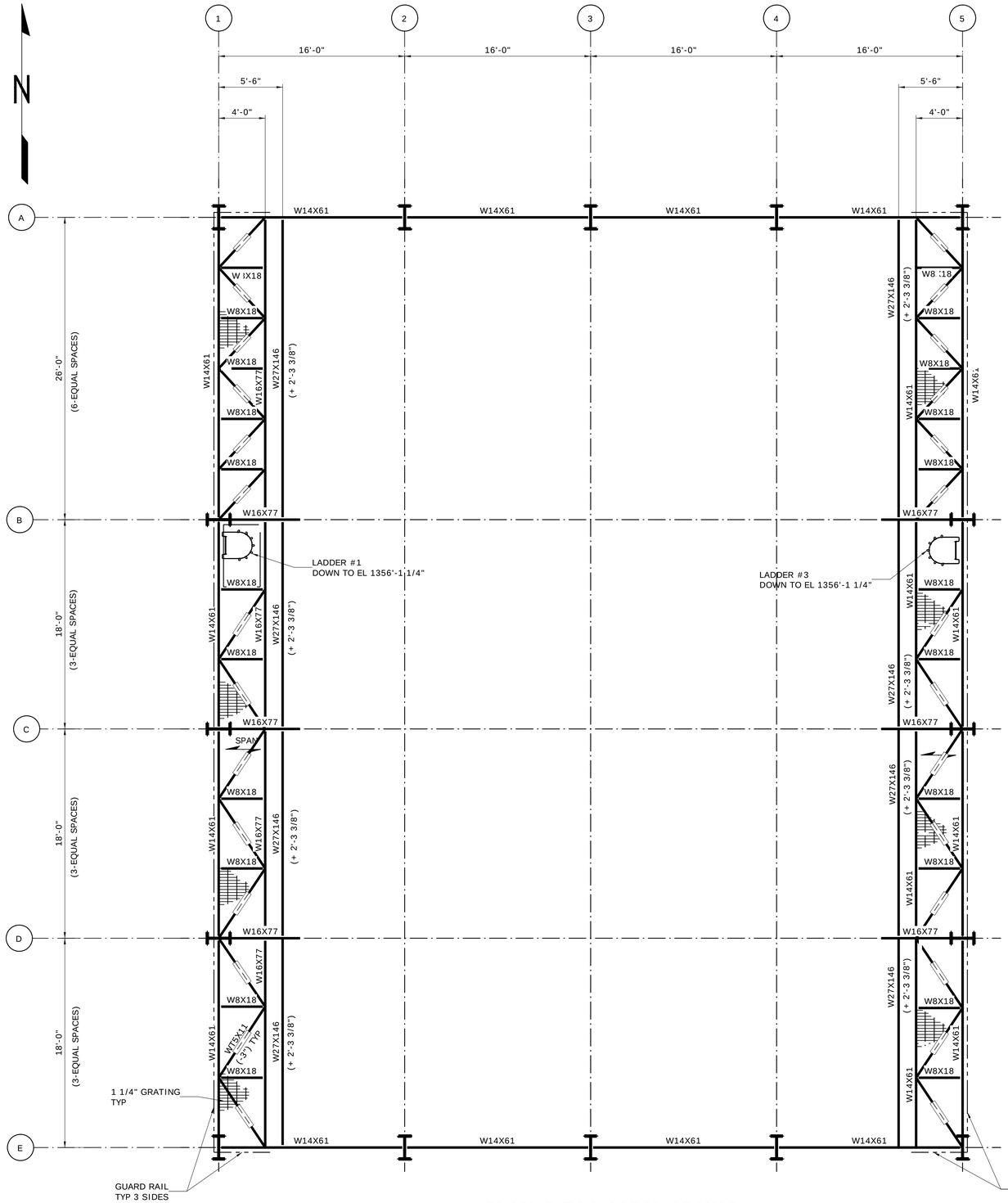
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

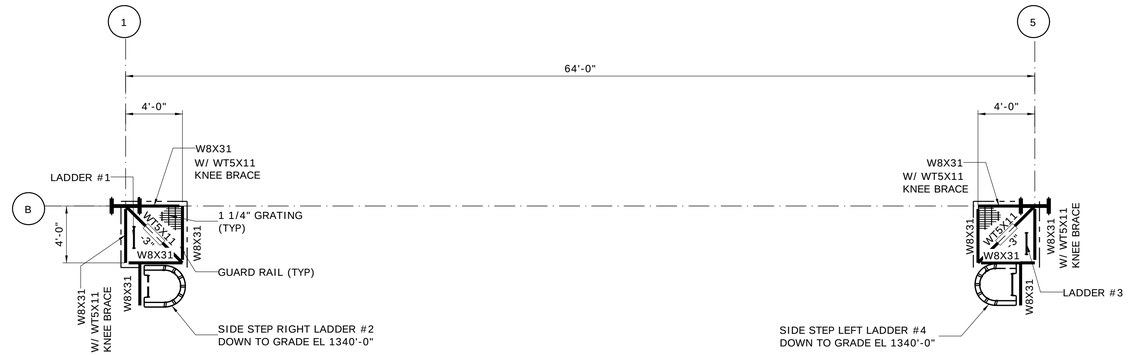
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
K-601 COMPRESSOR PLATFORM & SHELTER STEEL
PLAN @ TOS EL 1388'-4"

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00232	1 OF 1	C	3/16"=1'-0"



PLAN @ TOS 1372' 0" UNO

SCALE: 3/16 in: 1 ft



PLAN @ TOS 1356' 0"

SCALE: 3/16 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

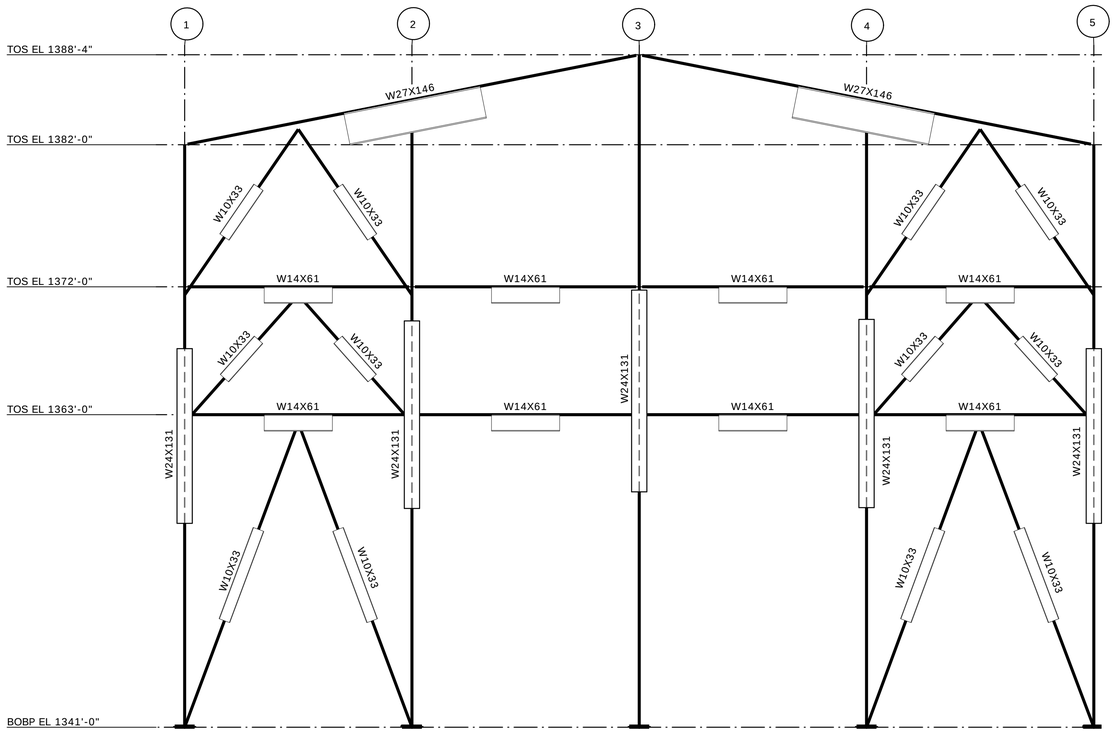
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

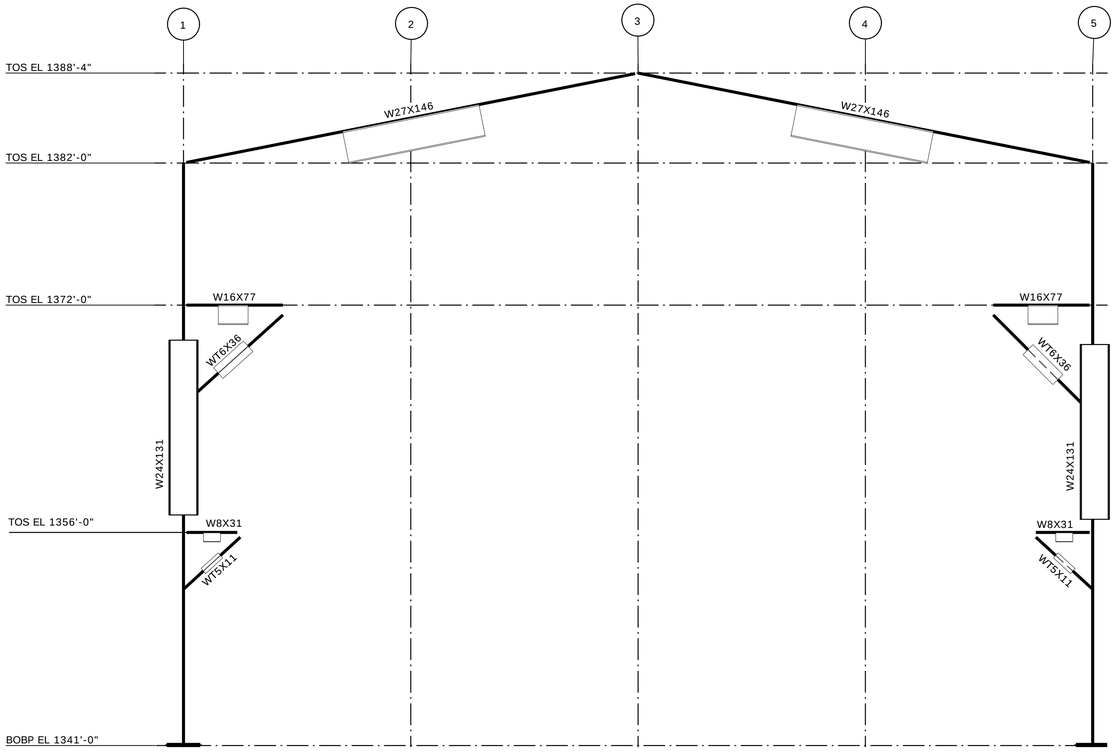
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
K-601 COMPRESSOR PLATFORM & SHELTER STEEL PLANS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00233	1 OF 1	C	3/16"=1'-0"



SOUTH ELEV AT COL LINE A & E

LOOKING NORTH
SCALE: 3/16 in: 1 ft



SOUTH ELEV AT COL LINE B, C & D

LOOKING NORTH
SCALE: 3/16 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

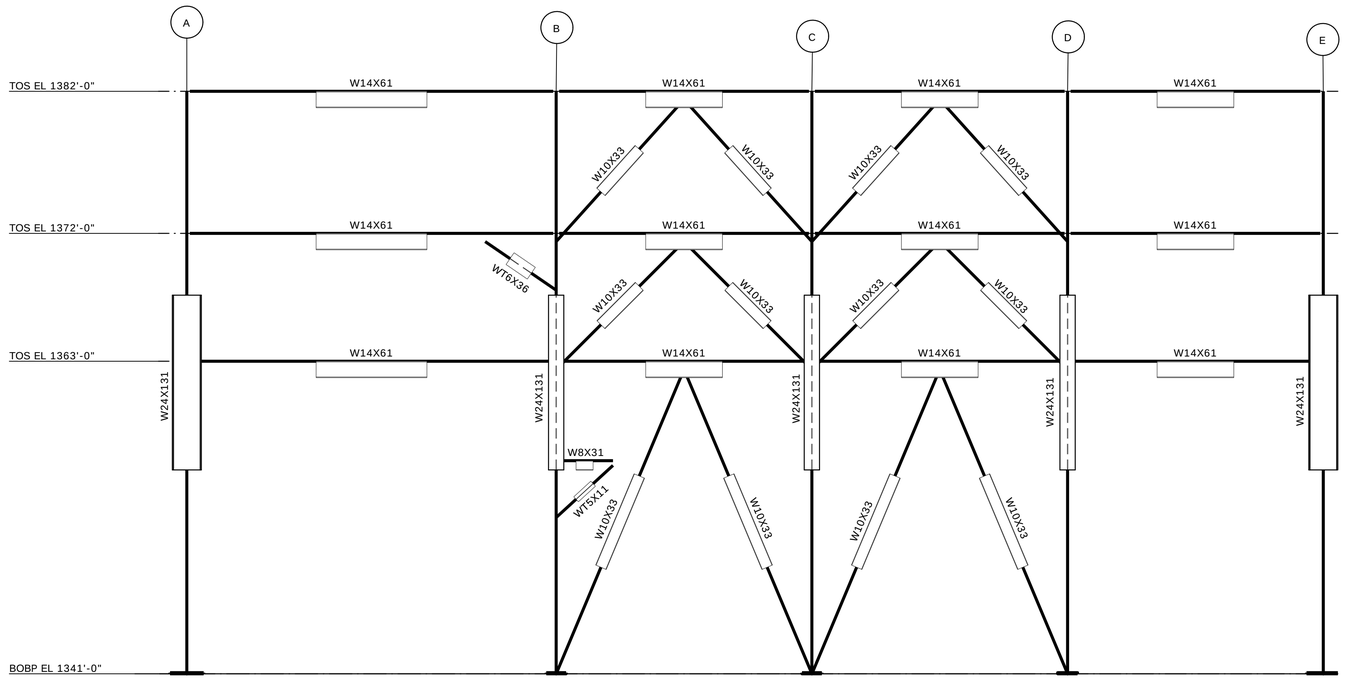
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

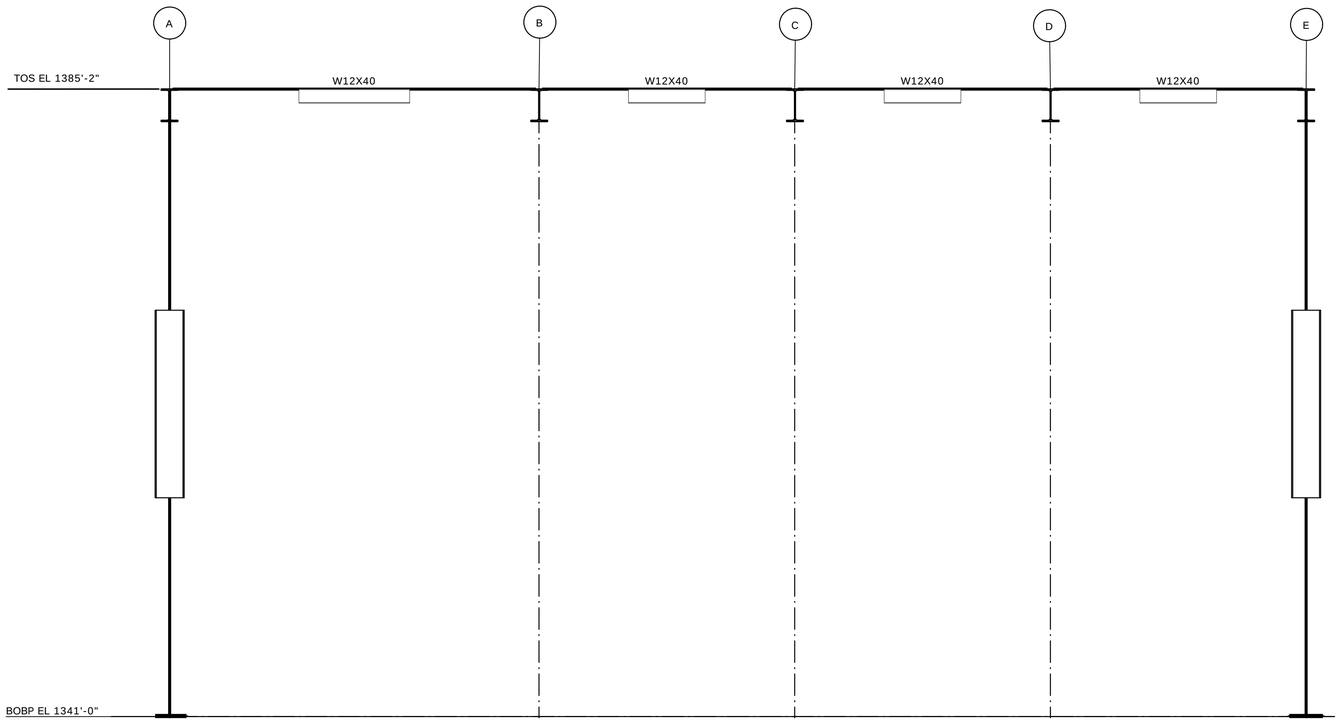
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
K-601 COMPRESSOR PLATFORM & SHELTER STEEL
SOUTH ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00234	1 OF 1	C	3/16"=1'-0"



WEST ELEV AT COL LINE 1 & 5

LOOKING EAST
SCALE: 3/16 in: 1 ft



WEST ELEV AT COL LINE 2 & 4

LOOKING EAST
SCALE: 3/16 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KB	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

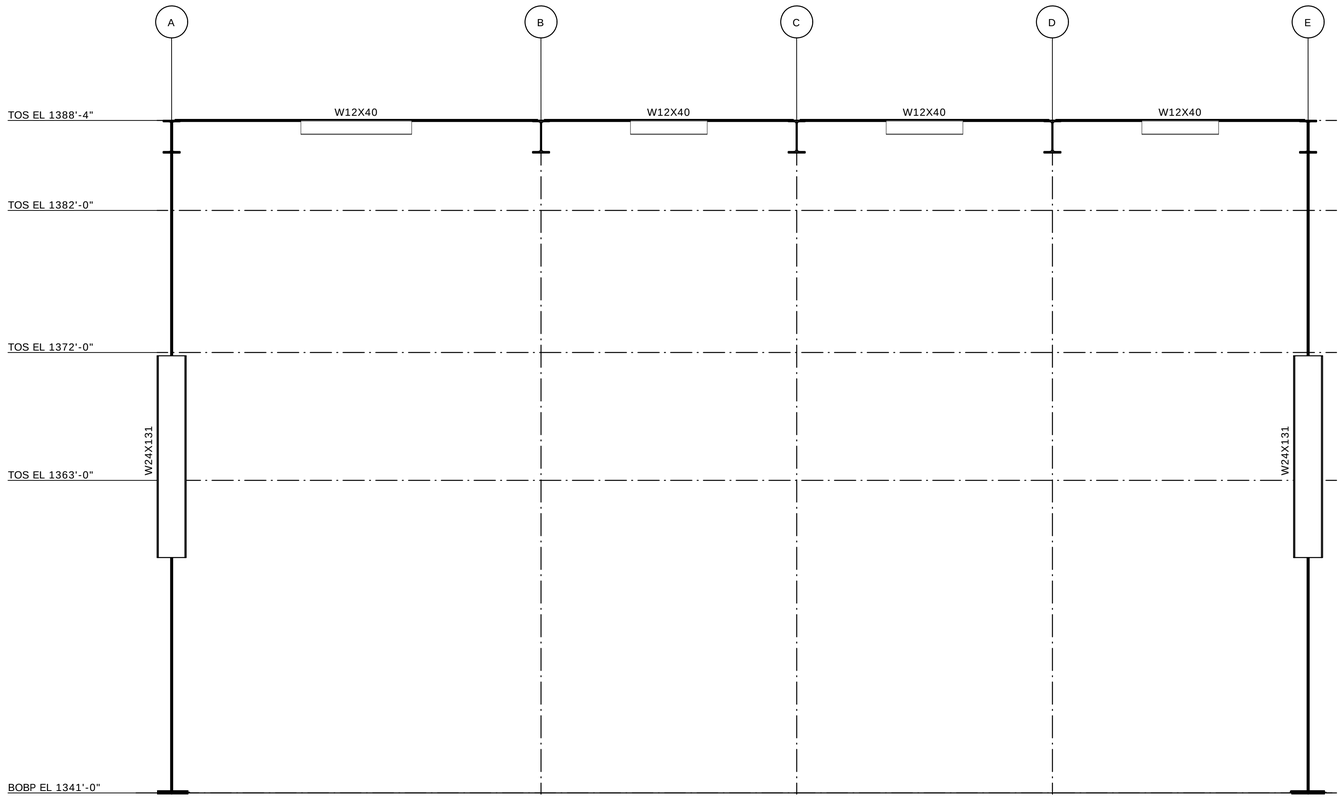
ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
K-601 COMPRESSOR PLATFORM & SHELTER STEEL
WEST ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00235	1 OF 1	C	3/16"=1'-0"

CRC



WEST ELEV AT COL LINE 3

LOOKING EAST
SCALE: 3/16 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

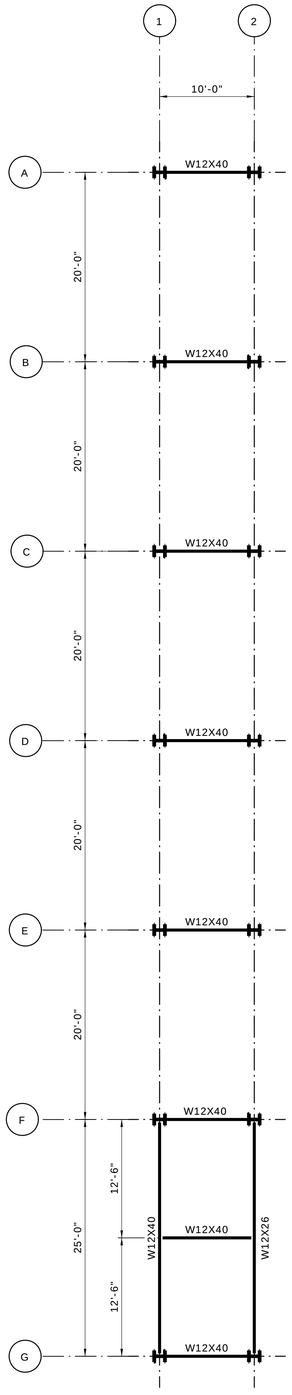
ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

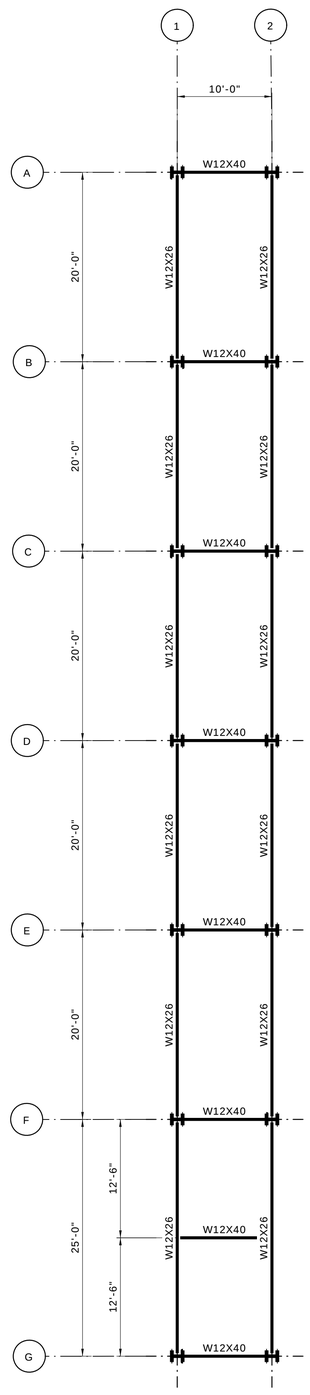
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
K-601 COMPRESSOR PLATFORM & SHELTER STEEL
WEST ELEVATION

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00236	1 OF 1	C	3/16"=1'-0"

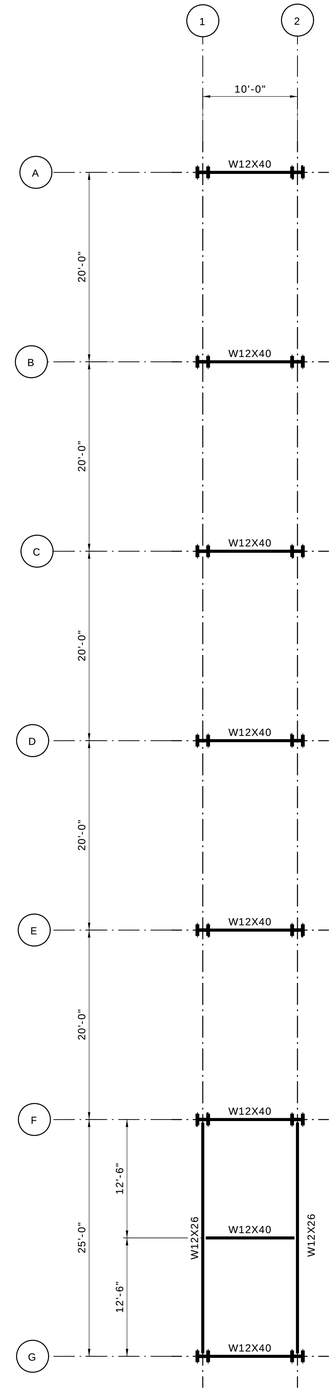
TYP ALL PLANS



PLAN @ TOS 1373' 9"
SCALE: 1/8 in: 1 ft



PLAN @ TOS 1370' 9"
SCALE: 1/8 in: 1 ft

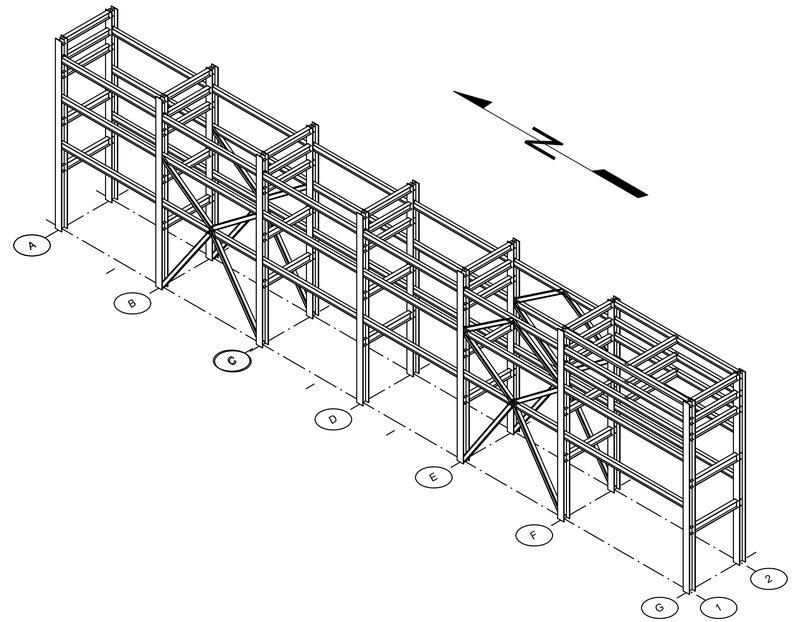


PLAN @ TOS 1368' 0"
SCALE: 1/8 in: 1 ft

* QUANTITIES LISTED ARE NET

BILL OF MATERIAL

P.O. NUMBER	MK	No. REQ'D	SIZE	LENGTH	DESCRIPTION
---	---	47	TONS	---	GALVANIZED STRUCTURAL STEEL PER SKETCH EH-35R-CCU1-SKT-215-00239 AND EH-35R-CCU1-SKT-215-00240



ISOMETRIC
LOOKING NORTHEAST (DOWN)
SCALE: 3/32 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

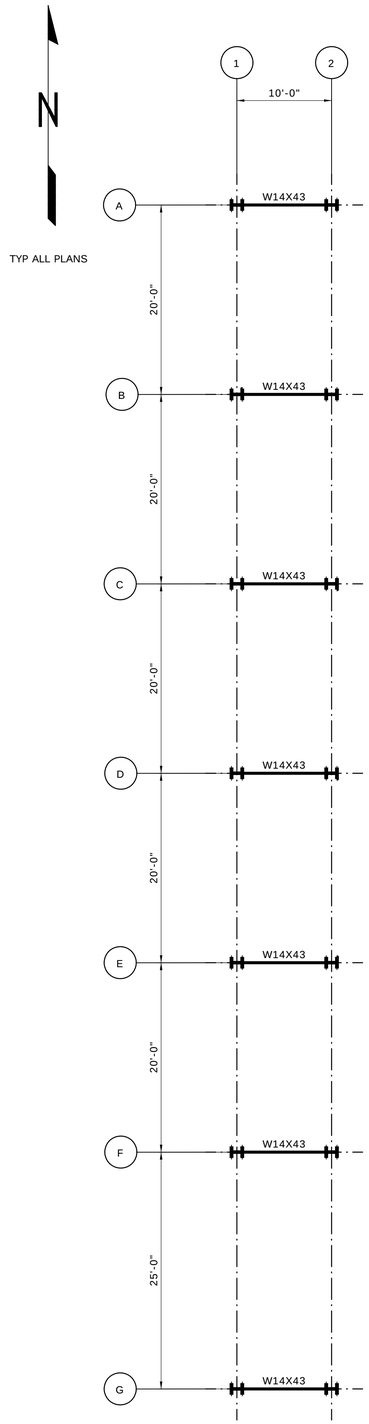
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

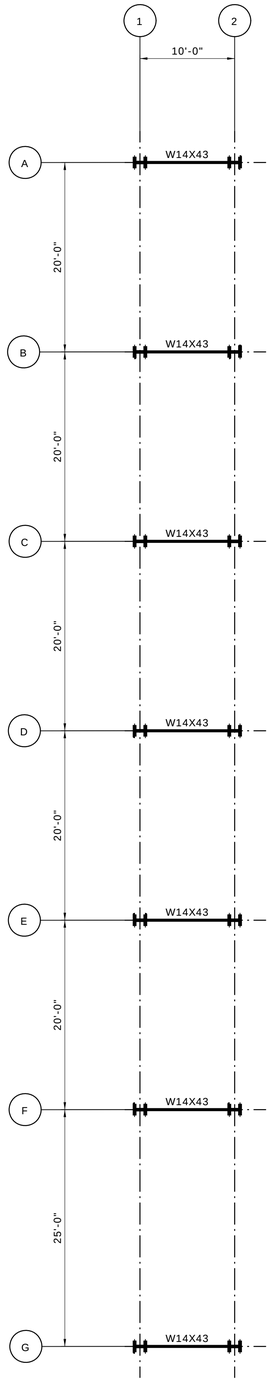
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
NORTH-SOUTH FINGER PIPERACK STEEL
ISOMETRIC & PLANS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00239	1 OF 1	C	AS NOTED



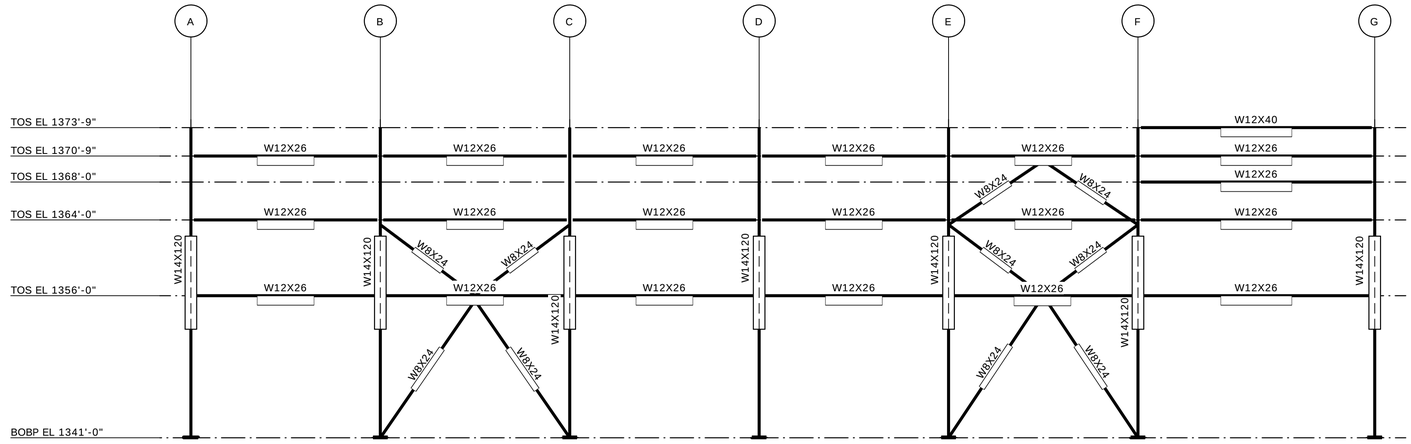
PLAN @ TOS 1360' 0"

SCALE: 1/8 in: 1 ft



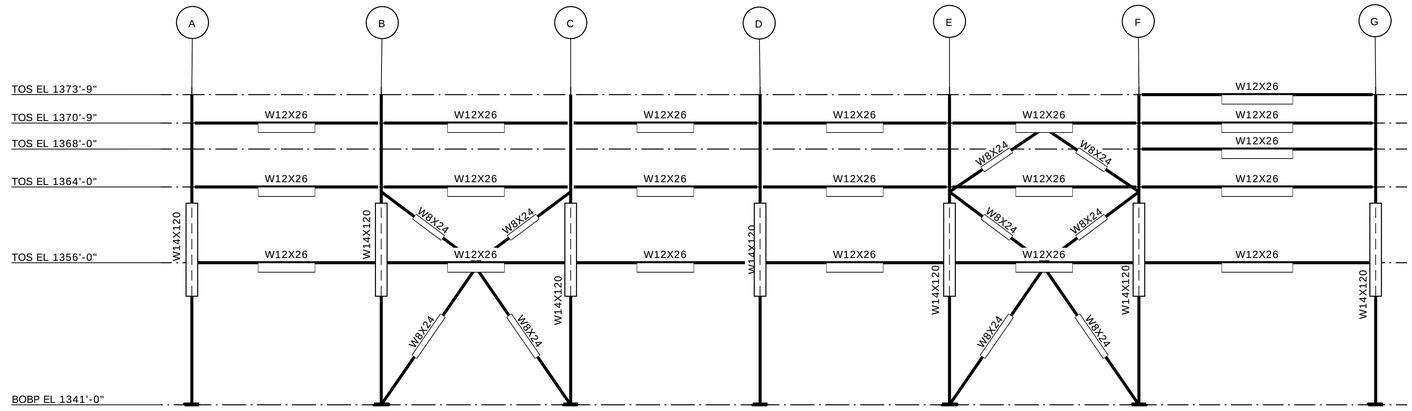
PLAN @ TOS 1352' 0"

SCALE: 1/8 in: 1 ft



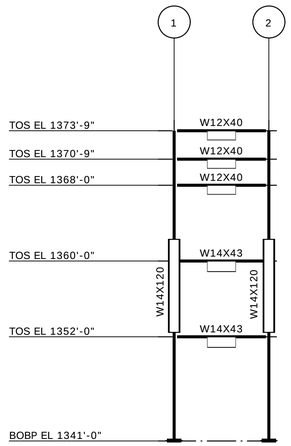
WEST ELEVATION AT COLUMN LINE 1

LOOKING EAST
SCALE: 1/8 in: 1 ft



WEST ELEVATION AT COLUMN LINE 2

LOOKING EAST
SCALE: 1/8 in: 1 ft



SOUTH ELEVATION AT COL LINES A THRU G

LOOKING NORTH
SCALE: 1/8 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	1/07/20	KD	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
NORTH-SOUTH FINGER PIPERACK STEEL
PLANS & ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00240	1 OF 1	C	1/8"=1'-0"

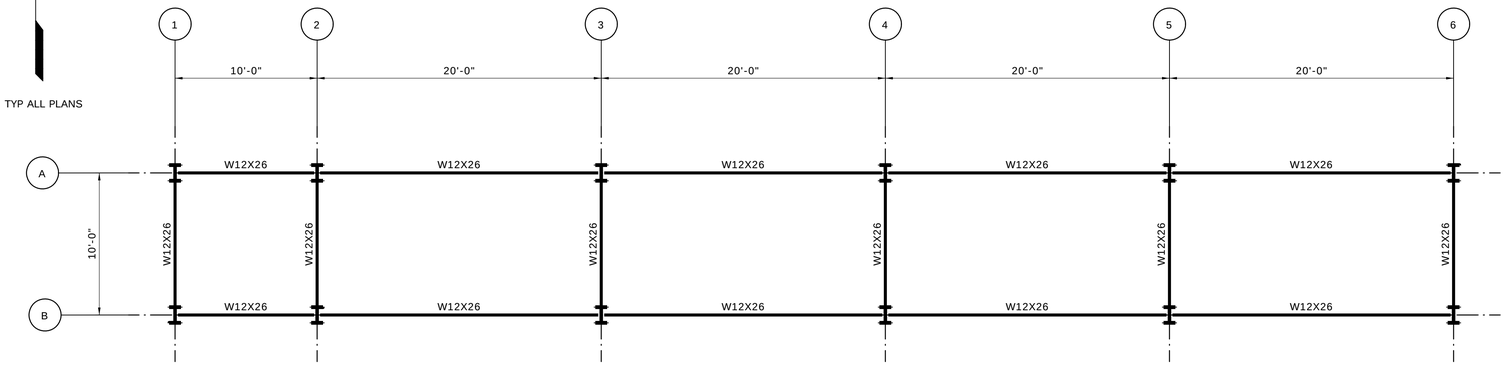
* QUANTITIES LISTED ARE NET

BILL OF MATERIAL

P.O. NUMBER	MK	No. REQ'D	SIZE	LENGTH	DESCRIPTION
---	---	23	TONS	---	GALVANIZED STRUCTURAL STEEL PER SKETCH EH-35R-CCU1-SKT-215-00241 AND EH-35R-CCU1-SKT-215-00242.

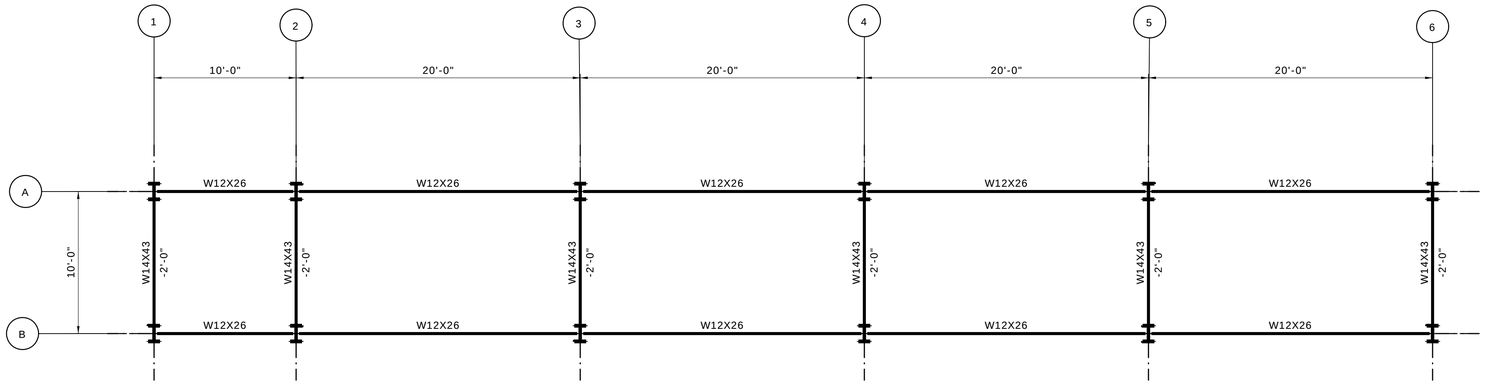
N

TYP ALL PLANS



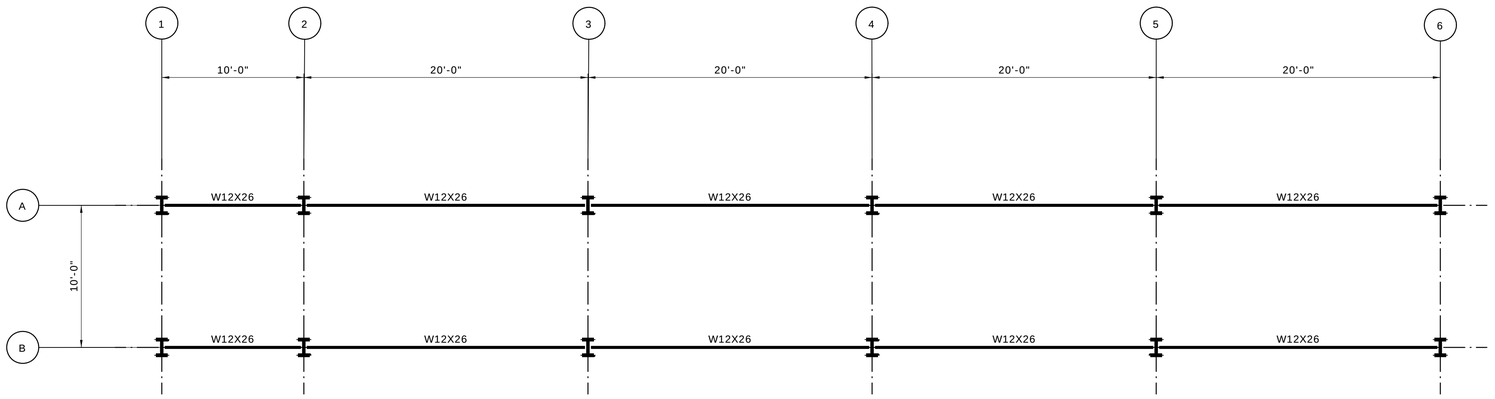
PLAN @ TOS 1364' 0"

SCALE: 3/16 in: 1 ft



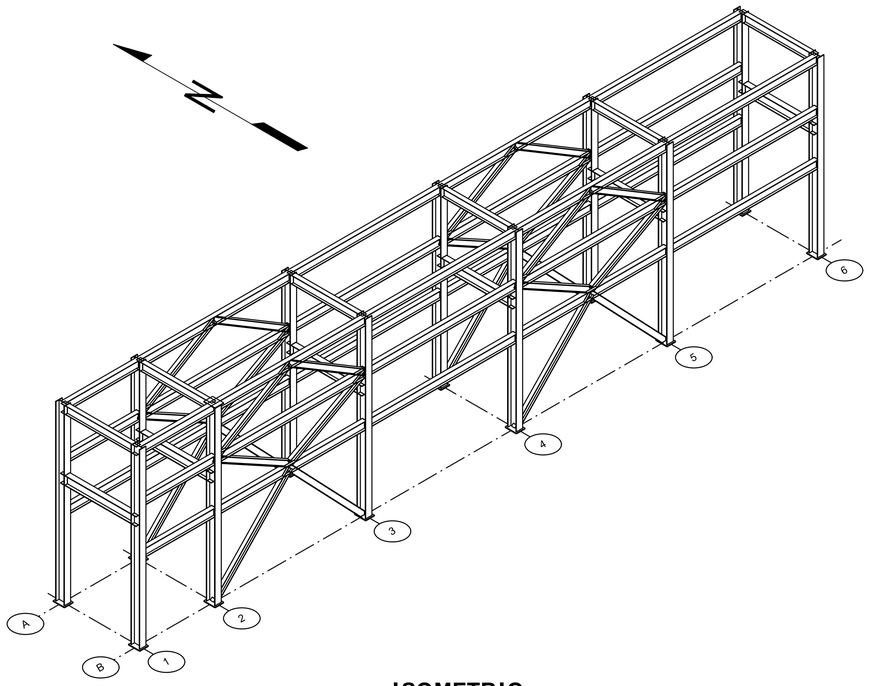
PLAN @ TOS 1358' 0"

SCALE: 3/16 in: 1 ft



PLAN @ TOS 1352' 0"

SCALE: 3/16 in: 1 ft



ISOMETRIC

LOOKING NORTHEAST (DOWN)
SCALE: Fit To Scale

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD KD	TY TY	WA WA	NP APP	WA WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

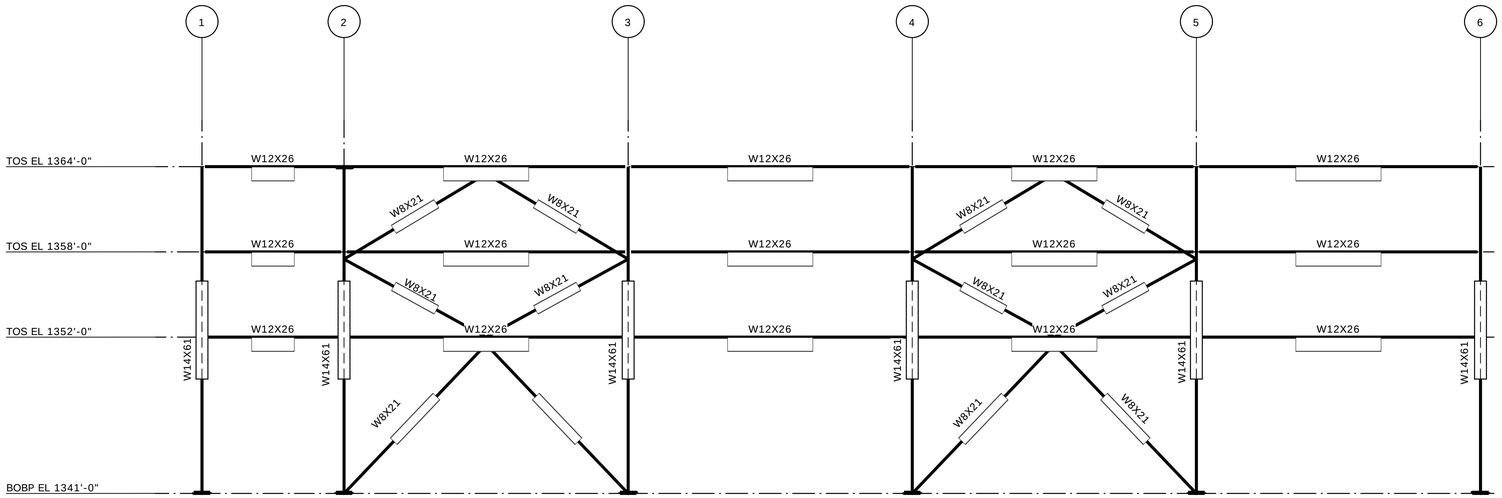
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

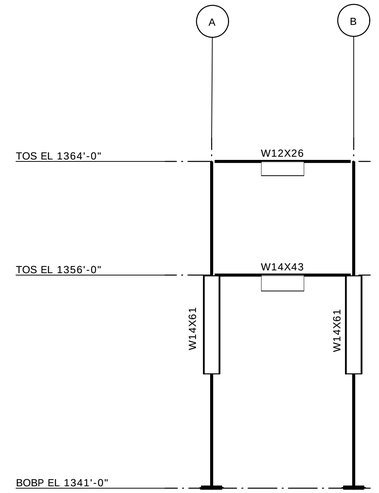
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
EAST-WEST FINGER PIPERACK STEEL
ISOMETRIC & PLANS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00241	1 OF 1	C	AS NOTED



SOUTH ELEVATION AT COLUMN LINES A & B

LOOKING NORTH
SCALE: 3/16 in: 1 ft



WEST ELEVATION AT COL LINES 1 THRU 6

LOOKING EAST
SCALE: 3/16 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

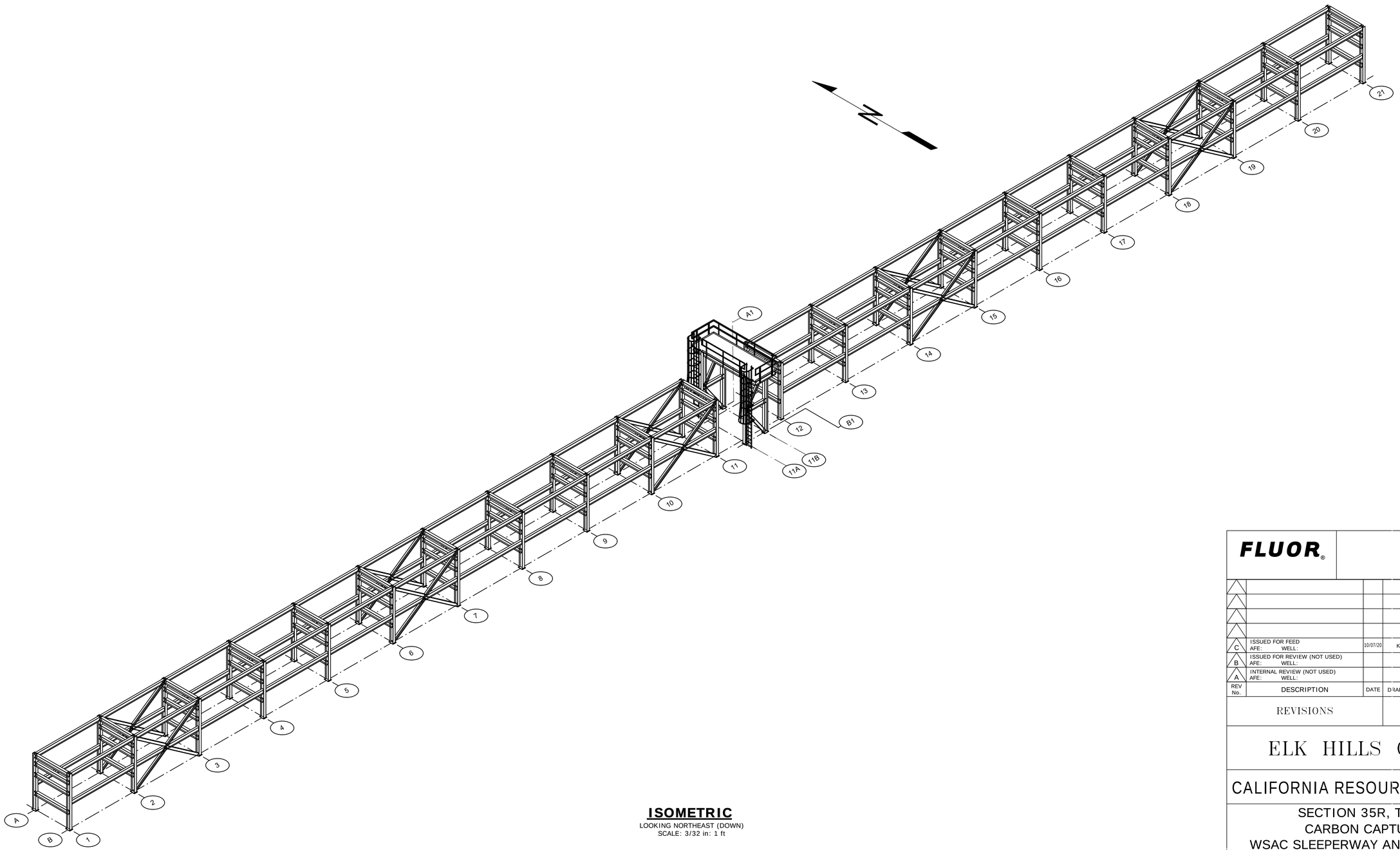
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
EAST-WEST FINGER PIPERACK STEEL
ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00242	1 OF 1	C	3/16"=1'-0"

* QUANTITIES LISTED ARE NET

BILL OF MATERIAL

P.O. NUMBER	MK	No. REQ'D	SIZE	LENGTH	DESCRIPTION
---	---	89	TONS	---	GALVANIZED STRUCTURAL STEEL INCLUDING GUARD RAILS, LADDERS AND GRATING PER SKETCH EH-35R-CCU1-SKT-215-00243 THRU 00246.



ISOMETRIC
LOOKING NORTHEAST (DOWN)
SCALE: 3/32 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

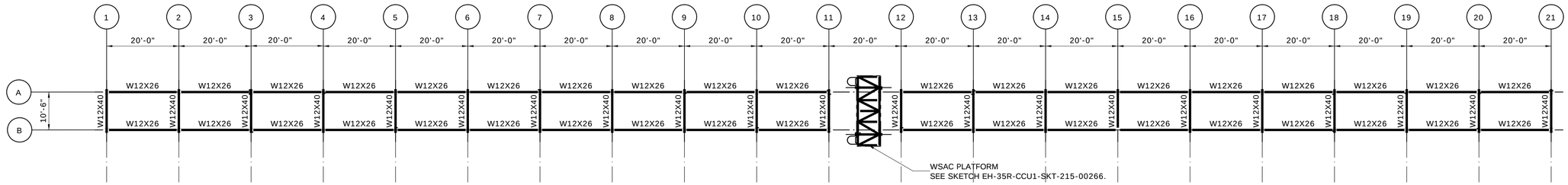
ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
WSAC SLEEPERWAY AND PLATFORM STEEL
ISOMETRIC

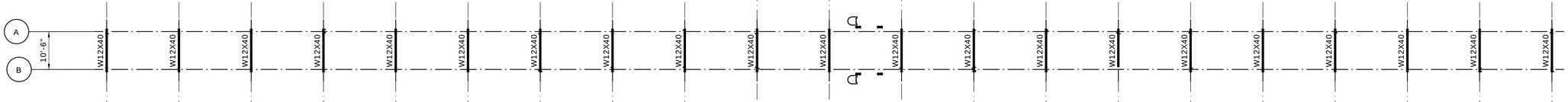
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00243	1 OF 1	C	3/32"=1'-0"

TYP ALL PLANS



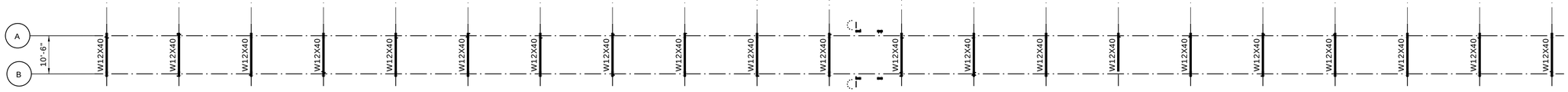
PLAN @ TOS 1356' 0"

SCALE: 1/16 in: 1 ft



PLAN @ TOS 1353' 11"

SCALE: 1/16 in: 1 ft



PLAN @ TOS 1351' 0"

SCALE: 1/16 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

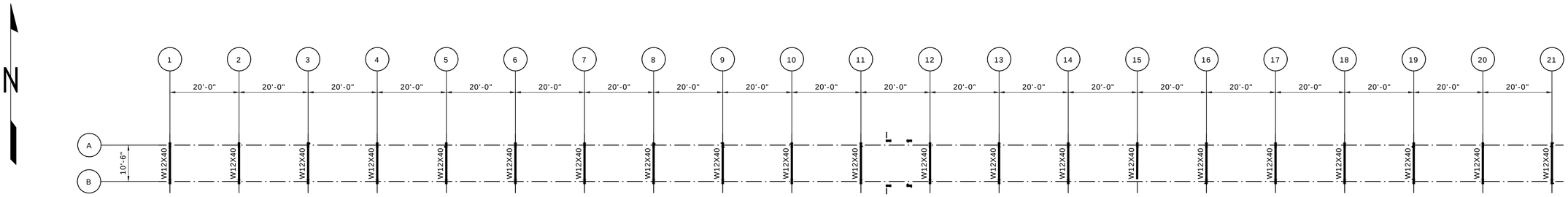
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

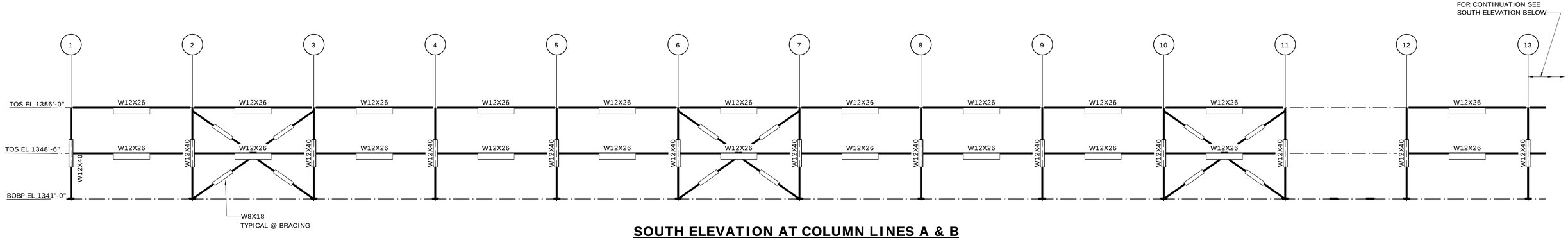
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
WSAC SLEEPERWAY AND PLATFORM STEEL PLANS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00244	1 OF 1	C	1/16"=1'-0"



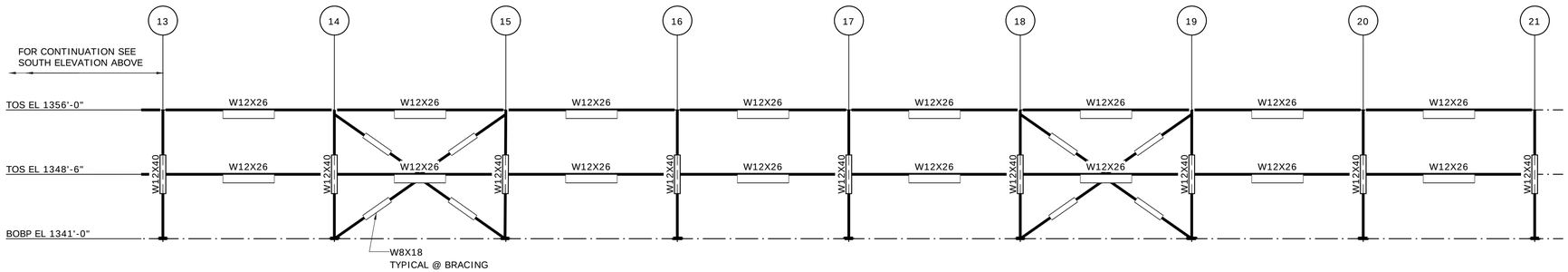
PLAN @ TOS 1346' 0"

SCALE: 1/16 in: 1 ft



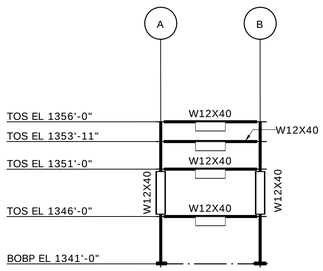
SOUTH ELEVATION AT COLUMN LINES A & B

LOOKING NORTH
SCALE: 1/8 in: 1 ft



SOUTH ELEVATION AT COLUMN LINES A & B (CONTINUATION)

LOOKING NORTH
SCALE: 1/8 in: 1 ft



WEST ELEVATION AT COL LINES 1 THRU 21

LOOKING EAST
SCALE: 1/8 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

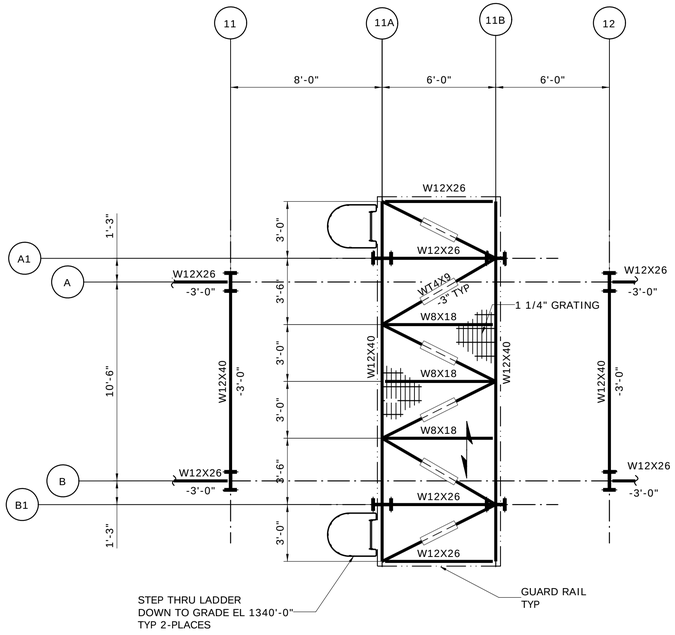
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

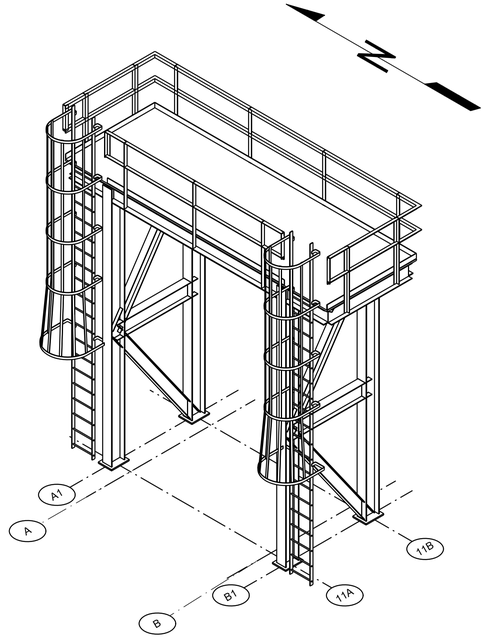
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
WSAC SLEEPERWAYAND PLATFORM STEEL
PLAN & ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00245	1 OF 1	C	AS NOTED



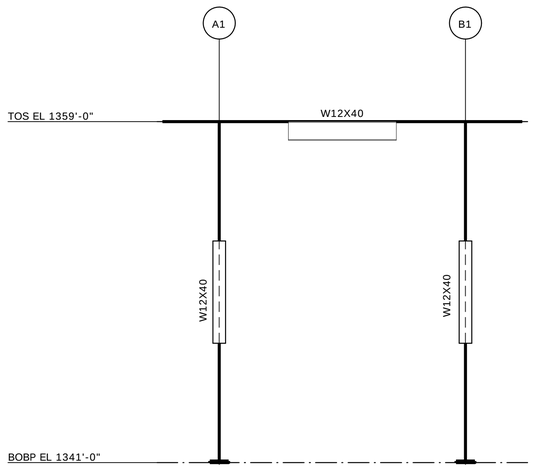
PLAN @ TOS 1359' 0"

SCALE: 1/4 in: 1 ft



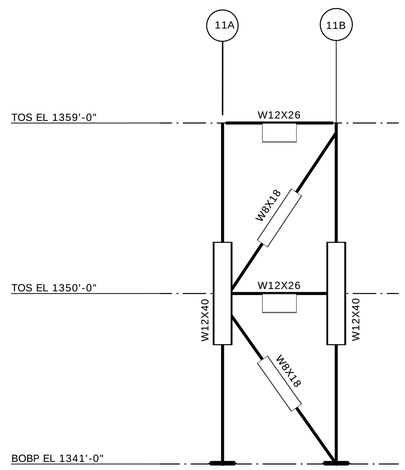
ISOMETRIC

LOOKING NORTHEAST (DOWN)
SCALE: 1/4 in: 1 ft



WEST ELEVATION AT COLUMN LINES 11A & 11B

LOOKING EAST
SCALE: 1/4 in: 1 ft



SOUTH ELEVATION AT COLUMN LINES A1 & B1

LOOKING NORTH
SCALE: 1/4 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

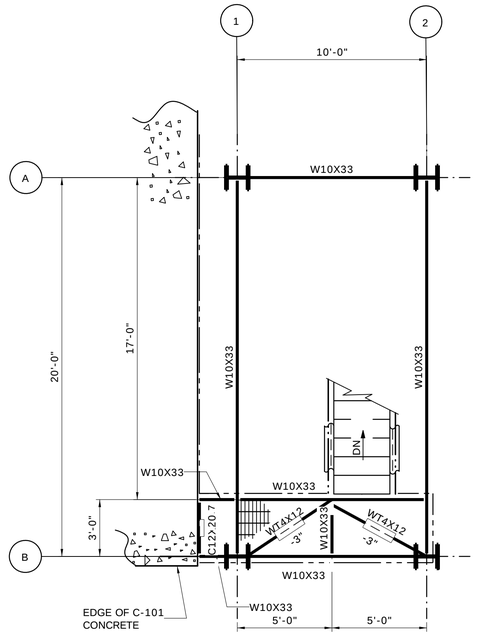
CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
WSAC SLEEPERWAY AND PLATFORM STEEL
ISOMETRIC, PLAN & ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00246	1 OF 1	C	AS NOTED

CRC

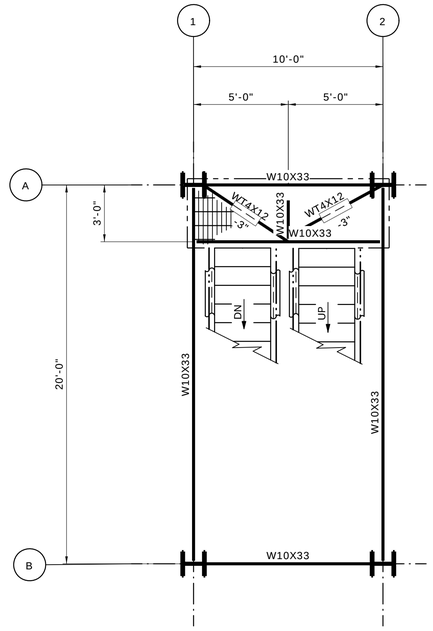
TYP ALL PLANS



PLAN @ TOS 1369' 10 3/4"

SCALE: 1/4 in: 1 ft

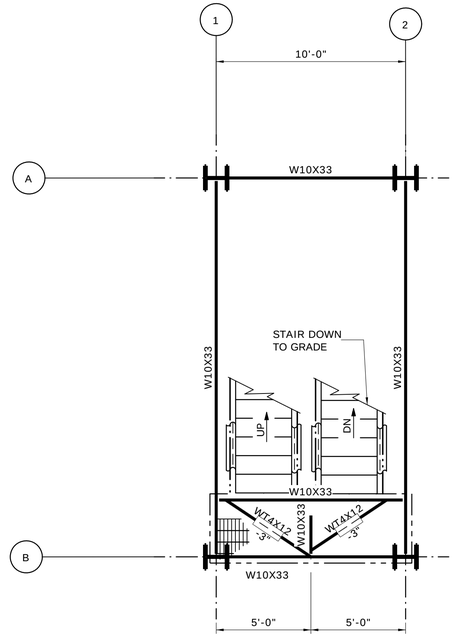
TOP OF PLATFORM EL 1370'-0"



PLAN @ TOS 1360' 0"

SCALE: 1/4 in: 1 ft

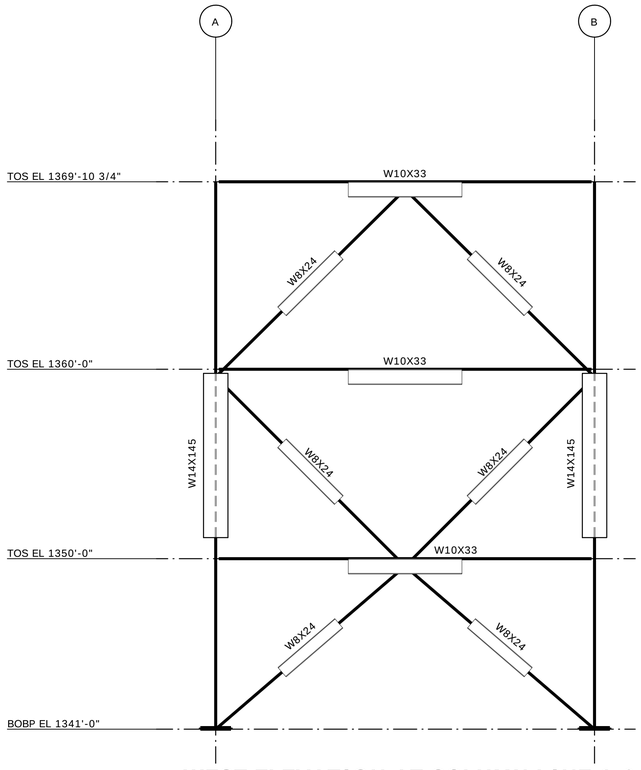
TOP OF PLATFORM EL 1360'-1 1/4"



PLAN @ TOS 1350' 0"

SCALE: 1/4 in: 1 ft

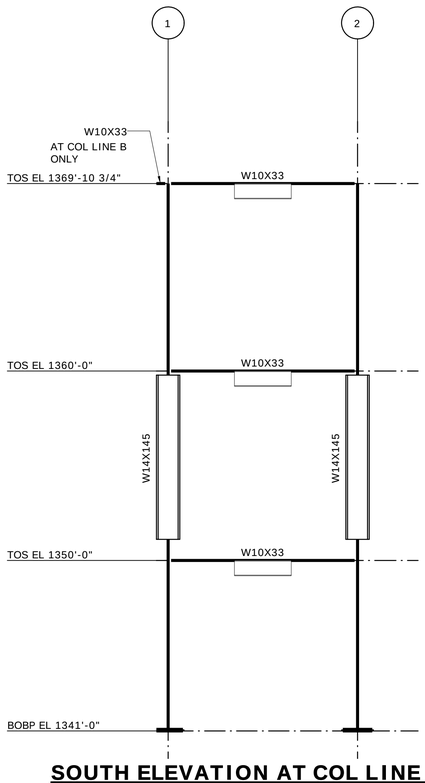
TOP OF PLATFORM EL 1350'-1 1/4"



WEST ELEVATION AT COLUMN LINE 1 & 2

LOOKING EAST

SCALE: 1/4 in: 1 ft



SOUTH ELEVATION AT COL LINE A & B

LOOKING NORTH

SCALE: 1/4 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

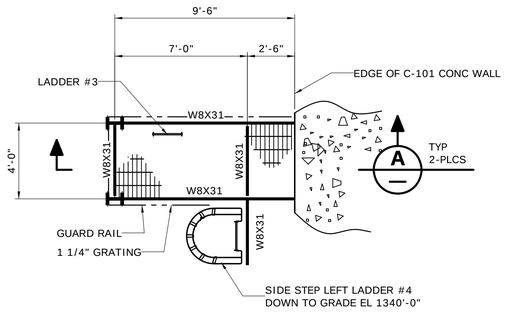
CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
C-101 DCC STAIR, LADDERS & STEEL
PLANS & ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00248	1 OF 1	C	1/4"=1'-0"

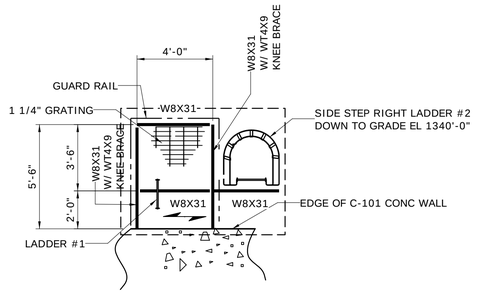
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TYPICAL ALL PLANS



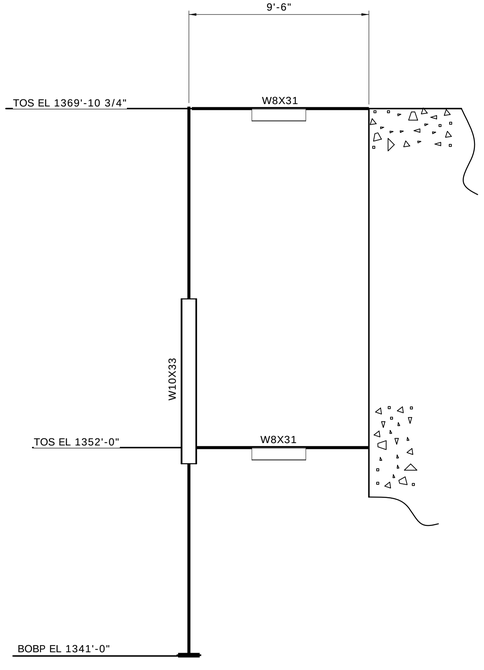
PLAN @ TOS 1352' 0"

SCALE: 1/4 in: 1 ft



PLAN @ TOS 1360' 0"

SCALE: 1/4 in: 1 ft



SECTION A

SCALE = 1/4" = 1'-0"

EH-35R-CCU1-SKT-215-00247 & 00249

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

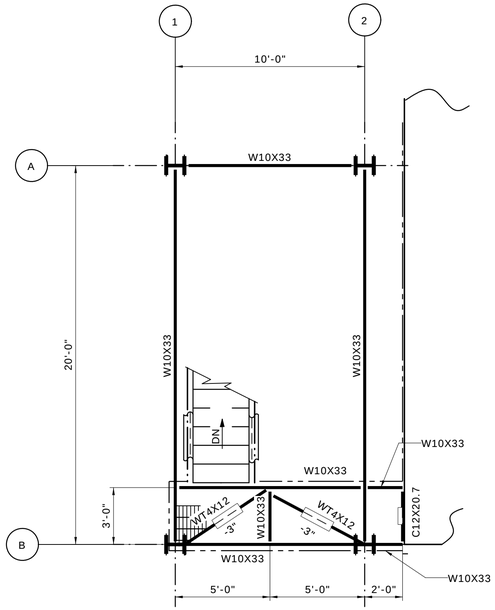
CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
C-101 DCC STAIR, LADDERS & STEEL
PLANS & SECTION

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00249	1 OF 1	C	1/4"=1'-0"

CRC

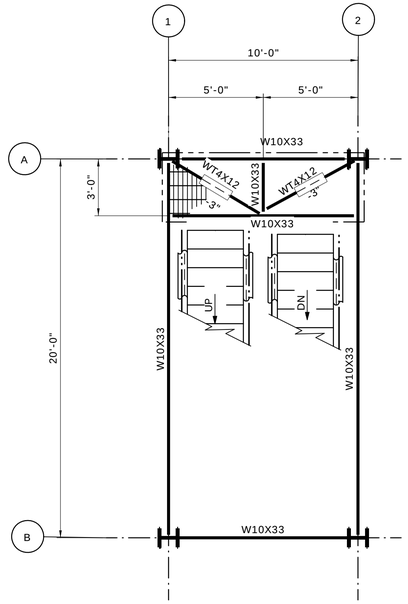
TYP ALL PLANS



PLAN @ TOS 1369' 4 3/4"

SCALE: 1/4 in: 1 ft

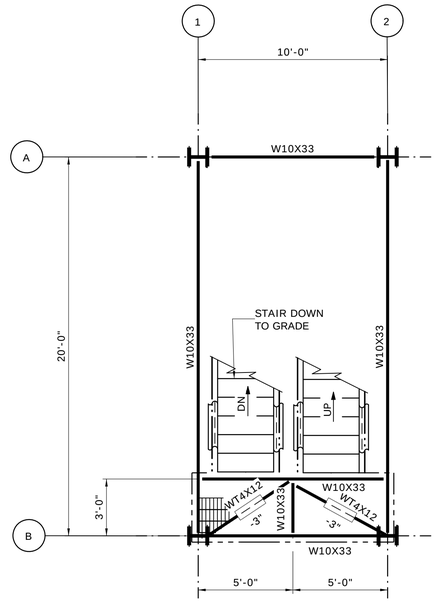
TOP OF PLATFORM EL 1369'-6"



PLAN @ TOS 1360' 0"

SCALE: 1/4 in: 1 ft

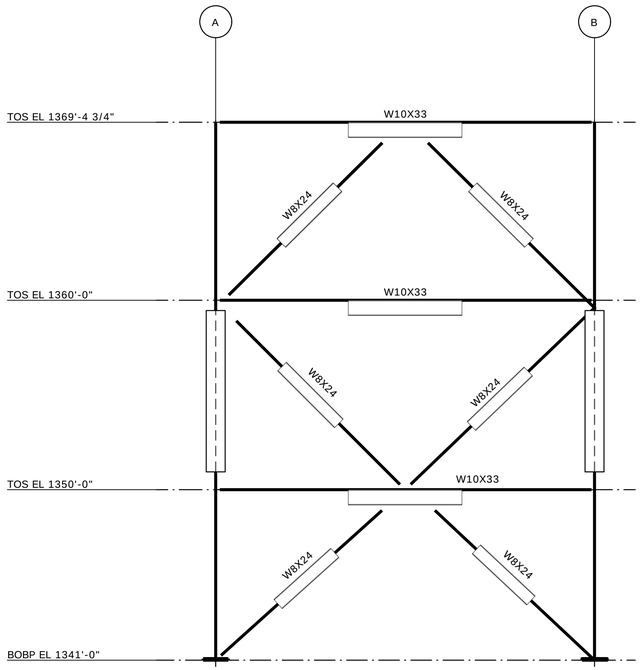
TOP OF PLATFORM EL 1360'-1 1/4"



PLAN @ TOS 1350' 0"

SCALE: 1/4 in: 1 ft

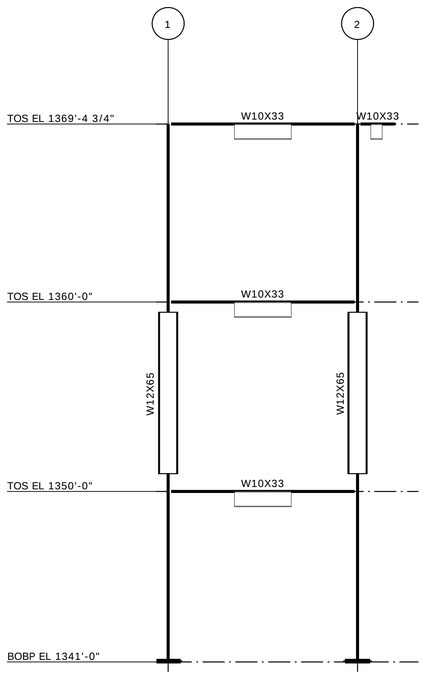
TOP OF PLATFORM EL 1350'-1 1/4"



WEST ELEVATION AT COLUMN LINE 1 & 2

LOOKING EAST

SCALE: 1/4 in: 1 ft



SOUTH ELEVATION AT COL LINE A & B

LOOKING NORTH

SCALE: 1/4 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

REVISIONS APPROVALS

ELK HILLS OPERATION

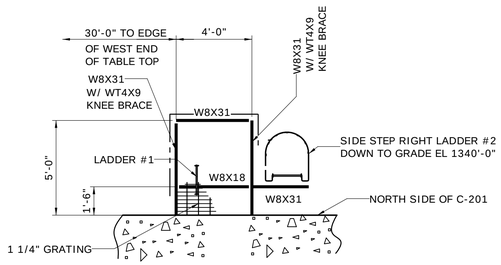
CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
C-201 ABSORBER STAIR, LADDERS & STEEL
PLANS & ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00251	1 OF 1	C	1/4"=1'-0"

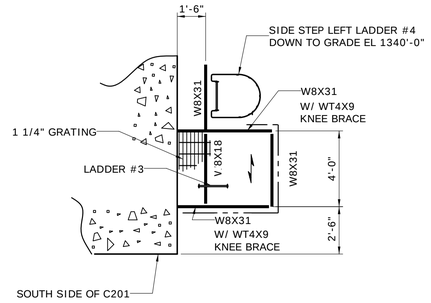
N

TYP ALL PLANS



PLAN @ TOS 1354' 0"

SCALE: 1/4 in: 1 ft



PLAN @ TOS 1360' 0"

SCALE: 1/4 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	KD	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
C-201 ABSORBER STAIR, LADDERS & STEEL PLANS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00252	1 OF 1	C	1/4"=1'-0"

CRC

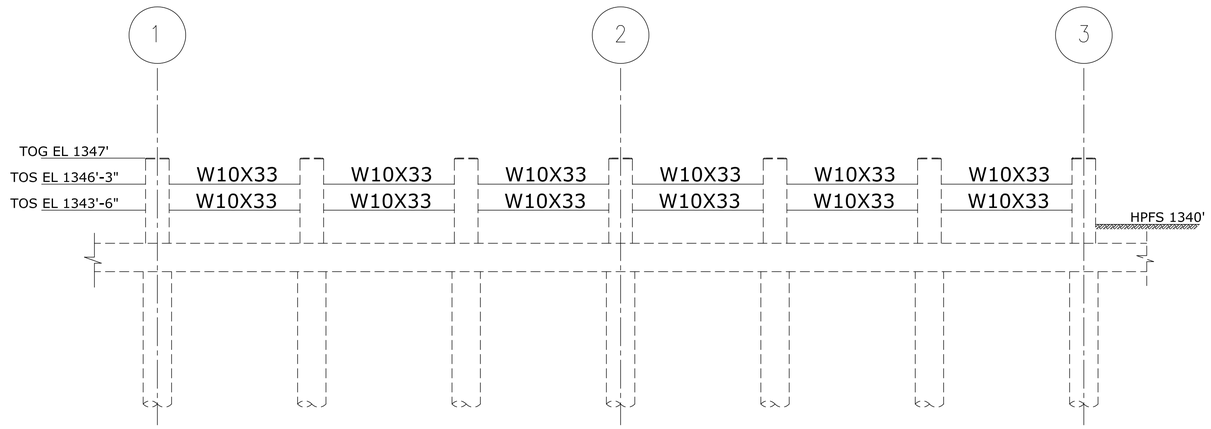


BILL OF MATERIAL

*SEE SPECIFICATIONS

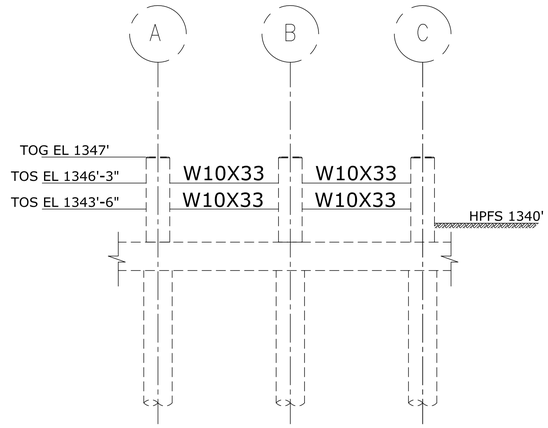
QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO. REQD	SIZE	LENGTH	DESCRIPTION
——	——	18.27	TON	——	TOTAL STEEL PER THIS SKETCH



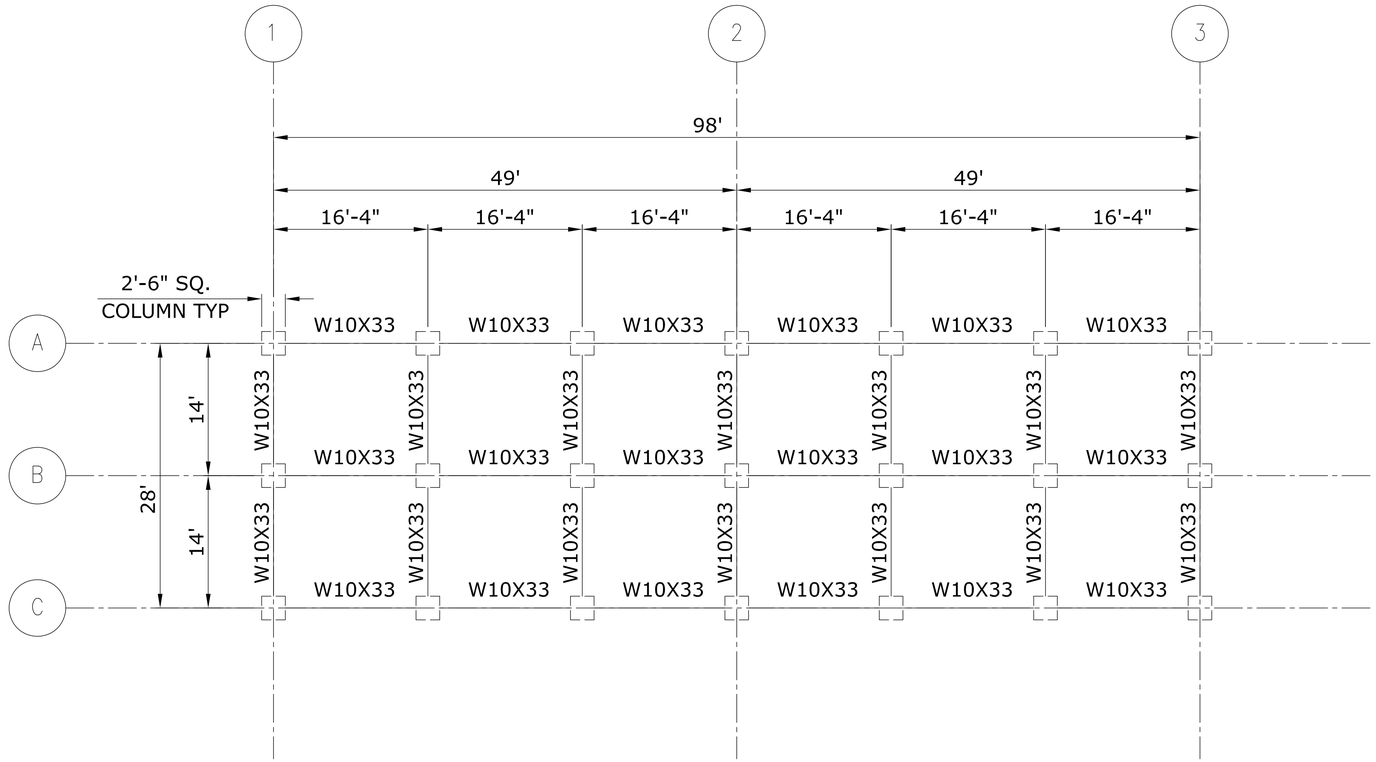
ELEVATION @ COLUMN A/B/C

SCALE: 1/8" = 1'-0"



ELEVATION @ NS DIRECTION

SCALE: 1/8" = 1'-0"



PLAN TOS 1343'-6" & 1346'-3"

SCALE: 1/8" = 1'-0"

FLUOR

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	TY	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

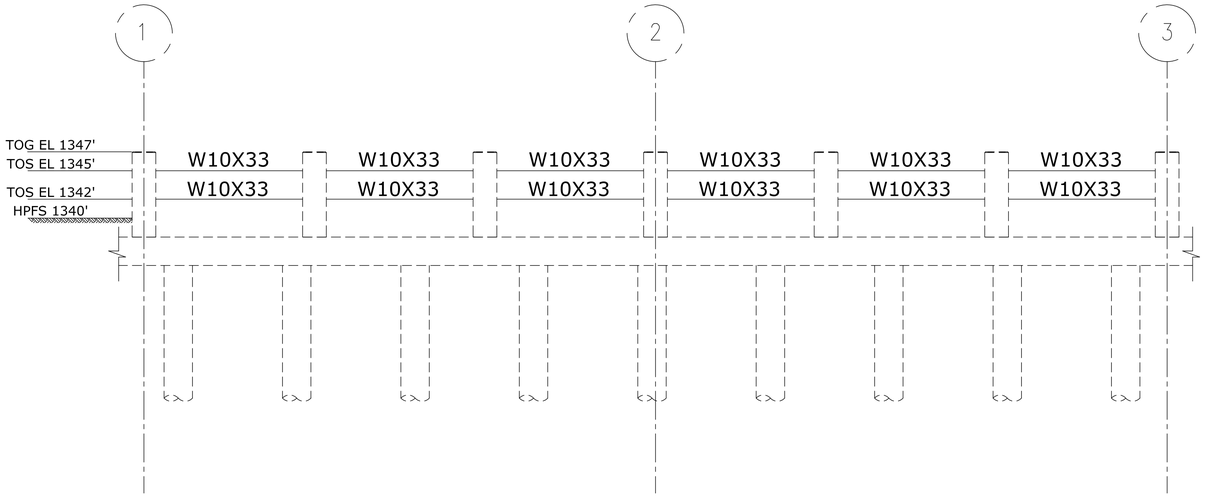
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
AUXILIARY POWER CENTER (APC) STEEL
PLAN AND ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00253	1 OF 1	C	1/8"=1'-0"

BILL OF MATERIAL

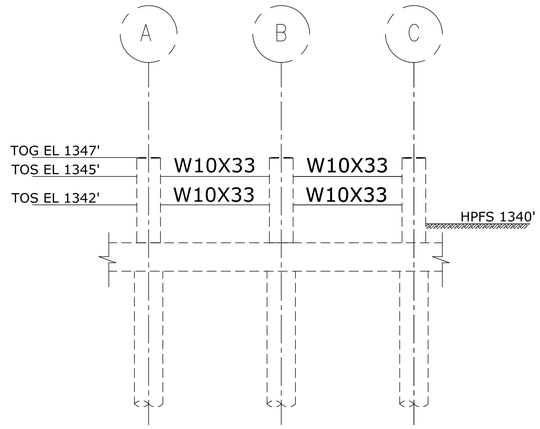
*SEE SPECIFICATIONS — QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO. REQD	SIZE	LENGTH	DESCRIPTION
——	——	19.4	TON	——	TOTAL STEEL PER SKETCHES EH-35R-CCU1-SKT-215-00156.



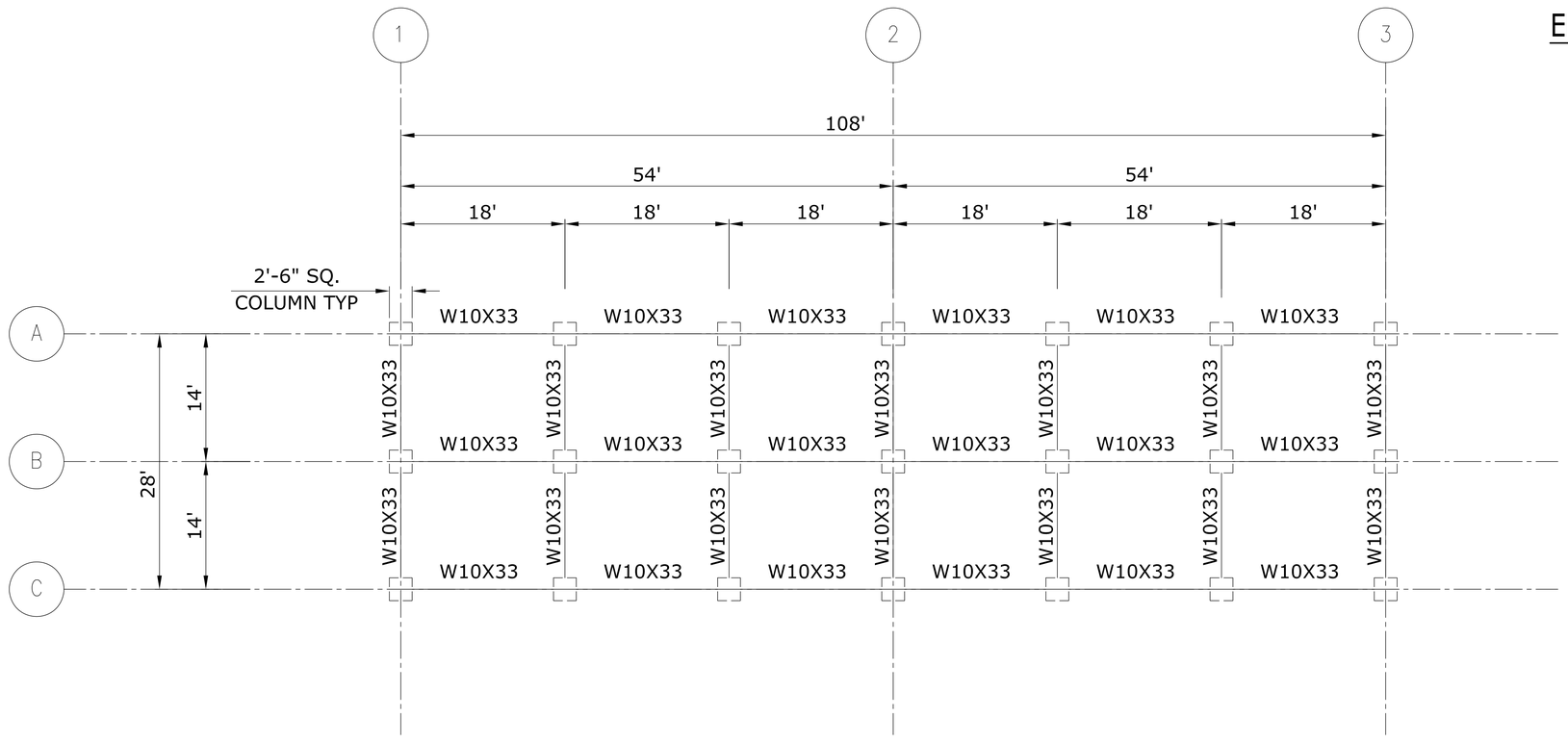
ELEVATION @ COLUMN A/B/C

SCALE: 1/8" = 1'-0"



ELEVATION @ EW DIRECTION

SCALE: 1/8" = 1'-0"



PLAN TOS 1342' & 1345'

SCALE: 1/8" = 1'-0"

FLUOR.

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/07/20	TY	TY	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS — APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

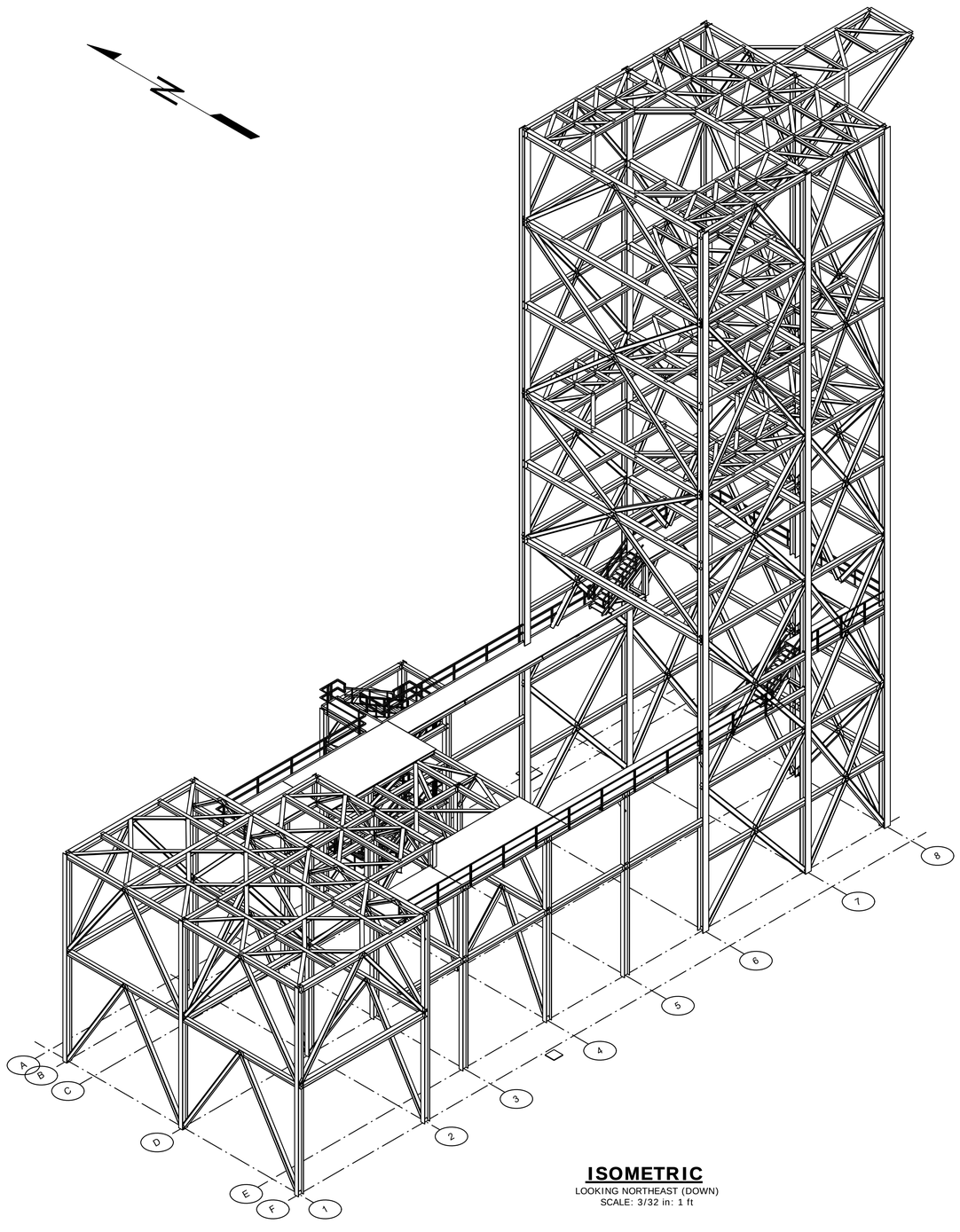
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
MAIN POWER CENTER (MPC) STEEL
PLAN & ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00254	1 OF 1	C	1/8"=1'-0"

* SEE SPECIFICATION

BILL OF MATERIAL

TYPE	MK	No. REQ'D	SIZE	LENGTH	DESCRIPTION
---	---	300	TONS		GALVANIZED STEEL INCLUDING STAIRS, HANDRAILS , AND GRATING PER SKETCH EH-35R-CCU1-SKT-215-00255 THRU 00265



ISOMETRIC
LOOKING NORTHEAST (DOWN)
SCALE: 3/32 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	MCC	JT	WA	NB	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

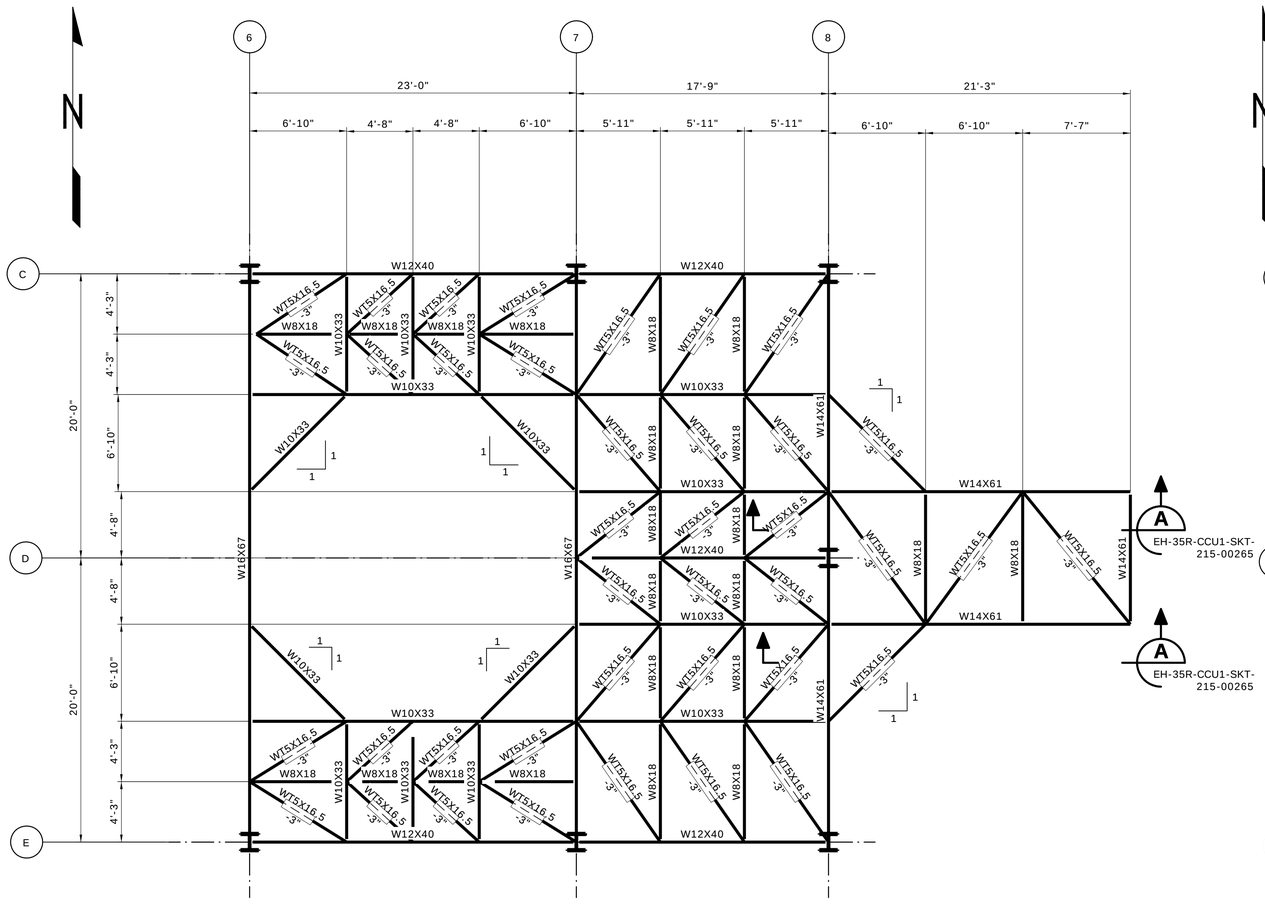
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

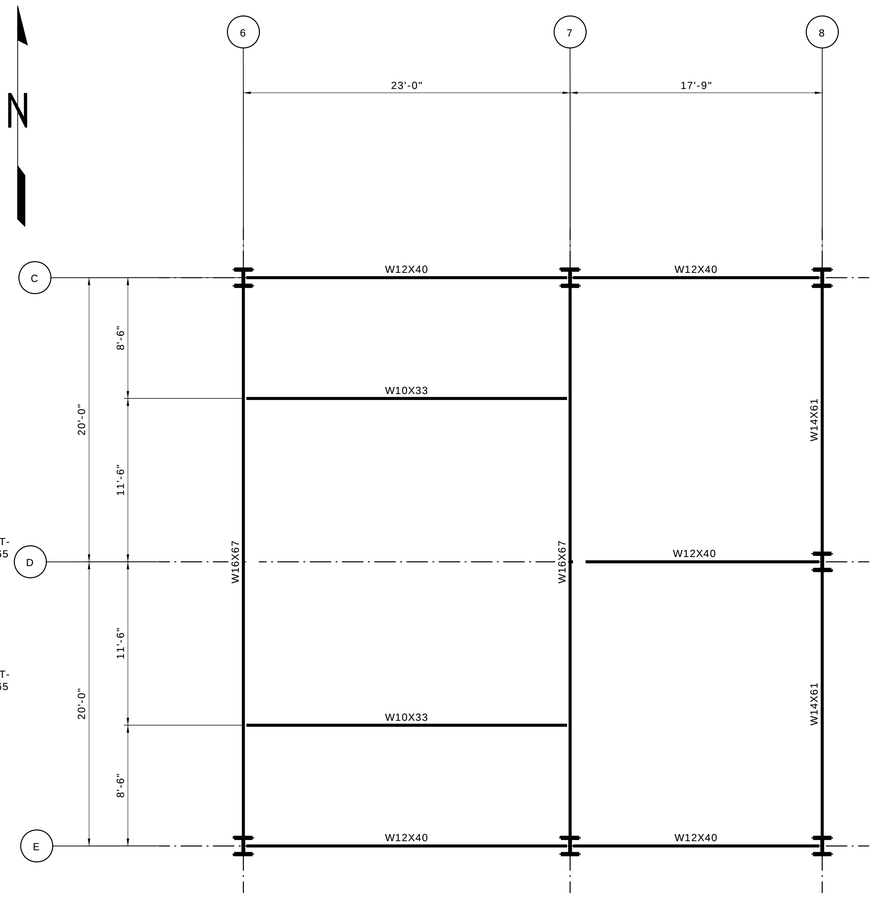
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
K-201 BLOWER DUCT SUPPORT STEEL
ISOMETRIC

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00255	1 OF 1	C	3/32"=1'-0"



PLAN @ TOS 1476' 10"

SCALE: 3/16 in: 1 ft



PLAN @ TOS 1459' 7"

SCALE: 3/16 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	MCC	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

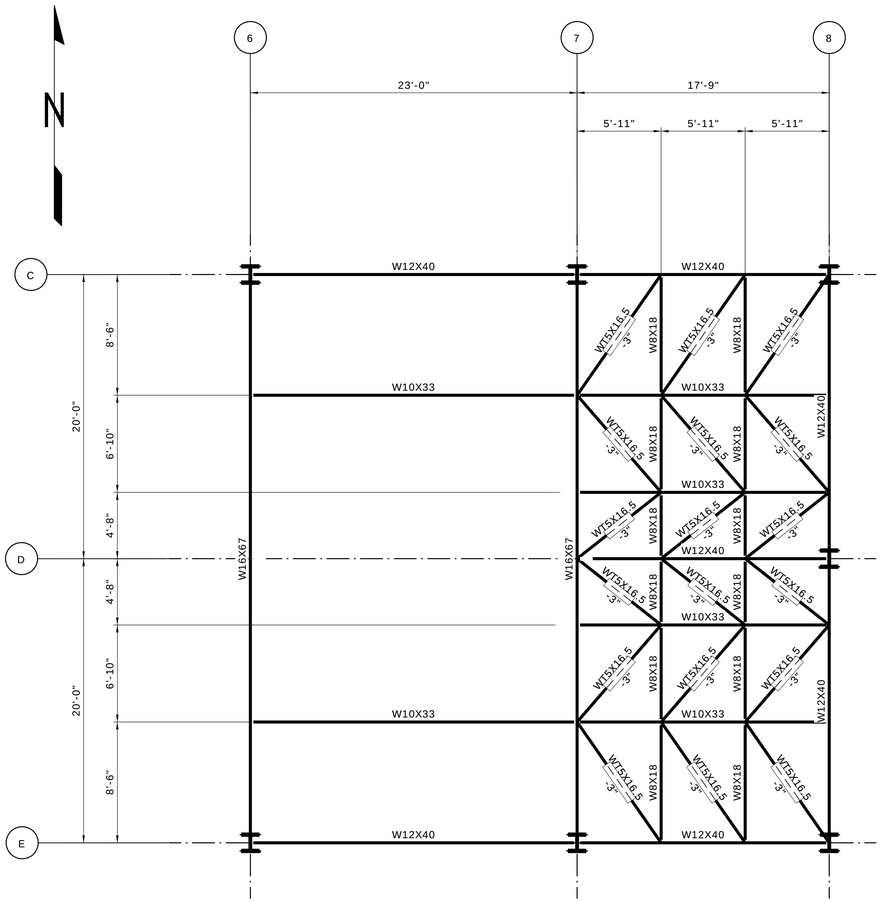
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

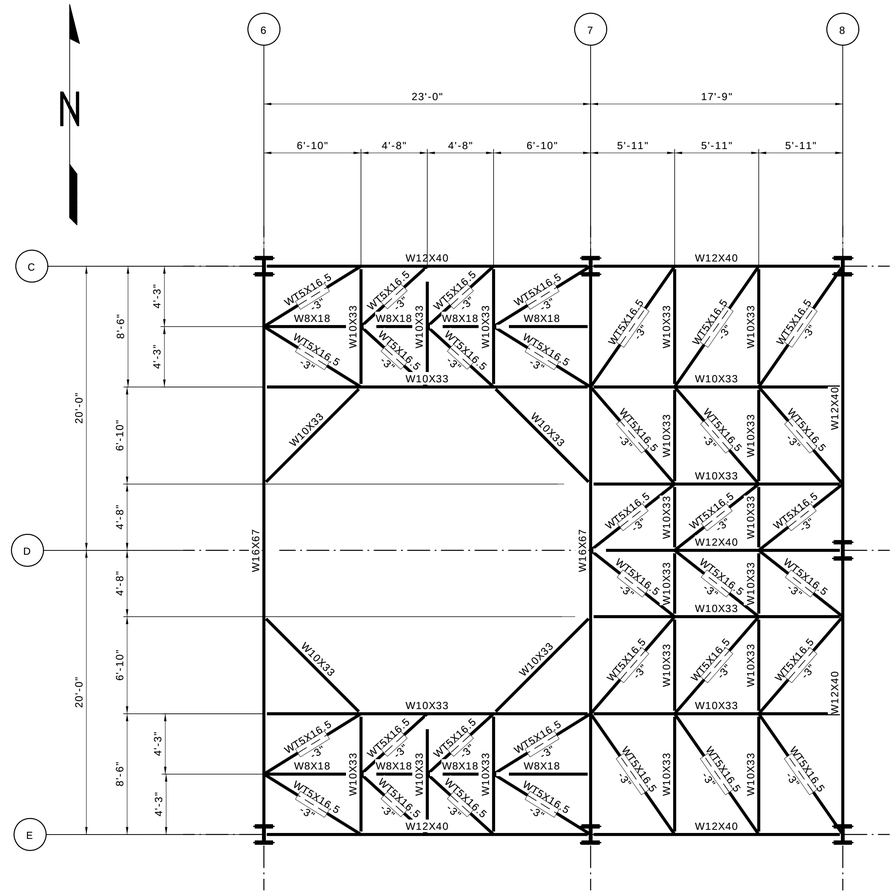
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
K-201 BLOWER DUCT SUPPORT STEEL
PLANS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00256	1 OF 1	C	3/16"=1'-0"



PLAN @ TOS 1443' 5"

SCALE: 3/16 in: 1 ft



PLAN @ TOS 1426' 2"

SCALE: 3/16 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	MCC	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

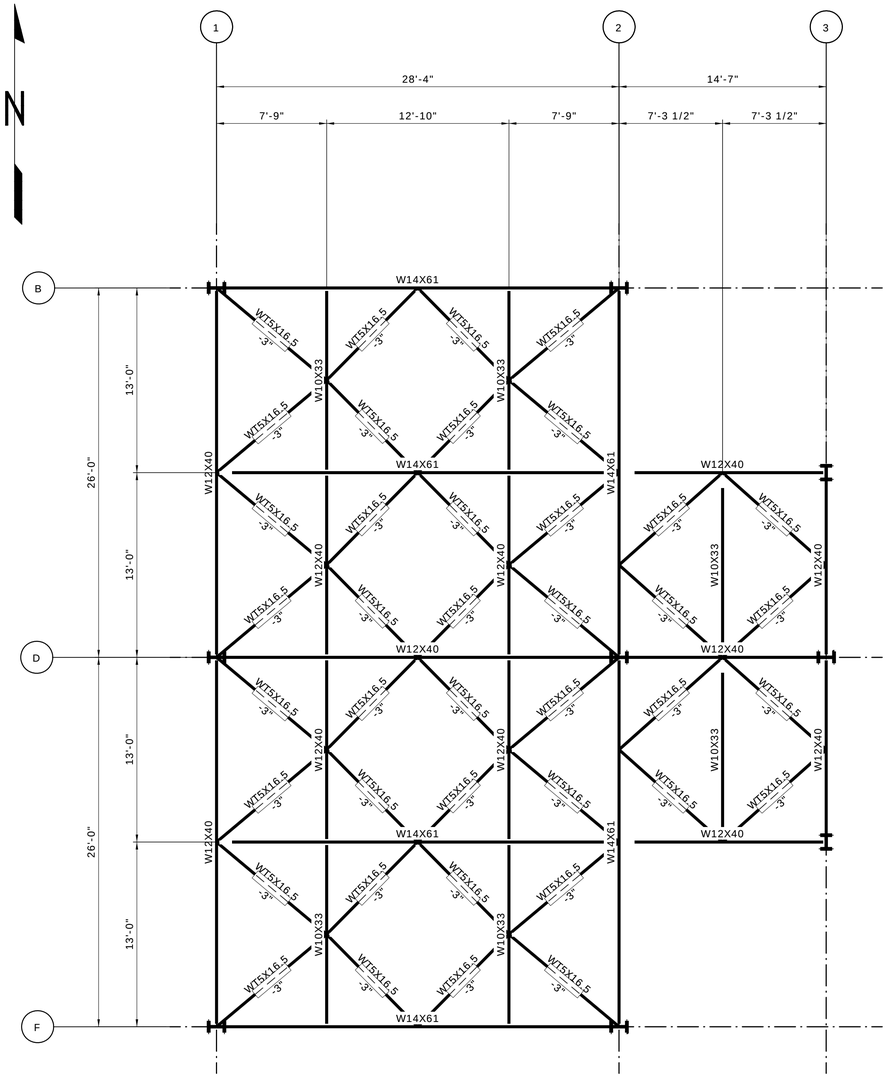
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

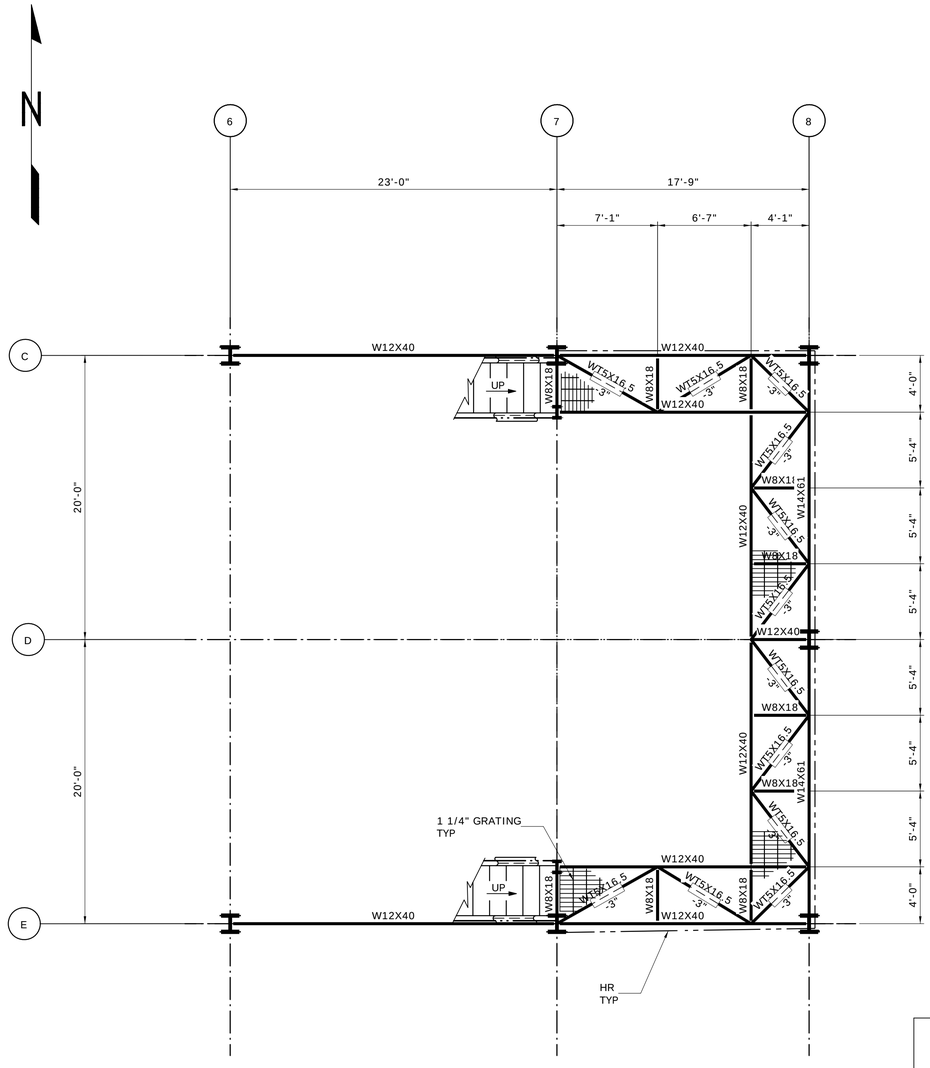
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
K-201 BLOWER DUCT SUPPORT STEEL
PLANS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00257	1 OF 1	C	3/16"=1'-0"



PLAN @ TOS 1381' 5"

SCALE: 3/16 in: 1 ft



PLAN @ TOS 1383' 6"

TOG @ ELEVATION 1383' 7 1/4"
SCALE: 3/16 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	MCC	JT	WA WA	NP NP	WA WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

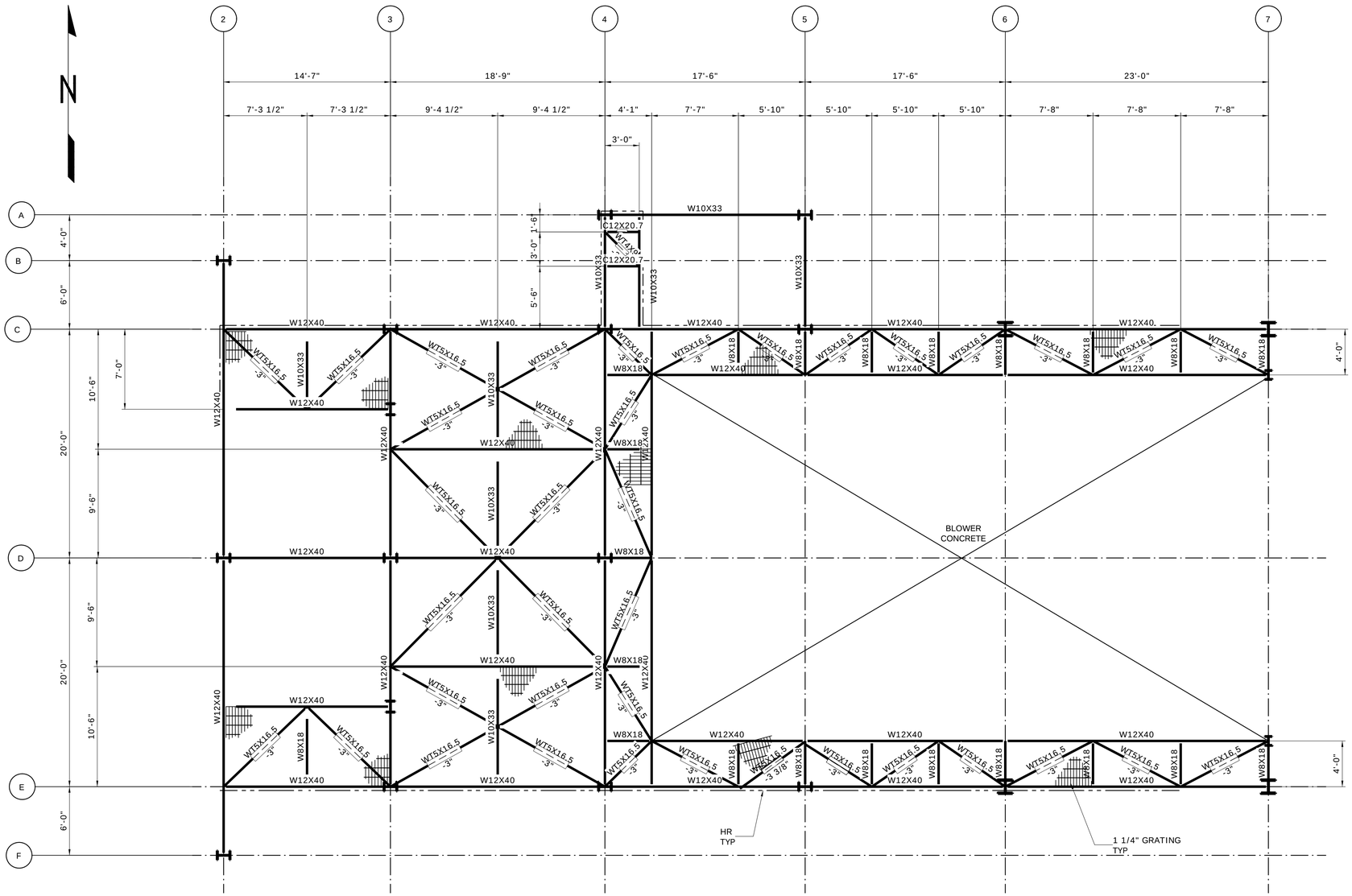
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
K-201 BLOWER DUCT SUPPORT STEEL
PLANS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00258	1 OF 1	C	3/16"=1'-0"



PLAN @ TOS 1376' 9"

SCALE: 3/16 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	MCC	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

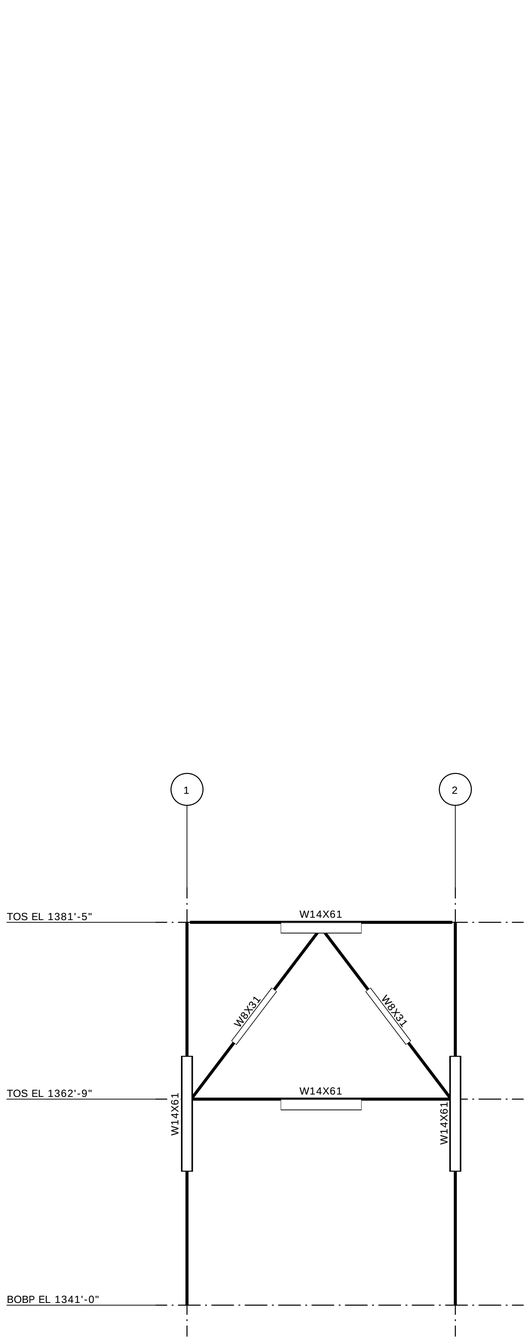
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

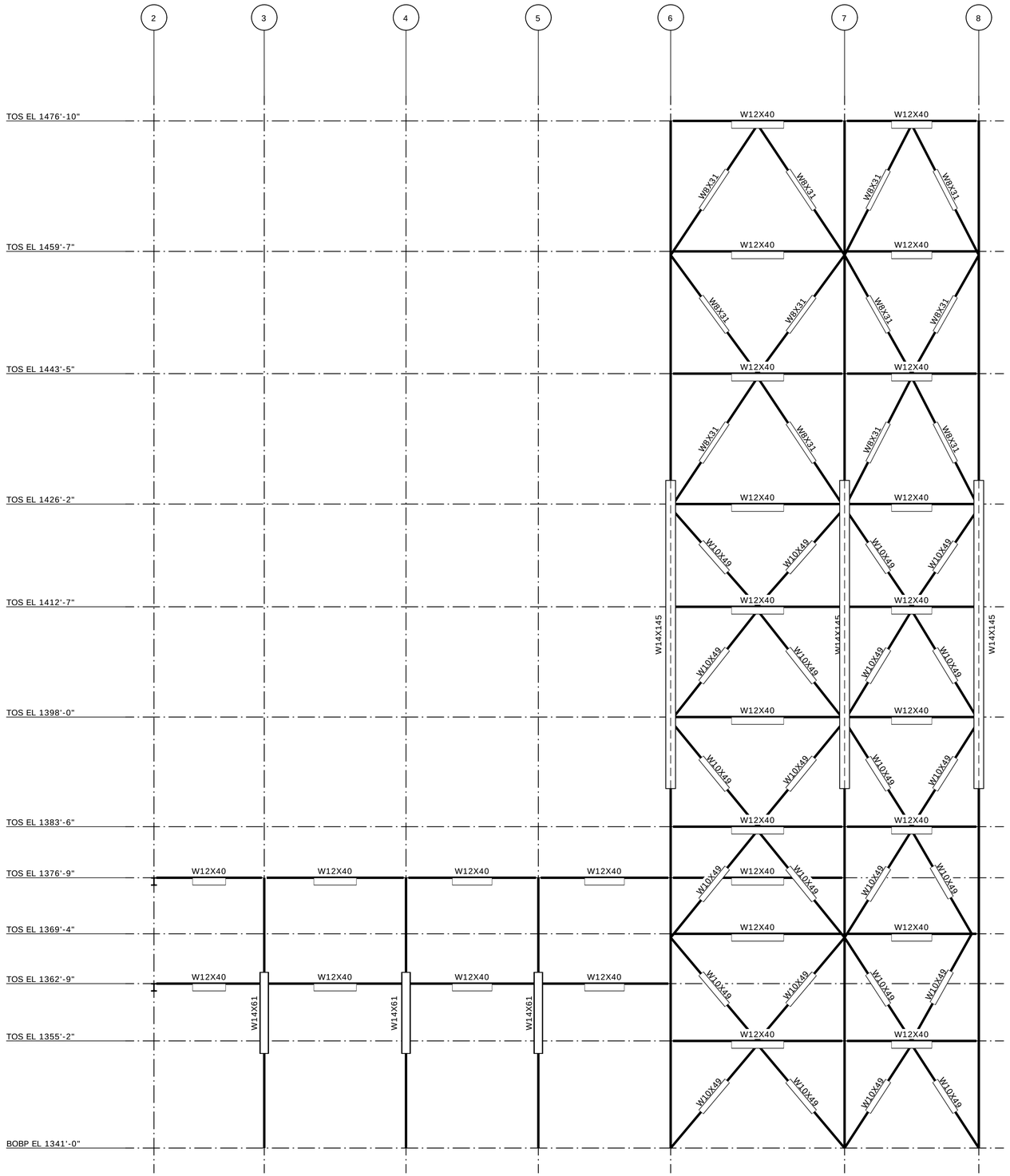
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
K-201 BLOWER DUCT SUPPORT STEEL
PLAN @ TOS 1376'-9"

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00259	1 OF 1	C	3/16"=1'-0"



SOUTH ELEVATION @ COL LINES B & F

LOOKING NORTH
SCALE: 1/8 in: 1 ft



SOUTH ELEVATION @ COL LINE C & E

LOOKING NORTH
SCALE: 1/8 in: 1 ft

FLUOR®

C	ISSUED FOR FEED AFE: WELL:	10/15/20	MCE	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						
REV. NO.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD

REVISIONS | APPROVALS

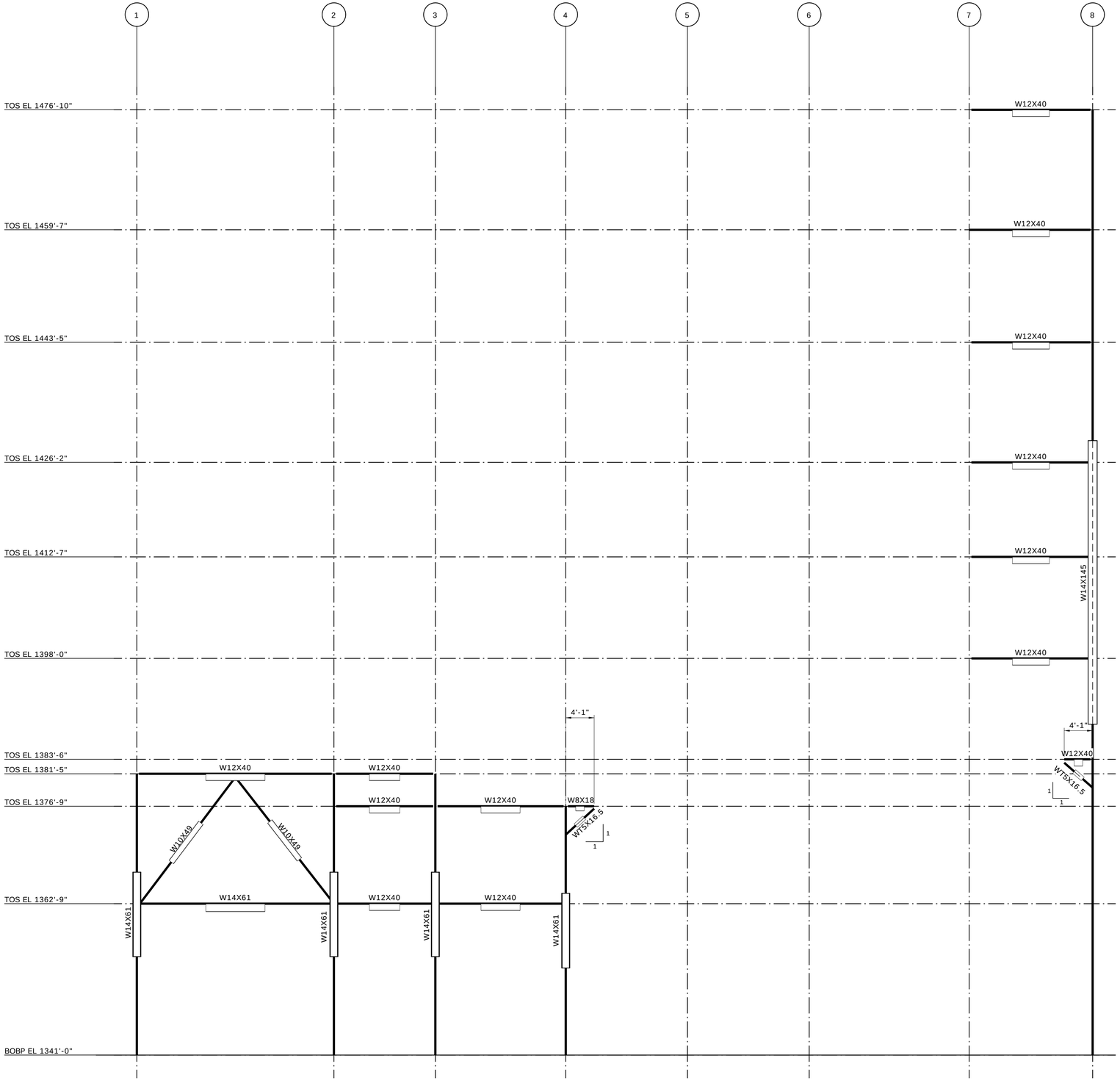
ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
K-201 BLOWER DUCT SUPPORT STEEL
SOUTH ELEVATIONS @ COL LINE B,C, E & F

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00260	1 OF 1	C	3/16"=1'-0"

CRC



SOUTH ELEVATION @ COL LINE D

LOOKING NORTH
SCALE: 1/8 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	MCC	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

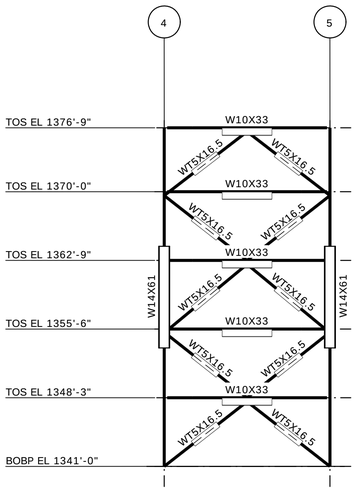
ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
K-201 BLOWER DUCT SUPPORT STEEL
SOUTH ELEVATION @ COL LINE D

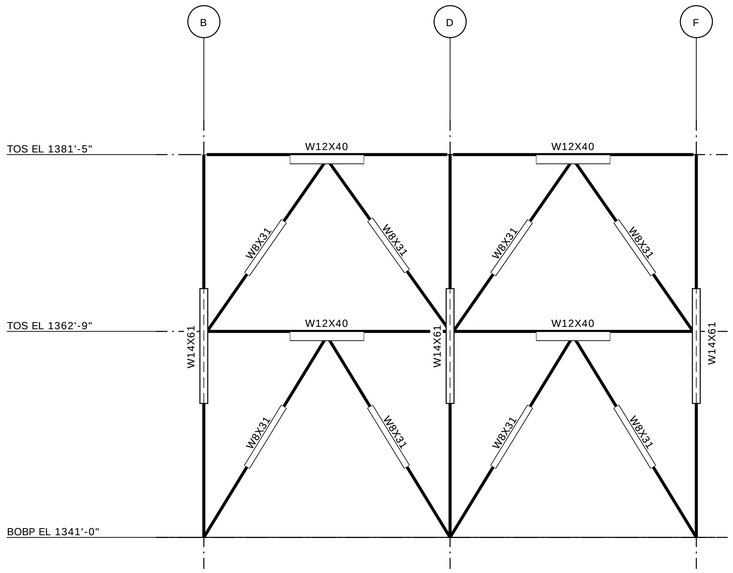
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00261	1 OF 1	C	1/8"=1'-0"

CRC



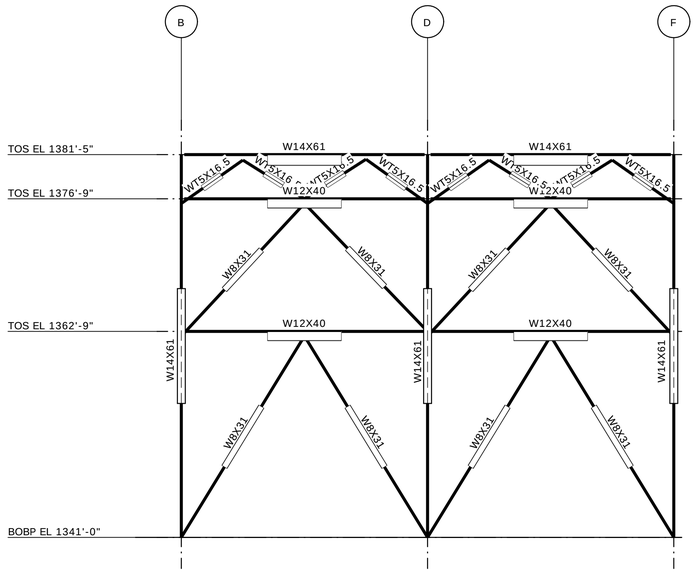
SOUTH ELEVATION @ COL LINE F

LOOKING NORTH
SCALE: 1/8 in: 1 ft



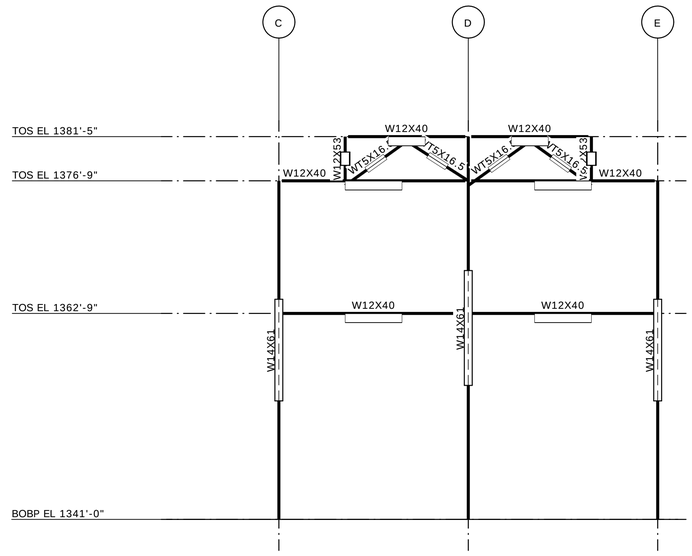
WEST ELEVATION @ COL LINE 1

LOOKING EAST
SCALE: 1/8 in: 1 ft



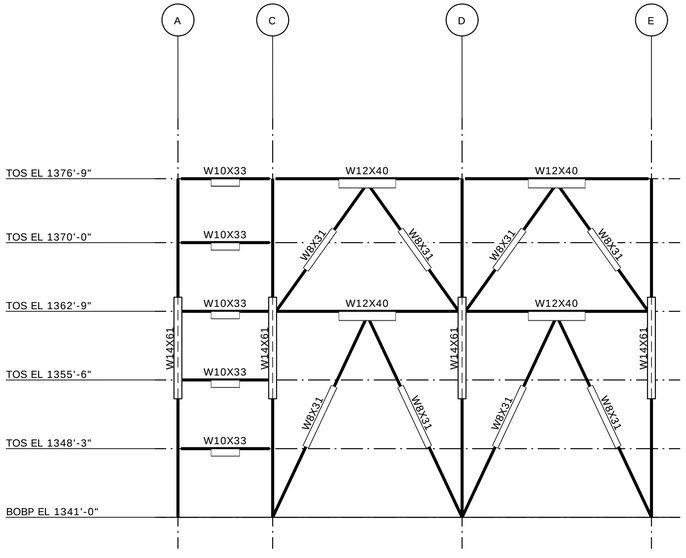
WEST ELEVATION @ COL LINE 2

LOOKING EAST
SCALE: 1/8 in: 1 ft



WEST ELEVATION @ COL LINE 3

LOOKING EAST
SCALE: 1/8 in: 1 ft



WEST ELEVATION @ COL LINE 4

LOOKING EAST
SCALE: 1/8 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	MCC	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

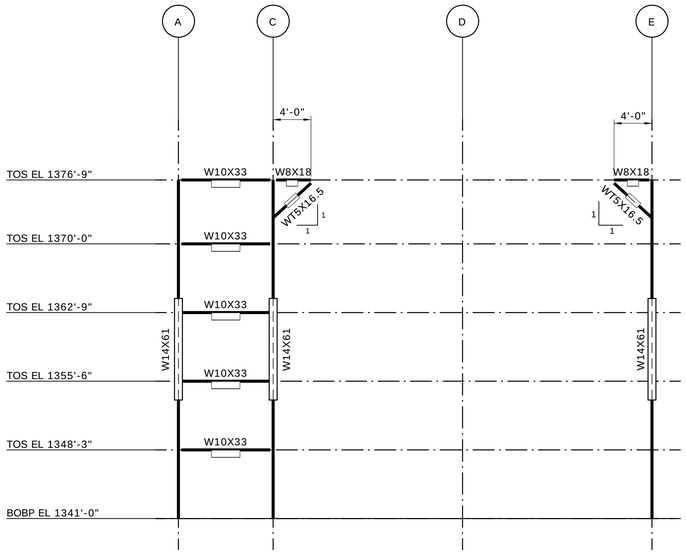
ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
K-201 BLOWER DUCT SUPPORT STEEL
ELEVATIONS

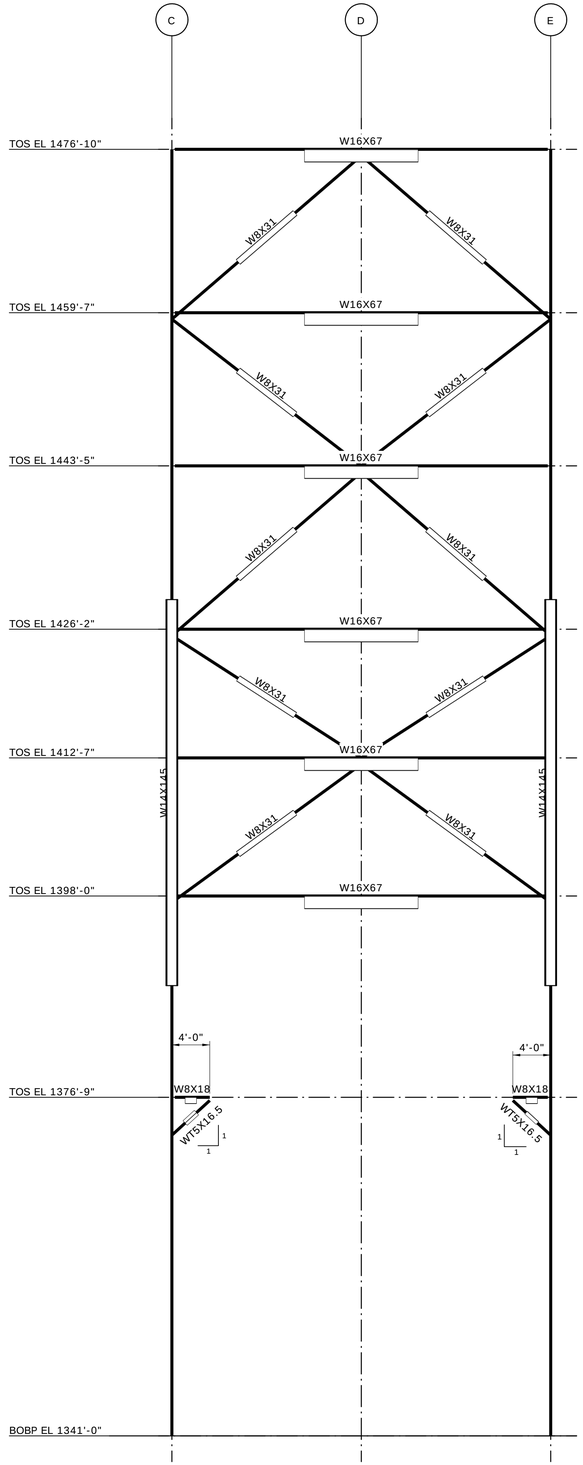
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00262	1 OF 1	C	3/16"=1'-0"

CRC



WEST ELEVATION @ COL LINE 5

LOOKING EAST
SCALE: 1/8 in: 1 ft



WEST ELEVATION @ COL LINE 6

LOOKING EAST
SCALE: 1/8 in: 1 ft

FLUOR®

REV. No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG.	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	MCC	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

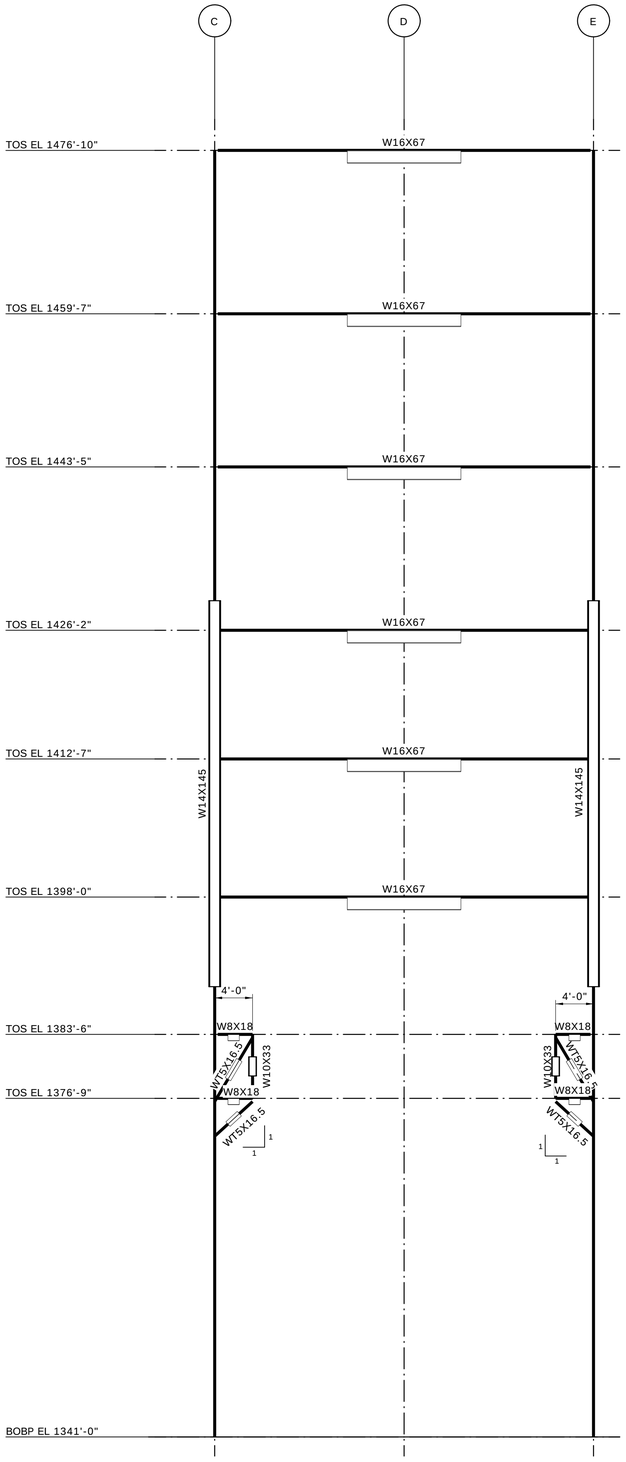
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

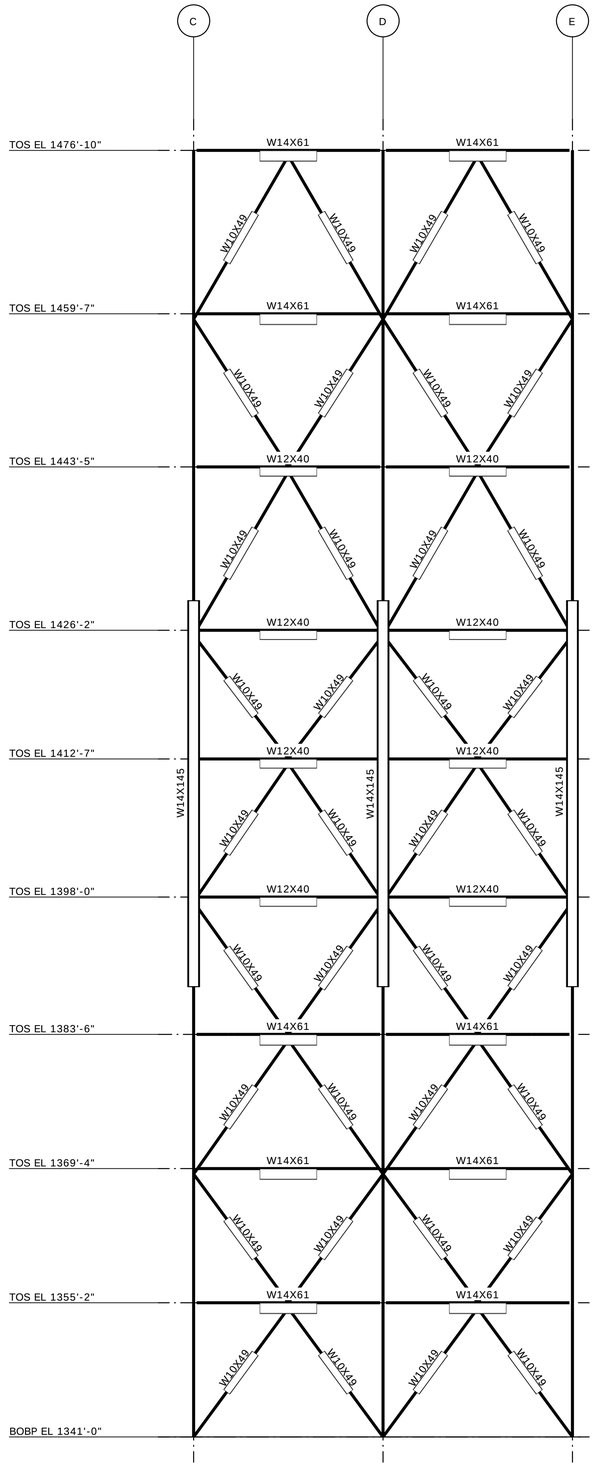
SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
K-201 BLOWER DUCT SUPPORT STEEL
WEST ELEVATION @ COL LINES 5 & 6

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00263	1 OF 1	C	1/8"=1'-0"



WEST ELEVATION @ COL LINE 7

LOOKING EAST
SCALE: 1/8 in: 1 ft



WEST ELEVATION @ COL LINE 8

LOOKING EAST
SCALE: 1/8 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	MCC	JT	WA WA	NP	WA WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

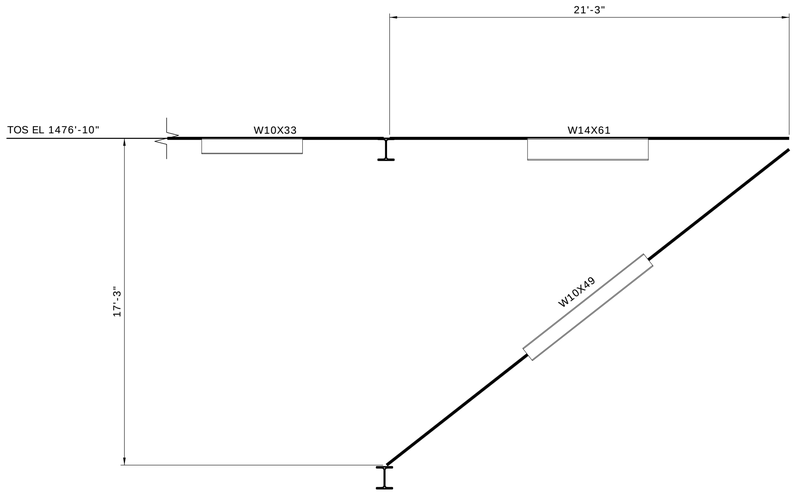
ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
K-201 BLOWER DUCT SUPPORT STEEL
WEST ELEVATIONS @ COL LINES 7 & 8

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00264	1 OF 1	C	1/8"=1'-0"

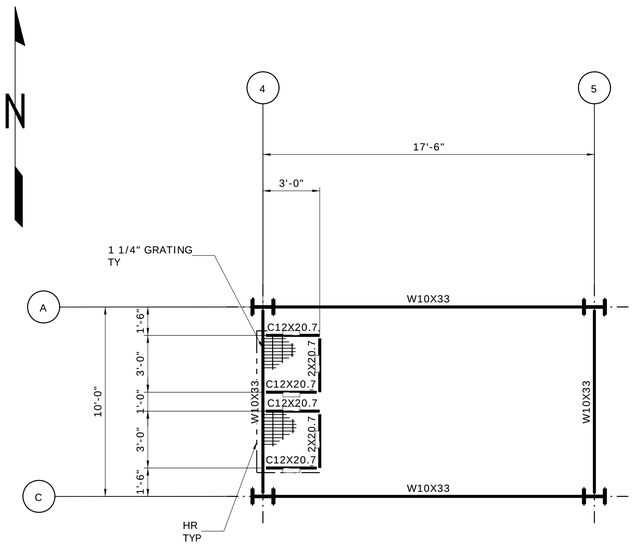
CRC



SECTION A

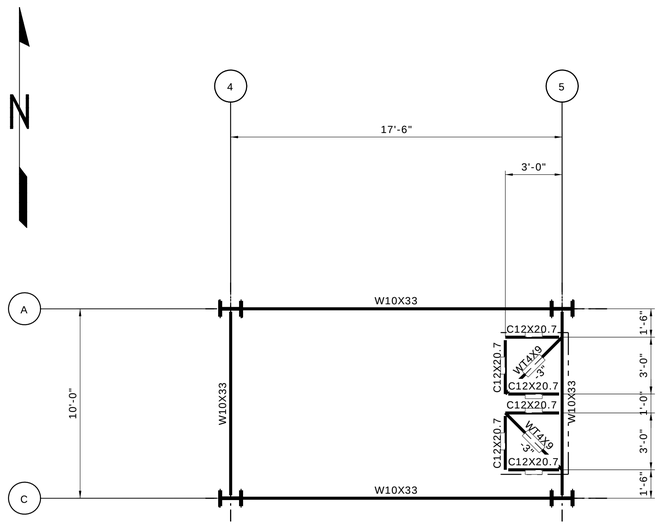
SCALE: 1/4"=1'-0"

EH-35R-CCU1-SKT-215-00256



PLAN @ TOS 1348'-3" & 1362'-9"

SCALE: 1/4 in: 1 ft



PLAN @ TOS 1355'-6" & 1370'-0"

SCALE: 1/4 in: 1 ft

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	MCC	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL REVIEW (NOT USED) AFE: WELL:						

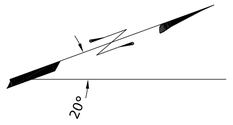
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R 23E
CARBON CAPTURE UNIT 1
K-201 BLOWER DUCT SUPPORT STEEL
SECTION & PLANS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00265	1 OF 1	C	1/4"=1'-0"

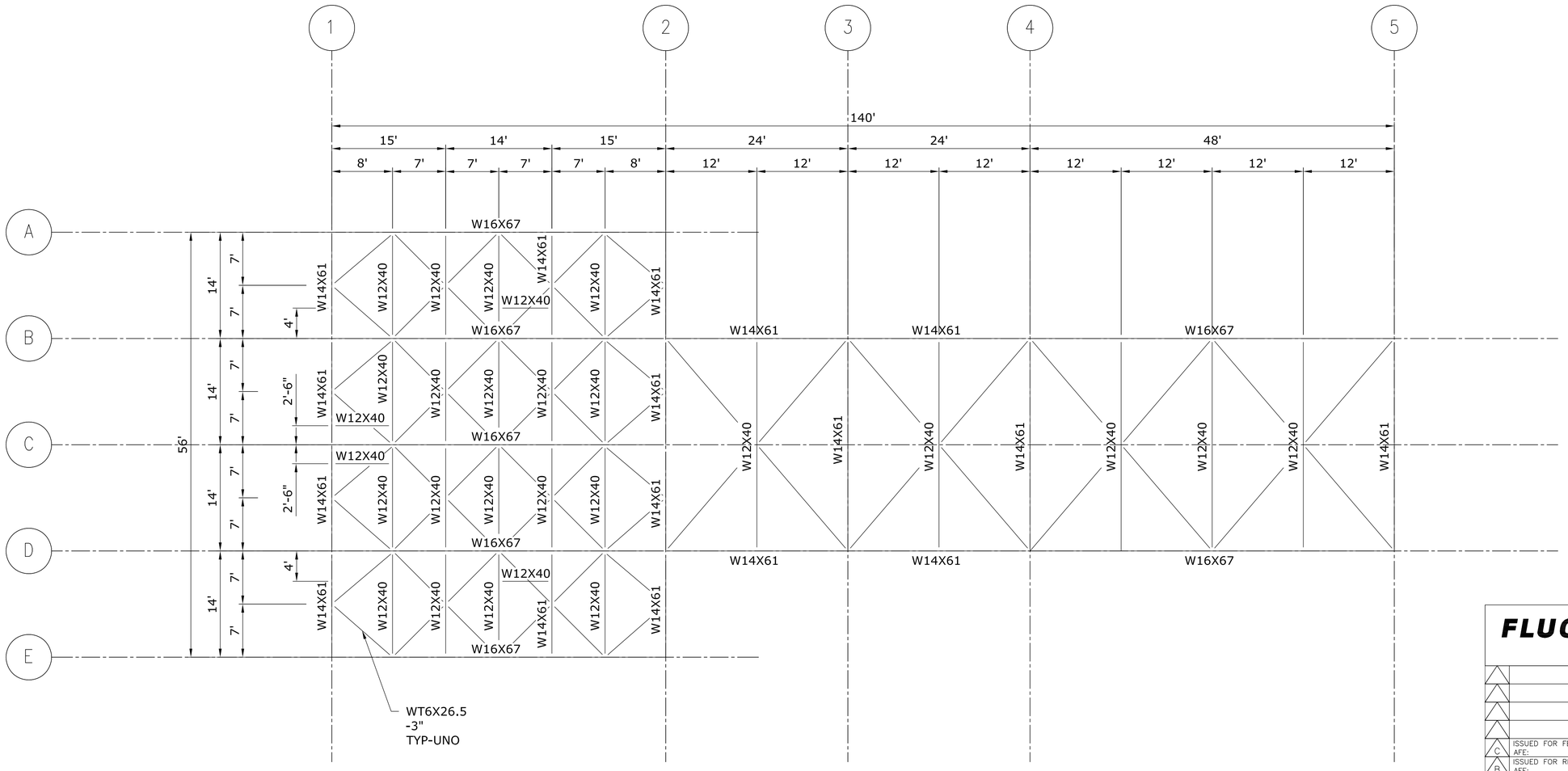


BILL OF MATERIAL

*SEE SPECIFICATIONS

QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO REQD	SIZE	LENGTH	DESCRIPTION
—	—	149.45	TON	—	GALVANIZED STEEL INCLUDING STARIS, HANDRAILSM AND GRATING PER SKETCH EH-35R-CCU1-SKT-215-00266 THRU 274.



PLAN @ TOS 1379' 10"

SCALE: 1/8"=1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	TY	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
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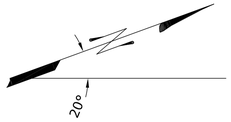
REVISIONS | APPROVALS

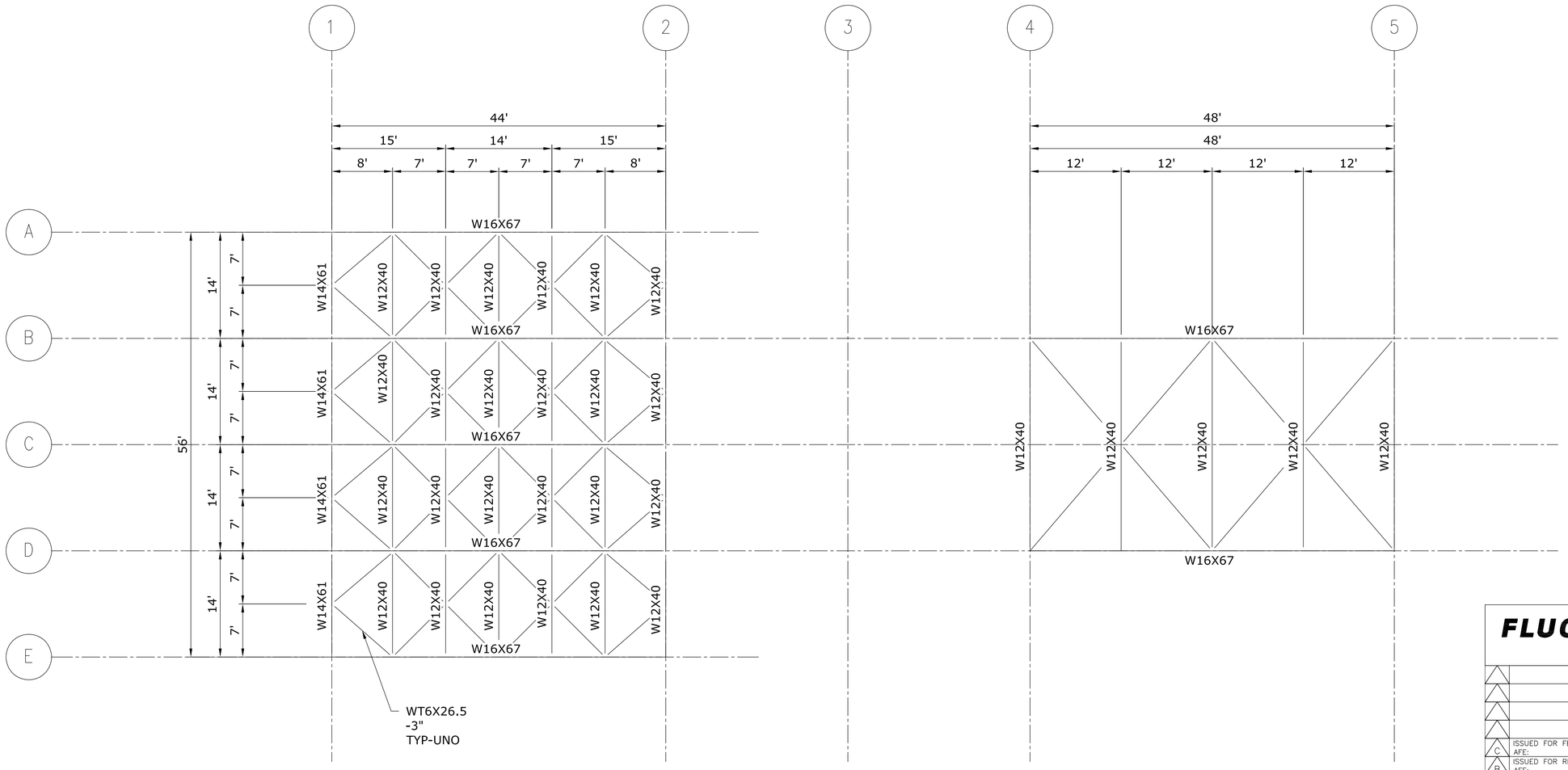
ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
DUCT SUPPORT SECTION A STEEL
PLAN

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00266	1 OF 1	C	AS NOTED





PLAN @ TOS 1375' 10"

SCALE: 1/8"=1'-0"

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	TY	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

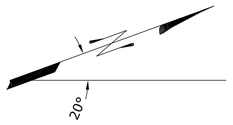
REVISIONS | APPROVALS

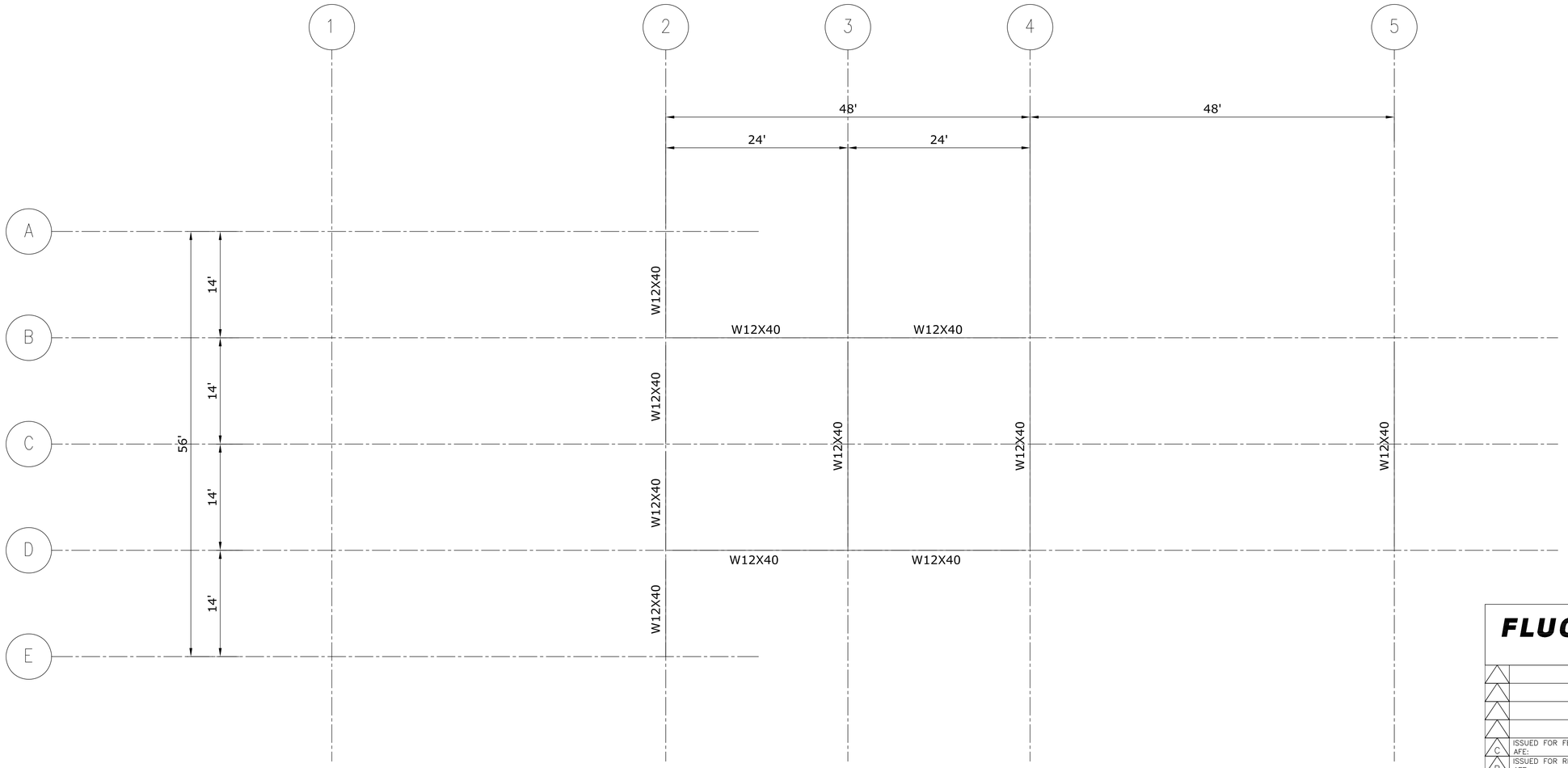
ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
DUCT SUPPORT SECTION A STEEL
PLAN

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00267	1 OF 1	C	AS NOTED





PLAN @ TOS 1357' 6"

SCALE: 1/8"=1'-0"

FLUOR.

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	TY	JT	WA WA	NP	WA WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
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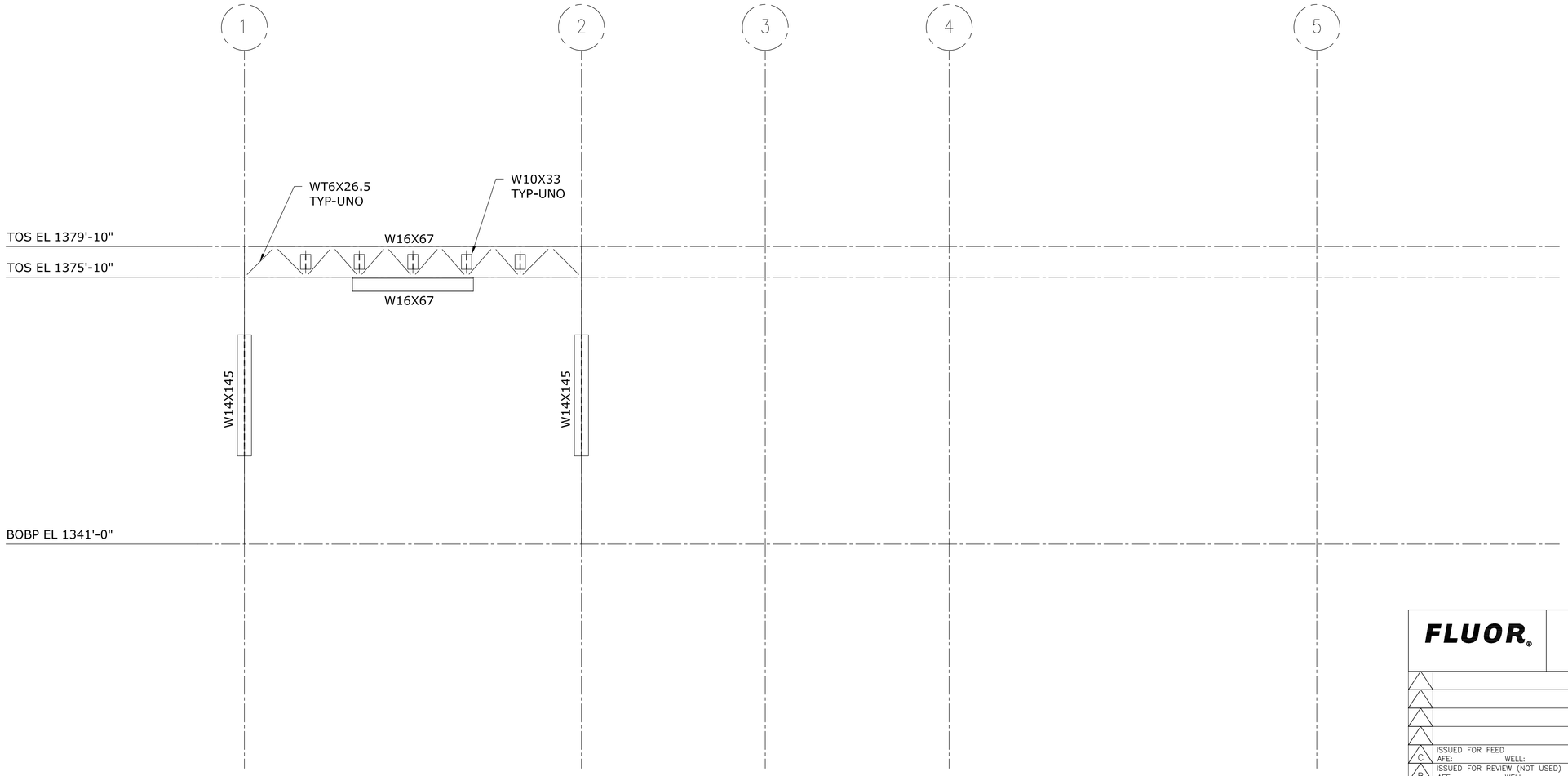
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
DUCT SUPPORT SECTION A STEEL
PLAN

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00268	1 OF 1	C	AS NOTED



SOUTH ELEVATION @ COL LINE A & E

SCALE: 1/8"=1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	TY	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

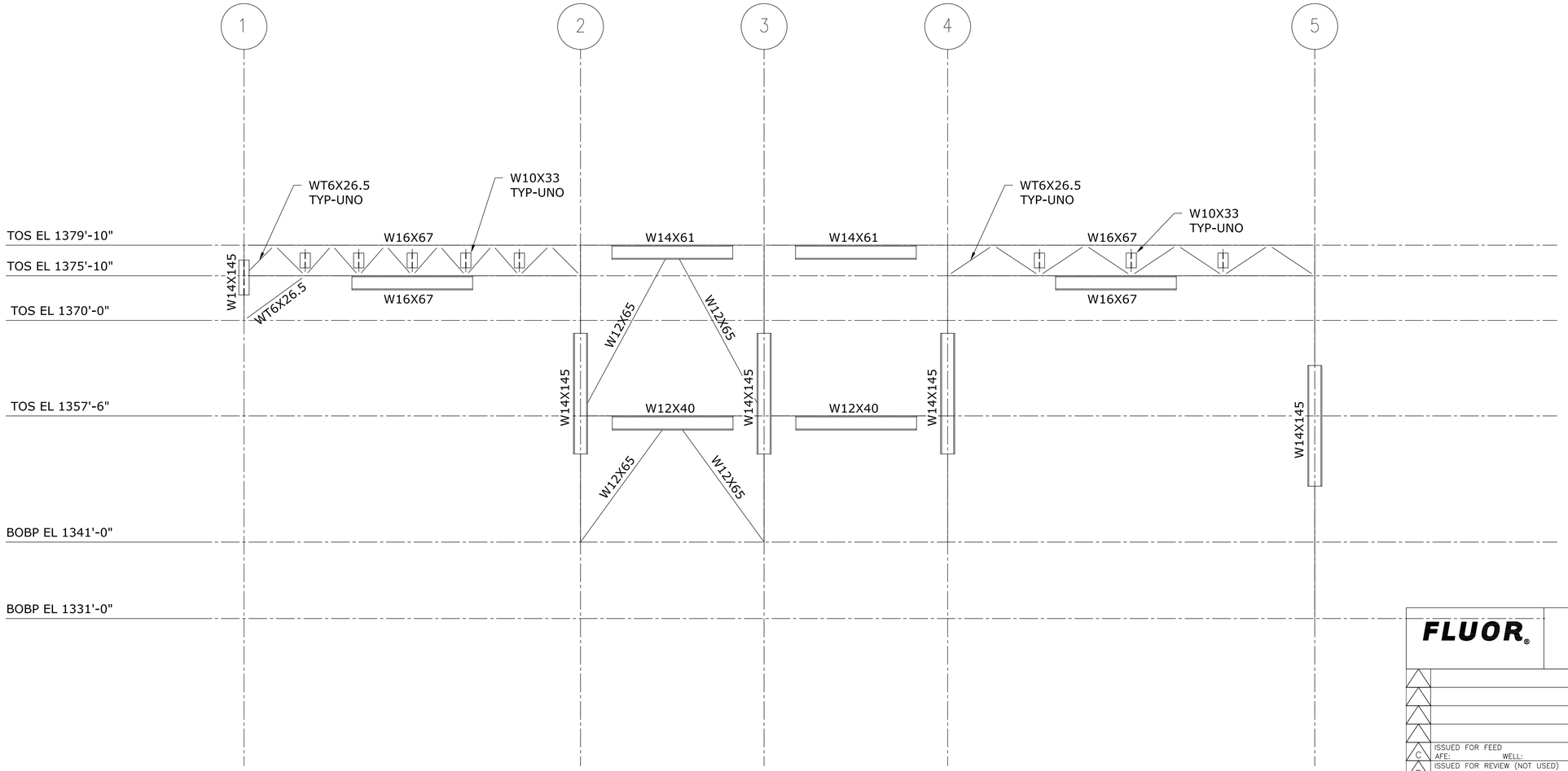
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
DUCT SUPPORT SECTION A STEEL
SOUTH ELEVATION @ COL LINES A & E

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00269	1 OF 1	C	AS NOTED



SOUTH ELEVATION @ COL LINE E & D

SCALE: 1/8"=1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	TY	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
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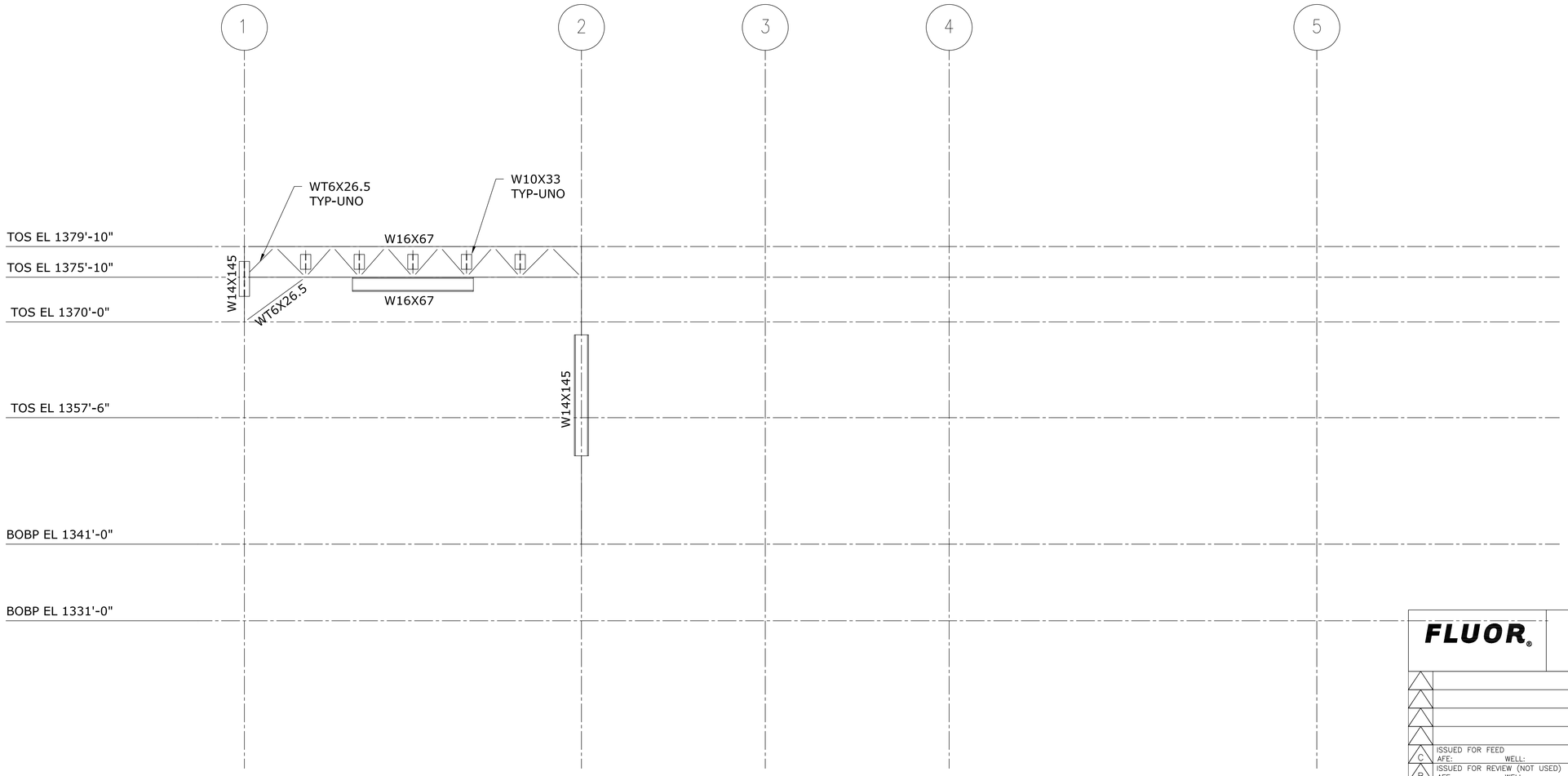
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
DUCT SUPPORT SECTION A STEEL
SOUTH ELEVATION @ COL LINES E & D

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00270	1 OF 1	C	AS NOTED



SOUTH ELEVATION @ COL LINE C

SCALE: 1/8"=1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	TY	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
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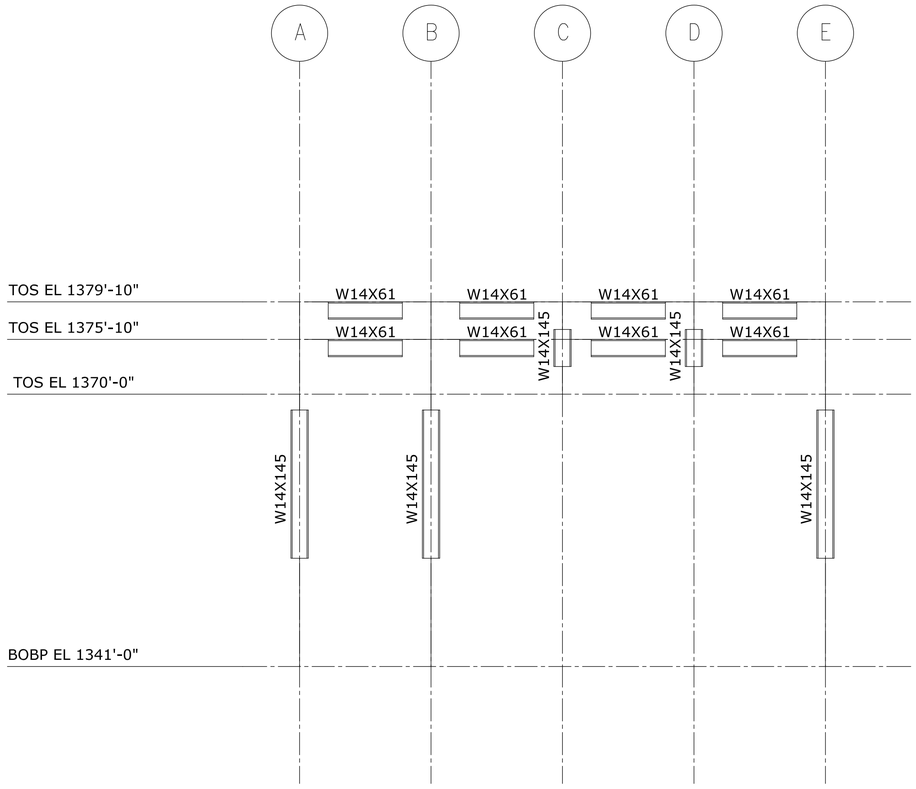
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

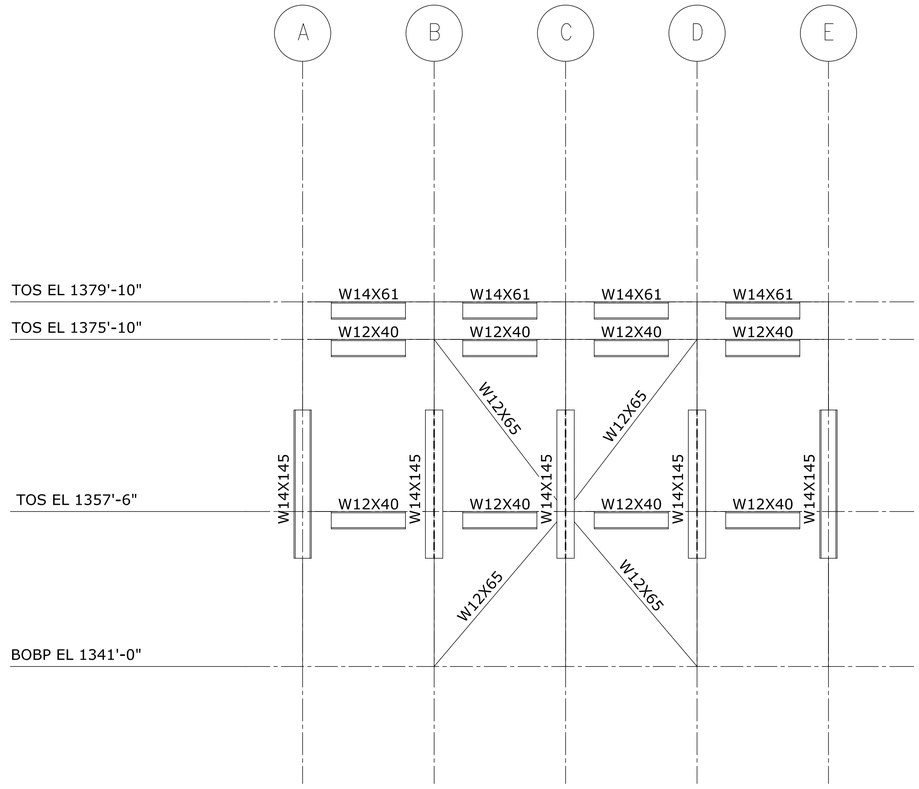
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
DUCT SUPPORT SECTION A STEEL
SOUTH ELEVATION @ COL LINE C

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00271	1 OF 1	C	AS NOTED



EAST ELEVATION @ COL LINE 1

SCALE: 1/8"=1'-0"



EAST ELEVATION @ COL LINE 2

SCALE: 1/8"=1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	TY	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

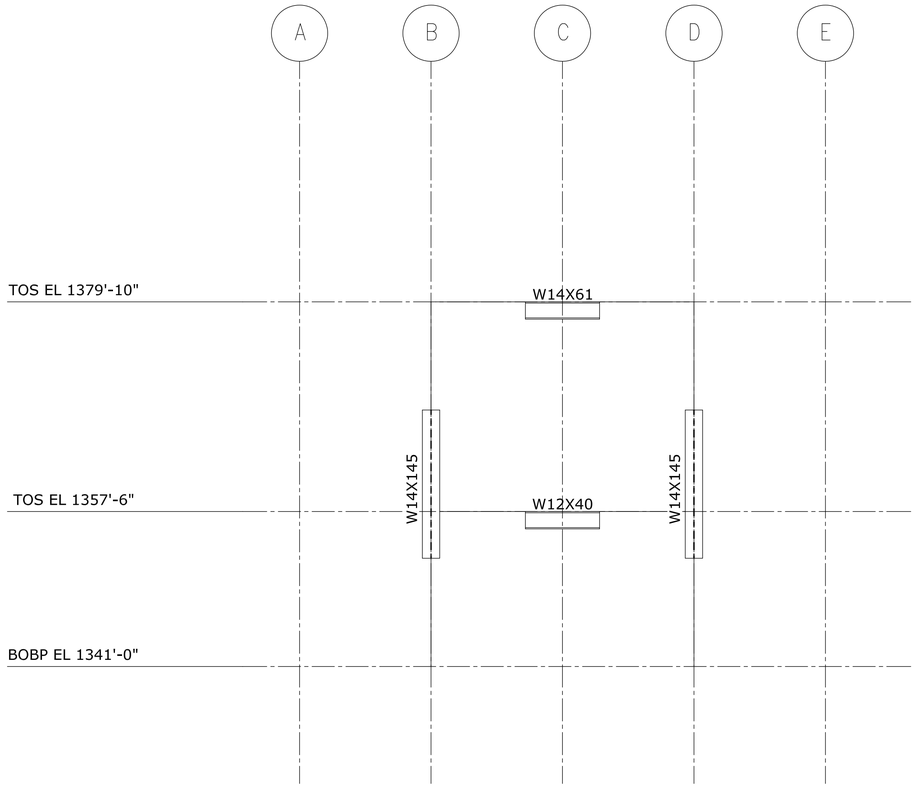
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

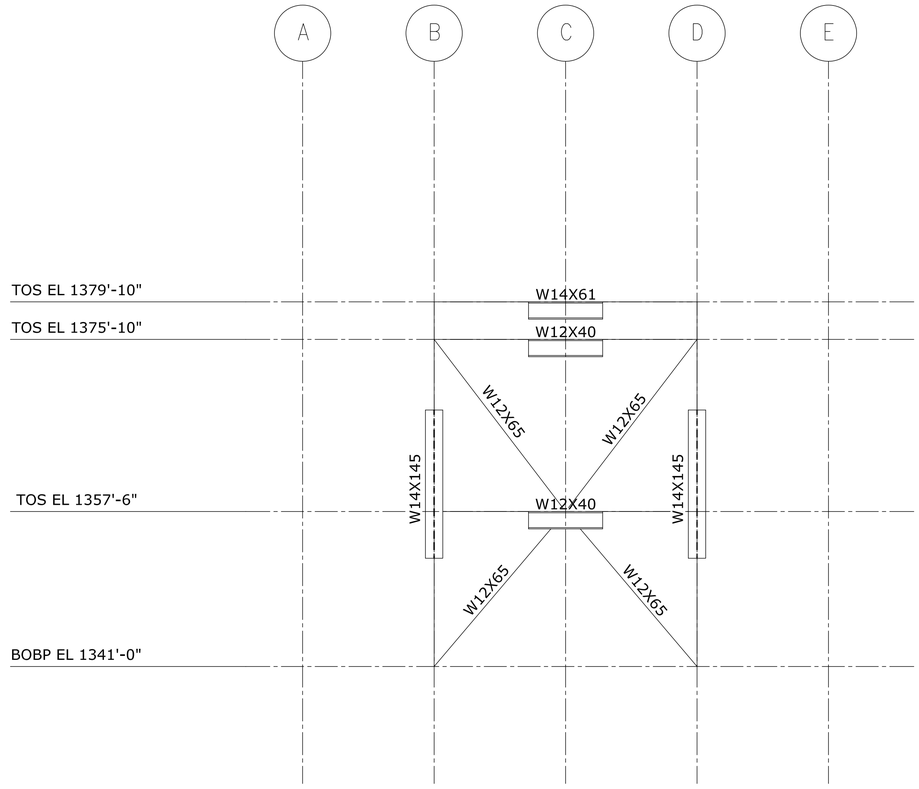
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
DUCT SUPPORT SECTION A STEEL
EAST ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-0271	1 OF 1	C	AS NOTED



EAST ELEVATION @ COL LINE 3

SCALE: 1/8"=1'-0"



EAST ELEVATION @ COL LINE 4

SCALE: 1/8"=1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	TY	JT	WA WA	NP	WA WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
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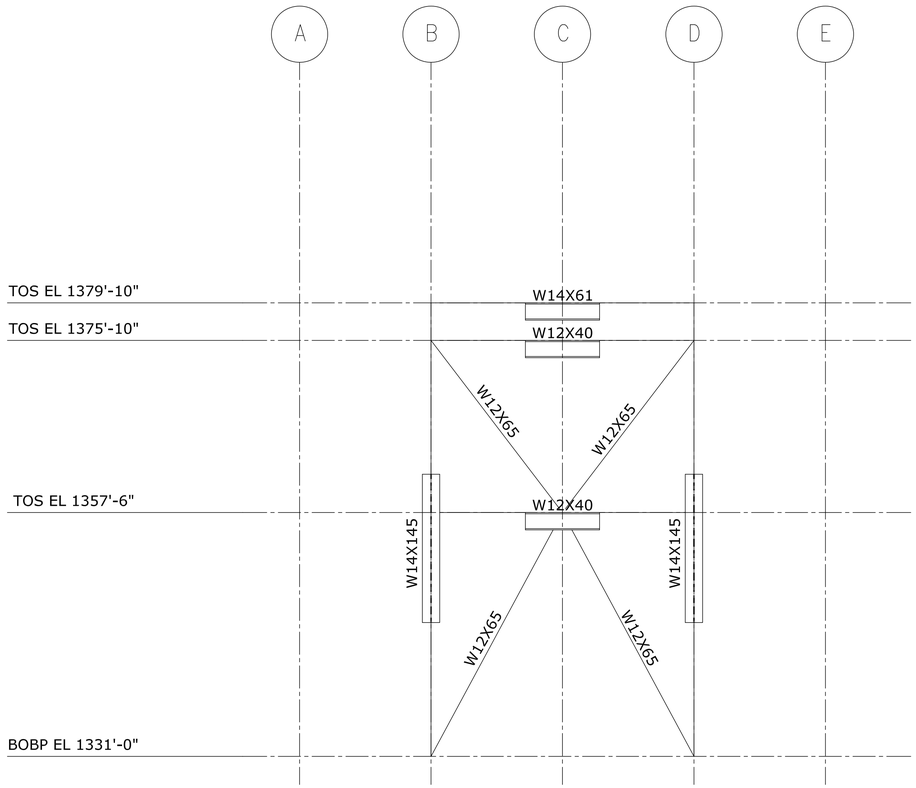
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
DUCT SUPPORT SECTION A STEEL
EAST ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00273	1 OF 1	C	AS NOTED



EAST ELEVATION @ COL LINE 5

SCALE: 1/8"=1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	TY	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
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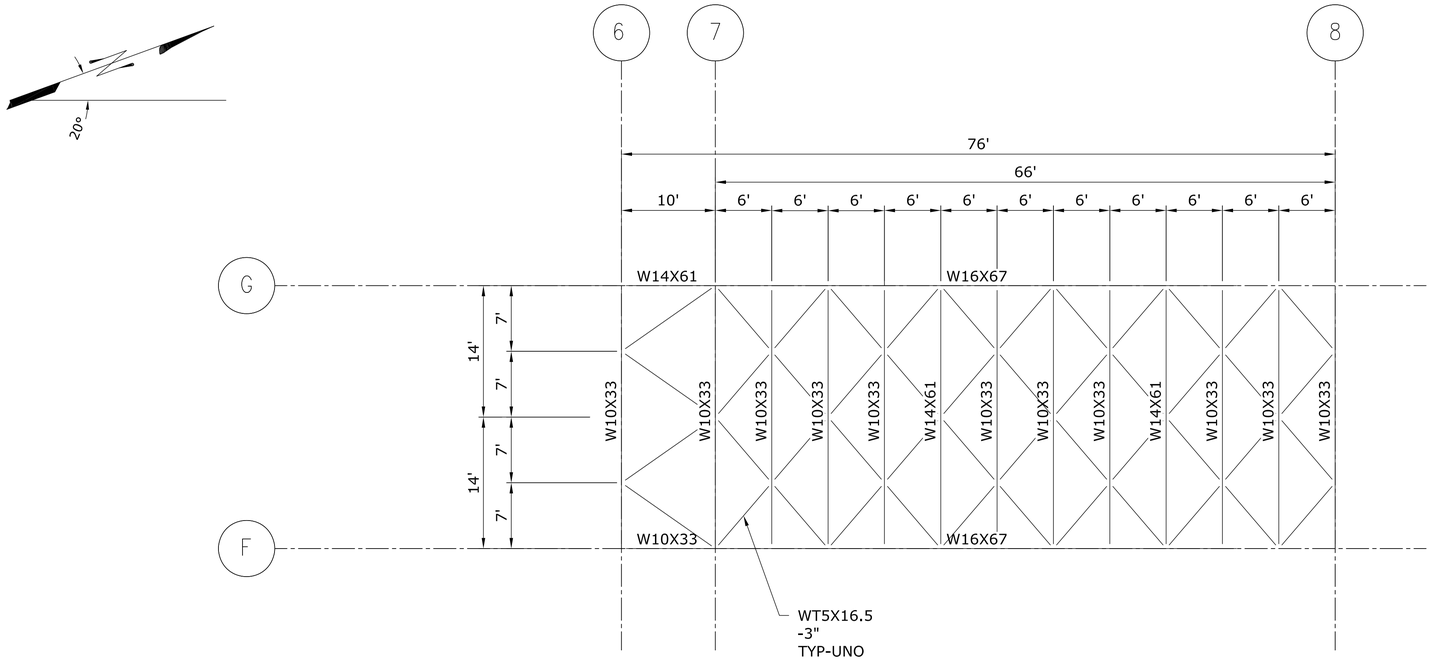
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

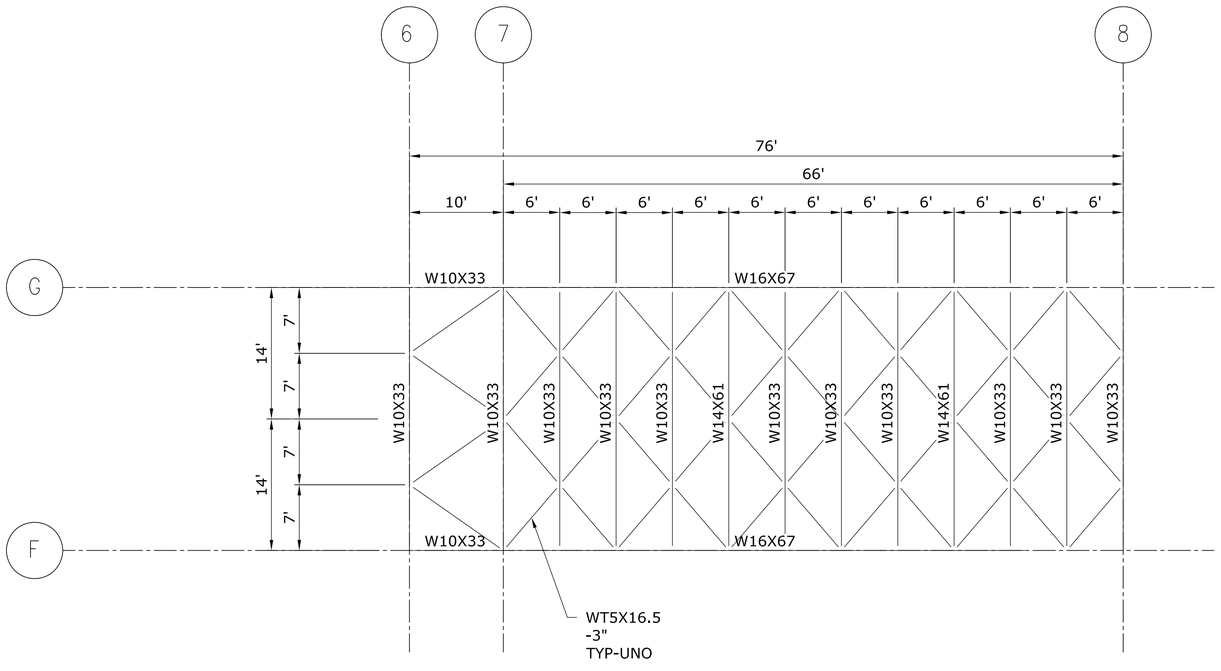
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
DUCT SUPPORT SECTION A STEEL
EAST ELEVATION @ COL LINE 5

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00274	1 OF 1	C	AS NOTED



PLAN @ TOS 1389' 10"

SCALE: 1/8"=1'-0"



PLAN @ TOS 1383' 10"

SCALE: 1/8"=1'-0"

BILL OF MATERIAL

*SEE SPECIFICATIONS

QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO REQD	SIZE	LENGTH	DESCRIPTION
—	—	78.95	TONS	—	GALVANIZED STEEL INCLUDING STARIS, HANDRAILSM AND GRATING PER SKETCH EH-35R-CCU1-SKT-215-00275 THRU 277.

FLUOR

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	TY	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

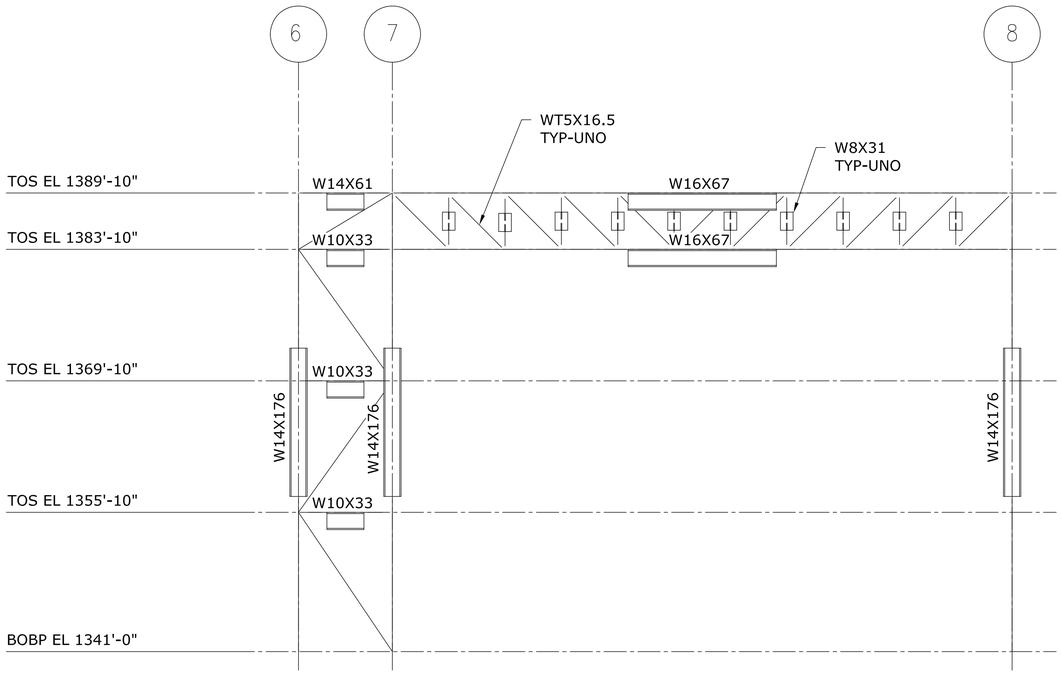
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

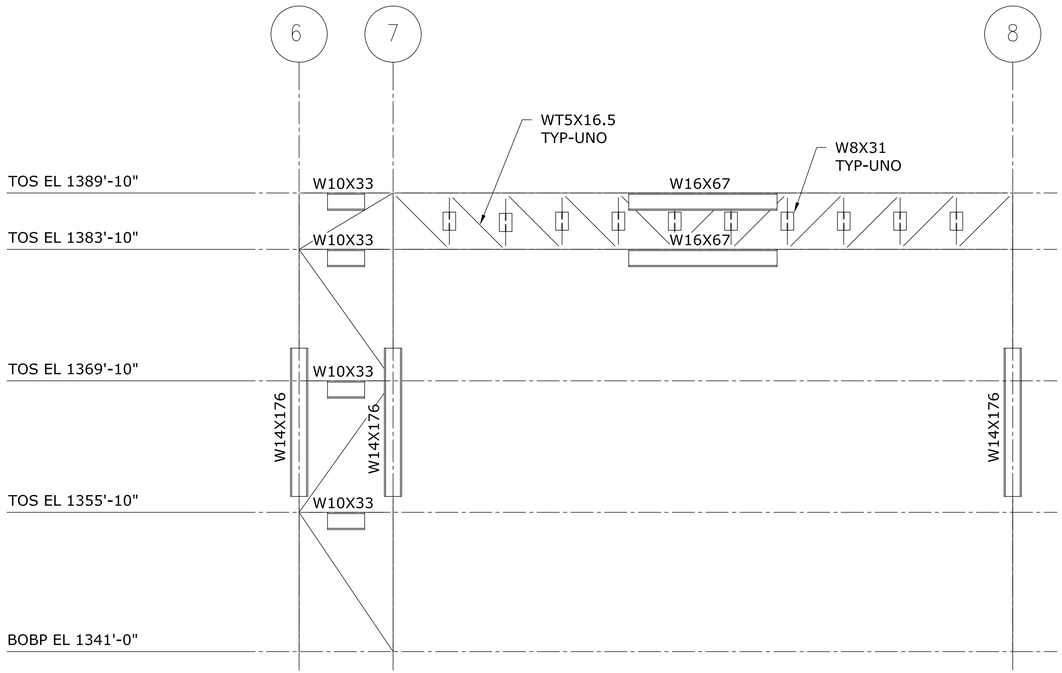
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
DUCT SUPPORT SECTION C STEEL
PLANS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00275	1 OF 1	C	AS NOTED



SOUTH ELEVATION @ COL LINE G

SCALE: 1/8"=1'-0"



SOUTH ELEVATION @ COL LINE F

SCALE: 1/8"=1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	TY	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

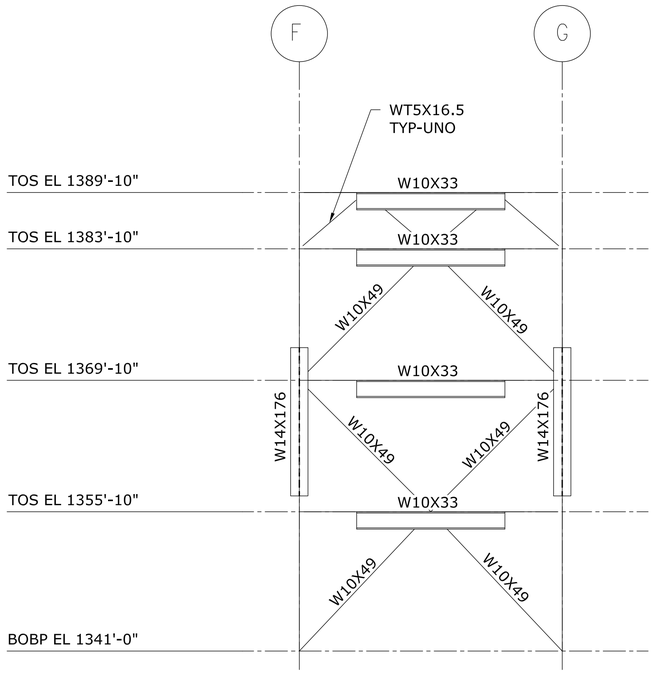
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

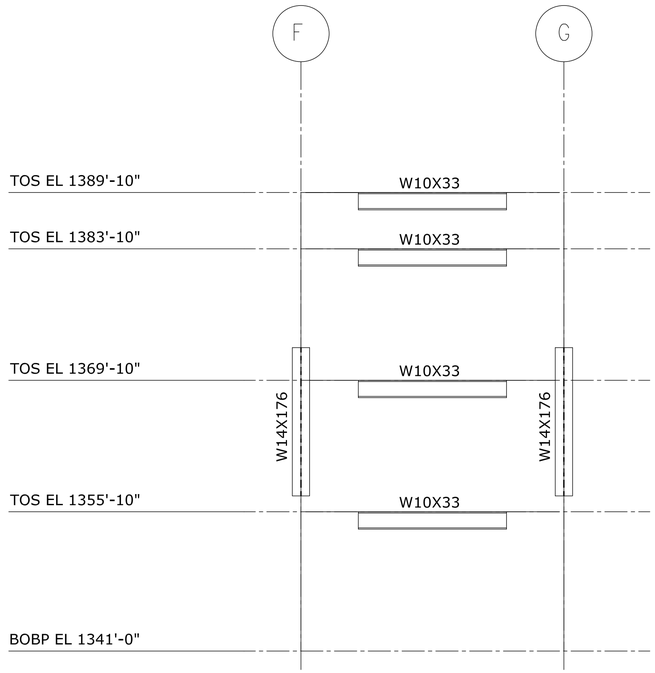
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
DUCT SUPPORT SECTION A STEEL
SOUTH ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00276	1 OF 1	C	AS NOTED



WEST ELEVATION @ COL LINE 6 & 8

SCALE: 1/8"=1'-0"



WEST ELEVATION @ COL LINE 7

SCALE: 1/8"=1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	TY	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

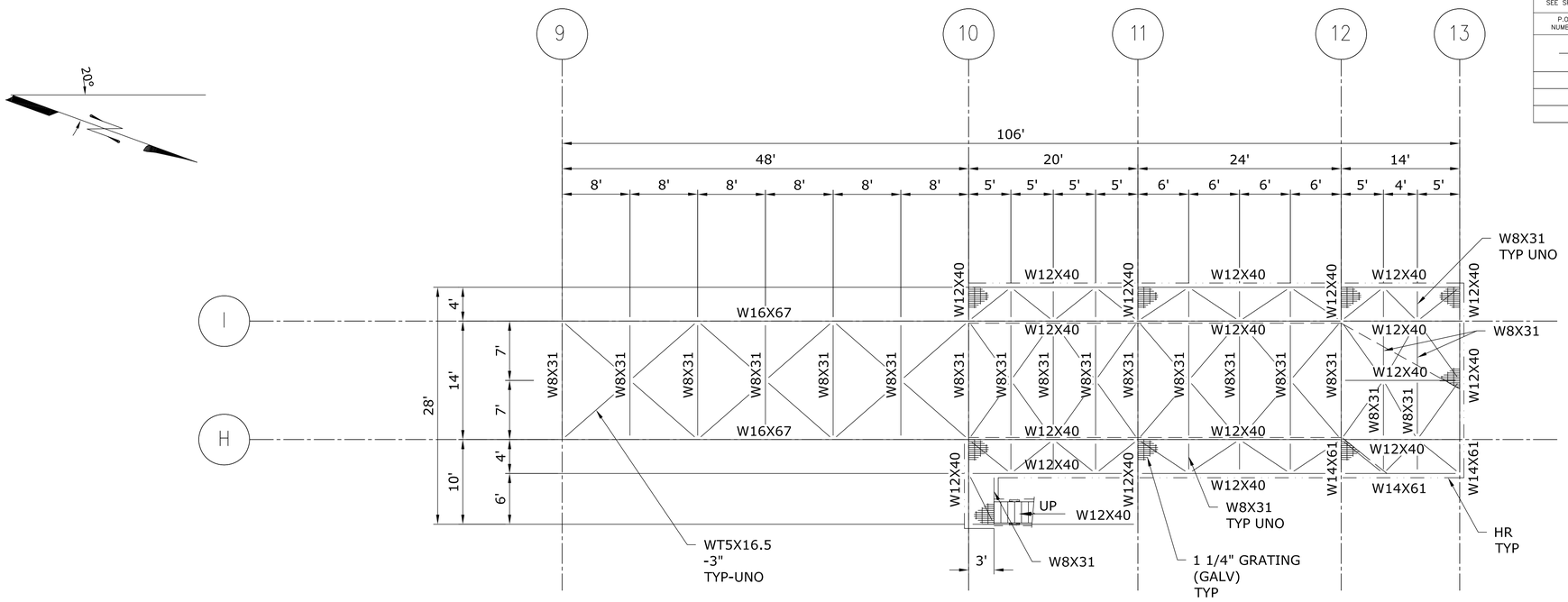
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

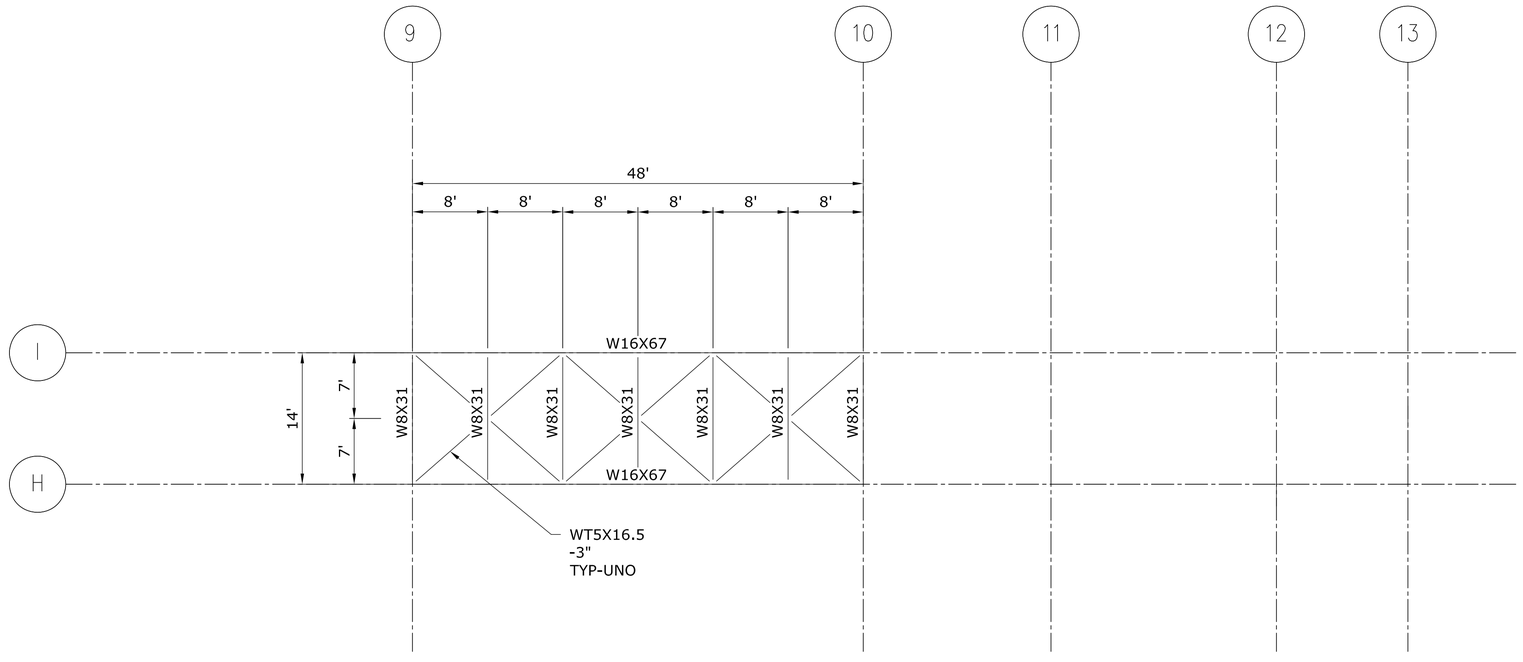
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
DUCT SUPPORT SECTION A STEEL
WEST ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00277	1 OF 1	C	AS NOTED



PLAN @ TOS 1389' 10"

SCALE: 1/8"=1'-0"



PLAN @ TOS 1385' 10"

SCALE: 1/8"=1'-0"

BILL OF MATERIAL

SEE SPECIFICATIONS — QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO REQD	SIZE	LENGTH	DESCRIPTION
—	—	237.93	TON	—	GALVANIZED STEEL INCLUDING STARIS, HANDRAILSM AND GRATING PER SKETCH EH-35R-CCU1-SKT-215-00278 THRU 281.

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	TY	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS — APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

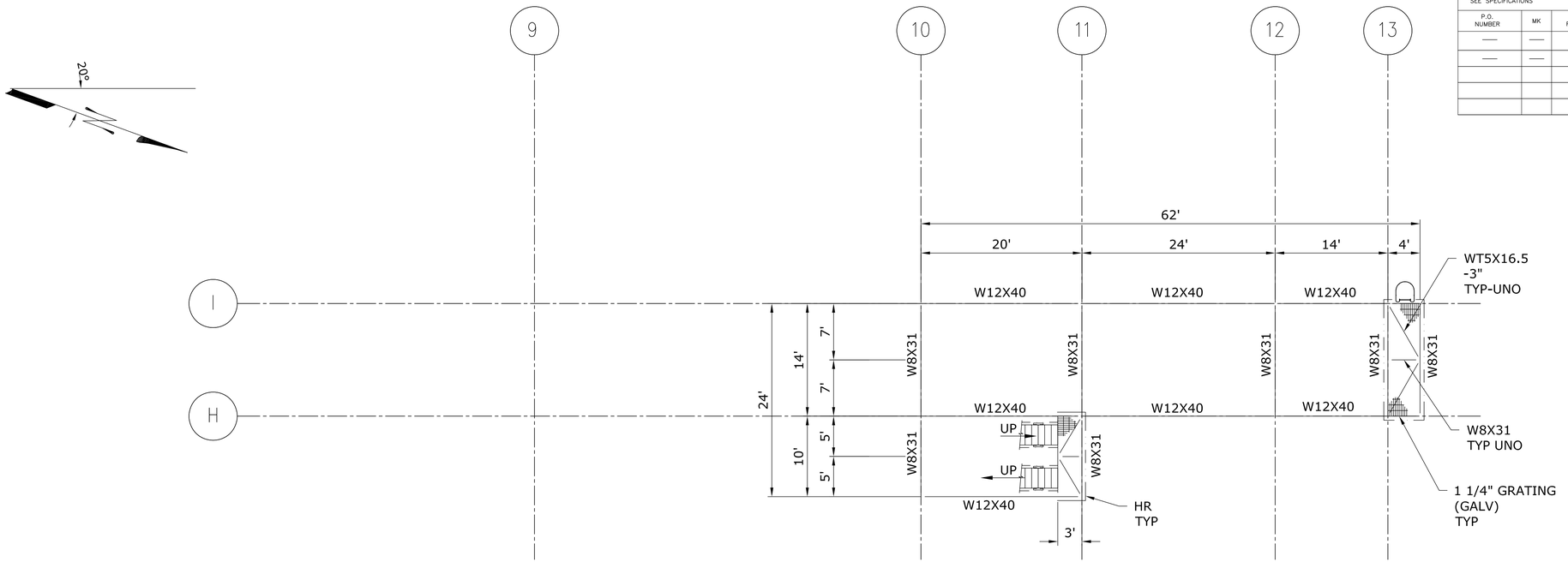
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
DUCT SUPPORT SECTION D1/D2 STEEL
PLANS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00278	1 OF 1	C	AS NOTED

BILL OF MATERIAL

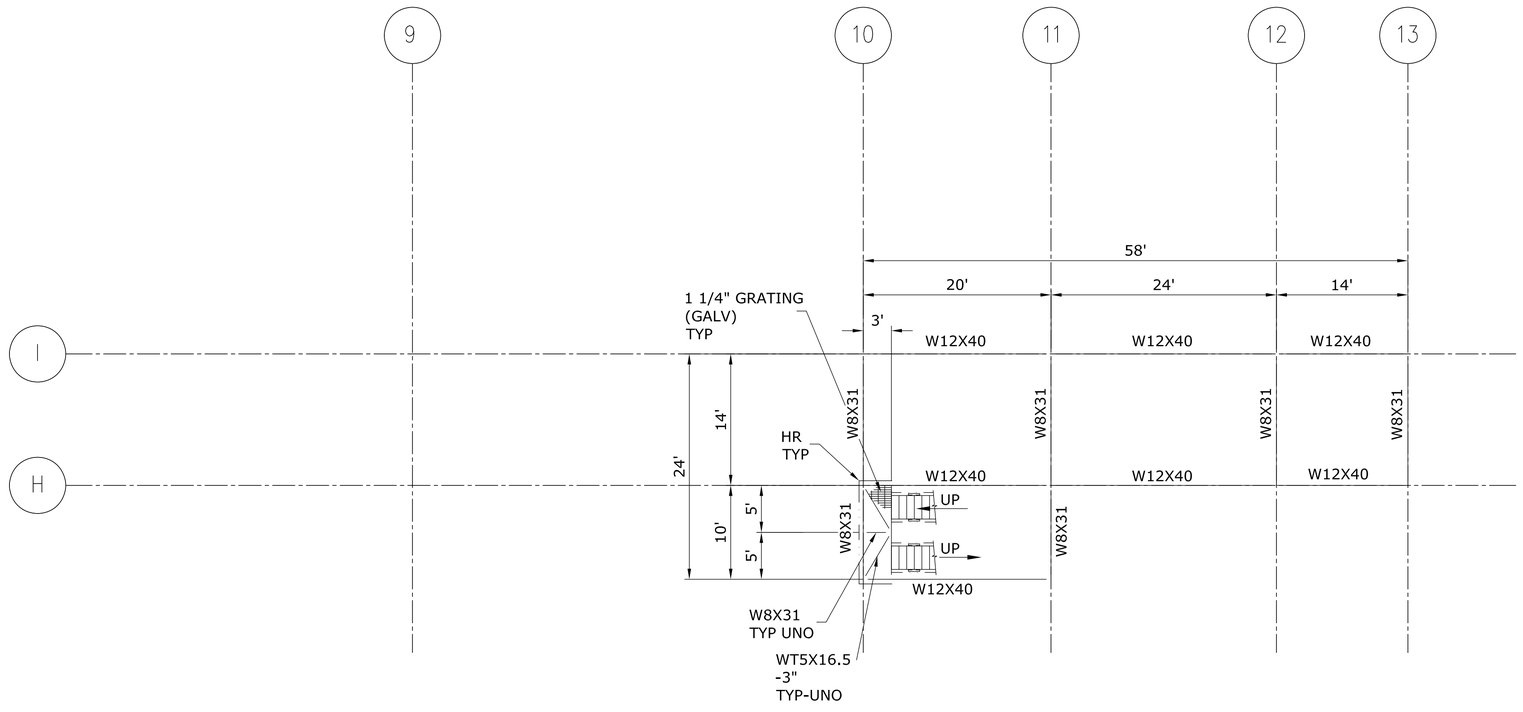
*SEE SPECIFICATIONS — QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO REQD	SIZE	LENGTH	DESCRIPTION
——	——	–	CU YDS	——	–
——	——	–	PILE	——	–



PLAN @ TOS 1380' 0" & TOS 1360'–0"

SCALE: 1/8"=1'-0"



PLAN @ TOS 1370' 0" & TOS 1350' 0"

SCALE: 1/8"=1'-0"

FLUOR.

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	TY	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

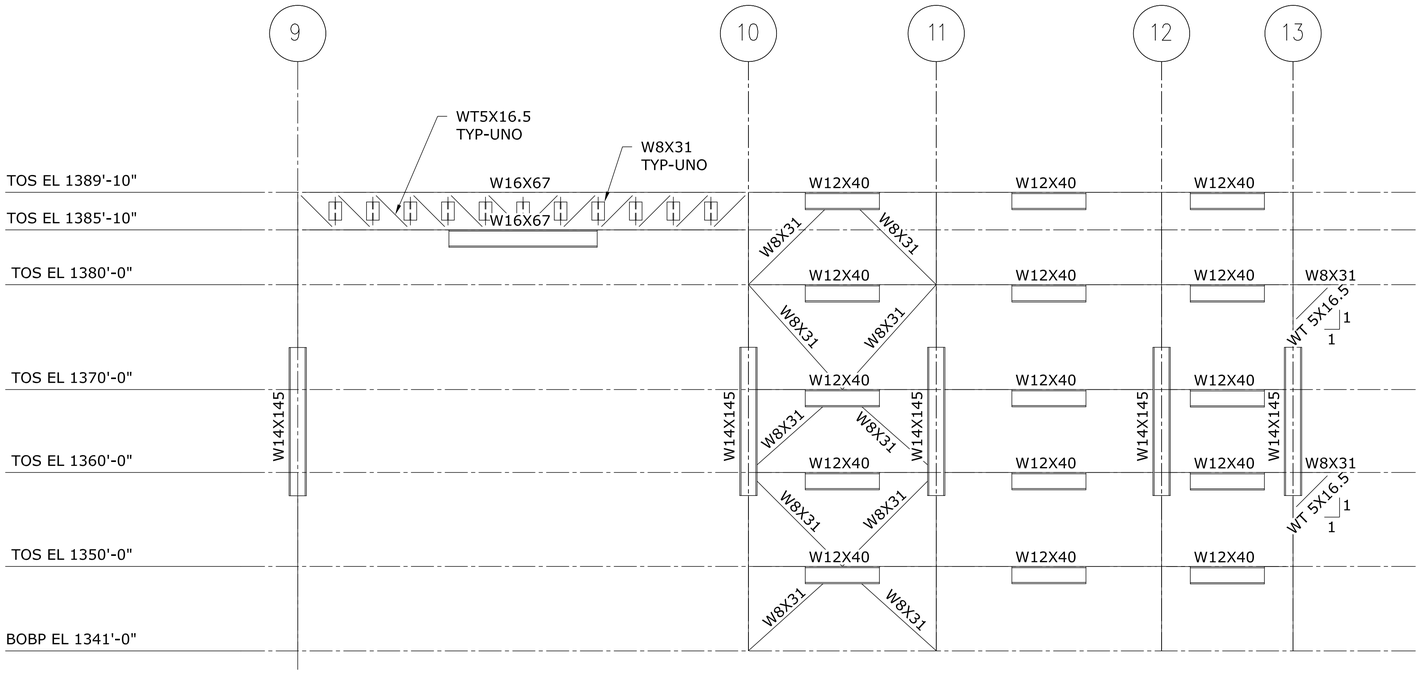
REVISIONS — APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

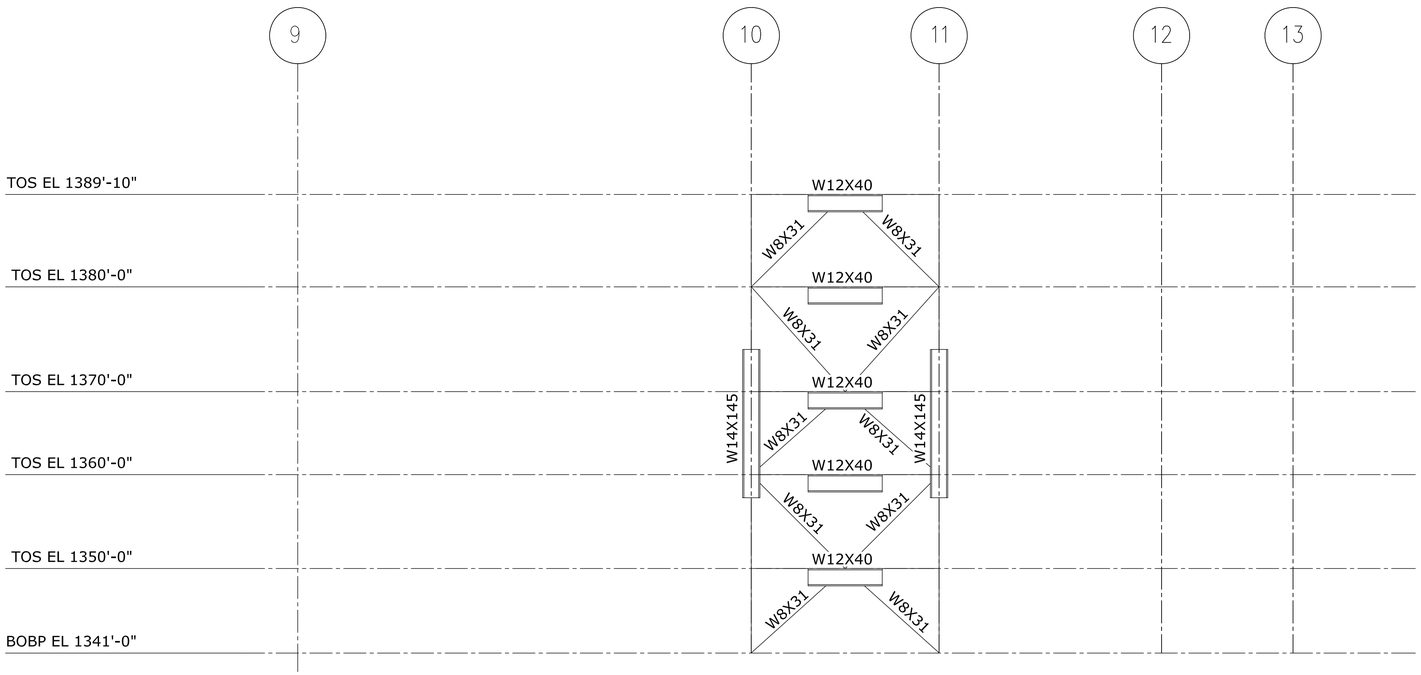
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
DUCT SUPPORT SECTION D1/D2 STEEL
PLANS

DRAWING No.	SHEET	REV.	SCALE
EH–35R–CCU1–SKT–215–00279	1 OF 1	C	AS NOTED



SOUTH ELEVATION @ COL LINE I & G

SCALE: 1/8"=1'-0"



SOUTH ELEVATION @ STAIR

SCALE: 1/8"=1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	TY	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

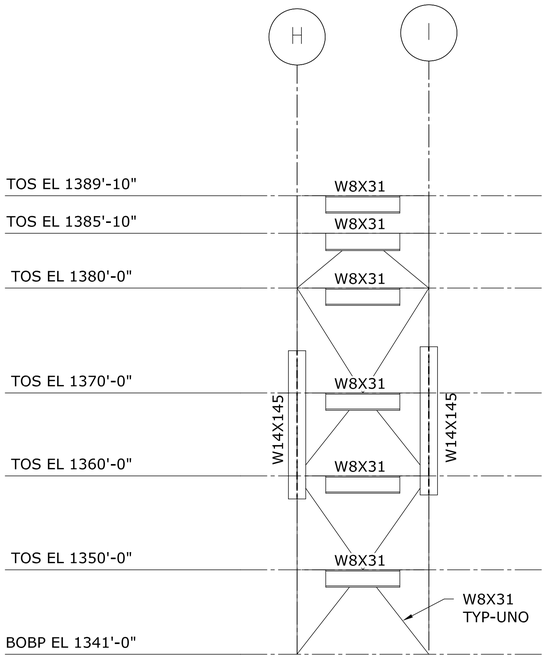
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

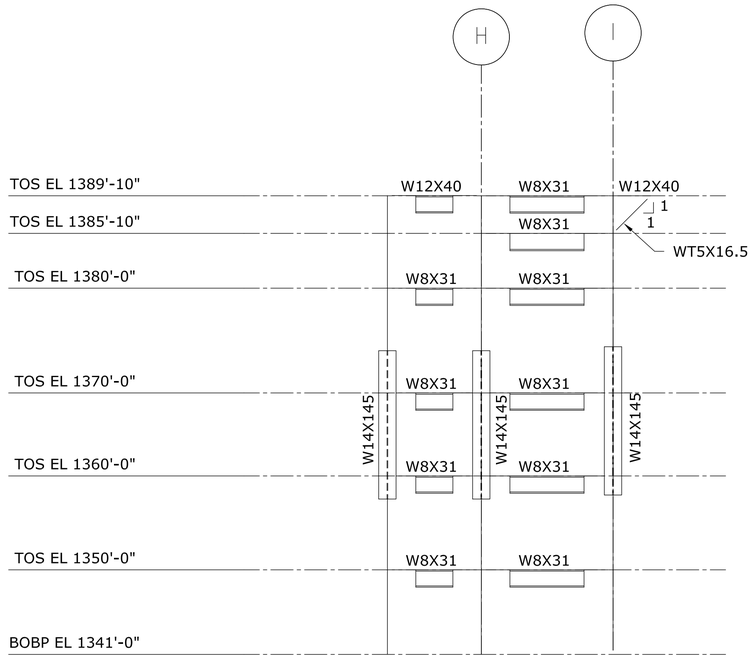
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
DUCT SUPPORT SECTION D1/D2 STEEL
SOUTH ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00280	1 OF 1	C	AS NOTED



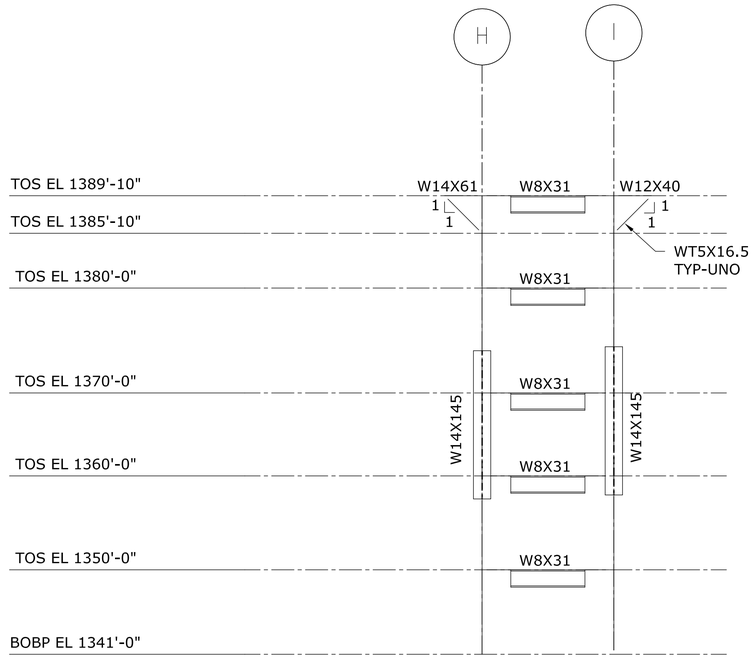
WEST ELEVATION @ COL LINE 9

SCALE: 1/8"=1'-0"



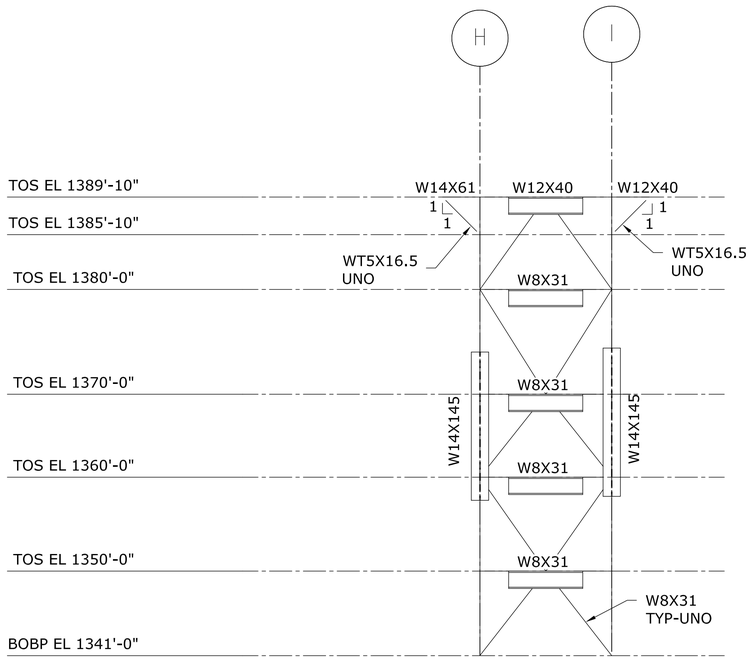
WEST ELEVATION @ COL LINE 10 & 11

SCALE: 1/8"=1'-0"



WEST ELEVATION @ COL LINE 12

SCALE: 1/8"=1'-0"



WEST ELEVATION @ COL LINE 13

SCALE: 1/8"=1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	TY	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
DUCT SUPPORT SECTION D1/D2 STEEL
WEST ELEVATIONS

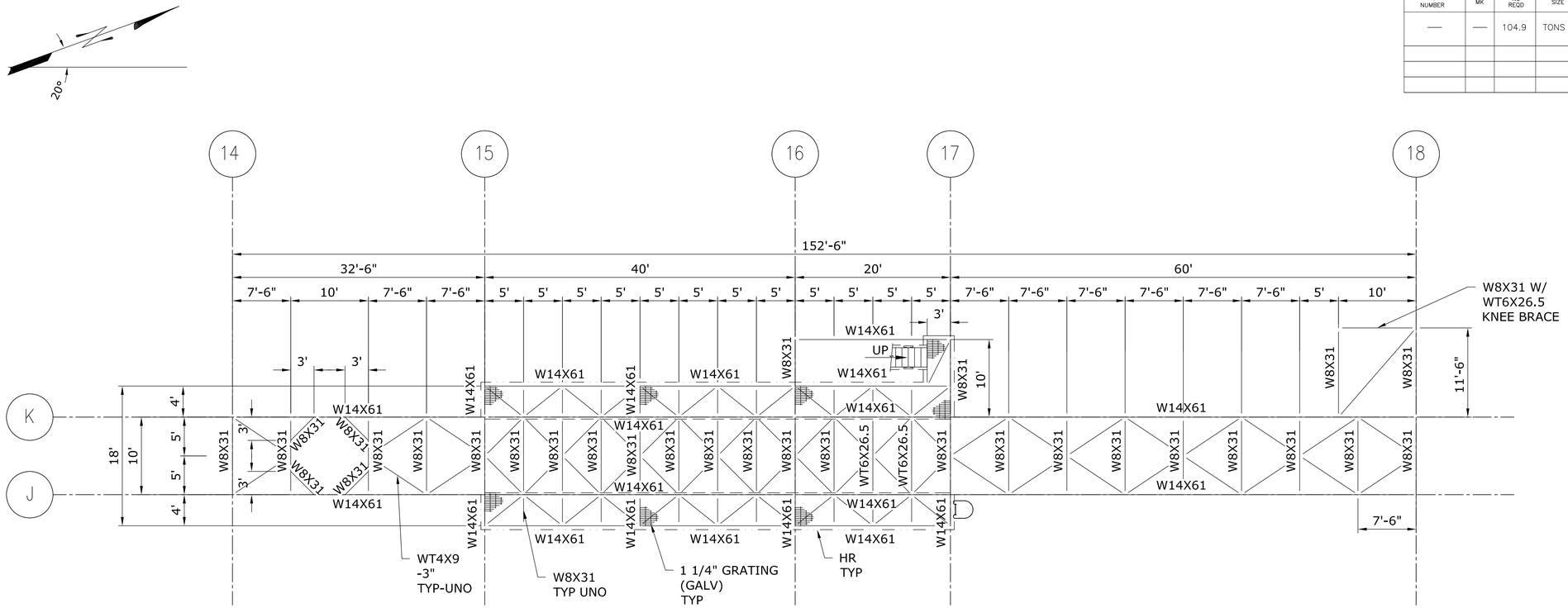
DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00281	1 OF 1	C	AS NOTED

BILL OF MATERIAL

*SEE SPECIFICATIONS

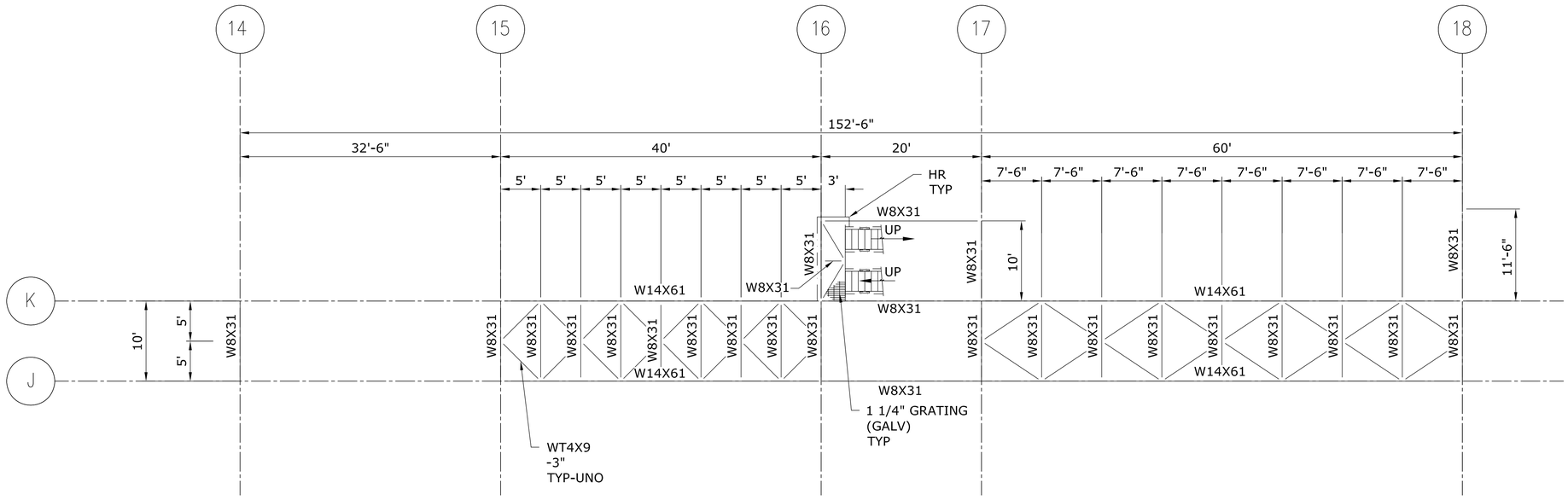
QUANTITIES LISTED ARE NET

P.O. NUMBER	MK	NO REQD	SIZE	LENGTH	DESCRIPTION
—	—	104.9	TONS	—	GALVANIZED STEEL INCLUDING STARIS, HANDRAILSM AND GRATING PER SKETCH EH-35R-CCU1-SKT-215-00282 THRU 285.



PLAN @ TOS 1386'-3"

SCALE: 1/8"=1'-0"



PLAN @ TOS 1380'-0"

SCALE: 1/8"=1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	TY	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

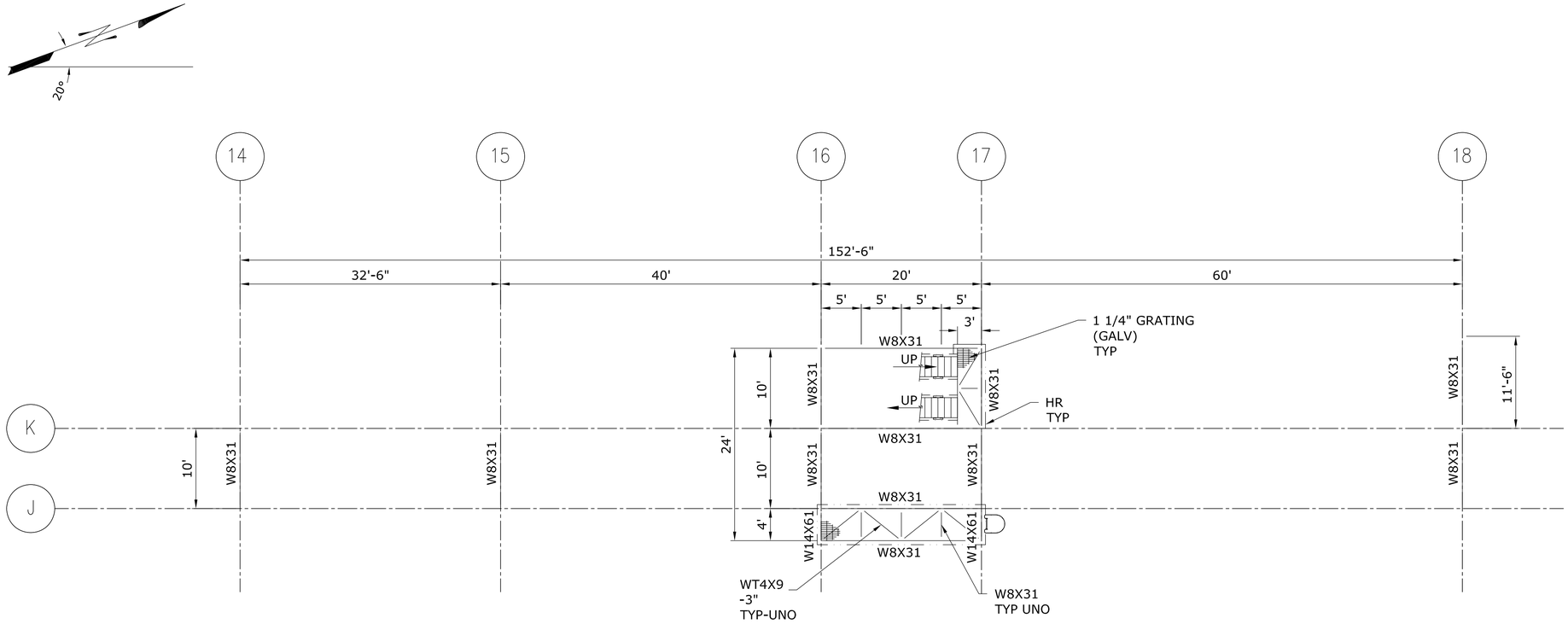
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

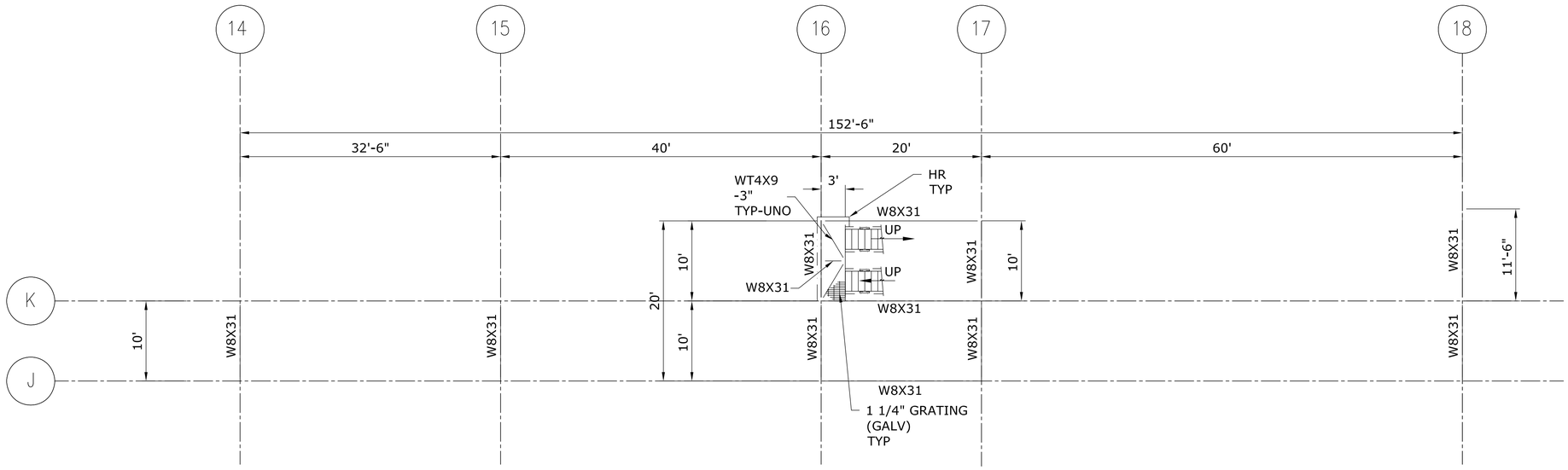
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
DUCT SUPPORT SECTION B STEEL
PLANS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00282	1 OF 1	C	AS NOTED



PLAN @ TOS 1370'–0" & 1350'–0"

SCALE: 1/8"=1'-0"



PLAN @ TOS 1360'–0"

SCALE: 1/8"=1'-0"

FLUOR.

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	TY	JT	WA	NP	WA
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A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

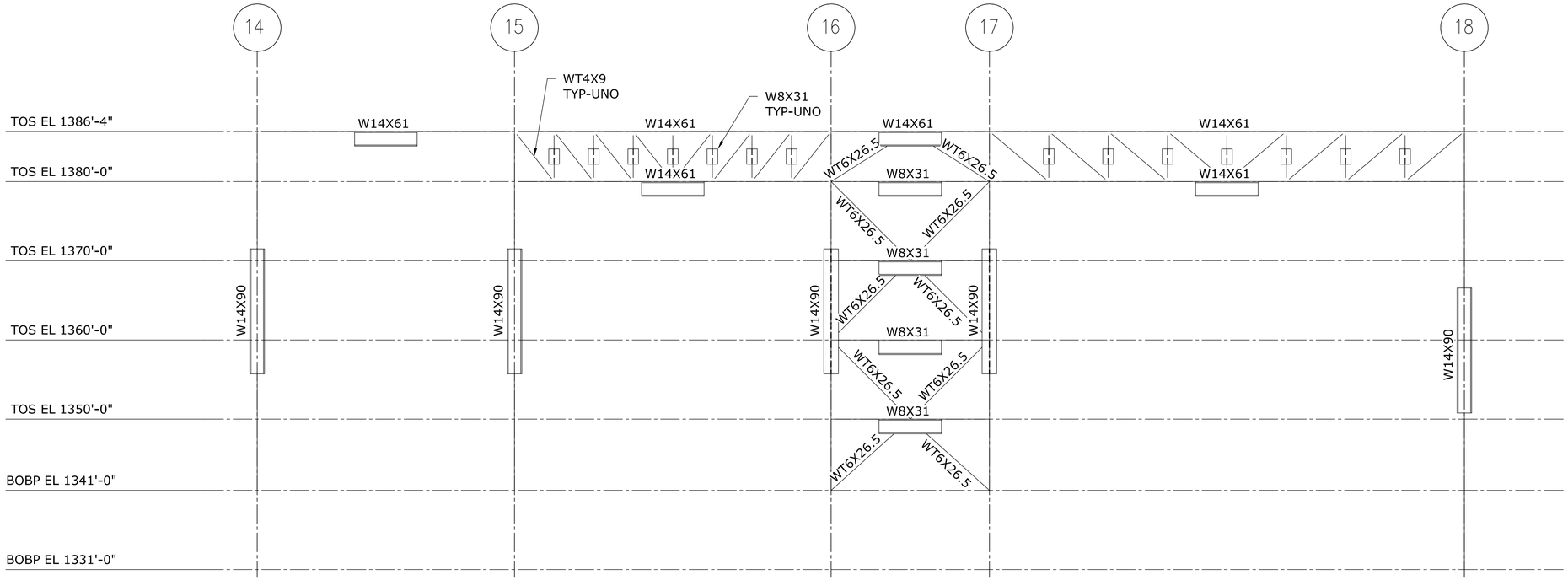
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

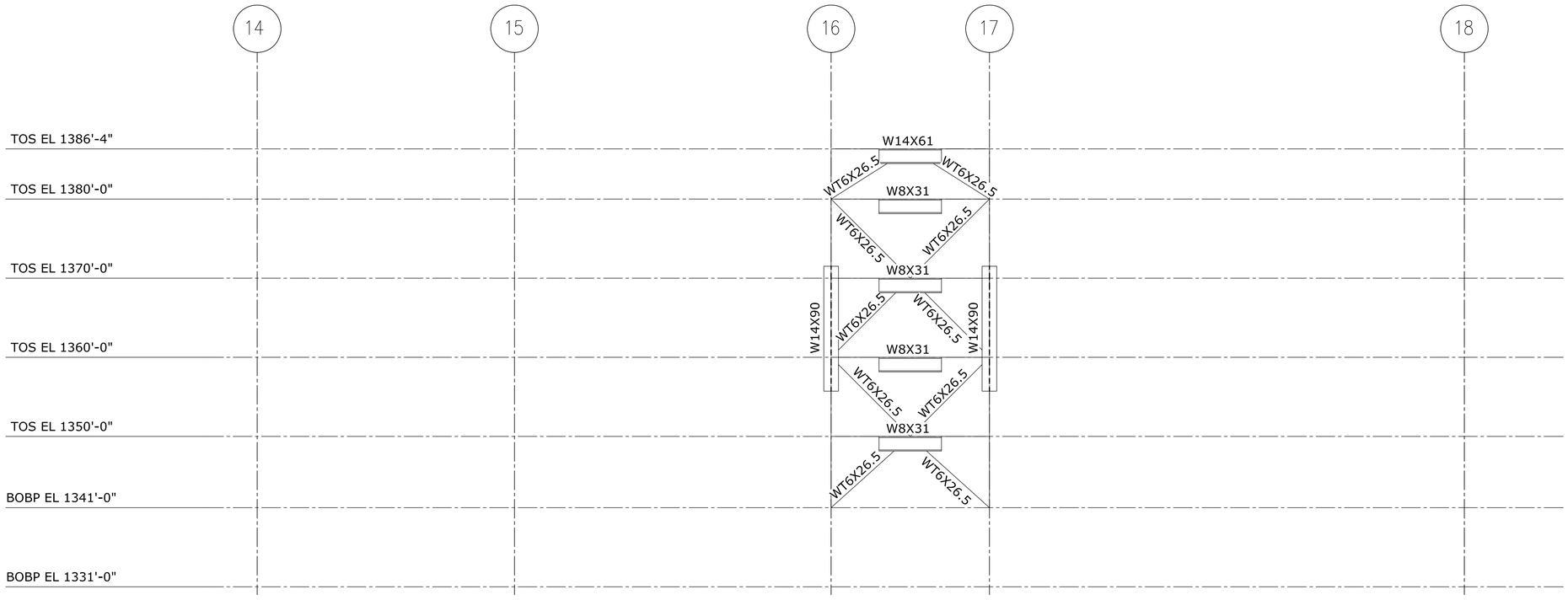
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
DUCT SUPPORT SECTION B STEEL
PLANS

DRAWING No.	SHEET	REV.	SCALE
EH–35R–CCU1–SKT–215–00283	1 OF 1	C	AS NOTED



SOUTH ELEVATION @ COL LINE K & J

SCALE: 1/8"=1'-0"



SOUTH ELEVATION @ STAIR

SCALE: 1/8"=1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	TY	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

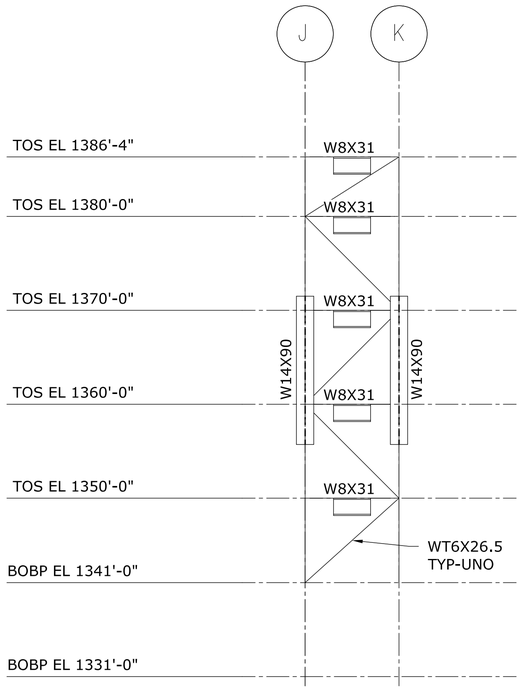
REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

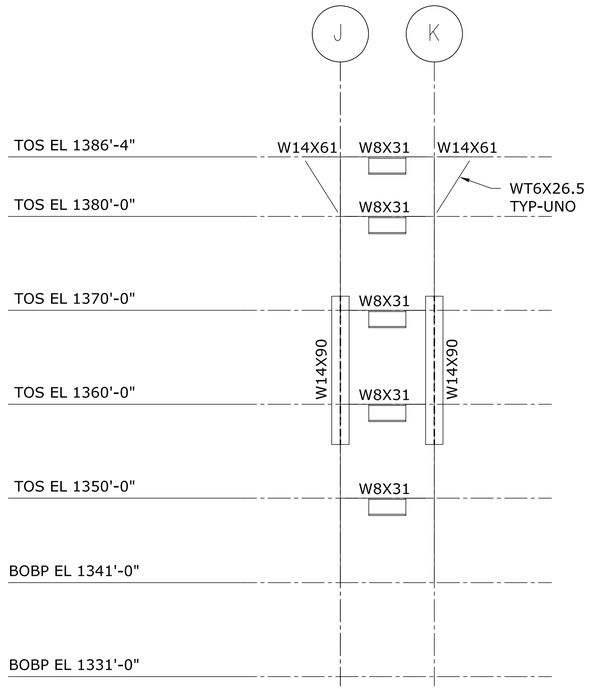
SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
DUCT SUPPORT SECTION B STEEL
SOUTH ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00284	1 OF 1	C	AS NOTED



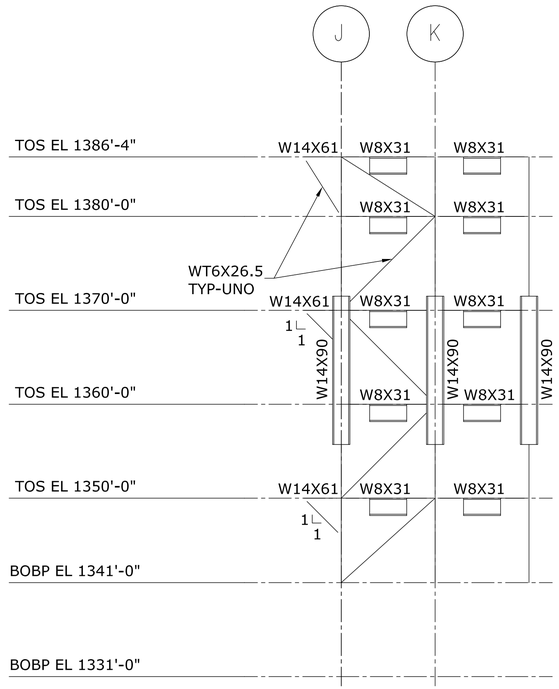
WEST ELEVATION @ COL LINE 14

SCALE: 1/8"=1'-0"



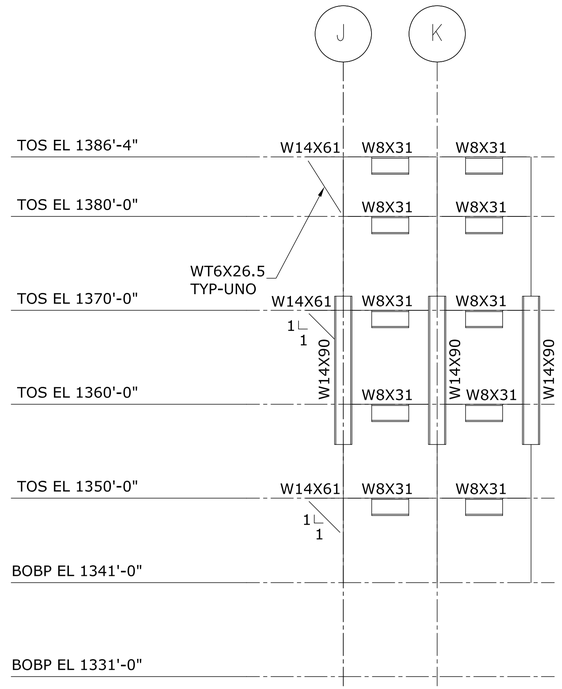
WEST ELEVATION @ COL LINE 15

SCALE: 1/8"=1'-0"



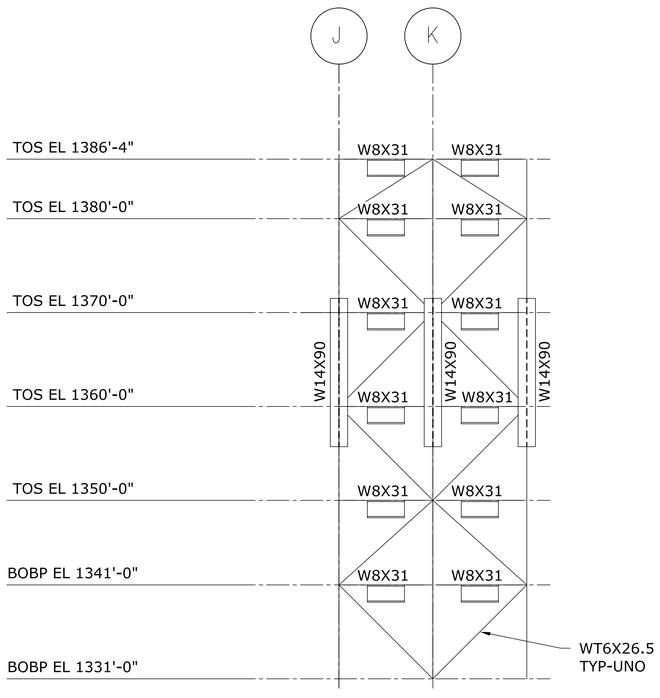
WEST ELEVATION @ COL LINE 15

SCALE: 1/8"=1'-0"



WEST ELEVATION @ COL LINE 16

SCALE: 1/8"=1'-0"



WEST ELEVATION @ COL LINE 18

SCALE: 1/8"=1'-0"

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	10/15/20	TY	JT	WA	NP	WA
B	ISSUED FOR REVIEW (NOT USED) AFE: WELL:						
A	INTERNAL ISSUE (NOT USED) AFE: WELL:						

REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT 1
DUCT SUPPORT SECTION B STEEL
WEST ELEVATIONS

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-SKT-215-00285	1 OF 1	C	AS NOTED

Attachment 8 – Mechanical Equipment Specifications

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

Axial and Centrifugal Compressors – API 617

Specification No. EH-35R-CCU1-SPC-255-56001

C	01-Jul-2020	Issued for FEED	24	AK	RB	BT	
B	08-Apr-2020	Issued for Review	24	AK	RB	BT	
A	30-Mar-2020	Issued for Internal Review	24	AK			
REV	**DATE**	**DESCRIPTION**	**PAGES**	**ORIG**	**CHK'D**	**APPV'D**	**CLIENT**

RECORD OF REVISIONS

REV. NO.	DATE	CHANGE DESCRIPTION
A	30-Mar-2020	Issued for Internal Review
B	08-Apr-2020	Issue for Client Review
C	01-Jul-2020	Incorporated Client Comments

Table of Contents

1.0 INTRODUCTION 4
1.1 Purpose 4
1.2 Scope 4
2.0 REFERENCES 4
2.1 Industry Codes and Standards 4
2.2 Project Specifications 4
3.0 DEFINITIONS 4
4.0 AMENDMENTS TO API 617 5
5.0 ATTACHMENTS 24

1.0 INTRODUCTION

1.1 Purpose

This specification, EH-35R-CCU1-SPC-255-56001, serves as an overlay for American Petroleum Institute (API) Standard 617 with applicable additions, deletions, modifications, and clarifications listed with associated paragraphs.

1.2 Scope

EH-35R-CCU1-SPC-255-56001, along with API 617, describes Axial and Centrifugal Compressors and Expander-compressors.

2.0 REFERENCES

Applicable requirements in the latest edition (or the edition indicated) of API 617 shall be considered an integral part of this Practice. Additional references are listed below. Short titles will be used herein when appropriate.

2.1 Industry Codes and Standards

- American Petroleum Institute (API)
  - API 617, *Axial and Centrifugal Compressors and Expander-compressors, Eighth Edition, September 2014 with Errata 1, August 2016.*

2.2 Project Specifications

- EH-35R-CCU1-SPC-215-00002, Structural Data For Mechanical Equipment
- EH-35R-CCU1-SPC-250-50112, Packaged Equipment Piping
- EH-35R-CCU1-SPC-255-56066, Special Purpose Gear Units – API 613
- EH-35R-CCU1-SPC-255-56070, General Purpose Induction Motors – 3/4 HP Through 200 HP – IEEE 841
- EH-35R-CCU1-SPC-255-56071, Special Purpose Induction Motors - API 541
- EH-35R-CCU1-SPC-255-56074, Synchronous Motors and Generators – API 546
- EH-35R-CCU1-SPC-255-85012, Positive Material Identification (PMI)
- EH-35R-CCU1-SPC-265-00002, Electrical Requirements for Packaged Equipment
- EH-35R-CCU1-SPC-270-00003, Packaged Equipment Instrumentation

3.0 DEFINITIONS

Definitions as provided in API 617 are applicable to this specification. No additional definitions are applicable.

4.0 AMENDMENTS TO API 617

The following items are amendments to API 617. The section and paragraph numbers refer to those given in that specification. An "**Add**" to a API paragraph expands on the requirements or selects options; "**Substitute**" replaces the entire paragraph or sentences; "**Modify**" means the original text has been changed to reflect project requirements; "**New**" is for a new paragraph/section to be added.

	Amendment Description
Part 1	**The following amendments apply to API 617, Part 1, General Requirements.**
Part 1 Par. 2.1	**Modify:** The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies. **To Read:** The following referenced documents are indispensable for the application of this document. For dated and undated references, the latest edition of the referenced document (including any amendments), regardless of the date or edition cited, applies.
Part 1 Par. 2.1	**Substitute:** AGMA 2015-1-A01 2001, *Accuracy Classification System—Tangential Measurements for Cylindrical Gears* **To Read:** ANSI/AGMA ISO 1328-1-B141, *Cylindrical Gears - ISO System of Flank Tolerance Classification - Part 1: Definitions and Allowable Values of Deviations Relevant to Flanks of Gear Teeth*
Part 1 Par. 2.1	**Add:** API Standard 692, *Dry Gas Sealing Systems for Axial, Centrifugal, Rotary Screw Compressors and Expanders*
Part 1 Par. 2.2	**Substitute:** The hierarchy of documents shall be specified. **To Read:** When conflicts exist between this specification and other documents, the following order of precedence will govern: a. Purchase Order b. Data Sheets c. This Specification d. Other Referenced Project Specifications

	e. API Standard 617, 8th edition, Sept. 2012 with Errata 1, Aug. 2016. f. Other Referenced Industry Standards
Part 1 Par. 4.1	**Substitute:** Drawings and maintenance dimensions shall be in SI units or U.S. customary (USC) units. Use of an SI datasheet indicates that SI units shall be used. Use of an USC datasheet indicates that USC units shall be used. **To Read:** Drawings and maintenance dimensions shall be in U.S. customary (USC) units. An USC datasheet shall be used.
Part 1 Par. 4.1.1	**New:** Metric 'o'-rings, seal parts, fasteners and flanges are acceptable only when specifically approved by Purchaser.
Part 1 Par. 4.3.1	**Modify:** The supplier shall assume unit responsibility for all equipment and all auxiliary systems included in the scope of the order. **To Read:** The compressor vendor shall assume unit responsibility for all equipment and all auxiliary systems included in the scope of the order.
Part 1 Par. 4.4.1.6	**Substitute:** The applicable electrical codes and area classification shall be specified. **To Read:** The *National Electrical Code* NFPA 70, Articles 500-505 shall be applied to all electrical equipment and installations. Equipment shall conform to the area classification specified.
Part 1 Par. 4.4.1.9	**Add:** The equipment shall be suitable for outdoor installation. Structural design data, such as wind loads and seismic zone, is specified in Project Specification EH-35R-CCU1-SPC-215-00002.
Part 1 Par. 4.4.1.10	**Modify:** The equipment furnished by the supplier shall conform to the maximum allowable sound pressure level specified. **To Read:** The equipment furnished by the supplier shall conform to a maximum allowable sound pressure level of 85 dBA measured at 3 ft (1 m) from the equipment boundary.
Part 1 Par. 4.4.5	**Modify:** Motors, generators, instrumentation, electrical components, and electrical installations … shall meet the requirements of IEC 60079-10-1:2008 or NFPA

	70:2008, Articles 500 through 505 as applicable, as well as local codes specified and furnished by the purchaser. **To Read:** Motors, generators, instrumentation, electrical components, and electrical installations … shall meet the requirements of NFPA 70, Articles 500 through 505 as applicable, as well as local codes specified and furnished by the purchaser.
Part 1 Par. 4.5.1.16	**Substitute:** If specified, copper or copper alloys shall not be used for parts of machines or auxiliaries in contact with process fluids. **To Read:** Copper and copper alloys shall not be used for parts of machines or auxiliaries in contact with process fluids.
Part 1 Par. 4.5.1.18	**Substitute:** The extent of positive material identification (PMI) testing shall be specified for materials, welds, fabrications, and piping. This shall be fully defined, including any sampling requirements. **To Read:** Positive material identification (PMI) testing shall be performed in accordance with Project Specification EH-35R-CCU1-SPC-255-85012.
Part 1 Par. 4.5.2.3.1	**Add:** Post weld heat treatment on individual weld repairs after final machining may be performed by local heat treatments.
Part 1 Par. 4.6.1.1.1	**Modify:** The allowable tensile stress used in the design of the pressure casing (excluding bolting) for any material shall not exceed 0.25 times the minimum ultimate tensile strength for that material at the maximum specified operating temperature. **To Read:** The allowable tensile stress used in the design of the pressure casing for any material shall be less than 0.25 times the minimum ultimate tensile strength and 0.67 times the minimum yield strength for that material at the maximum specified operating temperature. NOTE: This is intended to apply to the average hoop stress of the casing.
Part 1 Par. 4.6.1.3.3	**New:** Steel casings shall be used for predicted discharge temperatures over 350 °F at maximum continuous speed at any point within the operating range.

Part 1 Par. 4.6.2.4.3	**Substitute:** If specified, the quality control of welds that will be inaccessible on completion of the fabrication shall be agreed on by the purchaser and supplier prior to fabrication. **To Read:** The quality control of welds that will be inaccessible on completion of the fabrication shall be per supplier standards. Supplier shall advise the location of such welds and the methods of inspection to be employed.
Part 1 Par. 4.6.2.4.5	**Modify:** Casings and fabrications that require machining to precise dimensions and tolerances to assure assembly shall be heat treated regardless of thickness. **To Read:** Casings and fabrications shall be stress relieved by heat treating regardless of thickness.
Part 1 Par. 4.6.2.4.5	**Add:** All welding on the casing including but not limited to auxiliary piping, lifting lugs, clips, guide keys, support pads and feet shall be completed prior to heat treating unless specifically approved otherwise by Purchaser. Areas where temporary lugs or clips are removed after heat treatment shall be ground smooth and subjected to the same NDT as required for the case, with visual inspection as a minimum. Temporary connections shall not be hammered off.
Part 1 Par. 4.6.3.2.3	**New:** All pressure-containing casing welds shall be 100 percent radiographed or UT examined. This examination shall be performed prior to heat treating. Any welds which require repair as a result of the first radiograph or UT examination shall be given another examination after the weld has been repaired to assure weld integrity. A final UT examination shall be given after post-weld heat treatment.
Part 1 Par. 4.6.4.1.7	**Add:** Individual stage drains shall be provided if the vendor cannot show that their standard design provides complete drainage of all gas passages.
Part 1 Par. 4.6.4.1.8	**New:** Casing drains shall be flanged, individually valved, manifolded and terminated with a flanged connection at the edge of the baseplate.
Part 1 Par. 4.6.4.3.3	**Modify:** Auxiliary connections other than oil or dry gas seal connections shall be socket-welded and flanged or machined and studded. **To Read:** Auxiliary connections other than lube oil, seal oil, or dry gas seal operation shall be socket-welded and flanged or machined and studded.

Part 1 Par. 4.6.4.3.4	**Substitute:** Auxiliary connections for lube oil, seal oil, or dry gas seal operation shall use weld-neck or slip-on flanges only. NOTE Socket-weld is not allowed due to the possibility of a dirt trap. **To Read:** Auxiliary connections for lube oil, seal oil, or dry gas seal operation shall use weld-neck flanges or machined and studded. Socket-weld flanges are not allowed due to the possibility of a dirt trap.
Part 1 Par. 4.6.4.3.5	**Modify:** Pipe nipples screwed or welded to the casing, preferably not more than 150 mm (6 in.) long, shall be a minimum of Schedule 160 seamless for sizes DN 25 (NPS 1) and smaller and a minimum of Schedule 80 for DN 40 (NPS 1 1/2). **To Read:** Pipe nipples shall be a minimum of Schedule 160 seamless for sizes DN 25 (NPS 1) and smaller and a minimum of Schedule 80 for DN 40 (NPS 1 1/2).
Part 1 Par. 4.6.4.3.6	**Substitute:** Each pipe nipple shall be provided with a welding-neck, socket-weld, or slip-on flange, except as indicated below. **To Read:** Each pipe nipple shall be terminated with a welding-neck or socket-weld flange, as allowed in 4.6.4.3.3 and 4.6.4.3.4 above.
Part 1 Par. 4.6.4.3.8.1	**Substitute:** Threaded openings for tapered pipe threads shall conform to ASME B1.20.1 or ISO 7- l:1994 as specified. If ISO 7-1:1994 has been specified, tapered or straight internal threads shall also be specified. **To Read:** Threaded openings for tapered pipe threads shall conform to ASME B1.20.1.
Part 1 Par. 4.6.4.3.8.2	**Substitute:** Pipe threads shall be taper thread conforming to ASME B1.20.1 or ISO 7-1 as specified. **To Read:** Pipe threads shall be taper thread conforming to ASME B1.20.1.
Part 1 Par. 4.6.4.3.8.4	**Modify:** For threaded connections that are connected to pipe, a pipe nipple, preferably not more than 150 mm (6 in.) long, schedule 160 seamless minimum, shall be installed in the threaded opening. Each pipe nipple shall be provided with a welding-neck, socket-weld or slip-on flange. The nipple and flange

	materials shall meet the requirements of 4.6.4.1.4. **To Read:** For threaded connections that are connected to pipe, a pipe nipple, preferably not more than 150 mm (6 in.) long, schedule 160 seamless minimum, shall be installed in the threaded opening. Each pipe nipple shall be terminated with a welding-neck or socket-weld flange. The nipple and flange materials shall meet the requirements of 4.6.4.1.4.
Part 1 Par. 4.7.6	**Substitute:** When replaceable collars are furnished (for assembly and maintenance purposes), they shall be positively locked to the shaft to prevent fretting. **To Read:** Integral thrust collars are preferred. If removable collars are furnished (for assembly and maintenance purposes), they shall be locked to the shaft to prevent movement axially and tangentially and mounted to the shaft with an interference fit to minimize fretting.
Part 1 Par. 4.7.10.8	**Modify:** Metal plating of impeller bores is not permitted without purchaser's approval. **To Read:** Plating or coating of the impeller bore is not permitted without purchaser's approval.
Part 1 Par. 4.8.1.3	**Substitute:** If specified, the supplier with unit responsibility shall communicate the existence of any undesirable running speeds in the range from zero to trip speed. **To Read:** The vendor with unit responsibility shall communicate the existence of any undesirable running speeds in the range from zero to 150% N_{mc} (MCS).
Part 1 Par. 4.8.8.2.1	**Substitute:** c) The supplier shall provide historic unbalance data readings of the change in balance due to disassembly and reassembly. This change in unbalance shall not exceed 4 times the sensitivity of the balance machine. For this purpose, balance machine sensitivity is 0.254 μm (10 μin.) maximum. **To Read:** c) The supplier shall provide historic unbalance data readings of the change in balance due to disassembly and reassembly. This resulting unbalance shall not exceed two times the specified balance requirement.

Part 1 Par. 4.8.8.2.1	**Modify:** d) The supplier shall conduct an analysis in accordance with 4.8.2, to predict the vibration level during testing, using an unbalance equal to that in Item b), plus 2 times the average change in balance due to disassembly and reassembly as defined in Item c). The results of this analysis shall show that the predicted vibration at design speed on test shall be no greater than 2 times the requirements of 4.8.8.8. **To Read:** d) The supplier shall conduct an analysis in accordance with 4.8.2, to predict the vibration level during testing, using an unbalance equal to that in Item b), plus 2 times the average change in balance due to disassembly and reassembly as defined in Item c). The results of this analysis shall show that the predicted vibration at each vibration probe over the range N_{ma} to N_{mc} (MCS) shall be no greater than 2 times the requirements of 4.8.8.8.
Part 1 Par. 4.9.4.7	**New:** To prevent the buildup of potential voltages in the bearing housing, residual magnetism of the free air gauss level shall not exceed ±4 gauss when measured with a calibrated Hall effect probe.
Part 1 Par. 4.10.1.10	**Substitute:** NOTE 1 See API 614, Fifth Edition, Part 4, Annex D for definitions of buffer and seal gas. **To Read:** NOTE 1 See API 692, Part 1 for definitions of buffer and seal gas.
Part 1 Par. 4.10.4	**Substitute:** NOTE 1 Refer to API 614, Fifth Edition, Part 4, Annex D for dry gas seal nomenclature. **To Read:** NOTE 1 Refer to API 692, Part 2, Annex C for dry gas seal nomenclature.
Part 1 Par. 4.10.4	**Substitute:** NOTE 2 See API 614, Fifth Edition, Part 4, Annex A for dry gas seal support system datasheets. **To Read:** NOTE 2 See API 692, Part 3, Annex A for dry gas seal support system datasheets.
Part 1 Par. 4.10.4.1	**Add:** Dry gas seals shall be in accordance with API 692.
Part 1 Par. 4.10.4.1	**Modify:** Typical configurations are shown in Figure B.6, Figure B.7, Figure B.8, and Figure B.9. **To Read:** Typical configurations are shown in API 692, Part 2, Figures 1, 2, 3 & 4.

Part 1 Par. 4.10.4.1	**Modify:** The design of the gas seal support system is detailed in API 614, Fifth Edition, Part 4. **To Read:** The design of the gas seal support system is detailed in API 692, Part 3.
Part 1 Par. 4.10.4.2	**Modify:** Seal support systems for self-acting dry gas seals shall be in accordance with API 614, Fifth Edition, Part 4. **To Read:** Seal support systems for self-acting dry gas seals shall be in accordance with API 692, Part 3.
Part 1 Par. 4.12.4	**Modify:** SI or USC units shall be specified for use on the nameplate. **To Read:** USC units shall be used on the nameplate.
Part 1 Par. 5.1.5	**Add:** Motors shall also conform to Project Specification EH-35R-CCU1-SPC-255-56071 or EH-35R-CCU1-SPC-255-56074, as applicable.
Part 1 Par. 5.1.7	**New:** Separate gear units shall also conform to Project Specification EH-35R-CCU1-SPC-255-56066.
Part 1 Par. 5.1.8	**New:** Auxiliary motor drivers shall conform to IEEE 841 and Project Specification EH-35R-CCU1-SPC-255-56070.
Part 1 Par. 5.2.2	**New:** Coupling guards shall be fully enclosed and fabricated from spark-resistant materials.
Part 1 Par. 5.4.2.1.1	**Modify:** If specified, baseplates shall be equipped with a drain rim (see Figure 6). **To Read:** Baseplates shall be equipped with a drain rim (see Figure 6).
Part 1 Par. 5.4.2.4.1	**Modify:** If specified, horizontal solid decked surfaces shall be sloped to avoid collection of liquid. **To Read:**

	Horizontal solid decked surfaces shall be sloped to avoid collection of liquid.
Part 1 Par. 5.4.2.8	**Modify:** It shall be provided with at least one grout hole having a clear area of at least 100 cm2 (16 in.2) and no less than 75 mm (3 in.) in each bulkhead section. **To Read:** Each bulkhead section covered by decking shall be provided with grout holes having a total clear area of at least 125 cm^2 (20 $in.^2$). No grout hole shall be less than 75 mm (3 in.) in diameter.
Part 1 Par. 5.4.2.14	**New:** A minimum of two grounding lugs, installed diagonally at opposite ends of the baseplate, shall be provided. Lugs shall be NEMA standard two-hole, straight / long barrel compression type suitable to accept Purchaser's #4/0 AWG copper conductor.
Part 1 Par. 5.5.1.4	**Substitute:** The purchaser shall specify that controls and instruments are designed for outdoor or indoor installation. **To Read:** Controls and instruments shall be designed for outdoor installation.
Part 1 Par. 5.5.1.8	**Add:** The areas on either side of the coupling(s) shall be kept clear and unobstructed.
Part 1 Par. 5.5.1.9	**New:** All terminal connections and interconnecting wiring of the components installed on each skid shall be done by the Vendor. All wiring shall terminate in junction boxes for connection to Purchaser's external conduit and wiring.
Part 1 Par. 5.5.2.1	**Add:** A PLC-based control system with capability to communicate with Purchaser's DCS over Ethernet shall be provided by the Vendor.
Part 1 Par. 5.5.2.2	**Modify:** If specified, an anti-surge system shall be provided. The scope of supply shall be agreed. **To Read:** Vendor shall provide anti-surge control as part of the control system.
Part 1 Par. 5.5.2.3	**Modify:** If specified, the supplier shall supply the anti-surge valve. **To Read:**

	Vendor shall size and supply the anti-surge valve(s).
Part 1 Par. 5.5.2.4	**Modify:** If specified, the supplier shall supply the results of an anti-surge system transient response simulation. **To Read:** The supplier shall supply the results of an anti-surge system transient response simulation.
Part 1 Par. 5.5.3	**Add:** Refer also to Project Specification EH-35R-CCU1-SPC-270-00003.
Part 1 Par. 5.5.4	**Add:** Refer also to Project Specification EH-35R-CCU1-SPC-265-00002.
Part 1 Par. 5.5.5	**Modify:** Refer to API 614, Fifth Edition and API 670:2010 for details on alarms, shutdowns, and control systems. **To Read:** Refer to API 614, Fifth Edition and API 670 for details on alarms, shutdowns, and control systems.
Part 1 Par. 5.5.6	**Add:** Refer also to Project Specification EH-35R-CCU1-SPC-270-00003.
Part 1 Par. 5.6.1.2	**Modify:** Auxiliary systems furnished shall be in accordance with API 614, Fifth Edition, Part 2 (*Special Purpose Oil Systems*) and API 614, Fifth Edition, Part 4 (*Self-acting Gas Seal Support Systems*). **To Read:** Auxiliary systems furnished shall be in accordance with API 614, Fifth Edition, Part 2 (*Special Purpose Oil Systems*) and API 692, Part 3 (*Dry Gas Sealing Systems for Axial, Centrifugal, Rotary Screw Compressors and Expanders*.
Part 1 Par. 5.6.1.6	**Modify:** Provision shall be made for bypassing the dry gas seals to allow blowing of the supply lines prior to operation. **To Read:** Provision shall be made for flushing dry gas seal system interconnecting piping prior to operation. Note: Refer to API 692 Part 4 Annex B for cleaning/flushing of field installed piping.
Part 1 Par. 5.6.3	**Modify:**

	Process piping, if furnished, shall be in accordance with API 614, Fifth Edition, Part 1. **To Read:** Process piping, if furnished, shall be in accordance with Project Specification EH-35R-CCU1-SPC-250-50112.
Part 1 Par. 5.6.4	**New:** **5.6.4 Cooling Water Piping** Cooling water piping, if furnished, for process intercoolers, recycle coolers and aftercoolers furnished by the vendor shall be in accordance with Project Specification EH-35R-CCU1-SPC-250-50112.
Part 1 Par. 6.3.2.4	**New:** The test liquid shall be at a higher temperature than the nil-ductility transition temperature of the material being tested. NOTE: The nil-ductility temperature is the highest temperature at which a material experiences complete brittle fracture without appreciable plastic deformation.
Part 1 Par. 6.3.4	**Modify:** Dry gas seals shall be tested at seal supplier's shop per the requirements of Annex F. **To Read:** Dry gas seals shall be tested at seal supplier's shop per the requirements of API 692, Part 2, Annex B.
Part 1 Par. 6.4.3.1.9.1	**New:** All instruments shall have a permanently attached nameplate. The nameplates shall be made of stainless steel, stamped or engraved with the instrument tag number with minimum 3/16" high characters. Nameplates shall be either attached directly to the instrument using rivets or drive screws or secured to the instrument with a minimum 16-gauge stainless steel wire.
Part 1 Par. 7.3.5.1.2	**Modify:** If specified, a draft manual(s) shall be issued to purchaser 8 weeks prior to mechanical testing for review and comment. **To Read:** A draft manual(s) shall be issued to purchaser for review and comment prior to final issue.
Part 1 Par. 7.3.5.4	**Modify:** If specified, the supplier shall provide the purchaser with a technical data manual at shipment. **To Read:**

	The supplier shall provide the purchaser with one copy of the technical data manual at shipment.
Part 2	**The following amendments apply to API 617, Part 2, Nonintegrally Geared Centrifugal and Axial Compressors.**
Part 2 Par. 4.6.7.2.5	**Substitute:** The vanes shall be designed such that the vanes will tend to open on loss of the control signal. **To Read:** The vane position, on loss of the control signal, shall be agreed between the vendor and the purchaser. The final position of inlet guide vanes should not cause damage to the machine nor cause an internal stage surge event.
Part 2 Par. 4.6.7.4	**New:** The stationary guide vanes in an axial compressor shall be fully welded to create a completely sealed weld between the holder and the vanes.
Part 2 Par. 4.7.1.5	**New:** The use of rotors with eight or more wheels is not allowed without the specific approval of the purchaser.
Part 2 Par. 4.7.2.4	**New:** Shafts shall be ultrasonically inspected and checked with other appropriate NDT inspection as recommended by the supplier.
Part 2 Par. 4.7.3.1	**New:** Compressor designs that do not require a balance piston require the approval of the purchaser.
Part 2 Par. 4.9.1.3	**Modify:** As a design criteria, bearing metal temperatures shall not exceed 100 °C (212 °F) at specified operating conditions with a maximum inlet oil temperature of 50 °C (120 °F). Suppliers shall provide bearing temperature alarm and shutdown limits. **To Read:** As a design criteria, bearing metal temperatures shall not exceed 90 °C (200 °F) at specified operating conditions with a maximum inlet oil temperature of 50 °C (120 °F). Suppliers shall provide bearing temperature alarm and shutdown limits.
Part 2 Par. 5.5.7.3	**Substitute:** Purchaser shall specify the type of temperature detector to be supplied. Installation shall be per API 670. **To Read:** The standard temperature sensor shall be a 100-ohm, platinum, three-lead, dual element resistance temperature detector (RTD). Installation shall be per API 670.

Part 2 Par. 5.6.1.2	**Modify:** If specified, a liquid injection manifold shall be supplied. **To Read:** When liquid injection is required, a liquid injection manifold shall be supplied.
Part 2 Par. 6.3.1.1.10	**Modify:** The equipment shall be operated at speed increments of approximately 10 % from zero to the MCS and run at the MCS until bearing metal temperatures and shaft vibrations have stabilized. **To Read:** The equipment shall be operated at speed increments of approximately 10 % from zero to the trip speed and run at the trip speed until bearing metal temperatures and shaft vibrations have stabilized.
Part 2 Par. 6.3.1.1.11	**Modify:** The speed shall be increased to trip speed and the equipment shall be run for a minimum of 15 minutes. **To Read:** The equipment shall be run at trip speed for a minimum of 15 minutes.
Part 2 Par. 6.3.3.1.3	**Modify:** For variable speed machines, head and capacity shall have zero negative tolerance at the certified point, and the power at this point shall not exceed 104 % of the supplier predicted shaft power value. **To Read:** For variable speed machines, head shall have zero negative tolerance at the certified point capacity, and the power at this point shall not exceed 104 % of the vendor predicted shaft power value.

Part 3	**The following amendments apply to API 617, Part 3, Integrally Geared Centrifugal and Axial Compressors.**
Part 3 Par. 4.4.1.2	**Modify:** Unless otherwise specified, the design lubricant shall be hydrocarbon oil of viscosity Grade 32 with an FZG load stage of 5, in accordance with ISO 8068. Viscosity Grade 46 with an FZG load stage of 5 may be used as a design lubricant, with purchaser's approval. Oils with extreme pressure (EP) additives shall not be used. **To Read:** The design lubricant shall be hydrocarbon oil of viscosity Grade 32 with an FZG load stage of 6. Viscosity Grade 46 with an FZG load stage of 6 may be used as a design lubricant, with purchaser's approval. Oils with extreme pressure (EP) additives shall not be used.
Part 3 Par. 4.6.7.1	**Substitute:** Adjustable guide vanes shall be provided when specified or required by the supplier to meet specified operating conditions. **To Read:** Adjustable guide vanes shall be provided on the inlet of the first stage for compressors driven by constant speed electric motors. If required, adjustable guide vanes may also be provided on the inlet of other compression stages to meet specified operating conditions.
Part 3 Par. 4.7.3.1	**New:** Thrust bearings shall be used on pinions with dry gas seals.
Part 3 Par. 4.7.3.2	**New:** Use of thrust rider rings (collars) on pinions with dry gas seals requires purchaser approval. **NOTE** Dry gas seals are prone to premature failure in the presence of excessive axial motions and vibrations. Refer to section 5.5.7 for axial displacement and vibration monitoring.
Part 3 Par. 4.9.1.2.1	**Substitute:** As a design criteria, bearing metal temperatures shall not exceed 100 °C (212 °F) at specified operating conditions with a maximum oil inlet temperature of 50 °C (120 °F). **To Read:** The predicted bearing metal temperature at maximum operating thrust load and rated speed shall be a maximum of 95°C (200°F), with a maximum inlet oil temperature of 50°C (120°F) and with the specified nominal lube oil inlet pressure.
Part 3 Par. 4.9.1.2.3	**New:** The manufacturer shall provide, in the test procedure, the predicted bearing metal temperature at the mechanical run test conditions.

Part 3 Par. 4.9.1.2.4	**New:** If the measured bearing metal temperature during the mechanical run test at the manufacturer's test stand exceeds this predicted temperature, the purchaser and the supplier shall agree on requirements for any additional testing and on the gear unit's suitability for shipment. NOTE Mechanical run tests at the gear supplier's shop are typically conducted at no-load or low-load conditions. The bearing metal temperature during these tests will typically be less than the predicted temperature at rated load and rated speed.
Part 3 Par. 4.9.1.2.5	**New:** The minimum predicted film thickness, for any operating condition shall not be less than 20 µm (0.0008 in).
Part 3 Par. 4.9.1.2.6	**New:** For radial bearings, the maximum allowable bearing L/D will be 1.0.
Part 3 Par. 4.11.1.6	**Delete:** A single lube-oil supply connection is preferred.
Part 3 Par. 4.11.1.7	**Substitute:** A single lube-oil drain connection from the gear casing is preferred. The minimum drainpipe size shall be sized to be no more than half full and shall be based on the total inlet flow to the gear casing, as shown in Table 1 below. **To Read:** The minimum drain pipe size shall be sized to be no more than half full for a horizontal drain with a maximum velocity of 0.4 m/s (15 in/s). A vertical (bottom) drain may be sized full, but with a maximum velocity of 0.2 m/s (7.5 in/s). Both shall be based on the total inlet flow to the gear casing. Table 1, shown below, outlines the typical drain pipe sizes and the associated maximum flow rates.
Part 3 Table 1	**Substitute:**

Table 1—Drain Pipe Sizes

Inlet Flow Rate		Minimum Drain Size [a]	
L/min	U.S. gal/min	mm	in.
74	19	50	2
176	46	75	3
370	97	100	4
1146	302	150	6
[a] Nominal pipe size.			

To Read:

Table 1 – Drain Pipe Sizes

Maximum Inlet Flow Rate		Minimum Drain Pipe Size	
Liters per Min.	Gallons per Min.	Millimeters[a]	Inches[a]
54	14	75	3
93	25	100	4
212	56	150	6
365	96	200	8
585	155	250	10
830	220	300	12
[a] Nominal Pipe Size			

NOTE Sizing and sloping of the drain piping is specified in API 614. If the drain piping is not designed to ensure that it is never more than half full at any point, the gear unit cannot drain properly. Gear units with insufficient drainage can experience overheating, oil leakage, and potential damage.

Part 3 Par. 4.11.3.1	**Substitute:** When a gearbox has a gear mesh with a ratio of 7:1 or greater, all of the gearing in that gearbox shall be rated in accordance with Annex G. All other gear sets shall be rated per API 613. **To Read:** All gearing shall be rated in accordance with Annex G.
Part 3 Par. 4.11.3.4	**Modify:** Gearing shall be designed and manufactured to meet the requirements of ANSI/AGMA 2015-1-A01, accuracy grade 4. **To Read:** Gearing shall be designed and manufactured to meet the requirements of ANSI/AGMA ISO 1328-1-B14, Grade 4.
Part 3 Par. 4.11.3.14	**Delete:** Hunting tooth combinations are preferred. To achieve this, it may be necessary for the manufacturer to adjust the exact gear ratio. If such adjustment is impractical, the purchaser and the supplier shall negotiate a solution. At least one mesh shall be hunting tooth. NOTE A hunting tooth combination is preferred because the intent is for every tooth on a pinion to mesh with as many teeth as possible on the mating gear before the same teeth mesh again or repeat. However, with multiple pinion units a hunting tooth combination is not as critical because the gear wheel meshes with multiple pinions and is, therefore, not as susceptible to the problems of nonhunting tooth designs.
Part 3 Par. 5.5.7.1	**Substitute:** Unless otherwise specified, the following transducers shall be provided: two radial-vibration probes adjacent to each radial bearing, two axial-position probes for each shaft equipped with a thrust bearing, and a one-event-per-revolution probe for each shaft. **To Read:** The following transducers shall be provided: a) Two radial-vibration probes shall be provided adjacent to, or outboard of, each radial bearing. If necessary, the probes may be positioned inboard of the bearings with purchaser's approval. b) All shafts with thrust bearings shall be provided with two probes measuring axial position. c) All shafts with dry gas seals shall be provided with two probes measuring axial position and axial vibration. NOTE This is to monitor excess axial movement and vibration within the dry face seals. d) One-event-per-revolution probe for each shaft shall be provided.

Part 3 Par. 5.5.7.5	**Substitute:** Purchaser shall specify the type of temperature detector to be supplied. **To Read:** The standard temperature sensor shall be a 100-ohm, platinum, three-lead, dual element resistance temperature detector (RTD).
Part 3 Par. 6.3.1.3.2	**Delete:** Casing vibration shall not exceed an overall level of 4 Gs peak at gear mesh frequency.
Part 3 Par. 6.3.1.3.8	**New:** If probes are provided, axial vibration shall be monitored during the mechanical running test.
Part 3 Par. 6.3.1.3.8.1	**New:** The overall unfiltered axial vibration shall not exceed 0.6 mil (15 microns) p-p for all operating conditions. Note: For the purposes of this paragraph, vibration is periodic motion with a frequency greater than 0.5 Hz.
Part 3 Par. 6.3.1.3.8.2	**New:** The allowable slow roll axial runout shall be agreed and stated in the test agenda.
Part 3 Par. 6.3.1.4.1	**Modify:** The tooth mesh shall be inspected for proper contact and for surface damage resulting from the test. **To Read:** The tooth mesh shall be visually inspected for proper contact and for surface damage resulting from the test, and as specified in 6.2.1.
Part 3 Par. 6.3.1.4.3	**New:** In cases where the compressor is not fully loaded during shop testing, the acceptable criteria for proper contact shall be agreed prior to the test.
Part 3 Par. 6.3.2.2	**Substitute:** If design mole weight is less than 12, the test gas shall be helium. NOTE Test gas mole weight will approximate or be less than contract gas mole weight. **To Read:** Test gas mole weight shall be equal to or less than the contract gas mole weight.
Part 3 Par. 6.3.3.1.2	**Modify:** For variable speed or variable vane machines, head and capacity shall have zero negative tolerance at the normal operating point (or other point as

	specified), and the power at this point shall not exceed 104 % of the supplier predicted shaft power value. **To Read:** For variable speed machines, head shall have zero negative tolerance at the certified point capacity (or other point as specified), and the power at this point shall not exceed 104 % of the vendor predicted shaft power value.
Part 3 Annex F	**Modify:** The limiting criteria are the gear contact pattern and the impeller/stator gap. **To Read:** The limiting criteria are the gear contact pattern, impeller/stator gap and alignment of the dry gas seals (if furnished).
Part 3 Annex G, G.5	**Modify:** ISO 1328 Grade 5 = > K_v = 1.135 ISO 1328 Grade 4 = > K_v = 1.120 ISO 1328 Grade 3 = > K_v = 1.105 ISO 1328 Grade 2 = > K_v = 1.090 **To Read:** ANSI/AGMA ISO 1328-1-B14 Grade 5 = > K_v = 1.150 ANSI/AGMA ISO 1328-1-B14 Grade 4 = > K_v = 1.130 ANSI/AGMA ISO 1328-1-B14 Grade 3 = > K_v = 1.110 ANSI/AGMA ISO 1328-1-B14 Grade 2 = > K_v = 1.090

Part 4	**The following amendments apply to API 617, Part 4, Expander-compressors.**
Part 4 Par. 5.5.2.1	**Substitute:** The purchaser will specify the type of detector. **To Read:** The standard temperature sensor shall be a 100-ohm, platinum, three-lead, dual element resistance temperature detector (RTD).
Part 4 Par. 5.5.2.2	**Substitute:** The purchaser will specify the type of detector required. **To Read:** The standard temperature sensor shall be a 100-ohm, platinum, three-lead, dual element resistance temperature detector (RTD).

5.0 ATTACHMENTS

The following document is included as an attachment.

None

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

Axial Fans

Specification No. EH-35R-CCU1-SPC-255-56016

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1.0 GENERAL

1.1 Scope

1.1.1 This specification covers the requirements for fixed and variable pitch vane axial flow fans.

1.1.2 Compliance by the Supplier with this specification does not relieve him of the responsibility of furnishing fans and accessories of proper design, mechanically suited to meet operating guarantees at the specified service conditions.

1.2 Alternative Designs

1.2.1 The Supplier may offer alternative designs. Any exceptions to this specification shall be clearly stated in the proposal.

1.2.2 A minimum of 2 years successful field operating experience with similar equipment is required. The basic design and service under which such equipment is operating must be comparable to the service quoted. This experience requirement applies not only to main and auxiliary equipment, but individual mechanical components. In instances where existing designs in comparable service experience are not available, designs proven in other services may be considered.

1.3 Conflicting Requirements

Should conflicts exist between this specification and other documents, the following order of precedence shall govern:

a. Purchase Order
b. Data Sheets
c. Engineering Notes
d. Diagrams, Drawings and Schematics
e. This Specification
f. Other Referenced Specifications

1.4 Dimensions

Drawings and data related to equipment supplied in accordance with this specification shall use the USC system of units.

1.5 Normative References

1.5.1 The latest edition of the following standards are applicable to the extent specified in the text.

AMCA 203, *Field Performance Measurements of Fan Systems*

AMCA 210, *Laboratory Methods of Testing Fans For Certified Aerodynamic Performance Rating*

AMCA 802, *Industrial Process/Power Generation Fans: Establishing Performance Using Laboratory Mode*ls

AMCA 803, *Industrial Process/Power Generation Fans: Site Performance Test Standard*

API 541, *Form-wound Squirrel Cage Induction Motors – 375 kw (500 Horsepower) and Larger*

API 614, *Lubrication, Shaft-sealing and Oil-control Systems and Auxiliaries*

API 670, *Machinery Protection Systems*

API 673*, Centrifugal Fans for Petroleum, Chemical and Gas Industry Services*

ASME Power Test Code PTC 11, *Fans*

IEEE 841, IEEE Standard for Petroleum and Chemical Industry – *Premium-Efficiency, Severe Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors – Up to and Including 370 kW (500 hp)*

ISO 21940-11, *Mechanical vibration—Rotor balancing, Part 11: Procedures and tolerances for rotors with rigid behaviour*

1.5.2 The following specifications are referenced and applicable as noted herein and/or in the formal Purchase Order. Refer to the Purchase Order for the Revision in effect.

EH-35R-CCU1-SPC-215-00002	Structural Data for Mechanical Equipment
EH-35R-CCU1-SPC-255-56070	General Purpose Induction Motors – 3/4 hp Through 200 hp - IEEE 841
EH-35R-CCU1-SPC-255-56071	Special Purpose Induction Motors - API 541
EH-35R-CCU1-SPC-255-56084	Lubrication, Shaft-sealing and Oil-control Systems and Auxiliaries – API 614
EH-35R-CCU1-SPC-255-85012	Positive Material Identification (PMI)
EH-35R-CCU1-SPC-265-00002	Electrical Requirements for Packaged Equipment
EH-35R-CCU1-SPC-270-00003	Packaged Equipment Instrumentation

1.6 Statutory Requirements

Equipment supplied shall comply with any applicable governmental codes, regulations, ordinances, or rules.

1.7 Unit Responsibility

Supplier shall assume unit responsibility for the entire equipment package and associated auxiliary equipment within Supplier's scope of supply including, but not limited to, the following:

a. Invoke all applicable reference specifications in each Sub-supplier purchase order.

b. Ensure mechanical, process and electrical compatibility of all equipment.

c. Obtain and transmit all required equipment package component drawings and data to Purchaser.

d. Review all equipment package component drawings and data to ensure suitability for service and compliance with purchase requirements.

e. Prepare composite outline drawings, connection diagrams, piping and instrumentation drawings and wiring drawings for the complete equipment package.

f. Select suitable driver and coupling.

g. Coordinate all Supplier/Sub-supplier/Purchaser interfacing.

h. Setup and testing of equipment; coordination and cost for remedy of any testing deficiency will be Supplier's responsibility. These costs shall include any replacement parts and/or costs for Sub-Supplier representatives required during testing.

i. Preparation for shipment of entire equipment train.

2.0 BASIC DESIGN

2.1 General

2.1.1 Supplier shall use the values of weight flow (wet) noted on the Data Sheets as the basis to determine capacity requirements. While molecular weight is noted as part of the gas analysis, the Supplier shall use his own calculated value if a discrepancy should exist. In all cases, Supplier is responsible for calculations of specific heat ratios and compressibility factors.

2.1.2 Fan performance shall be established in accordance with AMCA 210 or AMCA 802, as approved by Purchaser.

2.1.3 Fans shall have a margin between the specified operating conditions and the onset of rotating stall such that the fan static pressure can rise by 5% of the specified pressures before the stall detection device is triggered. The margin between the stall detection device pressure limit and the onset of rotating stall shall be agreed.

2.1.4 The equipment shall be suitable for outdoor installation. Structural design data, such as wind loads and seismic zone, is specified in Project Specification EH-35R-CCU1-SPC-215-00002.

2.1.5 The entire drive train, including the fan, shall conform to a maximum allowable sound pressure level of 85 dBA measured at 3 ft (1 m) from the drive train boundary.

2.2 Materials

2.2.1 Materials in contact with the specified gas shall be suitable for continuous, long term operation and shall be subject to approval by the Purchaser.

2.2.2 Corrosion resistant materials suitable for the service are required. Use of coatings or linings to achieve this corrosion resistance is not preferred.

2.2.3 Chromium plating, iron plating, plasma spray and impregnation methods for repair of defective components are not acceptable.

2.2.4 Positive material identification (PMI) testing shall be performed in accordance with Project Specification EH-35R-CCU1-SPC-255-85012.

2.3 Stationary Parts

2.3.1 Inlet box, casing, diffuser, and inlet and discharge expansion joints shall be provided. Ducting will be furnished by Purchaser.

2.3.2 Fans shall be designed such that the detachment of a blade or fragment shall not lead to a breach of the casing. This shall be demonstrated by calculation.

2.3.3 The fan casing shall be designed to allow individual blade replacement or total impeller replacement without the need to remove ductwork on either side of the fan. However, it is allowed to remove the diffuser and the inlet box for maintenance purposes of the rotor/blades.

2.3.4 Access doors to the fan inlet, fan outlet and hub shall be provided.

2.3.5 Auxiliary connections shall be at least DN20 (¾ in.) nominal pipe size and shall be butt welded and flanged or machined and studded. Flanged connections shall be raised face with seamless nipples not longer than 150 mm (6 in.).

2.3.6 Only weld-neck flanges shall be used for auxiliary connections for lube oil, seal air, etc. Slip-on flanges are not allowed.

2.3.7 No tapped (threaded) openings shall be used which would be in contact with the process gas.

2.4 Bearing and Bearing Housings

2.4.1 Bearings and bearing housings shall be furnished in accordance with API 673.

2.4.2 Hydrodynamic radial and thrust bearings shall be provided.

2.5 Lubrication

2.5.1 Hydrodynamic bearings and bearing housings shall be arranged for hydrocarbon oil lubrication (mineral oil).

2.5.2 Where oil is supplied from a common system for two or more components of a machinery train (such as a fan and a motor), the fan vendor shall ensure compatibility of type, grade, pressure, and temperature of oil for all equipment served by the common system.

2.5.3 Lube and hydraulic oil systems shall be supplied in accordance with API 614, Part 1 and 2 and Project Specification EH-35R-CCU1-SPC-255-56084.

2.5.4 The fan lubrication system may be combined with the blade actuation circuit and the motor lubrication circuit provided that it can be demonstrated that the integrity of each system is not compromised by a single failure in the other system.

2.6 Dynamics, Vibration and Balancing

2.6.1 The vendor's standard lateral critical speed values may be acceptable to the Purchaser if they have been analytically derived and proven by testing of identical fans, similar fans, or fans where the first bending critical speed is a minimum of 20 % above the maximum continuous speed.

An identical fan is defined as one with the same size frame, aerodynamic design, rpm, size and type of shaft seal, size and type of bearings, and coupling mass and overhang. Similarity between fans shall be agreed considering the factors listed above.

2.6.2 If the vendor's standard lateral critical speed values are not accepted by the Purchaser, a lateral critical speed analysis shall be performed and the results assessed per Annex D of API 673.

2.6.3 Assembled rotors shall be dynamically balanced to ISO 21940-11, Grade G2.5. When spare rotors are supplied, they shall be dynamically balanced to the same tolerance as the main rotor.

2.6.4 Vibration limits for the installed fan during initial field operation shall be per Table 3 of API 673. (The table is reproduced below for reference.)

Table 3—Vibration Limits for Fans [a]

	Point of Measurement			
	Bearing Housing		Shaft [b]	
	All Fan Bearings		Hydrodynamic Fan Bearings (J/B)	
	mm/s (rms)	in./s (rms)	micron	mils (pk/pk)
Unfiltered	<2.8	<0.11	<50	<2
Filtered [c]	<1.8	<0.07	<40	<1.6

[a] At any flow within the specified operating envelope.

[b] Applies when optional API 670 proximity type probes are purchased and installed adjacent to hydrodynamic bearings.

[c] At discrete frequencies.

3.0 ACCESSORIES

3.1 Drivers

3.1.1 The driver shall be sized to accept any specified process variations such as changes in the pressure, temperature or properties of the fluids handled, and plant start-up conditions.

3.1.2 Electric motor drivers shall be rated with a 1.0 Service Factor. The motor nameplate rating shall be at least 110% of the greatest power required for any of the specified operating conditions. Consideration shall be given to the starting conditions of both the driver and driven equipment and the possibility that these conditions may be different from the normal operating conditions.

3.1.3 Motor drivers shall be in accordance with API 541 and Project Specification EH-35R-CCU1-SPC-255-56071.

3.1.4 The motor's starting torque shall meet the requirements of the driven equipment at a reduced voltage of 80% of the rated voltage.

3.1.5 The motor shall be capable of accelerating to full speed within 30 seconds, including under reduced voltage starting conditions.

3.1.6 Motor drivers for auxiliary equipment shall be in accordance with IEEE 841 and Project Specification EH-35R-CCU1-SPC-255-56070.

3.2 Couplings and Guards

3.2.1 Couplings and guards shall be supplied in accordance with API 673.

3.2.2 Couplings for auxiliary equipment shall be flexible disk type with stainless steel disks and a standard length spacer for the coupling size.

3.3 Soleplates

3.3.1 Soleplates shall be provided for mounting the equipment on Purchaser's concrete foundation.

3.3.2 Equipment jacking bolts shall be provided and attached prior to milling of mounting surfaces; no welding shall be done after milling of mounting surfaces. If space limitations exist, the positioning screw bases (or lugs) shall be made removable to prevent interference with shimming requirements.

3.3.3 Foundation bolts will be furnished by Purchaser. Supplier shall provide the necessary loading data to Purchaser as well as any special criteria relating to the equipment supplied.

3.4 Instrumentation, Control and Electrical Systems

3.4.1 General

3.4.1.1 Instrumentation, controls and solenoids, and their installation, shall conform to the requirements of Project Specification EH-35R-CCU1-SPC-270-00003.

3.4.1.2 Resistance temperature detectors (RTD's) shall be provided for temperature measurement of all bearings. RTD's shall be dual element, supplied and installed in accordance with API 670.

3.4.1.3 Seismic transducers shall be provided at each bearing housing for vibration measurement. Seismic transducers shall be supplied and installed in accordance with API 670.

3.4.1.4 If specified, radial shaft vibration transducers shall be supplied and installed in accordance with API 670.

3.4.1.5 If specified, vibration and temperature monitors shall be supplied in accordance with API 670.

3.4.2 Control Systems

3.4.2.1 Fan capacity control shall be by variable blade pitch utilizing a hydraulic cylinder to actuate the blades and shall include the necessary hydraulic oil supply system, control valves, etc. as required for proper operation.

3.4.2.2 Axial fan blade position detection shall be provided. A 2 out of 3 system shall be furnished if a magnetic device is used to detect the blade movement.

3.4.2.3 Axial fan stall detection shall be provided based on 2 out of 3 sensors.

3.4.3 Electrical Systems

Electrical systems shall conform to Project Specification EH-35R-CCU1-SPC-265-00002.

3.5 Piping and Appurtenances

3.5.1 Piping shall be furnished in accordance with API 673.

3.5.2 All piping and tubing within equipment packages or individual skids shall be provided by Supplier. Interconnecting piping between separate packages or skids will be furnished by Purchaser.

3.6 Auxiliary Systems

3.6.1 Sealing Air Systems

3.6.1.1 Sealing air systems, if required, shall be furnished by the vendor.

3.6.1.2 When the main fan is unspared, redundant sealing air fans shall be supplied.

3.6.2 Rotor Braking/Locking Device

3.6.2.1 A braking/locking device shall be provided to positively lock the rotor in position and prevent free-wheeling when the fan is shutdown. This device may be hydraulic, mechanical or a combination of the two.

3.6.2.2 Means shall provide for local and remote indication of locking device engagement or non-engagement. Locking device non-engagement shall be a permissive to start.

4.0 INSPECTION, TESTING, AND PREPARATION FOR SHIPMENT

4.1 General

4.1.1 All equipment covered by this specification shall be subject to inspection and witness testing by the Purchaser's representative.

4.1.2 Inspectors shall also be granted access to any and all parts of the Supplier's plant(s) or his sub-supplier's plant(s) engaged in the manufacture or testing of such an order.

4.1.3 Supplier shall be required to arrange with his sub-supplier to comply with these requirements by noting on the face of all copies of any subsequent sub-supplier's Purchase Orders the intent to inspect materials on those orders.

4.1.4 In general, this should be construed as major sub-suppliers including outside foundries, forging shops, and coupling manufacturers, as well as suppliers of major accessories such as pumps, filters, coolers and other outside purchased vessels. Purchaser reserves the right to inspect any and all equipment major or minor that forms part of the full scope of a basic Purchase Order.

4.2 Inspection

4.2.1 The extent of inspection shall be as outlined in this specification and in the pre-inspection meeting to be held at the factory with Purchaser's Engineer and Inspector.

4.2.2 Purchaser's Inspector will visually inspect for cleanliness of the fan, casing, oil systems and all piping and appurtenances.

4.2.3 Purchaser shall have access to the Supplier's quality control program for review.

4.3 Testing

4.3.1 Final test procedures and test agendas covering any running test specified shall be submitted a minimum of 8 weeks prior to testing. Any deviations from the agreed testing standards shall be clearly noted in the test procedures. The procedures shall include project specific test parameters.

4.3.2 If specified, field performance tests to verify quoted performance shall be performed in accordance with AMCA 203, AMCA 803 and/or ASME PTC-11 as agreed.

4.4 Preparation for Shipment

4.4.1 The Supplier shall be solely responsible for the adequacy of the preparation for shipment provisions.

4.4.2 Bearing and seal assemblies shall be fully protected from rusting and entry of moisture and dirt.

4.4.3 Moisture absorbing VPI crystals shall be installed in large cavities such as inlet and discharge nozzles (preferably attached to flange covers) and in bearing housings. The Supplier shall provide a list and a warning tag at each location detailing the quantity and location of materials required for shipping and storage purposes (i.e., moisture absorbers, moisture barrier paper, etc.) to ensure removal prior to start-up.

4.4.4 Equipment containing insulating oils, rust preventatives, antifreeze solutions or other fluids shall be tagged at openings to indicate the nature of contents and shipping and storage precautions.

4.4.5 Supports and rigging connections shall be provided to prevent damage during transit, lifting or unloading. Temporary supports shall be suitably tagged or painted yellow to indicate removal is required upon permanent installation.

4.4.6 Separate or loose parts, including piping, shall be boxed and each part individually protected as required. Spare parts shall be boxed separately. Crated equipment shall be shipped with duplicate packing lists, one inside and one on the outside of the shipping container.

4.4.7 Each individual container shall be marked outside with the following information:

a. Purchase Order Number

b. Equipment Tag Item Number

4.4.8 Each container shall also include a complete Bill of Materials identifying each part.

4.4.9 Where practical, each individual equipment item shall also be identified with the information listed above by attaching a corrosion resistant metal (not aluminum) impression stamped tag with a stainless steel wire.

4.4.10 Items that have their own respective tag numbers, such as instruments, shall have that tag number provided on a metal tag attached to the item. Such tag numbers are generally assigned on respective drawings and/or in the Purchase Order.

5.0 SUPPLIER'S DATA

5.1 General

A coordination meeting shall be held within 4 weeks after submission of the first issue of the equipment outline and foundation drawings and the Piping and Instrumentation Diagrams (P & ID's).

5.2 Contract Data

5.2.1 Refer to the Supplier's Drawing and Data Commitment form(s). This form contains specific information relating to the quantity and priority of drawings as well as when each drawing and other data shall be submitted.

5.2.2 Supplier shall add all reasonable data deemed necessary by the Purchaser for installation, hardware identification and maintenance and operation. Customer tagging and interface identification are typical Purchaser additions.

5.2.3 Certified copies of all major equipment test data shall be submitted to the Purchaser for approval prior to shipment.



CO_2 CAPTURE FROM ELK HILLS POWER PLANT

ASME Horizontal, End Suction Centrifugal Pumps

Specification No. EH-35R-CCU1-SPC-255-56028

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FOREWORD

This specification supplements Process Industry Practice (PIP) RESP73H (May 2018) *Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process*, which supplements ASME B73.1-2012, *Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process*, which are a part of this specification.

(Substitution) Paragraphs within this project specification are identified as follows to indicate the type of change from PIP RESP73H. Paragraph numbers not identified in the PIP refer to ASME B73.1. If not in ASME B73.1, they are New paragraphs added to ASME B73.1. This specification uses the following definitions to revise or replace the corresponding paragraph numbers in PIP RESP73H. These definitions differ from how the PIP relates to ASME B73.1:

(New) New paragraph.

(Addition) Supplemental requirements and/or clarifications to an existing paragraph.

(Deleted) Paragraph deleted.

(Decision) Decision made or option exercised.

(Substitution) Paragraph supersedes PIP in its entirety.

(Modification) Part of Paragraph modified.

The data sheet is an integral part of the specification. Individual data sheets address specification areas with these changes to the PIP, space permitting.

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1.0 SCOPE (Substitution)

This project specification provides requirements for supplying of horizontal end suction centrifugal pumps up to 200 hp (150 kW) and 300°F (149°C), as used for various services. For general services greater than 200 hp, use PIP RESPH003H as modified by the project specification.

Compliance with this specification does not relieve Supplier of the responsibility of furnishing pumps and accessories of proper design, mechanically suited to meet operating guarantees at the specified service conditions.

Together with the documents referenced herein, this specification covers the minimum mandatory requirements for the materials selection, design, fabrication, inspection, testing and preparation for shipment of horizontal centrifugal pumps and their accessories.

1.1 Order of Precedence (New)

Should any conflicts exist between this specification and other documents, the following order of precedence shall govern:

a.) Purchase Order
b.) Data Sheets
c.) This Specification
d.) Other Project Specifications
e.) Process Industry Practice (PIP) RESP73H (May 2018) *Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process*
f.) ASME B73.1-2012 *Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process*
g.) Other Referenced Practices and Standards.

In the event of a conflict, the Manufacturer shall immediately notify Purchaser for written resolution. The Manufacturer shall not assume deviation from the requirements specified as being acceptable.

1.2 Units of Measure (New)

Equipment shall have US Customary dimensions. All Vendor data, drawings and documents, and nameplates shall be in the 'English' language and in US Customary units.

2.0 REFERENCES

(Substitution) The paragraphs in this section add to the requirements of PIP RESP73H-2018 and ASME B73.1-2012. Codes and Standards shall be latest edition at the time of Purchase.

Industry Codes and Standards (Latest Edition)

(New) Society for Protective Coatings (SSPC) and NACE International Standard

- SSPC SP-10 (NACE #2), Near-White Metal Blast Cleaning

(Addition) If an American Standard and an ISO Standard are both referenced in a specification, the equipment supplied to this specification shall comply with the applicable U.S. standard.

Project Specifications (New)

EH-35R-CCU1-SPC-255-56070, General Purpose Induction Motors – ¾ HP through 200 HP – IEEE 841

EH-35R-CCU1-SPC-255-85012, Positive Material Identification (PMI)

EH-35R-CCU1-SPC-270-00003, Packaged Equipment Instrumentation.

3.0 ALTERNATIVE DESIGNS

3.1 Supplier's Quotation (New Heading)

(Substitution of line 3.1) Supplier shall conform to this project specification as it modifies the referenced PIP. At Supplier's option, Supplier may offer alternative designs in addition to the basic design required by this Specification if the requirements in 3.1.1 and 3.1.2 are met. Supplier shall list and provide details for any proposed design features having less than two years operating experience in similar service, for Purchaser's review and written approval.

4.0 NOMENCLATURE AND DEFINITIONS

(New) *Manufacturer, Supplier, Seller and Vendor:* When used, refer to the party within the supply chain, whether they be the same or separate parties, who is a part of the contract for furnishing of equipment in the purchase order.

(New) *Buyer, Purchaser, and Owner:* When used, refers to the buyer/purchaser of the goods and services contracted for, or the Buyer/Purchaser authorized representative, being or representing the Owner of the goods and services contracted.

5.0 DESIGN AND CONSTRUCTION FEATURES FOR METALLIC PUMPS

5.1 Pressure and Temperature Limits

5.1.1 Pressure Limits (Addition)

5.1.1.3 (Substitution, ASME B73.1) Casing, cover, and seal gland and jackets shall be designed for the maximum allowable working pressure (MAWP) of the pump casing at the specified maximum operating temperature or the mechanical design temperature, whichever is greater, and shall be suitable for hydro testing at 1.5 x MAWP. MAWP shall be based on the material of construction of the individual part (see ASME B73.1, paragraph 7.2.1.1). When an individual part has an MAWP lower than the pump casing, the nameplate MAWP of the pump shall represent the weakest component and shall be identified accordingly.

5.1.3 Hydraulic Selection Criteria

5.1.3.1 (Modification) Head-capacity curves that rise continuously to shutoff are required for all applications.

(Modification) A minimum 10% head rise from rated point to shut-off is required for parallel operation. The installation of an orifice plate on the pump discharge to meet head rise requirements is not preferred. Use of an orifice plate must be clearly identified in the Proposal and on the submittal drawings and documentation, inclusive of performance curves. Orifice plates shall be tagged with metal impression-stamped tags showing the orifice size and shall likewise be identified on submittal drawings.

5.1.3.5 (Addition) When multiple head/specific gravity/viscosity combinations are specified on the data sheets, the furnished impeller shall be the largest required to satisfy all conditions.

5.1.3.6 (Addition) Viscosity corrections, when required, shall be indicated on performance curves included in the Proposal and on the submittal documents.

5.2 Flanges

5.2.2 Class 300 Option

(Substitution) Class 300 suction and discharge flanges shall also meet the requirements of ASME/ANSI B16.5 and B16.42 for parallelism of the sealing face and the backside of the flanges.

5.2.3 X and Y Dimensions

(Addition) This paragraph in PIP RESP73H relates to 5.2.1 and 5.2.2 in ASME B73.1, not paragraph 5.2.3.

5.3 Casing

5.3.1 Drain Connection Boss(es)

(Modification, second PIP bullet item) Unless otherwise specified, all pump cases shall be furnished with a drain connection. Connection shall be drilled, tapped and plugged unless threaded or welded drain piping is specified in lieu of a plug. Drain plugs shall be carbon steel for iron or carbon steel pumps, or a compatible alloy for alloy pumps.

5.3.6 Gaskets(s) (New)

(Addition to B73.1) The casing-to-sealing cover gasket shall also be confined on the internal side for vacuum services.

5.5 Shaft

5.5.4 Deflection

5.5.4.1 (Addition) The L^3/D^4 shall be tabulated in the Proposal for all pump offerings.

5.6 Shaft Sealing

5.6.2 Seal Chamber

(Modification) Change the PIP from *"Add:"* to *"Modify Last Sentence to Read:"*

5.6.7 Gland

5.6.7.2 Gasket. (New in PIP, Addition to ASME B73.1) For pumps in vacuum service, the gland-to-seal-chamber gasket or O-ring shall be totally confined.

5.6.7.6 Pressurized and Unpressurized Dual Seal Requirements.

(Substitution, PIP paragraph 5.6.7) Change paragraph number from 5.6.7 to 5.6.7.6. Delete "5.6.7.6" from the first PIP paragraph.

(Addition) Seal pot and cooler mounting location shall be on the pump baseplate, when furnished, with interconnecting piping. Refer to pump data sheets for seal support specifics. Seal pot and cooler containment shell materials wetted by the process fluid shall meet the material requirements of the pump casing as a minimum.

5.6.8 Alternative Seal Specification (New)

(New) Seal Flush Plan instrumentation shall meet the requirements of Project Specification EH-35R-CCU1-SPC-270-00003.

5.7 Bearings, Lubrication, and Bearing Frame

5.7.2 Lubrication (New)

5.7.2.1 (Substitution, ASME B73.1) Oil lubrication is required. Refer to *PIP REEP005*. Oil flingers are preferred.

5.7.3 Bearing Frame (New)

(Addition, ASME B73.1) Bearing isolators shall be Inpro or equal design. Constant level oilers are required: Trico or equal.

5.8 Materials of Construction

5.8.1 General

5.8.1.3 (Addition) Proposal shall state the bearing frame material of construction.

5.8.1.3.1 (Modification) Unless otherwise specified, Supplier shall submit mill test reports (MTR's) for alloys of pressure retaining parts, impellers and shafts, including the heat numbers from which the material was produced. MTR's shall be included in the Quality Data Books for submittal to the Buyer.

5.8.1.8 (New) When PMI is specified on the data sheets, material shall be inspected per Project Specification EH-35R-CCU1-SPC-255-85012. PMI documents shall be included in the Quality Data Books for submittal to the Buyer.

5.12 Miscellaneous Design Features

5.12.7 Baseplates (Addition)

(Substitution, 1st and 2nd paragraphs of ASME B73.1) Baseplates shall meet the requirements of PIP RESP002. Unless otherwise specified, baseplates shall be groutable. Unless otherwise specified, the undersides of groutable baseplates shall be prepared for grouting per SSPC SP-10 and given an application of primer. Unless otherwise specified, primer shall be suitable for epoxy grout. All baseplate options numbered (a) through (e) shall be included with the baseplate.

5.12.8 C-Face Motor Adapter (Addition)

(Addition) Unless otherwise specified, motors shall be foot-mounted design for pad mounting in lieu of C-face mounting.

5.12.9 Shaft Coupling

(Addition) PIP REEE003 applies, with the following specific requirements:

a.) Unless otherwise specified, shaft couplings for motors shall be limited end float with stainless steel disk packs, in accordance with AGMA 9000 Class 9, ISO 1940-1 grade G6.3 balanced.

b.) Coupling spacer length shall be 5 inches minimum and shall permit pump back-pullout without disturbing the driver or the piping connections.

c.) Couplings and coupling junctures shall have a minimum 1.0 service factor at the maximum driver power, including the driver service factor power. Couplings shall be Rexnord-Thomas Series 71 or equal.

7.0 GENERAL INFORMATION

7.1 Application (New)

7.1.3 Sound

(Decision, ASME B73.1) Equipment sound pressure level shall not exceed 85 dBA at 3-ft. distance from the machinery. If Seller cannot meet the specified noise limits without addition of noise attenuation features, Seller shall include noise levels with and without these features in the Proposal.

7.1.4 Vibration

(Decision, ASME B73.1) Overall vibration measurements and recordings are required for all pumps.

7.1.8 NPSH Margin

(Decision, ASME B73.1) If a minimum margin of 3 ft. (0.9 m) or a margin ratio of 1.2 is not available at the rated flow, an NPSH test is required.

7.2 Tests and Inspections

(Addition) (Decision, ASME B73.1) Supplier shall give at least 10 working days of advanced notification of an observed or witnessed test or inspection.

7.2.1 Tests

7.2.1.1 Hydrostatic (Addition)

(a) Metallic Pumps (Substitution, ASME B73.1) Subsequent to machining, casings and covers shall be hydrostatically tested for a minimum of 10 minutes at 1.5 times the pump's maximum allowable working pressure (MAWP). MAWP shall be adjusted to the test temperature for the corresponding maximum-specified operating temperature or mechanical design temperature, whichever is greater, and using inhibited test water or water with 50 ppm maximum chlorides concentration when stainless steel parts are present, e.g., Buyer's mechanical seals. Cooling water jackets, when furnished, shall be tested per ASME B73.1. Visual leakage through the parts is not permitted. Drilled and tapped connections added post-hydro, when permitted, require visual inspection to ensure no voids exist and threads are well formed.

7.2.1.2 Performance

7.2.1.2(f) (Delete this paragraph number in PIP RESP73H)

(New) All pumps shall be performance tested inclusive of recording of overall vibration measurements, followed by a 1-hr. mechanical run test. Mechanical run test shall include recording and documentation of overall vibration measurements at 15-minute intervals. Paragraphs 7.2.1.2 (a) through (e) of ASME B73.1 apply.

7.2.1.6 Retesting

(Substitution) If it is necessary to dismantle a pump for any correction other than impeller trims of less than 5%, such as hydraulic performance, NPSH, or mechanical operation, the initial test shall be deemed as unacceptable, corrections made, and another test shall be run. A test shall be deemed as "final" when it meets all acceptance criteria.

7.2.2 Inspections (New)

7.2.2.2 Dismantling and Inspection After Test

(Substitution, ASME B73.1) Pumps shall not be disassembled after the "final" acceptable performance test (see 7.2.1.6). Upon completion of final testing, the pump and seal chamber shall be drained of water and thoroughly dried to the greatest extent practical within 4 hours of testing. Pump shall then be protected against moisture entry.

7.3 Nameplates (New)

(Modification, ASME B73.1) Change "maximum design pressure" to "maximum allowable working pressure (MAWP)".

(Addition, ASME B73.1) Nameplates shall be furnished for both pump and driver and shall include Purchaser's equipment Tag Item Number.

(New) A second "pump" nameplate shall include the following information:

a.) Owner's Name
b.) Owner's Purchase Order Number
c.) Owner's Purchase Order Item Number, pump
d.) Rated Flow (gpm)
e.) Rated Differential Head (ft.)
f.) Rated Specific Gravity (S.G.) and Horsepower (bhp)
g.) Installed Impeller Diameter (inches)

7.4 Driver Selection

7.4.1 (Delete this paragraph "number" in PIP RESP73H)

(Substitution for PIP paragraph 7.4.1) Table A applies to motor drivers. Motors shall also meet the requirements of Project Specification EH-35R-CCU1-SPC-255-56070.

Driver power shall, as a minimum, be equal to the rated shaft power at the rated point multiplied by the percentage listed in Table A.

Motor driver nameplate rating at 1.0 S.F. shall also meet the maximum power anywhere on the performance curve.

Steam turbine drivers shall be sized for 110% of pump rated power using Normal steam supply pressure and Maximum steam exhaust pressure, which shall also cover the maximum power at any point below the rated point for the furnished impeller. Steam turbines specified for parallel operation with motor-driven pumps shall be sized for maximum power anywhere on the pump's performance curves with the furnished impeller.

8.0 DOCUMENTATION

8.4 Specially Requested Documentation

(Substitution) Documentation in this section is required in addition to requirements of 8.3, as modified by the RFQ or Purchase Order documents; e.g., Attachment-C, equipment data sheets, Supplier Drawing and Data Commitment form (SDDC).

End of Specification

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

General Purpose Horizontal Centrifugal Pumps

Specification No. EH-35R-CCU1-SPC-255-56029

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A	03-Apr-2020	Issued for Internal Review
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C	18-May-2020	Issued IFF. Client IFR and Webex review comments addressed. References to the IEEE-841 Motor Standard and to the Project Specification for IEEE-841 Motors are also deleted as the Project Motor Specification no longer applies to pumps with motors 250 HP and above. (Pages 6 through 10, p.12)

FOREWORD

This specification supplements Process Industry Practice (PIP) RESP003H (January 2020) *Specification for High Power Horizontal Centrifugal Pumps for Water Service*, which is a part of this specification. Paragraph numbers of this specification correspond to those in PIP RESP003H and PIP REDP003/REDP003-T as noted. Paragraph numbers not found in PIP RESP003H and PIP REDP003 are new paragraphs.

Paragraphs are identified as shown below to indicate the type of change from the PIP Practice:

(New)	New paragraph.
(Addition)	Supplemental requirements and/or clarifications to an existing paragraph.
(Deleted)	Paragraph deleted.
(Decision)	Decision made or option exercised.
(Substitution)	Paragraph supersedes PIP in its entirety.
(Modification)	Paragraph modified in part.

The data sheet is an integral part of the specification. Individual data sheets address specification areas with these changes, space permitting.

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1.0 SCOPE

(Modification of 1st paragraph) This Practice provides requirements for design and manufacture of general purpose horizontal centrifugal pumps of 150 kW (200 HP) or greater used for water, solvent and glycol services.

(New) Compliance with this specification does not relieve Supplier of the responsibility of furnishing pumps and accessories of proper design, mechanically suited to meet operating guarantees at the specified service conditions.

(New) This specification together with the documents referenced herein covers the minimum mandatory requirements for the materials selection, design, fabrication, inspection, testing and preparation for shipment of general purpose horizontal centrifugal pumps and their accessories.

1.1 (New) Alternative Designs

(New) The Supplier may offer alternative designs *in addition to* the basic design required by this basic specification. Supplier shall list and provide details for any proposed design features having less than two years operating experience in similar service, for Purchaser's review and written approval.

1.2 (New) Order of Precedence

Should any conflicts exist between this specification and other documents, the following order of precedence shall govern:

a. Purchase Order

b. Data Sheets

c. This Specification

d. Other Project Specifications

e. *Process Industry Practice (PIP) RESP003H (January 2020), Specification for High Power Horizontal Centrifugal Pumps for Water Service*

f. *Process Industry Practice (PIP) REDP003 (December 2019), Document Requirements for High Power Centrifugal Pumps for Water Service*

g. Other Referenced Practices and Standards

In the event of a conflict, the Manufacturer shall immediately notify Purchaser for written resolution. The Manufacturer shall not assume deviation from the requirements specified as being acceptable.

1.3 (New) Units of Measure

Equipment shall have US Customary dimensions. All Vendor data, drawings and documents, and nameplates shall be in the 'English' language and in US Customary units.

2.0 REFERENCES

2.2 (Addition) Industry Codes and Standards (Latest Edition)

(New) American Petroleum Institute (API)

– API 547, General-purpose Form-wound Squirrel Cage Induction Motors-250 Horsepower and Larger

(New) Hydraulic Institute Standards

– ANSI/HI 14.6, Rotodynamic Pumps for Hydraulic Performance Acceptance Tests

(New) Society for Protective Coatings and NACE International Standard

– SSPC SP-10, Near-White Metal Blast Cleaning

(New) Equipment supplied for this project shall comply with the applicable U.S. standard when an American standard and an ISO standard are both referenced.

2.3 (New) Project Specifications

EH-35R-CCU1-SPC-255-56073, General Purpose Induction Motors – API 547

EH-35R-CCU1-SPC-255-85012, Positive Material Identification (PMI)

EH-35R-CCU1-SPC-270-00003, Packaged Equipment Instrumentation

3.0 DEFINITIONS

(New) *Manufacturer, Supplier, Seller, and Vendor:* When used, refer to the party within the supply chain, whether they be the same or separate parties, who is a part of the contract for furnishing of equipment in the purchase order.

(New) *Buyer, Purchaser, and Owner:* When used, refers to the buyer/purchaser of the goods and services contracted for, or the Buyer/Purchaser authorized representative, being or representing the Owner of the goods and services contracted.

(Substitution) *allowable operating region:* Portion of a pump's hydraulic coverage outside of the preferred operating region over which a pump's vibration is within the allowable vibration limit specified in this Practice.

(Substitution) *preferred operating region:* Portion of a pump's hydraulic coverage over which a pump's vibration is within the base limit specified in this Practice.

4.0 REQUIREMENTS

4.1 Basic Design

4.1.1 General

4.1.1.4 (Addition) When multiple head/specific gravity combinations are specified on the data sheets, the furnished impeller shall be the largest required to satisfy all conditions. Viscosity corrections, when required, shall be indicated on performance curves included in the Proposal and on the submittal documents.

4.1.1.15 (Modification) BEP for the *furnished* impeller shall be preferably between the rated point and the normal point.

4.1.1.21 (New) Equipment sound pressure level shall not exceed 85 dBA at 3-ft. from the machinery surface. If Seller cannot meet the specified noise limits without addition of noise attenuation features, Seller shall include noise levels with and without these features in the Proposal.

4.1.3 Nozzle and Pressure-Casing Connections

4.1.3.3 Pressure Casing Connections

5. (Addition) Drain valves may be threaded to the pipe nipple for water-only services if the valve can be easily removed without dismantling. Otherwise, flanged valves are required.

4.1.8 Shaft-Sealing Systems

4.1.8.10 (Addition) When required, throat bushings shall be as recommended by and supplied by the shaft mechanical seal manufacturer. Bushing design shall be adequate for the flush flow for thermal considerations and adequate for the seal chamber pressure for overpressure considerations.

4.1.9 Dynamics

4.1.9.2 Vibration

1. (Decision) Each pump shall be performance tested.

2. (Decision) Vibration measurements for each pump shall include a Fast Fourier Transfer (FFT) spectrum, inclusive of the time wave form.

d. (Substitution) Vibration levels shall not exceed the limits in *PIP REDP003-T, Inspection and Testing Requirements Sheet,* Table T3.

5. (Addition) Component balancing records shall be included in the Manufacturing Quality Data Books.

4.1.10 Bearings and Bearing Housings

4.1.10.2 Bearing Housings

3. (Addition) Constant-level oilers shall be Trico or equal with glass bottles and wire cages.

4. (Addition) Proposals shall state the method of oil level indication, e.g. gauge glass, bullseyes.

6. (Modification) Bearings housings shall have Inpro or equal bearing isolators.

4.1.11 Lubrication

(Addition) Oil-lubricated bearings shall be standardized for VG-32 viscosity mineral oil lubricant when feasible. Oil flingers are preferred when available.

4.1.12 Materials

4.1.12.1 General

8. (Addition) Refer to individual equipment data sheets for corrosive agents, if any.

9. (Addition) Refer to individual equipment data sheets for chlorides presence and concentration, if any.

10. (New) Alloys require positive material identification (PMI) inspection and documentation per project specification EH-35R-CCU1-SPC-255-85012.

11. (New) Unless otherwise specified, Supplier shall submit mill test reports (MTR's) for pressure retaining parts, impellers and shafts, including the heat numbers from which the material was produced. MTR's shall be included in the Quality Data Books for submittal to the Buyer.

4.1.12.2 Castings

1. (Addition) Refer to specific documentation requirements in the RFQ and P.O. for additional casting repair document submittal requirements.

4. b. (Addition) Plugging of iron casting defects in pump casings, and iron bearing power frames when allowed, is prohibited.

4.1.12.3 Welding

4. (Decision) Weld repairs are allowed for nodular iron casings only upon pre-approval of Seller's welding procedures and procedure qualification records (PQR's) by the Buyer.

4.1.13 Nameplates and Rotation Arrows

4.1.13.4 Nameplate shall be stamped with the following information:

a. (Substitution) Purchaser's equipment Tag Item Numbers, pump and driver

4.1.13.4.1 (New) A second *"pump"* nameplate shall include the following information:

a. Maximum Impeller Size [in.]

b. Installed Impeller Size [in.]

c. Shut-off Differential Head with Installed Impeller [ft.]

d. Shut-off Pressure with Installed Impeller [psig]

e. Rated Operating Speed [rpm]

f. Number of Stages.

4.1.14 (New) Packing

4.1.14.1 (New) If a packed stuffing box is specified, the following requirements shall apply:

4.1.14.1.1 (New) Packed stuffing boxes shall include a means to collect and drain leak-off.

4.1.14.1.2 (New) A hardened packing sleeve shall be provided to protect the pump shaft.

4.2 Accessories

4.2.1 Drivers

4.2.1.2 (Addition) Motor drivers shall also be in accordance with API-547 as supplemented by Project Specification EH-35R-CCU1-SPC-255-56073.

4.2.1.4 (Substitution) The motor shall be sized to cover maximum power anywhere on the curve or 110% of rated power, whichever is greater, at the motor nameplate rating (1.0 S.F.). Standardization of motor sizes will be considered by the Buyer, where feasible, at the time of any Purchase Order.

4.2.1.5 (Addition) The 80% refers to a starting Voltage dip.

4.2.1.6 (Substitution) Steam turbine drivers shall be sized for 110% of pump rated power using Normal steam supply pressure and Maximum steam exhaust pressure. When the maximum power point is at a capacity below the rated point, turbine sizing shall be based on that operating point. Steam turbines specified for parallel operation with motor-driven pumps shall be sized for 110% of maximum power anywhere on the pump's performance curves.

4.2.2 Coupling and Guard

4.2.2.1 (Addition) Coupling guards shall be non-sparking material for flammable process fluid service or when installed in electrical classified areas requiring such.

4.2.2.8 (Addition) The pump Supplier shall furnish and mount the drivers and the balanced and match-marked coupling halves for the drivers and the pumps. Pump Supplier can mount both coupling halves or elect to send the motor half to the motor Supplier for mounting.

4.2.3 Baseplates

(Addition) Grouted PIP baseplates are required for all pumps, with undersides sandblasted per SSPC SP-10 and with epoxy grout preparation.

4.2.4 Piping and Appurtenances – General

6. (Modification) Piping components wetted by the process fluid shall have a pressure/temperature rating, as a minimum, equal to the MAWP at the specified maximum service operating temperature of the pump casing. Refer to individual pump data sheets for design requirements of other auxiliary piping.

4.2.6 (New) Instrumentation

When specified, instrumentation for machinery protection, including vibration, position and temperature detectors, shall meet the requirements of Project Specification EH-35R-CCU1-SPC-270-00003.

4.3 Inspection and Testing

(Addition) The following paragraphs supplement the requirements of *PIP REDP003-T Inspection and Testing Requirements Sheet.* Paragraph numbers below correspond to those in *PIP REDP003-T*.

A. General

1. (Addition) Purchaser advance notice is required a minimum of ten (10) working days prior to any witnessed testing.

B. Material Inspection

1. General

a. (Addition) Refer to pump equipment data sheets for Buyer's "preferred" NDE inspection methods and parts inspection requirements, if any (UT, MP and LP). Otherwise, refer to paragraphs b., c. and d.

C. Testing

1. General

a. (Substitution) Each pump shall be given hydrostatic and performance tests. Tests shall be in accordance with Sections C.2 and C.3 of this requirements sheet. NPSH3 testing is required in accordance with Section C.4 of this requirements sheet when the NPSH margin is less than three (3) feet. Pumps shall be drained of all water, inclusive of the seal chamber and internal pockets, within four (4) hours after completion of the final test, thoroughly dried, and then protected against moisture entry.

b. (Substitution) Performance and NPSH3 tests shall be conducted in accordance with the Hydraulic Institute Standard, ANSI/HI 14.6, except that efficiency data shall be for information only, and test tolerances shall be in accordance with Table T2 of this requirements sheet.

2. Hydrostatic Test

f. (Modification) Test is satisfactory when neither leaks nor seepage through the casing or casing joints occurs and the test pressure holds steady when blocked in for the duration of the test.

3. Performance Test

g. (New) When mechanical run testing is specified on the data sheets, each pump shall be given a 1-hour minimum mechanical run test, including vibration data recording at 15 minute intervals, subsequent to the recording of performance test data.

4. NPSH Test for Horizontal and Vertical Centrifugal Pumps

a. (Modification) Unless otherwise specified, an NPSH test is required when the NPSH3 is within 1.0 m (3 ft.) of the NPSHA.

4.4 Preparation for Shipment

4.4.6 Shipment preparation shall include the following activities:

d. (Addition) Undersides of baseplates to be grouted shall have a primer-only finish.

g. (Addition) Flanged opening closures shall be gasketed rigid metallic material, secured with four (4) bolts. Flange faces shall be given a rust preventative that is suitable for shipping and storing.

m. (Addition) Shaft coupling spacers shall be removed for shipping, boxed with protective wrapping, identified by pump tag number, and firmly secured to or shipped with the pump and driver assembly.

4.4.10 (New) Instructions shall be affixed to equipment stating the rust inhibitors used, the applicable SDS for each, and directions for the Buyer as to removal requirements of said inhibitors and/or desiccants as applicable prior to start-up of equipment.

4.5 Documentation

(Substitution) Pump drawings, technical data, curves, parts list, manuals, and other documentation are required for submittal in accordance with Purchaser's SDDC form, Supplier Drawings and Documentation Commitment, as per the agreed-upon dates therein.

End of Specification

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

General Purpose Vertical Centrifugal Pumps

Specification No. EH-35R-CCU1-SPC-255-56032

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A	15-Apr-2020	Issued for Internal Review
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FOREWORD

This specification supplements Process Industry Practice (PIP) RESP003V (January 2020) *Specification for High Power Vertical Centrifugal Pumps for Water Service*, which is a part of this specification. Paragraph numbers of this specification correspond to those in PIP RESP003V and PIP REDP003/REDP003-T as noted. Paragraph numbers not found in PIP RESP003V and PIP REDP003 are new paragraphs.

Paragraphs are identified as shown below to indicate the type of change from the PIP Practice:

(New)	New paragraph.
(Addition)	Supplemental requirements and/or clarifications to an existing paragraph.
(Deleted)	Paragraph deleted.
(Decision)	Decision made or option exercised.
(Substitution)	Paragraph supersedes PIP in its entirety.
(Modification)	Paragraph modified in part.

The data sheet is an integral part of the specification. Individual data sheets address specification areas with these changes to the PIP, space permitting.

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1.0 SCOPE

(Modification of 1st paragraph) This Practice provides requirements for design and manufacture of vertical centrifugal pumps used for water, solvent or glycol services.

(Modification of 4th paragraph) Pumps covered by this Practice are broadly classified as vertically suspended pumps. These pumps can be of either diffuser or volute design. Pumps in the scope of this Practice, include vertical turbine pumps of both wet pit and vertical can design, as well as line-shaft-driven and cantilevered-type volute-style sump pumps.

(New) Compliance with this specification does not relieve Supplier of the responsibility of furnishing pumps and accessories of proper design, mechanically suited to meet operating guarantees at the specified service conditions.

(New) This specification together with the documents referenced herein covers the minimum mandatory requirements for the materials selection, design, fabrication, inspection, testing and preparation for shipment of vertical centrifugal pumps and their accessories.

1.1 (New) Alternative Designs

The Supplier may offer alternative designs in addition to the basic design required by this basic specification. Supplier shall list and provide details for any proposed design features having less than two years operating experience in similar service, for Purchaser's review and written approval.

1.2 (New) Order of Precedence

Should any conflicts exist between this specification and other documents, the following order of precedence governs:

a. Purchase Order

b. Data Sheets

c. This Specification

d. Other Project Specifications

e. *Process Industry Practice (PIP) RESP003V (January 2020) Specification for High Power Vertical Centrifugal Pumps for Water Service*

f. *Process Industry Practice (PIP) REDP003 (December 2019), Document Requirements for High Power Centrifugal Pumps for Water Service*

g. Other Referenced Practices and Standards

In the event of a conflict, the Manufacturer shall immediately notify Purchaser for written resolution. The Manufacturer shall not assume deviation from the requirements specified as being acceptable.

1.3 (New) Units of Measure

Equipment shall have US Customary dimensions. All Vendor data, drawings and documents, and nameplates shall be in the 'English' language and in US Customary units.

2.0 REFERENCES

2.2 (Addition) Industry Codes and Standards (Latest Edition)

(New) American Petroleum Institute (API)

– API 547, General-purpose Form-wound Squirrel Cage Induction Motors-250 Horsepower and Larger

(New) Hydraulic Institute Standards

– ANSI/HI 14.6, Rotodynamic Pumps for Hydraulic Performance Acceptance Tests

(New) The Institute of Electronic and Electrical Engineers (IEEE)

– IEEE 841, IEEE Standard for Petroleum and Chemical Industry – Premium-Efficiency, Severe Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors – Up to and Including 370 kW (500 hp)

(New) Society for Protective Coatings and NACE International Standard

– SSPC SP-10, Near-White Metal Blast Cleaning

(New) Equipment supplied for this project shall comply with the applicable U.S. standard when an American and an ISO standard are both referenced.

2.3 (New) Project Specifications

EH-35R-CCU1-SPC-255-56070, General Purpose Induction Motors – 3/4 HP through 200 HP – IEEE 841

EH-35R-CCU1-SPC-255-56073, General Purpose Induction Motors – API 547

EH-35R-CCU1-SPC-255-85012, Positive Material Identification (PMI)

EH-35R-CCU1-SPC-270-00003, Packaged Equipment Instrumentation.

3.0 DEFINITIONS

(New) *Manufacturer, Supplier, Seller and Vendor:* When used, refer to the party within the supply chain, whether they be the same or separate parties, who is a part of the contract for furnishing of equipment in the purchase order.

(New) *Buyer, Purchaser, and Owner:* When used, refers to the buyer/purchaser of the goods and services contracted for, or the Buyer/Purchaser authorized representative, being or representing the Owner of the goods and services contracted.

(Substitution) *allowable operating region:* Portion of a pump's hydraulic coverage outside of the preferred operating region over which a pump's vibration is within the allowable vibration limit specified in this Practice.

(Substitution) *preferred operating region:* Portion of a pump's hydraulic coverage over which a pump's vibration is within the base limit specified in this Practice.

4.0 REQUIREMENTS

4.1 Basic Design

4.1.1 General

4.1.1.4 (Addition) When multiple head/specific gravity combinations are specified on the data sheets, the furnished impeller shall be the largest required to satisfy all conditions. Viscosity corrections, when required, shall be indicated on performance curves included in the Proposal and on the submittal documents.

4.1.1.15 (Modification) BEP for the *furnished* impeller shall be preferably between the rated point and the normal point.

4.1.1.23 (New) Equipment sound pressure level shall not exceed 85 dBA at 3-ft. from the machinery surface. If Seller cannot meet the specified noise limits without addition of noise attenuation features, Seller shall include noise levels with and without these features in the Proposal.

4.1.2 Pressure Casing

4.1.2.4 (Deleted)

4.1.2.5 (Substitution) All pump bowls shall be flanged, unless threaded bowls are approved by the Purchaser in writing.

4.1.3 Nozzle and Pressure-Casing Connections

4.1.3.3 Pressure Casing Connections

1. (Addition) Auxiliary connections to the pressure casing of vertical *can-type* pumps shall be welded.

4.1.8 Shaft Sealing Systems

4.1.8.10 (Addition) For vertical turbine-type pumps, seal flush Plan 14 is preferred when it is feasible for the service.

4.1.9 Dynamics

4.1.9.2 Vibration and Balance

1. (Decision) Each pump shall be performance tested.

2. (Addition) Component balancing records shall be included in the Manufacturing Quality Data Books.

4. (Decision) Vibration measurements for each pump shall include a Fast Fourier Transfer (FFT) spectrum, inclusive of the Time Wave Form.

   d. (Substitution) Vibration levels shall not exceed the limits in *PIP REDP003-T, Inspection and Testing Requirements Sheet,* Table T3.

4.1.10 Bearings and Bearing Housings

4.1.10.2 Bearing Housings

2. (Addition) Vertical can-type pumps shall have a separate oil-lubricated bearing housing. Upper seal of oil-lubricated bearing housings shall have a labyrinth-type seal, Inpro or equal.

3. (Addition) Proposals shall state the external method of oil level indication, e.g. gauge glass, bullseye. Constant-level oilers, when applicable, shall be Trico or equal with glass bottles and wire cages.

4.1.11 Lubrication

(Addition) Oil-lubricated bearings shall be standardized for VG-32 viscosity mineral oil lubricant when feasible.

4.1.12 Materials

4.1.12.1 General

8. (Addition) Refer to individual equipment data sheets for corrosive agents, if any.

9. (Addition) Refer to individual equipment data sheets for chlorides presence and concentration, if any.

10. (New) Alloys require positive material identification (PMI) inspection and documentation per project specification EH-35R-CCU1-SPC-255-85012.

11. (New) Unless otherwise specified, Supplier shall submit mill test reports (MTR's) for pressure retaining parts, impellers and shafts, including the heat numbers from which the material was produced. MTR's shall be included in the Quality Data Books for submittal to the Buyer.

4.1.12.2 Castings

1. (Addition) Refer to specific documentation requirements in the RFQ and P.O. for any additional casting repair document submittal requirements.

4. b. (Addition) Plugging of iron casting defects in pump casings and bearing frames is prohibited.

4.1.12.3 Welding

4. (Decision) Weld repairs are allowed for nodular iron casings only upon pre-approval of Seller's welding procedures and procedure qualification records (PQR's) by the Buyer.

4.1.13 Nameplates and Rotation Arrows

4.1.13.4 Nameplate shall be stamped with the following information:

a. (Substitution) Purchaser's equipment Tag Item Numbers, pump and driver

4.1.13.4.1 (New) A second *"pump"* nameplate shall include the following information:

a. Maximum Impeller Size [in.]

b. Installed Impeller Size [in.]

c. Shut-off Differential Head with Installed Impeller [ft.]

d. Shut-off Pressure with Installed Impeller [psig]

e. Rated Operating Speed [rpm]

f. Number of Stages

4.1.14 Special Pump Considerations

4.1.14.1 Diffuser-and-Volute Pumps

2. (Addition) Columns with inside diameter less than 300 mm (12 inches) shall also have rabbeted fits, unless written Purchaser approval is given for threaded columns.

4.1.15 (New) Packing

When a packed stuffing box is specified, the following requirements shall apply:

4.1.15.1 Packed stuffing boxes shall include a means to collect and drain leak-off when exposed to the pumped fluid. Packing may be self-lubricating or grease lubricated when otherwise operating dry.

4.1.15.2 (New) Shaft area under the packing shall be coated with a hard material to protect the pump shaft; e.g. plasma sprayed ceramic, tungsten carbide, etc. Proposal shall state the furnished material.

4.2 Accessories

4.2.1 Drivers

4.2.1.2 (Addition) Motor drivers 200 hp and under shall meet the requirements of IEEE 841 as supplemented by Project Specification EH-35R-CCU1-SPC-255-56070. Motors 250 hp to 500 hp shall meet the requirements of API-547 as supplemented by Project Specification EH-35R-CCU1-SPC-255-56073. Motors greater than 500 hp shall have the features of API-547 as supplemented by project specification EH-35R-CCU1-SPC-255-56073. Project data sheets apply.

4.2.1.4 (Substitution) The motor shall be sized to cover maximum power anywhere on the curve or 110% of rated power, whichever is greater, at the motor nameplate rating (1.0 S.F.). Standardization of motor sizes will be considered by the Buyer, where feasible, at the time of any Purchase Order.

4.2.1.5 (Addition) The 80% refers to a starting Voltage dip.

4.2.2 Coupling and Guard

4.2.2.1 (Addition) Coupling guards shall be non-sparking material for flammable process fluid service or when installed in electrical classified areas requiring such.

4.2.2.3 (Addition) The pump Supplier shall furnish and mount the drivers and the balanced and match-marked coupling halves for the drivers and the pumps when spacer-type couplings are used. Pump Supplier can mount both coupling halves or elect to send the motor half to the motor Supplier for mounting.

4.2.3 Mounting Plate

4.2.3.1 (Addition) A groutable sole plate shall be furnished for all vertical pumps, unless pump is specified for mounting on a steel sump cover, in which case a mounting gasket shall be furnished unless otherwise specified.

4.2.3.3 (Addition) Soleplates shall include at least four vertical leveling screws to facilitate grouting, with undersides sandblasted per SSPC SP-10 and with epoxy grout preparation.

4.2.4 Piping and Appurtenances

4.2.4.2 Auxiliary Process Fluid Piping

2. (Addition) Piping components wetted by the process fluid in vertical can-type pumps shall have a pressure/temperature rating, as a minimum, equal to the MAWP of the pump discharge head at the specified maximum service operating temperature of the pump casing. Refer to individual pump data sheets for design requirements of other auxiliary piping.

4.2.6 Instrumentation

When specified, instrumentation for machinery protection, including vibration, position and temperature detectors, shall meet the requirements of Project Specification EH-35R-CCU1-SPC-270-00003.

4.3 Inspection and Testing

(Addition) The following paragraphs supplement the requirements of *PIP REDP003-T Inspection and Testing Requirements Sheet.* Paragraph numbers below correspond to those in *PIP REDP003-T*.

A. General

1. (Addition) Purchaser advance notice is required a minimum of ten (10) working days prior to any witnessed testing.

B. Material Inspection

1. General

a. (Addition) Refer to pump equipment data sheets for Buyer's "preferred" NDE inspection methods and parts inspection requirements, if any (UT, MP and LP). Otherwise, refer to paragraphs b., c. and d.

C. Testing

1. General

a. (Substitution) Each pump shall be given hydrostatic and performance tests. Tests shall be in accordance with the Sections C.2 and C.3 of this requirements sheet, as modified by this specification. NPSH3 testing shall be in accordance with Sections C.4 through C.6 of this requirements sheet, as modified by this specification. Pumps shall be drained of all water, inclusive of the seal chamber and internal pockets, within four (4) hours after completion of the final test, thoroughly dried, and then protected against moisture entry.

b. (Substitution) Performance and NPSH3 tests shall be in accordance with the Hydraulic Institute Standard, ANSI/HI 14.6, except that efficiency data shall be for information only, and test tolerances shall be in accordance with Table T2 of this requirements sheet.

2. Hydrostatic Test

f. (Modification) Test is satisfactory when neither leaks nor seepage through the casing or casing joints occurs and the test pressure holds steady when blocked in for the duration of the test.

3. Performance Test

g. (New) When mechanical run testing is specified on the data sheets, each pump shall be given a 1-hour minimum mechanical run test, including vibration data recording at 15 minute intervals, subsequent to the recording of performance test data.

4. NPSH Test for Horizontal and Vertical Centrifugal Pumps

a. (Substitution) NPSH3 testing is required when the NPSH margin is less than three (3) feet. Vertical can-type pumps shall have cans and columns of sufficient length to provide a minimum of 3-ft. NPSH margin at the Rated point, unless otherwise specified. Vertical turbine pumps in cooling water sump services shall have a minimum 3-ft. NPSH margin over the entire performance curve, in order to cover single-pump run-out, unless otherwise specified.

4.4 Preparation for Shipment

4.4.6 Shipment preparation shall include the following activities:

e. (Addition) Undersides of mounting plates to be grouted shall have a primer-only finish.

h. (Addition) Flanged opening closures shall be gasketed and covered with rigid metallic material, secured with four (4) bolts. Flange faces shall be given a rust preventative that is suitable for shipping and 6-months of on-site storage.

o. (Addition) Shaft coupling spacers shall be removed for shipping, boxed with protective wrapping, identified by pump tag number, and firmly secured to or shipped with the pump and driver assembly.

4.4.10 (New) Instructions shall be affixed to equipment stating the rust inhibitors used, the applicable SDS for each, and directions for the Buyer as to removal requirements of said inhibitors and/or desiccants as applicable prior to start-up of equipment.

4.5 Documentation

(Substitution) Pump drawings, technical data, curves, parts list, manuals, and other documentation are required for submittal in accordance with Purchaser's SDDC form

(when furnished), Supplier Drawings and Documentation Commitment, as per the agreed-upon dates therein.

End of Specification

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

Special Purpose Gear Units – API 613

Specification No. EH-35R-CCU1-SPC-255-56066

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1.0 INTRODUCTION

1.1 Purpose

This specification, EH-35R-CCU1-SPC-255-56066, serves as an overlay for American Petroleum Institute (API) Standard 613 with applicable additions, deletions, modifications, and clarifications listed with associated paragraphs.

1.2 Scope

EH-35R-CCU1-SPC-255-56066, along with API 613, describes Special Purpose Gear Units.

2.0 REFERENCES

Applicable requirements in the latest edition (or the edition indicated) of API 613 shall be considered an integral part of this Practice. Additional references are listed below. Short titles will be used herein when appropriate.

2.1 Industry Codes and Standards

- American Petroleum Institute (API)
  - API 613, *Special Purpose Gear Units for Petroleum, Chemical and Gas Industry Services, Fifth Edition, February 2003; Errata, December 5, 2005.*

2.2 Project Specifications

- EH-35R-CCU1-SPC-270-00003, Packaged Equipment Instrumentation

3.0 DEFINITIONS

Definitions as provided in API 613 are applicable to this specification. There are no additional definitions applicable to this specification.

4.0 AMENDMENTS TO API 613

The following items are amendments to API 613. The section and paragraph numbers refer to those given in that specification. An "**Add**" to a API paragraph expands on the requirements or selects options; "**Substitute**" replaces the entire paragraph or sentences; "**Modify**" means the original text has been changed to reflect project requirements; "**New**" is for a new paragraph/section to be added; **"Delete"** means the sentences shown are to be deleted.

Para. No.	Amendment Description
1.4	**Substitute:** In case of conflict between this standard and the inquiry, the inquiry shall govern. At the time of the order, the order shall govern. **To Read:** In the event of a conflict between this standard and the purchase order, it shall be the responsibility of the vendor to call attention to the conflict and request a written clarification from the purchaser. Any deviations from the order documents, not approved by the purchaser in writing, shall be brought into compliance at vendor's expense.

	The following hierarchy governs the order of precedence of documents: a. Purchase Order b. Data Sheets c. This Specification d. Other Referenced Project Specifications e. API Standard 613, 5th edition, Feb. 2003 f. Other Referenced Industry Standards.
1.5.14	**Substitute:** **maximum allowable speed** (in revolutions per minute) is the highest speed at which the manufacturer's design will permit continuous operation. **To Read:** (Deleted – refer to 1.5.15 for **maximum continuous speed**)
1.5.15	**Substitute:** **maximum continuous speed** (in revolutions per minute) is the speed at least equal to 105% of the rated pinion speed for variable-speed units and is the rated pinion speed for constant-speed units. **To Read:** **maximum continuous speed** is the highest rotational speed (revolutions per minute) at which the gear unit, as built and tested, is capable of continuous operation.
1.7	**Modify:** The purchaser shall specify whether the equipment supplied to this standard shall comply with the applicable ISO standards or applicable U.S. standards. **To Read:** The equipment supplied to this standard shall comply with the applicable U.S. standards.
1.8	**Modify:** The purchaser shall specify whether data, drawings, gear unit name plate, hardware (including fasteners) and equipment supplied to this standard shall use the SI or U.S. customary or both systems of units. **To Read:** Data, drawings, gear unit nameplate, hardware (including fasteners) and equipment supplied to this standard shall use U.S. customary system of units.
2.1.6	**Add:** The equipment furnished by the supplier shall conform to a maximum allowable sound pressure level of 85 dBA measured at 3 ft (1 m) from the equipment boundary.

2.1.7	**Substitute:** Unless otherwise specified, rotors for turbine-driven gear units shall be designed to operate safely at momentary speeds up to 130% of the rated speed. **To Read:** Turbine-driven and expander-driven gear units shall be designed to operate safely at momentary speeds above trip speed as specified by the driver vendor. If a momentary speed above trip speed is not provided, a design value of 110% of trip speed shall be used. NOTE This is intended to address the scenario of sudden full load rejection and subsequent acceleration above trip speed.
2.1.10	**Substitute:** Motors, electrical components, and electrical installations … shall meet the requirements of IEC 60079-0 (NFPA 70, Articles 500, 501, 502, and 504) as applicable, as well as local codes specified and furnished on request by the purchaser. **To Read:** Motors, electrical components, and electrical installations … shall meet the requirements of NFPA 70, Articles 500, 501, 502, and 504 as applicable, as well as local codes specified by the purchaser.
2.1.14	**Add:** The equipment, including all auxiliaries, shall be suitable for operating outdoors without a roof and in a high dust concentration area.
2.1.20.4	**New:** For increased rotordynamic stability, the configuration and shaft rotational direction should be selected in a way that achieves a downloaded bull gear. In order to achieve this, speed increasers should be oriented with an upmesh rotation and speed decreasers should be oriented with a downmesh rotation.
2.1.21	**New:** The equipment's maximum continuous speed shall not be less than 105% of the rated speed for variable speed machines and shall be equal to the synchronous speed for constant speed machines.
2.2.3.2	**Substitute:** In addition to specifying the service factor, the purchaser may specify the hardnesses of the pinion and gear wheel to establish power and frame sizes. The purchaser should consider the following factors when determining these hardnesses: a. The ductility of the gear teeth. b. Noise. c. Future upgrading. d. Conventional versus special machine finish requirements.

	To Read: The minimum tooth hardness shall be as follows: a. For through hardened: 300 HB b. For nitrided: 83.5HR15N c. For carburized: 55 HRC
2.2.6	**Modify:** To avoid scuffing, the gear shall meet the requirements of ANSI/AGMA 6011-C98, Annex B. To avoid dependency on extreme pressure additives, unless otherwise specified, the gear unit shall be designed for use with an oil meeting ISO 14365-1 load stage 5. **To Read:** To avoid scuffing, the gear unit shall meet the requirements of ANSI/AGMA 6011-J14, Annex B. The gear unit shall be designed for use with a load stage 6 oil according to FZG test A/8.3/90, as described in ISO 14635-1.
2.2.8	**New:** **Pinion Length to Diameter Ratio**
2.2.8.1	**New:** The length-to-diameter (L/d1) ratio of the pinion shall not exceed 2.2 for double helical and 1.6 for single helical gears without purchaser approval, where: L = face Width (b) for single helical gears; L = bull face width (b) plus the gap width for double helical gears; b = net active face width, (less gap), mm (in.),d1 = pinion pitch diameter, mm (in.).
2.2.8.2	**New:** Gears with unmodified leads shall not have a total lead mismatch of the rotors across the gear face width greater than 0.015 mm (0.00067 in.) at the normal operating point.
2.3.1.8	**Modify:** Where internal space does not permit the use of DN15, DN20, or DN25 (1/2-, 3/4-, or 1-in.) ASTM A 312 pipe, seamless steel tubing conforming to ASTM A 192 with stainless steel fittings, or stainless steel tubing conforming to ASTM A 269 with stainless steel fittings may be furnished. **To Read:** Where internal space does not permit the use of DN15, DN20, or DN25 (1/2-, 3/4-, or 1-in.) ASTM A 312 pipe, stainless steel tubing conforming to ASTM A 269 with stainless steel fittings shall be furnished.

2.4.3	**Modify:** When specified, casings shall be provided with an inlet purge connection at least NPS 1/2 in., located to assure a sweep of purge gas across the casing to the filter-breather. **To Read:** Casings shall be provided with an inlet purge connection at least NPS 1/2 in., located to assure a sweep of purge gas across the casing to the filter-breather.
2.5.3.1	**Delete:** Unless otherwise specifically approved by the purchaser, pinions shall be integrally forged with their shafts.
2.5.4.1	**Add:** Shafts shall be sized to accommodate maximum unidirectional and oscillatory torques associated with driving, driven equipment, or both.
2.5.4.2	**Substitute:** Unless otherwise specified, shafts shall be provided with integral flanges for couplings. **To Read:** Shafts shall be provided with integral flanges for couplings. Tapered or cylindrical keyed shaft ends may be provided with purchaser's approval.
2.5.4.4	**Substitute:** a. For areas to be observed by radial-vibration probes: 1. For shaft journals less than 305 mm (12 in.) diameter, 25% of the allowable peak-to-peak vibration amplitude or 6.5 µm (0.00025 in.), whichever is greater. 2. For shaft journals 305 mm (12 in.) and greater diameter, 25% of the allowable peak-to-peak vibration amplitude or 10 µm (0.0004 in.), whichever is greater. **To Read:** a. For areas to be observed by radial-vibration probes, 25% of the allowable peak-to-peak vibration amplitude or 6.5 µm (0.00025 in.), whichever is greater.
2.6.2.4.3	**Substitute:** When the specified minimum operating conditions are less than 40% of the gear unit rated power or less than 70% of the maximum continuous speed or the undamped analysis indicates the first critical is less than 120% of the maximum continuous speed, the vendor shall perform a damped unbalanced response analysis in addition to the undamped analysis. **To Read:** The vendor shall perform a damped unbalanced response analysis in addition to the undamped analysis for at least three load levels (10%, 50% and 100% of the torque corresponding to rated power at rated speed).

2.6.6.2	**Modify:** A residual unbalance check shall be performed in the balance machine and recorded in accordance with the residual unbalance work sheet (see Appendix G). **To Read:** ● If specified, a residual unbalance check shall be performed in the balance machine and recorded in accordance with the residual unbalance work sheet (see Appendix G).
2.6.6.10	**New:** A residual unbalance check shall be performed in the balance machine and recorded in accordance with the balancing machine manufacturer's procedure. Note: This check is not the one detailed in Appendix G.
2.6.6.11	**New:** The balance machine shall be checked for calibration within one month prior to use according to the gear vendor standard, and once per year by the balance machine manufacturer's procedure. The result of the calibration check shall be recorded. The record of the balancing machine calibration check shall be retained with the job rotor balancing record.
2.7.1.4	**New:** The predicted bearing metal temperature at rated speed shall be a maximum of 100ºC (212ºF), with an inlet oil temperature of 49ºC (120ºF) and with the specified nominal lube oil inlet pressure. The calculation shall be at rated load for radial bearings and at the maximum operating thrust load for thrust bearings. If the above criteria cannot be met, the purchaser and the gear vendor shall agree on acceptable bearing metal temperatures.
2.7.1.5	**New:** The gear vendor shall provide, in the test procedure, the predicted bearing metal temperatures (radial and thrust) at the mechanical run test conditions. If the measured bearing metal temperature during the mechanical run test at the gear vendor's test stand exceeds this predicted temperature, the purchaser and the gear vendor shall agree on requirements for any additional testing and on the gear unit's suitability for shipment.
2.7.2.1	**Modify:** When approved by the purchaser, copper-chrome may be used instead of steel for the backing. **To Read:** When approved by the purchaser, copper alloy may be used instead of steel for the backing.

2.7.3.2	**Substitute:** With the approval of the purchaser, tapered land thrust bearings may be used on the low speed shafts operating below 2000 rpm. **To Read:** With the approval of the purchaser, tapered land thrust bearings may be used on the low speed shafts operating below 3650 rpm but with a load limit not to exceed 1.5 N/mm2 (217 psi) based on the projected area.
2.8.3	**Substitute:** The oil system shall be furnished by either the purchaser or the vendor, as specified. **To Read:** The oil system shall be furnished by the driven equipment vendor as part of a combined system supplying oil to all equipment in the machinery train.
3.3.1.1	**Substitute:** If specified, the gear unit shall be furnished with soleplates or a baseplate. **To Read:** Baseplates shall be furnished by the driven equipment vendor. If required, soleplates shall be furnished by the gear vendor.
3.4.1.1	**Substitute:** When no detailed specifications are furnished, instrumentation and installation shall conform to the requirements of API Stds 614 and 670. **To Read:** Instrumentation and installation shall conform to the requirements of API 670 and Project Specification EH-35R-CCU1-SPC-270-00003.
3.4.1.2	**Substitute:** Unless otherwise specified, controls and instrumentation shall be designed for outdoor installation and shall meet the requirements of IP65 as detailed in IEC 60034-5 (NEMA 4 as detailed in Publication 250). **To Read:** Controls and instrumentation shall be designed for outdoor installation and shall meet a minimum rating of NEMA 4X as detailed in Publication 250.
3.4.2.7	**Substitute:** The type of temperature detectors shall be specified. **To Read:** The standard temperature sensor shall be a 100-ohm, platinum, three-lead, dual element resistance temperature detector (RTD).

3.4.2.8	**New:** Oscillator-demodulators for proximity probes shall be supplied and mounted in a junction box by the gear vendor.
4.3.2.1.6	**Substitute:** The mechanical running tests shall be conducted with the contract half couplings mounted and the moment simulators attached, resulting in a moment equal to one-half of the contract coupling spacer. If the coupling halves are not available, or are not compatible with the vendor's shop equipment, the moment simulator must simulate the moment equal to the contract half coupling plus one-half of the coupling spacer. When all testing is completed, if requested by the purchaser, the moment simulators shall be returned to the purchaser (see 3.2.6). **To Read:** The mechanical running tests may be conducted with shop coupling, provided that the overhung moment of the shop coupling (with or without moment simulator) does not differ from the contract coupling by more than ± 10%. NOTE In most cases, the use of the contract coupling during the test of the gear does not add value to the test results.

5.0 ATTACHMENTS

The following document is included as an attachment.

None

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

General Purpose Induction Motors 3/4 HP – 200 HP

Specification No. EH-35R-CCU1-SPC-255-56070

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FOREWORD

This project specification supplements IEEE Standard 841-2009 (IEEE-841), for the specification of project TEFC, Squirrel Cage Induction Motors – generally 3/4 HP through 200 HP. Paragraph numbers of this specification correspond to those in IEEE-841 as noted. Paragraph numbers not found in IEEE-841 are new paragraphs.

Paragraphs within this project specification are identified as follows to indicate the type of change from IEEE-841:

(New) New paragraph.

(Addition) Supplemental requirements and/or clarifications to an existing paragraph.

(Deleted) Paragraph deleted.

(Decision) Decision made or option exercised.

(Substitution) Paragraph supersedes PIP in its entirety.

(Modification) Part of Paragraph modified.

The data sheet is an integral part of the specification. Individual data sheets address specification areas with these changes to IEEE-841, space permitting.

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1.0 OVERVIEW

1.1 Scope

(Addition) This project specification, along with IEEE-841, provides requirements for supplying of horizontal and vertical, premium efficiency, single-speed, squirrel cage polyphase induction motors generally from 3/4 HP (0.66 kW) up to and including 200 HP (150 kW), as used for various equipment services on the project.

Compliance with this specification does not relieve Supplier of the responsibility of furnishing motors and accessories of proper design, mechanically suited to meet operating guarantees at the specified driven equipment service conditions.

1.1.1 **Order of Precedence** (New)

Should any conflicts exist between this specification and other documents, the following order of precedence shall govern:

a. Purchase Order

b. Data Sheets

c. This Specification

d. Other Project Specifications

e. IEEE Standard 841-2009, *IEEE Standard for Petroleum and Chemical Industry-Premium Efficiency, Severe Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors-Up to and Including 370 kW (500 hp)*

f. Other Referenced Standards.

In the event of a conflict, the Manufacturer shall immediately notify Purchaser for written resolution. The Manufacturer shall not assume deviation from the requirements specified as being acceptable.

1.1.2 **Units of Measure** (New)

Equipment shall have US Customary dimensions. All Vendor data, drawings and documents, and nameplates shall be in the 'English' language and in US Customary units.

1.1.3 **Nomenclature and Definitions** (New)

Manufacturer, Supplier, Seller and Vendor: When used, refers to the party within the supply chain, whether they be the same or separate parties, who is a part of the contract for furnishing of equipment in the Purchase Order.

Buyer, Purchaser, and Owner: When used, refers to the Buyer/Purchaser of the goods and services contracted for, or the Buyer/Purchaser authorized representative, being or representing the Owner of the goods and services contracted.

1.2 Purpose

(Modification) This specification covers motors generally from 3/4 HP (0.66 kW) up to and including 200 HP (150 kW).

4.0 RATINGS

4.1 Basis of Rating

(Addition) Motors shall have a service factor (S.F.) of 1.15. Driven equipment power requirements shall not exceed the motor nameplate rating at 1.0 S.F. at any point on the operating curves, or over the full range of driven-equipment operating capability under the specified conditions. Any required additional margin at 1.0 S.F. shall be as specified in driven equipment specifications and driven equipment data sheets. Motor sizing is the responsibility of the driven-equipment Supplier.

4.3 Voltage and Frequency Ratings

(Substitution) The standard Voltage ratings for 60 Hz, 3-phase motor operation on this project are 460V, and 4000V. Motors 3/4 hp through 200 hp shall be rated 460V, 3-ph, 60Hz.

4.5 Enclosures

(Substitution, 1st Two Sentences) Enclosures shall be TEFC and shall have a degree of protection of IP 55. Shaft seals shall be non-contacting Inpro or equal design with a minimum expected seal life of 5 years under the usual continuous service conditions.

5.0 ELECTRICAL PERFORMANCE

5.2 Motor Designs and Starting Characteristics

(Addition) The driven equipment Supplier shall specify to the motor Supplier when other than NEMA Design B torque characteristics and starting capability are required.

5.3 Power Supply Variations

5.3.1 Sine Wave Supply Voltage

c.) (New) Motors shall start successfully with an 80% of rated Voltage starting dip.

5.3.2 Adjustable speed drive (ASD) Supply

(Addition) Motors supplied by ASD, as documented on data sheet or other procurement documentation, shall be inverter duty rated.

5.4 Insulation System and Temperature Rise

5.4.1 Insulation System

(Decision) Form wound stator insulation systems shall meet NEMA MG 1, Part 20, immersion test requirements but an immersion test is not required.

5.4.2 Temperature Rise

(Substitution, 1st Sentence) When operated at rated Voltage, frequency and power, the average temperature rise on any phase of the stator winding shall not exceed 80°C over 40°C ambient at 1.0 S.F. and 90°C over 40°C ambient at 1.15 S.F., by the winding resistance method.

6.0 MECHANICAL FEATURES

(Addition) All windings shall be copper.

6.1 Bearings and Lubrication

c.) (Addition) When vertical loads are carried entirely by vertical motors (e.g., no bearing frame in the driven equipment), the driven-equipment Manufacturer shall provide to the motor Manufacturer the individual maximum vertical loads, both up and down, over the entire operating range of the driven equipment; e.g., for a vertical turbine-type pump this is from shut-off to end-of-curve.

6.2 Rotor and Shaft

6.2.1 Rotor Cage

(Addition) If Manufacturer's standard rotor cage material is other than copper or aluminum, or their respective alloys, Manufacturer may quote Manufacturer's otherwise standard materials for Buyer's consideration as an *alternate* to copper, or aluminum, or their respective alloys, for the Buyer's consideration. IEEE-841 materials shall be the primary offering.

6.3 Frames, Endshields, and Fan Covers

e.) (Addition) Tops of motor feet shall be spot faced for an appropriately sized washer.

f.) (New) Vertical jackscrew provisions are required for motors 1000 pounds or higher.

6.4 Fans

(Decision) Fans shall be non-sparking bronze alloy, not plastic.

(Decision) Bidirectional fans are required.

6.5 Main Terminal Boxes and Terminal Leads

6.5.1 445T Frame and Below

b) (Substitute) Terminal box volume shall be, as a minimum, one size larger than the values listed in Table 1.

6.5.3 General

f.) (New) Main Terminal Boxes shall be mounted in the standard F1 location (*left side viewed from the coupling end*), unless otherwise specified on motor data sheets or other purchase documents. All auxiliary termination boxes shall

always be mounted on the opposite side of the motor from the Main Terminal Box.

6.8 Airborne Sound

a.) (Addition) Motor sound pressure level shall not exceed 85 dBA overall at 3-ft. from any point on the motor.

6.9 Vibration

(Decision) Vibration measurements shall be made with motor bolted to a heavy flat base, not on elastic mounts.

6.10 Accessories (New)

6.10.1 Shaft Couplings

Shaft couplings and mounting are a part of the driven equipment Supplier's scope. Motor Manufacturer shall provide shaft coupling-end dimensions to the driven equipment Supplier for coordination of coupling hub-sizing requirements.

6.10.2 Instrumentation

Refer to Buyer's motor data sheets for instrumentation requirements, if any. Instrumentation leads shall be terminated in a separate stainless steel Auxiliary Terminal Box mounted 180 degrees opposite from the Main Terminal Box.

9.3 Additional Tests

(Addition) Refer to Buyer's motor data sheets for additional testing requirements, if any.

9.4 Test Information Supplied with Motor

(Substitution, 1st Paragraph) All routine test reports in section 9.2 and reports for any specified additional tests in 9.3 shall be shipped to the driven equipment Supplier at the time of motor shipment. Driven equipment Supplier shall include these test reports in the Quality Data Books for submittal to the Buyer.

10.0 NAMEPLATE

(New) Photographs of all nameplates shall be provided for approval prior to shipment.

(New) All electrical devices/material rated 600 Volts and under shall be labeled UL (Underwriter's Laboratories) or FM (Factory Mutual) suitable for the area classification listed on the datasheet(s). If such labeling is unavailable, the equipment shall be certified for use in Kern County by a third party agency acceptable to the Kern County Chief Electrical Inspector.

(New) All certifications shall be submitted to Purchaser prior to shipment of the equipment.

10.1 Nameplate Marking

g.) (New) Motor Service Factor

(New) All electrical devices/material rated 600 Volts and under shall be labeled UL (Underwriter's Laboratories) or FM (Factory Mutual) suitable for the area classification listed on the datasheet(s). If such labeling is unavailable, the equipment shall be certified for use in Kern County by a third party agency acceptable to the Kern County Chief Electrical Inspector.

(New) All certifications shall be submitted to Purchaser prior to shipment of the equipment.

11.0 SPACE HEATERS – REQUIREMENTS

(Substitution, 1st Paragraph) Space heaters are required for all motors 50 hp and above. The separate Auxiliary Terminal Box shall be per 6.5.3 f) of this project specification. Auxiliary box shall have a permanently affixed metal warning tag stating "Caution – Space Heaters May be Energized."

c.) (Substitution) Space heaters shall be rated 240V, 1-phase, 60 Hz and sized for 120V operation. Space heaters shall maintain a minimum 41°F temperature above ambient, as well as maintain insulation temperature below 266°F.

End of Specification

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

Special Purpose Induction Motors – API 541

Specification No. EH-35R-CCU1-SPC-255-56071

REV	DATE	DESCRIPTION	PAGES	ORIG	CHK'D	APPV'D	CLIENT
C	03-Jul-2020	Issued for FEED	14	AK	RB	BT	
B	30-Apr-2020	Issued for Review	14	AK	RB	BT	
A	15-Apr-2020	Issued for Internal Review	14	AK			

RECORD OF REVISIONS

REV. NO.	DATE	CHANGE DESCRIPTION
A	15-Apr-2020	First Internal Issue
B	30-Apr-2020	First Client Issue
C	03-Jul-2020	Client Comments Incorporated

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1.0 INTRODUCTION

1.1 Purpose

This specification, EH-35R-CCU1-SPC-255-56071, serves as an overlay for American Petroleum Institute (API) Standard 541 with applicable additions, deletions, modifications, and clarifications listed with associated paragraphs.

1.2 Scope

EH-35R-CCU1-SPC-255-56071, along with API 541, describes Form-wound Squirrel Cage Induction Motors – 375 kW (500 hp) and Larger.

2.0 REFERENCES

Applicable requirements in the latest edition (or the edition indicated) of API 541 shall be considered an integral part of this Practice. Additional references are listed below. Short titles will be used herein when appropriate.

2.1 Industry Codes and Standards

- American Petroleum Institute (API)
  - API 541, *Form-wound Squirrel Cage Induction Motors – 375 kW (500 hp) and Larger, Fifth Edition, December 2014.*

3.0 DEFINITIONS

Definitions as provided in API 541 are applicable to this specification. There are no additional definitions are applicable to this specification.

4.0 AMENDMENTS TO API 541

The following items are amendments to API 541. The section and paragraph numbers refer to those given in that specification. An "**Add**" to a API paragraph expands on the requirements or selects options; "**Substitute**" replaces the entire paragraph or sentences; "**Modify**" means the original text has been changed to reflect project requirements; "**New**" is for a new paragraph/section to be added.

Para. No.	Amendment Description
1.3.1	**Substitute:** Data, drawings, and hardware (including fasteners) related to equipment supplied to this standard shall use the system of units specified by the purchaser. An alternate system of units for hardware (including fasteners and flanges) may be substituted if mutually agreed upon by the purchaser and the vendor. **To Read:** Data, drawings, and hardware (including fasteners) related to equipment supplied to this standard shall use U.S. customary units.

<table>
<tr><td>2.0</td><td>Add:
ANSI C2, National Electrical Safety Code
California Code of Regulations, Title 8 (CAL-OSHA), Chapter 4, Subchapter 5, Electrical Safety Orders
California Code of Regulations, Title 24, Part 3 (California Electrical Code)
County of Kern Code of Building Regulations, Chapter 17.24, Electrical Code</td></tr>
<tr><td>4.1.8</td><td>Add:
The area classification system used shall be NFPA 70, Articles 500 through 505.</td></tr>
<tr><td>4.1.8</td><td>Add:
All electrical devices/material rated 600 Volts and under shall be labeled UL (Underwriter's Laboratories) or FM (Factory Mutual) or CSA-US suitable for the area classification listed on the datasheet(s). If such labeling is unavailable, the equipment shall be certified for use in Kern County by a third party agency acceptable to the Kern County Chief Electrical Inspector.
Equipment rated above 600 Volts shall be provided with supporting technical documentation to show conformity to recognized national standards, such as ANSI, NEMA and IEEE.
All certifications shall be submitted to Purchaser prior to shipment of the equipment.</td></tr>
<tr><td>4.2.1.2.3
Table 1</td><td>Modify:
Table 1—Voltage Ratings for Three Phase 60 Hz Systems
<table>
<tr><th>Horsepower</th><th>Motor Voltage</th><th>Bus Voltage</th></tr>
<tr><td>Up to 4,000</td><td>2,300</td><td>2,400</td></tr>
<tr><td>Up to 7,000</td><td>4,000</td><td>4,160</td></tr>
<tr><td>1,000 to 12,000</td><td>6,600</td><td>6,900</td></tr>
<tr><td>3,500 or Above</td><td>13,200</td><td>13,800</td></tr>
</table>
To Read:
a) Horsepower < 5,500: Motor voltage = 4,000; Bus voltage = 4,160
b) Horsepower ≥ 5,500: Motor voltage = 13,200; Bus voltage = 13,800</td></tr>
<tr><td>4.3.1.1 a)</td><td>Add:
All windings shall be copper.</td></tr>
<tr><td>4.3.1.1 a)</td><td>Add:
After each vacuum-pressure-impregnation (VPI) cycle, stators shall undergo a rotating-cure process. Stator coil and core assembly shall be immersed in VPI tank. “B_stage” VPI is prohibited.</td></tr>
<tr><td>4.3.1.1 c)</td><td>New:
Above 6 kV, stator-winding stress gradient tape shall be provided. Semi-conducting paint shall not be used on stator winding end turns. Stator winding insulation ground-wall voltage stress shall not exceed 72 volts/mil. Stator</td></tr>
</table>

	winding strands shall be insulated and shall be constructed to minimize both void count and size. Insulation on stator winding end turns, leads, and interconnecting wiring shall be at least as thick as insulation on windings.
4.4.1.2.1	**Substitute:** The purchaser shall specify the type of enclosure on the datasheets. **To Read:** Totally enclosed machines shall be provided for hazardous areas. Weather protected type II (WP-II) may be offered for non-hazardous areas.
4.4.1.2.3 a)	**Substitute:** Purchaser-approved fiber-reinforced materials may be used. **To Read:** Fiber-reinforced materials shall not be used.
4.4.1.2.4 c)	**Modify:** The location of the cooler, orientation of the water box inlet and outlet, materials and construction of the cooler, and means of leak detection shall be specified on the datasheets. **To Read:** The motor vendor shall describe the location of the cooler, orientation of the water box inlet and outlet, materials and construction of the cooler and means of leak detection in the proposal.
4.4.1.2.4 d)	**Modify:** When specified, coolers shall be of double tube construction. **To Read:** Coolers mounted above the motor shall be of double tube construction.
4.4.2.6	**Substitute:** When specified, the machine shall be furnished with soleplates or a baseplate. **To Read:** Baseplates will be furnished by the driven-equipment vendor. The machine shall be furnished with soleplates when it is intended to be mounted directly to a foundation and not on a baseplate.
4.4.5.1.8	**Modify:** When specified, shaft forgings shall be ultrasonically inspected in accordance with 6.2.2.3.1. **To Read:** Shaft forgings shall be ultrasonically inspected in accordance with 6.2.2.3.1.
4.4.6.2.1	**Substitute:**

	When specified, the vendor shall provide a lateral critical speed analysis of the machine to assure acceptable amplitudes of vibration at any speed from zero to maximum operating speed. **To Read:** The vendor shall provide a lateral critical speed analysis of the machine to assure acceptable amplitudes of vibration at any speed from zero to maximum operating speed for 2-pole motors ≥ 1000 HP, 4-pole motors ≥ 5000 HP and all 6-pole motors ≥ 10,000 HP.
4.4.6.2.2	**Modify:** When specified, the vendor(s) with unit responsibility shall perform a steady-state and transient torsional and stress analysis of the complete mechanical train including gears, pumps, compressors, fans, shaft driven auxiliaries, and the effects of the electrical system including ASDs (if applicable). **To Read:** When the machinery train includes a gearbox, ASD or variable speed driver, the vendor(s) with unit responsibility shall perform a steady-state and transient torsional and stress analysis of the complete mechanical train including gears, pumps, compressors, fans, shaft driven auxiliaries, and the effects of the electrical system including ASDs (if applicable).
4.4.6.3.4	**Modify:** When specified, the residual unbalance of the rotor shall be determined in accordance with 4.4.6.3.3 and Annex D. **To Read:** The residual unbalance of the rotor shall be determined in accordance with 4.4.6.3.3 and Annex D for motors with two or four poles, and for six pole motors above 2250 kW (3000 hp), as recommended in Annex C, Item 7-18.
4.4.7.1.3	**Substitute:** When specified, antifriction bearings shall be used for horizontal machines provided that the following conditions are met. **To Read:** Anti-friction bearings shall not be used for horizontal machines.
4.4.7.2.2	**Modify:** When specified, the housings shall be equipped with constant-level oilers at least 0.25 liter (8 fluid ounces) in size, with a positive level positioner (not a set screw), clear glass containers, protective wire cages, and supplemental support in addition to the piping. **To Read:** The housings shall be equipped with constant-level oilers at least 0.25 liter (8 fluid ounces) in size, with a positive level positioner (not a set screw), clear glass containers, protective wire cages, and supplemental support in addition to the piping for all motors except those with pressure-lubricated bearings.

4.4.8.3	**Modify:** When specified, thermostatically controlled heating devices shall be provided in the bearing housings. **To Read:** When required by the vendor, thermostatically controlled heating devices shall be provided in the bearing housings.
4.4.8.4	**Modify:** Where a pressure lubricated or circulating lubrication system is required by the driven equipment, the electrical machine bearing oil may be supplied from that system when specified. The purchaser will specify the supplier of the complete lubrication system. **To Read:** Where a pressure lubricated or circulating lubrication system is required by the driven equipment, the electrical machine bearing oil shall be supplied from that system. The driven equipment supplier shall supply the complete lubrication system.
4.4.9.4	**Modify:** When specified, the electrical machine vendor shall install the motor coupling hub (plus mass moment simulator, if applicable) and perform the vibration test in 6.3.1.5. **To Read:** The electrical machine vendor shall install the motor coupling hub (plus mass moment simulator, if applicable) and perform the vibration test in 6.3.1.5.
4.4.11.1	**Add:** Rotation arrows shall be provided at both ends of the frame (not on end bells).
4.4.11.2	**Add:** x) bearing oil type and viscosity; y) frame designation.
4.4.11.3	**Add:** b) ; … replacement element number; sign that states, “Warning - motor space heaters fed from alternate source”; i) bearing grounding connection.
5.1.1	**Modify:** Minimum dimensions and usable volumes shall not be less than those specified in NEMA MG 1, Part 20 for Type II terminal housings. **To Read:** Minimum dimensions and usable volumes shall be one size larger than those specified in NEMA MG 1, Part 20 for Type II terminal housings.

5.1.1	**Add:** Oversized terminal boxes shall be provided to accommodate stress cones.
5.1.3	**Substitute:** For machines rated at 601 V and higher, accessory leads shall terminate in a terminal box or boxes separate from the machine's main power terminal box. However, secondary connections for current and voltage transformers located in the main terminal box are permitted to terminate in the main terminal box if they are separated from power leads or buses by a suitable physical barrier to prevent accidental contact and are accessible without removal of the main terminal box door or cover. For machines rated at 600 V and lower, the termination of leads of accessory items that normally operate at 50 V root mean square (rms) or less shall be separated from other leads by a suitable physical barrier to prevent accidental contact or shall be terminated in a separate box. **To Read:** For all machines, accessory leads shall terminate in a terminal box or boxes separate from the machine's main power terminal box.
5.1.4.3	**New:** Auxiliary equipment terminal box shall be rotatable in four 90 degree steps, and (except for current transformers [CTs]), shall be located on opposite side of motor from main terminal box.
5.1.5	**Add:** Terminal box mounting studs shall not be used to secure equipment grounding.
5.1.6	**Modify:** When specified, the main terminal box shall be supplied with the following items as detailed on the purchaser datasheet: **To Read:** Unless specified otherwise on equipment data sheets, the main terminal boxes for motors > 1,000 HP shall be supplied with the following: b) space heaters in accordance with 5.4.2; d) removable links, if the motor is bus connected in the terminal box; m) insulated terminations and interior jumpers;
5.1.6	**Add:** Motor line and neutral connections shall be terminated on insulated, isolated, copper buses.
5.1.8	**Add:** Secondary leads shall be minimum #10 AWG.

5.1.10	**Add:** Terminations and jumper wires shall be insulated.
5.1.11	**Modify:** Except as noted in 5.1.12, all accessory wiring outside the motor enclosure and junction boxes shall be run in rigid metal conduit or other purchaser approved means. **To Read:** Except as noted in 5.1.12, all accessory wiring outside the motor enclosure and junction boxes shall be run in rigid metal conduit.
5.1.14	**Modify:** Terminal heads or boxes (as specified) shall be supplied for bearing temperature detectors and the bearing vibration sensing units. **To Read:** Terminal boxes shall be supplied for bearing temperature detectors and bearing vibration sensing units.
5.1.17	**New:** Terminal boxes that are self-supporting or are supported off the machinery train baseplate are preferred. Where terminal boxes require off-skid support, the structural support locations and weight of the box shall be clearly identified on the motor drawings.
5.2.1.1	**Add:** Extension leads from RTD wire leads to terminal box shall be 18 AWG.
5.3.1	**Add:** RTD's shall be dual element type. Extension leads from RTD wire leads to terminal box shall be 18 AWG.
5.3.1	**Modify:** When specified, bearing temperature sensors shall be provided in accordance with API 670. **To Read:** Bearing temperature sensors shall be provided in accordance with API 670.
5.4.1	**Modify:** When specified, machines shall be equipped with completely wired space heaters brought out to a separate terminal box. **To Read:** All machines shall be equipped with completely wired space heaters brought out to a separate terminal box.

5.4.2	**Modify:** Space heaters shall be low power density, one or three phase with a frequency and voltage as specified, and shall have all energized parts protected against contact. **To Read:** Space heaters shall be low power density, one phase, 60 Hz, rated for 240 V, sized for use at 115 V, and shall have all energized parts protected against contact.
5.5.5	**Add:** All WP-II motors shall be provided with a differential pressure switch.
5.6.1	**Substitute:** **Switches** Unless otherwise specified, alarm and control devices shall be equipped with single pole, double-throw switches with a minimum rated capacity of 10 amperes at 120 V AC and 125 V DC. **To Read:** Alarm and control device contacts shall be normally closed (NC) (open to alarm) rated 10 amperes at 115 Volts, 60 Hz AC and 125 Volts DC. Multiple contacts shall be provided if required for operation, or if specified.
5.6.2.1	**Modify:** When specified, surge capacitors shall be furnished. **To Read:** Surge capacitors shall be furnished for all motors ≥ 1,500 hp. Surge protection is not required for ASD driven motors.
5.6.2.1.1	**Add:** Three individual capacitors, one per phase, in separate housing with insulated bases shall be furnished on motors above 5 kV.
5.6.2.1.2	**Add:** Capacitors shall be rated above the motor terminal and bus voltages.
5.6.2.2	**Modify:** When specified, metal-oxide surge arresters shall be furnished and shall be installed in the terminal box. **To Read:** Metal-oxide surge arresters shall be furnished and shall be installed in the terminal box for all motors ≥ 1,500 hp. Surge protection is not required for ASD driven motors.

5.6.2.3	**Modify:** The surge arresters shall be rated for the system voltage … **To Read:** The surge arresters shall be rated above the motor terminal and bus voltages …
5.6.3	**Substitute:** When specified, differential protection current transformers shall be provided. **To Read:** Three (3) window-type differential current transformers shall be provided on all motors ≥ 1,500 HP. The current transformers shall not saturate during an electrical short circuit condition and shall have a minimum burden of C100.
5.6.4.1	**Substitute:** When specified, the vendor shall supply and install stator winding partial discharge monitoring equipment. **To Read:** As a minimum, the vendor shall supply and install stator winding partial discharge detectors on machines rated above 6.9 kV. If specified, the vendor shall also supply the monitoring equipment. Partial discharge monitoring is not required for ASD driven motors.
6.2.1.1	**Modify:** e) when specified, final assembly clearances of rotating parts (e.g. air gap, bearing and seal clearances). **To Read:** e) final assembly clearances of rotating parts (e.g. air gap, bearing and seal clearances).
6.2.3.2	**Modify:** When specified for machines having circulating pressure oil systems with a rated pump capacity of 19 liters (5 gallons) per minute or more, the oil system furnished shall meet the cleanliness requirements of API 614. **To Read:** For machines having circulating pressure oil systems with a rated pump capacity of 19 liters (5 gallons) per minute or more, the oil system furnished shall meet the cleanliness requirements of API 614.
6.3.5.1.1	**Substitute:** When specified, each motor shall be given the complete test described below [Items a) through g)] in addition to the tests specified in 6.3.2. **To Read:** The following motors shall be given the complete test described below [Items a) through g)] in addition to the tests specified in 6.3.2: • Two pole motors ≥ 1250 hp

	• Unspared 2-pole motors • All motors ≥ 3000 hp When duplicate motors of identical ratings are provided, only one of the motors shall be given a complete test.
6.3.5.3	**Substitute:** When specified, satisfactory dynamic performance (see 4.4.6.1.1) shall be verified by attaching the machine to a massive foundation support and subjecting the machine to the following unbalanced response test. **To Read:** Satisfactory dynamic performance (see 4.4.6.1.1) shall be verified by attaching the machine to a massive foundation support and subjecting each of the following machines to the following unbalanced response test: • Two pole motors ≥ 1500 hp • Four pole motors ≥ 5000 hp
6.3.5.4.1	**Substitute:** When specified, bearing housings or end bracket supports shall be checked for resonance on one fully assembled machine (see 6.3.1.3) of each group of identical machines. **To Read:** Bearing housings or end bracket supports shall be checked for resonance on one fully assembled machine (see 6.3.1.3) of each group of identical machines of the following: • Motors ≥ 1500 hp • Motors driven by an ASD
8.1.3 a), b), d) & e)	**Modify:** … at rated voltage and minimum starting conditions (voltage and short circuit MVA) and any other specified conditions. **To Read:** … at rated voltage and minimum starting conditions (voltage and short circuit MVA) and 90%, 80%, 65%, and 50% rated voltage.
8.1.8	**Modify:** When specified, the vendor shall provide typical drawings and literature to fully describe the details of the offering or offerings. **To Read:** The vendor shall provide typical drawings and literature to fully describe the details of the offering or offerings.
8.5.4	**Add:** Drawings shall include power requirements (voltage / wattage). Bills of material shall provide OEM part information.

8.5.7	**New:** Current transformer data including ratings, saturation curves, burdens and winding resistance shall be provided.
8.7.6	**Modify:** When specified, copies of documentation for Nationally Recognized Testing Laboratory (NRTL) certification, positive material identification (PMI), material certification, or other unique records relating to the provision of the order shall be provided. **To Read:** Copies of documentation for Nationally Recognized Testing Laboratory (NRTL) certification, material certification, or other unique records relating to the provision of the order shall be provided in the Manufacturer's Data Book. Copies of required documentation shall also be provided prior to shipment, when requested by the Purchaser (e.g. 4.1.8).
8.7.7	**New:** Photographs of all nameplates shall be provided for approval prior to shipment.

5.0 ATTACHMENTS

The following document is included as an attachment.

None



CO2 CAPTURE FROM ELK HILLS POWER PLANT

General Purpose Induction Motors – API 547

Specification No. EH-35R-CCU1-SPC-255-56073

C	03-Jul-2020	Issued for FEED	9	AK	RB	BT	
B1	07-May-2020	Issued for Review	8	AK	PC	BT	
B	04-May-2020	Issued for Review	8	AK	RB/PC	BT	
A	23-Apr-2020	Issued for Internal Review	8	AK			
REV	**DATE**	**DESCRIPTION**	**PAGES**	**ORIG**	**CHK'D**	**APPV'D**	**CLIENT**

RECORD OF REVISIONS

REV. NO.	DATE	CHANGE DESCRIPTION
A	23-Apr-2020	Issued for Internal Review
B	04-May-2020	First Client Review
B1	07-May-2020	Changes made to be consistent with Electrical Design Criteria. Added 4.4.5.1.2, 5.3, 5.7. Modified 5.2.1.1. Deleted 4.5.1.3.
C	03-Jul-2020	Incorporated Client Comments

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1.0 INTRODUCTION

1.1 Purpose

This specification, EH-35R-CCU1-SPC-255-56073, serves as an overlay for American Petroleum Institute (API) 547 with applicable additions, deletions, modifications, and clarifications listed with associated paragraphs.

1.2 Scope

EH-35R-CCU1-SPC-255-56073, along with API 547, describes General Purpose Form-wound Squirrel Cage Induction Motors – 185 kW (250 hp) through 2240 kW (3000 hp).

2.0 REFERENCES

Applicable requirements in the latest edition (or the edition indicated) of API 547 shall be considered an integral part of this Practice. Additional references are listed below. Short titles will be used herein when appropriate.

2.1 Industry Codes and Standards

- American Petroleum Institute (API)
  - API 547, *General Purpose Form-wound Squirrel Cage Induction Motors – 185 kW (250 hp) through 2240 kW (3000 hp), Second Edition, May 2017.*

3.0 DEFINITIONS

Definitions as provided in API 547 are applicable to this specification. There are no additional definitions are applicable to this specification.

4.0 AMENDMENTS TO API 547

The following items are amendments to API 547. The section and paragraph numbers refer to those given in that specification. An "**Add**" to a API paragraph expands on the requirements or selects options; "**Substitute**" replaces the entire paragraph or sentences; "**Modify**" means the original text has been changed to reflect project requirements; "**New**" is for a new paragraph/section to be added.

Para. No.	Amendment Description
1.1.4	**New:** The requirements of this standard shall also cover vertical motors rated 375 kW (500 hp) and greater to the maximum extent possible.
1.4.1	**Substitute:** Data, drawings, and hardware (including fasteners) related to equipment supplied to this standard shall use the system of units specified by the purchaser. An alternate system of units for hardware (including fasteners and flanges) may be substituted if mutually agreed upon by the purchaser and the vendor. **To Read:** Data, drawings, and hardware (including fasteners) related to equipment supplied to this standard shall use U.S. customary units.

2.0	**Add:** ANSI C2, *National Electrical Safety Code* California Code of Regulations, Title 8 (CAL-OSHA), Chapter 4, Subchapter 5, *Electrical Safety Orders* California Code of Regulations, Title 24, Part 3 (*California Electrical Code*) County of Kern Code of Building Regulations, Chapter 17.24, *Electrical Code*
4.1.4	**Add:** The area classification system used shall be NFPA 70, Articles 500 through 505.
4.1.5	**New:** All electrical devices/material rated 600 Volts and under shall be labeled UL (Underwriter's Laboratories) or FM (Factory Mutual) suitable for the area classification listed on the datasheet(s). If such labeling is unavailable, the equipment shall be certified for use in Kern County by a third party agency acceptable to the Kern County Chief Electrical Inspector. Equipment rated above 600 Volts shall be provided with supporting technical documentation to show conformity to recognized national standards, such as ANSI, NEMA and IEEE. All certifications shall be submitted to Purchaser prior to shipment of the equipment.
4.2.2	**Add:** API 547 motors supplied for this project shall have a rating of 60 Hz: 4000 V.
4.2.2.1	**New:** When specified, motors shall be suitable for operation with adjustable speed drive, i.e. “inverter duty.” Refer to 4.2.2 Note for proper selection of motor and drive.
4.2.3.8	**New:** Motors shall have the starting capabilities specified in Table 4 of API 541.
4.3.1.1	**New:** Stator windings shall be copper or copper alloy only.
4.3.1.2	**New:** After each vacuum-pressure-impregnation (VPI) cycle, stators shall undergo a rotating-cure process. Stator coil and core assembly shall be immersed in VPI tank. “B_stage” VPI is prohibited.
4.3.1.3	**New:** Allowable motor temperature rise shall be determined using the winding temperature detectors (RTD’s) supplied with the motor.
4.3.9	**New:** Insulation systems for motors operated with adjustable speed drives (ASD) shall be inverter duty rated.
4.4.1.1	**New:**

	e) Motors in hazardous areas shall be totally enclosed (TEFC). f) WP-II motors are preferred for non-hazardous areas.
4.4.1.2	**Add:** a) Fan covers shall not be made of aluminum or fiber-reinforced plastic.
4.4.1.3	**Substitute:** f) When specified, a switch, gauge, or transmitter to measure the pressure drop across the filters shall be provided. **To Read:** f) A differential pressure switch to measure the pressure drop across the filters shall be provided.
4.4.2.3	**Add:** Baseplates will be furnished by the driven equipment supplier. If baseplate mounting is not specified, the motor supplier shall provide soleplates for mounting of the motor.
4.4.3	**Add:** Fans shall preferably be made of non-sparking bronze alloy. Plastic fans are not allowed.
4.4.5.1.2	**Add:** Vibration detectors shall be provided on motors 1,000 hp and larger. Detectors should be wired out to dedicated terminals in RTD terminal box.
4.4.7.1.6	**Substitute:** When specified, antifriction bearings may be supplied for horizontal motors. **To Read:** Anti-friction bearings shall not be supplied for horizontal motors.
4.4.7.1.8	**New:** If specified, hydrodynamic guide bearings for vertical motors shall be provided.
4.4.7.1.9	**New:** If specified, hydrodynamic thrust bearings for vertical motors shall be provided.
4.4.11.1	**Add:** Rotations arrows shall be provided on both ends of the motor frame (not on end bells).
4.4.11.2	**Add:** x) bearing oil type and viscosity; y) frame designation.
4.4.11.3	**Add:**

	b) ; … replacement element number; sign that states, “Warning - motor space heaters fed from alternate source”; e) bearing grounding connection.
5.1.1	**Modify:** Terminal boxes and auxiliary equipment enclosures shall be constructed of cast or nodular iron, cast steel, cast aluminum, steel or stainless steel plate, or aluminum plate with a minimum rigidity equivalent to that of steel plate with a nominal thickness of 3 mm (1/8 in.). **To Read:** Terminal boxes and auxiliary equipment enclosures shall be constructed of cast or nodular iron, cast steel, steel or stainless steel plate with a nominal thickness of 3 mm (1/8 in.). Cast aluminum and aluminum plate shall not be used.
5.1.1	**Add:** Minimum dimensions and usable volumes shall be one size larger than those specified in NEMA MG 1, Part 20 for Type II terminal housings.
5.1.3	**Add:** Oversized terminal boxes shall be provided to accommodate stress cones.
5.1.3 d)	**Modify:** space heaters supplied in accordance with 5.4, when specified; and **To Read:** space heaters supplied in accordance with 5.4 for motors > 1000 hp; and
5.1.4	**Add:** Auxiliary terminal boxes shall be rotatable in four 90 degree steps, and shall be located on opposite side of motor from main terminal box.
5.1.7	**Add:** Terminal box mounting studs shall not be used to secure equipment grounding.
5.1.10	**New:** Accessory leads shall be wired in rigid conduit. Flexible conduit shall be provided at the device head if required to permit probe removal.
5.1.11	**New:** Terminal boxes that require external off-skid support shall be noted on the outline drawings. Appropriate structural interface points shall be identified with sufficient information for field tie-ins. Weight to be supported shall be noted. Terminal boxes that can be baseplate supported shall be supported by the driven-equipment / baseplate Supplier.
5.2.1.1	**Add:** Extension leads from RTD wire leads to terminal box shall be 18 AWG.

5.3	**Modify:** Bearing RTD shall be provided in motors with hydrodynamic bearings. **To Read:** Bearing RTDs shall be provided in motors with hydrodynamic bearings 1,000 hp and larger.
5.3	**Add:** RTD's shall be dual element type. Extension leads from RTD wire leads to terminal box shall be 18 AWG.
5.4.1.3	**Substitute:** Unless otherwise specified, space heaters shall be 120 V nominal single phase. **To Read:** Space shall be rated 240 V nominal single phase and properly sized for use at 115 V. Wiring schematics shall include Volt and Wattage ratings.
5.7	**New:** **5.7 Other Accessories** Differential CTs, surge capacitor, and surge arrester protection shall be provided on motors 1,500 hp and larger. These devices shall be wired out to a terminal box separate from the main terminal box and RTD terminal box.
6.1.5	**New:** d) bearing housing natural frequency test for motors to be operating with adjustable speed drive. The vendor shall propose a method to verify that the natural frequency of the bearing housing will not be excited within the designated operating speed range.
8.1.2	**Modify:** a) average torque versus speed during starting at rated voltage and 80% voltage; **To Read:** a) average torque versus speed during starting at rated voltage and minimum starting conditions (voltage and short circuit MVA) and 90%, 80%, 65% and 50% rated voltage;
8.1.2	**Modify:** b) current versus speed during starting at rated voltage and 80% voltage; **To Read:** b) current versus speed during starting at rated voltage and minimum starting conditions (voltage and short circuit MVA) and 90%, 80%, 65% and 50% rated voltage;

8.1.2	**Modify:** c) when load curves and inertia are supplied with the request for proposal, the estimated times for acceleration at rated voltage and 80% voltage; **To Read:** c) when load curves and inertia are supplied with the request for proposal, the estimated times for acceleration at rated voltage and minimum starting conditions (voltage and short circuit MVA) and 90%, 80%, 65% and 50% rated voltage;
8.1.2	**Modify:** d) the locked-rotor withstand time, with the motor at ambient temperature and at its maximum rated operating temperature, at rated voltage and 80% voltage; and **To Read:** d) the locked-rotor withstand time, with the motor at ambient temperature and at its maximum rated operating temperature, at rated voltage and minimum starting conditions (voltage and short circuit MVA) and 90%, 80%, 65% and 50% rated voltage; and
8.2.2	**Add:** n) power requirements (voltage / wattage).
8.2.5	**New:** Copies of required documentation shall be provided prior to shipment, when requested by the Purchaser (e.g. 4.1.4).
8.2.6	**New:** Photographs of all nameplates shall be provided for approval prior to shipment.

5.0 ATTACHMENTS

The following document is included as an attachment.

None

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

Synchronous Motors and Generators – API 546

Specification No. EH-35R-CCU1-SPC-255-56074

C	02-Jul-20	Issued for FEED	15	AK	RB	BT	
B	15-Apr-20	Issued For Review	16	AK	RB	BT	
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Record of Revisions

Rev. No.	Date	Description
A	31-Mar-20	First Internal Issue
B	15-Apr-20	First Client Issue
C	02-Jul-20	Incorporated Client Comments

Foreword

(Addition) This standard covers the minimum requirements for Brushless Synchronous Motors/Generators and supplements API Industry Standard 546, "Brushless Synchronous Machines – 500 kVA and Larger", Third Edition, September 2008. The numerical identification of the sections and paragraphs of this specification are the same as in the referenced API Standard. Reference is made only to those paragraphs of API 546 where options are exercised in bullet paragraphs, exception is taken or supplemental requirements are added. Motors/Generators manufactured to this specification shall conform to API 546, except as amended herein, or as noted on equipment datasheets or the Purchase Order.

Paragraphs are identified as shown below to indicate the type of change from the Standard:

(Addition)	New paragraph or supplemental requirements
(Decision)	A decision has been made regarding available options in an API bullet paragraph
(Deletion)	Paragraph deleted
(Modification)	Supplemental requirements /clarifications added to an existing paragraph as a modification of the existing paragraph, but not invalidating the API paragraph
(Substitution)	Paragraph supersedes the Standard in its entirety.

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1.0 GENERAL

1.1 Scope

(Addition) Motors/Generators shall be considered as “Special Purpose” (SP) unless specified otherwise on equipment data sheets.

1.3 Dimensions and Standards

(Decision) Data, drawings, and hardware (including fasteners) related to equipment supplied to this standard shall use U.S. Customary (USC) units.

1.4 Conflicting Requirements

(Substitution) In the event of conflict between this specification and accompanying or referenced documents, the order of precedence shall be as follows:

- Purchase Order
- Data Sheets
- Engineering Notes
- Material requisition for quotation or purchase
- This specification
- Other referenced specifications or Standards.

1.6 Referenced Publications

(Addition) ANSI C2, *National Electrical Safety Code*

(Addition) California Code of Regulations, Title 8 (CAL-OSHA), Chapter 4, Subchapter 5, Electrical Safety Orders

(Addition) California Code of Regulations, Title 24, Part 3 (*California Electrical Code*)

(Addition) County of Kern Code of Building Regulations, Chapter 17.24, *Electrical Code*

(Addition) IEEE 620, *IEEE Guide for the Presentation of Thermal Limit Curves for Squirrel Cage Induction Machines*

2.0 BASIC DESIGN

2.1 General

2.1.6 (Modification) The arrangement of the equipment, including number of bearings, terminal housings, conduit, piping, and auxiliaries, (including the rotating elements of the exciter, the field discharge resistor, and synchronizing controls as applicable) shall be subject to approval by the purchaser.

2.1.8 (Addition) All electrical devices/material rated 600 Volts and under shall be labeled UL (Underwriter's Laboratories) or FM (Factory Mutual) suitable for the area classification listed on the datasheet(s). If such labeling is unavailable, the equipment shall be certified for use in Kern County by a third party agency acceptable to the Kern County Chief Electrical Inspector. Equipment rated above 600 Volts shall be provided with supporting technical documentation to show conformity to recognized national standards, such as ANSI, NEMA and IEEE. All certifications shall be submitted to Purchaser prior to shipment of the equipment.

2.2 Electrical Design

2.2.2 Stator Windings

2.2.2.2 (Modification) Machines 750 kW (1000 hp) and larger, or when differential protection is specified, shall have both ends of each stator phase winding brought out to a terminal box (see 3.1.8).

2.2.3 Load Requirements

2.2.3.2 (Modification) Should the loads have characteristics other than those listed in NEMA MG1 Part 21, the driven equipment supplier shall fully specify the load characteristics of the driven equipment.

2.2.5.2 (Substitution) Table 4

Table 4 – Starting Capabilities

Number of Consecutive Successful Starts Under Starting Conditions Specified in 2.2.4 and with the Motor Coasting to Rest Between Starts	
Motor initially at or below rated ambient temperature (cold start)	3
Motor at a temperature above rated ambient but not exceeding its rated operating temperature (hot start)	2

2.2.5.2 (Deletion) Note 1 of Table 4

2.2.5.3 (Substitution) The motor vendor shall provide motor thermal capacity data (per 2.2.5.4) necessary to determine the waiting time before allowing a restart and to develop settings for the thermal time constant in the motor protective relay. As a minimum, this data shall include the following:

a) thermal limit curves (per IEEE 620) with the motor initially at ambient temperature;

Note: Although intended for induction machines, IEEE 620 gives useful information on developing thermal limit curves that could be used for synchronous motors.

b) thermal limit curves (per IEEE 620) with the motor initially at rated temperature;

c) acceleration time curves with the defined shaft load at rated voltage and at the starting voltage conditions specified in 2.2.4;

d) required wait time prior to another start after exhausting the defined number of starts, with the motor running at rated load;

e) required wait time prior to another start after exhausting the defined number of starts, with the motor stopped; and

f) after exhausting the defined number of starts, required wait time for the motor to return to ambient conditions with the motor stopped.

2.2.5.4 (Modification) If specified, the method of safe stall time calculation and the limits shall be described with the proposal.

2.2.5.4 (Addition) The minimum safe stall (locked rotor) time shall be clearly identified on the thermal limit curves.

2.2.5.5 (Addition) Generator Start/Stop Cycling Capabilities

Generators shall be designed and constructed to withstand the thermal cycling and mechanical fatigue of at least 10,000 start/stop cycles.

2.2.6 Performance

2.2.6.1 c) (Decision) For reciprocating loads, the current pulsations under the actual operating conditions shall not exceed 66 % of full load current as required by API 618.

NOTE The inertias and torque versus crank angle data at rated and worst-case operating conditions are needed to determine the current pulsation. The results of this analysis and any subsequent design changes could impact the drive train torsional analysis, which is commonly performed by a party other than the motor vendor (see 2.4.5.1.5).

2.3 Insulation Systems

2.3.1.1 (Addition) Above 6 kV, stator-winding stress gradient tape shall be provided. Semi-conducting paint shall not be used on stator winding end turns. Stator winding insulation ground-wall voltage stress shall not exceed 72 volts/mil. Stator winding strands shall be insulated and shall be constructed to minimize both void count and size. Insulation on stator winding end turns, leads, and interconnecting wiring shall be at least as thick as insulation on windings.

2.3.1.4 (Addition) Rotor insulation system shall be protected from transient overvoltages. A spark gap shall not be used.

2.3.1.6 (Decision) The exciter rotor and stator windings shall have a sealed insulation system, as defined by NEMA MG 1 Part 1.

2.3.1.10 (Addition) The stator windings, including the lead connections, shall have a sealed insulation system that is capable of withstanding a sealed winding conformance test in accordance with NEMA MG 1, Part 20.

2.3.1.11 (Modification) If specified, machines rated 6 kV and above shall use bus bar insulated for the rated voltage from the stator winding to the main terminal box connection.

2.3.1.13 (Addition) All winding connections except those completed in the main terminal box shall be brazed using a silver-based brazing material. Soft soldered connections are not permitted. Any exposed connections shall use a phosphorus free silver brazing material that is not subject to attack by hydrogen sulfide.

2.3.1.14 (Addition) All windings shall be copper.

2.3.1.15 (Addition) After each vacuum-pressure-impregnation (VPI) cycle, stators shall undergo a rotating-cure process. Stator coil and core assembly shall be immersed in VPI tank. "B_stage" VPI is prohibited.

2.4 Mechanical Design

2.4.1 Enclosures

2.4.1.1 General Requirements

a) (Modification) Fiber-reinforced materials shall not be used..

e) (Substitution) When enclosure pre-start purging is specified, machines shall be provided with provisions for effective purging as described on the datasheet. The vendor shall state the maximum allowed purge pressure on the datasheet.

(Modification) NOTE See NFPA 496, IEEE 303, IEEE 1349, and IEC 60079 for information.

2.4.1.2 Machine Enclosures and Corresponding NEMA or IEC Specifications

2.4.1.2.3 b) (Modification) Aluminum or fiber-reinforced fan covers are not permitted.

2.4.1.2.4 c) (Modification) The vendor shall describe the cooler design and leak detection offered in the Proposal.

2.4.1.2.4 d) (Decision) Coolers mounted above the motor/generator shall be of double-tube construction.

2.4.1.3 (Addition) Exciter enclosure shall meet the following requirements:

a) Exciter shall either be built into or ventilated from motor enclosure.

b) Exciter enclosure shall be same NEMA class as motor.

c) Excitation system shall be readily accessible (as defined by NEC, Article 100 A).

2.4.2 Frame and Mounting Plates

2.4.2.1 (Addition) The frame shall be of cast or nodular iron, cast steel, or welded steel plate construction with removable end brackets or end plates to permit removal of the rotor and facilitate repairs.

2.4.2.5 (Addition) Fine-threaded jackscrews shall be used.

2.4.5 Rotating Element

2.4.5.1 General

2.4.5.1.1 (Decision) The rotating element shall be designed and constructed to withstand the starting duties specified in 2.2.4, 2.2.5, and 2.2.6.

2.4.5.1.2 d) (Addition) components (such as keys, fan hubs, thrust collars, etc.) shall have a minimum chamfer equal to or greater than the adjacent radii.

2.4.5.1.3 (Substitution) Shafts shall be heat-treated forged steel.

2.4.5.1.7 (Modification) As a minimum, provisions for probes are required for all hydrodynamic bearings.

2.4.5.1.8 (Decision) Shaft forging shall be ultrasonically inspected in accordance with 4.2.2.3.1.

2.4.6 Dynamics

2.4.6.2 Dynamic Analysis

2.4.6.2.1 (Decision) A lateral critical speed analysis is required for all 2 pole machines and all machines 5,000 hp and greater. Machines with four or more poles shall be stiff shaft design. A typical undamped critical speed map of a machine of same frame size, rotor geometry and bearings shall be provided with the proposal for all motors/generators, including bearing support stiffness curves.

2.4.6.2.7 (Decision) If a train torsional analysis is specified, the vendor with unit responsibility for the complete equipment train (typically, the driven equipment supplier) shall perform the analysis.

2.4.7 Bearings, Bearing Housings and Seals

2.4.7.2 Bearing Housings

2.4.7.2.2 (Decisions) Housings for self-oil lubricated bearings shall be equipped with constant-level oilers.

2.4.8 Lubrication

2.4.8.3 (Modification) When specified, thermostatically controlled heating devices shall be provided in the bearing housings of self-lubricated bearings.

2.4.8.4 (Decision) Where a pressurized or circulating lubrication system is required by a gear, the mechanical equipment, or both, circulating oil shall also be supplied from that system to the electrical equipment bearings.

2.4.8.5 (Decision) Where oil is supplied from a common system to two or more machines (such as a compressor, a gear, and a motor), the oil's characteristics shall be specified by the vendor with unit responsibility for the complete equipment train (typically, the driven equipment supplier) on the basis of agreement with all equipment suppliers served by the common oil system.

2.4.9 End Play and Couplings

2.4.9.4 (Decision) The machine vendor shall install the machine coupling hub (plus mass moment simulator, if applicable) and perform the vibration test in 4.3.3.

2.4.10 Materials

2.4.10.6 Fans

2.4.10.6.1 (Modification) Plastic fans are not allowed. Seller shall specify the fan material in the Proposal.

2.4.10.8 Heat Exchangers

a) (Decision) Air-to-air exchanger tubes shall NOT be made of aluminum or aluminum alloy.

2.4.11 Nameplates and Rotation Arrows

2.4.11.2 ad) (Addition) electrical connection diagram and rotation referenced to ABC peaking sequence;

2.4.11.2 ae) (Addition) bearing oil type and viscosity.

2.4.11.3 c) (Addition) … ; replacement element number; sign that states, "Warning - motor space heaters fed from alternate source");

2.4.11.3 i) (Addition) bearing grounding connection.

3.0 ACCESSORIES

3.1 Terminal Boxes

3.1.1 (Decision) Oversized terminal boxes shall be provided to accommodate stress cones.

3.1.3 (Substitution) For all machines, accessory leads shall terminate in a terminal box or boxes separate from the machine's main power terminal box.

3.1.4 (Addition) Terminal enclosures housing surge capacitors, lightning arrestors and differential protection current transformers shall be provided with a gasketed and hinged cover. The cover shall be either bolted or provided with a lockable operating handle.

3.1.4 (Addition) Auxiliary equipment terminal box shall be rotatable in four 90 degree steps, and (except for current transformers [CTs]), shall be located on opposite side of motor from main terminal box.

3.1.5 (Addition) Terminal box mounting studs shall not be used to secure equipment grounding.

3.1.6 (Decision, Substitution) Unless specified otherwise on equipment data sheets, the main terminal boxes for motors/generators > 1,000 HP shall be supplied with the following:

b) (Decision, Substitution) space heaters with a thermostat rated for the area classification. Terminations shall be made in a separate enclosure per 3.1.3 and shall meet the requirements of Section 3.4.

d) (Decision, Modification) removable links, if the motor is bus connected in the terminal box;

m) (Decision) insulated terminations and interior jumpers.

3.1.6 (Addition) Motor line and neutral connections shall be terminated on insulated, isolated, copper buses.

3.1.8 (Modification) When differential current transformers per 3.6.3 or phase current transformers are provided...

3.1.10 (Addition) Terminations and jumper wires shall be insulated.

3.1.11 (Decision) Terminal boxes shall be supplied for bearing temperature detector and bearing vibration sensors.

3.2 Winding Temperature Detectors

3.2.1.1 (Decision) Extension leads from RTD wire leads to terminal box shall be 18 AWG.

3.3 Bearing Temperature Detectors

3.3.1 (Decision) RTD's shall be dual element type. Bearing temperature sensors shall be provided in accordance with API 670.

3.4 Space Heaters

3.4.1 (Decision) All machines shall be equipped with completely wired space heaters that use high temperature insulation leads (such as silicone insulation) brought out to a separate terminal box.

3.4.2 (Decision) Space heaters shall be single phase, 60 Hz, rated for 240 Volts and properly sized for use at 115 Volts. Wiring schematics shall include Volt and Watt ratings.

3.4.4 (Addition) Terminal box space heaters shall meet the same requirements as enclosure space heaters.

3.5 Screens and Filters

3.5.2 (Decision) Provisions for airflow inlet filters, using standard types and sizes of filters, shall be provided on all Weather Protected Type I (WP-I) enclosures.

3.5.4 (Decision) Filters shall be provided on all Weather Protected Type II (WP-II) motors.

3.5.5 (Decision) When filters are provided, a differential pressure switch to measure the pressure drop across the filters shall be furnished.

3.6 Alarm and Control Devices for Motor Protection

3.6.1 Switches

(Modification) Alarm and control device contacts shall be normally closed (NC) (open to alarm) rated 10 amperes at 115 Volts, 60 Hz AC and 125 Volts DC. Multiple contacts shall be provided if required for operation, or if specified. (All devices shall meet the labeling requirements of 2.1.8.)

3.6.2 Surge Protection

3.6.2.1 (Decision) (Modification) Surge capacitors shall be furnished on motors 1,500 HP and greater.

3.6.2.1.1 (New) Three individual capacitors, one per phase, in separate housing with insulated bases shall be furnished on motors above 5 kV.

3.6.2.1.2 (New) Capacitors shall be rated above the motor terminal and bus voltages.

3.6.2.1.3 (New) Partial discharge capacitive couplers shall be furnished for machines rated above 6.9 kV.

3.6.2.2 (Decision) Separate gap-less and spark-less type surge arrestor cans shall be provided for all motors > 1,500 HP. Arrestors shall be rated above the motor terminal and bus voltages.

3.6.3 Differential Current Transformers.

(Decision) Three (3) window-type differential current transformers shall be provided for all motors > 5,000 HP. The current transformers shall not saturate during an electrical short circuit condition and shall have a minimum burden of C100.

3.6.4 Partial Discharge Detectors

3.6.4.1 (Decision) As a minimum, the vendor shall supply and install stator winding partial discharge detectors on machines rated above 6.9 kV. If specified, the vendor shall also supply the monitoring equipment.

3.8 Vibration Detectors

3.8.1 (Decision) As a minimum, all hydrodynamic bearing machines shall have provisions for installation of vibration and phase-reference probes.

3.8.2 (Decision, Modification) Provisions shall be made on machines with hydrodynamic bearings for mounting a minimum of two (2) radial vibration probes in each bearing housing and where hydrodynamic thrust bearings are provided, they shall have provisions for two axial-position probes at the thrust end.

4.0 INSPECTION, TESTING AND PREPARATION FOR SHIPMENT

4.1 General

4.1.1 (Decision) Witnessed and observed inspections and testing require a minimum of ten (10) days advance notice.

4.2 Inspection

4.2.1 General

4.2.1.1 e) (Decision) Final assembly clearances are required only for equipment data books.

4.3 Final Testing

4.3.1.6 (Decision) The prebalanced coupling half (including idling adapters) shall be used during the unbalanced response tests.

4.3.2 Routine Test

4.3.2.1 d) (Decision) Insulation resistance test is required.

4.3.2.1 j) (Decision) Bearing clearance, crush, and alignment shall be determined and recorded before tests are run.

4.3.3 Vibration Test

4.3.3.1 (Modification) For hydrodynamic bearing machines, electrical and mechanical runout shall be determined…

4.3.3.2 (Modification) For hydrodynamic bearings machines, accurate records of electrical and mechanical runout…

4.3.3.3 (Modification) When non-contacting vibration probes or provisions are specified for hydrodynamic bearing machines, combined electrical and mechanical runout shall also be measured…

4.3.5 Special Tests

4.3.5.1 Complete Test

4.3.5.1.1 (Decision) Each machine shall be given a complete test.

4.3.5.2 Rated Rotor Temperature Vibration Test

4.3.5.2.2 (Modification) Complete details of an alternative test, if needed, shall be submitted with the Proposal.

4.4 Preparation for Shipment

4.4.1 (Decision) Preparation shall make the equipment suitable for at least 6 months of outdoor storage from the time of shipment.

6.0 VENDOR'S DATA, DRAWINGS AND MANUALS

6.2 Proposals

6.2.2.1 a) (Modification) (Performance curves and data) … at rated voltage and minimum starting conditions (voltage and/or short circuit MVA) and 90%, 80%, 65% and 50% rated voltage.

6.2.2.1 b) (Modification) (Performance curves and data) … at rated voltage and minimum starting conditions (voltage and/or short circuit MVA) and 90%, 80%, 65% and 50% rated voltage.

6.2.2.1 d) (Modification) (Performance curves and data) … at rated voltage and minimum starting conditions (voltage and/or short circuit MVA) and 90%, 80%, 65% and 50% rated voltage.

6.2.2.1 e) (Modification) (Performance curves and data) … at rated voltage and minimum starting conditions (voltage and/or short circuit MVA) and 90%, 80%, 65% and 50% rated voltage.

6.2.2.1 h) (Decision) For motors that drive reciprocating equipment, the data described in this paragraph shall be provided.

6.2.2.3 (Decision) Information shall be supplied with the Proposal to facilitate a preliminary power system short-circuit analysis.

6.2.14 (Decision) The Seller shall provide an outline of weather/winterizing protection if any is required for the site conditions given on equipment data sheets. Drawings shall include power requirements (voltage / wattage). Bills of material shall use OEM part information.

6.6 Drawings

6.6.4 (Addition) Schematic diagrams shall include wiring and terminal identification and locations of all devices and auxiliary systems included in the scope of supply.

6.6.7 (Addition) Current transformer data including ratings, saturation curves, burdens and winding resistance shall be provided.

6.7 Final Data

6.7.2 a. (Decision) The vendor shall submit certified copies of the test data to the purchaser for approval before shipment. Photographs of installed nameplates shall also be provided before shipment.

6.7.2 b. (Decision) Calculated rotor response curves shall be furnished.

6.8 Instruction Manuals

6.8.4 (Addition) One copy of the instruction manual shall be shipped with the equipment.

6.8.6 (Decision) Copies of the documentation described shall be included in the Final Data Book for each machine.

End of Specification

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

Lubrication, Shaft-Sealing and Oil-Control Systems and Auxiliaries – API 614

Specification No.: EH-35R-CCU1-SPC-255-56084

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1.0 INTRODUCTION

1.1 Purpose

This specification, EH-35R-CCU1-SPC-255-56084, serves as an overlay for American Petroleum Institute (API) Standard 614 with applicable additions, deletions, modifications, and clarifications listed with associated paragraphs.

1.2 Scope

EH-35R-CCU1-SPC-255-56084, along with API 614, describes Lubrication, Shaft-sealing and Oil-control Systems and Auxiliaries. Self-acting Gas Seal Support Systems are not covered by this specification and are described in API 692 (see Part 4 of this specification).

2.0 REFERENCES

Applicable requirements in the latest edition (or the edition indicated) of API 614 shall be considered an integral part of this Practice. Additional references are listed below. Short titles will be used herein when appropriate.

2.1 Industry Codes and Standards

- American Petroleum Institute (API)
  - API 614, *Lubrication, Shaft-sealing and Oil-control Systems and Auxiliaries, Fifth Edition, April 2008.*

2.2 Project Specifications

- EH-35R-CCU1-SPC-215-00002, Structural Data For Mechanical Equipment
- EH-35R-CCU1-SPC-255-56070, General Purpose Induction Motors – 3/4 HP Through 200 HP – IEEE 841
- EH-35R-CCU1-SPC-255-85012, Positive Material Identification (PMI)
- EH-35R-CCU1-SPC-265-00002, Electrical Requirements for Packaged Equipment
- EH-35R-CCU1-SPC-270-00003, Packaged Equipment Instrumentation

3.0 DEFINITIONS

Definitions as provided in API 614 are applicable to this specification. The following additional definitions are also applicable to this specification.

4.0 AMENDMENTS TO API 614

The following items are amendments to API 614. The section and paragraph numbers refer to those given in that specification. An "**Add**" to a API paragraph expands on the requirements or selects options; "**Substitute**" replaces the entire paragraph or sentences; "**Modify**" means the original text has been changed to reflect project requirements; "**New**" is for a new paragraph/section to be added.

	Amendment Description
Part 1	**The following amendments apply to API 614, Part 1, General Requirements.**
Part 1, 2.1	**Add:** API Standard 660, *Shell-and-tube Heat Exchangers* ASME BPVC (Boiler and Pressure Vessel Code), Section VIII, Division I, *Rules for Construction of Pressure Vessels* NFPA 70, *National Electrical Code*
Part 1, 4.1	**Substitute:** Drawings and maintenance dimensions shall be in SI units or U.S. customary (USC) units. Use of an SI datasheet indicates that SI units shall be used. Use of an USC datasheet indicates that USC units shall be used. **To Read:** Drawings and maintenance dimensions shall be in U.S. customary (USC) units. An USC datasheet shall be used.
Part 1, 4.1.1	**New:** Metric 'o'-rings, seal parts, fasteners and flanges are acceptable only when specifically approved by Purchaser.
Part 1, 4.4	**Substitute:** The pressure design code shall be specified or agreed by the purchaser. **To Read:** The pressure design code shall be ASME BPVC, Section VIII, Division 1.
Part 1, 4.4.9	**Modify:** If required by area classification, motors shall comply with IEEE 841 or explosion proof NEMA MG-1. **To Read:** Motors shall comply with IEEE 841 and Project Specification EH-35R-CCU1-SPC-255-56070.
Part 1, 4.5.2	**Modify:** The equipment, including all auxiliaries, shall be suitable for operation under the environmental conditions specified. **To Read:** The equipment, including all auxiliaries, shall be suitable for outdoor, unsheltered operation in a high dust concentration area. Structural design data, such as wind loads and seismic zone, is specified in Project Specification EH-35R-CCU1-SPC-215-00002. Other environmental conditions may also be specified.

Part 1, 4.8	**Substitute:** The hierarchy of documents shall be specified. **To Read:** When conflicts exist between this specification and other documents, the following order of precedence will govern: a. Purchase Order b. Data Sheets c. This Specification d. Other Referenced Specifications e. API Standard 614, 5th edition, April 2008 f. Other Referenced Industry Standards
Part 1, 5.1.2	**Modify:** Table 1: NOTE Threaded joints require seal welding; however, seal welding is not permitted on instruments or where disassembly is required for maintenance. **To Read:** Table 1: NOTE Seal welding is not permitted on instruments or where disassembly is required for maintenance.
Part 1, 5.1.2	**Modify:** Table 4: Flange: Stainless steel (e.g. ASTM A181 type 304 or 316 stainless steel or the equivalent material designation located in Annex E), weld neck or slip-on. Socket weld flanges are prohibited. Carbon steel (e.g. ASTM A105 or the equivalent material designation located in Annex E), slip-on **To Read:** Table 4: Flange: Stainless steel (e.g. ASTM A181 type 304 or 316 stainless steel or the equivalent material designation located in Annex E), weld neck or slip-on. Socket weld flanges are prohibited.
Part 1, 5.1.2	**Add:** Gaskets containing graphite are not permitted due to their tendency to contaminate the oil stream.
Part 1, 5.1.2	**Modify:** Table 4: NOTE Threaded joints require seal welding; however, seal welding is not permitted on instruments or where disassembly is required for maintenance. **To Read:** Table 4: NOTE Seal welding is not permitted on instruments or where disassembly is required for maintenance.

Part 1, 5.1.7	**Modify:** Pipe bushings shall be seal welded if used. Welded pipe bushings are acceptable only at the drain connections on pump suction strainers where the strainer cannot be rotated. **To Read:** Welded pipe bushings are acceptable only at the drain connections on pump suction strainers where the strainer cannot be rotated.
Part 1, 5.1.19	**Substitute:** All components, such as flanges, valves, control valve bodies or heads and relief valves, that contain oil, special and/or hazardous fluids or steam over 500 kPa (75 psig) shall be made of steel. **To Read:** All components, such as flanges, valves, control valve bodies or heads and relief valves that contain oil, toxic or flammable fluids or steam shall be made of steel.
Part 1, 5.1.20	**Substitute:** Threaded joints for special and/or hazardous fluids or for steam pressures greater than 500 kPa (75 psig) shall be seal-welded; however, seal welding is not permitted on cast iron equipment, instruments or locations that require disassembly for maintenance. Seal-welded joints shall be made in accordance with the codes specified. Where no codes have been specified, seal-welded joints shall be in accordance with ISO 15649. **To Read:** Threaded joints shall not be seal welded. Threaded joints are not permitted in hydrocarbon (include lube oil), steam, condensate, toxic or flammable service. NOTE Seal welding is not permitted because of the potential for crevice corrosion, corrosion from process fluids, residual stresses on the threads, difficulty of inspecting joints, etc.
Part 1, 5.1.21	**New:** All valves NPS 1-1/2 and larger shall have raised face flange connections.
Part 1, 5.1.24	**New:** In all cases where the instrument is located remote from the primary block valve, an instrument valve shall be provided at the instrument. Primary block valves shall be located as close as practical to the process lines.
Part 1, 5.2.2	**Substitute:** Non-consumable backup rings and sleeve-type joints shall not be used. **To Read:** Backup rings (consumable or non-consumable) and sleeve-type joints shall not be used.

Part 1, 5.2.3	**Modify:** Unless otherwise specified, piping and tubing, including fittings (excluding slip-on flanges), shall be made of stainless steel. (See Table 4.) **To Read:** Piping and tubing, including fittings shall be made of stainless steel. (See Table 4.)
Part 1, 5.2.5	**New:** Oil sample points shall be provided upstream and downstream of the oil filters.
Part 1, 5.5.5	**Modify:** Water-cooled, shell-and-tube intercoolers and aftercoolers shall be designed and constructed in accordance with TEMA Class C or R, as specified. When TEMA Class R is specified, the heat exchanger shall be in accordance with ISO 16812 as specified. **To Read:** Water-cooled, shell-and-tube intercoolers and aftercoolers shall be designed, constructed and tested in accordance with TEMA Class C.
Part 1, 6.1.2	**Add:** Instrumentation and controls shall conform to Project Specification EH-35R-CCU1-SPC-270-00003.
Part 1, 6.1.8	**New:** All terminal connections and interconnecting wiring of the components installed on each skid shall be done by the Vendor. All wiring shall terminate in junction boxes for connection to Purchaser's external conduit and wiring.
Part 1, 6.1.9	**New:** Controls, instrumentation and equipment shall be suitable for the area classification (class, group and division or zone) specified by the purchaser and shall meet the requirements of the applicable parts of NFPA 70, Articles 500, 501, 502, 504 and 505, as well as any local codes specified by the purchaser.
Part 1, 6.2.1.2	**Substitute:** If specified, shutdown-sensing devices shall be provided with valving, bridging links or other approved protocol to allow replacement with the equipment in operation. **To Read:** All instruments and controls, including shutdown-sensing devices shall be provided with sufficient valving to permit their calibration, testing and replacement with the equipment in operation.

Part 1, 6.3.1.3	**Modify:** The panel shall be freestanding, located on the base of the package or machine baseplate or in another location, as specified. **To Read:** The panel shall be freestanding within sight of the equipment.
Part 1, 6.3.3.1	**Substitute:** If specified, transmitters shall be provided. **To Read:** Transmitters shall be provided in lieu of switches.
Part 1, 6.3.8.3	**Substitute:** If specified, liquid-filled gauges or dampened movement gauges shall be furnished in locations subject to vibration. **To Read:** Liquid-filled gauges shall be furnished in locations subject to vibration.
Part 1, 6.3.10.3	**Modify:** Dual-coil solenoids may be specified for any trip function. **To Read:** Dual-coil solenoids are required for any trip function.
Part 1, 6.4.1	**Modify:** Motors, electrical instrumentation, components, and electrical installations shall be suitable for the are classification (class, group and division or zone) specified by the purchaser and shall meet the requirements of the applicable parts of IEC 60079-10-1:2008 or NFPA 70:2008, Articles 500, 501, 502 and 504), as well as any local codes specified and furnished on request by the purchaser. **To Read:** Motors, generators, electrical instrumentation, components, and electrical installations shall be suitable for the area classification (class, group and division or zone) specified by the purchaser and shall meet the requirements of the applicable parts of NFPA 70, Articles 500, 501, 502, 504 and 505, as well as any local codes specified by the purchaser.
Part 1, 6.4.2	**Add:** Electrical systems shall conform to Project Specification EH-35R-CCU1-SPC-265-00002.
Part 1, 7.2.2.6	**Add:** Positive material identification (PMI) shall be performed in accordance with Project Specification EH-35R-CCU1-SPC-255-85012.

Part 1, 7.4.3 m)	**New:** All instruments shall have a permanently attached nameplate. The nameplates shall be made of stainless steel, stamped or engraved with the instrument tag number with minimum 3/16" high characters. Nameplates shall be either attached directly to the instrument using rivets or drive screws or secured to the instrument with a minimum 16-gauge stainless steel wire.
Part 2	**The following amendments apply to API 614, Part 2, Special-purpose Oil Systems**
Part 2, 2	**Add:** API 676, *Positive Displacement Pumps - Rotary* ASME B73.1-2012, *Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process* ISO 3448: *Industrial Liquid Lubricants – ISO Viscosity Classification*
Part 2, 4.1.5	**Add:** The equipment furnished by the vendor shall conform to a maximum allowable sound pressure level of 85 dBA measured at 3 ft (1 m) from the equipment boundary.
Part 2, 4.1.7	**New:** The design lubricant shall be hydrocarbon oil of viscosity Grade 32 in accordance with ISO 3448. However, the vendor with overall unit responsibility may recommend a different oil suitable for all machines in an equipment train and submit for purchaser's review and approval.
Part 2, 4.1.9	**Modify:** The recycled oil shall originate upstream of the filters. **To Read:** Recirculated bypass oil shall originate upstream of the filters.
Part 2, 4.1.16	**Modify:** The purchaser shall specify when and where double block and bleed valves are required for isolating a component and how they are arranged. **To Read:** Double block and bleed valves are required for services in excess of 300 psi (20.7 Bar) pressure.
Part 2, 4.1.17	**Modify:** If specified by the purchaser, vessels shall be code stamped. **To Read:** Vessels shall be code stamped.
Part 2, 4.2.1	**Modify:** The system shall be designed as a single console, in multiple packages or in any other arrangement as specified.

	To Read: The system shall be designed as a single console.
Part 2, 4.2.2	**Substitute:** Unless otherwise specified, package baseplates shall be of the drain-gutter type with one or more drain connections at least DN 40 (NPS 1 1/2) in size. **To Read:** Package baseplates shall be provided with a sloped gutter type drain around the circumference of the base deck. Drain connections at least DN 50 (NPS 2) in size shall be provided to allow complete drainage.
Part 2, 4.2.10	**Substitute:** Levelling screws shall be provided in the proximity of each hold-down bolt. **To Read:** Baseplate levelling screws shall be provided at every anchor bolt location. A minimum of three (3) levelling screws per side are required.
Part 2, 4.2.11	**New:** A minimum of two grounding lugs, installed diagonally at opposite ends of the baseplate, shall be provided. Lugs shall be NEMA standard two-hole, straight / long barrel compression type suitable to accept Purchaser's #4/0 AWG copper conductor.
Part 2, 4.3.7.2	**Substitute:** Purchaser shall specify whether the heaters are steam or electric. **To Read:** When required, heaters shall be electric.
Part 2, 4.3.7.5	**Add:** The electric heater shall be furnished with a switch in series with the heater to operate a light indicating when the heater is on.
Part 2, 4.3.10.1	**Substitute:** If specified, the vendor shall provide a 25 mm (1 in) flanged, valved and blinded connection (see Figure B.24, Footnote i), located below the minimum operating level for use as an oil supply connection for an oil conditioner. **To Read:** The vendor shall provide two 25 mm (1 in) flanged, valved and blinded connections (see Figure B.24 – Oil reservoir, Footnote i) for oil conditioner. An oil supply connection shall be located below the minimum operating level. An oil return connection shall be equipped with a stilling tube and located above the rundown oil level.

Part 2, 4.4.1	**Substitute:** The purchaser shall specify whether horizontal centrifugal or rotary pumps shall be used. Except as modified in this part of ISO 10438, pumps shall conform to ISO 13709. **To Read:** Pumps shall be horizontal. Rotary pumps shall be used where possible. Rotary pumps shall conform to API 676. If centrifugal pumps are required, they shall conform to ASME B73.1.
Part 2, 4.4.32 c)	**Modify:** To minimize misalignment of the pump and driver shafts due to piping load effects, the pump and its baseplate shall be constructed with sufficient structural stiffness to limit total misalignment to within acceptable limits. **To Read:** To minimize misalignment of the pump and driver shafts, the pump and its baseplate shall be constructed with structural stiffness which will limit total misalignment to within the tolerance as outlined in API RP 686.
Part 2, 4.5.1.2	**Modify:** Unless otherwise specified, coolers shall be shell-and-tube type and shall be in accordance with the requirements of 4.5.1.4. **To Read:** Unless otherwise specified, coolers shall be shell-and-tube type and shall be in accordance with the requirements of 4.5.2.
Part 2, 4.5.1.15	**Modify:** If specified, shell-and-tube or plate-frame coolers shall be suitable for use of a 150 °C (300 °F) heating medium. **To Read:** Shell-and-tube or plate-frame coolers shall be suitable for use of a 150°C (300°F) heating medium, such as steam or a mixture of steam and water.
Part 2, 4.5.3.4	**Add:** The frame and tie bolts of the gasketed, or semi-welded plate-and-frame heat exchanger shall be designed to permit the future installation of at least 20 % additional plates.
Part 2, 4.6.6 b)	**Modify:** If specified, filter-element media shall be non-hydroscopic. **To Read:** Filter-element media shall be non-hydroscopic.
Part 2, 4.9.2.3	**Add:** The atmospheric rundown tank shall also be provided with a level gauge glass.

Part 2, 6.1.2	**Substitute:** Instrumentation shall be in accordance with ISO 10438-1:2007, Clause 6, except as modified in 6.2 to 6.4. **To Read:** Instrumentation shall be in accordance with API 614, Part 1, Clause 6. Arrangement 3 as described in 6.4 shall be used for alarms and shutdowns.
Part 2, 7.3.1.3	**Modify:** Complete-unit tests or other tests of the oil system and the equipment it serves shall be performed in place of or in addition to separate tests of the oil system as specified by the purchaser. Details of these tests shall be developed jointly by the purchaser and the vendor. **To Read:** Complete-unit tests or other tests of the oil system and the equipment it serves shall be performed in addition to separate tests of the oil system performed by the oil system supplier. Details of these tests shall be developed jointly by the purchaser and the vendor.
Part 2, 7.3.3.8 i)	**New:** System outlet flows, pressures and temperatures shall be recorded at 15-minute intervals during the entire test. The oil filter differential pressure shall be recorded at the beginning and the end of the test.
Part 3	**The following amendments apply to API 614, Part 3, General-purpose oil systems**
Part 3, 4.2.5	**Add:** The equipment furnished by the vendor shall conform to a maximum allowable sound pressure level of 85 dBA measured at 3 ft (1 m) from the equipment boundary.
Part 3, 4.2.8	**Modify:** Recycled oil originating upstream of the filters is preferred and is required when there is a possibility of an explosive mixture in the reservoir. **To Read:** Recirculated bypass oil shall originate upstream of the filters.
Part 3, 4.2.14	**Modify:** If specified by the purchaser, vessels shall be code stamped. **To Read:** Vessels shall be code stamped.
Part 3, 4.3.5	**Modify:** If specified, metal decking covering all walk and work areas shall be provided on the top of the baseplate. **To Read:**

	Metal decking covering all walk and work areas shall be provided on the top of the baseplate.
Part 3, 4.3.6	**Modify:** If specified, baseplates shall be suitable for installation in accordance with API RP 686. **To Read:** Baseplates shall be suitable for installation in accordance with API RP 686.
Part 3, 4.3.10	**New:** A minimum of two grounding lugs, installed diagonally at opposite ends of the baseplate, shall be provided. Lugs shall be NEMA standard two-hole, straight / long barrel compression type suitable to accept Purchaser's #4/0 AWG copper conductor.
Part 3, 4.4.4.2	**Modify:** If specified, to ensure complete drainage, the bottom of each reservoir shall be sloped to a low point drain. **To Read:** To ensure complete drainage, the bottom of each reservoir shall be sloped to a low point drain.
Part 3, 4.4.4.3	**Modify:** If specified, a drain connection (with a valve and a blind flange) at least 50 mm (2 in) in diameter shall be provided. **To Read:** A valved low point drain connection that is either plugged or blind-flanged shall be provided.
Part 3, 4.4.5 d)	**Modify:** If specified, an oil level glass arranged to cover the span from at least 25 mm (1 in) above the rundown level to 50 mm (2 in) below the pump suction-loss level. **To Read:** A weld pad type oil level glass arranged to cover the span from at least 25 mm (1 in) above the rundown level to 50 mm (2 in) below the pump suction-loss level shall be provided.
Part 3, 4.4.7	**Modify:** If specified, an electric heater shall be furnished in accordance with the following. **To Read:** An electric heater, if required by the site ambient conditions, shall be furnished in accordance with the following:

Part 3, 4.4.7 e)	**New:** The electric heater shall be furnished with a switch in series with the heater to operate a light indicating when the heater is on.
Part 3, 4.5.1	**Substitute:** The oil system shall include an oil pump suitable for continuous operation. The purchaser shall specify whether centrifugal or rotary pumps shall be used. If specified, pumps shall conform to ISO 13709 or ASME B73.2 or ASME B73.3 for the centrifugal pumps and to API STD 676 for rotary pumps. **To Read:** The oil system shall include an oil pump suitable for continuous operation. Rotary pumps shall be used.
Part 3, 4.5.5	**Modify:** Motors shall comply with the area classification and shall comply with NEMA MG1 or applicable part(s) of IEC 60034. **To Read:** Motors shall comply with the area classification, IEEE 841 and Project Specification EH-35R-CCU1-SPC-255-56070.
Part 3, 4.5.10	**Delete:** This valve shall not be used for pressure control.
Part 3, 4.5.11	**Delete:** Pressure-limiting valves shall not be used for continuous pressure regulation.
Part 3, 4.6.1.3	**Modify:** If specified, an oil bypass line around the cooler with a temperature-control valve shall be included to regulate the oil-supply temperature. **To Read:** An oil bypass line around the cooler with a temperature-control valve shall be included to regulate the oil-supply temperature.
Part 3, 4.7.7 l)	**Modify:** If specified, filter element media shall be non-hydroscopic. **To Read:** Filter element media shall be non-hydroscopic.
Part 3, 4.9.3	**Add:** The atmospheric rundown tank shall also be provided with a level gauge glass.

Part 3, 7.3.1.3	**Modify:** Complete-unit tests or other tests of the oil system and the equipment it serves shall be performed in place of or in addition to separate tests of the oil system as specified by the purchaser. Details of these tests shall be developed jointly by the purchaser and the vendor. **To Read:** Complete-unit tests or other tests of the oil system and the equipment it serves shall be performed in addition to separate tests of the oil system performed by the oil system supplier. Details of these tests shall be developed jointly by the purchaser and the vendor.
Part 3, 7.3.3.7 h)	**New:** System outlet flows, pressures and temperatures shall be recorded at 15-minute intervals during the entire test. The oil filter differential pressure shall be recorded at the beginning and the end of the test.
Part 4	**The following amendments apply to API 614, Part 4, Seal-acting Gas Seal Support Systems.**
Part 4, Section 1	**Substitute:** **Scope** This part of ISO 10438 in conjunction with ISO 10438-1 specifies requirements for support systems for self-acting gas seals (dry gas seals), for example as described in ISO 10439 and ISO 10440-1. These systems can serve equipment such as compressors, gears, pumps and drivers. NOTE For the purposes of this statement of scope, API 617 is equivalent to ISO 10439 and API 619 is equivalent to ISO 10440-1. **To Read:** **Scope** This part of API 614 (ISO 10438) in its entirety is superseded by API 692, Part 3, *Dry Gas Seal Support Systems* which specifies requirements for support systems for self-acting gas seals (dry gas seals), for example as described in API 617 and 619.
Section 2	**Add:** API Standard 692, *Dry Gas Sealing Systems for Axial, Centrifugal, Rotary Screw Compressors and Expanders*

5.0 ATTACHMENTS

None

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

Shell and Tube Heat Exchangers

Specification No. EH-35R-CCU1-SPC-255-57020

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FOREWORD

This specification covers the minimum requirements for the design and fabrication of shell-and-tube heat exchangers in general refinery service. It is also applicable for the chemical and petrochemical industries.

This specification supplements API Standard 660, Ninth Edition, March 2015 which shall be considered an integral part of this specification. Paragraph numbers of this specification correspond to those in API 660.

Paragraphs shall be highlighted as shown below to indicate the type of change to API 660:

(Addition)	Additional material has been added to the existing paragraph.
(Decision)	A decision has been made as required
(Deleted)	The existing paragraph has been deleted.
(Modification)	Minor changes have been made to the existing paragraph, but not a substitution invalidating the paragraph.
(New)	A new paragraph has been added (no existing paragraph).
(Substitution)	A new paragraph supersedes the existing paragraph in its entirety.

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1.0 SCOPE

(Addition) The requirements stated herein are supplementary to the data listed on the Shell-and-Tube Exchanger Data Sheets (hereinafter referred to as data sheets).

2.0 NORMATIVE REFERENCES

(Addition) The latest edition shall be the one in effect on the PO (Purchase Order) date. The following standards are added:

ASME	(American Society of Mechanical Engineers)
B16.20	Metallic Gaskets for Pipe Flanges Ring-Joint, Spiral-Wound, and Jacketed
B16.47	Large Diameter Steel Flanges – NPS 26 Through NPS 60
Section V	Nondestructive Examination
Section VIII	Divisions 1, 2 – Rules for Construction of Pressure Vessels

PROJECT SPECIFICATIONS

EH-35R-CCU1-SPC-215-00002 Structural Data for Mechanical Equipment

EH-35R-CCU1-SPC-255-85050 Welding/NDE Requirements for Equipment

EH-35R-CCU1-SPC-255-85012 Positive Material Identification (PMI)

EH-35R-CCU1-SPC-255-85210 Aboveground Coatings

3.0 TERMS AND DEFINITIONS

3.16 (New) Sour Service

Any stream containing 50 ppm or greater H2S (wet or dry).

3.17 (New) Local Authority

The governmental regulatory authority controlling laws, codes, rules and regulations for the design, fabrication, testing and inspection of unfired pressure vessels in the location where the exchanger is to be installed.

4.0 GENERAL

4.1 (Decision) The pressure design code shall be ASME Section VIII, Div. 1.

4.2 (Addition) Heat exchangers shall conform to the latest edition of TEMA and the supplemental requirements given in this specification. TEMA, Section 10, Recommended Good Practice is mandatory, except for RGP-T-2.4. Fouling factors are specified on the data sheet.

4.13 (New) The Supplier shall identify in writing any conflicts between the order, specifications, and other referenced documents for review by the Buyer. The Supplier shall obtain written approval from the Buyer before proceeding with work affected by a conflict.

4.14 (New) Heat exchangers shall be guaranteed by the Supplier against defective design, material and workmanship in accordance with the terms of the Purchase Order. In addition, the Supplier shall guarantee the performance of the heat exchangers with regard to heat duty and pressure drop in accordance with the process conditions on the individual data sheets. Upon satisfactory proof that the exchangers furnished do not meet the specified operating conditions, the Supplier shall furnish to the point of use, any necessary additional equipment to meet the specified conditions, or make changes, as required, to the original equipment furnished. When the thermal sizing is furnished by the Buyer, the Supplier shall verify the sizing and provide a thermal, hydraulic and vibration free guarantee.

5.0 PROPOSAL INFORMATION REQUIRED

5.5.b (Substitution) Unless otherwise specified, two complete sets of spare gaskets shall be supplied for each heat exchanger unit.

5.6 (New) The Proposal shall include tube-to-tube sheet fabrication details for expanded joint with clad tube sheet, strength welded joint and seal welded joint configurations.

6.0 DRAWINGS AND OTHER REQUIRED DATA

6.1.1.w (New) Bolt tightening torque and procedure for girth and floating head flanges.

6.2 Information Required After Outline Drawings are Reviewed

6.2.2 (Decision) Qualified welding procedure specifications and procedure qualification records as required by the ASME Code, Section IX and the Specification EH-35R-CCU1-SPC-255-85050 “Welding/NDE Requirements for Equipment”, shall be submitted for review in accordance with the Purchase Order.

6.2.4.f (New) Lifting lug design and calculations, along with lifting arrangement, shall be submitted to the Buyer for review.

7.0 DESIGN

7.3 Shell Supports

7.3.2.d (Substitution) Saddle-bearing plates shall have a 1/8 inch pipe size tapped hole at or near the low point.

7.3.2.f (Addition) Horizontal exchangers shall be provided with saddles designed to support the heat exchanger units under specified conditions, including wind and seismic loading in accordance with the Specification EH-35R-CCU1-SPC-215-XXXXX “Structural Data for Mechanical Equipment”.

7.3.8 (New) Unless otherwise specified, exchangers in series shall be stacked.

7.3.9 (New) saddles shall protrude beyond the bottom nozzles, including the drain nozzle with blind flange, by at least 1 inch to prevent damage to flange facings during fabrication, transport, storage and maintenance.

7.5 Tube Bundle

7.5.3 Baffles and Support Plates

7.5.3.4 (New) Floating head support plates shall be cut out as much as possible and trimmed beyond the top and bottom tube rows.

7.5.5 Bypass Sealing Devices

7.5.5.9 (New) The need for bypass seals in either peripheral or pass lanes shall be as noted on the datasheet. The location shall be according to 7.5.5.1.

7.6 Nozzles and Other Connections

7.6.5 (Substitution) Slip-on flange shall not be used.

7.6.13 (New) Nozzle flanges shall be in accordance with ASME B16.5 or ASME 16.47, Series B.

7.6.14 (New) Metallic gaskets for pipe flanges shall be in accordance with ASME B16.20.

7.6.15 (New) Auxiliary connections such as vents, drains, and instrument connections shall be provided with gaskets, bolting and blind flanges or plugs rated for design conditions. Gaskets shall be spiral wound unless specified otherwise by project specification.

7.6.16 (New) Facing for pressure connections shall be 125-250 AARH unless otherwise specified on the drawing.

7.6.17 (New) The minimum wall thickness of connections 3 in. diameter and smaller shall not be less than extra strong pipe wall thickness.

7.9 Expansion Joints

7.9.2.c (Substitution) Bellows type expansion joints shall be in accordance with EJMA Standards with a minimum design life of 5000 cycles.

7.9.3 (Addition) Flanged and flued expansion joints shall be in accordance with TEMA standards.

7.9.4 (Addition) Multi-ply expansion joints are not permitted in hydrogen service.

7.11 Handling Devices

7.11.5 (New) Lifting lugs shall be designed with maximum stress being no greater than 1/3 of yield stress.

8.0 MATERIALS

8.1.1 (Substitution) Castings shall not be used unless prior written authorization by Buyer has been obtained. The use of cast iron is not permitted.

8.1.2 (Substitution) Materials for external parts that are attached directly to the exchanger by welding such as legs, pads, brackets or lugs shall be of the same material specification, or Buyer approved equivalent, as the exchanger. When the external part is attached to a plate pad welded to the exchanger, only the pad material need conform with the same material specification.

8.1.3 (Substitution) Where high alloy steel linings are specified, they shall be weld overlay, integrally clad or explosion bonded. Applied liners or sleeves are unacceptable.

8.1.6 (Addition) Asbestos material is not allowed.

9.0 FABRICATION

9.1 Shells

9.1.4 (New) Openings and attachments (including reinforcing and support pads) shall clear weld seams by at least 2 inches. If this construction is not possible, the seam weld shall be ground flush and radiographed for a distance of 4 inches on either side of the opening or for the full length covered by an attachment plus 4 inches on both sides prior to welding the nozzle or attachment to the exchanger.

9.1.5 (New) All shell and head joints shall be full penetration, back welded joints.

9.3 Connection Junctions

9.3.1 (New) Reinforcing pads shall have at least 1 test hole, tapped 1/8 inch minimum pipe thread, located at least 45 degrees off the longitudinal axis of the exchanger. This requirement applies to each pad or segment thereof. The welds

of each pad or segment shall be given an air-and-soap solution test before pressure testing the exchanger. Test holes shall be left open for use as tell tale holes during the pressure test. Test holes shall be filled with grease after pressure test and prior to shipment.

9.5 Welding

9.5.1 (Substitution) Welding shall be in accordance with the Specification EH-35R-CCU1-SPC-255-85050 "Welding/NDE Requirements for Equipment".

9.6 Heat Treatment

9.6.2 (Decision) All U-bends shall be stress relief annealed after bending, except for duplex SS, titanium or if otherwise noted. Austenitic stainless steel U-bends shall be stress relief annealed after bending per SA-688. Stabilized stainless steel not covered by SA-688 shall be solution annealed. Stress relief requirements for other materials not otherwise defined herein shall be noted on the data sheet or purchase order.

9.8 Gasket Contact Surfaces Other Than Nozzle Flange Facings

9.8.3 (Decision) The flatness tolerance on peripheral gasket contact surfaces shall be as given in Table 5 for the following cases:

1. Hydrogen service
2. Design temperature exceeds 455 °C (850 °F)
3. Design pressure exceeds 14,000 kPa (2000 psig)
4. Cyclic service

10.0 INSPECTION AND TESTING

10.2 Quality Control

10.1.11 (Addition) Clad plate shall be 100 percent tested ultrasonically to verify the bond between the base material and the cladding. The test shall be in accordance with ASTM A-578. For hydrogen service, procedure and acceptance criteria shall be in accordance with Quality Level Class 1 as described in Paragraph 13.3.1 of ASTM A-263, A-264, or A-265, depending on metallurgy. For other services, procedure and acceptance criteria shall be in accordance with Quality Level Class 3 as described in Paragraph 13.3.2 of ASTM A-263, A-264, or A-265, depending on metallurgy.

10.1.12 (Addition) All weld overlay, whether by manual or automatic procedures, shall be liquid dye penetrant examined in accordance with ASME Code, Section VIII, Division 2, Article 9-2, for procedure and acceptance criteria. When the overlay involves two passes (layers) and the procedure uses an intermediate heat treatment with cooling to room temperature prior to applying the second layer, each layer shall be examined. Where overlay is to be machined, such as in nozzles and flange facing, machined surfaces shall be examined. Examination shall be performed after PWHT.

10.3 Nameplates And Stampings

10.3.4 (New) Exchangers with bundles designed for differential pressure shall have a visible warning plate adjacent to, or part of, the nameplate outlining test pressure restrictions for differential design pressure.

11.0 PREPARATION FOR SHIPMENT

11.1 Protection

11.1.2 (Addition) Each exchanger shall be thoroughly cleaned inside and outside, and shall be free of grease, weld spatter, scale, slag, rust, and other foreign matter. Exchangers shall be thoroughly dried after testing. Hot air drying by evaporation is not permitted.

11.1.7 (Decision) Each exchanger shall be coated in compliance with the Specification EH-35R-CCU1-SPC-255-85210 “Aboveground Coatings”.

11.1.8 (Substitution) Threads of bolts including exposed parts shall be coated with a metallic base waterproof lubricant to prevent aqueous corrosion during testing, shipping, and storage.

12.0 SUPPLEMENTAL REQUIREMENTS

12.1 General

(Decision) The supplemental requirements shall apply to the shell and/or tube side of exchangers in the following cases:

a) Cylinder thickness greater than 2 inches.

b) Design pressure greater than 2000 psig.

12.2 Design

12.2.1 (Addition) Acceptable nozzle-to-cylinder weld details are:

ASME VIII, Division 1

Figures UW-16.1 (a), (a-1), (b), (c), (d), (e), (f-1), (f-2), (f-3), (f-4), (g).

ANNEX B – SHELL-AND-TUBE HEAT EXCHANGER CHECKLIST

(INFORMATIVE)

(Addition) This checklist summarizes Buyer's requirements for the bulleted subclauses in this International Standard, i.e. the subclauses in which a decision is required by the Buyer.

Paragraph	Item	Requirement
4.1	Pressure design code to be used	ASME Section VIII, Division 1
4.3	Applicable local registrations	Per Inquiry/P.O.
4.7	Fluid characteristics requiring special considerations	Per data sheet
4.8	Cyclic service design	Per data sheet
4.10	Sour or wet hydrogen sulfide service design	Per data sheet
4.11	Hydrogen Service	Per data sheet
4.12	Data required to determine the need for an expansion joint on single tube pass floating-head and all fixed tubesheet heat exchangers	Per Inquiry/P.O.
6.1.2	Flow-induced vibration analysis to be submitted	Yes
6.2.2	Welding procedures and qualifications to be submitted for review	Yes
6.2.5	Design calculations for supports or lifting and pulling devices to be submitted for review	Yes
6.3	Number of copies of reports and records required	Per Inquiry/P.O.
7.1.1	Maximum design temperature	Per data sheet
	Minimum design metal temperature (MDMT)	Per data sheet
7.3.6	Method of analyzing local stresses in shell at supports	ASME Sect. VIII, Div. 2, Part 4.15
7.4.11	1/8 in. future machining allowance in girth flange, channel cover, floating head flange, and pass-partition gasket contact surfaces.	Yes
7.5.2.5	1/8 in. future machining allowance in tubesheet and pass-partition gasket contact surfaces	Yes
7.5.7.3	Degree of expansion and the use of grooves with strength welded tube-to–tubesheet joints	Minimum 3% thickness reduction. Grooves per data sheet
7.6.1	Flange Design Code	Up through NPS 24: ASME B16.5. NPS 26 through 60: ASME B16.47, Series B
7.6.2	Nozzles welded to connecting piping.	Per data sheet
7.6.6	Insulation thickness: shell	Per data sheet
	Insulation thickness: channel	Per data sheet
7.6.8	Chemical-cleaning connections required	Per data sheet
7.6.9	Forces and moments on connections specified	Per Inquiry/P.O.
7.6.10	Forces and moments on nozzles larger than NPS 24	Per Inquiry/P.O.
7.7.1	Studded-in bolts in channel and shell external girth joints	No

Paragraph	Item	Requirement
7.7.6	Alternate bolt tensioning method	Per Inquiry/P.O.
7.7.8	Design flange clearances for use of bolt-tensioning devices	Per Inquiry/P.O.
7.7.15	1/8 in. future machining allowance in external girth flange and pass-partition gasket contact surfaces.	Yes
7.8.1	Joint component approach (ASME PCC-1) applied.	Per Inquiry/P.O.
7.12.2	Supplemental requirements for low chrome steels in high temperature or high pressure hydrogen service	Per Inquiry/P.O.
8.1.4	Specify materials for all components	Per data sheet and inquiry/P.O.
8.2.3	Maximum allowable carbon equivalent for sour or wet hydrogen sulfide service	Per Inquiry/P.O.
9.5.11	Weld procedure qualifications for carbon steel in sour or wet hydrogen sulfide service, including tube-to-tubesheet welds, shall include a micro-hardness survey	Per Inquiry/P.O.
9.5.12	Weld procedure qualifications for duplex stainless steels, including tube-to tubesheet welds, shall include a micro-hardness survey	Per Inquiry/P.O.
9.6.2	Heat treatment requirements and procedures for U-tube bend sections	Refer to 9.6.2 in text
9.6.5	Stainless steels, copper, copper-nickel, and high nickel alloys (Ni > 30 %) heat treatment of U-tubes	Refer to 9.6.2 in text
9.6.8	De-scaling treatment for the heat treated portion of U-tubes	Per Inquiry/P.O.
9.6.10	Postweld heat treatment for weld-overlaid channels and bonnets	Per data sheet
9.6.12	Post-weld heat treatment for process reasons: shell side	Per data sheet
	Post-weld heat treatment for process reasons: tube side	Per data sheet
9.10.4	Groove within the tubesheet shell side cladding	Per data sheet
10.1.16	All carbon steel plate in sour or wet hydrogen sulfide service shall be subjected to an ultrasonic lamination check	Per Inquiry/P.O.
10.2.2	Helium leak test of tube-to-tubesheet joint integrity after final expansion of the tubes	Per Inquiry/P.O.
10.2.7	Additional equipment drying or preservation	Per Inquiry/P.O.
10.3.6	Removal of bonnet or channel cover for shell side hydrostatic test required	Yes
11.1.7	Painting requirements	Refer to 11.1.7 in text
11.1.10	Inert gas (e.g. nitrogen, argon) purge and fill required prior to shipment	Per Inquiry/P.O.
12.1	Supplemental requirements apply to: Shellside Tubeside	Refer to 12.1 in text

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

AIR COOLED HEAT EXCHANGERS

Specification No. EH-35R-CCU1-SPC-255-57030

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AIR COOLED HEAT EXCHANGERS

FOREWORD

This specification covers the minimum requirements for the design and fabrication of air-cooled heat exchangers used in the petroleum and petrochemical industries.

This specification supplements API Standard 661, Seventh Edition, July 2013, Reaffirmed June, 2018, which shall be considered an integral part of this specification. Paragraph numbers of this specification correspond to those in API 661.

Paragraphs shall be highlighted as shown below to indicate the type of change to API 661:

(Addition)	Additional material has been added to the existing paragraph.
(Decision)	A decision has been made as required.
(Deleted)	The existing paragraph has been deleted.
(Modification)	Minor changes have been made to the existing paragraph, but not a substitution invalidating the paragraph.
(New)	A new paragraph has been added (no existing paragraph).
(Substitution)	Paragraph supersedes the existing paragraph in its entirety.

Substitute the terms “Buyer” and “Seller” for the corresponding terms “Purchaser” and “Vendor” used in API 661.

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1.0 SCOPE

(Addition) The requirements stated herein are supplementary to the data listed on the Air Cooled Heat Exchanger Data Sheets (hereinafter referred to as data sheets).

2.0 NORMATIVE REFERENCES

(Addition) The latest edition shall be the one in effect on the PO (Purchase Order) date. The following standards and specifications are added.

AISC

360-10 Specifications for structural Steel Buildings

AISI

Specification for Design of Cold-Formed Steel Structure Members

ASME

Rules for construction of Pressure Vessels, Section VIII, Division 1

3.0 TERMS AND DEFINITIONS

4.0 GENERAL

4.1 (Decision) All pressure components of the exchanger, including supplemental steam coils, shall conform to the requirements of Section VIII, Division 1 of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code and the supplemental requirements herein, regardless of whether code stamping is required.

4.8 (New) Seller shall immediately identify any conflicts between the order, specifications, and other referenced documents for review by Buyer. Seller shall obtain written approval from buyer before proceeding with work affected by conflict.

4.9 (New) Heat exchangers shall be guaranteed by Seller against defective design, material, and workmanship in accordance with the terms of the purchase order. In addition, Seller shall guarantee performance of the exchangers with regard to heat duty and pressure drop, in accordance with the process conditions on the individual data sheets. Upon satisfactory proof that the exchangers furnished do not meet specified operating conditions, Seller shall furnish to the point of use any necessary additional equipment to meet specified conditions, or make changes, as required, to the original equipment furnished. When the thermal sizing is furnished by Buyer, Seller shall verify the sizing and provide a thermal and hydraulic guarantee meeting noise and vibration limits specified.

5.0 PROPOSALS

5.11 (New) Scope of supply

Seller's scope of supply shall include the following:

a. Base exchanger unit with all components per Figure 2

b. Actuators, positioners and I/P transducers

c. Vibration cut out switches

d. Motors

e. Walkways, platforms and ladders as described in paragraph 7.3.5.1

f. Construction and startup spare parts including:

1. One percent header plugs
2. Three percent header plug gaskets
3. One spare belt for each identical set of eight belt drives, with a minimum of one spare for each type.

6.0 DOCUMENTATION

6.1 Approval Information

6.1.1.u (New) Location of connections such as brackets, clips, anchor-bolt holes, and instrument connections.

6.1.1.v (New) Platform and ladder locations

6.1.2 (Addition) Field assembly drawings shall include: location of pieces requiring field assembly, exchanger item numbers and plot location, match mark number, legend defining match mark system, and bolt list.

Seller shall provide the following detail drawings:

a. Header detail drawing including tube and pass partition layout, plug and gasket detail, and dimensions of parts.

b. Bundle detail including side frame and tube support details.

c. Gasket detail.

d. Vibration switch or transducer.

e. Actuator.

f. Nameplate details.

g. Motor (or other driver) outline.

6.1.3 (Decision) Calculations shall be submitted for approval. Calculations shall also include:

a. Confirmation of nozzle loads where maximum allowable loads exceed those shown in 7.1.10.

b. Lifting lugs.

6.1.4 (Decision) Welding procedures and qualifications shall be submitted for approval. In addition, fabrication drawings or a weld map shall indicate where the procedures are applied. A weld map is preferred.

6.1.6 (Decision) Additional information shall include the following:

a. Motor (or other driver) datasheet.

b. Lubrication datasheet.

c. Spare parts recommendation.

6.1.7 (New) When transport sketches are required, these shall show the exact outline dimensions, dimensions and orientation of projections, as well as the total mass and center of gravity of each parcel. The sketches shall be submitted in accordance with the PO, or at least 60 days prior to shipment. Where necessary, the location of lifting slings shall be painted or otherwise indicated on the case or piece of equipment and on the transport sketch.

7.0 DESIGN

7.1 Tube Bundle Design

7.1.1 General

7.1.1.13 (New) The clearance between fins of adjacent tube rows shall be at least 6.35 mm (0.25 inch).

7.1.3 Design Temperature

7.1.3.2 (Decision) Unless specified otherwise on the data sheet, the selection of fin-type shall be based on the greater of:

(1) The maximum process fluid inlet temperature for the range of operating conditions noted on the data sheet.

(2) The steam-out temperature on the data sheet.

7.1.6 Headers

7.1.6.1 General

7.1.6.1.1 (Decision) The alternative operations of process flow at ambient air temperature, loss of fans due to power failure, cycling conditions, start-up, shut-down, external loading, and steam-out shall also be considered during analysis.

7.1.6.2 Removable Cover Plate and Removable Bonnet Headers

7.1.6.2.3 (Modification) Bolted joints shall be designed with confined gaskets.

7.1.8 Gaskets

7.1.8.9 (Substitution) Annex A.3.12 may be consulted for further guidance on gaskets.

7.1.8.10 (New) Gaskets for blinded nozzles shall be stainless steel, spiral wound, unless specified otherwise on the data sheet.

7.1.9 Nozzles and other connections

7.1.9.22 (New) All connections in Lethal Service shall be flanged.

7.1.11 Tubes

7.1.11.7 (Addition) The maximum allowable process temperature for the various type of fin bonding shall be in accordance with table A.1 in Annex A.

7.1.11.14 (New) Embedded fins shall not be used for hard to embed materials such as stainless steel, titanium and Duplex 2205, unless approved by the Buyer.

7.1.11.15 (New) Fin density shall not exceed 394 fins per meter (10 fins per inch).

7.1.11.16 (New) Integral fins shall be used in corrosive air-side environments such as damp ocean air. When these fins are used for air-side corrosion protection, the unfinned tube ends shall be coated with a purchaser approved, corrosion resistant coating.

7.2 Air-Side Design

7.2.2 Noise control

7.2.2.1 (Addition) Noise shall be limited to a maximum sound pressure level of 85 dBA at 1 meter (3 feet) from the fan ring.

7.2.3 Fans and fan hubs

7.2.3.10 (Decision) Pneumatic actuated fan pitch control shall not be specified.

7.2.7 Drivers

7.2.7.1 General

7.2.7.1.3 (New) Drivers shall be located below the bundle.

7.2.8 Couplings and power transmissions

7.2.8.2 Belt Drives

7.2.8.2.1 (Substitution) Belt drives shall be high-torque type positive-drive belts.

7.2.8.2.4 (Addition) Belt tension shall be adjustable without removing the fan guard.

7.2.8.2.5 (Deleted)

7.2.8.2.6 (Deleted)

7.2.8.2.8 (Deleted)

7.2.8.2.10 (Deleted)

7.2.11 Screens

7.2.11.2 Insect/Lint Screens

7.2.11.2.4 (New) Fan design shall include pressure drop across the screens, including a suitable allowance for fouling. The estimated fouled pressure drop shall be at least 2 times the clean pressure drop.

7.3 Structural Design

7.3.1 General

7.3.1.1 (Decision) Structural steel design, fabrication, and erection shall be in accordance with the AISC (American Institute of Steel Construction) *Specification for Structural Steel for Buildings Allowable Stress Design and Plastic Design*; the AISC *Code of Standard Practice for Steel Buildings and Bridges*; and the AISI (American Iron and Steel Institute) *Specification for the Design of Cold-Formed Steel Structural Members*.

7.3.2 Vibration testing

7.3.2.2 (Decision) Shop vibration tests are required for shop assembled units.

7.3.4 Plenums

7.3.4.5 (Decision) External recirculation ducts shall not be shared by adjacent bays of multi-bay exchangers. Other requirements, if applicable, are noted on the data sheet.

7.3.4.9 (New) Recirculation ducts shall be sized for a velocity not greater than 5.1 meter/s (1000 ft/min). Unless specified otherwise, the amount of recirculated air shall be as required to maintain a plenum temperature at least 5 degrees C (9 degrees F) above the critical winterization temperature, e.g. pour point, freeze point, etc.

7.3.5 Mechanical access facilities

7.3.5.1 (Addition) Unless specified otherwise or modified by the Purchase Order, Seller's scope of supply shall include platforms, walkways and ladders, to the extent noted below:

a. Pipe rack mounted exchangers shall have drive assembly maintenance platforms by others. Walkways that access the platforms shall run full length of an exchanger bank, or a full "dance floor" platform shall be provided. Platforms and walkways shall be at the same elevation. Some drive access platforms may require an extension that permits egress to grade and a maintenance area for lifting the motor with a

crane. The number and location of these platform extensions shall be determined by the maximum permitted egress distance.

b. Pipe rack and grade mounted exchangers shall have platforms for access to the headers. Platforms shall be located approximately 1 meter (3 feet) below the header. Platforms shall run full length of the exchanger bank and have intermediate ladder egress points if required to meet maximum permitted egress distance.

c. A cross walkway and ladders shall be provided at each end of a pipe rack mounted exchanger bank to connect the drive maintenance platform with the header access platform.

d. If an exchanger bank has both induced and forced draft bays, the header access platforms shall change in elevation as required, but the drive maintenance platform shall remain at the same elevation. Ladders or stairs shall be used to accommodate the elevation changes in the header access platforms.

e. The header access platforms for grade mounted exchangers shall have ladders to grade. For piperack mounted exchangers, ladders or stairways from the maintenance walkway level to grade shall be provided by others.

7.3.6 Lifting Devices

7.3.6.6 (New) Exchanger design shall allow for pipe rack mounted units to be fully assembled at grade and lifted to the pipe rack. Lifting devices and structural members shall be designed for the lift weight plus an appropriate impact factor per 7.3.3.4.

8.0 MATERIALS

8.1 GENERAL

8.1.2 (Substitution) The use of cast iron for pressure parts is prohibited.

8.1.7 (New) The use of asbestos is prohibited.

8.1.8 (New) Welded tubes shall have an eddy current test in the finished condition over the total length of tube. Tubes in service greater than 6900 kPa (1000 psig) shall also have a hydrostatic test in addition to the eddy current test.

9.0 FABRICATION OF TUBE BUNDLE

No changes to this section.

10.0 INSPECTION, EXAMINATION AND TESTING

10.3 (Decision) Shop Run-In

Shop run-in test shall be performed by the Seller for the minimum of one bay per each cooler service. A shop run-in test shall consist of:

a. Check of the fan-tip clearance

b. Set the fan pitch to the required operating angle

c. Perform functioning test on assembled louvers or auto-variable pitch fans with stops as required for loss of instrument air

d. Run the motor and fan for at least 5 minutes

e. Noise and vibration levels shall be measured and reported

11.0 PREPARATION FOR SHIPMENT

11.1 General

11.1.6 (New) Special preparation with inert gas, if required, shall consist of the following:

a. Exchangers shall be prepared for shipping immediately after hydrostatic test and drying.

b. Openings shall be sealed with gasketed and fully bolted blind flanges

c. A connection with valve and pressure gauge shall be installed

d. The bundle shall be pressurized and depressurized twice to 100 kPa (15 psig), and pressurized again to 100 kPa (15 psig) with dry nitrogen.

e. The exchanger headers shall be tagged with brightly colored waterproof labels that state: “Warning: Contents Under Nitrogen Pressure”.

12.0 SUPPLEMENTAL REQUIREMENTS

12.1 (Decision) General

The supplemental requirements apply for the following cases:

a. Design pressure greater than 14,000 kPa gauge (2000 psig).

b. Plate thickness of box-type header greater than 50 mm (2 inches).

c. Lethal service.

d. Special service as noted on the datasheet.

12.3 Examination

12.3.6 (Addition) 100% ultrasonic examination may be substituted for 100% radiographic examination. However, the minimum amount of radiography required by the pressure vessel design code shall be performed. When ultrasonic examination is used, Seller shall provide a written report that includes a map of indications found.

ANNEX A – RECOMMENDED PRACTICES

No changes to this section.

ANNEX B – (SUBSITUTION) CHECKLIST AND DATA SHEETS

This checklist is used for listing the Buyer's specific requirements when the standard provides a choice or designates that a decision must be made.

Subclause No.	Item	Requirement
4.1	Pressure design code:	ASME Section VIII, Div.1
4.4	Applicable local regulations:	Per P.O.
4.6	Is service designated as sour or wet hydrogen sulfide service?	Per data sheet
4.7	Winterization requirement and type?	Per data sheet
5.7	Is noise data sheet required?	Yes
6.1.1	Which documents are to be submitted? Which documents are subject to purchaser's approval?	Per P.O. Per P.O.
6.1.3	Are calculations to be submitted for approval?	Yes
6.1.4	Are welding data to be submitted for approval?	Yes
6.1.6	Additional engineering information required:	Refer to 6.1.6 text and P.O.
6.2.2	Records to be furnished and whether they shall be in electronic form:	Per P.O.
7.1.1.11	Is internal steam-out design required? Temperature, pressure and operating conditions:	Per data sheet
7.1.1.12	Is cyclic service design required? Type and magnitude of variation in pressure, temperature flowrate, time for the variation and number of cycles or frequency:	Per data sheet
7.1.3.1	Maximum design temperature: Minimum design temperature: Minimum design metal temperature:	Per data sheet Per data sheet Per data sheet
7.1.3.2	Maximum operating temperature for fin selection:	Refer to 7.1.3.2 in text
7.1.4	Design pressure for tube bundle:	Per data sheet
7.1.5.1	Corrosion allowance:	Per data sheet
7.1.6.1.1	Is an analysis required of alternative operating conditions in design of headers?	Analysis required for the range of conditions noted on the data sheet.
7.1.9.7	Plane of process flanges if not horizontal:	Per data sheet
7.1.9.15	Chemical cleaning connection size, type, and location:	Per data sheet
7.1.11.2	Maximum tube length:	Per data sheet and P.O.
7.1.11.7	Type of finned tube construction:	Per data sheet
7.1.11.12	Is heat-treatment required after bending of U-tubes?	Per data sheet
7.2.1.1	Special environmental factors affecting air-side design:	Per data sheet and P.O
7.2.1.8	Is an estimate of design exposure temperature for mechanical components required?	Per data sheet
7.2.2.1	Location of noise level values:	Refer to 7.2.2.1 text and P.O.
7.2.3.10	Use of automatic control for varying the blade pitch?	Per data sheet
7.2.3.11e	Any special blade pitch limit stop setting:	Per data sheet

Subclause No.	Item	Requirement
7.2.7.1.1	Type of drive system: Drive equipment supplier:	Per data sheet
7.2.7.2.1	Electric motor construction; supply and classification:	Per data sheet and P.O.
7.2.7.2.9	Is a self-actuating braking device required?	Per data sheet
7.2.7.3	Requirement for variable speed drive systems:	Per data sheet
7.2.9.1	Are vibration cut-out switches required?	Per data sheet
7.2.10.19	Louver position upon loss of control-air pressure:	Per data sheet
7.2.11.1	Are screens required? Type:	Per data sheet and P.O.
7.3.1.1	Structural code:	Refer to 7.3.1.1 text
7.3.2.2	Is shop test for vibration check required?	Yes
7.3.3.2	Extent and mass of fireproofing:	Refer to 7.3.3.2 text
7.3.3.11	Snow load:	No
7.3.3.12	Exact type, location, magnitude, and direction of other design loads:	Refer to 7.3.3.12 text
7.3.4.5	Plenum partition requirements for recirculation systems:	Refer to 7.3.4.5 text
7.3.5.1	Number and location of header access platforms, interconnecting walkways and ladders:	Refer to 7.3.5.1 text
7.3.5.8	Are there any special requirements for personnel protection against high air-outlet temperature? If yes, state:	Per data sheet
8.2.3	Maximum allowable Carbon Equivalent: Restriction on other residual elements and micro-alloying elements:	Per data sheet
9.1.1.5	Weld procedure qualifications for carbon steel in sour or wet hydrogen sulfide service to include cross-sectional micro-hardness testing? Additional restrictions for the qualification test material:	Per data sheet
9.3.4.1	Are tube-to-tubesheet joints to be seal welded? Are tube-to-tubesheet joints to be strength welded?	Per data sheet
10.1.12	Is carbon steel plate in sour or wet hydrogen sulfide service subject to ultrasonic lamination checks?	Per P.O.
10.2.6	Are special tests or additional requirements for drying or preservation required?	Per P.O.
10.3	Are shop run-in tests required? Details:	Refer to 10.3 text
11.1.4	Extend of skidding, boxing, crating, protection or coating for shipment:	Per P.O.
12.1	Supplemental requirements of clause 12 that apply:	Refer to 12.1 text

(Substitution) The Fluor Data Sheet for each item will be provided with the Inquiry or Purchase Order.

ANNEX C – WINTERIZATION OF AIR COOLED HEAT EXCHANGERS

No changes to this section.

End of Specification

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

PLATE AND FRAME HEAT EXCHANGERS

Specification No. EH-35R-CCU1-SPC-255-57035

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PLATE AND FRAME HEAT EXCHANGER

FOREWORD

This specification covers the minimum requirements for the design and fabrication of plate and frame exchangers.

This specification is intended to supplement API Standard 662, Part1, First Edition, Reaffirmed, 2011, which is part of this specification. Paragraph numbers of this specification correspond to those in API 662. Paragraph numbers not found in API 662 are new paragraphs.

Paragraphs shall be highlighted as shown below to indicate the type of change from the API Standard:

(Addition) New paragraph or supplemental requirements/clarifications to an existing paragraph.

(Deleted) Paragraph deleted.

(Decision) A decision has been made as required.

(Substitution) Paragraph supersedes API in its entirety.

Substitute the terms "Buyer" and "Seller" for the corresponding terms "Engineering Contractor" and "Vendor" used in API 662.

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1.0 SCOPE

(Addition) The requirements stated herein are supplementary to the data listed on the Plate and Frame Exchanger Specification Sheets (hereinafter referred to as Datasheets).

2.0 NORMATIVE REFERENCES

(Addition) The latest edition shall be the one in effect on the PO (Purchase Order) date. The following standards and specifications are added:

Pressure Design Code/Standards

ASME Section VIII, Division 1 Rules for construction of Pressure Vessels

3.0 TERMS AND DEFINITIONS

3.19 (Addition) The local Authority is defined as the governmental regulatory authority controlling laws, codes, rules and regulations for the design, fabrication, testing and inspection of unfired pressure vessels in the location where the exchanger(s) is to be installed.

4.0 GENERAL

4.1 (Decision) The pressure design code shall be ASME Section VIII, Division 1. The Recommended Practice section of API 662 Annex A is mandatory, except Section A.4-Fouling Margin.

4.3 Addition) Supplier shall identify in writing any conflicts between the order, specifications, and other referenced documents for review by Engineering Contractor. Supplier shall obtain written approval from Engineering Contractor before proceeding with work affected by a conflict.

4.4 (Addition) Heat exchangers shall be guaranteed by Seller against defective design, material, and workmanship in accordance with the terms of the Purchase Order. In addition, Seller shall guarantee performance of the exchanger(s) with regard to heat duty and pressure drop, in accordance with the process conditions on the individual datasheets. Upon satisfactory proof that the exchanger(s) furnished do not meet specified operating conditions, the Seller shall furnish FOB to the point of use any necessary additional equipment to meet specified conditions, or make changes, as required, to the original equipment furnished. When the thermal sizing is furnished by Buyer, Seller shall verify the sizing and provide a thermal and hydraulic guarantee.

5.0 PROPOSAL INFORMATION REQUIRED

5.7 (Substitution) The Seller shall provide a recommended spare parts list with unit costs for each plate and frame heat exchanger, Unless noted otherwise, spare parts shall consist of 5% spare plates with gaskets.

5.8 (Addition) The Seller shall provide a preliminary general arrangement drawing including overall dimensional information, weight, nozzle sizes and locations.

6.0 DRAWINGS AND OTHER DATA REQUIREMENTS

6.1 Drawings

6.1.5 (Decision) The Seller shall submit copies of applicable welding procedure specifications and weld map for review and approval.

6.1.6 (Decision) Complete design calculations shall be submitted for review and approval.

7.0 DESIGN

7.2 Design Temperature

7.2.1 (Decision) For Maximum Design Temperature and Minimum Design Metal Temperature refer to datasheet.

7.4 Fouling Margin

(Addition) For fouling, refer to datasheet.

7.6 Components

7.6.2 a) (Substitution) Fixed or movable covers shall not be designed with the use of stiffeners to compensate for thickness.

7.6.3 b) (Addition) Captive nuts shall be loaded at the fixed end cover and running nuts at the movable cover end.

7.6.6 (Decision) Reactions at the support points shall be provided by Seller.

7.7 Connections

7.7.9 (Decision) Nozzle neck shall be fabricated from materials compatible with the Process fluids, unless a liner is specified. If liners are necessary, these shall be fabricated from materials compatible with the Process fluid.

7.7.11 (Addition) Auxiliary connections such as vents, drains, and instrument connections shall be provided with blind flanges or plugs rated for design conditions.

7.7.12 (Addition) Facing for pressure connections shall be 125-250 microinch Ra unless otherwise specified on datasheet.

7.8 Plate gaskets

7.8.5 (Addition) Gasket material selection and compatibility with amine service shall be agreed by the Buyer.

7.8.6 (Addition) Sealing surface design and gasket volume shall be agreed by the Buyer.

10.0 INSPECTION AND TESTING

10.1 Quality Control

10.1.1 (Decision) The Seller shall supply information on its quality control system and a quality control plan.

11.0 REPARATION FOR SHIPMENT

11.1 (Substitution) Each exchanger shall be thoroughly cleaned inside and outside, and shall be free of grease, weld splatter, scale, slag, rust, and other foreign matter. Exchangers shall be thoroughly dried after testing. Hot air drying by evaporation is not permitted.

ANNEX A – RECOMMENDED PRACTICE

No changes to this section

ANNEX B - PLATE-AND-FRAME HEAT EXCHANGER CHECKLIST

This checklist is used for listing the purchaser's specific requirements for which the paragraphs or subsections within this standard include a choice or which designate, by use of a bullet (●) in the margin, that a decision is required.

Subsection	Requirement	Item
4.1	Specify (or agree) pressure design code	Per data sheet and P.O
4.1	Specify (or agree) structural welding code	Per P.O
4.2	Compliance with applicable local regulations	Per P.O
6.1.5	Welding procedure specifications and weld map furnished by vendor for review or record	For review
6.1.6	Calculations to be furnished by vendor for review or record	For review
7.2.1	Specify a maximum design temperature and a minimum design metal temperature	Per data sheet.
7.4	Specify fouling margin	Per data sheet.
7.6.6	Details of reaction at the support points to be furnished by vendor	Yes
7.6.7	Specify if shroud required to protect against spray leaks	Per data sheet and P.O
7.6.8	Specify if a fire-protection shroud is required and, if so, level of protection required	Per data sheet and P.O
7.6.9	Specify if drip tray required	Per data sheet and P.O
7.7.9	For alloy nozzles requirements for solid or lined connections	Per data sheet
10.1.1	Specify if information required on quality control system and if quality control plan required	Per P.O
10.1.2	Requirements and extent of non-destructive testing of the heat transfer plates	Per P.O
10.1.3	Requirements for non-destructive testing where set-on connections are used on covers fabricated from plate	Per P.O
10.2.7	Any additional requirements for equipment drying or preservation	Per P.O
11.1	Specific drying requirements	Per data sheet and P.O

ANNEX C - PLATE-AND-FRAME HEAT EXCHANGER DATA SHEETS

Fluor datasheet for each item will be provided with Inquiry or Purchase Order

End of Specification

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

Counter Flow Cooling Tower

Specification No. EH-35R-CCU1-SPC-255-57040

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1.0 GENERAL

1.1 Scope

1.1.1 All project specifications are intended to compliment the applicable Industry Standards and Codes. If there is any perceived conflict, the SUPPLIER is responsible for notifying PURCHASER'S Engineering and/or Purchasing Department for resolution prior to execution of work or any commitment of PURCHASER funds. The SUPPLIER is responsible for their work and deliverables meeting all requirements of PURCHASER Standards and Specifications unless PURCHASER issues written documentation of the exception prior to any commitment.

1.1.2 SUPPLIER shall furnish and install an induced-draft, film-filled, counter-flow type, field-erected, industrial duty cooling tower.

1.1.3 SUPPLIER'S proposed tower shall conform to the process/mechanical requirements and to the limiting physical dimensions listed on Data Sheet for Cooling Towers.

1.1.4 Scope of Supply – included:

Provisions by SUPPLIER shall include:

1.1.4.1 Fire retardant, pultruded FRP structural framework, hardware and enclosure,

1.1.4.2 Non-skid, FRP fan deck designed for a minimum live load of 60 lbs. per square foot,

1.1.4.3 High performance, fire resistant, non-combustible, PVC film fill with UV protection, suitable for the water quality specified on the data sheet.

1.1.4.4 Cellular PVC drift eliminators

1.1.4.5 FRP Inlet louvers if the air inlet height is greater than 14 feet,

1.1.4.6 FRP header with PVC self-draining, non-clogging type distribution system, and riser supports/guides,

1.1.4.7 Polypropylene Spray nozzles,

1.1.4.8 Velocity recovery fan stacks,

1.1.4.9 FRP fan blades,

1.1.4.10 Lightning protection system in compliance with the local code,

1.1.4.11 FRP Cable tray supports for power, control and instrument trays.

1.1.4.12 Partition walls: 12 oz. fire retardant, UV protected, corrugated chopped glass reinforced polyester or FRP,

1.1.4.13 Wind walls: 12 oz. fire retardant, UV protected, corrugated chopped glass reinforced polyester, or strand reinforced polyester or FRP,

1.1.4.14 Casing: 12 oz. fire retardant, UV protected, FRP,

1.1.4.15 Carbon Fiber Composite drive shafts with 304 grade stainless steel couplings and attaching hardware,

1.1.4.16 Vibration switches for gear boxes,

1.1.4.17 Electric motors (480V up to 200hp, 4000V for larger than 200hp) with oversized termination box, larger than NEC requirement, with a drain.

1.1.4.18 FRP Staircases, extended down to grade, for fan deck access.

1.1.4.19 FRP cross-over walkways on the fan deck, if a back to back arrangement tower,

1.1.4.20 FRP internal ladders accessing from the fan deck to fill packs and the tower distribution header.

1.1.4.21 304 grade stainless steel connection hardware and fasteners,

1.1.4.22 304 grade stainless steel anchors,

1.1.4.23 Provisions to support utility piping on top of the fan deck. Supplier proposal to indicate the number of supports included

1.1.4.24 Provisions to support lighting stanchions on the stair tower and on the fan deck. Supplier proposal to indicate the number of supports included.

1.1.4.25 Cooling tower erection and supervision at the job site,

1.1.4.26 Startup support,

1.1.4.27 Witness of Performance Test.

1.1.5 Scope of Supply – Excluded:

Responsibilities by Purchaser include:

1.1.5.1 Concrete Cooling Tower Basin,

1.1.5.2 Cooling water pumps,

1.1.5.3 External cooling water distribution manifold and cell isolation valves,

1.1.5.4 Chemical dosing equipment,

1.1.5.5 Electrical controls, wiring, lighting and electrical hookup,

1.1.5.6 All instrumentation except vibration and oil level monitoring equipment,

1.1.5.7 Foundation anchor bolts,

1.1.5.8 Fire protection system

1.1.5.9 Drift testing,.

1.1.5.10 Thermal performance test

1.2 Definitions

COMPANY	California Resources Corporation
PURCHASER	The COMPANY or an Engineering Contractor acting as the authorized representative for the COMPANY that issues the contract or purchase order and specifications to the SUPPLIER
SUPPLIER	The manufacturer of the equipment or the manufacturer agent

1.3 Referenced Publications

The applicable sections of the following publications form part of this specification. The latest edition as of this documents' issue date applies.

AGMA	**American Gear Manufacturer's Association**
6013	Standard for Industrial Enclosed Gear Drives
ASCE	**American Society of Civil Engineers**
7	Minimum Design Loads and Associated Criteria for Buildings and Other Structures
ASME	**American Society of Mechanical Engineers**
B16.5	Pipe Flanges and Flanged Fittings NPS ½ Through NPS 24
B16.47	Large Diameter Steel Flanges NPS 26 through NPS 60
ASTM	**American Society for Testing and Materials**
A48	Standard Specification for Gray Iron Castings
D4385	Standard Practice for Classifying Visual Defects in Thermosetting Reinforced Plastic Pultruded Products
E84	Standard Test Method for Surface Burning Characteristics of Building Materials
E119	Standard Test Methods for Fire Tests of Building Construction and Materials
CTI	**Cooling Tower Institute**
ATC-105	Acceptance Test Code for Water Cooling Towers
ATC-128	Test Code for Measurement of Sound from Water-Cooling Towers
BUL-109	Nomenclature for Industrial Water-Cooling Towers
ESG-120	Lightning Protection System Guideline
ESG-121	Construction Safety & Health Guidelines

ESG-138	Long Term Storage Procedures for Cooling Towers
ESG-144	CTI Fastener Material Guidelines
ESG-151	Variable Frequency Drive Application Guidelines for Cooling Towers
ESG-152	Structural Design of FRP Components
PTB-110	Recirculation
STD-111	Gear Speed Reducers for Application on Industrial Water Cooling Towers
STD-119	Timber Connection Specification
STD-131	Fiberglass-Reinforced Plastic Panels
STD-136	Thermoplastic Materials Used for Film Fill, Splash Fill, Louvers and Drift Eliminators
STD-137	Fiberglass Pultruded Structural Products for Use in Cooling Towers
STD-152	Structural Design of FRP Components
IBC	**International Building Code 2012**
ISO	**International Organization for Standardization**
20816-1	Mechanical Vibration – Measurement and Evaluation of Machine Vibration – Part 1: General Guidelines
NFPA	**National Fire Protection Association**
214	Standard on Water-Cooling Towers
780	**S**tandard for the Installation of Lightning Protection Systems
OSHA	**Occupational Safety and Health Administration**
Cal/OSHA	**California Occupational Safety and Health Regulations**
Title 8	Occupational Safety and Health Regulations
	All applicable local, county, state, and federal codes rules, regulations, and ordinances

Project Specifications

EH-35R-CCU1-SPC-215-00002 Structural Data for Mechanical Equipment
EH-35R-CCU1-SPC-255-56070 General Purpose Induction Motors – ½ HP Through 500 HP – IEEE 841

1.4 Thermal Performance

1.4.1 The tower shall satisfy the thermal performance conditions specified by PURCHASER on the Cooling Tower Data Sheet. The SUPPLIER shall guarantee that the tower supplied will meet the specified performance conditions. If, because of a suspected thermal deficiency, PURCHASER chooses to conduct an on-site thermal performance test in the presence of SUPPLIER during the first year of operation, and the tower fails to perform within the limits of test tolerance, then the SUPPLIER shall make the necessary alterations to overcome the indicated deficiency and pay for subsequent testing.

The test shall be conducted by a third party in accordance with CTI test code ATC-105. During design, provision must be made for enough available measuring points (as required by the test procedure and agreed upon in the contract or purchase order) in addition to the normal control room measuring points. The cooling tower SUPPLIER shall supply the necessary orifice data to the party responsible for the performance test, well in advance of the performance test in order to make provision for the correct size measurement equipment.

1.4.2 Should the alterations made by the SUPPLIER prove to be inadequate, The PURCHASER, at its option, shall be compensated by either of the following:

1.4.2.1 The installation of additional equipment and/or materials necessary to meet the specified cooling tower capacity requirement.

1.4.2.2 A refund of a percentage of the contract price proportional to the deficiency as established.

1.5 Noise

Noise levels shall be in accordance with the requirements noted on the cooling tower data sheet.

1.6 Drift

Drift testing may be performed at Buyer's option during the guarantee period per CTI ATC-140.

2.0 PROPOSALS

2.1 PURCHASER'S Responsibilities

The PURCHASER'S inquiry shall include the Cooling Tower Data Sheet, Sound Level Data Sheet, and applicable project specifications. All necessary data for the design of a counter-flow cooling tower shall be provided.

2.2 SUPPLIER'S Responsibilities

2.2.1 SUPPLIER shall have five years of proven continuous operational experience. References shall be provided.

2.2.2 The SUPPLIER shall complete the PURCHASER'S Data Sheets and return with the proposal.

2.2.3 This specification is for a base proposal that includes manually adjustable pitch fan blades and single-speed, nonreversible motor fan drivers. SUPPLIERS are

encouraged to submit alternate proposals for some combination of variable or two-speed reversible fan motors to permit more efficient operation and reduced icing problems (depending on location) based on tower type, number of fans, and location.

2.2.4 The proposal shall include a detailed description of all exceptions to the PURCHASER'S inquiry.

2.2.5 The shipping date for the cooling tower components shall be determined on the basis of a specified number of weeks after receipt of written notification of the contract or purchase order. This date should allow sufficient time for transmittal, review, and return of drawings.

2.2.6 Supplier data to be submitted shall include all applicable information listed in the data sheet and the following:

2.2.6.1 Percent recirculation (design)

2.2.6.2 Air temperature leaving tower

2.2.6.3 Fan efficiency (including gear loss)

3.0 DRAWINGS AND OTHER REQUIRED DATA

3.1 The following information as a minimum shall be included with the SUPPLIER proposal:

3.1.1 Descriptive literature for the proposed cooling tower.

3.1.2 Completed PURCHASER Data Sheets.

3.1.3 Performance curves and data for 90 percent, 100 percent and 110 percent of design water flow, showing tower temperatures versus ambient wet bulb temperature.

3.1.3.1 Curves shall cover cooling ranges corresponding to 60 percent, 100 percent, and 120 percent of design heat duty, at wet bulb temperature

3.1.3.2 Performance curves shall be on constant fan horsepower equal to design horsepower

3.1.4 Supplier data shall also include a tower characteristic curve showing k-area-volume/liquid flow rate vs. liquid flow rate/gas rate, based on CTI method of analysis. These shall be used for test evaluation per Part II-A-(b) of ATC-105 and shall be submitted prior to acceptance test.

3.1.5 Warranty statement.

3.1.6 User's list and contacts.

3.1.7 Outline dimension drawing of cooling tower and basin for reference

3.1.8 Plus other proposal information noted throughout the specification

3.2 The SUPPLIER shall submit for approval the number of copies of drawings and other documents specified in the contract or purchase order/inquiry. The drawings shall include, but not be limited to, the following information:

3.2.1 General Arrangement and Outline Drawings including but not limited to the following:

3.2.1.1 Overall dimensions and elevations of all assemblies and subassemblies, including all clearances which shall be maintained.

3.2.1.2 Location (elevation and orientation) of every specified connection to the equipment including electrical, piping, and instruments.

3.2.1.3 Spacing, orientation and clearances for the cooling tower, or towers, to minimize recirculation or interference.

3.2.1.4 Foundation loading and attachment.

3.2.1.5 Cold water basin arrangement.

3.2.1.6 Stairway, platform and ladder locations.

3.2.2 Inlet Water Distribution System Drawings.

3.2.3 Structural Design Calculations showing column reaction loads for conditions defined Structural Data for Mechanical Equipment Specification.

3.2.4 Foundation Requirements/Coordination Drawing.

3.2.5 The design data shall include, but not be limited to:

3.2.5.1 The design and manufacturing code with the year of issue.

3.2.5.2 Operating and design pressures and temperatures.

3.2.5.3 Reference to any further supplementary standards and specifications.

3.2.5.4 A nozzle schedule giving, for each nozzle, the item or mark number, quantity, size, rating, facing and designation of service, and, if not shown elsewhere, the orientation and elevation.

3.2.5.5 Nozzle allowable forces and moments.

3.2.5.6 Gearbox data

3.2.5.7 Guaranteed thermal performance curves.

3.2.5.8 Details of Louvers (if any), stairways, walkways and ladders.

3.2.5.9 Motor data.

3.2.5.10 Fan (manufacture, size and model number).

3.2.5.11 Fan performance curves with calculations showing the reduction in operating fan power due to velocity recovery fan stacks.

3.2.5.12 Fan stack consisting of a fan inlet shroud, fan ring and diverging fan outlet section.

3.2.5.13 Vibration monitoring, including wiring diagram.

3.2.5.14 Gearbox (manufacturer, size and model number).

3.2.5.15 Couplings (size and model number).

3.2.5.16 Electrical connections.

3.2.5.17 Fan motor details

3.2.5.18 Details of all instrument connections, including size and location.

3.2.5.19 Recommended spare parts list

3.2.5.20 Lifting drawing showing lifting loads and connections required for Transportation and maintenance

3.2.5.21 Inspection test plan

3.2.6 Shop fabrication or cross-sectional and other detail drawings shall contain the following information:

3.2.6.1 Full dimensions of all parts and subassemblies; and where applicable, the tolerances and finishing required.

3.2.6.2 A complete list of materials used, fully specified, together with the certification or degree of testing if this forms part of the material specification. This is required if the assembly drawing lists the materials used in general terms only.

3.2.6.3 Loading diagram of all structural members for vertical and lateral loads based on the wet operation of the tower.

3.2.7 Certificates of material country of origin

3.2.8 Installation, Operation, and Maintenance Instruction Manuals.
3.2.9 Tower erection assembly drawings.

3.2.9.1 Details of fill material, supports and drift eliminators.

3.2.9.2 Details of splash eliminators

3.3 For thermal design calculations, all assumptions, input data and output data shall form a part of the end of job documentation for the cooling tower.

3.4 Upon final review, the SUPPLIER shall revise all the drawings and submit copies of each for record with the following marked on every sheet separately and dated: "CERTIFIED FOR CONSTRUCTION." The number of prints and reproducible submitted shall be as specified in the inquiry/purchase documents.

3.5 All instructions, descriptions, warnings, etc., on the equipment shall be in English

4.0 DESIGN

4.1 General

4.1.1 Cooling tower shall be designed for 25 years of operation.

4.1.2 All mechanical components of the cooling tower such as fan, gear reducer, drive shaft and electric motor shall be designed to withstand the humid and corrosive atmosphere in which they will operate.

4.1.3 All components exposed to sunlight including PVC film fill and drift eliminators shall be UV Resistant.

4.1.4 All hardware fasteners shall be 304 grade stainless steel.

4.1.5 Cooling tower shall be suitable the addition of future cell.

4.1.6 Painting and color codes shall comply with project specifications.

4.2 Structural Requirements

4.2.1 The tower structure shall be adequately braced to safely withstand the horizontal wind load stated in the Contract acting in any direction on all its exposed surfaces. The wind load shall not cause leakage or overstressing of members beyond the allowable stresses stated in CTI Bulletins ESG-152.

4.2.2 Seismic load design shall be based upon the zone indicated in the contract or purchase order.

4.2.3 Unless otherwise specified, the tower shall be capable of operating satisfactorily with water having a pH of 6.5 to 8.0 and design hot water temperatures up to 125°F, with excursions to 140°F.

4.2.4 The cooling tower structure, casing, wind walls, and diagonals shall be fabricated out of flame retardant FRP with a flame spread rating of 25 or less per ASTM E-84, Class A. Pultruded structural materials shall be visually inspected per ASTM D 4385, acceptance level II.

4.2.5 All fill and drift eliminators shall bear the same flame spread rating. Fiberglass fans when specified are exempted with their normal flame spread rating of 35 or less.

4.2.6 All structural connections, splices, and joint connectors shall be 304 grade stainless steel.

4.2.7 Structural columns shall be 3" x 3" (nominal), or larger, spaced on no greater than 6'-6" centers both longitudinally and transversely. Columns requiring anchorage shall be attached to the concrete cold water basin by anchor castings or L-brackets.

4.2.8 Longitudinal and transverse girts shall be 3” x 3” (nominal) or larger. Fan deck support girts shall be located on both sides of interior columns and on the inside of all perimeter columns; size of these girts shall be 3” x 3” (nominal). Girt lines shall be located on vertical centers not to exceed 6’-6”, except as may be required in towers requiring fill heights that would encounter the girt line. In that case, the upper girt line in the fill area may be elevated to clear the fill. Girt splicing shall conform strictly to the requirements of CTI STD- 119.

4.2.9 A tension/compression system of diagonal braces shall stiffen the structure, and transfer wind, earthquake, and other live loads to the basin anchor points. Diagonal connectors shall be of fiber-reinforced plastic (FRP), or 304 grade stainless steel. Shear plates shall be integral with the connector side straps to prevent shear-loading of the connecting bolts. Connectors of cast iron, black steel, or galvanized steel, or those that have sharp edges or protrusions that penetrate the fiberglass veil will not be acceptable. Diagonals shall be anchored to the cold water basin using FRP or 304 grade stainless steel diagonal connectors and anchor. The line of action through the diagonal to the point of anchorage shall be direct. Eccentric loading of framing members is not permitted.

4.2.10 Critical framing joints shall be made with structural shear plates molded of glass-filled nylon or equally inert material of comparable strength. Framing specific to those joints shall be factory counter-bored to accept insertion of the shear plates.

4.2.11 All structural connections and splices shall be through bolted using ½” diameter, or larger, machine bolts, nuts, and washers. Bolting materials shall be 304 grade stainless steel.

4.2.12 Fan shroud bridging to the fan deck joist shall be bolted with 304 grade stainless steel fasteners. Tech screws are not acceptable.

4.2.13 Design Loads

4.2.13.1 The tower fill shall be designed for a minimum live load of 25 lbs./ft^2.

4.2.13.2 The drift eliminators shall be designed for a minimum live load of 25 lbs./ft^2.

4.2.13.3 The fan deck shall be designed for a minimum live load of 75 lbs./ft^2 or a concentrated load of 1000 lbs. Snow and ice load shall also be considered in the tower design.

4.2.14 Structural design calculations shall be stamped by a licensed Registered Professional Engineer in the state where facilities are located.

4.3 Fan Deck and Fan Stacks

4.3.1 The fan deck shall act as a working platform for maintenance personnel. It shall consist of a skid resistant or non-slip surfaced fiberglass material fastened to fiberglass C-channels or I-beam floor joists. To minimize turbulence of airflow into the fan stack, fan deck protrusion into the fan stack opening shall not exceed 1".

4.3.2 Fan stacks shall be constructed of molded FRP (fiberglass-reinforced plastic) with eased inlets to promote smooth airflow at blade tips; minimum height shall be 7 ft. The operating plane of the fan shall be at a level above the fan deck of at least 15% of the fan diameter. Fan tip clearance shall not exceed ½ inch or 0.3% of the fan diameter, whichever is greater. If velocity recovery fan stacks are used, they shall have a maximum flare angle of 12 degrees, with a maximum assumed velocity recovery of 75% of the difference in average velocity pressure. Each fan stack segment shall be through-bolted to both the fan deck and a primary fan deck framing member. Anchorage by lag screws into the fan deck alone will not be permitted. Fan stack connection and anchorage hardware shall be series 304 grade stainless steel.

4.3.3 Fan stacks shall comply with the following additional design requirements:

4.3.3.1 All reinforcements shall be external

4.3.3.2 The inside of the stack shall be smooth

4.3.3.3 The stack shall be reinforced to prevent drumming, ovalling, noise, fatigue, and the penetration of fan blade(s) due to equipment failure.

4.3.4 Minimum unobstructed access width of 3 ft. around the fan stack shall be provided. A minimum clearance of 2 ft-6 in. shall be provided on all sides of each fan motor.

4.3.5 Exposed fiber ends of the fan stack panels in the bolt holes shall be covered with epoxy.

4.4 Mechanical Equipment

4.4.1 Fans

4.4.1.1 Fans shall have a minimum of six FRP blades, with appropriate twist and taper to produce maximum air flow. Blades shall have manually adjustable pitch, and shall have drain holes at the blade tips. Blades of fans 20 ft. diameter and smaller may be hollow core. Blades for fans larger than 20 ft. diameter shall be foam-filled FRP with an erosion-resistant urethane leading edge molded into the outer 8'-0". All blades shall be fabricated with consistent moment weights to permit the change-out of individual blades without the need for total fan rebalance. Hubs shall be fabricated of hot-dip galvanized steel and ductile cast iron, and coated with the following three layer system: Prepare surface in accordance with SSPC SP-10, apply the first coat of polyamide epoxy primer to 3 mils minimum dry film thickness (DFT), apply the second coat of polyamide epoxy finish to 5 mils minimum DFT, then apply the third coat of polyurethane finish to 3 mils minimum DFT. Hubs shall be assembled with 304 grade series stainless steel hardware. Hub design shall prevent recirculation of air at the plane of the fan.

4.4.1.2 Maximum fan tip speed shall be 12,000 ft./min.

4.4.1.3 Each complete fan assembly shall be statically and dynamically balanced against a master blade prior to shipment. Vibration velocity shall not exceed 1/8 inch per second and displacement shall not exceed 5 mils, both measured r.m.s. filtered on fan, gear, and motor bearing housings in three directions.

4.4.1.4 The vibrations shall be measured after installation and, if necessary, dynamic balancing shall be repeated.

4.4.1.5 Crack inspection shall be performed before the fan blades are coated in epoxy. If cracks are detected during the fabrication or testing process of the fan blades, Owner shall be notified and repair procedure shall be provided for Owner's approval. The cracks shall be repaired and the blades shall be retested and re-inspected. Owner reserves rights to inspect the fan blades prior painting.

4.4.1.6 After crack inspection has been performed and the fan blades have been deemed satisfactory, fan blades shall be coated in epoxy.

4.4.2 Fan Drive System

4.4.2.1 The complete mechanical equipment assembly for each cell shall be supported by a rigid, unitized structure that prevents misalignment between the motor and the gear reducer. Support shall be heavy-wall tubular steel, to which heavy plate platforms for the motor and gear reducer have been welded, as well as outriggers to provide structural stability and to transmit

loads into the tower structure. The assembly shall be hot-dip galvanized after fabrication.

4.4.2.2 When the fan drive is mounted on the tower, the fan drive frame shall rest on vertical columns which are secured by both transverse and longitudinal girt lines with back bracing from each column to girt lines below so no column bearing fan drive component loads will be in shear in any direction.

4.4.2.3 Motors shall be located outside the fan stacks and shall be connected to the speed reducers by tubular, extended, full floating, non-lubricated drive shafts. Driveshaft tubes and flanges shall be manufactured of graphite composite shafts with flexible element couplings, as specified on the data sheet. Connecting hardware shall be 304 grade stainless steel. Driveshaft assemblies shall be dynamically balanced at the factory at full motor speed. Two galvanized steel driveshaft guards anchored to the mechanical equipment support shall surround the driveshaft for containment in the event of failure.

4.4.2.4 The driver shall be connected to the gearbox by means of a floating shaft and coupling assembly. The shaft shall be a torque-tube design using non-lubricated, flexible disc type couplings. Shaft and couplings shall have a minimum service factor of 2.0 times the motor nameplate rating. The drive shaft first critical speed shall be at least 120% of the highest shaft speed.

4.4.2.5 SUPPLIER shall ensure that the static and dynamic loading imposed by the torque tube will not adversely affect either motor or gearbox bearing life. In the event that bearing life is affected, torque tubes of composite construction can be installed or provide additional intermediate bearing.

4.4.2.6 All drive shafts and coupling assemblies shall be dynamically balanced per AGMA class 9 tolerance in lieu of 4W/N before shipment. If intermediate drive shaft bearings are required, they shall be designed for lubrication from outside the fan stack.

4.4.2.7 Shaft and coupling guard shall be of anti-sparking materials.

4.4.2.8 Guards shall be supplied and installed on rotating parts.

4.4.2.9 Guards, bolts, nuts and washers shall be fabricated from 304 grade stainless steel.

4.4.2.10 Belt drives shall not be used.

4.4.3 Gearbox

4.4.3.1 Gearbox units shall be right-angle type, utilizing spiral bevel, matched gear sets. Cases shall be epoxy-coated, ASTM A48 Class 20, gray cast iron. Bearings shall be the tapered roller type with a minimum L-10 rating of 100,000 hours at their design loading. Gears and bearings shall be splash

lubricated in a bath of synthetic oil, and units shall be capable of operating at any speed in both forward and reverse directions. Gear reduction units that require external oil pumps are not permitted. Gear reducers shall meet or exceed the requirements of CTI STD-111 and AGMA STD 6013, and the service factor at motor nameplate horsepower shall not be less than 2. They shall be tested under load and adjusted at the factory; the interior surfaces should be coated with rust preventative oil prior to shipment.

4.4.3.2 The gearbox internals shall be completely sealed off from the water saturated air stream within the cooling tower.

4.4.3.3 The gearbox shall be equipped with labyrinth and double lip seals on the gearbox input and output shafts. The running surface of the double lip seals must be hardened and it is preferable that a sleeve is used. Other sealing arrangements may be proposed to COMPANY for approval.

4.4.3.4 The gearbox bolts, nuts and washers shall be 304 grade stainless steel.

4.4.3.5 Anti-reversing device shall be provided.

4.4.3.6 The gearbox shall be capable to operate not less than 8,000 hours without maintenance. The lube oil level indicator, filling connection and drain line shall be extended to the outside of the fan stack to permit periodic filling and draining of the gearbox at a convenient and safe location.

4.4.4 Vibration Detection Instrumentation

4.4.4.1 An acceleration sensitive vibration cutoff switch with a 15 second delaying feature shall be provided by SUPPLIER and attached to the fan drive structure between the motor and gear support.

4.4.4.2 The vibration external sensor shall be located on a gearbox and its enclosure shall be outside of the fan stack on a column beside the fan motor. Instrument wire connecting between these devices shall also be provided by the SUPPLIER.

4.4.4.3 All instrument enclosures shall be rated for NEMA 4X and suitable for hazardous area classification.

4.4.5 Gearbox Lubricant Instrumentation

4.4.5.1 The gearbox shall be equipped with low oil level switch which will cut power to the motor in the event of a loss of sufficient oil level.

4.4.5.2 Each gearbox shall have an external oil breather, oil fill connection, level glass, and drip pan with drain line outside the fan stack. The gearbox shall be equipped with an oil filter and low oil level alarm, low oil flow alarm and cut-out switch. All instruments and the oil filter shall be wired or piped for

accessing from outside of fan stacks. The piping to and from the gearbox shall be 304 grade stainless steel.

4.4.5.3 Initial synthetic oil charge shall be provided by the SUPPLIER.

4.4.6 The mechanical equipment assembly shall be warranted for no less than five (5) years. This warranty shall cover the fan(s), speed reducers, drive shafts, couplings, and the unitized supports. All other warranties shall be submitted for review and approval by the PURCHASER prior to purchase.

4.5 Electric Motor

4.5.1 Motors shall be designed not to operate in the service factor range during any ambient or operating condition.

4.5.2 Mating surfaces of the terminal box cover shall be machined and a gasket shall be provided.

4.5.3 A separate terminal box for motor space heater leads shall be provided.

4.5.4 All motors shall have base drilled and tapped for addition of a ground lug.

4.5.5 Motors shall comply with project specification EH-35R-CCU1-SPC-255-56070 General Purpose Induction Motors – ½ HP Through 500 HP – IEEE 841.

4,5,6 Motors shall have fungus protection of all electrical parts, windings, rotor outside diameter and stator inside diameter.

4.5.7 Motors shall be provided with space heaters rated for 250 volts, but designed to operate at 120 VAC.

4.6 Fill

4.6.1 Fill shall consist of fire resistant, non-combustible, cellular film-type, thermal formed PVC or polypropylene, manufactured of 10 mil or heavier stock after forming. The fill selection shall be based on Cooling Water quality per datasheet.

4.6.2 Fill shall be assembled into sturdy packs equal in height to the height of the total fill requirement where practical. If multiple layers of fill beyond 2 are required, the risk of clogging the tower must be evaluated. The evaluation must take into account the effect of film fill in solids bearing water.

4.6.3 Fill shall be designed to allow personnel to walk on its bare surface without damage. Fill shall be supported by girths and joists on centers as required, accommodating operational loads in addition to the specified minimum live load.

4.6.4 Fill shall be designed to ensure even distribution of water at all loads up to 110% of the design flow and shall be adequately supported to prevent sagging. No area shall receive more than ± 10% of the average water flow rate

4.6.5 Fill shall not extend into the air inlet section of the tower.

4.7 Drift Eliminators

4.7.1 Drift eliminators shall be constructed of UV resistant, 17 mil or heavier PVC. They shall be a cellular-type, triple-pass design and shall limit drift losses guaranteed to no more than the limit stated in the data sheets.

4.7.2 Drift eliminators shall be factory-assembled into easily-handled packs that nest together to form a continuous plane of drift eliminators throughout the plan area of each tower cell.

4.7.3 Eliminators shall be supported by through-bolted 2" x 4" (nominal) or larger girths on centers no greater than 6'-6"

4.7.4 Drift eliminator installation in and around structural material should not permit water entry into the plenum and to the fan stack.

4.7.5 The deflection from snow load shall be considered for drift eliminator selection and design.

4.7.6 Drift eliminator panels shall be removable through a hatch door in the fan deck.

4.8 Louvers

If air inlet height is more than 14 ft., louvers shall be provided to eliminate splash when the fan is off. Louvers shall be removable to permit access to the tower and be sufficiently strong and adequately supported to prevent sagging. FRP louvers shall be provided in accordance with CTI STD-136 or CTI STD-131, respectively.

4.9 Hot Water Distribution System

4.9.1 Hot water shall be distributed to the fill in each cell via a system of headers, laterals, branch arms and nozzles; the system shall be installed in the region above the fill and beneath the drift eliminators. Main distribution headers exposed to sunlight shall be constructed of FRP or CPVC. Unexposed parts of headers may be constructed of PVC or polypropylene. Branch arms and nozzles shall be constructed of injection molded polypropylene. The joint between branch arms and nozzles shall be threaded so nozzles can be easily removed for cleaning of the branch arms. Nozzles shall be of the large orifice, low pressure, down spray type, having no moving parts or restrictions that will promote clogging. A means of cleanout shall be provided at the ends of all headers and branch arms.

4.9.2 The piping system shall be sized for a flow velocity that will ensure equal flow at all nozzles. Headers will be equipped with individual flat face flanged inlets located approximately 12 inches outside the tower casing at or near the transverse centerline of each cell. Bolt holes shall be drilled to ASME B16.5/B16.47 class

150# template. All bolts on FRP flanges shall have oversized washers or backing rings.

4.9.3 Each header shall be vented to atmosphere by an open standpipe at the downstream end of the header. Vent shall be extended above drift eliminator and coming down through the drift eliminator and to the tower fill. Drift eliminator and fill shall be designed to withstand the occasional impact of slugs of water from the vent during start-up.

4.9.4 Distribution headers and lateral branches shall be predrilled and completely dressed up for attaching the nozzles prior to shipment to the job site.

4.9.5 The distribution header shall be designed for 10% flow surge.

4.10 Spray Nozzles

4.10.1 Spray nozzles shall evenly distribute the cooling water across the fill.

4.10.2 Spray nozzles shall have a minimum 1.25 inch opening.

4.11 Cell Partitions

4.11.1 The tower shall be partitioned such that the fan of each cell can be operated and cycled independently of the remaining cells. Full width, 12 oz./sq. ft. FRP panel partitions shall extend from casing to casing across the tower and from the underneath side of the fan deck floor extending to 15 inches below the basin curb.

4.11.2 A full-length, 12 oz./sq.ft, FRP panel shall also extend from end wall to end wall along the approximate centerline of the tower, rising from the basin level girt line to the underneath side of the fill. If end-walls are open for air entry, wind walls shall extend inward at an approximate 45 degree angle to meet the longitudinal partition. The purpose of this partition system is to prevent falling water from being blown out the lee face of the tower.

4.12 Casing

The end-walls of the tower, as well as the sidewalls above the air inlet elevation, shall be cased with 12 oz./sq. ft. corrugated fire-retardant FRP panels attached to the tower columns with 304 or 316 grade stainless steel screw shank fasteners and self-sealing washers. Panels shall be installed with the corrugations running in a horizontal direction, and they shall be lapped to shed water inward to the tower. Vertical joints shall be lapped and sealed watertight. Casing ends at tower corners shall be covered with 12 oz./sq. ft. FRP 90° corner rolls.

4.13 Access and Safety

4.13.1 Each cell shall have a 30 inch square lift-off access hatch in the fan deck floor with a FRP ladder extending down through the drift eliminator and to the top of the fill packs. A 3 ft. x 6 ft. landing shall be provided at the drift eliminator level, and shall have a lift-off hatch for entry to the top of the fill and distribution level.

4.13.2 The top of the tower shall be equipped with a 42" high fiberglass guardrail, complete with knee rail and toe board conforming to OSHA standards. Posts shall be 3" x 3" on centers no greater than 6'-6". Guardrails shall be a minimum of 2" x 2".

4.13.3 Fan stacks shall have removable segments of sufficient size to allow removal of all mechanical equipment components. A coupling guard, conforming to OSHA standards, shall be provided to shroud that portion of the drive shaft that extends outside the fan stack.

4.13.4 Fan stacks shall have inspection openings for viewing movements of the fan blades, gears and shafts. View ports shall be accessible from the fan deck without the need for ladders or scaffolding.

4.13.5 There shall be a minimum of 3 ft. of headroom below the drift eliminators.

4.13.6 Access from grade to the top of the tower shall be provided by the following, as indicated on the Cooling Tower Data Sheet:

4.13.6.1 Stairway constructed of flame retardant pultruded fiberglass. The stairway shall be 30" wide, column-supported, with a maximum angle of 40 degrees rising from grade to the fan deck elevation. Stair columns shall be 3" x 3" minimum. Guard rails shall be 2" x 2" minimum. The upper guardrail shall have a rounded edge for the protection of maintenance personnel.

4.13.6.2 All stairways and ladders shall be designed and installed in accordance with OSHA standards. There shall not be any attachments on the tower basin walls.

4.13.6.3 The cooling tower shall be provided with at least one stairway at one end and an escape ladder on the other end.

4.14 Cold Water Collection Basin

The cold water collection basin shall be designed and installed by others. The design shall be based upon the certified loads and dimensions provided by the SUPPLIER.

4.15 Cable Tray Supports

FRP supports shall be provided along the length of the tower, near the top deck, for supporting 3 levels of 13.5" wide cable tray: one power cable tray and two instrument and control cable trays. There shall be 18" vertical separation between these stacked cable

trays. Maximum support spans shall be 18 ft. and each tray shall be designed for 100 lbs./ft. of cable tray. For both inline and back-to-back cooling tower configurations, additional cable tray supports shall be provided to extend the three cable trays (now 6" wide), side by side on one level, underneath the top deck, to each fan drive motor. Vertical, side by side cable tray supports from the top of the basin curb to the fan deck shall also be provided every 200 ft. along the length of the tower.

4.16 Lightning Protection

Lightning protection shall be designed per local codes and regulations and shall protect the entire cooling tower. The lightning protection devices (rods, bayonets) and cabling shall not obstruct any access way or removal of vent stack panels or any items requiring a regular maintenance basis. Sub-supplier shall be identified in the proposal.

5.0 COMMISSIONING

5.1 Completion

After erection is complete, all temporary attachments, both inside and outside the tower, shall be removed and any splits or extra holes in the fiberglass structure shall be repaired or replaced.

5.2 Cleaning

The tower interior, cold water basin, and all piping shall be cleaned so that the tower will be free of all dirt and debris.

End of Specification

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

Watertube Boilers

Specification No. EH-35R-CCU1-SPC-255-57110

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1.0 GENERAL

1.1 Introduction

This specification describes the minimum requirements for supplying fired Watertube Boilers (boilers) and associated auxiliary equipment. Boilers shall be natural circulation, drum-type designs firing fuel.

When specified to be part of the boiler package, auxiliary equipment shall comply with the requirements noted in the corresponding attachments referenced in Section 4.0. The requirements in Sections 1.0 through 3.0 of this specification that are not specific to the boiler shall also apply to the auxiliary equipment. When field erection is included, the requirements in Section 3.4 of this specification shall apply.

1.2 Purpose

This Specifications and other referenced specifications, drawings, codes and standards are intended to provide a full comprehensive set of requirements for the design, fabrication, shop inspection, and testing of watertube boilers herein referenced as boilers. It includes related equipment such as economizer, superheater, desuperheater, drums, burners, burner management, fans and drivers. The requirements outlined herein supplement the Watertube Boiler Data Sheets. All equipment shall be suitable for outdoor operation in a refinery environment.

1.3 References

The publications listed below form part of this specification. Each publication shall be the latest revision, including addendums, in effect on the date of purchase order placement unless noted otherwise. Except as modified by the requirements specified herein or in other documents attached to purchase order, all Work shall conform to the requirements of these publications

A. Laws and Regulations of Authorities Having Jurisdiction.

Supplier is responsible for identifying and complying with any requirements imposed on equipment design, construction, and operation by federal, state, or local authorities having jurisdiction (jurisdictional authorities) of Kern County, CA. Supplier shall submit all necessary documentation to jurisdictional authorities for approval. Supplier shall obtain and furnish to the Buyer all approval documentation issued by the jurisdictional authorities.

B. Codes and Standards

The Work shall conform to the applicable sections of the following codes and standards. When auxiliary equipment annexes are included in this specification, additional codes and standards referenced in those annexes shall also apply.

- Air Movement and Control Association International (AMCA)
  Publication 99-16 Standards Handbook

  Publication 201-02 Fans and Systems

Publication 203-90	Field Performance Measurement of Fan Systems
Standard 210-16	Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating
Publication 802-19	Industrial Process/Power Generation Fans: Establishing Performance Using Laboratory Model
Publication 803-02(R08)	Industrial Process/Power Generation Fans: Site Performance Test Standards

- American Institute of Steel Construction (AISC)

AISC 325 15th Edition	Steel Construction Manual
AISC 303-16	Code of Standard Practice for Steel Buildings & Bridges
AISC 360-16	Specification for Structural Steel Bridges

- American Petroleum Institute (API)

API 547 2nd Ed	General Purpose Form-Wound – Squirrel-Case Induction Motors 250 Horsepower and Through 3000hp (as adopted by EH-35R-CCU1-SPC-255-56073)
API 673 3rd Ed	Centrifugal Fans for Petroleum, Chemical and Gas Industry Services
API 677 3rd Ed	General Purpose Gear Units for Petroleum, Chemical and Gas Industry Services

- American Society of Civil Engineers (ASCE)

ASCE 7-16	Minimum Design Loads for Buildings and Other Structures

- American Society of Mechanical Engineers (ASME)

Boiler and Pressure Vessel Code Sections (referenced herein as the Code):

Section I-2019	Rules for Construction of Power Boilers
Section IIA-2019	Materials Part A- Ferrous Material Specifications

Section IIB-2019	Materials Part B- Non-Ferrous Material Specifications
Section IIC-2019	Materials Part C- Specifications for Welding Rods Electrodes and Filler Metals
Section IID-2019	Materials Part D- Properties
Section V-2019	Nondestructive Examination
Section VIII-2019	Rules for Construction of Pressure Vessels Division I
Section IX-2019	Welding, Brazing, and Fusing Qualifications
Other ASME Codes:	
A 13.1-2015	Scheme for the Identification of Piping Systems
BTH-1-2017	Design of Below-the-Hook lifting Devices
B31.1-2018	Power Piping
B31.3-2018	Process Piping
PTC-4 -2013	Field Steam Generators
STS-1-2016	Steel Stacks

- American Society for Nondestructive Testing (ASNT)

SNT-TC-1A-2016	Personnel Qualification and Certification in Nondestructive Testing

- American Society For Testing and Materials (ASTM)

A123/A123M-17	Standard Specification for Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products
A153/A153M-16a	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
C-27-98(2018)	Standards Classification of Fireclay and High-Alumina Refractory Brick
C-155-97(2018)	Standard Classification of Insulating Firebrick
C-401-12(2018)	Standard Classification of Alumina and Alumina-Silicate Castable Refractories

C-612-14(2019)	Standard Specification for Mineral Fiber Block and Board Thermal Insulation
C-892-19	Standard Specification for High-Temperature Fiber Blanket and Board Thermal Insulation
D1066-18e1	Standard Practice for Sampling Steam
D 3370-18	Standard Practices for Sampling Water from Flowing Process Streams

- American Welding Society (AWS)
  D1.1 Structural Welding Code- Steel
- Environmental Protection Agency (EPA)
  40 CFR 60 Code of Federal Regulations, Title 40, Part 60
  40 CFR 75 Code of Federal Regulations, Title 40, Part 75
- Expansion Joint Manufacturing Association (EJMA)
  Standards of the Expansion Joint Manufacturers Association, Inc.
- Factory Mutual (FM)
- Institute of Electrical and Electronic Engineers (IEEE)
  IEEE 841-2009 Premium-Efficiency, Severe Duty, Totally Enclosed Fan Cooled (TEFC) Squirrel Case Induction Motors-- Up to and Including 500 HP (as adopted by EH-35R-CCU1-SPC-255-56070).
- International Society of Automation (ISA)
- National Electrical Code (NEC)
- National Fire Protection Association (NFPA)
  NFPA 85-2019 Boiler and Combustion Systems Hazard Code
- Occupational Safety and Health Administration (OSHA)
  1910.21 subpart D OSHA Standards: Walking- Working Surfaces
- The Society for Protective Coatings (SSPC)
  SP 6 Commercial Blast Cleaning
- Underwriter's Laboratories (UL)

C. Specifications, Data Sheets, and Drawings

The Work shall conform to the following Buyer documents referenced herein. When auxiliary equipment annexes are included in this specification, additional documents in

those annexes shall also apply. The latest issue included in the Buyer's inquiry, purchase order or contract shall apply.

Specifications, Data Sheets, Drawings and Attachments	
Project Specifications	
EH-35R-CCU1-SPC-215-00002	Structural Data for Mechanical Equipment
EH-35R-CCU1-SPC-255-56070	General Purpose Induction Motors- ½ hp through 500hp-IEEE 841
EH-35R-CCU1-SPC-255-85210	Aboveground Coatings
EH-35R-CCU1-SPC-265-00002	Electrical Requirements for Packaged Equipment
EH-35R-CCU1-SPC-270-00001	Instruments and Control Systems Supplied with Package Equipment
Data Sheets	
EH-35R-CCU1-DST-255-M-710	Boiler Package
Drawings	
000.257.SD4510MOD	Supplier Drawing and Data Requirements (SDDR Form Water Tube Boiler & Aux Equipment)

D. Conflict Resolution

1. All Work shall conform in all respects with this specification and referenced documents. If conflicting requirements are found between this specification and other referenced documents or between any two referenced documents, the Supplier shall request clarification of the conflict in writing and shall comply with the Buyer's written instructions regarding the conflict.

2. The general order of precedence shall be as follows:

   a. Mandatory Jurisdictional Authority requirements

   b. Data Sheets

   c. This specification

   d. Other Buyer Specifications

1.4 Terms and Definitions

A. Abbreviations are defined as follows. When auxiliary equipment annexes are included in this specification, additional definitions in those attachments also apply.

Abbreviations	
ACFM	Actual Cubic Feet per Minute

Abbreviations	
AFCU	Ammonia Flow Control Unit
AIG	Ammonia Injection Grid
BMS	Burner Management System
CEMS	Continuous Emissions Monitoring System
CO	Carbon Monoxide
DCS	Distributed Control System
DN	European Pipe Size
FAT	Factory Acceptance Test
FD	Forced Draft
FGR	Flue Gas Recirculation
HHV	Higher Heating Value
ID	Induced Draft
ISA	International Society of Automation
MCR	Maximum Continuous Rating
NDE	Non-Destructive Examination
NPS	Nominal Pipe Size
P&ID	Piping and Instrumentation Diagram
PLC	Programmable Logic Controller
QCR	Quality Control Requirements
RFG	Refinery Fuel Gas
RPM	Revolutions Per Minute
SAT	Site Acceptance Test
SCFM	Standard Cubic Feet per Minute
SCR	Selective Catalytic Reduction System
Setting	Boiler refractory and insulation
UV	Ultraviolet
VIV	Variable Inlet guide Vanes

B. Furnace temperature is the flue gas temperature leaving the furnace section.

C. Fan rating point is the specified set of conditions of flow in ACFM, fan static pressure, temperature and density that include all specified margins and safety factors above the maximum expected operating conditions.

D. Fan normal operating point is the point at which usual operation is expected and optimum efficiency is desired.

E. Fan maximum allowable speed in RPM is the highest speed at which the fan manufacturer permits continuous operation.

F. Fan maximum allowable temperature is the maximum continuous operating temperature at which the fan manufacturer permits operating the fan when handling the specific fluid.

G. The Supplier is defined as the provider of the complete boiler package to the Buyer, including the auxiliary equipment specified. The Manufacturer is defined as the actual

equipment or component manufacturer. When "Supplier" is mentioned herein it shall also mean Sub-supplier or Manufacturer as applicable.

H. The Buyer is defined as California Resources Corporation (CRC), or authorized agent.

I. When the word "Work" is used, it shall mean each and every activity and equipment supply item assigned to the Supplier.

J. Metric unit equivalents shown herein may be "nominal" conversions rather than exact conversations in some cases.

1.5 Scope of Work

A. The Supplier's scope of work shall include the following:

1. All activities required for the completion of the Work including the following:

   a. All requirements specified in the Purchase Order.

   b. Design and Engineering.

   c. Material supply, fabrication and assembly.

   d. Shipping preparation, loading and securing on carrier.

   e. Submittal of drawings, data and documents. Structural calculations to include California PE stamped.

   f. Expediting of materials, equipment and submittals.

   g. Inspection, examination and testing.

   h. Monitoring and reporting.

2. Words such as "provided', "furnished", "shall be", "shall have" etc. used throughout this specification shall mean in the Supplier's scope unless specifically stated otherwise.

3. Interconnecting piping, ducting, bolts, nuts and gaskets, and other items required for connections between components are included in the Supplier's scope.

4. Instrumentation tubing, wiring, and wiring conduit within the boundaries of shop assembled boiler packages and auxiliary equipment skids are included in the Supplier's scope.

B. The supplier's scope of work shall not include the following:

1. Concrete foundations, sole plates, shear keys, imbedded anchor bolts, washers and nuts.

2. External piping not specified.

3. Heat tracing, external insulation and lagging not specified.

4. Instrumentation and controls outside of the package

5. Tubing, wiring, conduit, cable, and cable trays not specified.

6. Bolts, nuts, and gaskets at Buyer/Supplier terminal points.

7. Items specifically identified as not included herein.

8. Field erection, field hydrostatic testing, commissioning, performance testing, fuels, utilities, and field activity necessary to prepare the site for placement of the equipment.

C. Unit Responsibility

The Supplier shall be responsible for and ensure that all Work is performed in accordance with the requirements of the Buyer's Purchase Order/Contract.

1.6 Quality Assurance

A. Quality assurance and quality control requirements shall be specified in the Buyer's Purchase Order or Contract and acceptable codes. The Supplier's project specific quality assurance plan and equipment specific inspection and test plan shall be submitted to the Buyer for approval. The Supply shall ensure that:

1. The Work conforms to specifications and "authorization to proceed" drawings and procedures.

2. Non-conforming items are not shipped without Buyer's authorization.

3. Inspection and test records are maintained for the warranty period and are not destroyed without offering them to the Buyer.

B. Witness, Inspection, Review, and Hold Points

1. Inspection, review, witness, and hold points for both the Buyer and Supplier shall be as shown in the Buyer's QCR forms. Additional points may be established during pre-inspection meetings.

2. The Supplier shall promptly respond to notifications of damage or expected damage to components and of field installation problems. The Supplier shall physically inspect the components upon request to verify suitability for use, extent of damage and repair or replacement methods. These inspections shall be considered part of the Work.

C. Personnel performing NDE shall be qualified in accordance with SNT-TC-1A. Qualification records and the written procedure for qualification shall be available for review.

D. Buyer may conduct pre-inspection meeting(s) at major Sub-Supplier's offices and major fabrication shops to review the Supplier and Sub-Supplier's quality verification plan for design, fabrication, inspection, and testing. The meeting(s) are to be held at least 30 days before fabrication starts.

E. The Supplier shall physically monitor materials and fabrication and provide updated schedules and status reports to the Buyer. Specified witness, inspection, review, and hold points shall be addressed in schedules and status reports.

F. The Supplier shall arrange for and secure all necessary inspection by the ASME authorized inspector (AI) and other jurisdictional authority inspectors. ASME Code stamping and other jurisdictional authority certifications shall be included as part of the Work.

G. Supplier shall ensure all components are UL labeled/ listed or NRTL certified as acceptable to the local AHJ. Control panels shall be UL labeled.

1.7 Guarantee

A. In addition to any guarantees specified in the Purchase Order, the Supplier shall guarantee the following performance when the Boiler is operated in accordance with the Suppliers' operating instructions. Fuel, feedwater, and other utilities shall be as specified on Buyer's data sheets:

1. Steam flow at MCR with steam temperature and pressure as specified.

2. Thermal efficiency at MCR based on fuel LHV and HHV.

3. Average temperature (±10°F) of steam at MCR and at minimum effective turndown leaving the non-return valve.

4. Moisture content of steam (steam quality) leaving the steam drum and solids content of steam (steam purity) leaving the boiler.

5. Maximum noise levels throughout the boiler operating range.

6. Exhaust gas emissions throughout the boiler operating range.

2.0 PRODUCTS

2.1 Performance

A. Steam Generation

1. The boiler shall generate steam at the conditions specified on the Buyers' data sheets from minimum capacity to maximum continuous capacity (MCR) across the specified range of ambient temperatures. Unless specified otherwise on the Buyers' data sheets, minimum capacity shall be 10% of MCR.

2. The boiler and all auxiliary equipment shall operate safely and effectively under automatic control at all operating and design conditions specified on Buyer's data sheets as well as at any transient condition normally encountered during start-up, load change or shutdown.

3. The boiler shall be designed such that volumetric heat release does not exceed 80,000 Btu/hr/ft3 and furnace heat release does not exceed 150,000 Btu/hr/ft2 when operating at MCR and firing specified fuel gas(es). The Supplier may utilize lower heat release rates if required to meet specified emission limits.

4. When required, a steam superheater shall provide the final steam temperature specified on the Buyers' data sheets to the plant steam header for the specified range of steam generation. A steam desuperheater (attemperator) shall be supplied to maintain the final steam temperature within ±10°F of that specified.

5. When specified, an economizer shall preheat the boiler feedwater to a temperature no greater than 40°F below the saturation temperature occurring in the steam drum. Steam generation shall not occur in the economizer throughout the specified range of operation.

6. The Supplier shall furnish time-to-temperature curves/charts to cover startup from both a cold condition and from a warm standby condition to MCR. Specific Buyer requirements for start-up and load change minimum times shall be noted on Buyers' data sheets.

B. Combustion

1. The Boiler shall be designed for pressurized (forced draft) combustion. A balanced draft combustion design may be considered for certain boiler types. Combustion shall occur with 10% excess air at the burner unless specified otherwise on the Buyers' data sheets.

2. Fuel combustion shall be complete within the furnace length with no visible flame impingement on refractory, tubes, supports or baffles for the entire operating range.

3. The flue gas temperature throughout the stack shall be at least 25°F (14°C) above the flue gas water and acid dew points across the specified range of operation.

4. Velocities in air and flue gas ducts shall not exceed 58 ft/sec (17.7 m/s) to minimize noise and erosion.

5. The maximum stack emissions limits and maximum burner capacity shall be as specified on the Buyer's data sheets.

6. Unless specified otherwise on the Buyer's data sheets, stack exit velocity shall not be less than 10 ft/sec (3 m/s) at the minimum operating case.

C. Noise

1. Noise limits shall conform to the Buyer's noise data sheets.

2. Noise limits shall not exceed 85 dBA at 3 feet horizontal from the equipment surface and 5 feet vertically above operating platforms.

2.2 Design and Material- General

A. The boiler shall be designed, constructed, inspected, tested and stamped in accordance with ASME Section I and as amended by this Specification. The Boiler shall be registered with the National Board.

B. The boiler shall meet the requirements of local regulatory authorities for design and construction. The Supplier shall be responsible for verifying local regulatory authority requirements and shall obtain necessary approvals, stamps and certifications as required by local regulatory authorities. Such approvals and certifications shall be furnished to the Buyer.

C. The design pressure for all boiler pressure parts shall be as stated on the Buyers' data sheets. When the design pressure is not stated, a design pressure of 110% of the maximum operating pressure or the maximum operating pressure plus 25 psi, whichever is greater shall be used. Components exposed to pump shutoff pressure shall be designed for the pump shutoff pressure.

D. The design temperature for all boiler pressure parts absorbing heat shall be a minimum of 25°F (14°C) above the maximum calculated metal temperature for each pressure part section.

E. The following pressure part corrosion allowances shall apply:

Abbreviations		
Location	**Units**	**Corrosion Allowance**
Drums and Headers	inches(mm)	0.125, 1/8 (3)
External Piping	inches(mm)	0.0625, 1/16 (1.6)
Furnace Tubes (including Shield Tubes)	inches(mm)	0.030 (0.8)
Boiler Bank (Evaporator) Tubes	inches(mm)	0.015 (0.4)
Superheater Tubes (alloy)	inches(mm)	0.015 (0.4)

Economizer Tubes	inches(mm)	0.015 (0.4)

F. Except for pendant superheaters and reheaters, vents and drains and shall be provided to completely vent and drain pressure parts.

G. All components and completed assemblies shall be suitable for, and where necessary, specially treated and protected for delivery, storage and operation outdoors. Vermin screens shall be provided to prevent the entry of small animals into enclosures.

H. The boiler including all furnished auxiliary equipment shall be of a design and construction that has been proven to operate successfully in an identical or similar application.

I. All equipment and components shall be designed to accommodate expansion and contraction for all operating conditions.

J. The boiler enclosure shall be gas tight. All outer walls shall be water cooled. Membrane type water wall construction shall be used to the maximum extent practical. Application of refractory shall be limited to burner throats, top and bottom header of the circulation system and sealing of tube (superheater) protrusions.

K. Superheaters shall be integral with the boiler, fully drainable and of either the convective or radiant-convective type. The pressure drop through the superheater shall be sufficient to ensure adequate steam flow during start-up and part load operation in all superheater passes. Superheater headers shall be outside of the flue gas path.

L. Steam attemperation shall be by a direct contact, spray type desuperheater unless noted otherwise on the Buyers' data sheets. Desuperheaters shall be of the interstage type although exit type desuperheaters may be proposed when used in conjunction with an interstage desuperheater or when the amount of desuperheat is small. Desuperheater nozzles shall include internal liners and shall be removable. Nozzle location shall ensure complete mixing of the desuperheat medium and steam prior to temperature measurement or re-entry into the superheater coil.

M. Economizers shall be non-integral and shall employ their own gas tight enclosure. The coil arrangement shall permit complete gravity draining. A staggered tube arrangement is permissible when only gas fuels are to be fired. An inline tube arrangement is required when liquid fuels are to be fired or when so noted on the Buyers' data sheets.

N. Asbestos materials shall not be used in any components.

O. The general arrangement of the boiler and all furnished auxiliary equipment shall afford clear access to all access openings, inspection ports, drains and vents, and other components where periodic inspection or maintenance is required.

P. Corrosion prevention measures shall be provided in areas where the internal casing temperature is not at least 25°F (14°C) above the flue gas water and acid dew points for all fuels and for all operating conditions. An internal coating for corrosion protection shall

be provided on such areas. The details of the preventative measures shall be as shown in Section 3.1.E, Painting and Coating, of this specification.

Q. The Boiler shall include an FGR system for NOx control, if required to meet the emission requirements specified on the Buyer's data sheets.

R. All pressure parts shall include provisions for air blowing, steam blowing, chemical cleaning, hot and cold lay-up and nitrogen blanketing. Components subject to damage during these conditions shall be removable without cutting or welding. Necessary blinds, flanged connections and replacement gaskets shall be provided. Chemical cleaning connections shall be flanged with gaskets, bolts and blinds and shall be located at low points and oriented downward so that solids will be swept out and the chemicals can be fully drained.

S. Copper and copper bearing alloys shall not be used in contact with water, steam or fuel. Cast iron, ductile iron and nodular iron shall not be used for pressure parts.

2.3 Pressure Parts: Tubes and Fittings

A. Design pressure shall conform to the Code. Components that can be exposed to pump shutoff pressure upon valve closure shall be designed for the related pump shutoff pressure in accordance with the Code.

B. Design temperature shall not be less than 25°F (14°C) above the maximum calculated metal temperature for heat transfer surfaces.

C. Evaporator and economizer tubes shall be either seamless or electric resistance welded. Superheater tubes shall be seamless. Welding fittings shall be seamless.

D. Tube nominal diameter shall not be less than 2 inches (50 mm). Tube wall thickness shall not be less than 0.105 inch (2.67 mm).

E. Tubes shall have the minimum specified wall thickness including corrosion allowance after bending.

F. The inside diameter of welding fittings shall match that of the connecting tubes.

G. Extended surface shall not be used on evaporator or superheater tubes. Extended surface may be used on economizer tubes.

H. Extended surface shall be continuously welded, spiral wound, solid fins. Fin materials shall be selected based on the maximum fin tip temperatures shown below.

Maximum Fin Tip Temperatures			
Tube Material	**Fin Material**	**Units**	**Maximum Fin Tip Temperature**
Carbon Steel	Carbon steel plate	°F (°C)	850 (455)
TP 409 SS	409 SS plate	°F (°C)	1,200 (650)
TP 410 SS	410 SS plate	°F (°C)	1,300 (705)

I. Fin configurations shall be based on the criteria below.

Fin Configuration Requirements				
Fuel Fired	**Fin Type**	**Spacing Maximum fins/inch (m)**	**Height maximum inch (mm)**	**Thickness minimum inch (mm)**
Fuel Gas	Solid	4 (157)	0.75 (19)	0.049 (1.24)

2.4 Pressure Parts: Drums and Headers

A. Design pressure shall conform to the Code. Components that can be exposed to pump shutoff pressure upon valve closure shall be designed for the related pump shutoff pressure in accordance with the Code.

B. Design temperature shall not be less than 25°F (14°C) above the maximum calculated metal temperature for heat transfer surfaces.

C. Drums

1. Drums shall be provided with all baffles, shields, distribution piping, collection piping, connections and thermal sleeves required by the Code, as specified by the Buyer and as required for start-up, operation and wet or dry lay-up.

2. Drums shall have internal feedwater and chemical injection distribution pipes and blowdown collection pipes.

3. Steam drums shall accommodate water level swell and shrinkage during start-up, shutdown and load changes without water carryover or activation of high-high or low-low level switches. Steam drums shall be sized to provide water retention as specified on the Buyer's data sheets.

4. Steam drums and internals shall be designed to prevent water carryover and to provide the steam purity shown on the Buyer's data sheets.

5. Drum configuration shall permit inspection, cleaning, plugging and rolling of tubes with commercially available equipment. Steam purification devices, belly pan covers and other internals limiting inspection or maintenance shall be removable. Drum internals affected by chemical cleaning or boilout shall also be removable. Final fastening shall be by the double nut or lock-nut method.

6. A 14 x 18 inch (356 x 457 mm) manway shall be provided at each end of drums. Manway covers shall be internally opening and shall be removable from the drum. Davits shall be provided for manway covers.

7. Drums shall extend beyond the boiler setting and seals shall be provided at the setting interface. Steel rings, continuously welded to the drum, shall be provided for insulation support around manholes.

8. Pipe connections to drums and to headers shall be welded. Pipe nozzle connections on headers and drums shall not be less than 1 inch NPS (DN25) nominal size.

9. Tube connections to drums under 24 inches (610 mm) nominal ID and to headers shall be welded. Tube connections to drums 24 inches (610 mm) nominal ID and larger shall be rolled for operating pressures up to 1500 psig (105 kg/cm2). For operating pressure greater than 1500 psig (105 kg/cm2), tubes shall be rolled and seal welded to drums.

D. Headers

1. Headers shall be seamless pipe of material equivalent to connecting tube material.

2. Headers requiring field welded tube connections shall have shop welded stubs for the connections on the headers.

3. Welded enclosures shall be provided for tube access holes in headers. The exterior casing shall be provided with removable covers or other means for access to the hand holes.

4. Water wall headers and supply tubes shall be protected from flue gases.

2.5 Pressure Parts: Boiler External Piping, Trim

A. General

1. The Supplier shall, at a minimum, provide all pressure parts including piping, valves, flanges, fittings, bolting, gaskets, instruments, trim, controls and accessories associated with the Boiler Proper and the Boiler External Piping as defined within ASME Section I, Code Jurisdictional Limits for Piping, (Fig. PG-58.2-1, -2, -3, and -4) unless specifically stated to be provided by the Buyer. The Supplier shall furnish all necessary support for the above defined pressure parts.

2. The Supplier shall furnish non-boiler external piping as specified by the Buyer to include all necessary supports and guides. Non-boiler external piping shall conform to ASME B31.1. The Buyer will provide layout sketches, approximate location and loads associated with the supports and guides.

3. The Supplier shall provide start-up vents and safety relief valves with connecting piping between drums/piping and silencers when applicable. The Supplier shall include drip pan elbows, drains, discharge vent stacks and supporting structure for silencers in his scope. Drain piping shall extend to grade.

4. All points where steam can be released during operation of the boiler, including gauge glass blowdowns, shall be piped to a safe location.

5. Continuous and intermittent blowdown piping shall be designed for flashing and vibrating service and shall be provided with five diameter bends. Intermittent blowdown piping shall include two angle valves; continuous blowdown piping shall include a single angle valve followed by a control valve. All blowdown valves shall be designed for blowdown service and shall be suitable for chemical cleaning of the boiler.

6. Piping shall not be smaller than ¾ inch NPS (DN20). The wall thickness for ¾ inch NPS (DN 20) piping shall not be less than schedule 80.

7. Structural supports, pipe supports, shims, slide plates, pipe guides and anchors shall be provided for the Supplier's piping. Pipe supports shall include standoffs to permit insulation around the circumference.

8. Piping, valves, and fittings over 2" NPS (DN50) shall be butt-welded construction and piping 2" NPS (DN50) and under shall be socket-welded construction.

9. Piping flange bolt holes shall straddle normal centerlines.

10. Valves used for modulating control shall be globe type or equivalent rather than gate valves. This does not apply to valves that operate either open or closed for shutoff, such as steam stop valves.

11. When valve hand wheels are not within 6'-6" (2 m) of grade or an operating platform, operating chains shall be provided.

12. Nipples and caps, plugs or blind flanges shall be provided for all valves not used during normal operation.

13. High point vents and low point drains shall be provided for all pressure chambers, including piping. Low points in steam piping shall be provided with water sensing drains.

B. Nozzles and Terminals

1. The Supplier shall provide a single steam outlet and a single feedwater inlet terminal connection for the Buyer's piping. Terminals shall be flanged

2. Nozzles, terminal supports, guides and anchors shall be designed to accept forces, moments and movements from the connecting piping. Piping terminals shall be capable of sustaining the stress levels allowed by ASME B31.1.

3. The Supplier shall route upper level drains and blowdowns to grade level.

4. The Supplier shall route all piping originating beneath the boiler to the edge of the boiler.

C. Drum Piping and Valves

1. Drum level devices shall be provided in accordance with Code requirements and shall include water columns, gauge glasses, level transmitters, level indicators and associated root, vent and drain valves.

2. All isolation valves used on drum nozzles shall be metal seated ball valves.

3. Tri-cocks on level gauges and water columns shall be equipped with chains as required for safe operation from grade or an operating platform.

4. When specified on Buyer's data sheets, a lower drum heating coil or steam sparging system shall be provided. The Supplier/Buyer interface shall be a single piping connection. All drum heating coil and sparging system piping, stop valve, control valve, heating coil or sparger nozzles and connections downstream of the interface shall be included in Supplier's scope.

D. Desuperheater Piping and Valves

1. The Supplier shall provide all piping, valves and trim to take the desuperheating medium from the Buyer's interface to the desuperheater. A stop valve, check valve and a control valve shall be supplied as a minimum.

2. Stop valves, control valves and upstream pressure parts shall be operable without damage with the full pump shutoff pressure upstream of the valve and no pressure downstream Drum level devices shall be provided in accordance with Code requirements and shall include water columns, gauge glasses, level transmitters, level indicators and associated root, vent and drain valves.

E. Fuel Piping Valves

1. The Supplier shall provide complete piping systems with all required piping, valves, strainers, filters, fittings, local instruments and controls required to provide fuel, sealing air, cooling air and purge air to the burner and the boiler. Fuel and other utility piping shall conform to ASME B31.3 and NFPA 85.

2. Fuel piping shall be of welded construction with flanged ends to match flanged valves, flanged terminals and flanged expansion joints. Pilot gas and instrument air piping may be welded, flanged or threaded in accordance with the applicable Code.

3. Sealing and cooling air for observation ports and scanners shall be supplied from the FD fan discharge or from a separate dedicated blower. Plant or instrument air shall not be used for these services. Expansion joints shall be provided in cooling air systems. Rubber hose expansion joints with hose clamps are not acceptable.

4. Fuel piping materials of construction shall be as follows:

Burner Fuel Piping Materials	
Material	**Specification**

Pipe	ASTM A106, Gr. B
Fittings	ASTM A234, Gr. WPB
Forgings	ASTM A105
Bolts/Nuts	ASTM A193, Gr. B7/ A194, Gr 2H

5. Fuel and air piping shall include provisions for drainage of condensation.

6. The Buyer's interface shall be limited to a single inlet connection for each fuel, pilot gas, plant air and instrument air service.

7. The fuel skid shall be designed and provided with clearances to permit heat tracing and insulation by the Buyer of all fuel and air piping.

8. All pressure containing elements of trains shall be of steel construction. Valves may be of cast steel construction. Cast iron, ductile iron and nodular iron materials shall not be used. Bronze or aluminum parts shall not be used in contact with fuel gas. All pipe shall be of seamless construction.

9. Fuel train safety shutoff block and vent valves shall be fire safe and FM approved for the service.

10. Manual valves suitable for throttling shall be provided to regulate fuel to burners during manual fuel switchovers.

11. A single isolation valve for all auxiliary connections and a single instrument root valve for all instruments shall be provided.

F. Valve Operators

1. Manually operated valves shall be designed to function with a maximum of 360N (80 lbf) total rim force on the operator at a differential shut-off pressure equal to 100 percent of full pressure rating at 38°C (100°F) rating across the valve.

2. Gear operators shall be provided for sizes equal to or greater than what is listed below. Gear operators may be provided for sizes less than what is listed below if necessary to meet the requirements in section 2.5.F.1.

Rating	**Type of Valve**			
	Gate	Globe	Ball	Butterfly (Non-Triple Offset)
CL150	14"	10"	8"	8"
CL300	12"	8"	6"	6"
CL600	10"	6"	6"	6"
CL900	8"	6"		
CL1500	6"	4"		

2.6 Internal Tube Supports/ Guides, Baffles, and Flow Distribution

A. Combustion air flow distribution devices shall be provided to achieve proper flow distribution to the burner and prevent mechanical damage and pulsations resulting from flow-induced vibration and acoustic resonance.

B. Other combustion air and flue gas flow distribution devices shall be provided if necessary to meet boiler performance requirements or maintain components within design limitations.

C. Partition water walls, baffles and supports shall be provided to prevent flue gas bypassing of heat transfer surfaces and mechanical damage and pulsations resulting from flow-induced vibration and acoustic resonance.

D. Supports, guides, baffles and distribution devices exposed to flame radiation shall be suitable for at least 200°F (111°C) above the maximum local flue gas temperature. Supports, guides, baffles and distribution devices not exposed to flame radiation shall be suitable for at least 50°F (28°C) above the maximum local flue gas temperature.

E. Carbon steel shall not be used for supports, guides, baffles and distribution devices having a design temperature above 850°F (454°C). Cast iron shall not be used.

F. Supports, guides, baffles and distribution devices shall remain securely in place and shall be removable for pressure part inspection, cleaning and replacement.

G. Tube supports and guides shall not damage fins or tubes during operation.

H. The arrangement of supports, guides, baffles and distribution devices shall prevent erosion by and accumulation of flue gas deposits within the Boiler and erosion of Boiler internal components.

2.7 Steel Structures

A. The boiler structure, ductwork, stacks, ladders, platforms and stairways shall conform to the Buyer's Specification, EH-35R-CCU1-SPC-215-0002 *Structural Data for Mechanical Equipment*. All applicable load conditions and combinations occurring during shipment, erection and operation shall be included in the design

B. Structural calculations and drawings shall be stamped and signed by a structural engineer registered in the state where the project site is located. All local regulatory requirements shall be met.

C. All structural steel supports, base plates, slide plates and shims required for the work shall be provided. Main column sole plates including shims and shear keys under the sole plate will be provided and installed by the Buyer when required.

D. Lifting lugs and stiffening members shall be provided for lifting except where slings or similar devices are suitable for handling and field erection. Lifting lugs on the boiler stack shall be designed to allow stack assembly on the ground and lifting of the entire stack as a unit.

E. Drain holes shall be provided in structural members for rain water drainage.

F. Permanent structural materials shall conform to the following ASTM requirements. Hot and warm casing materials shall be suitable for flue gas temperatures.

Permanent Structural Materials	
Casing and Duct Plate	A36
Stack/Transition Plate	A36
Structural Steel	A36 or A572 Gr 50
Structural Pipe	A53 Type E or S, GrB
Pipe Handrail	A120, SCH 40
Common Bolts	A307 Gr A
High Strength Bolts	A325
Structural Tubing	A500 Gr B
Common Nuts	A307
High Strength Nuts	A325

G. Materials shall be adequate for all load combinations and for the lowest design ambient temperature when the boiler is not in operation.

H. The structural design shall control and accommodate the direction of thermal expansion.

I. The furnace shall conform to the structural design requirements of NFPA 85.

J. All lifting lugs, attachments, and special handling devices that will be used by the Buyer for handling and erection shall conform to the latest edition of AISC 360 Specification for Structural Steel Buildings, ASME B30.20 Below-The-Hook Lifting Devices and the ANSI/AWS Welding Code.

K. Field bolted connections for slip-critical connections shall include high strength bolts and nuts with threads included in the shear planes. Major moment connections where ductility is required shall be field bolted for shear and field welded for moment. Snug tight high strength bolted connections may be utilized for non-slip critical connections. High strength bolts shall be 3/4 inch (19 mm) minimum diameter.

L. Secondary or lightly loaded field connections shall be with 5/8 inch (16 mm) diameter common bolts and nuts.

M. The minimum requirements for connections shall be shop welded and field bolted AISC Framed Beam Connections, Tables II and III as shown in the AISC 325 Manual of Steel Construction.

N. The minimum gusset plate thickness shall be 3/8" (10 mm).

O. Columns shall have full bearing at splices and at end plates.

P. Beveled hardened washers shall be provided for connection of surfaces with slopes exceeding 1:20.

Q. Bolts shall project through nuts at least two full threads.

R. Anchor bolts imbedded in concrete foundations will be provided by the Buyer. The anchor bolt diameter, bolt location and projection above the bottom of base plates for imbedded anchor bolts shall be determined by the Supplier. The anchor bolt material and length for imbedded anchor bolts shall be determined by the Buyer.

2.8 Steel Casing and Ducts

A. The Supplier shall furnish all flue gas and combustion air ducts connecting furnished components of the boiler package. Duct sections shall be furnished with bolting flanges.

B. The combustion air and flue gas path shall be a pressure tight envelope. The design pressure shall be the greater of 20 inches (508 mm), WC, or 1.5 times the maximum operating pressure. When a damper is furnished in or upstream of the stack, the entire combustion air/flue gas path shall be designed to withstand the maximum FD fan pressure at shut-off.

C. Provisions shall be made for drainage of rain water including sloped casing when required.

D. Internal attachments shall allow for expansion and contraction and shall minimize localized increases in casing temperatures.

E. Casing plate deflection shall not exceed 1/360th of free span (1/180th of free span when supporting internal refractory). Maximum beam deflections as a fraction of free span for walkways and platforms shall be 1/240 and for major equipment support shall be 1/500.

F. Boiler, duct, and economizer casing plate thickness shall not be less than 3/16 inch (5 mm). Casing plate thickness shall include 1/16” (1.6 mm) corrosion allowance (total for both surfaces).

2.9 Steel Stacks

A. The Supplier shall be fully responsible for stack design, including consideration of critical wind velocities and ovalling. Critical wind velocities should be calculated based on a fixed cantilever for all different axes in corroded and un-corroded condition and with proper allowance for support flexibility.

B. The design of stack shall be in accordance with ASME STS-1.

C. The minimum stack height shall be as specified on the Buyer’s data sheets. Stack length shall satisfy regulatory requirements for emissions testing.

D. Stack plate thickness shall not be less than 1/4 inch (6 mm) including corrosion allowance. Stack design shall include a 1/16" (1.6 mm) corrosion allowance (total for both surfaces).

E. Stacks shall be self supporting without guy wires.

F. Stacks, including lifting lugs and fixtures, shall be designed for assembly at grade and a single lift for final placement.

G. Deflection at the top of the stack shall not exceed 0.06 inch per foot (5mm/m) of above grade.

H. Grade mounted stacks shall have a 1/4 inch (6 mm) thick sloped bottom plate located above the bolting chair. A 2 inch (DN50) drain pipe with cap shall be located at the floor low point.

I. The entire vibrating structure including the stack, insulation, supports and foundation shall have sufficient damping to absorb the cyclical energy input at critical wind velocities within an amplitude that results in acceptable stresses.

J. When used, vibration prevention devices may be strakes or a tuned mass dampener. Licensing and fees for strakes and dampeners shall be included.

K. When strakes are provided, the shape factor shall be in accordance with ASCE 7 and the wind load shall be applied to the area defined by the outside diameter of the stack plus strakes.

2.10 Internal Insulation/ Refractory

A. The Supplier shall furnish all internal refractories and insulation for the specified boiler package. All external insulation and lagging shall also be furnished unless noted otherwise on Buyer's data sheet.

B. Refractory and insulation type, thickness and placement shall be based on a 140°F (60°C) average external surface temperature at 80°F (27°C) ambient temperature and 0 mph (0 km/hr) wind.

C. Where external surface temperatures may exceed 140°F (60°C) and personnel contact may occur during normal operation, the Supplier shall provide personnel protection for these areas.

D. Drums, furnace wall headers and water-cooled furnace floors shall be protected from furnace radiation with refractory or refractory tile. External surfaces of drums shall be insulated and lagged in the shop.

E. Internal refractory and insulation shall be suitable for a continuous service temperature at least 300°F (167°C) above the maximum calculated hot face or interface temperature to which they are exposed.

F. Burner openings shall be lined with first quality firebrick, 3000°F (1670°C) rated plastic or castable refractory or equivalent material proven in successful, long-term operation.

G. Setting materials shall conform to applicable ASTM specifications including the following:

Boiler Setting Material Requirements	
Fire clay tile and brick	C-27, high duty spall resistant
High alumina brick	C-27
Insulating firebrick	C-155, Group 23 or higher
Material fiber block/ board	C-612, Class 5
Castable	C-401, Table 2
Ceramic Fiber	C-892 (1350°F material)

H. Heat flow from the boiler setting and auxiliary equipment shall not cause foundation concrete temperatures to exceed 300°F (150°C). Stack bottom plates shall be insulated to protect concrete pads and foundations if required.

2.11 External Insulation and Lagging

A. External duct insulation shall be ceramic fiber. Lagging shall be aluminum. Boiler casing and fan insulation and lagging materials shall be submitted to the Buyer for authorization.

B. The economizer, economizer outlet duct and the stack up to the damper shall be insulated for internal corrosion protection. Unless specified on the Boiler Data Sheets, the insulation shall be 2" (50 mm) thick with aluminum lagging.

C. Joints in multiple layer insulation systems shall be staggered.

D. External insulation and lagging shall be provided for all boiler external and non-external piping, headers and trim components.

2.12 Doors and Appurtenances

A. Accessways and access doors shall be provided to access all areas of the Boiler for inspection, maintenance and repairs, including access to the furnace, heat transfer surfaces, ducts, fans, dampers and stacks. The minimum access lanes clear width shall be 30 inches (760 mm). The access to the convection bank shall be at the furnace end and the boiler outlet end.

B. The minimum water wall access door opening shall be 16 x 18 inches (400 x 450 mm). The minimum access door opening in other areas shall be 18 x 24 inches (450 x 600 mm). Access doors shall be pressure tight, constructed of steel plate with reinforcement and frames. Doors shall be bolted to casing frames and shall have gaskets, hinges and handles. Heavy doors shall have davits that swing open in either direction. Lightweight door designs utilizing wedges for closure are permitted. Grab bars shall be provided above access doors.

C. Access doors in refractory or insulated sections shall have refractory or insulation and liner equivalent to the adjacent setting.

D. Obstructions, including doors in the open position, shall not reduce the clear access around the lanes and doors from the access lane and door dimensions specified.

E. Observation doors and ports shall be provided to permit visual observation of burners, pilots, flames and of waterwall and superheater surfaces.

F. Observation doors shall be pressure tight and air-cooled with glass window and flapper with handle. They shall be constructed from cast material with frames for internal insulation and liners. Doors shall be bolted and gasketed to casing frames. Glass shall be replaceable when the boiler is operating.

G. Air for observation door and port sealing, cleaning and cooling shall be supplied from the Supplier's combustion air fan or the Supplier's separate cooling and sealing air fans. All air piping and tubing from the fans to the doors and ports shall be provided.

2.13 Expansion Joints

A. Combustion air and flue gas expansion joints shall be provided as dictated by the Supplier's design. They shall include expansion joints at the FD fan discharge, economizer and stack inlets as a minimum.

B. Expansion joints shall be the fabric bellows type. Metal bellows type expansion joints shall be considered for flue gas ducting where temperature, flue gas composition or leak tightness requirements warrant.

C. Expansion joint materials shall be suitable for at least 100°F (56°C) above the internal combustion air or flue gas temperature. Flue gas expansion joint fabric shall be suitable for the flue gas composition when cooled to the external surface temperature.

D. Expansion joints shall permit repairs from the outside.

E. Expansion joints shall not have continuous flanges from the internal hot face to the outer casing.

F. Expansion joints shall be complete with frames, hardware, flanges, bolts, nuts and gaskets for both connecting surfaces.

G. Flue gas expansion joint fabric shall be layered with the internal layer resistant to acid dew point condensation and the outer layer resistant to ambient conditions.

H. Expansion joint design and installation shall prevent sources of damage during operation. Creases shall not be permitted in fabric bellows. The bellows shall have stainless steel or Inconel wire reinforcement with no exposed edges or stitching. The fabric shall be fitted with an insulating cuff to prevent direct contact with the hot frame.

I. External safety shrouds shall be provided for personnel protection where the external expansion joint temperature exceeds 140°F (60°C) and may be touched by personnel. The shrouds shall be designed for quick access to inspect the bellows.

J. Internal insulation of expansion joints shall be in pillow form. The insulation material shall be enclosed in a fabric sleeve with stainless steel mesh reinforcement as required to prevent insulation from being drawn into the combustion air or flue gas stream.

K. Internal flow liners (baffles) shall be provided for fabric expansion joints in flue gas to direct the gas flow away from internal insulation and to reduce particulate accumulation in insulation cavities.

L. Metal bellows expansion joints shall be formed with a radius at the flexing portion of the joint. Corners shall be rounded or double mitered. Movement shall be limited to axial and/or angular without torsion or shear. The movement shall be limited to 1 inch of compression or extension.

M. Piping expansion joints and metal flue gas expansion joints shall conform to EJMA Standards as supplemented or amended by the Buyer's Specification, EH-35R-CCU1-SPC-250-50112 *Package Equipment Piping*.

2.14 Dampers

A. A stack damper shall be provided for combustion control.

B. Dampers (including VIV's) with pneumatic operators shall be provided for combustion air and flue gas control and shutoff as required for operation, isolation and standby. The Supplier shall advise the maximum expected and guaranteed leakage through dampers when closed corresponding to operating conditions.

C. Damper pneumatic actuators shall be mechanically suitable for 150 psig (1034 KPa) air pressure and shall provide the required output with air pressure as low as 60 psig (414 KPa). Actuators shall have a local manual positioning override.

D. Dampers shall be flanged and drilled for leak-tight, bolted connections to fans and ductwork.

E. Dampers shall be of either the parallel or opposed blade type as appropriate. They shall be multi-blade louver type with a minimum of four blades. Butterfly type dampers may be used for FGR ducting.

F. Damper shafts shall be sealed or packed to prevent leakage.

G. Damper operating mechanisms shall have provisions to manually secure the damper in any position while not in automatic mode.

H. Damper operating mechanisms shall be located outside of combustion air and flue gas paths. The mechanisms shall be accessible for in-place inspection, maintenance and removal by un-bolting.

I. Dampers shall have a local blade position indicator and two Form C sets of limit switch contacts for Buyer's use.

J. Shutoff damper blades shall be 3/16 inch (5 mm) nominal or thicker plate closing against 1/4 inch (6 mm) nominal or thicker closure bars. Closure bars shall be serrated where required for expansion.

K. VIV damper bearings shall be antifriction or oil impregnated bushings. Other damper bearings shall be external, solid-lube flanged or permanently lubricated pillow block.

L. Provision shall be furnished for lubrication of damper mechanisms during operation.

M. Damper housings shall be ASTM A36 carbon steel. Damper shafts and blades shall be carbon steel unless noted otherwise on Buyer's data sheets. Damper linkage bolts and pins shall be stainless steel.

2.15 Burners and Igniters

A. Burner System General Requirements

1. The Supplier shall provide a complete system of firing equipment, including: fans and drivers, combustion air ductwork, burner windbox, main burners, pilot burners, igniters, burner fuel piping incorporating fuel flow control and safety shutoff valves, burner management system incorporating all local controls, instrumentation and a local control panel.

2. The burner system shall be capable of continuous sustained operation at all specified operating conditions.

3. The entire system shall be factory assembled, inspected and tested to the maximum practical extent.

4. The burner system shall conform to NFPA 85 and shall be supplied with UL and FM approvals.

5. The burner combustion control system shall provide an accurate fuel-air ratio control and thorough mixing of fuel and air throughout the load range. The turndown range for each burner shall not be less than 10:1. With all burners in operation, the boiler turndown shall be 5:1.

6. All equipment necessary to provide cooling air to flame scanners and observation doors and ports shall be provided.

B. Burners

1. Burners shall be designed for firing the fuels specified on the Buyer's data sheets. The burners shall be true low-NOx designs. The burners shall permit complete fuel combustion in the furnace envelope without causing flame impingement on furnace tubes and/or secondary fuel combustion in the superheater and boiler bank zones.

2. Flames shall be stable throughout the specified operating range without the need for operator adjustment of air registers and other combustion air flow distribution devices.

3. Gas burners shall be of the multi-port type. Gas tips shall be removable from their holders. Individual gas tips/holders shall be removable from the burner assembly without requiring the entire burner assembly to be removed.

C. Pilots and Igniters

1. Direct high energy ignition (HEI) or electric spark ignited pilots shall be provided at each main burner. Pilots shall operate on natural gas unless specified otherwise on Buyer's data sheets.

2. Igniter electrodes shall be removable for replacement with spares when the boiler is operating. Seals and blast gates shall be provided for removal.

3. Pilot type and capacity shall be appropriate for the ignitor class as defined in NFPA 85. Combustion air for pilots shall be supplied by the boiler combustion air fan. Maximum combustion air flow shall not extinguish pilots.

4. An ignition transformer shall be provided for each igniter including high voltage cable, prewired and located in an enclosure mounted on the windbox or boiler.

D. Windbox and Front Plate Assemblies

1. Burner windbox construction and the method of mounting to the boiler shall provide gas tightness over the entire range of boiler operation. Structural integrity and gas tightness shall be maintained at full FD fan discharge pressure when a damper is installed in the flue gas stack or ducting upstream of the stack.

2. Burner windboxes shall be either internally lined or externally insulated and lagged when combustion air preheat is used.

3. The Supplier shall provide piping with a single flanged point of connection for fuel and each utility service at the burner or windbox for the Supplier's connecting piping from the fuel train skid to the burner or windbox.

4. Tubing, wiring and conduit shall be provided from all instruments or electrical components mounted on the burner windbox, front plate assembly or fuel header assembly to junction boxes provided and mounted on the burner windbox, boiler or separate structural assembly. Igniter electrodes shall be removable for replacement with spares when the boiler is operating. Seals and blast gates shall be provided for removal.

2.16 Fans and Drivers

The following specifications for fans, drivers and associated equipment shall apply to the maximum extent practical. It is recognized that for certain services (e.g., cooling and sealing air fans) and for small package type boilers, the requirements noted herein may not be fully applicable. The Supplier shall clearly note where exception is taken in those circumstances. It is intended that all fans be supplied as a system package where, in addition to the fan itself, the driver, associated driveline components such as gears, clutches, and couplings, flow control devices and their operators, and necessary auxiliary equipment including inlet and

outlet flow ducting, silencers, flow measurement elements and instrumentation are included as part of the package.

The specifications herein are supplemental to those shown on the Buyer's fan data sheets.

A. Fans

1. Fans, drivers, related equipment and auxiliaries shall be designed and constructed for a minimum service life of twenty (20) years and for at least three (3) years of continuous operation (with monitoring and on-line service as specified by the fan Manufacturer).

2. Fans shall be of the centrifugal type for all services.

3. Fan arrangement and bearing support shall conform to AMCA Publication 99, arrangement 3 or 7. The fan wheel shall be located between bearings. The bearings shall be mounted independently of fan housing on pedestals and sole plates. The bearings shall be protected from the air or flue gas stream. Arrangements 1 and 3 may be considered for FD fans on small packaged boilers (under 150 hp or 110 kW rated). Belt drives shall not be used for any service.

4. The fan manufacturer shall formally review and provide written acceptance of the Supplier's inlet and outlet duct and equipment arrangement drawings. The review shall include structural alignment, loading on fan parts and configuration details that impact fan performance as described in AMCA 201.

5. Fans, drivers and related equipment shall be designed for the full range of ambient conditions shown on the Buyer's data sheets. FD fans shall be mechanically suitable for operation at 25°F (14°C) above the specified maximum ambient air temperature or ambient/flue gas recirculation mix temperature. ID and FGR fans shall be mechanically suitable for operation at 100°F (56°C) above the maximum inlet flue gas temperature. ID and FGR fans shall also be suitable for operation at the minimum ambient temperature if start-up or purging operations will encounter these temperatures.

6. Fans, components and accessories shall withstand all loads and stresses during rapid load changes such as starting, failure of damper operator or sudden position changes of dampers. The Supplier's combustion control logic shall incorporate all required safeguards.

7. The Supplier shall provide information to the fan manufacturer on any corrosive agents present in the flue gas and in the environment, including constituents that may cause stress corrosion cracking. The fan manufacturer shall provide materials suitable for these conditions.

8. Fan accessories shall include items shown on Buyer's data sheets.

9. Variable inlet vanes shall be continuously welded to the spindle or intermittently welded on the back side of the blade with full slot welds along the full length of the front side.

10. Fan performance shall be based on calculated combustion air requirements for all boiler operating conditions. Unless otherwise specified on the Buyer's data sheets, the following margins shall be added to the calculated fan performance requirements at 100 percent MCR design heat release to arrive at the test block:

    a. 20 percent to the air volume at design excess air.

    b. 25 percent to the static pressure.

    c. 25°F (14°C) to the plant design maximum ambient air temperature.

11. Unless otherwise specified on the Buyer's datasheets, fan characteristic curves shall have a rising pressure from rated flow to 35 percent of rated flow.

B. Fan Performance

1. The Supplier shall provide the arrangement of the boiler, ducting, fan and driver to the FD, ID and FGR fan Manufacturer. The fan Manufacturer shall provide written confirmation of his acceptance of the arrangement and the fan and driver capability to perform in the arrangement.

2. Fan performance curves, corrected for the specified gas at the specified conditions, shall be based on performance tests in accordance with AMCA 210 including any evase and inlet boxes. Alternatively, the fan performance may be based on prototype testing in the fan Manufacturer's AMCA certified laboratory with performance tolerances are as specified in AMCA 211.

3. The fan rating point (test block) shall include the flow required to meet the boiler maximum design firing rate including all overages for excess air, system leakage and design safety factors. In no case shall the rating point be less than 115% of the normal operating flow. The fan static head and temperature required for the rating point shall be specified by the Supplier and shall include the requirements of this specification.

4. The fan and driver efficiency shall be optimum at the normal operating point.

5. Fan performance shall be based on fan discharge static pressure not including discharge velocity pressure. Required performance shall include the effect of inlet velocity pressure. The silencer and inlet losses including control system losses shall be included in the fan static pressure differential.

6. Fans shall operate at the most efficient point of operation for the 100% MCR operating case.

C. Fan Inlets (FD Fans Only)

1. FD fan air inlets shall be a minimum of 15 feet (4.6 m) above grade.

2. FD fan inlet equipment shall include an intake rain cap or rain hood, trash screen, ducting and support, inlet boxes, transition pieces, silencer and inlet filter as required. All components shipped separately shall be flanged for field assembly.

3. The FD fan inlet trash screen shall be 0.125 inch (3 mm) minimum diameter Tp 300 series stainless steel wire with a mesh of 1-1/2 inch (38 mm) nominal opening suitably supported by cross members. When specified, an inlet filter shall be furnished. Filter elements shall be removable and washable. Screen supports and rain hoods shall be galvanized or painted carbon steel.

4. FD fan inlet silencers shall include a velocity tube differential pressure measurement device. Mineral wool shall not be used in FD fan silencer construction. The differential pressure across FD fan inlet and/or outlet silencers shall not exceed 0.8 “H2O (20 mm H2O).

5. Carbon steel FD fan inlet air duct plate and silencer shell shall not be less than 3/16 inch (5 mm) nominal plate thickness. Corrosion allowance and alternate materials shall be provided if required.

6. FD fan inlet duct and silencer connections shall be flanged.

D. Fan Housing

1. FD fan scrolls and housings shall be continuously welded ASTM A36 carbon steel plate construction. Housing inlet and discharge connections shall be flanged and bolted for seal welding. The fan casing shall have side and scroll liners. The complete scroll plate shall be provided with full width mild steel replaceable liners extending to the discharge flange.

2. The minimum FD, ID and FGR fan housing plate thickness shall be 1/4 inch (6 mm). The Supplier shall specify and include any corrosion allowance required for housings.

3. Stiffeners shall be provided on FD, ID and FGR housings to form a rigid housing free of structural resonance and to limit vibration and noise. The external stiffeners may be intermittently welded to the fan housing.

4. A bolted and gasketed access door, of the largest possible size up to 24 x 24 inches (610 x 610 mm), shall be provided in scrolls and inlet boxes for access to FD, ID and FGR fan internals for inspection, cleaning, rotor balancing and for any internal bolting removal necessary for rotor removal.

5. FD, ID and FGR fan housings shall be provided in split sections to permit removal of fan rotors without dismantling ductwork and without requiring personnel in the inlet boxes. Arrangement 3 and 7 fan housings and inlet boxes interfaces shall be flanged. Duct supports shall be provided as required.

6. The FD, ID and FGR fan inlet cone shall be constructed such that it does not impede rotor removal or installation. The cone shall be split, separately removed as a whole or removable in assembly with the rotor.

7. An opening or connection for insertion of a steam or water lance for rotor cleaning.

8. Low point drains shall be provided in FD, ID and FGR fan housings and inlet boxes. Drains shall be 3000# couplings with plugs. The minimum size shall be 2" (50 mm).

9. All FD, ID and FGR fan flanged connections shall include leak-tight flange facing, bolts, nuts and gaskets.

E. Rotors (Wheels)

1. FD fan wheels shall have non-overloading airfoil or backward curved blades with a horizontal forged and machined steel shaft. ID and FGR fan wheels shall have backward curved, radial or radial tipped blades and shall be designed for heavy-duty service.

2. Fan wheels shall be of welded construction. Shrouds, back plates and center plates shall normally be of one-piece construction. If fabricated they shall employ full penetration butt welds.

3. Fan wheels shall have solid hubs and shall be keyed to the shaft and secured with an interference fit. Cast or ductile iron hubs are acceptable for mechanical design temperatures below 300°F. When the impeller is bolted to the hub the design shall preclude relative movement between the impeller and hub.

4. Fan shafts shall be of one piece, heat treated and suitably machined. FD fan shaft material shall be AISI 4140 HRS. ID and FGR fan shaft material shall meets or exceeds the strength and the erosion-corrosion resistance of ASTM A688 material. Shafts over 6" in diameter shall be machined from forged steel and shafts 6" in diameter and smaller may be machined from hot rolled steel. Shaft diameter shall be stepped on both sides of the impeller fit area to facilitate impeller assembly and removal. Fillets shall be provided at all changes in shaft diameter and in keyways. Welding on the shaft is not permitted except where a welded integral hub is required to withstand rotor temperature change rates greater than 15°F per minute.

5. Fan shafts shall be capable of handling 110% of rated driver torque from rest to design speed.

6. When protection against the flue gas water and acid dew point corrosion is required, FD, ID and FGR fan shaft sleeves shall be provided. Shaft sleeves (or extended seal mounts) shall be attached to the fan housing, surround the fan shaft and shall be externally insulated. Shaft seals, if provided, shall be mounted on the outboard end of the sleeve. The in-leakage air shall be warmed by contact with the sleeve and shaft so that air temperature at the point of contact with flue gas is above the water and acid dew point temperatures.

7. Fan shaft seals shall be provided to minimize leakage from or into fans over the range of specified operating conditions and during periods of idleness. Seal operations shall be suitable for variations in inlet conditions that may prevail during start-up and shutdown or any special operation specified by the Supplier.

8. Fan shaft seals shall be replaceable from the outside of the inlet boxes without disturbing the shaft or bearings.

9. Fan critical speeds shall be determined analytically by means of a damped unbalanced rotor response and analysis and shall be confirmed by test stand data for shop assembled fans and a field test for field assembled fans. A drive train torsional analysis shall be conducted. A lateral analysis is not required.

10.

11. Fan resonances for support systems shall not occur within the specified operating speed range or the specified separation margins, unless the resonances are critically damped. The Buyer will provide a concrete foundation for the fans if required.

12. Fan Manufacturer shall determine that the drive-train critical speeds are compatible with the critical speeds of the machinery being supplied and that the combination is suitable for the specified operating speed range. A list of all undesirable speeds from zero to trip shall be submitted to the Buyer for review and shall be included in the instruction manual.

13. Fan shaft service factor shall not be less than 1.4 and the shaft shall be a classically stiff design. The separation margin of critical speeds from all lateral (including rigid and blending) modes shall be at least 25% over the maximum continuous speed. The separation margin is intended to prevent the overlapping of the resonance response envelope into the operating speed range.

F. Bearings and Bearing Housings

1. Fan bearings shall be static oil lubricated spherical roller bearings cooled by a circulating oil lubrication system or water-cooled ring oiled sleeve type with constant level oilers. ID and FGR fan bearings shall be water cooled sleeve bearings.

2. Fan thrust bearings shall be provided to take the total thrust of the fan rotor in either direction under any operating conditions. They shall be sized for continuous operation under all specified conditions including double-inlet fans operating with one inlet cone 100% blocked. Thrust bearings shall be applied at no more than 50% of the bearing Manufacturer's ultimate loading rating.

3. Fan shaft bearings shall be accessible without dismantling ducts or fan casings. Overhung impeller designs shall have provisions for supporting the rotor during bearing maintenance.

4. Fan bearing housings shall be drilled with pilot holes for use in final doweling.

5. ID and FGR fans shall be supplied with heat slingers (with safety guard) located between the fan housing or inlet box and the end of the adjacent bearing.

6. Fan bearing housing resonance shall not occur within the specified operating speed range or specified separation margins.

7. Permanently lubricated linkage, shaft fittings and bearings shall be provided for FD, ID and FGR fan damper and VIV's where possible. If periodic lubrication is required lubrication fittings which are accessible while the fan is in operation shall be provided.

G. Couplings

1. Fan couplings shall be a flexible gear type, Falk or equal with guard or Thomas Series 71 spacer couplings with guard.

2. Non-gear couplings shall be spacer type with the spacer length sufficient to allow removal of the coupling hubs for maintenance of adjacent bearings and seals without removal of the shaft or disturbing the equipment alignment.

3. Coupling guards shall sufficiently enclose the coupling and shafts to prevent danger to personnel when the fan is operating. Guards shall be removable for inspection and maintenance of the coupling without disturbing the coupled machines.

H. Fan Drivers

1. The type of driver shall be electric motor.

2. Electric motor drives shall conform to either API 547 or IEEE 841 and Buyer's Specification, EH-35R-CCU1-SPC-255-56070 *General Purpose Induction Motors- ½ hp through 500hp- IEEE 841*.

3. The drivers shall be sized to meet the fan rating point conditions, including external gear and/or coupling losses.

4. The drivers shall be suitable for satisfactory operation under the utility and site conditions specified on the Buyer's fan data sheets.

5. Anticipated process variations such as changes in the pressure, temperature or properties of the fluid handled and plant startup conditions shall be included in the design.

6. FD fan motor drives shall be capable of supplying combustion air to allow for full boiler MCR at the minimum ambient temperature.

7. The driver's starting-torque capabilities shall exceed the speed-torque requirements of the driven equipment. The fan manufacturer and the Supplier shall verify that the starting characteristics of the fan and drivers are compatible.

8. Motor driver nameplate rating, exclusive of the service factor, shall be at least 110 percent of the greatest power required including gear and coupling losses for any of the specified operating conditions.

9. Full load and starting current, system SR2, and motor curves showing speed-torque, speed-current and speed-power factor shall be provided for the fan motor driver.

I. Cooling Air and Sealing Air Fans

1. Cooling air to scanners and observation ports and doors may be provided from the FD fan discharge or two 110% capacity cooling air fans (one as backup).

2. Sealing air may be provided from the FD fan discharge or two 110% capacity sealing air fans (one as backup).

3. If the FD fan is used to supply cooling and sealing air, the FD system shall be designed for the additional cooling and sealing air.

4. Cooling air and sealing air fans shall be provided with rain hood, inlet screen or filter, silencer, electric motor driver and discharge backflow prevention device. The discharge backflow prevention device shall be a check valve, non-return damper or shut-off valve to prevent flue gas or air backflow through the fan inlet when the fan is not in operation. An external valve or blade position indicator visible from grade or platform shall be provided. Piping or duct supports shall be provided as required.

J. Steel supports for fan systems and components thereof shall be of welded carbon steel plate and shapes. Structure baseframes (skids) shall include necessary lifting lugs and other fixtures to allow for shipping and handling the entire skid assembly as a unit. The skid shall incorporate all furnished piping, tubing, wiring, and conduit, fully supported and terminated for Buyer's connection.

2.17 Platforms, Ladders, and Stairways

A. Platforms, ladders and stairways shall be provided as noted herein and on the Buyer's data sheets. They shall conform to federal OSHA standards and to any state and local requirements. Ladder gates shall conform to those for work areas, i.e. equivalent to the adjacent handrail system as per OSHA Standard 1910.21, subpart D: Walking – Working Surfaces.

B. Permanent platforms shall be provided to access burners, pilots, flame scanners, observation doors and ports, instruments and controls, PSVs, control and shutoff valves, steam drum trim, desuperheater stations, drum manways, dampers and actuators, steam sampling locations, flue gas sampling locations on the stack, and access doors unless accessible from grade. Burner platforms shall be provided with stairway access; all other platforms shall be provided with ladder access unless noted otherwise on Buyer's data sheets.

C. The top of grating on drum level platforms shall be located at least 18 inches (460 mm) below the lowest level transmitter root valve to permit installation of level transmitters

above the platform. Space for an 18” x 18” x 18” (460 x 460 x 460 mm) transmitter enclosure shall be included on upper level platforms at each transmitter location.

D. Platform and ladder access shall be provided to combustion air and flue gas path instrumentation and root valves. Permanent access shall be provided to exhaust gas thermocouple heads that cannot be accessed by temporary equipment located at grade. Permanent access is not required to combustion air and flue gas path test ports other than emission test ports located on the stack.

E. Platforms, ladders and stairways shall be supported from the Supplier's equipment or from separate structure provided by the Supplier.

F. Platform, stair treads and walkway flooring shall be galvanized serrated welded grating with 1-1/4 inch (32 mm) by 3/16 inch (5 mm) bearing bars at 1-3/16 inch (30 mm) centers and cross bars at 4 inch (100 mm) centers.

G. Stair treads shall be metal grating with checkered plate nosing. A non-slip nosing shall be provided on the grating at the head of stairs. Stairway slope shall not be steeper than 38.4° with 9-3/4” (20mm) treads and 7-3/4” (20mm) risers.

H. The minimum platform locations and clear widths shall include the following. The clear width shall be as necessary to provide accessibility but not less than 2'-6" (760 mm). When auxiliary equipment sections are included in this specification, additional minimum platform requirements in those sections also apply.

Minimum Platform Locations and Minimum Clear Widths	
Location	**Clear Width**
At both ends of the steam drums	4’ -0” (1200mm)
Along one side of the steam drum length connecting the end platforms when level instrumentation is located on the side of the drum	4’ -0” (1200mm)
Connecting steam drum end platforms when level instrumentation is not located on the side of the drum	2” -6” (760mm)
Along one side of steam drums for the full drum length located within 1’ -6” (450mm) of drum pressure relief valves and instrumentation	2” -6” (760mm)
For access to Boiler header hand holes	3’ -0” (900 mm)
Full 360° emission level platform for access to stack emission test ports and CEMS, flow, opacity and temperature instrument connections	4’ -0” (1200mm)
At dampers extending 3’ -0” (900mm) beyond damper shafts for access to bearing and actuator	3’ -0” (900 mm)
At all external exhaust gas path access doors	3’ -0” (900 mm)
At burners for access to burner, pilots and scanners	4’ -0” (1200mm)
At observation ports and doors	3’ -0” (900 mm)

I. The minimum clear widths and heights shall be maintained around and under piping, structural steel and insulation.

J. Headroom over platforms and walkways shall not be less than 7’ - 6” feet (2.3 m).

K. Valve hand wheels and instruments shall be considered accessible by platform if they are within 18 inches (460 mm) of the handrail.

L. Valve hand wheels shall be considered accessible if they are within 6'-6" (2 m) of platform floor or grade. Instruments and other items shall be considered accessible from grade or platform if they are within 7 feet (2.1 m) from platform floor or grade.

M. All items requiring operation, inspection or maintenance shall be located above the grating of their access platforms. Cutouts in the grating to access items located below the platform are not acceptable.

N. At least two egress paths shall be provided on opposite corners of operating platforms. The egress shall be clear and direct. The egress distance to a ladder or stairway shall not exceed 75 feet (22.8 m).

O. Step-off platforms (landings) shall be provided for ladders so that the climb distance between landings or platforms does not exceed 30 feet (9.1 m).

2.18 Special Tools

A. The supplier shall provide special tools required for installation, commissioning, start-up, operation and maintenance of the Boiler and auxiliary equipment.

B. Special tools shall include any tool, guide, jig or fixture required which cannot be readily procured in commercial hardware or tool supply establishments.

2.19 Spare Parts

A. All spare parts required for construction and commissioning shall be provided, including the following as a minimum:

1. Three sets of drum manway and all non-standard gaskets.
2. Setting, insulation and lagging repair materials.
3. Temporary gauge glasses for boilout.
4. Spares required to complete the construction.
5. Spares necessary for commissioning.
6. Other spares recommended by the Supplier and Sub-Suppliers.

B. Spare parts for operation shall be provided when specified in the Buyer's Inquiry, Purchase Order or Contract with the Supplier.

C. Material overages shall be provided as required to complete field installation. These overages are not considered optional spare parts. Overages are based on field installed quantities and shall include the following as a minimum:

1. 5 percent for bolts, nuts and washers (each type and length).

2. 15 percent for insulation, refractory and lagging.

3. 15 percent for personnel protection expanded metal.

4. 15 percent for internal corrosion protection coatings.

2.20 Instrumentation and Control

A. General

1. The Supplier shall provide all local instrumentation, controls, trim and accessories required by the ASME Section I Code to operate and monitor the operation of the boiler locally and from the Buyer's DCS.

2. Field performance test instrumentation shall be as specified in and shall conform to the requirements of ASME PTC 4.1. All temporary test instrumentation required for the performance test shall be provided by the Supplier.

3. Instrumentation and instrument connections shall be supplied in accordance with Buyer's Specification, EH-35R-CCU1-SPC-270-00003, *Instrumentation for Packaged Equipment*.

4. Instrument tagging shall conform to instrument tag numbers to be supplied by the Buyer.

5. Instruments shall be calibrated in the shop. Calibration sheets shall be furnished to the Buyer.

6. All trips shall be preceded by alarms.

7. All instrument air users shall be supplied with individual instrument air filters / regulators.

8. Temperature elements shall include thermowell, thermocouple, and weatherproof head and shall be furnished as a complete assembly.

9. Temperature indicators shall include thermowell, thermocouple, and temperature guage and shall be furnished as a complete assembly.

10. Tubeskin thermocouples (TSTC) shall be Type K and shall be furnished with gas tight type 310 SS sheaths. Weatherproof heads shall be supplied for each TSTC.

B. Combustion Air and Flue Gas Instrumentation

1. Two (2) combustion air / flue gas test ports shall be furnished at the FD fan inlet and outlet, in the windbox, at the furnace outlet, at the superheater outlet, at the convection bank outlet, at the economizer outlet and in the stack transition. Connections shall be 2" (DN50) 3000# threaded couplings with caps.

2. The Supplier shall furnish connections for Buyer's pressure transmitters at the following locations: for the combustion air flow measurement device, for combustion air pressure at the FD fan outlet, for combustion air pressure at the burner windbox, for flue gas pressure at the furnace near the burner, for flue gas pressure at the rear of the furnace, for flue gas pressure after the superheater, for flue gas pressure at the boiler exit, for flue gas pressure at the economizer exit. The Supplier shall provide root valves at the pressure connections. The Buyer will provide tubing hookups, transmitters and the manifolds. Connections shall be 2" (DN50) RFWN flanges with blinds.

3. If FD fan differential pressure is used to verify combustion air flow for the BMS, the Buyer will provide the differential pressure transmitter(s). The Supplier shall provide the pressure connections and root valves at the FD fan inlet and outlet. The Buyer will provide tubing hookups, transmitters and the manifold. Connections shall be 2" (DN50) RFWN flanges with blinds.

4. A pressure port for future use shall be provided downstream of the FD fan inlet silencer, downstream of the FD fan steam air coil heater, upstream and downstream of FGR fans, in the IFGR duct near the FD fan and upstream and downstream of the ID fan. Connections shall be 1" (DN25) 3000# threaded couplings with plugs.

5. A thermowell and thermocouple with head shall be provided for the Buyer's temperature transmitter (for control) for combustion air at the combustion air flow device and for flue gas at the furnace exit and in the stack at the EPA emission test ports. Connections shall be 1 1/2" (DN40) 150# RFWN.

6. A thermowell and thermocouple with head shall be provided for the Buyer's temperature transmitter (for indication) for combustion air at the FD fan discharge and for flue gas at the superheater outlet, convection bank outlet and economizer inlet and outlet and ID fan outlet. Connections shall be 1 1/2" (DN40) 150# RFWN. Thermowell/thermocouple installation in the furnace shall be placed to avoid direct flame radiation to the thermowell.

7. Combustion air and flue gas thermowells shall extend into the innermost 2/3 of the flue gas path cross sectional area. The internal thermowell length shall be 3 feet (1 m) for boiler or duct internal widths exceeding 18 feet (5.5 m).

8. Unless noted otherwise on the Buyer's data sheets, the Supplier shall provide a flue gas O2 analyzer in the economizer outlet for combustion control and O2 trimming. Connection shall be 4" (DN100) 150# RFWN flange.

9. Four emission test ports at 90° shall be provided on the stack. Lugs shall be provided above stack emission test ports for support of sample probes. The test ports shall be above the platform handrail and shall be 24 inches (610 mm) downstream of the CEMS connection. Connections shall be 6" (DN150) 150# RFWN with blind with a handle and a chain to casing.

10. Unless noted otherwise on the Buyer's data sheets, one CEMS connection shall be provided at the stack emission test port location in the stack for the CEMS analyzer. Flange bolt holes shall be at top dead center "TDC". The CEMS port shall be located directly under one of the four emission test ports. If the stack diameter exceeds five feet, a second CEMS port shall be provided on the opposite side for probe support. The CEMS will be provided by the Seller. Connections shall be 4" (DN100) 150# RFWN.

11. One set of two (2) flue gas opacity connections shall be provided in the stack at the emission test port location for an opacity measurement device. The opacity measuring device will be provided by the Seller if required by the air permit. Flue gas opacity connections shall be located 180° apart at the same elevation. The connections shall be installed true and concentric for a direct line of sight between the connections.

12. An airfoil, a venturi or a piezometer ring combustion air flow device shall be provided for combustion control, including root valves. The Buyer will provide a multi-variable type flow transmitter, manifold and hookups.

13. Stack emission test ports, CEMS, opacity, analyzer and flow device connections shall be located not less than 8 stack diameters downstream of any flow disturbance and not less than 2 stack diameters upstream of the stack exit. Flange faces shall project six inches from the outside surface of the casing plate. Flange bolt holes shall straddle natural centerlines unless otherwise specified.

14. Combustion air and flue gas connections and ports shall have sleeves in internally insulated sections. The sleeves shall extend through the full thickness of the insulation. Sleeve material shall be suitable for combustion air and flue gas temperatures. Parts external to the casing may be carbon steel. When a permanent instrument is not installed in the connection and the connection is in an insulated wall, a removable insulation plug attached to the test port cap or flange shall be provided in the connection.

15. Each combustion air and flue gas connection shall have a pipe cap, hex-head forged steel screwed plug or blind flange, gasket, bolts and nuts as applicable.

C. Steam and Water Instrumentation

1. Pressure gauges shall be provided on the steam drum, and lower drum heating coil inlet and outlet. The steam outlet pressure gauge shall be located upstream

of the non-return valve (or manual stop valve for boilers feeding a single header (1x1 units)).

2. Pressure transmitters, manifolds, tubing and support will be provided by the Buyer on connections furnished by the Supplier on the steam drum, lower drum heating coil inlet, steam outlet and desuperheater water inlet piping. The steam outlet pressure transmitter shall be located upstream of the non-return valve (or manual stop valve for Boilers feeding a single header (1x1 units)).

3. Temperature indicators shall be provided in economizer inlet piping, steam inlet piping to the superheater and steam outlet piping. The steam outlet temperature gauge shall be located upstream of the non-return valve (or manual stop valve for boilers feeding a single header (1x1 units)).

4. Temperature elements shall be provided for the Buyer's temperature transmitters (for control) in the steam outlet piping, in economizer outlet piping when a remotely operated venting system is provided and in lower drum heating coil inlet piping. The steam outlet temperature element shall be located upstream of the non-return valve (or manual stop valve for 1x1 units).

5. Temperature elements shall be provided by the Seller's temperature transmitters (for indication) in the economizer inlet piping, economizer outlet piping where a remotely controlled venting system is not required, and upstream and downstream of desuperheater elements.

6. Two (2) tube-skin thermocouples (Type K) shall be provided on each flow pass of superheaters. Wiring to a common junction box and the junction box shall be provided.

7. Three 3 DP type level transmitters with condensate pots and manifolds will be provided by the Seller on the steam drum. The Supplier shall provide connections and root valves. The transmitters shall be used for control and 2 out of 3 voting for level trips and alarms and signals to the BMS. Multiple level transmitter connections reading the same levels shall be at the same elevation on the drum. Level transmitters shall read the full range from high-high to low-low level. The drum taps shall be located above the high-high level and below the low-low level so that the high-high level does not exceed 90% of the level transmitter range and the low-low level is not less than 10% of the level transmitter range. Level tap nozzles shall be horizontal. The lower level tap shall be a minimum of 8" (203 mm) above the bottom of the drum ID. The Buyer will provide a level indicator visible from the intermittent blow down valves when the valves are not remotely operated. The Buyer will provide a continuously visible, color level indication of the combined level signal for each drum in the control room if an electronic level gauge is not provided.

8. An electronic level gauge shall be provided on the steam drum for direct level indication in the control room. The level gauge with probes, local control unit box with local indicator on the box and local cabling from the probes to the local box shall be provided. A separate, remote indicator for mounting in the control room shall be provided with a contact output (fault alarm) to the DCS. A local manual

hand switch shall be provided to bypass the signals when blowing down the water column. The Buyer will provide the cable from the local box to the remote indicator mounted in the control room.

9. Glass type level gauges shall be provided on the drum as required by the Code. Multiple level gauge connections shall be at the same elevation on the drum. Illuminators shall be provided for all level gauges.

10. Level and flow transmitter compensation for operating conditions will be made in the Buyer's DCS. The Supplier shall provide the algorithm for the single and three element drum level and feedwater control for the Buyer's configuration in the Buyer's DCS.

11. Removable insulated covers shall be provided for level gauges when the boiler is located outside where freezing may occur.

12. Steam sampling probes shall be provided for superheated steam and saturated steam. The steam probes shall conform to ASTM D1066, except that the nozzles shall be flanged to permit removal of the probes for inspection. Sample connections with valves shall be provided for drum water in the continuous blowdown line upstream of the blowdown valves.

13. Flow elements and transmitters shall be provided by the Buyer for steam, feedwater and desuperheating water. Process taps for all flow transmitters shall be 45 degrees below horizontal.

14. Steam flow elements will be located in the Buyer's piping downstream of the steam stop valves (or manual stop valves for boilers feeding a single header (1x1 unit)). Feedwater flow elements will be located in the Buyer's piping upstream of the control valves. Desuperheater water flow elements will be located in the Buyer's piping upstream of the stop valves.

15. Steam flow elements will be welded ASME nozzles or venturis. Venturis will include shop installed radiographic plugs. Feedwater flow elements will be calibrated meter runs. Other water flow elements will be orifice plates with flanges.

16. Water sensing devices shall be provided in the water sensing drains. Preferred water sensing devices are level switches. Conductivity probes shall not be used.

D. Burner Management System

1. The Supplier shall provide a complete burner management system (flame safeguard). The system shall be PLC based and shall provide safe operation, protect the boiler and related plant equipment and prevent nuisance shutdowns.

2. Burner management system shall be a single or multiple burner system as applicable, conforming to NFPA 85. For multiple burner systems, loss of flame for any one burner shall result in fuel shutoff to that burner only. Other alarms and trips shall be as agreed to by the Buyer and the Supplier.

3. Burner management system design and equipment approval by local authorities shall be included if required. Supplier shall be responsible for verifying local requirements and obtaining necessary approvals.

4. The BMS shall permit automatic start, shutdown, emergency trip and emergency trip reset from the DCS or the local panel. The Supplier shall provide burner system start and shut-down sequences from both the DCS and the local panel. The sequences shall show step-by-step operator actions, automatic actions and DCS and local panel indications

5. The Supplier shall develop and provide combustion control narratives and ISA logic diagrams to the Buyer. The logic designs shall be complete for direct implementation of the logic into the Buyer's DCS.

6. A flame safety system shall be included. Flame scanners shall be provided at each burner location to supervise flames. Main burner, low capacity gas gun and pilot gas flames shall be supervised either separately or in common as demonstrated by proven experience with the system components selected.

7. Unless noted otherwise on the Buyer's data sheets, two flame scanners shall be provided for each burner type/location. Failure to indicate flame with the first scanner shall be alarmed and failure with the second scanner shall trip the individual burner. Flame scanners shall be:

   a. Self-checking, air purged and cooled.

   b. Mounted on adjustable bases.

   c. Prewired to terminal strips in a water-tight, electrical enclosure suitable for the electrical area classification.

   d. Power supply for the flame scanners shall be provided by the BMS.

8. The BMS shall include 120V and 24V input and output modules. The local panel shall include 24VDC power supplies to accommodate 24VDC users including 24VDC solenoids in the burner system.

9. Fuel and instrument air high and low pressure alarm and trip signals shall be from transmitters not switches. When required due to fuel density variations, high and low pressure transmitter settings shall be adjusted by the BMS based on a fuel density signal from the DCS.

10. Fuel control valves shall be provided with mechanical or software stops as required for light-off and minimum fire positions depending on the fuel heating value.

E. Local Control Panel

1. The Seller shall provide a local control panel to be mounted on the boiler front or a separate support rack/skid to be furnished by the Seller.

2. The local control panel shall house the hardware related to the BMS and other supporting instrumentation which requires weather protection.

3. The local control panel shall serve as the terminal point for wiring and cabling to and from the Buyer's DCS and the Supplier's BMS.

4. The local control panel shall include terminals for the Buyer's DCS firing demand signals for fuel control valves. The signal continuation wiring and conduit from the fuel train skid junction box to the fuel train control valves shall be provided by the Supplier.

5. The local control panel shall contain AC and DC power distribution within the cabinet. Terminal boxes shall be provided for the Buyer's main power and UPS backup power. Distribution in the panel shall include a main breaker and individual breakers and fuses for various branch circuits with proper breaker/fuse coordination to eliminate propagation of faults.

6. All control panel power and control wiring shall be installed and tested prior to shipment.

7. Grounding shall be to plant ground that eventually leads to earth ground.

8. Local panels mounted outside shall be provided with a weather/sun shade over the panel display and operating controls. The local panel shall be suitable for outdoor use and shall conform to the electrical area classification. Access to all panel mounted instruments, controls, and other electrical apparatus shall be provided for maintenance.

F. Combustion Control System

1. The combustion control system shall be implemented in the Buyer's DCS.

2. The automatic combustion control system shall provide an automatic combustion control system to maintain set steam pressure by regulating fuel and combustion air flows.

3. The combustion control system shall include manual and automatic modes and shall provide automatic control over the entire operating range of the boiler without requiring local operator actions except for start-up and shut-down.

4. The combustion control system shall be the modulating type with automatic transfer to an on-off recycle mode if firing demand falls below the minimum turndown of the burner.

5. Combustion control system hardware shall be of the solid state, electronic type.

6. The Supplier shall develop and provide the boiler combustion control logic narratives and ISA logic diagrams to the Buyer. The documentation shall be specific to the project and clearly indicate all required boiler combustion control related components and tags. The logic designs shall be complete for direct

implementation into the Buyer's DCS. The design shall include all constants, signal ranges and scaling and algorithms based on the project specific requirements. The Supplier shall participate in the Buyer's DCS functional acceptance test to ensure that the implementation of the logic is consistent with Supplier's design.

7. All local instruments, gauges and valves utilized by the combustion control system and the BMS and located on the fuel train skid and in downstream burner piping shall be provided by the Supplier.

8. When more than one fuel train is supplied, the combustion controls shall include selection of the fuel train from either the DCS or the local panel. If fuels are fired simultaneously, the combustion controls shall condition the firing demand signals for the fuels to limit the total burner heat release to the maximum design release.

G. Feedwater Flow Control

1. The Supplier shall provide all feedwater piping, valves, trim and accessories included within the ASME Code, Section I, Jurisdictional Limits.

2. The Supplier shall provide all the interconnecting feedwater piping to and from Supplier-furnished equipment, including valves, trim and accessories placed in the Supplier's scope.

H. Damper Control

1. A pneumatic actuator and 3-way solenoid valve shall be provided to positively open, close or modulate dampers depending on the signal from the DCS or BMS.

2. Equipment shall be provided to automatically open or close fan control dampers or VIV upon loss of control signal and to automatically lock or brake the dampers or vanes in the last position upon loss of air supply or electric power.

3. Damper pneumatic actuators shall be mechanically suitable for 150 psig air pressure and shall provide the required output with air pressure as low as 60 psig. Actuators shall have a local manual positioning override.

4. Damper shafts shall include open and closed position switches for safeguarding and indication in the Buyer's DCS and the Supplier's BMS.

I. Fan Control

1. The fans may be controlled on the basis of inlet pressure, discharge pressure, flow or a combination of parameters accomplished by suction or discharge throttling or speed variation. The Supplier shall determine the type and source of the control signal, its sensitivity and range. The Supplier shall also provide the related instruments and local equipment. When suction throttling control for FD fans is specified, VIV with a pneumatic operator shall be used for FD fan combustion air flow control

2. Fan performance data and any requirements of the fan control system to be input into the Buyer's DCS shall be provided. The Supplier together with the fan manufacturer shall review the fan control system configuration for compatibility with the fan equipment and the boiler combustion control system.

3. The fan damper or VIV, actuator, linkage and operating shafts for remote control of the fan dampers shall be provided and located by the fan manufacturer. The actuator output shall be adequate for the complete range of blade or vane positions.

4. Equipment shall be provided to automatically open or close the fan control damper or VIV upon loss of control signal and to automatically lock or brake the dampers or vanes in the last position upon loss of air supply or electric power. The system and associated controls shall avoid creating hazardous or other undesirable conditions. The control signal shall actuate an operator which positions the fan damper or VIV.

J. Electrical Components

1. Electrical equipment and components shall conform to Buyer's Specification, EH-35R-CCU1-SPC-265-0002 *Electrical Requirements for Package Equipment*.

2. Electrical equipment and components shall conform to the requirements of local jurisdictional authorities. Supplier shall be responsible for verifying local jurisdictional authority requirements and obtaining necessary approvals. Proof of local authority approval shall be submitted to the Buyer.

3. Electrical power will be available at the conditions specified on the Buyer's data sheets. Components listed shall be designed for the voltages specified.

4. Electrical equipment, components and materials with the exception of explosion proof motors, shall be UL or FM approved and shall bear the appropriate label or stamp.

5. Electrical enclosures in outdoor installations shall be NEMA 4X, minimum. The electrical area classification shall be noted on Buyer's data sheets. Regardless of the area classification, all electrical equipment and components shall meet Class I, Division 2, Groups C, and D when available.

6. Buyer shall furnish motor starters.

7. Area lighting will be provided and installed by the Buyer.

8. Aviation lights, supports, and wiring from the lights to a grade mounted terminal box shall be furnished on stacks by the Supplier when noted on Buyer's data sheets.

9. UL approved 2-hole compression grounding lugs for #4/0 AWG bare copper grounding cable shall be provided on the boiler and all separate auxiliary equipment mounted at grade.

3.0 EXECUTION

3.1 Fabrication

A. General

1. Shop fabrication and assembly of the various components supplied by the Supplier shall be maximized, consistent with available shipping, receiving and handling facilities.

2. Buyer's written approval shall be obtained before any part of the fabrication or assembly is subcontracted by the Supplier.

B. Pressure Parts

1. Tube circumferential welds shall be minimized. Tubes shall be free of buckles and rippling after bending. Flattening or ovality of a bend shall not exceed 8% of the nominal outside diameter. Tubes shall have the minimum specified wall thickness including corrosion allowance after bending.

2. Welding of pressure parts and attachments shall be in accordance with ASME Section I, or ASME B31.1 where applicable. All welds shall be full penetration unless otherwise authorized by the applicable Code. Preparation for welds shall be in accordance with ASME B16.25.

3. Weldolet and sockolet connections shall be the same material as the component to which they are attached. A minimum gap of 1/16 inch (1.6 mm) shall be left between the fitting and tube to allow for shrinking of the root pass.

4. Tapered pipe threads (NPT) shall be used for any threaded connections when it is permitted.

5. The FCAW (spray or globular) process shall not be used unless authorized by the Buyer. General restrictions for FCAW include the following:

   a. FCAW may be used for weld out of pressure retaining welds in P-1, P-4, P-5A, P-8 and P-5B materials.

   b. FCAW shall not be used for root passes of butt welds when welding from one side.

   c. FCAW shall not be used for P-8 materials when the operating temperature exceeds 900°F (480°C).

   d. External gas shielding is required for FCAW (spray or globular) except that self-shielding wire is acceptable for non-pressure retaining welds in P-1 materials that are limited to 3/8 inch (9.5 mm) leg length and are not subject to impact requirements.

   e. FCAW using short circuit transfer shall not be used.

f. Electrode diameter for FCAW shall not exceed 1/8 inch (3.2 mm).

g. FCAW shall not be used for vertical downhill welding

6. For welding of 1-1/4Cr-0.5Mo-Si (T1/P11, P-4) materials and 2-1/4Cr-1Mo and 5Cr-0.5Mo (T22/P22 and T5/P5, P-5) materials, the metal temperature shall be maintained at the minimum preheat temperature until the weld and PWHT (if required) is completed. If this is not practical, the weld and adjacent area shall be uniformly heated from preheat temperature to 600°F-700°F (315°C-370°C) for one hour, wrapped with insulation, and allowed to cool slowly prior to PWHT. If post bake is not practical, the weld and adjacent area shall be wrapped with insulation and allowed to cool slowly prior to PWHT.

7. Welding of P-4 and P-5 (excluding 9Cr-1Mo-V) materials shall not be interrupted from the time the root pass is started until at least 3/8 inch (9.5 mm) thickness of weld is deposited or 25% of the weld groove is filled, whichever is less. When the welding is interrupted, the weld and adjacent area shall be uniformly heated from preheat temperature to 600°F-700°F (315°C-370°C) for one (1) hour, wrapped with insulation and allowed to cool. If post bake is not practical, the weld and adjacent area shall be wrapped with insulation and allowed to cool slowly.

8. Preheat shall be limited to electric resistance or inductance heating except for the following when authorized by the Buyer:

   a. Hand-held oxy-fuel flame “rosebud” is permitted for preheating the tube side prior to making tube to header tack welds and for 4 inch NPS (DN100) pipe and tubes and smaller for C-1/2Mo (P1/T1, P-3) material, P-4 material and P-5A material (material where the required preheat does not exceed 400°F (205°C)). Oxy-fuel flame is also permitted for P-1 material. Stationary gas burners are permitted for all sizes.

   b. Preheat temperatures shall be verified with temperature indicating crayons or equivalent.

9. Permanent backing strips shall not be used.

10. All shop fabricated piping spools shipped loose on projects with union field erection shall be fabricated by union shops. Shop assembled skids and components located within the boiler combustion air and flue gas boundaries are not required to be fabricated in union shops.

C. Structural Steel

1. Structural fabrication shall conform to AISC 303 Code of Standard Practice and other standards applicable to the job site location.

2. Structural welding shall conform to AWS D1.1.

3. Sections shipping in one piece shall be unitized elements.

4. Bolted sections shall be trial fitted and match marked when practical. When not practical, matching members shall be simultaneously punched or punched from templates to maintain bolting pattern alignment.

5. Casing plate joints shall be staggered at least 2 feet (600 mm) and shall clear openings and reinforcements.

6. Threads of bolts securing damper blades to shafts shall be scored or tack welded after installation.

7. Warped or distorted members or sections, including galvanized components, shall be pressed, straightened or replaced prior to shipment.

8. Stack circumferential field joints shall be tank type plate butt weld construction unless alignment angles are specified. When specified the angles shall be full circumferential back to back angles for bolting prior to welding. The angles shall be located to provide the necessary gap between plates for internal full penetration field welding of the joint.

9. Clips or angles shall be provided for positioning of other joints requiring field welding.

10. All flue gas path boundary plate joints shall be continuous full penetration butt welds or continuous fillet welds per AWS D1.1.

11. All external attachments to the casing shall be seal welded with continuous fillet welds to prevent rust behind members. These welds need not be per AWS D1.1.

12. Refractory and insulation anchor attachment shall be by manual or stud gun welding. Manual welding shall be continuous "all around" as per AWS D1.1.

13. Casing shall be spot ground or sandblasted before the installation of anchors.

14. Erection tolerances specified in the AISC 303 Code of Standard Practice, Section 7, Erection, shall apply to the steel fabrication.

D. Refractory and Insulation

1. All internal steel surfaces shall be cleaned of all oil, dirt, grease, weld spatter, paint, rust, loose scale and foreign materials prior to installation of insulation. Casing shall be spot ground or sandblasted prior to attaching anchors.

2. All material shall be handled, prepared and installed in accordance with the material manufacturer's recommendations, health and safety regulations and the requirements specified herein.

3. Seams at corners, between sections and between dissimilar materials shall be sealed in accordance with details proven successfully in operation.

4. Insulation voids between settings, casing and lagging shall not be permitted.

5. Insulation anchors shall be shop installed on all sections.

E. Painting and Coating

1. Painting and Coatings shall conform to the Buyer's Specification, EH-35R-CCU1-SPC-255-85210 *Aboveground Coatings*.

2. An internal corrosion preventative coating shall be provided when required in Section 2.2.P of this specification. The SSPC surface preparation and minimum dry film thickness shall be as specified by the coating manufacturer. The coating shall be suitable for the maximum operating surface temperature but no less than 400°F (204°C). The internal coating shall be authorized by the Buyer. Field weld joints shall be masked. Field touch-up paint shall be provided.

3. External structural steel, ducting, stack, burner, windbox, expansion joint and damper frames, boiler casing plate and other carbon steel external surfaces shall be cleaned in accordance with SSPC SP-6 and painted with a one coat, 3-5 mil minimum dry film thickness, of inorganic zinc paint. Field weld joints shall be masked. Field touch-up paint shall be provided for weld joints. Stainless steel, galvanized steel, and other metal surfaces not suitable for painting shall not be painted.

4. Shop assembled boilers may be furnished with manufacturer's standard finish paint suitable for plant and operating conditions.

5. External pressure parts, piping and silencers not to be insulated by the Buyer and saddles and clips for items to be insulated by the Buyer (including steam drum saddles) shall be cleaned per SSPC SP-6 and shop primed with one 3-5 mil minimum dry film thickness coat of inorganic zinc primer for operating temperatures up to 750°F (399°C) or one 3-5 mil minimum dry film thickness of silicone aluminum primer for operating temperatures over 750°F (399°C). Field weld joints shall be masked. Field touch-up paint shall be provided for weld joints. Additional finish painting for these items is not required

6. Paint systems for casing, ducts and stacks and their attached structural members and for combustion air and flue gas expansion joint hard parts shall be suitable for at least 400°F (204°C).

7. Ladders including cages, stairways including treads and handrails, platforms including decking, toe plates and handrails, and associated structure and hardware and all structural bolts, washers and nuts (for both shop and field joints and for both painted and galvanized connections) shall be galvanized in accordance with ASTM A123 and A153.

8. Control panels, junction boxes, electrical enclosures, instruments and controls, skids, fans and motors, damper assemblies, and other engineered components shall be finish painted with the manufacturer's standard paint suitable for plant and operating conditions. Skid finish painting shall include piping and structure. Stainless steel components shall not be painted.

9. External pressure parts and piping not to be insulated by the Buyer shall be cleaned per SSPC SP-6 and shop primed with one 3-5 mil minimum dry film thickness coat of inorganic zinc primer. Primer shall be masked at weld points. Stainless steel components shall not be painted.

10. Internal surfaces of FD fan air intake ducts, accessories, fan housings and internals shall be cleaned in accordance with SSPC SP-6 and painted with a one coat 3-5 mil minimum dry film thickness inorganic zinc paint.

11. External non-machined surfaces of all fan bearing pedestals, bearing housings, fan housings, inlet and discharge connections and accessories for both insulated and un-insulated surfaces shall be cleaned in accordance with SSPC SP-6 and painted with a one coat 3-5 mil minimum dry film thickness inorganic zinc paint.

3.2 Inspection and Testing

A. General

1. The following information shall be made available to the Buyer's inspector upon request:

   a. Evidence that parts are of specified materials.

   b. Material traceability.

   c. Material certificates for pressure parts.

   d. Copies of Supplier's unpriced Purchase Orders to Sub-Suppliers.

   e. Copies of shop test data.

2. The Boiler and auxiliary equipment shall be inspected for proper arrangement, critical dimensions and other requirements in accordance with approved drawings.

3. The Boiler and auxiliary equipment shall be inspected for proper workmanship and appearance.

4. Owner or representative shall have the right to witness inspection and tests at manufacturer/supplier shops for this reason manufacturer/ supplier shall submit the quality plan and fabrication schedule for approval and input.

B. Nondestructive Examination, Pressure Parts

1. Pressure Parts Inspection and Testing

   a. NDE procedures shall be in accordance with the applicable Code, specifications and the requirements herein.

b. At least 10 percent of economizer coil circumferential welds shall be 100% radiographed.

c. Where radiography is required but interpretation of radiographs is difficult, as on nozzle-to-shell welds, magnetic particle or liquid penetrant examination may be employed, with Buyer's approval.

d. The completed welds that attach supports, support lugs, lifting attachments to pressure parts shall be magnetic particle or liquid penetrant examined.

e. Post-weld heat treatment shall be performed in accordance with the applicable Code of construction. Required NDE shall be performed after completion of heat treatment.

f. Personnel performing NDE shall be qualified in accordance with SNT-TC-1A. Qualification records shall be available for review.

2. Extended Surface Inspection and Testing

a. Extended surface shall be visually inspected to verify materials and dimensions.

b. Fins shall be perpendicular to the tube within 15 degrees and uniformly spaced. The maximum discontinuity of resistance welds shall be 2-1/2 percent of the total tube length.

3. 100 percent of alloy pressure parts including weldments shall receive PMI examination. Examination procedures shall be subject to Buyer's approval.

C. Nondestructive Examination, Structural Steel

1. Structural inspection and testing shall be in accordance with the structural code of construction and shall conform to all regulatory codes and standards applicable to the jobsite location.

2. Stack radiographic inspection shall be as follows:

a. At least one radiograph for each girth seam and one for every two vertical seams at locations selected by the Buyer's representative shall be taken. Acceptance criteria shall be per AWS D1.1 and AISC 303. Film shall not be less than 10 inches (250 mm) long.

b. Defective areas shall be repaired by chipping, grinding or gouging to sound metal and re-welding. Repaired areas shall be 100 percent radiographed.

D. Nondestructive Examination, Refractories and Insulation

1. Bend and hammer tests shall be done to verify anchor attachment per AWS D1.1.

2. The installation of refractory and insulation materials shall be verified to be free of voids.

E. Pressure Testing: Pressure Parts, Steam/Water

Boiler and economizer assemblies shall be shop hydrotested (jumpovers shall be shop installed and 100% of the welds shall be radiographed). The hydrotest shall be in accordance with the applicable Code and as follows:

1. All air shall be vented from assemblies. Test pressure shall be held for sufficient time to examine the entire assembly for defects.

2. Water for shop hydrotest shall be potable. For ferritic materials the chloride content shall not exceed 200 ppm and the water temperature shall not be less than 60°F (16°C). The chloride content of water used for testing austenitic materials with more than 11 percent chrome shall not exceed 50 ppm unless treated with an inhibitor of 1.5 percent soda ash and 0.5 percent sodium nitrate. The chloride content of the soda ash shall not exceed 500 ppm. Required ppm levels are by weight. The Supplier shall have hydrotest water quality documentation available.

3. Hydrotest water shall be drained from assemblies and the assemblies shall be completely dried after hydrotest.

4. The hydrotest shall be successfully repeated after any repairs.

5. The hydrostatic tests shall be recorded on charts and shall be available for inspection by Buyer's representative.

F. Pressure Testing, Non-pressure Parts, Casing /Ducts/Stacks

An air pressure leak test of the Boiler walls shall be performed prior to the placement of the covering insulation. The test pressure shall be maintained for a minimum of one hour or longer if necessary to adequately check for leaks. The test pressure shall be the greater of discharge pressure of the FD fan or the maximum allowable Boiler pressure.

G. Auxiliary Equipment

1. Nondestructive examination of FD fan components

2. When radiographic, ultrasonic, magnetic particle or liquid penetrant inspection of welds or materials is specified on the Buyer's Centrifugal Fans Forced Draft Data Sheets, the procedural and acceptance criteria called out in Para 4.2.2.2 through 4.2.2.5 of API 673 shall apply.

H. Shop Functional Test

The following burner system inspection and tests shall be performed with the Supplier's test procedures as modified by the Buyer:

1. Flow Model

a. When specified, physical flow model test of the combustion air supply system to the burners shall be performed to demonstrate acceptable combustion air flow to the burners.

b. Three copies of the color test report and two copies of the model DVD shall be submitted for review and acceptance by the Buyer prior to finalizing duct and flow distribution devices.

c. The Supplier shall provide the Buyer written confirmation from the burner and FD fan Sub-Suppliers confirming that flow model test results are acceptable to them.

d. All fuel train skid, burner header and interconnecting piping for fuel and instrument air shall be leak tested in the shop.

e. The fuel train skid, burner header, local panel, BMS, junction boxes and control elements shall be tested for function and correct termination of wiring. UV scanners shall be checked for functionality. A complete BMS FAT shall be performed in the shop including fuel train skid, BMS panel and local panel. The Supplier, Sub-Supplier and Buyer shall witness the test. The Supplier shall provide a FAT plan for the Buyer's authorization prior to the test and a FAT report after the test. The Supplier shall provide a SAT procedure for the BMS.

f. The Buyer's Boiler combustion and level control system DCS FAT will be held in the Buyer's office or in the DCS Supplier's facility. The Supplier and burner Sub-Supplier shall attend this DCS FAT along with the Buyer. The Supplier shall provide a FAT plan for the Buyer's authorization prior to the test and a FAT report after the test.

I. Shop Performance Tests

A shop mechanical running and optional performance test of fans shall be performed per following requirements:

1. Mechanical running tests

a. The mechanical running tests and acceptance shall be performed in accordance with Para 4.3.3 of API 673.

b. The fan manufacturer shall submit to the Buyer, for his review and comment, detailed procedures for all running tests, including acceptance criteria for all monitored parameters.

c. A mechanical running test of the assembled fan and driver will be performed in the field for field assembled fans. A shop mechanical running test of the assembled fan and driver shall be performed in the shop prior to shipment for shop assembled fans. The equipment shall operate satisfactorily with vibration amplitudes in accordance with the specified requirements.

2. Performance tests

   a. Performance testing of fans shall be done unless waived by the Buyer authorization. The Buyer's authorization may be requested when the fan manufacturer has tested other identical or near-identical units. If the performance testing is waived by the Buyer, the Supplier shall provide performance curves in lieu of performance testing.

   b. Fan performance testing shall conform to Para 4.3.4 of API 673.

J. Field Performance Tests

1. Performance tests shall be performed at the Buyer's option and shall be conducted by the Buyer in accordance with the Supplier's test procedures as modified by the Buyer. Procedures are to be based on ASME PTC-4.1 as modified upon mutual agreement by Supplier and Buyer.

2. The Supplier shall provide correction curves as specified herein for use during performance tests.

3.3 Shipping and Handling

A. General

1. Preparation for shipment shall be the responsibility of the Supplier and shall include the minimum requirements specified herein. Preparation shall be subject to inspection by the Buyer. The Buyer's release for shipment shall not release the Supplier from obligations under the Buyer's purchase order or contract.

2. Bracing and supports shall be provided to prevent damage during shipment. Temporary steel shop attachments not required for field use shall be removed prior to shipment. Temporary bracing and supports shall be painted yellow to denote removal is required at the job site before field testing and operation.

3. The Supplier shall confirm shipping clearances and shall provide the status of shipments in transit upon request.

4. The Supplier shall ship properly marked grade mounted stack templates for foundations in advance of the Boiler for use as anchor bolt templates.

5. SHIPPING HOLD POINTS

   a. Photographs of all nameplates (motors, heaters, individual tagged equipment, etc.) shall be provided and approved by Purchaser.

   b. All testing and visual inspection defects shall be corrected and signed off by Purchaser's engineer (punchlist items may be approved by Purchaser's engineer utilizing photographic evidence), and

   c. Certified test reports shall be furnished and Purchaser approved.

B. Preparation for Shipment

1. Adequate protection shall be provided against mechanical damage and atmospheric corrosion in transit, and for at least six months outdoor storage at jobsite prior to installation.

2. All equipment and assemblies shall be cleaned inside and outside to remove grease, oil, weld spatter, scale, slag and foreign matter prior to shipment.

3. All liquids used for cleaning or hydrostatic testing shall be drained prior to shipment and assemblies shall be completely dried.

4. All openings shall be suitably protected to prevent the entry of water or foreign material.

5. Flange faces shall be clean and coated with a waterproof corrosion preventive and protected from damage. Protection shall be gasketed steel covers fastened by the greater of 50 percent of the required flange bolting or four bolts. Commercially available plastic covers specifically designed for flange protection or Buyer authorized equivalent are acceptable in lieu of steel covers.

6. Weld bevels shall be blanked with plastic caps or plugs securely attached. Threaded or socket connections shall be cleaned and plugged or capped with metal or plastic protectors.

7. Exposed finished and machined surfaces, including bolting, shall be given a heavy coating of rust inhibiting compound. The compound used for weld bevels shall not affect the quality of the weld. Bolt threads shall be protected from damage.

8. Loose items such as bolts, washers, nuts, rods, turnbuckles and clevises shall be shipped in boxes, crates, kegs or barrels.

9. Bolts, nuts, washers, gaskets and joint materials and other materials required for erection shall be included with the shipment of components to be erected.

10. Interconnecting piping that will be shipped loose shall be prefabricated and shop fitted. All such piping shall be match marked prior to dismantling and shipment.

11. Lifting devices and structural bracing (other than spreader bars) shall be provided by the Supplier to permit handling and lifting without damage during shipment and erection.

12. Shop installed refractory and insulation shall be protected against mechanical damage and degradation from adverse weather conditions.

13. Field installed refractory and insulation shall be shipped in original manufacturer's containers or plastic wrapped and palletized.

14. Shipping saddles, bracing, supports, and rigging connections shall be provided to prevent damage during shipment, lifting, or unloading.

15. Expansion joints shall be braced in the cold position.

16. An internal rust inhibitor in boiler hydro test water and a corrosion preventative solution with desiccant in drums shall be provided when these items are being shipped overseas or to be stored at the job-site. All preservative materials on the inside of pressure parts shall be completely water soluble. Module finned surfaces shall be coated with a protectant that will not produce smoke during the Boiler startup.

17. During assembly of fans and drivers and before testing, each component, including cast-in passages of these components, and all piping and appurtenances shall be cleaned to remove foreign materials, corrosion products and mill scale.

18. Fans shall be suitably prepared for shipment including blocking of the rotor when necessary. When specified, preparation shall be made to make the equipment suitable for six months of outdoor storage from the time of shipment. If storage for a longer time is contemplated, the manufacturer shall provide recommended protection procedures.

19. Fans preparation for shipment shall be made after all testing and inspection of the equipment has been accomplished and shipment has been authorized by the Buyer.

20. One complete set of installation, operation, and maintenance instructions shall be packed in the boxes or crates and shipped with the equipment.

C. Identification and Tagging

1. Austenitic stainless steel nameplates (and combustible gas or hazardous area warning plates when applicable) shall be furnished and installed by the Supplier. In addition to nameplates and markings required by the applicable Code, equipment nameplate stamping shall include the following information:

   a. Design temperatures and pressures.

   b. Equipment service and the Buyer's tag number.

   c. The Supplier's job number, year of manufacture and the Buyer's purchase order number.

2. Fan nameplates shall also include the following:

   a. Manufacturer, model number and serial number

   b. Size and type

   c. Volume (ACFM or ACMM)

   d. Static pressure differential (“H2O or mmH2O)

e. Inlet temperature

f. Rated RPM

g. Maximum allowable RPM at maximum allowable temperature

h. First critical speed

i. Rated power (BHP or KW)

j. Rated WR2

k. Rotor weight, lbs (kgs)

l. Design operating altitude, feet above sea level.

3. Fans shall be marked with rotation arrows cast into or attached to each major rotating item. Attached rotation arrow plates and attachment pins shall be TP 300 series stainless steel. Plates shall not be attached by welding.

4. If disassembly of fans and drivers is required for shipment, all mating parts shall be suitably match-marked and tagged for field assembly.

5. All shipments to the field shall be clearly identified in conspicuous locations with the Purchase Order number, the Buyer's tag number, erection mark number, lifting points, orientation, shipping weight and flow directions.

6. Painted casing and structural steel shall be marked with letters 2 inches (50 mm) high.

7. Pressure parts and other items not shipped in containers shall be marked by painting, dye stenciling or metal tags.

8. Color coding and stenciling of piping systems shall be in accordance with ASME A13.1.

9. Galvanized components shall be tagged with stamped galvanized metal tags or Buyer authorized substitute.

10. All instruments, valves and trim shall be directly tagged with stainless steel tags and packaging shall be tagged with the Buyer's tag number or Supplier's tag number for items for which the Buyer does not provide a tag number. An instrument list tabulating these tags with service shall also be furnished.

11. Wooden boxes, kegs, barrels, crates and containers shall be marked with the general nature of the contents and shall include a complete copy of the Bill of Material identifying each item in the container.

12. Marking materials shall be compatible with the equipment paint and component material.

13. Galvanized metal tag letters shall be 1/2 inch (13 mm) minimum height and readable after galvanizing. Un-galvanized metal tags shall be stainless steel attached with stainless steel wire, and markings shall be embossed or scribed with electric pencil with characters at least 3/16 inch (5 mm) high.

14. Expansion joints shall have the flue gas flow direction and cold position clearly marked.

15. All shop fabricated piping spools shipped loose shall be provided with union labels. Shop assembled skids do not require union labels.

D. Preservation

1. Methods of preservation must ensure protection from contamination or other effects that could be harmful or detrimental during transit and site storage.

2. The Supplier shall submit procedure for the preservation of the boiler and auxiliary equipment to the Buyer for approval.

3. Space Heaters, when provided, shall be wired to a terminal block which is accessible for connection to Buyer's Temporary power supply without having to uncrate the switchgear. The terminal block shall be clearly marked as to function, voltage and load requirements.

E. Storage and handling

1. The Supplier shall perform hot phosphate flushing, chelating agent, surfactant based, or an equivalent degreasing method of the work. The use of mineral-based oils during fabrication of pressure parts shall be minimized. Pressure parts shall be protected from internal contamination and rust.

2. Pressure part materials shall be protected during storage, handling and shipment from seawater, seawater spray, road salt and rain or dew when subject to industrial atmospheres.

3. The storage and handling of materials shall be done so as to prevent damage prior to application or installation. Protection shall include:

   a. Pressure part openings shall be blanked to prevent entry of moisture.

   b. Pressure parts shall not be stored in direct contact with the soil. Austenitic pressure parts shall not be supported on porous supports in contact with the soil.

   c. Settings and insulation shall be protected from water.

3.4 Field Erection

A. When field erection is included in the scope of supply, requirements specified herein shall apply.

B. It shall be the responsibility of the Supplier to ensure that the Boiler is erected in accordance with the specifications and drawings either furnished by the Buyer or developed by the Supplier and approved by the Buyer.

C. The Supplier shall mobilize all cranes, rigging, equipment, tools, consumables, materials, personnel and support facilities necessary to perform the installation work. Upon completion of the work, demobilize the same, including proper disposal of unused and scrap materials, as well as clean-up of office space, lay-down and work areas.

D. The Supplier shall clean foundations, clean and straighten anchor bolts, re-cut anchor bolt threads if required, ensure that threads are greased and nuts, locknuts and washers are available if required.

E. The Supplier shall supply and install all shims, packing plates and wedges as required for setting, leveling, and aligning equipment.

F. Prior to installation of insulation, the Supplier shall touch-up all damaged paint on equipment where required.

G. The Supplier shall install steam-tracing, insulation and/or fireproofing as specified in the drawings. Insulation and/or fireproofing shall only be installed after Buyer inspection of heat tracing installation.

H. The Supplier shall install the initial charge of lubricants in accordance with the manufacturer's instructions.

I. The Supplier shall take care not to damage the equipment in any way, including but not limited to paint and insulation. The Supplier shall be responsible to repair any damage sustained by the equipment while in the Supplier's possession. No repairs to the equipment shall be undertaken without consultation with and approval from the Buyer.

3.5 Documentation

A. Drawing submittals shall conform to the Buyer's Supplier Drawing and Data Requirements (SDDR) Form.

B. Submittals shall be in accordance with the specified requirements. The submittals shall be as specified and as necessary to provide all information required for the Buyer's related work.

C. Submittals shall clearly demonstrate that the Buyer's requirements are transmitted to responsible parties, Sub-Supplier's and Subcontractors for incorporation into the work.

D. All submittals other than those marked preliminary shall be certified for accuracy, completeness and conformance with applicable Codes and specifications.

E. Submittals shall be revised at the Buyer's request for corrections and to show tag or item numbers, orientation, interface points, identification or minor relocations.

4.0 ATTACHMENTS

Attachment 01 Deaerator Package (27Jul2020)

Attachment 02 Feedwater Pump Package (27Jul2020)

Attachment 03 Blowdown Drum Package (27Jul2020)

Attachment 04 SCR System (27Jul2020)

Attachment 05 CO Oxidation System (27Jul2020)

End of Specification

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ATTACHMENT 01 – DEAERATOR

A.1 General

A.1.1 This Section includes minimum requirements for a Deaerator supplied with the Boiler. The requirements outlined herein supplement the Deaerator data sheets on which the operating conditions and special requirements are listed in detail for Deaerator. Where conflicts exist, the Datasheets shall govern.

A.1.2 The requirements in Sections 1.0 through 3.0 of the EH-35R-CCU1-SPC-255-57110, Watertube Boiler Specification that are not specific to the Boiler only also apply to the Deaerator.

A.2 Codes and Standards

Additional Codes and Standards that apply to the Boiler Feedwater Package are as follows:

Heat Exchange Institute (HEI)

HEI 120 Standards and Typical Specifications for Tray Type Deaerators

National Association of Corrosion Engineers (NACE)

SP 0590 Prevention, Detection, and Correction of Deaerator Cracking

A.3 Specifications, Data Sheets and Drawings

Additional Buyer documents that apply to the Deaerator are as follows:

Deaerator Specifications, Data Sheets and Drawings	
Project Specifications	
EH-35R-CCU1-SPC-255-58001	Pressure Vessels
EH-35R-CCU1-SPC-270-00001	Instruments and Control Systems Supplied with Package Equipment
Data Sheets	
EH-35R-CCU1-DST-255-M-710	Boiler Package
Drawings	
000.257.SD4510MOD	Supplier Drawing and Data Requirements (SDDR Form Water Tube Boiler & Aux Equipment)

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ATTACHMENT 01 – DEAERATOR

A.1 Work Included in Supplier's Scope

A.1.1 All components required for a complete Deaerator Package and auxiliary equipment including items specified herein, on the Boiler Package data sheet, in other Sections of this specification and in the Buyer's purchase order.

A.1.2 Seller shall provide all mechanical and structural items including:

a. ASME code pressure vessel Deaerator.

b. Saddle supports for deaerator in accordance to Buyer's Specification, EH-35R-CCU1-SPC-255-57030 *Pressure Vessel*.

c. Ladders and platforms

d. Support clips for insulation

e. Instrumentation

f. Insulation

A.1.3 The following items will be furnished by others:

a. Equipment foundations

b. Equipment anchor bolts (per Seller's design requirements)

c. Erection of equipment

d. External piping and valves beyond nozzles of Deaerator by Buyer.

A.1.4 Interconnecting piping and supports between the Blowdown Drum Package components and between the Blowdown Drum Package and the Boiler and Deaerator.

A.2 General Requirements

A.2.1 All pressure vessels shall be designed, fabricated, examined, tested and stamped in accordance with the ASME Section VIII, Division 1.

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ATTACHMENT 01 – DEAERATOR

A.3 General Requirements

A.3.1 One Deaerator shall be provided. It shall provide Deaerated Feedwater to the Feedwater Pump Package sufficient to operate one or all of the Boilers provided by the Supplier individually or together and at all loads including MCR and Peak Load.

A.3.2 The Deaerator, instrumentation and controls, piping, valves and supports as required for the package and to connect the Deaerator to the Boiler and the Feedwater Pumps shall be provided.

A.3.3 The Deaerator elevation shall be established by the Supplier to provide the Feedwater Pumps with the correct NPSH during all startup, operating, and shutdown conditions.

A.3.4 Water Make-up shall be provided as feedwater to a single Deaerator connection at the conditions specified in the Buyer's Deaerator Data Sheets.

A.3.5 All external and internal parts shall be so arranged that, when installed, all parts requiring manipulation, observation and/or maintenance shall be readily accessible and safe to operating and maintenance personnel.

A.3.6 The Deaerator shall be properly sized and designed for startup, operation, shutdown, standby and layup of the boiler and auxiliary equipment.

A.3.7 The Deaerator shall be suitable for outdoor installation.

A.3.8 The Deaerator shall be furnished with provisions for grounding.

A.3.9 Loads due to temperature, friction, impact, vibration, operation, operation upsets, transportation, testing and erection shall be included in the design.

A.3.10 All tubing and wiring within the boundaries of the Deaerator Package shall be provided.

A.3.11 Noise limits shall not exceed 85dBA at 3 feet horizontal from the equipment surface and 5 feet vertically above operating platforms.

A.4 Materials

A.4.1 The Seller shall inform the Buyer of any flaws, damage or defects in materials prior to their introduction into fabrication, and all propose repair procedures for

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ATTACHMENT 01 – DEAERATOR

review and comment before commencing those repairs. The Buyer reserves the right to reject materials rather than permit repairs.

A.4.2 All materials used for pressure parts shall be in accordance with applicable ASME codes and supplied with the mill certificate showing the chemical and physical properties and material's country of origin and manufacture.

A.4.3 All materials furnished as compliant with Code requirement of "material traceability" shall be taken to mean traceable to the material's country of origin and manufacture of the final product. Furthermore, this shall be taken to mean traceable from the original material creation or production (smelting/refining, intermediate product forms (ingots, billets, blooms, slabs), and additional semi-finished forms encountered prior to and throughout the manufacture of the final product.

A.4.4 Materials that are in contact with the inlet un-deaerated water and vent gas shall be stainless steel.

A.5 Insulation, Lagging, and Heat Tracing

A.5.1 Deaerator and skid mounted piping and instrumentation shall be externally heat traced and insulated by the Supplier in the shop. Insulation shall only be installed after Buyer inspection of heat tracing installation.

A.5.2 Insulation and heat tracing for any field installed instruments and piping connecting the blowdown drum package to the Boiler and Deaerator Package shall be provided and installed by the Buyer.

A.6 Structure

A.6.1 The Supplier shall provide all structural steel supports required to support the deaerator.

A.7 Platforms and Ladders

A.7.1 The Supplier shall provide ladders and platforms for access, operation, operation and maintenance of valves, instruments and manways.

A.8 Piping and Valves

A.8.1 The Supplier shall provide all piping, valves, fittings and supports from the Blowdown Drum Package to the Boiler and the Deaerator Package.

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A.8.2 The Supplier shall provide a piping spool for instrumentation and controls provided by the Supplier for the condensate discharge to the plant condensate system.

A.8.3 All terminals shall be flanged.

A.8.4 Piping materials shall be selected and provided as required by the Code.

A.9 Instruments and Connections

A.9.1 The Supplier shall furnish all local instrumentation, controls trim, piping and accessories required by applicable codes and to operate and monitor the Deaerator locally and from the Buyer's DCS.

A.9.1 Instrumentation furnished with the Deaerator Package shall conform to Project Specification EH-35R-SPC-270-00003 *Instruments and Controls Supplied with Packaged Equipment*.

A.10 Fabrication and Shop Assembly

A.10.1 Whenever possible, reinforcing pads for nozzles and other attachments shall not be located over longitudinal and circumferential welded joints. If this is unavoidable, the welded joint shall be ground smooth and radiographed for the entire covered length, plus 1 inch (25 mm) on each side.

A.10.2 The nameplate shall be stainless steel and attached to the vessel by a bracket which extends a minimum of 2 inches (50 mm) beyond the specified insulation thickness.

A.10.3 Fabrication tolerances shall be according to the applicable ASME Code.

A.10.4 Welding shall be in accordance with the applicable ASME Code.

A.10.5 Welding procedure shall be submitted and reviewed before any welding fabrication starts.

A.10.6 All protrusions through insulation and portions not covered by insulation, such as nozzles, flanges, supports, clips, manways, saddles shall be cleaned per SSPC SP-6 and coated with one coat of self-priming polyamide epoxy to a minimum dry film thickness of 5 mils. No blast or priming is required for insulated surfaces.

A.10.7 The deaerator vessel shall be Post Weld Heat Treated (PWHT).

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ATTACHMENT 01 – DEAERATOR

A.11 Documentation

A.11.1 Drawing submittals shall conform to the Buyer's Supplier Drawing and Data Requirements (SDDR) Form – Watertube Boiler and Auxiliary Equipment.

A.12 Identification and Tagging

A.12.1 Austenitic stainless steel nameplates shall be permanently attached to the equipment with isolation preparation. Nameplates shall include equipment tag number, capacity, and all test and operating limitations with indelible letters.

A.12.2 All connections, including piping and instruments, shall be clearly identified on Seller's drawings. The actual connections on the equipment shall be permanently stamped or tagged with the same identification. If tags are used, they shall be non-flexible metal, attached by stainless steel wire.

A.13 Preparation for Shipment

A.13.1 Machined surfaces and all threads shall be coated with heavy, rust preventive grease or other approved corrosion preventative.

A.13.2 Welding stub ends shall be protected.

A.13.3 Screwed couplings shall be fitted with bull plugs, and socket-weld couplings shall have plastic caps.

A.13.4 Internal and external parts and piping assembled with the drum shall be suitably supported and braced to prevent damage during handling and transporting.

A.13.5 Shipping saddles shall be provided when required.

A.14 Inspection and Testing

A.14.1 Nondestructive Examination shall be in accordance with the following:

a. Deaerator and storage drum shall be 100 percent radiographed on all shell and head seams. Seams that become inaccessible after PWHT shall be Radiographic Tested (RT'd) prior to PWHT, then spot Ultrasonic Tested (UT'd) following PWHT. Seams that are accessible after PWHT shall be RT'd after PWHT.

b. Radiographic examination procedures shall be in accordance with the requirements and methods specified in ASME Code, Section V, Article 2.

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ATTACHMENT 01 – DEAERATOR

c. Interpretation and acceptance criteria of radiographs shall be in accordance with ASME Section VIII, Division 1.

d. All nozzle attachment welds shall be 100% UT'd after PWHT, per SP-70220I-90-1. Inspection and test plan shall include a separate line item for acceptance of the UT of all Stainless Steel nozzle welds.

e. All inside surfaces of pressure retaining welds, and attachment welds to inside surfaces of deaerator and storage section shall be wet fluorescent magnetic particle (WFMP) tested after PWHT. Welds that become inaccessible after PWHT shall be WFMP tested prior to PWHT in lieu of after PWHT.

f. Wet fluorescent magnetic particle examination procedures shall be in accordance with the requirements and methods specified in ASME Code, Section V, Article 7.

g. Wet fluorescent magnetic particle examination acceptance criteria shall be in accordance with ASME Code, Section VIII, Division 1.

h. All stainless steel welds and all stainless steel to carbon steel welds shall be 100 percent liquid penetrant examined.

i. Liquid penetrant examination procedure shall be in accordance with ASME Code, Section V, Article 6.

j. The evaluation of indication and the acceptance criteria for liquid penetrant examination shall be in accordance with ASME Section VIII, Div 1.

k. Nondestructive examination of any required interconnecting piping between the deaerator and storage vessel shall be in accordance with ASME B31.3.

l. The drum and pressure piping shall be pressure tested in accordance with the applicable ASME Code.

m. Personnel performing NDE acceptance evaluations shall be qualified in accordance with SNT-TC-1A.

n. Personnel interpreting NDE shall be Level II minimum.

A.14.2 Mechanical Testing of Welds

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a. A Brinell hardness test shall be performed on each vessel longitudinal and circumferential weld. Test shall be in accordance with SP-70220I-90-1, and hardness shall not exceed 200 HB. Radiographic examination procedures shall be in accordance with the requirements and methods specified in ASME Code, Section V, Article 2.

A.14.3 Inspection

a. All materials and work of the Seller and his Subsupplier(s) shall be subject to inspection by Buyer's inspectors.

b. Prior to post weld heat treatment, all internal stress concentration sites such as arc strikes, weld reinforcement, and weld toe undercut shall be “ground smooth, free of all defects” (not necessarily flush) in accordance with NACE RP0178, Appendix C, Designation “C”.

c. The deaerator will be inspected per drawings for arrangement, critical dimensions and other requirements. Vessel shell tolerances shall be per ASME Section VIII. Nozzle location tolerances shall be +/- 6mm from the vessel master reference line.

d. Intermediate inspection of the deaerator heater section before installation of the housing is required.

e. Preliminary review of welds and NDE records shall be completed before PWHT.

f. The deaerator will be inspected for proper workmanship and appearance.

g. The deaerator shall be completely assembled in shop and checked for accuracy of nozzle and saddle locations and fit-up. Precise downcommer and equalizer nozzle fit up is critical and shall be achieved.

h. Certified Manufacturer's Test Reports (e.g. Mill Certificates) are required for all alloys 1¼ % or higher Chrome content, all Copper alloys, and all Nickel alloys such as duplex, alloy 20, and other stainless steels. Buyer reserves the right to perform, or have performed, Positive Material Identification on any Seller supplied materials (at Buyer’s expense). Any materials which do not meet the purchase order requirements shall be removed and replaced at the Seller's expense.

i. Preparation for shipment will be subject to inspection. Radiographic examination procedures shall be in accordance with the requirements and methods specified in ASME Code, Section V, Article 2.

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ATTACHMENT 01 – DEAERATOR

A.14.4 Testing

a. The Buyer reserves the right to witness all tests.

b. The deaerator shall be subjected to pressure tests as specified in ASME Code, Section VIII, Division 1. The deaerating and storage section shall be checked for leaks.

c. Water used for testing the austenitic stainless steel shall be of potable quality with less than 50 ppm chloride content.

d. Welding shall not be permitted after completion of hydrotest unless approved in writing by the Buyer.

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ATTACHMENT 02 – FEEDWATER PUMPS PACKAGE

A.1 General

A.1.1 This Section includes minimum requirements for a horizontal, centrifugal Feed Water Pump Package supplied with the Boiler. The requirements outlined herein supplement the datasheets on which the operating conditions and special requirements are listed in detail for Feedwater Pump Package. Where conflicts exist, the data sheets shall govern.

A.1.2 The requirements in Sections 1.0 through 3.0 of the EH-35R-CCU1-SPC-255-57110, Watertube Boiler Specification that are not specific to the basic Boiler only also apply to the Feedwater Pump Package.

A.2 Codes and Standards

Additional Codes and Standards that apply to the Boiler Feedwater Package are as follows:

American Society of Mechanical Engineers (ASME)

ASME B31.1 Power Piping

ASME B73.1 Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process

Process Industry Practices (PIP)

PIP RESP73H Application of ASME B73.1- 2012, Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process

A.3 Specifications, Data Sheets and Drawings

Additional Buyer documents that apply to the Boiler Feedwater Pump Package as follows:

Boiler Feedwater Package Specifications, Data Sheets and Drawings	
Project Specifications	
EH-35R-CCU1-SPC-215-00002	Structural Data for Mechanical Equipment
EH-35R-CCU1-SPC-255-56028	ASME Horizontal, End Suction Centrifugal Pumps
EH-35R-CCU1-SPC-255-56070	General Purpose Induction Motors- ½ HP Through 500HP- IEEE 841
EH-35R-CCU1-SPC-255-85210	Aboveground Coatings

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ATTACHMENT 02 – FEEDWATER PUMPS PACKAGE

Boiler Feedwater Package Specifications, Data Sheets and Drawings	
EH-35R-CCU1-SPC-265-00002	Electrical Requirements for Packaged Equipment
EH-35R-CCU1-SPC-270-00001	Instruments and Control Systems Supplied with Package Equipment
Data Sheets	
EH-35R-CCU1-DST-255-M-710	Boiler Package
Drawings	
000.257.SD4510MOD	Supplier Drawing and Data Requirements (SDDR Form Water Tube Boiler & Aux Equipment)

A.4 Definitions

A.4.1 Pressure casing is the composite of all major stationary pressure containing parts of unit, including all nozzles or other parts attached thereto (excluding shaft and shaft sleeve).

A.4.2 Maximum Allowable Casing Working Pressure is the greatest pressure at the pumping temperature for which the pump casing is designed.

A.5 Work Included in the Supplier's Scope

The Supplier's scope of supply shall include, but is not limited to, the following:

A.5.1 All components required for a complete Feedwater Pumping Package and auxiliary equipment including items specified herein, in other sections of this specification and in the Buyer's Purchase Order.

A.5.2 Interconnecting piping and supports between Feedwater Pumping Package components and the Boiler and the Deaerator Package.

A.5.3 Instrument tubing and wiring within the boundaries of the shop assembled Feedwater Pumping Package.

A.6 General Requirements

A.6.1 One Feedwater Pump Package shall be provided. It shall provide feedwater sufficient to operate one or all of the Boilers provided by the Supplier individually or together and at all loads including MCR and Peak Load.

A.6.2 The Supplier shall provide the Feedwater Pumps, motor drivers, drains, instrumentation and controls, piping including minimum flow bypass, valves and supports for the package and as required to connect the pumps on the

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ATTACHMENT 02 – FEEDWATER PUMPS PACKAGE

Feedwater Pumping Package and the Feedwater Pumping Package to the Deaerator Package and the Boiler.

A.6.3 The Feedwater Pump Package shall be suitable for outdoor installation and shall be located at grade level.

A.6.4 The pumps shall include manual and automatic modes and shall provide. If the pump that is in operation goes down the standby pump shall automatically switchover.

A.6.5 All components shall be so arranged that, when installed, all parts requiring handling, observation and/or maintenance shall be readily accessible and safe to operating and maintenance personnel.

A.6.6 Electrical design, wiring and components shall conform to Buyer's Specification, EH-35R-CCU1- SPC-265-00002 *Electrical Requirements for Package Equipment*.

A.6.7 Noise limits shall not exceed 85 dBA at 3 feet horizontal from the equipment surface and 5 feet vertically above operating platforms.

A.7 Boiler Feedwater Pumps

A.7.1 Feedwater Pumps with electric motor drivers shall be provided in accordance with ASME B73.1, PIP RESP73H and Buyer's Specification, EHR-35-CCU1-SPC-255-56028 *ASME Horizontal, End Suction Centrifugal Pumps*.

A.7.2 Pumps shall be provided with temporary suction strainers for start-up.

A.8 Design and Fabrication

A.8.1 Pumps vibration levels shall be within limits established by ASME B73.1 as measured on the bearing frame and are guaranteed at the project foundation in the fully installed position and at the supplier's test facility.

A.8.2 Pumps and base plates shall be designed for satisfactory performance when subjected to the forces and moments per Supplier's standard.

A.8.3 Pinning of impellers is not acceptable. All impellers shall be keyed to their shafts.

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A.9 Accessories

A.9.1 All metal, spacer-type, non-lubricated couplings shall be furnished by the Pump supplier. Pumps shall have flexible couplings.

A.10 Driver

A.10.1 All induction motors supplied by the Pump Supplier shall conform to IEEE 841 and the Buyer's Specification EH-35R-CCU1-SPC-255-56070 *General Purpose Induction Motors- ½ HP Through 500HP- IEEE 841*.

A.11 Structure

A.11.1 The Supplier shall provide a structural steel skid and supports as required to support the Feedwater Pump Package.

A.11.2 The Feedwater Pump Package design shall conform to Buyer's Specification, EH-35R-CCU1-SPC-215-00002 *Structural Data for Mechanical Equipment*.

A.12 Piping and Valves

A.12.1 The Feedwater Pump Package shall include minimum flow bypass piping and valves.

A.12.2 The Supplier shall provide all piping, valves, fittings and supports from the Feedwater Pump Package to the Boiler and from the Deaerator to the Feedwater Pump Package.

A.12.3 The Supplier shall provide all required interconnecting piping and valves between the pumps and within the Feedwater Pump Package as required to provide a single feedwater inlet, feedwater outlet and minimum flow bypass feedwater outlet connection.

A.12.4 Piping shall be designed, fabricated, examined, tested and stamped in accordance with the ASME B31.1.

A.12.5 Cooling water systems shall be furnished by the Pump Supplier fully assembled and installed on the pump.

A.12.6 The Supplier shall furnish a check and manual valve for the main discharge and the minimum bypass discharge for each pump on the Feedwater Pump Package.

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A.12.7 The Supplier shall furnish a manual valve at each pump suction and at each pump drain.

A.12.8 The Supplier shall furnish a manual valve at the feedwater sample connection in the common discharge piping.

A.12.9 Seal flush systems, including all accessories such as gauges and valves, shall be furnished by Pump Supplier fully assembled and installed on the pump.

A.13 Painting

A.13.1 External surfaces of pumps, drivers, base plates, accessories and piping shall be painted in accordance with Buyer's Specification, EH-35R-CCU1-SPC-255-85210 *Aboveground Coatings*.

A.13.2 Stainless steel surfaces, internal surfaces, and finished surfaces such as flange faces, shafts and couplings, shall not be painted.

A.14 Instrumentation and Connections

A.14.1 The Supplier shall furnish all local instrumentation, controls trim, piping and accessories required by applicable codes and to operate and monitor the Feedwater Pump Package locally and from the Buyer's DCS.

A.14.2 The Supplier shall furnish as a minimum discharge pressure gauges, minimum bypass flow orifice with flow indicator and a local stop button for each pump on the pumping package, and a discharge pressure transmitter for the package common discharge.

A.14.3 A connection shall be provided for the Buyer's feedwater sample connection in the feedwater piping to the boiler.

A.14.4 Instrumentation furnished with the Feedwater pumps Package shall conform to Buyer's Specification, EHR-35-CCU1-SPC-270-00003 *Instruments and Controls Supplied with Packaged Equipment*.

A.15 Storage, Handling, and Shipping

A.15.1 Surfaces contacted by the working fluid, including stuffing boxes and flush piping, shall be thoroughly dried. Surfaces which are subject to atmospheric corrosion or rusting shall be coated with a suitable rust preservative.

A.15.2 Bearing, bearing housings, and oil systems shall be thoroughly cleaned and coated with suitable rust preventive.

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A.15.3 Mechanical seal assemblies shall be fully protected from rusting and entry of moisture and dirt.

A.15.4 The pumps and instruments shall be tagged with tag numbers furnished by the Buyer.

A.16 Documentation

A.16.1 Drawing submittals shall conform to the Buyer's Supplier Drawing and Data Requirements (SDDR) Form – Watertube Boiler and Auxiliary Equipment.

A.17 Identification and Tagging

A.17.1 Each major piece of equipment having an item number, as indicated by the Purchase Order shall have a permanently attached nameplate.

A.17.2 Connections furnished on the purchased equipment shall be impression stamped or permanently tagged to agree with the Supplier's connection table or general arrangement drawing.

A.17.3 Each item shall be identified with its Purchase Order Number and Item Number Tags shall be corrosion resistant metal and impression stamped.

A.18 Preparation for Shipment

A.18.1 Assembly and preparation for shipment shall be in accordance with Supplier's standards and as noted herein. The Supplier shall be solely responsible for the adequacy of the preparation for shipment with respect to materials and application, and to provide equipment at the destination in ex-works condition when handled by commercial carriers.

A.18.2 Pumps, drivers, and all furnished auxiliaries (except coupling spacers and bolts) shall be shipped fully assembled on the base plates, except as noted below.

A.18.3 Drivers that weigh over 500 pounds (227 kgs) shall be removed after shop mounting and alignment, and shipped separately but alongside pump.

A.18.4 Mechanical seals, carbon rings, and other sealing devices shall be installed before shipment.

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A.18.5 A corrosion resistant metal nameplate shall be permanently attached to the pump (not on baseplate) and contain the following information using specified units:

a. Equipment tag number

b. Manufacturer's name

c. Serial number of pump

d. Size and type of pump

e. Rated capacity

f. Pumping head

g. Specific gravity

h. RPM

i. Maximum allowable casing working pressure at maximum pumping temperature

A.19 Inspection and Testing

A.19.1 The Feedwater Pump Package shall be inspected for proper arrangement, critical dimensions and other requirements in accordance with approved drawings.

A.19.2 The Feedwater Pump Package shall be inspected for proper workmanship and appearance.

A.19.3 The Feedwater Pump Package shall be completely shop assembled and checked for nozzle and skid location and fit-up accuracy.

A.19.4 Nondestructive testing shall be performed when specified on the Buyer's Centrifugal Pumps data sheets. The examination and acceptance criteria shall be in accordance with the ASME Code.

A.19.5 Each pressure casing shall be tested with water at ambient temperature. The minimum test pressure shall be 1-1/2 times the maximum allowable casing working pressure or 115 psig (793 KPa), whichever is greater. Areas subjected to suction pressure shall be hydrotested to 1-1/2 times the maximum suction

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ATTACHMENT 02 – FEEDWATER PUMPS PACKAGE

pressure. All hydrostatic tests shall be maintained for a minimum period of 30 minutes.

A.19.6 Each pump shall be performance tested with water. The test speed of all pumps shall be the rated speed.

A.19.7 Mechanical seals, when provided, shall be used during the running test, but are not required for the hydrostatic test.

A.19.8 The complete Feedwater Pump Package shall be guaranteed for pressure, capacity and power consumption at the specified operating conditions, water NPSH, and satisfactory application in all respects to the required operating conditions.

A.19.9 The Buyer reserves the right to witness all tests.

A.19.10 Water used for testing the pumps made from austenitic stainless steel shall be potable water with less than 50 ppm chloride content.

A.19.11 Welding shall not be permitted after completion of hydrotest unless approved in writing by the Buyer.

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ATTACHMENT 03 – Blowdown Drum Package

A.1 General

A.1.1 This Section includes the requirements that apply when a Blowdown Drum Package is supplied with the Boiler. The requirements outlined herein supplement the Blowdown Drum Package data sheets on which the operating conditions and special requirements are listed in detail for Blowdown Drum Package. Where conflicts exist, the Datasheets shall govern

A.1.2 The requirements in Sections 1.0 through 3.0 of the EH-35R-CCU1-SPC-255-57110, Watertube Boiler Specification that are not specific to the basic Boiler only also apply to the Blowdown Drum Package.

A.2 Specifications, Data Sheets and Drawings

Additional Buyer documents that apply to Blowdown Drum Package are as follows:

Blowdown Specifications, Data Sheets and Drawings	
Project Specifications	
EH-35R-CCU1-SPC-215-00002	Structural Data for Mechanical Equipment
EH-35R-CCU-SPC-255-58001	Design and Fabrication Specification for Vessels
EH-35R-CCU-SPC-270-00003	Instruments and Control Systems Supplied with Package Equipment
Data Sheets	
EH-35R-CCU1-DST-255-M-710	Boiler Package
Drawings	
000.257.SD4510MOD	Supplier Drawing and Data Requirements (SDDR Form Water Tube Boiler & Aux Equipment)

A.3 Work Included in Supplier's Scope

A.3.1 All components required for a complete Blowdown Drum Package and auxiliary equipment including items specified herein, on the Blowdown Drum Package data sheets, in other Sections of this specification and in the Buyer's purchase order.

A.3.2 This Section covers the Supplier's scope of work terminating at the following points:

a. The outlet of the boiler continuous blowdown valve.

b. The outlet of the boiler intermittent blowdown valve.

c. The outlet of the blowdown drum vent stack.

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ATTACHMENT 03 – Blowdown Drum Package

d. The outlet of the blowdown drum outlet level control piping spool.

e. The inlet of the check valve on the deaerator pegging steam supply piping spool.

A.3.3 Interconnecting piping and supports between the Blowdown Drum Package components and between the Blowdown Drum Package and the Boiler and Deaerator Package.

A.3.4 Instrument tubing and wiring within the boundaries of the shop assembled Blowdown Drum Package.

A.4 General Criteria

A.4.1 The drum shall be designed, fabricated, examined, tested and stamped in accordance with Buyer's Specification, EH-35R-CCU-SPC-255-58001 *Design and Fabrication Specification for Vessels*.

A.4.2 Piping shall be designed, fabricated, examined, tested and stamped in accordance with the ASME B31.1.

A.5 General Requirements

A.5.1 One Blowdown Drum Package shall be provided. It shall handle the continuous and intermittent Blowdown from one or all of the Boilers provided by the Supplier individually or together and at all loads including MCR and Peak Load.

A.5.2 The Blowdown Drum Package shall collect continuous and intermittent blowdown discharge from the boiler and return drum overhead steam to the Deaerator Package.

A.5.3 The Blowdown Drum Package condensate discharge will be sent to the plant condensate system.

A.5.4 The Blowdown Drum Package shall be properly sized and designed for startup, operation, shutdown, standby and layup of the boiler and auxiliary equipment.

A.5.5 The Blowdown Drum Package shall be suitable for outdoor installation.

A.5.6 The Blowdown Drum Package shall be furnished with provisions for grounding.

A.5.7 Design loads shall be included in the design per Buyer's Specification, EH-35R-CCU-SPC-255-58001 *Design and Fabrication Specification for Vessels*.

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ATTACHMENT 03 – Blowdown Drum Package

A.5.8 All components shall be so arranged that, when installed, all parts requiring manipulation, observation and/or maintenance shall be readily accessible and safe to operating and maintenance personnel.

A.5.9 All tubing and wiring within the boundaries of the Deaerator Package shall be provided.

A.6 Blowdown Drum

A.6.1 One 100 percent capacity Blowdown Drum shall be provided common to the continuous and intermittent blowdown boiler systems.

A.6.2 The drum shall be self-supporting, welded steel construction, equipped with a skirt for mounting at grade level.

A.6.3 The drum skirt height and low-low level elevation shall be as required by the Supplier but not less than the minimum value shown on the Buyer's Blowdown Drum Package data sheets.

A.6.4 A access manhole shall be provided to the interior of the drum, cover shall be provided with handles.

A.6.5 The drum design pressure and temperature shall be established in accordance with the Code and the Supplier's standard practice.

A.6.6 In addition to the drum overhead line, each drum shall be provided with a vent to the atmosphere.

A.6.7 Each manhole shall be furnished with three spare gaskets.

A.6.8 Drum materials and thicknesses shall be selected and provided as required by the Code and for flashing service.

A.7 Insulation, Lagging, and Heat Tracing

A.7.1 Drum and skid mounted piping and instrumentation shall be externally heat traced and insulated by the Supplier in the shop. Insulation shall be only installed after Buyer inspection of heat tracing installation.

A.7.2 Insulation and heat tracing for any field installed instruments and piping connecting the blowdown drum package to the Boiler and Deaerator Package shall be provided and installed by the Buyer.

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ATTACHMENT 03 – Blowdown Drum Package

A.8 Structure

A.8.1 The Supplier shall provide all structural steel supports required to support the Blowdown Drum Package.

A.9 Platforms and Ladders

A.9.1 The Supplier shall provide ladders and platforms for access, operation, operation and maintenance of valves, instruments and manways.

A.9.2 The Blowdown Drum Package design shall conform to Buyer's Specification, EH-35R-CCU1-SPC-215-00002 *Structural Data for Mechanical Equipment*.

A.10 Piping and Valves

A.10.1 The Supplier shall provide all piping, valves, fittings and supports from the Blowdown Drum Package to the Boiler and the Deaerator Package.

A.10.2 The Supplier shall provide a piping spool for instrumentation and controls provided by the Supplier for the condensate discharge to the plant condensate system.

A.10.3 The Supplier shall provide drum outlet piping from the drum vent to the deaerator pegging steam inlet piping spool.

A.10.4 The Supplier shall provide drum inlet piping from the boiler continuous and intermittent blowdown valves. Piping shall be designed for vibrating service and equipped with 5 diameter bends.

A.10.5 Nozzle projections from the drum shell O.D. to face of flange shall be a minimum of 6 inches (150 mm) for 4" IPS (DN100)and smaller connections, 8 inches (200 mm) for 6" IPS (DN150) to 16" IPS (DN400) connections, and 10 inches (250 mm) for nozzles and manways 16 inches (DN400) and larger.

A.10.6 A single outlet connection for condensate return to the plant system by the Buyer shall be provided.

A.10.7 The drum connections for the boiler blowdown shall be designed for flashing, vibrating service. Nozzles shall be equipped with internal impingement boxes and shall be designed for the forces expected during all startup, operating, and shutdown conditions.

A.10.8 All terminals shall be flanged.

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ATTACHMENT 03 – Blowdown Drum Package

A.10.9 Piping materials shall be selected and provided as required by the Code and for vibrating and flashing service.

A.10.10 An automatic level control valve with isolation valves and bypass and drain valve shall be furnished by the Supplier for the drum condensate outlet. The valve shall include positioner, actuator, I/P transducer and transmitter. The signal shall be transmitted to the Supplier's local control panel.

A.10.11 The Supplier shall supply miscellaneous valves as follows:

a. Atmospheric vent valve.

b. Gauge glass isolation and drain valves.

c. Level transmitter isolation and drain valves.

d. Condensate outlet piping drain valve.

e. High and low point vent and drain valves as required.

A.11 Instruments and Connections

A.11.1 The Supplier shall furnish all local instrumentation, controls trim, piping and accessories required by applicable codes and to operate and monitor the Blowdown Drum Package locally and from the Buyer's DCS.

A.11.2 Instrumentation furnished with the Blowdown Drum Package shall conform to Buyer's Specification, EH-35R-CCU1-SPC-270-00003 *Instruments and Controls Supplied with Packaged Equipment*.

A.11.3 Specific instruments, controls and trim required and the Buyer's and Supplier's scope of supply shall include items specified herein and shown on the data sheets or in other Sections of this specification.

A.11.4 The Supplier shall furnish as a minimum the following items for the Blowdown Drum Package:

a. Drum pressure indicator.

b. Drum level gauge and illuminator.

c. Drum level transmitter.

d. Drum level indicator visible from drum level control valve.

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ATTACHMENT 03 – Blowdown Drum Package

e. Level indicating controller on local panel.

f. Level control valve with transmitter.

A.12 Fabrication and Shop Assembly

A.12.1 Whenever possible, reinforcing pads for nozzles and other attachments shall not be located over longitudinal and circumferential welded joints. If this is unavoidable, the welded joint shall be ground smooth and radiographed for the entire covered length, plus 1 inch (25 mm) on each side.

A.12.2 Exposed edges of manhole and nozzle necks shall be rounded at the inside surface of the drum.

A.12.3 The nameplate shall be stainless steel and attached to the vessel by a bracket which extends a minimum of 2 inches (50 mm) beyond the specified insulation thickness.

A.12.4 Fabrication tolerances shall be according to the applicable ASME Code.

A.12.5 Welding shall be in accordance with the applicable ASME Code.

A.12.6 Welding procedure shall be submitted and reviewed before any welding fabrication starts.

A.12.7 All protrusions through insulation and portions not covered by insulation, such as nozzles, flanges, supports, clips, manways, saddles shall be cleaned per SSPC SP-6 and coated with one coat of self-priming polyamide epoxy to a minimum dry film thickness of 5 mils. No blast or priming is required for insulated surfaces.

A.13 Documentation

A.13.1 Drawing submittals shall conform to the Buyer's Supplier Drawing and Data Requirements (SDDR) Form – Watertube Boiler and Auxiliary Equipment.

A.14 Identification and Tagging

A.14.1 Drum shall be clearly identified by painting or dye stenciling the purchase order number.

A.14.2 The drum and instruments shall be tagged with tag numbers furnished by the Buyer.

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ATTACHMENT 03 – Blowdown Drum Package

A.15 Preparation for Shipment

A.15.1 Machined surfaces and all threads shall be coated with heavy, rust preventive grease or other approved corrosion preventative.

A.15.2 Welding stub ends shall be protected.

A.15.3 Screwed couplings shall be fitted with bull plugs, and socket-weld couplings shall have plastic caps.

A.15.4 Internal and external parts and piping assembled with the drum shall be suitably supported and braced to prevent damage during handling and transporting.

A.15.5 Shipping saddles shall be provided when required.

A.16 Inspection and Testing

A.16.1 The Blowdown Drum package shall be inspected for proper arrangement, critical dimensions and other requirements in accordance with approved drawings.

A.16.2 The Blowdown Drum package shall be inspected for proper workmanship and appearance.

A.16.3 The Blowdown Drum package shall be completely shop assembled and checked for nozzle and skid location and fit-up accuracy.

A.16.4 Nondestructive examination and acceptance criteria shall be in accordance with applicable Code.

A.16.5 The drum shall be partially radiographed in accordance with the ASME Code. Two radiographs shall be taken for every 50 feet (15.3 m) of weld. One shall be at a circumferential and longitudinal junction and one shall be at random.

A.16.6 All stainless steel to carbon steel weld joints shall be 100 percent liquid penetrant examined.

A.16.7 The Buyer reserves the right to witness all tests.

A.16.8 The drum and pressure piping shall be pressure tested in accordance with the applicable ASME Code.

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ATTACHMENT 03 – Blowdown Drum Package

A.16.9 Water used for testing the austenitic stainless steel shall be of potable quality with less than 50 ppm chloride content.

A.16.10 Welding shall not be permitted after completion of hydrotest unless approved in writing by the Buyer.

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ATTACHMENT 04 – SELECTIVE CATALYTIC REDUCTION (SCR) SYSTEM

A.1 Scope – SCR System

A.1.1 This Attachment includes requirements that apply when a Selective Catalytic Reactor system (SCR) is supplied with the boiler. The following describes the general requirements for fixed-bed, SCR with aqueous ammonia reactant, to be used in the removal of nitrogen oxides (NOx) from combustion exhaust gas streams. The requirements outlined herein are supplemental to the data listed on the equipment specification sheets (hereinafter referred to as data sheets) and Attachment C Engineering Notes. It is the intent of this specification that the SCR system be capable of operating at design conditions, without shutdown for any reason for a minimum of 6 years.

A.1.2 **CAUTION!** This Attachment is supplemental to the base specification. It is not a stand-alone section including all of the requirements for the SCR system. The requirements in Sections 1.0 through 3.0 of the EH-35R-CCU1-SPC-255-57110, Watertube Boiler Specification that are not specific to the basic Boiler only also apply to the SCR system.

A.1.3 Maximum shop prefabrication is required to minimize field erection labor.

A.2 Definition of Terms – SCR System

A.2.1 Additional abbreviations specific to the SCR system are defined as follows:

Abbreviations	
AFCU	Ammonia Flow Control Unit
AIG	Ammonia Injection Grid
NH_3	Ammonia
NOx	Nitrogen Oxides

A.3 Codes and Standards – SCR System

Additional Codes and Standards that apply to the SCR system are as follows:

ASHRAE Refrigeration Handbook (ASHRAE)

Chapter 4 System Practices for Ammonia Refrigerant

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ATTACHMENT 04 – SELECTIVE CATALYTIC REDUCTION (SCR) SYSTEM

American Petroleum Institute (API)

API 536 Post-combustion NOx Control- For Fired Equipment in General Refinery and Petroleum Services

Electrical Testing Laboratories (ETL)

Occupational Safety and Health Administration (OSHA)

Title 8, Division of Industrial Safety Unfired Pressure Vessel Safety Orders, Register 76, No. 32, Article 6 (Anhydrous Ammonia)

Underwriter's Laboratories (UL)

A.4 Specifications, Data Sheets and Drawings – SCR System

Additional Buyer documents that apply to the SCR system are as follows:

SCR System Specifications, Data Sheets and Drawings	
Project Specifications	
EH-35R-CCU1-SPC-215-00002	Structural Data for Mechanical Equipment
EH-35R-CCU1-SPC-255-56070	General Purpose Induction Motors- ½ HP Through 500HP- IEEE 841
EH-35R-CCU1-SPC-255-58001	Design and Fabrication Specification for Vessels
EH-35R-CCU1-SPC-270-00003	Instruments and Controls Supplied with Packaged Equipment
Data Sheets	
EH-35R-CCU1-DST-255-M-710	Boiler Package
Drawings	
000.257.SD4510MOD	Supplier Drawing and Data Requirements (SDDR Form Water Tube Boiler & Aux Equipment)

A.5 Work Included in Supplier's Scope – SCR System

A.5.1 Additional summary items for the SCR system are as follows:

SCR System Buyer/Supplier Brief Scope of Supply Summary		
Item	**Component**	**Supplied By**
1.	CEMS equipment	Supplier
2.	NH_3 storage and piping to ammonia skid	Supplier
3.	SCR system PLC	Supplier
4.	Engineering and interface for SCR system controls	Buyer

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ATTACHMENT 04 – SELECTIVE CATALYTIC REDUCTION (SCR) SYSTEM

SCR System Buyer/Supplier Brief Scope of Supply Summary		
Item	**Component**	**Supplied By**
	implementation into the Buyer's DCS	
5.	SCR control in the Buyer's DCS	Buyer
6.	SCR recommended control logic narrative and logic diagrams	Supplier
7.	Space and pressure drop allowance for Buyer specified additional percentage of SCR catalyst	Supplier
8.	Operator training	Supplier
9.	Startup advisor	Supplier
10.	Field erection advisor	Supplier
11.	Physical flow model test/CFD Model	Supplier

A.5.2 Additional terminal points that apply to the SCR system are as follows:

SCR System Buyer/Supplier Terminal Points	
Supplier's Scope Includes	**Terminal Location**
Exhaust Gas	
SCR downstream casing water washing drain piping outlets	Grade
Steam/Water	
Ammonia Flow Control Unit skid atomizing steam inlet (if required)	Grade
Electrical	
Ammonia Flow Control Unit skid junction box terminals to off-skid destinations	Grade
SCR dilution air fan motor terminals	Grade
Off-skid individual actuator and instrument terminals	At actuator or instrument
Pneumatic	
Ammonia Flow Control unit skid instrument air inlet	Grade
Ammonia Flow Control Unit skid plant air inlet	Grade
Off-skid individual actuator and instrument terminals	At actuator or instrument
Ambient Air	
SCR dilution air fan air inlet	10 feet (3 m) above grade
SCR dilution air fan drain outlet	Fan housing
Ammonia	
Ammonia Flow Control Unit skid ammonia inlet	Grade

A.6 Boiler Requirements Related to SCR Systems

A.6.1 Evaporator and economizer coil elements located downstream of the SCR catalyst shall include provisions for water washing. Such provisions shall be subject to mutual agreement between the Buyer and Supplier. Water washing

of such elements shall not result in damage to the SCR catalyst or permanently reduce the effective activity of the catalyst. The same shall hold true for recuperative or regenerative air preheat elements located downstream of the SCR catalyst.

A.7 General Requirements – SCR System

A.7.1 The SCR system provider, if different from the boiler supplier, shall formally review and provide written acceptance of the boiler supplier's equipment general arrangement. The review shall include all aspects of the equipment arrangement and design that impact the SCR system layout and ultimate performance.

A.7.2 The SCR system shall use 19% (by weight) aqueous ammonia as specified on the Buyer's Boiler Data Sheets. If atomizing medium is required, it shall be plant air. The dilution medium shall be ambient air. Heating of the ammonia feed, the atomizing medium or the dilution medium shall be by electric heating.

A.7.3 The SCR system shall not limit the rate of thermal change, start-up or shut-down times of the boiler and shall accommodate introduction of hot flue gas into a cold SCR.

A.7.4 All flue gas shall be treated by the SCR. Ammonia shall be evenly distributed into the flue gas upstream of the catalyst bed. Flue gas shall be evenly distributed across the catalyst bed without bypassing.

A.7.5 The SCR system shall be capable of continuous sustained operation at all operating conditions including start-up, shut-down, and minimum turndown conditions.

A.7.6 The SCR system shall be complete including catalyst and support, injection system, reactor housing, control skid, atomizing air system, electric heaters and dilution air fans with drivers and ductwork. All related local piping, valves, fittings, gaskets, bolts, nuts, instrumentation, trim, supports and junction boxes shall be provided.

A.7.7 All items necessary to provide vaporizing, heating, dilution, mixing and distribution of aqueous ammonia shall be provided.

A.7.8 The SCR system design shall be successfully proven in operation in similar applications.

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ATTACHMENT 04 – SELECTIVE CATALYTIC REDUCTION (SCR) SYSTEM

A.7.9 Low pressure SCR dilution air (not containing ammonia) piping design, fabrication, examination and testing not specified herein may be the Sub-Supplier's standard.

A.7.10 SCR system pressure parts containing ammonia or an ammonia-dilution medium mixture shall be designed, fabricated, examined and tested as required for ammonia service and shall be in accordance with the applicable requirements of ASME B31.3, OSHA Title 8, ASHRAE Chapter 4 and UL 125. Flanges shall be in accordance with ANSI/ASME B16.5. Materials containing copper shall not be used.

A.7.11 Noise limits shall not exceed 85 dBA at 3 feet horizontal from the equipment surface and 5 feet vertically above operating platforms.

A.7.12 Electrical design, wiring and components shall conform to Buyer's Specification, EH-35R-CCU1- SPC-265-00002 *Electrical Requirements for Package Equipment*.

A.7.13 A complete SCR System shall be provided for each boiler.

A.7.14 The Seller shall confirm uniform flue gas flow at the inlet of the AIG, uniform flue gas/ammonia-air flow at the inlet face of the catalyst, and at the inlet plane of the sampling ports upstream of the catalyst by either a physical flow model test or CFD analysis. Seller shall provide test procedures along with test results and Seller recommendations for the Buyers review and approval.

The CFD shall confirm the pressure drop, as specified, though the SCR system, and stack.

A.8 SCR Catalyst

A.8.1 The catalyst shall be suitable for thermal cycling between the maximum system operating temperature and the minimum specified ambient temperature without injurious effect on the structure, catalyst or other system components. Seller shall specify acceptable heating rates.

A.8.2 Catalysts bonded to metallic or ceramic substrates shall not suffer or show delamination of the catalyst from the support material or permanent deformation of the support material due to stresses resulting from operating conditions, specified loading conditions, and/or normal shipping and handling.

A.8.3 Sufficient catalyst shall be supplied to treat the exhaust gas to meet emissions levels specified on the equipment data sheet without expecting cleaning,

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regeneration or replacement for a minimum period of 6 years. A 6 year guarantee period shall be specified.

A.8.4 The Seller shall submit with their proposal a comprehensive list of exhaust stream contaminants considered poisonous after contact with the catalyst.

A.8.5 A complete initial set of catalyst test coupon elements shall be installed in the catalyst modules. Sufficient initial coupons shall be provided for removal for testing at the intervals recommended by the Manufacturer for the catalyst guarantee period. Test coupons shall be accessible from access doors/panels and accessways provided in the reactor housing or adjacent ducting.

A.8.6 The Manufacturer shall provide continental US facility locations that will accept spent catalyst for disposal. The plant Owner will be responsible for removal and transport of spent catalyst to the facility and for the fees and costs involved unless the removal is the Supplier's responsibility under performance or warranty obligations.

A.8.7 The Seller shall advise what the predicted SO2 to SO3 conversion rate will be with the catalyst being offered. Seller shall advise the ammonia bisulfate (ABS) formation temperature.

A.8.8 Catalyst installation shall satisfy the following parameters:

a. All gas flow through the catalyst housing must be treated. Leakage past a catalyst array/module is not acceptable. Seals and baffles shall be provided as required.

b. Thermal expansion/contraction of the catalyst arrays/modules shall be accommodated without subjecting the catalyst, catalyst support, catalyst housing, seals and baffles to permanent strain.

A.9 SCR Catalyst Beds

A.9.1 The catalyst bed location shall be such that the average flue gas temperature entering the catalyst is within the Manufacturer's recommended operating temperature range for the entire range of boiler operation after reaching the minimum temperature during startup.

A.9.2 The catalyst bed shall be a fixed-bed parallel path design.

A.9.3 Catalyst elements shall be shop assembled into modules for field installation into the reactor housing. Module size shall be the maximum practical size considering shipping and handling limitations.

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A.9.4 Modules shall have a steel frame with lifting lugs for installation in and removal from the support structure. Provisions for field pre-assembly of multiple modules prior to installation shall be included when practical.

A.9.5 When multiple layers of catalyst modules are utilized (in the direction of the flue gas flow), each layer of modules shall be removable independent of other layers.

A.10 SCR Reactor Housing and Ductwork

A.10.1 The reactor housing shall be a self contained assembly with internal insulation, protective metal liners, and external steel casing. The housing shall be sized for the catalyst required by the Supplier for his emission and performance guarantees.

A.10.2 Additional housing length shall be included to accommodate an additional 100% layer of future catalyst. The reactor structural framework shall be designed to handle the additional load.

A.10.3 Inlet and outlet duct gas connections to the housing shall be flanged. Housing sections requiring field assembly shall have flanges at the splices. All field splices shall be field welded. Bolting at field splices shall be used for alignment purposes only. Isolation blinds shall be provided at both the inlet and outlet of the reactor housing.

A.10.4 Housing shall be designed to provide a uniform flow distribution of flue gas and ammonia across the face of the catalyst.

A.10.5 Housing casing shall have continuous full penetration welds between plates. Vertical or diagonal exterior seams between plates and structural and structural members shall be sealed by a continuous fillet weld no the top side and 2 inch long fillet welds on 9 inch centers on bottom side.

A.10.6 Housing structural support members and casing stiffener bars shall be external to the casing so they are not exposed to flue gases.

A.10.7 Reactor housing casing plate shall be carbon steel with a minimum thickness of ¼ inch. The casing shall be adequately stiffened to prevent warpage or distortion.

A.10.8 The reactor housing shall have gas tight, bolted and gasketed doors suitable for loading and unloading the required catalyst modules. When practical, these doors shall be attached to the housing with hinges. A catalyst loading monorail and electric hoist shall be provided when the loading doors are placed at an

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elevated location not serviceable from grade by motor operated vehicles equipped with suitable lifting equipment.

A.10.9 Seller shall provide necessary ducting to and from the SCR housing to integrate the SCR housing into the combustion exhaust gas system. This ducting shall include all supports, flow turning vanes and/or straighteners, expansion joints, and accessories as required for a complete system.

A.10.10 Catalyst module support structures shall be provided in the reactor housings. The structures shall securely support and retain the catalyst modules. The support structure, including all fastening hardware, shall be suitable for the flue gas temperature and composition at all boiler operating conditions.

A.10.11 When the reactor housing is located at grade, clearance shall be provided under the reactor housing for access to drains, piping, and valves.

A.10.12 Ducting shall be designed for a maximum flue gas velocity of 58 feet per second.

A.10.13 Necessary flue gas flow distribution elements and turning vanes shall be provided to ensure uniform gas flow at the entrance to both the ammonia injection grid and the catalyst bed. The design and location of flow distribution elements and turning vanes shall be confirmed by CFD analysis. CFD shall confirm pressure drop across the SCR system.

A.10.14 Expansion joints shall be provided as required. They shall be capable of absorbing deflections in all connected equipment for both operating and upset conditions. Expansion joints shall use a high temperature fabric for the bellows, consistent with the specified operating conditions. Lap type slip joints are not acceptable. Expansion joints shall be furnished complete with angle flanges, interior seal plates (if necessary) and exterior hoods. Provisions shall be made to prevent particulate accumulations in the bellows.

A.11 SCR Ammonia Injection Grid (AIG) and Header

A.11.1 The injection grid shall be designed to evenly distribute the ammonia/air mixture throughout the flue gas stream.

A.11.2 The location of the injection grid shall be chosen to maximize the distance between the grid and the catalyst to ensure a thorough mixing of ammonia and the flue gas stream.

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A.11.3 Internal AIG elements shall be fed from an external supply header. All internal elements, external piping, supports and expansion joints required shall be provided and shall be accessible.

A.11.4 The branch piping from the AIG header to each internal element shall include local flow indication as well as a manually operated flow control valve.

A.11.5 Internal AIG elements shall be designed for a temperature that is 100°F above the maximum flue gas temperature to which the elements are exposed. As a minimum, AIG elements shall be constructed of 300 series stainless steel. The AIG design shall include consideration of the cooling effect of the injection medium, however, design temperatures shall not be reduced due to the cooling effect.

A.11.6 The AIG shall be placed upstream of a boiler tube bank or specially designed flow modifier to promote intimate mixing of the ammonia and flue gas streams. If this is not practical, then the AIG shall be placed a minimum of 8 feet upstream of the catalyst bed.

A.11.7 AIG element connections inside the flue gas path shall be socket or butt welded.

A.11.8 AIG injection nozzles shall be oriented with respect to flue gas flow for optimum dispersion of ammonia into the flue gas upstream of the catalyst bed.

A.11.9 Internal supports for the AIG elements shall be provided as required to prevent deformation of the elements and to minimize any flow induced vibration.

A.12 SCR Ammonia Flow Control Unit (AFCU)

A.12.1 The skid shall be capable of functioning without having to shut down for a minimum of 6 years. An engineered local control panel shall be provided on the skid to control and monitor the operation of the heaters, which shall include switches, lights, power, controller and air purge low pressure alarm switch.

A.12.2 The ammonia flow control skid shall include the following components:

a. Ammonia vaporizer

b. Dilution air blowers (2)

c. Electric heater (1)

d. Pipe, valves and fittings for ammonia and dilution air

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e. Ammonia/dilution air mixing device

f. Ammonia filters (2)

g. Primary instrument and control elements

h. Instrument air manifold and tubing

i. Electrical and Instrument junction box(es) and conduit/wiring

j. Control Panel

k. Lighting and receptacle outlets

l. Required Steel Supports

A.12.3 A grade mounted AFCU skid shall be provided for each boiler.

A.12.4 The AFCU shall include all equipment, piping, instruments and controls necessary to supply a diluted ammonia mixture to the AIG at the required flow, temperature and pressure.

A.12.5 The AFCU skid shall be fully shop assembled with all necessary process and utility piping, instrument and plant air piping and tubing, and electrical wiring installed and tested to ensure a fully functional system.

A.12.6 Aqueous ammonia piping shall be austenitic stainless steel. Air and ammonia/air mixture piping shall be carbon steel. Seller shall get approval for materials of construction.

A.12.7 The AFCU skid shall include a rigid structural steel baseframe designed to be lifted and handled without damage to the included components. Adequate space shall be provided to permit inspection, servicing and repair of all components mounted on the skid. Skid decking shall be open grating. All necessary drains and vents shall be routed to a safe location. Drain piping and included valves shall terminate at the edge of the skid.

A.12.8 A single flanged point of connection for each process and utility service shall be provided at one of the outside edges of the AFCU skid for the Buyer's supply piping to the AFCU.

A.12.9 A single flanged outlet point of connection for the ammonia-dilution medium mixture shall be provided at the edge of the AFCU skid for the Supplier's interconnecting piping to the AIG.

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A.12.10 Wiring and conduit from all AFCU electrical components shall terminate in junction boxes provided and mounted on the skid.

A.12.11 Electric heaters shall be furnished to supply all necessary heat required to vaporize the ammonia stream. Electric heating may be direct to the ammonia stream, indirect to the dilution air stream or a combination of the two methods. Electric heaters shall be supplied with 100% capacity backup.

A.12.12 The dilution medium for the ammonia stream fed to the AIG shall be air. Two (2) 110% capacity direct driven air blowers (one operating and one standby) shall be provided to supply the dilution air. Belt driven blowers are not acceptable. Blowers must be in accordance with the design requirements of AMCA. The blower shall be designed per API RP 536 Post Combustion NOx Control for Fired Equipment in General Refinery and Petrochemical Services Section 5.17.3. Each blower shall be equipped with an isolation valve and check valve at the discharge. The blower shall be sized and selected based on the lowest ambient temperature specified in the data sheet

A.12.13 Fan intakes shall be provided with a rain hood, an inlet trash screen or filter, a silencer, and necessary connecting ductwork to provide the intake point at a minimum of 10 feet (3 m) above grade.

A.12.14 Fans shall be removable without disturbing adjacent ductwork. Duct supports shall be provided as required.

A.12.15 Dilution air blowers shall be furnished with electric motor drive. Blower blades shall be non-arcing type. Electric motors shall be designed, constructed, and tested in accordance with Buyer's Specification, EH-35R-CCU1-SPC-255-56070 *General Purpose Induction Motors- ½ HP Through 500HP- IEEE 841*. Motors shall be polyphase, squirrel cage induction type rated for 460 V / 3 Ph / 60 Hz. Motors shall be premium efficiency, severe duty, cast iron, totally enclosed, fan cooled (TEFC).with a service factor of 1.15, Class F insulation with NEMA B design temperature rise. Motors shall be single speed.

A.12.16 Combined filter/silencers shall be furnished at the blower inlets and shall be cleanable, reusable, and include provisions for the detection of excessive filter pressure drop. A weatherhood shall be furnished at each air intake. A local differential pressure indicator shall be installed to measure pressure drop across the assembly; high pressure reading is an indication the assembly needs to be cleaned.

A.12.17 Conduit and wiring shall be provided from primary elements to a local control panel/electrical junction box.

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A.12.18 Instrument air tubing shall be provided from primary elements to a single instrument air manifold.

A.12.19 The skid shall be supplied as a single structural system with all included components mounted and braced for shipping and handling.

A.12.20 The ammonia filter housing and filter element shall be stainless steel as a minimum and shall be designed to provide on-line maintenance and minimize plugging of vaporizer nozzle(s).

A.12.21 When atomization of liquid ammonia is required, direct mechanical atomization or air atomization may be used. For air atomization, the plant air supply may be used. If the air supply must be heated, independent electric heaters shall be furnished. If mechanical atomization is employed and the supply pressure downstream of the flow control valve is insufficient, the Supplier shall furnish a metering pump to supply the required pressure.

A.12.22 Mixing of the ammonia and dilution air shall take place in a suitable static mixing device.

A.12.23 Seller shall determine if spare components such as electrical heater and instrumentation are required/ recommended.

A.12.24 Provisions shall be made to service and maintain all skid mounted equipment and internal equipment.

A.13 SCR Ammonia Storage

A.13.1 A single storage tank shall be furnished. The storage tank and forwarding pumps can be mounted on the Ammonia Flow Control Unit (AFCU) skid if space permits, or can be mounted on a spate steel skid which will be shared with the forwarding pumps.

A.13.2 The volume of the ammonia storage tank shall be a minimum of 30 days or 6,000 gallons plus one week, whichever is greater. The tank shall include a 15% design margin.

A.13.3 The storage tank shall be designed, fabricated, examined, tested and stamped in accordance with Buyer's Specification, EH-35R-CCU-SPC-255-58001 *Design and Fabrication Specification for Vessels*.

A.13.4 Piping from the ammonia storage and supply system to the AFCU inlet shall be provided by the Seller.

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A.13.5 The storage tank shall include as a minimum: a separate fill connection, a separate drain connection, a manual vent connection, a pressure relief valve, a level gauge, a low level shut off, and a nitrogen fill connection. All connections shall be supplied with a single isolation valve, A local pressure gauge with isolation valve and test connection is also required.

A.14 SCR Ammonia Flow Supply System (Forwarding Pumps)

A.14.1 Two (2) metering pumps are required to transfer aqueous ammonia to the SCR system at a accurately controlled rate. Pumps shall be designed in accordance to API 675 Positive Displacement Pumps- Controlled Volume Petroleum, Chemical, and Gas Industry Services.

A.14.2 Pumps shall be furnished with electric motor drives. Electric motors shall be designed, constructed, and tested in accordance with Buyer's Specification, EH-35R-CCU1-SPC-255-56070 *General Purpose Induction Motors- ½ HP Through 500HP- IEEE 841*. Motors shall be polyphase, squirrel cage induction type rated for 460 V / 3 Ph / 60 Hz. Motors shall be premium efficiency, severe duty, cast iron, totally enclosed, fan cooled (TEFC).with a service factor of 1.15, Class F insulation with NEMA B design temperature rise. Motors shall be single speed.

A.15 Dampers and Actuators – SCR System

A.15.1 Control dampers for dilution air systems shall be provided when modulation is required. They shall include the following:

a. Damper control for ducts shall be louvered opposed blade type.

b. Louvered damper shafts shall be in the horizontal position and shall be supported by external solid-lube flanged or permanently lubricated pillow block bearings.

c. A pneumatic actuator, transducer and 3-way solenoid valve shall be provided to positively open or close or modulate the damper depending on the signal from the DCS. A spring fail open provision shall be included.

A.15.2 A non-return damper/check valve and shut-off valve shall be provided downstream of each dilution air fan to prevent ammonia backflow through the fan inlet when the fan is not in operation.

A.15.3 Blade position indicators shall be provided at the damper location. Open and closed position switches shall be provided for remote indication at the Buyer's DCS.

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A.16 Internal Supports, Guides, Baffles and Flow Distribution Devices – SCR System

Internal baffles or distribution devices shall be provided if required to maintain the required flue gas distribution over the SCR catalyst bed for all operating conditions. Such devices shall be attached to the structure by bolting. The design shall accommodate thermal expansion without imposing excessive stress on structural members.

A.17 Liners, Insulation and Lagging – SCR System

A.17.1 Catalyst housings and ducting shall be internally or externally insulated such that the casing (cold face) temperature does not exceed 150°F, based on ambient still air at 80°F. Internal insulation shall be per API 560 E.3.6.1. Seller shall submit design calculations for review by Buyer.

A.17.2 The SCR reactor housing, reactor housing spool piece and AIG enclosure modules shall preferably be internally insulated with castable refractory. Ceramic fiber material shall not be used. External insulation systems may be acceptable subject to Buyer's review and authorization.

A.17.3 Floor drains shall be provided at low points for water washing of coil sections downstream of the SCR catalyst bed where flue gas temperatures are 450°F (232°C) or below. The drains shall be provided with piping and valves extending to an accessible area.

A.18 Access and Access Doors – SCR System

A.18.1 Access doors shall be provided upstream and downstream of SCR catalyst beds for inspection and maintenance. Access doors shall be provided upstream and downstream of flow distribution devices. The minimum external access door opening for these areas shall be 24" x 24" (600 mm x 600 mm).

A.18.2 Removable doors shall be provided for SCR catalyst loading and removal. Piping, structures and other components shall not obstruct catalyst loading or door removal. Clearance shall allow for external insulation where employed. Metal liners shall be provided for internal ceramic fiber insulation where employed.

A.18.3 Access lanes and bolted and gasketed access panels shall be provided downstream of the SCR catalyst and upstream of any heat transfer surface where the flue gas temperature is 450°F (232°C) and below. The design, location and size of such provisions shall be sufficient to permit water washing of the heat transfer surface manually when permanent water washing equipment is not installed. The Supplier shall submit his proposed design for Buyer authorization.

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A.19 Platforms, Ladders and Stairways – SCR System

A.19.1 Platforms, walkways, stairways and ladders for access to equipment, access doors, inspection or maintenance openings, instruments and controls, test points and other appurtenances as required for ease of operation and maintenance shall be included as part of the overall SCR system.

A.19.2 Platforms, stairs, and ladders shall be in compliance with OSHA Title 29 CFR 1910 Subpart D.

A.19.3 Exterior walkways and stairs shall not be less than 3 feet wide; Inspection walkways internal to the equipment shall have a minimum width of 18 inches. Platforms and stairways shall include handrails complete with toe plates.

A.19.4 A minimum headroom clearance of 7'-6" is required.

Minimum Platform Locations and Minimum Clear Widths With SCR System	
Location	**Clear Width**
At SCR catalyst loading and removal panels	4'-0" (1200 mm)
At the Nox/O2 analyzer upstream of the SCR catalyst	3'-0" (900 mm)
At the differential pressure transmitters across the SCR catalyst bed	3'-0" (900 mm)
At valves and instruments for AIG headers	3'-0" (900 mm)

A.20 Structural Design and Fabrication

A.20.1 The SCR System design shall conform to Buyer's Specification, EH-35R-CCU1-SPC-215-00002 *Structural Data for Mechanical Equipment*.

A.20.2 Structural welding for the SCR system shall be in accordance with AWS-D1.1 or ASME, Section IX. All other welding shall be in accordance with ASME, Section IX. Welders shall be qualified as per Section 5 of AWS D1.1 or Section IX of the ASME Code, as applicable.

A.20.3 Any welding of the piping systems shall be in accordance with ANSI/ASME B31.3.

A.21 Painting and Coatings – SCR System

An internal corrosion preventative coating shall be provided on the casing plate of the reactor housing, the AIG module housing and all connecting ductwork where internal ceramic fiber insulation is employed. An internal corrosion preventative coating shall also

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be provided for non-internally insulated casing plate downstream of the SCR where flue gas temperatures are 450°F (232°C) and below, including the stack. The Supplier shall submit proposed coatings for Buyer authorization.

A.22 Piping and Valves – SCR System

A.22.1 Piping

a. All interconnecting piping, fittings, valves and utility tubing between the AFCU skid(s) and the AIG shall be furnished by the Supplier.

b. Piping shall be designed in accordance with ASME B31.3.

c. Flexible hose shall not be used in SCR ammonia piping. Flexible hose shall not be used in SCR ammonia/dilution air piping unless authorized by the Buyer.

d. High point vents and low point drains shall be provided for all piping. The vents and drains shall have a single manual isolation valve.

e. A single isolation valve for auxiliary connections and instrument root valves shall be provided. The instrument root valves shall be in addition to instrument manifold and gauge block valves.

A.22.2 Valves

a. Automatic and remotely operated valves shall be also be provided as required for operation and safeguarding for the system proposed, by local authorities, ASHRAE Chapter 4, OSHA Title 8 and the P&ID.

b. A three valve bypass shall be provided for the ammonia control valve.

c. All valves shall be suitable for aqueous ammonia service and shall be listed under UL 125.

d. Remotely operated valves shall be provided as follows:

SCR System Remotely Operated Valve Requirements			
Location	**Actuator Type**	**Shutoff Class**	**Accessories**
NH_3 safety shutoff	piston	V	Solenoid, local and remote open/closed control, local position indication, open/closed limit switches. Fail closed.

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SCR System Remotely Operated Valve Requirements			
Location	**Actuator Type**	**Shutoff Class**	**Accessories**
NH_3 control	diaphragm	IV	Positioner with pressure gauge. Fail closed. Smart positioner when the Buyer's DCS includes HART communication protocol.

A.23 Instruments and Connections – SCR System

A.23.1 The Supplier shall furnish all local instrumentation, controls trim, piping and accessories required by applicable codes and to operate and monitor the SCR System locally and from the Buyer's DCS.

A.23.2 Instrumentation furnished with the SCR System shall conform to Buyer's Specification, EHR-35-CCU1-SPC-270-00003 *Instruments and Controls Supplied with Packaged Equipment*.

A.23.3 Exhaust Gas

a. Flue gas test ports shall be provided upstream of the AIG and downstream of the SCR reactor as required to verify SCR performance, including flue gas flow distribution, pressure and temperature. The number of ports shall be according to the catalyst manufacturer's recommendations, but not less than three on each side wall at each location.

b. Ducting emission test ports shall be located not less than 2 stack diameters downstream of any flow disturbance and not less than 1.5 stack diameters upstream. Flange faces shall project six inches from the outside surface of the casing plate. Flange bolt holes shall straddle natural centerlines unless otherwise specified.

c. The CEMS and inlet NOx/O2 exhaust gas analyzer will be provided by the Supplier.

1. CEMS will be capable of monitoring NH_3 concentration in the flue gas stream.

2. Flue gas NO_x/O_2 analyzer connection shall be provided upstream of the SCR ammonia injection grid.

d. The Supplier will provide a differential pressure transmitter to measure flue gas pressure drop across the SCR catalyst bed and any flow distribution device including heat transfer coil sections placed upstream of the SCR

catalyst. The Supplier shall provide root valves at the casing connections. The Buyer will provide tubing hookups and manifolds.

e. A flue gas thermowell with thermocouple and weatherproof head shall be provided upstream of the AIG and upstream of the SCR catalyst bed if separated from the AIG by a heat transfer coil section.

A.23.4 Ammonia and Dilution Air

a. An ammonia flow element and root valves shall be provided by the Supplier and located on the AFCU skid. The flow transmitter shall also be provided by the Supplier.

b. A dilution air flow element and root valves shall be provided by the Supplier and located on the AFCU skid. The flow transmitter shall also be provided by the Supplier.

c. Thermowells, thermocouples and transmitters shall be provided by the Supplier as required for Supplier's recommended control system.

d. Pressure transmitters shall be provided by the Supplier as required for Supplier's recommended control system. Local pressure gauges shall be provided in both ammonia and dilution air streams upstream and downstream of control valves, filters, heaters and mixing devices. All pressure transmitters and local gauges shall be furnished with root valves.

e. Protection devices such as diaphragm seals, etc. shall be provided as required to prevent damage from exposure to ammonia.

A.23.5 SCR System Ammonia Control

a. SCR system control will be accomplished through local control panel(s). The Buyer will provide hardware, software and programming of the DCS control system.

b. The Supplier shall provide recommended SCR system control logic including start-up and shut-down sequences to the Buyer. The control logic shall show step-by-step operator actions, automatic actions and DCS indications.

c. The Supplier's recommended control logic shall include all permissives, interlocks, displays, alarms, annunciation and operator interfaces necessary to maintain the validity of the SCR performance guarantee and warranty.

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d. All interlock and control signals for the SCR system shall be hard-wired. The SCR system shall have as a minimum the signal interfaces and safety interlocks shown on the Supplier's conforming P&ID.

e. All trips shall be preceded by an alarm.

A.23.6 SCR System Dilution Air Fan Control

a. Selection of the operating fan and switchover to the backup fan shall be controlled by local control panel(s). The backup fan will be started from a low air pressure switch or low air flow signal.

b. Automatic fan start/stop will be controlled by a start/stop signal from the Buyer's DCS to the Buyer's MCC.

c. A manual hand/off/auto switch will be provided and installed by the Buyer for each fan.

A.24 Fabrication and Shop Assembly – SCR System

A.24.1 The SCR AFCU skid shall be shop assembled complete with support steel, piping, mechanical equipment, instrumentation and controls, electrical conduit/wiring and junction boxes, and instrument/plant air tubing shop installed and tested.

A.24.2 All piping shall be fabricated in accordance with ASME B31.3.

A.24.3 The SCR AIG shall preferably be shop fabricated as part of a duct spool piece complete with insulation and necessary structural steel. If the AIG elements will be inserted into space provided in the boiler proper, economizer or other unitary section provided as part of the basic boiler package, each element shall be fully shop fabricated for insertion into the space provided.

A.24.4 The SCR AIG headers shall be completely shop assembled with branches containing valves and instrumentation.

A.24.5 The SCR reactor housing (and reactor spool pieces for future catalyst installation) shall be shop assembled in a similar fashion to the boiler casing and ductwork. Shop assembled sections shall be the maximum size permitted by handling and shipping limitations.

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A.25 Documentation

A.25.1 Drawing submittals shall conform to the Buyer's Supplier Drawing and Data Requirements (SDDR) Form – Watertube Boiler and Auxiliary Equipment.

A.26 Identification and Tagging – SCR System

Identification and tagging shall be as noted in Section 3.3 C. of the boiler specification.

A.27 Preparation for Shipment – SCR System

A.27.1 SCR catalyst shall be packaged to protect the catalyst from damage during shipping, handling and storage.

A.27.2 Specific precautions shall be taken to protect the SCR catalyst from moisture. Precautions shall be clearly marked on shipping containers.

A.28 Inspection and Testing- SCR System

A.28.1 SCR ammonia and ammonia-dilution air piping shall be leak tested in the shop.

A.28.2 The AFCU skid junction box and control elements shall be type tested for function and correct termination of wiring. Electric heaters shall be checked for functionality including power measurement reading(s). A complete function test shall be performed in the shop. It shall be witnessed by the Seller, any Sub-Seller and Buyer. A test plan shall be submitted to the Buyer for authorization prior to the test. A preliminary issue of the test report shall be submitted to the Buyer for authorization before a final test report is issued.

A.28.3 The Seller shall examine at the Buyer's request any shipments that have been exposed to conditions creating concern over SCR catalyst condition. In such situations, the Seller shall re-affirm that the catalyst has not been damaged and that performance guarantees remain valid if the catalyst is used or shall replace the catalyst. The Seller shall bear all costs of this examination and of replacing damaged catalyst when the concern has been created during the time the Seller is responsible for the catalyst.

A.29 Quality Assurance – SCR System

A.29.1 The Supplier shall physically inspect materials and fabrication and provide updated reports to the Buyer. The specified witness, inspection, review and hold points shall be addressed. Inspection shall include:

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a. SCR spool or reactor housing including structure, casing, catalyst supports, insulation and liners on a regular basis including final.

b. SCR AIG, header and piping on a regular basis including final.

c. SCR AFCU skid and equipment on a regular basis including a functional check and final.

d. SCR catalyst module inspection prior to and after shipment.

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ATTACHMENT 05 – CO Oxidation System

A.1 General

A.1.1 This Section includes minimum requirements for a CO Oxidation system supplied with the Boiler. The requirements outlined herein supplement the Buyer's CO Oxidation System data sheet on which the operating conditions and special requirements are listed in detail for CO Oxidation system. Where conflicts exist, the Buyer's CO Oxidation System data sheet shall govern.

A.1.2 The requirements in Sections 1.0 through 3.0 of the EH-35R-CCU1-SPC-255-57110, Watertube Boiler Specification that are not specific to the basic Boiler only also apply to the CO Oxidation System.

A.2 Definition of Terms

A.2.1 Additional abbreviations specific to the CO Oxidation System are defined as follows:

Abbreviations	
VOC	Volatile Organic Compounds

A.3 Specifications, Data Sheets and Drawings

Additional Buyer documents that apply to the CO Oxidation System are as follows:

CO Oxidation System Specifications, Data Sheets and Drawings	
Data Sheets	
EH-35R-CCU1-DST-255-M-710	Boiler
Drawings	
000.257.SD4510MOD	Supplier Drawing and Data Requirements (SDDR Form Water Tube Boiler & Aux Equipment)

A.4 General Requirements

A.4.1 The CO oxidation system shall not limit the rate of thermal change, start-up or shut-down times of the Boiler and shall accommodate introduction of hot flue gas into a cold CO system.

A.4.2 The CO oxidation system shall be capable of continuous sustained operation at all operating conditions including continuous load, cycles, part load, flue gas conditions, fuel-switchovers, start-up, shut-down, stand-by and idle conditions.

A.4.3 All flue gas shall be treated by the CO oxidation system. Flue gas shall be evenly distributed across the catalyst bed without bypassing.

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ATTACHMENT 05 – CO Oxidation System

A.4.4 The CO oxidation system shall be complete including catalyst and support, reactor housing and ductwork. All related gaskets, bolts, nuts, instrumentation, trim and supports shall be provided.

A.4.5 CO oxidation system performance data shall be provided for each fuel including CO emissions, VOC reduction and SO2 to SO3 conversion.

A.4.6 The catalyst, support structure and reactor housing shall accommodate seismic, flue gas flow, pressure and thermal conditions without distortion, vibration or damage. They shall accommodate expansion and contraction under unlimited cycling within the range from minimum ambient temperature to maximum operating temperature.

A.4.7 The effects of flue gas composition and mal-distribution, vortex shedding and pulsations shall be incorporated into the CO oxidation system design.

A.4.8 The CO oxidation system shall be successfully proven in operation in similar applications.

A.5 CO Catalyst

A.5.1 The catalyst shall be the manufacturer's proposed design, subject to the Buyer's authorization.

A.5.2 The catalyst element design and bonding procedure shall ensure that de-lamination of the catalyst from the base material and permanent deformation of the base material does not occur.

A.5.3 A complete initial set of catalyst test coupon elements shall be installed in the catalyst modules. Sufficient initial coupons shall be provided for removal for testing at the intervals recommended by the manufacture for the catalyst guarantee period. Test coupons shall be accessible from the reactor housing floor.

A.5.4 The manufacturer shall provide continental US facility locations that will accept spent catalyst for disposal. The plant Owner will be responsible for removal and transport of spent catalyst to the facility and for the fees and costs involved unless the removal is the Supplier's responsibility under performance or warranty obligations.

A.6 CO Catalyst Bed

A.6.1 The catalyst bed location within the Boiler system shall be such that the flue gas temperature entering the catalyst is within the manufacturer's

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ATTACHMENT 05 – CO Oxidation System

recommended operating temperature range for the entire range of Boiler operation.

A.6.2 The flue gas temperature variation entering the catalyst bed shall not exceed the tolerance specified by the manufacturer.

A.6.3 The catalyst bed shall be a fixed-bed parallel path design.

A.6.4 Catalyst elements shall be shop assembled into modules for field installation into the reactor housing. Module size shall be the maximum practical size considering shipping and handling limitations.

A.6.5 Modules shall have a steel frame with lifting lugs for installation and removal from the support structure. Provisions for field pre-assembly of multiple modules prior to installation shall be included when practical.

A.6.6 The catalyst modules shall be removable from the reactor housing. Each layer of modules transverse to the flue gas path shall be removable independently of other layers.

A.7 Internal Supports, Guides, Baffles, and Flow Distribution Devices

A.7.1 Internal baffles or distribution devices shall be provided if required to maintain the required flue gas distribution over the CO catalyst bed for all operating conditions.

A.8 Settings, Insulation, and Lagging

A.8.1 The CO reactor housing insulation, liner or lagging system shall match the adjacent downstream section.

A.9 Access and Access Doors

A.9.1 Access doors shall be provided upstream and downstream of CO catalyst beds for inspection, maintenance and CO catalyst loading and removal. Access doors shall be provided upstream and downstream of flow distribution devices. The minimum external access door opening shall be 24” x 36” (600 mm x 900 mm), or larger if required for the catalyst module size. Piping, structures and other components shall not obstruct catalyst loading or door removal. Clearances shall allow for external insulation.

A.9.2 Three 2” (50 mm) roof sky climber ports shall be provided upstream and downstream of the CO catalyst, at the tube bundles upstream and downstream of the CO catalyst and upstream and downstream of flow distribution devices.

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ATTACHMENT 05 – CO Oxidation System

The ports shall be located at the mid-point and 4 feet (1200 mm) from each side at each location.

A.10 Platforms, Ladders, and Stairways

A.10.1 Platforms with handrails and ladder access shall be provided to CO catalyst loading and removal doors.

A.10.2 The minimum platform locations and clear widths shall include the following.

Minimum Platform Locations and Minimum Clear Widths With CO Oxidation System	
Location	**Clear Width**
At CO catalyst loading and removal panels	4'-0" (1200 mm)
At the differential pressure transmitters across the CO catalyst bed	3'-0" (900 mm)

A.11 Instrument and Connections

A.11.1 Flue gas test ports shall be provided upstream and downstream of CO catalyst beds as required to verify individual CO performance, including local flow distribution, pressures and temperatures. The number of ports shall be according to the catalyst manufacturer's recommendations, but not less than six on each side wall at each location.

A.11.2 The Buyer will provide a differential pressure transmitter to measure flue gas pressure drop across the CO catalyst bed. The Supplier shall provide root valves at the casing connections. The Buyer will provide tubing hookups and manifolds.

A.11.3 A flue gas thermowell and thermocouple with head shall be provided for the Buyer's temperature transmitter (for indication) upstream of CO catalyst beds.

A.12 Fabrication and Shop Assembly

A.12.1 The CO reactor housing and ductwork shall be shop-assembled to the maximum extent permitted by handling and shipping limitations.

A.13 Documentation

A.13.1 Drawing submittals shall conform to the Buyer's Supplier Drawing and Data Requirements (SDDR) Form – Watertube Boiler and Auxiliary Equipment.

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ATTACHMENT 05 – CO Oxidation System

A.14 Preparation for Shipment

A.14.1 CO catalyst shall be packaged to protect the catalyst from damage during shipping, handling and storage from mechanical damage or damage from weather conditions.

A.14.2 Specific precautions shall be taken to protect the CO catalyst from moisture. Precautions shall be clearly marked on shipping containers.

A.15 Inspection and Testing

A.15.1 The supplier shall examine at the Buyer's request any shipments that have been handled or exposed to elements creating concern over CO catalyst condition. The supplier shall re-affirm that the catalyst has not been damaged and that performance guarantees remain valid if the catalyst is used or shall replace the catalyst. The supplier shall bear all costs of this examination and of replacing damaged catalyst when the concern has been created during the time the supplier is responsible for the catalyst.

A.16 Quality Assurance

A.16.1 The supplier shall physically monitor materials and fabrication and provide updated schedules to the Buyer. The specified witness, inspection, review and hold points shall be addressed. Monitoring shall include:

a. Reactor housing including structure, casing, catalyst supports, insulation and liners on a regular basis including final inspection.

b. CO catalyst module inspection after shipment if damage is suspected.

A.17 Guarantee

A.17.1 The Supplier shall guarantee the following CO Oxidation System performance based on the specified fuel, burner firing and flue gas exhaust conditions:

a. Maximum CO measured downstream of the Catalyst bed. Maximum CO limits shall be specified on the Buyer's data sheets.

b. Flue gas pressure drop across the catalyst bed and reactor housing.

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

Design and Fabrication Specification for Vessels ASME Code Section VIII, Divisions 1 and 2

Specification No. EH-35R-CCU1-SPC-255-58001

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1.0 INTRODUCTION

1.1 Purpose

This specification, EH-35R-CCU1-SPC-255-58001, serves as a Cover Sheet for Process Industry Practice PIP VESV1002 with applicable additions, deletions, modifications, and clarifications listed with associated paragraphs.

1.2 Scope

EH-35R-CCU1-SPC-255-58001, along with PIP VESV1002, provides design and fabrication criteria for pressure vessels.

2.0 REFERENCES

Applicable requirements in the latest edition (or the edition indicated) of PIP VESV1002 Design and Fabrication Specification for Vessels, ASME Code Section VIII, Divisions 1 and 2 shall be considered an integral part of this Practice. Additional references are listed below. Short titles will be used herein when appropriate.

2.1 Project Standards and Specifications

- EH-35R-CCU1-SPC-215-00002, Structural Data for Mechanical Equipment
- EH-35R-CCU1-SPC-255-58005, Design of Lifting Components for Mechanical Equipment
- EH-35R-CCU1-SPC-255-58040, Design and Fabrication Specification for Pressure Vessel Internals
- EH-35R-CCU1-SPC-255-85050, Welding/NDE Requirements for Equipment
- EH-35R-CCU1-SPC-255-85210, Aboveground Coatings
- EH-35R-CCU1-SPC-255-85530, Materials and Fabrication Requirements for Duplex Stainless Steel
- △C EH-35R-CCU1-SPC-255-85012, Positive Material Identification

2.2 Process Industry Practices (PIP)

- See PIP VESV1002, Section 2.1

2.3 Industry Codes and Standards

- See PIP VESV1002, Section 2.2

3.0 DEFINITIONS

Definitions as provided in PIP VESV1002 Design and Fabrication Specification for Vessels, ASME Code Section VIII, Divisions 1 and 2, are applicable to this specification. The following additional definitions are also applicable to this specification.

Table 1: Definitions

Term	Description
Cover Sheet	A short specification style document that provides information application to its attached PIP or industry standard.
Parent Specification	The Specification, Practice, or Industry Standard used as the basis for the process being defined.
PIP	Process Industry Practice
Shall/Will	Denotes a minimum requirement in order to conform to the intent of the standard.
Should/Can/Could/May	Denotes a recommendation which is advised but not required in order to conform to the standard.

4.0 AMENDMENTS TO PIP VESV1002

The following items are amendments to PIP VESV1002. The section and paragraph numbers refer to those given in that specification. An "**Added**" to a PIP paragraph expands on the requirements or selects options; "**Substitute**" replaces the entire paragraph or sentences; "**Modified**" means the original text has been changed to reflect project requirements; "**New**" is for a new paragraph/section to be added, "**Deleted**" means the original text has been deleted.

Table 2: Amendments

Reference Location	Amendment Description
Section 1	Delete: Supplementary requirements for shell and tube heat exchangers are in PIP VESST002.
Section 2.1	Delete: – PIP VEDV1003 - Documentation Requirements for Vessels, ASME Code Section VIII, Divisions 1 and 2
Section 2.1	Substitute: – PIP VEFV1100 - Vessel/S&T Heat Exchanger Standard Details PIP VEFV1101 - Vessel Nameplate Bracket PIP VEFV1102 - Vessel Tolerances PIP VEFV1103 - Vessel Grounding Lug PIP VEFV1105 - Horizontal Vessel Saddles Supported on Concrete PIP VEFV1106 - Horizontal Vessel Saddles Supported on Steel PIP VEFV1116 - Vessel Manway Hinges PIP VEFV1117 - Vessel Vertical Manway Davit PIP VEFV1118 - Vessel Horizontal Manway Davit PIP VEFV1125 - Vessel Internal Ladders PIP VEFV1128 - Skirt Attachments PIP VEFV1129 - Vessel Studded Joints To Read:

Reference Location	Amendment Description
	EH-35R-CCU1-M001 – Vessel Nameplate Bracket EH-35R-CCU1-M002 – Vessel Grounding Lug EH-35R-CCU1-M003 – Horizontal Vessel Saddles Supported on Concrete EH-35R-CCU1-M004 - Horizontal Vessel Saddles Supported on Structural Steel EH-35R-CCU1-M005 – Vertical Vessel Type “A” Base Plate w/Gussets EH-35R-CCU1-M006 - Vertical Vessel Type “B” Base Plate w/Cap Plate and Gussets EH-35R-CCU1-M007 - Vertical Vessel Type “C” Base Plate w/Cap Plate and Offset Gussets EH-35R-CCU1-M008 - Vertical Vessel Type “D” Base Plate w/Top Ring and Gussets EH-35R-CCU1-M014 - Vessel Manway Hinges EH-35R-CCU1-M015 - Vessel Vertical Manway Davit EH-35R-CCU1-M016 - Vessel Horizontal Manway Davit EH-35R-CCU1-M026 - Vessel Internal Rungs EH-35R-CCU1-M027 - Skirt Attachments Sheet 1 of 5 EH-35R-CCU1-M028 - Skirt Attachments Sheet 2 of 5 EH-35R-CCU1-M029 - Skirt Attachments Sheet 3 of 5 EH-35R-CCU1-M030 - Skirt Attachments Sheet 4 of 5 EH-35R-CCU1-M031 - Skirt Attachments Sheet 5 of 5 EH-35R-CCU1-M033 – Skirt Openings Vertical Vessels Sheet 1 of 2 EH-35R-CCU1-M034 – Skirt Openings Vertical Vessels Sheet 2 of 2
Section 4.1.1.1.a.	Substitute: PIP VEDV1003 including the following purchaser’s forms: (1) PIP VEDV1003-D Data Sheet (2) PIP VEDV1003-T Inspection and Testing Documentation Requirements Sheet or equivalent (3) PIP VEDV1003-R Documentation Requirements Sheet (4) PIP VEDV1003-F Welded Pressure Joint Requirements To Read: Purchaser’s vessel drawings and any additional document included in the purchase order
Section 4.1.1.1.d.	Substitute: PIP VEFV1100 details: VEFV1101, VEFV1102, VEFV1103, VEFV1105, VEFV1106, VEFV1116, VEFV1117, VEFV1118, VEFV1125 To Read: Any project standard drawings referenced on the purchaser’s vessel drawings.
Section 4.1.1.6	Modify:

Reference Location	Amendment Description
	All aspects of the work shall be in accordance with applicable local, county, state, and federal rules, regulations and standards at installation site including but not limited to the rules and standards established by the EPA and OSHA, or equivalent national standards, if applicable, as designated by the purchaser. See purchaser's PIP VEDV1003-D Data Sheet. To Read: All aspects of the work shall be in accordance with applicable local, county, state, and federal rules, regulations and standards at installation site including but not limited to the rules and standards established by the EPA and OSHA, or equivalent national standards, if applicable, as designated by the purchaser. See purchaser's vessel drawings.
Section 4.1.3.1	Modify: Vessel documentation shall be provided in accordance with purchaser's PIP VEDV1003-R Documentation Requirements Sheet. To Read: Vessel documentation shall be provided in accordance with Supplier's Drawing & Data Commitment (SDDC) Form included in the PO.
Section 4.1.3.2	Delete: The data required for Part B of the PIP VEDV1003-D Data Sheet shall be provided with the approval drawings.
Section 4.2.1.1	Modify: Vessel design shall be in accordance with the applicable requirements of the Code, {User's Design Specification} this Practice, the purchaser's PIP VESV1003-D Data Sheet, and all other requirements in the contract documents. To Read: Vessel design shall be in accordance with the applicable requirements of the Code, {User's Design Specification} this Practice, the purchaser's vessel drawings, and all other requirements in the contract documents.
Section 4.2.3.2.e.	Substitute: Lift Condition See purchaser's PIP VEDV1003-D Data Sheet and Section 4.2.8.3 To Read: Lift Condition See purchaser's vessel drawings and Section 4.2.8.3

Reference Location	Amendment Description
Section 4.2.4.1	Modify: Unless specified otherwise, wind loads shall be determined in accordance with ASCE 7 design criteria using input data specified by the purchaser. To Read: Unless specified otherwise, wind loads shall be determined in accordance with the project specification EH-35R-CCU1-SPC-215-00002, Structural Data for Mechanical Equipment.
Section 4.2.5	Modify: Seismic loads shall be determined in accordance with ASCE 7 using design parameters provided or otherwise defined by the purchaser. To Read: Seismic loads shall be determined in accordance with the project specification EH-35R-CCU1-SPC-215-00002, Structural Data for Mechanical Equipment.
Section 4.2.8.2, 4.2.8.3, 4.2.8.4, and 4.2.8.5	Substitute: The entire paragraph of 4.2.8.2, 4.2.8.3, 4.2.8.4, and 4.2.8.5 To Read: 4.2.8.2 Rigging Loads and design of lifting components shall be per project specification EH-35R-CCU1-SPC-255-58005, Design of Lifting Components for Mechanical Equipment.
Section 4.2.9.1.f.	New: Pressure vessel is in hydrogen service
△C Section 4.2.9.5	New: All vessel connections are to be flanged except as stated below. Threaded connections are limited to 6,000-psi rated only, (NPS) 2 in. and smaller in non-hydrocarbon service (air, water, and low-pressure steam < 50 psig)
△C Section 4.2.9.6	New: The minimum instrument nozzle size shall be 2” [50 mm] RFLWN with a rating of 300#.
Section 4.2.10.9.1	Modify: If specified on purchaser’s PIP VEDV1003-D Data Sheet, Part D, line 23 for high bolt-load control accuracy during initial assembly and during operation at temperature, flanged joints with 2-inch (50 mm) diameter and greater bolting shall be provided with bolts having an indicator rod through the bolt center for measuring installed bolt elongation using a depth gauge. To Read:

Reference Location	Amendment Description
	If specified on purchaser's vessel drawings for high bolt-load control accuracy during initial assembly and during operation at temperature, flanged joints with 2-inch (50 mm) diameter and greater bolting shall be provided with bolts having an indicator rod through the bolt center for measuring installed bolt elongation using a depth gauge.
Section 4.2.10.9.4	Modify: If hydraulic tensioners are used, and unless otherwise specified on purchaser's PIP VEDV1003-D Data Sheet, indicator-type bolts for every fourth bolt is recommended in the joint assembly for calibration purposes during initial assembly and for bolt-load control during operation at temperature. To Read: If hydraulic tensioners are used, and unless otherwise specified on purchaser's vessel drawings, indicator-type bolts for every fourth bolt is recommended in the joint assembly for calibration purposes during initial assembly and for bolt-load control during operation at temperature.
Section 4.2.11.2.2.a	Modify: See purchaser's PIP VESV1003-D Data Sheet, Part C, for the required standard skirt attachment detail shown on PIP VEFV1128. Skirts shall be attached by a continuous weld sized so as to provide for the maximum imposed loadings. To Read: See purchaser's vessel drawings for the required standard skirt attachment detail shown on EH-35R-CCU1-M027 through M031, Skirt Attachments Sheet 1 of 5 thru 5 of 5. Skirts shall be attached by a continuous weld sized so as to provide for the maximum imposed loadings.
Section 4.2.11.2.2.d	Modify: Skirt-to-base ring attachments in vessel skirts shall in accordance with VEFV1107 through VEFV1110. To Read: Skirt-to-base ring attachments in vessel skirts shall in accordance with EH-35R-CCU1-M005 through M008.
Section 4.2.11.2.3	Modify: Skirts shall be vented with a minimum of two, 2-inch (50 mm) openings, located near the top of the skirt, but below the head insulation or fireproofing. To Read: Skirts shall be vented in accordance with EH-35R-CCU1-M033 and M034.

Reference Location	Amendment Description
Section 4.2.11.2.4.a.	Modify: All skirt openings shall be provided with rings or collars in accordance with VEFV1134 and sized to provide 100% reinforcement of the opening. To Read: All skirt openings shall be provided with rings or collars in accordance with EH-35R-CCU1-M033 & M034, Skirt Openings Vertical Vessels Sheet 1 of 2 & 2 of 2, and sized to provide 100% reinforcement of the opening.
Section 4.2.11.3.1	Modify: Horizontal vessels shall be designed for two saddle supports attached by welding. See VEFV1105/M and VEFV1106/M for saddle configuration guidance. To Read: Horizontal vessels shall be designed for two saddle supports attached by welding. EH-35R-CCU1-M003 and EH-35R-CCU1-M004 for saddle configuration guidance.
Section 4.2.12.7	Modify: The design loadings for anchor bolts embedded in concrete shall be determined by either the simplified method (i.e., neutral axis of bolt pattern at centerline of vessel) or the shifted neutral axis method in accordance with Process Equipment Design. The method used shall be specified on the purchaser's PIP VEDV1003-D Data Sheet. To Read: The design loadings for anchor bolts embedded in concrete shall be determined by either the simplified method (i.e., neutral axis of bolt pattern at centerline of vessel) or the shifted neutral axis method in accordance with Process Equipment Design. The method used shall be specified on the purchaser's vessel drawings.
Section 4.2.13.2	Modify: Unless otherwise specified on purchaser's PIP VEDV1003-D Data Sheet, the material for internal attachments shall be the same nominal composition as the cladding, weld overlay, or shell to which it is attached. To Read: Unless otherwise specified on purchaser's vessel drawings, the material for internal attachments shall be the same nominal composition as the cladding, weld overlay, or shell to which it is attached.
Section 4.2.13.5	Modify:

Reference Location	Amendment Description
	Grab rungs, if specified on purchaser's PIP VEDV1003-D Data Sheet, shall be in accordance with PIP VEFV1125. To Read: Grab rungs, if specified on purchaser's vessel drawings, shall be in accordance with EH-35R-CCU1-M026, Vessel Internal Ladders.
Section 4.2.13.7	Modify: If purchaser's PIP VEDV1003-D Data Sheet specifies that the vessel is subject to vibration and/or fatigue, internal welded non-pressure parts (e.g., baffles that can be subject to vibration or cyclic loading) shall be attached with continuous full penetration welds. To Read: If purchaser's vessel drawings specify that the vessel is subject to vibration and/or fatigue, internal welded non-pressure parts (e.g., baffles that can be subject to vibration or cyclic loading) shall be attached with continuous full penetration welds.
Section 4.2.13.8	Modify: If specified on purchaser's PIP VEDV1003-D Data Sheet, internal bolting in vessels, especially where vibration is expected (e.g., where agitators are installed), shall either be double-nutted, tack-welded to the clip or baffle, or have a lock wire placed in the nut/bolt or other supports. To Read: If specified on purchaser's vessel drawings, internal bolting in vessels, especially where vibration is expected (e.g., where agitators are installed), shall either be double-nutted, tack-welded to the clip or baffle, or have a lock wire placed in the nut/bolt or other supports.
Section 4.2.14.3.a.(2)	Modify: Attached securely using a nameplate support bracket in accordance with detail PIP VEFV1101. To Read: Attached securely using a nameplate support bracket in accordance with detail EH-35R-CCU1-M001, Vessel Nameplate Bracket.
Section 4.2.14.3.b.	Modify: Lifting attachments, as designed by the supplier or as specified by purchaser To Read:

	Reference Location	Amendment Description
		Lifting attachments, as designed by the supplier in accordance with EH-35R-CCU1-SPC-255-58005, Design of Lifting Components for Mechanical Equipment
	Section 4.2.14.3.d.	Modify: Grounding lug in accordance with detail PIP VEFV1103 To Read: Grounding lug in accordance with detail EH-35R-CCU1-M002, Vessel Grounding Lug
C	Section 4.3.9	New: Dual stamped materials are acceptable for CRC.
	Section 4.4.1.2	Modify: Tolerances on fabricated equipment shown on detail PIP VEFV1102 shall apply to the completed vessel after pressure test. To Read: Tolerances on fabricated equipment shown on Figure 2 of this specification shall apply to the completed vessel after pressure test.
	Section 4.4.3.1	Modify: Bolt holes in all fixed flanges and studding outlets shall straddle the natural centerlines. To Read: Bolt holes in all fixed flanges and studding outlets shall straddle the natural centerlines as shown on Figure 1 of this specification.
	Section 4.4.3.2	Modify: For nozzles in heads, the bolt holes shall straddle centerlines parallel to or coincident with the natural vessel centerlines. To Read: For nozzles in heads, the bolt holes shall straddle centerlines parallel to or coincident with the natural vessel centerlines as shown on Figure 1 of this specification.
C	Section 4.4.3.7	Add: “and shall be oriented parallel with the circumferential weld seams of the shell” right after “full penetration butt weld” To Read: If multi-segmental reinforcing pad elements are used, the weld between segments shall be a Type 1 or Type 2 full penetration butt weld and shall be oriented parallel with the circumferential weld seams of the shell, and the joint

	Reference Location	Amendment Description
		efficiency of the pad as applied to the allowable stress of the pad material, Sp, shall be not be greater than one of the following as applicable:
	Section 4.4.3.15.2	Modify: The height of a raised face shall be one of the following as specified on purchaser's PIP VEDV1003-D Data Sheet: To Read: The height of a raised face shall be one of the following as specified on purchaser's vessel drawings:
△C	Section 4.4.5.14	New: Dissimilar material welding is to be avoided and subject to CRC approval.
	Section 4.4.6.3	Modify: Unless otherwise specified on purchaser's PIP VEDV1003-D Data Sheet, PWHT of test specimens shall include one extra PWHT cycle for potential future field repair. To Read: Unless otherwise specified on purchaser's vessel drawings, PWHT of test specimens shall include one extra PWHT cycle for potential future field repair.
	Section 4.5.1.1	Modify: For specific welded pressure joint examination requirements, see the purchaser's PIP VEDV1003-F Welded Pressure Joint Requirements Form. For Code Division 2 vessels, the form is not applicable. To Read: For specific welded pressure joint examination requirements, see the purchaser's vessel drawings. For Code Division 2 vessels, the form is not applicable.
	Section 4.5.2.1	Substitute: Purchaser's inspection requirements (i.e., review, witness, inspection, hold points, and inspection documentation) are furnished on purchaser's PIP VEDV1003-T Inspection and Testing Requirements Sheet. To Read: Materials and work are subject to inspection by Buyer as well as the Authorized Inspection (AI) agency required for Code Stamping. The extent of examination and special documentation, over and above the minimum requirements of the Code, will be specified in the purchase order. All specified non-destructive examination, including that of non-pressurized parts and attachments shall be performed per Code. Waiver of any

Reference Location	Amendment Description
	phase of vessel inspection shall be obtained in writing from the Buyer.
Section 4.5.4.1	Modify: Unless otherwise specified on purchaser's PIP VEDV1003-D Data Sheet, Code paragraph UG-99(b) {8.2.1(d)}, including endnote 34 {2.2.2.1d 1)}, shall be regarded as the standard hydrostatic test. See the PIP VEDV1003-D Data Sheet for the test pressure or applicable Code paragraph number. To Read: Unless otherwise specified on purchaser's vessel drawings, Code paragraph UG-99(b) {8.2.1(d)}, including endnote 34 {2.2.2.1d 1)}, shall be regarded as the standard hydrostatic test. See purchaser's vessel drawings for the test pressure or applicable Code paragraph number.
Section 4.5.4.2	Modify: If specified on purchaser's PIP VEDV1003-D Data Sheet, liquids other than water may be used for hydrostatic testing in accordance with the Code. A detailed test procedure shall be submitted to the purchaser for approval. To Read: If specified on purchaser's vessel drawings, liquids other than water may be used for hydrostatic testing in accordance with the Code. A detailed test procedure shall be submitted to the purchaser for approval.
Section 4.5.5.3	Modify: If specified in the purchaser's PIP VEDV1003-D Data Sheet, pneumatic testing shall be performed in the field at the installation site. To Read: If specified in the purchaser's vessel drawings, pneumatic testing shall be performed in the field at the installation site.
Section 4.6.1.2	Modify: If specified on the purchaser's PIP VEDV1003-D Data Sheet, all or part of the following vessel cleaning procedure shall be performed before shipping: To Read: If specified on the purchaser's vessel drawings, all or part of the following vessel cleaning procedure shall be performed before shipping:
Section 4.6.3	New:

	4.6.3 Shipment by Water a. Vessels shall meet the general requirements of Section 4.6.2 above and those of the Buyer's vessel drawings and purchase order documents. b. All vessel openings shall be made watertight. c. All vessels shall be primed on all exterior surfaces as a minimum in accordance with the project "Painting" specification. d. Spare gaskets and building hardware shall be wrapped in a watertight barrier material and enclosed in plywood containers. e. Flanges, other than those provided with permanent blind flanges, shall be covered with a 1/8 inch [3mm] neoprene gasket and 1/2 inch [13 mm] (minimum) thick steel plate no smaller than the flange OD and secured with full bolting. Flanges drilled for bolting larger than 3/4 inch [19mm] diameter may be secured with 3/4 inch [19 mm] diameter bolts and suitable washers. f. Pressure Vessel Interior Surface Preparation **1.** Austenitic stainless steel vessels and vessels lined with austenitic stainless steel, when required by the Buyer

Reference Location	Amendment Description
	i. Seller shall provide a nitrogen pressure blanket of 5 psig [.35 barg] and the full pressure shall be maintained inside the vessel throughout shipment using a nitrogen cylinder and pressure regulators. ii. Seller shall provide a sign with 2 inch [50 mm] high letters adjacent to each manway and each opening over NPS 20 inch [.5 meters] reading, DANGER VESSEL FILLED WITH NITROGEN. DO NOT ENTER WITHOUT REMOVAL OF ALL NITROGEN. **2.** All non-austenitic stainless steel vessels shall be purged with dry air prior to closing and provided with stainless steel baskets welded to non-permanent blinds, each basket shall contain desiccant. The desiccant shall be packaged to prevent direct contact with vessel interior surface.
Section 4.7	New:

4.7 Requirements for Code Data, Material and Quality Control Records

4.7.1 Scope

This section covers requirements for supplier's submittal of code data, material and quality control records for pressure vessels constructed in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII.

4.7.2 General

a. All required documents shall be assembled as a package for each pressure vessel. Documents which are common to more than one vessel shall be duplicated in each package.

b. The following identification shall be shown on each document:

1. The Buyer Purchase Order Number

2. The Buyer Vessel Equipment Number

c. All documents shall be in legible reproducible form, and folded to 8-1/2" × 11" [.22 meters by .28 meters] size.

4.7.3 Requirements

Unless otherwise specified, as a minimum the following shall be included in the Manufacturer's Data Book. △C

a. "Manufacturer's Data Report" and "Manufacturer's Partial Data Report" as applicable per ASME Code, Section VIII

Reference Location	Amendment Description
	b. Certified "Manufacturer's Design Report" for each vessel designed in accordance with ASME Code, Section VIII, Division 2 c. Postweld heat treatment chart (if applicable) d. Hydrostatic test chart e. Nameplate rubbing or photograph f. Certified Mill Test Reports g. NDE reports h. Charpy impact test records (if applicable) i. PMI reports (if applicable) j. Certified as-built drawings k. Latest copy of the fabricator's approved calculations l. Surface preparation and painting inspection report m. Compilation of the Non-Compliance Reports (NCR) n. Inspection release notice
Section 4.8	New: **4.8 Nozzle Loads for Local Stress Analysis** 4.8.1 Unless actual external piping loads are specified by the Buyer, each nozzle, except for manways and instrument nozzles, shall be designed for the piping loads listed in Table 5. Buyer is responsible for providing special instructions for nozzle sizes greater than 24 in [.6 meters].

Reference Location	Amendment Description
	4.8.2 Nozzle loads listed in Table 5 are intended for preliminary nozzle designs. Buyer shall provide the supplier with actual nozzle loads "LATER" upon completion of piping flexibility analysis if the actual loads are greater than the values in Table 5. 4.8.3 Nozzle loads listed in Table 5 are to be considered to act at nozzle to shell or head intersections, and to be true normal or tangential to head/shell at the point. All loads in the table shall be considered as sustained loads and act simultaneously. 4.8.4 For nozzles located on the spherical portion of the vessel heads, the circumferential shear force and longitudinal shear force in Table 5 shall be combined to create one resultant shear force; the circumferential bending moment and longitudinal bending moment in the table shall be combined to create one resultant bending moment. Nozzle local load analysis shall use the resultant shear force and bending moment, as well as the radial force. 4.8.5 The impact of nozzle loads on vessel head/shell shall be analyzed in accordance with WRC 107/537, WRC 297 or Finite Element Analysis (FEA). No extrapolation is allowed when using the WRC bulletins. Circumferential and longitudinal stresses caused by vessel internal or external pressure shall also be considered in addition to stresses developed by nozzle loads. The allowable stress criteria due to combined loads shall be as per ASME VIII

Reference Location	Amendment Description
	Division 2, Part 5, using Division 1 allowable stresses for Division 1 vessels.

5.0 LIST OF ATTACHMENTS

△C The following documents are included as an attachment.

Attachment 01 Figure 1, Flange Bolt Hole Orientation
Attachment 02 Figure 2, Vessel Tolerances
Attachment 03 Table 5, Piping Nozzle Loads for Static Equipment
Attachment 04 PIP VESV1002, Design and Fabrication Specification for Vessels, ASME Code Section VIII, Divisions 1 and 2

End of Specification

Figure 1, Flange Bolt Hole Orientation

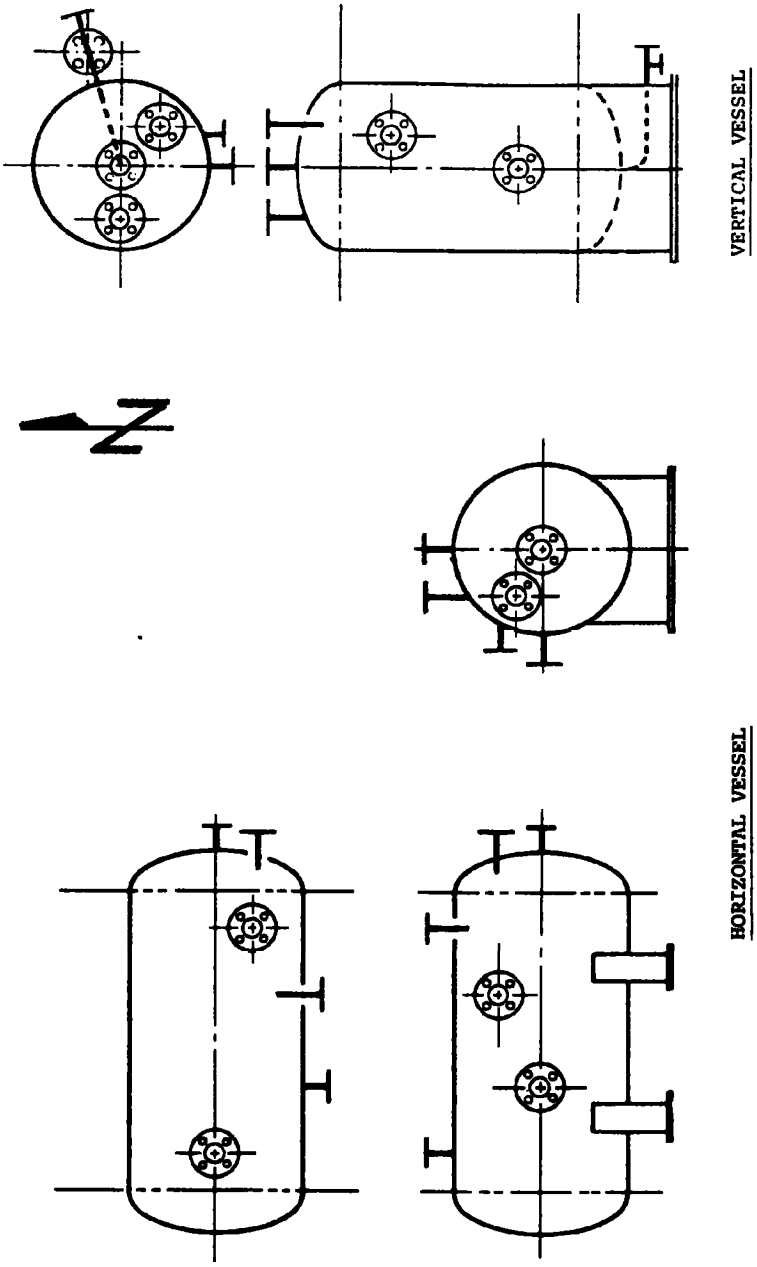
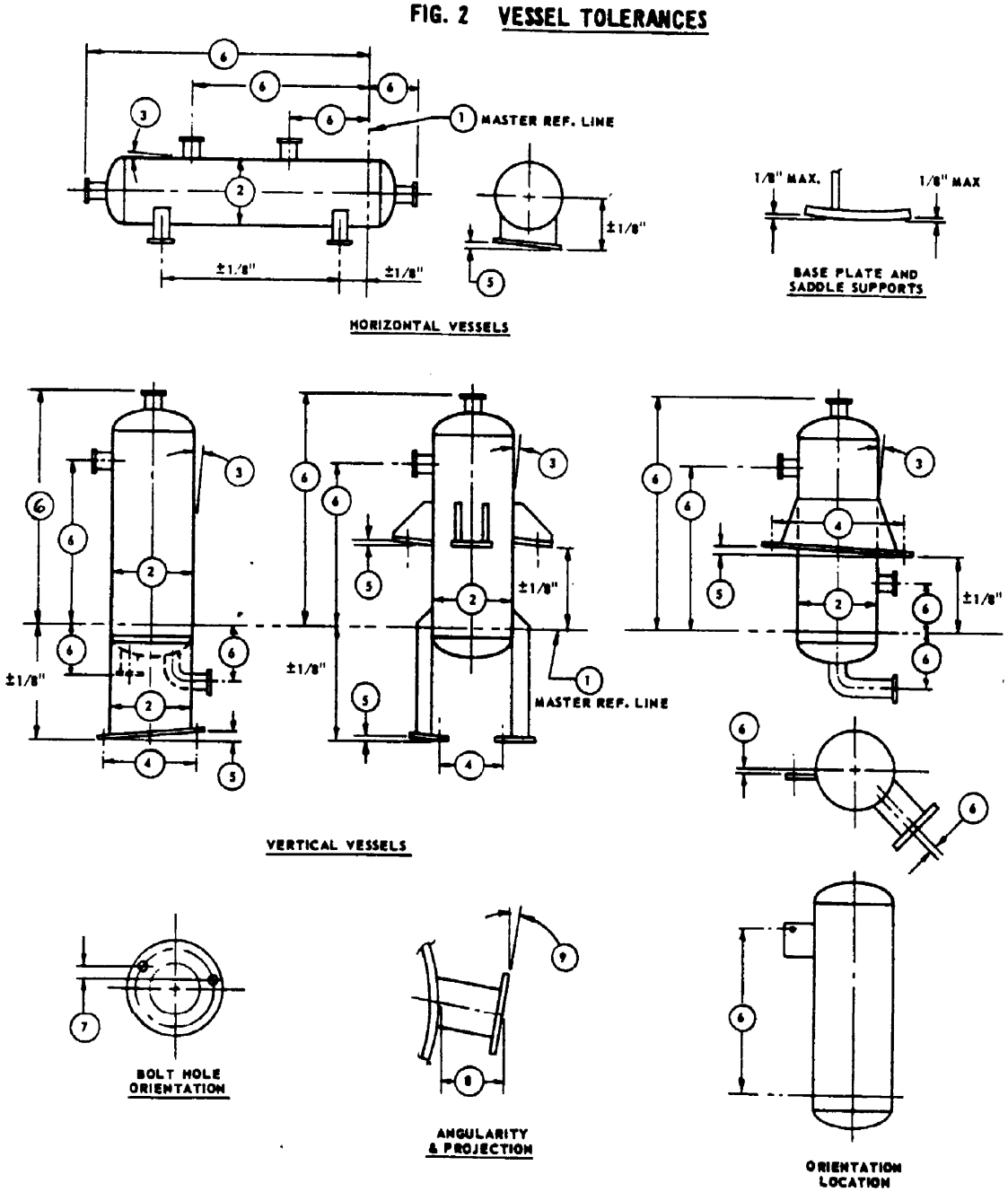


Figure 2, Vessel Tolerances

(All tolerances shown in Figure 2 are ± 3.18 mm (1/8") or 3.18 mm (1/8") max.)



The following notes are referenced to the number circles of Figure 2:

(1) The Master Reference Line shall be established by the vessel Manufacturer and clearly marked inside and outside of the shell prior to attaching the adjacent head. It shall be parallel to the root land of the shell course and perpendicular to the longitudinal axis of the vessel.

(2) Shell & Skirt Outside Circumference Tolerance

OUTSIDE DIAMETER	SHELL OR SKIRT THICKNESS		
	Up to 64mm (2 ½")	64mm (2 ½") to 102mm (4")	Over 102mm (4")
Less than 1.2m (4' - 0")	± 9.5mm (3/8")	± 12.7mm (1/2")	-
Over 1.2m (4' - 0") to 2.4m (8' - 0")	± 12.7mm (1/2")	± 19.1mm (3/4")	± 25.4mm (1")
Over 2.4m (8' - 0") to 4.6m (15' - 0")	± 19.1mm (3/4")	± 25.4mm (1")	± 38.1mm (1 -1/2")
Over 4.6m (15' - 0")	± 25.4mm (1")	± 38.1mm (1 -1/2")	-

Note: Matching Shell and Head shall be subject to CODE offset tolerance.

(3) Shell and Skirt Tolerance: Maximum slope from straight line is 3.18mm (⅛") in 3m (10' -0") with total maximum deviation as follows:

TANGENT TO TANGENT LENGTH	TOTAL MAXIMUM DEVIATION
Up to 15m (50' - 0")	12.7mm (1/2")
15m (50' - 0") to 30m (100' - 0')	19.1mm (3/4")
30m (100' - 0') and over	25.4mm (1")

(4) The center of an anchor bolt hole or pipe guide shall not deviate from the specified location on the bolt circle by more than the following:

VESSEL INSIDE DIAMETER	MAXIMUM DEVIATION
Less than 1.2m (4' - 0")	3.18mm (1/8")
Over 1.2m (4' - 0") to 2.4m (8' - 0")	4.76mm (3/16")
Over 2.4m (8' - 0")	6.35mm (1/4")

(5) Out of level slope = 2.6mm per meter with 20.8mm maximum (1/32" per foot with 1/4" maximum):

(6) through (9)

	(6)	(7)	(8)	(9)
Nozzles	± 6.35mm (1/4")	± 1.59mm (1/16")	± 4.76mm (3/16)	1/2º
Manways / Handholes	± 12.7mm (1/2")	± 6.35mm (1/4")	± 12.7mm (1/2")	1º
Clips	± 6.35mm (1/4")	- - - - - - -	- - - - - - -	- - - - - -

PIPING NOZZLE LOADS FOR STATIC EQUIPMENT

NOZZLE LOADING TABLE

Nozzle Size	CLASS 150 FLANGE						CLASS 300 FLANGE						CLASS 600 FLANGE						CLASS 900 FLANGE					
	LB_f			$FT\text{-}LB_f$			LB_f			$FT\text{-}LB_f$			LB_f			$FT\text{-}LB_f$			LB_f			$FT\text{-}LB_f$		
NPS	FR	FC	FL	MC	ML	MT	FR	FC	FL	MC	ML	MT	FR	FC	FL	MC	ML	MT	FR	FC	FL	MC	ML	MT
2	540	400	540	180	230	270	630	470	630	210	270	310	720	540	720	240	310	350	1600	1200	1600	530	690	800
3	810	610	810	400	520	600	940	710	940	460	600	700	1100	810	1100	530	690	800	2400	1800	2400	1200	1600	1800
4	1100	810	1100	710	920	1100	1300	940	1300	830	1100	1200	1400	1100	1400	940	1200	1400	3200	2400	3200	2100	2800	3200
6	1600	1200	1600	1600	2100	2400	1900	1400	1900	1900	2400	2800	2200	1600	2200	2100	2800	3200	4900	3600	4900	4800	6200	7200
8	2200	1600	2200	2800	3700	4200	2500	1900	2500	3300	4300	5000	2900	2200	2900	3800	4900	5700	6500	4900	6500	8500	11000	13000
10	2700	2000	2700	4400	5800	6600	3100	2400	3100	5200	6700	7700	3600	2700	3600	5900	7700	8900	8100	6100	8100	13000	17000	20000
12	3200	2400	3200	6400	8300	9600	3800	2800	3800	7400	9700	11000	4300	3200	4300	8500	11000	13000	9700	7300	9700	19000	25000	29000
14	3800	2800	3800	8700	11000	13000	4400	3300	4400	10000	13000	15000	5000	3800	5000	12000	15000	17000	11000	8500	11000	26000	34000	39000
16	4300	3200	4300	11000	15000	17000	5000	3800	5000	13000	17000	20000	5800	4300	5800	15000	20000	23000	13000	9700	13000	34000	44000	51000
18	4900	3600	4900	14000	19000	22000	5700	4200	5700	17000	22000	25000	6500	4900	6500	19000	25000	29000	15000	11000	15000	43000	56000	65000
20	5400	4000	5400	18000	23000	27000	6300	4700	6300	21000	27000	31000	7200	5400	7200	24000	31000	35000	16000	12000	16000	53000	69000	80000
22	5900	4500	5900	21000	28000	32000	6900	5200	6900	25000	32000	37000	7900	5900	7900	29000	37000	43000	18000	13000	18000	64000	84000	96000
24	6500	4900	6500	25000	33000	38000	7600	5700	7600	30000	39000	45000	8600	6500	8600	34000	44000	51000	19000	15000	19000	76000	99000	110000
26	7000	5300	7000	30000	39000	45000	8200	6100	8200	35000	45000	52000	9400	7000	9400	40000	52000	60000	21000	16000	21000	90000	120000	130000
28	7600	5700	7600	35000	45000	52000	8800	6600	8800	40000	53000	61000	10000	7600	10000	46000	60000	69000	23000	17000	23000	100000	140000	160000
30	8100	6100	8100	40000	52000	60000	9400	7100	9400	46000	60000	70000	11000	8100	11000	53000	69000	80000	24000	18000	24000	120000	160000	180000
32	8600	6500	8600	45000	59000	68000	10000	7600	10000	53000	69000	79000	12000	8600	12000	60000	79000	91000	26000	19000	26000	140000	180000	200000
34	9200	6900	9200	51000	67000	77000	11000	8000	11000	60000	78000	90000	12000	9200	12000	68000	89000	100000	28000	21000	28000	150000	200000	230000
36	9700	7300	9700	57000	75000	86000	11000	8500	11000	67000	87000	100000	13000	9700	13000	76000	99000	110000	29000	22000	29000	170000	220000	260000
42	11000	8500	11000	78000	101000	120000	13000	9900	13000	91000	120000	140000	15000	11000	15000	100000	135000	160000	34000	25000	34000	230000	300000	350000

NOTES:
1. All forces and moments act on the intersection of the nozzle axis with the mid-thickness of the shell.
2. Tabulated forces are in pounds (lb_f) and moments are in foot-pounds ($ft\text{-}lb_f$)
3. Indicated values are design loads and must be considered as 70% thermal and 30% sustained loads.
4. The equipment vendor must verify nozzles and equipment for the indicated loads.
5. For head nozzles use FR and MT over an axis leaving the nozzle plus $\sqrt{(M_L^2+M_C^2)}$ and $\sqrt{(F_L^2+F_C^2)}$ perpendicular.
6. The notation shall be as follows:
   - FR: Radial force
   - FC: Circumferential force
   - FL: Longitudinal force
   - MC: Circumferential moment
   - ML: Longitudinal moment
   - MT: Torsional moment

PROCESS INDUSTRY PRACTICES

COMPLETE REVISION
January 2019

Vessels

PIP VESV1002
Design and Fabrication Specification for Vessels ASME *Code* Section VIII, Divisions 1 and 2

PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

This Practice is subject to revision at any time.

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Design and Fabrication Specification for Vessels ASME *Code* Section VIII, Divisions 1 and 2

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1. Scope

This Practice provides design criteria, fabrication, examination, inspection, testing, and documentation requirements for pressure vessels constructed in accordance with ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1 or Division 2, henceforth referred to as the *Code*. Requirements that are specific to *Code,* Section VIII, Division 2 are shown in braces { }.

Supplementary requirements for shell and tube heat exchangers are in *PIP VESST002.*

2. References

Applicable parts of the following Practices, industry codes and standards, and references shall be considered an integral part of this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted. Short titles are used herein where appropriate.

2.1 Process Industry Practices (PIP)

- PIP VEDV1003 - *Documentation Requirements for Vessels, ASME Code Section VIII, Divisions 1 and 2*
- PIP VEFV1100 - *Vessel/S&T Heat Exchanger Standard Details*

  PIP VEFV1101 - *Vessel Nameplate Bracket*

  PIP VEFV1102 - *Vessel Tolerances*

  PIP VEFV1103 - *Vessel Grounding Lug*

  PIP VEFV1105 - *Horizontal Vessel Saddles Supported on Concrete*

  PIP VEFV1106 - *Horizontal Vessel Saddles Supported on Steel*

  PIP VEFV1116 - *Vessel Manway Hinges*

  PIP VEFV1117 - *Vessel Vertical Manway Davit*

  PIP VEFV1118 - *Vessel Horizontal Manway Davit*

  PIP VEFV1125 - *Vessel Internal Ladders*

  PIP VEFV1128 - *Skirt Attachments*

  PIP VEFV1129 - *Vessel Studded Joints*

2.2 Industry Codes and Standards

For each of the following reference documents, if *Code* Table U-3 {1.1} lists an edition or addenda different than the edition listed in the reference, the edition listed in *Code*, Table U-3 {1.1} shall be used.

- American Society of Civil Engineers (ASCE)
  - ASCE 7 – *Minimum Design Loads for Buildings and Other Structures*
- American Society of Mechanical Engineers (ASME)
  - *ASME Boiler and Pressure Vessel Code*

    Section II, Part D - *Properties*

    Section V - *Nondestructive Examination*

Section VIII - *Pressure Vessels, Divisions 1 and 2*

Section IX - *Welding and Brazing Qualifications*

Code Case 2260 - *Alternative Rules for Design of Ellipsoidal and Torispherical Formed Heads, Section VIII, Division 1*

- ASME B1.1 - *Unified Inch Screw Threads (UN and UNR Thread Form)*
- ASME B16.5 - *Pipe Flanges and Flange Fittings, Sizes NPS 1/2 through NPS 24*
- ASME B16.9 - *Factory-Made Wrought Buttwelding Fittings*
- ASME B16.47 - *Large Diameter Steel Flanges, NPS 26 through NPS 60*
- ASME PCC-1 - *Guidelines for Pressure Boundary Bolted Flange Joint Assembly*
- ASME PCC-2 - *Repair of Pressure Equipment and Piping*
- ASME SA-263 - *Corrosion-Resisting Chromium, Steel-Clad Plate*
- ASME SA-264 - *Stainless Chromium-Nickel, Steel-Clad Plate*
- ASME SA-265 - *Nickel and Nickel-Based Alloy-Clad Steel Plate*
- ASME SA-578 - *Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications*
- ASME SA-745 - *Ultrasonic Examination of Austenitic Steel Forgings*

- American Society for Testing and Materials (ASTM) International
  - ASTM A-380 - *Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment and Systems*
- American Welding Society (AWS)
  - AWS A2.4 - *Standard Symbols for Welding, Brazing and Nondestructive Examination*
- International Standards Organization
  - ISO 8573-1 - *Compressed Air - Part 1 Contaminants and Purity Classes*
- Welding Research Council (WRC)
  - WRC Bulletin 107 - *Local Stresses in Spherical and Cylindrical Shells Due to External Loadings*
  - WRC Bulletin 297 - *Local Stresses in Cylindrical Shells Due to External Loadings on Nozzles*
  - WRC Bulletin 537 - *Precision Equations and Enhanced Diagrams for Local Stresses in Spherical and Cylindrical Shells Due to External Loadings for Implementation of WRC Bulletin 107*

2.3 Government Regulations

The following references are applicable to US installations or as specified by Purchaser.

- U. S. Department of Labor, Occupational Safety and Health Administration (OSHA)
  - OSHA 29 CFR 1910.146(k)(3)(ii) - *Permit-Required Confined Spaces for General Industry*

2.4 Other References

– "*Dynamic Response of Tall Flexible Structures to Wind Loading*." Joseph Vellozzi, Ph.D., P.E. U.S. Department of Commerce, National Bureau of Standards, Building Science Series Number 32, 1966.

– "*Process Equipment Design*." Brownell and Young. Wiley & Sons Publishers, 1959.

– "*Stresses in Large Cylindrical Pressure Vessels on Two Saddle Supports*." L.P. Zick. Pressure Vessels and Piping: Design and Analysis, A Decade of Progress. Vol. 2, 1972.

3. Definitions

approved equal: A substitution to a specified product that has been approved in writing by the Purchaser

Code: The *ASME Boiler and Pressure Vessel Code,* Section VIII, Division 1 {or 2} and its referenced Sections (e.g., Section II, Section V, and Section IX) and any *Code* Cases permitted by the *User*. References to Division 2 are identified in braces { }

construction: An all-inclusive term comprising materials, design, fabrication, examination, inspection, testing, certification (i.e., *Code* stamp and Manufacturer's Data Report), {Manufacturer's Design Report}, and pressure relief

cyclic service: A service that requires fatigue analysis in accordance with *Code*, Section VIII, Division 2, Section 5.5.2. This applies to Division 1 and Division 2 vessels.

manufacturer: The party entering into a contract with the Purchaser to design and construct a vessel in accordance with the requirements in this Practice and the contract documents. In accordance with the *Code* definition, the *Manufacturer* is the party that possesses a valid Certificate of Authorization to manufacturer pressure vessels with the ASME Mark.

National Board: The National Board of Boiler and Pressure Vessel Inspectors, an organization comprised of chief inspectors of various governmental jurisdictions in the United States and Canada

owner: The party who owns the facility wherein the vessel will be used. The owner is typically also the User.

purchaser: The party who selects and specifies the mechanical design requirements (e.g., Vessel Drawing/Data Sheet {User's Design Specification}), consistent with User criteria, for use by the Manufacturer. The Purchaser is also responsible for placing the purchase order for the vessel or vessel components. The Purchaser may also be the Owner, User, or the Owner's or User's Designated Agent (e.g., engineering contractor).

user: The party who establishes construction criteria in accordance with the *Code* philosophy and service hazards. The User is the operator of the facility wherein the vessel will be installed.

purchaser's inspector: The person or company authorized by the Purchaser, Owner, and/or User to inspect pressure vessels to the requirements of this Practice and other Purchaser contract requirements

4. Requirements

4.1 General

4.1.1 Overall Responsibilities

4.1.1.1 Vessels shall be provided in accordance with this Practice and the following:

a. *PIP VEDV1003* including the following Purchaser's forms:

(1) *PIP VEDV1003-D* Data Sheet

(2) *PIP VEDV1003-T* Inspection and Testing Documentation Requirements Sheet or equivalent

(3) *PIP VEDV1003-R* Documentation Requirements Sheet

(4) *PIP VEDV1003-F* Welded Pressure Joint Requirements

b. The *Code*

c. Design criteria that may supersede the requirements of this Practice but not take exception to the requirements of the *Code*

d. *PIP VEFV1100* details: *VEFV1101*, *VEFV1102*, *VEFV1103*, *VEFV1105*, *VEFV1106*, *VEFV1116*, *VEFV1117*, *VEFV1118*, *VEFV1125*

e. Other codes and standards referenced in this Practice

f. Local requirements

g. Other contract requirements furnished by the Purchaser

4.1.1.2 Vessels shall be in total compliance with the *Code*, including stamping.

4.1.1.3 Unless otherwise specified by the Purchaser, *Code*-stamped vessels shall also be National Board (NB) registered.

4.1.1.4 Deviations from this Practice shall be submitted in writing for approval by the Purchaser.

4.1.1.5 If a conflict is identified between this Practice, the design drawings, data sheets, referenced codes and standards, or any supplementary specification, written clarification shall be obtained from the Purchaser before proceeding with any work.

4.1.1.6 All aspects of the work shall be in accordance with applicable local, county, state, and federal rules, regulations and standards at installation site including but not limited to the rules and standards established by the EPA and OSHA, or equivalent national standards, if applicable, as designated by the Purchaser. See Purchaser's *PIP VEDV1003-D* Data Sheet.

4.1.1.7 The Manufacturer shall be responsible for assuring that subcontracted fabrication work is in accordance with this Practice and the contract documents.

4.1.1.8 Purchaser's review of Manufacturer's documentation (e.g., fabrication drawings, design calculations or weld procedures) shall not relieve the

Manufacturer of his responsibility to comply with the requirements of this Practice and the contract documents.

4.1.1.9 If a vessel or vessel component design is furnished by the Purchaser, the Manufacturer shall not be relieved of his responsibility to comply with the requirements of this Practice and the contract documents.

4.1.1.10 Release for shipment by Purchaser Inspector shall not relieve the Manufacturer of his responsibility to comply with the requirements of this Practice and the contract documents.

4.1.2 Alternative Design Proposals

4.1.2.1 A base proposal for construction of the vessel shall be provided in full compliance with the Purchaser's request for quotation.

4.1.2.2 An alternative design proposal may be submitted; however, the change shall be realized without losing capability.

4.1.2.3 Alternate design proposals shall be in accordance with the following:

a. Shall be accompanied by the base proposal and be clearly identified as an alternate proposal

b. Shall clearly state the intended use of *Code Cases*

c. Shall be fully and clearly described and substantiated by sketches or drawings

d. Shall include a list of specific exceptions to Purchaser's request for quotation, this Practice, and the contract documents

e. Shall clearly identify the anticipated benefits(s)

4.1.2.4 Unless approved in writing by the Purchaser, an alternative design including the use of *Code Cases* shall not be used.

4.1.3 Documentation Responsibilities

4.1.3.1 Vessel documentation shall be provided in accordance with Purchaser's *PIP VEDV1003-R* Documentation Requirements Sheet.

4.1.3.2 The data required for Part B of the *PIP VEDV1003-D* Data Sheet shall be provided with the approval drawings.

4.2 Design

4.2.1 General

4.2.1.1 Vessel design shall be in accordance with the applicable requirements of the *Code*, {User's Design Specification} this Practice, the Purchaser's *PIP VESV1003-D* Data Sheet, and all other requirements in the contract documents.

4.2.1.2 Minimum corroded shell and head thickness shall be 3/16 inch (5 mm).

4.2.1.3 If two allowable stress values are given in *Code* Section II Part D for a material, the greater value shall not be used in the design of flanges for gasketed joints or other applications if minimal amounts of distortion can cause leakage or malfunction.

4.2.1.4 Unless approved by the Purchaser, *Code Case 2260* shall not be permitted for use in the design.

4.2.1.5 Half-pipe or pipe section jackets shall be designed in accordance with *Code* Appendix EE {4.11.6}.

4.2.2 Pressure and Temperature

4.2.2.1 Unless otherwise specified, vessels shall be assumed to operate completely filled with operating fluid.

4.2.2.2 Unless otherwise specified, Minimum Design Temperature shall not be warmer than 30ºF (-1ºC).

4.2.2.3 The maximum design temperature rating shall be increased to the highest temperature possible without affecting the minimum required thickness of the shell or heads and without changing the pressure class of nozzle flanges.

4.2.2.4 If appropriate, a vessel may be designed and *Code* stamped for more than one condition of pressure and coincident maximum metal temperature.

4.2.2.5 Unless otherwise specified, maximum design metal temperature shall not be colder than 150°F (65ºC).

4.2.2.6 Provisions for Future Field Hydrostatic Test

1. Unless provision for future field hydrostatic test is exempted, the vessel shall be designed to satisfy the load combination as specified in Section 4.2.3.2.d.
2. The design shall verify that any component in the corroded condition can withstand the following loads, without exceeding 95% of the Specified Minimum Yield Strength at the coincident test temperature, in both circumferential and longitudinal directions:
   a. Hydrostatic test pressure at the top of the vessel in accordance with *Code* Paragraph UG-99 {8.2.1}
   b. Hydrostatic head of the vessel full of water when the vessel is in its operating position
3. The stress level in Section 4.2.3.2.d shall not be permitted in those portions of the cylindrical shell within a meridional distance of $2.5\sqrt{Rt}$, where *R* is the mean radius of the shell and t is the thickness of the shell at the junction, from a gross structural discontinuity such as, but not limited to, the following:
   a. Cone-to-cylinder junctions
   b. Shell flange-to-cylinder junctions
   c. Torispherical head (inside crown radius/head thickness L/t ratio greater than 500) -to-cylinder junctions
   d. Openings in the shell that are larger than the dimensional limits given in *Code* Paragraph UG-36(b)(1) {4.5.2.1}

4. See Section 4.2.3 for additional requirements.

4.2.2.7 Maximum Allowable Working Pressure (MAWP) shall not be limited by the nozzle reinforcement.

4.2.2.8 *Code* Paragraph UG-20(b) {4.1.5.2€} shall be used for determining the Minimum Design Metal Temperature (MDMT) of carbon and low alloy steels.

4.2.2.9 Carbon and low-alloy steel material for separate nozzle reinforcing pads, and stiffening rings and other attachments which are welded to pressure-retaining components, shall not limit the MDMT.

4.2.2.10 Jacketed or compartmented vessels shall have common components designed for the maximum potential differential pressure on each of the concave and convex sides.

4.2.3 Design Loads and Load Combinations

4.2.3.1 Design Load Classifications and Definitions

1. Dead Load (L1)

   Dead Load is the installed weight of the vessel, including internals, catalyst or packing, refractory lining, platforms, insulation fireproofing, piping, and other permanent attachments.

2. Operating Live Load (L2)

   Operating Live Load is the weight of the liquid at the maximum operating level, including that on trays.

3. Pressure Load (L3)

   Pressure Load is the MAWP (internal or external at the coincident temperature) considering the pressure variations through the vessel, if any. MAWP shall be calculated (not set equal to the design pressure) unless otherwise specified by the Purchaser. For vessels with more than one independent chamber, see *Code* Paragraph UG-19(a) {4.1.8}.

4. Thermal Load (L4)

   Thermal Loads are caused by the restraint of thermal expansion/interaction of the vessel and/or its supports.

5. Test Load (L5)

   Test Load is the weight of the test medium, usually water. Unless otherwise specified, design basis shall consider that the vessel shall be field tested in its normal operating position. See Section 4.2.2.6.

6. Wind Load (L6)

   Wind Load shall be determined in accordance with Section 4.2.4.

7. Seismic Load (L7)

   Seismic Load shall be determined in accordance with Section 4.2.5.

8. Piping and Superimposed Equipment Loads (L8)

   Loads caused by piping (other than the Dead Load), and loads caused by superimposed equipment

9. Hydrotest Factor (L9)

   Hydrotest factor that, if multiplied by the lowest ratio (for the materials of which the vessel is constructed) of the stress value S for the test temperature of the vessel to the stress value for the design temperature, establishes the minimum required test pressure at every point in the vessel

10. Erected Load (L0)

    Erected Load is the weight of the vessel as initially placed in operating position. Normally this is the shell without contents (e.g., internals, catalyst, packing). Loads included in the erected load may include, but are not limited to, insulation, fireproofing, refractory lining, attachments (e.g., ladders, platforms, piping).

4.2.3.2 Load Conditions

Unless other conditions are specified by the Purchaser, vessels and their supports shall be designed to satisfy the most severe (i.e., controlling) of the following load conditions, and the controlling load condition shall be identified in the design calculations:

a. L1+L6

   Operating Dead Load with full Wind Load

b. L1+L2+L3+L4+L6+L8

   Design Condition with full Wind Load. Both full and zero pressure loads (L3) shall be included for check of maximum longitudinal tensile and compressive stress.

c. L1+L2+L3+L4+L7+L8

   Design Condition with Seismic Load. Both full and zero pressure loads (L3) shall be included for check of maximum longitudinal tensile and compressive stress.

d. L1+ L9+L5+(0.25)L6

   If specified by Purchaser, initial (i.e., new uncorroded) hydrostatic test condition and future (i.e., corroded) hydrostatic test condition with vessel in normal operating position and with 50% of design wind velocity (i.e., 25% of wind load)

   The general primary membrane tensile stress under this load condition, in the corroded shall not be greater than the following:

   (1) For hydrostatic testing, 95% of the Specified Minimum Yield Strength at 100°F (38°C) {that specified in 4.1.6.2(a)}

   (2) For pneumatic testing, 80% of the Specified Minimum Yield Strength at 100°F (38°C) {4.1.6.2 b)}

e. Lift Condition

See Purchaser's *PIP VEDV1003-D* Data Sheet and Section 4.2.8.3

f. L0 + (0.5)L6

Erected Condition with 70% wind velocity (i.e. 50% Wind Load). If the equipment is in the erected condition for an extended period full wind shall be applied.

4.2.4 Wind

4.2.4.1 Unless specified otherwise, wind loads shall be determined in accordance with ASCE 7 design criteria using input data specified by the Purchaser.

4.2.4.2 The maximum allowable deflection at the top tangent line of a vessel in the corroded condition shall not be greater than 6 inches per 100 feet (150 mm per 30 m) of vessel height.

4.2.4.3 Projected Area

1. The projected area of vessel accessories such as platforms, ladders, piping and other equipment attached to the vessel shall be considered in the wind load calculation.
2. If spoilers are to be added to a vessel, the column projected area normal to wind, and the corresponding force coefficient, for the column height where spoilers have been added, shall be used in the design of the vessel and supporting structure to calculate the overturning load.

4.2.4.4 Wind-Induced Vibration of Vertical Vessels

1. Vessels with an h/D ratio of 15 or greater shall be evaluated for dynamic behavior from wind excitation as described in *Dynamic Response of Tall Flexible Structures to Wind Loading* or by other similar proven evaluation methodology.
2. Vessels shall be evaluated for wind-induced vibration considering vortex shedding ranges described as follows:

   a. Lower Periodic Vortex Shedding Range

   If the Reynolds number is less than 300,000 and the Strouhal number is approximately 0.2, vibration because of periodic vortex shedding can occur with tall slender vessels that have very low fundamental frequencies.

   b. Random Vortex Shedding Range

   If the Reynolds number is between 300,000 and 3,500,000, random vortex shedding can occur. If the Strouhal number is approximately 0.2, the random vortex oscillations can lock-in and become periodic, causing the vessel to vibrate.

   c. Upper Periodic Vortex Shedding Range

   If the Reynolds number is above 3,500,000 and the Strouhal number is approximately 0.2, self-excited vibration can occur if

the natural frequency of the vessel corresponds with the frequency of vortex shedding.

3. If it is determined that a vessel can vibrate and the attributes of the vessel (e.g., normal attachments) cannot be changed to put the vessel in a range where vibration cannot occur, wind spoilers shall be added to the vessel in accordance with one of the following methods. The method used to deter wind-induced vibration shall be provided to the Purchaser.

   a. Helical Spoilers

      (1) A circumferentially equally spaced three-start system of spoilers in a helical pattern shall be provided on the top third of the vessel.

      (2) The exposed width of the spoilers beyond insulation shall be 0.1D and a pitch (i.e., the height of one helical wrap) of 5D, where D is the diameter of the top third of the vessel.

      (3) The spoiler system may be interrupted to provide clearance at vessel appendages.

   b. Short Vertical Spoilers

      (1) A three-start system of short vertical spoilers arranged in a helical pattern shall be provided on the top-third of the vessel.

      (2) The exposed width beyond insulation of the spoilers shall be 0.09D and the pitch (i.e., height of one helical wrap) between 5D and 11D.

      (3) A minimum of eight equal length spoilers shall be provided over the pitch distance (i.e., each complete helical wrap) and a minimum of 1.5 helical wraps over the top-third of the vessel.

      (4) The spoiler system may be interrupted to provide clearance at vessel appendages.

4.2.5 Seismic Loading

Seismic loads shall be determined in accordance with *ASCE 7* using design parameters provided or otherwise defined by the Purchaser.

4.2.6 Cyclic Loading

4.2.6.1 Fatigue Analysis

1. If Purchaser specifies that the vessel is in cyclic service, the rules in *Code* Section VIII, Division 2, Paragraph 4.1.1.4, shall be used as a basis for establishing further action.

2. A fatigue analysis shall always be performed for agitator mounting nozzles and their attachment to the vessel.

4.2.6.2 Agitator Installations on Formed Heads

If an agitator is to be mounted on a nozzle or studding outlet in a formed head, the head design shall be sufficient to provide the rigidity and stress levels appropriate for the associated dynamic loadings. The head design shall be agreed with the agitator supplier and Purchaser before the head is ordered.

4.2.6.3 Nozzle Reinforcement

1. Nozzles supporting agitators, pumps, or other mechanical equipment shall be suitably reinforced to withstand the mechanical loadings specified by the equipment manufacturer and approved by Purchaser.
2. Dynamic loading shall be evaluated for an infinite number of stress reversals using the applicable stress concentration factor as follows:
    a. 5 for as welded attachment welds
    b. 3.5 for contoured and blend ground nozzle attachment welds
3. Nozzle reinforcement for pressure relief devices shall be designed and reinforced for thrust reaction.
4. Gussets shall not be used to strengthen, stiffen, or reinforce nozzles, unless demonstrated by calculations to be suitable for the specified cyclic life or thermal condition, and the dimensional requirements (e.g., tolerances) of the device as furnished by the device manufacturer are considered.

4.2.7 Local Loading

4.2.7.1 If external loads are furnished by the Purchaser, the local membrane and surface stresses caused by local loads (e.g., piping loads, platform loads, etc.) shall be determined using the *WRC Bulletin 107, 297, 537* procedures, or other local stress analysis procedures approved by the Purchaser.

4.2.7.2 For local loads and pressure, the allowable stresses {5.2.2.4} are 1.5S for local primary membrane stress and 3S for primary membrane plus secondary bending stress at nozzles, platform lugs, etc., where S is the *Code*-allowable stress at the design temperature.

4.2.8 Shipping and Rigging Loadings

4.2.8.1 Transportation Loads

1. Vessels subject to transportation loadings shall be analyzed for the following conditions:
    a. Bending between supports
    b. General primary membrane tensile stress
    c. Compressive stress at supports and fixture attachment points
2. Calculated general primary membrane tensile stress shall not exceed that listed in Section 4.2.8.3.

3. Vessels shall be analyzed for actual vertical, lateral and longitudinal loadings as applicable.
4. Minimum acceleration loadings are shown in Table 1 for the various modes of transportation.
5. If erection loadings are greater than the transportation loadings, the vessel shall be designed for the most severe vertical, lateral and longitudinal loading condition.

Table 1 - Minimum Transportation Acceleration Loadings

Transportation Mode	Vertical Acceleration		Lateral Acceleration	Longitudinal Acceleration
	Downward	Upward		
Truck (Highway Speeds)	1.7g	0.5g	0.3g	1.8g
Truck (< 25 MPH or Multi-wheel Transporter)	1.3g	0.2g	0.2g	0.2g
Rail	2g	2g	2g	3g
Inland Barge	1g	0.2g	0.75g	0.4g
Oceangoing Ship or Barge	2g	2g	0.75g	0.4g

Notes:
1. If multiple modes of transportation are used, the most severe condition shall be used for evaluation.
2. 1.0g is a load equal to the weight of the vessel.

4.2.8.2 Impact Factor

1. A minimum impact factor of 2 shall be applied to the lift weight for the design of lifting devices.
2. The basis for the lift weight shall include all components to be included in the lift (e.g., trays, ladders/platforms, insulation, additional piping with insulation, etc.).

4.2.8.3 Lifting Stresses

For vertical vessels the following lifting stress calculations shall be performed:

a. Bending stresses in the vessel shell and skirt from the loadings imposed during the lift from the horizontal to vertical position shall be checked.

b. Calculated general primary membrane tensile stress shall not be greater than 80% of the material's specified minimum yield strength at 100ºF (38ºC).

c. Calculated compressive stress shall not be greater than 1.2 times the allowable compressive stress specified by the *Code* UG-23(b) {4.4.12}.

d. In some cases deflection is a concern and shall be evaluated.

4.2.8.4 Local Stresses

1. Local stresses in the vessel shell/head/skirt/base rings from lifting attachments (e.g., lugs, trunnions, etc.) shall be determined for the imposed loadings using *WRC Bulletins 107 , 297, or 537* procedures, or other accepted local stress analysis procedures (e.g., finite element analysis).
2. For the rigging condition, the allowable stresses specified in Section 4.2.7.2 {4.15.5} shall be used.

4.2.8.5 Welds

Shear stresses for fillet welds on the lifting attachments to the vessel shell or head shall not be greater than 0.55 times the *Code*-allowable stress at 100ºF (38ºC) for the material selected.

4.2.9 Nozzles and Manways

4.2.9.1 Nozzles and manways shall be integrally reinforced if any of the following conditions apply:

a. If located in vessel shell greater than 2 inches (50 mm) thick
b. Cyclic service is the controlling design consideration for the vessel
c. Maximum design metal temperature is warmer than 750°F (400ºC)
d. Radial nozzles are within the scope of *Code* Paragraph 1-7(b)
e. Radiography is required on nozzles or manway connections to the shell or head

4.2.9.2 Minimum nozzle neck thickness for carbon steel and low alloy steel nozzles shall be in accordance with *Code* Paragraph UG-45 {4.5.4}, except that the nominal thickness selected for nozzle necks smaller than or equal to NPS 3 (DN 80) shall not be less than Schedule 80.

4.2.9.3 Minimum nozzle neck thickness for high-alloy and non-ferrous alloy nozzles shall be in accordance with *Code* Paragraph UG-45 {4.5.4}, except that the nominal thickness selected for nozzle necks smaller than or equal to NPS 3 (DN 80) shall not be less than Schedule 40S.

4.2.9.4 Surface-attached nozzles in accordance with *Code* Figures UW-16.1(a), (a-1), (a-2), (a-3), and (b) {Table 4.2.10, Detail 1 and 2}, and those with internal reinforcing pads, shall not be permitted.

4.2.10 Custom-Designed Flanges

4.2.10.1 For recommended minimum gasket contact widths see Table 2.

Table 2 - Recommended Minimum Gasket Contact Widths

Flange ID inches (mm)	Gasket Contact Width inches (mm)
≤ 36 (900)	1 (25)
36 (900) < OD ≤ 60 (1500)	1-1/4 (32)
OD > 60 (1500)	1-1/2 (38)

Notes:

1. Gasket Contact Width is the recommended minimum width of the gasket in contact with both flange faces.
2. For 3-ply corrugated metal gaskets, the gasket OD shall be a minimum of 1/4 inch (6 mm) less than the raised face or lap ring OD.
3. See Section 4.2.10.10.d.

4.2.10.2 Flanges shall be designed not only for the design pressure, but also for other loadings specified by Purchaser in the contract documents, and applied to the joints during the project life (e.g., externally applied bending moment and axial thrust loadings).

4.2.10.3 Flange thickness shall be selected so that, considering all loadings that will be applied, the Rigidity Index as defined in *Code* paragraph 2-14 {Table 4.16.10} is less than or equal to 1.0, based on the recommended value of KL of 0.2 or K1 of 0.3, as applicable.

4.2.10.4 If specified by the Purchaser, flanges and their pressure-retaining covers for manways may be custom-designed, with consideration being given to providing a Rigidity Index in accordance with the recommendations in *Code* paragraph 2-14 {Table 4.16.10}.

4.2.10.5 Flange bolt diameters shall not be less than 3/4 inch (19 mm) nominal diameter.

4.2.10.6 Flange bolt hole diameters shall be 1/8 inch (3 mm) greater than the diameter of the bolts.

4.2.10.7 Unless otherwise approved by Purchaser, nubbins shall not be permitted.

4.2.10.8 The design of custom flanges shall include the effect of bolt spacing in accordance with the following:

1. Maximum bolt spacing $= 2a + \dfrac{6t}{m + 0.5}$
2. If bolt spacing is greater than (2a + t), the design moment (M_O) acting on the flange shall be multiplied by $\sqrt{\dfrac{B_S}{2a + t}}$

where: M_O, and m are as defined in *Code* Appendix 2, Paragraph 2-3;
a = nominal bolt diameter, inches (mm)
B_S = actual bolt spacing, inches (mm)

t = minimum finished flange thickness, exclusive of corrosion allowance, inches (mm)

4.2.10.9 Indicator-Type Bolting

1. If specified on Purchaser's *PIP VEDV1003-D* Data Sheet, Part D, line 23 for high bolt-load control accuracy during initial assembly and during operation at temperature, flanged joints with 2-inch (50 mm) diameter and greater bolting shall be provided with bolts having an indicator rod through the bolt center for measuring installed bolt elongation using a depth gauge.
2. Indicator-type bolts shall be purchased in accordance with *ASME PCC-1,* Figure 1 or Figure 2, as applicable.
3. Except as specified in Section 4.2.10.9.4, every bolt in the joint assembly shall be an indicator-type bolt.
4. If hydraulic tensioners are used, and unless otherwise specified on Purchaser's *PIP VEDV1003-D* Data Sheet, indicator-type bolts for every fourth bolt is recommended in the joint assembly for calibration purposes during initial assembly and for bolt-load control during operation at temperature.
5. The indicator rod material for low-alloy steel bolting shall be nickel alloy C-276.
6. The indicator rod for bolting materials other than low-alloy steel shall be the same as the bolts or a material having essentially the same coefficient of expansion and a composition suitable for welding to the bolts.
7. All bolts in the joint assembly shall have a through-hardened flat washer under each nut.

4.2.10.10 Custom-Designed Lap Joint Flanges

Unless otherwise specified in the contract documents, custom-designed lap joint flanges shall be provided in accordance with the following:

a. The minimum required radial lap width shall be in accordance with Table 3.

Table 3 - Minimum Radial Lap Width

Nozzle Vessel OD, inches (mm)	Radial Lap Width, inches (mm)
OD ≤ 18 (450)	1 (25)
18 (450) < OD ≤ 36 (900)	1-1/2 (38)
36 (900) < OD ≤ 60 (1500)	1-3/4 (44)
OD > 60 (1500)	2 (50)

Notes:
1. Radial lap width shall be measured from the toe of the lap-to-shell attachment weld to the outer edge of the lap ring.
2. See Section 4.2.10.10.d.

b. See Table 2 for the recommended minimum gasket contact width.

c. Finished lap ring thickness shall be a minimum of 3/16 inch (5 mm) greater than the nominal wall thickness of the nozzle or shell to which the ring is attached.

d. If the values in the Table 2 and Table 3 are waived by the Purchaser, the gasket/lap/flange design shall be configured so that the gasket load reaction on the lap (defined as "G" in *Code* Appendix 2 {4.16.12}) is as close as practicable to being coincident with the reaction of the flange against the back of the lap, taken at the midpoint of contact between the flange and lap.

e. The difference between the lap joint flange inside diameter and the shell outside diameter shall not be greater than the following:

(1) 1/16 inch (1.5 mm) for nominal nozzle diameters less than or equal to NPS 12 (DN 300)

(2) 1/8 inch (3 mm) for nominal nozzle diameters greater than NPS 12 (DN 300) through 48 inches (1200 mm) outside diameter

(3) 3/16 inch (5 mm) for nominal nozzle diameters greater than 48 inches (1200 mm) outside diameter

f. The lap ring weld and flange bevel shall be configured as follows:

(1) The weld attaching the lap ring to the shell shall be an equal leg fillet weld. The fillet weld leg dimension shall be equal to the nominal shell thickness with a tolerance of +1/16 inch (+1.5 mm) and -0.

(2) The difference between the diameter of the flange bevel where the lap ring contacts the surface of the flange and the nominal diameter at the toe of the lap ring attachment weld at the back of the lap ring shall be 1/8 inch (3 mm) with a tolerance of +1/16 inch (+1.5 mm) and -0.

g. The distance between the inside edge of the bolt hole in the lap joint flange and the outside diameter of the lap ring shall not be greater than 1/16 inch (1.5 mm).

h. The nominal outside diameter of shop-fabricated laps shall be in accordance with *ASME B16.9* standard diameters if used with ASME standard flanges.

4.2.10.11 Swing Bolt Closures

Swing Bolt closures shall be in accordance with the following:

a. Swing bolts (i.e., eye bolts) shall be of one-piece construction without welding.

b. Hinge pins shall be solid (i.e., not rolled) and of the same material as the swing bolts.

4.2.11 Supports

4.2.11.1 General

1. *Code*-allowable stresses shall be used for vessels and their supports. For combinations of earthquake or wind loadings with other loadings listed in *Code* Paragraph UG-22 {4.1.5.3}, the allowable stresses may be increased in accordance with *Code* Paragraph UG-23(d) {Table 4.1.2}. See Section 4.2.3.2 for load combinations to be considered. See also *Code* Appendix G {4.15}.
2. For structural-shape support members in compression, if slenderness ratio is a controlling design consideration, an increase in the allowable compressive stress shall not be applied.
3. For supports outside the scope of the *Code*, either *Code*-allowable stresses or, for structural shapes, those in the *AISC* Manual of Steel Construction may be used.
4. Localized shell and support stresses at all support-to-shell locations shall be considered, as applicable, for wind load, earthquake, and all other loadings in accordance with *Code* Paragraph UG-22 {4.1.5.3}. See Sections 4.2.4 and 4.2.5.
5. If reinforcing pads are used under supports, consideration shall be given to stresses caused by possible temperature differentials among the vessel, pads, and supports.
6. Unless otherwise specified, vertical vessels shall be designed as self-supporting units and shall resist overturning from wind or earthquake loadings (see Sections 4.2.4 and 4.2.5) and other applicable loadings in accordance with *Code* Paragraph UG-22 {4.1.5.3}.

4.2.11.2 Skirt Supports

1. Vessel skirts shall have a minimum thickness of ¼ inch (6 mm).
2. Skirt Construction
   a. See Purchaser's *PIP VESV1003-D* Data Sheet, Part C, for the required standard skirt attachment detail shown on *PIP VEFV1128*. Skirts shall be attached by a continuous weld sized so as to provide for the maximum imposed loadings.
   b. All butt weld joints within the skirt shall be Type No. 1 in accordance with *Code* Table UW-12 {Table 4.2.2}.
   c. Alignment tolerance at plate edges to be butt-welded shall be in accordance with *Code* Paragraph UW-33 {Paragraph 6.1.4.3}.
   d. Skirt-to-base ring attachments in vessel skirts shall in accordance with *VEFV1107* through *VEFV1110*.
3. Skirts shall be vented with a minimum of two, 2-inch (50 mm) openings, located near the top of the skirt, but below the head insulation or fireproofing.

4. Skirt Sleeves

   a. All skirt openings shall be provided with rings or collars in accordance with VEFV1134 and sized to provide 100% reinforcement of the opening.

   b. If the skirt is to be provided with insulation or fireproofing, the projection of the rings or collars (i.e., sleeves) shall not be less than the insulation or fireproofing thickness.

   c. Sleeves shall be of sufficient size to provide clearance for insulation and expansion.

   d. Sleeve material shall be the same material composition as that portion of the skirt and shall be continuously fillet-welded inside and outside.

4.2.11.3 Saddle Supports

1. Horizontal vessels shall be designed for two saddle supports attached by welding. See *VEFV1105/M* and *VEFV1106/M* for saddle configuration guidance.
2. Saddles shall be designed in accordance with the applicable loadings, including those to be used in conjunction with weigh cells or slide plates.
3. One saddle shall be fixed and the other allowed to slide to accommodate thermal expansion. The fixed saddle will be selected to minimize the vessel nozzle loads and movements imposed on the attached piping.
4. Design of saddle supports and calculation of localized shell stress shall be determined by a recognized analytical method such as the L. P. Zick *Stresses in Large Cylindrical Pressure Vessels on Two Saddle Supports*. See *Code* Appendix G {4.15.3}.
5. The minimum saddle support contact angle shall be 120 degrees.
6. Saddle Wear Plates

   a. Saddle wear plates, if required, shall have the following proportions:

      (1) Plate thickness shall be determined by design, but shall not be less than the smaller of vessel shell thickness or 6 mm (1/4 inch)

      (2) Plate width shall be the width of the saddle plus 5t on each side of the saddle, where t equals the vessel shell thickness in the corroded condition

      (3) Plate extension beyond the horn of the saddle shall be equal to r/10, where r equals the radius of the vessel shell in the corroded condition

   b. Wear plates shall have a minimum radius of 2 inches (50 mm) on the corners.

c. Wear plates shall be continuously welded to the shell.

d. Wear plates shall be provided with one 1/4 inch (6 mm) drilled telltale hole (or equivalent venting) per segment, and shall be vented.

e. Vent holes shall be located at the low point of the wear plate and shall not be plugged during hydrostatic testing.

7. Fixed Saddles

a. The fixed saddle, as designated by the Purchaser in the contract documents, shall be provided with round holes for the anchor bolts.

b. The anchor bolts are to be located at the center of the bolt holes.

c. The diameter of the bolt holes shall be 1/4 inch (6 mm) greater than the bolt diameter.

8. Sliding Saddles

a. The sliding saddle, as designated by the Purchaser in the contract documents, shall be provided with slotted holes for the anchor bolts.

b. The anchor bolts are to be located in the slot to accommodate the calculated movements.

c. The width of the slot shall be 1/4 inch (6 mm) greater than the bolt diameter.

d. The length of the slot shall be calculated using the following equation:

Slot length = $2.5\alpha(D_L)\Delta T$

where:

α = Coefficient of thermal expansion of shell material, inch/inch/°F (mm/mm/°C)

D_L = Length between saddle supports, measured to centerline of anchor bolts, inches (mm)

ΔT = Greatest absolute value of: ambient temperature at installation, but not warmer than 70°F (20°C), minus the maximum or minimum shell temperature to be stamped on the *Code* nameplate, °F (°C).

9. Slide Plates

When required slide plates shall be furnished and installed by Purchaser.

4.2.12 Anchor Bolts

4.2.12.1 Anchor bolting shall be furnished and installed by the Purchaser.

4.2.12.2 Anchor bolt loads, the size and quantity of anchor bolts, and base plate details shall be determined. The anchor bolt loads shall be provided to the Purchaser.

4.2.12.3 The allowable tensile design stress, as calculated using the tensile stress area of the threaded portion, shall not be greater than the following:

a. For carbon steel or stainless steel, 20,000 psi (138 MPa)

b. For low-alloy steel, 30,000 psi (207 MPa)

4.2.12.4 Allowable stresses used in the final design for anchor bolts shall be approved by the Purchaser.

4.2.12.5 Anchor bolts shall be specified with the following threads and the tensile stress area shall be selected accordingly:

a. For bolts 1 inch (25 mm) and less in diameter, coarse thread series, ASME B1.1

b. For bolts greater than 1 inch (25 mm) in diameter, 8 thread series, ASME B1.1

4.2.12.6 Unless otherwise specified, for vessels on concrete foundations, the design concrete bearing stress used shall be 1658 psi (11.4 MPa).

4.2.12.7 The design loadings for anchor bolts embedded in concrete shall be determined by either the simplified method (i.e., neutral axis of bolt pattern at centerline of vessel) or the shifted neutral axis method in accordance with *Process Equipment Design*. The method used shall be specified on the Purchaser's *PIP VEDV1003-D* Data Sheet.

Comment: The shifted-neutral-axis method does not apply for vessels supported by steel structures.

4.2.12.8 Anchor bolts for vessels shall not be less than 3/4 inch (19 mm).

4.2.12.9 Anchor bolts shall straddle normal centerlines.

4.2.12.10 If low-alloy steel bolting is required, the anchor bolt circle shall provide radial clearance for a bolt tensioning device.

4.2.13 Internals

4.2.13.1 Vessel internals constructed of alloy pipe shall have the following minimum wall thicknesses:

a. For pipe sizes smaller than or equal to NPS 12 (DN 300), Schedule 10S minimum

b. For pipe larger than NPS 12 (DN 300), 3/16 inch (5 mm) minimum nominal wall pipe or fabricate from plate

4.2.13.2 Unless otherwise specified on Purchaser's *PIP VEDV1003-D* Data Sheet, the material for internal attachments shall be the same nominal

composition as the cladding, weld overlay, or shell to which it is attached.

4.2.13.3 Verify that all removable internals can pass through designated vessel openings.

4.2.13.4 For vertical vessels with internals, if a vessel manway is not located in the top head, internal rigging clips shall be provided to facilitate handling of the internals.

4.2.13.5 Grab rungs, if specified on Purchaser's *PIP VEDV1003-D* Data Sheet, shall be in accordance with *PIP VEFV1125*.

4.2.13.6 Internal piping and baffles shall be mounted in a manner that cannot restrict thermal expansion.

4.2.13.7 If Purchaser's *PIP VEDV1003-D* Data Sheet specifies that the vessel is subject to vibration and/or fatigue, internal welded non-pressure parts (e.g., baffles that can be subject to vibration or cyclic loading) shall be attached with continuous full penetration welds.

4.2.13.8 If specified on Purchaser's *PIP VEDV1003-D* Data Sheet, internal bolting in vessels, especially where vibration is expected (e.g., where agitators are installed), shall either be double-nutted, tack-welded to the clip or baffle, or have a lock wire placed in the nut/bolt or other supports.

4.2.13.9 Flanges for internal non-pressure piping may be fabricated from plate but shall be in accordance with ASME B16.5 and B16.47 Class 150 bolting patterns.

4.2.13.10 Vessel internals and all portions of each vessel shall be self-draining to ensure complete elimination of liquid from the vessel when drained.

4.2.13.11 The minimum thickness of internal welded-in parts shall be 3/16 inch (5 mm) plus the corrosion allowance for each wetted side.

4.2.13.12 Internal support rings shall not be considered for vessel strength calculations.

4.2.13.13 All internal feed piping including piping supports shall be furnished and installed according to the tray manufacturer's designs and/or recommendations.

4.2.14 Attachments

4.2.14.1 All attachments welded to pressure-retaining vessel components shall be considered critical to the structural integrity of the vessel for evaluation of impact test requirements. See *Code* Paragraph UCS-66(a) {3.11.2.3c}.

4.2.14.2 For the purpose of establishing impact test requirements for carbon and low-alloy steel attachments welded to pressure-retaining components, the level of applied general primary membrane stress shall be considered to be the same as the maximum level applied to the pressure boundary component to which they are attached.

4.2.14.3 Unless otherwise specified, all clips, brackets, and other items welded to the outside surface of the vessel or skirt shall be provided and installed, including the following:

a. Manufacturer's nameplate configured as follows:

(1) Made either of 300 series stainless steel or of a nickel-copper alloy UNS N04400 or equivalent (i.e, Monel®)

(2) Attached securely using a nameplate support bracket in accordance with detail *PIP VEFV1101*.

b. Lifting attachments, as designed by the Manufacturer or as specified by Purchaser

c. For vessel shells under external pressure, *Code*-required stiffening rings placed on the outside of the vessel and configured as follows:

(1) Minimum thickness, 3/8 inch (10 mm)

(2) Maximum ring width-to-thickness ratio, 10

(3) Made from a structural form that cannot trap and hold water

(4) Drains or gaps may be provided if necessary to prevent water from collecting.

(5) Attached by continuous fillet welds on both sides of the ring

d. Grounding lug in accordance with detail *PIP VEFV1103*

4.3 Materials

4.3.1 All impact test values shall be reported in the material supplier's certified test reports.

4.3.2 Except for flanges in accordance with *ASME B16.5* and *B16.47,* all carbon, low-alloy, and high-alloy steel forgings greater than 3 inches (75 mm) in thickness shall be examined ultrasonically in accordance with *ASME SA-745* with the following requirements:

a. Quality levels for straight beam examinations from flat surfaces shall be in accordance with Table 4.

Table 4 - Quality Levels for Straight Beam Examinations from Flat Surfaces

FORGING THICKNESS (t)	QUALITY
Inches (mm)	LEVEL
3 (75) < $t \leq$ 8 (200)	QL-2
8 (200) < $t \leq$ 12 (300)	QL-3
t >12 (300)	QL-4

b. Quality level for straight beam examinations from curved surfaces shall be QL-5.

c. Quality level for all angle beam examinations shall be QA-1. Notch depth shall be in accordance with QA-1 or 1/4 inch (6 mm), whichever is less.

4.3.3 Integrally clad plate for vessels designed for vacuum service and for vessels whose design calculations include the cladding shall be examined in accordance with *ASME SA-578* Acceptance Standard - Level B and Supplementary Requirement S6.

4.3.4 The heat treatment of integrally clad plate in accordance with *ASME SA-263*, *ASME SA-264*, and *ASME SA-265* shall be performed by the plate manufacturer.

4.3.5 All integrally clad plate, including explosion clad plate, in accordance with *ASME SA-263*, *ASME SA-264*, and *ASME SA-265* shall be cold flattened, if required, after final heat treatment and descaling.

4.3.6 Except for blind flanges in accordance with *ASME B16.5* and *B16.47,* rolled carbon, low-alloy, and high-alloy steel plate for flat covers and blind flanges greater than 3 inches (75 mm) thick shall be examined in accordance with *ASME SA-578* Acceptance Standard - Level B after cutting to final size.

4.3.7 As an alternative to the materials specified by the Purchaser, other materials may be proposed for the attachments with consideration given to the following:

a. Potential problems associated with welding dissimilar materials

b. Compatibility with the Code nameplate maximum and minimum design metal temperatures

c. Whether the attachment is essential to the structural integrity of the vessel. See Code Paragraph UCS-66(a) {3.11.2.3c}.

d. Differential thermal expansion characteristics and associated stresses

e. Corrosion resistance

f. Painting requirements

g. Suitability for the anticipated loadings

4.3.8 Gaskets specified by Purchaser shall be provided. For test gaskets, see Section 4.5.3.7. For spare gaskets, see Section 4.6.2.3.

4.4 Fabrication

4.4.1 General

4.4.1.1 All equipment shall be in accordance with the manufacturing tolerances shown in the contract documents.

4.4.1.2 Tolerances on fabricated equipment shown on detail *PIP VEFV1102* shall apply to the completed vessel after pressure test.

4.4.1.3 Machining shall be performed after welding or heat treatment if such operations change machined surface characteristics or geometry (e.g., flange face flatness).

4.4.1.4 When forming any austenitic stainless or nonferrous plate, care shall be taken to prevent carbon pickup or contamination of formed material.

4.4.1.5 Only stainless steel brushes and clean, iron-free sand, ceramic or stainless steel grit shall be used for cleaning stainless steel and non-

ferrous surfaces. Cleaning tools or materials shall not have been previously used on carbon steel.

4.4.1.6 Unless otherwise specified, cutting stainless steel shall be performed by mechanical methods (i.e., shearing, sawing, or machining).

4.4.1.7 If cutting stainless steel by any thermal process (e.g., plasma arc or air arc) is approved by Purchaser, an allowance shall be made for the removal of not less than 1/8 inch (3 mm) of metal [e.g., ¼ inch (6 mm) in the diameter of an opening] by machining or grinding to the finished dimension.

4.4.1.8 Special care shall be taken to prevent stress raisers which can cause low impact strength because of notch effect or abrupt change in section.

4.4.1.9 Welder's and welding operator's symbols and reference lines may be stamped on the material in accordance with the provisions of *Code* Paragraph UW-37 {6.2.5.4}, provided that a round-nose stamp is employed and the symbol is located a minimum of 1 inch (25 mm) from the edge of the weld.

4.4.1.10 Materials that can cause corrosive attack when the vessel part is heated shall not be permitted. Such materials include the following:

a. Marking inks that contain halogens
b. Lubricants
c. Crayons
d. Adhesives
e. Tapes (e.g., duct tape)
f. Coatings to prevent adhesion of weld spatter
g. Paints containing sulfur
h. Chlorine compounds that decompose to hydrogen chloride
i. Carbon
j. Harmful metal or metal salts (e.g., zinc, lead, or copper)

4.4.2 Shells and Heads

4.4.2.1 Longitudinal joints of adjacent shell courses (including skirts) shall have a minimum offset of not less than 5 times the plate thickness or 6 inches (150 mm), whichever is greater.

4.4.2.2 Plate layouts shall be arranged so that longitudinal and circumferential weld seams clear all nozzles, manways, and their reinforcing pads by 2 inches (50 mm) minimum, measured from weld edge to weld edge.

4.4.2.3 If the requirement of Sections 4.4.2.1 and 4.4.2.2 cannot be met, the following shall apply:

a. Subject seam shall be ground flush and 100% radiographically examined before welding the nozzle.

b. Nozzles which intersect weld seams shall be located such that their centerline falls approximately on the centerline of the weld seam.

c. The seam shall be radiographed in accordance with *Code* Paragraph UW-51 {4.2.5, 7.5.3} in accordance with *Code* Paragraph UW-14 {7.4.3.5 a) 4)}.

4.4.2.4 Unless otherwise approved by Purchaser, the longitudinal seams shall not fall within the downcomer area of trays or behind any obstruction that prevents inspection of the welds.

4.4.2.5 Circumferential seams shall not fall on a tray ring, and shall be located not less than 2 inches (50 mm) above or below the tray ring.

4.4.2.6 Saddles

1. Saddles shall be continuously welded to the shell.
2. Welded seams under the saddle or wear plate are not permitted.
3. Longitudinal weld seams in the shell shall not be located within 15 degrees of the horn of the saddle, because this is a location of high stress.

4.4.2.7 Seams in Formed Heads

1. The flat plate from which formed heads are made shall be either seamless or made equivalent to seamless in which all Category A welds are Type (1) and fully radiographed in accordance with *Code* Paragraph UW-51{7.5.3} before forming.
2. Before forming, welds shall be ground flush with the plate surfaces.
3. After forming, the spin hole, if it remains in the final construction, shall be repaired with a metal plug butt-welded in place. The weld shall be in accordance with the Category A weld joint requirements.

4.4.2.8 Structural Attachment Welds

1. Structural attachment welds (e.g., internal support rings or clips, external stiffening rings, insulation support rings, and ladder, platform or pipe support clips) shall clear weld seams by a minimum of 2 inches (50 mm).
2. If overlap of pad type structural attachments and weld seams is unavoidable, the portion of the seam to be covered shall be ground flush and 100 percent radiographically examined before the attachment is welded on.
3. The seam shall be radiographed in accordance with *Code* Paragraph UW-51 {7.5.3} for a minimum distance of 2 inches (50 mm) beyond the edge of the overlapping attachment.
4. Radiographic examination of weld seams is not required if single-plate edge-type attachments (e.g., tray support rings, downcomer bolting bars, stiffening rings, insulation support rings, ladder, platform, or pipe support clips) cross weld seams.
5. External attachments shall be coped to clear main seams

4.4.3 Nozzles, Manways, and Flanges

4.4.3.1 Bolt holes in all fixed flanges and studding outlets shall straddle the natural centerlines.

4.4.3.2 For nozzles in heads, the bolt holes shall straddle centerlines parallel to or coincident with the natural vessel centerlines.

4.4.3.3 All inside nozzle neck edges shall be rounded to 1/8 inch (3 mm) minimum radius.

4.4.3.4 Nozzles for pressure relief devices and for drainage shall be flush with the inside wall of the shell or head.

4.4.3.5 Flanges shall be ASME B16.5 or ASME B16.47 or be designed in accordance with Code Appendix 2 {4.16}. Applied loadings shall be evaluated in accordance with Appendix A.

4.4.3.6 Nozzle reinforcing pads shall be external.

4.4.3.7 If multi-segmental reinforcing pad elements are used, the weld between segments shall be a Type 1 or Type 2 full penetration butt weld, and the joint efficiency of the pad as applied to the allowable stress of the pad material, Sp, shall be not be greater than one of the following as applicable:

a. If the weld is not radiographed or UT examined, 0.65

b. If the weld is 100% radiographed or alternatively UT examined, 0.90

c. If the weld is not less than 60 degrees from the longitudinal axis of the vessel the following joint efficiencies may be used as applicable:

(1) For 100% radiography, 1.0

(2) For spot radiography, 0.85

(3) For no radiography, 0.70

4.4.3.8 Each pad segment shall have one American Standard Taper Pipe Thread (NPT) 1/4 inch (6 mm) telltale hole for testing purposes. See Section 4.5.3.4 for testing of reinforcing pads. Each hole shall be located near the lowest point of a pad with the vessel in its operating position to permit drainage.

4.4.3.9 If not circular, nozzle reinforcing pads and attachment pads shall have rounded corners of 2 inches (50 mm) minimum radius.

4.4.3.10 Nozzles in dished heads shall be positioned such that the nozzle, reinforcing pads, and attachment welds, if applicable, are within the spherical portion of the head.

4.4.3.11 Flanges shall not be located inside the vessel skirt.

4.4.3.12 Unless projections are otherwise specified by Purchaser, when establishing nozzle and manway projections, the following shall apply:

a. Clearance shall be provided for removing flange stud bolts from between the flange and vessel and for accessing flange stud nuts.

b. Clearance shall be provided for flange studs and nuts if nozzles penetrate insulation or platforms.

c. Minimum projection from the outside of the vessel wall to the nozzle face shall be:

(1) For nozzles less than or equal to NPS 8 (DN 200), 8 inches (200 mm)

(2) For nozzles larger than NPS 8 (DN 200), 10 inches (250 mm)

d. The dimension from the face of the nozzle to the vessel centerline or reference line shall be rounded up to the next greater 1/2-inch (10 mm) increment.

4.4.3.13 For lap joint flanges NPS 4 (DN 100) and larger that face upward (i.e., the nozzle inclines from the horizontal at an angle of 30 degrees or greater), safety retainer clips shall be provided as follows:

a. A minimum of three equally spaced clips shall be welded to the nozzle neck at the back of the flanges.

b. The spacing of the clips between the back of the lap and the face of the flange shall be one length-through-hub dimension (i.e., dimension Y in *ASME B16.5*).

4.4.3.14 Except for lapped flanges and Purchaser specified facings (such as flat-face flanges or ring joint facings), flanges shall be raised face. Measurement shall be made using a dial indicator after all other operations (i.e., fabrication and heat treatment of the flange or lap ring, and attachment to the shell or nozzle neck) that can affect flatness tolerance have been completed.

4.4.3.15 Flange Facing and Surface Finish

1. Except for lapped flanges and Purchaser specified facings (such as flat-face flanges or ring joint facings), flanges shall have one of the following configurations:

a. Raised face

b. If required in accordance with Section 4.4.3.14.4, a construction that provides outer confinement to the gasket

2. The height of a raised face shall be one of the following as specified on Purchaser's *PIP VEDV1003-D* Data Sheet:

b. In accordance with *ASME B16.5*

c. In accordance with *ASME B16.47*

d. As specified by Purchaser

3. For standard flanges, custom flanges, and shop-fabricated and manufactured lap joint stub ends, the gasket contact surface shall have either a serrated concentric or serrated spiral finish suitable for the gasket

4. Gasketed flange joint designs (i.e., body flange and nozzle joints) larger than NPS 24 (DN 600) shall provide outer confinement of the gasket for any of the following conditions:
   a. Design pressure is equal to or greater than 300 psi (2 MPa)
   b. Design temperature is warmer than 500°F (260°C)
   c. MDMT is colder than minus 20°F (-29°C)
   d. Cyclic pressure or temperature service
   e. Joint requires metallic gasket
5. Gasketed flange joint designs (i.e., body flange and nozzle joints) larger than NPS 24 (DN 600) utilizing robust metal reinforced gaskets (e.g., spiral-wound with outer gauge ring, grooved metal covered layer, double-jacketed corrugated metal gaskets with a corrugated metal filler, etc.) do not require gasket confinement.

4.4.3.16 For corrosive service, the use of splice welds on gasket contact surfaces of a lap ring or flange shall be approved by Purchaser.

4.4.3.17 Joints shall be assembled in accordance with *ASME PCC-1*.

4.4.3.18 Hardened washers shall be provided under nuts for all bolts having diameters of 1-1/4 inches (32 mm) or larger to prevent damaging the back side of the flange. The washers shall be a minimum of 1/4 inch (6 mm) thick.

4.4.3.19 If studded connections are used, the following shall apply:

a. The holes in a studded connection and the studs shall be machined in accordance with *PIP VEFV1129*.
b. Indicator type studs for studded connections, if used, shall be in accordance with *ASME PCC-1* Figures 1 and 2.
c. A spacer ring of the same material as the nozzle flange may be provided behind the flange to increase the effective stud length. See note on *PIP VEFV1129*.
d. If a spacer ring is used, the thickness of the ring shall be equal to or greater than the mating flange thickness.
e. Studs and spacer ring, if required, shall be provided for each studded connection on the vessel.
f. Studded connections shall be checked to assure the remaining thickness of the drilled holes is in accordance with *Code* UG-43(d){4.5.3.1 b)}.

4.4.4 Vessel Attachments

4.4.4.1 For vessel attachments the following shall apply:

1. Welding of vessel internals attached to a pressure boundary component shall be continuous on all surfaces to eliminate corrosion pockets.

2. All seams and corner joints shall be sealed. Support ring welds shall be continuous on top and intermittent on the bottom as a minimum.
3. If a vessel corrosion allowance is specified, the size of welds shall include allowance for corrosion.
4. Minimum weld size shall be 3/16 inch (5mm) in the corroded condition.

4.4.4.2 Except as permitted in Section 4.4.4.3, all external supports, support rings, pads, and structural brackets attached to the vessel shall be seal-welded all around to prevent corrosion between the vessel and attachments.

4.4.4.3 If seal welding all around an external attachment is not practical, provision for drainage shall be made (e.g., a gap in the low-point weld).

4.4.4.4 Temporary Welded Attachments

1. Attachment point of spiders, braces, or other temporary attachments used in fabrication shall be of the same material alloy as the point on the vessel to which it is attached.
2. All temporary attachments shall be removed before hydrostatic testing.
3. Temporary attachments shall be removed flush with the vessel shell and nondestructively examined [i.e., Magnetic Particle Examination (MT) or Dye Penetrant Examination (PT)], in addition to visual examination, to ensure no cracks have been generated.
4. Temporary welds shall be in accordance with Section 4.4.5.4.

4.4.4.5 Galvanized clips or attachments shall not be welded to a vessel.

4.4.4.6 For half-pipe jackets or pipe sections welded to shells and/or heads, jacket to shell welds shall be full penetration and full strength welds, and 100% liquid penetrant examination shall be performed.

4.4.4.7 For integrally clad and weld overlayed vessels, attachments shall be in accordance with the following:

If an attachment (e.g., packing bed support rings) supports a significant load (e.g., greater than 25% of the allowable stress for fillet welds), the support shall be welded directly to the base metal. The attachment material exposed to the process should have the same nominal compostion of the lined surface.

4.4.5 Welding

4.4.5.2 The selected welded pressure joint requirements shall be consistent with service-specific needs; however, the following shall apply as a minimum:

a. Welded joints of Categories A, B, and, if used, butt-type Categories C and D shall be Type No. 1 of *Code* Table UW-12 {Table 4.2.2}.
b. Non-butt joints that connect nozzles including manways and couplings to the vessel wall (i.e., *Code* Category D joints) shall be

full penetration welds through the vessel wall and through the inside edge of reinforcing plates, if used.

c. Nozzle necks that extend beyond the inside surface of the vessel wall shall have a fillet weld at the inside corner.

d. For compartmented vessels having a flanged and dished intermediate head(s), the end of the intermediate head skirt(s) shall be seal-welded to the shell of the compartment. See *Code* Fig. UW-13.1 (e){Table 4.2.5 detail 6}.

4.4.5.3 The responsibility for welding shall be part of the overall construction responsibility of the Manufacturer.

4.4.5.4 All welds, including those for non-pressure parts and attachments, including temporary attachments and shipping attachments, shall be made by welders, welding operators, and welding procedures qualified under the provisions of *Code* Section IX.

4.4.5.5 Welds shall be in accordance with the supplementary provisions of the *Code,* and with recognized and generally accepted good welding practices including, but not limited to, the use of clean and dry materials, good techniques, and the proper chemistry.

4.4.5.6 Unless otherwise specified, the welding consumables used in the fabrication of the vessel and its components shall be of the same nominal chemistry as the base metal, and shall have material properties (e.g., tensile strength, yield strength, etc.) equal to or greater than the minimum requirements for the base metal at both ambient and design temperature.

4.4.5.7 Shielded metal arc electrodes used for pressure-retaining welds shall be of the low-hydrogen type.

4.4.5.8 Unless specifically approved in writing by Purchaser, use of weld materials with strengths higher than that of low-hydrogen weld materials for any welding processes is not permitted.

4.4.5.9 The following documents shall be provided to the Purchaser for review and approval before the start of fabrication:

a. Welding Procedure Specification

b. Procedure Qualification Record

c. Welder Performance Qualification

d. Detailed weld map

e. Welding procedures

f. Fabrication drawings

4.4.5.10 The detailed weld map shall include, as a minimum, a sketch of all weld joints, welding symbols used in accordance with *AWS A2.4*, and associated weld procedure numbers.

4.4.5.11 Pressure retaining butt-weld seams shall be in accordance with the following:

a. Type No. 1 of *Code* Table UW-12 {Table 4.2.2} (i.e., butt joints as attained by double-welding or by other means that obtain the same quality of deposited weld metal on the inside and outside weld surfaces in accordance with *Code* Paragraph UW-35 {6.2.4.1}).

b. Welds using permanent metal backing strips are not permitted.

c. Butt-weld seams shall be accessible for examination, inspection, and/or repair with welded attachments in place.

d. For joints inaccessible from the inside, an alternative method for obtaining a full penetration and full fusion weld from one side shall be submitted to Purchaser for review and approval.

4.4.5.12 Except as specified in Section 4.4.5.13, Gas Metal Arc Welding (GMAW) shall be used only in the spray transfer range.

4.4.5.13 The GMAW short arc transfer mode may be used for carbon steel materials less than or equal to 3/16 inch (5 mm) thick and for the root pass in carbon steel material of any thickness with the following provisions:

a. Vertical welding is performed in the uphill progression

b. The root pass is back gouged

c. GMAW-S is not used on branch connections, o-let, socket-type welds, or pipe less than or equal to 3 inches (75 mm) outside diameter

4.4.6 Postweld Heat Treatment (PWHT)

4.4.6.1 Unless otherwise approved by the purchaser, alternative PWHT requirements of *Code* Table UCS 56.1 {Table 6.16} shall not be used.

4.4.6.2 PWHT of test specimens shall be in accordance with *Code* requirements.

4.4.6.3 Unless otherwise specified on Purchaser's *PIP VEDV1003-D* Data Sheet, PWHT of test specimens shall include one extra PWHT cycle for potential future field repair.

4.4.6.4 PWHT shall be performed after all welding, weld repairs, and nondestructive examination is completed, but before any hydrostatic testing or other load testing.

4.4.6.5 Furnaces used for PWHT shall be constructed to prevent flame impingement on the work.

4.4.6.6 A sufficient number of thermocouples, attached directly to the unit being heat-treated, shall be used to accurately indicate the temperature of the work and detect uneven heating.

4.4.6.7 The equipment shall be adequately supported during the PWHT to avoid distortion.

4.4.6.8 Except as specified in Section 4.4.6.11, pressure parts made of austenitic stainless steel, if hot formed, shall be solution annealed between 1850°F (1010°C) and 2050°F (1120°C) followed by rapid cooling through the sensitization range.

4.4.6.9 Solution annealing of stabilized grades or "L" grades of austenitic stainless steel with 0.035% carbon max is not required.

4.4.6.10 Vessels shall not come into contact with galvanized components during PWHT.

4.5 Examination, Inspection and Pressure Testing

4.5.1 Examination

4.5.1.1 For specific welded pressure joint examination requirements, see the Purchaser's *PIP VEDV1003-F* Welded Pressure Joint Requirements Form. For *Code* Division 2 vessels, the form is not applicable.

4.5.1.2 The minimum degree of examination of welded butt joints shall be spot radiography in accordance with *Code* Paragraph UW-52 {7.4.3.1 and 7.4.3.5}. In applying the rules of *Code* Paragraph UW-52 {7.4.3.1 and 7.4.3.5}, the increments of weld shall be selected to include all Category A, B, and C butt welds, except for those Category B or C butt welds in nozzles and communicating chambers that are less than or equal to NPS 10 (DN 250) or less than or equal to 1-1/8 inches (29 mm) wall thickness.

4.5.1.3 See the Purchaser's contract documents for requirements for examining the accessible surfaces of completed Category D corner joint welds by magnetic particle, liquid penetrant, ultrasonic, or other nondestructive methods.

4.5.1.4 In addition to the above requirements welded joints that are inaccessible after assembly shall be examined by PT or MT in accordance with the following instructions, and repaired as required before painting, assembly, and testing:

a. After back-chipping to sound metal, the root pass and its opposite side shall be examined.

b. After any required machining or grinding, the finished surfaces of the weld shall be examined, and all indications on the finished weld surfaces shall be repaired by grinding or welding before the pressure testing.

4.5.1.5 If an examination reveals an unacceptable imperfection, the imperfection shall be repaired, and as a minimum, the repair shall be examined by the same method, to the same extent, and by the same acceptance criteria that revealed the condition.

4.5.1.6 The following items shall be examined by magnetic particle or liquid penetrant examination:

a. The following surfaces of Categories A and B, and Categories C and D butt-type joints greater than 2 inches (50 mm) thick:

(1) After back-chipping or gouging root pass to sound metal, the back-chipped or gouged surface

(2) All accessible surfaces of completed weld

b. The following surfaces of Category C and D non-butt type joints, including those in nozzles and communicating chambers, if the vessel section and/or head is designed using a joint efficiency of 1.00:

(1) After back-chipping or gouging root pass to sound metal, the back-chipped or gouged surface

(2) All accessible surfaces of completed weld

c. The cut edge of openings in vessel walls greater than 1/2-inch (13 mm) thick into which nozzles and communicating chambers are attached with a full penetration weld through the nozzle or communicating chamber wall. The examination shall be performed before nozzle attachment, and a re-examination performed after attachment if accessible.

d. All accessible surfaces of completed attachment welds for the following:

(1) Welds (i.e., internal and external) if the thickness of the pressure part is greater than 2 inches (50 mm)

(2) Welds attaching vertical vessel supports (e.g., skirts, lugs, legs, etc.)

(3) Welds attaching vessel lifting (i.e., erection) lugs

(4) Welds attaching manway davits

(5) Load bearing appurtenances

4.5.2 Inspection

4.5.2.1 Purchaser's inspection requirements (i.e., review, witness, inspection, hold points, and inspection documentation) are furnished on Purchaser's *PIP VEDV1003-T* Inspection and Testing Requirements Sheet.

4.5.2.2 If major components or services are obtained from sub-suppliers, the Purchaser's Inspector shall be notified and given the option of inspecting those items at their point of manufacture.

4.5.2.3 The Purchaser's quality surveillance and notification requirements shall be included in all suborders.

4.5.2.4 The Manufacturer shall arrange for certified drawings to be available for use by the Purchaser's Inspector at the sub-supplier's location.

4.5.2.5 The Manufacturer shall ensure, either directly or through sub-suppliers, that the inspections necessary for conformance to the Purchaser's contract documents are performed.

4.5.2.6 The performance of quality surveillance by the Purchaser's Inspector shall not relieve the Manufacturer or sub-suppliers of responsibility for meeting the requirements of the contract documents.

4.5.3 Pressure Testing – General

4.5.3.1 Vessels shall not be painted, controlled shot-peened or have refractory installed before the *Code* pressure test, with the following exceptions:

a. Surfaces that are to be painted, but are inaccessible after assembly (e.g., mating surfaces of lap-joint stub ends, flanges and nozzle necks, flange bolt holes, welded joints, etc.) shall be painted before assembly and pressure testing.

b. Welded joints that are inaccessible after assembly (e.g., joints covered by lap-type flanges) shall be examined by PT or MT and repaired as required before painting, assembly, and pressure testing. See Section 4.5.1.6 for specific examination requirements.

4.5.3.2 The test pressure shall be measured at the high point of the vessel in the test position.

4.5.3.3 All welds shall be sufficiently cleaned and free of scale or paint before pressure testing to permit proper examination for defects.

4.5.3.4 Reinforcing pad attachment welds and accessible surfaces of inside nozzle to vessel wall welds shall be tested for the absence of leaks with a gauge pressure of 15 psig (100 kPa) dry air or nitrogen and bubble forming solution. This test shall be performed before the final hydrostatic or pneumatic test as applicable.

4.5.3.5 All facilities and materials (e.g., blinds, bolting, and gaskets) required for testing shall be provided.

4.5.3.6 The temperature of the pressure-retaining components during the pressure test, regardless of test media, shall be:

a. At least 60° F (15°C), but not warmer than 120ºF (50ºC) and

b. At least 30ºF (17ºC) warmer than the minimum design metal temperature of the vessel.

4.5.3.7 Gaskets shall be used for test purposes in accordance with the following:

a. If a flanged joint is not to be disassembled after testing, the specified service gasket shall be used. Service gaskets used for testing shall be left installed for shipment for all blind flanged connections.

b. If a joint is to be disassembled after testing and has flanges in accordance with *ASME B16.5* or *ASME B16.47*, the test gasket may be selected by Manufacturer.

c. If the joint is to be disassembled after testing, employs nonstandard flanges (i.e., other than *ASME B16.5* or *ASME B16.47*), and the service gasket is not specified, the test gasket description shall be submitted to Purchaser for approval.

4.5.3.8 Unless specified for the service condition, joint sealing compound or gasket lubricant shall not be used.

4.5.3.9 All bolting and washers, if used for testing, shall be properly lubricated for assembly before the initial pressure test.

4.5.3.10 Except for leakage that can occur at temporary closures for those openings intended for welded connections, leakage shall not be permitted at the time of the required inspection.

4.5.3.11 Leakage from temporary seals shall be directed away to avoid masking leaks from other joints.

4.5.3.12 Sensitive leak tests, if specified, shall be performed before pressure testing.

4.5.3.13 Flanged joint assemblies specified to be provided with service gaskets (e.g., main body flange joints, manways, blind flange nozzles) and which are disassembled following tests shall be reassembled using new service gaskets. If the joints are shipped unassembled, new service gaskets for field installation shall be suitably packaged, marked, and shipped with the vessel. See Section 4.6.2.3.

4.5.3.14 Welding, burning or grinding, including cosmetic grinding of pressure retaining welds, shall not be performed on vessels that have been pressure tested unless approved by Purchaser. This includes but shall not be limited to welds for shipping attachments, refractory or insulation clips, stiffeners, spiders, or grinding for surface preparation.

4.5.3.15 If field assembly and erection is specified in the contract documents, the final pressure test shall be performed at the installation site. A detailed test procedure shall be provided to Purchaser for review before testing.

4.5.3.16 If hydrostatic testing at the installation site is specified in the contract documents, Purchaser shall furnish a fill line and a drain line for the test water at a location adjacent to the test site.

4.5.4 Hydrostatic Test

4.5.4.1 Unless otherwise specified on Purchaser's *PIP VEDV1003-D* Data Sheet, *Code* paragraph UG-99(b) {8.2.1(d)}, including endnote 34 {2.2.2.1d 1)}, shall be regarded as the standard hydrostatic test. See the *PIP VEDV1003-D* Data Sheet for the test pressure or applicable *Code* paragraph number.

4.5.4.2 If specified on Purchaser's *PIP VEDV1003-D* Data Sheet, liquids other than water may be used for hydrostatic testing in accordance with the *Code.* A detailed test procedure shall be submitted to the Purchaser for approval.

4.5.4.3 Horizontal vessels designed to support a full weight load of water shall be tested resting on its support saddles, without additional supports or cribbing.

4.5.4.4 Vertical vessels being tested in the erected position, whether shop or field, shall have design consideration given to the additional pressure and weight from the fluid head. See Section 4.2.2.6.

4.5.4.5 Vessels shall be adequately supported during the pressure test to prevent damage.

4.5.4.6 Testing of vessels shall be performed with potable test water that is clean and free of debris. Brackish or untreated water shall not be used.

4.5.4.7 Except as permitted in Section 4.5.4.8, testing of vessels or components made of austenitic stainless steel materials shall be performed with water containing a maximum of 50 ppm chloride.

4.5.4.8 If the duration of the test procedure is 72 hours or less and the procedure includes rinsing with water containing less than 50 ppm chloride, testing of vessels or components made of austenitic stainless steel materials may be performed with water containing greater than 50 ppm chloride but less than 250 ppm chloride.

4.5.4.9 Test water shall not be in contact with austenitic stainless steel for greater than 72 hours unless treated with an appropriate biocide.

4.5.4.10 Before application of the test pressure, the test water and the vessel material shall be permitted to equalize to approximately the same temperature.

4.5.4.11 The final pressure test shall be held for a minimum of one hour, or as specified in writing by the Purchaser.

4.5.4.12 After completion of the hydrostatic test, the vessel shall be drained, dried including drying internals, and closed as quickly as practicable.

4.5.5 Pneumatic Test

4.5.5.1 Pneumatic testing shall not be permitted unless hydrostatic testing is not feasible. See Code Paragraph UG-100 {8.3} and Code Paragraph UW-50 {Not Division 2 applicable}.

4.5.5.2 Pneumatic testing presents hazards that require strict attention as part of the design of the pressure vessel to ensure personnel safety. These considerations include, but shall not be limited to, the following:

a. Vessels shall be constructed of materials that ensure fracture toughness during the test.

b. Additional nondestructive examination of main seams, nozzle attachments, and some structural attachments in accordance with *Code* UW-50 {not Div. 2 applicable}. All additional nondestructive examination shall be performed in accordance with *Code* methods and acceptance criteria. The requirements for the details of all additional examinations shall be furnished by Purchaser.

c. Clearance of all personnel from the area.

4.5.5.3 If specified in the Purchaser's *PIP VEDV1003-D* Data Sheet, pneumatic testing shall be performed in the field at the installation site.

4.5.5.4 Detailed written procedures shall be prepared for any pneumatic testing. The procedure shall consider the extreme hazards which exposes the facility and nearby personnel. See ASME PCC-2 Article 5.1 (including the Appendices) for guidance on energy calculations for pneumatic tests and safe distances for personnel during the test. The procedures shall be agreed with the Purchaser and the User.

4.5.5.5 If acoustic emission monitoring of the pneumatic test is specified in the contract documents, procedures for the monitoring shall be submitted to Purchaser for approval before testing.

4.5.5.6 Except as permitted in Section 4.5.5.7, inert gas shall be used as the test medium for pneumatic testing because inert gas cannot support combustion.

4.5.5.7 Clean, dry, oil-free air in accordance with *ISO 8573-1* Class 1, 2 or 3 air, with a dew point ranging from +4°F to -94°F (-20°C to -70°C), may be used as the test medium.

4.6 Preparation for Shipment

4.6.1 Cleaning, Painting, and Marking

4.6.1.1 Before shipping or before leaving the installation site if field-erected, the vessel shall be thoroughly cleaned inside and outside. Grit, scale, oil, grease, weld rod stub ends, sand, water, free moisture, and all other foreign material shall be removed from the vessel.

4.6.1.2 If specified on the Purchaser's *PIP VEDV1003-D* Data Sheet, all or part of the following vessel cleaning procedure shall be performed before shipping:

a. Perform solvent or detergent wash

b. Rinse

c. Perform wet-dry test in accordance with *ASTM A 380*

d. If rust stains appear in wet-dry test, acid clean with passivation solution. Based on the extent of the rusting, the appropriate application method of hand wipe, spray, or circulating should be chosen.

e. Repeat wet-dry test.

f. If rusting reappears, consider pickling solution.

g. Rinse

h. Dry

4.6.1.3 Before shipping, painting shall be completed in accordance with the contract documents. See Section 4.5.3.1.

4.6.1.4 All vessel openings shall be closed and sealed immediately after completion of cleaning and drying. Sufficient internal desiccant or a positive pressure inert internal atmosphere (e.g., nitrogen) shall be provided to maintain a dry internal atmosphere until the vessel is opened. If an inert internal atmosphere is used, provide a means to maintain a positive pressure until the vessel is opened."

4.6.1.5 All PWHT vessels shall have the following notice painted on two sides of the shell and insulation covering, if present, in three-inch

high letters visible in the shipping position from grade. See Section 4.4.1.10:

POSTWELD HEAT TREATED - DO NOT BURN OR WELD

4.6.1.6 All vessels with non-metallic linings shall have the following notice painted on two sides of the shell and insulation covering, if present, in three-inch high letters visible in the shipping position from grade. See Section 4.4.1.10.

LINED VESSEL - DO NOT BURN OR WELD

4.6.1.7 All vessels using a positive pressure inert internal atmosphere shall have the following notice painted on two sides of the shell and insulation covering, if present, in three-inch (75mm) high letters visible in the shipping position from grade. See Section 4.4.1.10. The same notice shall be stamped onto stainless steel tags securely attached (by wire or other means) to each flange and opening.

CAUTION - UNDER INERT ATMOSPHERE - DO NOT OPEN WITHOUT PROPER PRECAUTIONS

4.6.2 Preparation and Closure

4.6.2.1 Machined surfaces, flange faces, threaded surfaces, and other finished or delicate parts shall be well-greased and protected against rusting and damage during shipment.

4.6.2.2 Holes in reinforcing pads (see Sections 4.2.11.3.4.d and 4.4.3.7) shall be plugged with Room Temperature Vulcanizing (RTV) silicone sealer or rust preventative grease that is compatible with the base material.

4.6.2.3 If flanged joints are specified to be provided with service gaskets, a spare gasket, in addition to any required for initial field assembly in accordance with Section 4.5.3.13, shall be provided and suitably packaged, marked, and shipped with the vessel for all joints except for flanged joints having standard ASME flanges. See Section 4.5.3.7.a.

4.6.2.4 Blind flanged connections, including manways, shall have the blinds attached with a full complement of new bolts.

4.6.2.5 Temporary Protective Covers

1. Except for flanges with permanent blinds, each flange face shall be protected with 1/2 inch (13 mm) thick wood or 1/8 inch (3 mm) thick suitable metal plate and soft rubber gasket, not less than the flange outside diameter, and secured with a minimum of the greater number of equally spaced bolts as follows:
   a. 25% complement of total flange bolting
   b. 4 bolts
2. Welding stub ends shall be protected with bevel protecting caps.
3. Threaded couplings shall be protected with bull plugs.
4. Socket weld fittings shall be protected with plastic caps.

4.6.2.6 Internals which cannot be safely shipped in place shall be identified, tagged, and shipped separately.

4.6.2.7 For internals which have specified clearances or tolerances, a minimum of one of each type (e.g., tray type or distributor type) shall be trial assembled into the vessel to ensure proper fit before shipment.

4.6.2.8 All bolting and other loose parts shall be suitably packaged and identified with the purchase order number.

4.6.2.9 Uncoated bolts and nuts shall be coated with a suitable thread lubricant to prevent corrosion during transportation and storage. The lubricant shall be easily removable with mineral spirits or a solvent.

4.6.2.10 Securing and Padding

1. Ropes, chains and straps may be used to secure the vessel and associated equipment to the transporter deck.
2. Padding shall be placed between cables or chains and stainless steel or high alloy equipment to prevent discoloration of the vessel shell and/or contamination of the metal.
3. Cables and chains are not permitted even with padding used, unless attached to tie down clips provided on the vessel.
4. If carbon steel shipping saddles are used for stainless steel or high alloy vessels, the saddles shall be padded.

4.6.2.11 Nozzles, including attached piping, within or passing through vessel support skirts shall be adequately supported during shipping and handling.

4.6.2.12 Special provisions for shipping saddles shall be agreed with Purchaser.

4.6.2.13 If the permanent saddles of horizontal vessels are used for support during shipment, saddle extensions constructed of timber or other suitable materials shall be secured to the saddles to provide adequate ground clearance for boot or nozzle projections, if any, that extend below the permanent saddle base plate.

4.6.2.14 Internal braces, spiders or other similar methods may be used to stiffen the vessel and prevent excessive deformation during shipping, handling and lifting. The stiffeners shall not be welded to the vessel.

Appendix A

Equivalent Pressure Formulas for Bending Moment and Axial Tensile Load

Equivalent Pressure Formulas for Bending Moment and Axial Tensile Load

When sustained bending moments or axial thrust loadings are applied to the flanged joint during operation in sufficient magnitude to warrant consideration in the flange selection or design, the design pressure, P, used in the calculation of total hydrostatic end load, H, in the flange design calculations shall be replaced by the following design pressure:

$$P_{FLG} = P + P_{EQ}$$

The equivalent pressure P_{EQ} is determined as follows:

$$P_{EQ} = \frac{16M}{\pi G^3} + \frac{4F}{\pi G^2}$$

Where:

M = Sustained bending moment (non-pressure generated) applied across full section at flange during the design condition

F = Sustained axial tensile force non-pressure generated) applied at flange

G = Diameter at location of gasket load reaction, in. (See Appendix 2 {4.16.12} of the *Code* for full definition.)

Therefore, the hydrostatic end load, H, used in the flange calculations is determined as follows:

$$H = 0.785\ G^2\ P_{FLG}$$

Dynamic Bending Moment

$$P_{EQ} = \frac{8M}{\pi G^3}$$

Where:

M = Bending moment, as defined above, but including dynamic bending moment (e.g., seismic moment) applied across full section at flange during the design condition, in-lb

Other Terms = Same as above

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

Design of Lifting Components for Mechanical Equipment

Specification No. EH-35R-CCU1-SPC-255-58005

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1.0 INTRODUCTION

1.1 Purpose

This specification describes the minimum requirements for the design, fabrication, testing, and inspection of components used for lifting, rigging, and erection of mechanical equipment.

1.2 Scope

A. The Designer shall design and provide the following as required for mechanical equipment based on the purchase order documents:

1. For the top end of pressure vessels: Welded lifting lugs, trunnions (with or without shackle plates), bolt-on flange lugs or other similar devices.

2. For the bottom end of pressure vessels: Welded tailing lugs, skirt reinforcement, bolt-on tailing frame or other similar devices.

3. For other mechanical equipment: Bolt-on lifting lugs, welded on lifting lugs, integral lifting lugs, or other similar lifting devices.

B. When bolt on lifting components are used the Seller shall provide a gasket and bolting for lifting purposes.

C. The lifting shackle with pin shall be provided by others. The Designer shall specify shackle size, capacity, and model number after award of purchase order. The lifting shackle with pin model and number shall be confirmed with the project rigging engineer.

D. The designer shall coordinate closely with the project rigging engineer to determine the requirements of the lifting components.

E. This specification does not prohibit the use of slings, straps or other lifting techniques not described here, provided they are designed properly and are in accordance with applicable sections of this specification

2.0 REFERENCES

The equipment furnished shall be in accordance with, but not be limited to, the following listed codes and standards, including all addenda, in effect as of the date of the Purchase Order.

2.1 Project Specifications and Standards

- EH-35R-CCU1-SPC-255-85050 Welding/NDE Requirements for Equipment
- EH-35R-CCU1-SPC-255-85210 Aboveground Coatings
- EH-35R-CCU1-SPC-255-58001 Design and Fabrication Specification for Vessels

2.2 Industry Codes and Standards

- American Institute of Steel Construction (AISC)
  - Manual of Steel Construction
- American Society of Mechanical Engineers (ASME)
  - B30.20 Below-the-Hook Lifting Devices
  - BTH-1 Design of Below-the-Hook Lifting Devices
- ASME Boiler and Pressure Vessel Code
  - Section I Rules for Construction of Power Boilers
  - Section II Materials
  - Section V Nondestructive Examination
  - Section VIII, Division 1 Rules for Construction of Pressure Vessels
  - Section VIII, Division 2 Alternative Rules for Construction of Pressure Vessels
  - Section IX Welding, Brazing, and Fusing Qualifications
- American Welding Society (AWS)
  - D1.1 Structural Welding Code – Steel
  - D1.6 Structural Welding Code – Stainless Steel
  - A2.4 Standard Symbols for Welding, Brazing, and Nondestructive Examination
- Occupational Safety and Health Administration (OSHA)
- Welding Research Council (WRC)
  - WRC-107 Local Stresses in Spherical and Cylindrical Shells due to External Loadings
  - WRC-297 Local Stresses in Spherical and Cylindrical Shells due to External Loadings on Nozzles – Supplement to ERC Bulletin No. 107
  - WRC-537 Precision Equations and Enhanced Diagrams for Local Stresses in Spherical and Cylindrical Shells due to External Loadings for Implementation of WRC Bulletin 107.

3.0 DEFINITIONS

The following definitions are applicable to this specification.

Table 1 Definitions

Term	Description
Below-the-Hook Lifting Devices	See Section 5.0.
Buyer	Owner's designated buying agent or its authorized representative.
Design Load or Rated Load	Estimated Lift Weight multiplied by a Weight Factor (see Paragraph 4.5).
Designer	Qualified engineer familiar with the design codes and regulations as listed in Section 2.2.
Estimated Lift Weight	The estimated weight of all components that are to be included in the lift.
Impact Factor	Load factor required to account for the lift dynamics.
Mechanical Equipment	Boilers, heaters, flare stacks, vertical heat exchangers, vertical pressure vessels, air coolers, etc. (See Section 6.0).
Owner	Owner of facility where equipment shall be installed.
Seller	Manufacturer of the equipment, the recipient of a purchase order from the Buyer.
Weight Factor	Weight multiplier used to account for possible unknowns (See Section 4.5).
F_y	Minimum specified material yield strength.

4.0 DESIGN REQUIREMENTS

4.1 Items meeting the definition of "Below-the-Hook Lifting Devices" shall be designed in accordance with ASME B30.20 and ASME BTH-1.

4.2 ASME B30.20 and ASME BTH-1 shall be used as a guide for the design of lifting components which do not meet the definition of the "Below-the-Hook Lifting Devices".

4.3 Design Category B - service class 0, as defined in BTH-1, shall be used as default in lifting attachment design unless approval from the Buyer allowing otherwise.

4.4 If required, adverse environmental conditions shall be considered in accordance with ASME BTH-1, Paragraph 2.1.4.

4.5 Design Load Weight Factors:

The Design Load (Rated Load) shall be calculated by multiplying the Estimated Lift Weight by the Weight Factor below. If an accurate weight is known and upon approval by the Buyer, this factor may not be applied.

Table 1 – Design Load Weight Factors

Erection Weight	Weight Factor
≤ 200,000 lbs. (90,700) kg	1.10
> 200,000 lbs. (90,700) kg	1.05

Erection weight shall include Fabricated weight + Internals + Insulation + L&P + External piping + Fireproofing (inside skirt only).

4.6 △C1 For pin connection devices such as lifting lugs, the Designer shall specify shackle type, size, and model that properly fit lugs in fabrication details and calculations which shall be submitted to Buyer for review and approval prior to fabrication.

5.0 BELOW –THE-HOOK LIFTING DEVICES

5.1 All lifting devices, including the bolts, pins, and welds that otherwise attach or fix the lifting devices to the mechanical equipment, shall be designed in accordance with ASME BTH-1, Chapter 3 using the Design Load and Nd = 3.0 for Design Category B (See Section 4.3). Common lifting devices for equipment may include and are not limited to the following: spreader bars, welded lugs, welded trunnions with or without shackle plates, a bolted-on flange lifting lug, or a bolted-on frame. An applied impact factor is included in the design equations of Chapter 3, per 3-5.1, whereby Category A and B devices have maximum impact multipliers of 50% and 100%, respectively. However in the case of Category A, if an impact factor beyond 1.50 is required, then Nd = 2.0 should be increased by a factor equal to the ratio of the desired impact factor divided by 1.50.

5.2 Lifting devices shall be designed with consideration of all potential orientations, load paths, and combined stress conditions that may occur throughout the lift. Considerations shall include out of plane sling loads or lateral thrusts loads causing weak axis bending in a lifting lug. As a minimum, each lifting lug shall be designed for an out of plane load of 3 degrees (or approximately 5% of the in-plane load). Bolts, pins, and welds that otherwise attach or fix the lifting devices to the mechanical equipment shall have allowable stresses consistent with the Code of construction. In the case of fillet welds, shear stresses using the minimum leg dimension shall not exceed 0.55 multiplied by the allowable stress in tension of the material at 100 °F (38 °C).

5.3 Lifting devices shall be designed with consideration of all potential interferences (e.g. insulation, platforms and platform support clips, davits and davit support clips).

5.4 For bolt-on devices, the Designer shall determine the correct bolt tension required for the lift. Consideration shall be given to the limitations of the equipment to prevent damage due to the bolt tensioning. Designer shall state design code used for design calculations and fabrication of lifting devices. For pin connection devices such as lifting lugs, the Designer shall specify shackle type, size, and model that properly fit lugs in fabrication △C1 details and calculations which shall be submitted to Buyer for review and approval prior to fabrication.

6.0 MECHANICAL EQUIPMENT

6.1 For all mechanical equipment, the Design Load increased by an impact factor shall be used to verify the local stresses in the equipment. Common equipment components that shall be evaluated may include and are not limited to the following: nozzle for flange lifting lug, local nozzle reinforcement, local shell reinforcement, base ring, and welded-in reinforcement for the shell, head or skirt.

A. Mechanical Equipment Impact Factor – 1.35

6.2 The acceptance criteria for mechanical equipment determined by using FEA (finite element analysis) or other methods (i.e. classical equations, WRC-107) shall be based on stress categories in accordance with Table 5.6 of ASME Section VIII, Division 2, Latest Edition. The allowable stress for equipment components shall be limited to the following:

A. The local or general primary membrane stress shall be limited to 0.9*Fy.

B. The local or general primary membrane stress plus bending stress shall be limited to 1.1*Fy.

C. The general or local primary membrane plus primary bending stress plus secondary bending stress shall be limited to 1.8*Fy.

D. The compressive membrane stress shall be limited to the maximum longitudinal or circumferential compressive stress as defined by ASME Section VIII.

6.3 An increase in allowable stress such as those for temporary, occasional or environmental conditions is not permitted.

7.0 MATERIAL REQUIREMENTS

7.1 For lifting device material, the Seller shall confirm with impact testing (if required by ASME Section VIII, Division 1, Fig. UCS-66), or material test reports that the toughness of the materials is adequate for the lowest ambient temperature (minimum design metal temperature) at the project jobsite where the lifts shall be made. The acceptance criteria for toughness shall be ASME Section VIII, Division 1, Fig. UG-84.1. The minimum lift environmental temperature shall be shown on the Seller's lifting component drawing(s).

7.2 All plates 2 inches (50 mm) and over in nominal thickness shall be UT examined in accordance with ASME SA-578. The acceptance standard shall be Level B of ASME SA-578. All forgings 2 inches (50 mm) and over in nominal thickness shall be UT examined in accordance with ASTM A-388. The straight beam technique shall be used.

7.3 Gaskets provided for flange lugs shall be non-asbestos ring sheet or equivalent.

8.0 FABRICATION REQUIREMENTS

8.1 All welding shall conform to the following:

A. Other than packaged equipment or skids – The welding shall conform to ASME Section IX. All welders shall be qualified for the procedures and techniques used as required by ASME Section IX.

B. Packaged equipment or skids not associated with ASME BPVC – All welding shall conform to AWS D1.1/D1.1M. All welders shall be qualified for the procedures and techniques used as required by AWS D1.1/D1.1M.

8.2 All welds attaching the lifting lug to the equipment or the equipment skid, such as lifting lugs, lifting trunnions or tailing lugs shall be MT or PT examined. For vessels over 20t (44,100 lbs), lifting lugs and trunnions shall be attached to a repad unless otherwise noted. Trunnion welds shall be full penetration, if repad is required, full pen weld trunnion to equipment first and then weld repad around trunnion.

8.3 All WPS/PQR's shall be qualified in accordance with ASME Section IX. For base material where impact testing is required, impact tested WPS/PQR shall be qualified in accordance with ASME Section IX.

8.4 The hole for the shackle pin (size listed below) shall be bored or drilled after PWHT.

Table 2 - Shackle Pin Hole Diameters

Pin Diameter	Hole Diameter
Up to 4 in. (100 mm)	Pin Dia. + 1/8 in. (3 mm)
Over 4 in. (100 mm)	Pin Dia. + 1/4 in. (6 mm)

When added, cheek plates shall be welded on before boring or drilling hole.

8.5 A copy of the NDE report for the lifting components' welds shall be sent to Buyer for review prior to delivery of the equipment.

8.6 Welded lifting components shall have surface preparation and paint (except pin hole) with the same requirement as other external attachments for the equipment.

8.7 Bolt-on flange lift lug welds:

A. The weld between the lug and cover should be full penetration. Other configurations can be utilized but must first be approved by the Buyer's rigging engineer.

B. The reinforcing fillet welds should be ground to radius, maintaining minimum throat dimension equal to 0.7 of fillet weld leg. The minimum size of the fillet welds shall equal to the larger of {1/16 of lug thickness, or 1/4 in. (6 mm)}.

C. The root pass on the first side shall be back-gouged and have MT examination before welding from the other side.

D. After completion of the bolt-on flange lifting lug, the full penetration weld shall be post weld heat treated in accordance with Part UCS of ASME Section VIII, Division 1.

E. The welds shall be UT and either MT or PT examined after the PWHT.

F. Other weld configurations can be used with approval from the Buyer prior to design.

8.8 All surfaces of bolt-on lifting devices (except flange faces, pin hole and bolt holes) shall be sandblasted per SSPC-SP6 and given one coat of inorganic zinc primer at 3.0 to 4.0 mils (75 – 100 μm) dry film thickness. The following shall be stenciled with easily readable letters on each bolt-on lifting component.

A. Vessel item number

B. Rated load (see Paragraphs 3.0 and 4.5)

C. Weight of the lifting component

D. The minimum lift environmental temperature (see Paragraph 7.1)

8.9 All spreader bars and bolt-on lifting devices (that are not an integral part of the equipment being lifted) shall be proof tested to 125% of the rated load. The Rated Load shall be marked on the component, easily visible, to indicate the safe lifting load per OSHA 1926.251(a)(4) requirement. A test certificate shall be furnished together with other test documents in the final Code Data Book. Spreader bars are considered "below-the-hook lifting devices" and shall be marked in accordance with ASME B30.20.

8.10 The Seller shall trial fit bolt-on lifting devices and then remove them for separate shipping if necessary for shipping clearances.

8.11 The shipping orientation shall be such that no rotation of mechanical equipment is required at the jobsite, unless requested by Buyer when rotation of mechanical equipment is required to reduce shipping clearance window.

9.0 FIELD NOTES

9.1 Lifting components shall be inspected prior to the lifting of the equipment. The inspection should include the following:

A. The size and quantity of all components to ensure that all parts, such as gussets and reinforcing plates have been installed according to the drawings.

B. The location and orientation of lifting components for conformance to drawing and specifications.

C. Attachment welds for lifting lugs shall be inspected for conformance to drawings.

D. Any damage or non-conformity noted shall be brought to the attention of the project quality control group and rigging superintendent.

9.2 Prior to lifting mechanical equipment, all lift-device bolting shall be tightened as specified on the lifting lug drawings (see Paragraph 5.4 above).

9.3 Equipment erection shall be conducted in such a manner that the loads in the lug weak axis are minimal, with a maximum out of plane sling angle of 3 degrees. A spreader beam or a two-crane lift can be used during erection to satisfy this requirement.

9.4 The removal of bolted or welded on lifting components should be based on the discretion of the project team and/or client. If a cutting torch is used, at least 1 inch (25 mm) of clearance shall be provided between the cut line and the equipment. Sharp edges resulting from cutting lugs shall be ground to a smooth radius. (Note: For all equipment under cyclic service, lifting components shall be removed and ground smooth after final installation unless demonstrated to be acceptable for fatigue.)

End of Specification

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

Design and Fabrication Specification for Pressure Vessel Internals

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1.0 INTRODUCTION

1.1 Purpose

This specification, EH-35R-CCU1-SPC-255-58040, serves as a Cover Sheet for Process Industry Practice PIP VESIN001 with applicable additions, deletions, modifications, and clarifications listed with associated paragraphs.

1.2 Scope

EH-35R-CCU1-SPC-255-58040, along with PIP VESIN001, provides design and fabrication criteria for pressure vessel internals.

2.0 REFERENCES

Applicable requirements in the latest edition (or the edition indicated) of PIP VESIN001 Design and Fabrication Specification for Pressure Vessel Internals shall be considered an integral part of this Practice. Additional references are listed below. Short titles will be used herein when appropriate.

2.1 Project Standards and Specifications

- EH-35R-CCU1-SPC-255-85050, Welding/NDE Requirements for Equipment
- EH-35R-CCU1-SPC-255-58001, Design and Fabrication Specification for Pressure Vessel
- EH-35R-CCU1-SPC-255-85012, Positive Material Identification

2.2 Process Industry Practices (PIP)

- See PIP VESIN001, Section 2.1

2.3 Industry Codes and Standards

- See PIP VESIN001, Section 2.2

3.0 DEFINITIONS

Definitions as provided in PIP VESIN001 Design and Fabrication Specification for Pressure Vessel Internals are applicable to this specification. The following additional definitions are also applicable to this specification.

Table 1: Definitions

Term	Description
Cover Sheet	A short specification style document that provides information application to its attached PIP or industry standard.

Term	Description
Parent Specification	The Specification, Practice, or Industry Standard used as the basis for the process being defined.
PIP	Process Industry Practice
Shall/Will	Denotes a minimum requirement in order to conform to the intent of the standard.
Should/Can/Could/May	Denotes a recommendation which is advised but not required in order to conform to the standard.

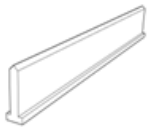
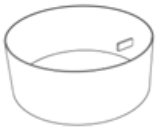
4.0 AMENDMENTS TO PIP VESIN001

The following items are amendments to PIP VESIN001. The section and paragraph numbers refer to those given in that specification. An "**Added**" to a PIP paragraph expands on the requirements or selects options; "**Substitute**" replaces the entire paragraph or sentences; "**Modified**" means the original text has been changed to reflect project requirements; "**New**" is for a new paragraph/section to be added.

Table 2: Amendments

Reference Location	Amendment Description
Section 2.1	Substitute: – PIP VEFV1100 - Vessel/S&T Heat Exchanger Standard Details To Read: EH-35R-CCU1-M036 – Mist Eliminator Details EH-35R-CCU1-M026 Vessel Internal Rungs – Vessel Internal Rungs EH-35R-CCU1-M032 – Internal Head Attachment
Section 4.1.2.3.	Add: Welding requirements for internal attachments to pressure boundaries that are in accordance with the Code shall be in accordance with ASME Section IX. To Read: Welding requirements for internal attachments to pressure boundaries that are in accordance with the Code shall be in accordance with ASME Section IX and EH-35R-CCU1-SPC-255-85050, Welding/NDE Requirements for Equipment.
Section 4.2.1.3	Substitute: Tray dimensions shall accommodate the maximum and minimum vessel diameters permitted by the vessel tolerances and the tray fabrication tolerances. To Read:

Reference Location	Amendment Description
	Trays will be designed to allow for manufacturing tolerances on both the vessel shell and trays. Specific allowance will be made for vessel shell out-of-roundness permitted by the applicable vessel code. Allowance will be made for differential thermal expansion between the vessel shell and the trays during normal start-up and operation, and during normal and emergency shut-down.
Section 4.2.2.1.d	New: Areas below downcomers will be designed for a uniform live load of 3064 Pa (64 psf) or a liquid load of 457 mm (18 in.) with dead load, whichever is greater.
Section 4.2.2.7	Substitute: Process trays shall not be installed out of level by greater than the tolerance provided in PIP VEFV1100 (VEFV1102 - Vessel Tolerances). To Read: All tray parts (except parts welded to the vessel) affected by the tolerance dimensions specified in Figures 1 and 2, will be made adjustable, so that when installed, the trays and pans will be within the specified tolerances.
Section 4.2.2.8	New: The supplier will furnish calculations that demonstrate the adequacy of his design to support the specified loads while not exceeding the specified deflections for service conditions.
Section 4.2.3.1	Add: Support beams shall be designed in accordance with AISC 360 and fabricated by the supplier. To Read: Support beams shall be designed in accordance with AISC 360 and fabricated by the supplier. Additional resources for stainless steel design can be found in "AISC Design Guide 27:Structural Stainless Steel" and for cold formed bent shapes in AISI S100-12 – North American Specification for the Design of Cold-Formed Steel Structural Members.
Section 4.2.3.7 △C1	New: The table below provides guidance on which parts of the structural code (ANSI/AISC 360-10) are applicable to the various components of the internals.

<table>
<tr><th>Reference Location</th><th>Amendment Description</th></tr>
<tr><td></td><td>
<table>
<tr><th colspan="3">ANSI/ANSI 360-10 “SPECIFICATION FOR STRUCTURAL STEEL BUILDINGS” PARAGRAPH REFERENCE FOR SIMPLE SUPPORTED AND CANTILEVER BEAMS IN BENDING ABOUT EITHER AXIS.</th></tr>
<tr><td>  </td><td>I-BEAM</td><td>B4, F2, F3, F4, F5, F6, G2, H and J10</td></tr>
<tr><td>  </td><td>CHANNEL</td><td>B4, F2, F6, G2, H and J10</td></tr>
<tr><td>  </td><td>TEE BEAM</td><td>B4, F9, G2, H and J10</td></tr>
<tr><td>  </td><td>CLIP ON VESSEL WALL</td><td>F11,G2, H and J10</td></tr>
<tr><td>  </td><td>FLAT PLATE</td><td>F11</td></tr>
</table>
</td></tr>
<tr><td>Section 4.2.3.8</td><td>New:
The material properties for yield and modulus of elasticity shall be taken from ASME BPV Section II part D at the appropriate design temperature. The use of ASME BPV allowable stresses is prohibited for the design of structural components.</td></tr>
<tr><td>Section 4.2.3.9 C1</td><td>New:
The following load cases shall be used for internals for Allowable Stress Design (ASD) and Load and Resistance Factor Design (LRFD):

ASD Load Combinations for Internals

1. D
2. D + L
3. D + 0.7E
4. D + 0.75L + 0.75(0.7E)
5. D + Th
6. D + L + Th
7. D + 0.7E + Th
8. D + 0.75L + 0.75(0.7E) + Th
9. 0.6D + 0.7E</td></tr>
</table>

Reference Location	Amendment Description
C1	**LRFD Load Combinations for Internals** 1. 1.4D 2. 1.2D + 1.6L 3. 1.2D + 1.0E + 0.5L 4. 1.4D + Th 5. 1.2D + 1.6L + Th 6. 1.2D + 1.0E + 0.5L + Th 7. 0.9D + 1.0E **Notes:** 1. Refer to Para. 2.2 of ASCE 7 “Minimum Design Loads for Buildings and Other Structures” for symbols used above except that symbol Th refers to thermal loads. 2. Earthquake (E) loads in the above combinations are strength level loads, therefore apply 0.7E in the ASD load combinations. If the loads are service level loads, then the 0.7E should change to 1.0E. For LRFD load combinations using service level loads, E must be factored up to 1.4E. 3. In most cases, operational loads (i.e. catalyst) on internals are considered as dead loads not live loads. 4. These load combinations are considered minimum and the analyst must assure all combinations of loading are addressed.
Section 4.2.3.10 C1	New: The use of finite element analysis (FEA) for the design of internals must show the ultimate capacity of the internal structures. A simple comparison of FEA stresses to Code allowables does not prove the worthiness of the structure. The FEA must show the structure’s resistance to local buckling and lateral-torsional buckling. Also, the model must include member deviation such as sweep and camber which are allowed by standard mill and forming practice.
Section 4.2.5.2 C1	Substitute: All parts shall be individually marked for assembly. To Read: Each part will be piece-marked with identification designations as shown on supplier's assembly drawings. Small parts such as bolting, washers, fasteners, and clips will be properly identified with purchase order number, tag item number, and piece-mark number as appropriate. Different types of alloy bolting etc. will not be placed in the same container/package, and the type/grade will be clearly identified on the container/package.

Reference Location	Amendment Description
Section 4.2.5.4	New: All like parts of tray assemblies and corresponding parts of similar trays will be made interchangeable. Symmetrical tray layouts will be used wherever possible.
Section 4.2.5.5	New: All tray and downcomer sections will be securely clamped, fastened, or bolted to the support-rings, bars and truss members. Where required, bolting will be 9.5 mm. (3/8 in.) minimum. Joints will be sealed with suitable gaskets where required.
Section 4.2.5.6	New: Tray spacing will be as specified on buyer vessel drawings or data sheets. C1
Section 4.2.5.7	New: The clearance between the bottom of downcomer and tray or seal pan below (including the permitted tolerance) will not be less than the weir height of the tray or seal pan below the downcomer.
Section 4.2.5.8	New: Holes of sieve trays will be punched downward from the top side of trays.
Section 4.2.5.9	New: Wedge type tray and cap hold-downs are not permitted.
Section 4.2.5.10	New: All bolting will be marked to permit positive identification of the material. When positive material identification of the internals is required, it shall be in accordance with EH-53R-CCU1-SPC-255-85532, Positive Material Identification.
Section 4.2.5.11	New: Cartridge and pedestal type trays will be designed to minimize edge leakage.
Section 4.2.5.12	New: Unless otherwise noted on process datasheets, small projections for valve trays will be provided on the valve seating surfaces to prevent sticking of the valves to the valve seats. The guide legs and vertical travel stops will be so arranged that the valves cannot work through the holes during normal operation. An anti-rotation device will be provided to prevent spinning of the valves.
Section 4.2.6.2	Add: Minimum tray manway clear opening shall be 300 mm by 450 mm (12 inches by 18 inches). To Read: Minimum tray manway clear opening shall be 300 mm by 450 mm (12 inches by 18 inches). The preferred tray

Reference Location	Amendment Description
	manway size is 457 mm by 610 mm (18 inches by 24 inches).
Section 4.2.6.3	Add: Bolting of tray manways shall be accessible, and manway removal possible, from both sides (top and bottom) of the tray manway. To Read: Bolting of tray manways shall be accessible, and manway removal possible, from both sides (top and bottom) of the tray manway. Tray manways shall be aligned vertically when practical.
Section 4.2.6.7	New: If the clearance between the tray deck and the bottom of major supporting beams of the tray above is less than 559 mm. (22 inches), tray manways will be provided on each side of the beams. Supplier will ensure that access is possible through tray manholes in the installed position.
Section 4.3.3.3 	Substitute: All parts shall be individually marked for assembly. To Read: Each part will be piece-marked with identification designations as shown on the supplier's assembly drawings. Small parts such as bolting, washers, fasteners, and clips will be properly identified with purchase order number, tag item number, and piece-mark number as appropriate. Different types of alloy bolting etc. will not be placed in the same container/package, and the type/grade will be clearly identified on the container/package.
Section 4.4.2.1 	Substitute: All parts shall be individually marked for assembly. To Read: Each part will be piece-marked with identification designations as shown on the supplier's assembly drawings. Small parts such as bolting, washers, fasteners, and clips will be properly identified with purchase order number, tag item number, and piece-mark number as appropriate. Different types of alloy bolting etc. will not be placed in the same container/package, and the type/grade will be clearly identified on the container/package.
Section 4.5.1.4	Substitute: A minimum of one tray of each type and size shall be assembled in the supplier’s shop before shipment. To Read:

Reference Location	Amendment Description
	All trays shall be assembled in the fabrication shop to verify that all parts fit together. The final shop assembly shall be confirmed and documented by the assigned QC party (assigned party as per the purchase contract, e.g. it may be the shop QC). The assembled tray(s) shall be photographed, photographs shall be detailed enough to provide guidance for field assembly. Assembled tray photographs shall be essential part of the shipment package. Trays can be disassembled for shipment as necessary afterwards.
Section 4.5.1.6	New: Leakage testing, when required, will be specified by the purchaser.
Section 4.7	New: **4.7 Preparation for Shipment** C1 4.7.1 Equipment will be packed to suit the particular mode of transportation selected so as to prevent damage during shipment. All packages will be marked with buyer's purchase order number, C1 vessel tag item number, and tray numbers. 4.7.2 When required, equipment will be packaged for overseas \ shipment in accordance with special instructions given in the purchase order. 4.7.3 Tray parts for different vessels shall not be intermixed. 4.7.4 A copy of parts list and installation instructions, assembled tray photographs (from 4.5.1.4) and drawings will be included in the shipment paperwork for each set of vessel trays. This is in addition to the requirements of Paragraph 4.6.
Section 4.8	New:

Reference Location	Amendment Description
	4.8 Guarantees 4.8.1 All materials, design, and construction will be subject to the conditions and guarantees required by the purchase order. 4.8.2 Leakage rates, when specified, will be certified by the supplier. 4.8.3 In addition, the supplier will guarantee that the equipment provided will meet the operating conditions specified without flooding. In the case that the equipment does not fulfill the performance guarantee, the supplier will, without cost to the purchaser furnish such new equipment or redesign and rebuild the equipment furnished so that the performance guarantee will be met.

5.0 LIST OF ATTACHMENTS

The following document is included as an attachment.

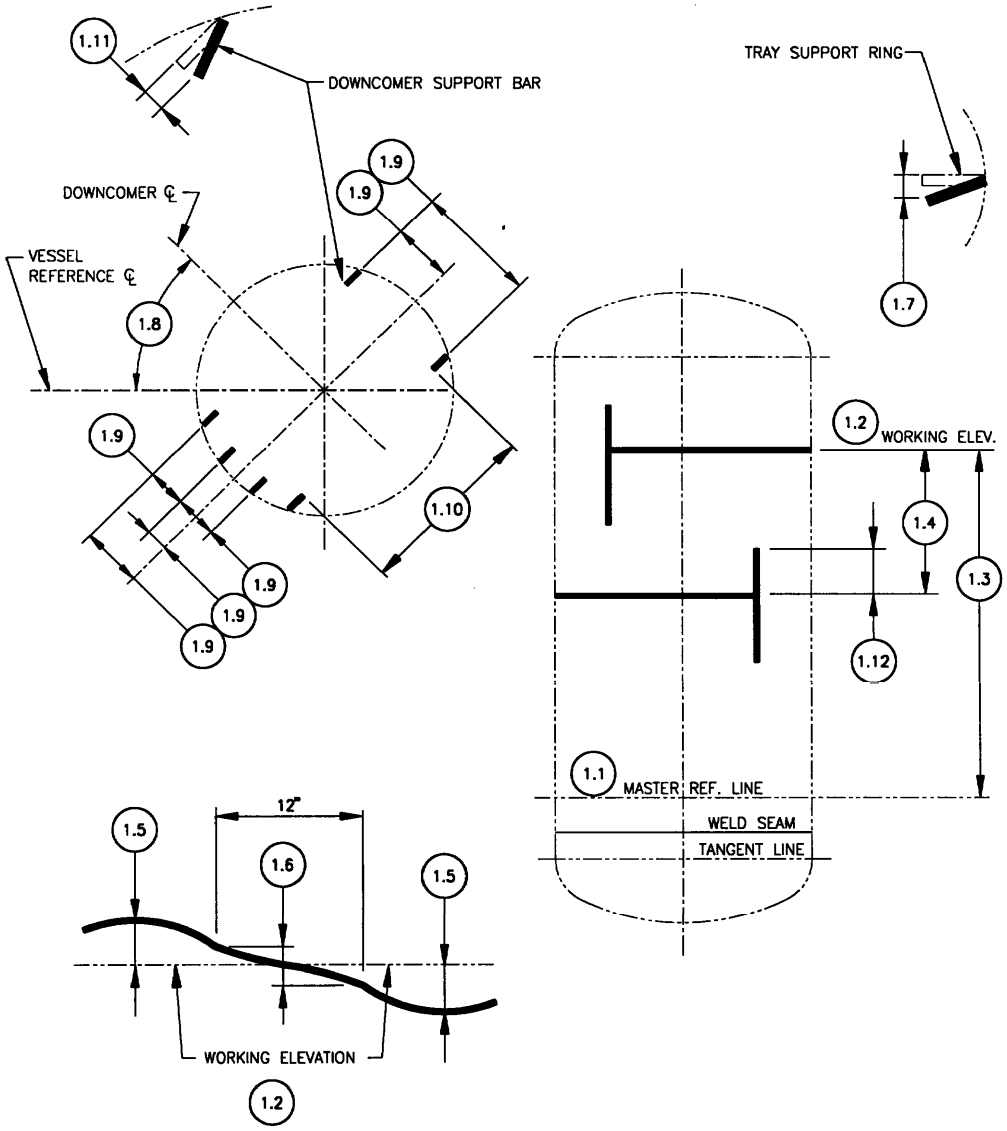
Attachment 01 Figure 1 – Tray Support Tolerances

Attachment 02 Figure 2 – Tray Tolerances

Attachment 03 PIP VESIN001, Design and Fabrication Specification for Pressure Vessel Internals

End of Specification

Figure 1 – Tray Support Tolerances



The following notes are referenced to the numbered circles of Figure 1.

A. (1.1) The Master Reference Line will be established by the Vessel Manufacturer and clearly marked inside and outside of the vessel prior to attaching the bottom head. It will be parallel to the root land of the bottom shell course, and perpendicular to the longitudinal axis of the vessel.

B. (1.2) The working elevation of a tray support ring will be the elevation specified on the buyer's vessel drawing. It will be a level plane parallel to the master reference line.

C. (1.3) The distance from the master reference line to the working elevation of any tray support ring will be within ± 6.35mm (1/4") of the nominal distance.

D. (1.4) The distance between working elevations of any 2 adjacent tray support rings will be within ± 3.18mm (1/8") of the nominal distance, and the accumulated tolerances between tray support rings will not exceed the tolerance in Note 3.

E. (1.5) The highest and lowest points of a tray support ring, measured adjacent to the vessel shell, will not exceed the following deviations from the working elevation:

	When Vessel Diameter Is
1.59mm (1/16")	1.22m (4 ft.) and smaller
2.38mm (3/32")	Over 1.22m (4 ft.) to 2.13m (7 ft.)
3.18mm (1/8")	Over 2.13m (7 ft.)

F. (1.6) Tray support rings will not have a waviness exceeding 1.59mm (1/16") for any 30.5cm (12") of circumferential length.

G. (1.7) Tilt of a tray support ring over its width will not exceed 1.59mm (1/16").

H. (1.8) Tilt Orientation of the downcomer centerline will be within 3.18mm (1/8") of its nominal distance from the vessel reference centerline for vessels up to 1.83m (6 ft.) diameter and within 6.35mm (1/4") for vessels over 1.83m (6 ft.).

I. (1.9) Distance from downcomer support bar to vessel centerline will be within ± 3.18mm (1/8") of the nominal distance; and on a multipass tray, the distance between downcomer support bars will also be within ± 3.18mm (1/8") of the nominal distance.

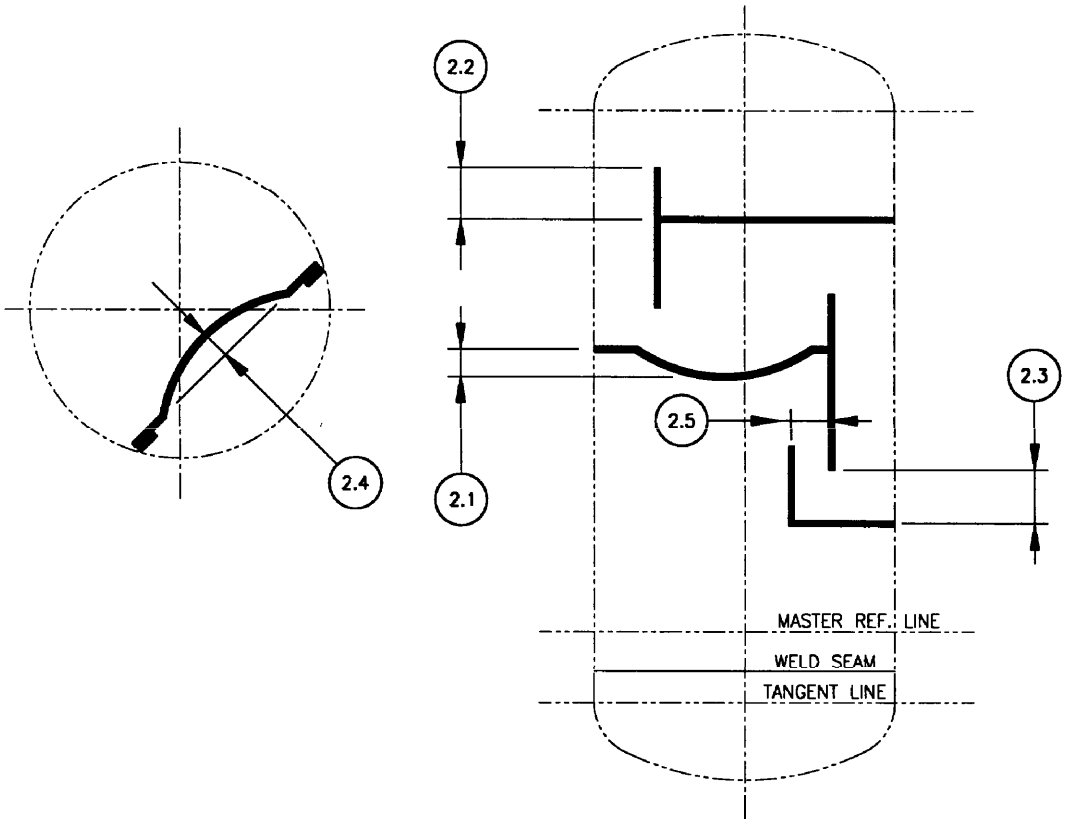
J. (1.10) Deviation from nominal distance between downcomer support bars will be subject to vessel out-of-roundness tolerance. Facility for adjustment must be provided in the downcomer and weir plates.

K. (1.11) Tilt of a downcomer support bar over its width will not exceed 1.59mm (1/16").

L. (1.12) Distance between top of downcomer (weir) support bar and top of tray support ring will be within ± 1.59mm (1/16") of the nominal distance.

M. (1.13) General tolerances on dimensions not specified will be considered to be ± 3.97mm (5/32").

Figure 2 – Tray Tolerances.



The following notes are referenced to the numbered circles of Figure 2.

A. (2.1) Tray decks will have a flat surface within 1.59mm (1/16") measured across a 1 foot square surface.

B. *(2.2)* The difference in height between the highest and lowest points of the weir, measured to a level plane, will not exceed:

	When Vessel Diameter Is
3.18mm (1/8")	1.83m (6 ft.) and smaller
4.76mm (3/16")	Over 1.83m (6 ft.) to 2.74m (9 ft.)
6.35mm (1/4")	Over 2.74m (9 ft.)

C. (2.3) Clearance between bottom of downcomer and top of tray or seal pan below will not deviate from nominal clearance by more than:

	When Vessel Diameter Is
± 3.18mm (1/8")	1.83m (6 ft.) and smaller
± 4.76mm (3/16")	Over 1.83m (6 ft.) to 2.74m (9 ft.)
± 6.35mm (1/4")	Over 2.74m (9 ft.)

D. (2.4) The bowing of a downcomer in a horizontal plane will not deviate from \ the straight by more than ± 3.18mm (1/8").

E. (2.5) Downcomer horizontal clearances, measured from bottom edge of downcomer to recessed seal pan or inlet weir, will be within ± 3.18mm (1/8") of nominal.

PROCESS INDUSTRY PRACTICES

February 2018

Vessels

PIP VESIN001
Design and Fabrication Specification for Pressure Vessel Internals

PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

This Practice is subject to revision at any time.

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PIP VESIN001
Design and Fabrication Specification for Pressure Vessels Internals

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1. Scope

This Practice provides the mechanical design, fabrication, examination, inspection, testing, and documentation requirements for pressure vessel process trays, tower structured packing, tower random packing, distributors, and related components welded to the pressure boundary.

2. References

Applicable parts of the following Practices and industry codes and standards shall be considered an integral part of this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted. Short titles are used herein where appropriate.

2.1 Process Industry Practices (PIP)

- VEFV1100 - *Vessel/S&T Heat Exchanger Standard Details (U.S. Customary Units)*

2.2 Industry Codes and Standards

- American Institute of Steel Construction
  - AISC 360 - *Specification for Structural Steel Buildings*
- American Society of Mechanical Engineers (ASME)
  - *ASME Boiler and Pressure Vessel Code (Code)*

    Section V - *Nondestructive Examination*

    Section VIII - *Rules for Construction of Pressure Vessels, Division 1*

    Section IX - *Welding, Brazing, and Fusing Qualifications*
  - ASME B16.5 - *Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard*
  - ASME B16.47 - *Large Diameter Steel Flanges: NPS 26 through NPS 60 Metric/Inch Standard*

3. Definitions

Code: The ASME Boiler and Pressure Vessel Code, Section VIII Division 1 (or 2), its references and any Code Cases permitted by the User and authorizing agencies.

construction: An all-inclusive term comprising materials, mechanical design, fabrication, examination, inspection, testing, and certification

owner: The party who owns the facility wherein the vessel will be used. The owner is typically also the User.

purchaser: The party who awards the contract to the supplier. The purchaser may also be the owner, user, or the owner's or user's designated agent (e.g., engineering contractor).

supplier: The party entering into a contract with the purchaser for the mechanical design and construction of vessel internals

user: The operator of the facility wherein the vessel will be installed. See *owner*.

vessel fabricator: The party responsible for the fabrication of the pressure vessel in which the internals will be installed, or the party responsible for welding the internals attachments to the vessel wall

purchaser's inspector: The person or company authorized by the purchaser, owner, and/or user to inspect pressure vessel internals to the requirements of this Practice and other purchaser contract requirements

4. Requirements

4.1 General

4.1.1 Overall Requirements

4.1.1.1 Internals shall be provided in accordance with this Practice and the following:

a. General internals design and operation (i.e., process) requirements provided by the purchaser

b. Codes and standards referenced in this Practice

c. Contract requirements furnished by the purchaser

4.1.1.2 It is the sole responsibility of the supplier to comply with the contract documents.

4.1.2 Components Welded to Pressure Boundary

4.1.2.1 Internal attachments to be welded to a vessel shall be designed by the supplier for fabrication and installation by the vessel fabricator.

4.1.2.2 Applied loads, including location, transmitted to the vessel via a vessel attachment shall be provided by the purchaser.

4.1.2.3 Welding requirements for internal attachments to pressure boundaries that are in accordance with the Code shall be in accordance with *ASME Section IX*.

4.1.2.4 Design of internal attachments welded to the pressure boundary shall account for differential thermal expansion between the vessel attachment and internals.

4.1.2.5 The material for internal attachments welded to the pressure boundary shall be the same nominal composition as the cladding, weld overlay, or shell to which it is directly attached.

4.1.2.6 The minimum thickness of internal parts welded to the pressure boundary shall be 5 mm (3/16 inch) plus the corrosion allowance.

4.1.2.7 Corrosion allowance for internal parts welded to the pressure boundary shall be applied to each surface exposed to the process.

Comment: A corrosion allowance equal to the vessel corrosion allowance is typical.

4.1.2.8 If specified in the contract documents that the vessel is subject to vibration and/or fatigue, internal welded non-pressure parts (e.g., support

rings, lugs, and baffles that can be subject to vibration or cyclic loading) shall be full penetration welded.

4.1.3 Bolting for Internal Components

Internal bolting shall be in accordance with the following:

a. Bolts shall be minimum 10 mm (3/8 inch) diameter.

b. Bolts shall have heavy hex heads and nuts.

c. Bolting material shall be specified by the owner.

d. If material is not specified in the contract documents, bolting shall be of highly corrosion resistant material.

e. High alloy (e.g., stainless steel) bolts and nuts shall resist galling.

Comment: Typically this requires a substantial difference between the bolt and nut hardness.

4.1.4 Vessel Manway Access

4.1.4.1 The minimum vessel manway inside diameter shall be furnished in the contract documents.

Comment: The minimum manway is typically DN 600 (NPS 24). A larger manway may be required for trays and supports in large diameter columns.

4.1.4.2 All removable components and parts (e.g., trays, packing (structured), distributors supports) shall be designed to pass through the vessel manways.

4.1.4.3 For trayed towers, a vessel manway shall be located above the top tray, below the bottom tray, and at each inlet distributor.

4.1.4.4 For trayed towers, vessel manways shall be located equal to or less than 18 m (60 feet) apart.

4.1.4.4 Vessel manways shall also be provided in accordance with the following tray limits.

a. Vessels with less than 60 trays manways are required every 20 trays

b. Vessels with 60 to 120 trays manways are required every 30 trays

c. Vessels with greater than 120 trays manways are required every 40 trays

4.1.4.6 For vessels with packing manways shall be provided above and below each packed bed.

4.1.4.7 Vessels with internal compartments that prevent access shall have a manway on both sides of the compartment.

4.1.5 Recommended Spares

4.1.5.1 The following minimum spares shall be provided with the internals:

a. Hardware 5%

b. Gaskets 20%, minimum 1 per size and type

c. Random Packing 10%

4.1.6 Fabrication

4.1.6.1 Plate edges to be welded shall be uniform, smooth, and free of cracks, scale, slag, oil, or other foreign matter.

4.1.6.2 Surfaces of fabricated parts shall be smooth and free of dents, hammer marks, kinks, or other defects.

4.1.6.3 Edges of all surfaces shall be free of burrs.

4.1.6.4 Edges exposed to passage of personnel shall be rounded.

4.2 Process Trays

4.2.1 General

4.2.1.1 Minimum tray thickness shall be 14 gauge in the corroded condition.

4.2.1.2 The corrosion allowance for tray components not welded to the pressure boundary shall be as specified in the contract documents.

Comment: A typical value for carbon and low alloy trays is 1/16 inch total. High alloy (e.g., stainless steel) trays typically have a corrosion allowance of zero.

4.2.1.3 Tray dimensions shall accommodate the maximum and minimum vessel diameters permitted by the vessel tolerances and the tray fabrication tolerances.

4.2.1.4 Cartridge trays shall be considered for vessels 750 mm (30 in) or less.

4.2.2 Mechanical Loads

4.2.2.1 Process trays and supports shall be designed to withstand the following:

a. Maximum operating process load of 2.15kN/m^2 (45 lbs/sq ft) in an upward direction at design temperature, evenly distributed

b. Tray weight plus a single maintenance load of 1330N (300 lbs) concentrated at any point on the tray assembly, at ambient temperature, in the corroded state

c. Tray weight plus the process liquid weight at the weir height plus an additional 50 mm (2 inches) at design temperature, or the tray weight plus 575 N/m^2 (12 lbs/sq ft), whichever is greater

4.2.2.2 Operating loads shall be considered to act on components in both the new and corroded condition.

4.2.2.3 Areas of trays under downcomers shall be designed to support their own weight at the design temperature plus the pressure from a water column half the height of the downcomer.

4.2.2.4 Draw-off and accumulation pans shall be designed to support their own weight at design temperature plus the greater of a uniform live load equal to 6.9 kN/m^2 (144 lbs/sq ft) or the pressure from a water column at the maximum operating level of the pan.

4.2.2.5 The maximum deflection of trays during operation, either upward or downward, shall not be greater than D/800 or 3 mm (1/8 inch), whichever is less, where D is the tower inside diameter.

4.2.2.6 The maximum deflection of tray support beams during operation shall not be greater than the lesser of 3 mm (1/8 inch) or L/900, where L is the length of the support beam.

4.2.2.7 Process trays shall not be installed out of level by greater than the tolerance provided in *PIP VEFV1100 (VEFV1102 - Vessel Tolerances)*.

4.2.3 Supports

4.2.3.1 Support beams shall be designed in accordance with AISC 360 and fabricated by the supplier.

4.2.3.2 Except for vibratory or hydrogen services, welding of supports shall be as follows:

a. Support rings shall be continuously welded on the top, and intermittently welded on the bottom.

b. Brackets shall be continuously welded on the top and sides only.

4.2.3.3 For vibratory or hydrogen services, all welding shall be full penetration. For Hydrogen service fillet welds can be use provided the bottom weld is vented.

4.2.3.4 A minimum overlap of 20 mm (3/4 inch) shall be provided between the tray support ring and outside diameter of the tray.

4.2.3.5 The depth of supporting members normal to the direction of liquid flow on the tray shall not be greater than 15% of the tray spacing.

4.2.3.6 Tray support members and stiffeners shall be provided as follows:

a. Located on the underside of the tray

b. Not greater than 75 mm (3 inches) in width

c. Not greater than 5% of the vessel diameter in depth

4.2.4 Draining

4.2.4.1 All trays including seal pans shall have a 12 mm (1/2 inch) diameter drain hole.

4.2.4.2 Inlet weirs shall have a 12 mm (1/2 inch) drain hole.

4.2.4.3 Chimney trays shall be drained through draw-off nozzles in lieu of drain holes.

4.2.4.4 Side draw-off nozzles shall be located flush with the bottom of the draw-off sump.

4.2.5 Assembly

4.2.5.1 A minimum clearance of 12 mm (1/2 inch) shall be provided between the outside radius of the tray and the inside radius of the vessel.

4.2.5.2 All parts shall be individually marked for assembly.

4.2.5.3 Marking materials and method shall not be deleterious to tray material.

Comment: For example, markings of stainless steel parts shall be chloride free.

4.2.6 Access

4.2.6.1 Access to all trays shall be provided by means of bolted tray manways.

4.2.6.2 Minimum tray manway clear opening shall be 300 mm by 450 mm (12 inches by 18 inches).

4.2.6.3 Bolting of tray manways shall be accessible, and manway removal possible, from both sides (top and bottom) of the tray manway.

4.2.6.4 Trays smaller than 1060 mm (42 inches) diameter may be split in lieu of providing tray manways.

4.2.6.5 Tray manways shall not form a part of the downcomer seal pan.

4.2.6.6 Tray manways shall not weigh greater than 300 N (65 lbs).

4.3 Packing

4.3.1 General

4.3.1.1 The maximum packed bed height shall be 9 m (30 feet).

4.3.1.2 Packing and supports shall be designed in accordance with the following:

a. Maximum downward operating load equal to the weight of the packing, liquid hold-up, and any other internals (e.g., hold-down grids) at design temperature.

b. Support assembly weight plus a single maintenance load of 1330 N (300 lbs) concentrated at any point on the assembly, at ambient temperature, in the corroded state

c. Maximum deflection in any direction not greater than 0.0035 times D, where D is the inside diameter of the column

d. Support assembly shall not installed out of level by greater than 0.3% of D, where D is the inside diameter of the column

4.3.2 Supports

4.3.2.1 For column diameters greater than 760 mm (30 inches), a self-supporting packing grid resting on a ring shall be provided.

4.3.2.2 The maximum distance between packing grid elements shall be 100 mm (4 inches).

4.3.2.3 Packing grid elements shall be bolted or clamped together.

4.3.2.4 Support beams shall be designed in accordance with AISC 360 and fabricated by the supplier.

4.3.2.5 Packing bed support beam shall be designed with a maximum deflection of L/300, where L is the length of the beam.

4.3.2.6 A bed limiter shall be provided to keep the packing in place.

4.3.3 Assembly and Installation

4.3.3.1 Beds of structured packing shall be designed for installation and removal from the top.

4.3.3.2 Beds of random packing shall be designed for installation from the top and removal from the side at the bottom of the bed.

4.3.3.3 All parts shall be individually marked for assembly.

4.3.3.4 Marking materials and method shall not be deleterious to packing or support material.

Comment: For example, markings of stainless steel parts shall be chloride free.

4.3.3.5 Manways shall not be provided in packing support/hold-down grids.

4.3.3.6 For inspection of the vessel shell the entire packed bed shall be removed.

4.3.3.7 Structured Packing

a. All structured packing layers shall be provided with a wall wiper.

b. The maximum gap between the vessel wall and structured packing shall be as follows:

1. Vessel diameter less than 900 mm (3 feet) the gap shall be 10 mm (0.4 inch)

2. Vessel diameter between 0.9 and 2.75 m (3 and 9 feet) the gap shall be 15 mm (0.6 inch)

3. Vessel diameter greater than 2.75 m (9 feet) the gap shall be 25 mm (1 inch)

4.3.3.8 Structured packing dimensions shall accommodate the maximum and minimum vessel diameters permitted by the vessel tolerances, and the packing fabrication tolerances.

4.3.3.9 Different types of random packing shall be separated by a bed limiter.

4.4 Distributors

4.4.1 General

4.4.1.1 Inlet distributors shall be able to withstand the weight of the feed pipe and the weight of its contents, liquid full, with a specific gravity of 1.0 or the specific gravity of the operating fluid, whichever is greater.

4.4.1.2 Thermal expansion shall be accounted for in the inlet distributors design, both during operation and transient conditions.

4.4.1.3 The supplier shall design and provide the inlets distributors.

4.4.1.4 The fluid from pipe distributors shall impinge on a smooth, unobstructed surface.

4.4.1.5 Unless trays are designed for the distributor load, distributors shall not be supported from trays.

4.4.1.6 Except in main headers of liquid distributors, drain holes shall not be provided.

4.4.1.7 Pipe distributors constructed of high alloy (e.g., stainless steel) pipe shall have the following minimum wall thicknesses.

a. For pipe sizes less than or equal to DN 300 (NPS 12), Schedule 40S minimum

b. For pipe larger than DN 300 (NPS 12), 5 mm (3/16 inch) minimum nominal wall pipe or fabricate from 5 mm (3/16 inch) plate

4.4.1.8 Flanges for internal non-pressure piping may be fabricated from plate but shall be in accordance with *ASME B16.5* and *B16.47* Class 150 bolting patterns.

4.4.2 Assembly and Installation

4.4.2.1 All parts shall be individually marked for assembly.

4.4.2.2 Marking materials and method shall not be deleterious to the distributor material.

Comment: For example, markings of stainless steel parts shall be chloride free.

4.4.2.3 Inlet distributors and redistributors shall be directly accessible from a column manway.

4.4.2.4 Internal distribution pipes shall have internal flanged connections to permit removal through the vessel manway.

4.5 Examination and Inspection

4.5.1 Examination

4.5.1.1 The methods and extent of examination shall be as specified in the contract documents.

4.5.1.2 All specified nondestructive examination, including that for non-pressure parts and attachments, shall be performed in accordance with *ASME Section V*.

4.5.1.3 All welds shall be 100% visually examined.

4.5.1.4 A minimum of one tray of each type and size shall be assembled in the supplier's shop before shipment.

4.5.1.5 If an examination reveals an unacceptable imperfection, the imperfection shall be repaired, and as a minimum, the repair shall be examined by the same method, to the same extent, and by the same acceptance criteria that revealed the condition.

4.5.2 Inspection

4.5.2.1 Fabrication inspection requirements shall be in accordance with the contract documents.

4.5.2.2 The purchaser's inspection and notification requirements shall be included in all suborders.

4.5.2.3 Certified drawings shall be provided for use by the purchaser's inspector at the supplier's and any sub-supplier's location.

4.5.2.4 Supplier shall ensure, either directly or through sub-suppliers, that the inspections specified in purchaser's contract documents are performed.

4.5.2.5 The performance of inspection by the purchaser's inspector shall not relieve the supplier or sub-suppliers of responsibility for meeting the requirements of the contract documents.

4.6 Documentation

4.6.1 The following information shall be provided:

a. Design temperature and all design loads

b. Extent and type of examination

c. Heat treatment requirements

d. All ASME or ASTM material specifications

e. Design corrosion allowance for all internals

f. Fabrication details for all internals, including attachments to the pressure boundary

g. Assembly drawings and instructions

h. All weld details

4.6.2 All structural design calculations shall be provided with the detailed fabrication drawings.

C

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

Packaged Mechanical Equipment Specification

Document No. EH-35R-CCU1-SPC-255-59010

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1.0 SCOPE

This specification covers the minimum requirements for the design, fabrication, assembly, inspection, testing, painting, insulation, and preparation for shipment for packaged equipment. In general, packaged equipment includes the assembly of mechanical equipment components onto a structural steel skid. The completed assembly will include piping, wiring, electrical, instrumentation and controls.

2.0 REFERENCE DOCUMENTS

The following publications form a part of this specification. Unless otherwise specified herein, the latest issues, amendments, and supplements to these documents shall apply. Supplier shall comply with the listed standards, codes, and specifications in addition to this specification. In case of a conflict, the Supplier shall call attention to the conflict and request for resolution by the Buyer in writing.

2.1 Codes and Standards

ANSI	American National Standards Institute
ANSI B1.1	Unified Inch Screw Threads
RMA IP-20	Classical Multiple V-Belts (A, B, C, D, and E Cross Sections)
RMA IP-24	Specifications for Drives Using Synchronous Belts
API	American Petroleum Institute
API RP 520	Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries
API RP 521	Pressure –Relieving and Depressurizing Systems
ASCE	America Society of Civil Engineers
ASCE 7	Minimum Design Loads for Buildings and Other Structures
ASME	American Society of Mechanical Engineers
ASME Sec II	Materials
ASME Sec V	Nondestructive Examination
ASME Sec VIII Div 1	Pressure Vessels
ASME Sec VIII Div 2	Pressure Vessels Alternative Rules
ASME Sec IX	Welding, Brazing and Fusing Qualifications
ASME B16.5	Pipe Flanges and Flanged Fittings
ASME B16.11	Forged Fittings, Socket-Welding and Threaded

ASME B16.42	Ductile Iron Pipe Flanges and Flanged Fittings, Classes 150 and 300
ASME B16.47	Large Diameter Steel Flanges
ASME B31.3	Process Piping
ASTM	American Society for Testing and Materials
ASTM A269	Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM B6	Standard Specification for Zinc
AWS	American Welding Society
AWS D1.1	Structural Welding Code-Steel
ISA	International Society of Automation
NEMA	National Electrical Manufacturers Association
NEMA MG 1	Standard for Motors and Generators
NFPA	National Fire Protection Association
NFPA 70	National Electrical Code (NEC)
IEEE	Institute of Electrical & Electronics Engineers
IEEE 841	Petroleum and Chemical Industry –Premium Efficiency, Severe Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors – Up to and Including 500 hp
OSHA	Occupational Safety and Health Administration
29 CFR, Part 1910	Occupational Safety and Health Standards

2.2 Applicable Project Specifications

Spec. Number	Title
EH-35R-CCU1-SPC-215-00002	Structural Data For Mechanical Equipment
EH-35R-CCU1-SPC-255-58005	Design of Lifting Components for Mechanical Equipment
EH-35R-CCU1-SPC-255-58001	Design and Fabrication Specification for Vessels ASME Code Section VIII, Divisions 1 and 2
EH-35R-CCU1-SPC-255-57020	Shell and Tube Heat Exchangers
EH-35R-CCU1-SPC-255-57030	Air-Cooled Heat Exchangers

EH-35R-CCU1-SPC-255-85012	Positive Material Identification (PMI)
EH-35R-CCU1-SPC-255-85050	Welding/NDE Requirements for Equipment
EH-35R-CCU1-SPC-255-85002	Welding of Shop or Field Fabricated Piping
EH-35R-CCU1-SPC-255-85110	Hot Insulation
EH-35R-CCU1-SPC-255-85210	Aboveground Coatings
EH-35R-CCU1-SPC-255-85400	Galvanizing
EH-35R-CCU1-SPC-250-50112	Packaged Equipment Piping
EH-35R-CCU1-SPC-250-50003	Piping - Material Specification Line Class - Process and Utility Piping
EH-35R-CCU1-SPC-265-00002	Electrical Requirements for Packaged Equipment
EH-35R-CCU1-SPC-255-56070	General Purpose Induction Motors 3/4 HP – 200 HP
EH-35R-CCU1-SPC-255-56073	General Purpose Induction Motors – API 547
EH-35R-CCU1-SPC-270-00003	Instruments and Controls Supplied with Packaged Equipment

C

C

3.0 REQUIREMENTS

3.1 General

3.1.1 The Supplier shall furnish all components and materials for a complete system as specified, with the exception of those items specifically stated by the Supplier and agreed upon by the Buyer as Buyer supplied items.

3.1.2 Supplier's Scope of Supply

In addition to the primary equipment the Supplier shall include in his scope, but not be limited to, the following:

3.1.2.1 Skid steelwork and supporting structures.

3.1.2.2 All permanent platforms, ladders, stairs, and walkways.

3.1.2.3 Skid lifting provisions as applicable.

3.1.2.4 Piping, pipe supports, fittings and valves (within confines of skid or as designated by Buyer on data sheets).

3.1.2.5 Unless otherwise specified, flanged piping terminations for all customer piping interfaces.

3.1.2.6 All required instrumentation and controls. All instrument wiring shall be terminated in junction boxes at the edge of skid.

3.1.2.7 Local control panel including indicating lights and switches.

3.1.2.8 Control and electrical wiring and conduit or cable trays contained on skid.

3.1.2.9 Grounding system within package as specified.

3.1.2.10 Surface preparation and finish painting as specified.

3.1.2.11 Insulation as specified.

3.1.2.12 Sound attenuation enclosures where required.

3.1.2.13 Necessary quantities of catalysts, chemicals, desiccant, molecular sieve, etc., required for start-up and one year operation of the package.

3.1.2.14 Required testing as specified.

3.1.2.15 Special tools for commissioning and operations.

3.1.2.16 Preservation and packing.

3.1.2.17 Supplier drawings and data per Supplier Drawing and Data Commitment (SDDC) Form.

3.1.2.18 Spare parts for commissioning and start up.

3.1.2.19 Supplier's terminal boxes and devices that are furnished loose for installation by the Buyer.

3.1.3 Sub-suppliers and sub-contractors used by the Supplier shall be subject to written approval by the Buyer prior to placement of suborders.

3.1.4 Unless otherwise specified, system components not addressed specifically in this specification shall be in accordance with the purchase order or contract and the requirements of the industry standards referenced therein.

3.1.5 Unless specifically approved in writing by Buyer, no substitution for materials, equipment, or components shall be made.

3.1.6 All parts shall be new and unused. Reconditioned parts shall not be furnished.

3.1.7 Unless otherwise specified on the data sheets, all equipment and auxiliaries shall be suitable for unprotected outdoor operation.

3.1.8 The packaged mechanical equipment shall be shop assembled to the maximum extent practical in order to minimize on-site erection work. All skids and equipment that mate directly (without interconnecting piping by Buyer) shall be trial fitted in the Supplier's shop. The Supplier shall identify in the proposal all loose-shipped components requiring field installation. All connections, including piping and instruments, shall be clearly identified on Supplier's drawings. The actual connections on the equipment shall be permanently stamped or tagged with the same identification. If tags are used, they shall be non-flexible corrosion resistant metal, attached by stainless steel wire.

3.1.9 The maximum allowable working pressure for each process or utility stream shall be no less than the greatest of the following:

3.1.9.1 The value(s) specified on the data sheets.

3.1.9.2 10% above the maximum operating pressure.

3.1.9.3 25 psi above the maximum operating pressure.

3.1.10 Safeguards and relief devices on equipment shall be provided where necessary to protect personnel, equipment, and piping.

3.1.11 Over pressure protection for piping and equipment shall be in accordance with API RP520, Parts I and II, or the Code, at a minimum. Documentation

that explains the basis for application and sizing of safeguards and relief devices shall be provided.

3.1.12 Unless otherwise approved by the Buyer, rupture disks shall not be used for pressure relief devices.

3.1.13 Steady state broadband A-weighted Sound Pressure Level (SPL) generated by equipment shall not exceed 85 dBA beyond a 3 foot perimeter from all equipment surfaces.

3.1.14 If sound pressure level (SPL) exceeds data sheet requirements, information shall be provided with the proposal indicating additional sound treatment required to obtain the conditions specified.

3.1.15 All equipment shall be so arranged that, when installed, all external and internal components requiring manipulation, observation, and maintenance shall be readily accessible and safe to operating and maintenance personnel.

3.1.16 The layout of all equipment packages, auxiliary systems, and control cabinets shall be orderly, compact, well supported and braced. The layout shall provide access for equipment maintenance.

3.1.17 The Supplier for the packaged mechanical equipment shall assume overall responsibility for all equipment and auxiliary systems included in the scope of supply for the package.

3.1.18 The equipment package shall be designed for unattended operation. In case regular operational activities are required, the Supplier shall provide data on frequencies and duration of such activities.

3.1.19 Platforms, walkways, handrails, ladders, coupling guards and insulation shall conform to the OSHA regulations, along with the applicable Codes and Standards, and the project specifications. All walkways must allow for access to operating equipment, instrumentation, and valves. No piping shall cross or intersect walkways; nor shall any piping inadvertently restrict passage.

3.1.20 For skid mounted equipment, all piping, instrument, electrical and skid drain connections shall be grouped and extended to the edge of the skid.

3.1.21 All special tools or instruments required for erection and maintenance of the packaged equipment shall be provided by Supplier.

3.1.22 Dimensions of each skid shall be no larger than 40 feet long, 14 feet wide and 13 feet high for shipping purposes. Larger skids may be acceptable depending on site conditions, shipping point and skid configuration. When larger skids are required, Supplier shall check with the Buyer for clearance information.

3.1.23 Unless otherwise specified, the minimum nozzle connection size shall be ¾ inch nominal pipe size NPS.

3.1.24 Connections of sizes NPS 1-1/4, 2-1/2, 3-1/2, 5, 7, and 9 shall not be permitted.

3.1.25 After award of Purchase Order, the Supplier shall submit a complete start-up and operation spare parts recommendation for all equipment within Supplier's scope of supply.

3.2 Clearance and Access Requirements

3.2.1 Buyer will review equipment layout for operation, in-place maintenance, and removal of equipment components prior to start of fabrication. A layout drawing of the skid must be furnished with the Supplier's quotation.

3.2.2 Platforms, walkways, and other main access routes shall have clear headroom of at least 7 feet.

3.2.3 The final skid assembly, including the layout of conduits, piping and instrumentation shall provide unobstructed access to all equipment requiring operation, viewing, or maintenance.

3.2.4 Components that are operated or serviced on a regular or emergency basis shall be located less than 6 feet above grade or platform.

3.2.5 Components that are maintained, operated, or serviced only occasionally shall be located within 14 feet of grade, with unobstructed access using a portable ladder or scaffolding, or less than 6 feet above platform.

3.2.6 A minimum of 12 inches clearance shall be provided between conduit and equipment or piping, taking into account any required thermal insulation.

3.2.7 Space shall be provided for the Buyer supplied and installed insulation system if applicable.

3.2.8 Spacing for valve actuation, equipment maintenance and other component functionality must be considered.

3.2.9 Rigid conduit and piping shall not be routed over the cases of rotating machinery (or other equipment) and shall not be routed over or in front of removable heads on vessels and exchangers, or where they impair the functionality of inspection openings or panel doors.

3.2.10 Access shall be provided for the removal of exchanger bundles, and all in-line devices.

4.0 UNITS OF MEASUREMENT

4.1 The units of measurement shall be U.S. customary units.

5.0 MATERIALS AND WELDING

5.1 Materials of construction shall be as specified on the individual data sheets and equipment specifications.

5.2 Welding of pressure vessels and heat exchangers shall be in accordance with Project Specification EH-35R-CCU1-SPC-255-85050, “Welding/NDE Requirements for Equipment”.

5.3 Pipe welding shall be in accordance with Project Specification EH-35R-CCU1-SPC-255-85002, "Welding of Shop or Field Fabricated Piping."

5.4 Backing rings shall not be permitted.

5.5 Positive Material Identification shall be in accordance with Project Specification EH-35R-CCU1-SPC-255-85012, “Positive Material Identification (PMI)”.

5.6 Asbestos or asbestos containing materials shall not be used by the Supplier as a material of construction for gaskets, packing, seals, or for any other item or component thereof.

5.7 Materials that are highly persistent or toxic to the environment or considered internationally potential carcinogens shall not be used (e.g. poly-chlorinated biphenols (PCB), etc.).

5.8 Care shall be taken to prevent chloride and free iron contamination of stainless steel materials during all phases of the manufacturing process.

5.9 Austenitic stainless steel equipment and piping shall be hydrotested with water having the chloride content not greater than 50 ppm.

6.0 VESSELS AND HEAT EXCHANGERS

6.1 Pressure vessels shall be designed and fabricated in accordance with Project Specification EH-35R-CCU1-SPC-255-58001, “Design and Fabrication Specification for Vessels”, ASME Code Section VIII, Divisions 1 and 2.

6.2 Shell and tube heat exchangers, if provided, shall be in accordance with Project Specification EH-35R-CCU1-SPC-255-57020, “Shell and Tube Heat Exchangers”.

6.3 Plate and frame heat exchangers, if provided, shall be in accordance with Project Specification EH-35R-CCU1-SPC-255-57035, "Plate Heat Exchangers”.

6.4 Air cooled heat exchangers, if provided, shall be in accordance with Project Specification EH-35R-CCU1-SPC-255-57030, "Air-Cooled Heat Exchangers."

6.5 All equipment shall be provided with valved vent and drain connections. The vent and drain connections shall be piped to the edge of the skid if the equipment is skid mounted.

6.6 All covers and blind flanges 50 pounds and greater shall be provided with a davit.

7.0 ROTATING EQUIPMENT

7.1 General

7.1.1 All rotating equipment shall be in accordance with standards and specifications as specified on the Purchaser’s Equipment Specification or Data Sheet.

7.1.2 All motors up to 200 HP shall be in accordance with Project Specification EH-35R-CCU1-SPC-255-56070, “General Purpose Induction Motors 3/4 HP – 200 HP’ and for all other motors, Project Specification EH-35R-CCU1-SPC-255-56073, “General Purpose Induction Motors – API 547”, shall be followed.

7.1.3 Coupling guards in accordance with OSHA regulations shall be provided over all moving parts that could be hazardous to personnel and shall be installed by the equipment vendor.

7.1.4 Guards shall be properly ventilated to prevent excessive heat build-up.

7.1.5 Unless otherwise specified, guards shall be supported from the base plate or sole plate.

7.1.6 Rotation arrows shall be either cast in or permanently attached (on fixed portion - non-removable - of equipment) to all rotating equipment at a readily visible location.

7.1.7 Supplier shall ensure that all rotating equipment is easily accessible for condition monitoring (vibration monitoring via hand held probes). Coupling guard shall provide access to bearing housing of rotating equipment for vibration monitoring.

7.1.8 The rotating equipment component data sheets shall be completed by the original equipment manufacturers, and provided by the Supplier of the packaged mechanical equipment after checking for accuracy and compliance, and reviewed by the Buyer.

7.2 Machinery Mounting

7.2.1 Unless otherwise specified, all equipment shall be installed on mounting plates.

7.2.2 Mounting plates shall extend at least 1 inch beyond the outer four sides of equipment feet.

7.2.3 All mounting plate anchor bolt holes shall have a minimum 0.12 inch annular clearance with the anchor bolt to allow for field alignment of mounting plates.

7.2.4 Equipment base plate mounting surfaces shall be machined flat to within 0.002 inch/ft of length with a maximum allowable difference of not more than 0.01 inch out of plane between any two mounting surfaces on the skid. The surface finish of the mounting surface shall be 250 micro inch average roughness (Ra) or better.

7.2.5 For drive train components 500 pounds and heavier, the equipment feet shall be provided with vertical and horizontal jackscrews and shall be drilled with pilot holes that are accessible for use in final doweling.

7.3 Rotating Machinery Alignment

7.3.1 Unless otherwise specified on the data sheet, the Supplier shall comply with the alignment criteria in this section.

7.3.2 Supplier shall demonstrate that final alignment can be achieved in the shop before shipping.

7.3.3 Unless otherwise specified, the shim configuration shall be specified by the Buyer on the data sheet and supplied by the Supplier.

7.3.4 All shims shall be full bearing. Shims shall be supplied by the equipment Supplier.

7.3.5 Unless otherwise specified on the data sheet, the Supplier shall provide all equipment hold-down bolts for the skid.

7.3.6 Slotted hold-down bolt holes are not permitted unless approved by the Buyer.

7.3.7 Through bolting of equipment feet is not permitted unless approved by the Buyer.

7.3.8 Undercutting of hold-down bolts to achieve alignment is not permitted.

7.3.9 Lock washers are not permitted at machinery hold-down bolts.

7.3.10 Hold-down bolting shall not be bolt-bound. This will prevent the movement of the equipment in a direction due to the lack of clearance between the hold-down bolt and the side of the bolt hole in the equipment feet through which they pass. In the equipment's final aligned position, a minimum of 1/32 inch of clearance shall be provided between the hold-down bolts and the sides of the bolt holes in the equipment feet.

7.3.11 The soft-foot checks shall be performed during the final alignment on each equipment foot (not at the coupling). Piping shall be disconnected from the equipment and all hold-down bolts shall be tightened and loosened one at a time. Maximum permissible movement is 0.002 inch as measured at each foot with a dial indicator.

7.3.12 Piping stress shall be checked before final shaft alignment check. Final shaft alignment checks shall be performed before and after connecting piping and conduit.

7.3.13 Final alignment checks shall not be performed until the process piping has been hydro-tested. If the piping is disturbed after the Buyer has accepted final alignment, train alignment shall be rechecked and approved by the Buyer.

7.3.14 Unless specific alignment acceptance criteria are specified on the data sheet, the Supplier shall demonstrate that the equipment manufacturer's standard alignment can be achieved, accounting for thermal offset and alignment bracket sag.

7.4 Drivers

7.4.1 The following requirement is applicable only if there is no driver sizing criteria in the equipment parent specification or data sheet.

7.4.2 Driver power shall, as a minimum, be equal to the rated shaft power at rated operating condition multiplied by the percentage listed below:

kW	BHP	% of Rated Shaft Power
0-22	0-30	125
22-75	30-100	115
>75	>100	110

7.5 Belt Drives

7.5.1 Unless otherwise specified, belt drives shall not be used for applications with greater than 150 shaft HP.

7.5.2 Unless otherwise specified, belt drives shall be synchronous in accordance with RMA IP-24.

7.5.3 Unless otherwise specified on the data sheet, multiple belt applications shall have banded construction. If more than one banded multiple V-belt is required, the Supplier shall furnish matched belt lengths.

7.5.4 All drive belts shall be oil resistant (with a Neoprene or equivalent cover).

7.5.5 Unless otherwise specified on the data sheet, the drive system rating shall be based on a service factor of 1.75 times the driver nameplate power rating.

7.5.6 Belt drives, if permitted, shall conform to ANSI/RMA IP-20 and this specification.

7.5.7 Minimum recommended motor sheave diameters shall conform to NEMA MG1.

7.5.8 Use of adjustable sheaves is prohibited.

7.5.9 Unless otherwise specified on the data sheet, sheaves shall be balanced to primary equipment balance specification.

7.5.10 Belt drives shall have a motor adjustment mechanism to allow belt tension adjustment. Slide rails shall have a dual adjustment.

7.5.11 When service in a hazardous area is specified, belt drives of the static conducting type shall be provided.

8.0 PIPING AND VALVES

8.1 Piping shall be designed and fabricated in accordance with Project Specification EH-35R-CCU1-SPC-250-50112, “Packaged Equipment Piping”.

8.2 Piping shall be designed and supported to minimize loads on equipment.

8.3 Piping, tubing and conduits shall be installed plumb to natural centerlines and visual surfaces.

8.4 Valves, flow meters, strainers, etc. shall be installed in such a manner that they are accessible and can be easily replaced or repaired. Breakout flanges or unions shall be provided to allow easy removal.

8.5 Valves shall be installed on, or as close to, the pressure vessel nozzles as possible, with no unions and a minimum of joints between valves and the nozzle. Care shall be taken to insure that globe, check, and control valves are installed correctly with regard to flow direction.

8.6 All purchaser piping interfaces shall be impression-stamped or permanently tagged in accordance with the supplier's connection table or general arrangement drawing. Service or utility connection designations shall be clearly indicated.

8.7 Flanges shall be in accordance with ASME B16.5. Flange bolt holes shall straddle the natural centerlines. Unless otherwise noted, flange face finish shall be 125-250 microinch Ra.

8.8 Cast iron shall not be used for piping components.

8.9 Corrosion allowance shall be per applicable specification/data sheet.

9.0 ELECTRICAL

9.1 Electrical systems shall be designed, fabricated and tested in accordance with Project Specification EH-35R-CCU1-SPC-265-00002, "Electrical Requirements for Packaged Equipment".

9.2 Flexible conduit connections shall be used to avoid transmission of vibration from vibrating equipment to the conduit system. It shall also be used to terminate periodically removable connections such as to motors, instruments, and thermocouples. Maximum length of flexible conduit connections shall be 36 inches.

9.3 Exposed conduit shall be run vertically, horizontally, or parallel to the structure line. Conduit bodies and junction boxes shall be accessible from platforms, ladders, and stairways and shall be supported independent of conduit system. Whenever practical, horizontal conduits shall be sloped for drainage. Conduit shall not be installed behind the ladder rungs or at platform levels in such a manner as may cause false and insecure step. Drain breathers shall be installed at low point of vertical conduit runs.

9.4 Conduit connections to junction box shall be made using insulated, watertight threaded hubs or factory threaded hubs. Conduits shall enter box from sides or bottom.

C 9.5 All metallic electrical equipment and enclosures shall be bonded to the supporting metal frame in accordance with the NEC.

C 9.6 Two (2) stainless steel grounding lugs welded to the skid structural steel or frame at diagonally opposite ends shall be provided for connection to the grounding grid.

10.0 INSTRUMENTATION AND CONTROLS

10.1 All Instruments and Controls shall be furnished in accordance with the requirements of Project Specification EH-35R-CCU1-SPC-270-00003, “Instruments and Controls Supplied with Packaged Equipment”.

10.2 Supplier shall provide all field Instrumentation required for the controlled start-up, normal operation and controlled shutdown of the package.

10.3 Instrumentation provided by the SUPPLIER shall be wired to a junction box or local panel located at the skid edge.

10.4 Where the BUYER must install SUPPLIER furnished instruments, panels or consoles etc., SUPPLIER shall provide detailed installation/wiring drawings.

10.5 SUPPLIER shall be responsible for producing the P&ID's which shall define the detailed Instrumentation & Control System. The P&ID's must reflect the final and correct configuration of all Instrumentation, control loops, alarms, interlocks and local field devices. The BUYER shall provide the SUPPLIER with Instrument tag numbers.

11.0 STRUCTURAL

11.1 The design, fabrication, and installation of structures, structural components and anchorage of Packaged Mechanical Equipment shall comply with Project Specification EH-35R-CCU1-SPC-215-00002, “Structural Data for Mechanical Equipment”.

11.2 All structural steel welds shall be in accordance with AWS D1.1 and shall be continuous.

11.3 All skid joints, including floor plates on both sides, shall be continuously seal welded. No skip welding or crevices are permitted. The skids shall have a perimeter drip rim, with valved drain, to contain leaks and shall be designed to avoid accumulation.

11.4 Ends of tubular structural members shall be closed and seal welded.

11.5 Butt-welded structural members shall have full penetration welds.

11.6 There shall be a sufficient number of adequately sized lifting attachments for lifting the package. Supplier shall provide spreader bar capacity and dimensions when spreader bar is required to lift package to prevent slings from damaging the package.

11.7 All lifting components shall be furnished in accordance with Project Specification EH-35R-CCU1-SPC-255-58005, “Design of Lifting Components for Mechanical Equipment”.

11.8 Center of gravity of the complete assembly shall be clearly identified on assembly drawings and clearly marked on the equipment package.

11.9 Projections of equipment outside the perimeter of the skid shall not be permitted.

11.10 The entire Skid Surface, except under equipment mounts, shall be supplied with grating or checker plate flooring.

11.11 Piping or conduit shall not be located below the top of the skid deck.

11.12 Skids shall be provided with vertical leveling screws located next to the anchor bolt holes.

11.13 Stairways, ladders and platforms shall comply with OSHA requirements.

12.0 DOCUMENTATION, INSPECTION AND TESTING

12.1 Supplier Documentation Requirements

12.1.1 Supplier shall submit the type and quantity of drawings and documentation for Purchaser's authorization or information as listed in the Supplier Drawing & Data Commitment Form ("SDDC form"). Submittals shall be in accordance with attached document "PDDM Attachment to Seller's Drawing and Data Commitment Form".

12.1.2 Mutual agreement on scheduled submittal of drawings and engineering data shall be an integral part of any formal Purchase Order.

12.1.3 Comments made by Purchaser on drawing submittal shall not relieve Supplier of any responsibility in meeting the requirements of the specifications. Such comments shall not be construed as permission to deviate from requirements of the order unless specific and mutual agreement is reached and confirmed in writing.

12.1.4 It is imperative that the SUPPLIER submit all required drawings and design documents per schedules attached. In addition to the project information, drawings shall be identified with PURCHASER's reference number (refer to the Supplier Data Commitment Form) to facilitate logging and documentation. SUPPLIER shall sign and return a copy of the SDDC form. SUPPLIER shall submit drawings and design documents, specific to the items being purchased and not mere standard drawings.

12.1.5 Photographs of all nameplates shall be submitted for Purchaser approval prior to shipping equipment.

12.2 Inspection and Testing

12.2.1 A pre-inspection meeting may be held before the start of fabrication. All pertinent specification and inspection requirements will be reviewed and details of the inspection program will be established.

12.2.2 The Seller shall provide an Inspection and Test Plan (ITP) for Buyer review and approval no later than 4 weeks after purchase order award. ITP shall include a complete listing of quality test and hold points required for this order.

12.2.3 Certified reports are required for all specified tests. The Purchaser's approval of test and other pertinent specified data is required for authorization to ship the equipment. Equipment acceptance by the Purchaser at the Supplier's factory or onsite shall not constitute a waiver or modification of any purchase order or contract requirements.

12.2.4 The manufacturer shall provide all personnel and simulation/test equipment for execution of all tests required.

12.2.5 Materials certificates, including heat treatment records where required, shall be obtained by the Supplier for alloy pressure-containing components. Copies of such certificates shall be provided to the Purchaser's inspector upon request.

12.2.6 An in-plant inspection shall be performed on the equipment purchased. The Purchaser's designated inspector shall have free entry at all times while work on this contract is being performed, to all parts of Supplier's and Sub-supplier's premises which involves the manufacture, inspection, or testing of the equipment.

12.2.7 Seller shall provide at least ten (10) working days tentative advance notice and three (3) working days firm advance notice prior to each inspection, test, or retest. However, Seller shall make every effort to provide as much advance notice as possible to allow the proper witnesses to make travel plans. If the originally scheduled test is not carried out as scheduled, Seller shall again notify the Buyer in writing of the new test date.

12.2.8 Purchaser shall be provided with free access to all inspection reports, test reports, etc. generated by the Supplier or Supplier's sub-suppliers and these documents shall be submitted to the Purchaser if requested during the life of the project. This shall be limited to documents that are provided as per the approved ITP. No other production documentation shall be submitted, but maybe reviewed at the point of use.

12.2.9 Inspection shall not relieve Seller of complying with all expressed or implied provisions of this package or of Seller's responsibility to provide material that shall perform satisfactorily under conditions of reasonable service. No change arising out of inspection shall be made on this contract until such change has been approved by Buyer.

12.2.10 Unless a written waiver is issued, all tests designated as “hold points” shall be witnessed by Buyer and/or Buyer’s representative.

12.2.11 Buyer and/or buyer’s representative shall provide final written approval to release equipment for shipment.

12.2.12 All testing and visual inspection defects shall be corrected prior to shipping. Punch-list items may be approved by Purchaser's engineer utilizing photographic evidence. Equipment shall not ship until all Punch-list items are resolved and signed off by the Purchaser's Engineer.

12.2.13 All Equipment and Piping systems shall be pressure tested (prior to finish painting).

12.2.14 All testing, whether witnessed or not, shall be certified by the Supplier and a test report shall be furnished to Buyer for approval prior to equipment shipment in accordance with 12.2.3.

12.2.15 Acceptance of shop tests shall not constitute a waiver of requirements to meet field needs under the specified operating conditions; nor does it relieve the Supplier from responsibility in any way whatsoever.

13.0 PAINTING, COATING, AND INSULATION

13.1 Painting shall be in accordance with the requirements of Project Specification EH-35R-CCU1-SPC-255-85210, “Aboveground Coatings”.

13.2 Galvanizing shall be in accordance with the requirements of Project Specification EH-35R-CCU1-SPC-255-85400, “Galvanizing”.

13.3 When galvanizing is specified, the Zinc used in galvanizing bath shall contain less than 0.03% lead and shall fully comply with the requirements of ASTM B6.

13.4 Insulation shall be in accordance with the requirements of Project Specification EH-35R-CCU1-SPC-255-85110, “Hot Insulation”.

14.0 PREPARATION FOR SHIPMENT

14.1 Supplier is responsible for packing, crating, bracing, closing openings and loading of the shipment. Care should be taken to prevent possible damage during transportation. Sufficient temporary bracing shall be installed to prevent damage due to vibration and shock. Temporary bracing shall be marked with paint high visibility (yellow preferred) for removal after installation.

14.2 Export packing shall be provided, by Supplier, for items shipped from outside of the United States.

14.3 Supplier shall adequately prepare all equipment for shipment and for outdoor storage at the job site. Supplier shall submit detailed procedures for preservation during storage at the job site. Any devices requiring electrical power during storage shall have readily accessible terminals brought out to the edge of the crate.

14.4 All openings shall be closed before shipping as follows:

14.4.1 All threaded openings shall be plugged with long shank hex pipe plugs. Plug material shall be equivalent to the material being plugged, except that carbon steel plugs shall be used with openings in cast iron.

14.4.2 Flanged openings shall be provided with full flange diameter protective covers. Cover material shall be 3/16 inch minimum thickness metal plate, except that openings larger than 36” may be covered with ¾” minimum thick plywood. A full diameter gasket shall be supplied between the flange and cover plate. The cover plate shall be held to the flange by a minimum of four (4) full diameter bolts and nuts, equally spaced around the flange.

14.4.3 All open ends of tubes and pipe shall be capped for protection.

14.5 If any part of the unit has to be removed during shipment, all connecting pieces shall be match-marked, tagged and keyed to assembly drawings and assembly instructions, which shall be enclosed in a weatherproof packet accompanying the unit.

14.6 One complete set of the installation, operation, and maintenance instructions shall be packed in the boxes or crates with equipment.

14.7 The equipment shall be provided with sufficient bracing and lifting lugs to permit handling at the construction site with slings or hooks without damage to the equipment. Lift points shall be clearly and permanently identified.

14.8 When a spreader bar or custom lifting device is required to lift equipment, Supplier shall provide sketch with capacity and dimensions.

14.9 Spare parts shall be marked as described above with the addition of the word SPARE clearly indicated on all tags, shipping documents and the crate/box/pallet. Spares shall be boxed separately from main equipment and may be shipped to a different address. Shipping information will be provided later in the project.

14.10 A stainless steel nameplate for each of the skid / package of major mechanical equipment showing at least the following information shall be securely attached by stainless steel rivets or continuous welding, easily readable, and located on the outside perimeter of the skid/ package.

14.10.1 Supplier Name.

14.10.2 Buyer's Purchase Order No.

14.10.3 Equipment Item Number/Tag

14.10.4 Serial Number

14.10.5 Design Condition

14.10.6 Hydrostatic Condition

14.10.7 Size and Type

14.10.8 Year built

End of Specification

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

Welding and NDE Requirements for Shop or Field Fabricated Piping

Specification No. EH-35R-CCU1-SPC-255-85002

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1.0 INTRODUCTION

1.1 Purpose

This specification, EH-35R-CCU1-SPC-255-85002, defines the welding, thermal treatment, examination and testing requirements for shop or field fabricated piping. This includes piping designed to ASME B31.3 and boiler or HRSG external piping designed to ASME B31.1.

1.2 Scope

This specification covers piping designed to ASME B31.3 and boiler or HRSG external piping designed to ASME B31.1, and supplements the Codes and Standards listed in Section 2.0 of this specification.

2.0 REFERENCES

Additional references are listed below. Short titles will be used herein when appropriate.

2.1 Industry Codes and Standards

- American Society of Mechanical Engineers (ASME)
  - B31.1 Power Piping
  - B31.3 Process Piping
  - Section II, Part C Materials - Specifications for Welding Rods, Electrodes and Filler Metals
  - Section V Nondestructive Examination
  - Section IX Welding and Brazing Qualifications
- American Society of Nondestructive Testing (ASNT)
  - SNT-TC-1A Recommended Practice for Nondestructive Testing Personnel Qualification and Certification
- American Society for Testing and Materials (ASTM)
  - A833 Standard Practice for Indentation Hardness of Metallic Materials by Comparison Hardness Testers
  - E10 Standard Test Method for Brinell Hardness of Metallic Materials
  - E18 Standard Test Methods for Rockwell Hardness of Metallic Materials
  - E92 Standard Test Method for Vickers Hardness and Knoop Hardness of Metallic Materials
  - E140 Standard Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness,

Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness

- American Welding Society (AWS)

A2.4	Standard Symbols for Welding, Brazing, and Nondestructive Testing
A3.0	Standard Welding Terms and Definitions Including Terms for Brazing, Soldering, Thermal Spraying and Thermal Cutting
A4.2	Standard Procedure for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Austenitic-Ferritic Stainless Steel Weld Metal
D10.10	Recommended Practices for Local Heating of Welds in Piping and Tubing
Z49.1	Safety in Welding, Cutting and Allied Processes

2.2 Reference Specifications

– EH-35R-CCU1-SPC-255-85012	Positive Materials Identification
– EH-35R-CCU1-SPC-255-85530	Material and Fabrication Requirements for Duplex Stainless Steels
– EH-35R-CCU1-SPC-255-50003	Material Specification Line Class – Process and Utility Piping

3.0 DEFINITIONS

The following additional definitions are also applicable to this specification.

Table 1: Definitions

Term	Description
Shall/Will	Denotes a minimum requirement in order to conform to the intent of the standard.
Should/Can/Could/May	Denotes a recommendation which is advised but not required in order to conform to the standard.

4.0 GENERAL REQUIREMENTS

4.1 Welding to this Specification shall conform to the requirements of ASME B31.1 or B31.3, whichever is applicable. Compliance with this Specification and approval of Welding Procedure Specifications (WPS), Procedure Qualification Records (PQR) and mill test reports shall in no way relieve the Seller of the responsibility of providing welds which are sound and suited to the services for which they are intended.

4.2 When requirements of the Codes, Standards and Specifications listed in Section 2.0 of this Specification conflict with this Specification, Seller shall immediately submit the matter to Buyer for determination and written clarification.

4.3 Welding and nondestructive examination symbols shall be in accordance with AWS A2.4.

4.4 Welding terms and definitions shall be in accordance with AWS A3.0.

4.5 Safety measures for the protection of welders and operators involved in welding and cutting shall be in accordance with the practices specified in AWS Z49.1 plus all local, state, federal and other governing regulations.

4.6 Tack welds shall be made with the same ASME classification consumable that is used for the root pass.

4.7 Peening the weld is not allowed, however chipping to remove slag using air tool is not considered peening.

4.8 All stubs, rods, flux, slag and other foreign material shall be removed from inside and outside the pipe after welding is finished.

4.9 Arc strikes, weld spatter, and burrs shall be removed/ground out in their entirety and blended smoothly with the pipe surface. The ground area shall not result in thinning below the specified wall thickness. The ground area in P-4 material and higher shall be magnetic particle (MT) examined for possible cracks or porosity. Liquid penetrant (PT) testing shall be used for non-magnetic materials.

4.10 Attachments such as lugs, clips, supports and similar items shall not be located on a weld seam without prior approval from Buyer.

4.11 Fabrication aids, temporary supporting lugs, etc. that are removed by gouging or thermal cutting shall not be reduced less than 1/8 inch (3.2 mm) from the surface. The remaining material shall be ground flush with the base metal. The ground area shall not result in thinning below the specified wall thickness. The ground area in P-4 material and higher shall be MT examined for possible cracks or porosity. PT shall be used for non-magnetic materials.

4.12 Visual examination shall be carried out for possible pinholes or arc scars caused by electric sparks from improperly grounded or damaged welding cables on the surface.

4.13 Lubricants, thread compounds, paints, crayon markers, pickling solution, ink markers, tapes and adhesives containing chlorides shall not be used on stainless steel (SS) or nickel alloys. SS shall not come in contact with zinc, aluminum or other low melting point metals.

4.14 Grinding wheels and austenitic SS wire brushes used on austenitic SS or other higher nickel and nonferrous alloys shall not have been previously used on ferrous materials, copper alloys, aluminum or zinc coatings (paint or galvanized).

4.15 Base materials that have been galvanized or coated with zinc-based paints shall not be welded to austenitic SS materials. Welding is not permitted even when the galvanized or zinc-based paint is removed by mechanical or chemicals means.

4.16 The application of heat to correct weld distortion and dimensional deviation in SS or Cr-Mo steels is prohibited. For all other materials, pre-approval by Buyer is required.

4.17 The weld shall be sheltered from the wind when the wind velocity exceeds 5 mph (2.2 m/s) in the weld area for gas shielded processes. Other welding processes shall be limited to 20 mph (8.9 m/s) maximum wind.

4.18 Welding of 9Cr-1Mo-V (P-15E) is outside the scope of this specification. If 9Cr-1Mo is specified, 9Cr-1Mo-V shall not be used. If 9Cr-1Mo-V is required, Buyer will provide a separate welding specification.

4.19 If duplex SS (such as UNS S32205/S31803, S32205, S32550, S32750, S32760, S32003, or other grades) is specified, Specification EH-35R-CCU1-SPC-255-85530, “Material and Fabrication Requirements for Duplex Stainless Steel” shall be required.

4.20 If the Purchase Order or Buyer’s data sheets/drawings require Positive Material Identification (PMI) to be performed, the testing shall meet the requirements of Specification EH-35R-CCU1-SPC-255-85012, “Positive Material Identification”.

4.21 Attachment 1 "Pipe Welding Data Sheets" summarizes the heat treatment, nondestructive examination and related requirements for each line class (as defined in Specification EH-35R-CCU1-SPC-255-50003, “Material Specification Line Class – Process and Utility Piping”.

5.0 WELDING PROCEDURE AND PERFORMANCE QUALIFICATIONS

5.1 WPS’s, PQR’s and Welder's Performance Qualification Records shall conform to the requirements of ASME Section IX and to the requirements of this and any other Specifications specific to the service or material. Requirements for PQR hardness testing are given in Paragraph 10.2.

5.2 WPS’s and PQR’s shall be submitted to the Buyer prior to the start of fabrication. Welding shall not start until these documents are returned to the Seller with approval to proceed.

5.3 Welder and Welding Operator Performance Qualification Records shall be made available to the Buyer upon request.

5.4 All WPS’s and PQR’s for items purchased or subcontracted by the Seller shall be reviewed by the Seller for content and contract compliance prior to submittal to the Buyer.

5.5 Welds that are deposited by procedures that differ from those approved by the Buyer may be subject to complete removal at Seller's expense.

6.0 ACCEPTABLE WELDING PROCESSES

6.1 SMAW, GTAW, SAW, FCAW and GMAW with Spray, Globular or Short Circuit Transfer, are acceptable when used in accordance with this specification and the applicable Codes. Using a combination of these processes within a weld joint is also acceptable.

6.2 Full penetration open root groove welds in P-4 materials and higher shall have the root pass welded with the GTAW process and shall have the interior of the pipe beneath the welding zone purged with an inert gas, unless otherwise approved by Buyer. The inert gas shall be held for the first two layers of weld metal. If other gas-shielded processes are approved for these root passes, they shall also be back purged.

6.3 FCAW (Spray or Globular Transfer) process shall be limited to:

6.3.1 Weldout of pressure retaining welds in P-1, P-4, P-5A, P-5B, and P-8.

6.3.2 FCAW is not acceptable for root passes of butt welds when welding from one side.

6.3.3 FCAW of P-8 materials shall not be allowed when the operating temperature exceeds 900°F (480°C).

6.3.4 External gas shielding is required except per Paragraph 5.3.5 of this Specification.

6.3.5 FCAW (spray or globular transfer) with self-shielding wire is acceptable for non-pressure retaining welds in P-1 materials that are limited to 3/8 inch (9.5 mm) leg length and are not subject to impact requirements.

6.3.6 FCAW using short circuit transfer is prohibited.

6.3.7 Electrode diameter shall not exceed 5/32 inch (4.0 mm).

6.3.8 Vertical downhill welding is not acceptable.

6.3.9 Wind velocity shall not exceed 5 mph (2.2 m/s) in the weld area, unless the weld is sheltered from the wind.

6.4 GMAW - Short Circuit Transfer process shall be limited to:

6.4.1 Carbon steel only.

6.4.2 Root pass and weldout through 3/8 inch (9.5 mm) wall thickness. Root pass only on wall thickness greater than 3/8 inch (9.5 mm).

6.4.3 Root passes can be made in any direction, but fill and cap passes shall not be made in the downhill direction below the two (2) o'clock position.

6.5 Other welding processes require specific written approval from Buyer. Seller shall submit all pertinent data and intended application of said process for evaluation. The Seller shall not assume application of these processes will be accepted during bid preparation.

7.0 FILLER MATERIALS

7.1 Filler metal shall be in accordance with ASME Section II, Part C.

7.2 Filler metal chemistry for similar metal welds shall match that of the base material. Similar metallurgical properties shall be produced.

7.3 Weld metal analysis for P-1 materials shall be “A-1” per ASME Section IX, Table QW-442. The use of carbon- ½ moly (such as ER70S-A1) or filler metals with Ni or Mn above A-1 limits are not acceptable for welding P-1 carbon steel.

7.4 Carbon and low alloy steel electrodes/bare wire that have a nonspecific chemistry as indicated by a "G" classification shall not be used.

7.5 The use of consumable root inserts requires Buyer’s approval. If approved, the insert shall be completely melted by welding and the chemistry of the insert shall match the material to be joined.

7.6 Dissimilar metal welds joints should be avoided whenever practical, as long as dissimilar flanges are acceptable. When used, dissimilar metal welds should comply with the guidelines listed below. Whenever “high nickel filler material” is referenced, it includes of ASME classification ENiCrFe-2, ENiCrFe-3, ENiCrMo-3 from ASME Section II, Part C, SFA-5.11 or ERNiCr-3 or ERNiCrMo-3 from SFA-5.14. Other classifications can also be proposed by Seller for Buyer approval.

7.6.1 For dissimilar joints in base metals consisting of carbon and low alloy steels (P-1 through P-5B), the filler metal shall be low hydrogen and compatible with the composition of either base material. The filler metal matching the lower P-number material is preferred. PWHT temperature and time requirements shall be based on the higher P-number material regardless of which filler metal is used, however the lower critical temperature of the lower P-number material shall not be exceeded.

7.6.2 For dissimilar joints in base metals consisting of a ferritic material (P-1 through P-7) on one side and iron-nickel-chrome (P-45) or nickel-chrome-moly (P-43) on the other, a high nickel filler material shall be used.

7.6.3 For ferritic steel (P-1 through P-7) to Monel (70 Ni-30 Cu, P-42), filler metal shall meet the requirements of ASME Classification ENiCu-7, ENiCrFe-3 or ERNiCu-7. All other filler metals require approval from Buyer.

7.6.4 For dissimilar joints in base metals consisting of a ferritic material (P-1 through P-7) on one side and austenitic SS (P-8) on the other, the filler material selection shall be reviewed and approved by Buyer. The following guidelines should be used:

a. For all operating temperatures: High nickel filler metal shall be used, except that for design temperatures below 600°F (315°C), the use of 309L filler metal can be considered, but requires Buyer review and approval.

b. Where postweld heat treatment (PWHT) of the joint is required, the ferritic material (P-1 through P-5B) can be buttered with high nickel filler metal and PWHT’d prior to welding to the austenitic SS. Such joints shall be qualified in accordance with ASME Section IX, QW-283.

7.6.5 For dissimilar joints in base metals consisting of austenitic SS (P-8) on one side and iron-nickel-chrome (P-45) or nickel-chrome-moly (P-43) on the other, high nickel filler metal shall be used.

7.7 Fluxes that the flux Manufacturer recommends for single pass shall not be used for multiple pass welds.

7.8 Solid wires for automatic welding processes shall contain the principal elements required for the deposited weld metal. Welds deposited by the SAW process shall not derive any principal elements from the flux.

7.9 Filler wires in Specification ASME SFA-5.2 shall not be used for welding with GTAW process.

7.10 When using the SMAW process, low hydrogen electrodes shall be used for all pressure-retaining welds or attachments to pressure boundaries. For carbon steel welded from one side only, E6010 may be used for the root pass.

7.11 After opening shipping containers of electrodes, fluxes and other welding materials, storage and handling shall be as specified in the Manufacturer's recommendations and ASME Section II, Part C.

7.12 When requested, the Seller shall submit his procedure for storage and handling of electrodes, filler metal and fluxes to the Buyer for review prior to the start of fabrication. The procedure shall include moisture, cleanliness and identification controls.

7.13 SAW multipass welding in carbon steel, alloy steel, and corrosion-resistant steels shall use an essentially neutral flux.

7.14 Submerged arc welding of production parts shall be performed using the same name brand flux and same name brand or same ASME classification of wire as used for the procedure qualification.

7.15 Coated electrodes shall be purchased in hermetically sealed containers. Low hydrogen electrodes shall be properly baked out and kept dry. This may be accomplished by the use of portable rod ovens and limiting the time out of the rod oven to four (4) hours. Coated electrodes that have become wet or oil soaked shall not be reused.

7.16 When required by Section 10.11 of this Specification, austenitic stainless steel filler metal shall be screened to meet the listed ferrite testing requirements.

8.0 WELD JOINT PREPARATION

8.1 Weld joint preparation shall be made by machining, grinding or thermal cutting. When thermal cutting is performed, the joint surfaces shall be mechanically cleaned to sound metal prior to welding.

8.2 Weld bevel edges over 2 inches (50 mm) shall be examined by MT (or PT for non-magnetic materials).

8.3 Double-welded butt joints are preferred and shall be implemented wherever the size of the pipe or plate cylinder makes it practical.

8.4 Permanent backing rings or bars are not permitted. If temporary backing rings are used and then removed, the weld area shall be dressed and examined for cracks and other defects. Examination of the weld surface shall be performed visually and by MT or PT in accordance with Section 10.0 of this Specification. Unacceptable defects shall be removed and repaired. When temporary backing rings or bars or consumable root inserts are used they shall be of the same nominal composition as the base metal.

8.5 Surfaces to be welded shall be cleaned for 1 1/2 inches (38 mm) on either side of the weld on the OD and ID. Surfaces shall be free from paint, oil, dirt, scale, oxides and other foreign material detrimental to welding.

8.6 Prior to welding, joints shall be visually inspected for: cleanliness, correct groove configuration, alignment and gap conditions, condition of tack welds if present, preheat if specified, and filler metal to be used. They shall meet the stated submitted, reviewed and approved WPS, Code and applicable standards.

9.0 PREHEAT AND POSTWELD HEAT TREATMENT

9.1 Preheat temperatures for thermal cutting, tack welding and welding shall be performed in accordance with ASME B31.1, Section 131, or ASME B31.3, Section 330, as applicable. Preheating listed as recommended in the Codes shall be required.

9.2 Preheat for piping components shall be limited to electrical resistance, inductance heating or the following methods. Hand-held oxy-fuel flame “rosebud” preheating is permitted for all P-1 materials, and for NPS 4 (and 4 inch tube) and smaller for P-4 and P-5A low alloy steels. Stationary gas burners are permitted for all sizes and materials including P-5B.

9.3 Preheat temperature shall be verified with temperature indicating crayons or equivalent.

9.4 After welding is complete, weld joints in chrome-moly steels (P-4, P-5A and P-5B) shall be cooled to preheat temperature and the preheat held until PWHT. If holding preheat until PWHT is not practical, the weld and adjacent area shall be wrapped with insulation and allowed to slow cool and postweld heat treated later.

9.5 Welding chrome-moly steels (P-4, P-5A and P-5B) shall not be interrupted from the time the root pass is started until at least 1/4 inch (6.3 mm) of weld thickness is deposited. Where interruption after 1/4 inch (6.3 mm) of weld thickness has been deposited, the weld and adjacent area shall be wrapped with insulation and allowed to slow cool.

9.6 The maximum interpass temperature for austenitic SS shall be 350ºF (175ºC), and the maximum interpass temperature for Alloy 20 (UNS N08020) shall be 200ºF (93ºC).

9.7 For ASME B31.3 piping, chrome-moly steels (P-4, P-5A and P-5B) require PWHT regardless of thickness. Hold times shall be per B31.3 if greater than one hour, and one hour minimum for other cases.

9.8 PWHT shall be done after attachment welds to the piping (such as pipe supports) are complete. No welding shall be performed on the piping after PWHT.

9.9 PWHT requirements for dissimilar metal welds are given in the applicable Code and in Section 7.6 of this specification.

9.10 Threads and gasket surfaces shall be suitably protected from excessive oxidation during heat treatment.

9.11 Exothermic heating for heat treatment is not permitted.

9.12 A maximum of two complete PWHT cycles is permitted for each weld. Further PWHT cycles shall not be carried out without Buyer’s approval.

9.13 PWHT temperature shall be continuously recorded. A chart of the heat up, soak and cooldown while at temperature above 500°F (260°C) is required. Time intervals shall be

recorded with temperature and time intervals indicated clearly. The chart shall be signed by the operator of the furnace, and shall be reviewed by Buyer.

9.14 PWHT shall be performed in accordance with ASME B31.1, Section 132, or ASME B31.3, Section 331, as applicable and Attachment 1 of this Specification.

9.15 PWHT may be required for carbon steel welds for service conditions. PWHT for these services will be indicated on Buyer's isometric drawings and by Attachment 1. When PWHT is specified on carbon steel for Amine, Caustic or Carbonate service, PWHT shall be performed at 1175°F ± 25°F (635°C ± 14°C) for one hour per inch of throat thickness of the weld, with a one (1) hour minimum holding time.

9.16 Acceptable PWHT methods are listed as follows in the order of preference and the furnace method shall be used whenever feasible. Other methods shall require written approval by Buyer.

a. Furnace Method

b. Local Resistance Method

c. Local Induction Method

9.17 When local PWHT is needed on carbon steel for amine, caustic or carbonate service, and for local PWHT on all other materials, the band widths and thermocouple placements shall be in accordance with AWS D10.10, "Recommended Practices for Local Heating of Welds in Piping and Tubing".

9.18 PWHT of welds and welds to pressure boundaries on alloys UNS N08800 (Alloy 800), UNS N08810 (Alloy 800H) and UNS N08811 (Alloy 800HT) with design temperatures above 1000°F (540°C) shall be done. The PWHT shall be at 1625°F (885°C) minimum for 1.5 hours for thicknesses up to 1 inch (25 mm) and 1.5 hours plus one hour per inch (25 mm) for thicknesses in excess of 1 inch (25 mm).

10.0 NONDESTRUCTIVE EXAMINATION (NDE)

10.1 All NDE shall be performed as required by ASME B31.1 or ASME B31.3, as applicable. Specific NDE requirements for each material and line class shall be as noted in Attachment 1.

10.2 All NDE shall be performed by personnel certified in accordance with ASNT Recommended Practice SNT-TC-1A or Seller's own equivalent certification program that has been approved by Buyer.

10.3 Interpretation of NDE results shall be performed by personnel certified to Level II or III.

10.4 When requested, all NDE procedures shall be submitted to Buyer, and examination shall not proceed until approved by the Buyer. In addition, all records pertaining to inspection and certification shall be available for review by Buyer.

10.5 Visual Examination

10.5.1 All welds shall receive 100% visual inspection (VT).

10.5.2 The Seller's written visual examination procedure and personnel qualifications shall be in accordance with ASME Section V, Article 9, and this specification.

10.5.3 The welds to be examined, the evaluation of indications and the acceptance criteria shall be in accordance with the applicable Code.

10.6 Magnetic Particle Examination

10.6.1 MT examination procedures shall be in accordance with the requirements and methods specified in ASME Section V, Article 7.

10.6.2 MT examination of welds shall include a band of base metal at least one (1) inch (25 mm) wide on each side of the weld.

10.6.3 The evaluation of indications and the acceptance criteria shall be in accordance with the applicable Code.

10.6.4 If arc burns occur during MT examination, the arc burns shall be ground out and the area reexamined by the magnetic yoke method.

10.6.5 For PWHT'd piping, the yoke method shall be used.

10.7 Liquid Penetrant Examination

10.7.1 Liquid penetrant examination procedures shall be in accordance with the requirements and methods specified in ASME Section V, Article 6, using solvent removable penetrant.

10.7.2 Penetrant materials shall meet the requirements of Paragraph T-641 of Article 6, Section V of ASME, for sulfur and halogen content regardless of the type of material to be examined.

10.7.3 Liquid penetrant examination of welds shall include a band of base metal at least one (1) inch (25 mm) wide on each side of the weld.

10.7.4 The evaluation of indications and the acceptance criteria shall be in accordance with the applicable Code.

10.8 Radiographic and Ultrasonic Examination

10.8.1 Radiographic and ultrasonic examination procedures and techniques for welds shall be in accordance with ASME Section V, Article 2 and Article 4, respectively.

10.8.2 The acceptance criteria shall be in accordance with the applicable Code.

10.8.3 All piping welds that require RT or UT may use the following options for possible cost savings:

a. $\geq$ 3/8 inch wall – Phased Array UT

b. < 3/8 inch wall – Digital or Computed RT

10.8.4 Phased array UT shall be in accordance with ASME Section V, Article 4, and the applicable Code.

10.8.5 Digital or Computed RT shall be in accordance with Section V, Article 2, and the applicable Mandatory Appendices. Selenium (Se) 75 sources should be used wherever feasible for both the safety risk reduction and savings in project

cost and schedule. The acceptance criteria shall be in accordance with the applicable Code.

10.8.6 100% RT is required for all 1500# and 2500# line classes designed to B31.3.

10.8.7 Buyer may witness and approve Practical Testing for Level I/II UT operators for flaw detection certification.

10.9 Control of Welder/Operator Quality

10.9.1 Progressive examination in accordance with ASME B31.3, Paragraph 341.3.4 shall have the following additional requirements:

a. If any of the items examined in accordance with Paragraph 341.3.4(c) reveals a defect, then the welder or welding operator shall be considered unacceptable for any further welding to that WPS with respect to Buyer's work done to this Specification without requalification and the agreement of Buyer.

b. Timing is essential for the control of welder or operator quality; therefore, the progressive examination required by Paragraph 341.3.4 shall be completed within sixteen (16) working hours of the first defect, unless otherwise agreed to by Buyer.

c. Welders shall not be permitted to weld production joints of any type while waiting for results of qualification.

10.10 Positive Material Identification

10.10.1 When Positive Material Identification is required for alloy materials and welds, Specification EH-35R-CCU1-SPC-255-85012 "Positive Material Identification" becomes part of this Specification.

10.11 Ferrite Testing

10.11.1 Ferrite content of the deposited weld metal on ten percent (10%) of austenitic SS piping welds which are intended for service at temperatures greater than 800ºF (427ºC) or will receive PWHT shall be determined using Ferritescope or Severn gauge. The instrument used for ferrite determination shall be calibrated in accordance with AWS A4.2. Alternatively, ferrite may be determined from the WRC-1992 diagram (found in ASME Section II-C, SFA-5.4) and a wet chemical analysis.

10.11.2 The ferrite number shall be three (3) to eleven (11) Ferrite Number (FN).

10.11.3 Marking of welds which have been tested and met the criteria shall be a circumferential, low chloride paint stripe in a color that is not being used for any other coding purposes. Other record keeping methods shall be approved by Buyer. The paint stripe marking does not need to be redone after full painting of the piping (if painting is required).

11.0 MECHANICAL TESTING OF WELDS

11.1 Mechanical Tests shall be conducted as required by ASME B31.1 or ASME B31.3 as applicable, ASME Section IX, and this Specification. Buyer may witness the mechanical testing.

11.2 Welding Procedure Qualification Record (PQR) Hardness Testing

11.2.1 General

a. Acceptable methods for PQR hardness testing are Brinell, Rockwell, Knoop and Vickers. Procedure and test methods shall be in accordance with ASTM E10, E18 or E92.

b. When PWHT and hardness testing are required, hardness testing shall be performed after PWHT.

c. Hardness testing shall be conducted on the deposited weld metal and both Heat Affected Zones (HAZ). Three hardness tests surveys shall be performed with one across the center of the weld and the others 1/16 inch (1.6 mm) from each surface. All test results shall be reported on the PQR or on a supplemental report.

d. Individual readings exceeding the criteria will be acceptable if the average of that reading plus two (2) additional readings taken within close proximity does not exceed the criteria and no individual reading is greater than eight (8) HB units above the criteria.

e. Hardness testing results shall be expressed in Brinell numbers. The actual Knoop, Rockwell or Vickers hardness results shall be reported along with the Brinell conversions. Conversion shall be in accordance with ASTM E140 for all materials covered within that specification.

11.2.2 P-1 Material

a. Hardness testing is required for wet H_2S services.

b. Hardness results shall not exceed 225 HB for HAZ and 200 HB for weld deposits.

11.2.3 P-4 Materials

a. Hardness testing shall be required for all welding processes.

b. Hardness results shall not exceed 235 HB for HAZ and 225 HB for weld deposits.

11.2.4 P-5A and P-5B Materials

a. Hardness testing shall be required for all welding processes.

b. Hardness results shall not exceed 235 HB for HAZ and 235 HB for weld deposits.

11.3 Production Hardness Testing

11.3.1 Equipment used for production hardness testing shall be inspected on a daily basis. Personnel performing hardness testing shall be familiar with the hardness testing procedures and calibration.

11.3.2 Hardness readings shall be taken with a portable Brinell hardness tester in accordance with ASTM A833, or with a Krautkramer MIC 10. Other techniques require approval by the Buyer.

11.3.3 Hardness testing shall be conducted on the deposited weld metal only. A hardness test shall consist of three (3) hardness readings, and each individual reading shall be reported.

11.3.4 Hardness testing results shall be expressed in Brinell numbers. The hardness report shall indicate actual hardness reading plus Brinell conversion if applicable. Conversion shall be in accordance with ASTM E140 for all materials covered within that specification.

11.3.5 The hardness test report shall indicate type of material, type of hardness tester, personnel conducting hardness tests, and last calibration date.

11.3.6 Buyer's representative may witness the performance of production testing. The documented test results shall be submitted to Buyer when requested.

11.3.7 Hardness tests shall be performed after postweld heat treatment if PWHT is required.

11.3.8 P-1 Material

a. Hardness testing is required on 10% of butt welds in wet H_2S service.

b. Hardness results shall not exceed 200 HB.

11.3.9 P-4, P-5A and P-5B (when designed to ASME B31.3)

a. Hardness testing is required for at least 10% of welds, hot bends, and hot formed components in each furnace heat treated batch and 100% of welds which are locally heat treated.

b. Hardness readings shall not exceed 225 HB for P-4, and 235 HB for P-5A and P-5B weld deposits or materials.

11.4 Impact Testing (Charpy V-Notch)

11.4.1 When impact testing (Charpy V-Notch) is required by engineering design and/or ASME B31.3, the Weld Procedure Qualification shall be tested in accordance with the methods and acceptance criteria of ASME B31.3, Paragraph 323.3.

12.0 WELD REPAIRS

12.1 Unacceptable discontinuities shall be completely removed by chipping, gouging, grinding or other approved methods (for the type of material being repaired) to clean, sound metal, and the excavated area shall be examined by MT or PT to ensure complete removal of the defects.

12.2 Repairs to correct weld defects shall be made using the same WPS used for the original weld, or other previously-approved WPS.

12.3 The repaired areas shall be reexamined using the same inspection procedures by which the defect was originally detected.

12.4 Two (2) repair attempts will be allowed on any one defective area. No further attempts to repair shall be carried out without the approval of Buyer.

12.5 When requested, weld repair procedures shall be submitted to Buyer. The procedure shall state, as a minimum, the following information:

12.5.1 Means of excavating defect from weld.

12.5.2 NDE method used to verify complete defect removal.

12.5.3 WPS used to fill excavated area.

12.5.4 NDE method used to verify repair weld is sound.

13.0 ATTACHMENT 1 – EXAMPLE PIPE WELDING DATA SHEETS

TABLE A-1. Weld Joint Abbreviations on Pipe Welding Data Sheets (PWDS)

ABBR	JOINT TYPE	DESCRIPTION OF APPLICABLE JOINTS
BW	Butt Weld	Pipe-to-Pipe including miters or any combination of Pipe/Fitting/Valve welds except branches.
GFW	Groove with Fillet Weld	Branch connection weld typically between integrally reinforced o-let and main pipe. Also includes pipe-to-header welds such as set-in or set-on groove joints (which are rarely used).
FW	Fillet Weld	Includes socket welds, seal welds, and non-pressure containing attachment welds.

TABLE A-2. NDE, Heat Treatment and Testing Abbreviations on PWDS

ABBR	TYPE OF OPERATION	REMARKS
RT	Radiography	All types, Random and 100%
MT	Magnetic Particle Examination	Wet or Dry Method
PT	Liquid Penetrant Examination	
UT	Ultrasonic Examination	Excludes thickness testing
VT	Visual Examination	
HT	Hardness Test	All methods
PMI	Positive Material Identification	All methods
FN	Ferrite Determination	
CVN	Impact Testing	
PWHT	Postweld Heat Treatment	

Design Code: ASME B31.3 Fluid Service: Normal ASME Flange Rating: 150, 300, 600

Design Conditions: TBD

Line Class (es): TBD

Service Description (s): *TBD - (no amine, caustic, carbonate, wet sour)*

Piping Material: Carbon Steel
P Number: P-1

Attachment Material: Carbon Steel
P Number: P-1

Valve Body Material: Carbon Steel
P Number: P-1

CVN Requirements: Per Code based on thickness PMI Requirements: None FN Requirements: None

Pipe Dia. NPS	Max Wall Thickness	Joint Type	Heat Treatment		NDE				HT		WPS/Comment
			Preheat	PWHT	RT or UT	MT	PT	VT	%	Max Value	
0.5-36	1.0 inch	BW	50°F	None	5%	N/A	N/A	100%	N/A	N/A	
All	All	GFW	Note 1	None	5%	N/A	N/A	100%	N/A	N/A	
All	All	FW	Note 1	None	N/A	N/A	N/A	100%	N/A	N/A	

Notes:

1. Welds with thickness of the materials being joined at the weld over 1 inch require preheat at 200°F. Preheat shall be 50°F for other cases.
2. Seal welds (when required) shall cover all exposed threads and be two passes minimum.

Design Code: ASME B31.3 Fluid Service: Normal ASME Flange Rating: 150, 300, 600
Design Conditions: TBD
Line Class (es): TBD

Service Description (s): *TBD - (primarily caustic)*

Piping Material: Carbon Steel Attachment Material: Carbon Steel Valve Body Material: Carbon Steel
P Number: P-1 P Number: P-1 P Number: P-1

CVN Requirements: Per Code based on thickness PMI Requirements: None FN Requirements: None

Pipe Dia.	Max Wall	Joint	Heat Treatment		NDE				HT		WPS/Comment
NPS	Thickness	Type	Preheat	PWHT	RT or UT	MT	PT	VT	%	Max Value	
0.5-24	1.0 inch	BW	50°F	1150-1200°F	5%	N/A	N/A	100%	N/A	N/A	
All	All	GFW	Note 1	1150-1200°F	5%	N/A	N/A	100%	N/A	N/A	
All	All	FW	Note 1	1150-1200°F	N/A	N/A	N/A	100%	N/A	N/A	

Notes:

1. Welds with thickness of the materials being joined at the weld over 1 inch require preheat at 200°F. Preheat shall be 50°F for other cases.
2. Seal welds (when required) shall cover all exposed threads and be two passes minimum. Threaded connections to be avoided for caustic service.

Design Code: ASME B31.3 | Fluid Service: Category D | ASME Flange Rating: 150, 300, 600

Design Conditions: TBD

Line Class (es): TBD

Service Description (s): *TBD - Plant Air, Instrument Air, Domestic Water, CWS/CWR, Oily Water Sewer*

Piping Material: Carbon Steel; P Number: P-1

Attachment Material: Carbon Steel; P Number: P-1

Valve Body Material: Carbon Steel; P Number: P-1

CVN Requirements: None

PMI Requirements: None

FN Requirements: None

Pipe Dia. NPS	Max Wall Thickness	Joint Type	Heat Treatment		NDE				HT		WPS/Comment
			Preheat	PWHT	RT or UT	MT	PT	VT	%	Max Value	
3-36	0.375 inch	BW	50°F	None	N/A	N/A	N/A	100%	N/A	N/A	
All	All	GFW	Note 1	None	N/A	N/A	N/A	100%	N/A	N/A	
All	All	FW	Note 1	None	N/A	N/A	N/A	100%	N/A	N/A	

Notes:

1. Welds with thickness of the materials being joined at the weld over 1 inch require preheat at 200°F. Preheat shall be 50°F for other cases.
2. Seal welds (when required) shall cover all exposed threads and be two passes minimum.

Design Code: ASME B31.3 | Fluid Service: Normal | ASME Flange Rating: 150

Design Conditions: TBD

Line Class (es): TBD

Service Description (s): Chemical Injection - TBD

Piping Material: 316/316L SS | Attachment Material: 304/304L SS | Valve Body Material: 316/316L SS

P Number: P-8 | P Number: P-8 | P Number: P-8

CVN Requirements: None | PMI Requirements: Yes | FN Requirements: None - TBD

Pipe Dia. NPS	Max Wall Thickness	Joint Type	Heat Treatment		NDE				HT		WPS/Comment
			Preheat	PWHT	RT or UT	MT	PT	VT	%	Max Value	
All	All	BW	50°F, Note 1	N/A	5%	N/A	N/A	100%	N/A	N/A	
All	All	GFW	50°F, Note 1	N/A	5%	N/A	5%	100%	N/A	N/A	
All	All	FW	50°F, Note 1	N/A	N/A	N/A	5%	100%	N/A	N/A	

Notes:

1. Interpass temperature shall be limited to 350°F.
2. Seal welds (when required) shall cover all exposed threads.

Design Code: ASME B31.3 | Fluid Service: Normal | ASME Flange Rating: 600

Design Conditions: TBD

Line Class (es): TBD

Service Description (s): Process - TBD

Piping Material: 321 SS | Attachment Material: 304/304L SS | Valve Body Material: 321 SS

P Number: P-8 | P Number: P-8 | P Number: P-8

CVN Requirements: None | PMI Requirements: Yes | FN Requirements: None - TBD

Pipe Dia. NPS	Max Wall Thickness	Joint Type	Heat Treatment		NDE				HT		WPS/Comment
			Preheat	PWHT	RT or UT	MT	PT	VT	%	Max Value	
All	All	BW	50°F, Note 1	N/A	5%	N/A	N/A	100%	N/A	N/A	
All	All	GFW	50°F, Note 1	N/A	5%	N/A	5%	100%	N/A	N/A	
All	All	FW	50°F, Note 1	N/A	N/A	N/A	5%	100%	N/A	N/A	

Notes:

1. Interpass temperature shall be limited to 350°F.
2. Seal welds (when required) shall cover all exposed threads.

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

Positive Material Identification

Specification No. EH-35R-CCU1-SPC-255-85012

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1.0 SCOPE AND DEFINITIONS

1.1 This specification defines the equipment, procedure and identification required for a program of Positive Material Identification (PMI).

1.2 This specification requires PMI for all pressure-containing alloy materials and non-pressure containing alloy vessel internals. Alloy materials are defined as any ferrous or nickel alloy material that is not carbon steel. Unless specifically noted, other non-ferrous materials (copper alloys, titanium, aluminum, etc.) do not require testing.

1.3 This specification shall be implemented to reinforce those procedures which are normally used to identify and control alloy materials during fabrication.

1.4 Equipment items requiring PMI shall reference this specification on the Bill of Materials, Equipment Data Sheets or drawings.

1.5 Piping items requiring PMI will be noted by piping Line Class or in the project Pipe Welding Data Sheets (Attachment to Specification EH-35R-CCU1-SPC-255-85002"Welding Shop and/or Field Fabricated Piping"), on drawings, and/or by reference on purchase documents to this specification.

1.6 Within the scope of this specification the term "Seller" refers to the provider of the original material. Material may be supplied directly to a Fabricator or to Buyer's construction site.

2.0 REFERENCE CODES AND STANDARDS

The following Codes and Standards apply to this Specification. When an edition date is not indicated for a code or standard, the latest edition and addenda in force at time of purchase shall apply.

2.1 Pipe Fabrication Institute

ES-22 Recommended Practice for Color Coding of Piping Materials

2.2 Buyer Specifications

EH-35R-CCU1-SPC-255-85050	Welding/ NDE Requirements for Equipment
EH-35R-CCU1-SPC-255-85002	Welding of Shop or Field Fabricated Piping

3.0 COMPONENTS TO BE TESTED

3.1 The following pressure-containing alloy items shall have the chemistry of materials verified and identified in accordance with this specification.

3.1.1 Pipe, valve bodies and bonnets (including control and relief type valves), flanges, fittings (including weld-o-lets and thread-o-lets), thermowells, and vent and drain plugs.

3.1.2 Shell courses, heads, flanges, nozzle necks, and fittings attached to equipment including overlay or cladding parts.

3.1.3 All instrumentation except for tubing, tube fittings, manifold valves and instrumentation components downstream of pipe-mounted instrument root valves. Instrumentation specifically requiring PMI of the pressure-containing components include: control valves, relief valves, flow elements, thermowells, displacers, level gauges, rotameters and other similar instruments.

3.1.4 Heat exchanger tubing or plates in plate heat exchangers.

3.1.5 Fired heaters process tubes, flanges, header and tube fittings (including pipe used for tubing).

3.1.6 Rotating equipment cases and pressure-containing heads.

3.1.7 Weld deposits (shop and/or field fabricated items).

3.2 The following non-pressure containing alloy internals shall have the chemistry of materials verified and identified in accordance with this specification. The extent of examination shall be 5% or two components minimum, whichever is larger, per heat number unless noted otherwise:

3.2.1 Trays

3.2.2 Supports and structural members

3.2.3 Attachments to the pressure boundary

3.2.4 Bolting hardware and fasteners

3.2.5 Distributors

3.2.6 Weld deposits between internals

3.2.7 Weld deposits made to the pressure boundary, 100% PMI required.

3.3 Acceptance of materials will be based on testing performed after fabrication. Testing may be performed prior to postweld heat treatment.

3.4 Valves and any components that will not be accessible after fabrication shall be tested upon receipt and immediately identified in accordance with Section 10.0.

3.5 The extent of examination of items listed in Paragraphs 3.1 shall be in accordance with Paragraphs 4.1 and 4.2 of this specification.

3.6 Gaskets, external bolting, nuts and other fasteners do not require testing unless indicated otherwise in purchase documents.

3.7 Purchase Orders to Sellers for the items listed in Paragraphs 3.1 shall include a reference to this specification for PMI requirements.

3.8 The Seller shall provide the Fabricator or the construction site mill certificates that show the chemical analysis of the alloy items along with the PMI testing documentation required by this Specification.

4.0 EXTENT AND RECORDING OF EXAMINATIONS

4.1 The extent of examinations for alloy material items (see Paragraph 3.1) shall be as follows:

4.1.1 All pressure-containing alloy materials excluding 304 and 304L stainless steel (SS), except heat exchanger tubes, 100%.

4.1.2 304 and 304L SS components to be PMI tested at 10% or minimum one per heat and 100% verification by material test report (MTR) and magnet check in the field.

4.1.3 All alloy heat exchanger tubes and plates for plate heat exchanger, 5% per heat of material.

4.1.4 Pressure-containing alloy butt welds excluding 304 and 304L SS in equipment and piping shall be 100% PMI tested.

4.1.5 304 and 304L SS welds to be PMI tested at 5% or minimum one per welder/shift and 100% verification by filler material check and magnet check in the field.

4.1.6 Internals shall be at the percentages given in Paragraph 3.2.

4.2 Shop fabricated piping spools and equipment which received PMI testing at the shop may be subject to PMI retesting on a random sample basis at the construction site. If any piece or weld from a representative percentage sample is found to be unacceptable, then the remainder of that material heat number or all welds on a completed pipe spool or equipment item (as applicable) shall be verified by performing 100% PMI examination at the Fabricator's expense. Materials and welds found to be incorrectly installed shall be replaced at the Fabricator's cost. Following installation, PMI shall be conducted on all replaced components and associated welds.

4.3 Results of all PMI examinations shall be noted on as-built drawings, spool sheets, or isometrics.

4.4 Results of all PMI examinations shall be recorded on report forms. See Attachment 2 as a typical example. Report forms shall indicate for each equipment item or pipe spool component the following information:

4.4.1 Seller's mill certification number.

4.4.2 Material heat number.

4.4.3 Representative percentage sample size and number of item(s) examined (welds or heat exchanger tubes).

4.4.4 Test result on each of the required elements

4.5 All PMI reports shall include a copy of or a reference to the Seller's material certification.

4.6 In addition, identification marking on the components or welds is required as detailed in Section 10.

4.7 The Fabricator shall provide PMI reports and material certifications to Buyer. In all cases where traceability of a material heat number cannot be established back to the Seller's mill certification or other positive means of identity, that material heat number, regardless of quantity, shall be PMI examined 100% at the Fabricator's expense.

4.8 PMI examinations may be witnessed by Buyer.

5.0 ALLOYING ELEMENTS TO BE ANALYZED

5.1 Attachment 1 lists the specific alloying elements for each alloy which shall be analyzed by PMI testing. The content that is measured shall be recorded and the results submitted to Buyer. The test results shall be within the range specified by the applicable material standard, except for the exceptions given in Paragraphs 5.2 through 5.4. A “match” reported by the testing instrument is not sufficient for accepting the material, and instead, the individual elements shall be within the required ranges.

5.2 Carbon content verification is required for low carbon ”L” or high carbon “H” grades of materials unless waived by Buyer. It is preferred that a non-destructive test instrument capable of measuring carbon be used; however, the carbon content can also be verified by wet chemical analysis.

5.3 Where weld overlay or clad material is used, the overlay of cladding shall meet alloying levels of the specified material. In addition, if the base material is an alloy, it shall also be tested.

5.4 For PMI of dissimilar metal welds or for weld overlay (i.e. backcladding) of welds between clad plates using a higher alloy weld metal than the cladding, the required chemical levels will be specified on a case-by-case basis by Buyer.

5.5 Any high alloy material not listed in Attachment 1 shall be reviewed with the Buyer to determine the elements to be analyzed.

6.0 ACCEPTANCE / REJECTION CRITERIA

6.1 If any of the major alloying elements of the material are below the range specified by the applicable material standard, the component shall be rejected.

6.2 If any of the major alloying elements of the material are greater than the range specified, the alloy content must be reported to Buyer for acceptance or rejection.

6.3 The Fabricator shall identify, mark, remove and segregate all unacceptable materials.

7.0 TEST PROCEDURES

7.1 Seller shall develop written operating procedures for PMI testing which shall be submitted to and authorized by Buyer prior to the start of fabrication.

7.2 Operating procedures shall ensure examinations are performed in accordance with this specification by specific reference to this specification via addendum to, or revision of operating procedures. Written operating procedures shall contain, as a minimum, the following information:

7.2.1 Name and manufacturer of test equipment to be used.

7.2.2 Description of equipment operating principle.

7.2.3 Calibration procedure and frequency.

7.2.4 Marking method for typical components.

7.2.5 Acceptance criteria.

7.2.6 Radiation Safety Operating and Emergency Procedures, if applicable.

7.2.7 Statement of operating personnel competency for PMI techniques.

8.0 PMI TESTING DURING FIELD INSTALLATION

8.1 A program shall be established for material handling in field prior to field construction work on facilities consisting of the following:

8.1.1 Storage facilities to segregate materials and parts by alloy content.

8.1.2 Procedures for transferring material stamping or marking to unused portions of materials and parts (such as plates, pipes, and studs) prior to returning to storage. Materials and parts without proper stamping or marking shall not be used nor returned to storage.

8.2 Preliminary PMI testing can be done on receipt of materials, but the final testing of components which are welded in shall be done after welding.

9.0 PMI EQUIPMENT

9.1 Test equipment or methods used for examinations shall be one of the following types that are capable of providing quantitative, recordable, elemental composition results: portable X-Ray Fluorescence (XRF), portable X-Ray Emission Analyzer or mobile Optical Emission Spectroscopy (OES). Commonly-used instruments include the NITON XL3 or XL5 series, and the Oxford Instruments X-MET8000 or PMI-Master.

9.2 If analysis in a laboratory becomes necessary, typical techniques are:

9.2.1 X-ray emission spectrometry

9.2.2 Optical spectroscopy

9.2.3 Wet chemical analysis

***Note**: If laboratory analysis is to be used, the method of sample(s) identification and traceability to original material shall be agreed to by Buyer prior to testing.*

10.0 IDENTIFICATION MARKING

10.1 Materials that have been PMI examined shall be marked and recorded.

10.1.1 Markings shall be immediately done after PMI examination either by low-stress (round bottomed) stamps or Vibra-Etch, paint marking each item in accordance with PFI Standard ES-22, Attachment 3 or wire tagging of each item if item is too small for stamping.

10.1.2 Paint used shall not contain additives that could be deleterious on alloy material.

10.2 Each item piece shall be marked to identify the alloy type (i.e., PMI 1¼ Cr or PMI 316) if stamping is used.

10.3 Vendor proposed PMI mapping may be submitted for review and approval by Buyer. Examples of PMI mapping are marking-up a drawing using the MTR heat codes and providing traceability to the PMI reports.

10.4 Cut lengths of pipe from PMI examined material shall have PMI markings transferred to all pieces. This marking is in addition to the marking normally required by applicable codes(s) or other job specifications.

10.5 Materials that are PMI examined shall remain identified until such time as their identity is necessarily obliterated by processing (painting, insulation or plant operations).

10.6 A quality plan shall be established to prevent the inadvertent use of materials which have failed PMI examinations.

11.0 EXAMINATION PERSONNEL

11.1 Procedures, as required by Section 7.0, shall contain a statement of personnel competency or qualification (by training and/or experience) in the techniques of material identification by the methods listed in Section 9.0 of this specification. Records shall be available for review on request by Buyer.

11.2 Buyer has the right to prohibit those personnel judged unqualified from performing examinations.

12.0 LIST OF ATTACHMENTS

Attachment 01 Elements of Alloy Materials Subject to PMI Testing and Acceptable Ranges

Attachment 02 Seller PMI Report Form

Attachment 03 Color Code for Alloy Material Identification

ATTACHMENT 1

ELEMENTS OF ALLOY MATERIALS SUBJECT TO PMI TESTING AND ACCEPTABLE RANGES (Note 1)

Alloy	ASTM Designation	Cr	Mo	Ni	C	Ti	Cb	Cu	Other Elements	Notes
Chrome-Moly Steels										
1 ¼ Cr – ½ Mo	ASTM Gr. P11	1.00-1.50	0.44-0.65							
2 ¼ Cr – 1 Mo	ASTM Gr.22	1.90-2.60	0.87-1.13						V: 0.05 max.	
2 ¼ Cr – 1 Mo -V	ASTM Gr.22V	1.90-2.60	0.87-1.13						V: 0.25-0.35	
5 Cr – ½ Mo	ASTM Gr.5	4.00-6.00	0.45-0.65							
9 Cr – 1 Mo	ASTM Gr.9	8.00-10.00	0.90-1.10						V: 0.05 max.	
9 Cr – 1 Mo - V	ASTM Gr.91	8.5-9.50	0.85-1.05						V: 0.18-0.25	
Austenitic Stainless Steels										
304 SS	A312 TP304	18.0-20.0		8.0-11.0						
304L SS	A312 TP304L	18.0-20.0		8.0-11.0	0.035 Max					Note 6
304H SS	A312 TP304H	18.0-20.0		8.0-11.0	0.04-0.10					Note 6
316 SS	A312 TP316	16.0-18.0	2.00-3.00	11.0-14.0						
316L SS	A312 TP316L	16.0-18.0	2.00-3.00	10.0-15.0	0.035 Max					Note 6
316H SS	A312 TP316H	16.0-18.0	2.00-3.00	11.0-14.0	0.04-0.10					Note 6
317 SS	A312 TP317	18.0-20.0	3.0-4.0	11.0-14.0						
317L SS	A312 TP317L	18.0-20.0	3.0-4.0	11.0-15.0	0.035 Max					Note 6
321 SS	A312 TP321	17.0-20.0		9.0-13.0		Note 2				
321H SS	A312 TP321H	17.0-20.0		9.0-13.0	0.04-0.10	Note 3				Note 6
347 SS	A312 TP347	17.0-20.0		9.0-13.0			Note 4			
347H SS	A312 TP347H	17.0-20.0		9.0-13.0	0.04-0.10		Note 5			Note 6
Ferritic & Martensitic Stainless Steels										
405 (12 Cr)	A268 TP405	11.5-13.5			0.08 Max	X				Note 10
410 (12 Cr)	A268 TP410	11.5-13.5								
410S (12 Cr)	A240 Type 410S	11.5-13.5			0.08 Max	X				Note 10
Nickel Based Alloys										
Alloy 20	B464, UNS N08020	19.0-21.0	2.00-3.00	32.0-38.0	0.07 Max		Note 7	3.00-4.00		
Alloy 600	B167, UNS N06600	14.0-16.0		72.0 Min					Fe: 6.0-10.0	
Alloy 625	B444, UNS N06625	20.0 Min	8.0-10.0	58.0 Min			Note 8		Fe: 5.0 Max	
Alloy 800	B407, UNS N0800	19.0-23.0		30.0-35.0	0.10 Max				Fe: 39.5 Min	
Alloy 800H	B407, UNS N08810	19.0-23.0		30.0-35.0	0.05-0.10	Note 11			Fe: 39.5 Min	
Alloy 800HT	B407, UNS N08811	19.0-23.0		30.0-35.0	0.06-0.10	Note 9			Fe: 39.5 Min	
Alloy 825	B423, UNS N08825	19.5-23.5	2.5-3.5	38.0-46.0		0.60-1.20		1.5-3.0	Fe: 22.0 Min	
Monel 400	B165, UNS N04400			63.0 Min				28.0-34.0	Fe: 2.50 Max	

ELEMENTS OF ALLOY MATERIALS SUBJECT TO PMI TESTING AND ACCEPTABLE RANGES (Note 1)

Alloy	ASTM Designation	Cr	Mo	Ni	C	Ti	Cb	Cu	Other Elements	Notes
Duplex Stainless Steels										
2304 Duplex SS	A790, UNS S32304	21.5-24.5	0.05-0.60	3.0-5.5						
2101 Duplex SS	A790, UNS S32101	21.0-22.0	0.10-0.80	1.35-1.70					Mn: 4.0-6.0	
2003 Duplex SS	A790, UNS S32003	19.5-22.5	1.50-2.00	3.0-4.0						
2205 Duplex SS	A790, UNS S31803	22.0-23.0	3.0-3.5	4.50-6.50					N: 0.14-0.20	
2507 Duplex SS	A790, UNS S32750	24.0-26.0	3.0-5.0	6.0-8.0					N: 0.24-0.32	

Notes:

1. The element chemistry limits in this table are for pipes. Other product forms (such as fittings, flanges, plates and castings) may have slightly different requirements. The applicable ASME/ASTM materials specification shall be met in each case.
2. The titanium content shall be not less than five times the carbon content and not more than 0.70%.
3. The titanium content shall be not less than four times the carbon content and not more than 0.60%.
4. The columbium plus tantalum content shall be not less than ten times the carbon content and not more than 1.00%.
5. The columbium plus tantalum content shall be not less than eight times the carbon content and not more than 1.00%.
6. See Paragraph 5.2 of this specification.
7. The columbium plus tantalum content shall be eight times the carbon content to 1.00% (8 X Carbon min. to 1.00% max).
8. The columbium plus tantalum content shall be 3.15 min - 4.15 max.
9. The titanium plus aluminum content shall be 0.85 min -1.20 max.
10. The presence of titanium may indicate that the material is 409 SS and further testing may be required to verify the materials.
11. For many services, this alloy is special ordered with titanium plus aluminum content limited to 0.70 Max. If so, this shall be included in the PMI testing and the material shall meet this criteria.

ATTACHMENT 2
EXAMPLE OF A SELLER PMI REPORT FORM

PMI REQUEST BY: SIGNATURE: DATE:	PURCHASE ORDER NUMBER
PMI PERFORMED BY: SIGNATURE: DATE:	PMI WILL BE/WAS PERFORMED AT:

ITEM OR TAG NUMBER	SAMPLE SIZE	MATERIAL	MILL CERT. NUMBER	HEAT NUMBER	DESCRIPTION

EXAMINATION RESULTS

ITEM OR TAG NUMBER	NO. OF PIECES EXAM.	NO. OF PIECES ACCEPT.	NO. OF PIECES REJ.	MATERIAL IDENTIFIED AS	Chemical Composition Percentage									
					Cr	Mo	Ni	C	Ti	Cb	Cu	Fe	V	

ADDRESS OF SELLER RESPONSIBLE FOR REJECTION(S)

ADDITIONAL INFORMATION

MANHOURS AND LOSS INCURRED FROM REJECTIONS, ETC.

PMI Supervisor _____
Signature/Date

ATTACHMENT 3

COLOR CODE FOR ALLOY MATERIAL IDENTIFICATION		
Alloy	**Example ASTM Designation**	**No. & Color of Stripe(s)**
Chrome-Moly Steels		
1 ¼ Cr – ½ Mo	A335 Gr. P11	1 Solid Yellow
2 ¼ Cr – 1 Mo	A335 Gr. P22	1 Solid Blue
5 Cr – ½ Mo	A335 Gr. P5	1 Solid Blue, 1 Solid Yellow
9 Cr – 1 Mo	A335 Gr. P9	2 Solid Orange
9 Cr – 1 Mo - V	A335 Gr. P91	1 Solid Pink, 1 Solid Gray
Austenitic Stainless Steels		
304 SS	A312 TP304	1 Solid Black
304L SS	A312 TP304L	2 Solid Black
304H SS	A312 TP304H	1 Intermittent Black
316 SS	A312 TP316	1 Solid Gray
316L SS	A312 TP316L	2 Solid Gray
316H SS	A312 TP316H	1 Intermittent Gray
317 SS	A312 TP317	1 Solid Brown, 1 Solid Green
317L SS	A312 TP317L	1 Solid Brown, 1 Solid Red
321 SS	A312 TP321	1 Solid Pink
321H SS	A312 TP321H	2 Solid Pink
347 SS	A312 TP347	1 Solid Brown
347H SS	A312 TP347H	2 Solid Brown
Ferritic & Martensitic Stainless Steels		
405 (12 Cr)	A268 TP405	1 Solid Green, 1 Solid Black
410 (12 Cr)	A268 TP410	1 Solid Green , 1 Solid Red
Nickel Based Alloys		
Alloy 20	B464, UNS N08020	1 Solid Black, 1 Solid Blue
Inconel 600	B167, UNS N06600	2 Solid Blue
Inconel 625	B444, UNS N06625	1 Solid Blue, 1 Solid Pink
Incoloy 800	B407, UNS N08800	1 Solid Black, 1 Solid Orange
Incoloy 800H	B407, UNS N08810	1 Solid Gray, 1 Solid Red
Incoloy 800HT	B407, UNS N08811	1 Solid Gray, 1 Solid Brown
Incoloy 825	B423, UNS N08825	1 Solid Gray, 1 Solid Blue
Monel	B165, UNS N04400	1 Solid Black, 1 Solid Yellow
Duplex Stainless Steels		
2205 Duplex SS	A790, UNS S31803	1 Solid Green, 1 Solid Blue
2507 Duplex SS	A790, UNS S32750	1 Solid Green, 1 Solid Pink

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

Welding and NDE Requirements for Equipment

Specification No. EH-35R-CCU1-SPC-255-85050

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1.0 INTRODUCTION

1.1 Purpose

This specification, EH-35R-CCU1-SPC-255-85050, defines the welding, thermal treatment, examination and testing requirements for welding pressure vessels and heat exchangers.

1.2 Scope

This specification includes all ASME Section VIII or Section I equipment. It supplements the Codes listed in Section 2.0 of this specification.

The CO_2 Capture project uses only austenitic stainless steels, duplex stainless steels and carbon steel for process-containing equipment. There may be uses of Cr-Mo steels elsewhere in the Power Plant for high temperature steam services. This specification is limited to these materials.

Structural welding done in accordance with AWS D1.1, D1.6 and/or D1.8 is outside the scope of this standard, as the requirements of those Codes sufficiently cover structural welding.

2.0 REFERENCES

Additional references are listed below. Short titles will be used herein when appropriate.

2.1 Industry Codes and Standards

- American Society of Mechanical Engineers (ASME)
  - Section I — Power Boilers
  - Section II, Part C — Specifications for Welding Rods, Electrodes and Filler Metals
  - Section V — Nondestructive Examination
  - Section VIII, Div. 1 — Rules for Construction of Pressure Vessels
  - Section VIII, Div. 2 — Rules for Construction of Pressure Vessels, Alternative Rules
  - Section IX — Welding and Brazing Qualifications
- American Society of Nondestructive Testing (ASNT)
  - SNT-TC-1A — Recommended Practice for Nondestructive Testing Personnel Qualification and Certification
- American Society for Testing and Materials (ASTM)
  - A833 — Standard Test Method for Indentation Hardness of Metallic Materials by Comparison Hardness Testers

–	E10	Standard Test Method for Brinell Hardness of Metallic Materials
–	E18	Standard Test Methods for Rockwell Hardness of Metallic Materials
–	E92	Standard Test Method for Vickers Hardness and Knoop Hardness of Metallic Materials
–	E140	Standard Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness

- American Welding Society (AWS)

–	A2.4	Standard Symbols for Welding, Brazing, and Nondestructive Examination
–	A3.0	Standard Welding Terms and Definitions Including Terms for Brazing, Soldering Thermal Spraying and Thermal Cutting
–	A4.2	Standard Procedure for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Austenitic-Ferritic Stainless Steel Weld Metal
–	D1.1	Structural Welding Code - Steel
–	D1.6	Structural Welding Code – Stainless Steel
–	D1.8	Structural Welding Code – Seismic Supplement
–	D10.10	Recommended Practices for Local Heating of Welds in Piping and Tubing
–	D18.2	Guide to Weld Discoloration Levels on Inside of Austenitic Stainless Steel Tube
–	Z49.1	Safety in Welding, Cutting and Allied Processes

- Welding Research Council (WRC)

WRC Bulletin 452	Recommended Practices for Local Heating of Welds in Pressure Vessels

2.2 Reference Specifications

–	EH-35R-CCU1-SPC-255-85012	Positive Materials Identification
–	EH-35R-CCU1-SPC-255-85530	Materials and Fabrication Requirements for Duplex Stainless Steel

3.0 DEFINITIONS

The following additional definitions are also applicable to this specification.

Table 1: Definitions

Term	Description
Shall/Will	Denotes a minimum requirement in order to conform to the intent of the standard.
Should/Can/Could/May	Denotes a recommendation which is advised but not required in order to conform to the standard.

4.0 GENERAL REQUIREMENTS

4.1 Welding shall conform to the requirements of the ASME Boiler and Pressure Vessel Code, whether or not the equipment is intended to carry a Code stamp. Compliance with these specifications and authorization to proceed on Welding Procedure Specifications (WPS), Procedure Qualification Records (PQR) and mill test reports shall in no way relieve the Seller of the responsibility of providing welds which are sound and suited to the services for which they are intended.

4.2 When requirements of the Codes, standards and specifications listed in Section 2.0 of this specification conflict with this specification, the more stringent requirement shall apply unless otherwise authorized by the Buyer. The Seller shall immediately submit the matter to Buyer for determination and written clarification.

4.3 Welding and nondestructive testing symbols shall be in accordance with AWS A2.4.

4.4 Welding terms and definitions shall be in accordance with the AWS A3.0.

4.5 Safety measures for the protection of welders and operators involved in welding and cutting shall be in accordance with the practices specified in AWS Z49.1 plus all local, state, federal and other governing regulations.

4.6 Peening the weld is not allowed. Chipping to remove slag using air tool is not considered peening.

4.7 All stubs, rods, flux, slag and other foreign material shall be removed from inside and outside the vessel after welding is finished.

4.8 Arc strikes, weld spatter, and burrs shall be removed/ground out in their entirety and blended smoothly with the vessel surface. The ground area shall not result in thinning below the specified wall thickness. The ground area in P-4 material and higher shall be magnetic particle (MT) examined for possible cracks or porosity as required by Paragraph 10.6.3. Liquid penetrant (PT) testing shall be used for non-magnetic materials.

4.9 Heat tints and oxidation on the internal, surfaces in contact with the amine solvent shall be removed. The acceptance for the surface visual appearance shall be AWS D18.2, Level 3 maximum.

4.10 Attachments such as lugs, clips, support rings and similar items shall not be located on a weld seam without prior approval from Buyer.

4.11 Fabrication aids, temporary supporting lugs, etc., that are removed by gouging or thermal cutting shall not be reduced less than 1/8 inch (3.2 mm) from the surface. The remaining

material shall be ground flush with the base metal; the ground area shall not result in thinning below the specified wall thickness. The ground area in P-4 material and higher shall be MT examined for possible cracks or porosity as required by Paragraph 10.6.3. PT examination shall be used for non-metallic materials.

4.12 Appropriate steps shall be taken to avoid distortion and warping due to welding, and all dimensions shall meet Code requirements.

4.13 Visual examination shall be carried out for possible pinholes or arc scars caused by electric sparks from improperly grounded or damaged welding cables on the surface.

4.14 Lubricants, thread compounds, paints, crayon markers, pickling solutions, ink markers, tapes and adhesives containing chlorides shall not be used on stainless steel (SS) or nickel alloys. SS shall not come in contact with zinc, aluminum or other low melting point metals.

4.15 The application of heat to correct weld distortion and dimensional deviation in SS or Cr-Mo steels is prohibited. For all other materials, pre-approval by Buyer is required.

4.16 Welded joints connecting nozzles (including manways and couplings) to a vessel wall shall be full penetration welds.

4.17 Head, nozzle, and shell longitudinal and circumferential welds shall be welded from both sides whenever accessible.

4.18 Grinding wheels and austenitic SS wire brushes used on austenitic or other higher nickel and nonferrous alloys shall not have been previously used on ferrous materials, copper alloys, aluminum or zinc coatings (paint or galvanizing).

4.19 Base materials that have been galvanized or coated with zinc-based paints shall not be welded to austenitic SS and nickel alloy materials. Welding is not permitted even when the galvanized or zinc-based paint is removed by mechanical or chemicals means.

4.20 Carbon steel wire brushes shall not be used to clean the surface of any materials in areas to be welded.

4.21 If Duplex SS (such as UNS S32205/S31803, S32205, S32550, S32750, S32760, S32003, or other grades) is specified, Specification EH-35R-CCU1-SPC-255-85530, “Material and Fabrication Requirements for Duplex Stainless Steel” shall be required.

4.22 If the Purchase Order or Buyer’s data sheets/drawings require Positive Materials Identification (PMI) to be performed, the testing shall meet the requirements of Specification EH-35R-CCU1-SPC-255-85012, “Positive Material Identification”.

4.23 Welding of 9Cr-1Mo-V (P-15E) is outside the scope of this specification. If 9Cr-1Mo is specified, 9Cr-1Mo-V shall not be used. If 9Cr-1Mo-V is specified, a separate project specification on Materials and Fabrication Requirements For 9Cr-1Mo-V (P91/T91, ASME P-15E) shall be issued and required.

5.0 WELDING PROCEDURE AND PERFORMANCE QUALIFICATIONS

5.1 WPS’s, PQR’s and Welder's/Welding Operator Performance Qualification shall conform to the requirements of ASME Section IX and to requirements of this and any other Specifications specific to the service or material.

5.2 WPS's and PQR's shall be submitted to Buyer prior to the start of fabrication. Welding shall not start until these documents are returned to the Seller with authorization to proceed.

5.3 Welder and Welding Operator Performance Qualification Records shall be made available to Buyer upon request.

5.4 All WPS's and PQR's for items purchased or subcontracted by the Seller shall be reviewed by the Seller for content and contract compliance prior to submittal to Buyer.

5.5 Welds that are deposited by procedures that differ from those approved by Buyer may be subject to complete removal at Seller's expense.

5.6 SAW of production parts shall be performed using the same name brand flux and same name brand or ASME classification of wire as used for the procedure qualification.

5.7 Seller shall submit a detailed weld map to Buyer at the time of WPS/PQR submittal. Fabrication shall not start until the weld map is returned with instruction to proceed. The weld map shall contain, as a minimum, the following information:

a. Sketch of the equipment item.

b. Material type(s) and grade(s) for each type of equipment component.

c. WPS to be used for each type of joint and any back cladding, if applicable.

d. Type of joint (i.e., full penetration, fillet, socket, partial penetration, etc.).

5.8 Heat exchanger tube-to-tubesheet welding procedure shall be qualified in accordance with the requirements of ASME Section IX, QW-193. The acceptance criteria for the sectioning and weld throat examination for welds made in accordance with Section VIII, Division 1 or Section I, Appendix A shall satisfy the "a" dimension required by design. When a tube-to-tube sheet "strength weld" is specified on a heat exchanger data sheet, drawing or specification, it shall consist of a minimum of two weld passes, with at least one pass made with filler metal.

6.0 ACCEPTABLE WELDING PROCESSES

6.1 SMAW, GTAW, SAW, FCAW, and GMAW with Spray, Globular or Short Circuit Transfer, are acceptable when used in accordance with this specification and the applicable Codes. Using a combination of these processes within a weld joint is also acceptable.

6.2 As required in Paragraph 5.6, SAW of production parts shall be performed using the same name brand flux and same name brand or ASME classification of wire as used for the procedure qualification.

6.3 Full penetration open root groove welds which will not be backgouged in P-4 material and higher shall have the root pass welded with the GTAW process and shall have the interior beneath the welding zone purged with an inert gas. The inert gas shall be held for the first two layers of weld metal.

6.4 Open-root welds made from one side with low hydrogen SMAW electrodes or FCAW require backgouging and rewelding.

6.5 FCAW (Spray or Globular Transfer) process shall be limited to:

6.5.1 Weldout of pressure-retaining welds in P-1, P-4, P-5A, P-8, and P-5B.

6.5.2 FCAW is not acceptable for root passes of butt welds when welding from one side (unless backgouged).

6.5.3 FCAW of P-8 materials shall not be allowed when the design temperature exceeds 900°F (480°C).

6.5.4 External gas shielding is required except per Paragraph 6.5.5 of this specification.

6.5.5 FCAW (spray or globular transfer) with self-shielding wire is acceptable for non-pressure retaining welds in P-1 materials that are limited to 3/8 inch (9.5 mm) leg length and are not subject to impact requirements.

6.5.6 FCAW using short circuit transfer is prohibited.

6.5.7 Electrode diameter shall not exceed 5/32 inch (4 mm).

6.5.8 Vertical downhill welding is not acceptable.

6.5.9 Wind velocity shall not exceed 5 mph (2.2 m/s) in the weld area, unless the weld is sheltered from the wind.

6.5.10 For welding pressure-containing equipment wall thickness in excess of 3/8 inch (9.5 mm), the diffusible hydrogen limit for FCAW electrodes (as manufactured) shall meet the specifications below:

Table 2: Diffusible Hydrogen Limit for FCAW Electrodes

Specified Minimum Tensile Strength for the Base Metal	Maximum Diffusible Hydrogen Designation (per ASME SFA 5.20 or SFA 5.29)
≤ 70 ksi (483 MPa)	H16
> 70 ksi (483 MPa) and ≤ 85 ksi (587 MPa)	H8
> 85 ksi (587 MPa)	H4

6.6 GMAW - Short Circuit Transfer process is allowed for:

6.6.1 Carbon steel only.

6.6.2 Root pass and weldout through 3/8 inch (9.5 mm) wall thickness. Root pass only on wall thickness greater than 3/8 inch (9.5 mm).

6.6.3 Root passes can be made in any direction, but fill and cap passes shall not be made in the downhill direction below the two (2) o'clock position.

6.7 Other welding processes require specific written approval from Buyer. Seller shall submit all pertinent data and intended application of said process for evaluation. The Seller during bid preparation shall not assume application of these processes is acceptable.

7.0 FILLER MATERIALS

7.1 Filler metal shall be as specified in ASME Section II, Part C.

7.2 Filler metal chemistry for similar metal welds shall match that of the base metal. Similar metallurgical properties shall be produced.

7.3 Weld metal analysis for P-1 materials shall be “A-1” per ASME Section IX, Table QW-442. The use of carbon- ½ moly (such as ER70S-A1) or filler metals with Ni or Mn above A-1 limits is not acceptable for welding P-1 carbon steel.

7.4 Carbon and low alloy steel electrodes/bare wire that have a nonspecific chemistry as indicated by a "G" classification shall not be used.

7.5 The use of consumable root inserts requires Buyer’s approval. If approved, the inset shall be completely melted by welding and the chemistry of the insert shall match the material to be joined.

7.6 Welds deposited by the SAW process shall not derive any principal element from the flux. Solid wires for automatic welding processes shall contain the principal elements required for the deposited weld metal.

7.7 Tack welds shall be made with the same ASME classification consumable that is used for the root pass.

7.8 All dissimilar metal welded joints should be avoided whenever practical, if dissimilar flanges are acceptable.

7.9 For dissimilar joints in base metals consisting of a ferritic material (P-1 through P-7) on one side and austenitic SS (P-8) on the other, the filler material selection shall be:

7.9.1 For all operating temperatures: High nickel filler metal shall be used, except that for design temperatures below 600°F (315°C), the use of 309L filler metal can be considered, but requires Buyer review and approval.

7.9.2 Where postweld heat treatment (PWHT) of the joint is required, the ferritic material (P-1 through P-5B) may be buttered with a high nickel filler metal and PWHT’d prior to welding to the austenitic SS. Such joints shall be qualified in accordance with ASME Section IX, QW-283.

7.9.3 “High nickel filler material” shall be ASME classification ENiCrFe-2, ENiCrFe-3, ENiCrMo-3 from ASME Section II, Part C, SFA-5.11 or ERNiCr-3 or ERNiCrMo-3 from SFA-5.14. Other grades can also be proposed by Seller for Buyer approval.

7.10 Fluxes that the flux Manufacturer recommends for single pass shall not be used for multiple pass welds.

7.11 SAW multipass welding in carbon steel, alloy steel, and corrosion-resistant steels shall use an essentially neutral flux.

7.12 Filler wires in specification ASME SFA-5.2 shall not be used for welding with GTAW process.

7.13 When using the SMAW process, low hydrogen electrodes shall be used for all pressure retaining welds or attachments to pressure boundaries, except E6010 may be used for the root pass for carbon steel welded from one side only.

7.14 After opening shipping containers of electrodes, fluxes and other welding materials, storage and handling shall be as specified in the Manufacturer's recommendations and ASME Section II, Part C.

7.15 When requested, the Seller shall submit his procedure for the storage and handling of electrodes, filler metal and fluxes to Buyer for review prior to the start of fabrication. The procedure shall include moisture, cleanliness and identification controls.

7.16 Coated electrodes shall be purchased in hermetically sealed containers. Low hydrogen electrodes shall be properly baked out and kept dry. This may be accomplished by the use of portable rod ovens and limiting the time out of the rod oven to four (4) hours. Coated electrodes that have become wet or oil soaked shall not be reused.

7.17 When required by Section 10.11 of this specification, austenitic SS filler metal shall be screened to meet the listed ferrite testing requirements.

8.0 WELD JOINT PREPARATION

8.1 Weld joint preparation shall be made by machining, grinding, or thermal cutting. When thermal cutting is performed, the joint surfaces shall be mechanically cleaned to sound metal prior to welding.

8.2 Weld bevel edges over 2 inch (50 mm) shall be examined by MT (or PT for austenitic SS materials).

8.3 Double-welded butt joints are preferred and shall be implemented wherever practical.

8.4 Permanent backing rings or bars are not permitted. If temporary attachments are used and then removed, the weld area shall be dressed and examined for cracks and other defects. Examination of the weld surface shall be performed visually and by MT or PT in accordance with Section 10.0 of this specification, whichever is applicable. Unacceptable defects shall be removed and repaired. When temporary backing rings or bars are used, they shall be of the same nominal composition as the base metal.

8.5 Surfaces to be welded shall be cleaned 1 1/2 inch (38 mm) on either side of the weld on the OD and ID. Surfaces shall be free from paint, oil, dirt, scale, oxides, and other foreign material detrimental to the weld.

8.6 Removable starting and stopping tabs shall be used with the SAW process, when practical.

8.7 Prior to welding, joints shall be visually inspected for: cleanliness, correct groove configuration, alignment and gap conditions, condition of tack welds if present, preheat if specified, and filler metal to be used. They shall be in accordance with the WPS.

9.0 PREHEAT AND POSTWELD HEAT TREATMENT

9.1 Preheat temperatures for thermal cutting, tack welding and welding shall be as recommended in the ASME Section VIII, Division 1 or 2, or Section I, as applicable, and are mandatory by this specification.

9.2 Cr-Mo steels used for ASME Section I require PWHT under the conditions defined in ASME Section I, Table PW-39.

9.3 The maximum interpass temperature for austenitic SS shall be 350ºF (175ºC).

9.4 PWHT of vessels shall be accomplished after all lugs or attachment welds to the pressure boundary are complete. No welding shall be performed on the vessel after PWHT.

9.5 Threads and gasket surfaces shall be suitably protected from excessive oxidation during heat treatment.

9.6 Exothermic heating for heat treatment is not permitted.

9.7 A maximum of two complete PWHT cycles is permitted for each weld. Further PWHT cycles shall not be carried out without Buyer's approval.

9.8 The reduced PWHT temperature ranges permitted by Table UCS-56.1 of Section VIII, Div.1 or Table PW-39.1 in Section I shall not be used when PWHT is required for process or service conditions or for Cr-Mo steels.

9.9 PWHT for vessels subject to special service conditions shall be noted on Buyer's equipment drawing and/or data sheet.

9.10 When requested, the PWHT procedures shall be submitted to Buyer and shall have received authorization to proceed prior to use. PWHT procedures shall include thermocouple number and locations, method of thermocouple attachment, heating and cooling methods, and heating and cooling rates. A sufficient number of thermocouples shall be firmly mechanically attached or flash welded to the vessel to accurately record temperature and ensure that it is being heated and cooled evenly during the heat treatment operations. A multi-point recording type instrument shall be used to record the temperatures during the heat treatment cycles.

9.11 For PWHT, a minimum of two thermocouples shall be used, attached adjacent to or on representative thickest and thinnest weldments of the pressure boundary. Sufficient thermocouples shall be used to determine the entire vessel, head and nozzle temperatures throughout heat treatment.

9.12 PWHT Temperature shall be continuously recorded. A chart of the heatup, soak and cooldown while at temperature above 500ºF (260ºC) is required. Time intervals shall be recorded with temperature and time intervals clearly indicated. The chart shall be signed by the operator of the furnace and shall be reviewed by Buyer.

9.13 When PWHT is specified on carbon steel for Amine or Caustic, PWHT shall be performed at 1175°F ± 25°F (635°C ± 14°C) for one hour per inch of throat thickness of the weld, with a one (1) hour minimum holding time. PWHT shall not be required on field-fabricated storage tanks.

9.14 For local PWHT, the band widths and thermocouple placements shall be in accordance with WRC Bulletin 452, "Recommended Practices for Local Heating of Welds in Pressure Vessels". For piping components, the band widths and thermocouple placements shall be in accordance with AWS D10.10, "Recommended Practices for Local Heating of Welds in Piping and Tubing".

10.0 NONDESTRUCTIVE EXAMINATION (NDE)

10.1 Specific NDE requirements, in addition to ASME Code requirements, will be noted on Buyer equipment drawings, purchase specifications, or Purchase Orders. When Buyer equipment drawings are not used, these requirements shall be noted on the Seller's equipment drawings and the Seller's Weld Map.

10.2 All NDE shall be performed by personnel certified in accordance with ASNT Recommended Practice SNT-TC-1A or Seller's own certification program that has been approved by Buyer.

10.3 Interpretation of NDE results shall be performed by personnel certified Level II or III.

10.4 When requested, all NDE procedures shall be submitted to Buyer for review and authorization to proceed. In addition, all other records pertaining to inspection and certification shall be available for review by Buyer.

10.5 Visual Examination

10.5.1 All welds shall receive 100% visual inspection (VT).

10.5.2 Visual examination procedures and evaluation criteria shall be in accordance with the applicable design Code and ASME Section V, Article 9, and this specification. The evaluation criteria listed for radiography shall also apply to visual inspection as applicable.

10.5.3 Welds shall be visually inspected after each pass of multipass welds to ensure that the weld bead has been properly cleaned of slag and is free of surface cracks, porosity, excess convexity, undercut and other defects. Noted defects shall be removed prior to making the next pass.

10.5.4 Visual inspection of welds shall be performed in a suitably lighted area. The use of spotlight, magnifier or other inspection devices is recommended whenever such devices will enhance the inspection operation.

10.5.5 The following is the minimum visual examination requirements on completed weld joints:

a. Weld size and length (for drawing conformance). Suitable gages shall be used.

b. No cracks, incomplete fusion, or incomplete penetration shall be present.

c. Weld shape and appearance shall be reviewed and questionable areas shall be further examined by other NDE methods.

d. Craters are to be filled to the full cross-section of the required weld.

e. No undercut exceeding Code limits shall be present.

f. No distortion exceeding Code limits shall be present.

10.6 Magnetic Particle Examination

10.6.1 MT examination procedures and evaluation criteria shall be in accordance with the applicable design Code and ASME Section V, Article 7, and this specification. The evaluation criteria listed for radiography shall also apply to MT as applicable.

10.6.2 MT examination of welds shall include a band of base metal at least one (1) inch (25 mm) wide on each side of the weld.

10.6.3 As required by Paragraphs 4.8 and 4.11, ground areas removing arc strikes, weld spatter, burrs, fabrication aids, or lugs in P-4 material and higher shall be MT examined for possible cracks or porosity.

10.6.4 As required by Paragraph 8.2, weld bevel edges over 2 inch (50 mm) shall be examined by MT.

10.6.5 If arc burns occur during magnetic particle examination, the arc burns shall be removed and the area reexamined by the magnetic yoke method.

10.6.6 For PWHT'd equipment, the magnetic yoke method shall be used.

10.7 Liquid Penetrant Examination

10.7.1 PT examination procedures and evaluation criteria shall be in accordance with the applicable design Code and ASME Section V, Article 6, and this specification. The evaluation criteria listed for radiography shall also apply to PT as applicable.

10.7.2 Penetrant materials shall meet the requirements of Paragraph T-641 of Article 6, ASME Section V, for sulfur and halogen content regardless of the type of material to be examined.

10.7.3 PT examination of welds shall include a band of base metal at least one (1) inch (25 mm) wide on each side of the weld.

10.8 Ultrasonic Examination

10.8.1 Ultrasonic examination (UT) procedures shall be in accordance with the requirements and methods specified in ASME Section V, Article 4.

10.8.2 The acceptance criteria shall be in accordance with ASME Section VIII, Division 1 or 2, or ASME Section I, whichever is applicable.

10.9 Radiographic Examination

10.9.1 Radiographic examination (RT) procedures shall be in accordance with the requirements and methods specified in ASME Section V, Article 2.

10.9.2 Interpretation and acceptance criteria of radiographs shall be in accordance with ASME Section VIII, Division 1 or 2, or ASME Section I, whichever is applicable.

10.9.3 Where spot radiography is required, as specified in ASME Section VIII, Division 1 or Section I, Paragraph UW-52, spots shall be selected so that examination is made of welds representing each WPS utilized on each type of equipment.

10.9.4 UT in lieu of RT is acceptable as allowed by and in accordance with the applicable Code requirements.

10.10 Control of Welder/Operator Quality

10.10.1 When spot RT examination results in a rejected increment of weld, at least one of the two new increments of weld selected for spot RT examination, shall have been welded by the same welder or operator to the same WPS. The locations of the additional spot radiographs shall be agreed to by Buyer. If this spot RT results in a rejected increment of weld, the welder or welding operator shall be considered unacceptable for any further welding to that WPS without requalification and the agreement of Buyer.

10.10.2 Timing is essential for the control of welder or operator quality; therefore, the second increment of weld radiography shall be completed within one day of the first rejection, unless otherwise agreed to by Buyer.

10.10.3 For equipment with full RT, three rejected weld increments by one welder or welding operator shall result in that welder or welding operator being considered unacceptable for any further welding to that WPS without requalification and the agreement of Buyer.

10.11 Ferrite Testing

10.11.1 Ferrite content of the deposited weld metal on ten percent (10%) of austenitic SS welds intended for service at temperatures greater than 800ºF (427ºC) or which will receive PWHT shall be determined using Ferritescope or Severn Gauge. This is to minimize the risk of sigma embrittlement which can occur with high operating temperatures. The instrument used for ferrite determination shall be calibrated in accordance with AWS A4.2. Alternatively, ferrite may be determined from the WRC-1992 diagram (found in ASME Section II-C, SFA-5.4) and a wet chemical analysis.

10.11.2 Testing shall be done before PWHT if PWHT is being done.

10.11.3 The ferrite content shall be three (3) to twelve (12) ferrite number (FN).

10.11.4 Marking of welds which have been tested and met the criteria shall be a circumferential, low chloride paint stripe in a color that is not being used for any other coding purposes. Other record keeping methods shall be approved by Buyer.

11.0 WELD REPAIRS

11.1 Unacceptable discontinuities shall be completely removed by chipping, gouging, grinding, or other methods (for the type of material being repaired) to clean, sound metal, and the excavated area shall be examined by MT or PT to ensure complete removal of defects.

11.2 Repairs to correct weld defects shall be made using the same WPS used for the original weld or other WPS previously given authorization to proceed.

11.3 The repaired areas shall be re-examined using the same examination method and procedure by which the defect was originally detected.

11.4 Two repair attempts will be allowed on any one defective area. No further attempts to repair shall be carried out without the approval of Buyer.

11.5 Weld repair procedures shall be submitted to Buyer prior to equipment repair for all repairs which exceed 25% of wall thickness. The procedure shall state, as a minimum, the following information:

11.5.1 Means of excavating defect from weld.

11.5.2 NDE method used to verify complete defect removal.

11.5.3 WPS used to fill excavated area.

11.5.4 NDE method used to verify repair weld is sound.

11.6 A map of the weld repair locations shall be maintained for repairs which exceed 20% of wall thickness or 1 inch whichever is smaller. This map shall be submitted to Buyer as part of the final documentation package.

12.0 WELD OVERLAY AND CLAD RESTORATION

This section defines the method, procedure, and acceptance criteria for fabrication of weld overlay and clad restoration.

12.1 Welding Procedure Qualification

12.1.1 Welding PQR shall include chemical analysis of the deposited weld metal. Chemical analysis shall be taken at a minimum of 1/8 inch (3.2 mm) from the overlay surface at its lowest point. The weld metal chemistry shall meet the requirements of Paragraph 12.3 unless otherwise agreed to by Buyer.

12.1.2 For weld overlay, the overlap of adjacent beads shall be an essential variable, must be specified in the PQR, and be similar to that used on the WPS.

12.1.3 For clad restoration, the WPS and PQR shall be in accordance with ASME Section IX, QW-217(a).

12.2 Welding Processes

12.2.1 GMAW (spray, globular or pulse transfer), GTAW, FCAW (spray or globular transfer), SAW or SMAW or combinations thereof are acceptable for application of overlay or clad restoration.

12.2.2 The use of other processes requires the prior approval of buyer. Application of such processes shall not be assumed acceptable by buyer during bid preparation, and if intended for use, must be submitted, discussed and accepted in writing prior to award of purchase.

12.3 Filler Materials

12.3.1 Filler metal composition shall match the alloy cladding, applied lining or weld overlay material as specified on Buyer design drawings or data sheets, except as noted in Paragraphs 12.3.2.

12.3.2 Filler metal composition for clad or applied liner restoration of austenitic SS clad material shall be within the specified chemistry range of the cladding material except for the following:

a. A higher chrome-nickel filler metal such as Type 309L may be used for the first pass or first layer to compensate for dilution. Note: Type 310 filler metal shall not be used.

b. For Type 304L clad or applied liner, AWS Classification E/ER 308L filler metal shall be used.

c. For Type 321 clad or applied liner, AWS Classification E/ER 347 filler metal shall be used.

12.3.3 For clad restoration where the filler metal is a higher alloy than the adjacent cladding, the required chemical analysis considering dilution can be proposed by Seller for approval by Buyer.

12.4 Surface Preparation

12.4.1 Surfaces to be welded shall be free from laps, pits or other surface irregularities and foreign matter such as scale, spatter, grease, etc.

12.4.2 For clad restoration, cladding shall be stripped back from the base metal for a minimum distance of 1/4 inch (6.4 mm) on each side prior to base metal welding.

12.4.3 The base metal for clad restored seams shall be completely welded before the clad restoration is applied. The base metal surface at the cladding interface shall be ground flush before cladding restoration.

12.5 Fabrication Welding Requirements

12.5.1 Minimum thickness of weld overlay after grinding and surface preparation shall be 1/8 inch (3.2 mm) unless otherwise specified in Buyer design drawings or data sheets.

12.5.2 Weld overlays may be deposited in one layer if they meet specified chemistry requirements.

12.5.3 Multiple-layer overlay welds shall have the same minimum number of layers as those qualified on the welding procedure qualification.

12.5.4 The weld overlay shall be deposited such that weld passes are oriented circumferentially around the inside of the vessel. In the case of small diameter nozzles less than 12 inches (300 mm) inside diameter, the weld passes may be deposited in the longitudinal direction.

12.6 Production Chemical Testing

12.6.1 The production weld overlay deposits shall be verified by check analysis of the principal elements. Chemical analysis shall be taken from a depth equal to one-half the overlay thickness. However, 1/8 inch (3.2 mm) on the specified overlay thickness is the minimum distance from the overlay surface that a sample shall be taken.

12.6.2 One test sample shall be taken from each 200 sq. ft. (18 sq. m.) of overlay surface for major components and one representative sample from each group of subassemblies, such as nozzles, welded by the same procedure.

12.6.3 For production clad restoration, overlay deposits shall have one sample for each circumferential seam and one sample for each longitudinal seam.

12.6.4 Testing can be by wet chemical analysis in a laboratory or by PMI testing (at the required depth) in accordance with Specification EH-35R-CCU1-SPC-255-85012, Positive Materials Identification.

12.6.5 For austenitic SS weld deposits, the following elements shall be reported: C, Ni, Mn, Cr and Mo. For stabilized stainless steels, Cb and Ti shall also be reported. Nitrogen shall be reported for overlay made with gas shielded welding processes, when available from the approved test method.

12.6.6 Ni-based weld overlays or backcladding shall meet the nominal chemistry at the test depth unless otherwise approved by Buyer. In equipment with SS cladding, some dilution is typically acceptable. If a diluted chemistry was accepted for the

PQR per Paragraph 12.1.1, it should also be accepted for the production welding.

12.6.7 For austenitic SS weld deposits which will see PWHT or service temperatures greater than 800°F (427°C), the FN shall be between 3 and 12 FN as determined by a using Ferritescope or Severn gauge in accordance with AWS A4.2. Alternatively, ferrite may be determined from the WRC-1992 diagram (found in ASME Section II-C, SFA-5.4). Ferrite content shall be measured prior to any PWHT.

12.7 Nondestructive Examination

Nondestructive examination shall be performed in accordance with the requirements of this specification.

12.7.1 Visual Examination

a. All welds shall be examined visually, and this shall be done before any other nondestructive examinations are performed.

b. All cracks, lack of fusion, surface slag/scale overlaps, undercuts, arc strikes and surface porosity are unacceptable.

12.7.2 Liquid Penetrant Examination

a. All weld overlay and clad restored weld surfaces, shall be 100% examined by PT examination. Examination shall be performed after PWHT when PWHT is required.

b. Surfaces examined shall be free of cracks, lack of fusion, porosity and other defects which would reduce the effectiveness of the overlay.

12.7.3 Radiographic Examination

a. Radiography of weld overlayed vessels shall be in accordance with ASME Section VIII, Division I, UCL-35 or Section I, PW-51, as applicable.

12.8 Weld Repairs in Overlays or Clad Restorations

12.8.1 Unacceptable indications shall be removed by mechanical means, dressed and rewelded, if necessary.

12.8.2 Areas excavated for cracks or porosity shall be examined by PT to ensure complete removal prior to welding. Buyer shall be notified of any defect extending into the base material, prior to repair.

12.8.3 Weld overlay, clad or liner restoration welds requiring welding repairs shall be welded with the original welding procedure or an approved welding repair procedure.

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

Hot Insulation

Specification No. EH-35R-CCU1-SPC-255-85110

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1.0 GENERAL

1.1 Scope

This specification covers external hot insulation of piping, vessels, exchangers, tanks and equipment which are located aboveground and either inside or outside of buildings exposed to operating temperatures of ambient to 1200°F (649°C).

The insulation systems specified herein are designed for one or more of the following purposes:

a. Controlling heat losses
b. Protecting personnel from hot surfaces
c. Minimizing heat gain during fire conditions
d. Noise attenuation and control

1.2 Exceptions

The requirements of this Specification are not applicable to the following insulation systems:

a. Insulation systems for surfaces operating above 1,200°F (649°C)
b. Insulation systems in underground service
c. Exterior insulation systems for surfaces with normal operating metal temperatures at or below the dew point (i.e. Cold insulation systems)
d. Refractory systems and/or internal insulation systems for process piping and equipment
e. Insulation systems for HVAC equipment
f. Insulation systems for coke drums where there are extreme and frequent temperature cycles

1.3 Terminology

a. CONTRACTOR - the insulation contractor or equipment supplier if insulation application is part of the equipment purchase order.
b. ENGINEER - the engineer responsible for development or maintenance of this Specification.
c. EQUIPMENT – cylindrical shapes of more than 24" outside diameter for which preformed sectional pipe insulation materials are not suitable. Subject to the size, this category of items include items such as pressure vessels, shop or field fabricated tanks, heat exchangers, reactors, piping and process equipment including attachments thereto such as nozzles. This definition does not include boilers and heat recovery steam generators (HRSGs). Note: Equipment with a cylindrical shapes of 24" or smaller diameter shall be treated as PIPE.
d. FLANGE – part of bolted joints on PIPE and EQUIPMENT with bolt holes.

e. OPERATING TEMPERATURE - the metal temperature which is assumed to be the process temperature in contact with metal surfaces except for refractory-lined items. Requirements for defining this temperature are given in Section 3.2.
f. OWNER - the Project Owner or its authorized representative.
g. PIPE/PIPING - cylindrical shapes with outside diameters of 24" NPS or smaller which can be insulated with preformed sectional pipe insulation materials. Subject to the size limitation of 24" outside diameter, this category includes piping (with or without heat tracing), pipe fittings, valves, flanges, in-line pipe accessories, and small diameter process equipment including attachments thereto such as nozzles.
h. WORK - Supply of consumable and installed materials, supply of all labor, supervision, testing instruments, application equipment, and every item of expense required to install a complete insulation system.

2.0 REFERENCES

Contractor shall meet or exceed the requirements of the latest edition of the following codes, regulations and standards, except as superseded herein. In cases where more than one code, regulation or standard apply to the same condition, the most stringent shall be followed. In the event of a conflict between this specification and other specifications or correspondence, the OWNER shall be consulted and a ruling, in writing, shall be obtained before any work is started.

2.1 ASTM (American Society for Testing and Materials)

- ASTM A240 Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
- ASTM B209 Aluminum and Aluminum Alloy Sheet and Plate
- ASTM C168 Terminology Relating to Thermal Insulation
- ASTM C449 Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
- ASTM C533 Calcium Silicate Block and Pipe Thermal Insulation
- ASTM C547 Mineral Fiber Pipe Insulation
- ASTM C552 Cellular Glass Thermal Insulation
- ASTM C795 Thermal Insulation for Use in Contact with Austenitic Stainless Steel
- ASTM C591 Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
- ASTM C592 Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)
- ASTM C612 Mineral Fiber Block and Board Thermal Insulation
- ASTM C795 Thermal Insulation for Use in Contact with Austenitic Stainless Steel

- ASTM C892 High Temperature Fiber Blanket Thermal Insulation
- ASTM C1423 Guide for Selecting Jacketing Materials for Thermal Insulation
- ASTM C1767 Stainless Steel Jacketing for Insulation
- ASTM C1696 Industrial Thermal Insulation Systems
- ASTM C1728 Flexible Aerogel Insulation
- ASTM E 84 Test Method for Surface Burning Characteristics of Building Materials

2.2 Process Industry Practices

- PIP INIH1000 Hot Insulation Installation Details
- PIP INSH1000 Hot Service Insulation Materials and Installation Specification
- PIP INSR1000 Installation of Flexible, Removable/Reusable Insulation Covers for Hot Insulation Service
- PIP INTG1000 Insulation Inspection Checklist

2.3 American Petroleum Institute

- API Standard 521 Pressure-relieving and Depressuring Systems
- API RP 583 Corrosion Under Insulation and Fireproofing

2.4 SSPC (Society for Protective Coatings)

- SSPC-SP 1 Solvent Cleaning

2.5 Project Specifications

- EH-35R-CCU1-SPC-255-85210 Aboveground Coatings

3.0 DESIGN

3.1 General

Equipment and piping shall be insulated as required for heat conservation, process heat control, freeze protection (with tracing), personnel protection and noise control.

The components to be insulated for each Insulation Code shall be as defined in PIP INSH1000-D003 and INSA1000.

The type and extent of insulation requirements shall be identified using the following Process Industry Practices (PIP) codes on the P&IDs, pipe line list, equipment drawings, and piping isometrics.

INSULATION CODES COVERED BY THIS SPECIFICATION

Insulation Description	PIP Code
Electric traced pipe/equipment	ET
Fire protection insulation	FP
Freeze prevention	PF
Heat conservation	HC
Hot fluid jacketed pipe/equipment	HJ
Hot fluid traced pipe/equipment	HT
Noise control	AC
Personnel protection	PP
Process stability	PS
Steam jacketed pipe/equipment	SJ
Steam traced pipe/equipment	ST

Note: Insulation for Cold Service (CC) and Condensation Control (CP) is covered by the specification for Cold Insulation which will be issued separately by projects when needed.

3.2 Determining the Operating Temperature

3.2.1 Where the operating temperature is reported as a range, the upper limit of the range shall be considered as the operating temperature for hot service. Temperatures reached during upset conditions and steam-out temperature shall not be considered as the operating temperature.

3.2.2 For steam-jacketed piping and equipment, the jacket fluid temperature shall be considered as the operating temperature.

3.2.3 For refractory-lined items, the metal temperature during normal operating conditions shall be considered as the OPERATING TEMPERATURE for insulation purposes if external insulation is specifically required.

3.2.4 For heat traced PIPING and EQUIPMENT, the operating temperature for the heat tracing shall not be considered the OPERATING TEMPERATURE unless otherwise stated by the ENGINEER.

3.2.5 For heat exchangers, the hottest temperature of the inlet and outlet temperatures of the particular side (shell or tube side that is being insulated) shall be considered the OPERATING TEMPERATURE. This includes assessment of the need for personnel protection, where the higher of the inlet and outlet temperatures for the particular side shall be considered.

3.2.6 For vertical equipment having fluid temperature variations over the equipment length, the operating temperature of the fluid under the relevant insulated section shall be used and the insulation thickness may be varied as required over the equipment length.

3.3 Insulation Thickness

For all Hot Insulation Codes except AC, PP, and PF, the minimum insulation thickness shall be as shown in Table 2. This table is based on the use of mineral fiber insulation. The use of Aerogel insulation, as described in ASTM C1728 is also acceptable. When selected, CONTRACTOR and/or ENGINEER shall develop a thickness table which shall be approved by OWNER.

3.4 Personnel Protection (Code PP)

3.4.1 Personnel protection shall be provided on all piping and equipment adjacent to work platforms or other operating areas where the maximum operating bare metal temperature exceeds 140ºF (60ºC):

- horizontal piping where the bottom of pipe elevation is less than 7 ft (2.1 m) above grade or a working platform;
- those portions of vertical piping less than 7 ft (2.1 m) above grade or a working platform;
- piping adjacent to and within 3 ft (0.9 m) of a working platform;
- Where specified by OWNER.

3.4.2 For process temperatures from 140ºF (60ºC) to 480ºF (250ºC) metal protection layer, without insulation, is preferred in order to avoid risks of corrosion under insulation (CUI) and future inspection costs. The metal protection layer shall be 60 % perforated 0.5 mm thick stainless steel sheet with a hole diameter of 5 mm, or 12 gage galvanized carbon steel expanded metal. Other similar options can be proposed for approval by OWNER.

3.4.3 Recommended standoff distances from piping or equipment bare surface to perforated sheet or grating shall be 2 inches (50 mm) for pipe sizes of 1” to 10”, and 4 inches (100 mm) for pipe sizes of 12” and greater and for equipment.

3.4.4 Insulation of piping for personnel protection shall be limited to pipe and pipe fittings, excluding flanges and valves.

3.4.5 For process temperatures >480ºF (250ºC), insulation with metal jacketing shall be used for PP. The HC systems shall be used, unless otherwise approved by OWNER.

3.5 Freeze Prevention Insulation (Code FP)

The primary consideration for the use of this category is freeze prevention and HC insulation is used along with steam or electric tracing. The tracing shall be designed to maintain temperature of media considering the site minimum temperature. Mineral fiber for FP shall be 1.5 inches (40 mm) thick.

3.6 Noise Control Insulation (Codes AC)

3.6.1 The thickness of insulation shall be determined by the noise control engineer. Insulation thickness requirements for items requiring insulation for both HC and noise control shall be determined as follows:

- The noise control insulation requirement shall govern, if the acoustic insulation material materials are resistant to the operating temperature. However, the thickness shall be equal to the higher of the noise control and HC requirements.
- The hot service insulation requirement shall govern, if acoustical insulation materials are not resistant to operating temperature. However, the thickness shall be equal to the higher of the noise control and HC requirements with acoustical coating used as weatherproofing.

3.6.2 The extent and thickness of acoustic insulation shall be as noted on the P&IDs and piping isometrics.

3.7 Insulation Code FP

Insulation used as fire protection (as defined by API 521) shall be:

3.7.1 a minimum of 4” (100 mm) thick ASTM C533, Type II, or ASTM C892, Type III, Grade 8 applied in two layers of 2” thickness each layer, or an alternate insulation type and thickness approved by OWNER, and

3.7.2 weatherproofed with 0.010” (0.25 mm) thick, ASTM A240 Type 304 stainless steel jacketing.

4.0 MATERIALS FOR HOT INSULATION CODES (EXCEPT FP)

4.1 Insulation Material Selection

4.1.1 Material for temperature up to 1200ºF (650ºC) shall be mineral fiber according with:

- ASTM C547 Type II Grade A for NPS 24 and below pipe and equipment (it comes as pipe covers), or
- ASTM C612 Type IVB for the piping and equipment and vessels >24 inches diameter (it comes as block or v-grooved boards).

4.1.2 Ceramic fiber in accordance with ASTM C892 Type III Grade 10, or Aerogel in accordance with ASTM C1728 can also be proposed for specific application for review and approval by OWNER.

4.1.3 Installation details, weatherproofing material, etc. for Aerogel shall be in accordance with the insulation Manufacturer's recommendations.

4.2 Metal Jacketing and Termination Covers

Material	Description
Aluminum jacketing	ASTM B209, aluminum alloy 3003 or 5005-H14 with factory applied moisture barrier Thicknesses: 0.020" (nominal) Finish: smooth or stucco embossed Corrugations: 3/16", 1 1/4"
Aluminum fitting and termination covers	ASTM B209, aluminum alloy 3003 or 5005-H14 with factory applied moisture barrier, 0.024" minimum thickness
Acoustical jacketing	ASTM B209, aluminum alloy 3003 or 5005-H14 with factory applied acoustical coating 0.010" thick viscoelastic film adhesive having STC rating of 23 and weighing 0.537 lbs./sq. ft. The metal thickness shall be 0.016". Product reference: Johns Manville Muffl-Jac Lead Free

4.3 Adhesives, Cements, Coatings, and Sealers

Material	Description
Adhesive	Pittcote 88 or approved equivalent.
Finishing Cement	Thermocote 1-FW or approved equivalent.
Flashing Compound	Flexible nonshrinking permeable type, resistant to 200F. Childers Chil-Joint CP-70, GE SCS 1200 or 1209 silicone mastic or approved equivalent.
Insulating Cement	Thermocote 1-GP/FF, Thermocote 1-FW, or approved equivalent.
Joint Sealant	Non-shrinking, permanently flexible type. Chil-Joint CP-70, Pittseal 444 or approved equivalent.

4.4 Banding and Wire (Securements)

Materials	Size	Applications
304 SS wire	16 gauge	
304 SS bands (strapping) – to be colored blue	0.75 inch wide x 0.020 inch thick	For piping and cylindrical equipment with OD >24 inch
	0.5 inch wide x 0.016 inch thick	For piping and cylindrical equipment with OD ≤24 inch

4.5 Miscellaneous Materials

Expansion Joint Filler Material	Mineral fiber or glass fiber with temperature limits equivalent to or better than the required operating temperatures.
Expansion Springs	Type 304 SS, 4” long by 1” wide by 1/8” thick. Johns Manville Chil-Springs or approved equivalent.
Seals – wing or closed type	Type 304 SS, hard temper, 0.032” thick, matching band width.
Glass Fabric	Glassfab (open weave).
S-Clips (Straps)	0.020 inch min. type 304 SS.
Wire Mesh	1 inch nominal hexagonal mesh of 20-gauge stainless steel wire.
Self-drilling screws	No.10 x $^5/_8$ inch, type 304 SS, with EPDM or neoprene washers

4.6 Flexible Insulation Covers

4.6.1 Flexible insulation covers shall be a quilted construction of a layer of thermal insulation between a stainless steel foil and silicone impregnated or Teflon coated fiberglass cloth. The materials of construction from the hot side shall be:

- Knitted stainless steel wire mesh
- Stainless steel foil, 0.002” (0.051 mm) thick
- Thermal insulation, 2” thick (ASTM C1086)
- Silicone impregnated or Teflon coated fiberglass cloth
- Knitted stainless steel wire mesh
- Stainless steel or Teflon coated sewing thread

4.6.2 Insulation material shall be 2” thick fiberglass, unsupported needled felt thermal insulation per ASTM C1086. Aerogel insulation (3/4” thick) can be used if approved by OWNER.

4.6.3 Silicone impregnated fiberglass cloth shall have a weight of one lb/yd^2 min. and contain a minimum of 25% silicone by weight, Alpha Maritex Style # 3259-2-SS or approved equal.

4.6.4 Teflon coated fiberglass cloth shall have a weight 0.98 lb/yd^2 min. and a thickness of 0.008 to 0.010", Energy Control Systems Inc. E.C.S. # 13d or approved equal.

4.6.5 All materials shall be quilted together on maximum of 9" centers with stainless steel quilt anchors and outer seams shall be sewn together with stainless steel or Teflon coated thread. Sewing shall be double straight stitched with a minimum of 7 stitches per inch.

4.6.6 The covers shall be of a minimum number of pieces with joints located to eliminate any water penetration into the insulation or towards the hot facing. The weight of any single piece of the cover shall not exceed 30 pounds.

4.6.7 The covers shall be constructed so that their natural seam is positioned on the gravitational bottom of the fitting.

4.6.8 The covers shall fit tight to the fittings and protrusions and held in be place with 16 gauge Type 304 SS wire. They shall be of sufficient width to overlap the adjacent weatherproofing by a minimum of 5" on each side of the fitting.

4.6.9 Each piece of the cover shall have an embossed metal tag permanently attached with applicable information such as equipment or pipeline number, size, rating, fitting type.

4.6.10 Valve covers shall include the bonnet cover.

4.6.11 Rainwater Protection: The entire cover shall be covered with a silicone-coated fabric to prevent rain water from entering the insulation at the seams. The rain protection cover shall extend 6" beyond the insulation cover and be secured in place with drawstrings.

5.0 PROTECTION REQUIREMENTS FOR AUSTENITIC STAINLESS STEEL PIPING AND EQUIPMENT

5.1 Insulated austenitic and duplex stainless steel operating below 350°F can experience external chloride stress corrosion cracking (SCC) as describe in API RP 583. The external coatings or aluminum foil wrap described in Project Specification, EH-35R-CCU1-SPC-255-85210, Aboveground Coatings, shall be applied before insulating. Coatings shall be used for piping and equipment >24" diameter, and aluminum foil wrapping shall be used for ≤24", unless otherwise stated in contract documents.

5.2 The CONTRACTOR will be responsible for installing the aluminum foil wrap.

5.3 The foil shall be 2.5 mm min. thickness. The aluminum foil shall be applied without an adhesive to achieve a good metallic contact with the surface. At the edges, a self-

adhesive aluminum tape can be used to hold the aluminum foil in place. The adhesive layer shall be free of chlorides.

5.4 Prior to wrapping, the surface preparation shall be washed with demineralized water (to remove chlorides from the piping surface), and if there is oil or grease on the surface, solvent cleaned per SSPC SP-1.

5.5 Wrapping should be in a continuous spiral pattern with the width of overlap to be about 20% of the wrap width up to a maximum of 2 inches. Vertical sections of piping should be wrapped from the lowest point of the run to the highest, so that the overlaps are oriented in the direction that prevents water from getting under the aluminum foil.

5.6 Aluminum or SS wire shall be used to hold the foil in place.

5.7 Foil shall be molded around flanges and fittings.

5.8 Steam-traced lines shall be double wrapped, with the first layer applied directly to the pipe, followed by steam tracing, and then the second layer of foil over the top of the steam tracing.

5.9 Insulation materials for application to stainless steel shall comply with ASTM C795.

6.0 LOCATION AND INSTALLATION OF INSULATION SUPPORTS

6.1 Welded type supports shall be installed in the fabrication shop prior to heat treatment of piping or equipment, whenever heat treatment is required.

6.2 The installation of welded supports by the CONTRACTOR at the jobsite is not allowed, except when the item to be insulated is not heat treated and written approval is given by the OWNER that welding of insulation supports may proceed.

6.3 Unless otherwise specified, insulation supports shall be Type 304 stainless steel for stainless steel surfaces, and carbon steel for carbon steel surfaces.

6.4 The width of the supports shall be 1/2 the insulation thickness for single layer insulation. For multiple layers, the width shall be 1/2" less than the total insulation thickness.

6.5 All insulation supports shall be slightly sloped to allow water to drain.

6.6 Insulation supports for piping, when required, shall be provided and welded-on by the piping fabricator.

6.7 Insulation supports for vertical equipment shells shall be welded rings on 12'-1" centers. They shall be provided and welded on by the equipment fabricator.

6.8 Insulation supports for equipment bottom heads shall be welded clips (suitable for attaching 3/4" bands) supplied and installed by the fabricator.

6.9 Insulation supports for horizontal shells and for the heads on these vessels with diameters greater than 8'-0" shall be supplied by the fabricator.

6.10 Insulation supports for storage tanks shall consider the first support ring to be the bottom base plate. Other insulation supports shall be similar in spacing and size to insulation supports of vertical equipment shells and vessels.

7.0 INSULATION APPLICATION INFORMATION

7.1 General

7.1.1 The hot insulation installation should be according with the requirements of this specification, the code "PIP INIH1000 Hot Insulation Installation Details". If use of Aerogel insulation is approved, installation shall follow the Manufacturer's recommendations.

7.1.2 The Contractor shall perform all work with the highest quality workmanship throughout to provide a neat, uniform appearance with no sharp edges exposed.

7.1.3 Insulation shall not be applied until all testing such as hydrostatic, radiography (with film numbers recorded on isometric piping drawings) etc., has been

completed on all piping and equipment involved and all leaks have been repaired or made tight.

7.1.4 All surfaces to be insulated shall be thoroughly cleaned of all dirt, grease, rust, scale, etc., and shall be perfectly dry before insulation is applied.

7.1.5 Insulation shall not be installed during weather which might cause the metal surface or insulation to become wet. Insulation to be installed over an extended period must be protected to ensure it remains dry until it has been properly sealed.

7.1.6 Insulation shall be installed such that shrinkage is held to a minimum. Any cracks or openings that occur in the insulation or weatherproofing are to be filled in with additional insulation or weatherproofing to provide a smooth sealed surface.

7.1.7 Insulation shall not cover the face of gauge glasses, equipment name plates or tags, nor be applied so as to interfere with dynamic parts of instruments or equipment.

7.1.8 All openings in metal jacketing for manways, nozzles, nipples, pipe supports, etc. are to be neatly cut to provide a snug fit and shall be thoroughly sealed and weatherproofed to prevent moisture from penetrating under the jacket. Openings shall be fitted with a metal collar or suitable flashing embedded in sealant and screwed firmly in place.

7.1.9 At all flanges, unions, and pipe terminations, the pipe or equipment insulation shall be beveled at a 45° angle to facilitate removal of flange bolts and union collars without damage to the main pipe insulation and metal jacketing. A screwed and sealed metal cover shall be installed.

7.1.10 All insulation shall be clad with metal jacketing as far as is reasonably practical. Jacketing shall be installed so as to shed water and protect against wind and blowing rain.

7.2 Piping

7.2.1 Factory fabricated sectional pipe insulation shall be applied in staggered joint construction and secured with wire loops or bands on 9 inch centers. On multiple layer construction, all joints shall be lapped one-half of each section between layers. Each layer shall be secured separately. All joints shall be securely butted and all cracks, joints, etc., shall be filled with insulating calcium silicate or mineral fiber as appropriate.

7.2.2 Mastic sealer shall be used around pipe supports where the insulation is punctured by the support.

7.2.3 Heat traced lines shall be insulated so as to completely cover both line and tracing.

7.2.4 Insulation shall be covered with metal jacketing lapped a minimum of 2 inch on all seams and secured with bands, locating one band at each lap joint and spaced a maximum 18 inch on center. Vertical jacketing shall be secured with "S" clips.

7.3 Fittings, Flanges and Valves

7.3.1 Fittings, valves, flanges, and unions shall be insulated unless specified by OWNER.

7.3.2 Fittings shall be insulated with standard factory formed insulation and secured with wire loops or bands, minimum two per section. All joints shall be filled with insulating calcium silicate or mineral fiber as appropriate. Insulation shall be covered with factory formed standard metal jacketing.

7.3.3 The thickness of basic insulation on pipe fittings shall be the same as the thickness of insulation on adjoining pipe.

7.3.4 Insulation and jacketing on valves flanges and unions shall be installed so as to be removable without damage to the main pipe insulation. Removable insulation covers shall be in accordance with Section 4.6, unless approved otherwise by OWNER.

7.4 Equipment

7.4.1 Vessel shells shall be insulated with factory-fabricated insulation curved or grooved to fit the shell contour. If additional layers are required, insulation shall be installed with staggered joints. Each layer shall be secured with bands, machine stretched, and fastened on 12 inch centers. Breather springs shall be included with the bands per the requirements given in 7.0.N.

7.4.2 All cracks or voids shall be filled with insulating cement. Insulation shall be covered with metal jacketing lapped a minimum of 3 inch on all seams. Jacketing shall be secured with metal screws on 6 inch centers on longitudinal seams and with bands, located at lap and spaced a maximum of 18 inch on center.

7.4.3 Vessel heads shall be insulated in the same manner as the shell. Insulation shall be covered with metal jacketing in a pie shape or segmented arrangement.

7.4.4 Insulation at the base of equipment in contact with ground and within 24 inch shall be non-wicking type and impervious to water e.g. Cellular Glass as per ASTM C552.

7.4.5 Jacketing on vertical vessels shall be installed using the “S” clip method.

7.4.6 For vessels 20 to 36 inch O.D., jacketing shall be secured using plain bands. For vessels greater than 36 inch O.D., banding shall be sealed.

7.4.7 Expansion joints are to be provided under each insulation support ring. A 1 inch space between the top of the insulation and the underside of the support ring shall be filled with mineral fiber insulation.

7.4.8 A band is to be placed adjacent to heads of horizontal vessels and at the top sheet on vertical vessels to secure flashing between head and shell jackets.

7.4.9 Insulation on support skirts for vertical vessels with and without fireproofing shall be as shown on vessel drawings. For horizontal vessels, the insulation shall not extend down the saddle supports unless indicated on the drawings.

7.4.10 Vessel flanged connections shall not normally be insulated unless specified by OWNER.

7.4.11 Insulation and jacketing on exchanger flanges and heads shall be installed so as to be removable without damage to the main shell insulation.

7.4.12 Whenever possible, for equipment of irregular shape, insulation shall be of the same type and thickness as specified for vessels. Insulation and metal jacketing shall be installed so as to be removable.

7.4.13 Insulating cement, where required, shall be applied in layers 0.8 to 1 inch thick. Every layer shall be reinforced with steel mesh. The outer surface of the insulating cement shall be finished with a smooth layer of finish cement.

7.4.14 Where specified, insulation over manways and inspection openings shall be removable.

7.4.15 Provision for the expansion of hot equipment shall include the installation of expansion springs in circumferential banding securing insulation and jacketing, to absorb the difference in the thermal expansion between the component to the insulated and the metal jacket. The expansion joints shall be placed at such points where it is also possible for the insulation holding structure to expand. The recommended maximum expansion joint spacing shall refer to Table 4 of ASTM C1696, which is shown below:

TABLE 4 Maximum Expansion Joint Spacing

Operating Temperature, °F (C)	Maximum Expansion Joint Spacing, Linear Feet (Meters)	
	Ferritic Steel	Austenitic Steel
200 (93.3)	75 (22.9)	51 (15.6)
300 (149)	41 (12.5)	28 (8.6)
400 (204.4)	27 (8.3)	19 (5.6)
500 (260)	20 (6.1)	15 (4.6)
600 (315)	16 (9.9)	12 (3.7)
700 (371)	12 (3.7)	10 (3.1)
800 (427)	12 (3.7)	8 (2.5)
900 (482.6)	10 (3.1)	7 (2.2)
1000 (538)	10 (3.1)	6 (1.8)

8.0 QUALITY CONTROL AND DOCUMENTATION

8.1 When specific details preclude the use of general insulating practices, CONTRACTOR shall submit drawings complete with full details to OWNER for approval indicating proposed insulation details for piping and equipment and at support rings, insulation expansion joints, insulation termination points and flashing, and pipe/equipment supports.

8.2 CONTRACTOR shall institute and maintain a quality control program with supporting documentation to assure compliance with the Specification and the good workmanship practices in the referenced industry standards regardless of inspection by the OWNER. The quality control program shall include all items described in this Specification as a minimum. The documentation shall be available for review by OWNER on demand.

TABLE 1: INSULATION AND WEATHERPROOFING APPLICATION SCHEDULE

The following requirements apply to all hot insulation codes except FP.

Items to be Insulated	Base Insulation (Note 1,2)	Weatherproofing (Note 1,2)			Band Seals
		Material	Thick-ness	Corrugation	
Pipe, all sizes	Mineral fiber	Aluminum	0.020”	3/16	Wing
Screwed fittings	Insulated cement or preformed fittings	Aluminum	0.024”	None	Wing
Welded fittings	Mineral fiber	Aluminum	0.024”	None	Wing
Bellows type expansion joints	Flexible Insulation Covers (when specified)	Silicone or Teflon Cloth		None	Wing
Vessel top heads	Calcium silicate	Aluminum	0.020”	None	Closed
Vessel bottom and horizontal heads	Mineral fiber	Aluminum	0.020”	None	Closed
Vertical shells	Mineral fiber	Aluminum	0.020”	1-1/4	Closed
Horizontal shells	Calcium silicate for top 1/3; Mineral fiber for lower 2/3	Aluminum	0.020”	3/16	Closed
Tank Shells, bottom 18”	Cellular Glass	Aluminum	0.020”	2-1/2	Closed
Tank Shells, above lower 18”	Mineral Fiber	Aluminum	0.020”	2-1/2	Closed
Access ways, flanges, flanged fittings, flanged valves, heads of heat exchangers, instruments, pumps, relief devices	Flexible Insulation Covers (when specified)	N/A	N/A	N/A	N/A

Note 1: See Paragraph 3.7 for insulation and weatherproofing materials when Insulation Code FP is indicated.

Note 2: For Aerogel insulation, follow Manufacturer’s recommendations.

TABLE 2: INSULATION THICKNESS CHART

The following table is valid for the following design conditions:

Insulation:	Mineral fiber
Emissivity:	0.10
Ambient Temperature:	92°F
Wind Velocity:	0 miles per hour
Weatherproofing:	Aluminum
Maximum Allowable Surface Temperature:	140°F

The following chart contains the required insulation thickness at an operating temperature. (Example: A 6" NPS operating at 570°F will require a 3.5" insulation thickness.)

NPS Pipe Size Inches	Maximum Operating Temperature, °F															
	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850
	Insulation Thickness, Inches															
1	1	1	1	1	1	1.5	1.5	2	2	2.5	2.5	3	3	3.5	4	4.5
1.5	1	1	1	1	1	1.5	1.5	2	2	2.5	2.5	3	3.5	3.5	4	4.5
2	1	1	1	1	1	1.5	1.5	2	2.5	2.5	3	3.5	3.5	4	4.5	5
2.5	1	1	1	1	1	1.5	1.5	2	2.5	2.5	3	3.5	3.5	4	4.5	5
3	1	1	1	1	1.5	1.5	2	2	2.5	3	3.5	3.5	4	4.5	5	5.5
4	1	1	1	1	1.5	1.5	2	2.5	2.5	3	3.5	4	4	4.5	5	5.5
6	1	1	1	1	1.5	1.5	2	2.5	3	3	3.5	4	4.5	5	5.5	6
8	1.5	1.5	1.5	1.5	1.5	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5
10	1.5	1.5	1.5	1.5	1.5	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	7
12	1.5	1.5	1.5	1.5	1.5	2	2	2.5	3	3.5	4	4.5	5	6	6.5	7
14	1.5	1.5	1.5	1.5	1.5	2	2.5	3	3.5	3.5	4	5	5.5	6	6.5	7.5
16	1.5	1.5	1.5	1.5	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6.5	7	8
18	1.5	1.5	1.5	1.5	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6.5	7	8
20	1.5	1.5	1.5	1.5	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6.5	7	8
24	1.5	1.5	1.5	1.5	1.5	2	2.5	3	3.5	4	4.5	5.5	6	6.5	7.5	8.5
≥30 and Equipment	1.5	1.5	1.5	1.5	1.5	2	2.5	3	3.5	4.5	5	6	7	8	9	10

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

Aboveground Coatings

Specification No. EH-35R-CCU1-SPC-255-85210

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1.0 GENERAL

1.1 Scope

This specification covers external painting of aboveground plant facilities exposed to weather and operating at temperatures less than 1000°F (538°C).

1.2 Exceptions

This Specification is not applicable to architectural components and buildings, internal linings or coatings for underground vessels and piping.

1.3 Terminology

a. Application Data – application instructions, recommendations and guidelines described in the published literature of the coating materials' Manufacturer, referenced industry standards and any specific requirements noted in this specification and any drawings issued to the Contractor. In case of conflicting requirements between the documents, Contractor shall submit all conflicting information to the Buyer for resolution. If the published literature of the Manufacturer does not contain required information, Contractor shall obtain additional information from the parent corporate office of the Manufacturer. Any deviations from or changes to Manufacturer's published literature shall be subject to Buyer's review, acceptance or rejection.

Note: Where recommendations, instructions and guidelines are given in permissive language such as "may," "should," and "recommended," compliance with those recommendations, instructions and guidelines shall be considered mandatory unless otherwise instructed by the Buyer.

b. Buyer – engineering contractor, acting for the Owner.

c. Bulk pipe – piping that is not welded and will be sent to the field or fabrication shop for assembly and paint.

d. Carbon Steels (CS) – carbon steels including alloy steels 9¼Cr or less.

e. Catalog Equipment – catalog items or assemblies of catalog items such as bulk valves, actuators, control instruments, electrical equipment, compressors, motors, pumps and similar items that are not specifically designed and custom fabricated for the project.

f. Coat – one full layer of the specified material applied to the specified thickness. Multiple passes including initial mist pass and/or stripe coats may be necessary to form a coat. A mist pass is not considered a full coat. The cost of a coat shall include the cost of mist pass(es) and stripe coats.

g. Contractor – the painting contractor.

h. Custom Equipment – items specifically designed and fabricated for the project, such as piping spools, process equipment, skid units, boilers, heat exchangers, heaters, heat recovery steam generators (HRSGs), vessels, drums, shop fabricated tanks,

stacks and other made-to-order equipment and related items including associated structural components.

i. Dry Film Thickness (DFT) – the thickness of the dry film of the coating.

j. Insulated Surfaces – steel surfaces that will receive external insulation.

k. Manufacturer – manufacturer of the specified paint.

l. Operating Temperature – the maximum temperature of fluid during normal operating conditions. The operating temperature of refractory lined equipment for painting purposes shall be the temperature of the metal surface exposed to the weather during operation. The steam out temperature of piping and equipment *shall not* be considered as a basis for paint system selection, unless specifically instructed in writing by the Owner and acknowledged in writing by the Buyer.

m. Owner – Owner of the Project or its authorized representative.

n. PFP – Passive Fire Protection, usually intumescent type

o. Piping / Pipe spool – assembly of one or more: pipes, flanges, pipe fittings, welded valves, pipe supports, and accessories

p. Stainless Steel (SS) shall mean austenitic stainless steel such as Type 304L, 304, 316L, 316, 317L, 321 and 347, and duplex stainless steels such as grade 2205.

q. Structural steel - structural steel other than the structural steel that is an integral part of fabricated equipment by the Supplier. For example, vessel skirts are not considered structural steel.

r. Supplier – fabricator and/or supplier of pipe, equipment, structural steel, and other items to be painted.

s. Tagged valves – tagged valves include control, on/off, relief, and specialty relief valves.

t. Tanks – field fabricated above ground storage tanks (AST). Shop fabricated tanks are considered Custom Equipment.

u. Uninsulated Surfaces – steel surfaces that will not receive external insulation.

v. Work – all labor, supervision, installed and consumable materials, services, equipment, instruments, tools, and each and every item of expense necessary for preparing the surfaces for paint application, application of paint materials, repairs, quality control, and cleanup thereafter.

2.0 REFERENCES

The latest revision, including addenda, of the following references in effect on the latest date of this Specification form a part of this Specification. Except as modified by the requirements specified in this Specification or on the drawings, all Work performed shall comply with the following references.

Any conflicts between the following references and this Specification shall be resolved by the Buyer.

2.1 ASTM (American Society for Testing And Materials)

D3276 Standard Guide for Painting Inspectors (Metal Substrates)

D4285 Standard Test Method for Indicating Oil or Water in Compressed Air

D4752 Measuring MEK Resistance of Ethyl Silicate Zinc Rich Primers by Solvent Rub

2.2 SSPC (Society for Protective Coatings)

SSPC-AB 1	Mineral and Slag Abrasives
SSPC-SP 1	Solvent Cleaning
SSPC-SP 10	Near-White Metal Blast Cleaning
SSPC-SP 11	Power Tool Cleaning To Bare Metal
SSPC-SP 16	Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals
SSPC-VIS 1	Visual Standard For Abrasive Blast Cleaned Steel (Standard Reference Photographs)
SSPC-PA 2	Procedure for Determining Conformance to Dry Coating Thickness Requirements
SSPC Guide 15	Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates (SSPC Painting Manual, Ch 9 – Technology Guides)

2.3 ANSI (American National Standards Institute)

Z535.1	Safety Color Code

2.4 ASME (American Society of Mechanical Engineers)

A13.1	Scheme for the Identification of Piping Systems

2.5 ISO (International Standards Organization)

ISO 8502-6	Preparation of steel substrates before application of paints and related products – Tests for the assessment of surface cleanliness – Part 6: Extraction of soluble contaminants for analysis – The Bresle method
ISO 8502-9	Preparation of steel substrates before application of paints and related products – Tests for the assessment of surface cleanliness – Part 9: Field method for the conductometric determination of water-soluble salts

ISO 12944-5 Paints and varnishes – Corrosion protection of steel structures by protective paint systems Part 5: Protective paint systems

2.6 Related Project Specifications

EH-35R-CCU1-SPC-255-85400 *Galvanizing*

EH-35R-CCU1-SPC-255-85110 *Hot Insulation*

3.0 EXECUTION

3.1 The Supplier shall perform all Work related to surface preparation, priming and finish painting of catalog or off-the-shelf equipment and other components, including all attachments thereto, in accordance with the Supplier's standard paint system. Supplier shall submit a description of the paint system with generic types, brands, number of coats and DFT per coat for review and acceptance by Buyer.

A. For all carbon steel and insulated stainless steel: pumps, compressors, tagged valves bodies, fans, and blowers the Supplier's standard system shall be in compliance with or exceed ISO 12944-5 C3 environment, High Durability coatings. If Supplier does not have a system that complies, Supplier shall choose the appropriate system from Table 1.

B. For all carbon steel flow meters (all types) and other in-line instrumentation with the Supplier's standard system shall be in compliance with ISO 12944-5 C3 environment, Medium Durability coatings with a total DFT of 6 mils (150 µm) minimum. If Supplier does not have a system that complies, Supplier shall choose the appropriate system from Table 1.

C. Transmitters, actuators, solenoids, etc. shall be coated with the Supplier's standard system.

D. Uninsulated stainless steel catalog equipment and other components do not require painting.

3.2 The Supplier shall perform all Work related to surface preparation, priming and finish painting of the following items including all attachments (excluding prepainted off-the-shelf items) thereto in accordance with the Painting Schedule of this specification:

- Custom Equipment
- Piping
- Structural steel (non-galvanized) and miscellaneous items.

3.3 The Contractor shall perform all Work related to the following tasks, by way of example but not by limitation, necessary to complete the application of all painting systems in accordance with this specification:

- Cleaning of surfaces to remove all dirt, foreign matter, grease, oil, etc. with fresh water and/or degreaser in accordance with SSPC SP1.
- Repair of damaged surfaces of shop coating
- Surface preparation and priming of bare metallic surfaces.

- Finish painting of primed surfaces.
- Repainting of custom equipment with damaged finish paint.
- Application of safety color coding and pipe identification.

3.4 The Contractor shall provide a coating procedure including, but not limited to:

- Identification of the structures, systems and components to be coated, the coating system and finish coat color to be applied, and the specific coating products to be used for each coat of each system
- Latest product data sheets
- Method for identification and removal of soluble salts and other contaminants
- Coating material handling and storage and inventory controls.
- Metal preparation at welds and edges.
- Description of the degree of cleanliness and surface profile to be achieved during surface preparation. Indicate the abrasive to be used. Where different types of surfaces comprising the item(s) to be coated will be prepared to different criteria, define the criteria applicable for each.
- Description of the specific type/configuration of tools to be used for any alternative surface preparation techniques other than abrasive blasting.
- Application, touch-up, and curing.
- Techniques to correct out-of-spec film thickness and surface treatment processes for "freshening" coatings that have exceeded their recoat windows.
- Inspection.
- Disposal of waste, debris, and unconsumed coating materials.

4.0 COATING SYSTEM SELECTION REQUIREMENTS

4.1 Coating systems for new construction shall be selected using Table 1.

4.2 Coating systems for repair and field painting shall be selected using Table 2. Field painting shall be used at site where an indoor shop environment is not available. Where a project site has a fabrication shop, coating that is performed indoors shall meet Table 1.

4.3 For heat exchangers, the hotter temperature for each side (i.e. shell / tube) shall be used for selecting the appropriate coating system. For refractory lined items, the skin temperature shall be used.

4.4 Items that are in cyclic service shall be coated with a system suitable for the higher operating temperature.

4.5 Items that have personnel protection in the form of metal guards shall be treated as “uninsulated”.

4.6 Items specified to be coated with System A for temporary protection in transit and laydown need not be repaired (including welds) in the field.

4.7 Each item on a packaged equipment skid shall be considered independently and the applicable system selected from Table 1.

5.0 GENERAL PAINTING REQUIREMENTS

5.1 Items Which Do Not Require Painting

The following items do not require any surface preparation or painting unless otherwise specified.

- Non-metallic items glass, plastic, wood, etc. except where required for safety
- FRP except when required for UV protection
- Non-ferrous metals such as aluminum, copper, brass, etc.
- Galvanized surfaces except for safety color coding or coating repair.
- Aboveground cast iron products such as manhole covers and grating

5.2 Items Which Require Protection from Painting

Surfaces which could be damaged by abrasives, dust, or paint overspray shall be protected by wrapping, taping, or other means to prevent damage. Such surfaces shall include, by way of example, but not by limitation, the following:

- High Alloys (such as Monel, Incoloy, or Hastelloy)
- Bearings
- Conduit
- Control panels
- Couplings
- Nameplates
- Expansion joint bellows
- Fire sprinkler heads
- Machined surfaces and sealing surfaces
- Glass, rubber, gasket materials etc.
- Identification tags
- Instrument glasses and gauge dials
- Spring hanger graduations
- Valve stems and position indicators

Note: Stainless steel surfaces shall be protected from zinc- and aluminum-rich coatings at all times. Any accidental overspray of zinc and aluminum, including trace amounts, over stainless steel surfaces must be completely removed.

5.3 Scheduling Of Work

Unless otherwise stated in the Application Data and approved by the Buyer, painting shall be done when:

- Pressure testing is complete
- Ambient temperature is above 32°F (0°C) and below 110°F (43°C)
- Metal surface temperature is at least 5°F (3°C) above the dew point
- Relative humidity is less than 85%
- There is no likelihood of rain within 24 hours after painting
- Protection of surfaces not required to be painted, e.g. stainless steel, is in place

6.0 SURFACE PREPARATION

6.1 General

A. Surfaces shall be thoroughly pressure washed with potable water to remove all dirt, dust and water soluble salts. The water washing shall be considered critical, especially if the surfaces are, or have been, exposed to a salt environment. If any grease and oils are present on the surface, the surfaces shall be washed with biodegradable non-ionic detergent solution or suitable hydrocarbon solvent until the surfaces are completely free of all surface contamination. There shall be no smudge on the surface when rubbed with a clean cloth. Surfaces cleaned with detergent shall be thoroughly rinsed with potable water to remove traces of detergent.

B. Testing for soluble salts shall be conducted prior to commencing abrasive blasting. Extraction and assessment of the soluble salts shall be done in accordance with ISO 8502-6 and ISO 8502-9 or SSPC Guide 15, Section 4.6 and SSPC Guide 15, Section 5.3. Six samples per 2000 m^2 shall be taken for immersion surfaces and 4 samples per 2000 m^2 shall be taken for atmospheric surfaces. Acceptable average conductivity for immersion surfaces shall correspond to ≤ 20 mg/m^2 and maximum conductivity shall correspond to ≤ 30 mg/m^2. Acceptable average conductivity for atmospheric surfaces shall correspond to ≤ 30 mg/m2 maximum conductivity shall correspond to ≤ 40 mg/m^2. Surfaces not in compliance with these limits shall be steam cleaned or fresh water washed and re-tested until the requirements are met.

C. Welded areas shall be blast cleaned or ground to remove burrs, spatter, or protrusions. Weld reinforcement shall not be removed and base metal shall not be ground below the surface.

D. All sharp edges shall be ground to a minimum 2 mm radius.

E. Surface preparation and anchor pattern (surface profile) shall be as specified in the Application Data for each individual paint system as shown in Table 1.

F. Before applying any coating, blast cleaned surfaces shall be vacuumed and wiped with a clean cloth to remove all traces of dust. Care shall be taken to ensure that no lint or other residue is left on the cleaned surface by the cloth.

G. Cleaned surfaces shall be coated within four hours and before occurrence of any trace of rust. If rust is noticed, the surface shall be blast cleaned again. Where the item to be painted is large, it shall be cleaned and primed in sections.

6.2 Carbon Steels

A. Carbon steels shall be solvent washed per SSPC-SP 1 and blasted to SSPC-SP10 cleanliness as shown in Table 1.

B. Power tool cleaning shall not be used for new construction unless approved in writing by the Buyer.

C. Contractor shall obtain a surface profile of 1.5 – 2.5 mils or as otherwise required by the Manufacturer.

6.3 Pre-painted or Primed Surfaces Requiring Further Coating

A. All surfaces shall be thoroughly degreased and washed in the manner stated for bare carbon steels above. Coated surfaces shall not be washed until the previously applied coating(s) have reached full water resistance. Consult coating Manufacturer for curing schedule.

B. The washed surfaces shall be completely dry prior to further application of paint materials. Any additional surface preparation, such as sanding required by the coating Manufacturer shall be followed prior to top coating.

6.4 Galvanized Surfaces

A. Galvanized surfaces requiring painting for safety color identification purposes shall be solvent washed per SSPC-SP 1 and sweep blasted per SSPC-SP 16.

B. A minimum surface profile of 1 mil (25 µm) or greater as required by the coating Manufacturer shall be created. Blasting shall not remove the galvanized layer.

6.5 Stainless Steel

A. Stainless steel shall be solvent washed per SSPC-SP 1 and blasted per SSPC-SP16 as shown in Table 1. A minimum surface profile of 1.5 mils (25 µm) or greater as require by the paint Manufacturer shall be created.

B. Any power or hand tool cleaning of stainless steel shall be done using SS brushes or equipment that have not been used on carbon steel surfaces.

C. Solvents used for removal of oil or grease from SS surfaces shall be non-chlorinated and suitable for use on stainless steel.

7.0 MATERIAL AND APPLICATION EQUIPMENT REQUIREMENTS

7.1 Environmental Compliance

All cleaners, primers, finishes and solvent materials shall be environmentally safe products and regardless of local regulations, shall not contain hazardous materials such as CFCs, lead, chromates, and other heavy metals which cause air, soil and water pollution. Coating products' volatile organic compound (VOC) content shall meet the minimum requirements of local, state and/or federal requirements. Products that do not comply with the pollution regulations of the governmental agencies are not allowed for use on this Project. The Supplier and the Contractor are responsible for verifying the product compliance with local environmental regulations.

7.2 Compressed Air

A. The compressed air shall be passed through a cooler.

B. All air compressors shall be of a sufficient size to deliver 100 psi at the nozzle. Each compressor shall have two coalescing oil/moisture filters, one located at the compressed air discharge and one located just before the after-cooler.

C. Compressed air used for blasting and coating application must be clean, oil and water free and dry. Testing for evidence of oil or water shall be done in accordance with ASTM D4285 at the beginning of each shift, every four hours thereafter, at the end of each shift and after any interruption of compressor operation.

7.3 Abrasives

A. Abrasives shall be composed of clean, dry, hard particles free of foreign substances such as dirt, oil, grease, toxic substances, organic matter, mill scale and water soluble salts, meeting the requirements of SSPC-AB 1, Class A.

B. The pH of the abrasive materials shall be 6.0 to 8.5. Abrasives shall be sharp garnet or aluminum oxide grit of Rockwell hardness 40 to 50 and properly graded. Abrasive particle size shall be suitable for producing an angular sharp anchor profile of 1½ to 2½ mils (40 to 65 µm) or as specified in the Application Data. Steel shot alone is not acceptable.

C. Mineral abrasives shall meet the requirements of SSPC-AB 1, Type I or II, Class A. Silica sand, other abrasives containing more than 1% crystalline silica, and copper slag shall not be used.

D. Abrasives used for blasting stainless steel or galvanized steel shall be garnet or aluminum oxide and shall contain no metals.

7.4 Cleaners and Paint Materials

A. The degreaser shall be a non-toxic and non-ionic biodegradable water based cleaner.

B. Primer and finish paint materials shall be those listed in Table 1 and Table 3.

C. Primers and finishes shall be factory tinted, sealed, and labeled products. Each label shall show the product name, number, type of paint, lot or batch number, color and instructions for mixing and/or thinning. Solvents shall be products of the same manufacturer and be used in accordance with the Application Data.

D. Coating materials that have exceeded their shelf life shall not be used.

E. Paint and markers used on stainless steel shall be halogen and chloride free.

F. Mixing of partial kits is not allowed.

7.5 Paint Application Equipment

Spray equipment shall be as recommended in the Application Data. Sufficient number of spare parts shall be made available at the work site. Brush application may be used for touch-up/repairs or where spray application is not possible.

8.0 APPLICATION OF PRIMERS AND FINISHES

8.1 Proper functioning of the in-line moisture and oil traps shall be evaluated daily by allowing the air supply (downstream of the traps) to blow against a clean, white cloth in accordance

with ASTM D4285 and as indicated in 6.2 above. No moisture or oil should be deposited on the cloth. If contaminants are detected, the equipment deficiencies shall be corrected and the air stream shall be retested. Cleaned surfaces determined to have been blasted since the last successful test shall be degreased and re-blasted with clean air and abrasive. Primers and finishes determined to have been applied using contaminated air shall be removed and recoated using clean air.

8.2 All painting shall be in accordance with this specification and Table 1, Coating Selection for New Construction, Table 2, System Definitions, Table 3, Approved Products and Suppliers and Table 4, Finish and Safety Colors.

8.3 Storing; thinning; mixing order; mixing procedure, including the mixer speed and mixing time; handling; and application of paint materials shall be in accordance with the Application Data.

8.4 Pigmented and catalyzed materials shall be thoroughly mixed and strained before applying. Materials that have not been applied within the pot-life times shall be discarded and properly disposed of.

8.5 Paints with metallic pigments such as zinc and aluminum shall be continuously agitated to prevent settling of the pigment while being applied.

8.6 Ends of straight pipe 24” and smaller that will require welding shall be masked off after blast cleaning and left unpainted 2” from the edge to facilitate welding and weld inspection. Ends of straight pipe larger than 24” shall be masked off and left unpainted 4” from the edge. Edges of structural steel items that will require welding shall be masked off after blast cleaning and left unpainted 2” from the edge. The masking material shall be removed as soon as possible after painting.

8.7 Paint shall be spray applied unless the adjacent surfaces cannot be protected from overspray. When spray application cannot be done, the paint shall be applied by roller or brush (except for inorganic zinc for which brush-applied epoxy zinc should be used).

8.8 Weld lanes, bolt heads, corners, and edges require an initial brush or “stripe” coat before the application of the paint system to assure wetting of the surface and adequate film build.

8.9 Paint materials shall be uniformly applied in even, parallel passes overlapping each pass 50% immediately followed by cross-spray passes to obtain a continuous film without bare spots, pinholes or holidays. The coated surface shall have no runs, sags, solvent blisters, dry spray or other blemishes. All irregularities shall be removed or repaired and recoated.

8.10 Inter-coat contamination shall be minimized by maintaining proper cleanliness and by applying all coatings within the time period stated in the Application Data. If contaminants are present, they shall be removed before applying subsequent coats.

8.11 Coatings applied over inorganic zinc primer shall be applied using a mist coat/full coat method.

8.12 Colors of each coat shall be contrasting (except for aluminum-filled coatings).

9.0 PIPE IDENTIFICATION

9.1 The identification of piping systems shall be in accordance with American National Standards Institute document *ASME A13.1, Scheme for the Identification of Piping Systems.* Identification on painted items may be in the form of paint or stickers. Stickers shall not be used on unpainted items. Paint on unpainted metallic piping shall be halogen and chloride free.

9.2 Fluid services not identified by Table 2 of *ASME A13.1* shall be identified with black background color and white letters.

9.3 Identification markings may be stenciled on, or applied using coil wraps where permitted by the Owner.

9.4 Stickers or coils shall not be used on bare carbon steel or stainless steel piping.

9.5 The coating used for stenciled markings shall be the same as the coating of the parent pipe. If the pipe is not painted, a silicone acrylic chosen from Table 3 may be used.

9.6 When specified, piping shall be stripe coated at both ends for ease of geographical or process area location identification during laydown. This coating may be temporary or permanent but shall be in addition to the required paint system given in Table 1. Paint used on normally unpainted stainless steel shall be halogen and chloride free.

10.0 COATING REPAIRS AND FIELD PAINTING

10.1 Shop and Field Repairs

A. Damaged coatings, areas with spot rust, burnt residue, weld spatter and other solid adherent foreign matter shall be cleaned per SSPC-SP 11, Power Tool Cleaning to Bare Metal, using 3M ScotchBrite surface conditioning discs, MBX Bristle Blaster or similar tools that will yield a 1 ½ to 2 ½ mil (40 to 65 µm) profile.

B. The surface shall be wiped with a clean rag to remove all dust and loose materials, then cleaned per SSPC-SP 1. The surface shall then be dried using a clean, dry cloth.

C. Weld joints of galvanized items shall be cleaned with 3M Clean 'N Strip cup wheels or MBX Bristle Blaster prior to feathering with 3M ScotchBrite surface conditioning discs.

D. All dust shall be removed from the surface by vacuuming, brushing and wiping with a clean cloth.

E. The surrounding existing coating shall be feathered and roughened at the edges with sandpaper a minimum of 1 in (25 mm) from the repair area.

F. Primer material shall not overlap the existing adjacent finish. However, the finish material shall overlap the adjacent existing finish a minimum of two inches (50 mm).

G. Repair coating systems are specified in Table 2.

H. ZRC Galvalite, Zinga, or Galvacon may be used to repair galvanized surfaces with operating temperatures at or below 200°F (93°C). Aerosol versions of these coatings are not to be used. Cold galvanizing compounds shall not be used to repair galvanized steel that will be fireproofed and instead the coatings shown in Table 2 shall be used.

I. QA/QC requirements in Section 11.0 also apply to repairs.

10.2 Coating Field Welds and Field Fabricated Steel and Piping

A. A closed loop system or wet blasting are the preferred methods of surface preparation for field welds. Dry abrasive blasting, where permitted by the Owner, shall be contained using tarps. Where blasting cannot be performed, the surface shall be prepared using the methods listed in Section 10.1A.

B. Requirements in 10.1B thru 10.1I apply to all field coating. The appropriate system from Table 1, 2 and 3 shall be used.

11.0 QA/QC (QUALITY ASSURANCE AND QUALITY CONTROL)

11.1 Documentation

A. The Supplier and Contractor are solely responsible for all QA/QC activities regardless of any QA/QC activities performed by the Buyer. The Supplier and Contractor shall maintain documentation to comply with the guidelines of ASTM D3276 and shall submit their daily surface preparation and coating report form for review and approval. Inspection shall also comply with the following additional requirements. Any approvals for products and procedures submitted by the Supplier and Contractor shall be considered additional to the requirements stated in the specification and shall not be considered as a substitution to the requirements of this specification. Exceptions to the specification are only acceptable when specifically documented by Contractor and approved by Buyer.

B. All QA/QC documentation for work performed shall be made available to the Buyer on demand and without notice. If the Supplier and Contractor are unable to produce the QA/QC documentation to the satisfaction of the Buyer, such absence of documentation shall be sufficient cause for the Buyer to reject the work performed.

C. The Buyer's review (or lack thereof) of quality control documents shall not be construed as acceptance of omissions or defective work. Nor shall it in any way lessen the Supplier's responsibilities to provide a completely operative system or component in full compliance with this specification.

11.2 Instruments

The Supplier and Contractor shall supply, calibrate and maintain the following instruments for inspection. Alternate instruments may be approved by the Buyer.

Measured Property	Instrument
Temperature and Humidity	Gardner Certified Hygrometer and Temperature Indicator

Measured Property	Instrument
Surface cleanliness	SSPC-VIS 1 or NACE blast cleaned panels
Surface profile	Elcometer surface profile gauge (Model 123), Keane-Tator Surface Profile Comparator or Testex Press-O-Film
Wet Film Thickness	Elcometer Model 154 or Nordson Wet Film Thickness Gauge
Dry Film Thickness	SSPC-PA 2 Type 2 gauge or approved equal
Bond or Adhesion Strength	Elcometer Adhesion Tester Model 106, PosiTest Adhesion Tester or Approved Equal

11.3 Minimum Inspection Required Prior To and During Surface Preparation

A. Verify that all oil, grease, dirt, chlorides and other contaminants have been removed.

B. Verify that nearby inlets of air intake and vacuum systems equipment are properly protected before initiation of blast cleaning operations.

C. Verify that items requiring protection from abrasives and dust are properly protected.

D. Verify that the surface temperature is 5°F (3°C) above the dew point and rain is not forecasted within the scheduled painting time plus 24 hours.

E. Check abrasive quality, air quality and surface profile.

F. Verify that cleaned surfaces are free of contamination and that chloride (soluble salts) testing has been completed in accordance with Section 6.2 of this specification.

11.4 Minimum Inspection Required Prior To Painting

A. Verify that the storage, shelf life, mixing, thinning and application of primers and finishes are in accordance with the Application Data.

B. All surfaces shall be visually inspected to assure that the proper surface cleanliness and surface profile necessary for painting exist.

C. Document the temperature, humidity and substrate surface temperature.

D. Verify that surfaces not to be coated are masked off or otherwise protected prior to painting of adjacent surfaces. Stainless steel must be protected from zinc- and aluminum- rich coatings.

11.5 Minimum Inspection Required During Painting

A. Verify that the recoating time is in accordance with the Application Data.

B. Verify that the paint materials are applied within the shelf life and pot life.

C. Verify that the materials are properly strained and mixed in the recommended order and that the reaction time as necessary was allowed.

D. Verify that the moisture and oil filters of the air lines are functioning properly.

E. Check for initial mist pass of the coating to avoid bubbling.

F. Check for criss-cross spray pattern to assure proper film buildup.

G. Check for proper atomization and avoid dry spray.

H. Verify the wet film thickness of each coat. The wet film shall be uniform without runs or sags.

11.6 Minimum Inspection Required After Painting

A. Verify that the paint film is free of defects. The painted surface shall be free of blisters, bubbles, craters, sags, runs, dry spray, lap marks and unnecessary brush marks.

B. Verify that all masking tape has been removed.

C. Verify that the coating is cured as specified in the Application Data. Cure of catalyzed materials may be determined by exposure to a suitable solvent as recommended by the coating Manufacturer. Inorganic zinc primers may be tested for cure by testing in accordance with ASTM D4752 (latest version). Rating shall be 4 or better.

D. SSPC-PA 2 Type 2 dry film thickness gauges shall be verified for accuracy in accordance with SSPC-PA 2. A record of annual calibration by instrument manufacturer shall be provided for approval.

E. Dry film thickness measurements shall be taken and recorded after each coat in the painting system.

F. Dry film thickness measurements shall be made in accordance with SSPC-PA 2, Level 3, Procedure for Determining Conformance to Dry Coating Thickness Requirements. However, maximum DFT shall be within the limits per the Manufacturer, regardless of PA 2 allowables.

APPENDIX A. COATING SELECTION TABLES

Table 1: Coating Selection for New Construction

	Item Description	Operating Limits (°F)	Insulated	System	Surface Prep	1st Coat (mils DFT)	2nd Coat (mils DFT)	3rd Coat (mils DFT)	Notes
	STRUCTURAL STEEL								
	Structural Steel – bolted galvanized steel	≤250	N	Hot dipped galvanized (HDG) per project specification EH-35R-CCU1-SPC-255-85400					
	Structural Steel – welded carbon steel	≤250	N	1	SP 10	EH (4.0-6.0)	PU (2.0-3.0)	-	
	Ladder cages and handrails for color identification	≤250	N	3	SP 16	HDG	EH (4.0-6.0)	PU (2.0-3.0)	Sweep blasted per SSPC SP 16 taking care to not remove galvanizing.
	Fireproofed structural steel and equipment supports (bare carbon steel)	≤200	N	4	SP 10	EH (4.0-6.0)	FP	PU (2.0-3.0)	Surfaces greater than 200°F shall not be fireproofed with intumescent epoxy without a thermal barrier. Steel shall not be galvanized.
	CARBON STEEL PIPING, VESSELS, TANKS, SKIDS, & HEAT EXCHANGERS								
	Bulk pipe and fittings sent to the field for fabrication	All	Y or N	Mill standard finish. After welding and hydrotesting, paint per this specification with appropriate system from this Table, using Field Products in Table 2.					
	Pressure retaining parts of equipment and shop piping and non-fireproofed supports	≤250	N	1	SP 10	EH (4.0-6.0)	PU (2.0-3.0)		Non-fireproofed saddles, lug type supports, and welded pipe shoes may be coated with the same system as the equipment / pipe.
		>250 & ≤400	N	2	SP10	IZ (2.5-4.0)	SA (1.5-2.0)	SA (1.5-2.0)	
		>400 & ≤1000	N	5	SP10	IC (5.0-6.0)	IC (5.0-6.0)	-	
	Pressure retaining parts of equipment and shop piping and non-fireproofed supports	≤400	Y	6	SP10	EN (8.0-10.0)	-	-	
		Cycles below 250 to above 400	Y	5	SP10	IC (5.0-6.0)	IC (5.0-6.0)	-	PPG Hi-Temp 1027 shall only be used if an additional primer of inorganic zinc is applied.
		>400	Y	A	SP10	IZ (2.5-4.0)	-	-	Primer for protection during shipment and laydown. Does not require repair in the field after installation.
	Saddles, lugs, clips, shoes, and other welded appurtenances	All	N	Use the same coating system as the shell / pipe. Supports on vessels, exchangers, and piping coated with system A shall be coated with the appropriate uninsulated system.					
	Structural steel for equipment skids	≤250	N	1	SP 10	EH (4.0-6.0)	PU (2.0-3.0)	-	

	Item Description	Operating Limits (°F)	Insulated	System	Surface Prep	1st Coat (mils DFT)	2nd Coat (mils DFT)	3rd Coat (mils DFT)	Notes
	Grout contact area of equipment skid frames	≤250	N	1 (with no topcoat)	SP 10	EH (4.0-6.0)	-	-	
	Bottom of shop-fabricated tanks	≤250	N	7	SP 10	EH (4.0-6.0)	-	-	
	GALVANIZED PIPING								
	Galvanized Piping	≤250	N	Galvanized piping does not require coating, except for firewater lines which shall be coated per System 3 with a RAL 3004 top coat color.					
	STAINLESS STEEL PIPING, VESSELS, TANKS, SKIDS, & HEAT EXCHANGERS								
	Bulk pipe and fittings sent to the field for fabrication	All	Y or N	Cleaned only at mill. After welding and hydrotesting, paint per this specification with appropriate system from this Table, using Field Products in Table 2					
	Pressure retaining parts of equipment and shop piping and non-fireproofed supports	All	N	None	n/a	-	-	-	
	Pressure retaining parts of equipment and shop piping and non-fireproofed supports	>120 & ≤350 or Cyclic up to 350; and >24"	Y	6	SP 16	EN (8.0-10.0)	-	-	This system can also be used for items <24" if the aluminum foil wrap option shown below is not practical.
		Cycles below 350 to above 350; and >24"	Y	5	SP 16	IC (5.0-6.0)	IC (5.0-6.0)	-	This system can also be used for items <24" if the aluminum foil wrap option shown below is not practical.
		>120 & ≤350 or Cyclic thru this range; and ≤24"	Y	n/a	See Notes	See Notes	-	-	The item shall be wrapped with 2.5 mil thick aluminum foil per API 583. This work including surface preparation will be done by the Insulation Installation contractor and details are given in specification EH-35R-CCU1-SPC-255-85110, Hot Insulation.
		<120 or >350 with no cycling to below 350	Y	None	n/a	-	-	-	Cycling refers to cycling as part of normal operation. Infrequent cycling for major turnarounds is not included, but as normal practice, all wet insulation detected during turnarounds should be removed and replaced.
	Saddles, lugs, clips, shoes, and other welded appurtenances	All	N	Use the same coating system as the shell / pipe					
	CATALOG EQUIPMENT AND OTHER OFF-THE-SHELF ITEMS								
	Valves, Pump, Compressors, Instruments, Motors, Transmitters	Supplier standard coatings as long as they meet the minimum requirements listed in Section 3.1.							

Table 2: System Definitions

System Number	New Construction - Shop			Repair and Field Coating		
	First Coat	Second Coat	Third Coat	First Coat	Second Coat	Third Coat
1	EH	PU	-	EH[1]	PU[1]	
2	IZ	SA	SA	IC	SA	-
3	HDG	EH	PU	EH	PU	-
4	EH	FP	PU	EH	FP	PU
5	IC	IC	-	IC	IC	-
6	EN[2]	-	-	EN[2]	-	-
7	EH	-	-	EH	-	-
-	HDG Structural Steel			EA, or Cold Galvanizing per Section 10.1H		
-	HDG Piping			EA or EZ, or Cold Galvanizing per Section 10.1H		

Note 1: EZ primer can also be used with the EH/PU topcoats.
Note 2: Two coats of EN with 4.0-6.0 mils dft per coat can also be used.

Table 3: Approved Products (Note 1)

Type Abbreviation	Generic Type Description	DFT (mils)	Carboline	Hempel	International	Jotun	PPG	Sherwin Williams
IZ	Inorganic Zinc	2.5 – 4.0	Carbozinc 11	Galvosil 15680	Interzinc 22	Resist 86	Dimecoate 9	Zinc Clad II
EZ	Zinc Epoxy	2.0 - 2.5	Carbozinc 859	Hemapdur Zinc 17360	Interzinc 52	Barrier 80	Amercoat 68 SP	Zinc Clad IV
EH	High Build Epoxy	4.0 – 6.0	Carboguard 890	Hempadur 45880/1	Interguard 475	Penguard Universal	Amerlock 2/400	Macropoxy 646
EA	Epoxy Aluminum	5.0 – 7.0	Carboguard 890 Al	Hempadur 45880/1 Al	Interguard 670 Al	Penguard Universal	Amerlock 2/400 Al	Epoxy Mastic Al
EN	Epoxy Novolac	4.0 – 10.0	Thermaline 450	Hempadur 85671	Interbond 2340UPC	Jotatemp 250	Amercoat 91	Phenicon HS
SA	Silicone Acrylic	1.5 – 2.0	Thermaline 4900	Silicone Acrylic 56940	Intertherm 875	Solvalitt Midtherm	Hi-Temp 500V	Heat Flex Hi-Temp 500
PU	Polyurethane	2.0 – 3.0	Carbothane 134HG	Hempathane	Interthane 990	Hardtop XP	Amercoat 450	Acrolon 218HS
IC	Inorganic Copolymer / Multipolymeric Matrix	5.0 – 6.0	Thermaline Heat Shield	Versaline CUI 56990	Interbond 1202UPC	Jotatemp 1000 Ceramic	Hi-Temp 1027 (Note 2)	Heat Flex Hi-Temp 1200
PFP	Intumescent Fireproofing for 2hr Pool Fire	0.5in			Chartek 1709	Jotachar 1709	Pittchar XP/2	Firetex M90
HDG	Hot Dip Galvanizing	-	-	-	-	-	-	-

Notes:

1. *Unless otherwise specified, all products of a series are acceptable. (i.e. Carboguard 890, 890LT, etc).*
2. *See Table 1, for need for IZ primer for use of this product on insulated CS.*

APPENDIX B. TOP COAT COLOR REQUIREMENTS

The following table shall be used to select the top coat color. If RAL colors are not available, Contractor may propose Federal or Munsell equivalent for Buyer approval. If a finish coat is not able to be tinted, manufacturer light grey shall be used for components operating 400°F and below, and manufacturer standard silver used for components operating above 400°F (black for boiler and furnace components). Requirements for safety colors shall be adhered to.

Table 4: Finish and Safety Colors

Item	COLOR	RAL CODE
Storage Tanks	White	9001
Structural steel	Light grey	7035
Drums, Reactors, Filters, Exchangers, Towers, etc.		
Pipe and welded pipe spools (except fire/deluge service)		
Boiler and Furnaces (components ≤400°F)		
Boiler and Furnaces (components >400°F)	Manufacturer standard black	
Ground flare runners	Manufacturer standard grey or silver	
Elevated flare stacks		
Instrument panels, racks, enclosures, etc.		
Rotating equipment (compressors, pumps, fans, blowers, etc.)	Fabricator standard, RAL 7035 preferred	
Flanged control valves and manual valves		
Handrails, ladder cages, posts, and barricades	Safety Yellow	1003
Pressure relief valves	Safety Orange	2010
Coupling guards / Dangerous parts of machinery		
Firefighting equipment and piping	Safety Red	3004
Safety showers and eye wash stations	Safety Green	6024

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

Galvanizing

Specification No. EH-35R-CCU1-SPC-255-85400

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1.0 INTRODUCTION

1.1 Scope

This Specification covers the requirements for hot-dip galvanizing of aboveground carbon steel items with operating temperatures[1] below 390°F which are not in immersion service.

2.0 REFERENCES

Applicable requirements in the latest edition (or the edition indicated) of the following industry standards and referenced documents shall be considered an integral part of this Specification.

2.1 Industry Codes and Standards

- American Society for Testing and Materials (ASTM)
  - A123 – Standard Specification for Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products
  - A143 – Standard Practice for Safeguarding Against Embrittlement of Hot Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
  - A307 – Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
  - A384 – Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies
  - A385 – Standard Practice Providing High Quality Zinc Coating (Hot-Dip)
  - A392 – Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric
  - A563 – Standard Specification for Carbon and Alloy Steel Nuts
  - A653 – Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
  - A780 – Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
  - B6 – Standard Specification for Zinc
  - B695 – Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel

NOTES:
[1] Continuous exposure to temperatures above 390°F can cause the outer free zinc layer to peel from the underlying zinc-iron alloy layer. However, the remaining zinc-iron alloy layer will provide good corrosion resistance for temperatures up to 480°F. *Source: www.Glavanizeit.org*

- F436 – Standard Specification for Hardened Steel Washers Inch and Metric Dimensions
- F959 – Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners, Inch or Metric Series
- F1136 – Standard Specification Zinc/Aluminum Corrosion Protective Coatings for Fasteners
- F1554 – Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength
- F2329 – Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners
- F2833 – Standard Specification for Protective Fastener Coatings with Zinc Rich Base Coat and Aluminum Organic/Inorganic Type
- F3125 – Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength

- American Galvanizers Association
  - Inspection of hot-dip galvanized steel products.
- Steel Structures Painting Council (SSPC)
  - SSPC-SP1 – Solvent cleaning
  - SSPC-SP11 – Power tool cleaning to bare metal
  - SSPC-SP14 – Industrial Blast cleaning

2.2 Project Specifications

EH-35R-CCU1-SPC-255-85210 Aboveground Coatings

2.3 Definitions

The following definitions are applicable to this specification.

Term	Description
Shall/Will	Denotes a minimum requirement in order to conform to the intent of the standard.
Should/Can/Could/May	Denotes a recommendation which is advised but not required in order to conform to the standard.
Purchaser	Owner or Owner's designee
Seller	Seller of steel products who is also responsible for galvanizing.

3.0 DESIGN AND FABRICATION REQUIREMENTS

3.1 Seller shall comply with the requirements of ASTM A143, A384 and A385 for all design and fabrication requirements. Cold working of carbon steel items to be galvanized shall not be permitted unless the items are safeguarded against embrittlement per ASTM A143.

3.2 The Seller shall bring potential problems that require a modification in design, in order to eliminate possible embrittlement or warpage, to the attention of Purchaser, before proceeding with fabrication and galvanizing. It shall be the Seller's responsibility to safeguard against embrittlement, bending, and warpage.

3.3 Floor plates and shop assembled platforms shall be limited in size so that multiple dipping shall be avoided when possible.

3.4 The following points shall be considered during the design and galvanizing:

3.4.1 Vent/drain holes shall be provided to avoid high internal pressures and air locks.

3.4.2 Defects in the substrate such as cracks, laminations, laps, and folds shall be removed prior to galvanizing.

3.4.3 Drilling, cutting, welding, forming, and final fabrication of unit members and assemblies shall be completed before galvanizing.

3.4.4 Welds shall be continuous.

3.4.5 Where laps cannot be avoided all overlaps or contacted surfaces shall be seal welded.

3.4.6 Rough spots and burns shall be removed by grinding prior to galvanizing.

4.0 GENERAL REQUIREMENTS FOR GALVANIZING

4.1 Identification markings on the items to be galvanized shall be provided by:

4.1.1 Welding the identifying marks on the items,

4.1.2 Embossing the identifying marks on a steel tag of no less than No. 12 gage (0.105" thick) and securing to the items with a heavy wire such as No. 9 gage (0.148" diameter), or

4.1.3 Die stamping the identifying marks onto the items with characters ½" high and a minimum of 1/32" deep.

4.2 Zinc used for galvanizing which is required to meet ASTM A123 shall be 99.990% pure, ASTM B6 Grade SHG (Special High Grade) with lead content less than 0.003%.

4.3 Surfaces shall be cleaned to remove oil and grease by solvent or detergent cleaning per SSPC-SP1.

4.4 Welding residues must be removed prior to hot-dip galvanizing.

4.5 Seller shall follow safe practices per ASTM A143 during galvanizing process.

4.6 The Seller shall exercise the required care to safeguard against warpage and distortion during hot-dip galvanizing of steel products in accordance with ASTM A384.

4.7 After immersion in the molten zinc, the items shall not be subjected to any process of scraping or wiping which may reduce the uniformity or the specified weight of the zinc coating. Galvanizing practice shall comply with the requirements of ASTM A385.

4.8 The zinc coating shall be continuous, smooth and uniform in thickness. The zinc coating shall be free of voids, blisters, flux spots, inclusions, dross, acid or black spots. The coating shall be adherent so it will not be removed by any reasonable process of handling or erection. Lumps, globules, or heavy deposits of zinc, which could interfere with the intended use of the galvanized item, are not permitted.

4.9 The Seller shall submit to Purchaser procedure for tagging or otherwise applying the original piece identification marking after galvanizing. Once approved, the procedure shall then be implemented.

5.0 GALVANIZING OF STRUCTURAL STEEL AND ACCESSORIES

5.1 Carbon steel items, listed below, shall be galvanized in accordance with the following table:

Item to be galvanized	*Galvanizing Reference ASTM Std.*
Structural steel products listed in Note 1	A123
Checkered plates, grating, embedded plates, stair treads with nosing	A123
Electrical conduit, cable trays and covers including fasteners, and light standards.	A123
High strength bolts (ASTM F3125):	
Grade A325	F2329
Grade A490	F1136 (Grade 3 for bolts and Grade 5 for nuts), or F2833 (Grade 1)
Grade F1852	B695 (Class 55)
Grade F2280	None
Anchor bolts (ASTM F1554) Common or Machine Bolts (ASTM A307) Nuts (ASTM A563) Washers (ASTM F436) DTI Washers (ASTM F959)	F2329 B695 (Class 55, Type 1)
Sheet metal decking (such as roof and floor decking)	A653 (Interior - Grade 60, Exterior - Grade 90)
Carbon steel chain link fence fabric	A392, Class 2
Piping (when specified)	Per piping item description

Note 1: Structural steel and accessories: Beams, columns, handrails, ladders, cages, platforms, stair assemblies, chain link fence, checker plates, guardrails, nosings, and similar items. See also ASTM A123, Section 1.

6.0 REPAIR OF DAMAGED ZINC COATINGS

6.1 Repairs to damaged surfaces, galvanized with the hot-dip process, shall be in accordance with ASTM A780 and the project Aboveground Coatings specification, EH-35R-CCU1-SPC-255-85210.

6.2 The procedure used to repair damaged mechanically-applied zinc coating (galvanizing) shall be submitted to the Purchaser for approval.

6.3 Where a galvanized item is welded to a painted item, weld area shall be painted using paint system used for the painted item.

7.0 INSPECTION

7.1 The Seller is responsible to implement a quality control program to verify compliance with this Specification.

7.2 Galvanized products shall be sampled and inspected in accordance with American Galvanizers Association publication “Inspection of hot-dip galvanized steel products” with the following additional requirements.

7.3 Bare spots (except those caused by lifting devices) on the galvanized items are unacceptable and the Purchaser reserves the right to reject the batch without explanation. Galvanizer shall repair the bare spots caused by lifting devices before the parts are accepted.

7.4 Clogged threads must be cleaned and free of excess zinc before parts are accepted. Drainage spikes must be removed before acceptance of the parts.

7.5 Zinc coating that is delaminating and peeling-off is unacceptable even if the underlying coating meets the thickness requirement.

7.6 Coating is unacceptable if bare surface is exposed when dross particles are removed.

7.7 Coated areas with flux inclusions are subject to rejection if the areas are large or repairs would not be satisfactory as determined by the Purchaser.

7.8 Rough zinc coating on hand rails is unacceptable and may be a cause for rejection. Galvanizer shall make the surface smooth before the part can be accepted.

7.9 Galvanizing over weld spatter where the coating can be easily removed, leaving an uncoated area or bare spot, is not acceptable. If this defect occurs, the area must be cleaned and properly repaired, which may require re-galvanizing.

7.10 Coated surfaces with wet storage stains must be re-galvanized.

7.11 Thickness of the coating shall be determined by a magnetic thickness measurement in accordance with ASTM A123 using an Elcometer 456 Integral, ElectroPhysik MiniTest 70 Series, or approved equal. [Conversion factors (thickness to weight of zinc): 1.0 mil thickness = 0.6 oz/ft^2 = 25 microns thickness = 178 gms/m^2]

7.12 At least five readings should be taken to obtain a true value representative of the sample. Readings should not be taken near an edge or hole. Measurements on large products should be made at least 4 inches from the edge, Measurements on curved surfaces should be avoided if possible. Readings should be taken on regular areas of the coating. Measurements should be spread out as widely as possible.

7.13 Adhesion of the coating shall be tested as stated in ASTM A123.

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

Materials and Fabrication Requirements for Duplex Stainless Steel

Specification No. EH-35R-CCU1-SPC-255-85530

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1.0 INTRODUCTION

1.1 Purpose

This specification, EH-35R-CCU1-SPC-255-85530, defines the materials, welding, thermal treatment, examination and testing requirements for duplex stainless steel (SS) equipment and piping. It supplements the other Buyer Specifications and purchase documents.

1.2 Scope

a. This specification applies to new, duplex SS pressure vessels, heat exchangers and piping components including pipe, fittings, valves and castings. Requirements for castings are given in Attachment A.

b. Pumps and other rotating equipment are not in the scope of this specification.

c. Tanks are outside the scope of this specification and any special requirements will be individually specified on the data sheet.

d. This specification supplements the Codes and Standards listed in Section 2.0 of this specification. This specification also supplements the project welding and other specifications which are listed in the data sheet or other purchase documents. In any case of conflicting requirements, the strictest requirement shall be met unless otherwise approved by Buyer.

2.0 REFERENCES

Additional references are listed below. Short titles will be used herein when appropriate.

2.1 Industry Codes and Standards

- American Society of Mechanical Engineers (ASME)
  - Section II, Part A — Materials - Ferrous Material Specifications
  - Section II, Part C — Materials – Specifications for Welding Rods, Electrodes, and Filler Metals
  - Section V — Nondestructive Examination
  - Section VIII, Div. 1 — Rules for Construction of Pressure Vessels
  - Section IX — Welding, Brazing and Fusing Qualifications
  - SA-182 — Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
  - SA-240 — Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels
  - SA-789 — Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service

- SA-790 Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe
- SA-815 Wrought Ferritic, Ferritic/Austenitic, and Martensitic Stainless Steel Piping Fittings
- SFA-5.4 Stainless Steel Electrodes for Shielded Metal Arc Welding
- SFA-5.9 Bare Stainless Steel Welding Electrodes and Rods for Gas Shielded Arc Welding
- B31.3 Process Piping

- American Society for Testing and Materials (ASTM)
  - A182 Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
  - A240 Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels
  - A789 Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service
  - A790 Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe
  - A815 Wrought Ferritic, Ferritic/Austenitic, and Martensitic Stainless Steel Piping Fittings
  - A923 Detecting Detrimental Intermetallic Phase in Duplex Austenitic/Ferritic Stainless Steels
  - A1084 Detecting Detrimental Phases in Lean Duplex Austenitic/Ferritic Stainless Steels
  - E92 Standard Test Method for Vickers Hardness and Knoop Hardness of Metallic Materials
  - E562 Determining Volume Fraction by Systematic Manual Point Count

- American Welding Society (AWS)
  - A4.2 Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Ferritic-Austenitic Stainless Steel Weld Metal

- International Organization for Standardization (ISO)
  - ISO 17781 Test Methods for Quality Control of Microstructure of Ferritic/Austenitic (Duplex) Stainless Steels

- Reference Specifications
  - EH-35R-CCU1-SPC-255-85002 Welding and NDE Requirements for Shop or Field Fabricated Piping
  - EH-35R-CCU1-SPC-255-85050 Welding and NDE Requirements for Equipment

3.0 DEFINITIONS

The following additional definitions are also applicable to this specification.

Table 1: Definitions

Term	Description
Shall/Will	Denotes a minimum requirement in order to conform to the intent of the standard.
Should/Can/Could/May	Denotes a recommendation which is advised but not required in order to conform to the standard.

4.0 MATERIALS REQUIREMENTS

4.1 Materials shall be specified as UNS S32205 or dual certified UNS S32205/S31803 for the "standard" 22% Cr duplex grades. The nitrogen content shall be 0.14%-0.20%.

4.2 For the "super duplex" SS grades (25% Cr), material shall be specified as UNS S31260, S32550, S32750, S32760, S39274, S39277 or Buyer-approved equivalent.

4.3 The 25% Cr super duplex SS grades shall meet a minimum PREN of 40. PREN shall be defined as:

PREN = % Cr + 3.3*(%Mo + 0.5*%W) + 16*%N

4.4 "Lean" duplex SS grades such as UNS S32003, S32101 and S32304 shall meet the requirements given for S32205 within this specification except for chemistry and where otherwise approved by Buyer.

4.5 For each product form, the material shall be supplied and certified in accordance with the listed ASME or ASTM specification as shown on the purchase order.

	ASME Specification	ASTM Specification
Pipe material (seamless or welded)	SA-790	A790
Fittings (seamless or welded)	SA-815	A815
Forged fittings and valves	SA-182 (Grade F60 for standard duplex SS)	A182 (Grade F60 for standard duplex SS)
Plate	SA-240	A240
Tubing (seamless or welded)	SA-789	A789

4.6 Materials (except tubing) shall be furnished fully annealed, water-quenched, and pickled. All welding by materials suppliers shall be completed prior to the final quench anneal.

4.7 ASTM A923 or A1084 Testing

4.7.1 Suppliers can propose to use similar testing in accordance with ISO 17781 for Buyer approval.

4.7.2 For all product forms (with the exception of tubing), each lot of standard grade duplex SS material shall be impact tested in accordance with Test Method B of ASTM A923 and each lot of lean grade duplex SS material shall be impact tested in accordance with Test Method B of ASTM A1084. The Rapid Screening Test included in ASTM standards shall not be used to accept material.

4.7.3 For the 25% Cr super duplex SS grades, both ASTM A923 Test Methods B and C shall be done.

4.7.4 For standard grades, the Test Method B criteria shall be >54 J (>40 ft-lb) (3 specimens) at -40ºC (-40ºF) or a lower temperature. For super grades, testing shall be at -46ºC (-50ºF), and shall be >70 J (> 52 ft-lb) average. For lean grades, the Test Method B temperature and criterias in ASTM A1084 shall be used.

4.7.5 With Test Method B, lateral expansion measurements shall be reported for information and if applicable, to meet ASME Code requirements.

4.7.6 For Test Method C, the criteria given in ASTM A923 and A1084 shall be met as applicable.

4.8 Definition of Lot

4.8.1 When a batch-type furnace is used for final anneal, a lot shall include only pipe or fittings of the same heat that are heat treated in the same furnace charge.

4.8.2 When a continuous furnace is used for final anneal, a lot shall include all pipe and fittings of the same heat, heat treated in the same furnace at the same temperature, time at heat, and furnace speed.

4.9 Welded fittings (nozzles, etc.) made from plate shall be 100% RT examined at the fitting fabricator's shop. Interpretation and acceptance of the RT film shall be

performed by the fitting fabricator, the equipment Fabricator (if applicable) and the Buyer's inspector.

4.10 Swaged nozzles shall be heat treated in accordance with Table 1 of SA-790 after the swaging operation.

4.11 Every effort shall be made to locate the longitudinal weld in swaged nozzles made from rolled and welded plate out of the 180° radius area of the swaged end.

4.12 Full section tensile specimens (except tubing) are required.

4.13 Repair welding of pipes, tubes, and fittings shall not be permitted.

4.14 Solution annealing is required after cold working on components other than tubing if the deformation exceeds 10% for the lean or standard grades of duplex SS. All cold formed 25% Cr super duplex SS (other than tubing) shall be solution annealed after cold forming.

4.15 Certified material test reports (CMTR's) are required for all materials.

4.16 Additional Requirements for Tubing

4.16.1 Welded tubing shall receive both hydrostatic testing and non-destructive electric testing in accordance with ASME SA-789.

4.16.2 Each heat lot of standard and super duplex SS tube material shall be corrosion tested per ASTM A923 Test Method C and shall meet the given criteria. In addition, one specimen representing each heat lot of lean, standard and super duplex SS shall receive a microstructural examination per the requirements of ASTM A923 Test Method A. The presence of Possibly Affected, Affected or Centerline Structures shall be grounds for rejection of the solution anneal batch represented by the specimen, and the batch shall require reheat treatment and retesting. The sample size shall be a 25 mm (1 inch) long tube specimen for each heat lot.

4.16.3 Tubing shall be solution annealed within the temperature range listed for the particular grade in ASME SA-789 for sufficient time to eliminate intermetallic precipitates and then rapidly cooled by water quenching, or air or inert gas cooling to below 315ºC (600ºF). Other heat treatments and quenching media other than water must be approved by Buyer.

4.16.4 No weld repairs of base materials and no repair of tube dents are permitted. These tube sections shall be rejected.

4.16.5 Hardness testing of tubing shall be done in accordance with SA-789 except that the maximum hardness shall be Rockwell C 28 for lean and standard grades, and Rockwell C 30 for super duplex grades. Failure to meet this hardness requirement shall constitute failure of the specimen and shall

result in hardness testing being required on each length in the heat lot represented by the specimen.

4.16.6 Unless otherwise restricted by Buyer, tube u-bends with bend radii equal to or greater than 3.3D for lean and standard duplex SS shall not receive post bend heat treatment. Heat treatment for tighter bends shall use electric clamp methods, and the procedure shall be submitted to Buyer for approval. Furnace heat treatments are not allowed. Super duplex SS u-bends can use all bending radii and post bend heat treatment is not allowed.

4.16.7 After heat treating, other than bright anneal procedures, all tubing shall receive a descaling treatment of pickling followed by a neutralizing and appropriate rinsing treatment. All mill scale shall be removed.

5.0 WELDING AND FABRICATION

5.1 Joint Preparation

5.1.1 Duplex stainless steel may be cut using the plasma-arc process, a machine cutter, or a grinding disc dedicated solely for the use on duplex stainless steel. Carbon-arc shall not be used for cutting or backgouging. If plasma-arc cutting is used, the inside surface must be thoroughly cleaned of all spatter. Sufficient metal shall be removed in the beveling process to remove any heat affected zone (HAZ) that occurred as a result of plasma-arc cutting. Once used for cutting duplex stainless steel, grinding discs shall be used exclusively for that purpose. The final surface preparation and configuration shall be obtained by machining. During machining operations, only a cutting fluid compatible with stainless steel shall be used.

5.1.2 Before any welding takes place, all weld bevels shall be visually inspected internally and externally for nicks, dents, general damage, or other surface defects. Defects shall be dealt with as stated below, after which, the final cleaning prior to welding shall take place.

5.1.3 Any small burrs, nicks, or other irregularities on the weld bevel shall be repaired, if possible, by light grinding. Any suspected edge defects or laminations shall be reported to the Buyer before proceeding with investigation or repairs. Repairs by welding shall not proceed without prior approval of the Buyer.

5.1.4 Each beveled edge and internal and external surfaces over a distance of at least 50 mm (2 inches) back from the bevel shall, immediately prior to welding, be thoroughly dried, and shall be cleaned with a stainless steel wire brush. The beveled edge shall then be wiped clean with acetone, or other Buyer approved solvent.

5.2 General Welding Requirements

5.2.1 All welds, including tack and fit up welds, shall be done with approved procedures, materials and certified welders / welding operators.

5.2.2 For equipment, weld maps shall be submitted with applicable weld procedures for review by Buyer and authorization to proceed.

5.2.3 All welds, including tack welds, shall be made with filler metal. The following processes and consumables shall be used unless otherwise authorized by Buyer:

Process	Standard 22% Cr (Note i)	Super 25% Cr (Notes ii, iii)
SMAW	SFA 5.4 E2209	SFA 5.4 E2594
GTAW/GMAW	SFA 5.9 ER2209	SFA 5.9 ER2594
SAW	SFA 5.9 ER2209 with a flux designated for duplex SS	SFA 5.9 ER2594 with a flux designated for duplex SS

Notes:

i. The Fabricator may propose the use of 25% Cr or nickel-based filler materials (which do not contain niobium) for 22% Cr base metals to Buyer for approval, especially if needed to pass corrosion resistance testing.

ii. This table does not cover some of the 25% Cr super duplex SS alloys with additional alloying elements; hence, the alloy manufacturer's recommendations on filler metals shall be followed.

iii. The use of nickel-based filler metals which do not contain niobium, such as SFA 5.11 ENiCrMo-4, -10, -13 or -14, can be proposed, but require Buyer's approval.

5.2.4 All single sided welds shall be made with a GTAW root pass and be back purged until at least 6 mm (1/4 inch) of weld metal thickness has been deposited.

5.2.5 GMAW shall be by the spray transfer mode and shall use the shielding gas recommended by the alloy manufacturer. GMAW shall not be used for non-backgouged root passes.

5.2.6 Maximum and minimum heat inputs shall not exceed the values qualified in accordance with Paragraph 6.4.1.g, with no value exceeding 2.5 KJ/mm or being below 0.5 KJ/mm for standard 22% Cr alloys. Limits for 25% Cr super alloys shall be based on the alloy manufacturer's recommendations (which typically involve a tighter range). Tighter ranges may also be

required depending on thickness, type of weld, base metal chemistry, etc., which will be shown by the procedure qualification testing.

Heat input (KJ/mm) shall be calculated by the expression:

$$\text{Heat Input} = \frac{V \times A \times 60}{S \times 1000}$$

Where: V = Voltage (volts)
A = Amperage (amps)
S = Travel Speed (mm./min.)

5.2.7 The maximum interpass temperature shall not exceed the values given in the following table:

Base Metal or Component Thickness	Maximum Interpass Temperature	
	Standard Duplex SS (e.g. UNS S32205)	Super Duplex SS (e.g. UNS S32750)
< 3 mm (1/8 in.)	50°C (120°F)	50°C (120°F)
3-6 mm (1/8-1/4 in.)	70°C (160°F)	70°C (160°F)
6-9.5 mm (1/4-3/8 in.)	100°C (210°F)	100°C (210°F)
< 9.5 mm (3/8 in.)	150°C (300°F)	120°C (250°F)
NOTE: For these P-No. 10H materials, the production interpass temperature shall also not exceed the interpass temperature used during weld procedure qualification.		

5.2.8 Measurements of interpass temperatures shall be taken on the parent metal surface, directly adjacent to the weld groove, using a contact thermometer with an instant digital display. Temperature indicating crayons shall not be used, unless approved by Buyer, and if allowed, shall have a maximum halogen content of 200 ppm and a maximum sulfur content of 200 ppm.

5.2.9 Backing and Shielding Gases

a. Backing gas shall be welding grade pure argon, argon/nitrogen mixture or 90% nitrogen/10% hydrogen mixture. The oxygen content of the back-purged volume shall be less than 0.25% (2500 ppm). The Fabricator shall submit details of the method and equipment to be used for monitoring oxygen content as part of the welding procedure specification.

b. Shielding gasses can be argon or argon with 2% maximum nitrogen (with or without helium).

c. Signs of sugaring/oxidation of the weld shall result in rejection and repair.

5.2.10 Under no circumstances shall the welding arc be struck outside the weld bevels. If this occurs, the arc strike shall be removed by grinding. The

ground area shall be inspected with liquid penetrant, and any relevant indications shall be repaired.

5.2.11 During production welding, calibrated equipment for measuring the following variables shall be available at all times:

a. Welding current (amperage)
b. Arc voltage
c. Interpass temperatures
d. Oxygen content of backing gas
e. Wire feed speed (for machine welding)
f. Welding head travel speed
g. Shielding and backing gas flow rate (using floating ball type flowmeter)

The intent of this requirement is that calibrated equipment (by electrical measurement or mechanical measurement means) be available to the welder and inspector to monitor on an as-needed basis the above listed variables during actual production, not to require calibration/re-calibration of all the welding equipment within the Fabricator's shop. As an example, an amprobe can be used to measure welding current and compare the value versus that shown on the welding machines amperage meter. Shop calibration programs for welding equipment/meters would be expected to be found in the Fabricator's QA/QC manual as part of their normal Quality Control function.

5.2.12 Welds that are backgouged for welding on the opposite side shall be liquid penetrant inspected after cleaning prior to backwelding. All backgouging shall be accomplished with approved procedures, ensuring complete removal of oxides from plasma-cut surfaces. Carbon-arc gouging shall not be used.

5.2.13 All accessible welds exposed to the process side shall be cleaned after welding by hand wire brushing (with a stainless steel brush) on the as-welded surfaces.

6.0 WELDING PROCEDURE SPECIFICATIONS AND QUALIFICATION REQUIREMENTS

6.1 The WPS/PQRs shall be qualified in accordance with ASME Section IX and the requirements of this specification. Existing WPS/PQRs, or parts of existing WPS/PQRs may be acceptable provided all of the following requirements are satisfied.

6.2 Each WPS shall contain the information required by ASME Section IX, QW-250, and the following:

6.2.1 The specific welding process or combination of processes to be used in production.

6.2.2 For filler metal(s), the specific manufacturer(s) and trade name(s) to be used in production.

6.2.3 Electrical characteristics of welding, i.e., current and voltage range and polarity for each size (diameter) of filler metal.

6.2.4 Heat input range.

6.2.5 Welding head travel speed.

6.2.6 Maximum interpass temperature.

6.3 For repair welding, details of technique for removing, and verifying removal of defects shall be supplied to Buyer for approval before any repairs are done.

6.4 Essential variables for procedure qualification shall be in accordance with ASME Section IX, QW-250 (including supplementary essential variables for notch toughness), and those listed below. Any changes in the essential variables of an approved WPS shall require re-qualification.

6.4.1 For manual, semi-automatic and machine welding:

a. Filler metal type: Any change in manufacturer beyond those approved by Buyer.

b. Filler metal size: Any change in filler metal diameter.

c. Shielding gas flow rate: Any change in flow rate beyond -20% / +10%.

d. Backing gas composition: Any change in the gas composition.

e. Electrical characteristics: Any change in type of current, polarity, or pulse range.

f. Interpass temperature: Any increase in the maximum interpass temperature.

g. Heat input: Any change greater than -50% or +10%.

h. Thickness: In addition to ASME Section IX requirements given in QW-403.6 and QW-403.8 for minimum and maximum qualified thickness requirements, the following limits shall apply:

Coupon Thickness (T)	Qualified Minimum Thickness	Qualified Maximum Thickness
≤16 mm (5/8 in.)	T	The lessor of 2T or 16 mm (5/8 in.)
>16 to <29 mm (5/8 to 1-1/8 in.)	16 mm (5/8 in.)	29 mm (1-1/8 in.)
≥29 mm (1-1/8 in.)	T	1.2T

6.4.2 For machine welding only:

a. Filler metal: For SAW, any change in the brand name and type of flux.

b. Joint configuration: Any change in joint configuration outside tolerances specified shown on the PQR.

c. Weld orientation: Any change in the weld orientation (e.g., vertical to horizontal or from 1G, 2G or 4G to 3G).

6.5 The minimum number of mechanical test specimens required for a welding procedure qualification test weld shall be in accordance with ASME Section IX, with the addition of:

Test	Lean and Standard Duplex SS	Super Duplex SS
	Quantity of Specimens	
ASTM A923 or A1084 Test Methods as applicable with:		
Test Method B: Charpy V-notch:		
Weld centerline	3	3
HAZ - Fusion line +0.5 mm (0.02 inch)	3	3
	Or:	And:
Test Method C: Ferric Chloride Corrosion Test	2	2
Cross section for ferrite measurements macro-examination and photo-micrographs	1	1
Transverse Hardness Test Surveys	2	2

6.6 Test procedures and acceptance standards for supplementary welding procedure qualification tests shall be as follows:

6.6.1 Charpy Test (Method B) and Ferric Chloride Corrosion Test (Method C)

a. Charpy impact testing shall be in accordance with ASTM A923 or A1084 as applicable Test Method B with test results reported. It shall meet the test temperatures and criterias given in Section 4.7 except that weld metal samples shall meet 34 J (25 ft-lbs) average. The number of specimens shall be in accordance with Paragraph 6.5. Specimens shall be removed from the thru-thickness locations specified by ASME Section IX. Lateral expansion measurements shall be reported for information and if applicable, to meet ASME Code requirements.

b. Ferric chloride corrosion tests shall be in accordance with ASTM A923 or A1084 as applicable, Method C for procedure and criteria with test

results reported. The test specimens shall include weld, HAZ and base metal.

c. The Rapid Screening Test (ASTM A923 or A1084 Test Method A) shall not be used to approve procedures.

6.6.2 Ferrite Tests (Modified ASTM E562)

a. For ferrite assessment during procedure qualification tests, metallurgical sections shall be polished and etched to clearly reveal the two-phase austenite/ferrite microstructure. The area being point counted (parent material, weld metal or HAZ) shall be examined and photographed under a microscope at a sufficient magnification to fill the field of view and to be able to clearly discriminate between the constituent phases. For parent plate and weld metal, a magnification of approximately 400X is required, and for HAZ, about 700X to 1000X is recommended.

b. The photographs shall be overlaid with a circular grid of at least 24 points at 30 fields of view per test locations, and the percentage ferrite shall be calculated from the number of points that fall on the ferrite phase and the total number of points used. Automated counting

methods using quantitative metallography equipment can also be used.

c. The ferrite content shall be measured on metallurgical sections using the point counting technique at the following test locations:

   i. In the parent metal, one test location on each side of the weld at mid thickness (total of two).

   ii. In the heat affected zone on each side of the weld, in the region of the root pass (total of two).

   iii. In the weld metal near to the vertical center line of the weld, one in the cap, one in the root, and one at mid thickness (total of three).

d. Ferrite content at these locations shall be 35-65% in base metal, 30-45% in the HAZ, and 30-65% in weld metal.

e. Experience within the refining industry indicates that this is a difficult test to perform properly (especially on HAZ) and results are often not accurate. Experienced laboratories should be used.

6.6.3 Photomicrographs and Macro-Examination

a. Photomicrographs at approximately 400X shall be provided to the Buyer for each of the locations where a phase balance (ferrite test) assessment is performed.

b. Photomicrographs shall show a typical austenite/ferrite microstructure, and shall meet the Rapid Screening Test of ASTM A923 Test Method A.

c. The macro-examination shall provide evidence that the weld is sound and free from cracks and other defects with full penetration and fusion between weld passes and parent metal.

6.6.4 Hardness Testing

a. Hardness testing is required on all weld procedure qualification records. Hardness readings shall be taken in Vickers with a 10 kg load (or lighter) for base and weld metal testing and a 5 kg load for HAZ testing.

b. At least eight readings at a depth of 2.5 mm (0.1 inch) below the inside and below the outside surfaces shall be recorded for both base metals, heat-affected zones on both sides and weld deposit.

c. Average hardness shall not be above 310 HV, with no single reading over 320 HV for the lean and standard 22% Cr grades. The average

for the 25% Cr super duplex grades shall not be over 320 HV and no reading over 350 HV.

6.7 Dissimilar metal welds, i.e., carbon steel to duplex SS or austenitic stainless steel to duplex SS shall require qualification and testing to the requirements of this specification except that the non-duplex HAZ need not be subject to Charpy tests, and corrosion testing is not an option.

7.0 TUBE-TO-TUBESHEET WELDING AND ROLLING REQUIREMENTS

7.1 General

7.1.1 The general welding requirements of Paragraph 5.2 shall apply to tube-to-tubesheet welding, as applicable. Joints which are rolled only can also be used if qualified by the mockup required by Paragraph 7.3.

7.1.2 Tube-to-tubesheet welds shall be made using the GTAW process with the addition of filler metal. The weld throats (minimum leak paths) shall not be less than the thickness of the tube wall.

7.1.3 The filler metal shall be in accordance with Paragraph 5.2.3.

7.1.4 The shielding gas shall be argon with 2 to 3% nitrogen unless an alternate shielding gas is approved by Buyer.

7.1.5 For strength welded joints, a light roll (<3%) may be used before welding to maintain fitup. A light roll (<3%) may also be required on shell and tube exchangers after welding (with no harder rolling) to remove the crevice between the tube and tubesheet.

7.1.6 For rolled joints or rolled and welded joint, rolled surfaces shall not extend past the tubesheet or into the weld area.

7.2 Welding Procedure Qualification Requirements

The tube-to-tubesheet welding procedures shall be qualified using a mockup qualification test in accordance with ASME Section IX, QW-193, and the requirements found in section Paragraph 7.3 below.

7.3 Mockup Samples for Rolled and/or Welded Joints

7.3.1 Mockup samples shall have a minimum of 10 tubes 152 mm (6 in) in length from the backside of the tubesheet, using the same pitch arrangement as the piece of equipment involved.

7.3.2 The test assembly shall simulate all steps of the production joint including both rolling and welding. In addition, if production welding is to be performed through the plug sheet, this should be simulated in the test

assembly. (Access hole diameter and distance from hole to tubesheet shall be equal to production distances +/-10%).

7.3.3 For welded joints, the tube material, tubesheet and filler metals used for the weld procedure qualification/mockup test sample shall be from the purchased lot to be used in actual production. For Fabricators with good proven experience, past mockup qualifications on the same grades of materials (but not the same production heats) can be submitted for possible Buyer approval.

7.3.4 Hardness readings using Vickers with a 10 Kg load shall be taken in the tube (in and out of the rolled area), in the tubesheet base metal, and in the weld deposit and with a 5 Kg load in the tube and tubesheet heat-affected zones. Readings shall also be obtained on the tube base metal in the area of tubesheet grooves if grooves are used. A minimum of six readings in each of the above areas shall be taken on three tubes prepared for metallography. Hardness shall meet the criteria given in Paragraph 6.6.4.c.

7.3.5 In addition to the macro-examination required by ASME Section IX, QW-193, the microstructure and ferrite content of one randomly selected weld section shall be assessed using the procedures detailed in Paragraphs 6.6.2 and 6.6.3.

7.3.6 For standard and super duplex SS, a quadrant section of a tube-to-tubesheet weld shall be subject to corrosion testing in accordance with ASTM A923, Method C with test results reported. The test specimens shall include weld HAZ and base metal. No pitting is allowed.

7.3.7 Production tube-to-tubesheet welding is not permitted until the mockup samples are approved by Buyer.

7.3.8 Rolled joints shall be prequalified by a mockup and hardness testing. The mockup test assembly shall be in accordance with ASME Section IX, QW-193, with a minimum of ten rolled-in tube samples. The rolling procedure should be the same as the procedure that will be used during production. Hardness readings on tube cross-sections shall be taken in Vickers with a 10 kg load. Readings shall also be obtained on the tube base metal in the area of tubesheet grooves if grooves are used. At least eight readings shall be recorded. Hardness values shall not exceed the criteria given in Paragraph 6.6.4.c. Rolled surfaces shall not extend past the tubesheet or into weld areas.

8.0 NDE AND TESTING

8.1 Liquid Penetrant Examination (PT)

8.1.1 All accessible completed production welds shall be examined by PT. PT examination (100%) is required of butt, seal, fillet, socket, weldolet and branch welds and at all pipe support connection welds.

8.1.2 PT of welds shall include a band of base metal at least 25 mm (1 inch) wide on each side of the weld and on both faces of the joint (if accessible).

8.1.3 PT procedures shall be in accordance with ASME Code, Section V, Article 6 using solvent removable penetrant.

8.1.4 The evaluation of indications and the acceptance criteria shall be in accordance with Section VIII, Division 1, Appendix 8.

8.1.5 For tube-to-tubesheet welds, PT shall be required after rolling where access permits an accurate evaluation. If not accessible, leak testing per Paragraph 8.2 will be required.

8.2 Tube-to-Tubesheet Joints Leak Testing

8.2.1 The use of a pressurized nitrogen or helium (at approximately 6.3 kg/cm^2 {90 psi}) and soap solution test may be substituted for the PT required in Paragraph 8.1.5 above provided the test details are reviewed and approved by the Buyer.

8.2.2 The use of a pressurized nitrogen or helium test combined with complete submergence of the tube bundle in a water tank may be substituted for the PT required in Paragraph 8.1.5 above provided the test details are reviewed and approved by the Buyer.

8.3 Production Ferrite Checks

The ferrite content of all accessible completed external surfaces of production welds shall be checked using either a Magne-Gage or Fischer Ferrite Scope calibrated in accordance with AWS A4.2. A minimum of three tests shall be made on each 1.7 m (5 feet) of weld. The average value of the tests on each weld shall be 30-70% ferrite. A report shall be produced, and the format shall be by prior agreement between the Seller and Buyer.

8.4 Radiography

All duplex SS piping with a pressure class rating in excess of 600# or that are in hydrogen or wet sour service shall have 100% radiography, per ASME B31.3 paragraph 344.5.2(a). Also, 100% radiography is required for vessels and heat exchangers in hydrogen or wet sour service. All other welds require spot radiography.

9.0 ATTACHMENT A - DUPLEX SS CASTING SPECIFICATION

A1. GENERAL

A1.1 Scope

This specification covers the material, testing, and inspection requirements for duplex stainless steel castings. This specification supplements ASTM A995 and is applicable for Grades 1B, 4A and 6A (UNS J93372, J92205 and J93380) only. Supplementary Requirements S6 and S10 of ASTM A995 and S14 of ASTM A703 apply. If any requirement of this document conflicts with ASTM A995 or other documents, the Buyer shall be notified for resolution.

A1.2 Definitions

A1.2.1 The term “Buyer” as used in this specification shall mean Fluor, or their representatives.

A1.2.2 The term “Seller” as used in this specification shall include those who have been contracted to provide the specified materials.

A1.2.3 A "heat lot" is defined as one heat treatment batch from the same heat, melt of material.

A1.3 Referenced Documents

The following codes, standards, and specifications shall be considered as a part of this specification. All documents shall be the latest editions in force.

ASNT-TC-1A	Personnel Qualification and Certification in Nondestructive Testing
ASTM A703/A703M	Specification for Steel Castings, General Requirements for Pressure-Containing Parts
ASTM A802/A802M	Steel Castings, Surface Acceptance Standards, Visual Examination
ASTM A903/903M	Steel Castings, Surface Acceptance Standards, Magnetic Particle and Liquid Penetrant Inspection
ASTM A923	Detecting Detrimental Intermetallic Phase in Wrought Duplex Austenitic/Ferritic Stainless Steels
ASTM A995	Castings, Austenitic-Ferritic (Duplex) Stainless Steel, for Pressure-Containing Parts
ASTM E165	Liquid Penetrant Inspection Method
ASTM E433	Standard Reference Photographs for Liquid Penetrant Inspection

ASTM E562	Standard Practice for Determining Volume Fraction by Systematic Manual Point Count
ASTM E1245	Determining Inclusion Content of Steel and Other Metals by Automatic Image Analysis
ISO 10204	European Standard, Metallic Products, Types of Inspection Documents
ISO 17781	Test Methods for Quality Control of Microstructure of Ferritic/Austenitic (Duplex) Stainless Steels
MSS SP-54	Quality Standard for Steel Casting for Valves, Flanges and Fittings and Other Piping Components, Radiographic Examination Method
MSS SP-55	Quality Standard for Castings for Valves, Flanges and Fittings and other Piping Components, Visual Method

A2. PROCESS AND MANUFACTURE

A2.1 Castings shall be made by one of the following processes:

a. electric arc or induction furnace melting followed by separate refining such as vacuum oxygen decarburized (VOD) or argon oxygen decarburized (AOD),

b. electric induction furnace melting with virgin metal or refined ingots; melt shall be protected with slag or other means from atmospheric contamination or degassing. Foundry revert cannot be used without separate refining.

A2.2 All castings furnished to this specification shall be solution annealed at 1120ºC (2050ºF) to 1150ºC (2100ºF) for 0.5 hours per 25 mm (1 inch) section thickness, with a minimum of two hours and water quenched to room temperature to obtain the required Duplex micro-structure. Prior to water quenching, the casting may be furnace cooled from the solution annealing temperature to no lower than 1040ºC (1900ºF). The furnace to water quench time shall be less than one minute. Air cooling is not permitted.

A2.3 The heat treatment of the castings shall be performed in-house by the foundry. Sub-contracting of the heat treatment needs Buyer's approval.

A3. CHEMICAL COMPOSITION AND TESTS

A3.1 Composition

A certified product analysis of the casting is required and in addition to meeting the ASTM A995 specification requirements, shall also meet the limits in Table A-1 (most of which are stricter than ASTM).

Table A-1

UNS	Gr.	ACI	C	P	S	Cu	Ni	Cr	Mo	N	W
J93372	1B	CD4MCuN	0.03 max	0.03 max	0.02 max	2.7-3.3	5.0 - 6.0	25-26.5	1.8-2.3	0.15-0.25	-
J92205	4A	CD3MN	0.03 max	0.03 max	0.02 max	0.7 max	5-6.5	22-23.5	3.0-3.5	0.15-0.3	-
J93380	6A	CD3MWCuN	0.03 max	0.03 max	0.02 max	0.5-1.0	7-8.5	25-26	3.5-4.0	0.2-0.3	0.5-1

A3.2 Acceptance

A3.2.1 One product analysis per ASTM A703, Paragraph 5.3, shall be performed per heat lot and the results reported to the Buyer. If the product analysis fails to conform to these specifications, the Buyer has the option to reject the heat lot or individually check the remaining castings for compliance. The sample for product analysis shall be removed from prolongations or extra stock, where feasible, to prevent destruction of a usable casting.

A3.2.2 An individual casting may have a composition outside the limits of Table A-1 if all of the following conditions are met:

1. All requirements of ASTM A995, including chemical composition limits are met.
2. The casting meets all other requirements of this specification.
3. The casting has no weld repairs and is a non-welded part.
4. The casting passes the corrosion test of Section A5 and Table A-2 with a weight loss of 10 mg/dm2/day (mdd) or less.
5. Prior to further processing Buyer's approval is obtained.

A4. FERRITE CONTENT

A4.1 One specimen from each heat lot shall also be examined to determine the ferrite/austenite ratio.

A4.2 The ferrite content shall be 35% to 60%. The ferrite content shall be determined by the manual point count in accordance with ASTM E562; minimum magnification shall be 500X. The maximum percent error per E562 shall be 10%. Or, a computerized microstructural analysis per ASTM E1245, or any other method previously agreed to in writing by the Buyer may be used.

A5. SPECIAL TESTS FOR DETRIMENTAL INTERMETALLIC PHASES

A5.1 An impact test in accordance with the requirements in Table A-2 and Paragraph A5.3 is required for every melt and heat treatment lot. Exceptions require written approval of the Buyer. For castings with a net weight over 450 kg (1000 lb), both the impact test and corrosion test are required in accordance with the requirements in Table A-2.

Table A-2

UNS	Grade	ACI	Impact Test Temperature	Corrosion Test Temperature (when required)
J93372	1B	CD4MCuN	-40ºC	40ºC
J92205	4A	CD3MN	-40ºC	25ºC
J93380	6A	CD3MWCuN	-40ºC	50ºC

A5.2 Corrosion Test

A5.2.1 When required, one test specimen from each heat lot of material shall be tested in accordance with the requirements of Table A-2. Exemption by ASTM A923, Paragraph 15 “Rapid Screening Test” is not permitted. The corrosion rate calculated from weight loss shall be reported in mdd (mg/dm2/day). No pitting is allowed.

A5.2.2 All specimens shall be prepared per ASTM A923, Paragraph 18. Corrosion test specimens shall be machined from a section taken from, or representing the maximum cross-section of the casting. The maximum required sample section thickness is 150 mm (6 inches). Mechanical deformation shall not have been performed on the corrosion specimen prior to testing. The corrosion test specimen shall have the same temperature as the test solution when placed into the ferric-chloride solution.

A5.2.3 In the event a specimen does not meet the acceptance criteria, two new specimens from the given heat lot may be taken and retested. Buyer must be notified before proceeding with retesting. These must meet the same acceptance criteria. If either retest specimen fails, the Seller has the option of re-solution annealing and retesting.

A5.2.4 Suppliers can propose to use similar testing in accordance with ISO 17781 for Buyer approval.

A5.3 Impact Testing

A5.3.1 One set of ASTM A370 Charpy-V notch impact tests in accordance with the requirements of Table A-2 is required for one sample from each heat lot. Location of all specimens shall be from the center of the maximum cross-section. The maximum required sample section thickness is 150 mm (6 inches). Where feasible to prevent destruction of a usable casting, the impact specimens, full-size may be removed from prolongations or extra stock.

A5.3.2 The Charpy tests shall be performed at maximum -40ºC (-40ºF) and shall meet the requirements of 54 J (40 ft-lb) minimum.

A6. NONDESTRUCTIVE EXAMINATION

A6.1 Nondestructive examination shall be based upon ASME Code, Section V, and the requirements given below.

A6.1.1 Buyer shall approve in writing the proposed procedures prior to nondestructive examination.

A6.1.2 All personnel performing nondestructive examinations (NDE) shall be certified in accordance with ASNT SNT-TC-1A. Personnel interpreting or evaluating results of nondestructive examination for acceptance or rejection shall be certified to SNT-TC-1A Level II or Level III.

A6.1.3 Equipment shall meet the requirements of and be calibrated in accordance with ASME Code, Section V.

A6.2 Visual Inspection

All castings shall be visually inspected per MSS SP-55 or ASTM A802. For ASTM A802 acceptance shall be in accordance with Level II.

A6.3 Liquid Penetrant Examination

A6.3.1 Liquid penetrant examination is required for all castings.

A6.3.2 Procedures for liquid penetrant examination (PT) shall be per ASTM E165.

A6.3.3. The external surface, accessible wetted surfaces, and repairs require 100% PT. Acceptance criteria shall be in accordance with ASTM A903 Level I.

A6.4. Radiography

A6.4.1 All castings for pressure rating Class 1500 and higher require radiography of all critical areas and butt weld ends after the final heat treatment per ASTM A703, Supplementary Requirement S5.

A6.4.2. Castings for rating Class 600 and 900 require radiography after the final heat treatment per ASTM A703, Supplementary Requirement S5:

- of all butt weld ends, and
- of the critical areas of the pilot casting of each pattern.

A6.4.3. The acceptance shall be per MSS SP 54.

A7. REPAIRS

A7.1. Welding processes shall be SMAW or GTAW.

A7.2 No autogenous welding is allowed.

A7.3. Welding procedures (WPS and PQR) and welders shall be qualified per ASME Code, Section IX. This includes impact testing of full size specimens at -40ºC (-40ºF) to meet minimum weld metal and heat affected zone impact energy of 34 J (25 ft-lb) and 54 J (40 ft-lb) respectively.

A7.4 Castings require post weld (solution annealing) heat treatment and water quenching, per Paragraph A2.2, after all major repair welding of Grade 1B, 4A, and 6A. Post weld solution annealing and water quenching is also required for minor repair welding on the wetted surfaces of Grade 1B and 6A.

A7.5 The filler materials for Grade 4A repairs shall be E2209 for SMAW or ER2209 for GTAW, for Grade 1B, they shall be E2553 or ER2553, and for Grade 6A, they shall be E2595 or ER2594, unless otherwise approved by Buyer.

A8. CERTIFICATION

A8.1 The Seller shall certify in writing that the castings meet the requirements of the latest edition of ASTM A995 (including applicable supplementary requirements of ASTM A703) and this specification.

A8.2 Certified copies of the material certifications meeting the requirements of ISO 10204 3.1.B and the results of all tests shall be furnished to Buyer.

A8.3 All certifications shall be signed by a responsible officer of the Seller, whose identity shall be legibly displayed

Attachment 9 - Electrical Equipment List

Rev	Item No.	WBS	SPEC #	Location	Equipment No.	Description	Manufacturer / Model	Dimensions (H X W X D) in.	Weight, lbs	Notes
A2	100	23	24	MPC	MPC	**Main Power Center** - Shipping - 5 days FAT - Fire Alarm Panel - HVAC Equipment - Stairs and Landings	Powell	2 x (180 X 1320 X 360)	950,600	2-Story Bldg 4 sections each floor to be field connected
A2	101	23	20	MPC	TH-100	**Station Service Transformer** 115-13.8Y/7.910kV 50/66.7/83.3//56/74.1/93.3 MVA	ABB	215 X 240 X 300	180,000	
D	102	23	35	MPC	LRG-100	**Low-Resistance Neutral Grounding Resistor** 200A, 10 Sec	ABB	108 X 42 X 52	1,500	
A2	103	23	34	MPC	CAP-100	**Power Factor Correction Cap Bank** GE AutoVAR MV 13.8kV 16MVAR Unit	GE	94 X 52 X 225	11,750	
A2	104	23	20	MPC	TH-111	**Station Auxiliary Transformer** 13.8-4.16kV, 15/16.8 MVA	ABB	125 X 128 X 155	63,000	
D	~~105~~	~~23~~	~~20~~	~~MPC~~	~~TH-112~~	~~**Station Auxiliary Transformer**~~ ~~13.8-4.16kV, 15/16.8 MVA~~	~~ABB~~	125 X 128 X 155	63,000	
D	106	23	35	MPC	LRG-111	**Low-Resistance Neutral Grounding Resistor** 400A, 10 Sec	ABB	108 X 42 X 52	1,500	
D	~~107~~	~~23~~	~~35~~	~~MPC~~	~~LRG-112~~	~~**Low-Resistance Neutral Grounding Resistor**~~ ~~400A, 10 Sec~~	~~ABB~~	108 X 42 X 52	1,500	
A2	108	23	Future	MPC	BD-111	**Non-Segregated Phase Bus Duct** 4160V, 3000A	EATON	18 X 26 X 612 (4 90º Elbows)	5,151	Spec. 32
D	~~109~~	~~23~~	~~Future~~	~~MPC~~	~~BD-112~~	~~**Non-Segregated Phase Bus Duct**~~ ~~4160V, 3000A~~	~~EATON~~	18 X 26 X 420 (2 90º Elbows)	3,535	Spec. 32
A	110	23	N/A	MPC	PP-140	**Essential Lighting & Battery Charger Panel** 240/120V, 1PH	EATON	60 X 21 X 14	60	
D	111	23	27	MPC	SWGR-100	**Medium Voltage Switchgear** 3000A, 13.8kV, 40kA RMS - Shipping - 2 days FAT	EATON	95 X 252 X 96.25	17,600	
A	112	23	CRC	MPC	RP-CRC	**Relay Panel**	BY CRC	90 X 120 X 30	4,000	
A2	113	23	42	MPC	VFD-201	**Medium Voltage VFD** Blower - 13.8 kV - Transformer - Sync Gear 1.5 day FAT	Toshiba	**VFD:** 103.7 X248 X 48 **TR:** 90 X 90 X 48 **SYNC:** 108 X 78 X 42	38,800	
A	114	23		MPC	DP-160	**125VDC DISTRIBUTION PANEL**	Ametek	36 X 12 X 12	100	
A	115	23	49	MPC	BC-161	**Battery Charger** 40 Amp / 125 VDC DCR Series Battery Charger	Ametek	48 X 24 X 24	430	
A	115	23	49	MPC	BC-162	**Battery Charger** 40 Amp / 125 VDC DCR Series Battery Charger	Ametek	48 X 24 X 24	430	
A	116	23	51	MPC	BY-160	**125VDC BATTERY WITH ACID DRIP PAN** - 125 VDC / 60 Cell EnerSys 20 Year Flooded Battery with seismic rack, drip pan - 125 VDC / 60 Cell Individual Cell Battery Monitoring System	Ametek	68 X 92 X 32	6,000	
A	117	23	49	MPC	DS-160	**BATTERY DISCONNECT**	Ametek	78 X 24 X 32	375	

Rev	Item No.	WBS	SPEC #	Location	Equipment No.	Description	Manufacturer / Model	Dimensions (H X W X D) in.	Weight, lbs	Notes
A2	119	23	42	MPC	VFD-601	**Medium Voltage VFD** CO2 Compressor 13.8 kV 1.5 day FAT	Siemens	133.2 X 495.6 X 63.6	30,000	
A	120	23	OTHERS	MPC		**HVAC Control Panel**	Volta	36 X 36 X 24	200	
A2	121	23	Future	MPC	BD-131	**Non-Segregated Phase Bus Duct** 480V, 3200A	EATON	18 X 26 X 420 (2 90º Elbows)	3,535	Spec. 32
D	~~122~~	~~23~~	~~Future~~	~~MPC~~	~~BD-132~~	~~**Non-Segregated Phase Bus Duct**~~ ~~480V, 3200A~~	~~EATON~~	18 X 26 X 612 (4 90º Elbows)	5,151	Spec. 32
A2	123	23	20	MPC	TH-131	**Station Auxiliary Transformer** 4.16-0.48kV, 2/2.66 MVA	ABB	102 X 75 X 130	12,000	
D	~~124~~	~~23~~	~~20~~	~~MPC~~	~~TH-132~~	~~**Station Auxiliary Transformer**~~ ~~4.16-0.48kV, 2/2.66 MVA~~	~~ABB~~	102 X 75 X 130	12,000	
A	125	23	OTHERS	MPC	HVAC-130-1	**HVAC #1**	Volta	144 X 216 X 192	20,000	
A	126	23	OTHERS	MPC	HVAC-130-2	**HVAC #2**	Volta	144 X 216 X 192	20,000	
A	201	23	OTHERS	MPC	DCS-100	**DCS Cabinets**	BY CONTROL SYSTEMS	BY CONTROL SYSTEMS	BY CONTROL SYSTEMS	
A	202	23	50	MPC	UPS-141	**Uninterruptible Power Supply (UPS) System** - 30 kVA 3 DDP Series PWM UPS with 2 hour heat run prior to shipment - Remote Manual Bypass Switch - K4 Rated Bypass Transformer - VRLA Battery - Battery Disconnect	Ametek	79 x 54 x 36 24 X 24 X 12 36 X 30 X 30 60 X 96 X 24 42 X 12 X 12	8,225	
A2	203	23	38	MPC	MCC-111	**Medium Voltage MCC** 1200A, 4.16kV, 50kA RMS - Shipping - 1.5 day FAT	EATON	92 X 72 X 30	4,200	
D	204	23	27	MPC	SWGR-110	**Medium Voltage Switchgear** 3000A, 4.16kV, 50kA RMS	EATON	115 X 324 X 101.25	27,900	
A2	205	23	38	MPC	MCC-112	**Medium Voltage MCC** 1200A, 4.16kV, 50kA RMS - Shipping - 1.5 day FAT	EATON	92 X 72 X 30	4,200	
A	206	23	C/S	MPC		**OPERATOR CONSOLE (DELTA-V)**	BY CONTROL SYSTEMS	BY CONTROL SYSTEMS	BY CONTROL SYSTEMS	
D	207	23	29	MPC	SWGR-130	**Low Voltage Switchgear** 3200A, 480V, 65kA RMS 1 day FAT	EATON	96 X 110 X 78	8,685	
A2	208	23	39	MPC	MCC-131	**Low Voltage MCC** 1200A, 480V, 65kA RMS 1 day FAT	EATON	90 X 260 X 21	3,380	
A2	209	23	39	MPC	MCC-132	**Low Voltage MCC** 1200A, 480V, 65kA RMS 1 day FAT	EATON	90 X 180 X 21	2,340	
A2	210	23	39	MPC	MCC-133	**Low Voltage MCC** 1200A, 480V, 65kA RMS 1 day FAT	EATON	90 X 220 X 21	2,860	

Rev	Item No.	WBS	SPEC #	Location	Equipment No.	Description	Manufacturer / Model	Dimensions (H X W X D) in.	Weight, lbs	Notes
A2	211	23	39	MPC	MCC-134	**Low Voltage MCC** 1200A, 480V, 65kA RMS 1 day FAT	EATON	90 X 220 X 21	2,860	
A2	212	23	N/A	MPC	TH-142	**Dry-Type MPC Transformer** 480-208/120VAC, 15kVA	EATON	18 X 20 X 8	295	
A2	213	23	N/A	MPC	PP-142	**Electrical Power Panel** 120/208V, 3PH	EATON	60 X 21 X 14	60	
A2	214	23	N/A	MPC	TH-141	**Dry-Type MPC Transformer** 480-208/120VAC, 15kVA	EATON	18 X 20 X 8	295	
A2	215	23	N/A	MPC	PP-141	**Electrical Power Panel** 120/208V, 3PH	EATON	60 X 21 X 14	60	
A2	216	23	N/A	MPC	PP-131	**Electrical Power Panel** 480/277V, 3PH	EATON	48 X 20 X 5.75	60	
								MPC TOTAL WEIGHT =	1,539,437	
A2	300	23	24	APC	APC	**Auxiliary Power Center** - Shipping - 5 days FAT - Fire Alarm Panel - HVAC Equipment - Stairs and Landings	Pioneer	144 X 1200 X 360	322,300	1-Story Bldg 4 sections to be field connected
A2	301	23	38	APC	MCC-211	**Medium Voltage MCC** 1200A, 4.16kV, 50kA RMS - Shipping - 1.5 day FAT	EATON	92 x 504 x 30	28,700	
A	302	23	42	APC	VFD-704A	**Medium Voltage VFD** DCC WSAC Pump A 400 HP, 4.16kV 1.5 day FAT	Toshiba	103.7 X 48 X 48	6,000	
A	303	23	42	APC	VFD-704C	**Medium Voltage VFD** DCC WSAC Pump C 400 HP, 4.16kV 1.5 day FAT	Toshiba	103.7 X 48 X 48	6,000	
A	304	23	42	APC	VFD-705A	**Medium Voltage VFD** Wash Water WSAC Pump A 400 HP, 4.16kV 1.5 day FAT	Toshiba	103.7 X 48 X 48	6,000	
A	305	23	42	APC	VFD-705C	**Medium Voltage VFD** Wash Water WSAC Pump C 400 HP, 4.16kV 1.5 day FAT	Toshiba	103.7 X 48 X 48	6,000	
A	306	23	42	APC	VFD-101A	**Medium Voltage VFD** DCC Water Pump A 1000 HP, 4.16kV 1.5 day FAT	Toshiba	103.7 X 60 X 48	7,600	
A	307	23	OTHERS	APC	DCS-200	**DCS Cabinets**	BY CONTROL SYSTEMS	BY CONTROL SYSTEMS	BY CONTROL SYSTEMS	
A2	308	23	38	APC	MCC-212	**Medium Voltage MCC** 1200A, 4.16kV, 50kA RMS - Shipping - 1.5 day FAT	EATON	92 X 468 X 30	26,600	
A	309	23	50	APC	UPS-241	**Uninterruptible Power Supply (UPS) System** - 15 kVA 3 DDP Series PWM UPS with 2 hour heat run prior to shipment - Remote Manual Bypass Switch - K4 Rated Bypass Transformer - VRLA Battery - Battery Disconnect	Ametek	79 x 32 x 36 24 X 24 X 12 30 X 24 X 24 60 X 60 X 24 42 X 12 X 12	5,000	

Rev	Item No.	WBS	SPEC #	Location	Equipment No.	Description	Manufacturer / Model	Dimensions (H X W X D) in.	Weight, lbs	Notes
A	310	23	42	APC	VFD-101B	**Medium Voltage VFD** DCC Water Pump B 1000 HP, 4.16kV 1.5 day FAT	Toshiba	103.7 X 60 X 48	7,600	
A	311	23	42	APC	VFD-704B	**Medium Voltage VFD** DCC WSAC Pump B 400 HP, 4.1kV 1.5 day FAT	Toshiba	103.7 X 48 X 48	6,000	
A	312	23	42	APC	VFD-705B	**Medium Voltage VFD** Wash Water WSAC Pump B 400 HP, 4.16kV 1.5 day FAT	Toshiba	103.7 X 48 X 48	6,000	
A	313	23	OTHERS	APC		**HVAC Control Panel**	Specific Systems	36 X 36 X 24	200	
A	314	23		APC	DP-260	**125VDC DISTRIBUTION PANEL**	Ametek	36 X 12 X 12	100	
A	315	23	49	APC	BC-261	**Battery Charger** 40 Amp / 125 VDC DCR Series Battery Charger	Ametek	48 X 24 X 24	430	
A	315	23	49	APC	BC-262	**Battery Charger** 40 Amp / 125 VDC DCR Series Battery Charger	Ametek	48 X 24 X 24	430	
A	316	23	51	APC	BY-260	**125VDC BATTERY WITH ACID DRIP PAN** - 125 VDC / 60 Cell EnerSys 20 Year Flooded Battery with seismic rack, drip pan - 125 VDC / 60 Cell Individual Cell Battery Monitoring System	Ametek	68 X 92 X 32	6,000	
A	317	23	49	APC	DS-260	**BATTERY DISCONNECT**	Ametek	78 X 24 X 32	375	
D	318	23	29	APC	SWGR-230	**Low Voltage Switchgear** 3200A, 480V, 65kA RMS 1 day FAT	EATON	96 X 110 X 78	8,685	
A2	319	23	N/A	APC	TH-241	**Dry-Type APC Transformer** 480-208/120VAC, 30kVA	EATON	24 X 20 X 11	555	
A2	320	23	N/A	APC	PP-241	**Electrical Power Panel** 120/208V, 3PH	EATON	60 X 21 X 14	60	
A2	321	23	N/A	APC	TH-242	**Dry-Type APC Transformer** 480-208/120VAC, 15kVA	EATON	18 X 20 X 8	295	
A2	322	23	N/A	APC	PP-242	**Electrical Power Panel** 120/208V, 3PH	EATON	60 X 21 X 14	60	
A2	323	23	39	APC	MCC-231	**Low Voltage MCC** 1200A, 480V, 65kA RMS 1 day FAT	EATON	90 X 440 X 21	5,720	
A2	324	23	39	APC	MCC-232	**Low Voltage MCC** 1200A, 480V, 65kA RMS 1 day FAT	EATON	90 X 280 X 21	3,640	
D	325	23	27	APC	SWGR-210	**Medium Voltage Switchgear** 3000A, 4.16kV, 50kA RMS	EATON	252 X 115 X 101.25	22,100	
A2	326	23	N/A	APC	TH-240	**Dry-Type APC Transformer (Lighting & Batt Charger)** 480-208/120VAC, 15kVA	EATON	18 X 20 X 8	295	
A2	327	23	N/A	APC	PP-240	**Essential Lighting & Battery Charger Panel** 240/120V, 1PH	EATON	60 X 21 X 14	60	
D	~~328~~	~~23~~	~~Future~~	~~APC~~	~~BD-232~~	~~**Non-Segregated Phase Bus Duct**~~ ~~480V, 3200A~~	~~EATON~~	18 X 26 X 444 (4 90º Elbows)	3,737	Spec. 32
A2	329	23	Future	APC	BD-231	**Non-Segregated Phase Bus Duct** 480V, 3200A	EATON	18 X 26 X 288 (2 90º Elbows)	2,424	Spec. 32
D	~~330~~	~~23~~	~~20~~	~~APC~~	~~TH-232~~	~~**Station Auxiliary Transformer**~~ ~~4.16-0.48kV, 1.5/1.932 MVA~~	~~ABB~~	85 X 62 X 105	10,000	

Rev	Item No.	WBS	SPEC #	Location	Equipment No.	Description	Manufacturer / Model	Dimensions (H X W X D) in.	Weight, lbs	Notes
A2	331	23	20	APC	TH-231	**Station Auxiliary Transformer** 4.16-0.48kV, 1.5/1.932 MVA	ABB	85 X 62 X 105	10,000	
A	332	23	OTHERS	APC	HVAC-230-1	**HVAC #1**	Specific Systems	102 X 72 X 74	3,900	
A	333	23	OTHERS	APC	HVAC-230-2	**HVAC #2**	Specific Systems	102 X 72 X 74	3,900	
D	~~334~~	~~23~~	~~Future~~	~~APC~~	~~BD-212~~	~~**Non-Segregated Phase Bus Duct**~~ ~~4160V, 3000A~~	~~EATON~~	18 X 26 X 444 (4 90º Elbows)	3,737	Spec. 32
A2	335	23	Future	APC	BD-211	**Non-Segregated Phase Bus Duct** 4160V, 3000A	EATON	18 X 26 X 288 (2 90º Elbows)	2,424	Spec. 32
D	~~336~~	~~23~~	~~35~~	~~APC~~	~~LRG-212~~	~~**Low-Resistance Neutral Grounding Resistor**~~ ~~200A, 10 Sec~~	~~ABB~~	108 X 42 X 52	1,500	
A	337	23	35	APC	LRG-211	**Low-Resistance Neutral Grounding Resistor** 200A, 10 Sec	ABB	108 X 42 X 52	1,500	
D	~~338~~	~~23~~	~~20~~	~~APC~~	~~TH-212~~	~~**Station Auxiliary Transformer**~~ ~~13.8-4.16kV, 15/16.8 MVA~~	~~ABB~~	125 X 128 X 155	63,000	
A2	339	23	20	APC	TH-211	**Station Auxiliary Transformer** 13.8-4.16kV, 15/16.8 MVA	ABB	125 X 128 X 155	63,000	
								APC TOTAL WEIGHT =	651,927	
A2	400	24	N/A	FIELD	TH-143	**Dry-Type MPC Transformer (Lighting)** 480-208/120VAC, 15kVA	EATON	18 X 20 X 8	295	
A2	401	24	N/A	FIELD	TH-144	**Dry-Type MPC Transformer (Lighting)** 480-208/120VAC, 15kVA	EATON	18 X 20 X 8	295	
A	402	24		FIELD	HP-231	**Heat Trace Panel**	EATON	36 X 30 X 16	400	
A	403	24		FIELD	HP-131	**Heat Trace Panel**	EATON	36 X 30 X 16	400	
A2	404	24	N/A	FIELD	PP-143	**Electrical Power Panel - FIELD** 120/208V, 3PH	EATON	60 X 21 X 14	100	
A2	405	24	N/A	FIELD	PP-144	**Electrical Power Panel - FIELD** 120/208V, 3PH	EATON	60 X 21 X 14	100	
A2	406	24		FIELD	HC-231	**Heat Trace Controller**	PENTAIR	42 X 30 X 9	150	
A2	407	24		FIELD	HC-131	**Heat Trace Controller**	PENTAIR	42 X 30 X 9	150	
A3	BULK	23	N/A	FIELD	K-201-CP	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	FIELD	KM-301-HTR	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	FIELD	K-301-CP	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	FIELD	PM-202A-HTR	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	FIELD	PM-202B-HTR	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	FIELD	PM-301A-HTR	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	FIELD	PM-301B-HTR	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	FIELD	C-201 CAR	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	FIELD	C-201 PIT	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	30	N/A	FIELD	K-601-CP	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	FIELD	PM-730A-HTR	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	FIELD	PM-730B-HTR	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	MPC	SWGR-100	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	MPC	SWGR-110	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	BUS A
A3	BULK	23	N/A	MPC	SWGR-110	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	BUS B
A3	BULK	23	N/A	MPC	MCC-111	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	MPC	MCC-112	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	MPC	SWGR-130	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	BUS A
A3	BULK	23	N/A	MPC	SWGR-130	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	BUS B
A3	BULK	23	N/A	MPC	MCC-131	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	MPC	MCC-132	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	MPC	MCC-133	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	MPC	MCC-134	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	

Rev	Item No.	WBS	SPEC #	Location	Equipment No.	Description	Manufacturer / Model	Dimensions (H X W X D) in.	Weight, lbs	Notes
A3	BULK	23	N/A	FIELD	PM-101A-HTR	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	FIELD	PM-101B-HTR	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	FIELD	PM-201A-HTR	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	FIELD	PM-201B-HTR	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	FIELD	M-720-KM-001AH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	FIELD	M-720-CP	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	FIELD	M-720-KM-001BH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	22	N/A	FIELD	M-710-KM-001AH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	22	N/A	FIELD	M-710-KM-001BH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	22	N/A	FIELD	M-710-PM-001AH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	22	N/A	FIELD	M-710-PM-001BH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	22	N/A	FIELD	M-710-PM-001CH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	MM-701MAH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	MM-701MBH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	PM-701A-HTR	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	PM-701B-HTR	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	FIELD	M-711	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	FIELD	M-711-CP	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-704A-MM-001AH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-704A-MM-001BH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-704A-MM-001CH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-704A-MM-001DH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-704B-MM-001AH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-704B-MM-001BH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-704B-MM-001CH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-704B-MM-001DH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-704C-MM-001AH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-704C-MM-001BH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-704C-MM-001CH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-704C-MM-001DH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-704D-MM-001AH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-704D-MM-001BH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-704D-MM-001CH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-704D-MM-001DH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-704-PM-001AH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-704-PM-001BH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-704-PM-001CH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-705A-MM-001AH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-705A-MM-001BH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-705A-MM-001CH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-705A-MM-001DH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-705B-MM-001AH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-705B-MM-001BH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-705B-MM-001CH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-705B-MM-001DH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-705C-MM-001AH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-705C-MM-001BH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-705C-MM-001CH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-705C-MM-001DH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-705D-MM-001AH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-705D-MM-001BH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-705D-MM-001CH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-705D-MM-001DH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-705-PM-001AH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	21	N/A	FIELD	M-705-PM-001BH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	

Rev	Item No.	WBS	SPEC #	Location	Equipment No.	Description	Manufacturer / Model	Dimensions (H X W X D) in.	Weight, lbs	Notes
A3	BULK	21	N/A	FIELD	M-705-PM-001CH	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	APC	SWGR-210	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	BUS A
A3	BULK	23	N/A	APC	SWGR-210	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	BUS B
A3	BULK	23	N/A	APC	SWGR-230	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	BUS A
A3	BULK	23	N/A	APC	SWGR-230	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	BUS B
A3	BULK	23	N/A	APC	MCC-211	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	APC	MCC-212	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	APC	MCC-231	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	APC	MCC-232	**Heater Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	FIELD	KM-201-HTR	**Heater Disconnect (2-Pole Toggle EDS21100)**	EATON	6 X 3.5 X 5	5	
A3	BULK	30	N/A	FIELD	KM-601-HTR	**Heater Disconnect (2-Pole Toggle EDS21100)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	MPC	BC-161	**Heater Disconnect (2-Pole Toggle EDS21100)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	MPC	BC-162	**Heater Disconnect (2-Pole Toggle EDS21100)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	FIELD	C-201 CEMS	**Heater Disconnect (2-Pole Toggle EDS21100)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	APC	BC-261	**Heater Disconnect (2-Pole Toggle EDS21100)**	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	APC	BC-262	**Heater Disconnect (2-Pole Toggle EDS21100)**	EATON	6 X 3.5 X 5	5	
A3		23	N/A	FIELD	T-501-GND	**Ground Verification Rack Monitor System** 120V, 10VA	OPW-ES	14 X 12 X 9	15	
A3	BULK	23	N/A	FIELD	T-501-GND	**Power Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3		23	N/A	FIELD	T-503-GND	**Ground Verification Rack Monitor System** 120V, 10VA	OPW-ES	14 X 12 X 9	15	
A3	BULK	23	N/A	FIELD	T-503-GND	**Power Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3		23	N/A	FIELD	T-730-GND	**Ground Verification Rack Monitor System** 120V, 10VA	OPW-ES	14 X 12 X 9	15	
A3	BULK	23	N/A	FIELD	T-730-GND	**Power Disconnect (1-Pole Toggle EDS2199)**	EATON	6 X 3.5 X 5	5	
A3	LTG	23	N/A	FIELD	C-201 FAA LTG UPPER	**Lighting FAA L864 (12004-D664-R13-001 repl. CWLFR/120-240)** Red Flashing Medium Intensity Beacon, FAA Type L-864, 120V, 20W Including 5810--018S Heat/Sun Shield	EATON	24 X 24 X 24	30	
A3	LTG	23	N/A	FIELD	C-201 FAA LTG UPPER	**Lighting FAA L864 (12004-D664-R13-001 repl. CWLFR/120-240)** Red Flashing Medium Intensity Beacon, FAA Type L-864, 120V, 20W Including 5810--018S Heat/Sun Shield	EATON	24 X 24 X 24	30	
A3	LTG	23	N/A	FIELD	C-201 FAA LTG UPPER	**Lighting FAA L864 (12004-D664-R13-001 repl. CWLFR/120-240)** Red Flashing Medium Intensity Beacon, FAA Type L-864, 120V, 20W Including 5810--018S Heat/Sun Shield	EATON	24 X 24 X 24	30	
A3	LTG	23	N/A	FIELD	C-201 FAA LTG UPPER	**Lighting FAA L864 (12004-D664-R13-001 repl. CWLFR/120-240)** Red Flashing Medium Intensity Beacon, FAA Type L-864, 120V, 20W Including 5810--018S Heat/Sun Shield	EATON	24 X 24 X 24	30	
A3	LTG	23	N/A	FIELD	C-201 FAA LTG LOWER	**Lighting FAA L861 (12004-RTO-CR27-001 repl. OWLFSR/120)** Single Head, Obstruction Light, FAA - Type L810, 120V, 18W	EATON	12 X 6 X 6	6	
A3	LTG	23	N/A	FIELD	C-201 FAA LTG LOWER	**Lighting FAA L861 (12004-RTO-CR27-001 repl. OWLFSR/120)** Single Head, Obstruction Light, FAA - Type L810, 120V, 18W	EATON	12 X 6 X 6	6	
A3	LTG	23	N/A	FIELD	C-201 FAA LTG LOWER	**Lighting FAA L861 (12004-RTO-CR27-001 repl. OWLFSR/120)** Single Head, Obstruction Light, FAA - Type L810, 120V, 18W	EATON	12 X 6 X 6	6	
A3	LTG	23	N/A	FIELD	C-201 FAA LTG LOWER	**Lighting FAA L861 (12004-RTO-CR27-001 repl. OWLFSR/120)** Single Head, Obstruction Light, FAA - Type L810, 120V, 18W	EATON	12 X 6 X 6	6	
A3		23	N/A	FIELD	C-201 FAA LTG CP	**Lighting FAA Obstruction Light Controller (OLC72070-4-0/4R-I-N4)** NEMA 4, 120V, 200W	EATON	30 X 24 X 6	20	
A3	BULK	23	N/A	FIELD	C-201 FAA LTG CP	**Lighting Power Disconnect (2-Pole Toggle EDS21100)** 1-pole 120V Disconnect / 1-pole Bypass Alarm Contact	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	FIELD	C-201 FAA LTG PC	**Lighting Photocell, FAA Type (70439)** Weathertight Photocell, AC, Red, Steady 2nd Output	EATON	5.5 X 3 X 2.25	5	
A3	LTG	23	N/A	FIELD	C-301 FAA LTG UPPER	**Lighting FAA L864 (12004-D664-R13-001 repl. CWLFR/120-240)** Red Flashing Medium Intensity Beacon, FAA Type L-864, 120V, 20W Including 5810--018S Heat/Sun Shield	EATON	24 X 24 X 24	30	

Rev	Item No.	WBS	SPEC #	Location	Equipment No.	Description	Manufacturer / Model	Dimensions (H X W X D) in.	Weight, lbs	Notes
A3	LTG	23	N/A	FIELD	C-301 FAA LTG UPPER	**Lighting FAA L864 (12004-D664-R13-001 repl. CWLFR/120-240)** Red Flashing Medium Intensity Beacon, FAA Type L-864, 120V, 20W Including 5810--018S Heat/Sun Shield	EATON	24 X 24 X 24	30	
A3	LTG	23	N/A	FIELD	C-301 FAA LTG UPPER	**Lighting FAA L864 (12004-D664-R13-001 repl. CWLFR/120-240)** Red Flashing Medium Intensity Beacon, FAA Type L-864, 120V, 20W Including 5810--018S Heat/Sun Shield	EATON	24 X 24 X 24	30	
A3	LTG	23	N/A	FIELD	C-301 FAA LTG UPPER	**Lighting FAA L864 (12004-D664-R13-001 repl. CWLFR/120-240)** Red Flashing Medium Intensity Beacon, FAA Type L-864, 120V, 20W Including 5810--018S Heat/Sun Shield	EATON	24 X 24 X 24	30	
A3	LTG	23	N/A	FIELD	C-301 FAA LTG LOWER	**Lighting FAA L861 (12004-RTO-CR27-001 repl. OWLFSR/120)** Single Head, Obstruction Light, FAA - Type L810, 120V, 18W	EATON	12 X 6 X 6	6	
A3	LTG	23	N/A	FIELD	C-301 FAA LTG LOWER	**Lighting FAA L861 (12004-RTO-CR27-001 repl. OWLFSR/120)** Single Head, Obstruction Light, FAA - Type L810, 120V, 18W	EATON	12 X 6 X 6	6	
A3	LTG	23	N/A	FIELD	C-301 FAA LTG LOWER	**Lighting FAA L861 (12004-RTO-CR27-001 repl. OWLFSR/120)** Single Head, Obstruction Light, FAA - Type L810, 120V, 18W	EATON	12 X 6 X 6	6	
A3	LTG	23	N/A	FIELD	C-301 FAA LTG LOWER	**Lighting FAA L861 (12004-RTO-CR27-001 repl. OWLFSR/120)** Single Head, Obstruction Light, FAA - Type L810, 120V, 18W	EATON	12 X 6 X 6	6	
A3		23	N/A	FIELD	C-301 FAA LTG CP	**Lighting FAA Obstruction Light Controller (OLC72070-4-0/4R-I-N4)** NEMA 4, 120V, 200W	EATON	30 X 24 X 6	20	
A3	BULK	23	N/A	FIELD	C-301 FAA LTG CP	**Lighting Power Disconnect (2-Pole Toggle EDS21100)** 1-pole 120V Disconnect / 1-pole Bypass Alarm Contact	EATON	6 X 3.5 X 5	5	
A3	BULK	23	N/A	FIELD	C-301 FAA LTG PC	**Lighting Photocell, FAA Type (70439)** Weathertight Photocell, AC, Red, Steady 2nd Output	EATON	5.5 X 3 X 2.25	5	
A3	LTG	23	N/A	FIELD	FL-140/2AH	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-140/2BH	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-140/2CH	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-140/2DH	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-140/2EH	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-140/2FH	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-140/2GH	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-140/2HH	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-140/3AA	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-140/4AA	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-140/5AD	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-140/5BD	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-140/5CD	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-140/5DD	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-240/2AB	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-240/2BB	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	

Rev	Item No.	WBS	SPEC #	Location	Equipment No.	Description	Manufacturer / Model	Dimensions (H X W X D) in.	Weight, lbs	Notes
A3	LTG	23	N/A	FIELD	FL-240/3AB	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-240/3BB	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-240/4AC	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-240/4BC	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-240/4CC	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-240/5AD	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-240/5BD	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-240/5CD	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-240/5DD	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-240/6AC	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-240/6BC	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	
A3	LTG	23	N/A	FIELD	FL-240/6CC	**Light Pole** Class 5, 35 ft, Kiln-Dried Douglas Fir Utility Pole	Northland Wood	420 X 10diam	700	

Attachment 10 - Cable Schedule

REV NO.	CABLE NO.	CABLE CODE	PROJECT PHASE	CABLE REEL NO.	FROM (SOURCE)					TO (USER)					CABLE DESCRIPTION				
					EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	INSUL VOLTAGE	RATED VOLTAGE	CABLE TYPE	NUMBER & SIZE OF CONDUCTORS	LENGTH (FEET)
	C-FFM301A1	K-01			MCC-133		BA			FFM-301A1		BA			600V		K	3/C #12 WITH #12 GND	410
C2	P-FFM301A1	K-03			MCC-133		BA			FFM-301A1		BA			600V		K	3/C #8 WITH #10 GND	410
	C-FFM301A2	K-01			MCC-134		BA			FFM-301A2		BA			600V		K	3/C #12 WITH #12 GND	425
C2	P-FFM301A2	K-03			MCC-134		BA			FFM-301A2		BA			600V		K	3/C #8 WITH #10 GND	425
	C-FFM301B1	K-01			MCC-133		BA			FFM-301B1		BA			600V		K	3/C #12 WITH #12 GND	425
	P-FFM301B1	K-05			MCC-133		BB			FFM-301B1		BB			600V		K	3/C #6 WITH #8 GND	425
	C-FFM301B2	K-01			MCC-134		BA			FFM-301B2		BA			600V		K	3/C #12 WITH #12 GND	440
	P-FFM301B2	K-05			MCC-134		BB			FFM-301B2		BB			600V		K	3/C #6 WITH #8 GND	440
	C-FFM301C1	K-01			MCC-133		BA			FFM-301C1		BA			600V		K	3/C #12 WITH #12 GND	440
	P-FFM301C1	K-05			MCC-133		BB			FFM-301C1		BB			600V		K	3/C #6 WITH #8 GND	440
	C-FFM301C2	K-01			MCC-134		BA			FFM-301C2		BA			600V		K	3/C #12 WITH #12 GND	455
	P-FFM301C2	K-05			MCC-134		BB			FFM-301C2		BB			600V		K	3/C #6 WITH #8 GND	455
	C-FFM301D1	K-01			MCC-133		BA			FFM-301D1		BA			600V		K	3/C #12 WITH #12 GND	455
	P-FFM301D1	K-05			MCC-133		BB			FFM-301D1		BB			600V		K	3/C #6 WITH #8 GND	455
	C-FFM301D2	K-01			MCC-134		BA			FFM-301D2		BA			600V		K	3/C #12 WITH #12 GND	460
	P-FFM301D2	K-05			MCC-134		BB			FFM-301D2		BB			600V		K	3/C #6 WITH #8 GND	460
	C-FFM301E1	K-01			MCC-133		BA			FFM-301E1		BA			600V		K	3/C #12 WITH #12 GND	460
	P-FFM301E1	K-05			MCC-133		BB			FFM-301E1		BB			600V		K	3/C #6 WITH #8 GND	460
	C-FFM301E2	K-01			MCC-134		BA			FFM-301E2		BA			600V		K	3/C #12 WITH #12 GND	475
	P-FFM301E2	K-05			MCC-134		BB			FFM-301E2		BB			600V		K	3/C #6 WITH #8 GND	475
	C-FFM301F1	K-01			MCC-133		BA			FFM-301F1		BA			600V		K	3/C #12 WITH #12 GND	475
	P-FFM301F1	K-05			MCC-133		BB			FFM-301F1		BB			600V		K	3/C #6 WITH #8 GND	475
	C-FFM301F2	K-01			MCC-134		BA			FFM-301F2		BA			600V		K	3/C #12 WITH #12 GND	490
	P-FFM301F2	K-05			MCC-134		BB			FFM-301F2		BB			600V		K	3/C #6 WITH #8 GND	490
	C-FFM301G1	K-01			MCC-133		BA			FFM-301G1		BA			600V		K	3/C #12 WITH #12 GND	490
	P-FFM301G1	K-05			MCC-133		BB			FFM-301G1		BB			600V		K	3/C #6 WITH #8 GND	490
C2	C-FFM301G2	K-02			MCC-134		BA			FFM-301G2		BA			600V		K	3/C #10 WITH #10 GND	505
	P-FFM301G2	K-05			MCC-134		BB			FFM-301G2		BB			600V		K	3/C #6 WITH #8 GND	505

REV NO.	CABLE NO.	CABLE CODE	PROJECT PHASE	CABLE REEL NO.	FROM (SOURCE)					TO (USER)					CABLE DESCRIPTION				
					EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	INSUL VOLTAGE	RATED VOLTAGE	CABLE TYPE	NUMBER & SIZE OF CONDUCTORS	LENGTH (FEET)
C2	C-FFM301H1	K-02			MCC-133		BA			FFM-301H1		BA			600V		K	3/C #10 WITH #10 GND	505
	P-FFM301H1	K-05			MCC-133		BB			FFM-301H1		BB			600V		K	3/C #6 WITH #8 GND	505
C2	C-FFM301H2	K-02			MCC-134		BA			FFM-301H2		BA			600V		K	3/C #10 WITH #10 GND	520
	P-FFM301H2	K-05			MCC-134		BB			FFM-301H2		BB			600V		K	3/C #6 WITH #8 GND	520
C2	C-FFM301I1	K-02			MCC-133		BA			FFM-301I1		BA			600V		K	3/C #10 WITH #10 GND	505
	P-FFM301I1	K-05			MCC-133		BB			FFM-301I1		BB			600V		K	3/C #6 WITH #8 GND	505
C2	C-FFM301I2	K-02			MCC-134		BA			FFM-301I2		BA			600V		K	3/C #10 WITH #10 GND	520
	P-FFM301I2	K-05			MCC-134		BB			FFM-301I2		BB			600V		K	3/C #6 WITH #8 GND	520
C2	C-FFM301J1	K-02			MCC-133		BA			FFM-301J1		BA			600V		K	3/C #10 WITH #10 GND	520
	P-FFM301J1	K-05			MCC-133		BB			FFM-301J1		BB			600V		K	3/C #6 WITH #8 GND	520
C2	C-FFM301J2	K-02			MCC-134		BA			FFM-301J2		BA			600V		K	3/C #10 WITH #10 GND	535
	P-FFM301J2	K-05			MCC-134		BB			FFM-301J2		BB			600V		K	3/C #6 WITH #8 GND	535
	P-FFM601A1	K-07			MCC-133		BB			FFM-601A1		BB			600V		K	3/C #4 WITH #8 GND	345
	C-FFM601A1	K-01			MCC-133		BA			FFM-601A1		BA			600V		K	3/C #12 WITH #12 GND	345
	P-FFM601A2	K-07			MCC-134		BB			FFM-601A2		BB			600V		K	3/C #4 WITH #8 GND	360
	C-FFM601A2	K-01			MCC-134		BA			FFM-601A2		BA			600V		K	3/C #12 WITH #12 GND	360
	P-FFM601B1	K-07			MCC-133		BB			FFM-601A1		BB			600V		K	3/C #4 WITH #8 GND	360
	C-FFM601B1	K-01			MCC-133		BA			FFM-601B1		BA			600V		K	3/C #12 WITH #12 GND	360
	P-FFM601B2	K-07			MCC-134		BB			FFM-601B2		BB			600V		K	3/C #4 WITH #8 GND	375
	C-FFM601B2	K-01			MCC-134		BA			FFM-601B2		BA			600V		K	3/C #12 WITH #12 GND	375
	P-FFM730A1	K-07			MCC-133		BB			FFM-730A1		BB			600V		K	3/C #4 WITH #8 GND	550
	P-FFM730A2	K-07			MCC-134		BB			FFM-730A2		BB			600V		K	3/C #4 WITH #8 GND	550
C2	C-FFM730A1	K-02			MCC-133		BA			FFM-730A1		BA			600V		K	3/C #10 WITH #10 GND	565
C2	C-FFM730A2	K-02			MCC-134		BA			FFM-730A2		BA			600V		K	3/C #10 WITH #10 GND	565
C2	C-FFM730B1	K-02			MCC-133		BA			FFM-730B1		BA			600V		K	3/C #10 WITH #10 GND	565
	P-FFM730B1	K-07			MCC-133		BB			FFM-730B1		BB			600V		K	3/C #4 WITH #8 GND	565
	P-FFM730B2	K-07			MCC-134		BB			FFM-730B2		BB			600V		K	3/C #4 WITH #8 GND	565
C2	C-FFM730B2	K-02			MCC-134		BA			FFM-730B2		BA			600V		K	3/C #10 WITH #10 GND	580

REV NO.	CABLE NO.	CABLE CODE	PROJECT PHASE	CABLE REEL NO.	FROM (SOURCE)					TO (USER)					CABLE DESCRIPTION				
					EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	INSUL VOLTAGE	RATED VOLTAGE	CABLE TYPE	NUMBER & SIZE OF CONDUCTORS	LENGTH (FEET)
	P-FFM730C1	K-07			MCC-133		BB			FFM-730C1		BB			600V		K	3/C #4 WITH #8 GND	580
	P-FFM730C2	K-07			MCC-134		BB			FFM-730C2		BB			600V		K	3/C #4 WITH #8 GND	580
C2	C-FFM730C1	K-02			MCC-133		BA			FFM-730C1		BA			600V		K	3/C #10 WITH #10 GND	595
C2	C-FFM730C2	K-02			MCC-134		BA			FFM-730C2		BA			600V		K	3/C #10 WITH #10 GND	595
	P-FFM730D1	K-07			MCC-133		BB			FFM-730D1		BB			600V		K	3/C #4 WITH #8 GND	595
	P-FFM730D2	K-07			MCC-134		BB			FFM-730D2		BB			600V		K	3/C #4 WITH #8 GND	595
C2	C-FFM730D1	K-02			MCC-133		BA			FFM-730D1		BA			600V		K	3/C #10 WITH #10 GND	610
C2	C-FFM730D2	K-02			MCC-134		BA			FFM-730D2		BA			600V		K	3/C #10 WITH #10 GND	610
	P-FFM730E1	K-07			MCC-133		BB			FFM-730E1		BB			600V		K	3/C #4 WITH #8 GND	610
	P-FFM730E2	K-07			MCC-134		BB			FFM-730E2		BB			600V		K	3/C #4 WITH #8 GND	610
C2	C-FFM730E1	K-02			MCC-133		BA			FFM-730E1		BA			600V		K	3/C #10 WITH #10 GND	625
C2	C-FFM730E2	K-02			MCC-134		BA			FFM-730E2		BA			600V		K	3/C #10 WITH #10 GND	625
	P-FFM730F1	K-07			MCC-133		BB			FFM-730F1		BB			600V		K	3/C #4 WITH #8 GND	625
	P-FFM730F2	K-07			MCC-134		BB			FFM-730F2		BB			600V		K	3/C #4 WITH #8 GND	625
C2	C-FFM730F1	K-02			MCC-133		BA			FFM-730F1		BA			600V		K	3/C #10 WITH #10 GND	640
C2	C-FFM730F2	K-02			MCC-134		BA			FFM-730F2		BA			600V		K	3/C #10 WITH #10 GND	640
	P-FFM730G1	K-07			MCC-133		BB			FFM-730G1		BB			600V		K	3/C #4 WITH #8 GND	640
	P-FFM730G2	K-07			MCC-134		BB			FFM-730G2		BB			600V		K	3/C #4 WITH #8 GND	640
C2	C-FFM730G1	K-03			MCC-133		BA			FFM-730G1		BA			600V		K	3/C #8 WITH #10 GND	655
C2	C-FFM730G2	K-03			MCC-134		BA			FFM-730G2		BA			600V		K	3/C #8 WITH #10 GND	655
	P-FFM730H1	K-07			MCC-133		BB			FFM-730H1		BB			600V		K	3/C #4 WITH #8 GND	655
	P-FFM730H2	K-07			MCC-134		BB			FFM-730H2		BB			600V		K	3/C #4 WITH #8 GND	655
C2	C-FFM730H1	K-03			MCC-133		BA			FFM-730H1		BA			600V		K	3/C #8 WITH #10 GND	670
C2	C-FFM730H2	K-03			MCC-134		BA			FFM-730H2		BA			600V		K	3/C #8 WITH #10 GND	670
	P-FFM730I1	K-07			MCC-133		BB			FFM-730I1		BB			600V		K	3/C #4 WITH #8 GND	670
	P-FFM730I2	K-07			MCC-134		BB			FFM-730I2		BB			600V		K	3/C #4 WITH #8 GND	670
C2	C-FFM730I1	K-03			MCC-133		BA			FFM-730I1		BA			600V		K	3/C #8 WITH #10 GND	685
C2	C-FFM730I2	K-03			MCC-134		BA			FFM-730I2		BA			600V		K	3/C #8 WITH #10 GND	685

REV NO.	CABLE NO.	CABLE CODE	PROJECT PHASE	CABLE REEL NO.	FROM (SOURCE)					TO (USER)					CABLE DESCRIPTION				
					EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	INSUL VOLTAGE	RATED VOLTAGE	CABLE TYPE	NUMBER & SIZE OF CONDUCTORS	LENGTH (FEET)
	P-FFM730J1	K-07			MCC-133		BB			FFM-730J1		BB			600V		K	3/C #4 WITH #8 GND	685
	P-FFM730J2	K-07			MCC-134		BB			FFM-730J2		BB			600V		K	3/C #4 WITH #8 GND	685
C2	C-FFM730J1	K-03			MCC-133		BA			FFM-730J1		BA			600V		K	3/C #8 WITH #10 GND	700
C2	C-FFM730J2	K-03			MCC-134		BA			FFM-730J2		BA			600V		K	3/C #8 WITH #10 GND	700
	P-FFM730K1	K-07			MCC-133		BB			FFM-730K1		BB			600V		K	3/C #4 WITH #8 GND	700
	P-FFM730K2	K-07			MCC-134		BB			FFM-730K2		BB			600V		K	3/C #4 WITH #8 GND	700
C2	C-FFM730K1	K-03			MCC-133		BA			FFM-730K1		BA			600V		K	3/C #8 WITH #10 GND	715
C2	C-FFM730K2	K-03			MCC-134		BA			FFM-730K2		BA			600V		K	3/C #8 WITH #10 GND	715
	P-FFM730L1	K-07			MCC-133		BB			FFM-730L1		BB			600V		K	3/C #4 WITH #8 GND	715
	P-FFM730L2	K-07			MCC-134		BB			FFM-730L2		BB			600V		K	3/C #4 WITH #8 GND	715
C2	C-FFM730L1	K-03			MCC-133		BA			FFM-730L1		BA			600V		K	3/C #8 WITH #10 GND	730
C2	C-FFM730L2	K-03			MCC-134		BA			FFM-730L2		BA			600V		K	3/C #8 WITH #10 GND	730
C2	C-K201CP	K-02			SWGR-100		BA			K-201-CP		BA			600V		K	3/C #10 WITH #10 GND	625
	P-K201E001	K-02			MCC-131		BA			K-201-E-001		BA			600V		K	3/C #10 WITH #10 GND	625
	P-K201KM001A	K-05			MCC-131		BB			K-201-KM-001A		BB			600V		K	3/C #6 WITH #8 GND	625
C2	C-K201KM001A	K-02			MCC-131		BA			K-201-KM-001A		BA			600V		K	3/C #10 WITH #10 GND	625
	P-K201KM001B	K-05			MCC-132		BB			K-201-KM-001B		BB			600V		K	3/C #6 WITH #8 GND	625
C2	C-K201KM001B	K-02			MCC-132		BA			K-201-KM-001B		BA			600V		K	3/C #10 WITH #10 GND	625
	P-K201PM001A	K-02			MCC-131		BA			K-201-PM-001A		BA			600V		K	3/C #10 WITH #10 GND	625
C2	C-K201PM001A	K-02			MCC-131		BA			K-201-PM-001A		BA			600V		K	3/C #10 WITH #10 GND	625
	P-K201PM001B	K-02			MCC-132		BA			K-201-PM-001B		BA			600V		K	3/C #10 WITH #10 GND	625
C2	C-K201PM001B	K-02			MCC-132		BA			K-201-PM-001B		BA			600V		K	3/C #10 WITH #10 GND	625
	P-K201PM002A	K-02			MCC-131		BA			K-201-PM-002A		BA			600V		K	3/C #10 WITH #10 GND	625
C2	C-K201PM002A	K-02			MCC-131		BA			K-201-PM-002A		BA			600V		K	3/C #10 WITH #10 GND	625
	P-K201PM002B	K-02			MCC-132		BA			K-201-PM-002B		BA			600V		K	3/C #10 WITH #10 GND	625
C2	C-K201PM002B	K-02			MCC-132		BA			K-201-PM-002B		BA			600V		K	3/C #10 WITH #10 GND	625
C2	P-KM301	J-05			SWGR-110		-			KM-301		-			5kV		J	3/C 350 WITH #2 GND	300
C2	P-KM301	J-05			SWGR-110		-			KM-301		-			5kV		J	3/C 350 WITH #2 GND	300

REV NO.	CABLE NO.	CABLE CODE	PROJECT PHASE	CABLE REEL NO.	FROM (SOURCE)					TO (USER)					CABLE DESCRIPTION				
					EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	INSUL VOLTAGE	RATED VOLTAGE	CABLE TYPE	NUMBER & SIZE OF CONDUCTORS	LENGTH (FEET)
C2	R-KM301BR	ED			SWGR-110		AB			KM-301		AB			RTD		ED	12 TRIADS #16, IS & OS	300
C2	~~R-KM301SR~~	~~EB~~			~~SWGR-110~~		~~AB~~			~~KM-301~~		AB			~~RTD~~		~~EB~~	~~8 TRIADS #16, IS & OS~~	~~0~~
C2	CT-KM301	C-03			SWGR-110		-			KM-301		-			600V		C	1/C #10	300
C2	CT-KM301	C-03			SWGR-110		-			KM-301		-			600V		C	1/C #10	300
	P-K301CP	K-01			PP-141		BA			K-301-CP		BA			600V		K	3/C #12 WITH #12 GND	300
	P-K301E001	K-02			MCC-131		BA			K-301-E-001		BA			600V		K	3/C #10 WITH #10 GND	300
C1	C-KM301	K-01			SWGR-110		BA			KM-301		BA			600V		K	3/C #12 WITH #12 GND	300
	P-K301PM001A	K-01			MCC-131		BA			K-301-PM-001A		BA			600V		K	3/C #12 WITH #12 GND	300
C1	C-K301PM001A	K-01			MCC-131		BA			K-301-PM-001A		BA			600V		K	3/C #12 WITH #12 GND	300
	P-K301PM001B	K-01			MCC-132		BA			K-301-PM-001B		BA			600V		K	3/C #12 WITH #12 GND	300
C1	C-K301PM001B	K-01			MCC-132		BA			K-301-PM-001B		BA			600V		K	3/C #12 WITH #12 GND	300
C2	P-K601CP	K-01			PP-141		BA			K-601-CP		BA			600V		K	3/C #12 WITH #12 GND	310
	P-K601E001	K-01			MCC-131		BA			K-601-E-001		BA			600V		K	3/C #12 WITH #12 GND	310
C1	C-K601E001	K-01			K-601-CP		BA			K-601-E-001		BA			600V		K	3/C #12 WITH #12 GND	50
	P-K601PM001A	K-03			MCC-131		BA			K-601-PM-001A		BA			600V		K	3/C #8 WITH #10 GND	310
C1	C-K601PM001A	K-01			K-601-CP		BA			K-601-PM-001A		BA			600V		K	3/C #12 WITH #12 GND	50
	P-K601PM001B	K-03			MCC-132		BA			K-601-PM-001B		BA			600V		K	3/C #8 WITH #10 GND	310
C1	C-K601PM001B	K-01			K-601-CP		BA			K-601-PM-001B		BA			600V		K	3/C #12 WITH #12 GND	50
C2	P-KM201CP	K-02			PP-141		BA			K-201-CP		BA			600V		K	3/C #10 WITH #10 GND	625
C2	C-KM201	K-02			SWGR-100		BA			KM-201		BA			600V		K	3/C #10 WITH #10 GND	625
C2	R-KM201BR	ED			VFD-201		AB			KM-201		AB			RTD		ED	12 TRIADS #16, IS & OS	625
C2	~~R-KM201SR~~	~~EB~~			~~KM-201-CP~~		~~AB~~			~~KM-201~~		~~AB~~			~~RTD~~		~~EB~~	~~8 TRIADS #16, IS & OS~~	~~0~~
C2	CT-KM201	C-03			VFD-201		-			KM-201		-			600V		C	1/C #10	625
C2	CT-KM201	C-03			VFD-201		-			KM-201		-			600V		C	1/C #10	625
	P-KM201	D-05			SWGR-100		AH			KM-201		AH			15kV		D	3/C 350 WITH #2 GND	625
C2	P-KM201HTR	K-02			SWGR-100		BA			KM-201-HTR		BA			600V		K	3/C #10 WITH #10 GND	625
C2	P-KM301HTR	K-02			SWGR-110		BA			KM-301-HTR		BA			600V		K	3/C #10 WITH #10 GND	300
	P-KM601A1	A-05			SWGR-100		-			KM-601		-			15kV		A	1/C 350	310

REV NO.	CABLE NO.	CABLE CODE	PROJECT PHASE	CABLE REEL NO.	FROM (SOURCE)					TO (USER)					CABLE DESCRIPTION				
					EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	INSUL VOLTAGE	RATED VOLTAGE	CABLE TYPE	NUMBER & SIZE OF CONDUCTORS	LENGTH (FEET)
	P-KM601B1	A-05			SWGR-100		-			KM-601		-			15kV		A	1/C 350	310
	P-KM601C1	A-05			SWGR-100		-			KM-601		-			15kV		A	1/C 350	310
	P-KM601A2	A-05			SWGR-100		-			KM-601		-			15kV		A	1/C 350	310
	P-KM601B2	A-05			SWGR-100		-			KM-601		-			15kV		A	1/C 350	310
	P-KM601C2	A-05			SWGR-100		-			KM-601		-			15kV		A	1/C 350	310
C2	C-KM601	K-01			SWGR-100		BA			KM-601		BA			600V		K	3/C #12 WITH #12 GND	310
C2	R-KM601BR	ED			VFD-601		AB			KM-601		AB			RTD		ED	12 TRIADS #16, IS & OS	310
C2	~~R-KM601SR~~	~~EB~~			~~K-601-CP~~		AB			~~KM-601~~		AB			~~RTD~~		~~EB~~	~~8 TRIADS #16, IS & OS~~	~~0~~
C2	CT-KM601	C-03			VFD-601		-			KM-601		-			600V		C	1/C #10	310
C2	CT-KM601	C-03			VFD-601		-			KM-601		-			600V		C	1/C #10	310
	P-KM601HTR	K-02			SWGR-100		BA			KM-601-HTR		BA			600V		K	3/C #10 WITH #10 GND	310
	P-M102AMM001A	K-01			MCC-231		BA			M-102A-MM-001A		BA			600V		K	3/C #12 WITH #12 GND	600
	P-M102AMM001B	K-01			MCC-231		BA			M-102A-MM-001B		BA			600V		K	3/C #12 WITH #12 GND	600
C2	C-M102BMM001A	K-02			MCC-231		BA			M-102B-MM-001A		BA			600V		K	3/C #10 WITH #10 GND	600
C2	C-M102BMM001B	K-02			MCC-231		BA			M-102B-MM-001B		BA			600V		K	3/C #10 WITH #10 GND	600
	P-M104MM001A	K-07			MCC-231		BB			M-104-MM-001A		BB			600V		K	3/C #4 WITH #8 GND	600
C2	C-M104MM001A	K-02			MCC-231		BA			M-104-MM-001A		BA			600V		K	3/C #10 WITH #10 GND	600
	P-M104MM001B	K-07			MCC-232		BB			M-104-MM-001B		BB			600V		K	3/C #4 WITH #8 GND	600
C2	C-M104MM001B	K-02			MCC-232		BA			M-104-MM-001B		BA			600V		K	3/C #10 WITH #10 GND	600
	C-M401PM401A	K-01			MCC-131		BA			M-401-PM-401A		BA			600V		K	3/C #12 WITH #12 GND	225
	P-M401PM401A	K-01			MCC-131		BA			M-401-PM-401A		BA			600V		K	3/C #12 WITH #12 GND	225
	C-M401PM402A	K-01			MCC-131		BA			M-401-PM-402A		BA			600V		K	3/C #12 WITH #12 GND	225
	P-M401PM402A	K-01			MCC-131		BA			M-401-PM-402A		BA			600V		K	3/C #12 WITH #12 GND	225
	C-M401PM403A	K-01			MCC-131		BA			M-401-PM-403A		BA			600V		K	3/C #12 WITH #12 GND	225
	P-M401PM403A	K-01			MCC-131		BA			M-401-PM-403A		BA			600V		K	3/C #12 WITH #12 GND	225
	C-M401PM404A	K-01			MCC-131		BA			M-401-PM-404A		BA			600V		K	3/C #12 WITH #12 GND	225
	P-M401PM404A	K-02			MCC-131		BA			M-401-PM-404A		BA			600V		K	3/C #10 WITH #10 GND	225
	C-M401PM404B	K-01			MCC-132		BA			M-401-PM-404B		BA			600V		K	3/C #12 WITH #12 GND	225

REV NO.	CABLE NO.	CABLE CODE	PROJECT PHASE	CABLE REEL NO.	FROM (SOURCE)					TO (USER)					CABLE DESCRIPTION				
					EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	INSUL VOLTAGE	RATED VOLTAGE	CABLE TYPE	NUMBER & SIZE OF CONDUCTORS	LENGTH (FEET)
	P-M401PM404B	K-02			MCC-132		BA			M-401-PM-404B		BA			600V		K	3/C #10 WITH #10 GND	225
	C-M401MM402	K-01			MCC-132		BA			M-401-PM-402		BA			600V		K	3/C #12 WITH #12 GND	225
	P-M401MM402	K-02			MCC-132		BA			M-401-PM-402		BA			600V		K	3/C #10 WITH #10 GND	225
	P-M602	K-01			MCC-131		BA			M-602		BA			600V		K	3/C #12 WITH #12 GND	200
	P-M602E101	K-01			MCC-131		BA			M-602-E-101		BA			600V		K	3/C #12 WITH #12 GND	200
	P-M602PM101A	K-02			MCC-131		BA			M-602-PM-101A		BA			600V		K	3/C #10 WITH #10 GND	200
C1	C-M602PM101A	K-01			MCC-131		BA			M-602-PM-101A		BA			600V		K	3/C #12 WITH #12 GND	200
	P-M602PM-101B	K-02			MCC-132		BA			M-602-PM-101B		BA			600V		K	3/C #10 WITH #10 GND	200
C1	C-M602PM-101B	K-01			MCC-132		BA			M-602-PM-101B		BA			600V		K	3/C #12 WITH #12 GND	200
	P-M703	K-01			MCC-231		BA			M-703		BA			600V		K	3/C #12 WITH #12 GND	325
	P-M703PM001A	K-01			MCC-231		BA			M-703-PM-001A		BA			600V		K	3/C #12 WITH #12 GND	325
C1	C-M703PM001A	K-01			MCC-231		BA			M-703-PM-001A		BA			600V		K	3/C #12 WITH #12 GND	325
	P-M703PM001B	K-01			MCC-231		BA			M-703-PM-001B		BA			600V		K	3/C #12 WITH #12 GND	325
C1	C-M703PM001B	K-01			MCC-231		BA			M-703-PM-001B		BA			600V		K	3/C #12 WITH #12 GND	325
	P-M703PM001C	K-01			MCC-231		BA			M-703-PM-001C		BA			600V		K	3/C #12 WITH #12 GND	325
C1	C-M703PM001C	K-01			MCC-231		BA			M-703-PM-001C		BA			600V		K	3/C #12 WITH #12 GND	325
	P-M703PM002A	K-01			MCC-231		BA			M-703-PM-002A		BA			600V		K	3/C #12 WITH #12 GND	325
C1	C-M703PM002A	K-01			MCC-231		BA			M-703-PM-002A		BA			600V		K	3/C #12 WITH #12 GND	325
	P-M703PM002B	K-01			MCC-231		BA			M-703-PM-002B		BA			600V		K	3/C #12 WITH #12 GND	325
C1	C-M703PM002B	K-01			MCC-231		BA			M-703-PM-002B		BA			600V		K	3/C #12 WITH #12 GND	325
	P-M703PM002C	K-01			MCC-231		BA			M-703-PM-002C		BA			600V		K	3/C #12 WITH #12 GND	325
C1	C-M703PM002C	K-01			MCC-231		BA			M-703-PM-002C		BA			600V		K	3/C #12 WITH #12 GND	325
	P-M703PM003A	K-01			MCC-231		BA			M-703-PM-003A		BA			600V		K	3/C #12 WITH #12 GND	325
C1	C-M703PM003A	K-01			MCC-231		BA			M-703-PM-003A		BA			600V		K	3/C #12 WITH #12 GND	325
	P-M703PM003B	K-01			MCC-231		BA			M-703-PM-003B		BA			600V		K	3/C #12 WITH #12 GND	325
C1	C-M703PM003B	K-01			MCC-231		BA			M-703-PM-003B		BA			600V		K	3/C #12 WITH #12 GND	325
	P-M703PM003C	K-01			MCC-231		BA			M-703-PM-003C		BA			600V		K	3/C #12 WITH #12 GND	325
C1	C-M703PM003C	K-01			MCC-231		BA			M-703-PM-003C		BA			600V		K	3/C #12 WITH #12 GND	325

REV NO.	CABLE NO.	CABLE CODE	PROJECT PHASE	CABLE REEL NO.	FROM (SOURCE)					TO (USER)					CABLE DESCRIPTION				
					EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	INSUL VOLTAGE	RATED VOLTAGE	CABLE TYPE	NUMBER & SIZE OF CONDUCTORS	LENGTH (FEET)
	P-M703PM004A	K-01			MCC-231		BA			M-703-PM-004A		BA			600V		K	3/C #12 WITH #12 GND	325
C1	C-M703PM004A	K-01			MCC-231		BA			M-703-PM-004A		BA			600V		K	3/C #12 WITH #12 GND	325
	P-M703PM004B	K-01			MCC-231		BA			M-703-PM-004B		BA			600V		K	3/C #12 WITH #12 GND	325
C1	C-M703PM004B	K-01			MCC-231		BA			M-703-PM-004B		BA			600V		K	3/C #12 WITH #12 GND	325
	P-M703PM004C	K-01			MCC-231		BA			M-703-PM-004C		BA			600V		K	3/C #12 WITH #12 GND	325
C1	C-M703PM004C	K-01			MCC-231		BA			M-703-PM-004C		BA			600V		K	3/C #12 WITH #12 GND	325
	P-M703PM005A	K-01			MCC-231		BA			M-703-PM-005A		BA			600V		K	3/C #12 WITH #12 GND	325
C1	C-M703PM005A	K-01			MCC-231		BA			M-703-PM-005A		BA			600V		K	3/C #12 WITH #12 GND	325
	P-M703PM005B	K-01			MCC-231		BA			M-703-PM-005B		BA			600V		K	3/C #12 WITH #12 GND	325
C1	C-M703PM005B	K-01			MCC-231		BA			M-703-PM-005B		BA			600V		K	3/C #12 WITH #12 GND	325
	P-M703PM005C	K-01			MCC-231		BA			M-703-PM-005C		BA			600V		K	3/C #12 WITH #12 GND	325
C1	C-M703PM005C	K-01			MCC-231		BA			M-703-PM-005C		BA			600V		K	3/C #12 WITH #12 GND	325
	C-M704AMM001A	K-01			MCC-211		BA			M-704A-MM-001A		BA			600V		K	3/C #12 WITH #12 GND	450
C2	P-M704AMM001A	J-01			MCC-211		-			M-704A-MM-001A		-			5kV		J	3/C #2 WITH #6 GND	450
C1	R-M704AMM001ASR	EB			MCC-211		AB			M-704A-MM-001A		AB			RTD		EB	8 TRIADS #16, IS & OS	450
C2	P-M704AMM001AH	K-02			MCC-211		BA			M-704A-MM-001AH		BA			600V		K	3/C #10 WITH #10 GND	450
	C-M704AMM001B	K-01			MCC-212		BA			M-704A-MM-001B		BA			600V		K	3/C #12 WITH #12 GND	450
C1	R-M704AMM001BSR	EB			MCC-212		AB			M-704A-MM-001B		AB			RTD		EB	8 TRIADS #16, IS & OS	450
C2	P-M704AMM001B	J-01			MCC-212		-			M-704A-MM-001B		-			5kV		J	3/C #2 WITH #6 GND	450
C2	P-M704AMM001BH	K-02			MCC-212		BA			M-704A-MM-001BH		BA			600V		K	3/C #10 WITH #10 GND	450
	C-M704AMM001C	K-01			MCC-212		BA			M-704A-MM-001C		BA			600V		K	3/C #12 WITH #12 GND	450
C1	R-M704AMM001CSR	EB			MCC-212		AB			M-704A-MM-001C		AB			RTD		EB	8 TRIADS #16, IS & OS	450
C2	P-M704AMM001C	J-01			MCC-212		-			M-704A-MM-001C		-			5kV		J	3/C #2 WITH #6 GND	450
C2	P-M704AMM001CH	K-02			MCC-212		BA			M-704A-MM-001CH		BA			600V		K	3/C #10 WITH #10 GND	450
	C-M704AMM001D	K-01			MCC-211		BA			M-704A-MM-001D		BA			600V		K	3/C #12 WITH #12 GND	450
C1	R-M704AMM001DSR	EB			MCC-211		AB			M-704A-MM-001D		AB			RTD		EB	8 TRIADS #16, IS & OS	450
C2	P-M704AMM001D	J-01			MCC-211		-			M-704A-MM-001D		-			5kV		J	3/C #2 WITH #6 GND	450
C2	P-M704AMM001DH	K-02			MCC-211		BA			M-704A-MM-001DH		BA			600V		K	3/C #10 WITH #10 GND	450

REV NO.	CABLE NO.	CABLE CODE	PROJECT PHASE	CABLE REEL NO.	FROM (SOURCE)					TO (USER)					CABLE DESCRIPTION				
					EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	INSUL VOLTAGE	RATED VOLTAGE	CABLE TYPE	NUMBER & SIZE OF CONDUCTORS	LENGTH (FEET)
C2	C-M704BMM001A	K-02			MCC-211		BA			M-704B-MM-001A		BA			600V		K	3/C #10 WITH #10 GND	550
C1	R-M704BMM001ASR	EB			MCC-211		AB			M-704B-MM-001A		AB			RTD		EB	8 TRIADS #16, IS & OS	550
C2	P-M704BMM001A	J-01			MCC-211		-			M-704B-MM-001A		-			5kV		J	3/C #2 WITH #6 GND	550
C2	P-M704BMM001AH	K-02			MCC-211		BA			M-704B-MM-001AH		BA			600V		K	3/C #10 WITH #10 GND	550
C2	C-M704BMM001B	K-02			MCC-212		BA			M-704B-MM-001B		BA			600V		K	3/C #10 WITH #10 GND	550
C1	R-M704BMM001BSR	EB			MCC-212		AB			M-704B-MM-001B		AB			RTD		EB	8 TRIADS #16, IS & OS	550
C2	P-M704BMM001B	J-01			MCC-212		-			M-704B-MM-001B		-			5kV		J	3/C #2 WITH #6 GND	550
C2	P-M704BMM001BH	K-02			MCC-212		BA			M-704B-MM-001BH		BA			600V		K	3/C #10 WITH #10 GND	550
C2	C-M704BMM001C	K-02			MCC-212		BA			M-704B-MM-001C		BA			600V		K	3/C #10 WITH #10 GND	550
C1	R-M704BMM001CSR	EB			MCC-212		AB			M-704B-MM-001C		AB			RTD		EB	8 TRIADS #16, IS & OS	550
C2	P-M704BMM001C	J-01			MCC-212		-			M-704B-MM-001C		-			5kV		J	3/C #2 WITH #6 GND	550
C2	P-M704BMM001CH	K-02			MCC-212		BA			M-704B-MM-001CH		BA			600V		K	3/C #10 WITH #10 GND	550
C2	C-M704BMM001D	K-02			MCC-211		BA			M-704B-MM-001D		BA			600V		K	3/C #10 WITH #10 GND	550
C1	R-M704BMM001DSR	EB			MCC-211		AB			M-704B-MM-001D		AB			RTD		EB	8 TRIADS #16, IS & OS	550
C2	P-M704BMM001D	J-01			MCC-211		-			M-704B-MM-001D		-			5kV		J	3/C #2 WITH #6 GND	550
C2	P-M704BMM001DH	K-02			MCC-211		BA			M-704B-MM-001DH		BA			600V		K	3/C #10 WITH #10 GND	550
C2	C-M704CMM001A	K-03			MCC-211		BA			M-704C-MM-001A		BA			600V		K	3/C #8 WITH #10 GND	650
C1	R-M704CMM001ASR	EB			MCC-211		AB			M-704C-MM-001A		AB			RTD		EB	8 TRIADS #16, IS & OS	650
C2	P-M704CMM001A	J-01			MCC-211		-			M-704C-MM-001A		-			5kV		J	3/C #2 WITH #6 GND	650
C2	P-M704CMM001AH	K-02			MCC-211		BA			M-704C-MM-001AH		BA			600V		K	3/C #10 WITH #10 GND	650
C2	C-M704CMM001B	K-03			MCC-212		BA			M-704C-MM-001B		BA			600V		K	3/C #8 WITH #10 GND	650
C1	R-M704CMM001BSR	EB			MCC-212		AB			M-704C-MM-001B		AB			RTD		EB	8 TRIADS #16, IS & OS	650
C2	P-M704CMM001B	J-01			MCC-212		-			M-704C-MM-001B		-			5kV		J	3/C #2 WITH #6 GND	650
C2	P-M704CMM001BH	K-02			MCC-212		BA			M-704C-MM-001BH		BA			600V		K	3/C #10 WITH #10 GND	650
C2	C-M704CMM001C	K-03			MCC-212		BA			M-704C-MM-001C		BA			600V		K	3/C #8 WITH #10 GND	650
C1	R-M704CMM001CSR	EB			MCC-212		AB			M-704C-MM-001C		AB			RTD		EB	8 TRIADS #16, IS & OS	650
C2	P-M704CMM001C	J-01			MCC-212		-			M-704C-MM-001C		-			5kV		J	3/C #2 WITH #6 GND	650
C2	P-M704CMM001D	J-01			MCC-211		-			M-704C-MM-001D		-			5kV		J	3/C #2 WITH #6 GND	650

REV NO.	CABLE NO.	CABLE CODE	PROJECT PHASE	CABLE REEL NO.	FROM (SOURCE)					TO (USER)					CABLE DESCRIPTION				
					EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	INSUL VOLTAGE	RATED VOLTAGE	CABLE TYPE	NUMBER & SIZE OF CONDUCTORS	LENGTH (FEET)
C2	P-M704CMM001CH	K-02			MCC-212		BA			M-704C-MM-001CH		BA			600V		K	3/C #10 WITH #10 GND	650
C2	C-M704CMM001D	K-03			MCC-211		BA			M-704C-MM-001D		BA			600V		K	3/C #8 WITH #10 GND	650
C1	R-M704CMM001DSR	EB			MCC-211		AB			M-704C-MM-001D		AB			RTD		EB	8 TRIADS #16, IS & OS	650
C2	P-M704CMM001DH	K-02			MCC-211		BA			M-704C-MM-001DH		BA			600V		K	3/C #10 WITH #10 GND	650
C2	C-M704DMM001A	K-03			MCC-211		BA			M-704D-MM-001A		BA			600V		K	3/C #8 WITH #10 GND	750
C1	R-M704DMM001ASR	EB			MCC-211		AB			M-704D-MM-001A		AB			RTD		EB	8 TRIADS #16, IS & OS	750
C2	P-M704DMM001A	J-01			MCC-211		-			M-704D-MM-001A		-			5kV		J	3/C #2 WITH #6 GND	750
C2	P-M704DMM001AH	K-02			MCC-211		BA			M-704D-MM-001AH		BA			600V		K	3/C #10 WITH #10 GND	750
C2	C-M704DMM001B	K-03			MCC-212		BA			M-704D-MM-001B		BA			600V		K	3/C #8 WITH #10 GND	750
C1	R-M704DMM001BSR	EB			MCC-212		AB			M-704D-MM-001B		AB			RTD		EB	8 TRIADS #16, IS & OS	750
C2	P-M704DMM001B	J-01			MCC-212		-			M-704D-MM-001B		-			5kV		J	3/C #2 WITH #6 GND	750
C2	P-M704DMM001C	J-01			MCC-212		-			M-704D-MM-001C		-			5kV		J	3/C #2 WITH #6 GND	750
C2	P-M704DMM001D	J-01			MCC-211		-			M-704D-MM-001D		-			5kV		J	3/C #2 WITH #6 GND	750
C2	P-M704DMM001BH	K-02			MCC-212		BA			M-704D-MM-001BH		BA			600V		K	3/C #10 WITH #10 GND	750
C2	C-M704DMM001C	K-03			MCC-212		BA			M-704D-MM-001C		BA			600V		K	3/C #8 WITH #10 GND	750
C1	R-M704DMM001CSR	EB			MCC-212		AB			M-704D-MM-001C		AB			RTD		EB	8 TRIADS #16, IS & OS	750
C2	P-M704DMM001CH	K-02			MCC-212		BA			M-704D-MM-001CH		BA			600V		K	3/C #10 WITH #10 GND	750
C2	C-M704DMM001D	K-03			MCC-211		BA			M-704D-MM-001D		BA			600V		K	3/C #8 WITH #10 GND	750
C1	R-M704DMM001DSR	EB			MCC-211		AB			M-704D-MM-001D		AB			RTD		EB	8 TRIADS #16, IS & OS	750
C2	P-M704DMM001DH	K-02			MCC-211		BA			M-704D-MM-001DH		BA			600V		K	3/C #10 WITH #10 GND	750
C2	C-M704BPM001A	K-02			MCC-211		BA			M-704-PM-001A		BA			600V		K	3/C #10 WITH #10 GND	605
C1	R-M704BPM001ASR	EB			MCC-211		AB			M-704-PM-001A		AB			RTD		EB	8 TRIADS #16, IS & OS	605
C2	P-M704BPM001A	J-01			MCC-211		-			M-704-PM-001A		-			5kV		J	3/C #2 WITH #6 GND	605
C2	P-M704BPM001AH	K-02			MCC-211		BA			M-704-PM-001AH		BA			600V		K	3/C #10 WITH #10 GND	605
C2	C-M704BPM001B	K-02			MCC-212		BA			M-704-PM-001B		BA			600V		K	3/C #10 WITH #10 GND	610
C1	R-M704BPM001BSR	EB			MCC-212		AB			M-704-PM-001B		AB			RTD		EB	8 TRIADS #16, IS & OS	610
C2	P-M704BPM001B	J-01			MCC-212		-			M-704-PM-001B		-			5kV		J	3/C #2 WITH #6 GND	610
C2	P-M704BPM001BH	K-02			MCC-212		BA			M-704-PM-001BH		BA			600V		K	3/C #10 WITH #10 GND	610

REV NO.	CABLE NO.	CABLE CODE	PROJECT PHASE	CABLE REEL NO.	FROM (SOURCE)					TO (USER)					CABLE DESCRIPTION				
					EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	INSUL VOLTAGE	RATED VOLTAGE	CABLE TYPE	NUMBER & SIZE OF CONDUCTORS	LENGTH (FEET)
C2	C-M704BPM001C	K-02			MCC-212		BA			M-704-PM-001C		BA			600V		K	3/C #10 WITH #10 GND	615
C1	R-M704BPM001CSR	EB			MCC-212		AB			M-704-PM-001C		AB			RTD		EB	8 TRIADS #16, IS & OS	615
C2	P-M704BPM001C	J-01			MCC-212		-			M-704-PM-001C		-			5kV		J	3/C #2 WITH #6 GND	615
C2	P-M704BPM001CH	K-02			MCC-212		BA			M-704-PM-001CH		BA			600V		K	3/C #10 WITH #10 GND	615
	C-M705AMM001A	K-01			MCC-211		BA			M-705A-MM-001A		BA			600V		K	3/C #12 WITH #12 GND	450
C1	R-M705AMM001ASR	EB			MCC-211		AB			M-705A-MM-001A		AB			RTD		EB	8 TRIADS #16, IS & OS	450
C2	P-M705AMM001A	J-01			MCC-211		-			M-705A-MM-001A		-			5kV		J	3/C #2 WITH #6 GND	450
C2	P-M705AMM001AH	K-02			MCC-211		BA			M-705A-MM-001AH		BA			600V		K	3/C #10 WITH #10 GND	450
	C-M705AMM001B	K-01			MCC-212		BA			M-705A-MM-001B		BA			600V		K	3/C #12 WITH #12 GND	450
C1	R-M705AMM001BSR	EB			MCC-212		AB			M-705A-MM-001B		AB			RTD		EB	8 TRIADS #16, IS & OS	450
C2	P-M705AMM001B	J-01			MCC-212		-			M-705A-MM-001B		-			5kV		J	3/C #2 WITH #6 GND	450
C2	P-M705AMM001BH	K-02			MCC-212		BA			M-705A-MM-001BH		BA			600V		K	3/C #10 WITH #10 GND	450
	C-M705AMM001C	K-01			MCC-212		BA			M-705A-MM-001C		BA			600V		K	3/C #12 WITH #12 GND	450
C1	R-M705AMM001CSR	EB			MCC-212		AB			M-705A-MM-001C		AB			RTD		EB	8 TRIADS #16, IS & OS	450
C2	P-M705AMM001C	J-01			MCC-212		-			M-705A-MM-001C		-			5kV		J	3/C #2 WITH #6 GND	450
C2	P-M705AMM001CH	K-02			MCC-212		BA			M-705A-MM-001CH		BA			600V		K	3/C #10 WITH #10 GND	450
	C-M705AMM001D	K-01			MCC-211		BA			M-705A-MM-001D		BA			600V		K	3/C #12 WITH #12 GND	450
C1	R-M705AMM001DSR	EB			MCC-211		AB			M-705A-MM-001D		AB			RTD		EB	8 TRIADS #16, IS & OS	450
C2	P-M705AMM001D	J-01			MCC-211		-			M-705A-MM-001D		-			5kV		J	3/C #2 WITH #6 GND	450
C2	P-M705AMM001DH	K-02			MCC-211		BA			M-705A-MM-001DH		BA			600V		K	3/C #10 WITH #10 GND	450
C2	C-M705BMM001A	K-02			MCC-211		BA			M-705B-MM-001A		BA			600V		K	3/C #10 WITH #10 GND	550
C1	R-M705BMM001ASR	EB			MCC-211		AB			M-705B-MM-001A		AB			RTD		EB	8 TRIADS #16, IS & OS	550
C2	P-M705BMM001A	J-01			MCC-211		-			M-705B-MM-001A		-			5kV		J	3/C #2 WITH #6 GND	550
C2	P-M705BMM001AH	K-02			MCC-211		BA			M-705B-MM-001AH		BA			600V		K	3/C #10 WITH #10 GND	550
C2	C-M705BMM001B	K-02			MCC-212		BA			M-705B-MM-001B		BA			600V		K	3/C #10 WITH #10 GND	550
C1	R-M705BMM001BSR	EB			MCC-212		AB			M-705B-MM-001B		AB			RTD		EB	8 TRIADS #16, IS & OS	550
C2	P-M705BMM001B	J-01			MCC-212		-			M-705B-MM-001B		-			5kV		J	3/C #2 WITH #6 GND	550
C2	P-M705BMM001BH	K-02			MCC-212		BA			M-705B-MM-001BH		BA			600V		K	3/C #10 WITH #10 GND	550

REV NO.	CABLE NO.	CABLE CODE	PROJECT PHASE	CABLE REEL NO.	FROM (SOURCE)					TO (USER)					CABLE DESCRIPTION				
					EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	INSUL VOLTAGE	RATED VOLTAGE	CABLE TYPE	NUMBER & SIZE OF CONDUCTORS	LENGTH (FEET)
C2	C-M705BMM001C	K-02			MCC-212		BA			M-705B-MM-001C		BA			600V		K	3/C #10 WITH #10 GND	550
C1	R-M705BMM001CSR	EB			MCC-212		AB			M-705B-MM-001C		AB			RTD		EB	8 TRIADS #16, IS & OS	550
C2	P-M705BMM001C	J-01			MCC-212		-			M-705B-MM-001C		-			5kV		J	3/C #2 WITH #6 GND	550
C2	P-M705BMM001CH	K-02			MCC-212		BA			M-705B-MM-001CH		BA			600V		K	3/C #10 WITH #10 GND	550
C2	C-M705BMM001D	K-02			MCC-211		BA			M-705B-MM-001D		BA			600V		K	3/C #10 WITH #10 GND	550
C1	R-M705BMM001DSR	EB			MCC-211		AB			M-705B-MM-001D		AB			RTD		EB	8 TRIADS #16, IS & OS	550
C2	P-M705BMM001D	J-01			MCC-211		-			M-705B-MM-001D		-			5kV		J	3/C #2 WITH #6 GND	550
C2	P-M705BMM001DH	K-02			MCC-211		BA			M-705B-MM-001DH		BA			600V		K	3/C #10 WITH #10 GND	550
C2	C-M705CMM001A	K-03			MCC-211		BA			M-705C-MM-001A		BA			600V		K	3/C #8 WITH #10 GND	650
C1	R-M705CMM001ASR	EB			MCC-211		AB			M-705C-MM-001A		AB			RTD		EB	8 TRIADS #16, IS & OS	650
C2	P-M705CMM001A	J-01			MCC-211		-			M-705C-MM-001A		-			5kV		J	3/C #2 WITH #6 GND	650
C2	P-M705CMM001AH	K-02			MCC-211		BA			M-705C-MM-001AH		BA			600V		K	3/C #10 WITH #10 GND	650
C2	C-M705CMM001B	K-03			MCC-212		BA			M-705C-MM-001B		BA			600V		K	3/C #8 WITH #10 GND	650
C1	R-M705CMM001BSR	EB			MCC-212		AB			M-705C-MM-001B		AB			RTD		EB	8 TRIADS #16, IS & OS	650
C2	P-M705CMM001B	J-01			MCC-212		-			M-705C-MM-001B		-			5kV		J	3/C #2 WITH #6 GND	650
C2	P-M705CMM001BH	K-02			MCC-212		BA			M-705C-MM-001BH		BA			600V		K	3/C #10 WITH #10 GND	650
C2	C-M705CMM001C	K-03			MCC-212		BA			M-705C-MM-001C		BA			600V		K	3/C #8 WITH #10 GND	650
C1	R-M705CMM001CSR	EB			MCC-212		AB			M-705C-MM-001C		AB			RTD		EB	8 TRIADS #16, IS & OS	650
C2	C-M705CMM001D	K-03			MCC-211		BA			M-705C-MM-001D		BA			600V		K	3/C #8 WITH #10 GND	650
C1	R-M705CMM001DSR	EB			MCC-211		AB			M-705C-MM-001D		AB			RTD		EB	8 TRIADS #16, IS & OS	650
C2	P-M705CMM001C	J-01			MCC-212		-			M-705C-MM-001C		-			5kV		J	3/C #2 WITH #6 GND	650
C2	P-M705CMM001D	J-01			MCC-211		-			M-705C-MM-001D		-			5kV		J	3/C #2 WITH #6 GND	650
C2	P-M705CMM001CH	K-02			MCC-212		BA			M-705C-MM-001CH		BA			600V		K	3/C #10 WITH #10 GND	650
C2	P-M705CMM001DH	K-02			MCC-211		BA			M-705C-MM-001DH		BA			600V		K	3/C #10 WITH #10 GND	650
C2	C-M705DMM001A	K-03			MCC-211		BA			M-705D-MM-001A		BA			600V		K	3/C #8 WITH #10 GND	750
C1	R-M705DMM001ASR	EB			MCC-211		AB			M-705D-MM-001A		AB			RTD		EB	8 TRIADS #16, IS & OS	750
C2	P-M705DMM001A	J-01			MCC-211		-			M-705D-MM-001A		-			5kV		J	3/C #2 WITH #6 GND	750
C2	P-M705DMM001AH	K-02			MCC-211		BA			M-705D-MM-001AH		BA			600V		K	3/C #10 WITH #10 GND	750

REV NO.	CABLE NO.	CABLE CODE	PROJECT PHASE	CABLE REEL NO.	FROM (SOURCE)					TO (USER)					CABLE DESCRIPTION				
					EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	INSUL VOLTAGE	RATED VOLTAGE	CABLE TYPE	NUMBER & SIZE OF CONDUCTORS	LENGTH (FEET)
C2	C-M705DMM001B	K-03			MCC-212		BA			M-705D-MM-001B		BA			600V		K	3/C #8 WITH #10 GND	750
C1	R-M705DMM001BSR	EB			MCC-212		AB			M-705D-MM-001B		AB			RTD		EB	8 TRIADS #16, IS & OS	750
C2	P-M705DMM001B	J-01			MCC-212		-			M-705D-MM-001B		-			5kV		J	3/C #2 WITH #6 GND	750
C2	P-M705DMM001BH	K-02			MCC-212		BA			M-705D-MM-001BH		BA			600V		K	3/C #10 WITH #10 GND	750
C2	C-M705DMM001C	K-03			MCC-212		BA			M-705D-MM-001C		BA			600V		K	3/C #8 WITH #10 GND	750
C1	R-M705DMM001CSR	EB			MCC-212		AB			M-705D-MM-001C		AB			RTD		EB	8 TRIADS #16, IS & OS	750
C2	P-M705DMM001C	J-01			MCC-212		-			M-705D-MM-001C		-			5kV		J	3/C #2 WITH #6 GND	750
C2	P-M705DMM001CH	K-02			MCC-212		BA			M-705D-MM-001CH		BA			600V		K	3/C #10 WITH #10 GND	750
C2	C-M705DMM001D	K-03			MCC-211		BA			M-705D-MM-001D		BA			600V		K	3/C #8 WITH #10 GND	750
C1	R-M705DMM001DSR	EB			MCC-211		AB			M-705D-MM-001D		AB			RTD		EB	8 TRIADS #16, IS & OS	750
C2	P-M705DMM001D	J-01			MCC-211		-			M-705D-MM-001D		-			5kV		J	3/C #2 WITH #6 GND	750
C2	P-M705DMM001DH	K-02			MCC-211		BA			M-705D-MM-001DH		BA			600V		K	3/C #10 WITH #10 GND	750
C2	C-M705PM001A	K-02			MCC-211		BA			M-705-PM-001A		BA			600V		K	3/C #10 WITH #10 GND	605
C1	R-M705PM001ASR	EB			MCC-211		AB			M-705-PM-001A		AB			RTD		EB	8 TRIADS #16, IS & OS	605
C2	P-M705PM001A	J-01			MCC-211		-			M-705-PM-001A		-			5kV		J	3/C #2 WITH #6 GND	605
C2	P-M705PM001AH	K-02			MCC-211		BA			M-705-PM-001AH		BA			600V		K	3/C #10 WITH #10 GND	605
C2	C-M705BMM001B	K-02			MCC-212		BA			M-705-PM-001B		BA			600V		K	3/C #10 WITH #10 GND	610
C1	R-M705BMM001BSR	EB			MCC-212		AB			M-705-PM-001B		AB			RTD		EB	8 TRIADS #16, IS & OS	610
C2	P-M705BMM001B	J-01			MCC-212		-			M-705-PM-001B		-			5kV		J	3/C #2 WITH #6 GND	610
C2	P-M705BMM001BH	K-02			MCC-212		BA			M-705-PM-001BH		BA			600V		K	3/C #10 WITH #10 GND	610
C1	R-M705BMM001CSR	EB			MCC-211		AB			M-705-PM-001C		AB			RTD		EB	8 TRIADS #16, IS & OS	615
C2	C-M705BMM001C	K-02			MCC-211		BA			M-705-PM-001C		BA			600V		K	3/C #10 WITH #10 GND	615
C2	P-M705BMM001C	J-01			MCC-211		-			M-705-PM-001C		-			5kV		J	3/C #2 WITH #6 GND	615
C2	P-M705BMM001CH	K-02			MCC-211		BA			M-705-PM-001CH		BA			600V		K	3/C #10 WITH #10 GND	615
	C-710KM001A	K-01			MCC-211		BA			M-710-KM-001A		BA			600V		K	3/C #12 WITH #12 GND	425
C1	R-710KM001ASR	EB			MCC-211		AB			M-710-KM-001A		AB			RTD		EB	8 TRIADS #16, IS & OS	425
	P-710KM001A	E-01			MCC-211		AF			M-710-KM-001A		AF			5kV		E	3/C #2 WITH 3#10 GND	425
C2	P-710KM001AH	K-02			MCC-211		BA			M-710-KM-001AH		BA			600V		K	3/C #10 WITH #10 GND	425

REV NO.	CABLE NO.	CABLE CODE	PROJECT PHASE	CABLE REEL NO.	FROM (SOURCE)					TO (USER)					CABLE DESCRIPTION				
					EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	INSUL VOLTAGE	RATED VOLTAGE	CABLE TYPE	NUMBER & SIZE OF CONDUCTORS	LENGTH (FEET)
	C-710KM001B	K-01			MCC-212		BA			M-710-KM-001B		BA			600V		K	3/C #12 WITH #12 GND	425
C1	R-710KM001BSR	EB			MCC-212		AB			M-710-KM-001B		AB			RTD		EB	8 TRIADS #16, IS & OS	425
	P-710KM001B	E-01			MCC-212		AF			M-710-KM-001B		AF			5kV		E	3/C #2 WITH 3#10 GND	425
C2	P-710KM001BH	K-02			MCC-212		BA			M-710-KM-001BH		BA			600V		K	3/C #10 WITH #10 GND	425
	C-M710KM002A	K-01			MCC-231		BA			M-710-KM-002A		BA			600V		K	3/C #12 WITH #12 GND	425
	P-M710KM002A	K-02			MCC-231		BA			M-710-KM-002A		BA			600V		K	3/C #10 WITH #10 GND	425
	C-M710KM002B	K-01			MCC-232		BA			M-710-KM-002B		BA			600V		K	3/C #12 WITH #12 GND	425
	P-M710KM002B	K-02			MCC-232		BA			M-710-KM-002B		BA			600V		K	3/C #10 WITH #10 GND	425
	C-710PM001A	K-01			MCC-231		BA			M-710-PM-001A		BA			600V		K	3/C #12 WITH #12 GND	425
	P-710PM001A	K-10			MCC-231		BE			M-710-PM-001A		BE			600V		K	3/C #4/0 WITH #4 GND	425
C2	P-710PM001AH	K-02			MCC-231		BA			M-710-PM-001AH		BA			600V		K	3/C #10 WITH #10 GND	425
	C-710PM001B	K-01			MCC-232		BA			M-710-PM-001B		BA			600V		K	3/C #12 WITH #12 GND	425
	P-710PM001B	K-10			MCC-232		BE			M-710-PM-001B		BE			600V		K	3/C #4/0 WITH #4 GND	425
C2	P-710PM001BH	K-02			MCC-232		BA			M-710-PM-001BH		BA			600V		K	3/C #10 WITH #10 GND	425
	C-710PM001C	K-01			MCC-231		BA			M-710-PM-001C		BA			600V		K	3/C #12 WITH #12 GND	425
	P-710PM001C	K-10			MCC-231		BE			M-710-PM-001C		BE			600V		K	3/C #4/0 WITH #4 GND	425
C2	P-710PM001CH	K-02			MCC-231		BA			M-710-PM-001CH		BA			600V		K	3/C #10 WITH #10 GND	425
	C-M710PM002A	K-01			MCC-231		BA			M-710-PM-002A		BA			600V		K	3/C #12 WITH #12 GND	425
	P-M710PM002A	K-02			MCC-231		BA			M-710-PM-002A		BA			600V		K	3/C #10 WITH #10 GND	425
	C-M710PM002B	K-01			MCC-232		BA			M-710-PM-002B		BA			600V		K	3/C #12 WITH #12 GND	425
	P-M710PM002B	K-02			MCC-232		BA			M-710-PM-002B		BA			600V		K	3/C #10 WITH #10 GND	425
	P-M710E001	K-02			MCC-231		BA			M-710-E-001		BA			600V		K	3/C #10 WITH #10 GND	425
	P-M711E001	K-02			MCC-231		BA			M-711-E-001		BA			600V		K	3/C #10 WITH #10 GND	250
	P-M711E002	K-02			MCC-231		BA			M-711-E-002		BA			600V		K	3/C #10 WITH #10 GND	250
C1	C-M711MM001A	K-01			MCC-231		BA			M-711-MM-001A		BA			600V		K	3/C #12 WITH #12 GND	250
C1	C-M711MM001B	K-01			MCC-231		BA			M-711-MM-001B		BA			600V		K	3/C #12 WITH #12 GND	250
	P-M711PM001A	K-03			MCC-231		BA			M-711-PM-001A		BA			600V		K	3/C #8 WITH #10 GND	250
	P-M711PM001B	K-03			MCC-231		BA			M-711-PM-001B		BA			600V		K	3/C #8 WITH #10 GND	250

REV NO.	CABLE NO.	CABLE CODE	PROJECT PHASE	CABLE REEL NO.	FROM (SOURCE)					TO (USER)					CABLE DESCRIPTION				
					EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	INSUL VOLTAGE	RATED VOLTAGE	CABLE TYPE	NUMBER & SIZE OF CONDUCTORS	LENGTH (FEET)
	P-M711PM002	K-02			MCC-231		BA			M-711-PM-002		BA			600V		K	3/C #10 WITH #10 GND	250
C1	C-M711PM002	K-01			MCC-231		BA			M-711-PM-002		BA			600V		K	3/C #12 WITH #12 GND	250
	P-M711PM003A	K-02			MCC-231		BA			M-711-PM-003A		BA			600V		K	3/C #10 WITH #10 GND	250
C1	C-M711PM003A	K-01			MCC-231		BA			M-711-PM-003A		BA			600V		K	3/C #12 WITH #12 GND	250
	P-M711PM003B	K-02			MCC-231		BA			M-711-PM-003B		BA			600V		K	3/C #10 WITH #10 GND	250
C1	C-M711PM003B	K-01			MCC-231		BA			M-711-PM-003B		BA			600V		K	3/C #12 WITH #12 GND	250
	P-M711PM004A	K-01			MCC-231		BA			M-711-PM-004A		BA			600V		K	3/C #12 WITH #12 GND	250
C1	C-M711PM004A	K-01			MCC-231		BA			M-711-PM-004A		BA			600V		K	3/C #12 WITH #12 GND	250
	P-M711PM004B	K-01			MCC-232		BA			M-711-PM-004B		BA			600V		K	3/C #12 WITH #12 GND	250
C1	C-M711PM004B	K-01			MCC-232		BA			M-711-PM-004B		BA			600V		K	3/C #12 WITH #12 GND	250
	P-M711PM005A	K-01			MCC-231		BA			M-711-PM-005A		BA			600V		K	3/C #12 WITH #12 GND	250
C1	C-M711PM005A	K-01			MCC-231		BA			M-711-PM-005A		BA			600V		K	3/C #12 WITH #12 GND	250
	P-M711PM005B	K-01			MCC-232		BA			M-711-PM-005B		BA			600V		K	3/C #12 WITH #12 GND	250
C1	C-M711PM005B	K-01			MCC-232		BA			M-711-PM-005B		BA			600V		K	3/C #12 WITH #12 GND	250
	P-M711PM006A	K-01			MCC-231		BA			M-711-PM-006A		BA			600V		K	3/C #12 WITH #12 GND	250
C1	C-M711PM006A	K-01			MCC-231		BA			M-711-PM-006A		BA			600V		K	3/C #12 WITH #12 GND	250
	P-M711PM006B	K-01			MCC-232		BA			M-711-PM-006B		BA			600V		K	3/C #12 WITH #12 GND	250
C1	C-M711PM006B	K-01			MCC-232		BA			M-711-PM-006B		BA			600V		K	3/C #12 WITH #12 GND	250
	P-M711PM007A	K-05			MCC-231		BB			M-711-PM-007A		BB			600V		K	3/C #6 WITH #8 GND	250
C1	C-M711PM007A	K-01			MCC-231		BA			M-711-PM-007A		BA			600V		K	3/C #12 WITH #12 GND	250
	P-M711PM007B	K-05			MCC-232		BB			M-711-PM-007B		BB			600V		K	3/C #6 WITH #8 GND	250
C1	C-M711PM007B	K-01			MCC-232		BA			M-711-PM-007B		BA			600V		K	3/C #12 WITH #12 GND	250
	P-M711PM008A	K-01			MCC-231		BA			M-711-PM-008A		BA			600V		K	3/C #12 WITH #12 GND	250
C1	C-M711PM008A	K-01			MCC-231		BA			M-711-PM-008A		BA			600V		K	3/C #12 WITH #12 GND	250
	P-M711PM008B	K-01			MCC-232		BA			M-711-PM-008B		BA			600V		K	3/C #12 WITH #12 GND	250
C1	C-M711PM008B	K-01			MCC-232		BA			M-711-PM-008B		BA			600V		K	3/C #12 WITH #12 GND	250
	P-M711PM009A	K-01			MCC-231		BA			M-711-PM-009A		BA			600V		K	3/C #12 WITH #12 GND	250
C1	C-M711PM009A	K-01			MCC-231		BA			M-711-PM-009A		BA			600V		K	3/C #12 WITH #12 GND	250

REV NO.	CABLE NO.	CABLE CODE	PROJECT PHASE	CABLE REEL NO.	FROM (SOURCE)					TO (USER)					CABLE DESCRIPTION				
					EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	INSUL VOLTAGE	RATED VOLTAGE	CABLE TYPE	NUMBER & SIZE OF CONDUCTORS	LENGTH (FEET)
	P-M711PM009B	K-01			MCC-232		BA			M-711-PM-009B		BA			600V		K	3/C #12 WITH #12 GND	250
C1	C-M711PM009B	K-01			MCC-232		BA			M-711-PM-009B		BA			600V		K	3/C #12 WITH #12 GND	250
	P-M711PM010A	K-01			MCC-231		BA			M-711-PM-010A		BA			600V		K	3/C #12 WITH #12 GND	250
C1	C-M711PM010A	K-01			MCC-231		BA			M-711-PM-010A		BA			600V		K	3/C #12 WITH #12 GND	250
	P-M711PM010B	K-01			MCC-232		BA			M-711-PM-010B		BA			600V		K	3/C #12 WITH #12 GND	250
	P-M711PM011	K-02			MCC-231		BA			M-711-PM-011		BA			600V		K	3/C #10 WITH #10 GND	250
C1	P-M720CP	K-02			MCC-231		BA			M-720-CP		BA			600V		K	3/C #10 WITH #10 GND	475
	P-M720E001	K-02			MCC-231		BA			M-720-E-001		BA			600V		K	3/C #10 WITH #10 GND	475
	C-M720E001	K-01			M-720-CP		BA			M-720-E-001		BA			600V		K	3/C #12 WITH #12 GND	50
	P-M720E002	K-03			MCC-231		BA			M-720-E-002		BA			600V		K	3/C #8 WITH #10 GND	475
C1	C-M720E002	K-01			M-720-CP		BA			M-720-E-002		BA			600V		K	3/C #12 WITH #12 GND	50
C2	C-M711PM010B	K-01			MCC-232		BA			M-711-PM-010B		BA			600V		K	3/C #12 WITH #12 GND	250
	P-M720KM001A	K-12			MCC-231		BF			M-720-KM-001A		BF			600V		K	3/C 350 WITH #3 GND	475
C1	C-M720KM001A	K-01			M-720-CP		BA			M-720-KM-001A		BA			600V		K	3/C #12 WITH #12 GND	50
C2	P-M720KM001AH	K-02			MCC-231		BA			M-720-KM-001AH		BA			600V		K	3/C #10 WITH #10 GND	475
	P-M720KM001B	K-12			MCC-232		BF			M-720-KM-001B		BF			600V		K	3/C 350 WITH #3 GND	475
C1	C-M720KM001B	K-01			M-720-CP		BA			M-720-KM-001B		BA			600V		K	3/C #12 WITH #12 GND	50
C2	P-M720KM001BH	K-02			MCC-232		BA			M-720-KM-001BH		BA			600V		K	3/C #10 WITH #10 GND	475
	P-M720PM001	K-01			MCC-231		BA			M-720-PM-001		BA			600V		K	3/C #12 WITH #12 GND	475
C1	C-M720PM001	K-01			M-720-CP		BA			M-720-PM-001		BA			600V		K	3/C #12 WITH #12 GND	50
	C-MM701A	K-02			MCC-211		BA			MM-701A		BA			600V		K	3/C #10 WITH #10 GND	375
	P-MM701A	K-09			MCC-211		BD			MM-701A		BD			600V		K	3/C #2/0 WITH #6 GND	375
C2	P-MM701AH	K-02			MCC-211		BA			MM-701AH		BA			600V		K	3/C #10 WITH #10 GND	375
	C-MM701B	K-02			MCC-212		BA			MM-701B		BA			600V		K	3/C #10 WITH #10 GND	375
	P-MM701B	K-09			MCC-212		BD			MM-701B		BD			600V		K	3/C #2/0 WITH #6 GND	375
C2	P-MM701BH	K-02			MCC-212		BA			MM-701BH		BA			600V		K	3/C #10 WITH #10 GND	375
	C-PM101A	K-01			MCC-211		BA			PM-101A		BA			600V		K	3/C #12 WITH #12 GND	200
C2	R-PM101ABR	ED			MCC-211		AB			PM-101A		AB			RTD		ED	12 TRIADS #16, IS & OS	200

REV NO.	CABLE NO.	CABLE CODE	PROJECT PHASE	CABLE REEL NO.	FROM (SOURCE)					TO (USER)					CABLE DESCRIPTION				
					EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	INSUL VOLTAGE	RATED VOLTAGE	CABLE TYPE	NUMBER & SIZE OF CONDUCTORS	LENGTH (FEET)
C2	~~R-PM101ASR~~	~~EB~~			~~MCC-211~~		~~AB~~			~~PM-101A~~		~~AB~~			~~RTD~~		~~EB~~	~~8 TRIADS #16, IS & OS~~	~~0~~
C2	P-PM101A	J-02			MCC-211		-			PM-101A		-			5kV		J	3/C #2/0 WITH #4 GND	200
C2	P-PM101AHTR	K-02			MCC-211		BA			PM-101A-HTR		BA			600V		K	3/C #10 WITH #10 GND	200
	C-PM101B	K-01			MCC-212		BA			PM-101B		BA			600V		K	3/C #12 WITH #12 GND	225
C2	~~R-PM101BSR~~	~~EB~~			~~MCC-212~~		~~AB~~			~~PM-101B~~		~~AB~~			~~RTD~~		~~EB~~	~~8 TRIADS #16, IS & OS~~	~~0~~
C2	R-PM101BBR	ED			MCC-212		AB			PM-101B		AB			RTD		ED	12 TRIADS #16, IS & OS	225
C2	P-PM101B	J-02			MCC-212		-			PM-101B		-			5kV		J	3/C #2/0 WITH #4 GND	225
C2	P-PM101BHTR	K-02			MCC-212		BA			PM-101B-HTR		BA			600V		K	3/C #10 WITH #10 GND	225
	C-PM201A	K-01			MCC-211		BA			PM-201A		BA			600V		K	3/C #12 WITH #12 GND	150
C2	~~R-PM201ASR~~	~~EB~~			~~MCC-211~~		~~AB~~			~~PM-201A~~		~~AB~~			~~RTD~~		~~EB~~	~~8 TRIADS #16, IS & OS~~	~~0~~
C2	R-PM201ABR	ED			MCC-211		AB			PM-201A		AB			RTD		ED	12 TRIADS #16, IS & OS	150
C2	P-PM201A	J-02			MCC-211		-			PM-201A		-			5kV		J	3/C #2/0 WITH #4 GND	150
C2	P-PM201AHTR	K-02			MCC-211		BA			PM-201A-HTR		BA			600V		K	3/C #10 WITH #10 GND	150
	C-PM201B	K-01			MCC-212		BA			PM-201B		BA			600V		K	3/C #12 WITH #12 GND	175
C2	~~R-PM201BSR~~	~~EB~~			~~MCC-212~~		~~AB~~			~~PM-201B~~		~~AB~~			~~RTD~~		~~EB~~	~~8 TRIADS #16, IS & OS~~	~~0~~
C2	R-PM201BBR	ED			MCC-212		AB			PM-201B		AB			RTD		ED	12 TRIADS #16, IS & OS	175
C2	P-PM201B	J-02			MCC-212		-			PM-201B		-			5kV		J	3/C #2/0 WITH #4 GND	175
C2	P-PM201BHTR	K-02			MCC-212		BA			PM-201B-HTR		BA			600V		K	3/C #10 WITH #10 GND	175
C2	C-PM202A	K-02			MCC-111		BA			PM-202A		BA			600V		K	3/C #10 WITH #10 GND	525
C2	~~R-PM202ASR~~	~~EB~~			~~MCC-111~~		~~AB~~			~~PM-202A~~		~~AB~~			~~RTD~~		~~EB~~	~~8 TRIADS #16, IS & OS~~	~~0~~
C2	R-PM202ABR	ED			MCC-111		AB			PM-202A		AB			RTD		ED	12 TRIADS #16, IS & OS	525
C2	P-PM202A	J-03			MCC-111		-			PM-202A		-			5kV		J	3/C #4/0 WITH #3 GND	525
C2	P-PM202AHTR	K-02			MCC-111		BA			PM-202A-HTR		BA			600V		K	3/C #10 WITH #10 GND	525
C2	C-PM202B	K-02			MCC-112		BA			PM-202B		BA			600V		K	3/C #10 WITH #10 GND	550
C2	~~R-PM202BSR~~	~~EB~~			~~MCC-112~~		~~AB~~			~~PM-202B~~		~~AB~~			~~RTD~~		~~EB~~	~~8 TRIADS #16, IS & OS~~	~~0~~
C2	R-PM202BBR	ED			MCC-112		AB			PM-202B		AB			RTD		ED	12 TRIADS #16, IS & OS	550
C2	P-PM202B	J-03			MCC-112		-			PM-202B		-			5kV		J	3/C #4/0 WITH #3 GND	550
C2	P-PM202BHTR	K-02			MCC-112		BA			PM-202B-HTR		BA			600V		K	3/C #10 WITH #10 GND	550

REV NO.	CABLE NO.	CABLE CODE	PROJECT PHASE	CABLE REEL NO.	FROM (SOURCE)					TO (USER)					CABLE DESCRIPTION				
					EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	INSUL VOLTAGE	RATED VOLTAGE	CABLE TYPE	NUMBER & SIZE OF CONDUCTORS	LENGTH (FEET)
	C-PM301A	K-01			MCC-111		BA			PM-301A		BA			600V		K	3/C #12 WITH #12 GND	475
C1	R-PM301ASR	EB			MCC-111		AB			PM-301A		AB			RTD		EB	8 TRIADS #16, IS & OS	475
C2	P-PM301A	J-01			MCC-111		-			PM-301A		-			5kV		J	3/C #2 WITH #6 GND	475
C2	P-PM301AHTR	K-02			MCC-111		BA			PM-301A-HTR		BA			600V		K	3/C #10 WITH #10 GND	475
C2	C-PM301B	K-02			MCC-112		BA			PM-301B		BA			600V		K	3/C #10 WITH #10 GND	500
C2	R-PM301BSR	EB			MCC-112		AB			PM-301B		AB			RTD		EB	8 TRIADS #16, IS & OS	500
C2	P-PM301B	J-01			MCC-112		-			PM-301B		-			5kV		J	3/C #2 WITH #6 GND	500
C2	P-PM301BHTR	K-02			MCC-112		BA			PM-301B-HTR		BA			600V		K	3/C #10 WITH #10 GND	500
	C-PM302A	K-01			MCC-131		BA			PM-302A		BA			600V		K	3/C #12 WITH #12 GND	450
	P-PM302A	K-07			MCC-131		BB			PM-302A		BB			600V		K	3/C #4 WITH #8 GND	450
	C-PM302B	K-01			MCC-132		BA			PM-302B		BA			600V		K	3/C #12 WITH #12 GND	450
	P-PM302B	K-07			MCC-132		BB			PM-302B		BB			600V		K	3/C #4 WITH #8 GND	450
	C-PM303A	K-01			MCC-131		BA			PM-303A		BA			600V		K	3/C #12 WITH #12 GND	320
	P-PM303A	K-07			MCC-131		BB			PM-303A		BB			600V		K	3/C #4 WITH #8 GND	320
	C-PM303B	K-01			MCC-132		BA			PM-303B		BA			600V		K	3/C #12 WITH #12 GND	320
	P-PM303B	K-07			MCC-132		BB			PM-303B		BB			600V		K	3/C #4 WITH #8 GND	320
	C-PM501	K-01			MCC-131		BA			PM-501		BA			600V		K	3/C #12 WITH #12 GND	400
	P-PM501	K-01			MCC-131		BA			PM-501		BA			600V		K	3/C #12 WITH #12 GND	400
	C-PM502	K-01			MCC-131		BA			PM-502		BA			600V		K	3/C #12 WITH #12 GND	400
	P-PM502	K-01			MCC-131		BA			PM-502		BA			600V		K	3/C #12 WITH #12 GND	400
	C-PM503	K-01			MCC-131		BA			PM-503		BA			600V		K	3/C #12 WITH #12 GND	425
	P-PM503	K-01			MCC-131		BA			PM-503		BA			600V		K	3/C #12 WITH #12 GND	425
	C-PM701A	K-01			MCC-211		BA			PM-701A		BA			600V		K	3/C #12 WITH #12 GND	375
C1	R-PM701ASR	EB			MCC-211		AB			PM-701A		AB			RTD		EB	8 TRIADS #16, IS & OS	375
C2	P-PM701A	J-01			MCC-211		-			PM-701A		-			5kV		J	3/C #2 WITH #6 GND	375
C2	P-PM701AH	K-02			MCC-211		BA			PM-701AH		BA			600V		K	3/C #10 WITH #10 GND	375
	C-PM701B	K-01			MCC-212		BA			PM-701B		BA			600V		K	3/C #12 WITH #12 GND	375
C1	R-PM701BSR	EB			MCC-212		AB			PM-701B		AB			RTD		EB	8 TRIADS #16, IS & OS	375

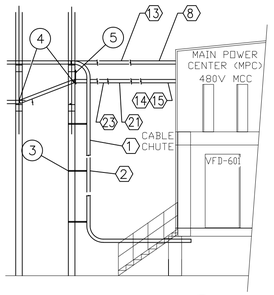
REV NO.	CABLE NO.	CABLE CODE	PROJECT PHASE	CABLE REEL NO.	FROM (SOURCE)					TO (USER)					CABLE DESCRIPTION				
					EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	INSUL VOLTAGE	RATED VOLTAGE	CABLE TYPE	NUMBER & SIZE OF CONDUCTORS	LENGTH (FEET)
C2	P-PM701B	J-01			MCC-212		-			PM-701B		-			5kV		J	3/C #2 WITH #6 GND	375
C2	P-PM701BH	K-02			MCC-212		BA			PM-701BH		BA			600V		K	3/C #10 WITH #10 GND	375
	C-PM730A	K-01			MCC-111		BA			PM-730A		BA			600V		K	3/C #12 WITH #12 GND	340
C1	R-PM730ASR	EB			MCC-111		AB			PM-730A		AB			RTD		EB	8 TRIADS #16, IS & OS	340
C2	P-PM730A	J-01			MCC-111		-			PM-730A		-			5kV		J	3/C #2 WITH #6 GND	340
C2	P-PM730AH	K-02			MCC-111		BA			PM-730AH		BA			600V		K	3/C #10 WITH #10 GND	340
	C-PM730B	K-01			MCC-112		BA			PM-730B		BA			600V		K	3/C #12 WITH #12 GND	340
C1	R-PM730BSR	EB			MCC-112		AB			PM-730B		AB			RTD		EB	8 TRIADS #16, IS & OS	340
C2	P-PM730B	J-01			MCC-112		-			PM-730B		-			5kV		J	3/C #2 WITH #6 GND	340
C2	P-PM730BH	K-02			MCC-112		BA			PM-730BH		BA			600V		K	3/C #10 WITH #10 GND	340
	P-PM601A	K-01			MCC-131		BA			PM-601A		BA			600V		K	3/C #12 WITH #12 GND	350
	C-PM601A	K-01			MCC-131		BA			PM-601A		BA			600V		K	3/C #12 WITH #12 GND	350
	P-PM601B	K-01			MCC-132		BA			PM-601B		BA			600V		K	3/C #12 WITH #12 GND	350
	C-PM601B	K-01			MCC-132		BA			PM-601B		BA			600V		K	3/C #12 WITH #12 GND	350
	P-PM710A	K-02			MCC-231		BA			PM-710A		BA			600V		K	3/C #10 WITH #10 GND	460
	C-PM710A	K-01			MCC-231		BA			PM-710A		BA			600V		K	3/C #12 WITH #12 GND	460
	P-PM710B	K-02			MCC-232		BA			PM-710B		BA			600V		K	3/C #10 WITH #10 GND	460
	C-PM710B	K-01			MCC-232		BA			PM-710B		BA			600V		K	3/C #12 WITH #12 GND	460
	P-PM711A	K-05			MCC-231		BB			PM-711A		BB			600V		K	3/C #6 WITH #8 GND	460
	C-PM711A	K-01			MCC-231		BA			PM-711A		BA			600V		K	3/C #12 WITH #12 GND	460
	P-PM711B	K-05			MCC-232		BB			PM-711B		BB			600V		K	3/C #6 WITH #8 GND	460
	C-PM711B	K-01			MCC-232		BA			PM-711B		BA			600V		K	3/C #12 WITH #12 GND	460
	P-MM104	K-02			MCC-231		BA			MM-104		BA			600V		K	3/C #10 WITH #10 GND	600
C2	C-MM104	K-02			MCC-231		BA			MM-104		BA			600V		K	3/C #10 WITH #10 GND	600
	P-MM104A	K-02			MCC-231		BA			MM-104A		BA			600V		K	3/C #10 WITH #10 GND	600
C2	C-MM104A	K-02			MCC-231		BA			MM-104A		BA			600V		K	3/C #10 WITH #10 GND	600
	P-MM104B	K-02			MCC-232		BA			MM-104B		BA			600V		K	3/C #10 WITH #10 GND	600
C2	C-MM104B	K-02			MCC-232		BA			MM-104B		BA			600V		K	3/C #10 WITH #10 GND	600

REV NO.	CABLE NO.	CABLE CODE	PROJECT PHASE	CABLE REEL NO.	FROM (SOURCE)					TO (USER)					CABLE DESCRIPTION				
					EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	INSUL VOLTAGE	RATED VOLTAGE	CABLE TYPE	NUMBER & SIZE OF CONDUCTORS	LENGTH (FEET)
	P-MM202	K-01			MCC-131		BA			MM-202		BA			600V		K	3/C #12 WITH #12 GND	600
C2	C-MM202	K-02			MCC-131		BA			MM-202		BA			600V		K	3/C #10 WITH #10 GND	600
	P-M202F2	K-05			MCC-132		BB			M-202F2		BB			600V		K	3/C #6 WITH #8 GND	600
C1	C-M202F2	K-05			MCC-132		BB			M-202F2		BB			600V		K	3/C #6 WITH #8 GND	600
	P-M401A	K-02			MCC-131		BA			M-401A		BA			600V		K	3/C #10 WITH #10 GND	350
	P-M401B	K-02			MCC-132		BA			M-401B		BA			600V		K	3/C #10 WITH #10 GND	350
	P-MM102A	K-02			MCC-231		BA			MM-102A		BA			600V		K	3/C #10 WITH #10 GND	600
C2	C-MM102A	K-02			MCC-231		BA			MM-102A		BA			600V		K	3/C #10 WITH #10 GND	600
	P-MM102B	K-02			MCC-231		BA			MM-102B		BA			600V		K	3/C #10 WITH #10 GND	600
C2	C-MM102B	K-02			MCC-231		BA			MM-102B		BA			600V		K	3/C #10 WITH #10 GND	600
	P-MM103	K-02			MCC-231		BA			MM-103		BA			600V		K	3/C #10 WITH #10 GND	600
C2	C-MM103	K-02			MCC-231		BA			MM-103		BA			600V		K	3/C #10 WITH #10 GND	600
	P-MM106AA	K-01			MCC-231		BA			MM-106AA		BA			600V		K	3/C #12 WITH #12 GND	950
C2	C-MM106AA	K-05			MCC-231		BB			MM-106AA		BB			600V		K	3/C #6 WITH #8 GND	950
	P-M106AMM001A	K-08			MCC-231		BC			M-106A-MM-001A		BC			600V		K	3/C #2 WITH #6 GND	950
C2	C-M106AMM001A	K-05			MCC-231		BB			M-106A-MM-001A		BB			600V		K	3/C #6 WITH #8 GND	950
	P-MM106B	K-01			MCC-231		BA			MM-106B		BA			600V		K	3/C #12 WITH #12 GND	950
C2	C-MM106B	K-05			MCC-231		BB			MM-106B		BB			600V		K	3/C #6 WITH #8 GND	950
	P-MM106BA	K-01			MCC-231		BA			MM-106BA		BA			600V		K	3/C #12 WITH #12 GND	950
C2	C-MM106BA	K-05			MCC-231		BB			MM-106BA		BB			600V		K	3/C #6 WITH #8 GND	950
	P-M106BMM001A	K-08			MCC-231		BC			M-106B-MM-001A		BC			600V		K	3/C #2 WITH #6 GND	950
C2	C-M106BMM001A	K-05			MCC-231		BB			M-106B-MM-001A		BB			600V		K	3/C #6 WITH #8 GND	950
	P-MM106AB	K-01			MCC-232		BA			MM-106AB		BA			600V		K	3/C #12 WITH #12 GND	950
C2	C-MM106AB	K-05			MCC-232		BB			MM-106AB		BB			600V		K	3/C #6 WITH #8 GND	950
	P-M106AMM001B	K-08			MCC-232		BC			M-106A-MM-001B		BC			600V		K	3/C #2 WITH #6 GND	950
C2	C-M106AMM001B	K-05			MCC-232		BB			M-106A-MM-001B		BB			600V		K	3/C #6 WITH #8 GND	950
	P-MM106BB	K-01			MCC-232		BA			MM-106BB		BA			600V		K	3/C #12 WITH #12 GND	950
C2	C-MM106BB	K-05			MCC-232		BB			MM-106BB		BB			600V		K	3/C #6 WITH #8 GND	950

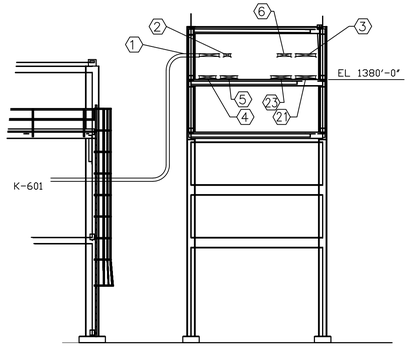
REV NO.	CABLE NO.	CABLE CODE	PROJECT PHASE	CABLE REEL NO.	FROM (SOURCE)					TO (USER)					CABLE DESCRIPTION				
					EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	INSUL VOLTAGE	RATED VOLTAGE	CABLE TYPE	NUMBER & SIZE OF CONDUCTORS	LENGTH (FEET)
	P-M106BMM001B	K-08			MCC-232		BC			M-106B-MM-001B		BC			600V		K	3/C #2 WITH #6 GND	950
C2	C-M106BMM001B	K-05			MCC-232		BB			M-106B-MM-001B		BB			600V		K	3/C #6 WITH #8 GND	950
	P-M701AMM001	K-09			MCC-231		BD			M-701A-MM-001		BD			600V		K	3/C #2/0 WITH #6 GND	575
C2	C-M701AMM001	K-02			MCC-231		BA			M-701A-MM-001		BA			600V		K	3/C #10 WITH #10 GND	575
C2	P-M701AMM001SH	K-02			MCC-231		BA			M-701A-MM-001H		BA			600V		K	3/C #10 WITH #10 GND	575
	P-MPCWR131	K-09			MCC-131		BD			WR-131		BD			600V		K	3/C #2/0 WITH #6 GND	180
	P-MPCWR132	K-05			MCC-132		BB			WR-132		BB			600V		K	3/C #6 WITH #8 GND	300
	P-MPCWR133	K-09			MCC-131		BD			WR-133		BD			600V		K	3/C #2/0 WITH #6 GND	320
	P-APCWR231	K-09			MCC-231		BD			WR-231		BD			600V		K	3/C #2/0 WITH #6 GND	125
	P-APCWR232	K-09			MCC-232		BD			WR-232		BD			600V		K	3/C #2/0 WITH #6 GND	200
	P-APCWR233	K-09			MCC-231		BD			WR-233		BD			600V		K	3/C #2/0 WITH #6 GND	325
	P-HP231	K-07			MCC-231		BB			HP-231		BB			600V		K	3/C #4 WITH #8 GND	230
	P-PP143	K-05			MCC-131		BB			PP-143		BB			600V		K	3/C #6 WITH #8 GND	200
	P-PP144	K-05			MCC-131		BB			PP-144		BB			600V		K	3/C #6 WITH #8 GND	375
C2	CT-KM301	C-03			SWGR-110		-			KM-301		-			600V		C	1/C #10	300
C2	CT-KM301	C-03			SWGR-110		-			KM-301		-			600V		C	1/C #10	300
C2	CT-KM301	C-03			SWGR-110		-			KM-301		-			600V		C	1/C #10	300
C2	CT-KM301	C-03			SWGR-110		-			KM-301		-			600V		C	1/C #10	300
C2	CT-KM201	C-03			VFD-201		-			KM-201		-			600V		C	1/C #10	625
C2	CT-KM201	C-03			VFD-201		-			KM-201		-			600V		C	1/C #10	625
C2	CT-KM201	C-03			VFD-201		-			KM-201		-			600V		C	1/C #10	625
C2	CT-KM201	C-03			VFD-201		-			KM-201		-			600V		C	1/C #10	625
C2	CT-KM601	C-03			VFD-601		-			KM-601		-			600V		C	1/C #10	310
C2	CT-KM601	C-03			VFD-601		-			KM-601		-			600V		C	1/C #10	310
C2	CT-KM601	C-03			VFD-601		-			KM-601		-			600V		C	1/C #10	310
C2	CT-KM601	C-03			VFD-601		-			KM-601		-			600V		C	1/C #10	310
C2	C-KM201	L-10			SWGR-100		BC			KM-201		BC			600V		L	12/C #10	625
C2	C-K601CP1	L-04			MCC-131	13M	BB			K-601-CP		BB			600V		L	12/C #12	310
C2	C-K601CP2	L-03			MCC-132	9M	BA			K-601-CP		BA			600V		L	7/C #12	310

REV NO.	CABLE NO.	CABLE CODE	PROJECT PHASE	CABLE REEL NO.	FROM (SOURCE)					TO (USER)					CABLE DESCRIPTION				
					EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	EQUIP NO.	CUBICLE OR DEVICE	CABLE GLAND	ASSY NO.	PLAN DWG	INSUL VOLTAGE	RATED VOLTAGE	CABLE TYPE	NUMBER & SIZE OF CONDUCTORS	LENGTH (FEET)
C2	C-M720CP1	L-05			MCC-231	23M	BC			M-720-CP		BC			600V		L	19/C #12	475
C2	C-M720CP2	L-03			MCC-232	15M	BA			M-720-CP		BA			600V		L	7/C #12	475
C2	C-K201E001	L-08			MCC-131		BA			K-201-E-001		BA			600V		L	5/C #10	625
C2	C-K301E001	L-02			MCC-131		BA			K-301-E-001		BA			600V		L	5/C #12	300
C2	C-M602E101	L-02			MCC-131		BA			M-602-E-101		BA			600V		L	5/C #12	200
C2	C-M710E001	L-02			MCC-231		BA			M-710-E-001		BA			600V		L	5/C #12	425
C2	C-M711E002	L-02			MCC-231		BA			M-711-E-002		BA			600V		L	5/C #12	250
C2	C-M711E001	L-02			MCC-231		BA			M-711-E-001		BA			600V		L	5/C #12	250
C2	C-M711PM011	K-01			MCC-231		BA			M-711-PM-011		BA			600V		K	3/C #12 WITH #12 GND	250
C2	C-M711PM001A	K-01			MCC-231		BA			M-711-PM-001A		BA			600V		K	3/C #12 WITH #12 GND	250
C2	C-M711PM001B	K-01			MCC-231		BA			M-711-PM-001B		BA			600V		K	3/C #12 WITH #12 GND	250
C2	P-IP141	K-02			MCC-131		BA			IP-141		BA			600V		K	3/C #10 WITH #10 GND	400
C2	P-IP143	K-02			MCC-131		BA			IP-143		BA			600V		K	3/C #10 WITH #10 GND	400
C2	P-HP131	K-07			MCC-131		BB			HP-131		BB			600V		K	3/C #4 WITH #8 GND	250
C2	P-C201ELCAR	K-05			PP-141		BB			C-201-ELCAR		BB			600V		K	3/C #6 WITH #8 GND	300
C2	P-C201ELPIT	K-07			PP-141		BB			C-201-ELPIT		BB			600V		K	3/C #4 WITH #8 GND	300
C2	P-C201CEMS	K-02			UPS-141		BA			C-201-CEMS		BA			600V		K	3/C #10 WITH #10 GND	300
C2	P-IP142	K-02			MCC-132		BA			IP-142		BA			600V		K	3/C #10 WITH #10 GND	400
C2	P-IP144	K-02			MCC-132		BA			IP-144		BA			600V		K	3/C #10 WITH #10 GND	400
C2	P-HP231	K-07			MCC-231		BB			HP-231		BB			600V		K	3/C #4 WITH #8 GND	250
C2	P-IP241	K-02			MCC-231		BA			IP-241		BA			600V		K	3/C #10 WITH #10 GND	400
C2	P-IP243	K-02			MCC-231		BA			IP-243		BA			600V		K	3/C #10 WITH #10 GND	400
C2	P-IP242	K-02			MCC-232		BA			IP-242		BA			600V		K	3/C #10 WITH #10 GND	400

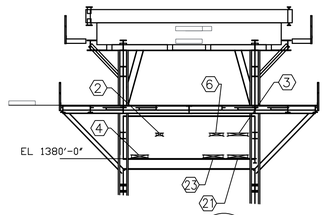
Attachment 11 – Cable Tray Routing Drawings



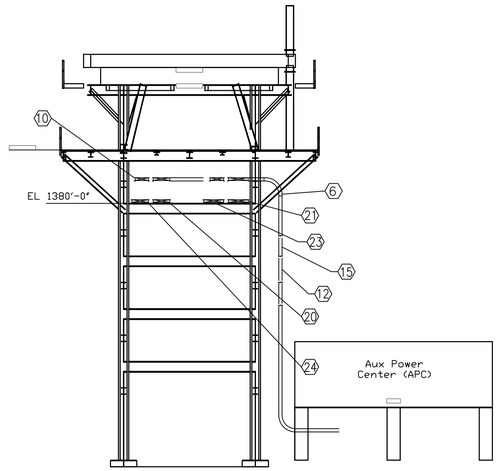
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NTS LOOKING SOUTH
EH-35R-CCU1-E071



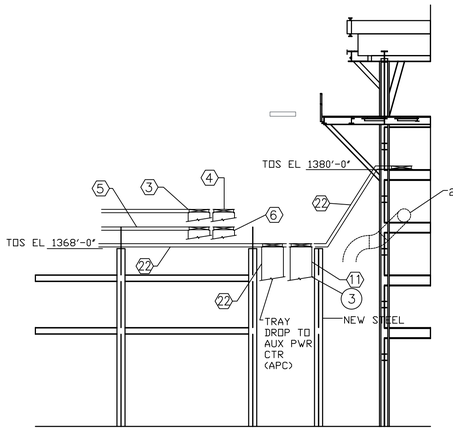
SECTION B
NTS LOOKING EAST
EH-35R-CCU1-E072



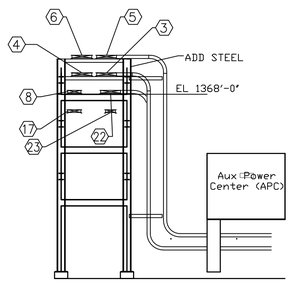
SECTION C
LOOKING EAST
EH-35R-CCU1-E072



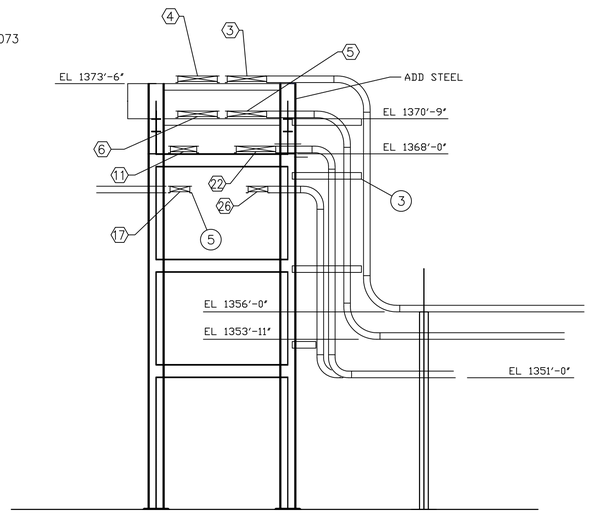
SECTION D
NTS LOOKING EAST
EH-35R-CCU1-E073



SECTION E
LOOKING WEST
EH-35R-CCU1-E073



SECTION F
LOOKING NORTH
EH-35R-CCU1-E073



SECTION G
LOOKING NORTH
EH-35R-CCU1-E073

TRAY MATERIALS LEGEND

1	DOUBLE TRAY GROUND	*ET142A
2	TRAY HOLD DOWN CLAMP	*ET021A
3	VERTICAL CABLE TRAY SUPPORT	*ET063A
4	VERTICAL ADJUSTABLE SPLICE PLATE	*ET121A
5	CABLE TRAY TRAPEZE SUPPORT FROM STRUCTURAL STEEL	*ET002A

NOTES:

1. FOR ELECTRICAL GENERAL NOTES, REFER TO ELK HILLS DRAWING #E-0530
2. THE MAXIMUM DISTANCE BETWEEN CABLE TRAY SUPPORT SHALL BE 10 FEET UNLESS OTHERWISE SPECIFIED
3. CABLE TRAY NUMBERS REPEAT ACROSS DRAWINGS. BUT MAY HAVE DIFFERENT SIZES SHOWN.

CABLE TRAY LEGEND

NO.	TRAY #	SIZE
1	13.8KV1	36"
2	13.8KV2	12"
3	4160V1	36"
4	4160V2	36"
5	4160V3	30"
6	4160V4	30"
7	4160V5	24"
8	4160V6	30"
9	4160V7	24"
10	4160V8	12"
11	480V1	12"
12	480V2	30"
13	480V3	30"
14	480V4	30"
15	480V5	30"
16	480V6	12"
17	480V7	12"
18	480V8	12"
19	480V9	12"
20	480V10	36"
21	CS1	36"
22	CS2	36"
23	RTD	36"
24	480V11	12"
25	480V12	12"
26	RTD2	12"

FLUOR

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED	9/17/20	SL	SL	GN	NP	PC
B	NOT USED						
A	ISSUED FOR INTERNAL REVIEW AFE: WELL:	9/1/20	SL	SL	GN	NP	PC

REVISIONS | APPROVALS

PLOT TIME CAD NO. EH-35R-CCU1-E070.dwg

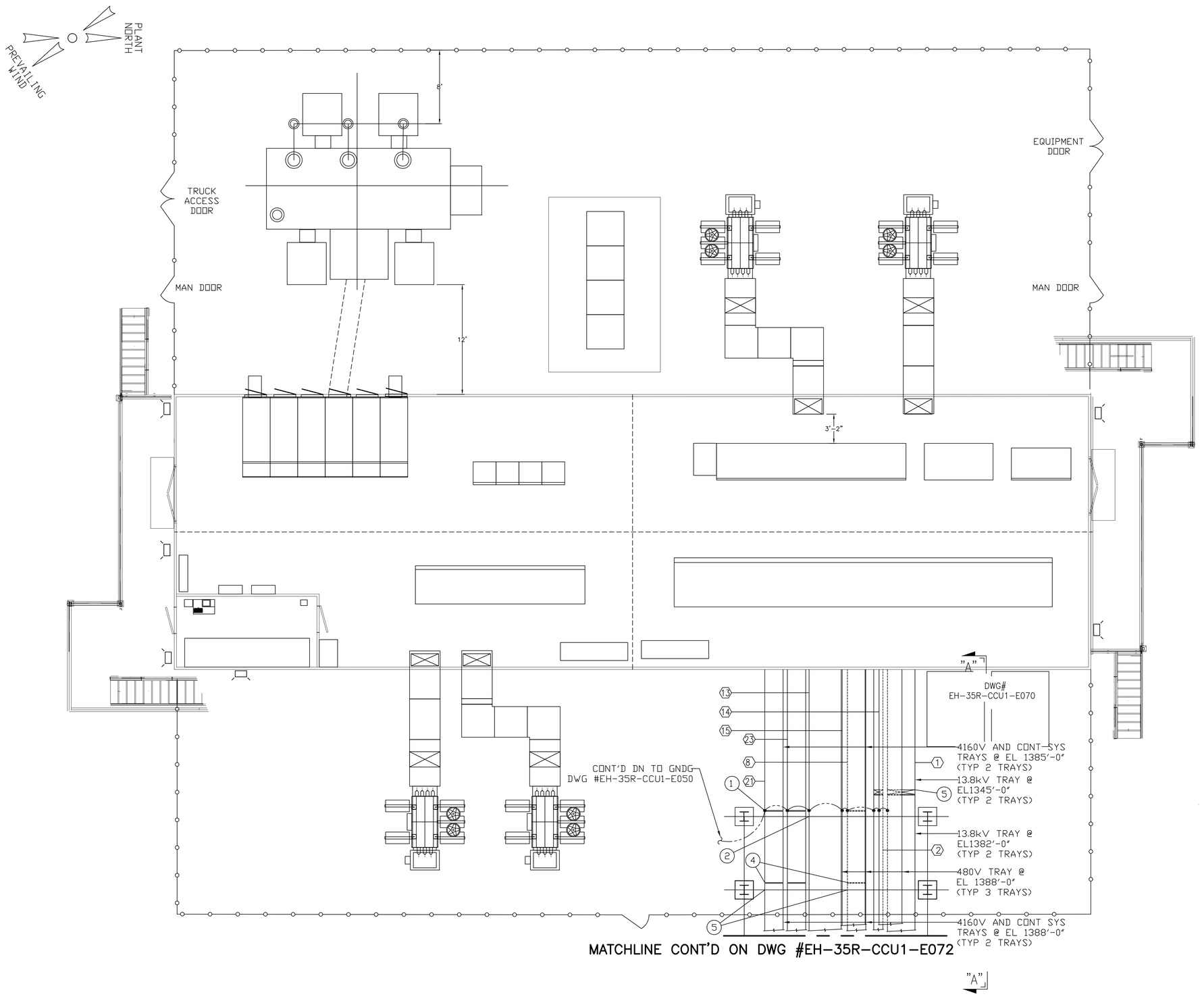
PLOT DATE

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S / R.23E
CARBON CAPTURE UNIT 1
SECTIONS AND DETAILS
ELECTRICAL CABLE TRAY

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-E070	1 OF 1	C	NONE



NOTES:

1. FOR ELECTRICAL GENERAL NOTES, REFER TO ELK HILLS DRAWING #E-0530
2. THE MAXIMUM DISTANCE BETWEEN CABLE TRAY SUPPORT SHALL BE 10 FEET UNLESS OTHERWISE SPECIFIED

CABLE TRAY LEGEND

NO.	TRAY #	SIZE
1	13.8KV1	36"
2	13.8KV2	12"
8	4160V6	30"
13	480V3	30"
14	480V4	24"
15	480V5	30"
21	CS1	36"
23	RTD	12"

TRAY MATERIALS LEGEND

1	DOUBLE TRAY GROUND	*ET142A	ONE PER TRAY PIECE
2	TRAY HOLD DOWN CLAMP	*ET021A	6
3	VERTICAL CABLE TRAY SUPPORT	*ET063A	6
4	VERTICAL ADJUSTABLE SPLICE PLATE	*ET121A	4
5	CABLE TRAY TRAPEZE SUPPORT FROM STRUCTURAL STEEL	*ET002A	4

FLUOR®

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	ISSUED FOR FEED AFE: WELL:	9/17/20	SL	SL	GN	NP	PC
B	NOT USED AFE: WELL:						
A	ISSUED FOR INTERNAL REVIEW AFE: WELL:	8/25/20	SL	GN	SL	NP	PC

REVISIONS | APPROVALS

ELK HILLS OPERATION

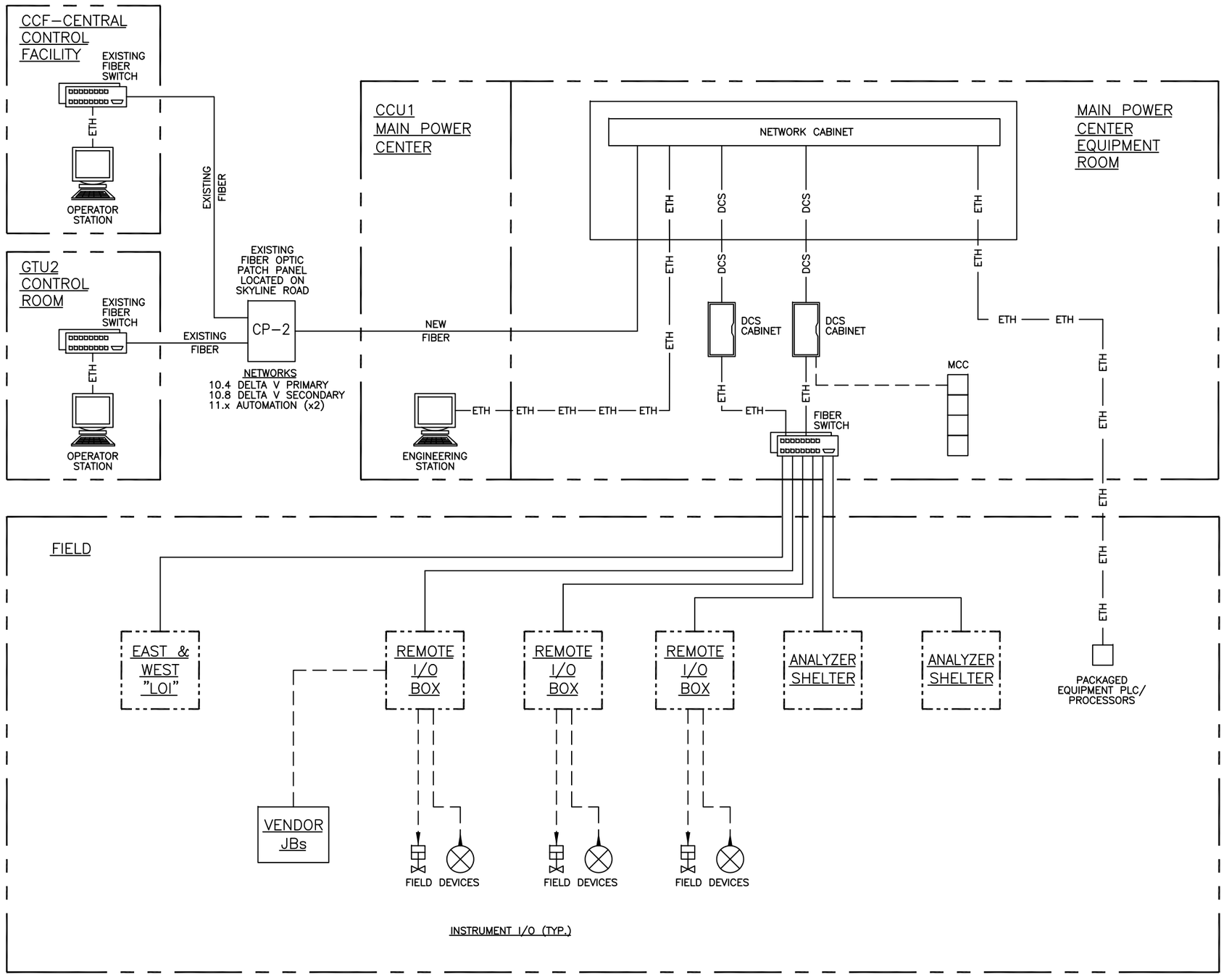
CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S / R.23E
CARBON CAPTURE UNIT 1 (CCU1)
MAIN POWER CENTER (MPC)
EXTERIOR CABLE TRAY ROUTING

DRAWING No.	SHEET	REV.	SCALE
EH-35R-CCU1-E071	1 OF 1	C	1/8"=1'-0"

PLOT DATE
PLOT TIME CAD NO. EH-35R-CCU1-E071.dwg

Attachment 12 – Network Architecture Drawing



LEGEND:

- DCS — DISTRIBUTED CONTROL SYSTEM
- ETH — ETHERNET
- FIBER OPTIC
- FIELD HARD WIRING

FLUOR.

REV No.	DESCRIPTION	DATE	DRAFTER	DSNR/ENG	QC	PROJECT ENG	TEAM LEAD
C	IFF – ISSUED FOR FEED	7/20/20	DVH	DM		NP	
B	NOT USED						
A	IFR – ISSUED FOR REVIEW AFE: WELL:	7/16/20	DVH	DM		NP	

REVISIONS | APPROVALS

ELK HILLS OPERATION

CALIFORNIA RESOURCES CORPORATION

SECTION 35R, T.30S/R.23E
CARBON CAPTURE UNIT No. 1
INSTRUMENTATION
NETWORK ARCHITECTURE

DRAWING No.	SHEET	REV.	SCALE
EH–35R–CCU1–E002		C	NONE

CAD NO. EH–35R–CCU1–E002.dwg
PLOT TIME
PLOT DATE

Attachment 13 – Fire Protection Design Basis

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

Fire Protection Design Basis

Document No. EH-35R-CCU1-DBD-653-00001

C2	14-July-2020	Re-issued for FEED	8	SD	OS	NP	
C1	13-May-2020	Re-issued for FEED	7	SD	OS	NP	
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C	01-May-2020	Issued for FEED
C1	13-May-2020	Re-issued for FEED (See Client Comments dated 5/12/2020. In Section 5.3 added requirement for isolation valve to be located at each gate valve per NFPA 24)
C2	14-July-2020	Re-issued for FEED (Added in Section 5.1 and 5.6 CO2 gas detectors. Changed in Section 5.3 description of firewater arrangement and updated from ductile iron material to HDPE).

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1.0 INTRODUCTION

California Resources Corporation (CRC) is California's largest natural gas and NGL producer. CRC owns and operates the Elk Hills oil and gas field along with the Elk Hills Power Plant (EHPP), a 550 MW cogeneration facility located in Tupman, California. EHPP consists of two General Electric 7FA gas turbines along with a General Electric D-11 steam turbine. To sustain production from the depleting oil fields, CRC is considering capturing and compressing CO_2 from the flue gas produced at EHPP, with the compressed CO_2 to be injected into the oil fields for enhanced oil recovery.

CRC has engaged Fluor to conduct a FEED for a new CO_2 capture and compression unit using Fluor's proprietary Econamine FG PlusSM (EFG+) CO_2 recovery technology. The unit shall be designed to recover 4,000 metric tonnes per day (MTPD) of CO_2 from the flue gases produced by the two existing GE combustion turbine generators (CTGs), along with flue gas produced by a new boiler that is required to produce the necessary steam for the EFG+ unit.

This document describes the associated Fire Protection Basis of Design. This document is developed to consolidate the fire protection and detection review carried out during FEED, including the sketches and fire water demand calculation. This document will form the basis for any future work done on the firewater system during next phase. This document will be further updated during Detail Design of the project.

2.0 SCOPE

The Fire Protection Design Basis discuss the following items:

- Fire water underground main, fire hydrants
- Passive Fire Protection
- Fire Alarm System and Gas Detectors
- Fire Extinguishers
- Eyewash Safety Showers

3.0 IDENTIFIED HAZARDS

The above mentioned FEED scope involves review from the Process Design Basis involving any potential flammable hydrocarbon liquids and gases.

The fire risk in this new unit is low due to no known flammable hydrocarbons being processed. The remaining fire hazards are:

- A presence of combustibles with high flash points such as lube oil for the CO_2 Product Compressors.
- Natural gas is used as fuel in the steam boiler package.

The majority of the other type of chemicals in this unit are either caustic or acidic.

4.0 REGULATIONS, STANDARDS AND PROJECT SPECIFICATIONS

4.1 Standards & Codes

California Fire Code
Section 12. Chapter 17.32, Title 17 of the Ordinance Code of the County of Kern
ANSI Z358.1 – Emergency Showers and Eyewash Stations
API 2218 Fire Proofing Practices in Petroleum and Petrochemical Processing Plants
NFPA 10 Standard for Portable Fire Extinguishers
NFPA 24 Standard for the Installation of Private Service Mains and Their appurtenances
NFPA 70 National Electric Code
NFPA 72 National Fire Alarms and Signaling Code
NFPA 1961 Standard on Fire Hose
Factory Mutual (FM) Guide
Underwriters Laboratories (UL) Fire Protection Equipment Directory

4.2 Project Specifications

ELKH-1-TS-10522	Fire Extinguishers
ELKH-1-TS-16721	Fire Alarm Systems
PPSD-1-LS-12F5-1	Piping Line Specification
174127-35R-CGP1-ME-SP-16400	Fire Protection Materials
174127-35R-CGP1-SE-SP- 000000	Fire Protection

4.3 Project Drawings

EH-35R-CCU1-P001	Rev.A	California Resources Corp. Capture Unit 1 Plot Plan Grade

5.0 FIRE PROTECTION AND SAFETY REQUIREMENTS

5.1 General

The objective is to minimize personnel injury, equipment damage and avoid escalation in the event of a major fire. The Fire Protection System shall protect all structures and equipment that are critical to life safety, as well as enclosures housing critical systems, equipment or services.

The fire risk in this new unit is low due to no known flammable hydrocarbons being processed. The majority of the other type of chemicals in this unit are either caustic or acidic.

The Fire Protection System will include the following:

- Confirmation of Active Fire Protection consisting of hydrants for the new unit.
- Confirmation that no Passive Fire Protection is required.
- Confirmation of a Fire Alarm Detection System required in the new MCC Building and CO2 detectors are required for the CO2 Compressor K-601.

Portable Fire Extinguishers will be provided as required.

New Eye Wash Safety Showers (EWSS) to be reviewed and provided where required.

5.2 Firewater Demand

The new UG fire water loop pipe sizing was based upon maximum fire water demand of 1,500 gpm with three (3) new hydrants operating at 500 gpm with two (2) 2 ½ hoses operating at 250 gpm each.

The design pressure for the underground main shall not exceed 165 psi according to the fire pump main relief valve setting for fire pump 572-P-9001 as shown on Fire Water P&ID ELKH-1-DW-572-302-001.

This new unit fire water demand is not exceeding the current plant wide worst case demand and is within the capacity being supplied from the Elk Hills Power Plant fire water pumps.

5.3 Firewater Distribution System

The new CO2 Capture and Compression Unit will require a 10” firewater loop routed around and along the new roadway on the north, west, and south side, with a new 12” tee connection coming from the power plant 12” supply, with the continuation of a 12” firewater loop routed around the NE corner along the roadway on the east side and then around the other half of the south side of the Unit. One additional 10” tee connection on the south side between the 10” and 12” new piping will be feeding the existing 10” firewater supply line going to LTS1 and LTS2 Units.

All new underground firewater material shall be high density polyethylene (HDPE) DR11, Class 200 piping UL listed or FM approved for firewater service.

Much of the existing firewater loop from the previous unit has been taken out of service. There is a remaining partial outer loop consisting of 6” and 8” piping, some of which is located on the north side in a piperack that is going to be taken out of service during construction. This existing piping is all Class 150 carbon steel.

Velocity will be kept under 15 fps with minor friction losses allowed throughout the underground piping system.

Post indicator valves (PIV) shall be provided at junction points and within loop mains to isolated no more than five (5) system users (hydrants).

The underground firewater distribution system shall be designed and installed in accordance with NFPA 24 requirements.

5.4 Firewater Hydrants

Fire hydrants will be located on all four (4) sides of the unit spaced approximately 330 ft. apart. The fire hydrants are required to be located a minimum of 50 ft. away from the equipment being protected.

All hydrants shall be dry barrel type equipped with two (2) 2 ½” NST hose outlets and (1) 4” NST hose connection. Hydrants shall comply with NFPA 24 and listed or approved for firewater service.

The minimum residual pressure at hydrant and monitor inlets shall be 100 psig.

A NRS gate valve with T handle operation shall be supplied at each hydrant branch line as required by NFPA 24.

See Attachment 01 for location of the hydrants, PIVs and firewater piping.

5.5 Fire Hazard Area and Fireproofing

Fire hazards due to potential hydrocarbon pool fires were evaluated in accordance with API 2218 with no fireproofing required due to the low fire potential in the unit. The fire risk is low due to no known flammable liquid hydrocarbons, and no known combustibles with low flash points.

5.6 Fire Alarm and Detection System

An addressable fire alarm panel shall be installed in the MCC Electrical Building protected with smoke detection and manual fire alarm system designed and installed in accordance with NFPA 72 and Fire Alarm System Specification ELKH-1-TS-16721.

A total of four (4) CO2 infrared gas detectors will be located around the new K-601 CO2 Compressor and will be tied into the plant fire and gas detection system. An audible horn and visual strobe unit will be located near the compressor mounted in an unobstructed visible location operated by the fire and gas detection panel.

5.7 Fire Extinguishers

Portable 20lb dry chemical (Model 4020) fire extinguisher for Class 20A:120B:C fires shall be located around the new unit and inside the new MCC transformer yard.

At least one (1) Class 10B:C carbon dioxide (Model 4415) fire extinguisher shall be placed inside the entrance door of motor control center for Class C fires.

Portable fire extinguishers shall be UL listed or FM approved.

All fire extinguishers shall be located throughout the unit in accordance with NFPA 10 and Fire Extinguishing Specification ELKH-1-TS-10522.

5.8 Eyewash Safety Shower (EWSS)

EWSS combinations are required at locations where operators can be exposed to hazardous materials during operations and maintenance activities. Examples are:

- Sampling of corrosive fluids
- Equipment maintenance in corrosive service, such as pumps and heat exchangers
- Loading/unloading operations of hazardous materials through hoses or drums.

The maximum travel distance to a EWSS from a work location involving exposure to hazardous materials shall not be more than 50 ft., not involve any change in elevation and be free of obstructions such as doors. The design of the EWSS shall be done in accordance with ANSI Z358.1.

Electrical heat tracing will be installed for the aboveground portion for potential freezing condition.

A Scald Protection Valve (95-105°F) and Over Pressure Protection devices for personal safety to be provided by EWSS vendor.

The location of new EWSS will be validated during the plot plan review.

Attachment 14 – Firefighting Equipment Specification

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

Firefighting Equipment Specification

Document No. EH-35R-CCU1-SPC-653-00001

C	30-July-2020	Issued for FEED	12	SD	OS	NP	
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1.0 GENERAL

1.1 This specification, in conjunction with the listed documents, defines the requirements for design, material, fabrication, testing, painting and preparation for shipment of the items listed in section 6 and 7 of this document.

1.2 Compliance by the manufacturer with the provisions of this specification does not relieve the Buyer or its Supplier of the responsibility of furnishing equipment of proper design, mechanically suited to meet operating guarantees at the specified service conditions, and compliance with applicable code.

1.3 All firefighting equipment shall be UL listed or FM approved.

1.4 Site dry bulb temperatures, extreme high/low: 115°F / 20°F.

1.5 Buyer through its Supplier shall retain responsibility for guarantee statements and shall also review and be responsible for all design calculations. Calculations provided by a sub-supplier or sub-vendor shall be reviewed and marked approved by Buyer prior to submittal to Company for review.

1.6 Company shall not be responsible for searching out deviations in the Buyer's or their Supplier's drawings.

1.7 It is the responsibility of the Buyer to ensure that his completed work, and that of their suppliers, conforms in all respect with these documents and all referenced documents, as well as any rules or regulations specified.

1.8 Buyer shall submit all data required by the Purchase Order documents for review and acceptance by Company.

1.9 It is imperative that the Buyer or Supplier submit all required drawings and design documents in accordance to the "Supplier Drawing & Data Commitment, (SDDC)"provided by the Company.

1.10 All Codes and Standards referenced herein shall be to the latest editions and addenda. The most stringent conditions shall govern between the latest editions and the specifications, unless otherwise specified.

1.11 All materials must be traceable to country of origin. Buyer or Supplier shall provide names of manufacturers and countries of origin for all items of supply.

1.12 The equipment shall be the Supplier's standard design as much as possible except where specified otherwise herein and shall include all necessary accessories, system design, fabrication, and component assembly to provide reliable operation and ease of access for cleaning and maintenance. The equipment shall be suitable for installation in an outdoor environment.

1.13 Fabrication is to be in accordance with manufacturer's standard shop practices and recognized industry practices.

1.14 All painting and/or protective coating system shall be in accordance with the paint specification, unless the manufacturer's process is equal or better.

2.0 OBJECTIVE

2.1 The purpose of this document is to determine the requirements of Fire Fighting Equipment including fire hydrants, firewater monitors, post indicator and isolation valves that are to be used to complete the underground Firewater piping systems for the CO2 Capture from Elk Hills Power Plant Project located in Tupman, California.

3.0 DEFINITIONS

3.1 "Approved Equal" shall mean a product approved by the Company as equal to the product specified in this specification.

3.2 "Company" shall mean Fluor Enterprises, Inc.

3.3 "Buyer" shall mean the Site Prep Contractor.

3.4 "Manufacturer" shall mean the manufacturer of the specified equipment.

3.5 "Supplier" shall mean fabricator and/or supplier of manufactured firefighting equipment and PIV valves.

3.6 "Workshop" shall mean any location including offices, premises and workshops where any equipment, materials, manufactured items shall be engineered, manufactured and assembled.

4.0 REGULATIONS, STANDARDS AND PROJECT SPECIFICATIONS

4.1 Standards & Codes

California Fire Code 2019 Edition

Section 12. Chapter 17.32, Title 17 of the Ordinance Code of the County of Kern

NFPA-10	2018 Edition: Standard for Portable Fire Extinguishers
NFPA-24	2019 Edition: Installation of Private Fire Service Mains & Their Appurtenances
NFPA-25	2020 Edition: Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems
NFPA-1963	2019 Edition: Fire Hose Connection
NSF/ANSI 61	Drinking Water System Components
NSF/ANSI 372	Drinking Water System Components – Lead Content
UL	Underwriters Laboratories Listing Directory
FM	Factory Mutual Approval Guides

4.2 Project Specifications

ELKH-1-TS-10522	Fire Extinguishers
PPSD-1-LS-12F5-1	Piping Line Specification
174127-35R-CGP1-ME-SP-16400	Fire Protection Materials
174127-35R-CGP1-SE-SP- 000000	Fire Protection

4.3 Project Drawings

SK-50-001 Rev.0	California Resources Corp. Elk Hills CO2 Recover Project Plot Plan Grade

5.0 SCOPE OF SUPPLY

5.1 The type and size of the miscellaneous firefighting equipment is described herein with the quantity specified.

5.2 The scope of supply shall consist of, but not limited to the following:

- Provision of equipment according to the requirements of this specification, requisition, codes and standards listed in this specification
- All equipment shall be UL Listed or FM Approved
- External painting, surface protection and insulation, as required
- Shop testing and inspection
- Preservation and protection
- Packing and marking for shipment
- Documentation as per the SDDC
- All necessary bolts, nuts, washers, flanges, gaskets and any other necessary attachments to provide a complete firefighting unit
- Special tools required for installation and maintenance
- Spare parts, for commissioning, start-up and insurance (if any)
- Mechanical and performance guarantees
- Operating and maintenance procedures

Supplier shall be responsible for all equipment in accordance with the supplier data schedule agreed with the Contractor at the inquiry stage.

6.0 EQUIPMENT TO BE SHIPPED

6.1 Bill of Quantities

6.2 Table 01 – Hydrants

Item No.	Description	Quantity	Depth Trench
1	Fire Hydrant	6	**4'-0" TBD**

6.2 Table 02 – Post Indicator Valve (PIV)

Item No.	Description	Quantity	Depth Trench
2	10" Post Indicator Valve	2	**4'-0" TBD**
2	12" Post Indicator Valve	2	**4'-0" TBD**

6.3 Table 03 – Isolation Valve

Item No.	Description	Quantity
3	6" NRS Gate Valve	6

6.4 Table 04 – Fire Extinguishers

Item No.	Description	Quantity
4	Dry Chemical Portable Extinguisher for Class B & C Fires 9 kg (20 Lbs)	**4**

7.0 EQUIPMENT DESCRIPTION

7.1 The Supplier's minimum scope of supply shall include, but not be limited to, design, material, manufacture, shop assembly, testing, spare parts, corrosion protection, identification, packing for shipment and delivery to a nominated delivery point. The equipment shall be in complete compliance with the attached drawings, specifications and requirements listed below.

Item No.	Description	Quantity
1	**CLOW Model 850 Fire Hydrant, or Equivalent Manufacturer** UL Listed / FM Approved. Per AWWA C503 6" Main Valve at 200 psi Water Working Pressure 304 stainless steel exterior bolting. 6" 125 lbs. flat face flange 90^0 elbow type base type inlet connection with 250/125 lbs. flat face flange drilling per ANSI B.16 class 125. Two (2) 2-1/2" male NST hose nozzles. One (1) 4" male NST pumper nozzle. All nozzles are furnished with caps and chains. Below ground section given two (2) coats of special black asphaltum paint. Above ground exterior section painted with grade enamel (color safety red) per Clow control's standard paint system.	**6**

2	**AFC- Model IP16 Post Indicator, or Equivalent Manufacturer** "OPEN-SHUT" indicator post that is UL Listed and FM Approved for use with 3"-24" gate valves. Features -Easy adjustable and corrosion preventative stainless steel and bronze construction target carrier system -Stainless steel operating nut and bronze target plate carrier -Aluminum target plate with stamped valve size for easy adjustment of target sign to match valve size -Telescopic design of metal construction -Iron head, iron support pipe, steel extension pipe -Upper and lower telescopic steel rods -UL Listed and FM Approved -No plastic components in target system or barrel assembly -Guide stop/tube collar for target accessibility and keeps internal components clean. Benefits OPEN-SHUT Indication System Removal of the post head exposes the target carry system for the "OPEN" and "SHUT" signs. The sliding SHUT target sign is easily adjusted to a corresponding valve size stamped on the aluminum target plate. Preventative Dissimilar Metal Corrosion The threaded components making up the indicating system consist of a stainless steel operating nut and a bronze target plate carrier to prevent dissimilar metal corrosion. The target plate which carries the OPEN-SHUT signs without any loading shall be aluminum. No plastic components are used. Telescopic Barrel and Rod Design of All Metal Construction. The indicator post has a telescopic design that allows extension capabilities of 22" increased height for the barrel and rod from the minimum collapsed position. Support or extension piping for the indicator post assembly consists of an outside iron support pipe and an internal steel adjustment pipe. The upper rod is a solid 1" square steel rod with telescoping lower rod using square steel tubing. No plastic components are used. Guide Stop / Tube Collar Rod is center drilled and pinned with a cotter pin that rests on a guide stop/tube collar which allows easy access to the operating nut and targets without the rod assembly or target assembly dropping into the	5

	lower section of the post assembly. The guide stop also serves to catch debris from entering the barrel section.	
3	**6" AFC-Series 2500 Resilient Wedge Gate Valve with Indicator Plate, or Equivalent Manufacturer** Valves 3"-24" in size shall be of a resilient wedge design and be provided with an indicator plate. The mounting dimensions on the plate shall comply with UL Standard 789 and exhibit a 10 ½" bolt circle. The valve shall have cold water rated working pressure of 250 psig. All cast ferrous components shall be ductile iron and shall be manufactured in compliance with the latest edition of ANSI/AWWA C515. The valve shall also be UL Listed and FM Approved in applicable configurations. The valve design shall be lightweight, easy to handle, and constructed with wall thickness per Table 2 of ANSI/AWWA C515. Heavy wall and/or cast gray-iron bodies are not acceptable. The valve shall have a smooth and oversize waterway and have the marking "D.I." or "Ductile Iron" cast on the body. The valve wedge shall be constructed of ductile iron and provided with protective wedge guide covers in sizes 4"-24". All wedges 3" and smaller shall be constructed of bronze. All wedges shall be encapsulated with EPDM rubber. The valve shall be provided with a 2" square wrench nut. The valve shall be Certified to NSF 61-G, or NSF 372, as applicable. Valve stems shall be sealed by three O-rings. Two of the O-rings shall reside above the thrust collar. The upper two O-rings shall be replaceable under full working pressure and with the valve in the full open position. O-rings set in a cartridge shall not be allowed. The valve shall also be equipped with thrust washers above and below the stem thrust collar for reduction of operating torque. All exterior valve body bolting shall be Type 304 stainless steel and shall be provided with hexagonal heads, with dimensions conforming to ANSI B18.2.1. Metric size and/or socket head cap screws or bolts, are not allowed. The operating nut shall be 2" square and shall be constructed of ductile iron fitted to a square tapered stem to help ensure even valve operating input torque. All body gaskets shall be of the pressure energized O-ring style design.	**6**

	All internal and external ferrous surfaces of the valve body and bonnet shall have a fusion-bonded epoxy coating, complying with ANSI/AWWA C550. The coating shall be electro-statically applied prior to assembly.	
4	**Ansul Model No. CR-PK20l Portable Extinguisher (Purple K), with Brooks Model No. FEC3 Red Vinyl Cover or Equivalent Manufacturer** Class B and C fires (120-B:C), 20 lbs., red glossy polyester coated steel cylinder with hose, squeeze grip control nozzle and wall mounting bracket, hose discharge.	**4**

8.0 INSPECTION AND TESTING

8.1 General

8.1.1 Inspection & testing of all the firefighting equipment shall be carried out in accordance with an approved Supplier Inspection & Test Plan.

8.2 Inspection

8.2.1 The Supplier shall provide free access to their Workshop for the authorized representative of the Buyer or Company.

8.2.2 All necessary certification on materials, shop test data, etc., shall be made available to verify that the requirements of the purchase order are being met. No equipment surface shall be painted until all inspection is completed unless otherwise waived by the Company.

8.2.3 Approval of all Buyer or Supplier's drawings, weld procedures, calculations, etc., is required by the Company where applicable, prior to the commencement of fabrication.

8.3 Hydrostatic/Performance Testing

8.3.1 The Buyer or Supplier shall provide a hydrostatic test procedure for Company approval prior to test and a hydrostatic test certificate per unit for final documentation.

8.3.2 All equipment shall be subjected to an individual performance test where appropriate in accordance with the requirements of the Material requisition.

8.3.3 Performance test with measured parameters, recording log sheets and certificates shall be provided on successful and accepted completion of the test.

8.4 Equipment Testing

8.4.1 The Supplier shall submit test procedures at least six (6) weeks prior to the commencement of testing and covering the full extent of testing on the completed assembly. The test procedure shall be approved by the Company prior to the commencement of testing and shall be complete with all equipment tests and checklists. The Supplier shall be responsible for providing all necessary utility services to conduct the tests.

8.4.2 The Supplier shall provide all equipment necessary to undertake the above tests and shall be responsible for ensuring that all calibration and test equipment have valid certification.

8.4.3 Performance test running parameters record log sheets and certificates shall be provided for all tests.

8.4.4 When required by the Buyer or Company representative, equipment shall be dismantled for visual inspection after testing.

9.0 SPARE PARTS/TOOLS

9.1 Supplier will provide special maintenance tools with the equipment.

9.2 Supplier will provide required spare parts for 10 years of operation.

10.0 PREPARATION FOR SHIPMENT

10.1 Equipment and piping must be cleaned of all foreign material, dirt, scale, grease, oil and chemical residues, etc., in accordance with approved cleaning methods. Items will be inspected for compliance with approved cleaning procedures. Items that are not immediately packaged or shipped must be protected from contamination until preservation or packing is complete.

10.2 Methods of preservation must ensure protection from contamination or other effects that could be harmful or detrimental during transit and site storage.

10.3 Supplier shall ensure that all equipment is adequately packed, crated, boxed, skidded or otherwise protected and prepared for shipment in such a manner as to prevent loss and damage during handling, transportation and storage.

10.4 All exposed machinery surfaces (threads, flange faces, gasket sealing surfaces, etc.) shall be coated with an easily removable protective coating. All weld bevels of carbon or ferritic alloy steel piping or equipment components that are to be welded by others shall be coated on the inside and outside surfaces for a distance of three inches from the end of the component.

10.5 All equipment shall be identified with permanent punched stamped stainless steel tag.

10.6 Tags shall contain: Item Code Number
Equipment Tag Number
PO Number.

10.7 Tags shall be secured on the components with stainless steel bolts, rivets or stainless steel wire.

10.8 Laminated plastic equipment nameplates and tags are not acceptable. Nameplates and tags with adhesive backing are not acceptable.

Attachment 15 – Construction Laydown Area



100% Camera: 11,460 m 35°14'53"N 119°25'54"W 270 m

Attachment 16 – Basis of Cost Estimate

CO_2 CAPTURE FROM ELK HILLS POWER PLANT

Basis of Estimate
Fluor Class 3 Estimate

Document No. EH-35R-CCU1-RPT-300-00001

Fluor Contract No. C1RC

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1.0 EXECUTIVE SUMMARY

Purpose

The purpose of the Basis of Estimate (BoE) document is to provide an overview of how the Class 3 estimate values were developed and compiled into the finished deliverable.

2.0 ESTIMATE CONTENT AND SCOPE

Fluor has been contracted to conduct Front-End Engineering and Design (FEED) services by Electric Power Research Institute (EPRI) who has a contract with the Department of Energy (DOE). California Resources Corporation's (CRC) has the facility where the project would be implemented. It is located at CRC's 550 megawatt Elk Hills Power Plant (EHPP), a Natural Gas Combined Cycle (NGCC) unit, located near Tupman, California. Fluor will use its Econamine FG Plus℠ (EFG+) licensed technology to capture 4,000 MTPD of CO_2 from the power plant's flue gas. The Carbon Capture and Sequestration (CCS) project will compress and utilize the captured CO_2 for Enhanced Oil Recovery (EOR) at CRC's Elk Hills reservoirs. The project scope includes the CO_2 capture plant, compression and treating of the CO_2, and the required utility systems to support the new facility.

The purpose of the estimate is to provide an end of FEED deliverable to be used as a baseline for the project cost.

The estimating deliverable is a Class 3 end of FEED estimate. The estimate was developed utilizing propriety estimating systems owned and licensed by Fluor including RIB - Construction Suite, and MS Office™ products.

3.0 KEY MILESTONES AND SCHEDULE DATES

Key Milestone	Dates
Estimate completion	11/23/2020
Begin Detail Engineering	12/08/2021
Model Review 1	06/10/2022
Model Review 2	11/08/2022
Model Review 3	03/24/2023
95% Engineering Complete	08/22/2023
Begin Construction	02/06/2023
Final Completion	08/19/2025

4.0 GENERAL ESTIMATE OVERVIEW

4.1 General Assumptions and Qualifications

- All labor, material and equipment costs have been estimated as of 3rd Qtr. 2020.
- The construction schedule assumes normal weather conditions for the site location. No allowance has been made for dramatic weather events.
- No allowance has been included for all risk subcontractor liability insurance. This is a client cost.

- Material and equipment pricing is based on an International slate of approved vendors and manufacturers for Fluor's Econamine FG+ projects and in accordance with the Approved Manufacturers List.

- Engineering, Procurement and Construction services will utilize Fluor's domestic and workshare offices/personnel as described herein.

4.2 Exclusions

- Demolition, removal of underground obstructions or dealing with contaminated soils has been excluded from the project scope.

- Relocation of existing piping on the east end of the project plot.

- The Engineering, Procurement and Construction of the high voltage substation (switchyard)

- Provision of a stairway for secondary access of the Absorber Column – basis for secondary access is ladders.

- Modifications to vents for existing NH_4 storage tanks which duct will pass over

- Two year or Operating Spares

5.0 ESTIMATE DETAILS AND DIRECT FIELD COSTS (DFC)

5.1 Labor Hours & Craft Labor Costs

5.1.1 Direct Field Work

The BoE is that execution of the project will be by Fluor acting as Construction Manager using primarily union construction contractors to perform the work. The majority of the construction cost estimate is developed using Fluor's Construction Unit Effort Hours with local subcontractor reimbursable wage rates applied per hour.

Composite crew mixes for labor rates and effort hour adjustments to the Fluor Construction Unit Effort Hours were provided by Fluor Construction using the current approved templates. Craft effort hour adjustments consider project site conditions including weather, project schedule, overtime, estimated craft skill level, plot saturation/congestion and other "complexity" factors.

The basis for subcontractor craft wage rates is a 2020 area labor market analysis, as described above. Wage rates include benefits and burdens, contractor's overhead and profit, spot overtime, premium time, and per diem. The standard construction work week will be 50 hours with a premium paid on all hours over 40 per week. Selection of the crafts, and proportions of those, to receive per diem are based upon CRC's current labor agreements. Gross up of per diems is excluded. The average labor rate for direct costs is $90.79 per hour.

5.1.2 Module Yard Fabrication

The construction execution is 100% stick built with local labor. However the design of the pipe racks incorporates modularization/pre-assembly. These modules will be assembled at a designated preassembly area which is located offsite, approximately 4 miles from the job. The preassembly area is located on CRC property which will also be utilized for material laydown. Appropriate effort hour adjustments have been made for the work taking place in this area.

5.2 Earthwork and Civil Site Works (Account-00)

Piling was quantified as Cast in-drilled hole (CIDH).

5.3 Concrete (Account-10)

Engineering provided quantities for concrete for all site requirements. Quantities for anchor bolts, embeds, and rebar were provided based on business rules and adjusted for seismic and project specific requirements.

5.4 Structural Steel (Account-20)

The estimate includes quantities for site, and pre-assembly/module steel for the pipe racks.

5.5 Architectural and Buildings (Account-30)

There is no scope for buildings in the project. The existing Control Room will be utilized for control of the CO_2 capture facilities and no modifications are required to the building to install the new equipment. Based upon current information no modifications are required to compensate for the additional heat load due to the new electronic equipment.

5.6 Machinery and Equipment (Account-40)

The mechanical equipment list consists of approximately 160 tagged items including turnkey subcontracts for the field fabricated Columns and field assembled Wet Surface Air Coolers. Estimating included construction hours to install shipped loose items associated with skid packages.

An allowance has been included for the duct tie-in to the Power Plant Stacks. This scope needs further development in order to adequately plan and estimate the work. Currently this scope is outside of Fluor's scope of supply and an allowance has been included in Owner's cost.

The estimate includes vendor reps, capital spares, and a construction spares allowance based on a percentage of the mechanical equipment pricing.

5.7 Piping (Account-50)

Assumptions and Clarifications

- There are no requirements for a Deluge Process Fire Protection system in this project or estimate.
- Estimate items for labor, shop fabrication, paint and insulation were developed based on information provided by engineering.

- The relocation of existing piping on sleeper ways at the East end of the Plot Plan is excluded from this scope.

5.8 Electrical (Account-60)

Electrical Engineering provided electrical equipment pricing. Pricing was based on budgetary quotes, except for a few small equipment items that were priced in-house and make up less than 1% of the total electrical equipment cost.

Major electrical equipment includes:

- (2) Power Distribution Centers
- MV and LV switchgears
- MV and LV MCCs
- MV and LV transformers
- MV VFDs
- UPS
- Panel boards

The main substation (high voltage switchyard) is in CRC's scope and is excluded from this estimate.

Foundations for electrical equipment were provided by CSA Engineering and are included in the concrete account.

The estimate includes cost for electrical heat tracing based on in-house pricing.

The estimate does not include cost for cathodic protection. Sacrificial anode cathodic protection may be required during future design development.

5.9 Control Systems (Account-70)

Control Systems Engineering provided pricing for instrumentation, the DCS package and the analyzer shelter package.

Vendor supplied instruments will come pre-mounted to equipment or skids, or in a few cases, be field installed. Only testing and loop check hours have been included in the estimate for these instruments.

Foundations for analyzer buildings were provided by CSA Engineering and are included in the concrete account.

5.10 Communications and Security (Account-75)

There is no project scope for Communication and Security.

5.11 Modularization (Account-83)

Pre-Assembly of the pipe rack modules, and setting the Solvent Maintenance System modules is included in the estimate based on the number of modules to set, and connections at the foundations. Hours for module rigging support are included.

5.12 Demolition and Environmental Works (Account-84)

Not applicable

5.13 General Requirements (Account-87)

5.13.1 Scaffolding

Scaffolding is included as a percentage of Direct Field Craft (DFC) effort-hours excluding civil and earthworks.

5.13.2 Freight / Logistics

The Logistics group provided freight cost for key mechanical equipment items. A factor was used for the balance of field materials.

5.13.3 Freight Related Duties and Fees

Freight related duties and fees are part of Owner's Cost (excluded from estimate)

5.13.4 Brokerage and Agent Fees

Brokerage and Agent Fees are part of Owner's Cost (excluded from estimate)

5.13.5 Port Terminal Charges

Port Terminal Charges are part of Owner's Cost (excluded from estimate)

5.13.6 Import Duties

Import Duties are part of Owner's Cost (excluded from estimate)

5.13.7 Import Taxes

Import Taxes are part of Owner's Cost (excluded from estimate)

5.14 Start-Up and Commissioning (Account-88)

5.14.1 Pre-Commissioning, Commissioning, and Start-Up (PCSU)

The estimate includes activities required to attain Mechanical Completion (MC) for the permanent facilities. Activities post MC are considered Owner's Commissioning/Start-up scope. Pre-Commissioning, Startup and Commissioning are included in the estimate. The Commissioning Team provided a detailed estimate based on PFD's, plot plans and the EPCC schedule. The scope includes the following stages of the start-up and commissioning process as required:

- Pre-commissioning – By Fluor
- Commissioning – By Fluor
- Startup – By CRC, Fluor support labor only
- Validation/Performance Test – By CRC, Fluor support labor only

5.15 Spare Parts

5.15.1 Capital Spares

Mechanical Engineering provided an estimate of the Capital Spares on the Mechanical Equipment list.

5.15.2 Construction Spares

Estimating included an allowance for all construction spares based on a percentage of Mechanical Equipment material.

5.15.3 Startup and Commissioning Spares

Included with the Startup and Commissioning Estimate

5.15.4 Two Year / Operating Spares

Excluded from the Estimate (Owner's Cost)

5.16 Vendor Representatives and Consultants

5.16.1 Vendor Reps during Construction

Engineering provided a list of vendor reps required for the Mechanical, Electrical and Control Systems equipment including durations and number of people. Estimating included cost for rates, airfare and per diems.

5.16.2 Vendor Reps during Startup & Commissioning

Included in the PCSU Estimate.

5.17 Allowances

An allowance has been included in the estimate for painting of the field erected columns (C-101, C-201, C-301).

An allowance has been generated for the tie-in of the flue gas ducts to the existing power plant stacks. This cost has been included as an Owner's cost. The BoE is that no modifications of the stacks foundations or anchor bolts will be required.

6.0 CONSTRUCTION INDIRECT FIELD COSTS (IFC)

6.1 Temporary Facilities (Account-90)

A forced detail quantity based estimate, based upon the temporary facilities plan was developed by Construction specifically for this project.

The estimate includes the following temporary facilities:

- Construction Site Location – (1) craft lunch tent 82' x 148', (1) staff office trailer 16' x 60', (1) One Medical Trailer 12' x 40', (3) turnstiles (The BoE is that, CRC is providing all required property at no charge). Currently no space within the staff office trailer has been included for CRC personnel.

- Laydown Yard - (1) Lunch Tent (20' x 40'), (1) Turnstile.
- Warehouse and warehouse office space for Fluor Staff will be provided by the client (at no cost to Fluor).
- The parking lot area contains geogrid, crushed concrete surfacing, temporary fencing, and lighting, and appropriate parking space.
- Temporary power requirements have been identified and priced by Estimating.
- Temporary utility cost for water and electrical consumption is based on unit rate pricing provided by CRC and consumption requirements calculated by construction and estimating.
- Temporary construction and silt fencing requirements are based on quantities provided by construction and engineering.

6.2 Construction Camps (Account-91)

Not Applicable

6.3 Construction Services (Account-92)

Construction services estimate includes cost for the following:

- Firewatch / Hole Watch
- Job Cleanup, Janitorial, & Dumpster services
- Warehouse & Site Services
- Work Stoppages. Show Up Pay and Dewatering activities
- Health & Safety services & supplies, craft training, craft testing
- Site security (provided by CRC)
- Monthly IT charges, Office Supplies
- Misc. Professional services, such as soil testing, pest control, weed control, RFID

6.4 Field Staff (Account-93)

Fluor Site Staff is based on a staffing plan. The Subcontractor's Site Staff is based on a staffing plan provided by Construction and priced by Estimating using historical information.

6.5 Field Craft (Account-94)

Field Craft Burdens & Benefits are included in the all-in subcontract rate for both direct and indirect labor.

6.6 Construction Equipment & Small Tools (Account-95)

Subcontractor Construction Equipment rental was developed to quantify the various types of equipment required for the construction activities, and includes cranes 200 tons and below. Durations were based on the EPCC Schedule. Rental rates were estimated using a dollar per direct field work hours.

- Additional cost for Concrete Pump Truck was included at a rate of $15.00 / CY

- Construction equipment required at the lay down yard is based on a detailed equipment plan by Construction and priced using recent pricing.
- Heavy Haul costs are included in the freight estimate.
- Heavy Lift Cranes for lump sum contracts are included in the DFC.
- Heavy Lift Cranes pricing for installing the pipe rack modules is based on a 330 Ton Crane.
- Equipment fuel, oil, & lubes are included in the pricing.
- Small Tools and Consumables cost was estimated using $3.00 per craft hour.

6.7 Insurance, Bonds, Permits, & Fees (Account-96)

Insurance has been included for Worker's Comp., Commercial General Liability, Auto and Marine Insurance. Builder's Risk insurance is provided by the Owner.

An allowance has been included for Subcontractor's Letter of Credit and Bond costs.

No cost has been included for Plan Check or Building Permits.

7.0 HOME OFFICE COSTS, ENGINEERING AND OFFICE EXPENSES

The Home Office Estimate is priced on a 40 hour work week basis with the work split between Fluor's US based offices and workshare office(s). Escalation was excluded in the Home Office Cost Estimate and included in the project escalation calculation. Business travel was developed based upon a detailed buildup of required travel.

The overall workshare content is estimated to be 40%.

Both Construction and Commissioning and Startup Support, which will occur in the Home Office prior to site mobilization, are included in the Home Office Estimate.

8.0 OTHER COSTS AND FEES

8.1 Sales and Use Tax (Direct & Indirect)

As stated by CRC we have included Sales and Use Taxes at 3.25% on all field material.

8.2 Escalation

The estimate has been prepared with a third quarter 2020 pricing basis. Forward escalation has been applied.

8.3 Cost Contingency

The project execution estimate cost contingency is based on a risk analysis model with variables that are project specific. The contingency value was calculated utilizing a computerized Monte Carlo simulation with the risk variables determined by the project team.

8.4 Event Contingency

A project execution event risk allowance has been included with the estimate contingency cost. This execution event risk allowance does not include commercial, contractual or performance risks currently since theyare not yet defined or agreed. For information, the commercial / contractual / performance risk typically range from 1.5 to 3 percent of the Total Installed Cost, depending on the the allocation of contractual risk and the value of the LD's and performance guarantees.

8.5 Warranty

Warranty has been included as 0.5% of TFOC cost.

8.6 Licensor Fees

Licensor Fees have been included as an Owner cost.

8.7 Management Fees

Management Fees are included in the project cost.

9.0 BELOW THE LINE COSTS

9.1 Client Furnished Materials – Fluor Scope

None provided

9.2 Non-Fluor Scope

Mass excavation and grading of site (bath tubbing)

Tie-in of flue gas duct to power plant stacks

EPC for high voltage substation (switchyard)

First fill of chemicals

9.3 Taxes and Incentives

Included at 3.25% of all field material. The rate was provided by the client.

10.0 PROJECT WORK BREAKDOWN STRUCTURE (WBS)

The estimate was compiled according to the agreed upon project work breakdown structures with all quantities and costs organized accordingly into the level of detail for the WBS structure.

00	Combined
10	ISBL CO_2 Capture Plant
11	ISBL CO_2 Capture Plant – Pipe Rack
12	ISBL CO_2 Capture Plant – Solvent Maintenance Sys
21	Utilities – CT and Wet Surface Air Coolers
22	Utilities – Boilers
23	Utilities – Power Infrastructure
24	Utilities – Other
30	CO_2 Compression and Treatment
41	Bathtub Site
42	Power Plant Stack Modifications

Attachment 17 – Estimate Summaries

Client:	California Resources Corp.	**Currency: USD**
Client's Project Name:	CO2 Capture From Elk Hills Power Plant	Estimator: MBG
Location:	Tupman, California	26-Oct-2021
Estimate Purpose:	FEED	
Reference Plant Type	Carbon Capture	
Project/Plant Capacity:	4,000 MTPD	

Estimate Grand Summary

Estimate with Capex Reductions

Account	Description	Total Cost / Price Rev 1
S	**Direct Field Cost - Site**	
00	Earthwork & Civil	19,387,000
05	Marine & Heavy Civil Works	-
10	Concrete	51,140,000
20	Structural Steel	19,114,000
30	Architectural & Buildings	-
40	Machinery & Equipment (Tag Count)	183,375,000
50	Piping Avg dia inch = 8.38"	69,416,000
55	Pipelines	-
60	Electrical	38,126,000
70	Control Systems (Fluor + Vendor Tag Count)	9,092,000
75	Aux Systems (Communications & Security)	-
81	Painting & Coatings	2,655,000
82	Insulation & Refractory	6,496,000
83	Modularization - Rigging & Setting (18 Piperack Modules)	1,137,000
84	Demolition and Environmental Work	-
8705	Scaffolding	12,975,000
8710-8720	Int'l Shipping, Logistics & Related Duties & Fees	17,544,000
8810-8830	Pre-Comm., Comm. & SU (Excl Fld Staff Labor)	5,753,000
		-
	Sub-Total Direct Field Costs (DFC)	436,210,000
	Sub-Indirect Field Costs (IFC)	91,918,000
	Total Field Costs (TFC)	**528,128,000**
	Sub-Total Home Office Costs (HOC)	47,837,000
BARE ITC	**Total Field & Office Costs (TFOC)**	**575,965,000**
	Other Costs & Fees	
9910	Escalation	39,009,000
9920	Contingency & Warranty	57,016,000
9930	Management Fee	66,504,000
9940	Sales and Use Taxes (Direct & Indirect)	8,475,000
	Late Changes	1,264,000
	Sub-Total Other Costs	172,268,000
	Indicated Total Cost (ITC)	**748,233,000**

Client:	California Resources Corp.	**Currency: USD**
Client's Project Name:	CO2 Capture From Elk Hills Power Plant	Estimator: MBG
Location:	Tupman, California	26-Oct-2021
Estimate Purpose:	FEED	
Reference Plant Type	Carbon Capture	
Project/Plant Capacity:	4,000 MTPD	

AREA SUMMARY - Balance of Plant

Estimate with Capex Reductions

Account	Description	Total Cost / Price Rev 1
S	**Direct Field Cost - Site**	
00	Earthwork & Civil	3,365,000
05	Marine & Heavy Civil Works	-
10	Concrete	2,693,000
20	Structural Steel	-
30	Architectural & Buildings	-
40	Machinery & Equipment (Tag Count)	-
50	Piping Avg dia inch = 8.38"	3,805,000
55	Pipelines	-
60	Electrical	341,000
70	Control Systems (Fluor + Vendor Tag Count)	-
75	Aux Systems (Communications & Security)	-
81	Painting & Coatings	654,000
82	Insulation & Refractory	-
83	Modularization - Rigging & Setting (18 Piperack Modules)	-
84	Demolition and Environmental Work	-
8705	Scaffolding	899,000
8710-8720	Int'l Shipping, Logistics & Related Duties & Fees	1,668,000
8810-8830	Pre-Comm., Comm. & SU (Excl Fld Staff Labor)	5,753,000
		-
	Sub-Total Direct Field Costs (DFC)	19,178,000
	Sub-Indirect Field Costs (IFC)	4,002,000
	Total Field Costs (TFC)	**23,180,000**
	Sub-Total Home Office Costs (HOC)	2,087,000
BARE ITC	**Total Field & Office Costs (TFOC)**	**25,267,000**
	Other Costs & Fees	
9910	Escalation	1,710,000
9920	Contingency & Warranty	2,497,000
9930	Management Fee	2,914,000
9940	Sales and Use Taxes (Direct & Indirect)	368,000
	Sub-Total Other Costs	7,489,000
	Indicated Total Cost (ITC)	**32,756,000**

Client:	California Resources Corp.	Currency: USD
Client's Project Name:	CO2 Capture From Elk Hills Power Plant	Estimator: MBG
Location:	Tupman, California	26-Oct-2021
Estimate Purpose:	FEED	
Reference Plant Type	Carbon Capture	
Project/Plant Capacity:	4,000 MTPD	

AREA SUMMARY -ISBL

Estimate with CAPEX Reductions

Account	Description	Total Cost / Price Rev 1
S	**Direct Field Cost - Site**	
00	Earthwork & Civil	12,604,000
05	Marine & Heavy Civil Works	-
10	Concrete	25,815,000
20	Structural Steel	11,903,000
30	Architectural & Buildings	-
40	Machinery & Equipment (Tag Count)	104,723,000
50	Piping Avg dia inch = 8.38"	47,242,000
55	Pipelines	-
60	Electrical	58,000
70	Control Systems (Fluor + Vendor Tag Count)	2,437,000
75	Aux Systems (Communications & Security)	-
81	Painting & Coatings	1,823,000
82	Insulation & Refractory	5,772,000
83	Modularization - Rigging & Setting (18 Piperack Modules)	1,137,000
84	Demolition and Environmental Work	-
8705	Scaffolding	5,833,000
8710-8720	Int'l Shipping, Logistics & Related Duties & Fees	6,736,000
8810-8830	Pre-Comm., Comm. & SU (Excl Fld Staff Labor)	-
		-
	Sub-Total Direct Field Costs (DFC)	226,083,000
	Sub-Indirect Field Costs (IFC)	47,138,000
	Total Field Costs (TFC)	**273,221,000**
	Sub-Total Home Office Costs (HOC)	24,481,000
BARE ITC	**Total Field & Office Costs (TFOC)**	**297,702,000**
	Other Costs & Fees	
9910	Escalation	20,174,000
9920	Contingency & Warranty	29,095,500
9930	Management Fee	34,363,500
9940	Sales and Use Taxes (Direct & Indirect)	4,517,000
	Late Changes	1,264,000
	Sub-Total Other Costs	89,414,000
	Indicated Total Cost (ITC)	**387,116,000**

Client:	California Resources Corp.	**Currency: USD**
Client's Project Name:	CO2 Capture From Elk Hills Power Plant	Estimator: MBG
Location:	Tupman, California	26-Oct-2021
Estimate Purpose:	FEED	
Reference Plant Type	Carbon Capture	
Project/Plant Capacity:	4,000 MTPD	

AREA SUMMARY - Utilities

Estimate with CAPEX Reductions

Account	Description	Total Cost / Price Rev 1
S	**Direct Field Cost - Site**	
00	Earthwork & Civil	2,249,000
05	Marine & Heavy Civil Works	-
10	Concrete	20,208,000
20	Structural Steel	5,834,000
30	Architectural & Buildings	-
40	Machinery & Equipment (Tag Count)	58,537,000
50	Piping Avg dia inch = 8.38"	12,601,000
55	Pipelines	-
60	Electrical	36,821,000
70	Control Systems (Fluor + Vendor Tag Count)	5,719,000
75	Aux Systems (Communications & Security)	-
81	Painting & Coatings	52,000
82	Insulation & Refractory	595,000
83	Modularization - Rigging & Setting (18 Piperack Modules)	-
84	Demolition and Environmental Work	-
8705	Scaffolding	5,152,000
8710-8720	Int'l Shipping, Logistics & Related Duties & Fees	7,380,000
8810-8830	Pre-Comm., Comm. & SU (Excl Fld Staff Labor)	-
		-
	Sub-Total Direct Field Costs (DFC)	155,148,000
	Sub-Indirect Field Costs (IFC)	33,310,000
	Total Field Costs (TFC)	**188,458,000**
	Sub-Total Home Office Costs (HOC)	17,373,000
BARE ITC	**Total Field & Office Costs (TFOC)**	**205,831,000**
	Other Costs & Fees	
9910	Escalation	13,932,000
9920	Contingency & Warranty	20,786,000
9930	Management Fee	23,785,000
9940	Sales and Use Taxes (Direct & Indirect)	2,917,000
	Sub-Total Other Costs	61,420,000
	Indicated Total Cost (ITC)	**267,251,000**

Client:	California Resources Corp.	**Currency: USD**
Client's Project Name:	CO2 Capture From Elk Hills Power Plant	Estimator: MBG
Location:	Tupman, California	26-Oct-2021
Estimate Purpose:	FEED	
Reference Plant Type	Carbon Capture	
Project/Plant Capacity:	4,000 MTPD	

AREA SUMMARY - C02 Compression and Treatment

Estimate with CAPEX Reduction

Account	Description	Total Cost / Price Rev 1
S	**Direct Field Cost - Site**	
00	Earthwork & Civil	1,169,000
05	Marine & Heavy Civil Works	-
10	Concrete	2,424,000
20	Structural Steel	1,377,000
30	Architectural & Buildings	-
40	Machinery & Equipment (Tag Count)	20,115,000
50	Piping Avg dia inch = 8.38"	5,768,000
55	Pipelines	-
60	Electrical	906,000
70	Control Systems (Fluor + Vendor Tag Count)	936,000
75	Aux Systems (Communications & Security)	-
81	Painting & Coatings	126,000
82	Insulation & Refractory	129,000
83	Modularization - Rigging & Setting (18 Piperack Modules)	-
84	Demolition and Environmental Work	-
8705	Scaffolding	1,091,000
8710-8720	Int'l Shipping, Logistics & Related Duties & Fees	1,760,000
8810-8830	Pre-Comm., Comm. & SU (Excl Fld Staff Labor)	-
		-
	Sub-Total Direct Field Costs (DFC)	35,801,000
	Sub-Indirect Field Costs (IFC)	7,468,000
	Total Field Costs (TFC)	**43,269,000**
	Sub-Total Home Office Costs (HOC)	3,896,000
BARE ITC	**Total Field & Office Costs (TFOC)**	**47,165,000**
	Other Costs & Fees	
9910	Escalation	3,193,000
9920	Contingency & Warranty	4,638,000
9930	Management Fee	5,441,000
9940	Sales and Use Taxes (Direct & Indirect)	673,000
	Sub-Total Other Costs	13,945,000
	Indicated Total Cost (ITC)	**61,110,000**

Attachment 18 – EPCC Level 1 Schedule

Elk Hills CO2 Recovery Project
Econamine FG PlusSM

EPCC Summary Schedule

FLUOR.
Nov. 2020

