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Weldon Spring Site Remedial Action Project

DOE/OR/21548--147

DE91 004714

Quarry Geotechnical Report

Report No. 5121R-305-A

November 1990

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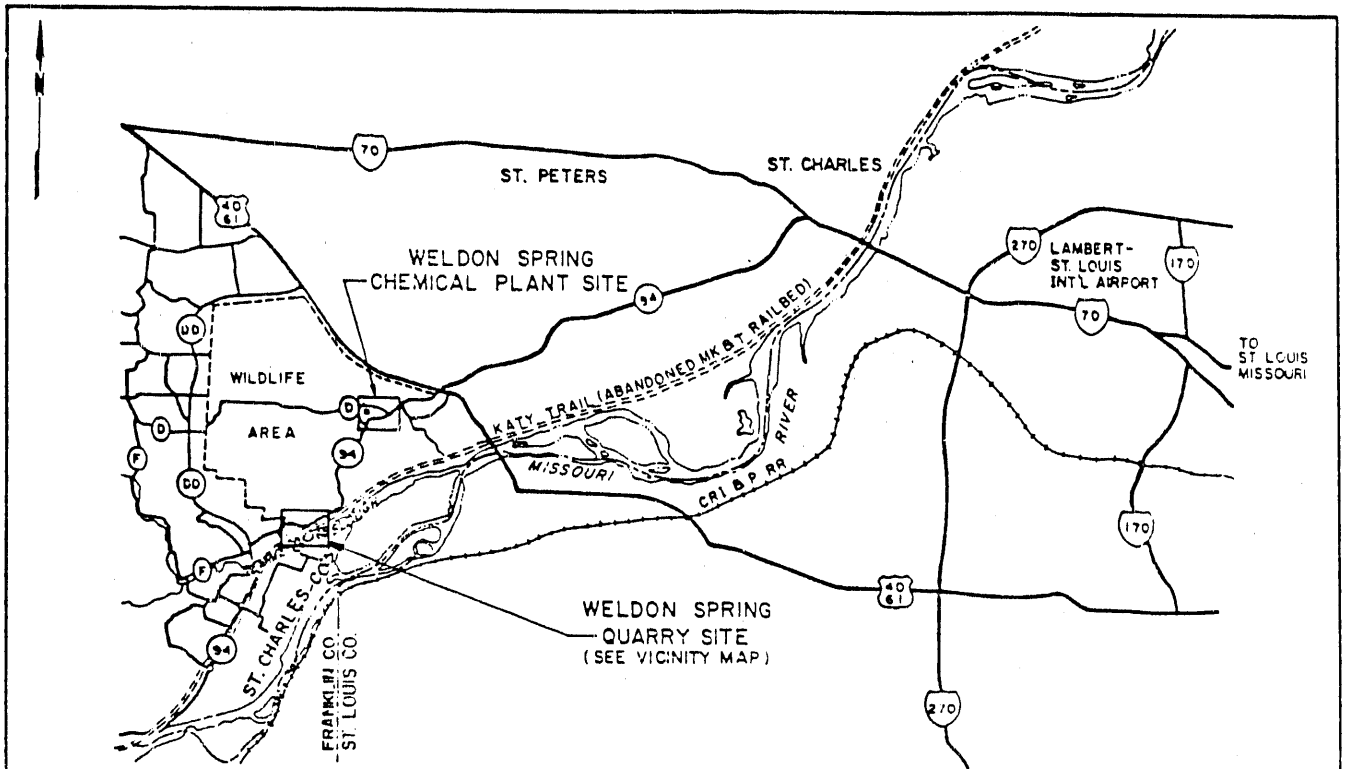
1 INTRODUCTION

1.1 General

This report has been prepared for the United States Department of Energy's (DOE) Weldon Spring Site Remedial Action Project (WSSRAP) by the Project Management Contractor (PMC), which is MK-Ferguson Company (MK-Ferguson) with Jacobs Engineering Group (JEG) as its designated subcontractor. The Weldon Spring site (WSS) comprises the Weldon Spring quarry area and the Weldon Spring chemical plant and raffinate pit areas.

This report presents the results of geotechnical investigations conducted during 1989-1990 at the proposed Weldon Spring quarry staging and water treatment facilities in the quarry area. The facilities are intended for treatment of water removed from the quarry area. An access road and a decontamination pad will be necessary for handling and transportation of bulk waste. Results of previous geotechnical investigations performed by other geoscience and environmental engineering firms in the quarry area, were reviewed, summarized and incorporated into this report.

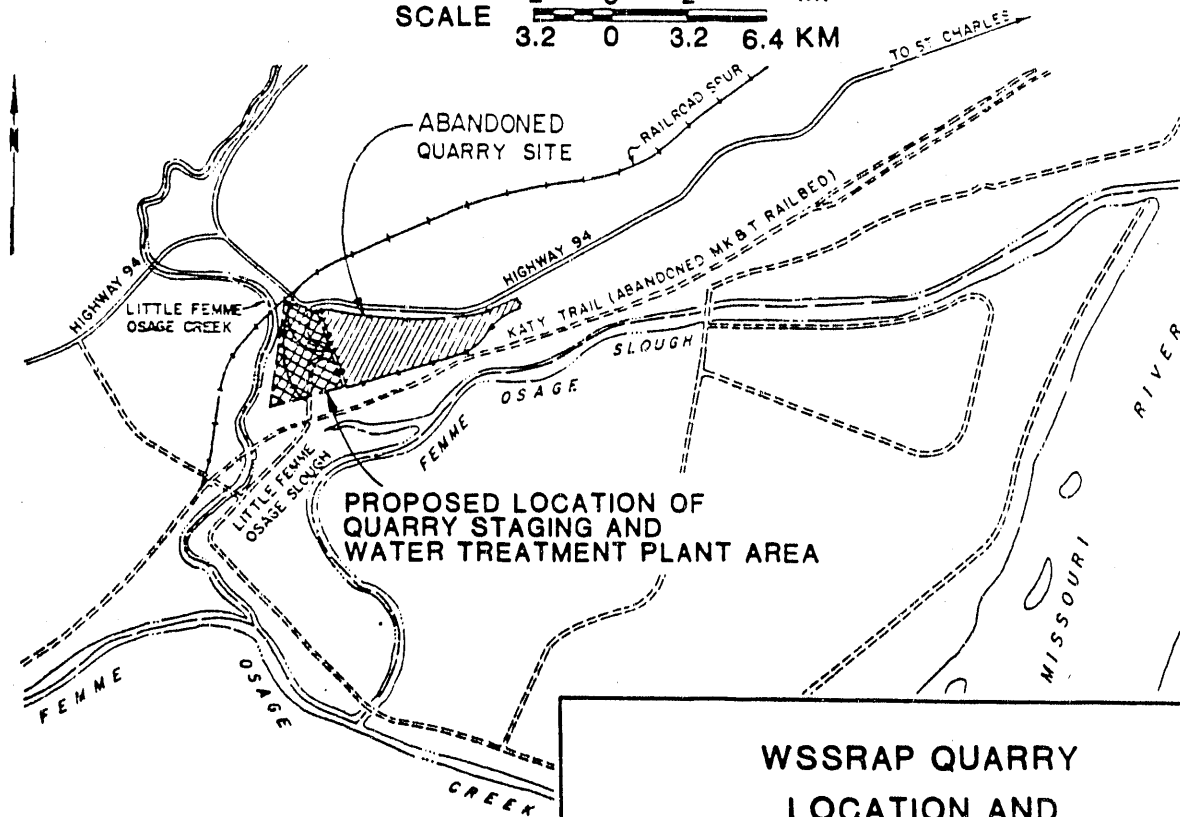
The location of the Weldon Spring quarry site and vicinity is shown on Figure 1-1. The site comprises the abandoned Weldon Spring quarry and the proposed quarry staging and water treatment plant area. The quarry site is located south of Highway 94, near the town of Weldon Spring, approximately 34 miles west of St. Louis, Missouri. The site is approximately 2.5 miles south-southwest of the Weldon Spring chemical plant site. The Femme Osage Slough lies immediately south and southeast of the quarry site. The Missouri River is located approximately 1 mile to the southeast and, in the vicinity of the quarry, flows toward the northeast. The quarry was excavated into a limestone bluff on



LOCATION MAP

SCALE 2 0 2 4 MI

3.2 0 3.2 6.4 KM



VICINITY MAP

1000 0 1000 2000 FT

304.8 0 304.8 609.6 M

SCALE

WSSRAP QUARRY
LOCATION AND
VICINITY MAPS

FIGURE 1-1

REPORT NO.	DOE/OR/21548-147	EXHIBIT NO.	A/VP/052/1190
ORIGINATOR	SDG	DRAWN BY.	GLN
		DATE	11/90

the west edge of the Missouri River floodplain just north of the Femme Osage Slough.

1.2 Purpose and Scope

The purpose of this report is to provide geotechnical data, summarize findings, and propose recommendations for the design of the proposed quarry staging and water treatment facilities. The geotechnical program was planned and executed based on early 1989 preliminary design of the proposed facilities provided by the PMC. The scope of the PMC field investigation program at the quarry included reviewing and summarizing previous investigations, overseeing drilling and piezometer installation, preparing laboratory test programs, evaluating test results, performing foundation analyses, preparing geotechnical recommendations, and reporting on these items in this report.

Field investigations were performed between February and May 1989. Laboratory testing was conducted from May 1989 through July 1990. Data were reviewed and analyses and recommendations were made between February and November 1989, unless otherwise indicated.

An additional slope stability analysis was performed in April 1990 to evaluate the embankments of the equalization basin and effluent ponds under the effect of a 100-year flood in the Little Femme Osage Creek. This analysis is outside of original scope but is included in Appendix C for reference.

1.3 Proposed Construction

The proposed temporary construction facilities will be located in the quarry staging and water treatment plant area west of the quarry as shown in Figure 1-2.

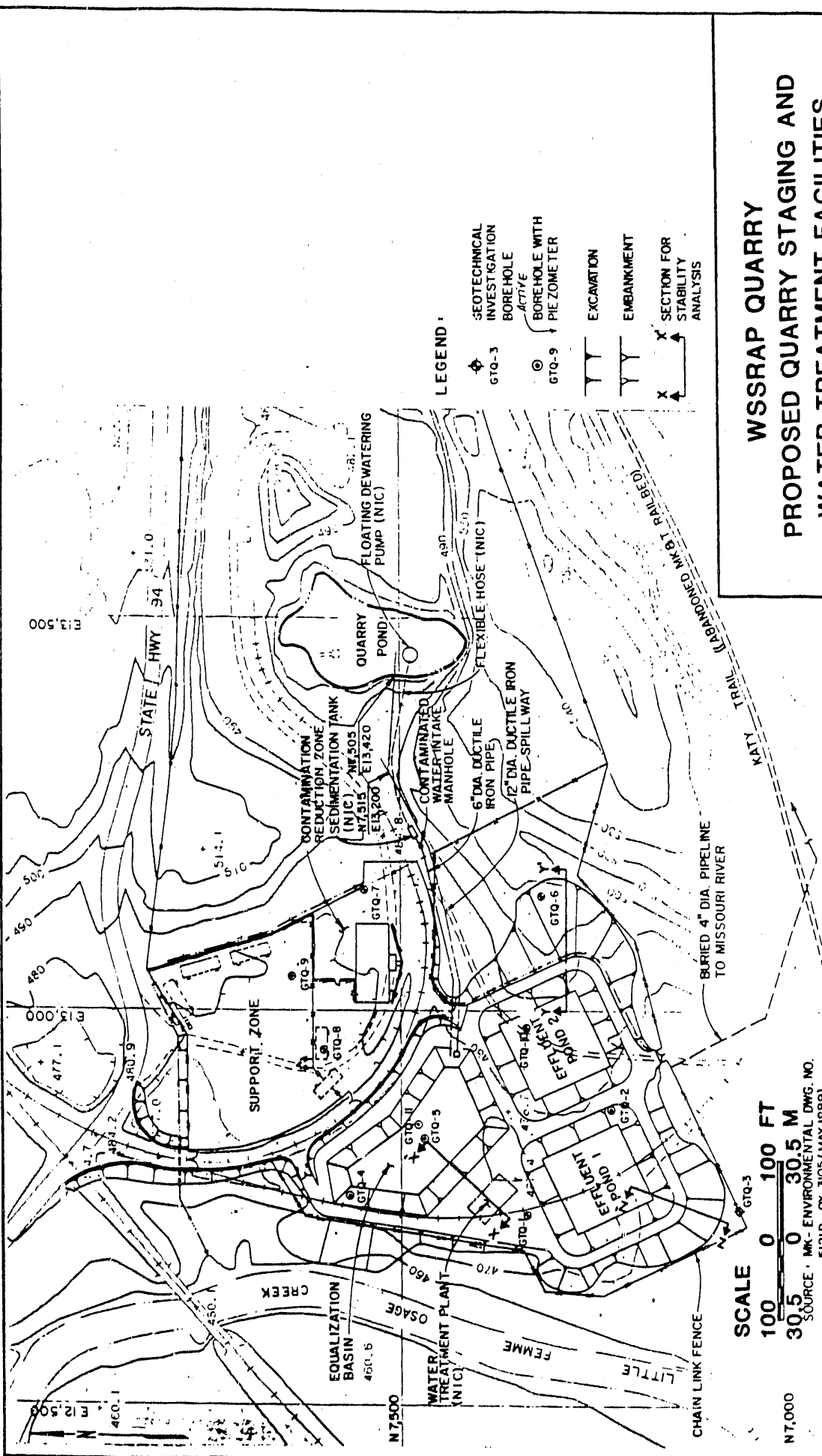
The staging area will consist of a support zone and a contamination reduction zone. The support zone will include contractor trailers, parking, portable chemical toilets, and other personnel support facilities. The contamination reduction zone will include the quarry access control gate, access control trailers, a personnel decontamination trailer, subcontractor trailers, a decontamination pad, and an underground utility water supply line. An access road will be located along the west side of the support zone.

The water treatment area will include two effluent ponds, an equalization basin, a contaminated-water treatment plant and an effluent discharge pipeline pump station.

1.4 Previous Site Investigations

The history of the site and site investigations have been summarized in detail in the Quarry Bulk Waste Removal, Remedial Investigations Report (MKF and JEG 1989).

Numerous investigations within the quarry site and adjacent areas have been conducted by government agencies and by various consultants under contract to the Department of Energy (DOE) and its predecessor agencies, the Atomic Energy Commission (AEC) and the Energy Research and Development Administration (ERDA). The investigations have been conducted to characterize the soils, hydrogeologic setting, and nature and extent of radiological and



- LEGEND:**
- ◆ GEOTECHNICAL INVESTIGATION BOREHOLE
 - BOREHOLE WITH ACTIVE PIEZOMETER
 - ⊕ EXCAVATION
 - ⊖ EMBANKMENT
 - X SECTION FOR STABILITY ANALYSIS

**WSSRAP QUARRY
PROPOSED QUARRY STAGING AND
WATER TREATMENT FACILITIES**

FIGURE 1-2

REPORT NO. DOE/OR/21548-147	EXHIBIT NO. A/QY/029/1190
DRAWN BY: SDG	DATE: 11/90
GLN	

SCALE
 100 0 100 FT
 30.5 0 30.5 M
 SOURCE: MK- ENVIRONMENTAL DWG. NO. 5121D - QT-3105 (MAY 1989)

N7,000

chemical contamination within the quarry and its vicinity. Previous investigation programs at the site and vicinity are summarized in Table 1-1.

Site-specific tasks related to geotechnical investigation for these studies have included field reconnaissance and mapping; borehole drilling, sampling and logging; monitoring well installation; groundwater level measurements; aquifer testing; and borehole and surface sampling of soils, water, and wastes.

The techniques employed in geotechnical investigations conducted at the quarry site since 1978 have included recording blow counts from standard penetration tests (SPT) in boreholes, field classifying soil types, measuring rock quality designation (RQD) of bedrock cores, and surveying bedrock jointing (Huey 1978; BNI 1985, 1987; BGA 1984; Marutzky et al. 1988). Generally, boreholes drilled for these investigations have been intended for radiologic and chemical sampling of soils and bulk wastes. Monitoring wells have been installed for sampling groundwater and characterizing site hydrogeology.

TABLE 1-1 Pre-1989 Site Investigation Wells and Boreholes at the Weldon Spring Quarry
Weldon Spring, Missouri (MKF and JEG 1989).

Date	Contractor	Lead Agency	Driller	No. of Holes	Hole Series (Alternate Designation)	Comments	Report
1951	USGS	AEC	--	--	--	Hydrological/Geological (Regional)	Preliminary Investigation of Ground Water Occurrences in the Weldon Springs Area, St. Charles County, Missouri (Roberts 1951)
1960	USGS	AEC	--	2	TWN/TWS	Hydrological/Geological; Pump Test	Possible Use of the Quarry at Mallinckrodt Chemical Works, Weldon Spring Missouri, for the Disposal of Uranium Contaminated Building Debris Rubble and Residues Containing Thorium and Uranium (Richards June 1960 & Sept 1960)
1976-1977	National Lead Co. of Ohio	AEC	Test Drilling Serv.Co.	12	TW1-TW12	Hydrological/Geological; TWN/TWS Cleaned; Chemical/Radiological Sampling of Water; Monitoring Wells Installed	Report on Preliminary Geological, Hydrological, and Radiological Survey at the Weldon Spring Quarry during 1976 and 1977 (Husey 1978)
1979-1981	LBL	DOE	--	22	0-, 1-, 2-, 3-, 4-, B-, B1-, C-, C1-, D1-, T-	Radiological Sampling of Soils in Quarry Area	Characterization and assessment for the Weldon Spring Quarry Low Level Radioactive Waste Storage Site (Berkeley Geoscience Associates 1984)
1980-1981	LBL	DOE	--	42	OB, OBS	Radiological Tests of Alluvium; Hydrochemical Testing; 10 Pumping Tests	(BGA 1984)
1979-1981	LBL	DOE	--		TW7-TW10(MW1002-MW1005)TWN/TWS (MW1012/MW1001)	Holes Rejuvenated Core for TW7-TW10 Relogged	(BGA 1984)
1984	Bechtel	DOE	--	76	QB1-QB-74, S1/S2	Radiological Sampling of Water; Radiological/Chemical Sampling of Soil, Holes Gamma Logged	Radiological Survey Report for the Weldon Spring Quarry, Weldon Spring, Missouri (BNI 1985)
1983-1986	--	USGS	--	--	--	Hydrological\Geological Summary of Previous Investigations; Chemical/Rad. Sampling of Water	Compilation and Preliminary Interpretation of Hydrologic Data for the Weldon Spring Radioactive Waste-Disposal Sites, St. Charles County, Missouri -A Progress Report (Kleeschulte and Emmet 1986)
1984-1986	--	County	Layne Western	20	11W-16LW(1984) RMW1-RMW4(1986)	Monitoring Wells Installed; Radiological and Chemical Sampling of Water	Groundwater Hydrology Investigation Weldon Spring Missouri (Layne Western 1986)
1986	Bechtel	DOE	--	6	TW7-TW10 TWN/TWS	Holes Redrilled; Old Holes Grouted Up	Ground Water Monitoring Program, St. Charles County Weldon Spring Well Field (Soil Consultants Inc. 1988)
1986	Bechtel	DOE	Brotcke Eng.	6	(MW1006-MW1011)	Monitoring Wells Drilled Near Previous LBL OB Wells; Radiological Sampling	Chemical Characterization Report for the Weldon Spring Quarry, St. Charles County, Missouri (BNI 1987)

111590

TALBE 1-1 Pre-1989 Site Investigation Wells and Boreholes at the Weldon Spring Quarry, Weldon Spring, Missouri (Continued)

Date	Contractor	Lead Agency	Driller	No. of Holes	Hole Series (Alternate Designation)	Comments	Report
1987	MCF/Jacobs	DOE	UNC/Brotcke Eng.	15	WS	Radiological Soil and Water Sampling	Radiologic Characterization of the Weldon Spring, Missouri Remedial Action Site
1987	MCF	DOE	Brotcke Eng.	7	MW1013-MW1028	Monitoring Wells Installed (1020-1028 8/88-9/88)	Annual Environmental Monitoring Report, Weldon Spring, Missouri (MCF and JEG 1988a, personal communication, phone conversation with Ken Meyer and Don Penniman, MK Environmental, May 25 and 26, 81989)

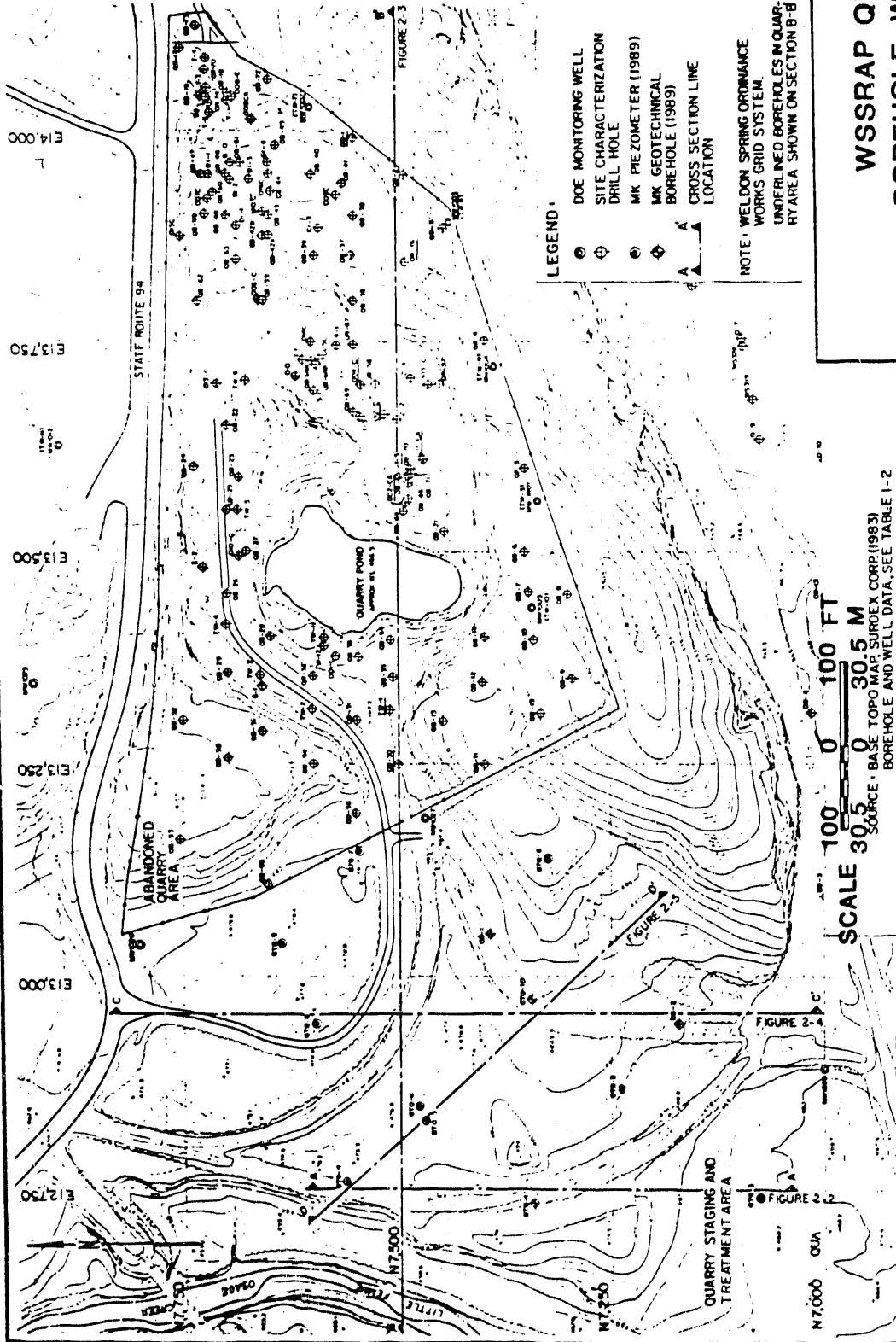
2 SITE CONDITIONS

2.1 Surface Features

The Weldon Spring quarry, including the proposed quarry staging and water treatment plant area, is located in eastern Missouri, near the Missouri River floodplain. The region surrounding the site is part of the dissected upland of the northern flank of the Salem Plateau physiographic area. This area, with the exception of the Missouri River floodplain, is characterized by rugged topography with heavily wooded hills and ridges dissected by narrow, sinuous streams and steep, rocky slopes (MSG 1977). Figure 2-1 includes a topographic map of the area immediately surrounding the quarry site.

The Little Femme Osage Creek flows along the west side of the proposed quarry staging and water treatment plant area through a narrow floodplain towards its confluence with the Femme Osage Creek, approximately (0.5 mile) to the southwest. The Femme Osage Creek drains a rugged, heavily wooded area west of the quarry site. The Femme Osage Slough is the old channel of the Femme Osage Creek. It is separated from the present creek channel, and from the Missouri River, by dikes. The Missouri River, located approximately 1 mile to the southeast, flows towards its confluence with the Mississippi River some 40 miles to the northeast.

The quarry was excavated into a steep limestone bluff, common along the banks of the Missouri River in the region. The quarry site consists of approximately 9 acres. The abandoned quarry floor covers approximately 2 acres. The original floor of the quarry was excavated to a bottom elevation of approximately 446 feet above mean sea level (MSL) at its deepest point. On



- LEGEND:**
- ⊙ DOE MONITORING WELL
 - ⊕ SITE CHARACTERIZATION DRILL HOLE
 - ⊙ MK PIEZOMETER (1989)
 - ⊕ MK GEOTECHNICAL BOREHOLE (1989)
 - A—A— CROSS SECTION LINE LOCATION

NOTE: WELDON SPRING ORDINANCE WORKS GRID SYSTEM. UNDERLINED BOREHOLES IN QUARRY AREA SHOWN ON SECTION B-B

SCALE 100 0 100 FT
 30.5 0 30.5 M
 SOURCE: BASE TOPOGRAPHY (1983)
 BOREHOLE AND WELL DATA, SEE TABLE 1-2

**WSSRAP QUARRY
 BOREHOLE, WELL AND
 PIEZOMETER LOCATION MAP**

FIGURE 2-1

REPORT NO: DOE/OR/21548-147 EXHIBIT NO: A/QY/030/1190

ORIGINATOR: SDG DRAWN BY: GLN DATE: 11/90

average, the floor of the quarry is approximately 482 feet msl (MKES 1988).

The southern rim of the quarry site rises to an elevation of between 540 and 560 feet MSL and is highest along the south and east sides. It forms a ridge or prominent bluff trending east-northeast that is well defined by topographic contours as shown on Figure 2-1. The west side of the quarry is lower, and the higher adjacent ridges to the north (514 feet, MSL) and south (551 feet, MSL) form a saddle shaped entrance to the quarry. The bottom of this saddle has an elevation of 492 feet MSL, approximately equal to the present quarry floor. A 0.5 acre pond has formed in the deepest part of the quarry. A pyramidal shaped limestone hill located just northeast of the pond is a remnant of the quarried rock. This hill has a maximum elevation of 518 feet MSL, approximately equal to that of the quarry's northern rim. Overall, there is approximately 80 feet of relief between the floor of the quarry and the top of the highest southern rim. The quarry is enclosed by a chain link (cyclone) fence, with locked gates at the two entrances. A wooden pier that extends into the pond was used in the early 1960s when water from the pond was pumped into the Little Femme Osage Slough (MKES 1988).

A rail spur line runs across the proposed quarry staging and water treatment plant area and enters the lower level of the quarry through its low western saddle. This railroad spur extends approximately one-third of the quarry's length. Another spur branches off to the south of the proposed site area. The spur lines have deteriorated and become overgrown with vegetation. The Missouri-Kansas-Texas (MKT) railroad mainline located south of the quarry site was recently dismantled and the elevated railroad bed has been turned into a hiking trail called the Katy Trail.

2.2 Flooding

Flooding by the Missouri River is most likely from April through July of each year. Such flooding is usually caused by prolonged spring and early summer rains coupled with maximum snow melt. Flooding by the Femme Osage and Little Femme Osage Creeks is most likely during May and June of each year. These creeks are prone to flash floods, generally due to thunderstorms which are common at that time of the year.

The 100-year water surface elevation is estimated to be 474 feet MSL near the quarry (MKES 1988). Most of the proposed quarry staging and treatment area, except for small portions along the Femme Osage Slough and Little Femme Osage Creek, are above this elevation. Although flood data for the nearby streams is not available, flooding caused by these streams is unlikely (MKES 1988).

2.3 Geology

The following summary discussion of the geology in the region is based primarily on reports by Berkeley Geosciences Associates (BGA 1984) and by Morrison-Knudsen Environmental Services (MKES 1988). The first section contains a brief overview of the regional geology. It is followed by stratigraphic descriptions and an overview of regional and site hydrogeology.

2.3.1 Regional Setting

The site is situated in low limestone bluffs near the west bank of the Missouri River in St. Charles County, Missouri. The surface of the region is almost entirely covered by

unconsolidated Quaternary materials consisting of Holocene alluvium, Pleistocene glacial drift, and residual soils developed on highly weathered rock. Bedrock consists of Paleozoic limestone, shale, sandstone, and dolomite. The uppermost bedrock unit around much of the site is the Ordovician age Kimmswick Limestone. The Kimmswick Limestone is underlain by other Ordovician strata which include, in descending order, the Decorah Group (shale and limestone), Plattin Limestone, Joachim Dolomite, and St. Peter Sandstone. Strata overlying the Kimmswick Limestone have generally been eroded from the vicinity of the quarry.

In the Weldon Spring area, the bedrock has a regional strike of N60°W and dips approximately 0.5° to the northeast. The strata of the region have been uplifted by the Ozark doming, resulting in a northeast dipping monoclinial structure (BNI 1987). The Eureka/House Springs anticline is a minor structure located about 1 mile southwest of the quarry site. The axis of this anticline trends northwest (Kleeschulte and Emmett 1986). The limestone strata beneath the quarry staging and water treatment plant area are nearly flat, with a very slight (0.5°) dip to the northeast. Two major joint sets have been identified. One trends between N30°E and N72°E and the second trends between N30°W and N65°W. Both joint sets are nearly vertical (Roberts and Theis 1951).

2.3.2 Stratigraphy

Table 2-1 is a generalized description of the stratigraphy beneath the quarry site. Bedrock beneath the proposed construction areas is chiefly Ordovician limestone and dolomite overlying sandstone and shale. The bedrock is overlain by as much as 90 feet of Quaternary sediments. In upland areas, soil

TABLE 2-1 GENERALIZED STRATIGRAPHIC COLUMN FOR THE WELDON SPRING QUARRY AREA

<u>Age</u>	<u>Formation</u>	<u>Thickness (feet)</u>	<u>Description</u>
Quaternary	Alluvium and Residual Soils	0-100	Predominantly silty clay, clayey silt, and highly weathered bedrock.
Ordovician	Kimmswick Limestone	70	Medium- to coarsely-crystalline, fossiliferous, massive bedded, white to light gray limestone. Contains large voids due to solution effect along vertical fractures.
	Decorah Group	20-40	Green to brown shales with numerous, thin interbedded limestone layers in lower part. Grades upward into a medium- to thinly-bedded limestone containing thin shale partings.
	Plattin Limestone	100-120	Gray to dark gray, fine- to medium-grained, thin-bedded fossiliferous limestone.

Source: (MKES 1988)

cover may be 10 to 40 feet thick, although rock outcrops do occur. In the Missouri River floodplain to the south of the site, up to 100 feet of alluvial clays, silty clay, sand, and gravels can be found (BGA 1984, MKES 1988). The generalized descriptions that follow are of geologic units in the vicinity of the Quarry site. Units described are those found in the proposed construction areas.

The oldest rocks encountered on the site are part of the Champlainian Series of the Ordovician system. Geologic units from this series that are found on the site are the Plattin Limestone, Decorah Group, and Kimmswick Limestone (MKES 1988).

The Plattin Limestone is a buff to light gray, fine-to medium-grained, moderately hard, moderately fractured, fossiliferous limestone (BGA 1984, MKES 1988). Beneath the quarry site it is 100 to 120 feet thick and was the deepest unit encountered in the boreholes. In outcrop exposures, the Plattin is reported to be dolomitic, yellowish brown, with a weathered, pitted surface. Thin, fissile, light green to greenish gray shales are present in the upper portion, and small amounts of dark gray chert are present throughout the formation.

The Decorah Group is a light gray, thin-bedded, argillaceous limestone. It is fossiliferous in its upper portion with numerous shale and non-calcareous to calcareous silt and clay partings. The Decorah Group is 20 to 40 feet thick at the quarry site. Part of the western half of the lower quarry area is excavated into the upper 15 feet of this bedrock unit (BGA 1984, MKES 1988).

The Kimmswick Limestone, uppermost of the Ordovician formations on the site, unconformably overlies the Decorah Group.

The Kimmswick is the chief rock unit that was quarried in the former quarry, where it is approximately 70 feet thick. This unit is a light gray to buff or tan limestone. It is medium to coarsely crystalline, moderately weathered, moderately hard, fossiliferous, and medium to massively bedded. The unit contains chert nodules scattered along bedding planes. Macrofossils are common. Where exposed in outcrop, the Kimmswick Limestone shows a rough, pitted weathered surface. The Kimmswick Limestone contains numerous voids and exhibits solution features associated with the intersections of vertical joints and bedding planes (Huey 1978). Clay fillings are present in many of the joints.

The Quaternary units in the vicinity of the quarry site are chiefly alluvial sediments deposited along the Missouri River and its tributaries and glacial deposits in upland areas. An older weathering surface forms the base of the soil sequence (MKES 1988).

The fill in the quarry area is quite variable in composition. It ranges from quarry rubble and weathered bedrock to silt and clay. Typical sources are quarry spoils and on-site or off-site soils residuum which may have been excavated, transported, and recompactd (e.g., railroad bed aggregate and soil).

2.3.3 Hydrogeology

The summary of regional and site hydrogeology presented here has been abstracted from investigations in the adjacent quarry area (MKES 1988) and earlier studies (BGA 1984, Kleeschulte and Emmett 1986).

There are two distinct aquifers and one leaky confining layer in the shallow subsurface groundwater regime of the quarry site and vicinity. Ground water occurs in the upper portion of what has been referred to as the deep bedrock aquifer of St. Charles County (Kleeschulte and Emmett 1986). The aquifer extends completely through the bedrock sequence to the bottom of the (Cambrian) Potosi Dolomite. The upper section is a thinner (400 feet) less permeable part of the aquifer and acts generally as a leaky confining layer. On the site, this confining layer is water bearing and is comprised of the Kimmswick Limestone, Decorah Group, Plattin Limestone, and Joachim Dolomite. The thicker (1,000 foot) more permeable sequence underlying this confining layer is found throughout the county where the older formations have not been eroded (MKES 1988). Overlying this bedrock aquifer is an alluvial aquifer existing primarily in the Missouri River valley.

The fracture patterns observed in the quarry walls have been found to extend through the Decorah Group and probably into the Plattin Limestone (BGA 1984). Thus, the three bedrock formations (Kimmswick Limestone, Decorah Group, Plattin Limestone) encountered at the quarry site (together with the soil units) may be considered as one hydrogeologic unit, although the Decorah Group, which contains a large number of shale beds, is considered regionally to be a leaky confining layer (Kleeschulte and Emmett 1986). Groundwater flow most likely has formed the enlarged solution cavities found in the top of the Kimmswick Limestone. Recharge of the aquifer is through the exposed weathered limestone around the quarry rim; through fractures and joints exposed to the overlying silts, sands, and gravel; and through the quarry pond itself. Hydraulic connections between the overlying alluvial aquifer and the underlying bedrock aquifer are very likely in the quarry staging and treatment plant area.

An unconfined alluvial aquifer at the quarry staging and water treatment plant area occurs in the deposits overlying the limestone bedrock. Near the Little Femme Osage Creek and the Femme Osage Slough the aquifer is contained chiefly in alluvium of the Missouri River floodplain. The vadose zone in this aquifer occurs generally in the upper 10 feet of silt and, where it is exposed, the upper weathered portion of the Kimmswick Limestone. Generally, the water table elevation lies within 10 feet of the surface and exhibits seasonal fluctuations. The aquifer is readily recharged by precipitation, flood water, or both, and by infiltration through the soil or fractures and joints in the bedrock.

2.4 GEOTECHNICAL INVESTIGATION

2.4.1 General

A geotechnical exploration program for the quarry staging and water treatment plant area was performed in 1989 under the Weldon Spring Site Phase II Geotechnical Investigations Program. The purpose of this drilling program was primarily to provide geotechnical design parameters for the foundation of the proposed water treatment plant and for the embankments of the equalization basin and effluent ponds. Additionally, piezometers were installed in some of the boreholes to obtain groundwater levels.

Figure 2-1 shows the locations of the GTQ (GeoTechnical Quarry) series boreholes in the immediate area of the proposed construction. These boreholes, numbered GTQ-1 through GTQ-11, were drilled from February to May in 1989 by Hannibal Testing Laboratories (HTL) of Hannibal, Missouri, using a CME Model 55 truck-mounted drill rig. The PMC provided project direction and field geologists who logged samples, documented field operations,

and supervised drilling. To document the field work, the PMC geologists kept daily written records of all drilling activities in a bound log book. In soil, the drilling was generally advanced using continuous flight hollow stem augers with a 6-7/8 inch outside diameter (O.D.) by 3-1/4 inch inside diameter (I.D.). In borehole GTQ-11, 7-1/4 inch O.D. by 4-1/4 inch I.D. augers were used. Coring in bedrock was achieved by using an NQ wireline core barrel (see Appendix A).

Soil sampling was performed at 2.5 foot intervals. Disturbed soil samples were obtained using a 2.0-inch O.D., 1.5-inch I.D. Standard Penetration Test (SPT) sampler. Relatively undisturbed samples were obtained using a California split-barrel sampler having an O.D. of 3.0 inches and I.D. of 2.5 inches. Both the SPT and California samplers were driven a depth of 18 inches, using a 140-pound hammer free-falling 30 inches. The number of blows required to drive each 6-inch interval was recorded. Undisturbed samples were obtained by hydraulically pushing 3.0-inch diameter, 36 inch long Shelby tubes to a depth of 30 inches. Table 2-2 summarizes the GTQ borehole data found in Appendix A. Appendix A also contains the borehole logs, piezometer data, and a brief drilling report by the field geologists. The drilling report describes the procedures for the exploration program, including soil sampling, bedrock coring, sample chain-of-custody form, and constant head field permeability testing. The report also contains summary data tables, and health and safety precautions taken during the field program.

Piezometers were installed for measuring water levels in all the boreholes, except GTQ-1 and GTQ-10. Piezometers GTQ-3, GTQ-6, GTQ-7 and GTQ-8 were abandoned when the exploration program was completed. The abandonment consisted of removing each

TABLE 2-2 Geotechnical Borehole and Piezometer Summary

Borehole/ Piezometer Number	Date Completed	Total Depth (feet)	Screened Interval (feet)	Comments
GTQ-1	3/16/89	95.7	N/A	No Piezometer
GTQ-2	4/3/89	98.0	11.5 to 31.5	
GTQ-3	2/24/89	88.0	10.0 to 29.0	Abandoned ¹ 4/19/89
GTQ-4	3/13/89	77.0	17.5 to 36.5	
GTQ-5	4/27/89	110.0	95.0 to 104.0	Redrilled. Screened into bedrock. ²
GTQ-6	2/28/89	58.5	38.5 to 57.5	Abandoned ¹ 4/20/89
GTQ-7	2/10/89	56.5	25.5 to 55.0	Abandoned ¹ 4/18/89
GTQ-8	2/17/89	76.0	17.5 to 36.5	Abandoned ¹ 4/24/89
GTQ-9	4/13/89	76.2	12.0 to 32.0	
GTQ-10	4/6/89	109.5	N/A	No piezometer
GTQ-11	5/3/89	80.0	60.0 to 79.0	

¹ Piezometers GTQ-3, 6, 7 and 8 were abandoned by first drilling out the hole to total depth and backfilling with Volclay grout.

² GTQ-5 was first completed on 3/8/89, the original screened interval 15.0 - 34.0 feet. This borehole was redrilled to place a piezometer screen in the bedrock rather than the alluvium.

piezometer, redrilling the hole, and sealing with Volclay grout. The original piezometer in GTQ-5 was replaced with a new piezometer, with screen placed 10 feet into the limestone bedrock. Piezometer GTQ-11 was constructed 20 feet away and screened within the overlying sediments. Groundwater elevation data from this piezometer couple should help determine the degree of hydraulic separation between the bedrock aquifer and the overlying alluvial sediments.

Groundwater elevation data are shown in the cross sections and summarized in Table 2-3. Water levels in backfilled boreholes (GTQ-1, GTQ-10) were taken after the groundwater level had stabilized for a few days. Groundwater elevations monitored on a regular basis in the remaining active piezometers in the quarry staging and water treatment plant area after the initial exploration program are included in Table 2-4.

2.4.2 Geotechnical Cross-Sections

Geotechnical cross sections shown on Figures 2-2 through 2-5 were developed to provide site subsurface information to assist design. The cross sectional data were derived from the recent WSS Phase II Geotechnical Investigations boreholes (GTQ-1 through GTQ-11) and existing wells and boreholes. Units shown are major correlatable soils and lithologies that were traced across the site. Less areally extensive but significant units (e.g., quarry rubble fill) are also shown. The lateral extents of the units are inferred and approximate only. Queries indicate areas where unit continuity or thickness is inferred. The soil units shown were subdivided according to their distinguishable geologic and geotechnical properties (color, grain size distribution, water content, etc.) and classified using the Unified Soil Classification System (USCS).

TABLE 2-3 Groundwater Elevations Measured in Wells
(April-May 1989)

Well or Piezometer	Well Elevation	Groundwater Elevation (feet)	Date Measured (year)	Comments
<u>Quarry Staging and Water Treatment Plant area</u>				
GTQ-1	474.38	451.38	3/16/89	No well. Groundwater elevation measured in borehole prior to grouting.
GTQ-2	475.26	455.02	5/04/89	
GTQ-3	460.86	454.76	4/07/89	Grouted 4/19/89.
GTQ-4	476.12	454.79	5/04/89	
GTQ-5	477.22	453.79	5/04/89	
GTQ-6	508.30	460.40	4/07/89	Grouted 4/20/89
GTQ-7	480.62	456.52	4/17/89	Grouted 4/18/89
GTQ-8	477.62	457.32	4/20/89	Grouted 4/24/89
GTQ-9	478.02	457.58	5/04/89	
GTQ-10	485.97	453.87	4/07/89	No well. Groundwater elevation measured in borehole prior to grouting.
GTQ-11	477.17	453.17	5/04/89	
MW-1026	481.50	454.92	5/13-14/89	
MW-1027	485.53	457.78	5/13-14/89	
MW-1028	467.77	450.50	5/13-14/89	
<u>Abandoned Quarry Area</u>				
MW-1002 (TW-7)	557.11	466.30	5/13-14/89	

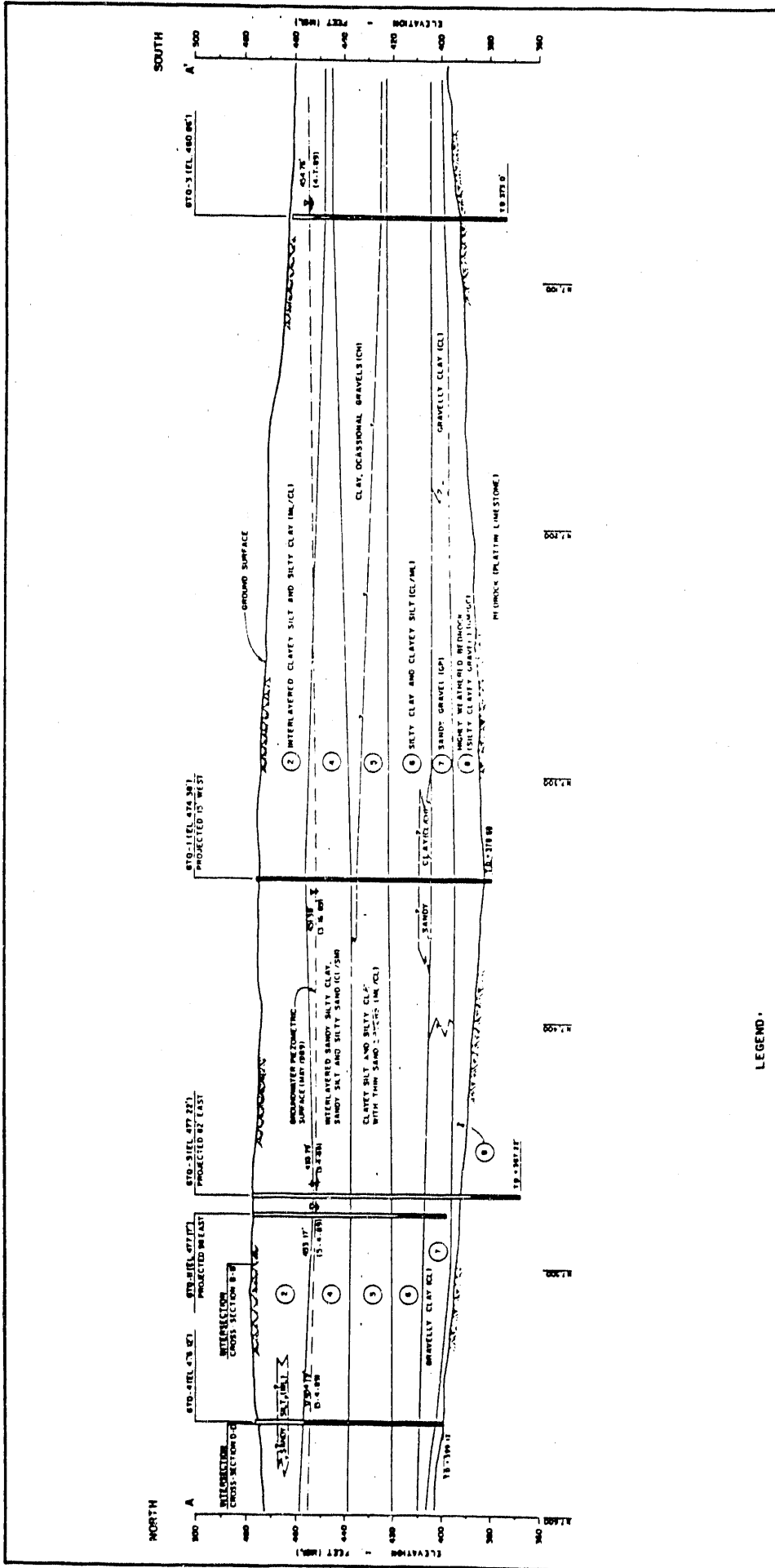
NOTES: Groundwater elevations are taken from Appendix A.

MW - series is re-designation of wells installed for earlier investigations by others.

TABLE 2-4. SUMMARY OF GROUNDWATER ELEVATIONS IN ACTIVE
PIEZOMETERS

Active Piezometer	Water Level Elevations (feet, msl)		
	5/4/89	7/5/89	10/30/89
GTQ-2	455.12	452.36	451.06
GTQ-4	454.57	454.15	453.07
GTQ-5	453.36	452.79	452.64
GTQ-9	457.25	456.24	455.12
GTQ-11	453.15	452.35	452.06

NOTES: Piezometer GTQ-5 screened in bedrock; all other
piezometers screened in soil



WSSRAP QUARRY GEOTECHNICAL CROSS-SECTION B-B'

FIGURE 2-3

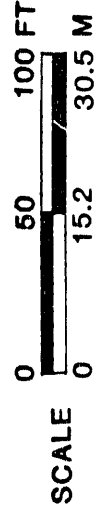
REPORT NO	DOE/OR/21548-147	EXHIBIT NO:	A/QY/032/1190
ORIGINATOR	SDG	DRAWN BY:	GLN
		DATE	11/90

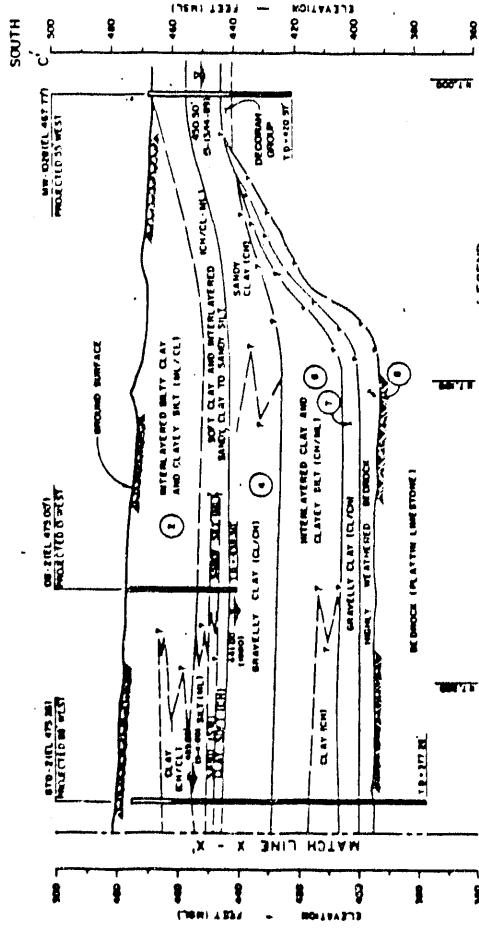
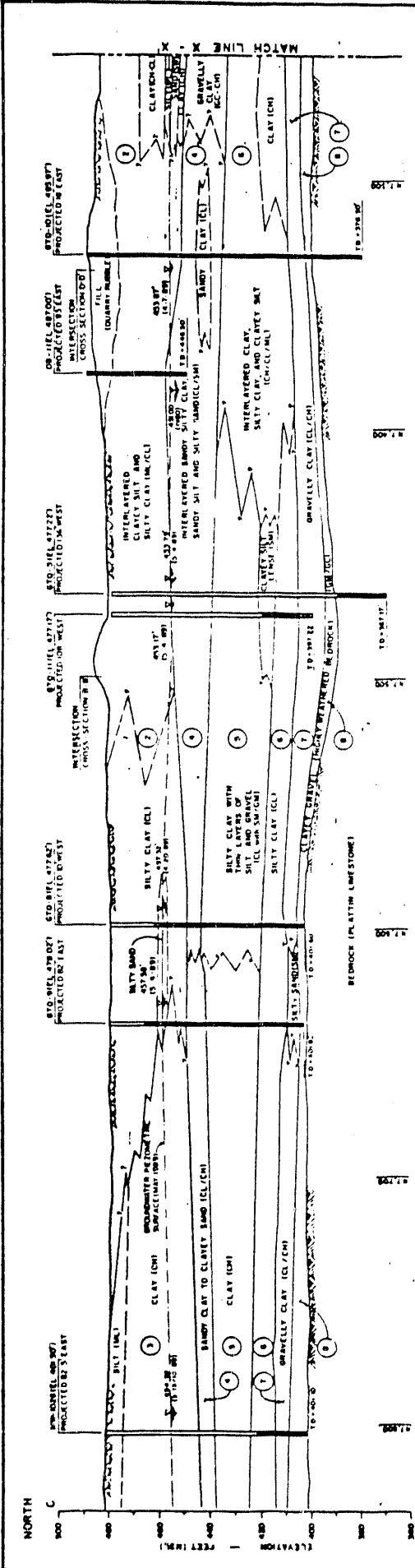
LEGEND:

- GROUND SURFACE AND/OR BEDROCK SURFACE
- - - - - GEologic CONTACTS BETWEEN MAJOR SOIL UNITS, OTHERS WHERE APPROPRIATE
- BOREHOLE LOCATIONS
- BOREHOLE OR BACKFILL PORTION OF WELL
- INDICATES GROUNDWATER ELEVATION AT TIME OF INSTALLATION
- UNITS MEASURED BETWEEN INTERNAL BOUNDS
- DATE SHOWN IN PARENTHESES
- ① UNIT DESCRIPTIONS FOUND IN TABLE 2-3

NOTES:

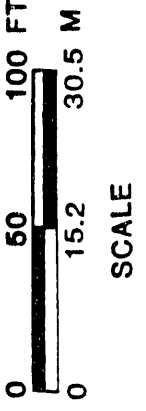
1. METERS 870-3 ASSUMED AND ROUNDED 470/90





LEGEND.

- GROUND SURFACE AND/OR BEDROCK SURFACE
- - - - - GEOTECH CONTACTS BETWEEN MAJOR SOIL UNITS, OBTAINED FROM BORINGS
- - - - - GEOTECH CONTACTS BETWEEN MAJOR SOIL UNITS, OBTAINED FROM DRILL LOGS, OBTAINED FROM BORINGS
- - - - - BOUNDARIES BETWEEN SURFACE DATE AND INTERIORS
- BORING OR SAMPLE LOCATION OF WELL
- (WITH NUMBER) INDICATES UNSATURATED ELEVATION AT TIME OF SAMPLING
- (WITH DATE) INDICATES UNSATURATED ELEVATION MEASURED IN WELL DATE SHOWN IN PARENTHESIS
- (WITH DATE) UNIT DESCRIPTIONS FOUND IN TABLE E-3.



WSSRAP QUARRY GEOTECHNICAL CROSS-SECTION C-C'

FIGURE 2-4

REPORT NO: DOE/OR/21548-147	EXHIBT NO: A/QY/033/1190	DRAWN BY: GLN	DATE: 11/90
ORIGINATOR: SDG			

NOTES: 1. PEZOMETER BTO-8 ABANDONED AND ROUTED 4/24/89

TABLE 2-5 Geotechnical Cross-Sections Soil Units Descriptions

Unit Name and Number	Description	Comments
1. Fill/Quarry Rubble	Poorly sorted chert and limestone gravels, cobbles, and boulder; angular to subrounded; intermixed with sands, silts and clays.	Limited areal extend in quarry staging and treatment plant area; Sections B-B', C-C' and D-D'.
2. Interlayered Clayey Silt and Silty Clay (ML/CL)	Distinct layers: very dark gray, light brownish gray, greenish gray, and dark brown all with rust brown staining, clays, silty clays, clayey silts and silts, occasional very fine grained, thin sand lenses; nonplastic or low plasticity; stiff; dry to moist; plant roots common in upper few feet, with decayed organics and iron staining common throughout.	Numerous interbeds at south end of site; highly plastic clays (CH) also occur as isolated lenses; Section C-C'.
3. Clay (CH)	Grayish brown, with rust brown iron oxide stains, clay; stiff to very stiff.	Areally restricted to north end of site, where it forms a 30 foot thick layer; Section C-C' only.
4. Interlayered Gravely Clay, Sandy Silty Clay, Sandy Silt, Silty Sand (CL/SM)	Dark greenish gray to dark bluish gray, sandy silty clay to sandy silt and fine- to medium-grained silty sand; low to medium plasticity; loose to medium dense; wet.	Discontinuous layers throughout. Sand occurs in lenses 1-3 feet thick.

TABLE 2-5 Geotechnical Cross-Sections Soil Units Descriptions (Continued)

Unit Name and Number	Description	Comments
----------------------	-------------	----------

The highly weathered bedrock residuum indicated on the cross sections is usually the zone where coarse gravel with sand or clay was described in a boring log just above the bedrock. This material was interpreted as having been weathered from the underlying bedrock because of the high percentage of limestone and chert rock fragments in the gravel. The top of the bedrock was defined as the depth where auger drilling could not be advanced further, labeled "refusal" on the drill logs.

2.5 SUBSURFACE CONDITIONS

2.5.1 Soils

The soils at the quarry staging and water treatment plant area are primarily the products of alluviation in the floodplain of the Missouri River and its tributaries. The principal surficial deposit on the major upland flats and narrow summits consists of silty clay.

Thinner silty clay deposits overlie the highly weathered limestone bedrock on hill tops and valley side slopes. The surface soils on the narrow valley floodplains of the Little Femme Osage Creek and other tributary streams to the Femme Osage Creek and Missouri River are moderately thick to thin lenses of gravelly to silty loams and chert gravels deposited from erosion of the valley sides. Most of these gravels are very close to their source and show very few signs of down-valley erosional transport. Alluvium dominates the lowest elevations in the quarry and vicinity to the south and southwest of the quarry staging and treatment plant area (MKES 1988).

Subsurface soil units usually consist of silty clays and clayey silts. In general, some sands and gravels were

5. **Clayey Silt and Silty Clay with Thin Sand Layers (ML/CL with SM)** Dark greenish gray to dark bluish gray; silt, with minor very fine- to fine-grained sands; medium to low plasticity; stiff to very stiff; wet. Occasional gravel lenses at south end of site (Section A-A'). Very clayey at north end of site (Section C-C').
6. **Interlayered Clay, Silty Clay and Clayey Silt (CH/CL)** Dark gray to dark bluish or greenish gray; clay and silt, with occasional chert gravels, and trace medium- to coarse-grained sand; very stiff to hard; medium to high plasticity; wet.
7. **Gravelly Clay and Clayey Gravel (CL/GC)** Dark greenish gray to dark bluish gray clay with angular to subrounded tan to white limestone and pale blue chert gravels, and trace fine- to medium-grained sand; clay is medium to high in plasticity, gravel is medium dense; wet.
8. **Highly weathered Bedrock** Dark greenish gray to dark bluish gray clayey gravel; subangular to angular coarse limestone and chert gravel, to cobble size; medium dense, with traces of fine- to medium-grained sand, and silt; clayey matrix is medium to highly plastic and very stiff to hard; wet.
- Clayey Gravel (GM/GC)** Old weathering surface; decomposed bedrock of gravel to cobble size fragments. Found throughout site and region.

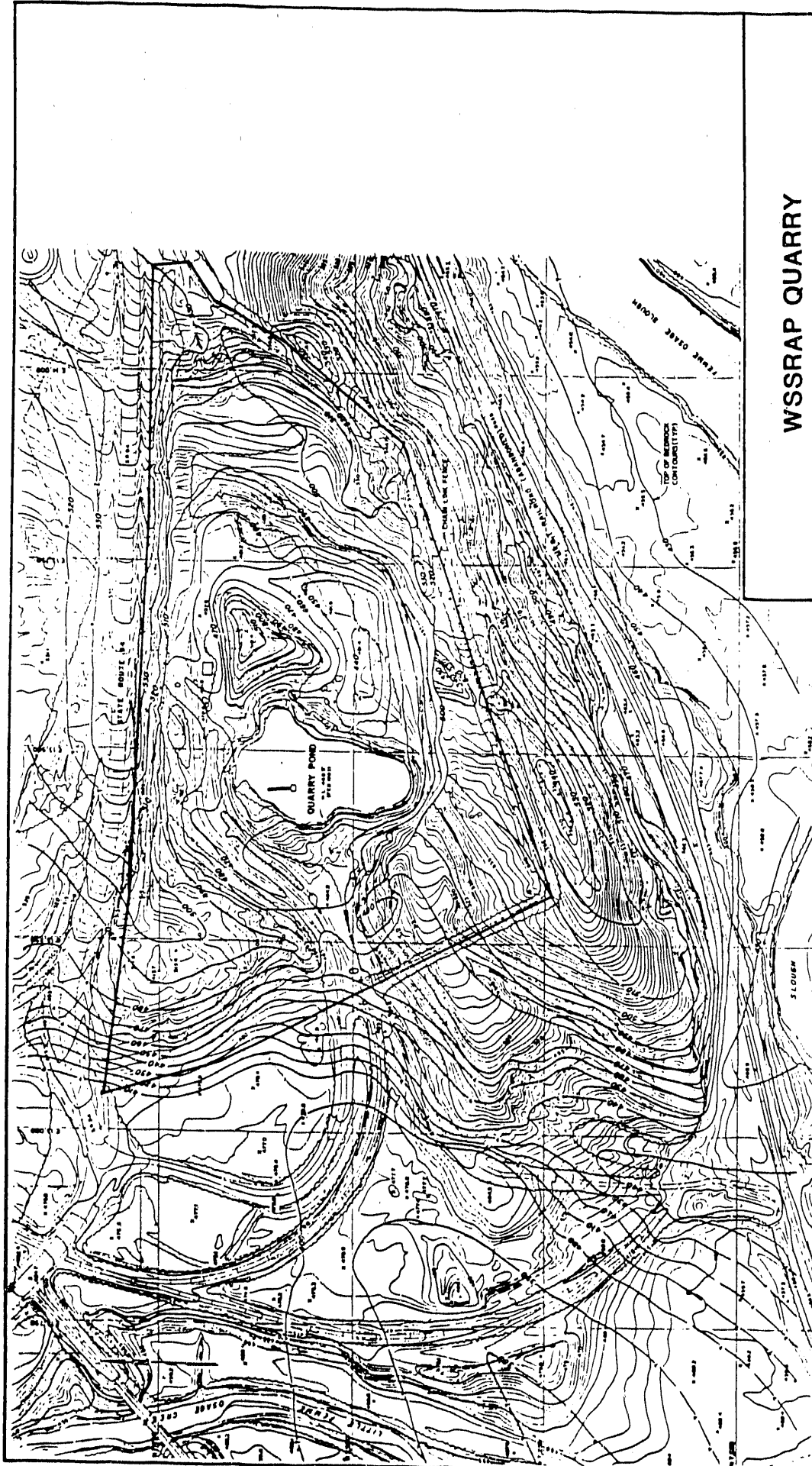
encountered in the lowest units and in the western half of the quarry staging and water treatment plant area. The thickest soil accumulations (up to 90 feet) occur around boreholes GTQ-11, GTQ-5 and GTQ-1 (near the intersection of cross-sections A-A', B-B' and D-D').

The most extensive or significant materials that comprise the alluvium in the subsurface are described in Table 2-5. Descriptions are based on soil geotechnical properties and are keyed to numbers in the appropriate cross sections (Figures 2-2 through 2-5).

2.5.2 Bedrock

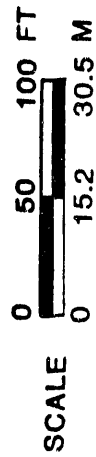
Bedrock at the quarry site includes the Kimmswick Limestone, the Decorah Group, and the Plattin Limestone (Table 2-1). These rock units comprise, in turn, the uppermost bedrock units beneath the subsurface of the site. The Kimmswick Limestone itself was quarried for use as crushed stone aggregate (MKES 1988). The Kimmswick Limestone is most extensive around the quarry area and forms the cliffs and bluffs of the quarry rim. West of the fence line separating the quarry from the quarry staging and water treatment plant area, the Kimmswick Limestone and the underlying Decorah Group have been eroded away. Thus the Plattin Limestone is the chief bedrock unit in the subsurface of the quarry staging and water treatment plant area, except for the south-southwest trending ridge where boreholes GTQ-6 and MW-1028 are located (see west half of cross section B-B', and all other cross sections).

Figure 2-6 shows the top-of-bedrock elevations beneath the quarry site. The map is based on all available depth-to-bedrock data from the boreholes and wells listed in Table 1-2, as well as on the geotechnical boreholes drilled for this investigation. The top-of-bedrock surface is defined as the depth below the ground surface where drilling by hollow stem auger was no longer possible. Since different drill rigs and varying diameter augers were used for drilling the boreholes used in compiling the map, the top-of-bedrock contact is not



**WSSRAP QUARRY
ELEVATION TOP OF BEDROCK**

FIGURE 2-6



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	DATE: 11/90

sharp but gradational, indicating the transition from clayey gravel and the decomposed bedrock rubble to relatively unweathered rock.

The lowest bedrock elevations (381 feet MSL) are found near the far western boundary of the proposed quarry staging and water treatment plant area (borehole GTQ-1). The bedrock surface rises from this low area to an elevation of 400 feet in the northern half of the site and to its highest elevation of 530 feet along State Route 94, just north of the center of the quarry.

One of the prominent features of the top-of-bedrock surface beneath the site is the bedrock slope extending from boreholes MW-1027 and QB-11 south-southwest to boreholes GTQ-6 and MW-1028 (see Figure 2-6). Southwest of GTQ-6 this slope drops a total of 74 feet in two steps, with a middle bench most prominent in the subsurface between boreholes GTQ-10 and GTQ-6. To the north and west of this bedrock slope the underlying Plattin Limestone forms the bedrock surface beneath the site.

A narrow depression cuts across this slope just east of monitoring well MW-1028. This depression, interpreted as a buried stream channel, bears north and slightly northeast along the base of an elevated bedrock plateau centered roughly on the quarry area. It is likely that this channel was cut by an ancestral Femme Osage Creek or tributary as it flowed across the western half of the site. The source of the former stream was most likely to the northwest, as shown by a rise in bedrock surface topography to the northwest and north of State Route 94. This rise continues to the northwest, off the edge of the map (Figures 2-1 and 2-6).

2.5.3 Alluvial Aquifer Properties

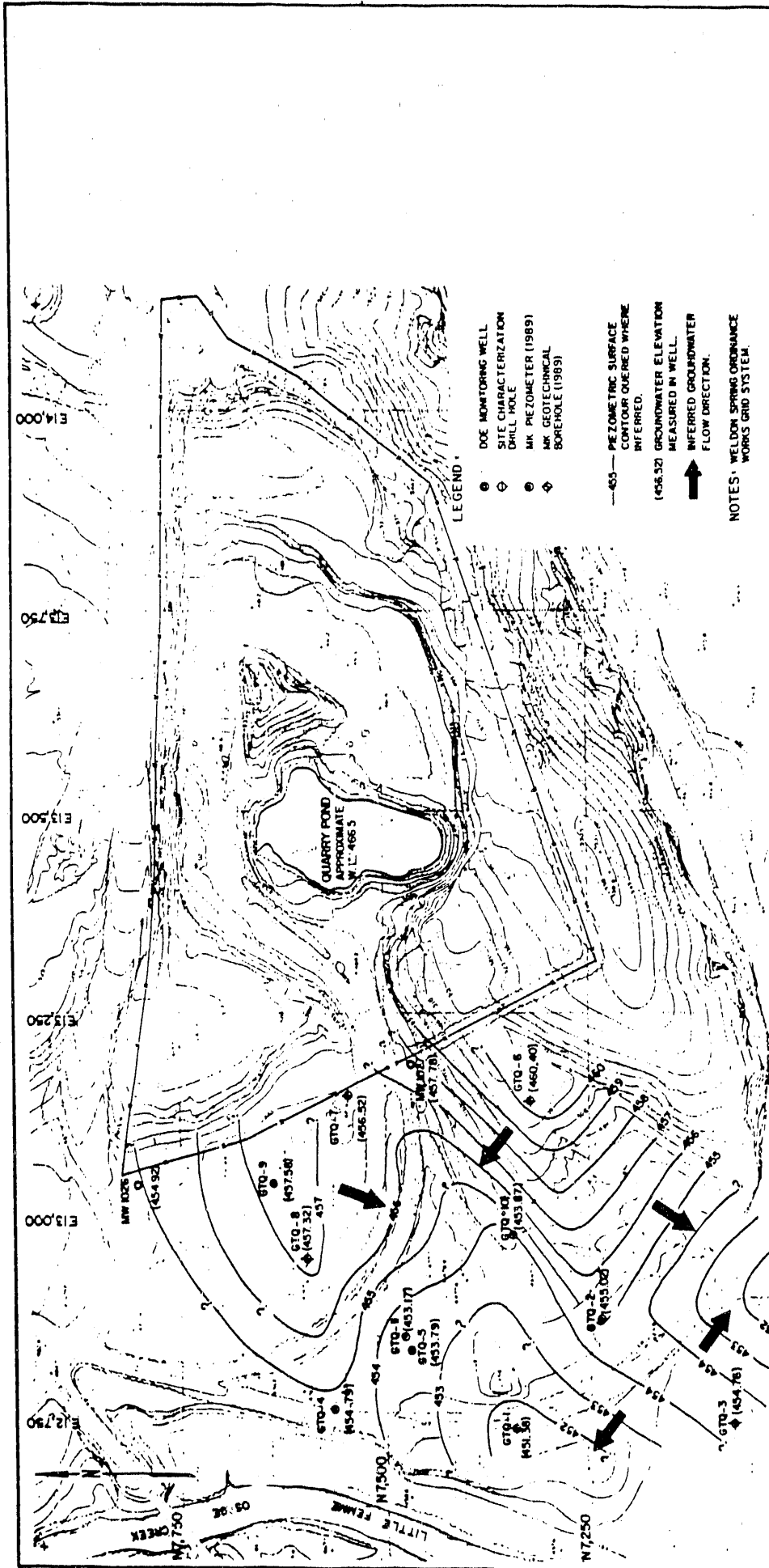
The hydrogeologic investigations at the quarry staging and water treatment plant area were conducted to determine alluvial aquifer properties. Accordingly, the program included in situ testing of soil

to determine the hydraulic conductivity (permeability), and installation of monitoring wells to obtain groundwater elevation data and determine groundwater flow and vertical gradients. Soil permeability values are summarized in Table 2-6, groundwater elevations in Tables 2-3 and 2-4, and the piezometric surface beneath the site on Figure 2-7. All values are summarized from data presented in Appendix A.

Field constant-head permeability tests were performed according to the following procedure. After augering to the desired depth and clearing the borehole, a sampling rod or instrument was lowered to the bottom of the temporary casing formed by the auger and/or NQ hollow-stem drilling rods. The sampling rods were pushed into the test formation approximately 4 to 6 inches to ensure a good contact with the formation. The temporary casing (auger and/or NQ rod) was then filled with water until the water level was maintained even with the top of the rods. Water was added as needed to maintain the water level at the top of the rods for a period of 10 minutes. The volume of water needed to keep the rods full was measured and recorded. This procedure was repeated twice more for a maximum test interval of 30 minutes (USBR 1970).

Constant head permeability test results are summarized in Table 2-6. Results showed permeabilities in the range of 10^{-5} to 10^{-6} cm/sec for most soils. Average permeabilities for clays and silty clays (CH and CL) were often below the test detection limit (approximately 10^{-8} cm/sec). Average permeabilities for silts and clayey silts (ML) and some silty/clayey sands (SM/SC) ranged between 10^{-6} and 10^{-5} cm/sec. No tests were performed in gravels or gravelly layers. One test (GTQ-10) in a material that appeared most likely to be rubble fill yielded a permeability value of greater than 3.3×10^{-2} cm/sec.

Groundwater elevation data for all geotechnical boreholes (GTQ-1 through GTQ-11) from late April to early May 1989 are summarized in Table 2-3 and shown on the geotechnical cross sections (Figures 2-2



LEGEND

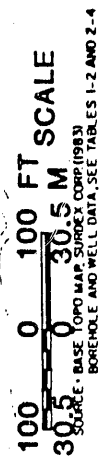
- DOE MONITORING WELL
- SITE CHARACTERIZATION DRILL HOLE
- ⊕ MK PEZOMETER (1989)
- ⊕ MK GEOTECHNICAL BOREHOLE (1989)

—455— PEZOMETRIC SURFACE CONTOUR DERIVED WHERE INFERRED.

(456.32) GROUNDWATER ELEVATION MEASURED IN WELL.

↑ INFERRED GROUNDWATER FLOW DIRECTION.

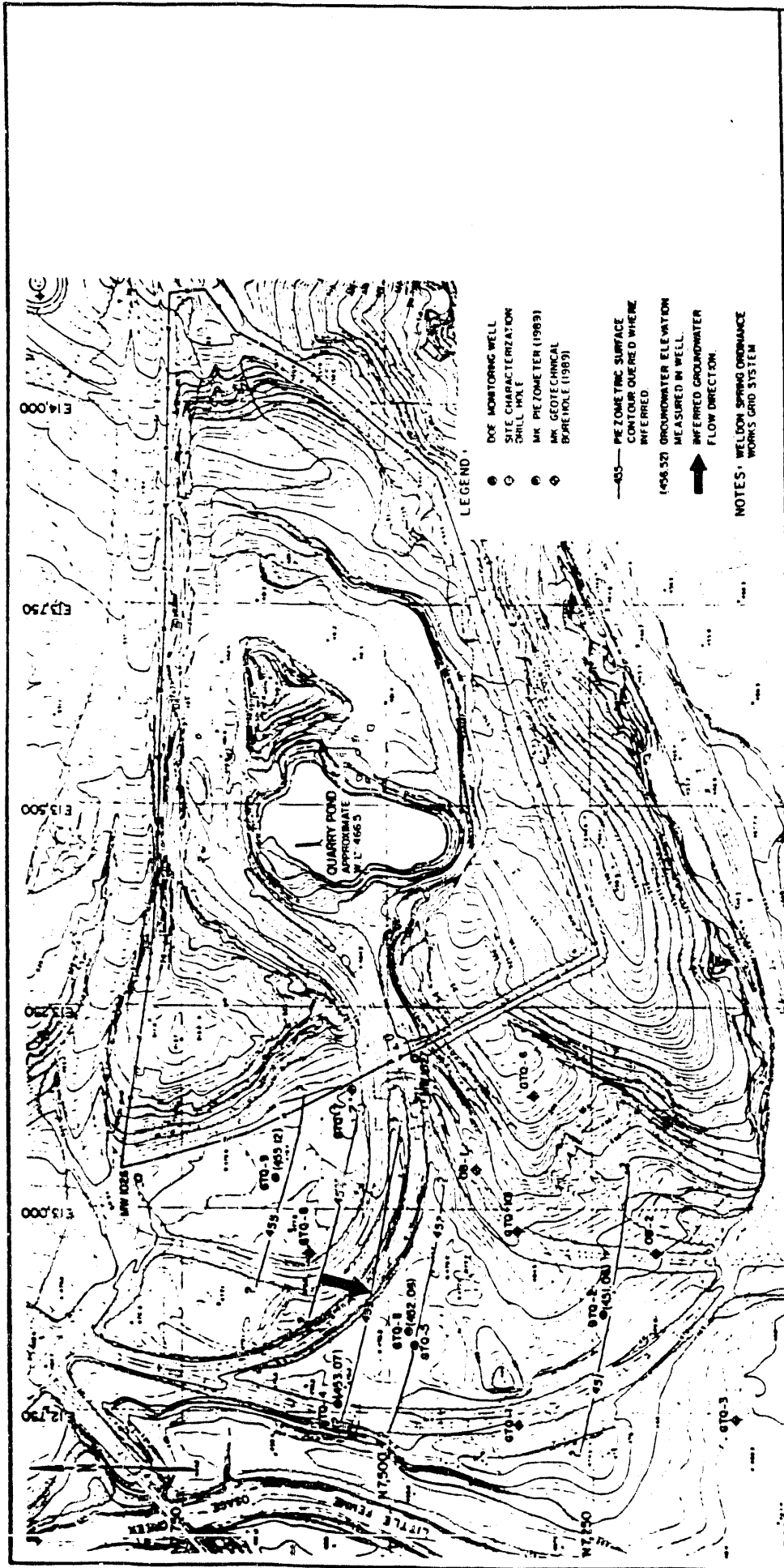
NOTES: WELDON SPRING ORDINANCE WORKS GRID SYSTEM.



WSSRAP QUARRY GROUNDWATER ELEVATION CONTOUR MAP (MAY 1989)

FIGURE 2-7

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ORIGINATOR: SDG	DRAWN BY: GLN
	DATE: 11/90



100 0 100 FT SCALE
 30.5 0 30.5 M
 SOURCE - BASE TOPO MAP, SINGLETY CORP (1983)
 BOREHOLE AND WELL DATA, SEE TABLES 1-2 AND 2-4

**WSSRAP QUARRY
 GROUNDWATER ELEVATION
 CONTOUR MAP (OCT. 1989)**

FIGURE 2-7B

REPORT NO: DOE/OR/21548-147	EXHIBIT NO: A/QY/037/1190
DRAWN BY: SDG	GLN
DATE: 11/90	

TABLE 2-6 Summary of In Situ Soil Permeability Values

Bore-hole No.	Test Depth (feet)	Calculated Permeability (cm/sec)	Soil Type
GTQ-1	10.0	6.72×10^{-6}	ML
	15.0	3.50×10^{-5}	CL
	20.0	7.96×10^{-6}	CL
GTQ-2	12.5	NO FLOW*	CH
	17.5	NO FLOW*	CH
	22.5	5.0×10^{-6}	ML
GTQ-3	11.5	1.36×10^{-3}	ML
	17.5	NO FLOW*	CH
	22.5	2.05×10^{-5}	CH
GTQ-4	12.5	6.50×10^{-6}	CL
	17.5	2.44×10^{-6}	CL
	22.5	2.80×10^{-6}	ML-CL
GTQ-5	12.5	NO FLOW*	CH
	17.5	4.87×10^{-6}	CH
	22.5	3.51×10^{-5}	ML
	32.5	3.16×10^{-5}	ML
GTQ-9	12.5	1.30×10^{-5}	CL
	17.5	NO FLOW*	CH
	22.5	6.84×10^{-5}	SM
GTQ-10	12.5	$>3.33 \times 10^{-2}$	CL (fill)
	17.5	NO FLOW*	CH-CL
	22.5	NO FLOW*	CH
GTQ-11	42.0	1.74×10^{-6}	CH
	46.5	1.04×10^{-5}	CH
	51.5	1.11×10^{-5}	CH

* No water added in 10 minutes.

through 2-5). Groundwater elevation data for the remaining active piezometers (GTQ-2,-4,-5,-9,-11) measured on a regular basis from May through October 1989 are listed in Table 2-4. The water table in the alluvial aquifer is relatively flat, ranging between 450 and 460 feet in elevation (20 to 30 feet below the surface) for most of the proposed quarry staging and water treatment plant area, with a general flow to the south. This reflects flow direction measured in the bedrock aquifer at the quarry site and vicinity (MKES 1988). The piezometric surface based on all boreholes mimics topographic highs and lows in the bedrock surface (Figure 2-7).

The map on Figure 2-7 shows two groundwater divides that are centered on a high portion of the bedrock beneath boreholes GTQ-8 and GTQ-9 and a southwest trending ridge extending from boreholes GTQ-6 through GTQ-2 and OB-2. Inferred flow directions closely coincide with the locations of the bedrock depressions discussed earlier. Groundwater flow over the larger southern ridge is inferred to be channeled east of MW-1028, the location of the postulated local buried stream channel. A broader channel-like pattern directs groundwater to the west, along the postulated channel.

3 GEOTECHNICAL LABORATORY TESTING

Laboratory tests were performed to provide a basis for foundation design, recommendations for embankment design, settlement evaluation, and slope stability analyses. Representative samples from the borings were tested to determine their physical properties, compressibility, permeability, and shear strength. Geotechnology Inc. (GSI) was awarded the contract for laboratory testing in 1989 and 1990. A summary of laboratory testing results is presented in Table B-1. A brief description of the laboratory tests procedures, significance, and applicability is presented in this chapter.

3.1 Test Methods and Procedures

The gradation test, or particle-size analysis, determines the distribution of the various particle sizes in soil. Standard sieves are used to separate the particles for all sizes except silts and clays, for which a hydrometer analysis is used. Particle size distribution is used to classify soils, estimate permeability (using empirical correlations), and analyze particle migration potential at the interface of two soils. These tests were carried out in accordance with ASTM Test Method D422 and D1140.

The specific gravity test is used to determine the unit weight of the solid particles of a soil with respect to the unit weight of water. Specific gravity is used in equations expressing relationships of air, water, and soil solids. The standard test procedure is ASTM D854.

Plasticity characteristics of the clayey soils are provided from Atterberg limits. They include liquid limit, plastic limit,

and plasticity index. These properties are used in classifying soils and estimating relative consistency and activity. These index properties are also used in correlations with compressibility, permeability, compactability, shrink-swell, and shear-strength characteristics. Tests were performed in accordance with ASTM D4318.

Moisture content and dry density tests were performed on selected undisturbed samples to help assign foundation design parameters. The moisture content, which is the pore water content of a soil, is used to determine soil index properties and soil consistency. It is used in most equations expressing relationships among air, water, and solids in a soil. In situ dry density is used to determine the in situ unit weight of a soil. It is the basis for determining overburden stresses for settlement calculations. It can also be used as an indicator of past stresses and loadings on the soil. These tests were performed in accordance with ASTM procedures D2216 and D2937.

Compaction tests were carried out on composite samples considered to be representative of the soils that are to be used in embankments. The compaction test develops moisture-density characteristics for a given soil. A series of tests at varying moisture contents will yield a compaction curve from which the maximum dry density and the optimum moisture content can be determined. Standard procedure used in compaction tests is U.S. Army Corps of Engineers, EM 1110-2-1906.

The settlement characteristics of the in situ clayey soils were evaluated from results of one-dimensional consolidation tests under the proposed design loading conditions. A sample is axially loaded and allowed to drain while being restrained laterally. The decrease in void ratio is measured as a function

of loading and time. The consolidation characteristics obtained are used to estimate both the rate and magnitude of consolidation under actual loading. They are also used to estimate the permeability of the soil. These tests were carried out in accordance with ASTM test method D2435.

Shear strength of the on site soils was evaluated by conducting consolidated, undrained triaxial compression tests (CU or R) and unconsolidated, undrained triaxial compression (UU or Q) tests. The CU triaxial compression determines total and effective shear strength parameters and stress-strain characteristics of a soil. The test simulates long-term conditions by allowing consolidation of the soil sample prior to applying the uniaxial loading. The UU triaxial compression test determines the total shear strength parameters and stress-strain characteristics of a soil. The test simulates short-term or end-of-construction conditions by not allowing excess pore pressures resulting from confining and axial stresses to dissipate. All triaxial testing was conducted according to procedures outlined in U.S. Army Corps of Engineers EM 1110-2-1906.

The permeability characteristics of the on-site fine-grained soils were evaluated using constant head permeability tests in the triaxial cells under confining pressures of 1 and 3 ksf for code specimen. The hydraulic conductivity data obtained from the test are used to determine seepage and flow rates, and as a measure of relative imperviousness. Test procedures U. S. Army Corps of Engineers EM 1110-2-1906 were followed to conduct the permeability tests.

3.2 Geotechnical Testing Results

The results of laboratory tests are summarized in Appendix B, Table B-1.

Laboratory sieve analyses indicate that subsurface soils usually consist of silts and clays with source sands and gravels encountered in the lowest units. The percent of fines (passing No. 200 sieve) ranges from 68% to 100% for silts and clays and is about 15% for silty sands.

The natural moisture content ranges from 22% to 50% and the dry unit weight from 71 to 106 pcf. The more plastic, clayey soils have liquid limits and plasticity indexes ranging from 30% to 81% and 10% to 55%, respectively. Atterberg limits for silty soils are between 24% and 36% (liquid limit) and 2% to 5% (plasticity index).

Triaxial shear tests performed on undisturbed samples under undrained, unconsolidated conditions show an undrained shear strength ranging from 400 to 3000 psf. The total and effective cohesion and angle of internal friction were determined from triaxial tests and undisturbed samples under undrained consolidated conditions. Effective cohesion is between 50 to 800 psf. Effective angle of friction ranges from 12° to 35°.

Laboratory consolidation tests and field standard penetration tests indicate that the on-site clayey soils are slightly to moderately over consolidated, with an over consolidation ratio of approximately 3 to 8. Permeability testing under confining pressures of 1,000 and 3,000 psf indicate that the clayey soils have coefficients of permeability ranging from 5×10^{-7} to 6×10^{-8} cm/sec.

that the clayey soils have coefficients of permeability ranging from 5×10^{-7} to 6×10^{-8} cm/sec.

SUMMARY OF SOIL TEST RESULTS
TABLE B-1

Hole or Trench Number	Sample Number	Depth (ft)		Laboratory Classification	Mechanical Analysis			Atterberg Limits		Specific Gravity G	Natural		Compaction		Shear Strength			Permeability		Consolidation							
		From	To		Gravel	Sand	Fines	LL	PI		W	γ_d (pcf)	W _x	γ_d	Optimum	C	Test	CU	UU	c_v	k	c_c	e_r	P_i			
G10-1	ST-02	7.5	10.0	ML	32	68		30	2		21.7	93.73				CU											
	SS-03	10.0	11.5	ML							23.7					CU											
	ST-04	12.5	15.0	CH	1	99		63	35		37.4	82.14				CU											
	SS-05	15.0	16.5	CL							36.					CU											
	SS-07	20.0	21.5	CL	19	81					27.1					CU											
G10-2	ST-08	22.5	25.0	CL-ML	11	89		24	5	2.69	29.5	91.0				CU											
	ST-10	27.5	30.0	CL	32	68		30	10		24.1	98.8			UU		SU=	800									
	ST-15	45.0	47.5	CL	2	98		49	27		35.7	85.3				CU											
	SS-09	23.0	24.5	ML	13	87					26.7					CU											
	SS-11	27.5	29.0	CH	4	88					42.4					CU											
G10-3	ST-03	5.0	7.5	CH							35	93.0				CU											
	ST-07	15.0	17.5	CH	1	99		76	50		40.4	79.0				CU											
	ST-08	20.0	22.0	CH	4	78		71	47		29	104.0			UU		SU=	400									
G10-4	SS-05	12.5	14.0	CL							27.8																
	ST-06	15.0	17.5	CH	1	99		57	33		23.5	98.2			CU												
	SS-07	17.5	19.0	CL							27.8																
	ST-12	30	32.5	CL-CH	3	97					50.3	71.8															
	SS-15	45.0	46.5	ML	5	95					27.4																
G10-5	ST-16	50.0	52.5	CH				74	49		43.4	75.7															
	ST-02	5.0	7.5	CH	1	99		53	28	2.63	23	103.3			CU												
G10-6	ST-04	10.0	12.5	CH	1	99		89	50		23.4				CU												
	ST-04	10.0	12.5	CH	1	99		89	50		23.4				CU												

SUMMARY OF SOIL TEST RESULTS
TABLE B-1

Hole or Trench Number	Sample Number	Depth (ft)		Laboratory Classification	Mechanical Analysis			Atterberg Limits		Specific Gravity G	Natural		Optimum		Shear Strength		Permeability		Consolidation				
		From	To		Gravel	Sand	Fines	LL	PI		w	Yd (pcf)	Ux	Ld	Test	C (PSF)	φ	k cm/sec	Cc	Cr	Pi Pci		
G10-5	SS-05	12.5	14.0	CH				74	48		34.6												
	ST-06	15.0	17.5	CH	6	94		79	55	2.70	26.9	92											
	SS-07	17.5	19.0	CH							23.4												
	ST-12	30.0	32.5	ML	6	73					27.4												
	SS-14	40.0	41.5	SM	1	84	15				26.3												
G10-8	ST-02	5.0	7.5	CH	2	98		89	55		32.3	88.6											
	ST-04	10.0	12.0	CH	2	98		56	32		22.6	94.4											
	ST-05	15.0	17.0								25.9												
	ST-07	22.5	25.0	ML-CL	0.5	99.5					37.2	87.0											
	ST-09	25.0	27.5		0.3	99.7					22.8	95.0											
G10-9	ST-14	40.0	42.5	ML	0.5	99.5		36	5		31.9	90.0											
	ST-16	55.0	57.5							32.0	82.0												
	ST-02	5.0	7.0	CH	0	100		84	55		32.1	93.1											
	ST-06	15.0	17.5	CH	4	93.5		50	24		29.4	88.0											
	SS-11	27.5	29.0	CL				30	15		22.7												
G10-10	ST-05	15.0	17.5	CH	4	94		68	39		28.5	93.0											
	ST-09	25.0	27.5							27.1													
	ST-11	30.0	32.0	CH	2	98		51	25		33.3	91.0											
	ST-16			CL	0.5	99.5					28.5	94.1											
	Composite Samples																						
**	1	10.0	27.5	CH				54	29				21.6	93.1									

* Composite sample SS-05 and SS-07
 ** Composite sample: G10-5 (SS-3), G10-1 (SS-5), G10-8 (ST-5), G10-10 (ST-9)

SP = Standard Proctor
 MP = Modified Proctor
 S = Special - See Test

TC = Triaxial Compressor
 UC = Unconfined Compressor
 DS = Direct Shear

UU = Unconsolidated Undrained
 CU = Consolidated Undrained
 CD = Consolidated Drained

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 General

The results of field investigations and geotechnical laboratory testing indicate that the proposed construction at the site is geotechnically feasible provided that the recommendations presented in this report are incorporated into the final design and construction.

The on-site saturated cohesionless soils have a high potential to liquefy during a strong earthquake capable of inducing a ground acceleration of about 0.2g. However, the effect of liquefaction on the ground surface is expected to be limited due to the bridging and capping actions of the upper 20 feet of stiff clayey soils overlying the cohesionless soils.

The proposed slopes (2:1 to 3:1, horizontal to vertical, H:V) for fill and cut embankments for the equalization basin and effluent ponds will be stable under the design seismic and static loading conditions. Ground settlements resulting from embankment construction are estimated to occur primarily during construction and decrease to negligible amounts soon after the completion of construction. Both time-dependent and post-construction settlement are anticipated to be insignificant.

4.2 Site Preparation and Earth Work

4.2.1. General

The preliminary project grading plan shows that minimal grading will be required to construct level pads for the support of the proposed decontamination pad, parking and roadway areas,

and the site drainage. Cuts and fills to about 22 feet and 14 feet in height, respectively, are planned for the proposed effluent ponds and equalization basin and the surrounding embankments. Earthwork can be performed by using conventional equipment including bulldozer, scraper, front-end loader, and vibratory sheepsfoot compactor.

4.2.2 Topsoil Stripping and Scarifying

Areas to be graded should be cleared and stripped of all vegetation, debris, loose fill, and any other organic materials present on the surface at the time of grading. Final stripping depths should be determined in the field by the construction engineer at the time of grading. In no case should the stripped material be reused as engineered fill. However, this stripped material may be used for landscaping as topsoil.

The exposed surface should be scarified to a minimum depth of 12 inches. The scarified material should be properly moisture-conditioned to near optimum moisture content and be compacted to at least 95% of maximum dry density as determined by the American Society of Testing Materials (ASTM) D698 test method. If significant pumping or yielding, or both, occur during scarification or recompaction, it will be necessary to stabilize the exposed subgrade. The actual stabilization method used will depend on exposed conditions and suitability should be judged by a geotechnical engineer.

4.2.3 Fill Materials and Placement

The existing on-site soils can be used as compacted fill, provided that all vegetation and deleterious materials are cleared. Imported granular fill materials should have a low

expansion potential (Plasticity Index less than 15), be free of organic material and rocks greater than 4 inches in size, have no more than 15% silt and clay particles, and be approved by the geotechnical engineer prior to importation. It is recommended that the upper 2 feet of the subgrade soils lying within 3 feet beyond the foundation lines should be selected granular material with low expansion characteristics. Fill should be placed in thin lifts (normally 6 to 8 inches, depending on compaction equipment), moisture conditioned to near optimum moisture content, and compacted to not less than 95% of maximum dry density based on test method ASTM D698. Observation and soil density tests should be carried out during grading to ascertain that the construction subcontractor has obtained the required degree of compaction and the proper moisture content.

4.2.4 Excavation Conditions

Conventional equipment such as bulldozers or backhoes can be used for site grading and trench excavation. Unusual difficulty is not expected in excavating the on-site soils. However, in some localized areas, special effort may be required to remove large rock particles or boulders. Construction dewatering may not be necessary provided that excavation does not extend below the water table at elevation of 460 feet. In all cases where excavation dewatering is required, all proper health and safety precautions should be taken to avoid contamination of personnel and equipment.

4.2.5 Permanent Cut and Fill Slopes

Generally, 2:1 (H:V) slopes may be used for cuts are not greater than 20 feet in height and 3:1 (H:V) slopes for heights up to 30 feet. Slopes greater than 30 feet high should be

provided with intermediate benches at least 8 feet wide and spaced every 20 and 30 vertical feet for 2:1 and 3:1 cut slopes, 2 respectively. Both inside and outside fill slopes on the embankments of the effluent ponds and equalization basin should be no steeper than 2:1 (H:V). These slopes should be over-filled prior to cut-back to expose a firm and compacted surface. Alternatively, the slope surface can be track rolled to at least 90% maximum dry density within the upper 1 foot of the surface and 95% maximum dry density below 1 foot from the surface, as determined by ASTM D698 test method.

4.2.6 Temporary Construction Slopes

Temporary construction slopes and excavations should be stabilized as follows: In excavations less than 5 feet deep, a vertical cut slope may be used with minimal shoring system for short construction periods. In excavations deeper than 5 feet, either shoring or cuts sloped 0.75 to 1 (H:V) may be used. Flatter slopes may be required in localized areas due to soil strength variation. If temporary cut slopes for the construction of the effluent ponds and equalization basin, are no steeper than 1:1 (H:V), they are expected to be generally stable.

4.2.7 Trench Backfill

For the purpose of this section of the report, backfill is defined as material placed in a trench starting at the pipe spring line and bedding is defined as all materials placed in a trench below the spring line.

Unless concrete bedding is required around utility pipes, bedding material should be well graded crushed rock, gravel or free draining sand meeting the gradation requirements of sizes

ranging from 0.75 inch to the No. 40 sieve. The bedding material should be placed to achieve an in-place density equivalent to at least 98% of the maximum dry density based on ASTM D698 test method. Due to the low permeability of the on-site clayey soils, jetting or ponding of sand bedding to aid in achieving the desired relative compaction will not be permitted.

The on-site inorganic soil may be used as trench backfill. The backfill material should be compacted to at least 90% beneath unpaved areas and paved areas deeper than 3 feet from the subgrade. It should be compacted to 95% of the maximum dry density within 3 feet of the subgrade in the paved area. All maximum dry density should be based on the ASTM D698 test method. The backfill material should be free of deleterious material and rocks greater than 4 inches in size, placed in thin lifts, and moisture conditioned prior to compaction.

4.3 Liquefaction

Liquefaction is a phenomenon in which saturated, cohesionless soils are subject to a temporary loss of shear strength under the reversing cyclic shear stresses associated with earthquakes. Field sampling, standard penetration-test blow counts and laboratory grain size analyses indicate that the loose fine silty sand encountered from 25 to 45 feet beneath the proposed effluent ponds and equalization basin has a high potential to liquefy. Liquefaction analysis was conducted using Seed's methods (Seed and Idriss 1971; Seed et al. 1984). The results suggest that these silty sands may liquify during an earthquake that induces a ground acceleration of about 0.2g at the site. Such an acceleration has an annual probability of being exceeded lower than 0.0006 (Nuttli and Hermann 1981).

Interpretation of boring logs reveals that the loose silty sands are localized strata interlayered within layers of clayey silts, sandy silts and silty clays. Also, there is no evidence of interconnection of the sand strata in a continuous manner between boreholes. The proposed facilities in the quarry staging and water treatment plant area are temporary; and the probability of an earthquake occurring with ground acceleration greater than 0.2g within a ten year period is low.

If such an earthquake should occur and the loose silty sand strata liquifies, the upper 20 feet of clayey soils would bridge the localized, liquefied sands. The bridging effects would prevent ground subsidence and minimize differential settlement at the ground surface. It is expected that the total and differential settlement at the ground surface due to liquefaction would be small. Consequently, the effect of sand liquefaction at the site is not to be a problem, and the proposed water treatment facilities can be constructed at the site.

4.4. Slope Stability Analyses for Equalization Basin and Effluent Ponds

4.4.1 General

Slope stability analyses of the proposed cuts and embankments surrounding the equalization basin and effluent ponds were performed in 1989 using the STABR slope stability computer program developed at the University of California, Berkeley. These analyses incorporated a limit equilibrium method of analysis based on the Modified Bishop Method. Input parameters for the model were surface topography, soil strata boundaries, boundaries of vertical slices, soil material properties (friction angle, cohesion, unit weight), pore pressure data, and surcharge

load. Three cross sections, X-X', Y-Y', and Z-Z' were analyzed. These cross sections are located in the areas of the equalization basin, effluent pond No. 2 and effluent pond No. 1, respectively (Figure 1-2). These sections are considered to be the most critical section for each facility. Soil properties used in the analyses were established from a review of laboratory index and physical properties and shear test results. A circular failure surface mode was assumed in all slope stability analyses. This assumption was made because no shallow weak continuous foundation layer was observed from available data.

4.4.2 Methodology and Soil Parameters

In evaluating embankment stability, different potential failure mechanics and failure surfaces were first considered. Initially, several general locations of possible failure were examined in each section to determine the most critical failure circles. These included locations through the toe of the embankment and through the foundation materials (toe and base failures, respectively). Data for the long-term case with seismic coefficient, which is expected to be the most critical case, were used in these initial searches. After determining the general location of the critical circle, minimum factors of safety were determined for these other cases: long-term static case, short-term seismic case, and short-term static case. Additionally, a rapid drawdown analysis was performed for the short- and long-term seismic conditions at section Z-Z' of Pond 1. A pseudo-static seismic coefficient of 0.1g was utilized for the short-term and long-term seismic cases. In the STABR program, the seismic coefficient was applied at the bottoms rather than at the middles of the slices, this being the more conservative assumption.

Soil strength parameters used for computation of embankment stability were primarily based on laboratory shear strength tests, field standard penetration tests, and experience with the characteristics of soils that are similar to the on-site soils. Table 4-1 presents the strength data used for stability analyses. For long-term static conditions, effective stress parameters were used. For short-term seismic cases (seismic and static conditions), undrained shear strength (s_u) was used in the calculation.

4.4.3 Stability Analyses Results

Stability analyses of the proposed embankments for the equalization basin and effluent ponds indicate that the minimum calculated factor of safety for each section analyzed is greater than the minimum required safety factors of 1.1, 1.3, and 1.5 for long-term and short-term seismic, short-term static, and long-term static conditions, respectively (COE 1970). The calculated factors of safety are presented in Table 4-2. These results indicate that the proposed cut and fill slopes, which range from 2:1 to 3:1 (H:V) will be stable under the short-term and long-term conditions with seismic, static, and maximum design flooding conditions. However, the proposed cut slopes located in the east and south of effluent pond No. 2 should not be steeper than 3:1 (H:V) nor higher than 30 feet.

4.5 Additional Slope Stability Analyses for Flood Conditions

In April 1990, a slope stability analysis was performed on the embankment slopes of the equalization basin and effluent ponds under a 100-year flood condition on the Little Femme Osage Creek. This analysis was performed specifically to address permitting needs and is not within the original scope of this

report. The findings show that the slopes will be stable under flood conditions. For completeness, a detailed document of this study is included in Appndix C.

4.6 Foundations

The 1989 design plans indicate that a slab-on-grade (thin mat) foundation is best suited to support the decontamination pad and the water treatment plant, with design loads of about 50 and 500 pounds per square foot (psf), respectively. The preliminary grading plan shows that a proposed fill up to about 5 feet will be constructed to create a pad for the water treatment plant and a fill of about 1 to 2 feet for the decontamination pad.

It is recommended that the upper 2 feet of these fills consist of non expansive granular soils with a plasticity index of less than 15. Provided that the aforementioned recommendations are followed, an allowable bearing capacity of 1,000 psf may be used for the static condition, and a bearing capacity of 1,300 psf may be used for the seismic or wind loading condition. A friction coefficient of 0.35 can be used for lateral load design.

4.7 Settlement

Settlement analyses were performed at the proposed sites for the water treatment plant and in the vicinity of the highest embankment fill at the southwest corner of effluent pond No. 1. Approximately 14 feet of fill is proposed at this pond. Approximately 5 feet of fill placement is planned to create a level pad for the water treatment plant.

Laboratory consolidation tests and field standard penetration tests conducted on the on-site clayey soils indicate that these soils are slightly to moderately overconsolidated, with an overconsolidation ratio (OCR) of approximately 3 to 8. The expected load increases that the proposed structures will create on those soils that have compressible characteristics are much less than the corresponding preconsolidation pressures on the soils. Consequently, most of the expected settlement will be elastic and should occur upon load application during construction. Time-dependent (consolidation) settlement will be minor.

Post-construction settlement at the proposed facilities was estimated to range from approximately 0.25 to 0.75 inch. This is considered to be insignificant and should take place within about six months following completion of construction.

4.8 Lateral Earth Pressures

Basement walls for underground sumps and pump stations should be designed to resist lateral earth pressures equivalent to a fluid weighing 60 pounds per cubic foot (pcf). This pressure is essentially the at-rest pressure for a leveled backslope and is appropriate for walls restrained at their top by the ground level slab. In addition to the earth pressure, the walls should be designed to resist a surcharge pressure of one-third of the design floor load or any other surcharge loads such as those exerted by heavy vehicles, or both. These design lateral pressures were derived assuming that a backdrain consisting of 18-inch wide drainage material is installed and that no hydrostatic pressure will develop behind the walls by entrapped water.

4.9 Site Drainage

Surface drainage gradients should be planned to prevent ponding and to direct surface water away from foundations, slabs and edges of pavements and toward suitable collection and discharge facilities.

4.10 Erosion Consideration

Areas adjacent to the top of the proposed 3:1 (H:V) cut slope in the eastern side of effluent pond No. 2 should be smoothly graded to direct surface runoff away from the slope and prevent it from flowing over the slope. Immediately after grading, slopes should be planted with vegetation to minimize erosion. Landscape water demand should be kept to a minimum by using native flora.

TABLE 4-1 Soil Strength Parameters

Section X-X

Material	Elevation (ft)	C (psf)	ϕ (degree)	c (psf)	ϕ (degree)	Su (psf)
Engineered Fill	480-468	260	17	250	21	1200
Alluvium	468-450	260	17	250	21	700
Alluvium	450-435	260	17	250	21	1000

Section Y-Y

Material	Elevation (ft)	C (psf)	ϕ (degree)	c (psf)	ϕ (degree)	Su (psf)
Engineered Fill	508-468	260	17	250	21	850
Alluvium	468-450	260	17	250	21	1100
Alluvium	450-435	260	17	250	21	1200

Section Z-Z

Material	Elevation (ft)	C (psf)	ϕ (degree)	c (psf)	ϕ (degree)	Su (psf)
Engineered Fill	480-468	320	20	300	23	1100
Alluvium	468-450	320	20	300	23	1100
Alluvium	450-435	320	20	300	23	1200

Notes:

C, ϕ = Total Stress Parameter
c, ϕ = Effective Stress Parameter
Su = Undrained Shear Strength

TABLE 4-2 Summary of Calculated Factor of Safety

Cases & Conditions	Equalization Basin Section X-X'	Effluent Pond 1 Section Z-Z'	Effluent Pond 2 Section Y-Y'	Required Minimum Factor of Safety
Long Term Seismic	1.39	1.50	1.14	1.1
Long Term Static	2.26	2.40	1.71	1.5
Short Term Seismic	1.33	2.40	1.71	1.5
Short Term Static	2.16	3.10	1.79	1.3

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APPENDIX A

GEOTECHNICAL BOREHOLE LOGS

GEOTECHNICAL INVESTIGATIONS PHASE II QUARRY STAGING AREA

INTRODUCTION

The Phase II geotechnical investigation program performed at the Weldon Spring Remedial Action Project (WSSRAP) consisted of several tasks. These included drilling at the Weldon Spring Quarry (WSQ) staging area; drilling at the temporary storage and disposal cell areas of the Weldon Spring Site (WSS); installation of piezometers at WSS and WSQ; and test pit excavation for clay borrow sources located near the WSS. This report presents the procedures used for characterizing the subsurface conditions at the quarry staging area. Included with this report are drill logs, well completion drawings, boring location plan, photographs, borehole summary table and borehole constant head permeability measurements.

LOCATION

The quarry staging area is located approximately 2.5 miles southeast of the WSS (3.6 miles via Highway 94) and is bounded to the north by Highway 94, on the east by Weldon Spring quarry, on the south by Femme Osage Slough and on the west by Little Femme Osage Creek. The area is heavily forested and displays approximately 40 feet of topographic relief. Topographic highs are mounds of soil and rock spoil removed as overburden from the adjacent limestone quarry.

PURPOSE

The subsurface investigation was performed to provide geotechnical design parameters for a water treatment plant. This plant, consisting of several holding ponds will treat contaminated water pumped from the adjacent quarry. The investigation included drilling, soil sampling, coring, in-situ permeability testing, piezometer construction and development, and hole abandonment.

PROJECT PERSONNEL

Subcontract WP117 was awarded to Hannibal Testing Laboratories (HTL), Hannibal, Missouri for drilling. HTL subcontracted drill pad locations and access clearing to Bleigh Construction, also of Hannibal, Missouri. HTL employees Tom Clay and Terry Hemme performed as driller and drillers helper, respectively. Nick McNew operated the D-6 caterpillar dozer for Bleigh
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Construction. MK-Environmental Services geologists Alan Benfer, Marie Schauer, Ray Parsons, Mark Cantrell and Paul Patchin, alternated for logging, documentation and supervision of the drilling and site activities. Charles Payton, WSSRAP geologist provided project direction.

HEALTH/SAFETY AND DECONTAMINATION

Because the quarry staging area is outside of the contaminated quarry, personal protective equipment was not required for site personnel. TLD badges and entrance/exit urine samples were not required. Hard hats and sturdy work boots were required and worn by all workers.

Scanning of samples for radioactivity was not required except for the first hole drilled, GTQ-7. An initial 1/2-hour safety meeting was presented and attended by all project personnel. The driller, Tom Clay was required to attend a weekly, one-hour subcontractor safety meeting.

The drill rig and all tools were decontaminated by steam cleaning upon arrival at the site and were decontaminated between borings and prior to demobilizing the site.

DRILLING AND SAMPLING

Eight borings, GTQ-1 through GTQ-8 were originally scheduled for the quarry staging area. During the project, three optional holes, GTQ-9, 10 and 11 were added. Figure 1 shows the boring locations. The GTQ designation for borings imply geotechnical quarry.

The quarry staging area investigation was performed between February 7 and May 4, 1989. Piezometer development occurred between June 9 and June 15, 1989. Drilling was accomplished using a CME Model 55 truck mounted drill rig. Continuous flight hollow stem augers with a 6-7/8 inch outside diameter (O.D.) by 3-1/4 inch inside diameter (I.D.) were used to drill the overburden to the top of bedrock. s with a 7-1/4 inch (O.D.) by 4-1/4 inch (I.D.) were used to modify piezometer GTQ-5 and to drill GTQ-11. Upon reaching bedrock, borings GTQ-2, 3, 5, 6, 7, and 10 were cored 20 feet using a NQ wireline core barrel. GTQ-1 was cored 2.7 feet, then abandoned due to a lost core barrel.

SOIL SAMPLING

Soil sampling was performed on 2-1/2 foot centers through the overburden. Disturbed soil samples were obtained using a 2.0-inch O.D., 1.5-inch I.D. Standard Penetration (SPT) sampler. SPT samples were placed in capped plastic jars. Relatively undisturbed samples were obtained using a California split-barrel sampler having an O.D. of 3.0 inches and I.D. of 2.5 inches. Four, 6-inch long, 2.5-inch I.D. brass liners were placed inside the California sampler. Each retained 6-inch liner was capped and taped. Both the SPT and California samplers were driven a depth of 18 inches beyond the lead auger using a 140-pound safety hammer free-falling 30 inches. The number of blows required to drive each 6-inch interval was recorded and the final two 6-inch drives were summed and expressed as blows per foot. Undisturbed samples were obtained by hydraulically pushing 3.0-inch diameter, 36-inch long steel Shelby tubes to a depth of 30 inches. Upon retrieval, both ends of the tube were sealed with molten bee's wax, capped, and taped. Care was taken to maintain the tubes in a vertical position at all times.

Soils encountered were described in accordance with the Unified Soil Classification System. Soil colors were described according to Munsell soil color charts. SPT and other selected samples were photographed. These photos, as well as the boring logs, accompany this report.

All samples were labeled and chain-of-custody forms were completed showing samples collected. All soil samples were stored in WSS building 404 in a heated room to prevent sample freezing. A daily field diary was maintained documenting all drilling activities. A daily record of work progress was submitted to Charles Payton daily as well as a weekly summary of pay items. Copies of field logs were sent weekly to Edward Tom, geotechnical engineer, MK-Environmental Services, San Francisco.

PERMEABILITY TESTING

Constant head permeability testing was performed in all borings except GTQ-6, 7 and 8. Testing and calculations followed the procedures outlined in the U.S. Bureau of Reclamation Earth Manual, appendix E-18 (open-end gravity flow tests). Individual tests were typically performed at depths of 12.5, 17.5, and 22.5 feet. In general, the 12.5 and 22.5 foot

intervals were within the unsaturated zone above the water table. Tests were performed in GTQ-11 at saturated depths of 42.0, 46.5 and 51.5 feet.

The permeability testing procedures consisted of lowering threaded NQ (2.375-inch, I.D.) drill rods through the hollow stem augers to the hole bottom. In all cases, testing followed the retrieval of a Shelby tube sample. The rods were pushed into undisturbed soil approximately 4-inches to provide a seal. Clear water was used to completely fill the inside of the rods and a full level was maintained by adding water as the water level dropped. The volume of water added after initial filling was recorded for the testing period of typically 10 minutes. Table 2 presents a summary of test results.

ROCK CORING

Soil sampling was continued to auger refusal at the top of bedrock. The hollow-stem augers were left in the hole to serve as casing and the boring was continued using a 10-foot NQ wireline core barrel having a 2.98-inch diameter diamond impregnated bit, providing 1.875-inch diameter core. A split inner-tube was used within the core barrel to maintain core integrity. Borings GTQ-2, 3, 5, 6, 7 and 10 were cored 20-feet and GTQ-1 cored 2.7 feet. Borings GTQ-4, 8, 9 and 11 were not cored (Table 1). Clear water only was used and was transported from the St. Charles County Water Plant using a 750-gallon water truck.

The core was striped red and blue to maintain orientation and the footage was marked on the core. Selective portions of the core were photographed. Discontinuities were graphically recorded on the log and described. Penetration rate, water return, recovery, and RQD were recorded. Wooden blocks, marking core runs and estimated loss zones were placed within the core as it was boxed. Photographs taken of the boxed core and selective portions of the core accompany this report. Core logs are also enclosed.

PIEZOMETER INSTALLATION

Piezometers were installed to measure water levels in each boring except GTQ-1 and GTQ-10. Piezometers were constructed of 2-inch (I.D.), flush-threaded PVC pipe. Screen lengths varied from 10 to 30-feet and were 2-inch PVC having

TABLE 1
BOREHOLE SUMMARY

Boring Number	Coordinates		Elevation TOC ¹ . Ground	Top of Rock	Total Depth	Date Completed	Monitoring Interval ² .	Approximate Groundwater Elevation	Remarks
	North	East							
G10-1	N7343.09	E12734.81	-	85	95.7	3/16/89	-	451 3/11/89	Grouted; no piezometer
G10-2	N7238.57	E12871.34	478.76	78.0	98.0	4/03/89	10.0-32.0	458.86 4/07/89	Active
G10-3	N7077.21	E12758.67	460.86	68.0	88.0	2/24/89	8.0-30.0	454.76 4/07/89	Abandoned and grouted 4/19/89
G10-4	N7562.43	E12759.90	479.20	77.0	77.0	3/13/89	14.0-37.5	455.22 4/07/89	Active
G10-5	N7471.32	E12832.31	478.32	90.0	110.0	4/27/89	93.5-105.0	453.79 5/04/89	Modified piezometer depth from 35.0 Active
G10-6	N7325.31	E13140.86	508.30	38.5	58.5	2/28/89	30.0-58.5	460.4 4/07/89	Abandoned and grouted 4/20/89
G10-7	N7546.09	E13148.45	480.62	36.5	56.5	2/10/89	18.5-56.5	456.52 4/07/89	Abandoned and grouted 4/18/89
G10-8	N7597.07	E12946.27	477.62	76.0	76.0	2/17/89	15.5-37.5	457.22 4/07/89	Abandoned and grouted 4/24/89
G10-9	N7635.84	E13039.46	480.39	76.2	76.2	4/13/89	10.0-33.0	457.65 4/19/89	Active
G10-10	N7344.88	E12974.48	485.97	89.5	109.5	4/06/89	-	453.87 4/07/89	Grouted; no piezometer
G10-11	N7479.28	E12848.48	479.77	-	80.0	5/03/89	57.0-80.0	453.17 5/04/89	Active

NOTE: All dimensions in feet.
1. TOC, top of casing
2. Top and bottom of sand pack

TABLE 2
CONSTANT HEAD PERMEABILITY TESTS

<u>Boring</u>	<u>Test Depths</u>	<u>Water Level</u>	<u>Soil Class</u>	<u>Take</u>	<u>Calculated Permeability (cm/sec)</u>
GTQ-1	10.0	22.8	ML	1.0 oz./10 min.	6.72×10^{-6}
	15.0		ML, CL	7.0 oz./10 min.	3.50×10^{-5}
	20.0		SC	2.0 oz./10 min.	7.96×10^{-6}
GTQ-2	12.5	17.5	CH	0/14 min.	0.0
	17.5		CH	0/11 min.	0.0
	22.5		ML	1.5 oz./15 min.	5.0×10^{-6}
GTQ-3	11.5	12.3	ML	128 oz./6-1/3 min.	1.36×10^{-3}
	17.5		CH	0/10 min.	0.0
	22.5		CH	3.0 oz./10 min.	2.05×10^{-5}
GTQ-4	12.5	23	ML	1.0 oz./10 min.	6.50×10^{-6}
	17.5		CH	0.5 oz./10 min.	2.44×10^{-6}
	22.5		ML	2.0 oz./10 min.	2.80×10^{-6}
GTQ-5	12.5	25.3	CL	0/10 min.	0.0
	17.5		ML	1.0 oz./10 min.	4.87×10^{-6}
	22.5		ML	9.0 oz./10 min.	3.51×10^{-5}
	32.5			9.0 oz./10 min.	3.16×10^{-5}
GTQ-9	12.5	20.3	CL	2.0 oz./10 min.	1.30×10^{-5}
	17.5		CL	0/10 min.	0.0
	22.5		SM	16 oz./10 min.	6.84×10^{-5}
GTQ-10	12.5	32.1	CL (F111)	Could Not Fill	$>3.33 \times 10^{-2}$
	17.5		CH	0/10 min.	0.0
	22.5		CH	0/10 min.	0.0
GTQ-11	42.0	25.0	CH	0.05 oz./10 min.	1.74×10^{-6}
	46.5		CH	3.0 oz./10 min.	1.04×10^{-5}
	51.5		CH	3.2 oz./10 min.	1.11×10^{-5}

0.010-inch slots. Meramec Warrior brand silica sand having WB-30 or WB-40 gradation served as a filter pack. Volclay grout provided a seal above the sand pack and to the ground surface. Piezometer completion drawings accompany this report.

Because hole depths averaged about 80 feet and water levels to be monitored averaged only about 20 feet, the initial four piezometers, GTQ-3, 6, 7 and 8 were constructed by filling the drill holes with sand to the bottom of the piezometer. Later it was decided that the sand-filled holes provided a conduit for vertical migration of potential contaminants. These four piezometers were therefore abandoned by drilling out the hole to total depth, removing the PVC pipe and backfilling with Volclay grout.

GTQ-5 was modified to place a 10-foot screen within the limestone to determine if a separate bedrock aquifer existed. GTQ-11 was placed 20-feet away and screened within the alluvial sediments. Volclay grout seals were placed in GTQ-5 and 11 by the tremie method.

PIEZOMETER AND BOREHOLE ABANDONMENT

Piezometers GTQ-3, 6, 7, 8 and borings GTQ-1 and GTQ-10 were abandoned by plugging with Volclay grout manufactured by American Colloid Company. Volclay consists of a high-solids bentonite clay powder with a 4% added initiator which causes the grout to set up to a plastic consistency. Each 50-pound bag of Volclay was mixed with 23 gallons of clear water. The Volclay powder was jetted through a hopper into a tub and thoroughly mixed by circulating through the rig mud pump. Two pounds of initiator were added per 50-pound bag of Volclay. Once mixed, the grout slurry was pumped through the hollow stem augers, the augers were retrieved, and the hole topped off.

PIEZOMETER DEVELOPMENT

Active piezometers GTQ-2, 4, 5, 9 and 11 were developed by purging water to remove sediment and to promote aquifer flow. Initially, all piezometers were bailed to remove the muddiest water. Subsequently, additional water was pumped using a TriLoc 1.7-inch PVC hand pump. In addition, GTQ-5 and GTQ-11 were pumped with a nitrogen-charged bladder pump. Development occurred between June 9 and June 16, 1989 and was performed by HTL

and supervised by Alan Benfer. All pumps and bailers were decontaminated prior to placing in a piezometer.

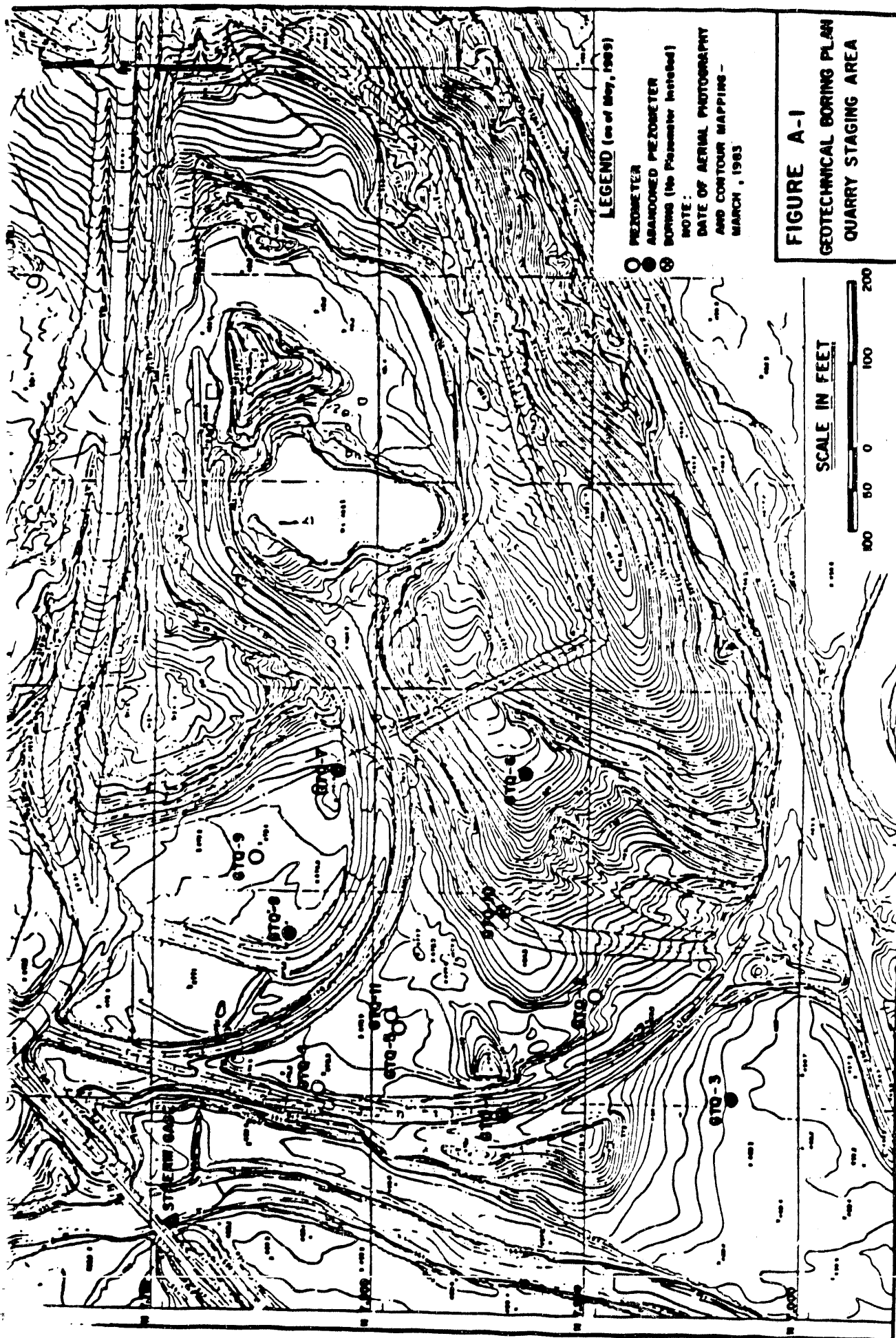
Project specifications required the purging of ten casing volumes of water for development. Even though greater than ten volumes were removed, the water in all piezometers remained somewhat turbid. The lack of clear water is probably due to sand filters being too coarse to trap the fine-grained alluvial materials. Initially, the piezometers were designed for water level monitoring only and were later developed in order to serve as water quality monitoring wells.

Table 3 presents a summary of the casing volumes and water purged from each of the active piezometers.

TABLE 3

<u>Piezometer</u>	<u>Casing Volume (Water Column=Gal.)</u>	<u>Volume Removed</u>
GTQ-2	10.4' = 1.7 gal.	146 gal.
GTQ-4	15.8' = 2.58 gal.	118 gal.
GTQ-5	81.3' = 13.2 gal.	212 gal.
GTQ-9	11.8' = 1.9 gal.	150 gal.
GTQ-11	55.4' = 9.0 gal.	185 gal.

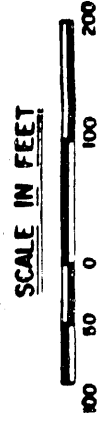
NOTE: 2.0-inch I.D. casing has a volume of 16.3 gallons per
100 feet of casing



LEGEND (as of May, 1963)

- PIEZOMETER
 - ABANDONED PIEZOMETER
 - ⊙ BORINGS (No Piezometer Included)
- NOTE:
 DATE OF AERIAL PHOTOGRAPHY
 AND CONTOUR MAPPING -
 MARCH, 1963

FIGURE A-1
GEOTECHNICAL BORING PLAN
QUARRY STAGING AREA



WELDON SPRING REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 4 of 7
 Project Number: MKE 5121
 Hole Number: GTQ-10













Project: Geotechnical Investigation Phase II

Location: Quarry Staging Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY	6"-6"-6" (N)		
85	85.0 86.5	SS 22	10"	4.10.4 14		CLAYEY GRAVEL, medium to high plasticity, dark greenish gray (5G 4/1) to dark bluish gray (5B 4/1) matrix with tan (7.5YR 7/4) and white (N8) gravel, wet, medium dense, fine to coarse, angular chert gravel, maximum size 1½", a little fine to medium sand, GC.	
89.5	89.5						
90						Auger refusal at 89.5'. Switched to NQ wireline core *Constant Head Permeability Tests NQ Wireline rods 2.375" I.D. @12.5', couldn't fill hole with 40 gal/10 min. @17.5', take 0 oz./ 10 min. @22.5', take 0 oz./ 10 min.	

GEOTECHNICAL BORING LOG LEGEND

SYMBOLIC LOG

	CLAY		GRAVELLY CLAY
	SILT		CLAYEY GRAVEL
	SAND		SANDY CLAY
	GRAVEL		TOPSOIL
	SILTY CLAY		SHALE
	CLAYEY SILT		CHERTY LIMESTONE

SAMPLER DESIGNATIONS

SS = STANDARD PENETRATION SAMPLER (2.0" SPLIT SPOON)

SB = CALIFORNIA SAMPLER (3.0" SPLIT BARREL)
X = LINERS COLLECTED

ST = 3.0" SHELBY TUBE

P.P. = POCKET PENETROMETER, UNCONFINED COMPRESSIVE STRENGTH (Tons/Sq.Ft.)

GROUNDWATER MEASUREMENTS

6.5'; 6/9  = DEPTH & DATE OF INITIAL WATER LEVEL MEASUREMENT

2.9'; 6/16  = DEPTH & DATE OF STABILIZED WATER LEVEL MEASUREMENT

COLORS

SOIL & ROCK COLORS FROM MUNSELL SOIL AND GSA ROCK COLOR CHARTS

WELDON SPRING REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 1 of 6

Project Number:
Contract WP 117

Hole Number
GTQ-1

Project:
Geotechnical Investigation - Phase II

Location:
Quarry staging area adjacent to RR tracks

Coordinates:
N. 7343.09, E. 12734.81

Drilling Contractor:
Hannibal Testing Labs

Drill Make and Model:
CME 55, Hollow Stem Auger, 6-7/8", 3/4"

Depth Top of Rock:
~ 80.0'

Depth Casing & Size:
Augers to 80'

Hole Size:
6-7/8" / 2.98"

Elevation:
474.38 g.s.

Angle from Vert. and Bearing:
Vertical

Depth Bottom of Hole:
95.7'

Water Level:
~ 23' 3/10/89

Fluid & Additives:
clear water

Date Start:
3/14/89

Date Finish:
3/16/89

Logger:
A. Benfer
M. Cantrell

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-8"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY			
						XXX O A A	Soil fill over 1/2" angular limestone gravel (Railroad ballast). ~ 2.0'
	4.0	SS			4-7-8		SILT, nonplastic, light brownish gray (10YR 6/2) with strong brown (7.5YR 5/8), very moist to wet, stiff (1.25) ML. Micaceous.
5	5.5	01	12"		15		
	7.5	ST					as above, pale brown (10YR 6/3), moist, very stiff (2.75)
	10.0						as above, light brownish gray (2.5Y 6/2), with FeOx, strong brown (7.5YR 4/4), med. stiff to stiff (1.0)
10 *	10.0	SS			6-7-7		
	11.5	03	12"		14		
	12.5	ST					Intermixed SILT to SILTY CLAY, nonplastic to low plasticity, light brownish gray (2.5Y 6/2), with FeOx, strong brn. (7.5YR 4/4), moist, stiff (1.75) ML, CL
	15.0	04	33"				
15 *	15.0	SS			1-3-3		SILTY CLAY, low to med. plasticity, brown (10YR 5/3) with disseminated FeOx, strong brown (7.5YR 4/6), moist very stiff (1.75) CL
	16.5	05	18"		6		
	17.5	ST					SAND, fine to medium, clayey (~30%), dark yellowish brown (10YR 4/4), moist med. stiff (0.75), SC
	20.0						
20 *	20.0	SS			1-2-2		SILTY CLAY, med. plasticity, mottled gray (10YR 5/1) and yellowish brown (10YR 5/6)-FeOx, moist, med. stiff (0.75) CL. Minor MnOx, 1" sand lens as above, SC: 24.0
	21.5	07	8"		4		
	22.5	ST					Intorbedded slightly SILTY FINE SAND (10% silt), (cont'd)
3/16/89	22.5	08	33 1/2"				
	25.0						

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 2 of 6

BOREHOLE LOG

Project Number:
Contract WP 117

Hole Number
GTQ-1

Project: Geotechnical Investigation - Phase II

Location: Quarry Staging Area

3/14/89
3/15/89

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS 8"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY			
		25	25.0 26.5	SS 09			
	27.5 30.0	ST 10	33"		CLAYEY SANDY SILT, sand very fine (15%) low plasticity, dark gray (2.5Y 4/0), moist, ML.		
	30.0 31.5	SS 11	16"	3-7-6 13	[Symbolic Log: Diagonal lines]	Very fine SANDY SILT, 25% sand, nonplastic, minor organics, dark gray (5Y 4/1), wet, stiff (1.5), ML.	
	35	35.0 37.5	ST 12	0			
		37.5 39.0	SS 13	14"	2-3-8 11	[Symbolic Log: Diagonal lines]	CLAY, highly plastic, dark gray (5Y 4/1), moist, stiff (1.75), CH. light gray claystone in shoe
	40	40.0 41.5	SS 14	18"	2-4-5 9		
		45.0 47.5	ST 15	33"		[Symbolic Log: Diagonal lines]	CLAYEY SILT, low plastic, very dark gray (5Y 3/1), moist to wet, (2.0) stiff, ML. Noted fine gr. sand slough in top of tube.
	50	50.0 51.5	SS 16	14"	2-2-6 8		
	55						

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 3 of 6

BOREHOLE LOG

Project Number:
Contract WP 117

Hole Number
GTQ-1

Project: Geotechnical Investigation - Phase II

Location: Quarry Staging Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-8"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY			
55	55.0 56.5	SS 17	12"	2-6-8 14		SILT, SILTY CLAY, (Medium to high plastic) no sand, moist, stiff (1.75), ML, CL/CH	
60	60.0 61.5	SB 18	12"	5-5-10 15		SILT, SILTY CLAY, (medium to high plastic), very dark gray (5Y 3/1), moist, stiff to very stiff (2.0), ML, CL/CH. Contains organics. Organic, CH	
65	65.0 66.5	SS 19	18"	3-6-9 15		SANDY CLAY, fine-coarse grain, ≈ 30% sand, moist very stiff, (2.25), organics, trace fine gravel, angular, (looks like glacial till). Clay is CH, very dark gray, (5Y 3/1). 65.5	
70	70.0 71.5	SS 20	14"	6-16-1 27		Same as above with 1 inch clean sand layer 71.0	
75						SANDY GRAVEL, up to 1", chert, light gray to dk gray, wet, med. dense, GW	
80	80.0 83.0	NQ-1	3" 8%			Hard drilling, probable weathered bedrock	
85						Predominantly angular chert fragments with minor limestone and gray clay	
						Auger drilled from 83.0' to 93.0', hard, relatively smooth drilling	

3/15/89
3/16/89

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 4 of 6

BOREHOLE LOG

Project Number:
Contract WP 117

Hole Number
GTQ-1

Project: Geotechnical Investigation - Phase II

Location: Quarry Staging Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION
		INTERVAL	TYPE & NUMBER	RECOVERY	6"-6"-6" (2)		Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
85							Appears to be weathered bedrock as opposed to gravel
90							
95							Auger refusal 93.0' 9:15 3/16/89 Switched to NQ core, pages 5-6 *Constant Head Permeability Tests NQ wireline rods: 2.375" I.D. @10.0' take 1.0 oz/10 min. @15.0' take 7.0 oz/10 min. @20.0' take 2.0 oz/10 min.

WELDON SPRING REMEDIAL ACTION PROJECT

 Sheet 5 of 6

BOREHOLE LOG

 Project Number:
 Contract WP 117

 Hole Number
 GTQ-1

Project: Geotechnical Investigation - Phase II

Location: Quarry Staging Area

DEPTH	COMMENTS TESTS/MONITORING INSTRUMENTATION CORING RATE AND SMOOTHNESS CORING FLUID LOSS CONTAMINATION	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES		GRAPHIC LOG	LITHOLOGY	
					FOO	FRACTURES PER FOOT		DESCRIPTION TIGHTNESS PLANARITY SMOOTHNESS FILLING, STAINING ORIENTATION	MINERALOGY CLASSIFICATION COLOR GRAIN SIZE ALTERATION
80	Begin core	80.0							
	3 mins/ft	NQ-1		1	0%				Recovered ~2" of chert, gravel and ~1." of limestone and minor gray clay.
	75% water return	0.25 3.0							
81	3½ mins/ft.	8%							
82	3 mins/ft								
	75% return								
83		83.0							
									Note numbering sequence Augured 83.0-93.0 See soil log
93		93.0							Moist joints spun
	3½ mins/ft	NQ-2		1					93.0-95.7 Limestone, pale yellowish brown (10YF 6/2) to dark yellowish brown (10YR 4/ fine grained, fossiliferous. Generally slight weathering. Minor, thin coating on joints: slight weathering.
	75% water return	1.8 2.7			.7 2.7	5		" " "Minor FeOx	
94	3 mins/ft	66%			P=.7			Rough, open ¼"	
	75% return					3		open, rough	94.3 - stylolites
95									94.75 - closed weathered (1/8 deep) fracture

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 6 of 6

BOREHOLE LOG

Project Number:
Contract WP 117

Hole Number:
GTQ-1

Project: Geotechnical Investigation - Phase II

Location: Quarry Staging Area

DEPTH	COMMENTS TESTS/MONITORING INSTRUMENTATION CORING RATE AND SMOOTHNESS CORING FLUID LOSS CONTAMINATION	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES			GRAPHIC LOG	LITHOLOGY	
					ROD	FRACTURES PER FOOT	DESCRIPTION TIGHTNESS PLANARITY SMOOTHNESS FILLING, STAINING ORIENTATION		MINERALOGY CLASSIFICATION COLOR GRAIN SIZE ALTERATION	CEMENTATION HARDNESS WEATHERED STATE
95			XX			4	open rough (4)		95.6 stylolites	
96									T.D. 95.7' 1:45 3/16/89 Core barrel cut off. Hole grouted with Volclay.	

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 1 of 7

BOREHOLE LOG

Project Number:
Contract WP 117

Hole Number
GTQ-2

Project: Geotechnical Investigation - Phase II		Location: Quarry Staging Area	
Coordinates: N.7238.57, E.12871.34		Drilling Contractor: Hannibal Testing Labs	
Drill Make and Model: CM5-55, H.S. Auger 6-7/8", 3/4"		Depth Top of Rock: 78.0'	Depth Casing & Size: 78.0'; 6-7/8" Auger
Elevation: TOC 478.76; 475.26 g.s.		Angle from Vert. and Bearing: vertical	
Water Level: 4/3/89 17.5' b.g.s.		Date Start: 9:30 3/23/89	Date Finish: 3/24/89
Fluid & Additives: water		Hole Size: 2.980"	
		Depth Bottom of Hole: 98.0'	
		Logger: M. Cantrell/ M. Schauer	

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-5"-5" (N)	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY			
						XXX	
	2.5 - 4.0	SS 01		0	2-2-3 5		Split spoon caught on rock, pushed rock causing no recovery. Area is fill near the surface, from 0-4'.
5	5.0 - 7.5	ST 02		25"			SILT, low plasticity, olive brown (2.5Y4/4) moist to wet, med. stiff-stiff (1.0) micaceous ML.
	7.5 - 9.0	SS 03		16"	1-3-5 8		SILTY CLAY, med. plasticity grayish brown (2.5Y 5/2) with Fe Ox, strong brown (7.5YR 5/6), moist, stiff (1.5) CL/CH. (contains organics)
10	10.0 - 12.5	ST 04		31"			CLAY, high plasticity, dark gray (2.5Y 4/2) with Fe Ox, dark brown (7.5YR 4/4) moist, stiff (1.75) CH.
	13.0 - 14.5	SS 05		18"	1-3-3 6		CLAY, highly plastic, same as above, pp=1.25 stiff CH
15	15.0 - 17.5	ST 06		24"			as above, with increasing Fe Ox, moist pp=1.25, CH
	18.0 - 19.5	SS 07		18"	1-1-1 2		as above, with increasing silt content pp= .75 med. stiff CL
20	20.0 - 22.5	ST 08		30"			SILT, med. plasticity, very dark gray (5Y 3/1) moist pp= .75 med stiff, ML
	23.0 - 24.5	SS 09		17"	1-2-3 5		as above, with minor fine sand, ML pp= .75
25							

4/3/89

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 2 of 7

BOREHOLE LOG

Project Number:
Contract WP 117

Hole Number
GTQ-2

Project: Geotechnical Investigation - Phase II

Location: Quarry Staging Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION
		INTERVAL	TYPE & NUMBER	RECOVERY			
25	25.0	ST				[Symbolic Log: Dotted pattern]	25.0-27.4 SAND, gray (2.5Y 4/0), wet, fine to medium grain, pp=1.25, stiff, SW.
	27.5	10	30"				27.4-27.5 CLAY, dark gray (2.5Y 5/0), highly plastic, medium stiff, CH.
	27.5	SS			1-3-3	[Symbolic Log: Diagonal lines]	27.5-28.6 CLAY, as above, pp=0.5
	29.0	11	16"		6		
30	30.0	SS			1-2-3	[Symbolic Log: Diagonal lines]	GRAVELLY CLAY, highly plastic with coarse sand, dark gray (7.5YR 4/0), moist, medium stiff (0.75), CH.
	31.5	12	16"		5		
35	35.0	SS			4-7-9	[Symbolic Log: Diagonal lines]	CLAY, highly plastic, dark gray (7.5YR 4/0) wet, soft to med. stiff (0.5), CH.
	36.5	13	14"		16		
40	40.0	SS			6-6-7	[Symbolic Log: Diagonal lines]	CLAY, medium plasticity, contains minor gravel and fine sand, dark gray (5Y 4/1), wet, stiff (1.25), CL-CH.
	41.5	14	9"		13		
45	45.0	SS			3-6-9	[Symbolic Log: Diagonal lines]	45.0-45.5 as above
	46.5	15	13"		15		
50	45.5					[Symbolic Log: Diagonal lines]	45.5-46.2 CLAYEY SILT, medium plasticity, very dark gray (5Y 3/1), stiff to very stiff (2.0), wet, minor organics, ML.
	46.5						46.2-46.5 CLAY, highly plastic, dark gray (2.5Y 4/0) pp=1.5 stiff, wet, CH.
55	50.0	SS			3-12-15	[Symbolic Log: Diagonal lines]	CLAYEY SILT, low plasticity, very dark gray (5Y 3/1), stiff to very stiff (2.0), wet, minor organics, ML.
	51.5	16	10"		27		

3/23/89
3/24/89

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 3 of 7

BOREHOLE LOG

Project Number:
Contract WP 117

Hole Number
GTQ-2

Project:
Geotechnical Investigation - Phase II

Location:
Quarry Staging Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY	6"-8"-8"		
					(N)		
55	55.0	SS	15"	15"	3-5-7	[Symbolic Log]	as above, pp=1.75
	56.5	17			12		
60	60.0	SS	15"	15"	4-5-8	[Symbolic Log]	CLAY, highly plastic, dark gray (7.5YR 4/0), stiff to very stiff (2.0), wet, CH
	61.5	18			13		
65	65.0	SS	18"	18"	4-5-6	[Symbolic Log]	CLAY, as above, bottom 6" contains minor sand and silt, pp=1.75, stiff, soft white specks possibly weathered limestone frag., CH
	66.5	19			11		
70	70.0	SS	9"	9"	2-7-6	[Symbolic Log]	GRAVELLY CLAY, medium to high plasticity, very dk gray (5Y 3/1), very stiff (2.5), wet, angular chert and limestone gravel, maximum size 1 1/4", CH
	71.5	20			13		
75	75.0	SS	7"	7"	16-12-1	[Symbolic Log]	as above, with increasing gravel and coarse sand ≈ 30% some clay is (5G 4/1) (rock color chart) pp=1.5, stiff
	76.5	21			22		
80	78.0' auger refusal 3/24/89 Switched to NQ core						*Constant Head Permeability Tests NQ wireline rods: 2.375" I.D. @12.5' take 0 oz/10 min. @17.5' take 0 oz/11 min. @22.5' take 1.5 oz/15 min.

3/24/89

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 4 of 7



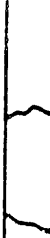
BOREHOLE LOG

Project Number:
MKE 5121

Hole Number
GTQ-2

Project: Geotechnical Investigation Phase II

Location: Quarry Staging Area

DEPTH	COMMENTS TESTS/MONITORING INSTRUMENTATION CORING RATE AND SMOOTHNESS CORING FLUID LOSS CONTAMINATION	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES			GRAPHIC LOG	LITHOLOGY	
					ROD	FRACTURES PER FOOT	DESCRIPTION TIGHTNESS PLANARITY SMOOTHNESS FILLING, STAINING ORIENTATION		MINERALOGY CLASSIFICATION COLOR GRAIN SIZE ALTERATION	CEMENTATION HARDNESS WEATHERED STATE
76										
77										
78	3/31/89 Run1 average 6½ min/ft 100% fluid return, white (N8) to light gray (N7)	78.0 Run1 4.0 5.5	78.0	1	3.4 5.5				Started coring at 78.0'	
79		73%			62%				Core loss 78.0-79.5'	
80					LP = 1.4'	3	Irreg., rough Chert nodule Irreg, smooth, Open, irreg, rgh, slt. solution Open, irreg, rgh trace MnOx Tight, irreg, rgh, trace MnOx		LIMESTONE, buff (7.5YR 8/4) to light gray (N7), fine grained, crystalline, fossiliferous (crinoids), large calcite crystals, moderately hard, fresh, with large blebs and wavy stringers and bands of white (N8) chert and tan (7.5YR 7/4) hard clay. Thinly bedded. Closely to medium fractured (spacing 2½" to 2'), occasionally widely fractured (spacing 3' to 4').	
81					5 4"	2	Tight, irreg, rough, MnOx			
82						2	Tight, irreg, rgh, trace MnOx			
83						0			Possibly PLATTIN FM	

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 5 of 7

BOREHOLE LOG

Project Number:
MKE 5121

Hole Number
GTQ-2

Project: Geotechnical Investigation Phase II

Location: Quarry Staging Area

DEPTH	COMMENTS TESTS/MONITORING INSTRUMENTATION CORING RATE AND SMOOTHNESS CORING FLUID LOSS CONTAMINATION	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	ROD	FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION TIGHTNESS PLANARITY SMOOTHNESS FILLING, STAINING ORIENTATION	GRAPHIC LOG	LITHOLOGY	
									MINERALOGY CLASSIFICATION COLOR GRAIN SIZE ALTERATION	CEMENTATION HARDNESS WEATHERED STATE
83		83.5		1			Tight, irreg., rgh, abund blk MnOx, solution		LIMESTONE, as above	
	Run2 average 6 min/ft	Run2 10.0 10.0		1	9.7 10.0	2				
84	100% fluid return, white (N8) to light gray (N7)	100%			97%		Tight, irreg, rgh			
					LP = 3.8'	1				
85					5 V 4"		Tight, irreg, rgh, MnOx, sol'n			
						1	Tight, irreg, rgh, MnOx			
86										
						2	Tight, irreg, rgh			
87							Open, irreg, rgh, MnOx			
						0				
88										
						0				
89	50% fluid return			89.0						
				2						
90						1	Tight, irreg, rgh, abund, blk MnOx			

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 6 of 7

BOREHOLE LOG

Project Number:
MKE 5121

Hole Number
GTQ-2

Project: Geotechnical Investigation Phase II

Location: Quarry Staging Area

DEPTH	COMMENTS TESTS/MONITORING INSTRUMENTATION CORING RATE AND SMOOTHNESS CORING FLUID LOSS CONTAMINATION	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES		GRAPHIC LOG	LITHOLOGY	
					ROD	FRACTURES PER FOOT		DESCRIPTION TIGHTNESS PLANARITY SMOOTHNESS FILLING, STAINING ORIENTATION	MINERALOGY CLASSIFICATION COLOR GRAIN SIZE ALTERATION
90				2		0		LIMESTONE, as above	
91						0			
92						0			
93						0			
94	Run 3 average 6 min/ft 75% fluid return, white (N8) to light gray (N7)	93.5 Run 3 4.5 4.5		2	4.3 4.5 96%	1	Tight, irreg, rgh, MnOx		
95		100%			LP = 1.9'	0			
96	4/3/89				5 V 4"	2	Tight, irreg., rgh, black MnOx, sol'n, stylolitic		95.45-98.0 Numerous stylo- lites with black (N2) MnOx and dark gray (N4) hard clay (get fractures along). Also less blebs and wavy stringers and bands.
97						1	Tight, rough, MnOx, sol'n, stylolitic, dark clay		

WELDON SPRING REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 7 of 7

Project Number:
MKE 5121

Hole Number
GTQ-2

Project: Geotechnical Investigation Phase II

Location: Quarry Staging Area

DEPTH	COMMENTS TESTS/MONITORING INSTRUMENTATION CORING RATE AND SMOOTHNESS CORING FLUID LOSS CONTAMINATION	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES			GRAPHIC LOG	LITHOLOGY	
					ROD	FRACTURES PER FOOT	DESCRIPTION TIGHTNESS PLANARITY SMOOTHNESS FILLING, STAINING ORIENTATION		MINERALOGY CLASSIFICATION COLOR GRAIN SIZE ALTERATION	CEMENTATION HARDNESS WEATHERED STATE
97				2					LIMESTONE, as above	
98		98.0							Tight, irreg, rgh, black MnOx, sol'n, stylo- litic, thin dk gray hard clay filling	
									T.D. @ 98.0' 4/3/89 Installed piezometer - see attached completion record	

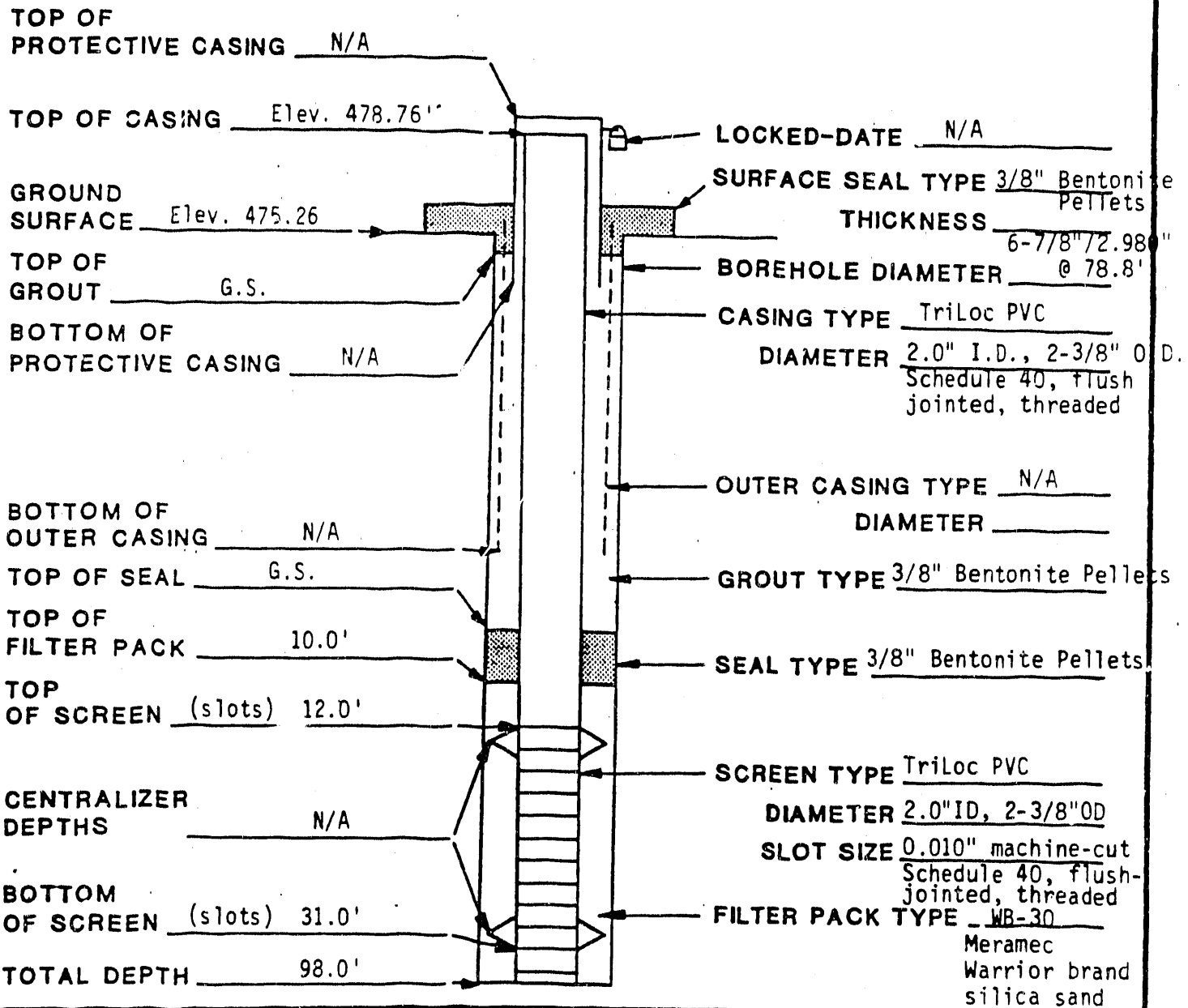
WELDON SPRING SITE REMEDIAL ACTION PROJECT

WELL COMPLETION RECORD

(Piezometer)

WELL NUMBER GTQ-2 DATE INSTALLED 4/3/89

PMC REPRESENTATIVE M. Schauer DRILLER Hannibal - Tom Clay



COMMENTS All depths are below ground surface.

Top of screened pipe 11.5', bottom of screened pipe 31.5', bottom of pointed tip 32.0'.

Borehole grouted with Volclay grout from 98.0' (T.D.) to 78.0', hole caved 78.0' to 37.0', bentonite pellets 37.0' to 33.0, then sand filter pack.

PMC REPRESENTATIVE SIGNATURE Marie Schauer JAB DATE 4/3/89
 Marie Schauer

WELDON SPRING REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 1 of 6

Project Number:
Contract WP 117

Hole Number
GTQ-3

Project: Geotechnical Investigation - Phase II		Location: Quarry Staging Area	
Coordinates: N. 7077.21, E. 12758.67		Drilling Contractor: Hannibal Testing Labs	
Drill Make and Model: CME-55, H.S. Auger, 6-7/8", 3/4" I.D.		Depth Top of Rock: 68.0	Depth Casing & Size: 6-7/8" auger 68
Elevation: 460.86 g.s.		Angle from Vert. and Bearing: vertical	
Water Level: 2/24/89: 2.3'; 2/23/89: ≈23.2'		Fluid & Additives: 2' clear water	
Date Start: 10:40 2/22/89		Date Finish: 11:00 2/24/89	Logger: A. Benfer
Depth Bottom of Hole: 88.0'		Hole Size: 6-7/8" / 2.98"	

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY			
	1.0 - 2.5	SS 01		8"	2-2-4 6	[Diagonal Hatching]	SILTY CLAY, med. plasticity, dark gray (10YR 4/1), moist, stiff (1.5)
	2.5 - 4.0	SS 02		11"	1-2-3 5		as above pp=2.5, very stiff, grayish brown (10YR 5/2)
5	5.0 - 7.5	ST 03		11"		[Diagonal Hatching]	as above pp=1.0, med. stiff to stiff, CH
	7.5 - 9.0	SS		12"	1-2-3 5		as above, pp=2.0, stiff to very stiff, dark brown (10YR 4/3) with FeOx (7.5YR 4/6) strong brown
10	9.0 - 11.5	ST 05		15"		[Diagonal Hatching]	
2/24/89	11.5 - 12.5	SS 06		14"	1-2-4 6		CLAYEY SILT to SILTY CLAY, low plasticity, thin sandy zones (very fine), mottled dark brown (10YR 4/3), and strong brown (7.5YR 4/6) (FeOx), moist, stiff (1.25). ML-CL.
15	12.5 - 15.0					[Diagonal Hatching]	SILT, 25% very fine sand, grayish brown (2.5Y 5/2), moist (wet from test), med. stiff (.75), thinly laminated, 25% FeOx, ML
	15.0 - 17.5	ST 07		29"			
*	17.5 - 19.0	SS 08			2-1-1 2	[Diagonal Hatching]	CLAY, high plasticity, gray (5Y 5/1), moist, (possibly wet), med. stiff to stiff (1.0), CH as above, pp < .25, very soft, 25% fine rounded gravel, 17.5-18.0', CL
20	19.0 - 20.0	ST 08		29"			as above, pp=2.0 stiff to very stiff CH, possibly some gravel, tube tip slightly bent.
*	20.0 - 22.5					[Diagonal Hatching]	
25	22.5 - 25.0						

WELDON SPRING REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 2 of 6

Project Number:
Contract WP 117

Hole Number
GTQ-3

Project: Geotechnical Investigation - Phase II

Location: Quarry Staging Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY			
		25	25.5 26.5	SS 09			
	22.5 29.0	SS 10		3-4-6		as above, pp= 1.75 stiff, CH	
30	30.0 31.5	SS 11	0	1-2-4 6		Appears to be CH, no recovery	
35	35.0 36.5	SB 12	6"	3-3-9 12		35.0-36.0, as above, pp=0.75, medium stiff, CH 36.0-36.5, SILT, 25% very fine sand, nonplastic, dark gray (5Y 4/1), wet, medium stiff (0.75), ML	
40	40.0 41.5	SS 14	14"	2-2-4 6		Alternating between CLAY, SILTY CLAY and FINE SANDY SILT, predominantly CH. Medium stiff to stiff (0.75 - 1.0)	
45	45.0 46.5	SS 14	18"	2-3-7 10		as above, pp= 1.0-1.5, slightly greener color. SM in shoe, 40% silt.	
50	50.0 51.5	SB 15	12"	4-8-8 16		as above, pp= 1.5 stiff, CL, CH	
55							

1/22/89
1/23/89

WELDON SPRING REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 3 of 6

Project Number:
Contract WP 117

Hole Number
GTQ-3

Project: Geotechnical Investigation - Phase II

Location: Quarry Staging Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY	6"-8"-6" (N)		
55							
60	60.0 61.5	SS 16	12"	7-8-7 15			CH with 15% angular chert up to 1/2"
65							
							68' auger refusal
							T.D. 68.0' 11:20 2/23/89 switched to NQ core
							*Constant Head Permeability Tests NQ Wireline rods: 2.375" I.D. @11.5' take 128 oz/6-1/3 min. @17.5' take 0 oz/10 min. @22.5' take 3.0 oz/10min

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 4 of 6

BOREHOLE LOG

Project Number:
Contract WF 117

Hole Number
GTQ-3

Project: Geotechnical Investigation - Phase II

Location: Quarry Staging Area

DEPTH	COMMENTS TESTS/MONITORING INSTRUMENTATION CORING RATE AND SMOOTHNESS CORING FLUID LOSS CONTAMINATION	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES			GRAPHIC LOG	LITHOLOGY	
					FOOD	FRACTURES PER FOOT	DESCRIPTION TIGHTNESS PLANARITY SMOOTHNESS FILLING, STAINING ORIENTATION		MINERALOGY CLASSIFICATION COLOR GRAIN SIZE ALTERATION	CEMENTATION HARDNESS WEATHERED STATE
68	Begin Core	68.0								
69	2 1/2 mins/ft. 75% water return	10.0 10.0 100%	0	1	8.7 10.0	4	Fragments open 1/4", rough " " " minor staining smooth, open 1/16"	68.0-69.1' limestone, pale yellowish brown (10YR 6/2), fine grained, slight weathering, trace fossils		
	3 mins/ft. 75% return	NQ-1			87% LP= 4.8'	2	fragmented 1/2", rough rough, open 1/8"			
70	6 mins/ft. 75% return					1	rough, open 1/2"	69.1-80.2' limestone pale yellowish brown (10YR 6/2), highly marbled with dusky brown (5YR 2/2) which appears to be carbonaceous non calcareous		
71	5 mins/ft. 75% return					1	stylolites, tight	Marbled texture is generally wavy and 1/8" to 1/2" thick spaced about 1/2"		
72	2-3/4 mins 75% return					0		71.6' stylolites Rock Quality throughout run from 69.1 good. Very slight weathering, hard. 72.7' stylolite.		
73	2-3/4 mins 75%					0	hairline, mech.	Thought to be Kimmswick Fm., fossiliferous throughout		
74										

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 5 of 6

BOREHOLE LOG

Project Number:
Contract WP 117

Hole Number
GTQ-3

Project: Geotechnical Investigation - Phase II

Location: Quarry Staging Area

DEPTH	COMMENTS TESTS/MONITORING INSTRUMENTATION CORING RATE AND SMOOTHNESS CORING FLUID LOSS CONTAMINATION	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES			GRAPHIC LOG	LITHOLOGY	
					ROD	FRACTURES PER FOOT	DESCRIPTION TIGHTNESS PLANARITY SMOOTHNESS FILLING, STAINING ORIENTATION		MINERALOGY CLASSIFICATION COLOR GRAIN SIZE ALTERATION	CEMENTATION HARDNESS WEATHERED STATE
74	3 mins/ft	NQ-1 con't		2		0		74.9' Stylolites		
	50% return									
75	3½ mins					0				
	50%									
76	3½ mins					0	tight, mech.	76.2' Stylolites		
	50%									
77	3½ mins					0				
2/23 78	50%	78.0		77.75 2			Hairline, mech			
2/24 79	2½ mins	NQ-2			9.7 10.0	0		80.2-88.0' Limestone, fresh, slight weathering, hard, pale yellowish brown (10YR 6/2) wi dusky brown (5Y 2/2) carbonac residue spaced inches apart a stylolites.		
	75% return	9.8 10.0 98%			97%					
	3 mins/ft				LP= 4.3'	0				
80	75%									
	3-3/4					0				
81	75%								80.7-81.0 several stylolites	

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 6 of 6

BOREHOLE LOG

Project Number:
Contract WP 117

Hole Number
GTQ-3

Project: Geotechnical Investigation - Phase II

Location: Quarry Staging Area

DEPTH	COMMENTS TESTS/MONITORING INSTRUMENTATION CORING RATE AND SMOOTHNESS CORING FLUID LOSS CONTAMINATION	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES			GRAPHIC LOG	LITHOLOGY	
					ROD	FRACTURES PER FOOT	DESCRIPTION TIGHTNESS PLANARITY SMOOTHNESS FILLING, STAINING ORIENTATION		MINERALOGY CLASSIFICATION COLOR GRAIN SIZE ALTERATION	CEMENTATION HARDNESS WEATHERED STATE
81	4-3/4 mins (reduced RPMS) 75%	NQ-2 con't		1		0			additional stylolites spaced a few inches apart to 88.0	
82	5 1/2 mins 75%					1	stylolite, tight			
83	6 mins/ft. 75%					0				
84	5-3/4 mins 75%					1	tight			
85	5 1/2 mins 25% return at 85.5'		85.25 X 85.45			1+	fragmented		85.25-85.45 water loss zone	
86	4-3/4 mins 25%					0				
87	4 mins 25%					0				
88										

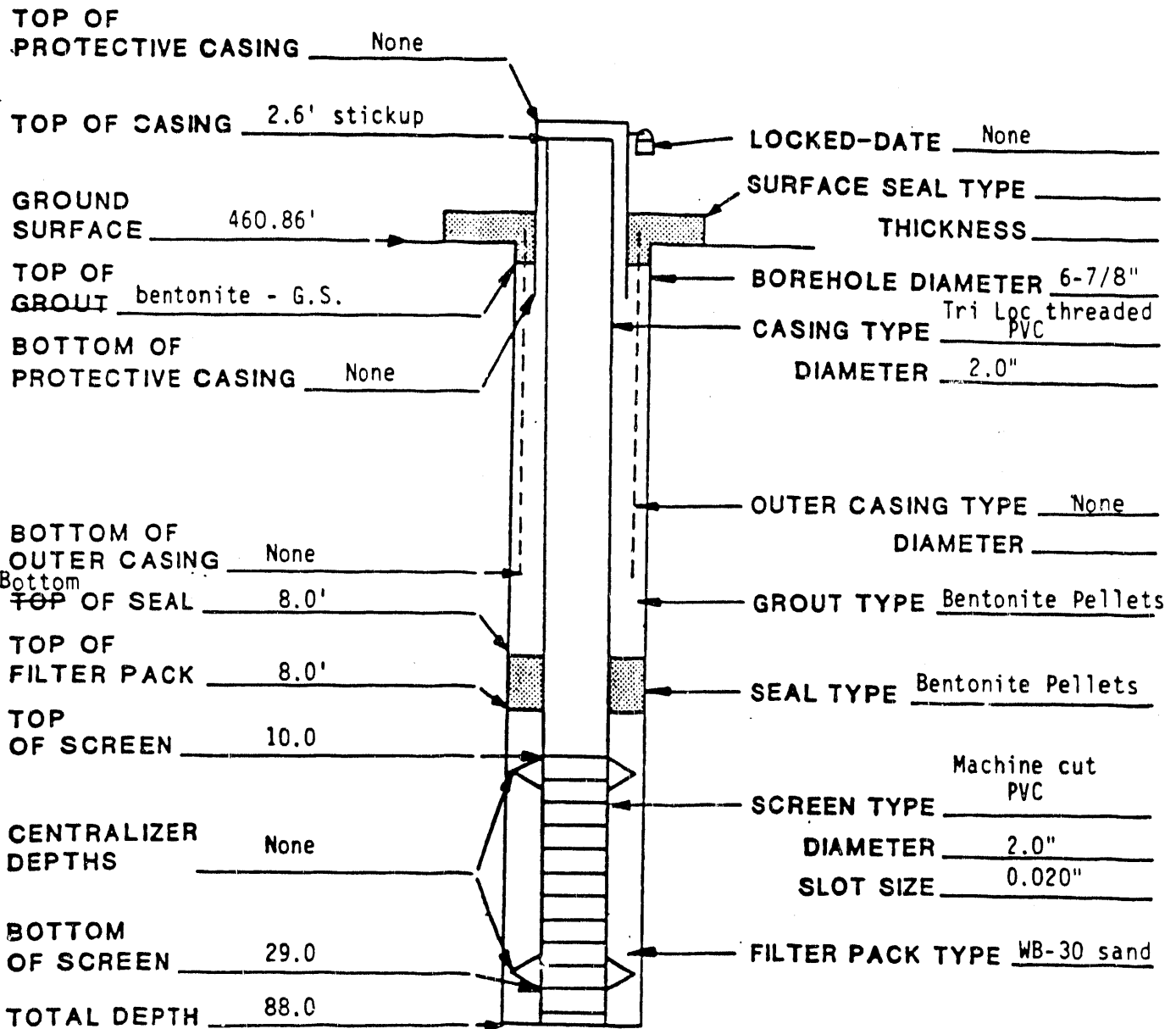
T.D. 88.0' 11:00 2/24/89
Piezometer installed
See attached completion record

WELDON SPRING SITE REMEDIAL ACTION PROJECT

WELL COMPLETION RECORD (PIEZOMETER)

WELL NUMBER GTQ-3 DATE INSTALLED 2/24/89

PMC REPRESENTATIVE A. Benfer DRILLER Hannibal, Tom Clay



COMMENTS All measurements below ground surface. Hole diameter 68.0-88.0 is 2.90".
Backfilled hole from 88.0-30.0 with WB-30 sand. Piezometer abandoned and grouted 4/19/89.

PMC REPRESENTATIVE SIGNATURE J. Alan Benfer DATE 2/24/89
 J. Alan Benfer

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 1 of 3
 Project Number:
 Contract WP 117
 Hole Number
 GTQ-4

Project: Geotechnical Investigation - Phase II		Location: Quarry Staging Area	
Coordinates: N. 7562.43, E. 12759.90		Drilling Contractor: Hannibal Testing Laboratories	
Drill Make and Model: CME 55 (truck-mounted); Hollow Stem Auger 6-7/8" O.D., 3/4" I.D.		Depth Top of Rock: 77.0'	Depth Casing & Size: 77.0'; 6-7/8" Auger
Elevation: 479.20 TOC; 476.12 g.s.		Angle from Vert. and Bearing: Vertical	
Water Level:		Depth Bottom of Hole: 77.0'	
Fluid & Additives: None		Date Start: 3/9/89	Date Finish: 3/10/89
		Logger: M. Schauer	

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION
		INTERVAL	TYPE & NUMBER	RECOVERY	6"-8"-8" (N)		Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
	2.5 4.0	SS 01	13"		4-10-10 (20)		SILT, medium brown (7.5YR 5/4), nonplastic, moist, stiff, ML. 4.5
5	5.0 7.5	ST 02	5"				CLAYEY SILT, mottled orangish brown (5YR 5/6)(FeOx) to grayish brown (10YR 5/2), nonplastic to low plasticity, dry, stiff, ML. Didn't keep sample -- too short.
	7.5 9.0	SS 03	16"		3-5-11 (16)		as above, to dark grayish brown (10YR 4/2), moist, stiff to very stiff.
10	10.0 12.5	ST 04	23"				SANDY SILT, medium gray (N5), nonplastic, moist, med. stiff (firm) to stiff, fine sand, ML. 12.5
	12.5 14.0	SS 05	17"		2-4-5 (9)		CLAYEY SILT - SILTY CLAY, medium gray (N5), low to medium plasticity, moist, medium stiff (firm) to stiff, with trace FeOx, ML-CL.
15	15.0 17.5	ST 06	16"				SILTY CLAY, greenish gray (5G 5/1), medium to high plasticity, moist, stiff, CH.
	17.5 19.0	SS 07	18"		2-3-4 (7)		SILTY CLAY, greenish gray (5G 5/1), medium plasticity moist, medium stiff (firm), CL-CH. 19.5
20	20.0 22.5	ST 08	24"				SANDY CLAYEY SILT, greenish gray (5G 5/1), low plasticity, moist, soft to medium stiff (firm), fine to medium sand, ML. 22.5
	22.5 24.0	SS 09	18"		2-2-3 (5)		SILTY CLAY, mottled orangish brown (5YR 5/6)(FeOx) to grayish brown (10YR 5/2) to medium gray (N5), medium to high plasticity, moist, stiff, with trace fine subangular chert gravel in shoe, max. size 3/4", with a few thin lenses of medium sand, CH.
25							

WELDON SPRING SITE REMEDIAL ACTION PROJECT

Sheet 2 of 3






BOREHOLE LOG

Project Number:
Contract WP 117

Hole Number
GTQ-4

Project: Geotechnical Investigation - Phase II

Location: Quarry Staging Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION
		INTERVAL	TYPE & NUMBER	RECOVERY	6"-5"-6" (N)		Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		25	25.0 26.5	SS 10	18"		2-1-2 (3)
	27.5 29.0	SS 11	18"	1-2-3 (5)			
30	30.0 32.5	ST 12	30"			CLAYEY SILT-SILTY CLAY, greenish gray (5G 5/1) to bluish gray (5B 5/1), low to med. plasticity, wet, stiff, ML-CL. SILTY CLAY, greenish gray (5G 5/1) to bluish gray (5B 5/1), med. to high plasticity, wet, med. stiff (firm), CH. Driller reported a little gravel @ 34.5.	
35	35.0 36.5	SS 13	18"	1-2-3 (5)		SILTY CLAY, as above.	
	3/10/89						
						38.0	
40	40.0 42.5	ST 14	30"			SANDY CLAYEY SILT, dark greenish gray (5G 4/1), non-plastic to low plasticity, wet, medium stiff (firm), fine sand, ML.	
45	45.0 46.5	SS 15	18"	4-4-7 (11)		SANDY CLAYEY SILT-SILTY SAND, dark greenish gray (5G 4/1), low plasticity, wet, stiff-med. dense, fine sand, ML-SM.	
50	50.0 52.5	ST 16	30"			CLAYEY SILT-SILTY CLAY, dark greenish gray (5G 4/1), low to medium plasticity, wet, stiff, ML-CL-CH.	
55							

WELDON SPRING SITE REMEDIAL ACTION PROJECT

Sheet <u>3</u> of <u>3</u>
Project Number Contract WP 117
Hole Number GTQ-4

BOREHOLE LOG

Project: Geotechnical Investigation - Phase II	Location: Quarry Staging Area
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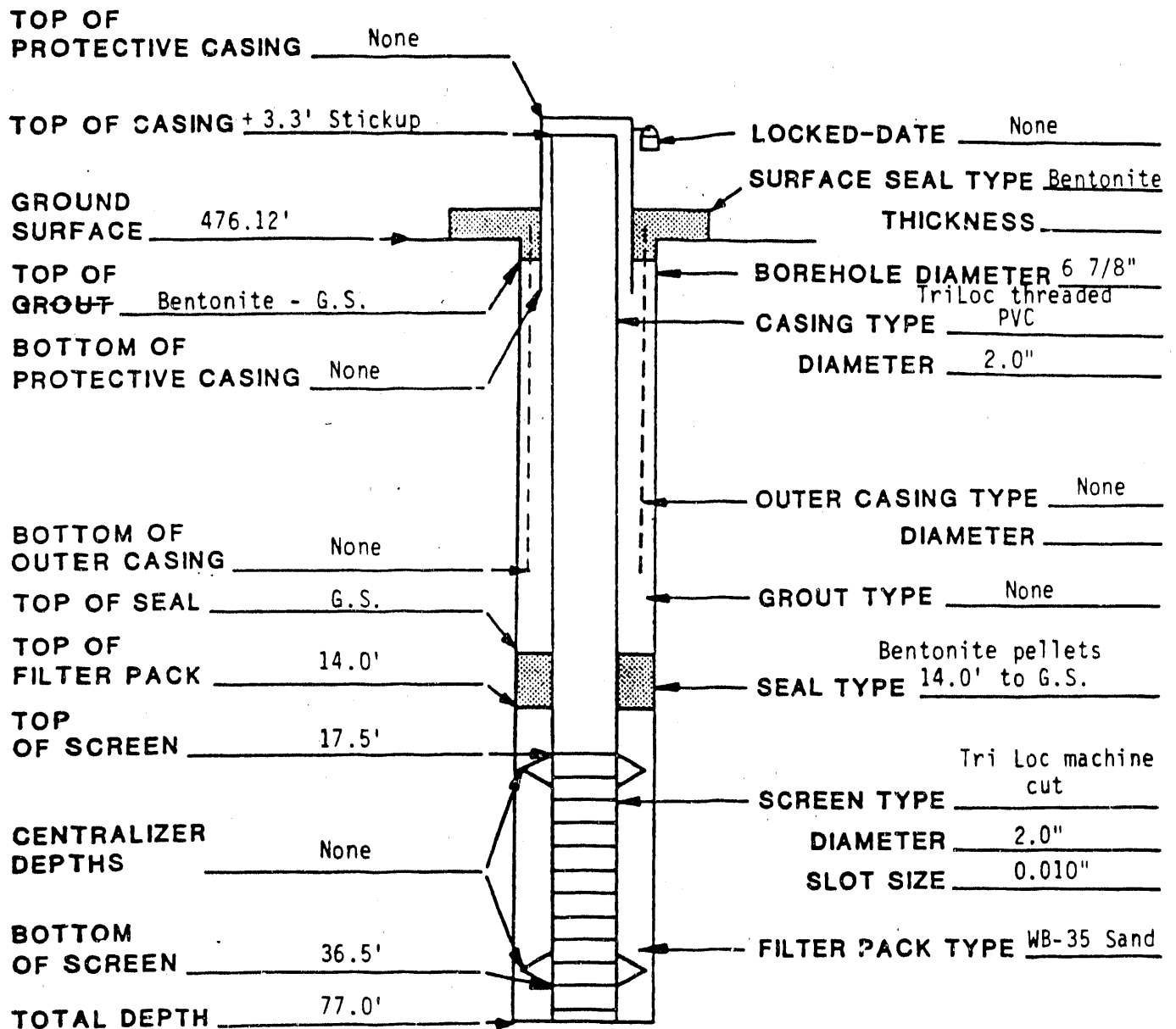
ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION
		INTERVAL	TYPE & NUMBER	RECOVERY	6"-6"-6" (N)		Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
	55	55.0 56.5	SS 17	18"	1-3-5 (8)		SANDY CLAYEY SILT-SILTY SAND, dark greenish gray (5G 4/1), low plasticity, wet, medium stiff (firm) to stiff - med. dense, fine sand, with one very small clam shell, ML-SM. 58.0
	60	60.0 62.5	ST 18	23"		/ / / / /	SILTY CLAY, dark greenish gray (5G 4/1) to dark bluish gray (5B 4/1), med. to high plasticity, wet, stiff, with white (N8) soft specks (weathered shells?), CH.
	65	65.0 66.5	SS 19	18"	3-4-5 (9)	\ \ \ \ \	SILTY CLAY, dark greenish gray (5G 4/1) to dark bluish gray (5B 4/1), med. to high plasticity, wet, stiff to very stiff, CH. 67.0 Driller reported gravel starting @ 67.0.
	70	70.0 71.5	SS 20	18"	4-10-28 (38)	o o o o o	GRAVELLY SILTY CLAY, dark greenish gray (5G 4/1) to dark bluish gray (5B 4/1), med. to high plasticity, wet, very stiff to hard, fine to coarse angular to subrounded white (N8) to tan (7.5 YR 7/4) chert and limestone gravel, max. size 1 1/2", CH. 73.0
	75	75.0 76.0 77.0	SS 21	7"	11-50/6 (50)	A A A A A	SILTY CLAYEY GRAVEL, dark greenish gray (5G 4/1) to dark bluish gray (5B 4/1), med. to high plasticity, wet, very dense, fine to coarse angular white (N8) to tan (7.5 YR 7/4) chert gravel, max. size 1" GC. 77.0 Auger refusal @ 77.0' T.D. @ 77.0' 3/10/89 Installed piezometer, see attached completion record.
	80						*Constant Head Permeability Tests NQ wireline rods: 2.375" I.D., stickup 2.5' @12.5' take 1 oz/10 min. @17.5' take 1/2 oz/10 min. @22.5' take 2 oz/10 min.

WELDON SPRING SITE REMEDIAL ACTION PROJECT

WELL COMPLETION RECORD (PIEZOMETER)

WELL NUMBER GTQ - 4 DATE INSTALLED 3/13/89

PMC REPRESENTATIVE Alan Benfer DRILLER Hannibal, Tom Clay



COMMENTS Hole allowed to cave 77.0' to 44.0'. Placed bentonite pellets 44.0' to 40.0'. Placed sand 40.0 to 37.5. Piezo. tip at 37.5'. All depths from ground surface.

PMC REPRESENTATIVE SIGNATURE J. Alan Benfer DATE 3/13/89
 J. Alan Benfer

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 1 of 7
 Project Number:
 Contract WP 117
 Hole Number
 GTQ-5

Project: Geotechnical Investigation - Phase II		Location: Quarry Staging Area	
Coordinates: N. 7471.32, E. 12832.31		Drilling Contractor: Hannibal Testing Laboratories	
Drill Make and Model: CME-55; Hollow stem auger, 6-7/8" O.D., 3-1/4" I.D./NO Wireline Core		Depth Top of Rock: 90.0'	Depth Casing & Size: 90.0'; 6-7/8" auger
Elevation: 477.22' g.s.		Angle from Vert. and Bearing: Vertical	
Water Level: 25.3' b.g.s. 3/8/89		Date Start: 3/1/89	Date Finish: 3/7/89
Fluid & Additives: None/Water		Logger: M. Schauer	
		Depth Bottom of Hole: 110.0'	Hole Size: 6-7/8"/2.98"

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-5"-5" (N)	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE # NUMBER	RECOVERY			
						FILL	Driller reported gravel 0.0-1.0
	2.5 4.0	SS 01	13"	2-2-4 (6)	A 14		SILTY CLAY, greenish gray (5G 5/1), low to medium plastic, moist, med. stiff (firm) to stiff, w/ trace fine angular white (N8) to tan (7.5YR 7/4) limestone gravel up to 1/4", w/ trace organics-plant roots, CL. 4.5
5	5.0 7.5	ST 02	29"		B 14		CLAYEY SILT, SILTY CLAY AND CLAY, mottled lt. gray (N7) to greenish gray (5G 5/1) to yellowish brown (10YR 5/6), nonplastic to high plasticity, dry to moist, med. stiff (firm) to stiff, with FeOx with MnOx blebs, ML/CL/CH
	7.5 9.0	SS 03	12"	4-10-14 (24)	C 14		CLAYEY SILT, greenish gray (5G 5/1), nonplastic to low plasticity, dry to moist, nonplastic to low plasticity stiff, with some FeOx, with trace MnOx blebs, ML 10.0
10	10.0 12.5	ST 04	23"		D 14		SILTY CLAY to CLAY, greenish gray (5G 5/1), medium to high plasticity, moist, stiff, with FeOx, with trace MnOx blebs, CL-CH
	12.5 14.0	SS 05	18"	3-4-5 (9)	E 14		14.5
15	15.0 17.5	ST 06	30"		F 14		CLAYEY SILT, greenish gray (5G 5/1), non plastic to low plasticity, dry to moist, medium stiff (firm) to stiff, with trace fine sand, with FeOx, with trace MnOx blebs, ML.
	17.5 19.0	SS 07	18"	3-5-7 (12)	G 14		CLAYEY SILT-SILTY CLAY, greenish gray (5G 5/1), low plasticity, moist, medium stiff (firm) to stiff, with some FeOx, ML-CL.
20	20.0 22.5	ST 08	25"		H 14		CLAYEY SILT, greenish gray (5G 5/1) to brownish gray (10YR 5/1), nonplastic to low plasticity, moist, soft to medium stiff (firm), with abundant FeOx, with MnOx ML.
	22.5 24.0	SS 09	18"	1-2-3 (5)	I 14		CLAYEY SILT, as above, soft to medium stiff (firm) some fine sand. 24.5
25					J 14		

WELDON SPRING SITE REMEDIAL ACTION PROJECT

Sheet 2 of 7

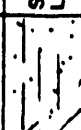
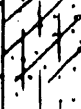
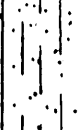




BOREHOLE LOG

Project Number:
Contract WP 117

Hole Number:
GTQ-5

Project: Geotechnical Investigation - Phase II

Location: Quarry Staging Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY	6"-6"-6" (N)		
25	25.0	ST 10	30"				Interbedded silty sand, sandy silty clay, and silty clay 24.5-58.0.
	27.5						SILTY SAND, dark greenish gray (5G 4/1), nonplastic, moist, loose, fine sand, SM.
27.5	27.5	SS 11	16"		1-3-4		SANDY SILTY CLAY, dark greenish gray (5G 4/1) to dark bluish gray (5B 4/1), low to medium plasticity, moist, medium stiff (firm) to stiff, fine sand, CL-CH.
	29.0				(7)		
30	30.0	ST 12	30"				SILTY SAND, dark greenish gray (5G 4/1) to dark bluish gray (5B 4/1), low plasticity, moist, loose to medium dense, fine sand, with trace low to medium plasticity clay, SM.
	32.5						
35	35.0	SS 13	18"		2-8-18		SANDY SILTY CLAY, dark greenish gray (5G 4/1) to dark bluish gray (5B 4/1), medium plasticity, wet, medium stiff (firm) to stiff, fine sand, with silty sand lenses (layered light to dark, medium dense, fine to medium sand) CL-CH. Driller reported sand flowing up inside augers 36.5-55.0. Cleaned out with water before sampling.
	36.5				(26)		
40	40.0	SS 14	6"		3-5-6		SILTY SAND, dark greenish gray (5G 4/1) to dark bluish gray (5B 4/1), low to medium plasticity, wet, loose to medium dense, fine to medium sand, with trace low to medium plasticity clay, SM.
	41.5				(11)		
45	45.0	SS 15	18"		1-1-2		SILTY SAND-SILTY CLAY, dark greenish gray (5G 4/1) to dark bluish gray (5B 4/1), low to medium plasticity, wet, loose-soft, fine to medium sand, SM-CL-CH.
	46.5				(3)		
50	50.0	SS 16	18"		3-4-5		SILTY CLAY, dark greenish gray (5G 4/1) to dark bluish gray (5B 4/1), low to medium plasticity, wet, stiff to very stiff, with trace fine sand, CL-CH.
	51.5				(9)		
55							

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 3 of 7

Project Number:
Contract WP 117

Hole Number
GTQ-5

Project: Geotechnical Investigation - Phase II

Location: Quarry Staging Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION
		INTERVAL	TYPE & NUMBER	RECOVERY	6"-8"-6" (N)		
55	55.0 56.5	SS 17	18"	3-4-5 (9)		SANDY SILTY CLAY, dark greenish gray (5G 4/1) to dark bluish gray (5B 4/1), low to medium plasticity, wet, stiff to very stiff, fine sand, with trace organics - plant stems, CL-CH.	
58.0							
60	60.0 62.5	ST 18	29"				
64.0							
65	65.0 66.5	SS 19	18"	4-5-6 (11)		SILTY CLAY, dark greenish gray (5G 4/1) to dark bluish gray (5B 4/1), medium to high plasticity, wet, stiff to very stiff, with trace white (N8) soft specks (weathered shells?), CH. Driller reported gravelly, hard drilling starting @67.0. No sample @ 70.0 due to clay up inside augers.	
70							
75							No sample @75.0 due to clay up inside augers.
80	80.0	SS 20	14"	5-17-25 (42)		SILTY CLAY, as above, stiff to hard, with fine angular white (N8) to light brown (7.5YR 6/4) chert gravel in shoe, max size 3/4", CH.	
85							

WELDON SPRING REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 4 of 7

Project Number:
Contract WP 117

Hole Number
GTQ-5

Project: Geotechnical Investigation - Phase II

Location: Quarry Staging Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY	6"-6"-6" (N)		
85	85.0	SS			4-1/12"		SILTY CLAY, as above, soft to firm, max gravel size 1.5" - stuck in shoe, CH
	86.5	21	10"	(1)			
90	90.0						Auger refusal @90.0', Switched to NQ wireline core *Constant Head Permeability Tests NQ wireline rods 2.375" I.D.; 2.5' stickup @12.5' take 0 oz/ 10 min. @17.5' take 1.0 oz/10 min. @22.5' take 9.0 oz/10 min. @32.5' take 9.0 oz/10min.

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 6 of 7

Project Number:
Contract WP 117

Hole Number
GTQ-5

Project: Geotechnical Investigation - Phase II

Location: Quarry Staging Area

DEPTH	COMMENTS TESTS/MONITORING INSTRUMENTATION CORING RATE AND SMOOTHNESS CORING FLUID LOSS CONTAMINATION	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES		GRAPHIC LOG	LITHOLOGY	
					ROO	FRACTURES PER FOOT		DESCRIPTION TIGHTNESS PLANARITY SMOOTHNESS FILLING, STAINING ORIENTATION	MINERALOGY CLASSIFICATION COLOR GRAIN SIZE ALTERATION
96		NQ-1 con't		1		4			
									Rock has FeOx stain 96.5-97.0.
		97.0							Large vug with crinoid fossils 96.5 - 96.7. 97.0
97	Run 2 average 5 min/ft, 100% fluid return, lt. brownish gray (10YR 5/1) to white (N8)	NQ-2 10.0 10.0 100%		1	9.9 10.0	2			LIMESTONE, same as above, except: thinly to medium bedded with some dark gray (N4) to black (N2) MnOx and hard clay stringers.
					L.P =				Medium fractured (spacing 8" - to 1.25'), occasionally closely fractured (4" to 6").
					1.2	2			Occasional stylolites.
					12 > 4"				
98									
						1			possibly PLATTIN FM.
100				100		1			Tight, smooth MnOx and 1-1/16" to 1/8" thick hard clay (2)
				2					
101						1			
102						1			Tight, smooth black MnOx and thin hard clay (2)
103						1			

WELDON SPRING SITE REMEDIAL ACTION PROJECT

Sheet 7 of 7

BOREHOLE LOG

Project Number:
Contract WP 117

Hole Number
GTQ-5

Project: Geotechnical Investigation - Phase II

Location: Quarry Staging Area

DEPTH	COMMENTS TESTS/MONITORING INSTRUMENTATION CORING RATE AND SMOOTHNESS CORING FLUID LOSS CONTAMINATION	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES		GRAPHIC LOG	LITHOLOGY	
					ROD FRACTURES PER FOOT	DESCRIPTION TIGHTNESS PLANARITY SMOOTHNESS FILLING, STAINING ORIENTATION		MINERALOGY CLASSIFICATION COLOR GRAIN SIZE ALTERATION	CEMENTATION HARDNESS WEATHERED STATE
103		NQ-2 con't		2		1		LIMESTONE, as above	
104						>6			
105						1			
106	3/7/89					1			
107		107.0				1			
108	Run 3 average 5 min/ft, 100% fluid return, light brownish gray (10YR5/1) to white (N8)	NQ-3 3.0 3.0 100%		2	2.7 3.0 90% L.P. = 1.0 3 > 4"	1			
109						1			
110		110.0							

mechanical

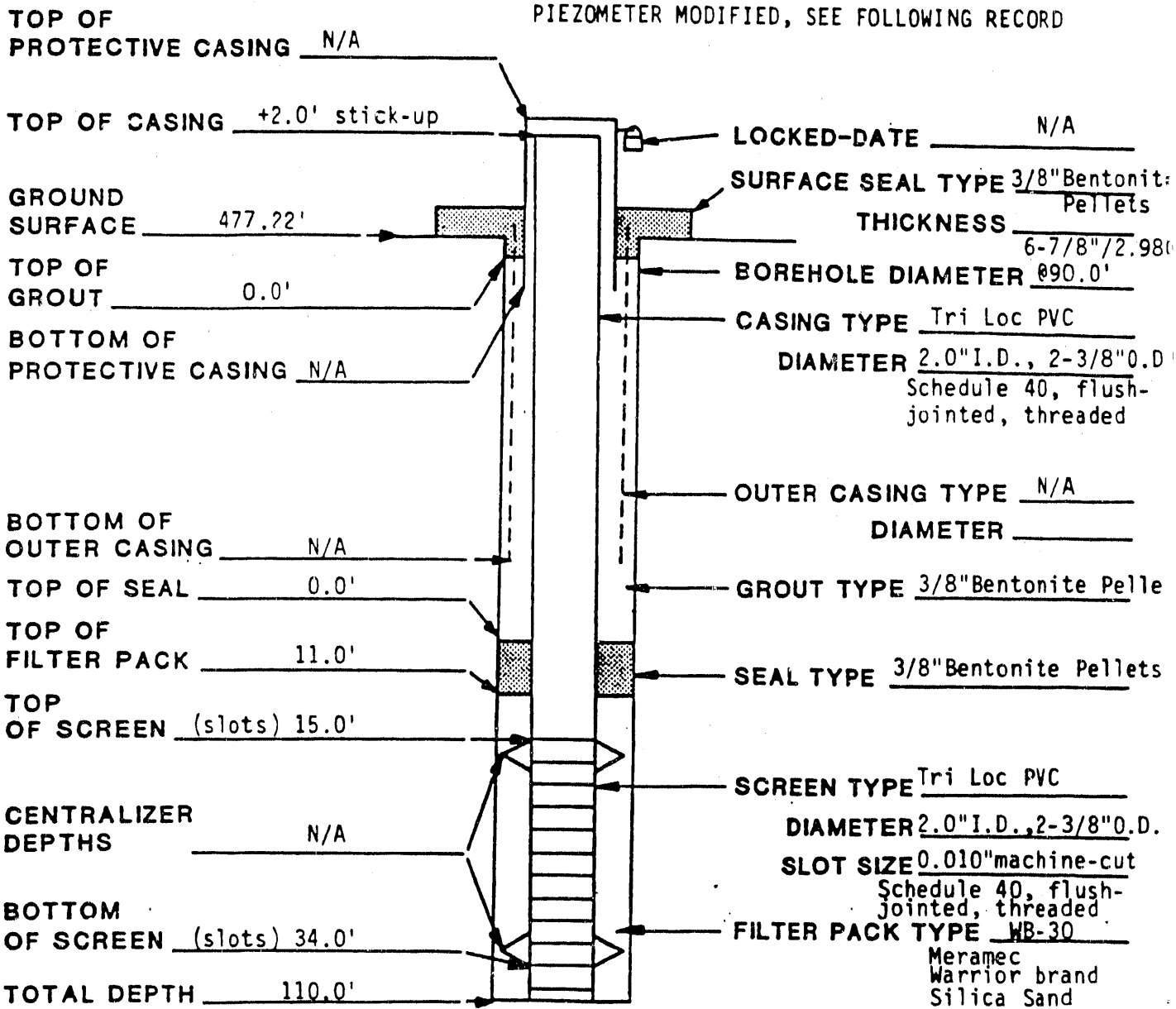
T.D. @110.0' 3/7/89 Installed
piezometer-see attached completion
record.

WELDON SPRING SITE REMEDIAL ACTION PROJECT

WELL COMPLETION RECORD (PIEZOMETER)

WELL NUMBER GTQ-5 DATE INSTALLED 3/8/89

PMC REPRESENTATIVE M. Schauer DRILLER Hannibal - T. Clay



COMMENTS All depths are below ground surface. Top of screened pipe 14.5', bottom of screened pipe 34.5', bottom of pointed tip 35.0'. Borehole backfilled with sand from 110.0' (I.D.) to 35.0'.

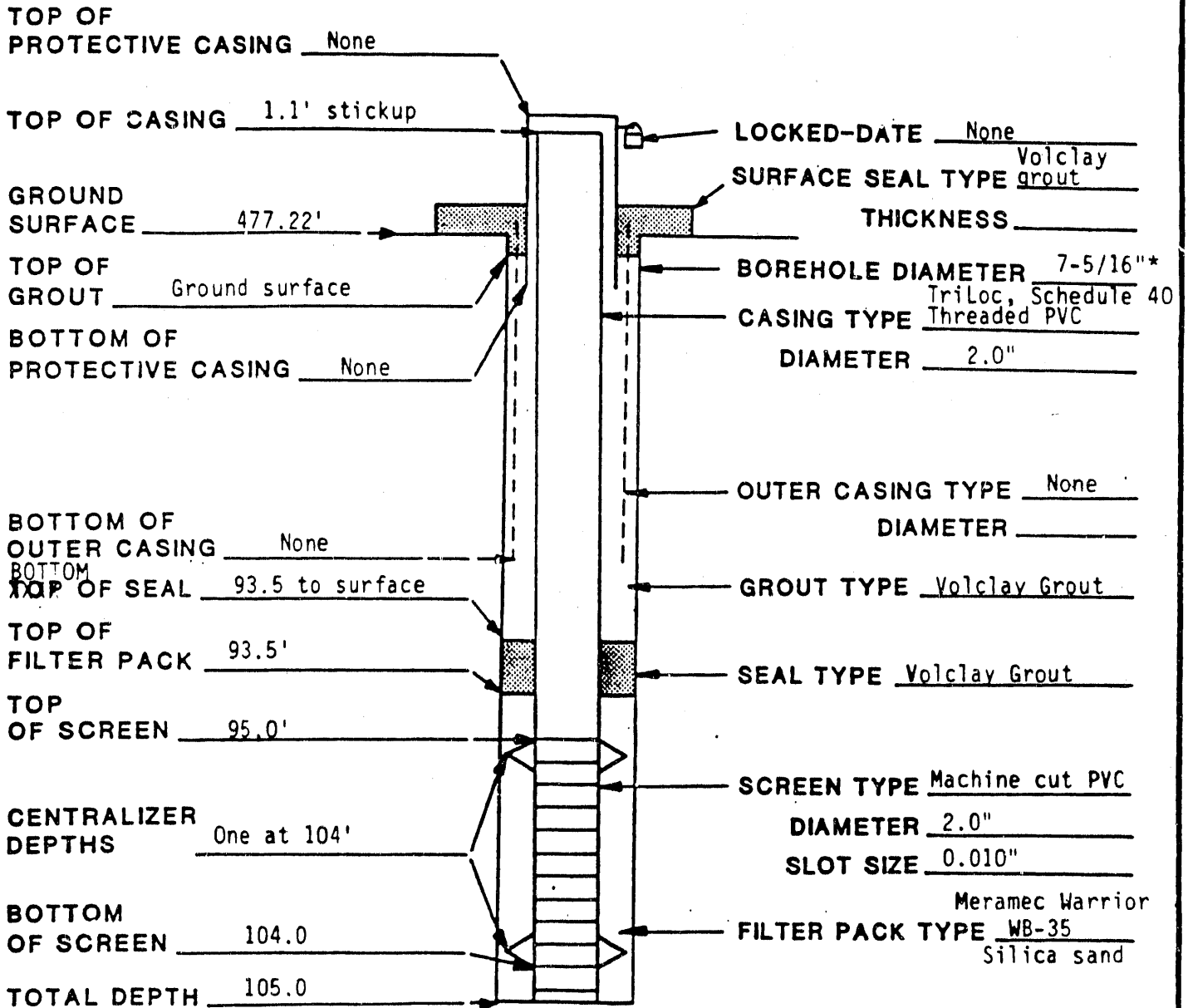
PMC REPRESENTATIVE SIGNATURE Marie Schauer *SAB* DATE 3/8/89
 Marie I. Schauer

WELDON SPRING SITE REMEDIAL ACTION PROJECT

WELL COMPLETION RECORD

WELL NUMBER GTQ-5 (modified) DATE INSTALLED 4/27/89

PMC REPRESENTATIVE Alan Benfer DRILLER Tom Clay, Hannibal



COMMENTS *7-5/16" auger hole to top of rock at 90.0'. 4" hole 90.0' to 110.0'.
Cuttings 110.0 to 105.0'.

All depths from ground surface.

PMC REPRESENTATIVE SIGNATURE *Alan Benfer* DATE 4/27/89

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 1 of 5

BOREHOLE LOG

Project Number:
Contract: WP 117

Hole Number
GTQ-6

Project: Geotechnical Investigation-Phase II		Location: Quarry Staging Area	
Coordinates: N.7325.31, E.13140.86		Drilling Contractor: Hannibal Testing Laboratories	
Drill Make and Model: CME 55 (truck-mounted); H.S. Auger 6-7/8", 3/4" NQ Wireline Core		Depth Top of Rock: 38.5'	Depth Casing & Size: 38.5'; 6-7/8" Auger
Elevation: 508.3' g.s.		Angle from Vert. and Bearing: Vertical	
Water Level: 44.7' b.g.s. 3/1/89		Date Start: 02/27/89	Date Finish: 02/28/89
Fluid & Additives: None / Water		Logger: M. Schauer	
		Hole Size: 6-7/8" / 2.98"	
		Depth Bottom of Hole: 58.5'	

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY			
0							ALLUVIUM
	2.5	SS		10"	2-4-4		CLAYEY SILT, orangish brown (5YR 5/6), low plasticity, moist, medium stiff (firm), with trace coarse angular chert gravel, maximum size 1 1/2", with trace organics-wood fibers and roots, ML
	4.0	01			(8)		
5	5.0	SS		5"	7-8-6		CLAYEY SILT, orangish brown (5YR 5/6), nonplastic to low plasticity, moist, medium stiff (firm), with some organics-wood branches and roots, ML. Driller reported pushing a rock
	6.5	02			(14)		
	7.5	ST		30"			SILT, medium brown (7.5YR 5/4), nonplastic, moist, medium stiff (firm), ML
	10.0	03					
10	10.0	SS		16"	4-7-9		CLAYEY SILT, orangish brown (5YR 5/6), nonplastic to low plasticity, moist, medium stiff (firm) to stiff, with trace fine sand, ML
	11.5	04			(16)		
	12.5	SS		18"	3-13-15		CLAYEY SILT, as above, stiff to v. stiff,
	14.0	05			(28)		
15	15.0	SS		14"	6-14-16		SILT, medium brown (7.5YR 5/4), nonplastic, moist, stiff, with trace fine sand, ML
	16.5	06			(30)		
	17.5	SS		16"	8-15-15		SILT, as above to light brown (7.5YR 6/4), with trace MnOx patches.
	19.0	07			(30)		
20	20.0	SS		18"	6-12-15		SILT, as above, a little to some fine sand. Driller reported hard drilling 21.5-22.5.
	21.5	08			(27)		
	22.5	SS		13"	6-7-9		SILT, as above.
	24.0	09			(16)		
25							

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 2 of 5

BOREHOLE LOG

Project Number:
Contract: WP 117

Hole Number
GTQ-6

Project

Geotechnical Investigation - Phase II

Location:

Quarry Staging Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY	6"-6"-6" (N)		
25	25.0	ST 10	30"				SANDY SILT-SILTY SAND, medium gray (N5) to dark grey (N4), nonplastic, moist, medium stiff (firm)-medium dense, fine sand, with a little organics-plant roots, ML-SM SANDY SILT-SILTY SAND, as above, to medium brown (7.5YR 5/4), trace organics.
	27.5	SS 11	14"	2-6-7 (13)			
30	29.8	ST 12	30"				SILTY SAND-SANDY SILT, mottled light brown (7.5YR 6/4) to orangish brown (FeOx stained) (5YR 5/6), nonplastic, moist, medium dense-medium stiff (firm), fine sand, SM-ML 33.5
	32.3						
35	35.0	SS 13	17"	7-9-10 (19)			SANDY SILT, mottled light brown (7.5YR 6/4) to orangish brown (FeOx stained) (5YR 5/6), nonplastic, moist, medium stiff (firm) to stiff, fine sand, ML 38.5
	36.5						
40	38.5						Auger refusal @ 38.5' Switched to NQ wireline core

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 3 of 5

BOREHOLE LOG

Project Number:
Contract: WP 117

Hole Number
GTQ-6

Project: Geotechnical Investigation - Phase II

Location: Quarry Staging Area

DEPTH	COMMENTS TESTS/MONITORING INSTRUMENTATION CORING RATE AND SMOOTHNESS CORING FLUID LOSS CONTAMINATION	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES			GRAPHIC LOG	LITHOLOGY	
					ROD	FRACTURES PER FOOT	DESCRIPTION TIGHTNESS PLANARITY SMOOTHNESS FILLING, STAINING ORIENTATION		MINERALOGY CLASSIFICATION COLOR GRAIN SIZE ALTERATION	CEMENTATION HARDNESS WEATHERED STATE
38		38.5							Started coring @ 38.5'	
39	2/28/89 Run 1 average 3 min/ft 0% fluid return	NQ-1 3.3 5.0 66%	39.2	1	0.5 5.0 10%	6	Open, irregular, rough, FeOx 38.5-43.5		LIMESTONE, light grey (N7), medium to coarse grained, crystalline, fossiliferous, moderately hard, moderately weathered (rock shows slight color change to buff (7.5YR 8/4) or tan (7.5YR 7/4 to slightly weathered, vuggy 30% 1/8" to 2" with FeOx and calcite crystals. Massive. Very closely to closely fractured (spacing 3/4" to 6"	
40				L.P. =	6	Rubble				
41				0.5'						
42				1 >	1					
43				4"						
44	Run 2 average 6 min/ft 0% fluid return	43.5 NQ-2 4.0 5.0 80%	44.5	1	1.7 5.0 34%	6	Rubble	Possibly KIMMSWICK FM		
45					L.P. 0.9'	6	43.5-48.5 Open, irregular, rough Rubble			
					3 >					
					4"					

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 4 of 5

BOREHOLE LOG

Project Number:
Contract: WP 117

Hole Number
GTQ-6

Project: Geotechnical Investigation - Phase II

Location: Quarry Staging Area

DEPTH	COMMENTS TESTS/MONITORING INSTRUMENTATION CORING RATE AND SMOOTHNESS CORING FLUID LOSS CONTAMINATION	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	ROD	FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION TIGHTNESS PLANARITY SMOOTHNESS FILLING, STAINING ORIENTATION	GRAPHIC LOG	LITHOLOGY	
									MINERALOGY CLASSIFICATION COLOR GRAIN SIZE ALTERATION	CEMENTATION HARDNESS WEATHERED STATE
45		NQ-2 con't		1		4	yellowish brown (10YR5/6) soft clay filling with angular chips of rock.			45.5
46						6	with hard clay filling.		LIMESTONE, same as above, except: medium grained, not vuggy, with clay layers to 1"-2" thick, with occasional chert nodules to 2". Closely fractured (spacing 2½" to 6")	
47						5	yellowish brown (10YR5/6) soft layered clay filling.		Possibly KIMMSWICK FM	47.5
48		48.5				0	very closely fractured (1" pieces) with yellowish brown (10YR5/6) clay with grayish brown (10YR5/2) hard clay filling		LIMESTONE, interbedded light grey (N7), medium grey (N5), argillaceous, and occasional white (N8) chert, looks almost banded rather than bedded. Fine grained, crystalline, fossiliferous (includes shell layers), hard, fresh, with disseminated pyrite. Very thinly bedded (spacing 1" to 2"), horizontal. Widely fractured (spacing 2' to 4')	
49	Run 3 average 9 min/ft 0% fluid return	NQ-3 10.0 10.0 100%		1	10.0 10.0 100% L.P. 3.4'	0	grayish brown (10YR5/2) firm layered clay filling.			
50					5 > 4"	0	orangish brown (5YR5/6) clay layers.			
50				50 2	2	0	mechanical break.		Possibly DECORAH FM	
51										
52						1	tight, planer, rough with small calcite crystals			10-20°

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 5 of 5

BOREHOLE LOG

Project Number:

Contract: WP 117

Hole Number

GTQ-6

Project: Geotechnical Investigation - Phase II

Location: Quarry Staging Area

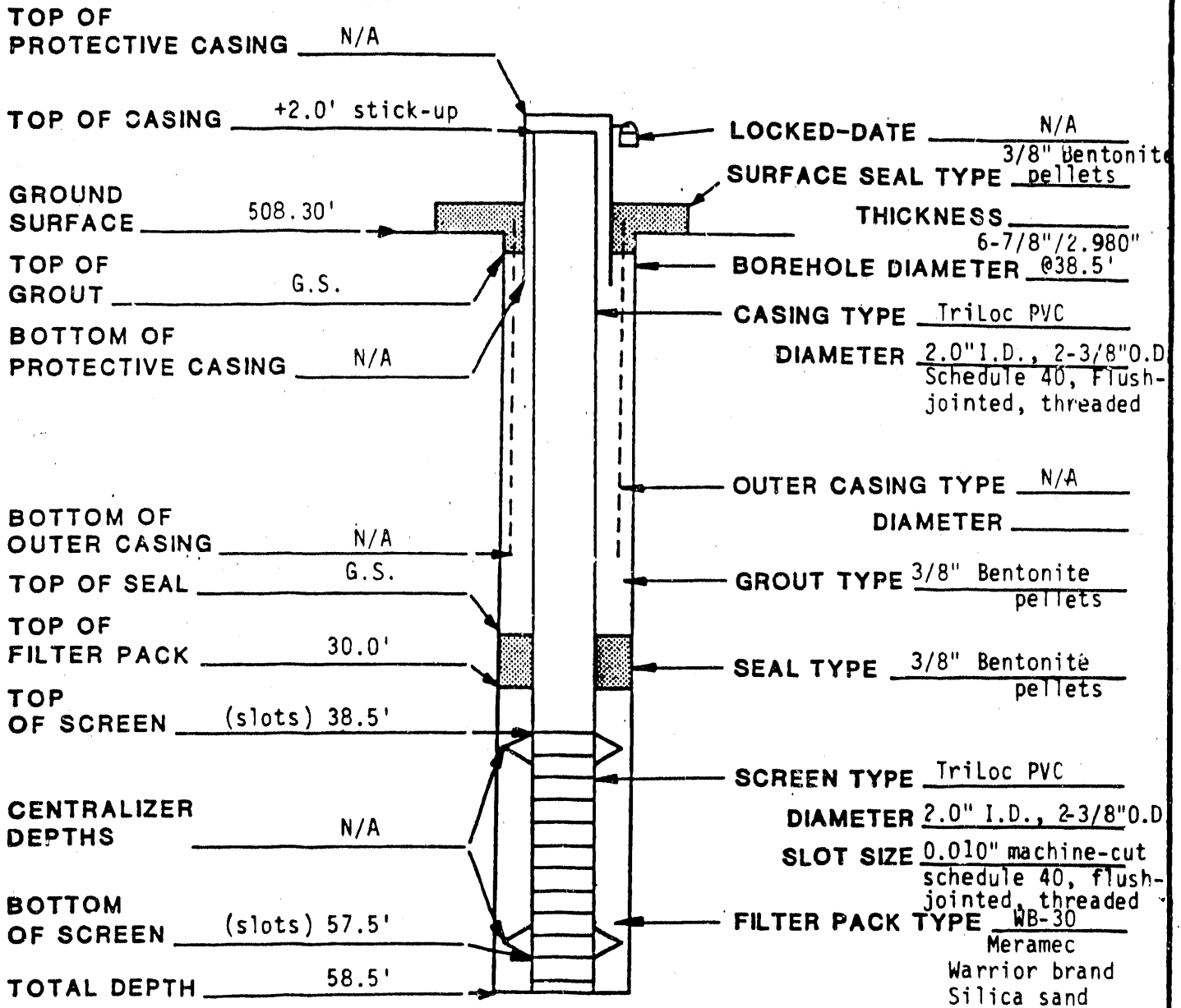
DEPTH	COMMENTS TESTS/MONITORING INSTRUMENTATION CORING RATE AND SMOOTHNESS CORING FLUID LOSS CONTAMINATION	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES		GRAPHIC LOG	LITHOLOGY	
					ROD	FRACTURES PER FOOT		DESCRIPTION TIGHTNESS PLANARITY SMOOTHNESS FILLING, STAINING ORIENTATION	MINERALOGY CLASSIFICATION COLOR GRAIN SIZE ALTERATION
52		NQ-3 con't		2		0		LIMESTONE, as above	
53						1			
54						1	20°	53.8	Orangish brown (5YR 5/6) lay: ½" thick
55						1	10°	54.3	Yellowish brown (10YR 5/6) layer, ½" thick
56						0			
57						1	0°		Tight, irregular, rough, FeOx, with small calcite crystals
58						0			
		58.5				0			mechanical break
59								T.D. @ 58.5' 2/28/89 Installed piezometer--see attached completion record	

WELDON SPRING SITE REMEDIAL ACTION PROJECT

WELL COMPLETION RECORD (PIEZOMETER)

WELL NUMBER GTQ-6 DATE INSTALLED 2/28/89

PMC REPRESENTATIVE M. Schauer DRILLER T. Clay - Hannibal



COMMENTS All depths are below ground surface.
 Top of screened pipe 38.0', bottom of screened pipe 58.0', bottom of pointed tip 58.5'. Borehole diameter 6-7/8" to 38.5'; 2.98" to 58.5'.
 Piezometer abandoned and grouted 4/20/89

PMC REPRESENTATIVE SIGNATURE Marie Schauer DATE 2/28/89
 M. Schauer

WELDON SPRING SITE REMEDIAL ACTION PROJECT

Sheet 1 of 5

BOREHOLE LOG

Project Number:
Contract WP 117

Hole Number
GTQ-7

Project: Geotechnical Investigation - Phase II		Location: Quarry Staging Area	
Coordinates: N.7546.09, E.13148.45		Drilling Contractor: Hannibal Testing Labs	
Drill Make and Model: CME 55, Hollow Stem Auger 6-7/8", 3 1/2", NQ Wireline Core		Depth Top of Rock: 36.5	Depth Casing & Size: augers to 36.5'
Elevation: 460.82' g.s.		Angle from Vert. and Boring: vertical	
Water Level: 25.3 2/10/89		Date Start: 1:10 2/9/89	
Fluid & Additives: Clear water		Date Finish: 2:05 3/20/89	
		Logger: A. Benfer	

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-5"-3" (N)	SYMBOLIC LOG	SOIL DESCRIPTION
		INTERVAL	TYPE & NUMBER	RECOVERY			
	0.0		SS 01		3-4-6 10	/ / / / /	SILTY CLAY, low plasticity, yellowish brown (10YR 5/4) moist, stiff CL
	1.5					/ / / / /	
	2.5		ST 02	5"		/ / / / /	SILT, nonplastic, mottled grayish brown (10YR 5/2) and brownish yellow (10YR 5/6), black, moist, stiff (1.5), ML. possible seepage ~ 4'
	4.5					/ / / / /	
5	5.0		SS 03	13"	2-4-6 10	/ / / / /	CLAY, highly plastic, dark grayish brown (10YR 4/2), moist, stiff (1.5), CH. 5% oxidized roots.
	6.5					/ / / / /	
	7.5		ST 04	33"		/ / / / /	as above, mottled dark grayish brown (10YR 4/2) and yellow brown (10YR 5/6). Trace angular fine chert gravel. Hard (4.5)
	9.5					/ / / / /	
10	10.0		SS 05	12"	3-7-10 17	/ / / / /	pp=2.5, bottom 3" very silty 11.25-13.0, color as above
	11.5					/ / / / /	
	12.5		SS 06	13"	3-7-9 16	/ / / / /	13.0'
	14.0					/ / / / /	SILTY CLAY, mottled grayish brown (10YR 5/2) & yellow red (10YR 5/8), moist, very stiff (2.5), CL. Minor black MnOx
15	15.0		SS 07	14"	4-5-6 11	/ / / / /	16.0' pp=3.0
	16.5					/ / / / /	
	17.5		ST 08	29"		/ / / / /	SILT, 20% very fine sand, pale brown (10YR 6/3) moist med. stiff-stiff (1.0), ML.
	19.5					/ / / / /	as above, no sand, pale brown (10YR 6/3) mottled with brown (7.5YR 5/4), med. stiff to stiff (1.0)
20	20.0		SS 09	18"	3-3-5 8	/ / / / /	21.0'
	21.5					/ / / / /	CLAY, light brownish gray (10YR 6/2) and yellow brown (10YR 5/6) moist, very stiff (2.5) CH
	22.5		SS 10	18"	2-2-6 8	/ / / / /	SILT, nonplastic, lt. brownish gray, very moist, very soft (< 2.5) ML
	24.0					/ / / / /	SILTY CLAY, med. plasticity, mottled gray (10YR 5/2) & yellow brown (10YR 5/4) moist, very stiff (2.25) CL
25						/ / / / /	

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 2 of 5

Project Number:
Contract WP 117

Hole Number:
GTQ-7

Project: Geotechnical Investigation - Phase II

Location: ~ 50' N. 2nd Quarry Gate

2/10/89

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY	6"-8"-8" (N)		
25	25.0	SS		18"	2-2-3		pp=1.0 med. stiff to stiff
	26.5	11			5		
27.5	27.5	SS		12"	20-10-8		SILT, nonplastic, dark gray (10YR 4/1), very moist, very soft (<.25) ML highly weathered limestone, wet at 29.0
	29.0	12			18		
30							
32.5	32.5	SS		12"	2-2-1		SILT, dark gray, wet, soft, ML with 20% fine limestone fragments, weathered limestone at 35' Auger refusal at 36.5'
	34.0	13			3		
35							Switched to NQ core at 36.5'

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 3 of 5

Project Number:
Contract WP 117

Hole Number
GTQ-7

Project: Geotechnical Investigation - Phase II Location: ~ 50' N. 2nd Quarry Gate

DEPTH	COMMENTS TESTS/MONITORING INSTRUMENTATION CORING RATE AND SMOOTHNESS CORING FLUID LOSS CONTAMINATION	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES			GRAPHIC LOG	LITHOLOGY	
					ROD	FRACTURES PER FOOT	DESCRIPTION TIGHTNESS PLANARITY SMOOTHNESS FILLING, STAINING ORIENTATION		MINERALOGY CLASSIFICATION COLOR GRAIN SIZE ALTERATION	CEMENTATION HARDNESS WEATHERED STATE
			36.5						Begin NQ Core 36.5	
37	100% water return 3800 rpm	NQ-1	▲	1					Estimated core loss 36.5 - 37.3	
	3½ mins/ft	4.2 5.0	▲			4+	Rough Fragmented		LIMESTONE throughout run 1 is slightly weathered, minor iron oxide stain	
38	100% return	84%			2.3 5.0		Shaley		37.7-37.9 argillaceous, dark yellowish orange (10YR 6/5)	
	2½ mins/ft				46%		Stylolite, tight			
39	100% return				LP= .65 (2)	3+	tight, weathered surfaces		38.3-38.95 fossiliferous	
	3-3/4 mins/ft					6	shaley and fragmented		38.95-39.2 argillaceous pale green (10G 6/2)	
40	100% return						rough, open ½" all weathered		39.3-39.6 shallow pits ¼" limestone throughout generally a dark yellowish brown 10YR 4/2	
	5 mins/ft					1	" " " " " " " " "		fine to medium grained throughout	
41	100% return						vertical, open rough, open			
	3½ mins/ft					1	Rough, open ½"			
42	75% return	41.5 NQ-2	▲	41.5 1					Estimated loss 41.5-42.5	

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 4 of 5

Project Number:
Contract WP 117

Hole Number
GTQ-7

Project: Geotechnical Investigation - Phase II

Location: 50' N. 2nd Carry Gate

DEPTH	COMMENTS TESTS/MONITORING INSTRUMENTATION CORING RATE AND SMOOTHNESS CORING FLUID LOSS CONTAMINATION	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES		GRAPHIC LOG	LITHOLOGY	
					ROD	FRACTURES PER FOOT		DESCRIPTION TIGHTNESS PLANARITY SMOOTHNESS FILLING, STAINING ORIENTATION	MINERALOGY CLASSIFICATION COLOR GRAIN SIZE ALTERATION
42	3½ mins 75% return	NQ-2 con't	▲ 42.51			0		tumbled fragments. Breaks throughout run 2 mostly at stylolites. Minor staining	
43		9.9 10.9			7.5 10.9	4		LIMESTONE throughout run 2, generally fine grained, pale yellowish brown (10YR 6/2)	
44		91%			69%			to dark yellowish brown (10YR 7/2) Minor secondary calcite 42.9-43.5' Rock quality good from 44'	
45					LP= 1.85'	2			
46	5 mins/ft 25% return				(2)	2		45.2-45.5 CLAYSTONE mottled mod. brown (5YR 4/4) and dark gray	
47	5-¾ mins/ft 25% return					1		46-48 thin 1/16"-1/8" stylolites filled with dark clay. Approximately 46 ft. limestone becomes very slight weathering	
48	4½ mins/ft 25% return					0		47.8-47.95 CHERT pale yellowish brown (10YR 6/2)	
49						1		48.3-49.7 scattered wavy sandstone beds ½"-1" and pockets. Moderate yellowish brown (10YR 5/4). Less frequently to 52.4'	

2/9
2/10

WELDON SPRING SITE REMEDIAL ACTION PROJECT

Sheet 5 of 5

BOREHOLE LOG

Project Number:
Contract WP 117

Hole Number
GTQ-7

Project: Geotechnical Investigation - Phase II

Location: 50' N. 2nd Quarry Gate

DEPTH	COMMENTS	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES		GRAPHIC LOG	LITHOLOGY	
	TESTS/MONITORING INSTRUMENTATION CORING RATE AND SMOOTHNESS CORING FLUID LOSS CONTAMINATION				ROD	FRACTURES PER FOOT		DESCRIPTION TIGHTNESS PLANARITY SMOOTHNESS FILLING, STAINING ORIENTATION	MINERALOGY CLASSIFICATION COLOR GRAIN SIZE ALTERATION
49	4-3/4 mins/ft <25% return	NQ-2 con't		2		0			
50	5 mins/ft <25% return					0	Stylolite closed	50.0-50.25 wavy bedding	
51	9 mins/ft <25% return					0	Stylolite closed	51.1 - 1/4" hard, wavy clay	
52		52.4					Stylolite tight Mechanical		
53	3 1/2 mins/ft 0 water return	NQ-3 4.1 4.1		2	4.1 4.1	100 %	tight	LIMESTONE - color generally more yellowish brown (10YR 5/4)	Rock quality throughout run good. Very slight weathering, hard. Sandstone scattered throughout run ~25% generally wavy bedded or pockets spaced 1-2" apart and approximately 1" thick
54	4 mins/ft 0 return				LP= 3.2	0			
55	4 1/2 mins/ft 25% return					0			
56						0			

TD 56.5' 2:05 2/10/89

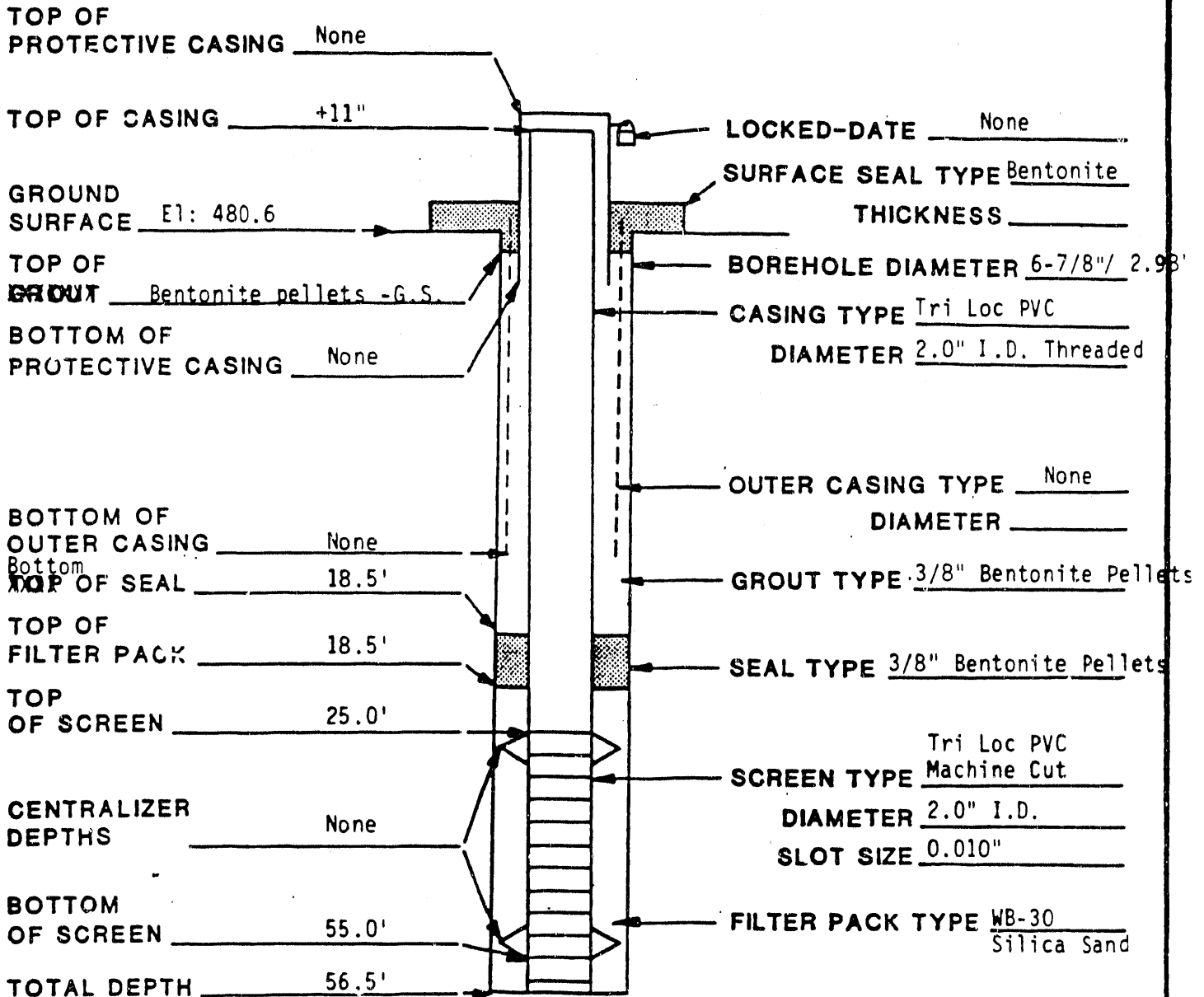
Piezometer installed, see attached completion drawing

WELDON SPRING SITE REMEDIAL ACTION PROJECT

WELL COMPLETION RECORD (PIEZOMETER)

WELL NUMBER GTQ-7 DATE INSTALLED 2/10/89

PMC REPRESENTATIVE Alan Benfer DRILLER Tom Clay - Hannibal



COMMENTS All depths below ground surface.
6-7/8" hole diameter to 36.5'; 2.98" diameter 36.5 to 56.5'.
Piezometer abandoned and grouted 4/18/89

PMC REPRESENTATIVE SIGNATURE J. Alan Benfer DATE 2/10/89
 J. Alan Benfer

WELDON SPRING REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 1 of 3

Project Number:
Contract WP 117

Hole Number
GTQ-8

Project: Geotechnical Investigation - Phase II		Location: Quarry Staging Area	
Coordinates: N.7597.07; E.12946.27		Drilling Contractor: Hannibal Testing Labs	
Drill Make and Model: CME 55, H.S. Auger, 6-7/8", 3 1/4"		Depth Top of Rock: 76.0'	Depth Casing & Size: None
Elevation: 477.62 g.s.		Angle from Vert. and Bearing: vertical	
Water Level: 20.9' BGS 2/16/89		Date Start: 1:25 2/13/89	Date Finish: 9:20 2/16/89
Fluid & Additives: None		Logger: A. Benfer	
		Hole Size: 6-7/8"	
		Depth Bottom of Hole: 76.0'	

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-8"-8" (N)	SYMBOLIC LOG	SOIL DESCRIPTION
		INTERVAL	TYPE & NUMBER	RECOVERY			
							SILTY CLAY, grayish brown (10YR 5/2), moist, stiff, CL-CH. Upper 1 ft. contains rock fragments. Mottled light grayish brown (10YR 6/2) and strong brown (7.5YR 5/6), stiff (1.25), CH.
	2.0 - 3.5	SS 01		8"	2-2-3 5		
5	5.0 - 7.0	ST 02		20"			as above, pp=3.75, very stiff, CH.
	7.5 - 9.0	SS 03		8"	3-5-11 16		SILTY CLAY, mottled light brownish gray (10YR 6/2) and very dark gray (10YR 3/2), minor strong brown (7.5YR 5/6), moist, hard, (4.5+), CL.
10	10.0 - 12.0	ST 04		24"			as above, pp=3.5, very stiff.
	12.5 - 14.0	SS 05		12"	4-7-9 16		as above, pp=2.25, very stiff, mottled light gray (10YR 7/1) and strong brown (7.5YR 5/6), bottom 4" very silty.
15	15.0 - 17.0	ST 05		29"			as above
	17.5 - 19.0	SS 06		12"	3-3-5 8		17.5-18.5 as above, pp=3.0, mottled light gray (10YR 7/1) and light yellowish brown (10YR 6/4), minor white (calcareous), CH.
	18.5 - 19.0						18.5-19.0 SILT, non-plastic, pale brown (10YR 6/3) very moist, very soft (<.25), ML.
20.9' 2/16/89	20.0 - 22.5	ST 07		25"			20.0-22.5 CLAY, mottled light gray (10YR 7/1) and yellowish brown (10YR 5/8) with minor black MnOx, moist, stiff (1.75), CH, contains minor limestone fragments and FeOx.
	22.5 - 24.0	SS 03		15"	2-3-3 6		22.5-24.0 as above, pp=2.25, very stiff contains thin lenses of silt
25							

WELDON SPRING REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 2 of 3

Project Number:
Contract WP 117

Hole Number
GTQ-8

Project: Geotechnical Investigation - Phase II

Location: Quarry Staging Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION
		INTERVAL	TYPE & NUMBER	RECOVERY	6"-5"-6" (N)		
25	25.0	ST 09	34"			as above, pp=2.25, CL-CH, wet ~26', blocky.	
	27.5	SS 10	12"	1-2-5 7			
30	30.0	SS 11	4"	1-2-4 6		FINE SANDY SILT, 25% sand, non-plastic, gray (5Y 5/1) moist, stiff to very stiff (2.0), ML. Contains minor oxidized roots. Color suggests reducing conditions below water table.	
	31.5	ST 12	0				
	32.5					No recovery	
35	35.0	SS 13	13"	2-4-6 10		SILTY CLAY, medium plasticity, gray (5Y 6/1) moist, very stiff (2.5), CL. Contains minor oxidized root.	
	36.5						
40	40.0	ST 14	32"			as above, pp=3.5, with silt lenses. ML	
	42.5						
45	45.0	SS 15	12"	3-2-5 7		Alternating every few inches between low plasticity silt to high plasticity clay and silty clay. pp=1.75, very stiff, medium to high plasticity clay predominates from ~35-71 feet.	
	46.5						
50							
55							

/13/89
/14/89

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 3 of 3





BOREHOLE LOG

Project Number:
Contract WP 117

Hole Number
GTQ-8

Project: Geotechnical Investigation - Phase II

Location: Quarry Staging Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY			
55	55.0	ST					as above, pp=2.25, closest color is dark greenish gray (5GY 4/1) GSA Rock Color Chart.
	57.5	16	32"				
60							pp=2.0 stiff to very stiff, with minor white (5Y 8/1) ~ 67.5 - Driller says gravelly
65	65.0	SS		2-3-7			
	66.5	17	11"	10			
70	70.0	SS		16-22	6" wt. of rods		pp=1.5, CH with 10% fine angular gravel
2/16/89	71.5	18	11"	38			
75							CLAYEY, SANDY GRAVEL, of angular limestone and chert fragments, generally light gray, moist to wet, dense GC. Gravel up to 1".
							76.0' auger refusal 9:20 2/16/89 2.0" PVC Piezometer installed. Screened from 17.5' - 36.5' Monitoring interval 15.5-76.0' See attached completion record.

2/14/89

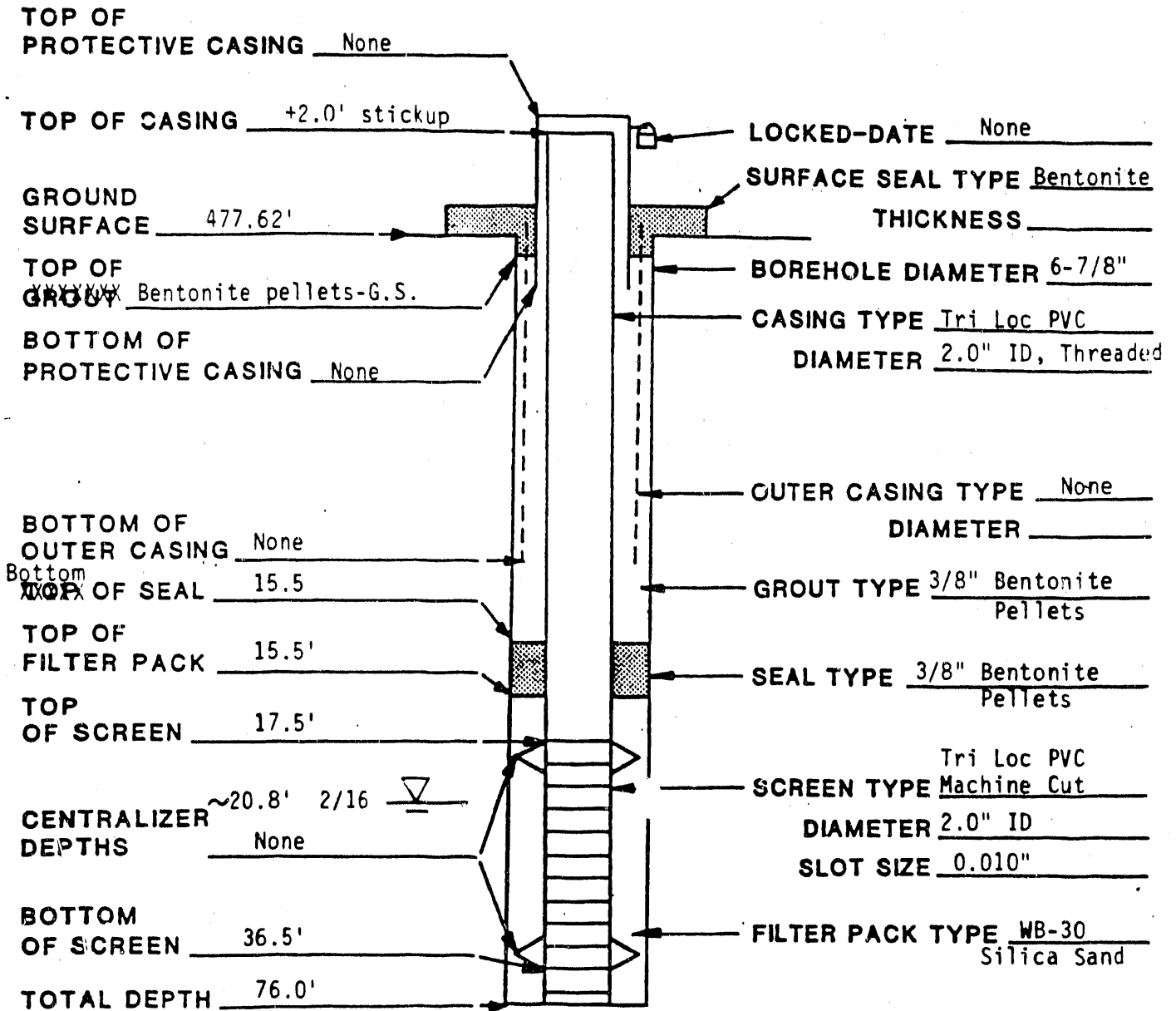
2/16/89

WELDON SPRING SITE REMEDIAL ACTION PROJECT

PIEZOMETER WELL COMPLETION RECORD

WELL NUMBER GTQ-8 DATE INSTALLED 2/16/89, 2/17/89

PMC REPRESENTATIVE A. Benfer DRILLER Hannibal, Tom Clay



COMMENTS All depths below ground surface. Boring backfilled with sand from 76.0' (T.D.) to 37.5'. Piezometer abandoned and grouted 4/24/89.

PMC REPRESENTATIVE SIGNATURE J. Alan Benfer DATE 2/17/89
 J. Alan Benfer

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 1 of 3

BOREHOLE LOG

Project Number: 5121
 Contract WP117
 Hole Number
 GTQ-9

Project: Geotechnical Investigation Phase II		Location: Quarry Staging Area	
Coordinates: N.7635.84, E E.13039.46		Drilling Contractor: Hannibal Testing Labs	
Drill Make and Model: CME 55 H.S. Augers 6-7/8", 3-1/4" I.D.		Depth Top of Rock: 76.2'	Depth Casing & Size: None
Elevation: 480.39 TOC, 478.02 GS		Angle from Vert. and Bearing: Vertical	
Water Level: 20.3' 4/14/89		Depth Bottom of Hole: 76.2'	
Fluid & Additives: None		Date Start: 4/11/89	Date Finish: 4/13/89
		Logger: R. Parsons	

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION
		INTERVAL	TYPE & NUMBER	RECOVERY	6"-6"-6" (N)		
							Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		2.5 4.0	SS 01	15"	3.6.7 13		SILTY CLAY, low plasticity, brownish gray (10YR 5/1) moist, stiff, CL. Some limestone gravel and FeOx stringers.
5		5.0	ST 02	21"			-- pp = 4.0, very stiff to hard, CL as above.
		7.5 9.0	SS 03	12"	3.5.8 13		CL as above, brownish gray (10YR 5/1) to moderate brown (5YR 3/4).
10		10.0	ST 04	30"			
		12.5					-- pp = 4.5+, hard, CL as above.
		12.5 14.0	SS 05	14"	4.7.9 16		CL as above, moderate brown (5YR 3/4) to light gray (N7).
15		15.0	ST 06	30"			SILTY CLAY, medium to high plasticity, moderate brown (5YR 3/4) to light gray (N7), moist, stiff to very stiff (2.0). CL-CH
		17.5 19.0	SS 07	18"	1.7.8 15		CL as above, medium stiff to stiff, some limestone gravel.
4/13/89	20	20.0	ST 08	29"			SILTY SAND, moderate brown (5YR 3/4) moist, loose (0.5). SM.
		22.5 24.0	SS 09	18"	1.6.7 13	SILTY CLAY, medium plasticity, moderate brown (5YR 3/4) to light gray (N7), moist, stiff, CL.	
25							

NOTE: Color descriptions from GSA Rock Color Charts

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 2 of 3
 Project Number: 5121
 Contract WP117
 Hole Number
 GTQ-9

BOREHOLE LOG

Project: Geotechnical Investigation Phase II

Location: Quarry Staging Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION
		INTERVAL	TYPE & NUMBER	RECOVERY	6"-6"-6" (N)		Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
25	25.0					[Diagonal Hatching]	CL as above
	27.5	ST 10	30"				
27.5	27.5	SS 11	18"	2.5.7		[Diagonal Hatching]	CL as above
	29.0			12			
30	30.0	ST 12	0			[Dotted]	No recovery
	32.5						
32.5	32.5	ST 13	30"			[Dotted]	CLAYEY SAND, dark greenish gray (5GY 4/1), moist, loose (0.5) SC
	35.0						
35	35.0	SS 14	18"	4.10.11		[Dotted]	SC as above
	36.5			21			
40	40.0	ST 15	27"			[Diagonal Hatching]	SILTY CLAY, medium plasticity, greenish gray (5GY 4/1), moist, very stiff (3.0). CL-CH.
	42.5						
45	45.0	SS 16	2"	5.10.12		[Diagonal Hatching]	Clay as above
	46.5			22			
50	50.0	SS 17	18"	4.9.10		[Diagonal Hatching]	Clay as above with some limestone gravel
	51.5			19			
55						[Diagonal Hatching]	

4/11/89
4/12/89

WELDON SPRING REMEDIAL ACTION PROJECT

BOREHOLE LOG






Sheet 3 of 3

Project Number: 5121
Contract WP117

Hole Number
GTQ-9

Project: Geotechnical Investigation Phase II

Location: Quarry Staging Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-8"-8" (N)	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol	
		INTERVAL	TYPE & NUMBER	RECOVERY				
	55	55.0	ST 18	30"			Clay with some gravel as above, stiff (1.5)	
		57.5						
	60	60.0	SS 19	18"	4.10.12 22		As above, dark greenish gray (5GY 4/1) to moderate brown (5YR 3/4)	
		61.5						
4/12/89 4/13/89	65	65.0	SS 20	18"	5.10.11 21		As above	
		66.5						
	70	70.0	SS 21	17"	8.19.33 52		SILTY SAND, dark greenish gray (5GY 4/1) to light gray (N7), moist, dense, occasional limestone gravel up to 1/2". SM	
		71.5						
	75	75.0	SS 22	12"	13.22.50/2 72+		SILTY GRAVEL, dark greenish gray (5GY 4/1) to light gray (N7), moist, very dense, GM. Limestone gravel up to 1/2".	
		76.2						
	80	Auger refusal 76.2', T.D. Probable limestone Installed piezometer, see well completion record. *Constant Head Permeability Tests NQ wireline rods 2.375" I.D.						
		@12.5' take 2.0 oz/10 min						
		@17.5' take 0 oz/10 min.						
		@22.5' take 16 oz/10 min.						
	85							

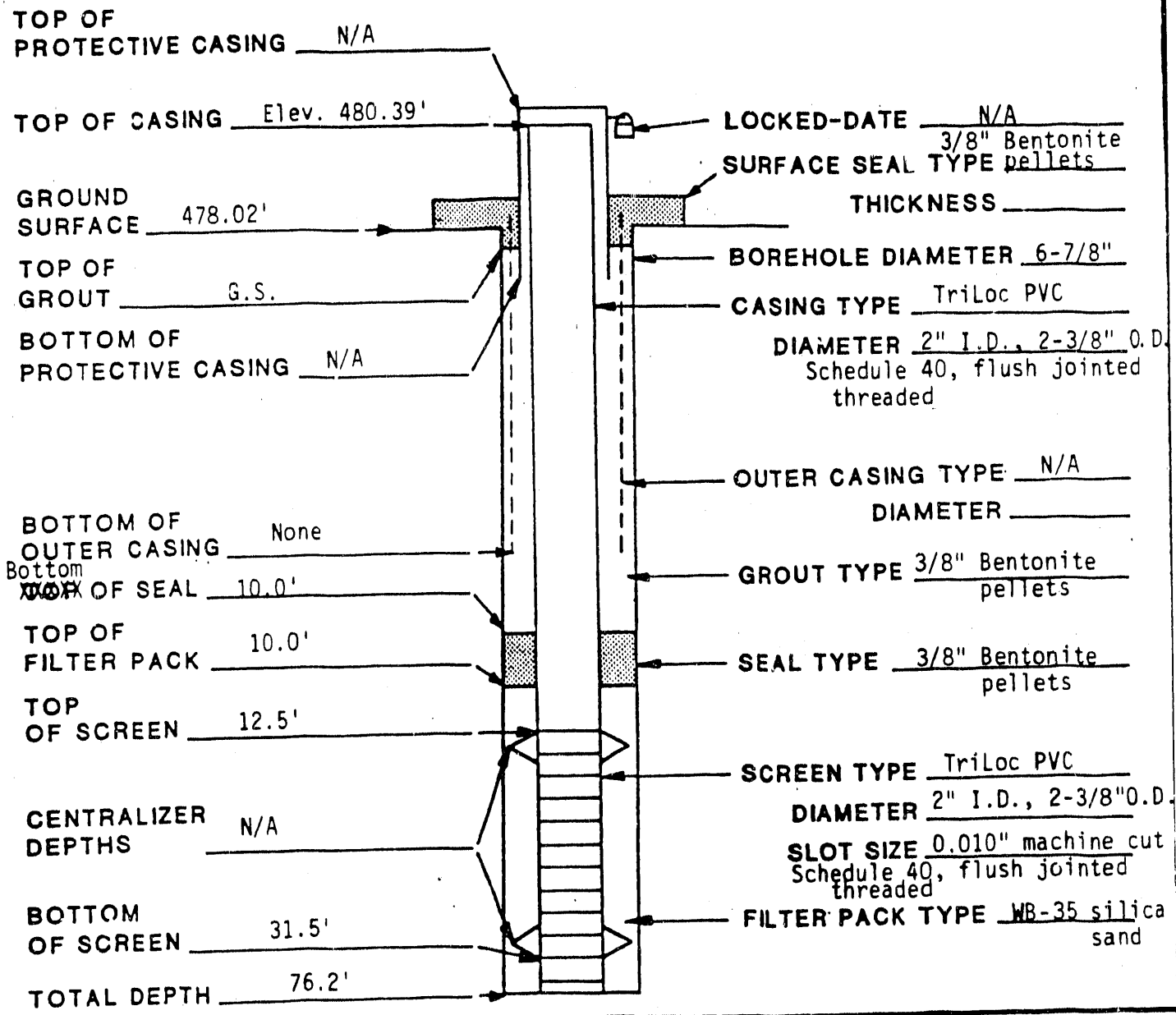
WELDON SPRING SITE REMEDIAL ACTION PROJECT

WELL COMPLETION RECORD

(PIEZOMETER)

WELL NUMBER GTQ-9 DATE INSTALLED 4/13/89

PMC REPRESENTATIVE Ray Parsons DRILLER Hannibal - Tom Clay



COMMENTS All depths below ground surface. Borehole caved from 76.2' to 36.5', bentonite pellets 36.5' to 34.5', sand 34.6' to 10.0'

PMC REPRESENTATIVE SIGNATURE Ray Parsons SAB DATE 4/13/89
 Ray Parsons

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 1 of 7

BOREHOLE LOG

Project Number: MKE 5121
Hole Number: GTQ-10

Project: <u>Geotechnical Investigation Phase II</u>		Location: <u>Quarry Staging Area</u>	
Coordinates: <u>N.7344.88, E.12974.48</u>		Drilling Contractor: <u>Hannibal Testing Laboratories</u>	
Drill Make and Model: <u>CME 55 (truck mounted); H.S. Auger 6-7/8" O.D., 3 1/2" I.D./NQ Wireline Core</u>		Depth Top of Rock: <u>89.5'</u>	Hole Size: <u>6-7/8"/2.980"</u>
Elevation: <u>485.97 g.s.</u>		Angle from Vert. and Bearing: <u>Vertical</u>	Depth Bottom of Hole: <u>109.5'</u>
Water Level: <u>32.1' b.g.s 4/7/89</u>	Fluid & Additives: <u>None/Water</u>	Date Start: <u>04/04/89</u>	Date Finish: <u>04/06/89</u>
		Logger: <u>N. Schauer/R. Parsons</u>	

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION
		INTERVAL	TYPE & NUMBER	RECOVERY	6"-5"-5" (N)		
		2.5 4.0	SS 01	11"	2.3.9 12		CLAYEY SILT GRAVEL, low plasticity, white (N8) with reddish brown (2.5YR 5/4) matrix, moist, medium dense, fine to coarse, subangular to subrounded limestone and chert gravel, maximum size 1", GC. As above, except maximum size 1 1/2"-stuck in bucket catcher Driller skipped sample at 7.5'-same.
5		5.0 6.5	SS 02	5"	4.2.6 8		
10		10.0	ST 03	6"			SILTY CLAY, dark gray (N4), low plasticity, moist, medium stiff with one large coarse, subrounded limestone gravel, CL.
		12.5 14.0	SS 04	18"	2.3.6 9		
15		15.0	ST 05	22"			CLAY, medium to high plasticity, medium gray (N5), wet, stiff to very stiff, CH. SILTY CLAY, medium to high plasticity, medium gray (N5) to brownish gray (10YR 5/1), wet, very stiff, (2.5) FeOx stain, trace fine gravel, CH.
		17.5 19.0	SS 06	18"	4.7.9 16		
20		20.0	ST 07	0"			SILTY CLAY, medium to high plasticity, greenish gray (5G 5/1), wet, very stiff to hard, FeOx stain, CH. No recovery
		22.5 24.0	SS 08	18"	3.4.6 10		
25							CLAYEY SILT, low plasticity, mottled greenish gray (5G 5/1) to reddish brown (2.5YR 5/4), moist, stiff, FeOx stain, ML.

4/4/89
4/5/89

NOTE: Color descriptions from GSA Rock Color Chart

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 2 of 7

BOREHOLE LOG

Project Number:
MKE-5121

Hole Number
GTQ-10

Project: Geotechnical Investigation Phase II

Location: Quarry Staging Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY	6"-6"-6" (N)		
25	25.0	ST 09	25"			[Symbolic Log: Diagonal Hatching]	SILTY CLAY, low plasticity, mottled greenish gray (5G 5/1) to reddish brown (2.5YR 5/4), moist, very stiff (2.5), FeOx stain, CL.
	27.5						
	27.5	SS 10	18"		3.5.7 12	[Symbolic Log: Diagonal Hatching]	SILTY CLAY, medium plasticity, greenish gray (5G 5/1), moist, very stiff to soft in places, FeOx stain, CL-CH.
	29.0						
30	30.0	ST 11	28"			[Symbolic Log: Diagonal Hatching]	SILTY CLAY, low plasticity, mottled greenish gray (5G 5/1) to reddish brown, (2.5YR 5/4), moist, stiff (1.5), FeOx stain, trace fine sand, CL.
	32.5						
35	35.0	SS 12	18"		3.4.4 8	[Symbolic Log: Diagonal Hatching]	SANDY SILTY CLAY, low plasticity, mottled greenish gray (5G 5/1) to reddish brown (2.5YR 5/4), moist, soft to medium stiff, fine sand, abundant FeOx stain and red and yellow discoloration, CL.
	36.5						
							38.0
40	40.0	ST 13	28"			[Symbolic Log: Dotted]	SILTY SAND, non-plastic to low plasticity, medium gray (N5) to greenish gray (5G 5/1) to bluish gray (5B 5/1), wet, loose, fine sand, trace clay, SM. ST13 only pushed 28"-hit a rock.
	42.3						
							43.0
							Driller reported gravel at 43'
45	45.0	SS 14	18"		5.14.14 28	[Symbolic Log: Diagonal Hatching]	SILTY SANDY CLAY, low plasticity, greenish gray (5G 5/1), wet, soft, fine sand, trace coarse subrounded limestone and weathered limestone gravel, maximum size 1½", CL.
	46.5						
							48.0
50	50.0	SS 15	18"		2.3.6 9	[Symbolic Log: Dotted]	SILTY SAND, greenish gray (5G 5/1), wet, loose, fine to medium sand, trace clay, SM.
	51.5						
							53.0
55							

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 3 of 7

BOREHOLE LOG

Project Number:
MKE 5121

Hole Number
GTQ-10

Project: Geotechnical Investigation Phase II

Location: Quarry Staging Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION
		INTERVAL	TYPE & NUMBER	RECOVERY	6"-5"-5" (N)		
55	55.0 57.5	ST 16	30"			[Symbolic Log Pattern]	SILTY CLAY, medium plasticity, dark greenish gray (5G 4/1) to dark bluish gray (5B 4/1), wet, stiff (1.5) to very stiff, CL.
60	60.0 61.5	SS 17	18"	3.5.7 12			SILTY CLAY-CLAYEY SILT, medium plasticity, dark greenish gray (5G 4/1) to dark bluish gray (5B 4/1), wet, stiff to very stiff, trace fine sand, CL/CH-ML/MH.
65	65.0 67.5	ST 18	30"			[Symbolic Log Pattern]	CLAY, medium to high plasticity, dark greenish gray (5G 4/1) to dark bluish gray (5B 4/1), wet, very stiff (2.0), CH.
70	70.5 71.5	SS 19	18"	3.5.8 13			SILTY CLAY, medium to high plasticity, dark greenish gray (5G 4/1), wet, very stiff to hard, CH.
75	75.0 76.5	SS 20	18"	4.6.9 15		[Symbolic Log Pattern]	SILTY CLAY, medium to high plasticity, dark greenish gray (5G 4/1) to dark bluish gray (5B 4/1), wet, very stiff to hard, a little fine white (N8) limestone and chert gravel, maximum size 1/2", trace medium to coarse sand, CH.
80 4/5/89 4/6/89	80.0 81.5	SS 21	7"	7.14.50 64			CLAYEY GRAVEL, medium plasticity, dark greenish gray (5G 4/1) to dark bluish gray (5B 4/1) matrix with tan (7.5YR 7/4) and white (N8) gravel, wet, very dense, fine to coarse angular chert gravel, maximum size 1 1/2", GC.
85							

80.25

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 5 of 7

BOREHOLE LOG

Project Number:
MKE 5121

Hole Number
GTQ-10

Project: Geotechnical Investigation Phase II

Location: Quarry Staging Area

DEPTH	COMMENTS TESTS/MONITORING INSTRUMENTATION CORING RATE AND SMOOTHNESS CORING FLUID LOSS CONTAMINATION	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES		GRAPHIC LOG	LITHOLOGY	
					ROD	FRACTURES PER FOOT		DESCRIPTION TIGHTNESS PLANARITY SMOOTHNESS FILLING, STAINING ORIENTATION	MINERALOGY CLASSIFICATION COLOR GRAIN SIZE ALTERATION
89	Begin Core	89.5	89.5						
		NQ-1 9.6		1	7.5				
90		10.0			10.0				
	2 min/ft 100% fluid return	96%			75%				
					LP = 2.1	4			
91					6				
	2 min/ft				> 4"	1			
92									
	2 min/ft					1			
93									
	2 min/ft								
			93.5						
						3			
94			93.9						
	2 min/ft					0			
95									
	2 min/ft					1			
96									
				1					

89.5-99.5 LIMESTONE; buff (7.5YR 3/4) to light gray (N7), fine grained xtn, moderate hard, fresh clay (hard) tan (7.5YR 7/4), blebs and wavy stringers .5" to 1", occ. white (N8) chert nodules, thin to very thin bedding, occ. vugs. Closely to medium fractured (spacing 2½' to 2').

Possibly PLATTIN FM

Core loss 93.5-93.9 (Driller reported void - drop of rods at this interval)

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 7 of 7

BOREHOLE LOG

Project Number:
MKE 5121

Hole Number
GTQ-10

Project: Geotechnical Investigation Phase II

Location: Quarry Staging Area

DEPTH	COMMENTS TESTS/MONITORING INSTRUMENTATION CORING RATE AND SMOOTHNESS CORING FLUID LOSS CONTAMINATION	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES			GRAPHIC LOG	LITHOLOGY	
					ROD	FRACTURES PER FOOT	DESCRIPTION TIGHTNESS PLANARITY SMOOTHNESS FILLING, STAINING ORIENTATION		MINERALOGY CLASSIFICATION COLOR GRAIN SIZE ALTERATION	CEMENTATION HARDNESS WEATHERED STATE
103	3 min/ft		103.3	2					As above	
104	3 min/ft					1	Open, rough Rubble			
105	3 min/ft					5	Open, rough (3) Open, rough Rubble			
106	3 min/ft					1	Open, rough			
107	3 min/ft					0				
108	3 min/ft					1	Open, rough			
109	3 min/ft									
110		109.5		2					Total depth 109.5'	

Grouted hole with volclay grout to ground surface.

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 1 of 2
 Project Number:
 Contract: WP 117
 Hole Number
 GTQ-11

Project: Geotechnical Investigation - Phase II		Location: Quarry Staging Area	
Coordinates: N.7479.28 E.12848.48		Drilling Contractor: Hannibal Testing Laboratories	
Drill Make and Model: CME 55; 7-5/16" O.D. Hollow Stem Auger with 4 1/2" I.D.		Depth Top of Rock: --	Depth Casing & Size: 80.0'; 7-5/16"
Elevation: Ground: 477.17'		Angle from Vert. and Bearing: Vertical	
Water Level: 24.0' bgs; 5/4/89		Fluid & Additives: None	Date Start: 05/01/89
		Date Finish: 05/03/89	Logger: P. Patchin
		Depth Bottom of Hole: 80.0'	

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION
		INTERVAL	TYPE & NUMBER	RECOVERY			
							Auger drilled to 35.5 ft. without sampling. See log from borehole GTQ-5 for description of soils to 35.5'
35							Begin sampling 35.5
	35.5		ST 01	26"			SILT, slightly clayey, slightly plastic, dark gray (5Y 4/1), damp, very stiff (2.5) ML
	38.0						
40							SILT, as above, P.P.=1.25
	39.5		ST 02	26"			
	42.0						41.9
*							CLAY, mod. to high plasticity; dark gray (5Y 4/1), moist, slightly silty, approx. stiff, CH
	44.0		ST 03	30"			CLAY, as above, P.P.=2.25 CH
45							
	46.5						
*							
	49.0		ST 04	30"			CLAY, high plasticity, very dark gray (5Y 3/1) slightly mottled with black (5Y 2.5/1), moist, stiff (1.25), occasional FeOx blebs, CH
50							
	51.5						
*							
55							See next page for sample ST05 description

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

 Sheet 2 of 2

Project Number:

Contract: WP 117

Hole Number

GTQ-11

Project:

Geotechnical Investigation - Phase II

Location:

Quarry Staging Area

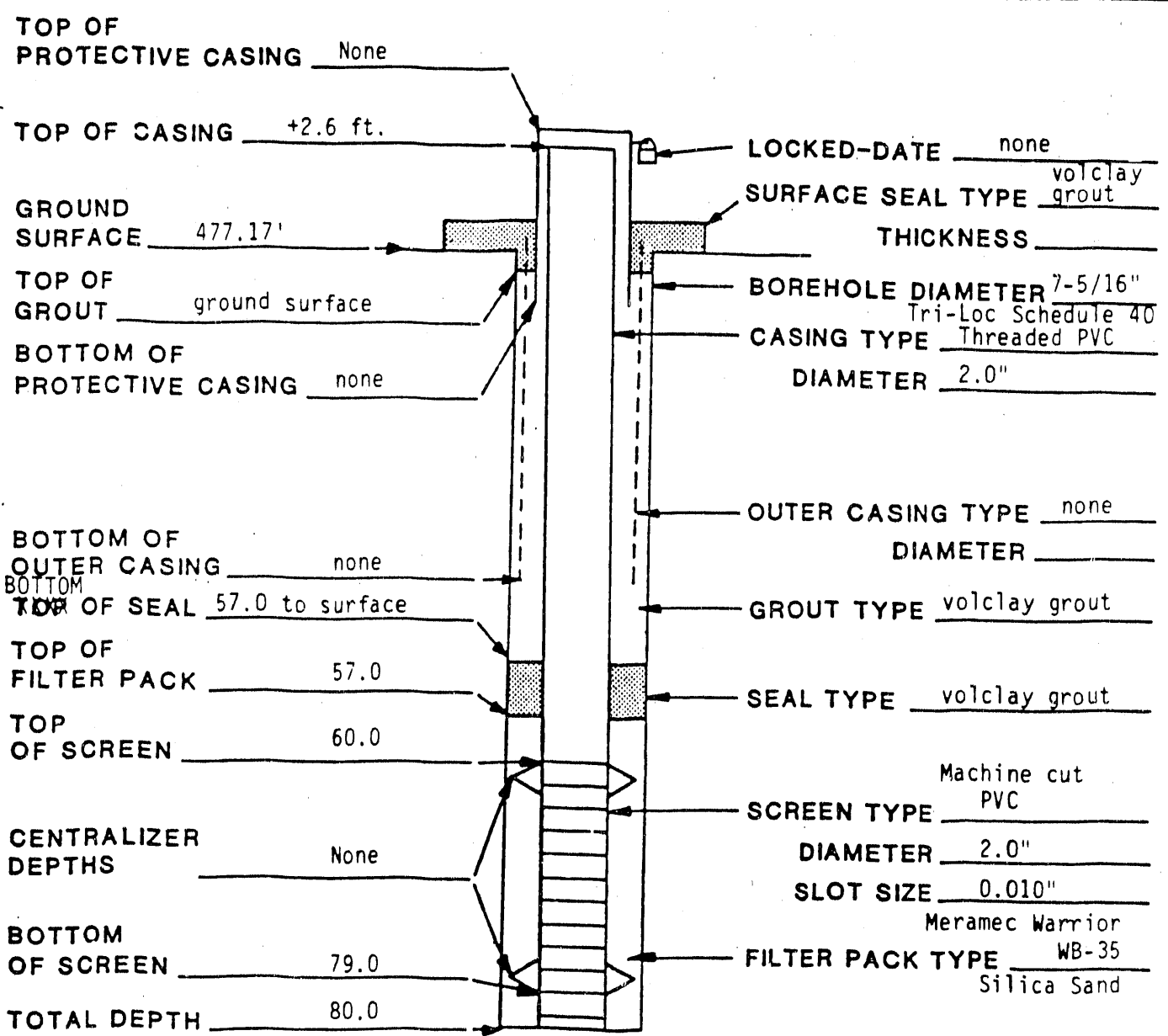
ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION
		INTERVAL	TYPE & NUMBER	RECOVERY	8"-6"-6" (N)		Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
55	55.0 57.5	ST 05	22.5"			CLAY, mod. plasticity, slightly silty, greenish gray (5G 4/1) damp to moist, stiff (2.25), CL-CH	
60							
65	65.0 66.5	SS 06	18"	6-11-13 24		CLAY, as above, grading to dark gray (5Y 4/1), slightly increased plasticity (med. to high), stiff (2.0), occasional light gray blebs (unknown) CL-CH	
70	70.0 71.0	ST 07	12"			CLAYEY GRAVEL, clay fraction is dark gray (5Y 4/1) comprises ~20%; sandy (coarse) approx. 10%, poorly sorted, gravel fraction is fine to 2 cm, angular to subrounded pale blue chert, moist to wet, no limestone, GC	
75	75.0 76.5	SB 08	12"	17-43-42 > 50		CLAYEY GRAVEL, as above, with FeOx blebs, chert is white (10 YR 8/1) more weathered, clay has mod. plasticity, GC	
80						Total Depth 80.0'	
						@ 3:00 p.m. 5/2/89	
						Installed piezometer consisting of 2" schedule 40 PVC. Screened from 79.0' to 60.0'. Sand pack from 80.0' to 57.0'. See attached completion record. *Constant Head Permeability Tests, NQ wireline rods 2.375" I.D., @42.0' take 0.05 oz/10 min.; @46.5' take 3.0 oz/10 min.; @51.5' take 3.2 oz/10min.	

WELDON SPRING SITE REMEDIAL ACTION PROJECT

WELL COMPLETION RECORD (PIEZOMETER)

WELL NUMBER GTQ-11 DATE INSTALLED 5/3/89

PMC REPRESENTATIVE P. Patchin DRILLER Tom Clay - Hannibal



COMMENTS All depths from ground surface.

PMC REPRESENTATIVE SIGNATURE Paul Patchin DATE 5/3/89
 Paul Patchin

APPENDIX B

LABORATORY TEST RESULTS

Laboratory testing was conducted on representative soil samples obtained from exploratory boreholes to determine their physical properties, compressibility, permeability and shear strength. The laboratory testing was performed by GEOTECHNOLOGY, INC., St. Louis, Missouri, and the results have been reviewed and approved by MKES.

The following procedures were followed in performing the tests:

- ASTM D422 - Sieve analysis with hydrometer
- ASTM D1140 - Test Method for Amount of Material in Soils Finer than the No. 200 Sieve
- ASTM D854 - Specific gravity
- ASTM D4318 - Atterberg limits
- ASTM D2216 - Moisture content of Soil
- ASTM D2435 - One-dimensional consolidation
- EM 1110-2-1906 - Three point sets Triaxial R
Three point sets Triaxial Q
Triaxial permeability

A summary of laboratory testing results is presented in, Table B-1

SUMMARY OF SOIL TEST RESULTS
TABLE B-1

Hole or Trench Number	Sample Number	Depth (ft)		Laboratory Classification	Mechanical Analysis			Atterberg Limits		Specific Gravity G	Natural		Compaction		Shear Strength		Permeability		Consolidation				
		From	To		Gravel	Sand	Fines	LL	PI		W	Y _d (pcf)	Optimum	Y _d	Test	C	φ	k	k	C _c	C _r	P _a	
G10-1	ST-02	7.5	10.0	ML	32	68	2	30	2		21.7	93.73			CU	Total stress	300	13°					
																						CU	Eff. stress
	SS-03	10.0	11.5	ML							23.7												
																							CU
	SS-05	15.0	16.5	CL				63	35		38.		82.14		CU	Total stress	400	13°		0.37	0.09	4000	
CU																							Eff. stress
G10-2	SS-07	20.0	21.5	CL	19	81				27.1													
																						CU	Total stress
	SS-08	22.5	25.0	CL-ML	11	89	5	24	5	2.69	29.5	91.0			CU	Total stress	0	33°					
																							CU
	SS-10	27.5	30.0	CL	32	68	10	30	10		24.1	98.8			UU	SU _u	800						
CU																							
SS-15	45.0	47.5	CL	2	98	27	49	27		35.7	85.3												
																							CU
G10-3	SS-09	23.0	26.5	ML	13	87				26.7													
																						CU	Total stress
	SS-11	27.5	29.0	CH	4	88				42.4													
																							CU
	SS-03	5.0	7.5	CH				51	31		35	93.0											
CU																							
SS-07	15.0	17.5	CH	1	99	33	74	50		40.4	79.0			CU	Total stress	200	33°						
																							CU
SS-08	20.0	22.0	CH	4	78	47	71	47		29	104.0			UU	SU _u	400							
																							CU
G10-4	SS-05	12.5	14.0	CL						27.8													
																						CU	Total stress
	SS-06	15.0	17.5	CH	1	99	33	57	33		23.5	98.2			CU	Total stress	200	33°					
	SS-12	30	32.5	CL-CH	3	97					50.3	71.8											
CU																							
SS-15	45.0	46.5	ML	5	95					27.4													
																							CU
SS-16	50.0	52.5	CH				74	49		43.4	75.7												
																							CU
G10-5	5.0	7.5	CH	1	99	28	53	28	2.63	23	103.3			CU	Total stress	1200	8.5°						
																							CU
G10-6	10.0	12.5	CH	1	99	50	89	50		23.4				CU	Total stress	800	8°						
																							CU

* Mixed with SS-07

SP = Standard Proctor
MP = Modified Proctor
S = Special - See Text
TC = Triaxial Compression
UC = Unconfined Compression
DS = Direct Shear
UU = Unconsolidated Undrained
CU = Consolidated Undrained
CD = Consolidated Drained

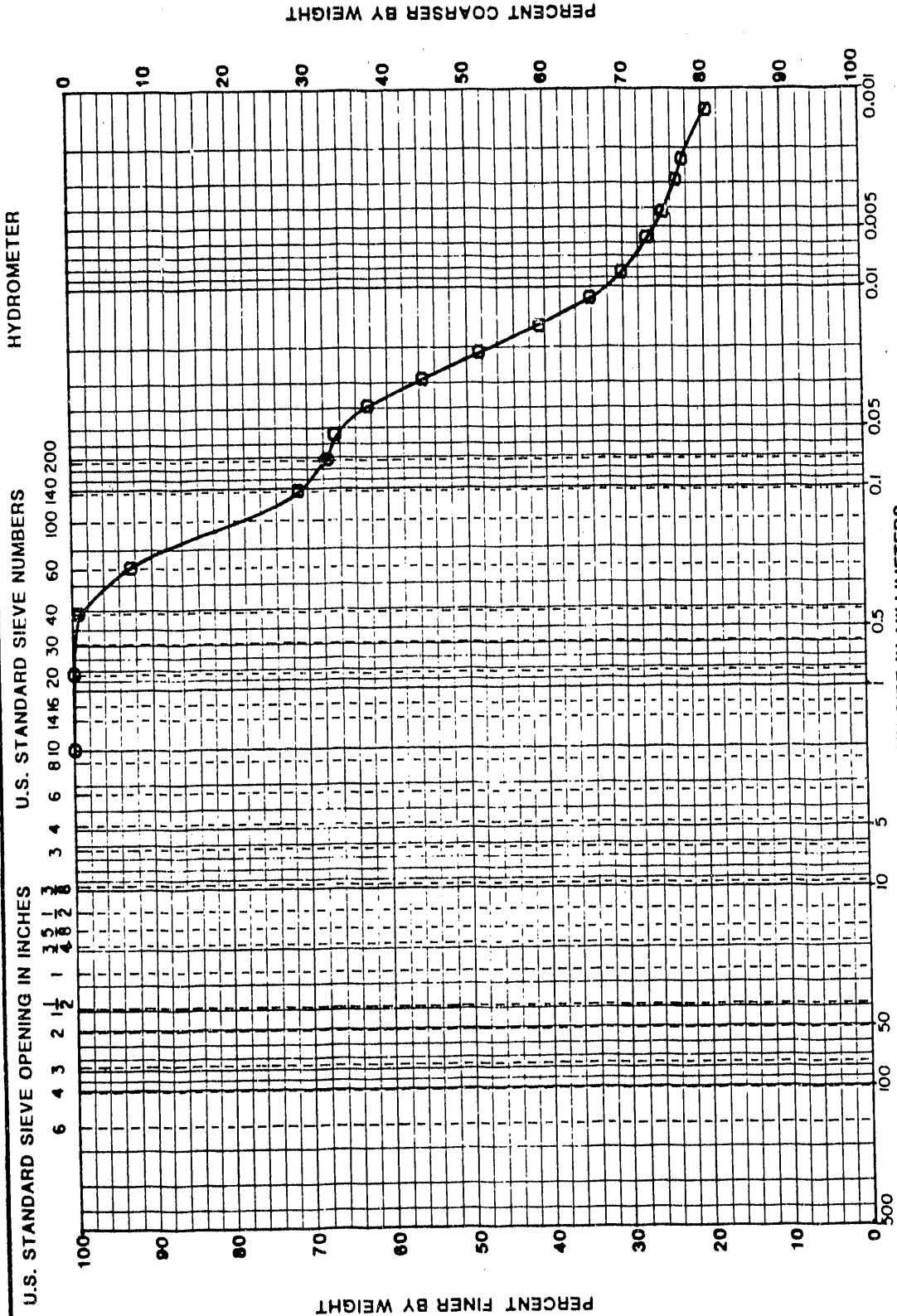
SUMMARY OF SOIL TEST RESULTS
TABLE B-1

Hole or Trench Number	Sample Number	Depth (ft)		Laboratory Classification	Mechanical Analysis			Atterberg Limits		Specific Gravity G	Natural		Optimum		Shear Strength		Permeability		Consolidation			
		From	To		Gravel	Sand	Fines	LL	PL		W	γ_d (pcf)	U _z	γ_d	Test	C	c (psf)	k (cm/sec)	c_c	c_r	P_i (psf)	
GTO-5	SS-05	12.5	14.0	CH				74	20		34.6											
	ST-06	15.0	17.5		6	94		79	55	2.70	26.9	92										
	SS-07	17.5	19.0	CH							23.4											
	ST-12	30.0	32.5	ML	6	73					27.4											
	SS-14	40.0	41.5	SM	1	84	15				26.3											
GTO-8	ST-02	5.0	7.5	CH	2	98		89	55		32.3	88.6									9000	
	ST-04	10.0	12.0	CH	2	98		56	32		22.6	94.4										
	ST-05	15.0	17.0								25.9- 33.7											
	ST-07	22.5	25.0	ML-CL	0.5	99.5					37.2	87.0									8500	
	ST-09	25.0	27.5		0.3	99.7					22.8	95.0										
	ST-14	40.0	42.5	ML	0.5	99.5		36	5		31.9	90.0									9000	
	ST-16	55.0	57.5								32.0	82.0										
GTO-9	ST-02	5.0	7.0	CH	0	100		84	55		32.1	93.1										
	ST-06	15.0	17.5	CH	4	93.5		50	24		29.4	88.0									8000	
	SS-11	27.5	29.0	CL				30	15		22.7										8000	
GTO-10	ST-05	15.0	17.5	CH	4	94		68	39		28.5	93.0										
	ST-09	25.0	27.5								27.1											
	ST-11	30.0	32.0	CH	2	98		51	25		33.3	91.0										
	ST-16			CL	0.5	99.5					28.5	94.1										
Composite Samples																						
**	1	10.0	27.5	CH				54	29					21.6	93.1							

SP = Standard Proctor TC = Triaxial Compressor UU = Unconsolidated Undrained

** Composite sample SS-05 and SS-07

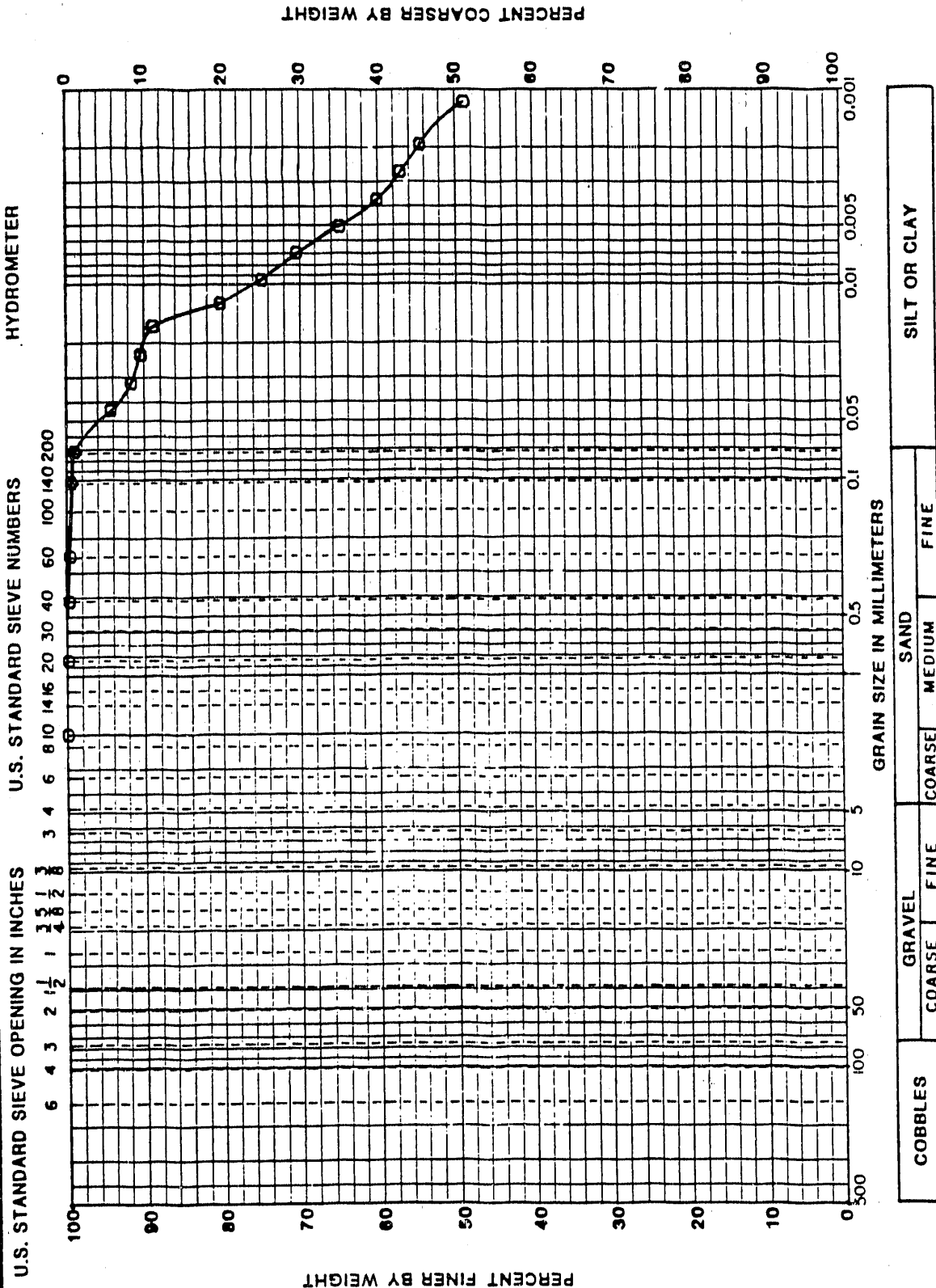
GRADATION CURVES



COBBLES	GRAVEL		SAND			SILT OR CLAY	
	COARSE	FINE	COARSE	MEDIUM	FINE		

SAMPLE NO.	EL. or DEPTH	CLASSIFICATION	NAT. WT. %	LL	PL	PI	PROJECT
ST - 02	7.5-10.0	ML	21.7	30	28	2	WSSRAP
							BORING NO. GTQ - 1
							DATE 10-23-89
							 GEOTECHNOLOGY ENGINEERING AND ENVIRONMENTAL SERVICES SAINT LOUIS, MISSOURI

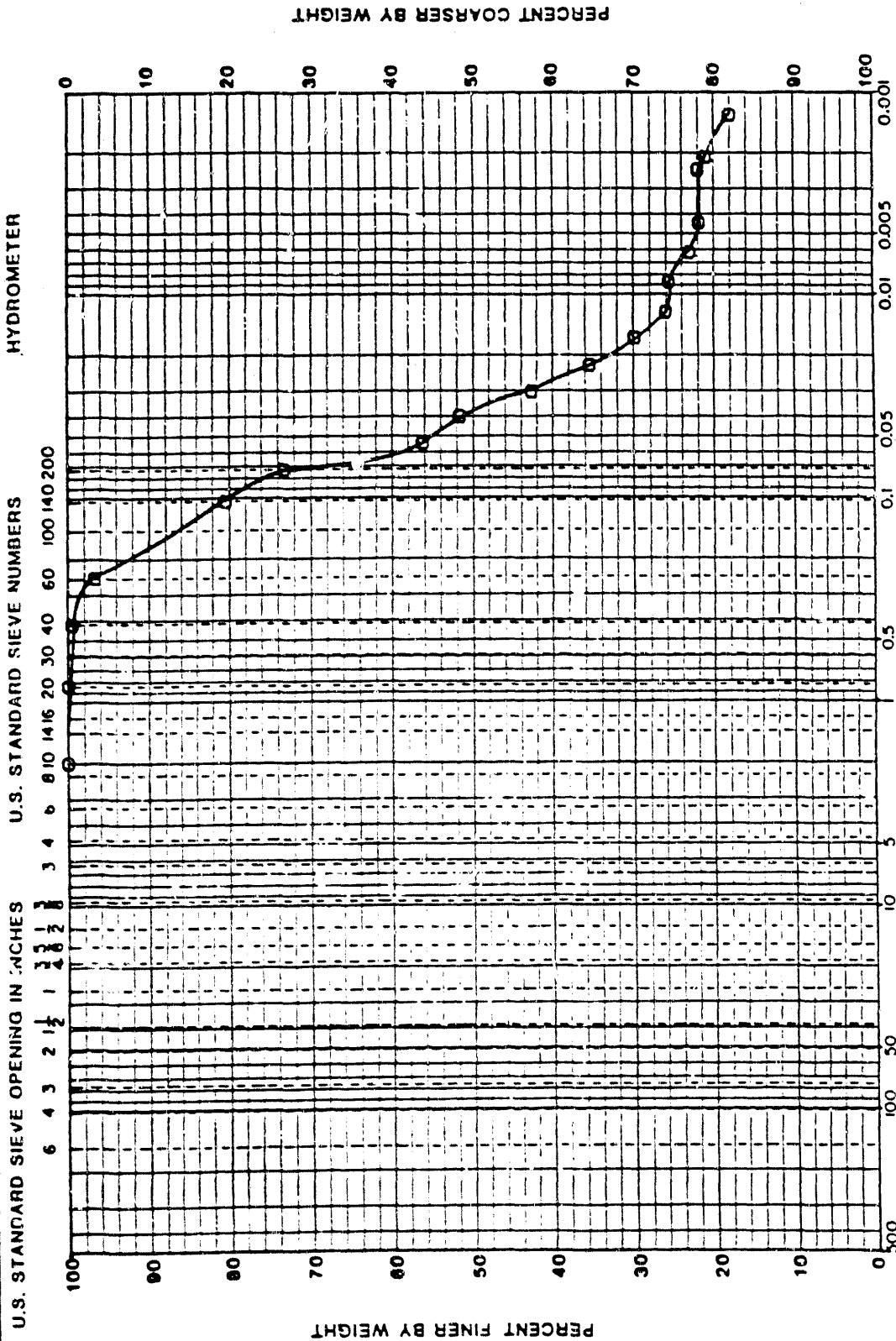
GRADATION CURVES



SAMPLE NO.	EL. or DEPTH	CLASSIFICATION	NAT. WT. %			PI	PROJECT
			COARSE	MEDIUM	FINE		
ST 04	12.5-15.0	CH	37.4	63	28	35	WSSRAP
							BORING NO. GTQ-1
							DATE 6-22-88

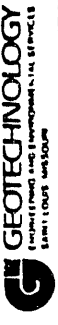


GRADATION CURVES

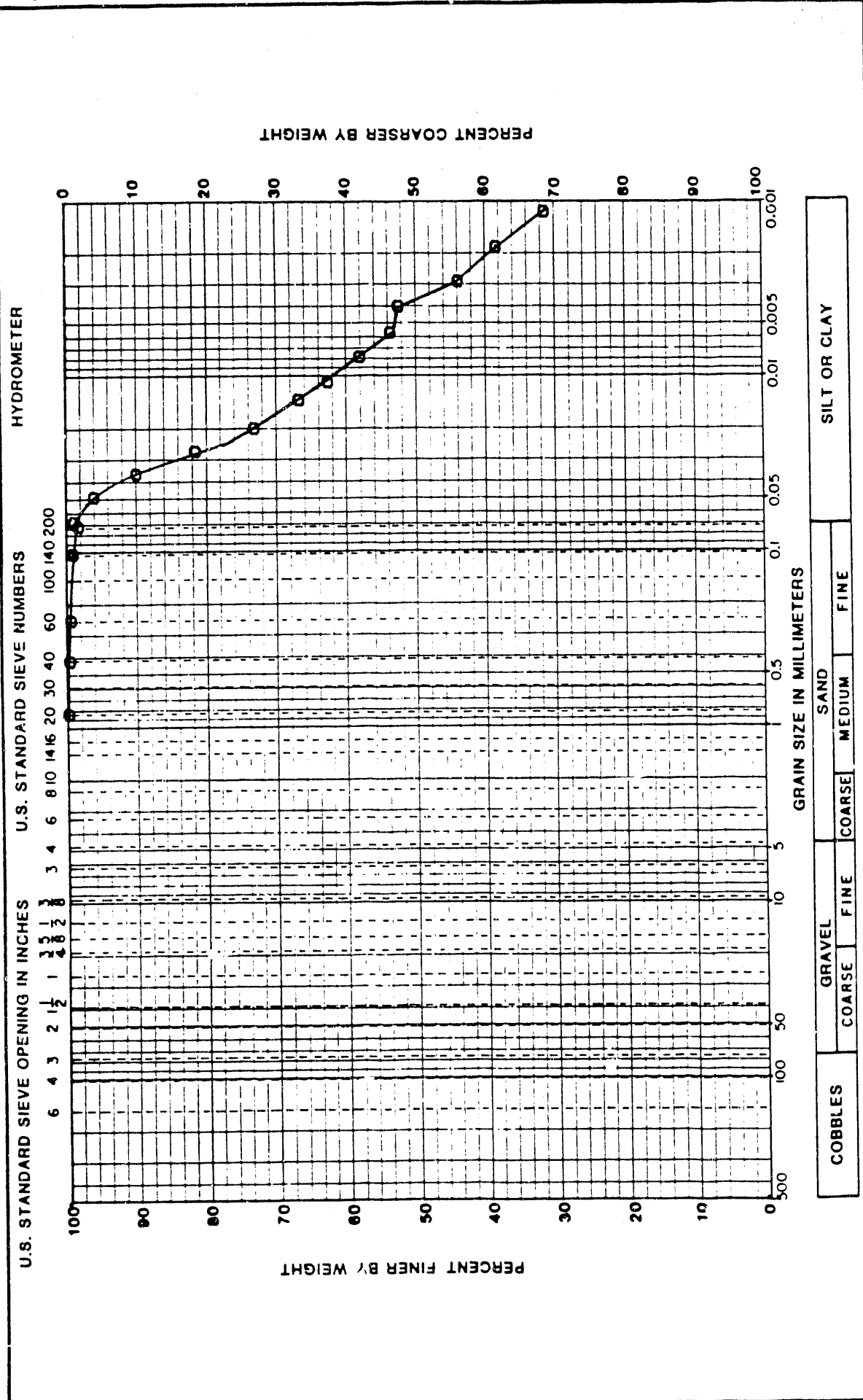


COBBLES	GRAVEL		SAND			SILT OR CLAY	
	COARSE	FINE	COARSE	MEDIUM	FINE		

SAMPLE NO.	EL. or DEPTH	CLASSIFICATION	NAT. WT. %	LL	PL	PI	PROJECT
ST 10	27.5-30	CL	0.5	30	20	10	WSSRAP
							BORING NO. GTD 1
							DATE 6-22-89



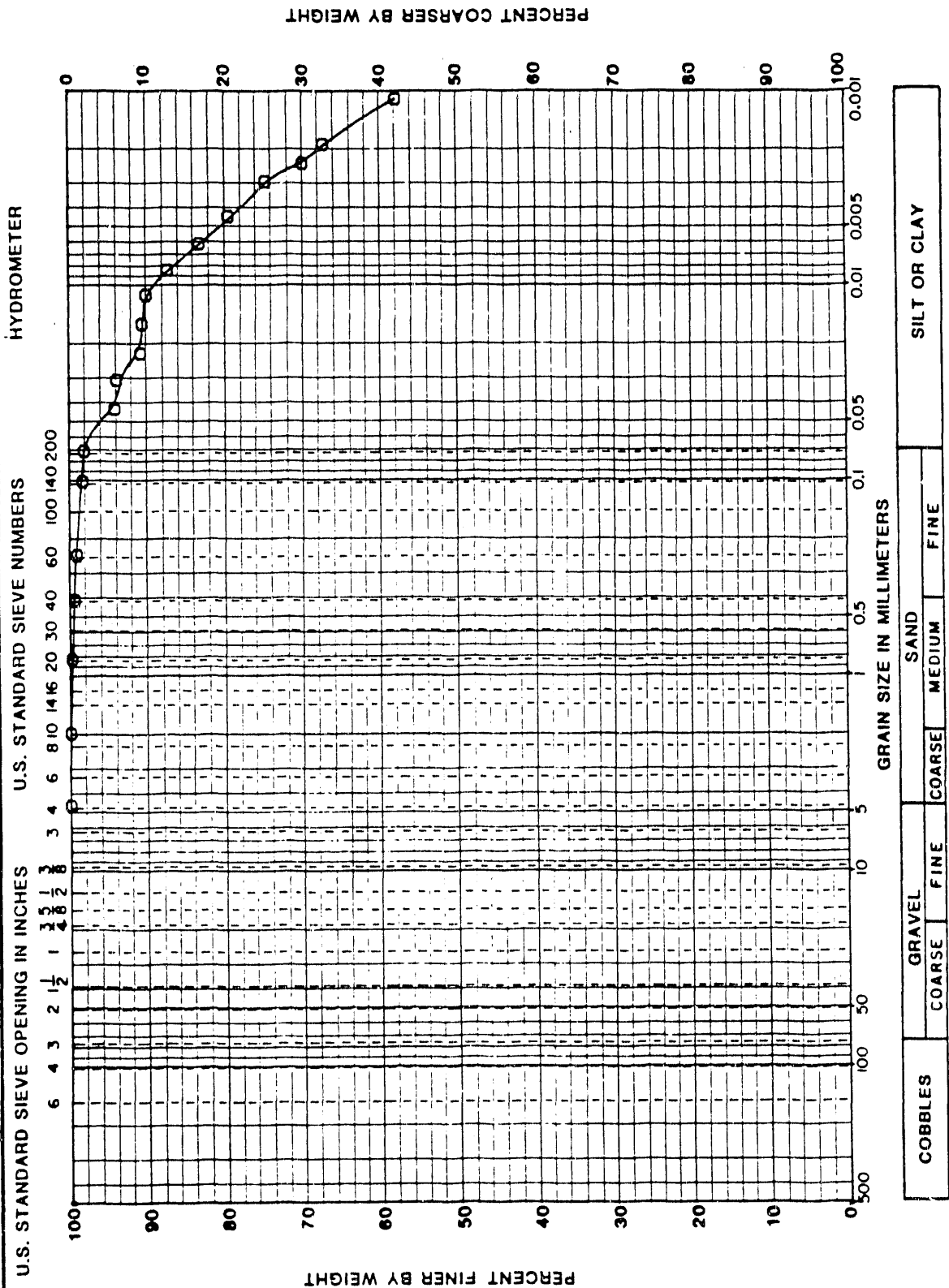
GRADATION CURVES



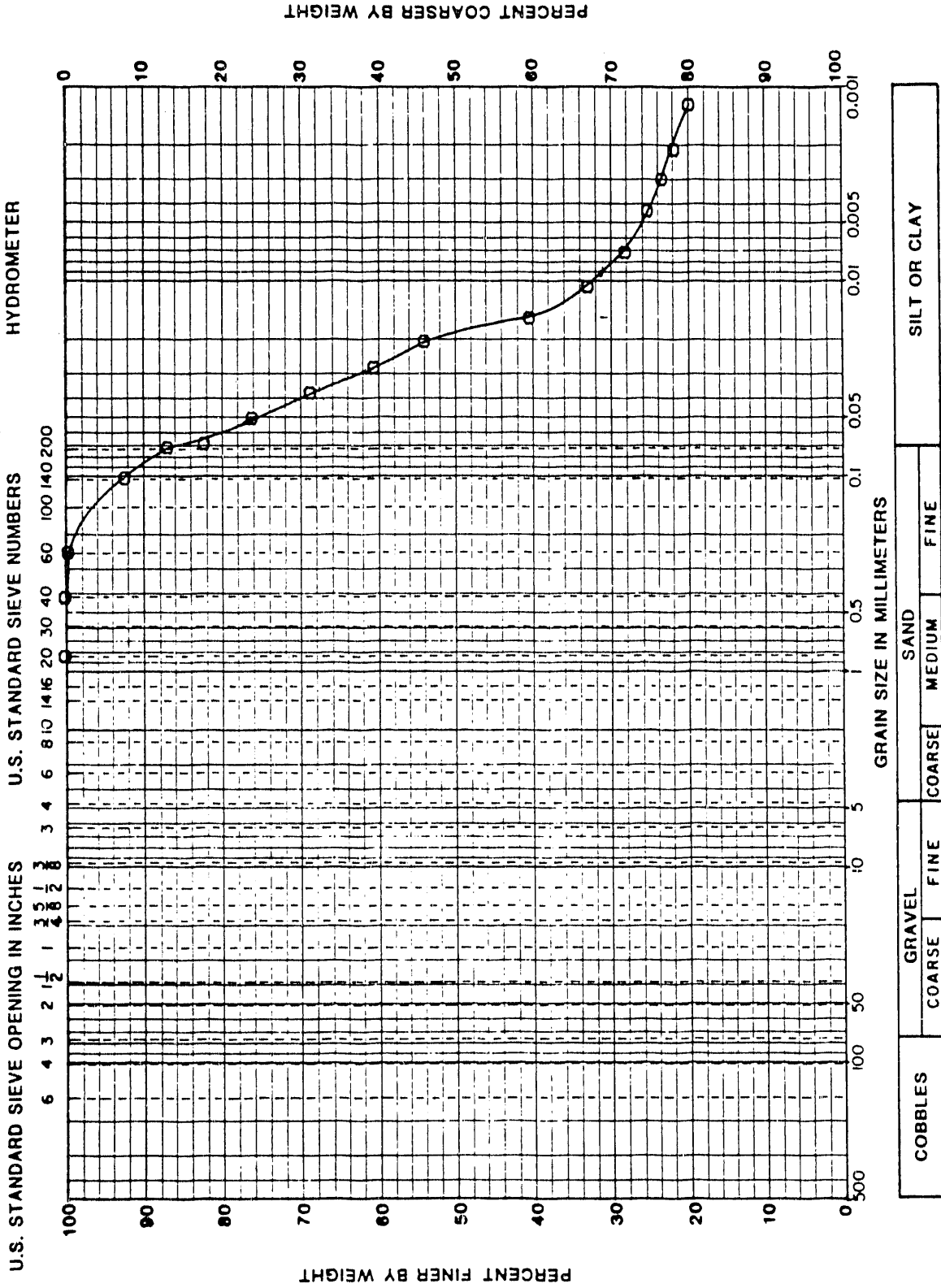
SAMPLE NO.	EL. or DEPTH	CLASSIFICATION	NAT. WT. %	SAND			SILT OR CLAY		PROJECT
				COARSE	MEDIUM	FINE	PI	PL	
ST-15	45.0-47.0	CL	36.1		49	22	27		YSSRAP
									BORING NO. GTQ-1
									DATE 9-29-89



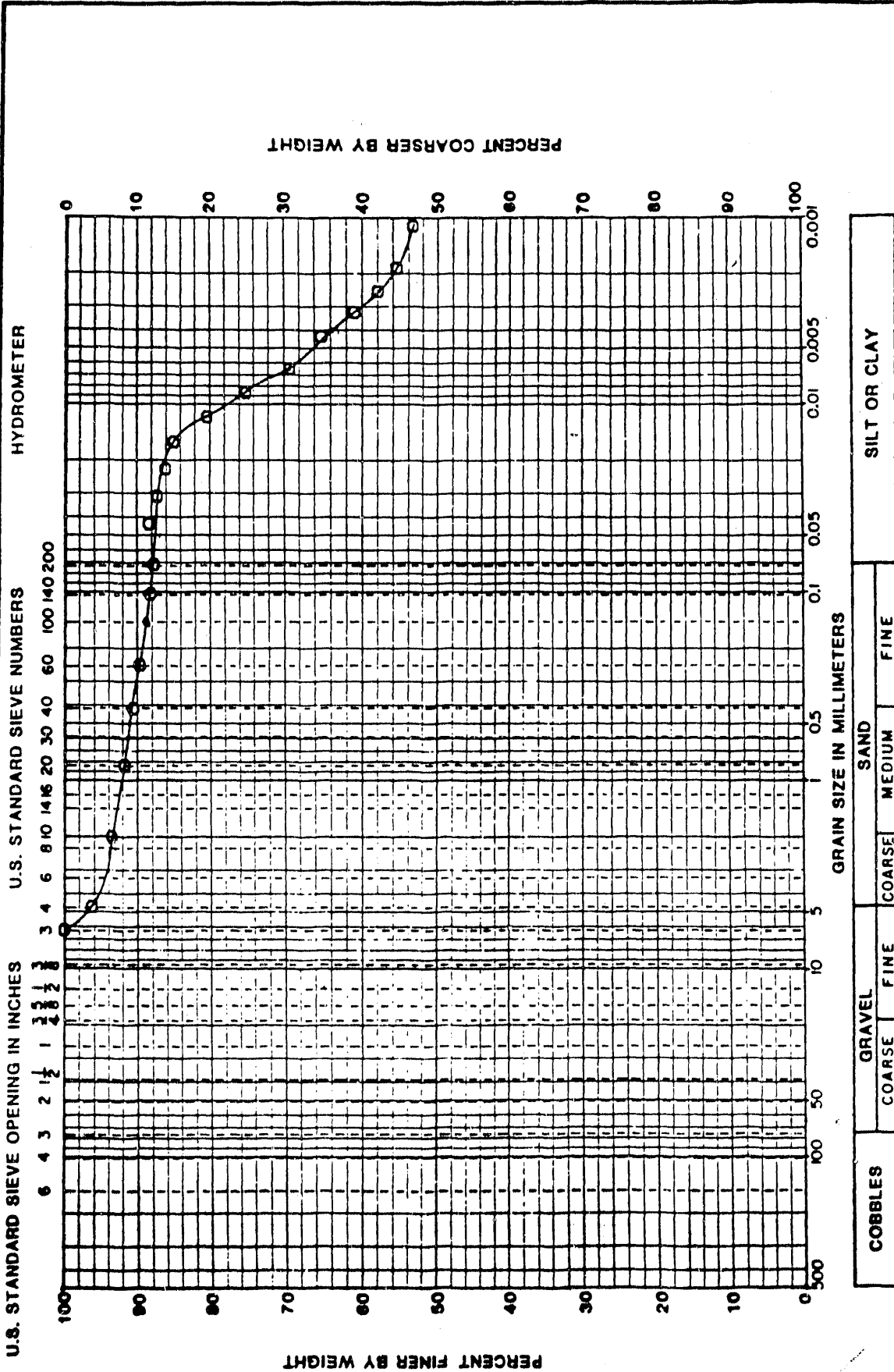
GRADATION CURVES



GRADATION CURVES

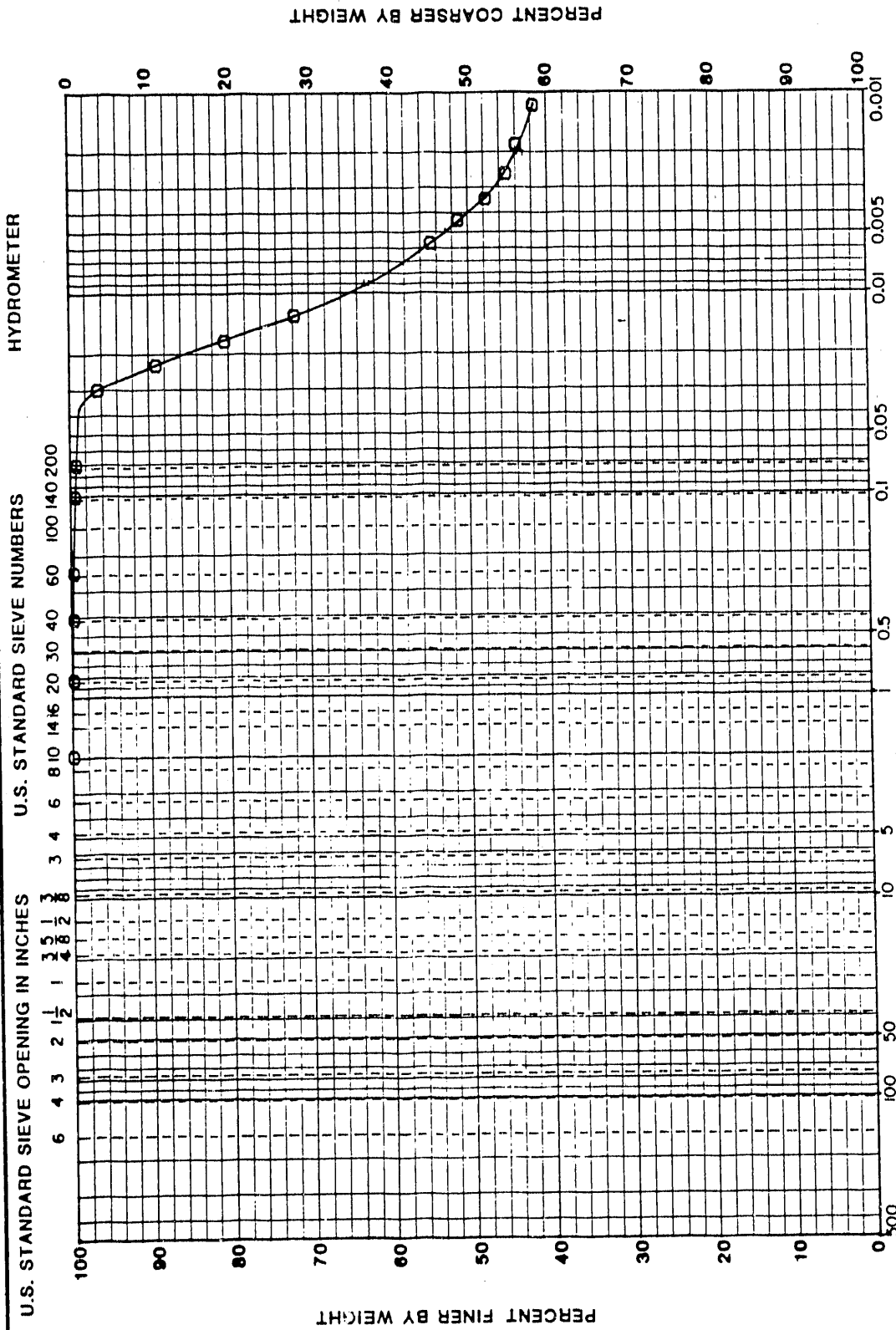


GRADATION CURVES



COBBLES		GRAVEL		SAND			SILT OR CLAY		
COARSE		FINE		COARSE	MEDIUM	FINE			
SAMPLE NO.	EL. or DEPTH	CLASSIFICATION			NAT. WT. %	LL	PL	PI	PROJECT
SS-11	27.5-29	CH			42.4				WSSRAP
									BORING NO. GTQ-2
									DATE 5-26-89
 <small>ENGINEERING AND ENVIRONMENTAL SERVICES</small> <small>SAINT LOUIS, MISSOURI</small>									

GRADATION CURVES

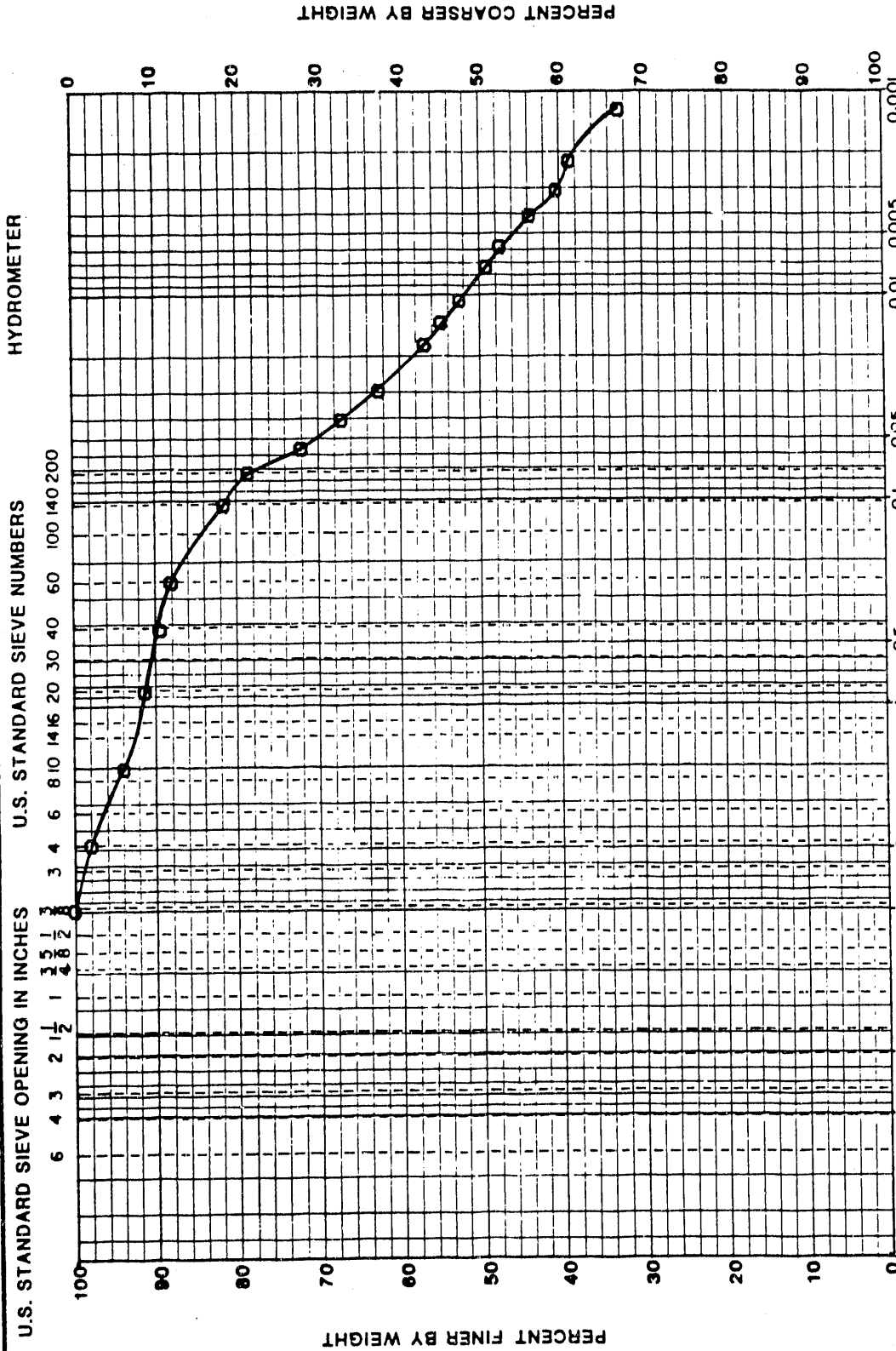


COBBLES		GRAVEL		SAND			SILT OR CLAY	
COARSE	FINE	COARSE	FINE	COARSE	MEDIUM	FINE		

SAMPLE NO.	EL. or DEPTH	CLASSIFICATION	NAT. WT. %	LL	PL	PI	PROJECT
ST-07	15-17.5	CH	41.5	74	24	50	WSSRAP
							BORING NO. GTD-3
							DATE 5-26-89



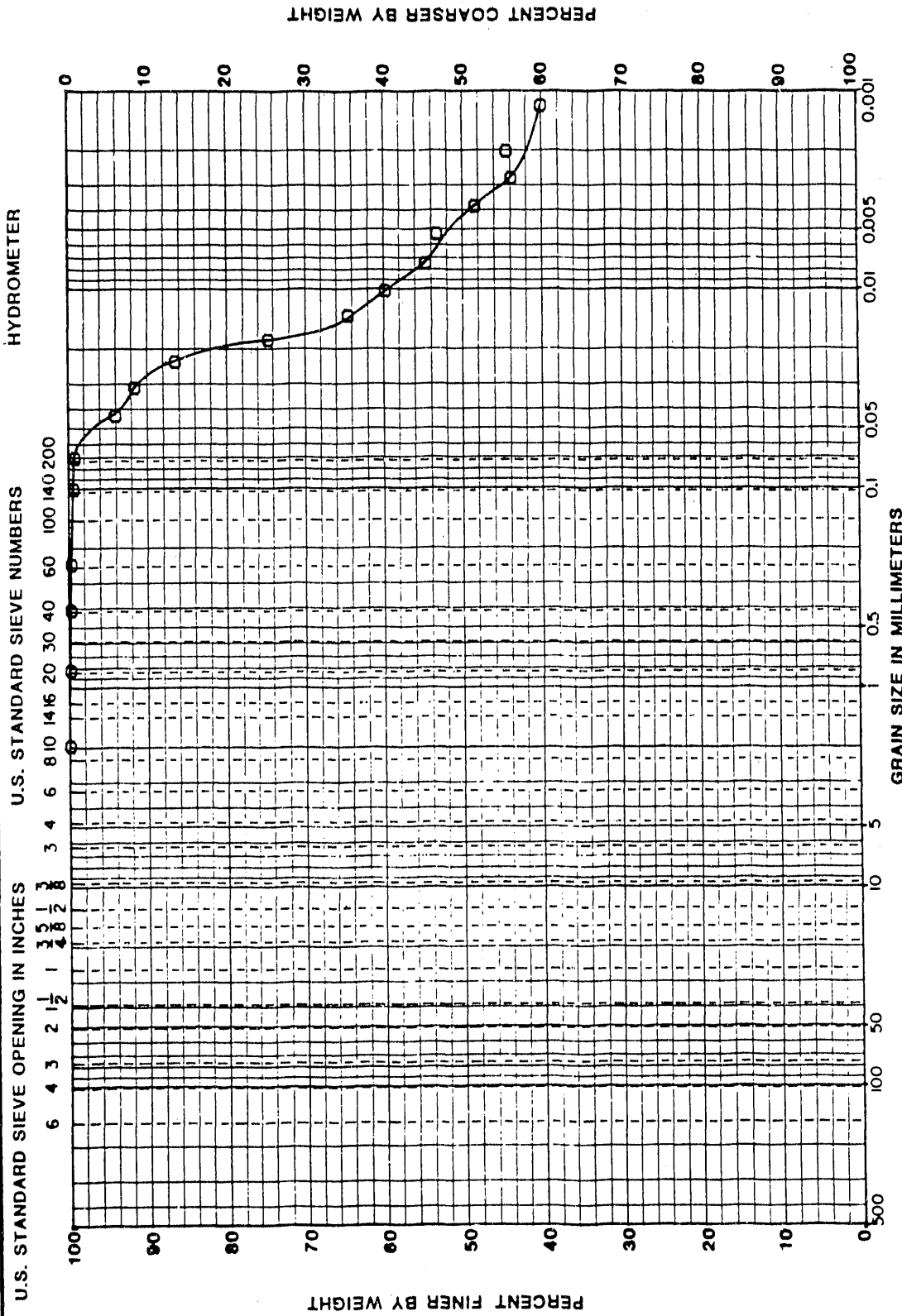
GRADATION CURVES



COBBLES		GRAVEL		SAND			SILT OR CLAY	
COARSE	FINE	COARSE	MEDIUM	FINE				

SAMPLE NO.	EL. or DEPTH	CLASSIFICATION	NAT. WT. %	LL	PL	PI	PROJECT
ST 08	20.0-22.0	CH	24.2	71	24	47	WSSRAP
			BORING NO.	GTO-3			
			DATE	9-29-89			
 GEOTECHNOLOGY <small>ENGINEERING AND ENVIRONMENTAL SERVICES</small> <small>SAMUELSON, MISSOURI</small>							

GRADATION CURVES

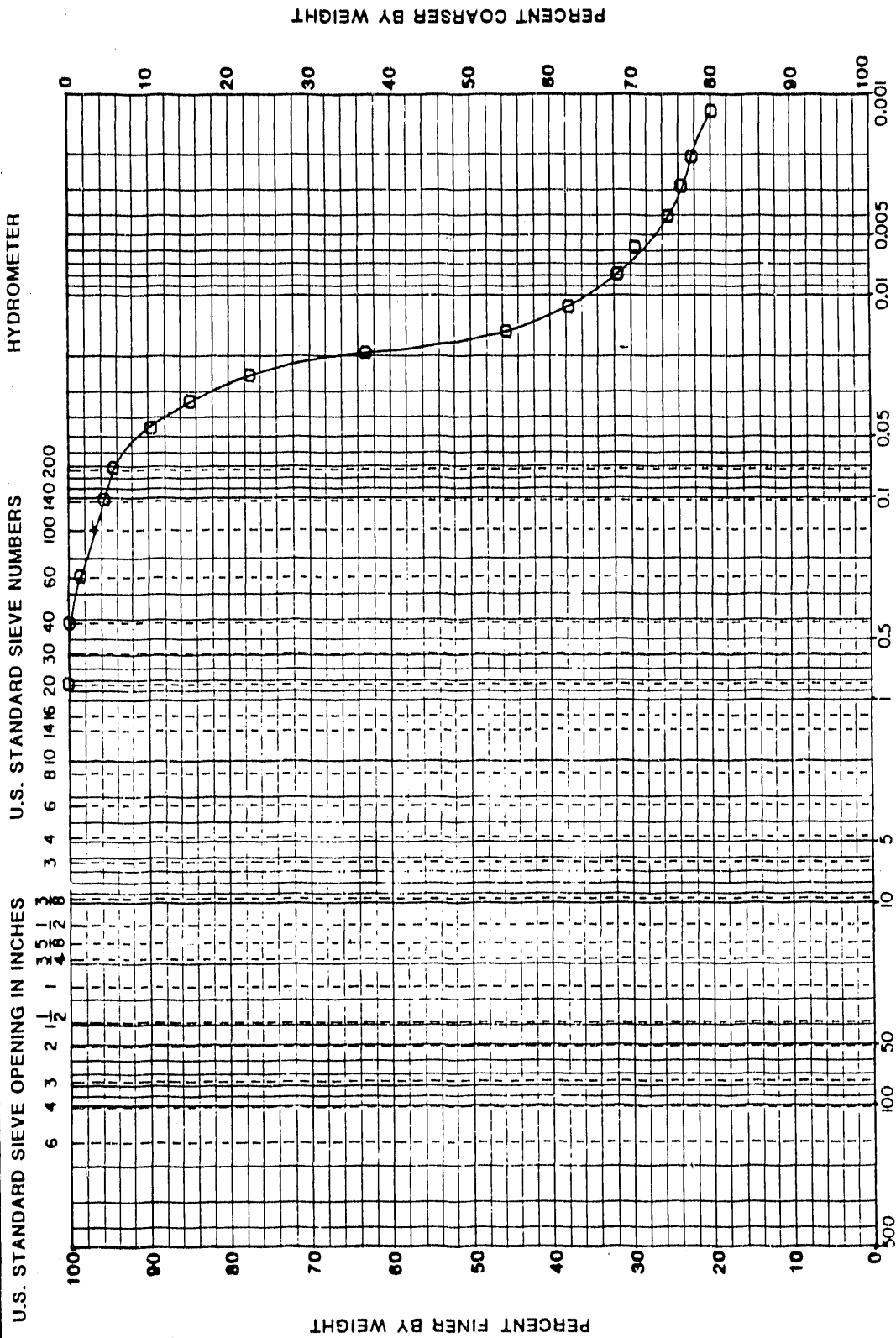


COBBLES GRAVEL SAND SILT OR CLAY
 COARSE FINE COARSE MEDIUM FINE

SAMPLE NO.	EL. or DEPTH	CLASSIFICATION	NAT. WT. %	LL	PL	PI	PROJECT
ST-06	15-17.5	CH	32.4	57	24	33	WSSRAP
							BORING NO. GTQ-4
							DATE 6-5-89



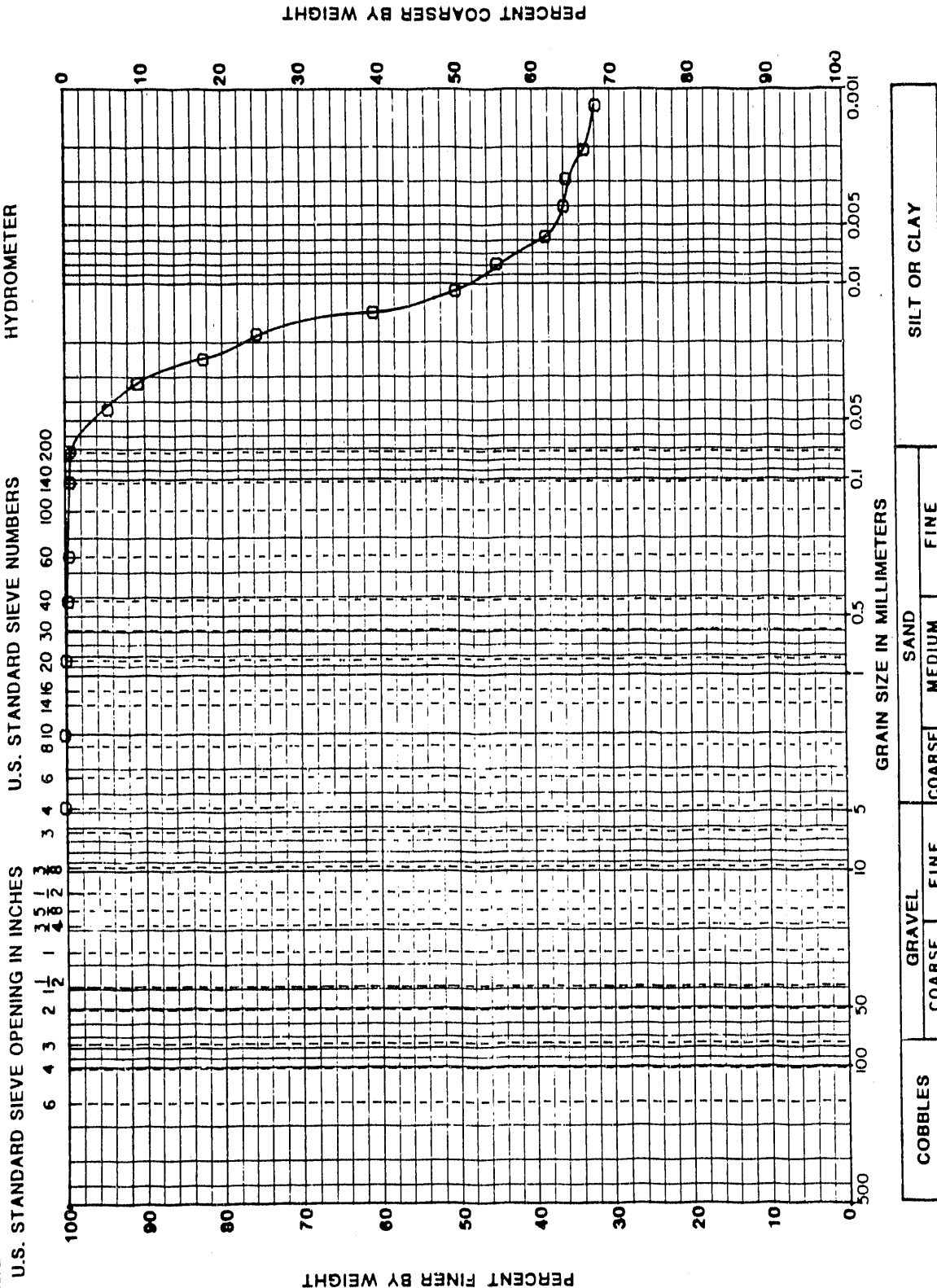
GRADATION CURVES



COBBLES		GRAVEL		SAND			SILT OR CLAY	
COARSE	FINE	COARSE	MEDIUM	FINE				

SAMPLE NO.	EL. or DEPTH	CLASSIFICATION	NAT. WT. %	LL	PL	PI	PROJECT
SS-15	45-46.5 ML		27.4				WSSRAP
							BORING NO. GTQ-4
							DATE 5-24-89
GEOTECHNOLOGY ENGINEERING AND ENVIRONMENTAL SERVICES SAINT LOUIS, MISSOURI							

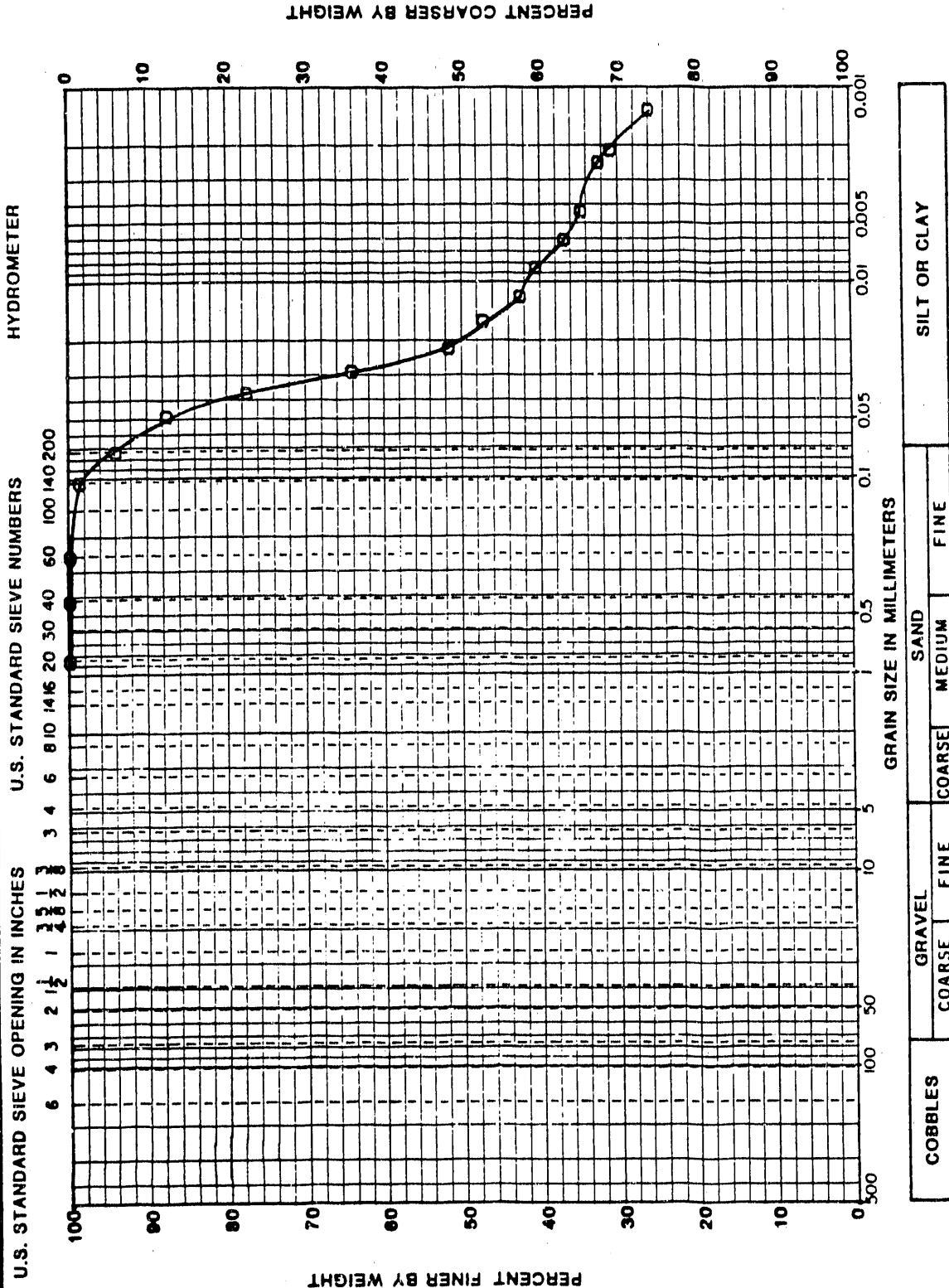
GRADATION CURVES



SAMPLE NO.	ST-02	EL. or DEPTH	5.0-7.5	CLASSIFICATION	CH	NAT. WT. %	13.6	LL	53	PL	25	PI	28	PROJECT	WSSRAP
														BORING NO.	GTQ-5
														DATE	6-2-89

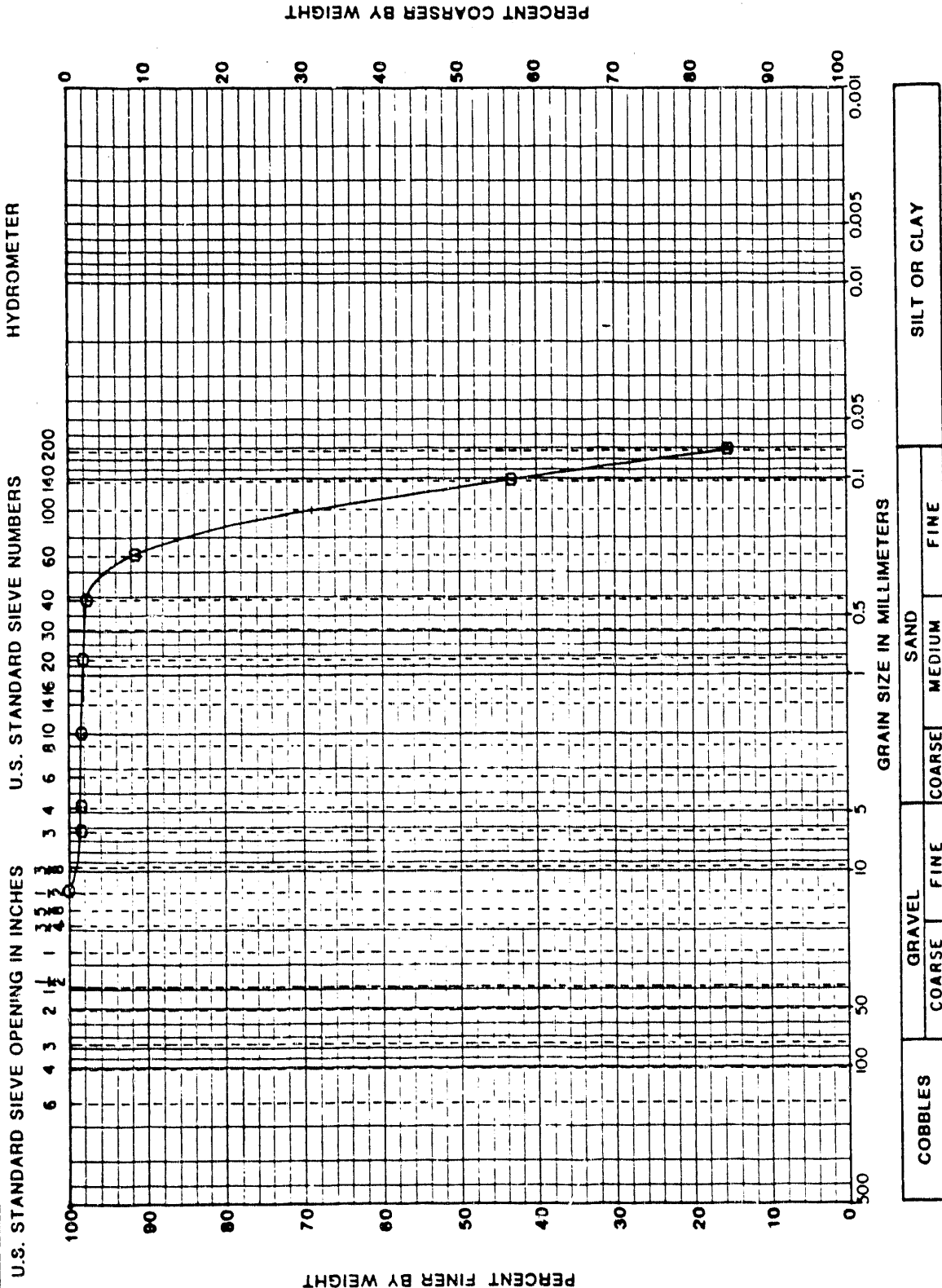


GRADATION CURVES



SAMPLE NO. ST 06	EL. or DEPTH	CLASSIFICATION	GRAVEL			SAND			SILT OR CLAY			PROJECT YSSRAP
			COARSE	FINE	COARSE	MEDIUM	FINE	PL	PI	PL	PI	
												BORING NO. GTD 5
												DATE 6-22-88
												 GEOTECHNOLOGY <small>ENGINEERING AND ENVIRONMENTAL SERVICES</small> <small>SANIT LOUIS MISSOURI</small>

GRADATION CURVES



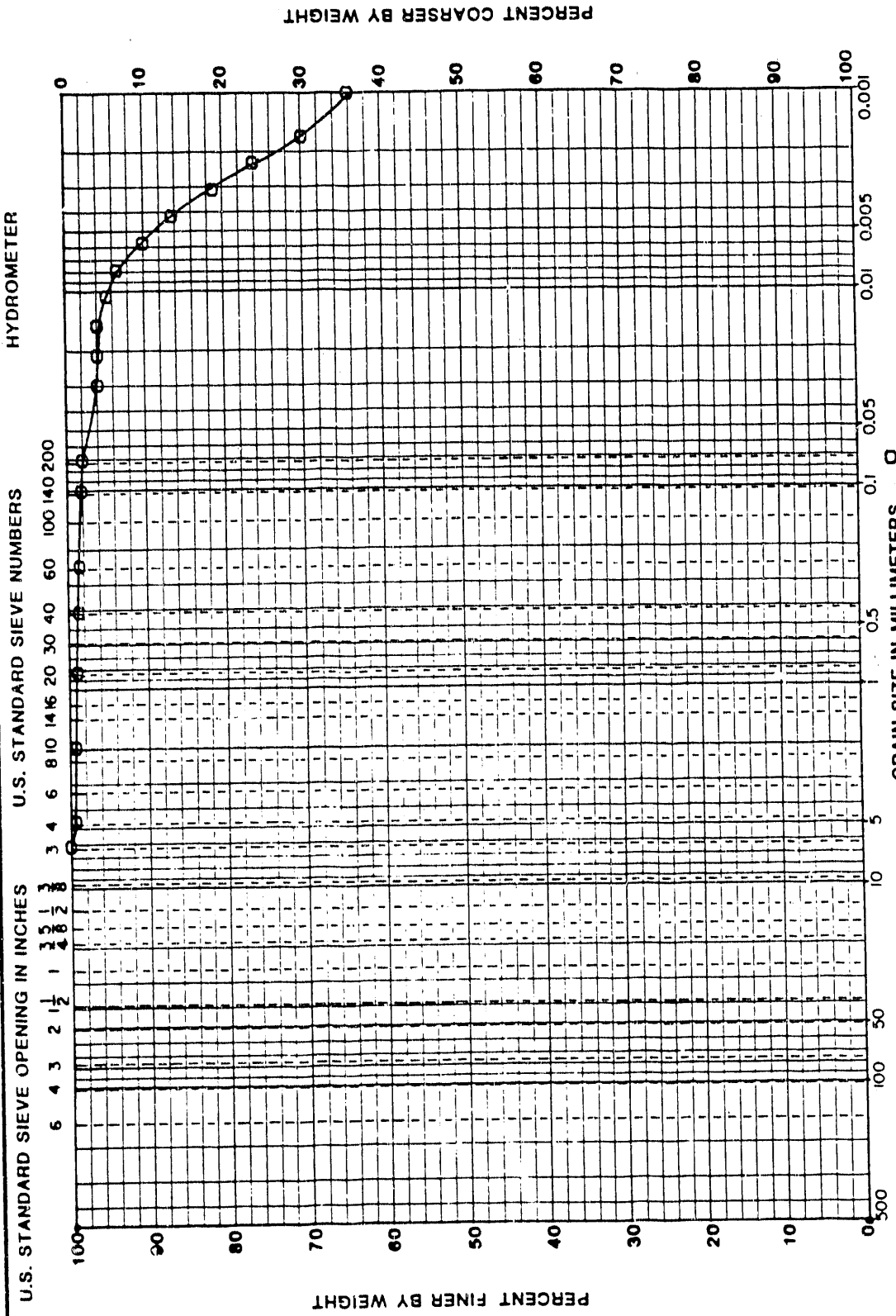
COBBLES GRAVEL SAND SILT OR CLAY

COARSE FINE COARSE MEDIUM FINE

SAMPLE NO.	EL. or DEPTH	CLASSIFICATION	NAT. WT. %	LL	PL	PI	PROJECT
SS-14	40-41.5	SM	26.3				WSSRAP
							BORING NO. GTQ-5
							DATE 5-22-89



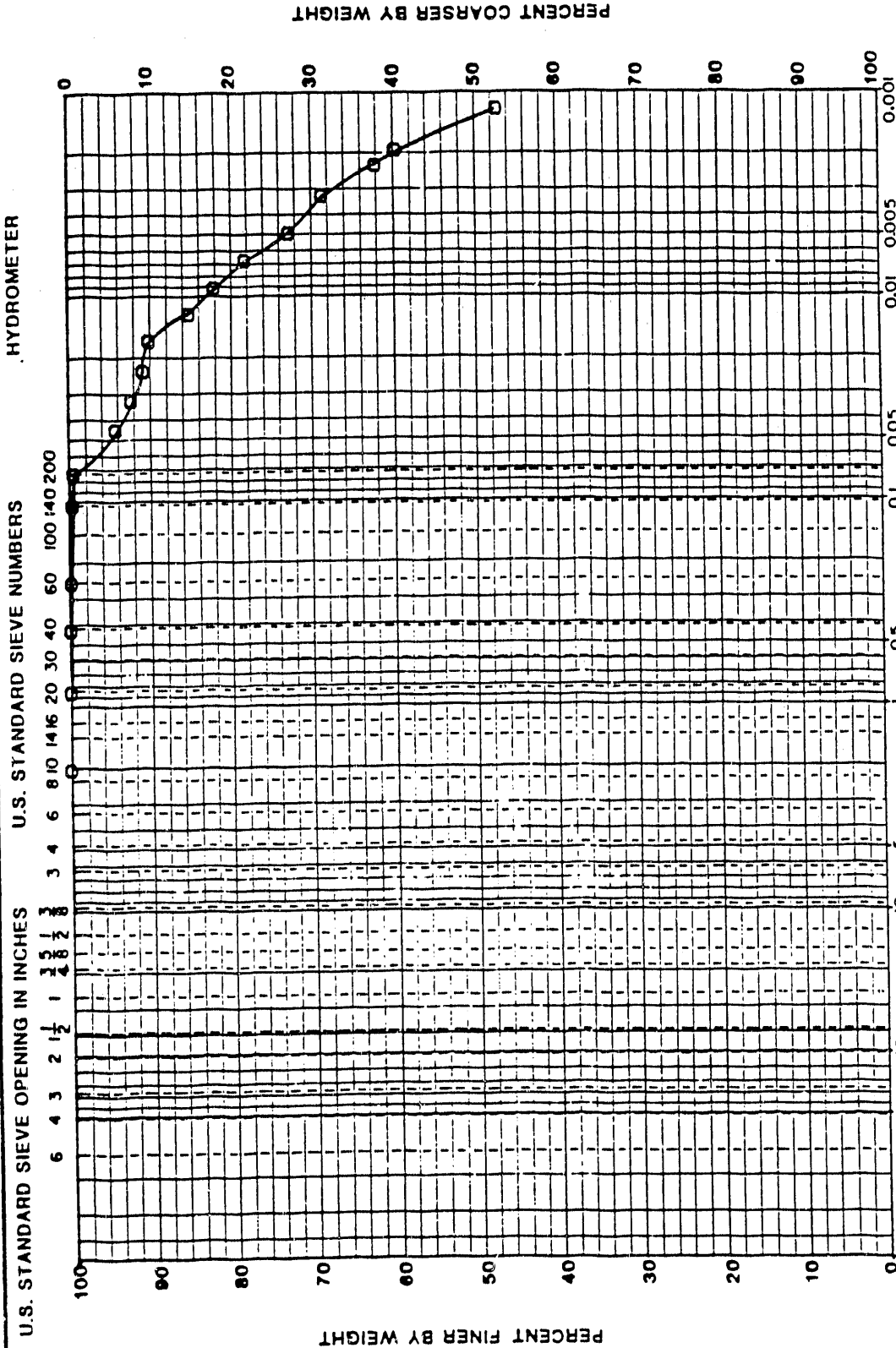
GRADATION CURVES




COBBLES	GRAVEL		SAND			SILT OR CLAY	
	COARSE	FINE	COARSE	MEDIUM	FINE		

SAMPLE NO.	EL. or DEPTH	CLASSIFICATION	NAT. WT. %	LL	PL	PI	PROJECT	
ST-02	5.0-7.5	CH	35.6	89	34	55	WSSRAP	
							BORING NO. GTQ-8	
							DATE 6-5-89	
							 GEOTECHNOLOGY <small>ENGINEERING AND ENVIRONMENTAL SERVICES</small> <small>SAFETI GROUP, INC.</small>	

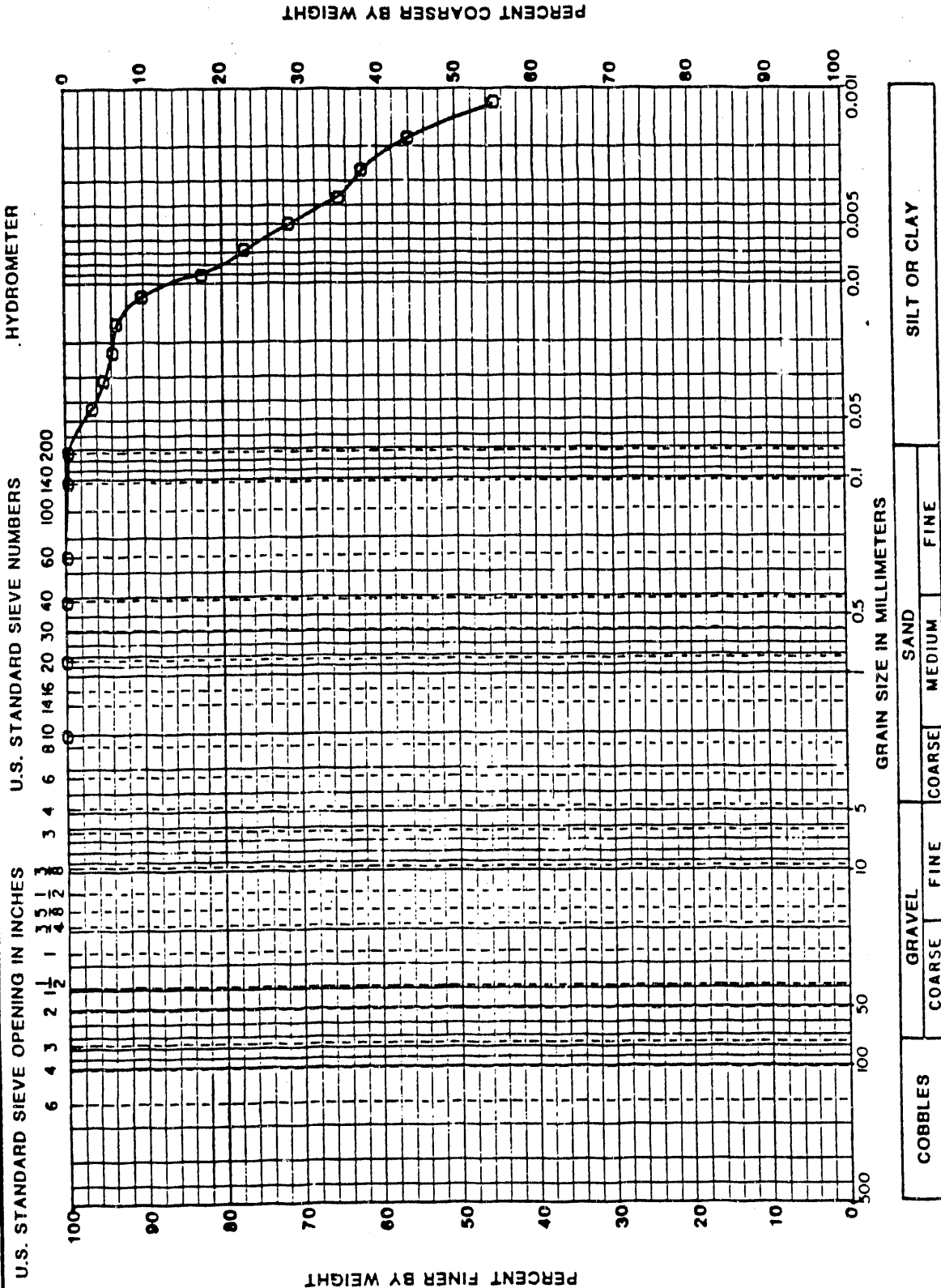
GRADATION CURVES



COBBLES		GRAVEL		SAND			SILT OR CLAY	
COARSE	FINE	COARSE	FINE	COARSE	MEDIUM	FINE		

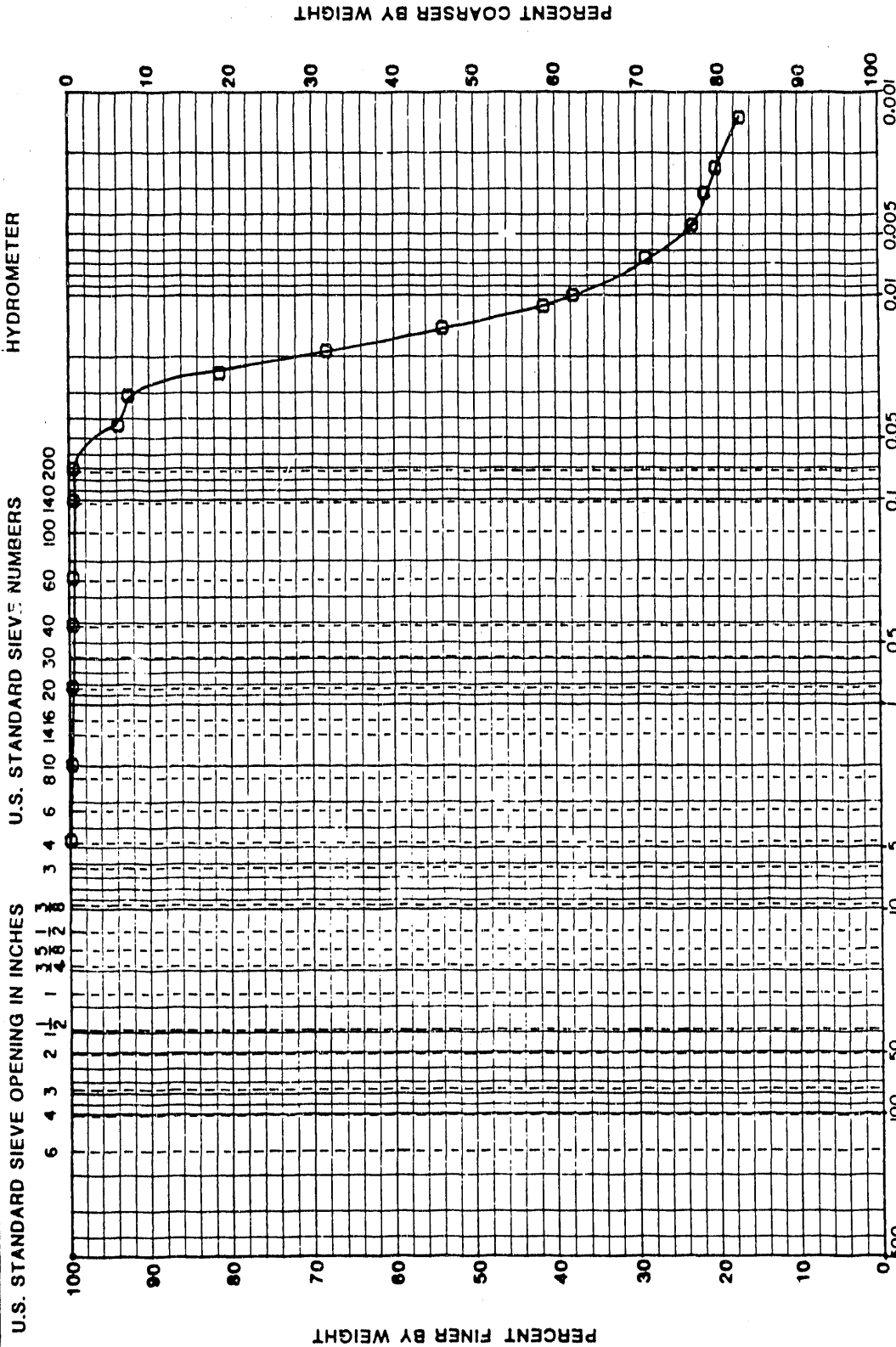
SAMPLE NO.	EL. or DEPTH	CLASSIFICATION	NAT. WT. %	LL	PL	PI	PROJECT
ST 07	22.5-25.0		37.2				WSSRAP
							BORING NO. GTQ-8
							DATE 6-22-89
 GEOTECHNOLOGY <small>ENGINEERING AND ENVIRONMENTAL SERVICES</small> <small>EST. 1965 INC. 50304</small>							

GRADATION CURVES



U.S. STANDARD SIEVE OPENING IN INCHES		U.S. STANDARD SIEVE NUMBERS		HYDROMETER	
6	4	3	4	6	8
10	20	40	60	100	200
150	10	5	2.5	1.25	0.625
75	60	30	15	7.5	3.75
37.5	20	10	4.75	2.36	1.18
15	10	5	2.5	1.25	0.625
7.5	6	3	1.5	0.75	0.375
3	4	2	0.85	0.425	0.2125
1.5	1	0.425	0.25	0.125	0.0625
0.75	0.425	0.25	0.15	0.075	0.0375
0.425	0.25	0.15	0.075	0.0375	0.01875
0.25	0.15	0.075	0.0375	0.01875	0.009375
0.15	0.075	0.0375	0.01875	0.009375	0.0046875
0.075	0.0375	0.01875	0.009375	0.0046875	0.00234375
0.0375	0.01875	0.009375	0.0046875	0.00234375	0.001171875
0.01875	0.009375	0.0046875	0.00234375	0.001171875	0.0005859375
0.009375	0.0046875	0.00234375	0.001171875	0.0005859375	0.00029296875
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GRADATION CURVES

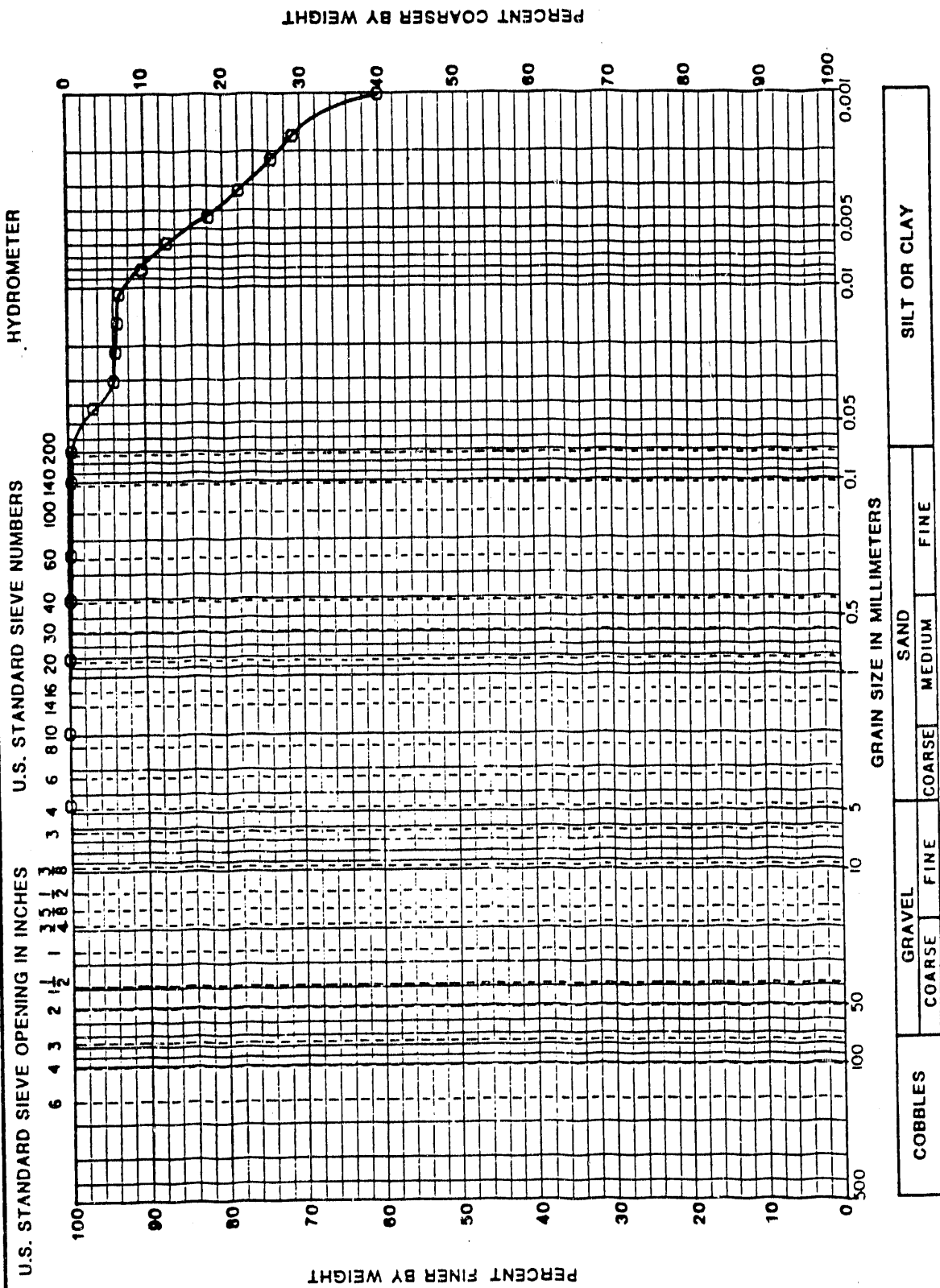


GRAVEL		SAND			SILT OR CLAY	
COARSE	FINE	COARSE	MEDIUM	FINE	PI	PL

SAMPLE NO.	EL. or DEPTH	CLASSIFICATION	NAT. WT. %	LL	PL	PI	PROJECT
ST-14	40-42.5	ML	31.6	36	31	5	WSSRAP
							BORING NO. GTQ-8
							DATE 6-5-89

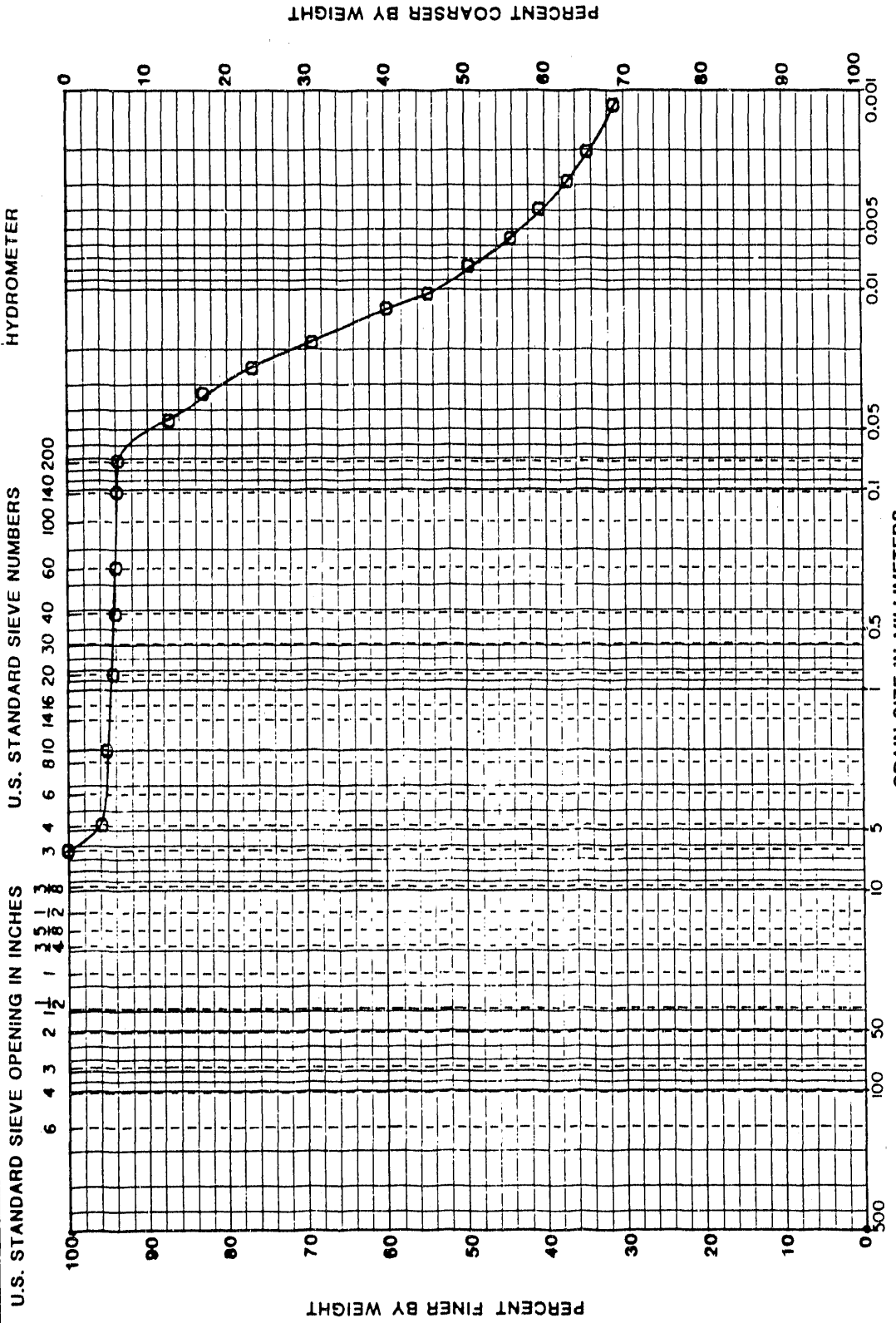


GRADATION CURVES



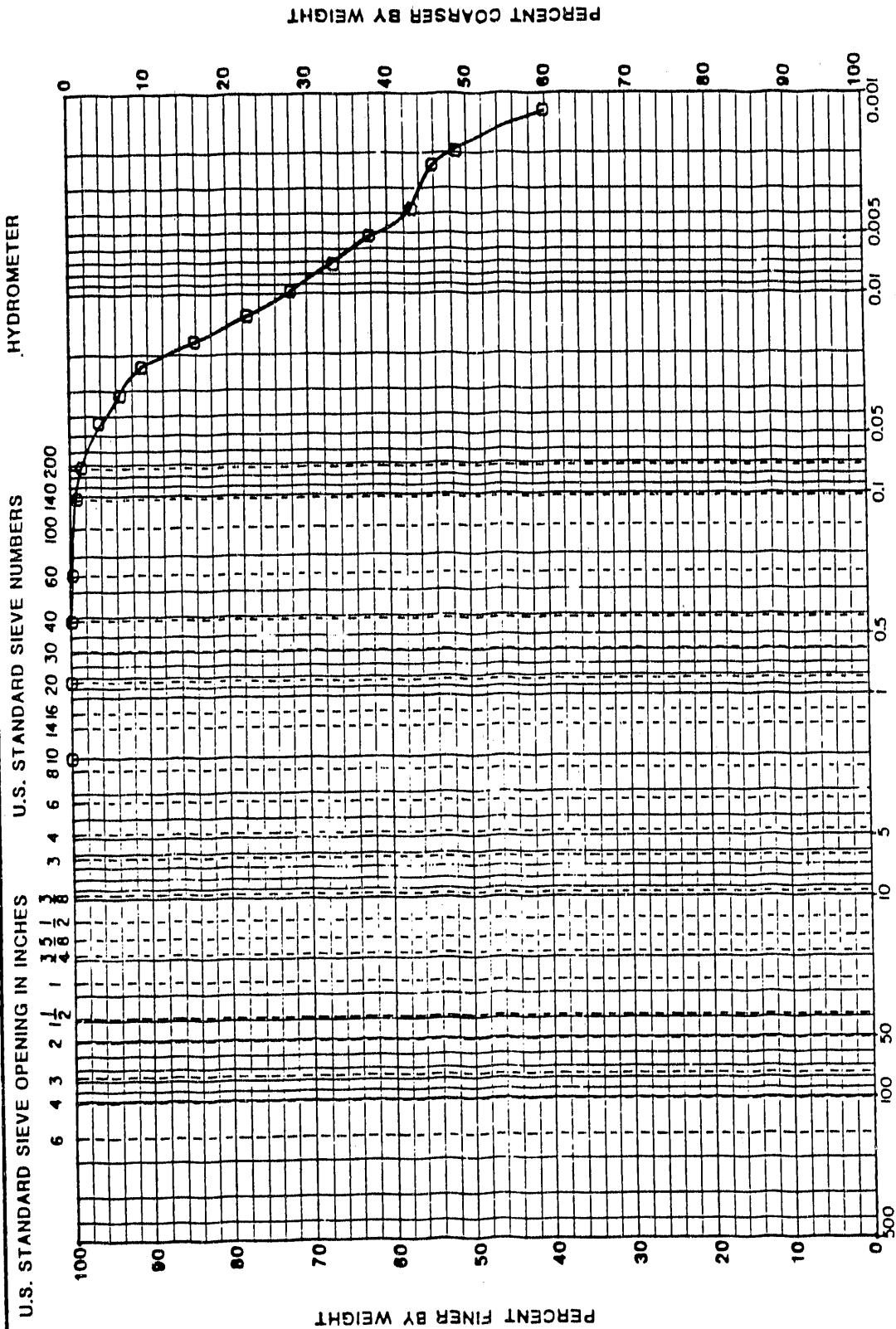
SAMPLE NO. ST-02	EL. OF DEPTH 5-7	CLASSIFICATION CH	NAT. WT. % 31.6	LL 84	PL 29	PI 55	PROJECT WSSRAP
							BORING NO. GTQ-9 DATE 6-9-89

GRADATION CURVES



SAMPLE NO.	EL. OF DEPTH	CLASSIFICATION	SAND			PI	PROJECT
			NAT. WT. %	LL	PL		
ST-06	15-17.5	CH	28.0	50	26	24	WSSRAP
							BORING NO. GTQ-9
							DATE 6-5-89
							 ENGINEERING AND ENVIRONMENTAL SERVICES SAINT LOUIS, MISSOURI

GRADATION CURVES



COBBLES		GRAVEL		SAND			SILT OR CLAY	
COARSE	FINE	COARSE	MEDIUM	FINE				

SAMPLE NO.	EL. or DEPTH	CLASSIFICATION	NAT. WT. %	LL	PL	PI	PROJECT
ST-11	30-32	CH	33.3	51	26	25	WSSRAP
							BORING NO. GTQ-10
							DATE 6-6-89



IN-SITU MOISTURE AND DENSITY DETERMINATION

SITE ID: Quarry Staging Area

CHECKED BY: LAB ADD

DATE: May 19, 1989

TAC _____

LAB NAME: Geotechnology, Inc

LOCATION ID	SAMPLE ID	DEPTH INTERVAL (FT)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
GTQ-3	ST07	^{Bottom} 15.0-17.5	40.4	79.2
GTQ-3	ST07	^{Middle} 15.0-17.5	31.2	NA
GTQ-3	ST07	^{Top} 15.0-17.5	50.8	NA
GTQ-5	ST12	^{Top} 30.0-32.5	43.8	NA
GTQ-5	ST12	^{Bottom} 30.0-32.5	25.2	NA
GTQ-3	ST03	^{Top} 5.0-7.5	30.5	NA
GTQ-3	ST03	^{Bottom} 5.0-7.5	30.1	93.0
GTQ-2	ST06	^{Top} 15.0-17.5	39.2	NA
GTQ-2	ST06	^{Bottom} 15.0-17.5	51.3	NA
GTQ-10	ST-16	^{Top} 55-57.5	32.6	89.2
GTQ-10	ST-16	^{Bottom} 55-57.5	28.5	94.1

TEST PROCEDURE: Moisture Content (ASTM D2216)
Dry Density (ASTM D2937)

IN-SITU MOISTURE AND DENSITY DETERMINATION

SITE ID: Quarry Staging Area

CHECKED BY: LAB RBD

DATE: June 12, 1989

TAC _____

LAB NAME: Geotechnology, Inc.

LOCATION ID	SAMPLE ID	DEPTH INTERVAL (FT)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
GTQ-1	ST-10	27.5-30.0	24.1	98.8
GTQ-5	ST-02	5.0-7.5	17.6	103.3
GTQ-5	ST-06	15.0-17.5	21.4	95.0
GTQ-8	ST-04	10.0-12.0	24.1	94.4
GTQ-8	ST-07	^{Top} 20.0-22.5	33.1	86.9
GTQ-8	ST-07	^{Bottom} 20.0-22.5	39.6	NA
GTQ-9	ST-02	^{Top} 5.0-7.0	38.4	NA
GTQ-9	ST-02	^{Middle} 5.0-7.0	28.4	93.1
GTQ-9	ST-02	^{Bottom} 5.0-7.0	32.1	NA
GTQ-10	ST-11	30.0-32.0	29.9	90.7

TEST PROCEDURE: Dry Density (ASTM D2937)
Moisture Content (ASTM D2216)

IN-SITU MOISTURE AND DENSITY DETERMINATION

SITE ID: Quarry Staging Area

CHECKED BY: LAB 44

DATE: 8-8-89

TAC: _____

LAB NAME: Geotechnology

LOCATION ID	SAMPLE ID	DEPTH INTERVAL (FT)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
GTQ-1	ST04	Middle 12.5 - 15	43.6	75.8
GTQ-1	ST04	TOP 12.5 - 15	20.2	N/A
GTQ-1	ST04	Bottom 12.5 - 15	29.6	N/A
GTQ-1	ST10	Middle 27.5 - 30	26.3	96.7
GTQ-1	ST10	TOP 27.5 - 30	20.3	N/A
GTQ-1	ST10	Bottom 27.5 - 30	25.9	N/A
GTQ-8	ST14	Middle 40 - 42.5	31.3	90.3
GTQ-8	ST14	TOP 40 - 42.5	38.8	N/A
GTQ-8	ST-14	Bottom 40 - 42.5	33.3	N/A
GTQ-8	ST-16	55 - 57.5	38.8	N/A
GTQ 9	ST06	15 - 17.5	29.4	88.3
GTQ 10	ST03	TOP 15 - 17.5	32.2	N/A
GTQ 10	ST03	Bottom 15 - 17.5	32.1	N/A
GTQ 10	ST03	15 - 17.5	28.9	92.9

TEST PROCEDURE: _____

Request #1

IN-SITU MOISTURE AND DENSITY DETERMINATION

SITE ID: WJRP

CHECKED BY: LAB 44

DATE: 10-19-89

TAC _____

LAB NAME: GEOTECHNOLOGY INC

LOCATION ID	SAMPLE ID	DEPTH INTERVAL (FT)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
G70-1	ST04	12.5 - 12	36.8	82.1
G70-1	ST15	45 - 47.5	35.9	85.3
G70-4	ST-12	30 - 32.5	50.3	71.8
G70-4	ST-16	50 - 52.5	43.4	75.7
G70-5	ST06	15 - 17.5	26.9	93.4
G70-8	ST09	TOP 25 - 27.5	34.8	N/A
G70-8	ST09	MIDDLE 25 - 27.5	22.8	94.5
G70-8	ST09	BOTTOM 25 - 27.5	35.2	N/A
G70-8	ST16	55 - 57.5	31.5	87.1
G70-9	ST-06	TOP 15 - 17.5	17.8	N/A
G70-9	ST06	Bottom 15 - 17.5	24.4	N/A
G70-10	ST-11	30 - 32.5	29.9	93.0
G70-3	ST03	TOP 20 - 22.5	51.2	N/A
G70-3	ST03	MIDDLE 20 - 22.5	29.0	103.9
G70-3	ST03	bottom 20 - 22.5	37.0	N/A

TEST PROCEDURE: AJTM D 2216

Request # 1

Job # 3589-1002 3445



MK-FERGUSON

A MONRISSON KNUDSEN COMPANY

IN-SITU MOISTURE AND DENSITY DETERMINATION

SITE ID: QUARRY STAGING AREA

CHECKED BY: LAB 44

DATE: 12-19-89

TAC _____

LAB NAME: Geotechnology Inc

LOCATION ID	SAMPLE ID	DEPTH INTERVAL (FT)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
G7Q-1	ST02	7.5-10	22.1	93.73
G7Q-1	ST08	22.5-25.0	29.5	91.0
G7Q-1	ST-10	27.5-30.0	24.1	95.5
G7Q-1	ST-15	45-47.5	35.7	85.3
G7Q-4	ST-06	15-17.5	23.5	98.2 ✓
G7Q-4	ST-12	30-32.5	50.3	71.8 ✓
G7Q-4	ST-16	50-52.5	43.4	75.7 ✓
G7Q-5	ST-04	10-12.5	^{TOP} 17.6	103.3
G7Q-5	ST-04	5-12.5	^{MIDDLE} 23.4	105.5 ✓
G7Q-5	ST-04	10-12.5	^{BOT} 13.4	101.6 ✓
G7Q-8	ST02	5.0-7.0	32.3	88.6
G7Q-8	ST04	10-12.0	24.1	94.4 *
G7Q-8	ST16	55.0-57.5	38.8	82.0 *
G7Q-10	ST05	15-17.5	^{TOP} 27.7	91.1
G7Q-10	ST05	15-17.5	^{MIDDLE} 29.9	92.9 ✓

TEST PROCEDURE: _____

Request # 5 of 517190



MK-FERGUSON
A MORRISON KNUDSEN COMPANY

This summary has
been submitted
earlier. Page 0-66

P.O # 3509-1002-3445

IN-SITU MOISTURE AND DENSITY DETERMINATION

SITE ID: WJRAP

CHECKED BY: LAB 47

DATE: 6-5-90

TAC: _____

LAB NAME: Geotechnical

LOCATION ID	SAMPLE ID	DEPTH INTERVAL (FT)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
GTO-1	SS-03	10-11.5	23.7	N/A
GTO-1	SS-05	15-16.5	38.0	N/A
GTO-4	SS-05	12.5-14.0	27.8	N/A
GTO-4	SS-07	17.5-19.0	27.8	N/A
GTO-5	SS-05	12.5-14.0	34.6	N/A
GTO-5	SS-07	17.5-19.0	23.4	N/A
GTO-8	ST-05	TOP 15-17.0	31.4	N/A
GTO-8	ST-05	MIDDLE 15-17.0	33.7	N/A
GTO-8	ST-05	BOTTOM 15-17.0	25.9	N/A
GTO-10	ST-09	TOP 25-27.5	28.5	N/A
GTO-10	ST-09	BOTTOM 25-27.5	25.6	N/A

TEST PROCEDURE: Moisture Content (ASTM D2216)

Form # 5 of 5/7/90



MK-FERGUSON

A MORRISON KNUDSEN COMPANY

P.O. # 3509-1002-3445

IN-SITU MOISTURE AND DENSITY DETERMINATION

SITE ID: WUEA?

CHECKED BY: LAB 44

DATE: 6-5-90

TAC _____

LAB NAME: Geotechnical

LOCATION ID	SAMPLE ID	DEPTH INTERVAL (FT)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
G70-1	SS-03	10-11.5	23.7	N/A
G70-1	SS-05	15-16.5	38.0	N/A
G70-4	SS-05	12.5-14.0	27.8	N/A
G70-4	SS-07	17.5-19.0	27.8	N/A
G70-5	SS-05	12.5-14.0	34.6	N/A
G70-5	SS-07	17.5-19.0	23.4	N/A
G70-8	ST-05	TOP 15-17.0	31.4	N/A
✓ G70-8	ST-05	MIDDLE 15-17.0	33.7	N/A
✓ G70-8	ST-05	BOTTOM 15-17.0	25.9	N/A
✓ G70-10	ST-09	TOP 25-27.5	28.5	N/A
✓ G70-10	ST-09	BOTTOM 25-27.5	25.6	N/A

TEST PROCEDURE: Moisture Content (ASTM D2216)



MK-FERGUSON

A MORRISON KNUDSEN COMPANY

PHYSICAL PROPERTY TEST RESULTS

SITE ID: Quarry Steeping Area

LOCATION ID: _____

DATE: June 1st, 1989

CHECKED BY: LAB ML

LAB NAME: Geotechnology, Inc.

TAC _____

SAMPLE ID	DEPTH INTERVAL (FT)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	SPECIFIC GRAVITY	SOIL CLASSIFICATION
GTQ-2 ST-06	15-17.5	79	27	52	NA	CH
GTQ-3 ST-03	5-7.5	51	20	31	NA	CH
GTQ-3 ST-07	15-17.5	74	24	50	NA	CH
GTQ-5 ST-04	10-12.5	89	39	50	NA	CH
GTQ-5 ST-02	5-7.5	35	24	11	NA	CL
GTQ-9 SS-11	27-29	30	15	15	NA	CL

TEST PROCEDURE: Soil Classification (ASTM D2487)
American



PHYSICAL PROPERTY TEST RESULTS

SITE ID: Quarry Staging Area

LOCATION ID: _____

DATE: June 12, 1989

CHECKED BY: LAB RBD

LAB NAME: Geotechnology, Inc

TAC _____

SAMPLE ID	DEPTH INTERVAL (FT)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	SPECIFIC GRAVITY	SOIL CLASSIFICATION
GTQ-1 ST-08	22.5-25.0	24	19	5	NA	CL-ML
GTQ-4 ST-06	15.0-17.5	57	24	33	NA	CH
GTQ-5 ST-02	5.0-7.5	53	25	28	NA	CH
GTQ-8 ST-02	5.0-7.5	89	34	55	NA	CH
GTQ-8 ST-14	40.0-42.5	36	31	5	NA	ML
GTQ-9 ST-06	15.0-17.5	50	26	24	NA	CH
GT-2T 79 BV-01A	1.0-6.5	49	23	26	NA	CL
GT-2T 82 BV-01A	0.5-3.5	42	19	23	NA	CL

TEST PROCEDURE: _____

PHYSICAL PROPERTY TEST RESULTS

SITE ID: Disposal Cell
 DATE: June 16, 1989
 LAB NAME: Geotechnology, Inc.

LOCATION ID: _____
 CHECKED BY: LAB ML
 TAC: _____

SAMPLE ID	DEPTH INTERVAL (FT)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	SPECIFIC GRAVITY	SOIL CLASSIFICATION
GT-Q8 ST-4	10-12	56	24	32		CH
GT-Q9 ST-02	5-7	84	29	55		CH
GT-Q10 ST-11	30-32	51	26	25		CH
GT-Q1 ST-04	12.5-15	63	28	35		CH
GT-2T-72 BU-01A	7.5-10.5	27	21	6		CL
GT-2T-78 BU-01A	4.0-6.5	28	18	10		CL
GT-2T-74 BU-01A	4.0-8.5	42	18	24		CL
GT-2T-75 BU-01A	4-8.5	39	22	17		CL
GT-2T-80 BU-01A	0.5-8	38	20	18		CL

TEST PROCEDURE: ASTM D 4318



MK-FERGUSON

A MORRISON KNUDSEN COMPANY

PHYSICAL PROPERTY TEST RESULTS

SITE ID: Borrow Source No. 1

LOCATION ID: _____

DATE: 6-27-89

CHECKED BY: LAB ML

LAB NAME: Geotechnology Inc.

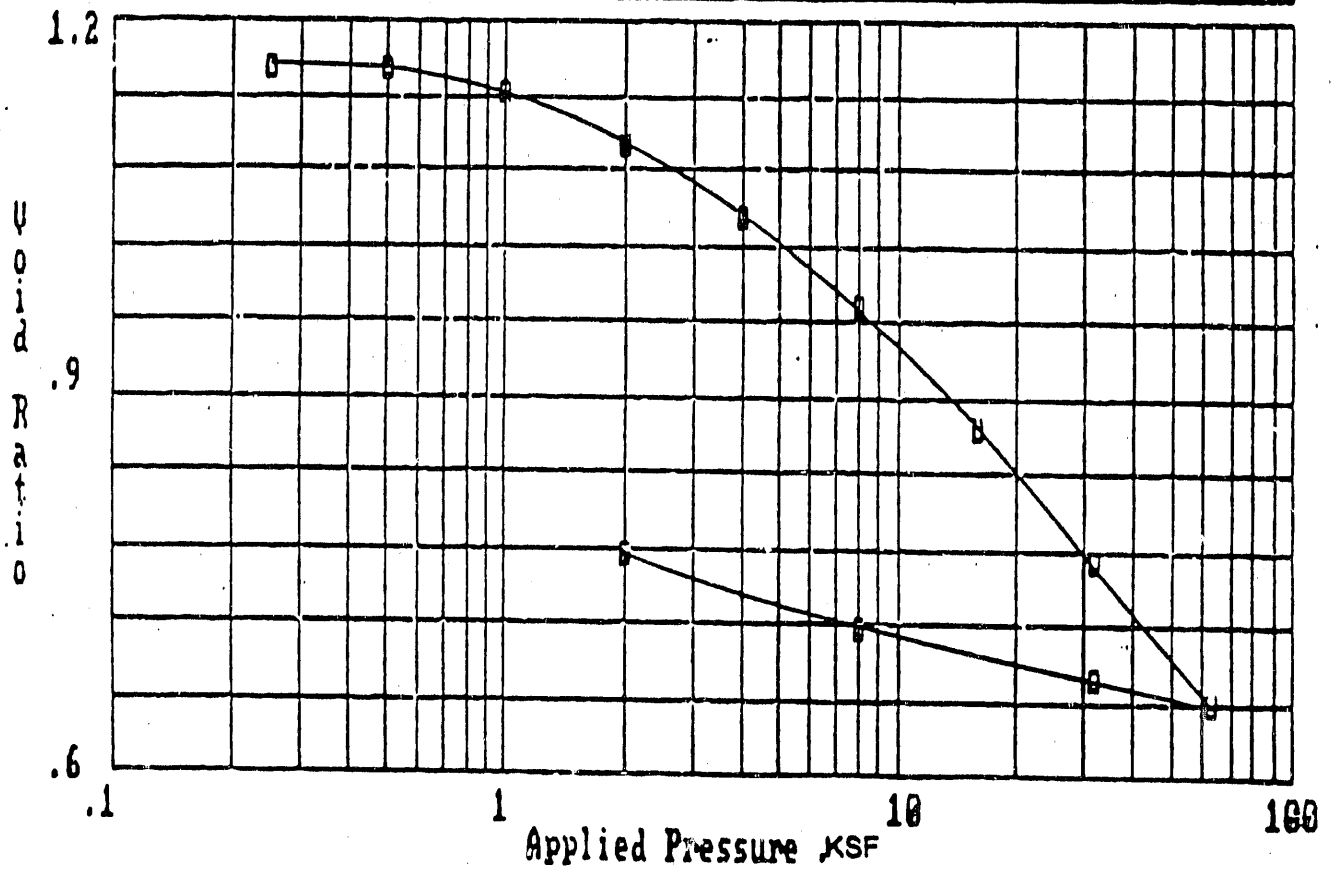
TAC _____

SAMPLE ID	DEPTH INTERVAL (FT)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	SPECIFIC GRAVITY	SOIL CLASSIFICATION
TPBS-15 1A	2.4-10.8	41	32	9		ML
TPBS-15 2A	10.8-12.9	71	21	50		CH
TPBS-23 1A	0.7-13.1	37	16	21		CL
TPBS-28 1A	0.7-9.9	38	19	19		CL
TPBS-30 1A	1.8-12.4	37	25	12		ML
GTQ-5 ST 06	15.0-17.5	79	24	55		CH
TPBS-10 3A	10.9-13.4	61	18	43		CH

TEST PROCEDURE: ASTM D 4318

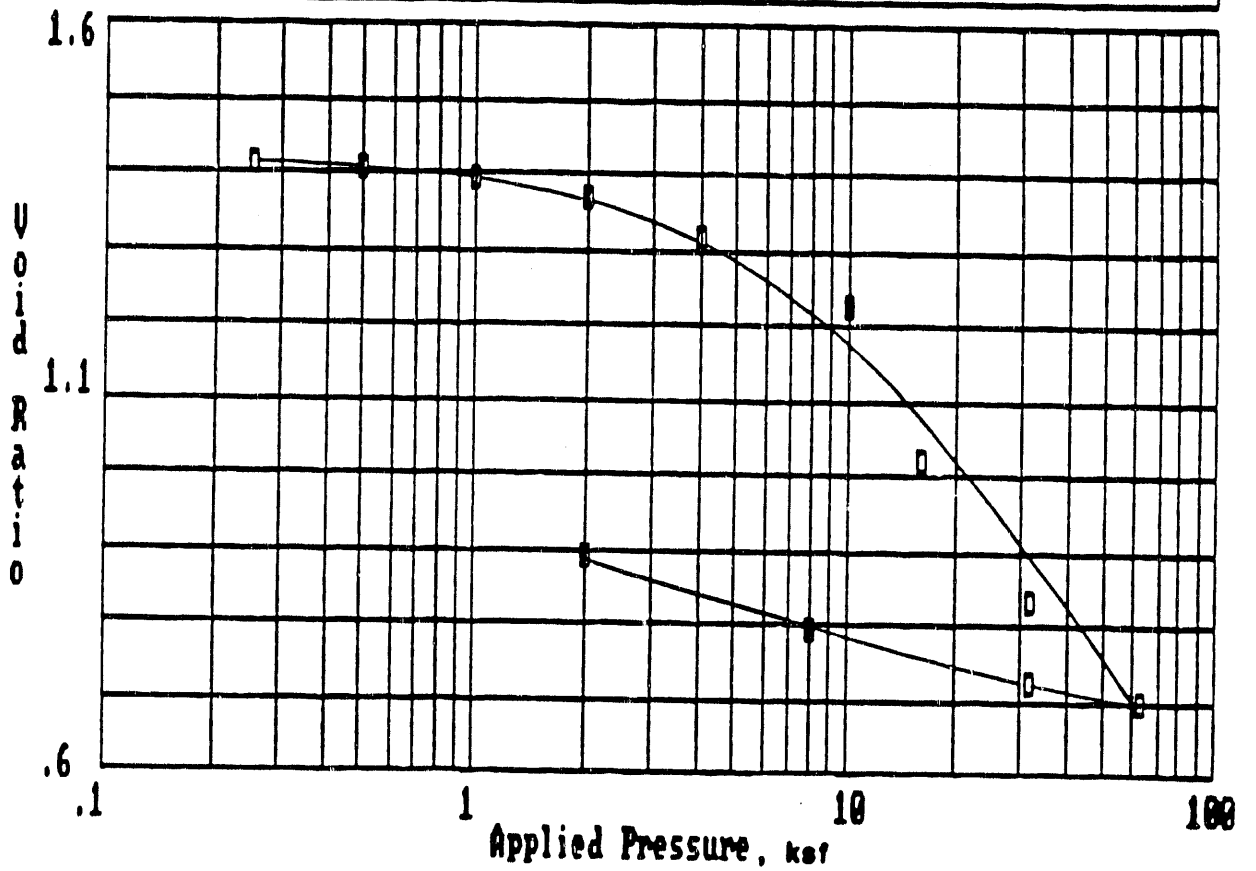
CONSOLIDATION TEST DATA

Boring No. = GTQ-1	Depth = 12.5-15	Number = ST04
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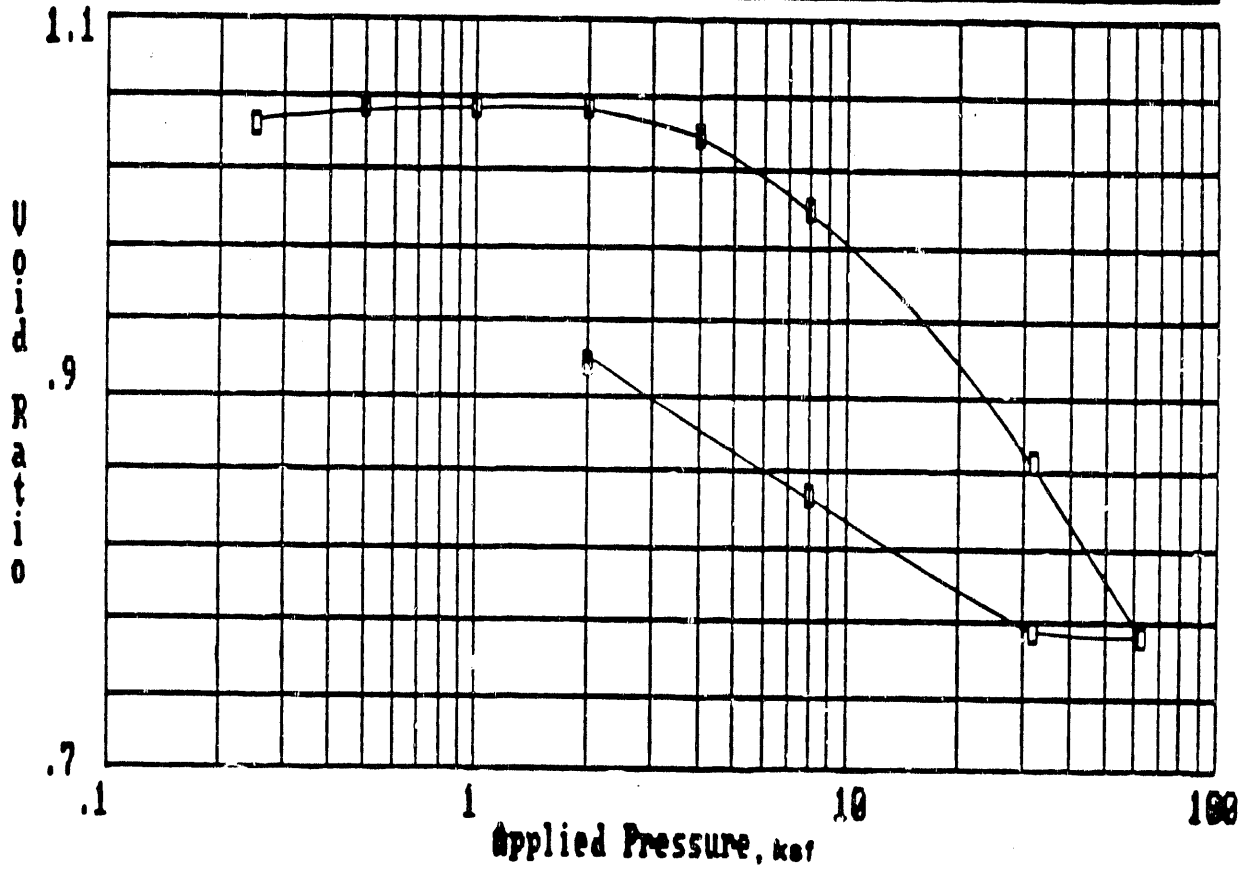
CONSOLIDATION TEST DATA

Boring No. = GTQ-3	Depth = 15-17.5	Number = ST-7
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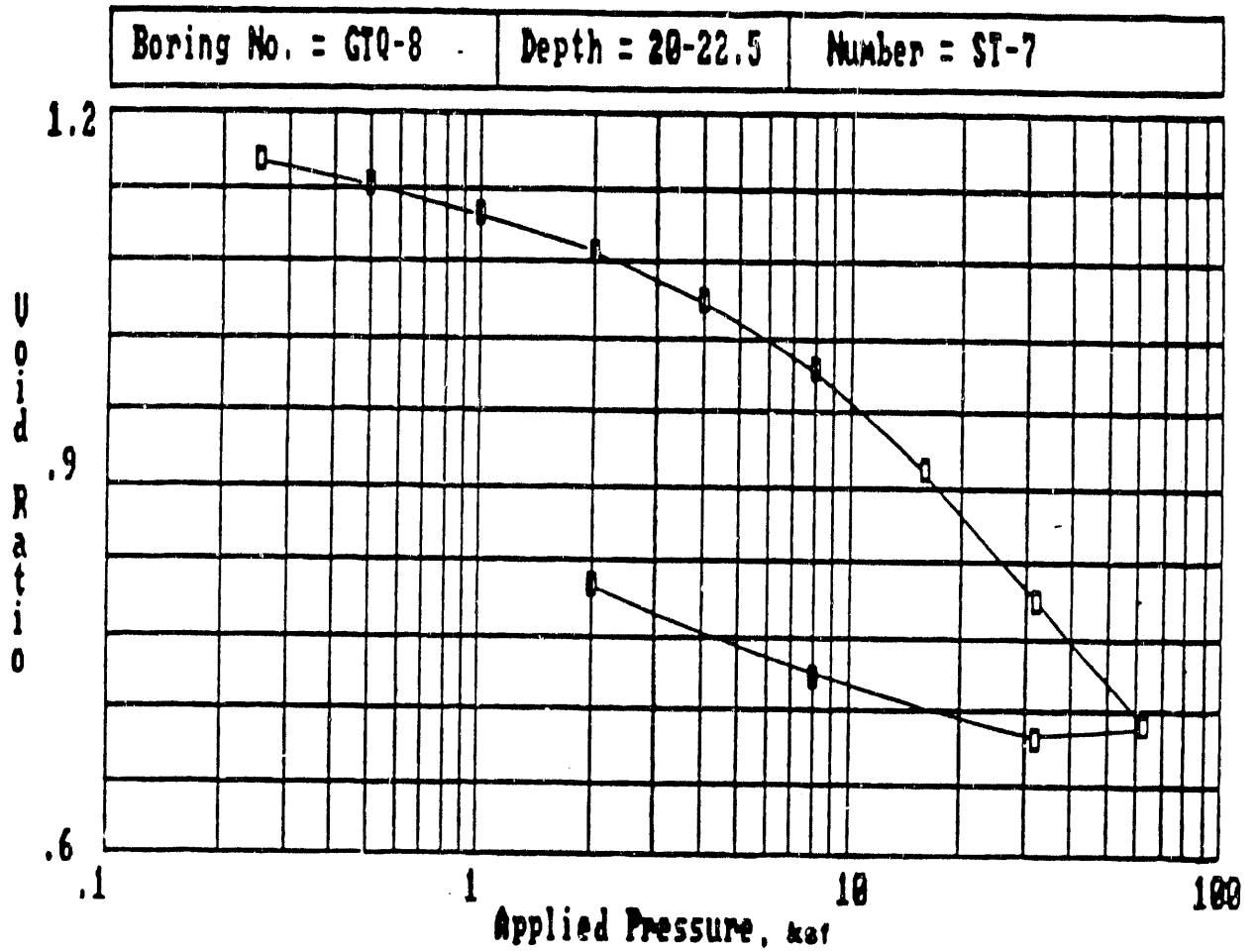


CONSOLIDATION TEST DATA

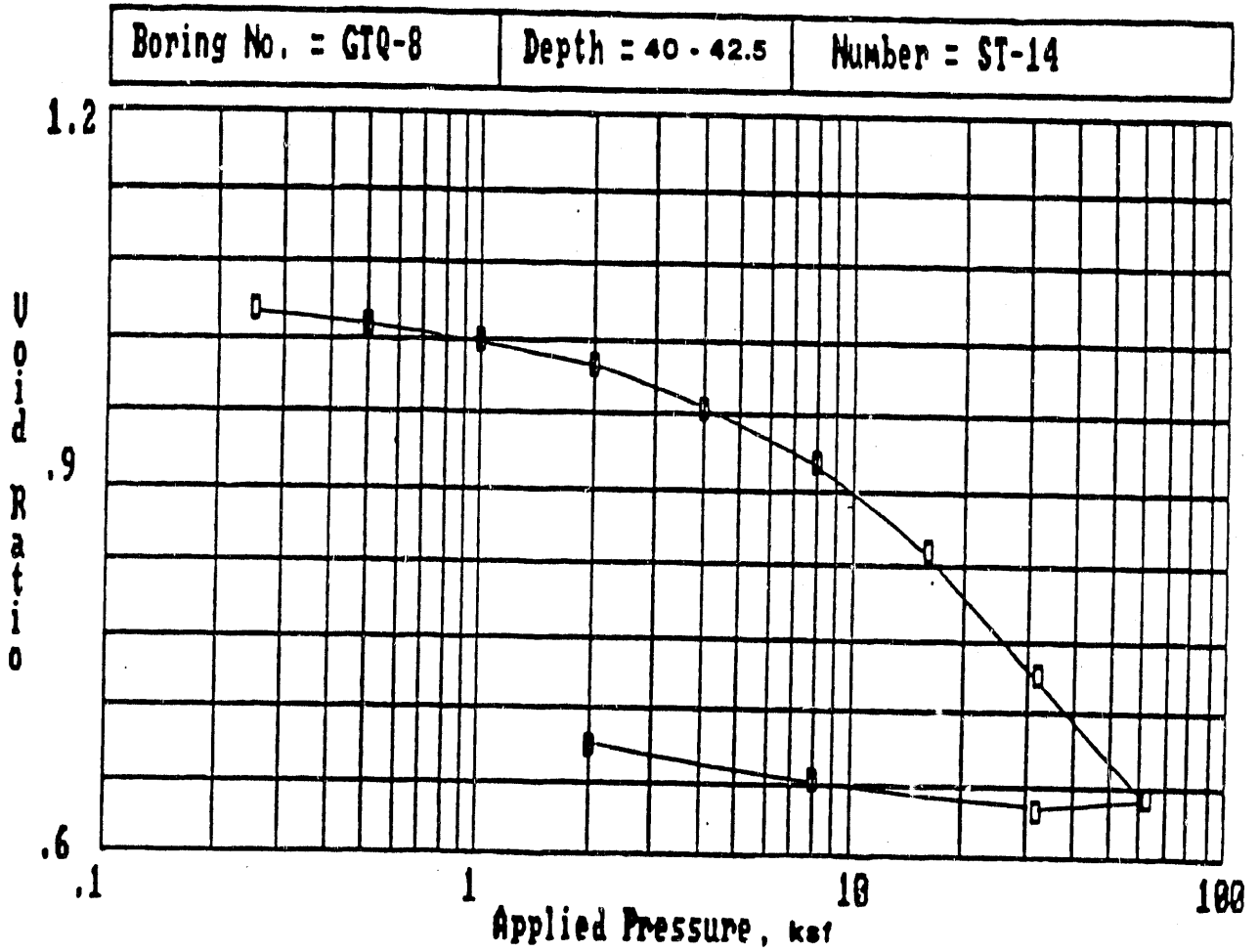
Boring No. = GTQ-8	Depth = 5-7	Number = ST-02
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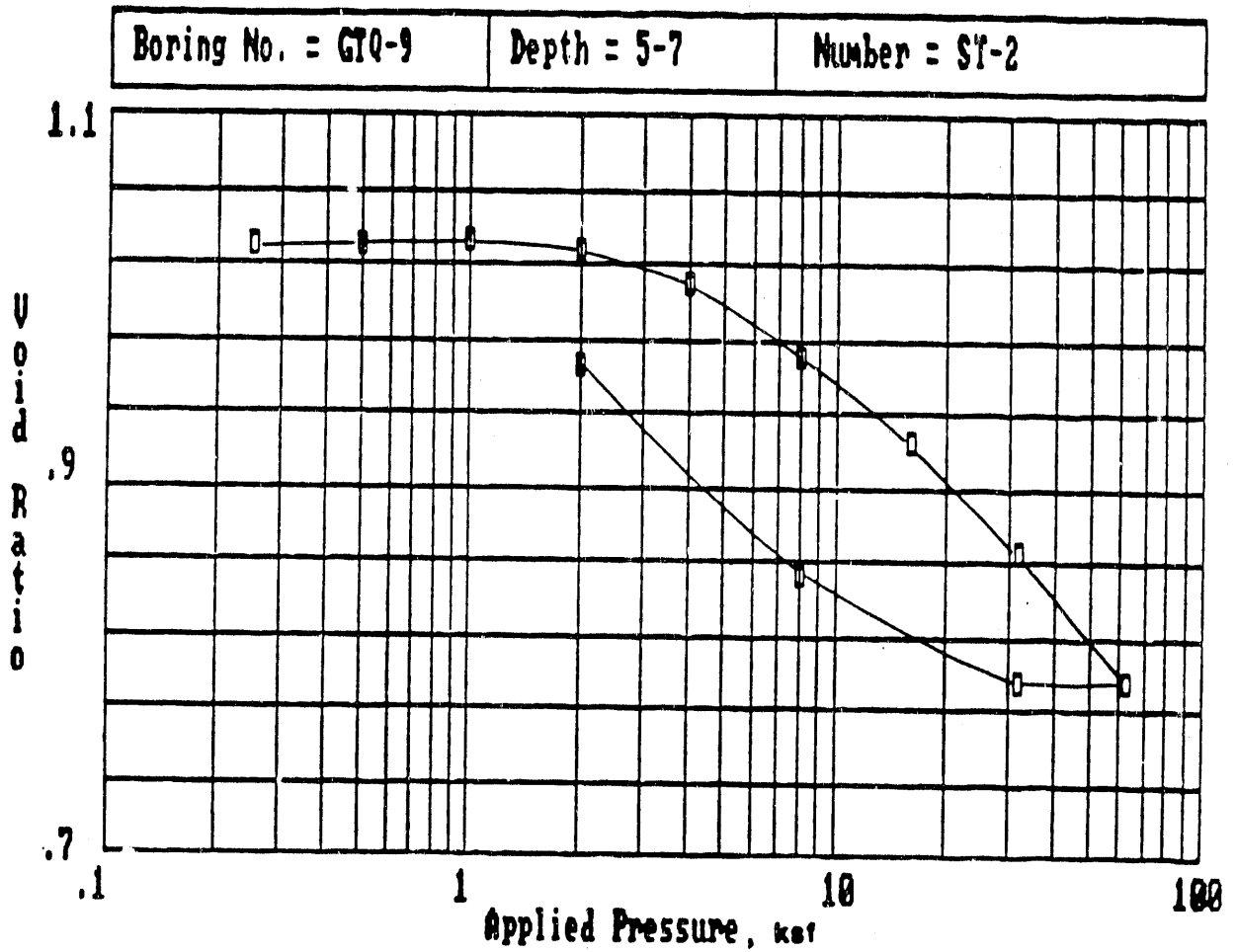
CONSOLIDATION TEST DATA



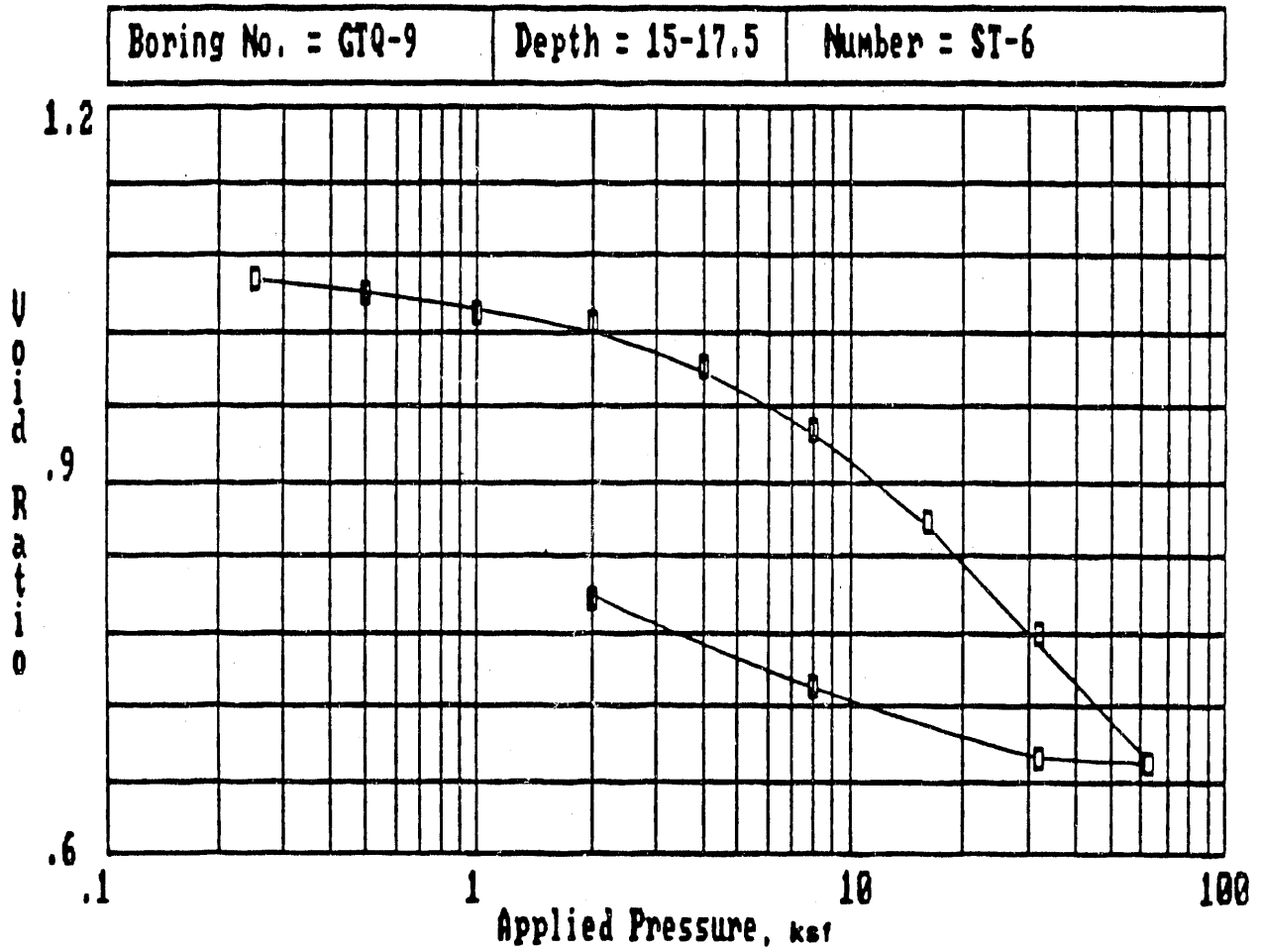
CONSOLIDATION TEST DATA



CONSOLIDATION TEST DATA



CONSOLIDATION TEST DATA



Job # 11295.001

Date: 5-11-90

SPECIFICATIONS

STANDARD PROCTOR

MSHD T 99-70, ASTM D 690-70

(Method A)

MAX DRY DENSITY (PCF)	WATER CONTENT %	
	OPTIMUM	NATURAL
93.1	21.6	

DESCRIPTION

Brown and gray, clayey SILT and gray CLAY

ATTEBERG LIMITS

LL - 54 PL - 25 PI - 29

CLASSIFICATION SYSTEM

UNIFIED: CH

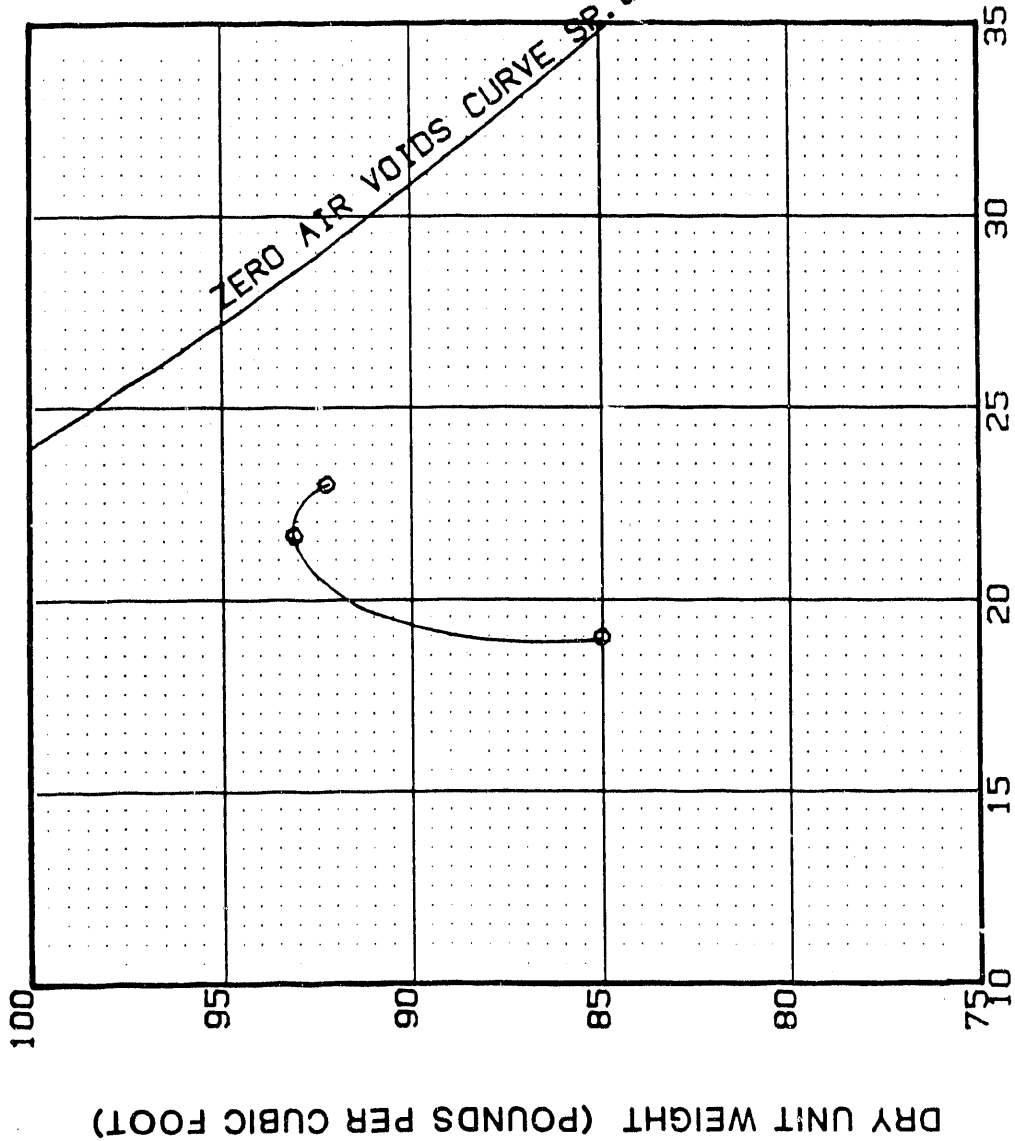
AASHTO:

SAMPLE INFORMATION

Composite

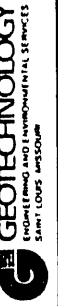
GT0-1 SS-3/5, GT0-8 ST-5, GT0-10 ST-8

WSSRAP



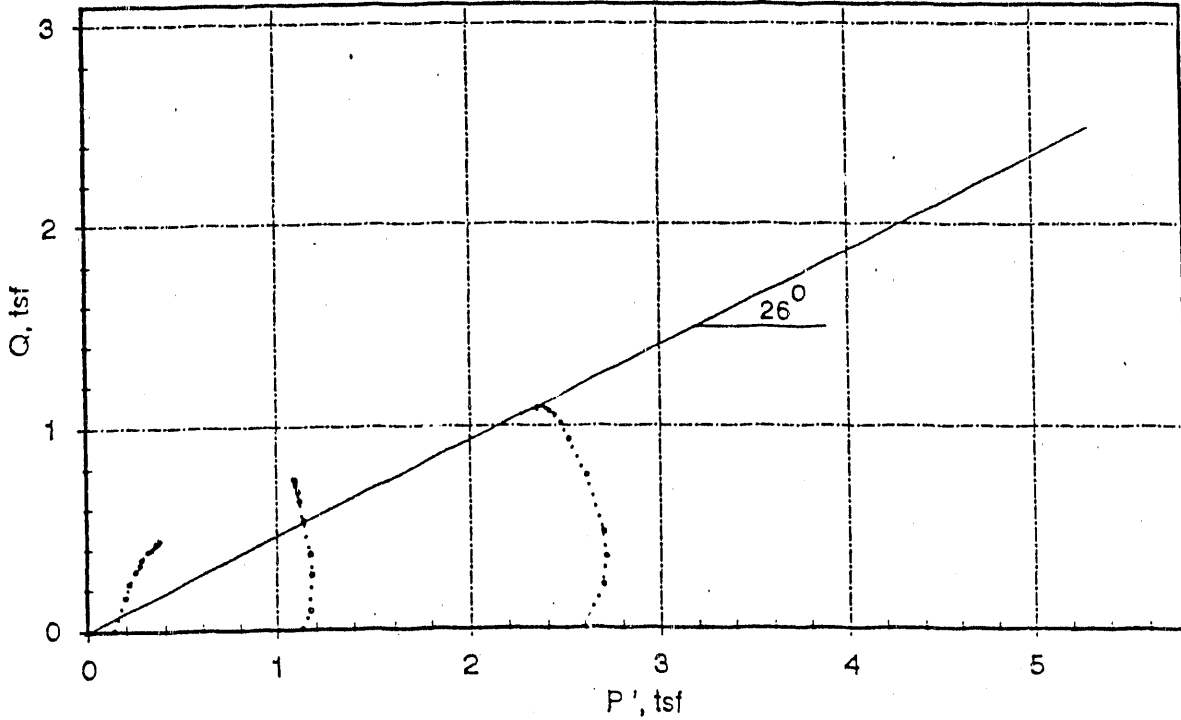
WATER CONTENT (PERCENT)

COMPACTION TEST

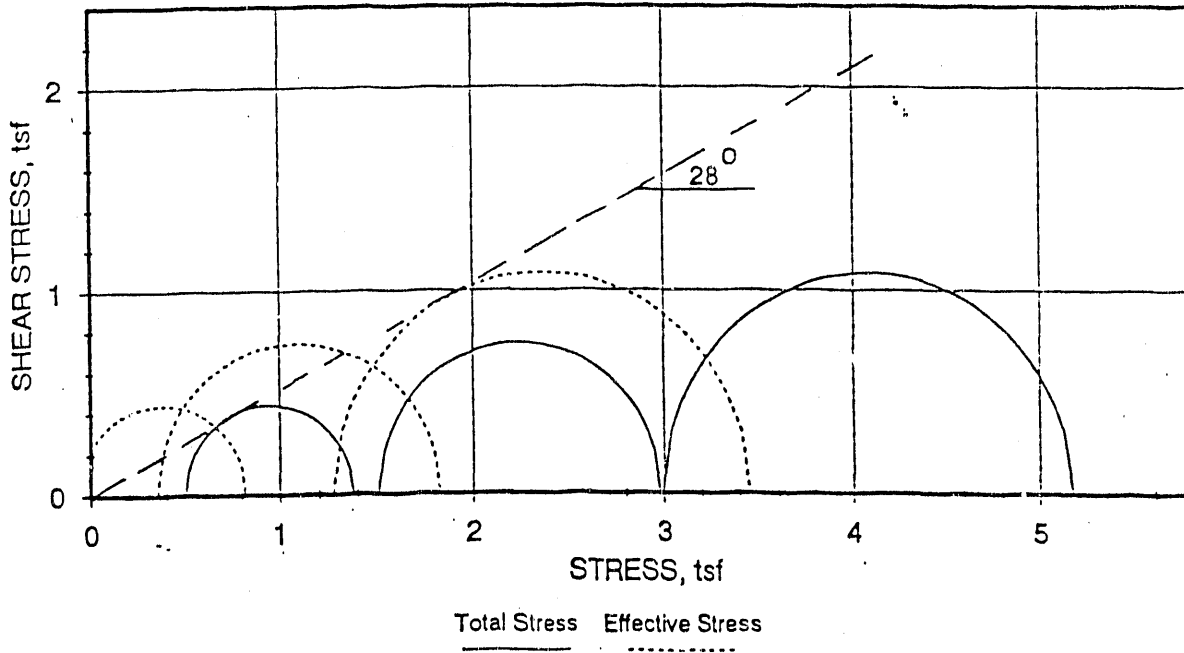


Ch. 11-20-90

WSSRAP - JOB NO: - 11295.000
 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST
 STRESS PATH



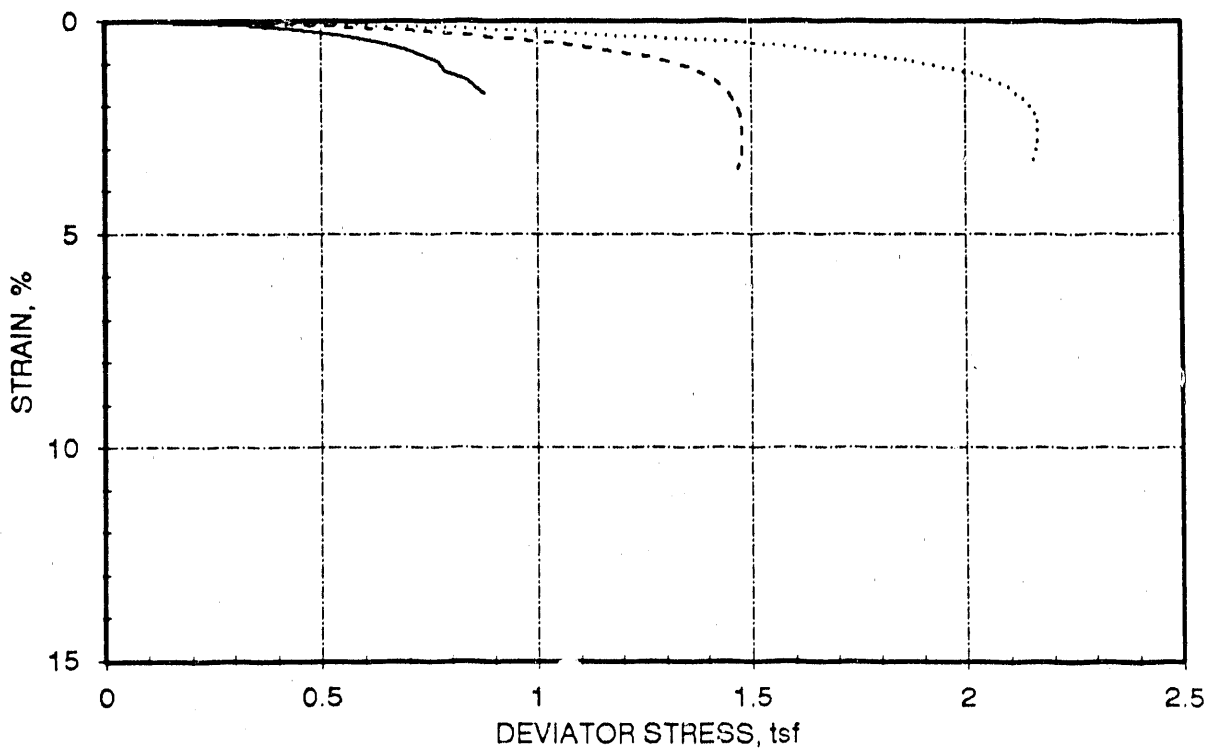
MOHR'S CIRCLES



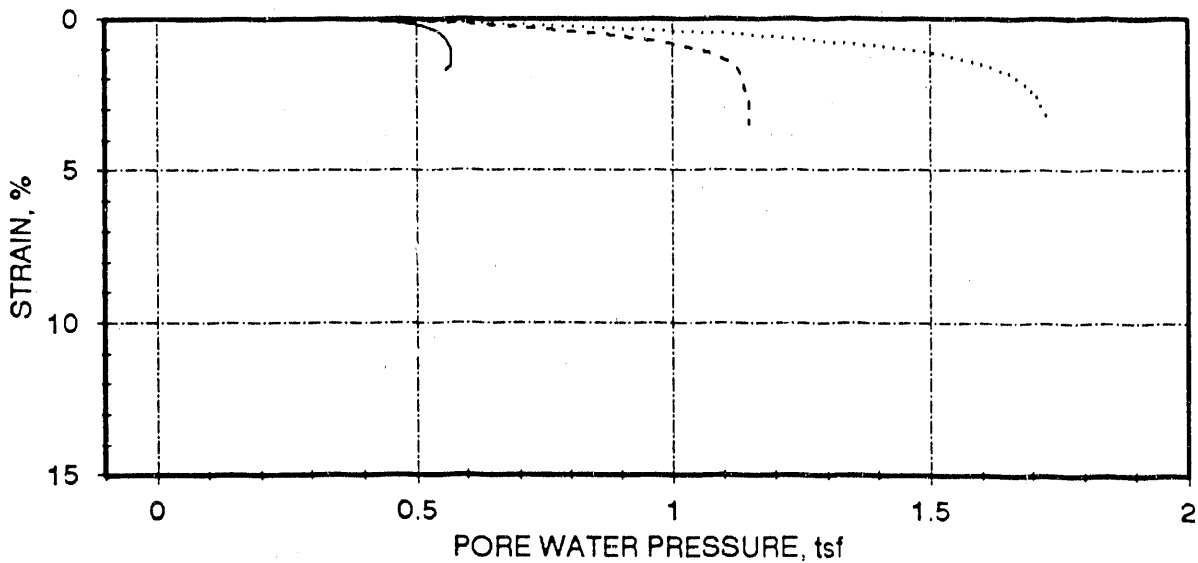
Boring No: GTQ-1
 Sample No: ST-02
 Depth: 7.5-10 FT

checked by: J. A

STRESS - STRAIN PLOT



PORE WATER PRESSURE - STRAIN PLOT

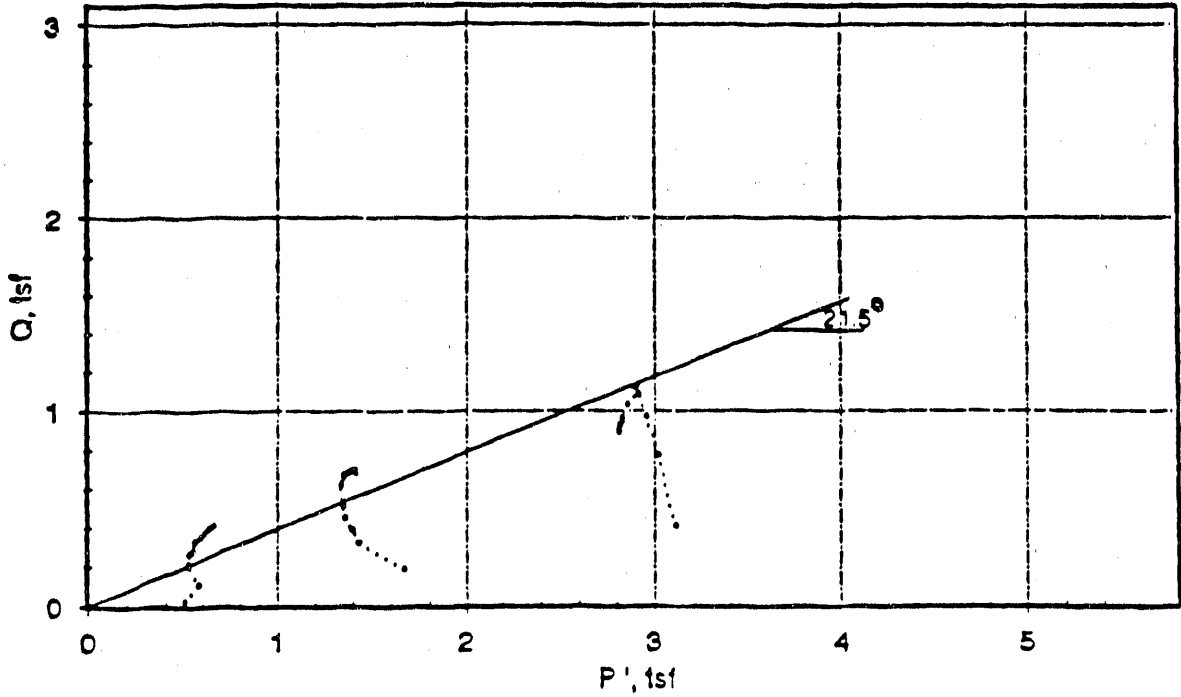


STAGE 1 STAGE 2 STAGE 3
 ————— - - - - - ·······

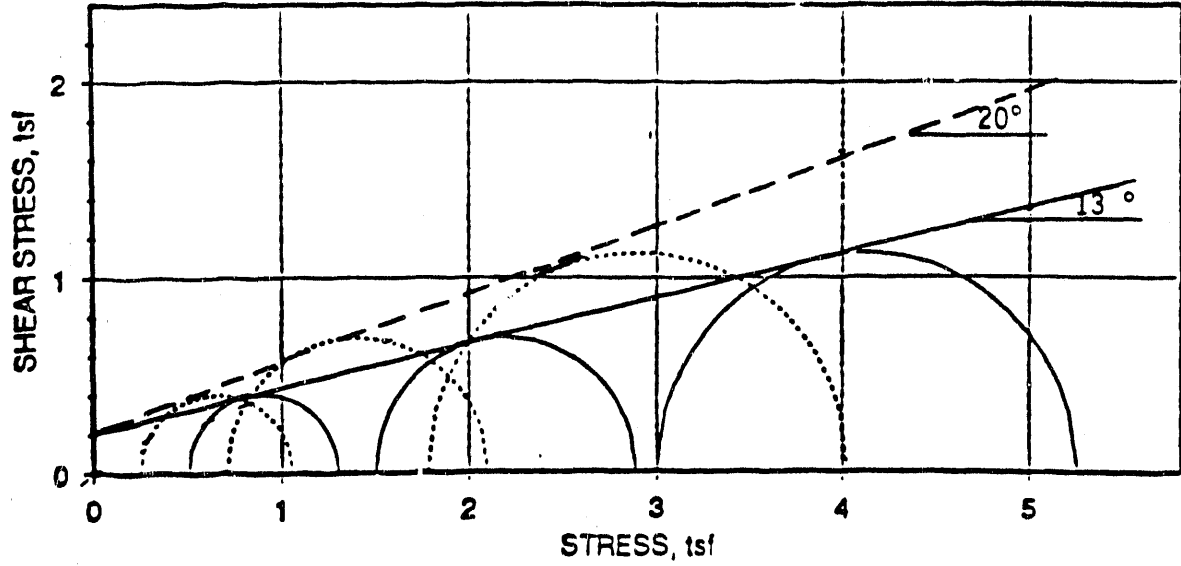
Boring No: GTQ-1
 Sample No: ST-02
 Depth: 7.5-10 FT

checked by: JA

WSSRAP - JOB NO:- 11295.000
 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST
 STRESS PATH



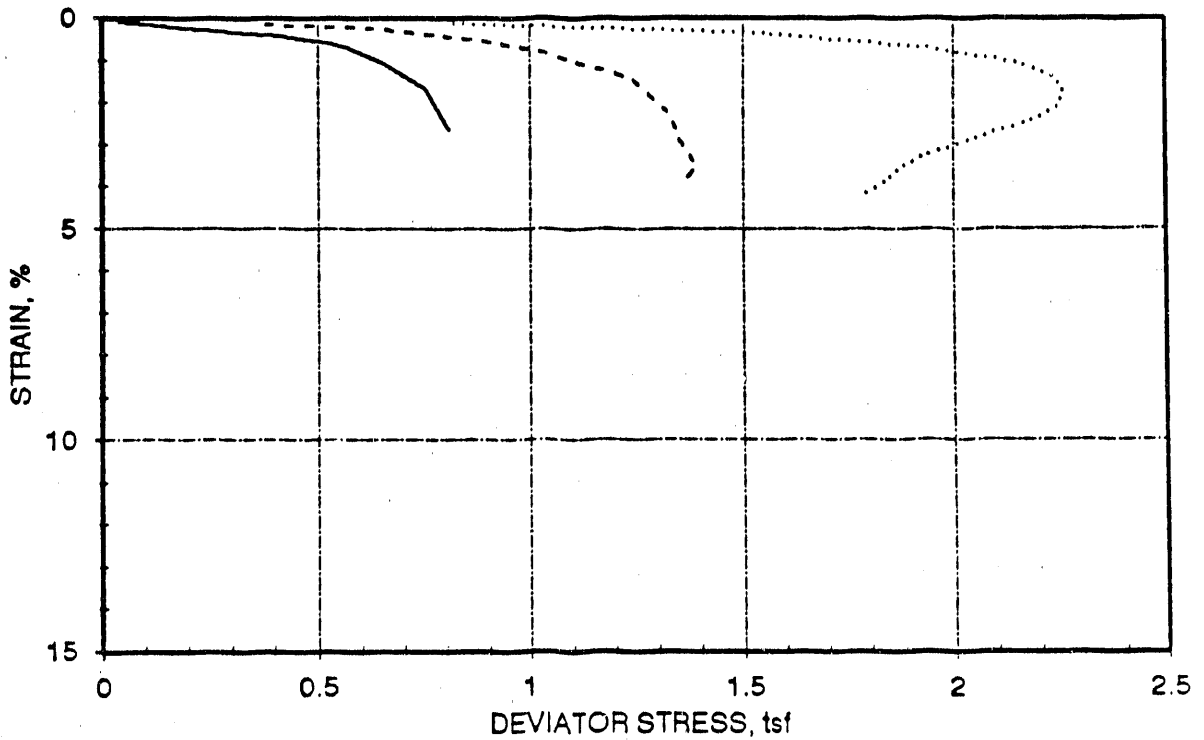
MOHR'S CIRCLES



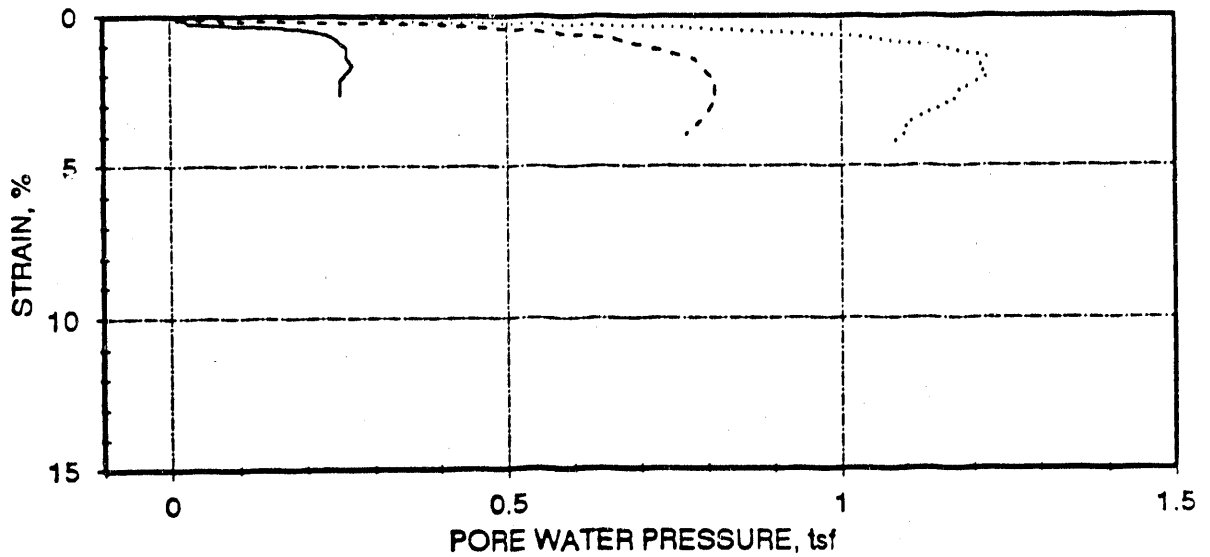
Total Stress	Effective Stress
$\phi = 13^\circ$	$\phi' = 20^\circ$
$C = 400 \text{ psf}$	$C' = 400 \text{ psf}$

Boring No: GTC-1
 Sample No: ST-04
 Depth: 12.5-15 feet

STRESS - STRAIN PLOT



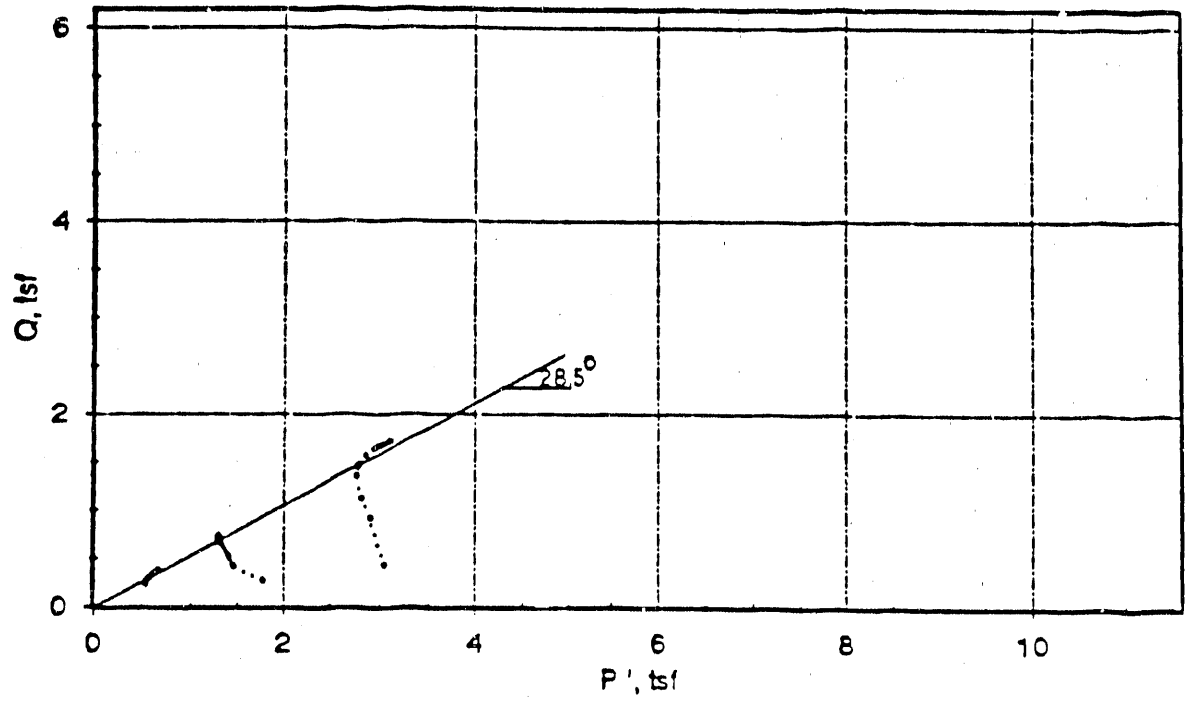
PORE WATER PRESSURE - STRAIN PLOT



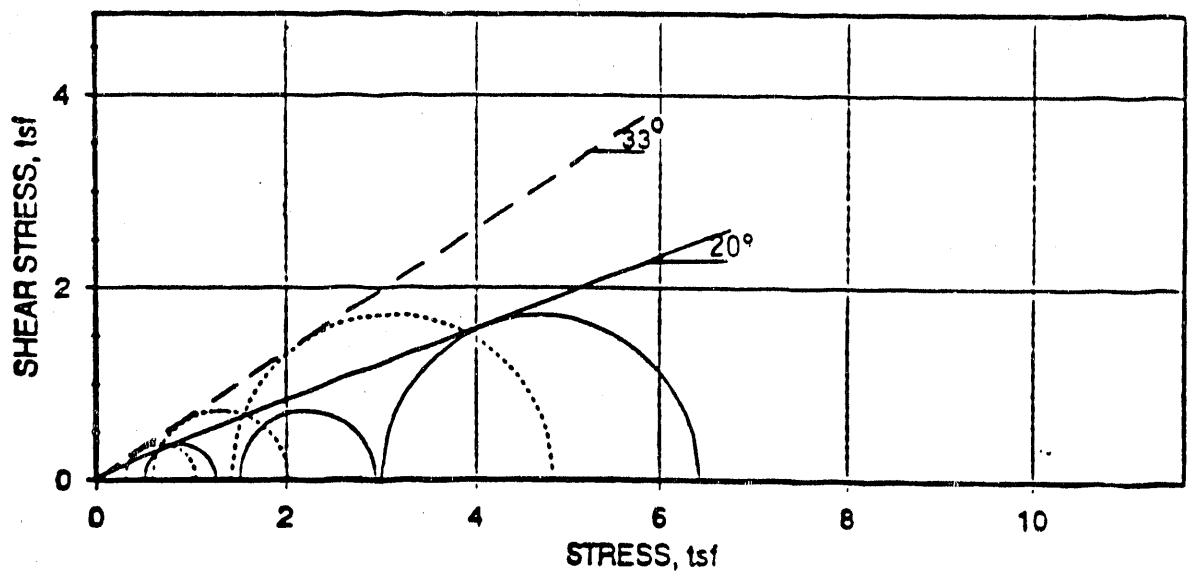
STAGE 1 **STAGE 2** **STAGE 3**
 _____ - - - - -

Boring No: GTQ-1
 Sample No: ST-04
 Depth: 12.5-15 feet

WSSRAP - JOB NO:- 11295
 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST
 STRESS PATH



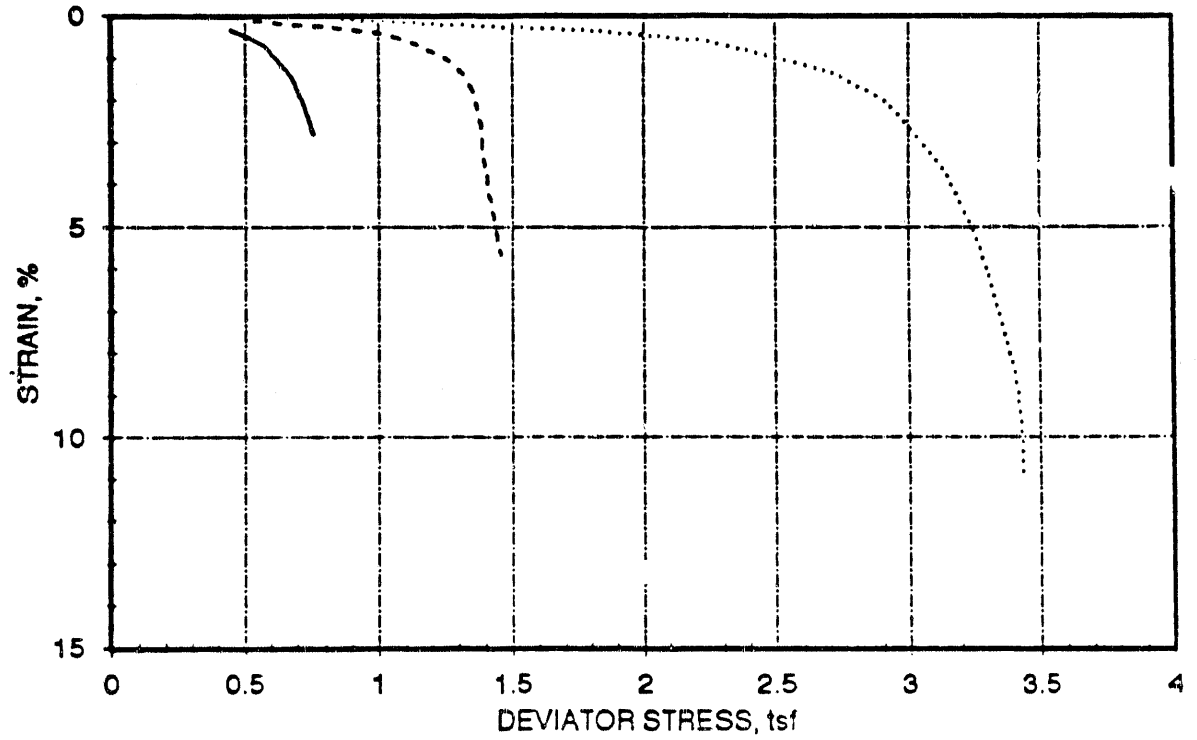
MOHR'S CIRCLES



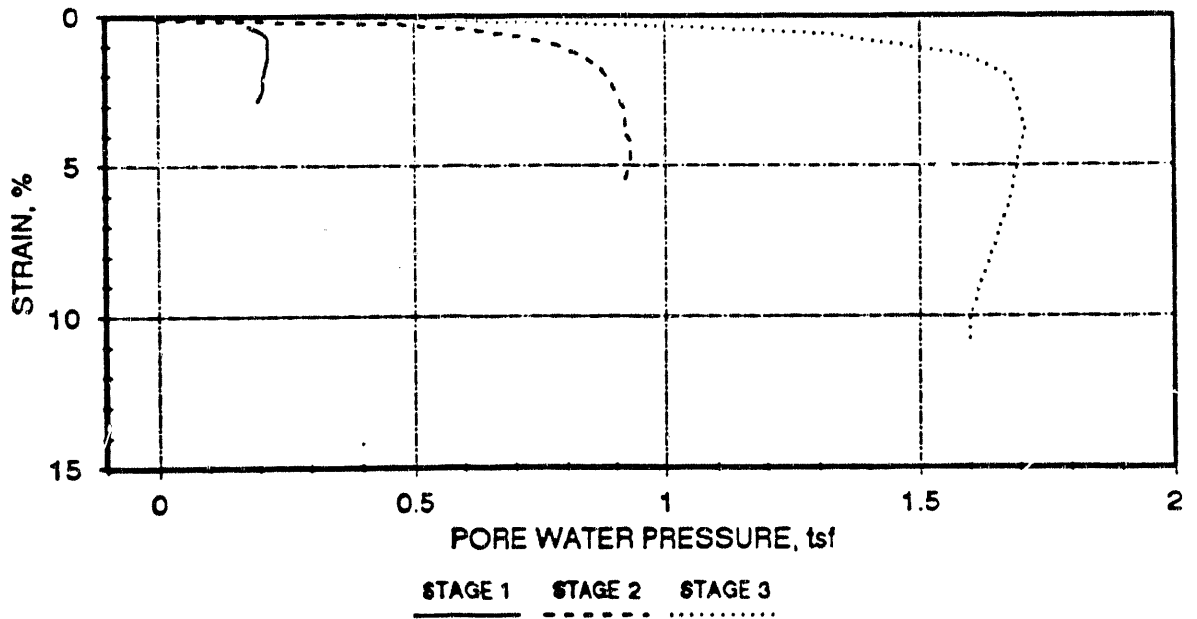
Boring No: GTC-1
 Sample No: ST-08
 Depth: 22.5-25 Feet

Total Stress	Effective Stress
$\phi = 20^\circ$	$\phi' = 33^\circ$
$C = 0$ psf	$C' = 0$ psf

STRESS - STRAIN PLOT

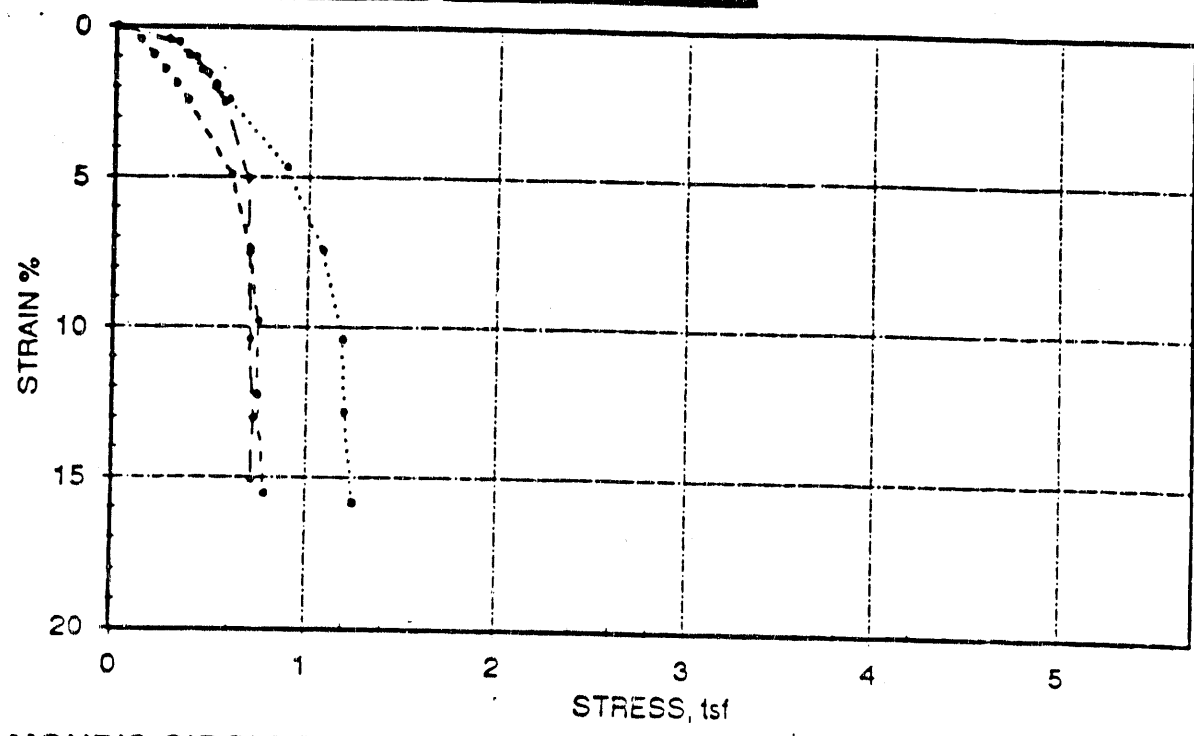


PORE WATER PRESSURE - STRAIN PLOT

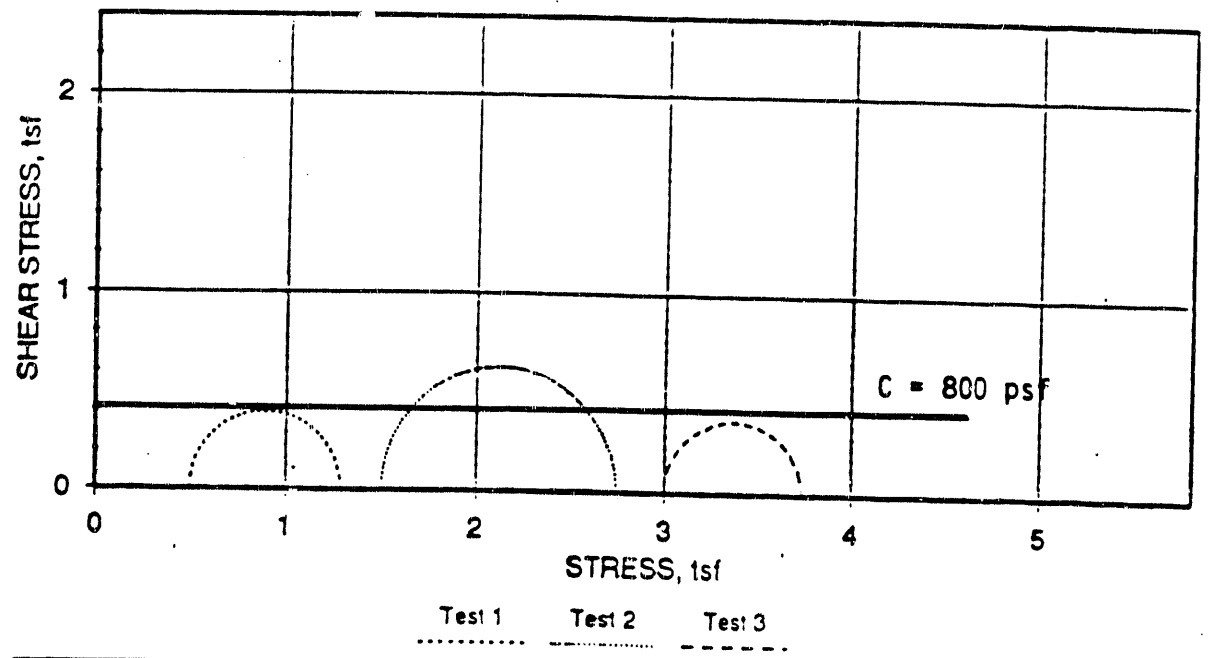


Boring No: GTQ-1
 Sample No: ST-08
 Depth: 22.5-25 Feet

WSSRAP - JOB NO:- 11295
 UNCONSOLIDATED - UNDRAINED TEST
 STRESS PATH

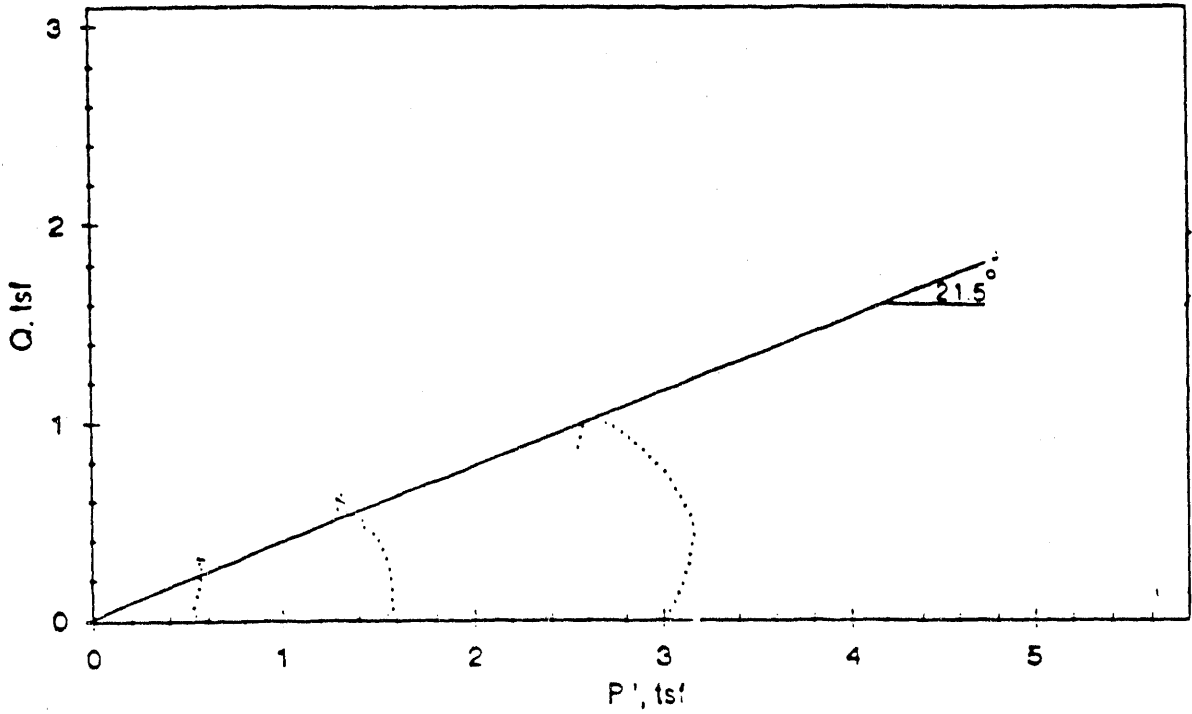


MOHR'S CIRCLES

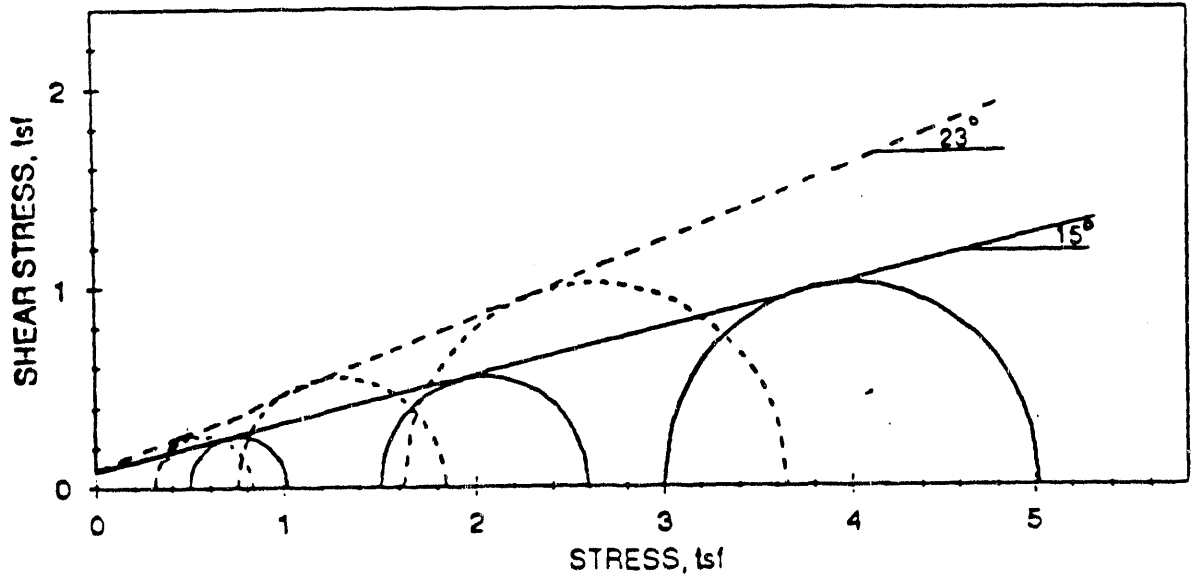


Boring No: GTO-1
 Sample No: ST-10
 Depth: 27.5-30 FT

WSSRAP - JOB NO:- 11295.000
 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST
 STRESS PATH



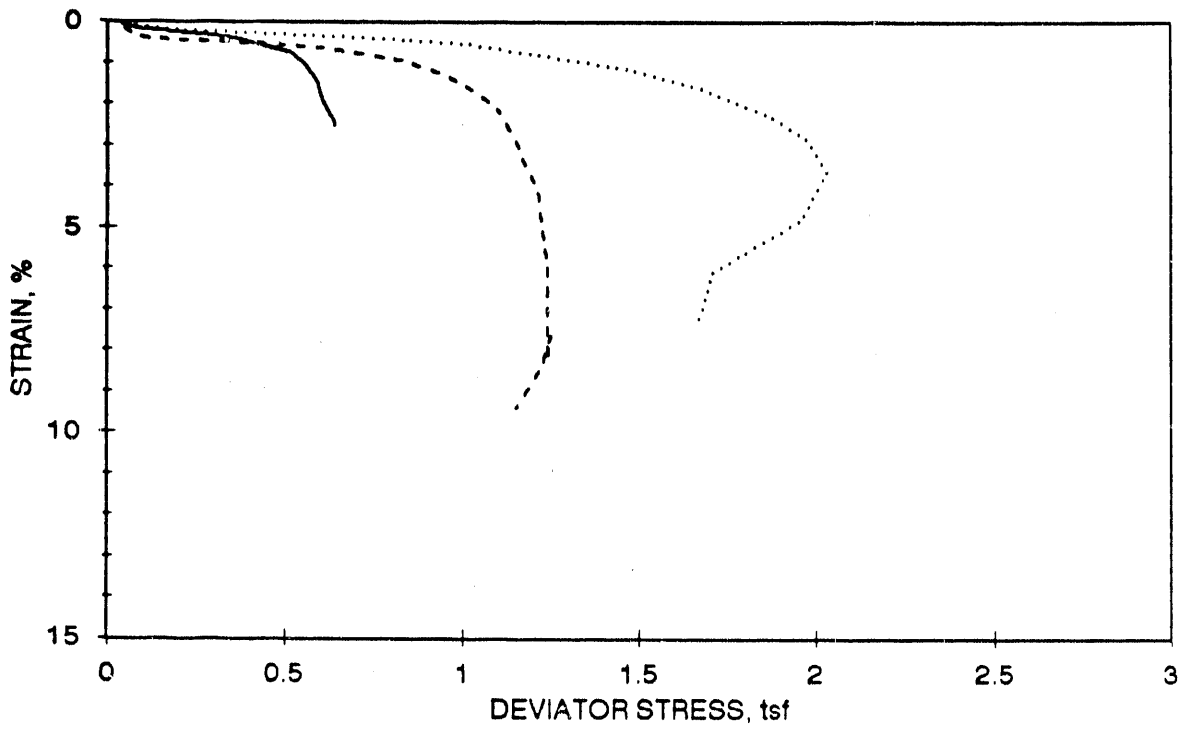
MOHR'S CIRCLES



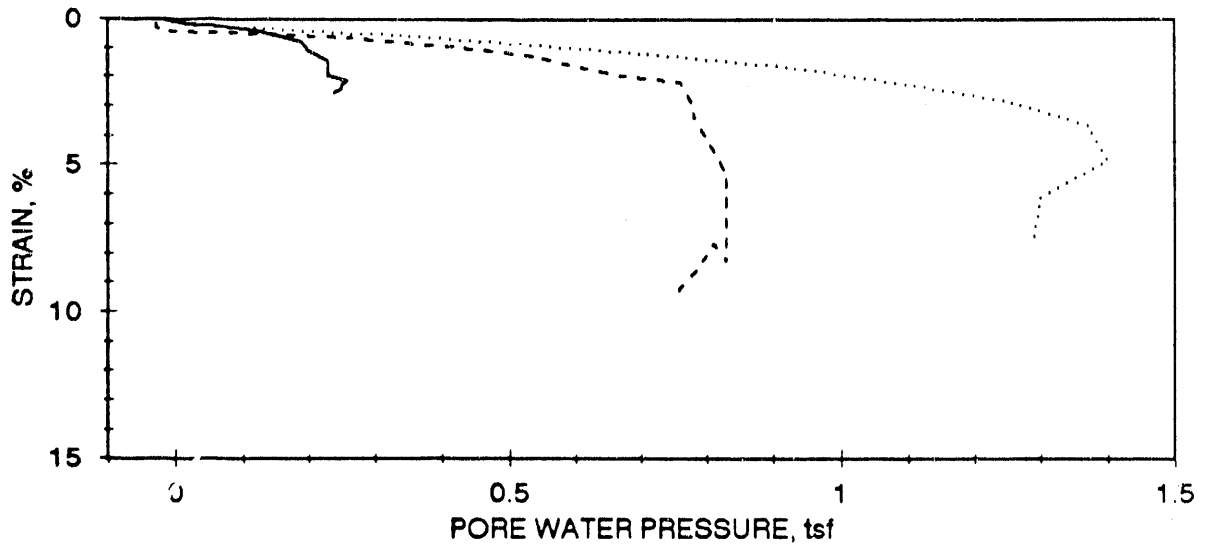
Total Stress	Effective Stress
$\phi = 15^\circ$	$\phi' = 23^\circ$
$C = 200 \text{ psf}$	$C' = 200 \text{ psf}$

Soing No: GTO-02
 Sample No: STO-6
 Depth: 15-17.5 feet

STRESS - STRAIN PLOT



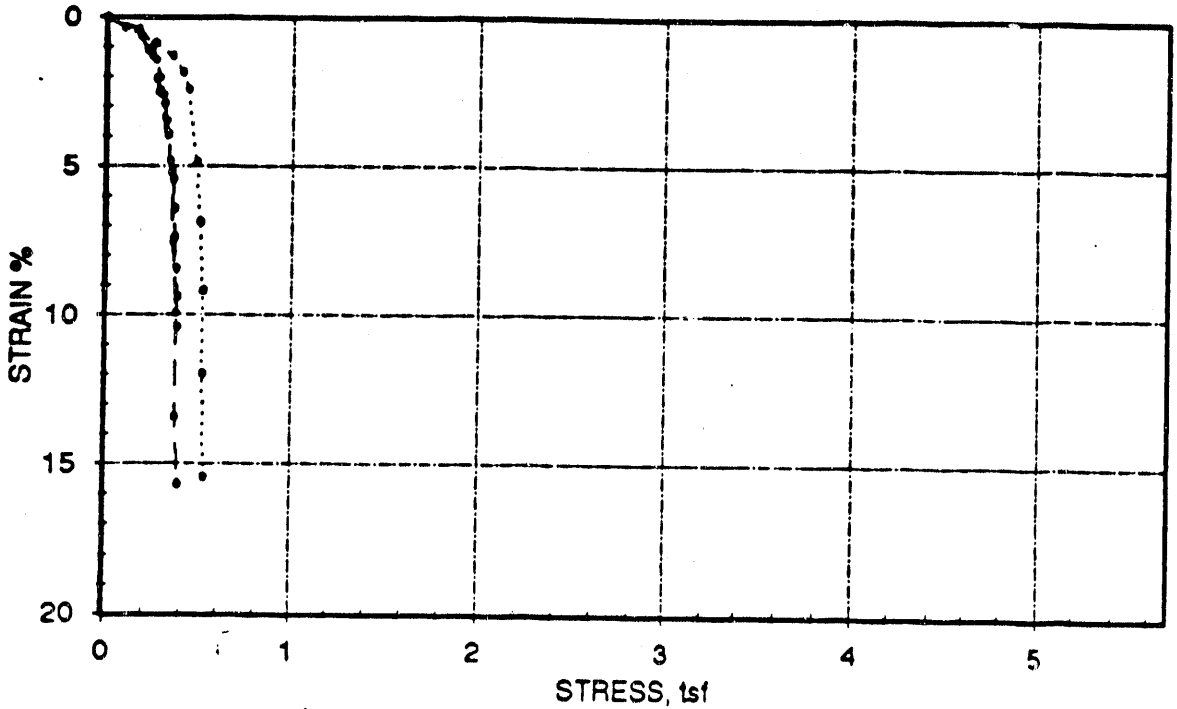
PORE WATER PRESSURE - STRAIN PLOT



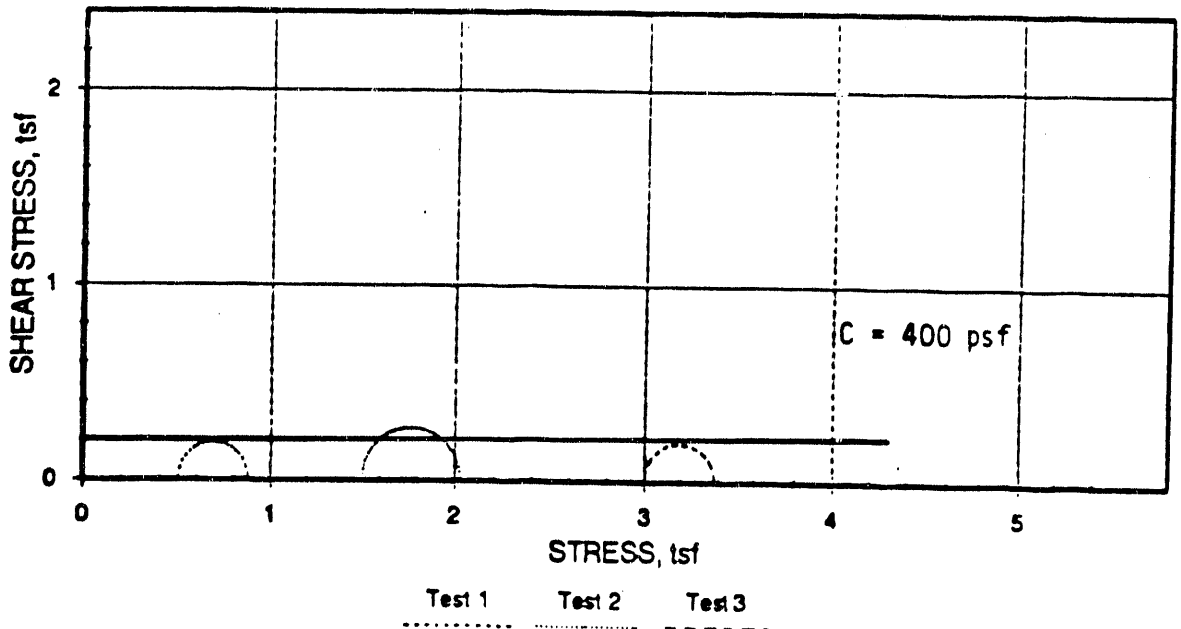
STAGE 1 STAGE 2 STAGE 3
 _____ - - - -

Boring No: GTQ-02
 Sample No: STO-6
 Depth: 15-17.5 feet

WSSRAP - JOB NO: 11295.000
 UNCONSOLIDATED - UNDRAINED TEST
 STRESS PATH

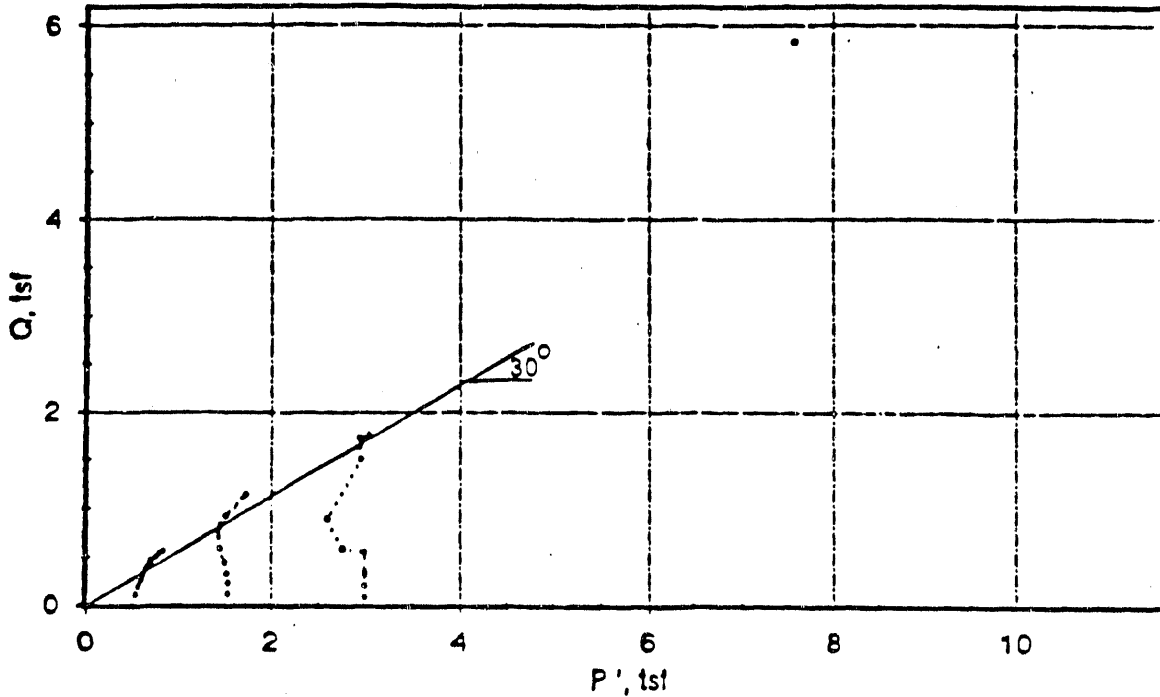


MOHR'S CIRCLES

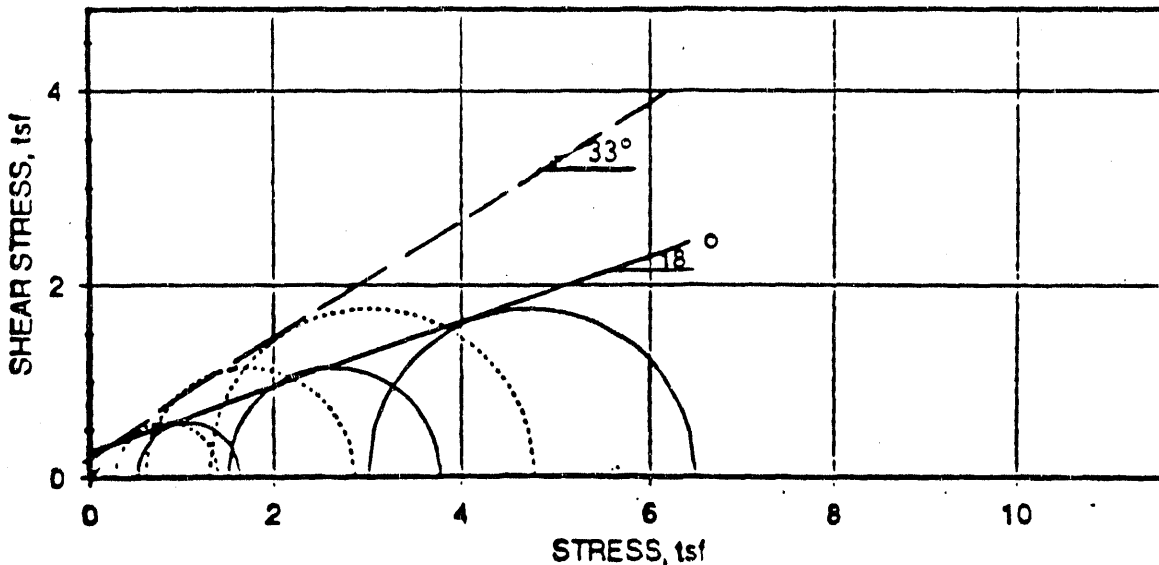


Boring No: GTQ-3
 Sample No: ST-08
 Depth: 20-22.5 ft

WSSRAP - JOB NO:- 11295.000
 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST
 STRESS PATH



MOHR'S CIRCLES

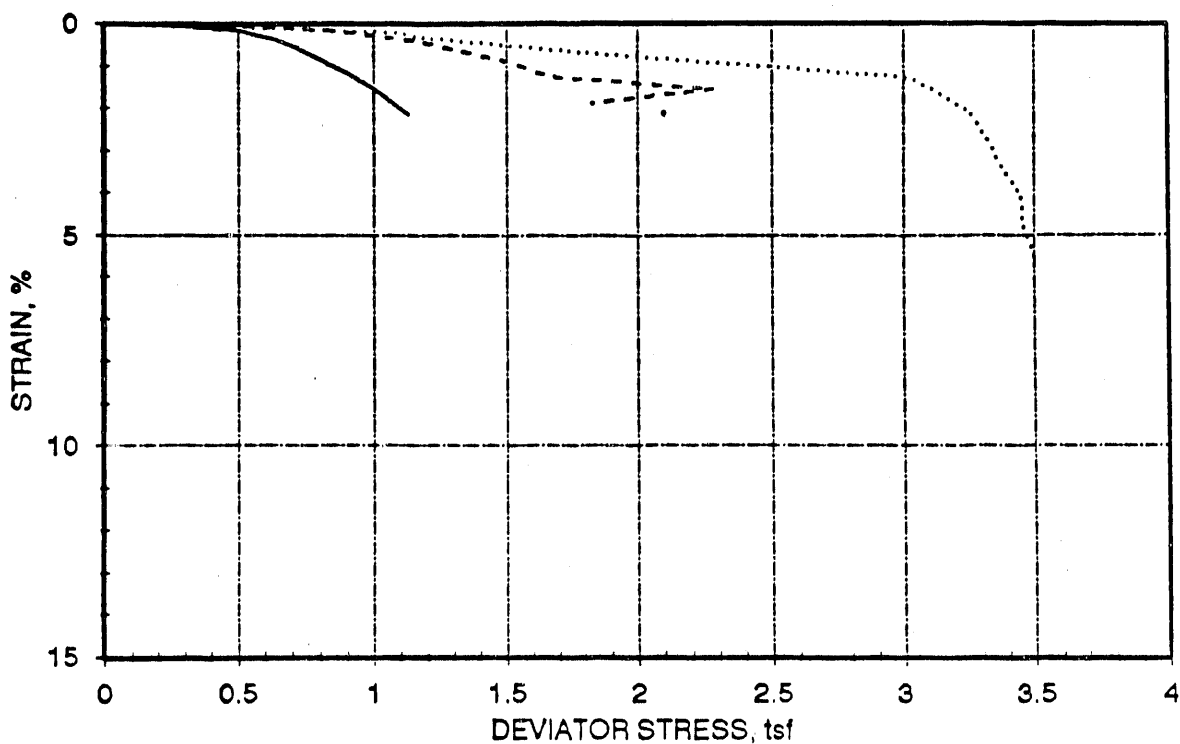


Total Stress Effective Stress

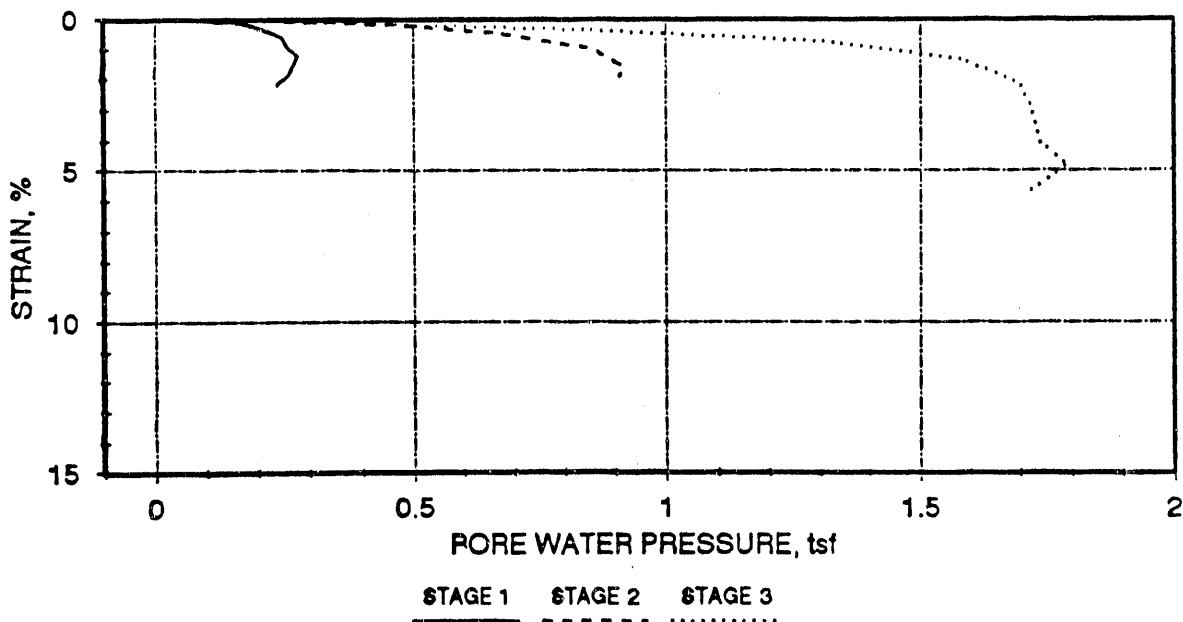
$\phi = 18^\circ$ $\phi' = 33^\circ$
 C = 200 psf C' = 150 psf

Boring No: GTO-4
 Sample No: ST-06
 Depth: 15-17.5 FT

STRESS - STRAIN PLOT

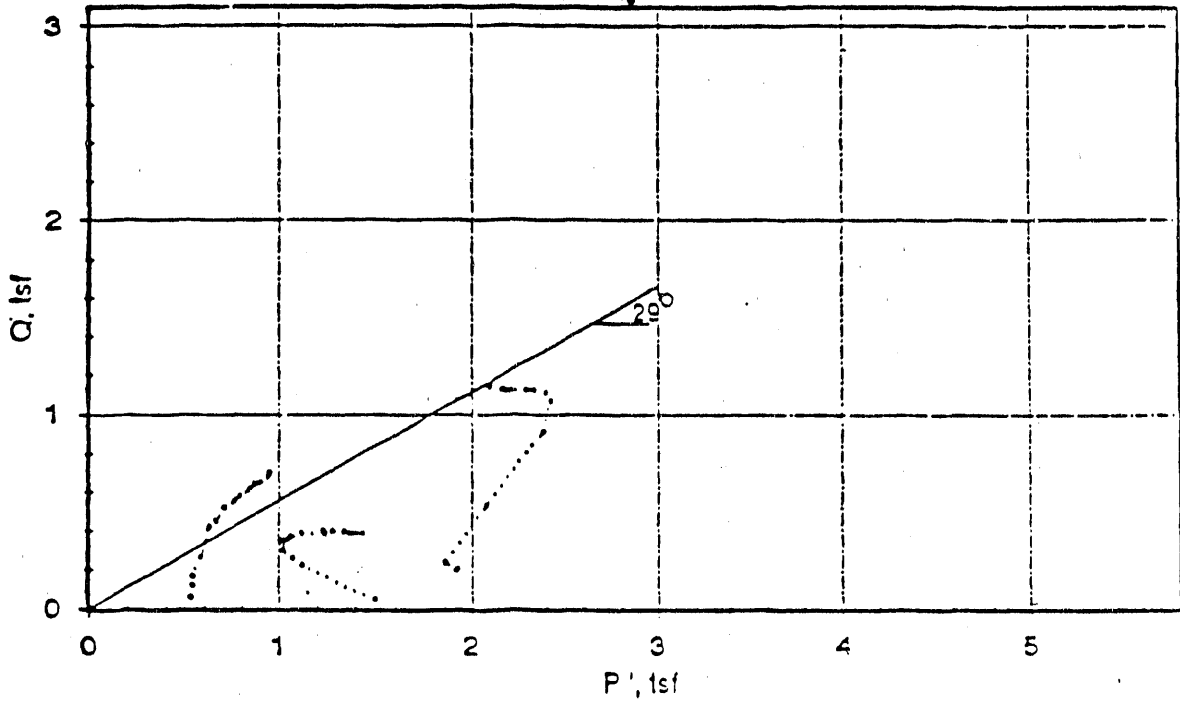


PORE WATER PRESSURE - STRAIN PLOT

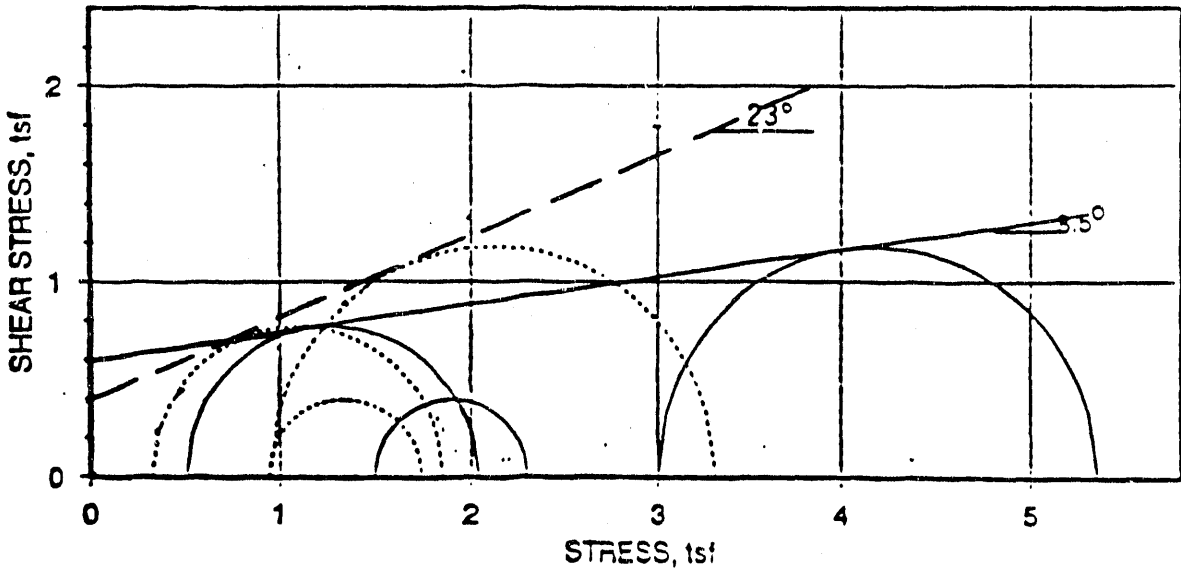


Boring No: GTQ-4
 Sample No: ST-06
 Depth: 15-17.5 FT

WSSRAP - JOB NO:- 11295
 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST
 STRESS PATH



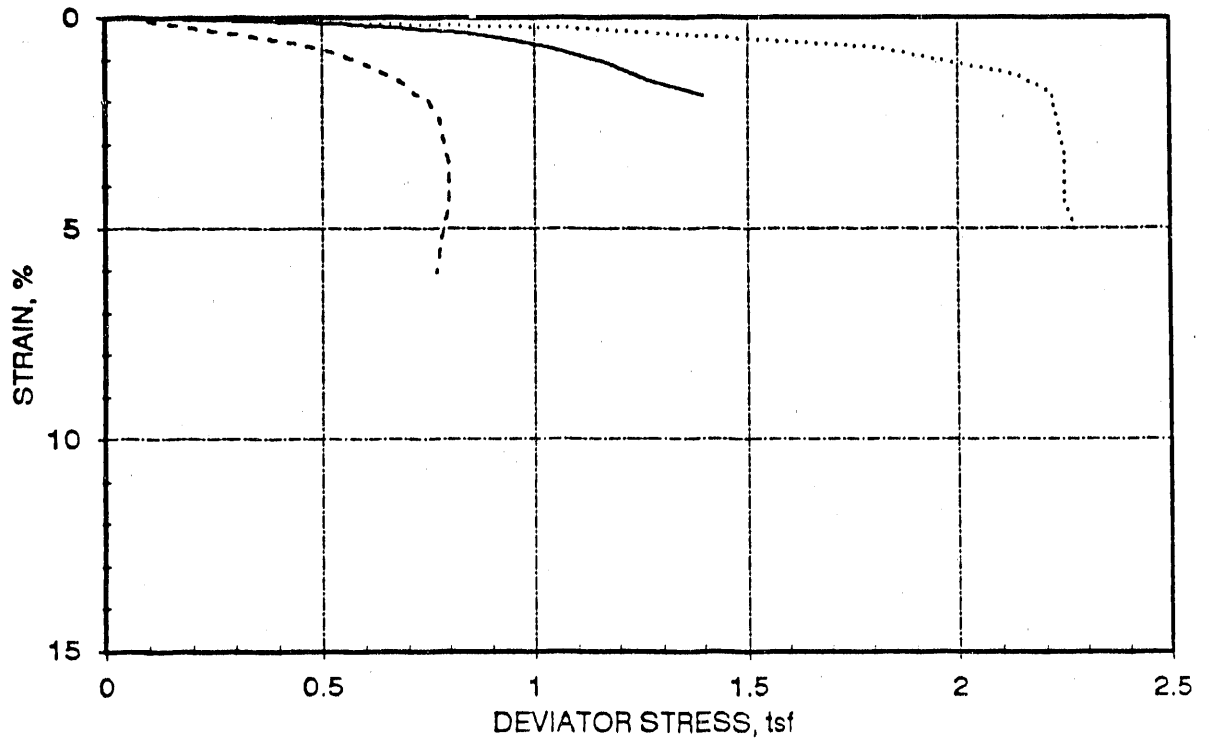
MOHR'S CIRCLES



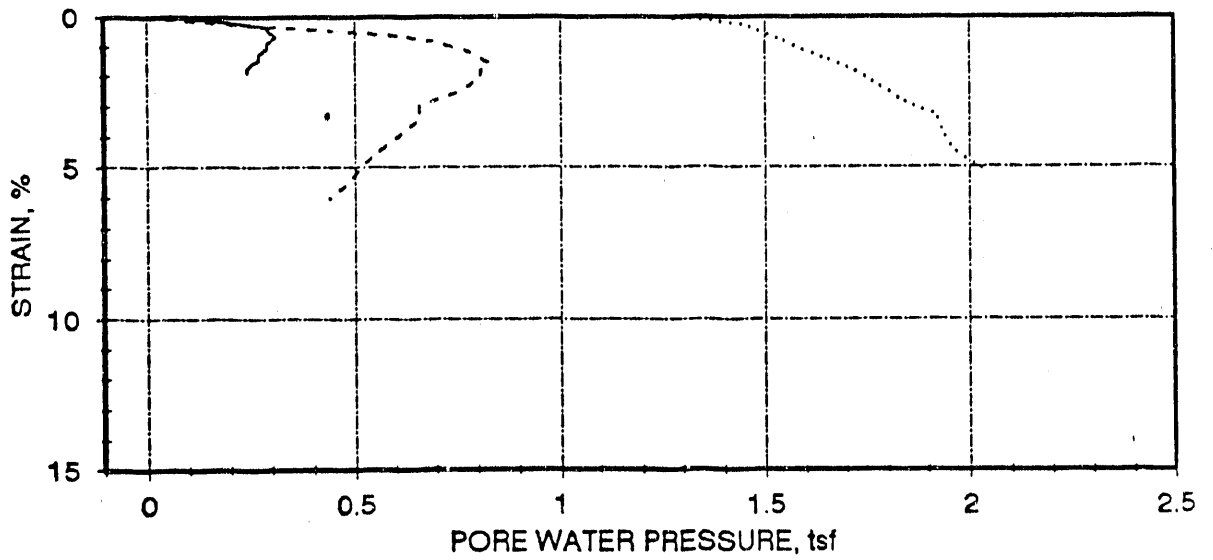
Boring No: GT-05
 Sample No: ST-02
 Depth: 5-7.5 ft.

Total Stress Effective Stress
 ————— - - - - -
 $\phi = 8.5^\circ$ $\phi' = 23^\circ$
 $C = 1200$ psf $C' = 800$ psf

STRESS - STRAIN PLOT



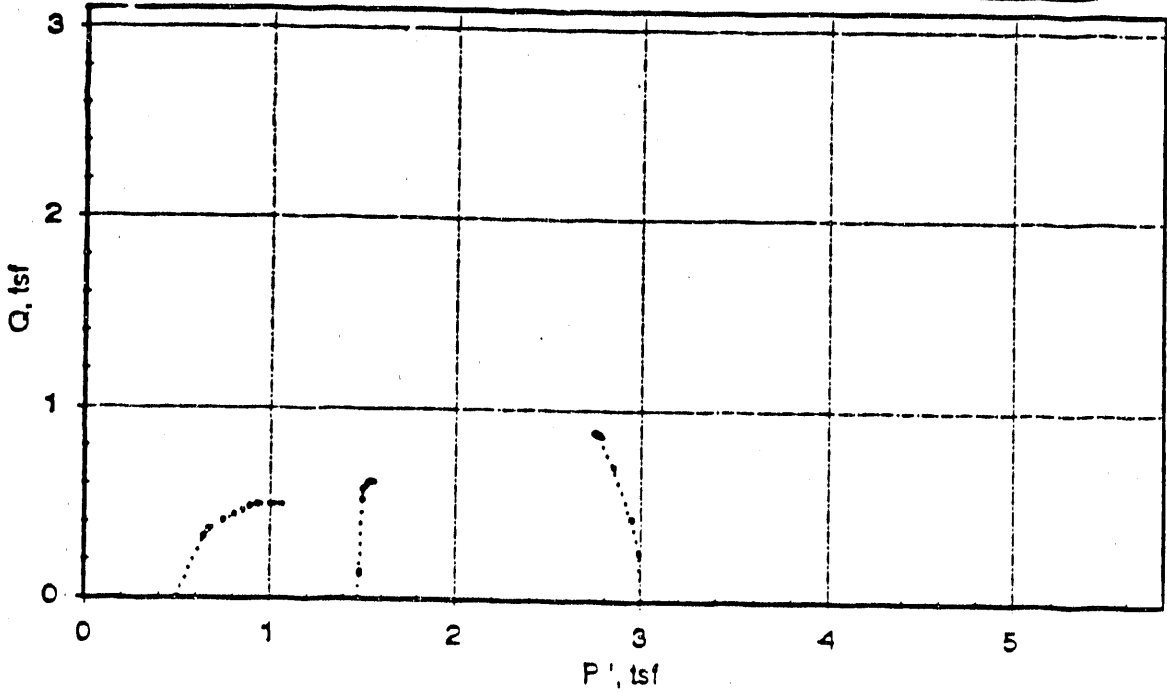
PORE WATER PRESSURE - STRAIN PLOT



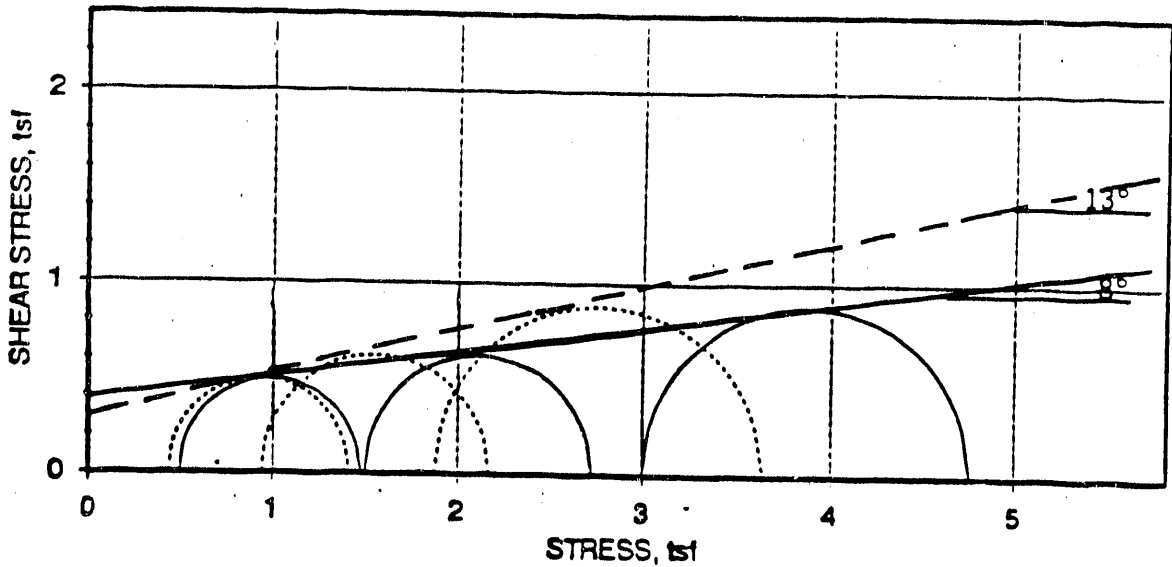
STAGE 1 STAGE 2 STAGE 3
 _____ - - - -

Boring No: GT-05
 Sample No: ST-02
 Depth: 5-7.5 ft.

WSSRAP - JOB NO:- 11295.000
 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST
 STRESS PATH



MOHR'S CIRCLES

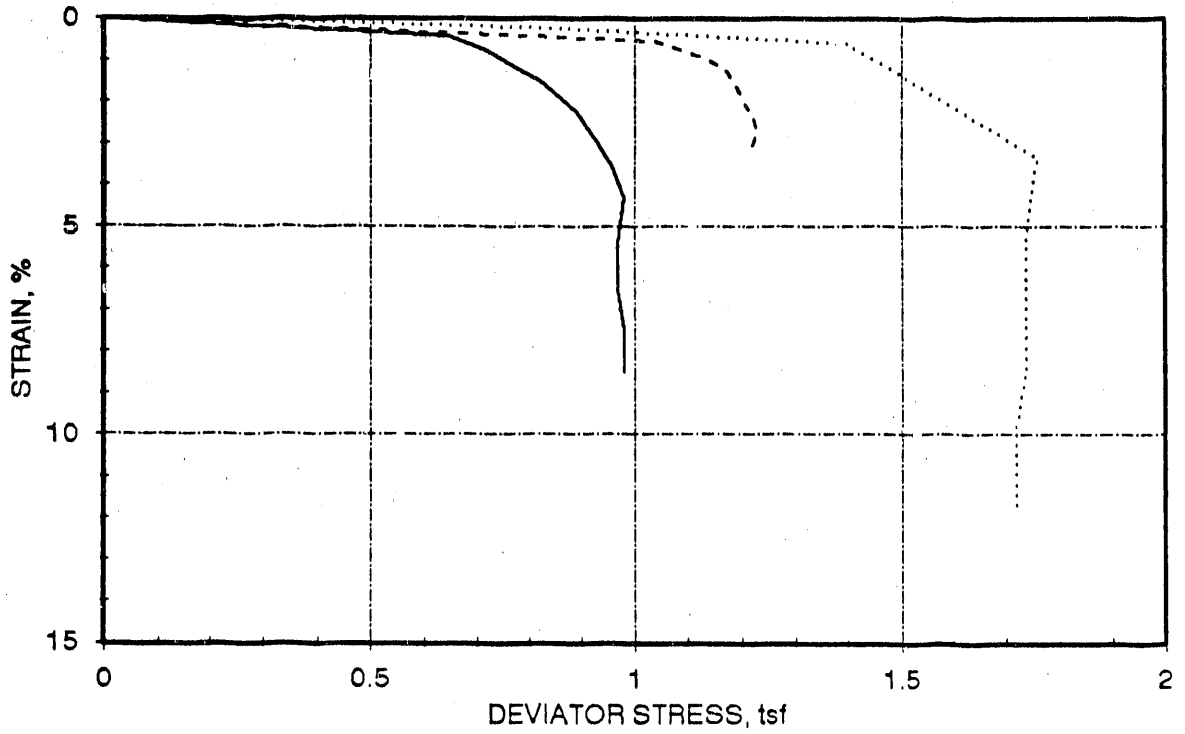


Total Stress Effective Stress

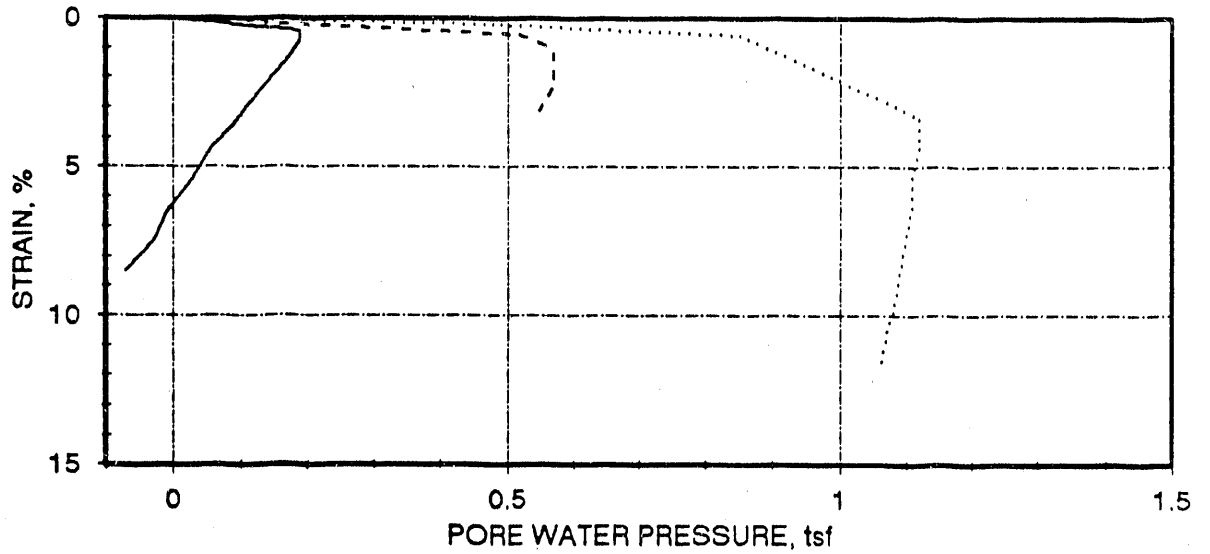
$\phi = 8^\circ$ $\phi' = 13^\circ$
 $C = 800 \text{ psf}$ $C' = 600 \text{ psf}$

Boring No: GTQ-5
 Sample No: ST-04
 Depth: 10-12.5 FT

STRESS - STRAIN PLOT



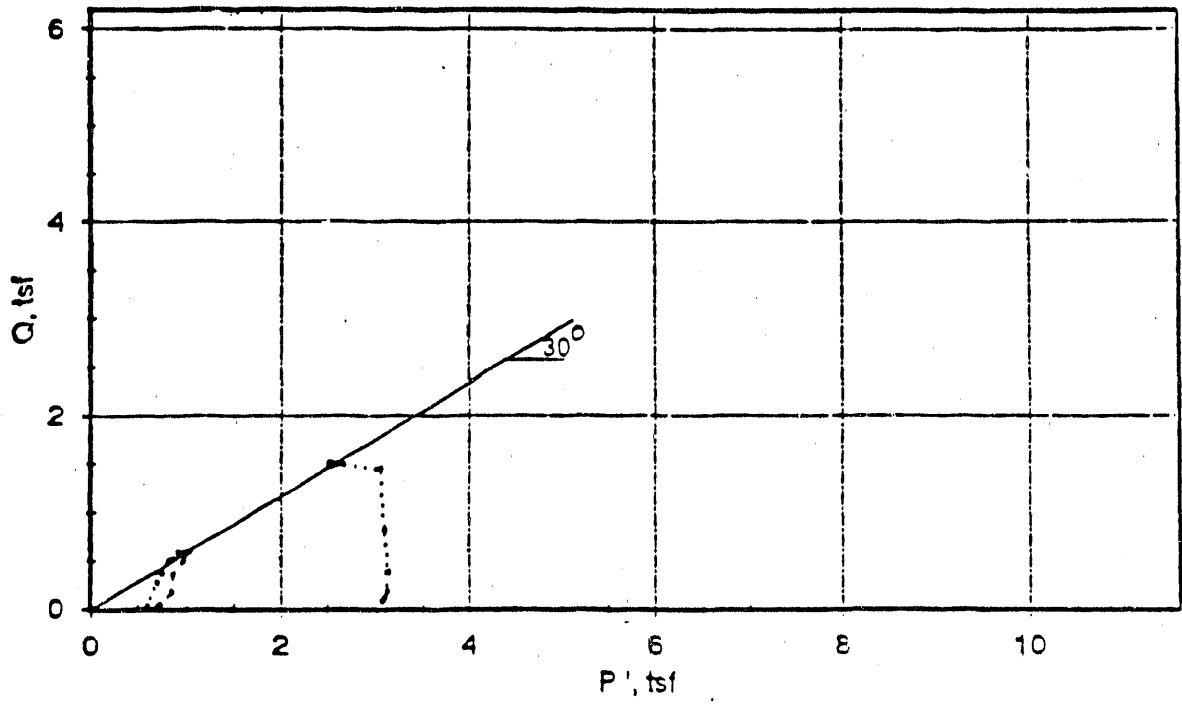
PORE WATER PRESSURE - STRAIN PLOT



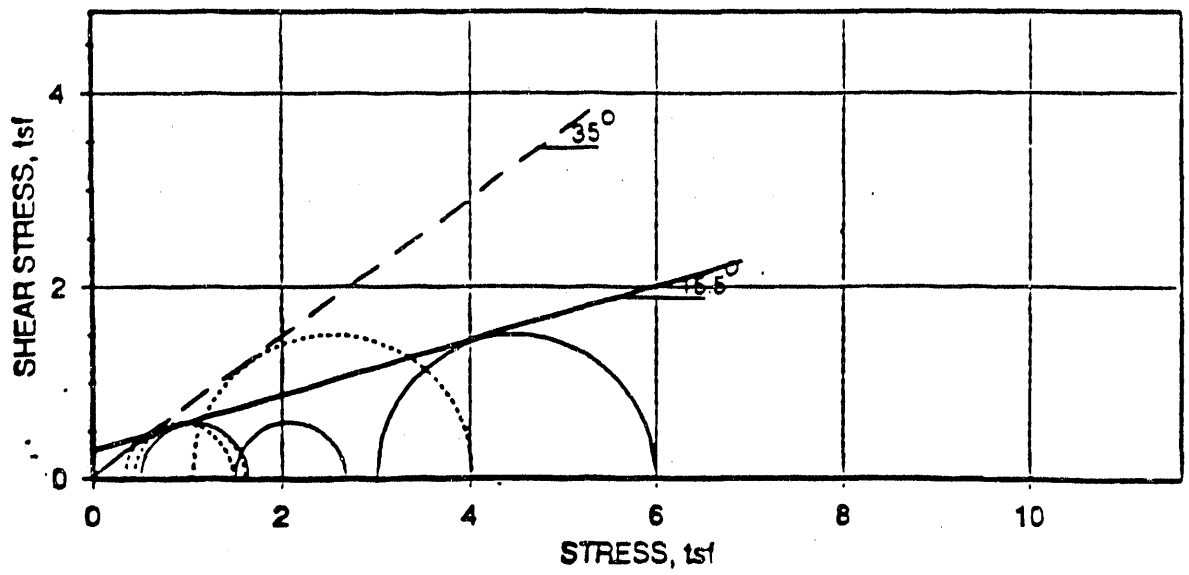
STAGE 1 STAGE 2 STAGE 3
 _____ - - - -

Boring No: GTQ-5
 Sample No: ST-04
 Depth: 10-12.5 FT

WSSRAP - JOB NO:- 11295
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST
STRESS PATH



MOHR'S CIRCLES

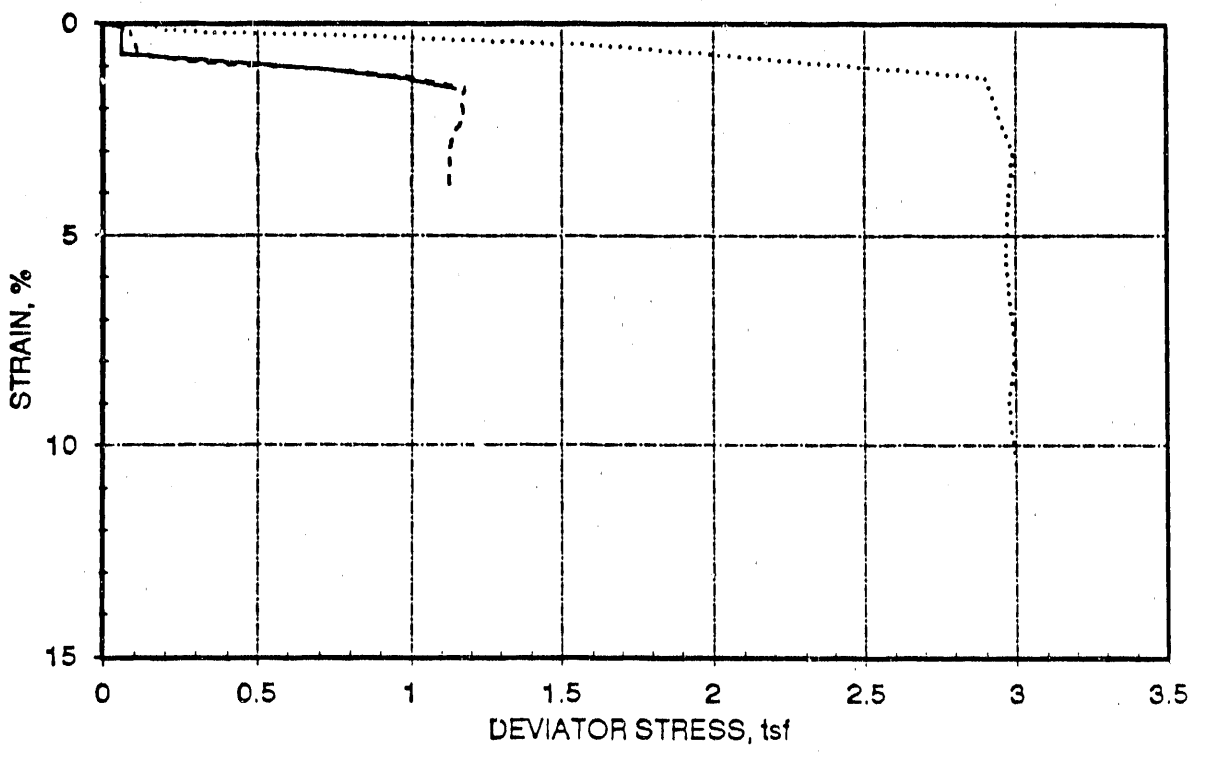


Boring No: GTQ-8
 Sample No: ST-04
 Depth: 10 - 12.5 feet

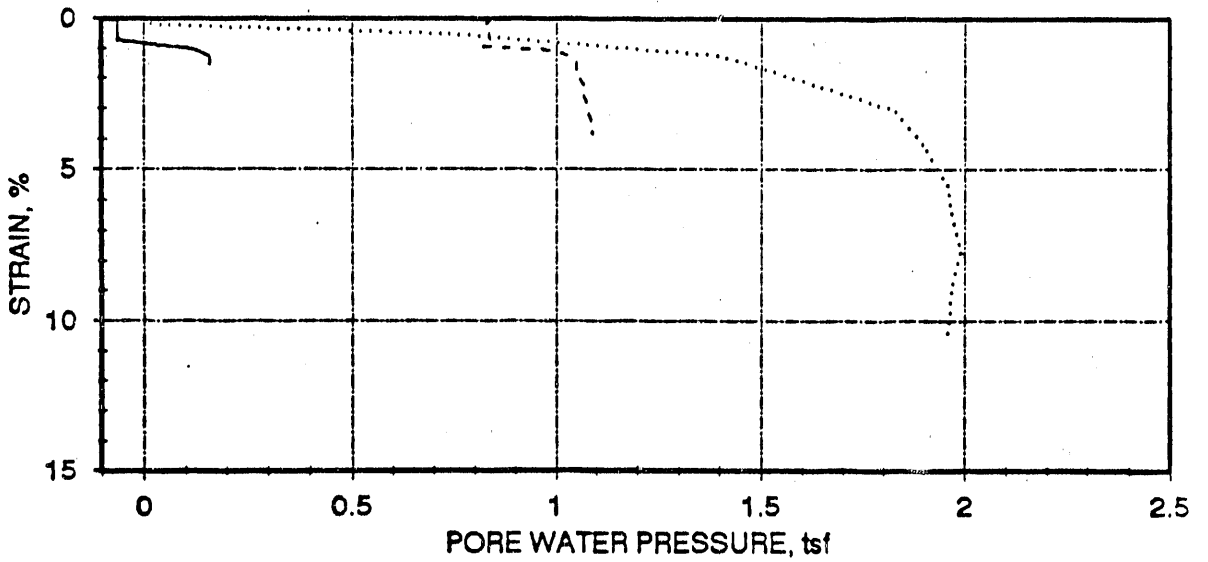
Total Stress Effective Stress

 $\phi = 15.5^\circ$ $\phi' = 35^\circ$
 $C = 250 \text{ psf}$ $C' = 50 \text{ psf}$

STRESS - STRAIN PLOT



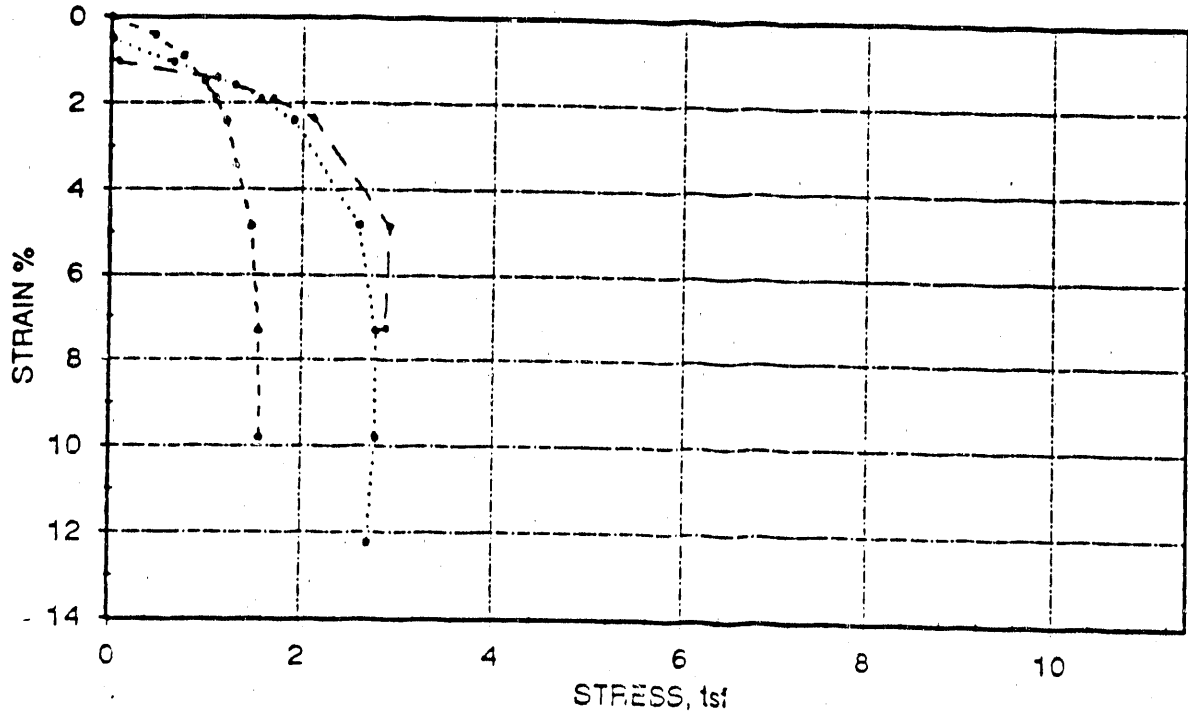
PORE WATER PRESSURE - STRAIN PLOT



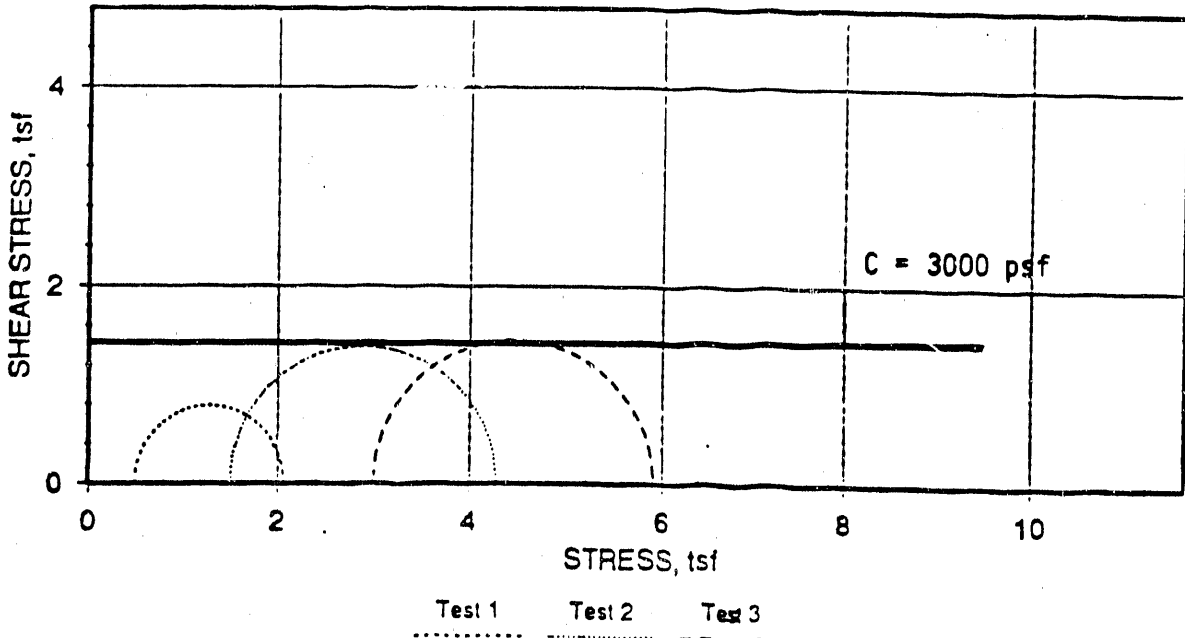
STAGE 1 STAGE 2 STAGE 3
 _____ - - - -

Boring No: GTQ-8
 Sample No: ST-04
 Depth: 10 - 12.5 feet

WSSRAP - JOB NO:- 11295
 UNCONSOLIDATED - UNDRAINED TEST
 STRESS PATH

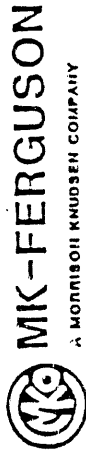


MOHR'S CIRCLES



Boring No: GTO10
 Sample No: ST05
 Depth: 15 - 17.5 FT

Request #1



PERMEABILITY TEST RESULTS

SITE ID: WSJ RAP CHECKED BY: LAB 44
 DATE: 10-12-89 TAC _____
 LAB NAME: GEOTECHNOLOGY, INC

LOCATION ID	SAMPLE ID	DEPTH INTERVAL (FT)	TEST METH.	COMPACTION (%)	MOISTURE CONTENT (%)		DRY DENSITY (PCF)		SATURATION (%)		TOTAL PRESSURE HEAD (FT)	PERMEABILITY (CM/SEC)
					INIT.	FINAL	INIT.	FINAL	INIT.	FINAL		
Quarry Slurry AREA	GTQ1 ST 15	45-47.5			35.9	31.0	85.3		99.4		16.1	2.006×10^{-7}
"	GTQ4 ST 15	45-47.5			35.9	31.0	85.3		99.4		48.2	3.193×10^{-8}
"	GTQ4 ST 12	30-32.5			50.3	53.1	71.8		98.3		16.1	1.412×10^{-7}
"	GTQ4 ST 12	30-32.5			50.3	53.1	71.8		98.3		48.2	4.317×10^{-8}
"	GTQ4 ST 16	50-52.5			43.4	44.8	75.7		95.6		16.1	1.063×10^{-7}
"	GTQ4 ST 16	50-52.5			43.4	44.8	75.7		95.6		48.2	8.853×10^{-9}
"	GTQ8 ST 09	25-27.5			22.8	27.7	94.5		77.6		16.1	5.309×10^{-5}
"	GTQ8 ST 09	25-27.5			22.8	27.7	94.5		77.6		48.2	2.351×10^{-5}
"	GTQ8 ST 16	55-57.5			31.5	33.5	87.1		91.0		16.1	3.182×10^{-7}
"	GTQ8 ST 16	55-57.5			31.5	33.5	87.1		91.0		48.2	2.080×10^{-8}
"	GTQ10 ST 11	30-32.5			29.9	26.4	93.0		99.5		16.1	3.136×10^{-7}
"	GTQ10 ST 11	30-32.5			29.9	26.4	93.0		99.5		48.2	8.116×10^{-8}

2

INTER-OFFICE CORRESPONDENCE

		FILE NUMBER	5121-Q:EN-L-01-1295-02
		DATE	4 April 1990
TO	D. E. Steffen	FROM	<i>ECT. DWK</i> E.C. Tom/D.W. Reppond
LOCATION	Weldon Springs	LOCATION	San Francisco
SUBJECT	WSSRAP - QY SLOPE STABILITY FOR QUARRY EQUALIZATION BASIN AND EFFLUENT PONDS FOR LITTLE FEMME OSAGE CREEK	cc:	C. Dille G. Valett R. Whiton File 3840 -001

As requested, we have evaluated the stability of the embankment slope of the WSS Quarry Equalization Basin and Effluent Ponds under a 100-year flood condition on the Femme Osage Creek. Our findings show that the slopes will be stable under the flood conditions. The analyses are summarized below.

Critical Cross-Sections for Analyses

Geotechnical data from boring logs and laboratory test results (see Attachment A) as well as the topography of the proposed pond area were evaluated in selecting critical cross-sections for analysis. A plan showing the proposed facilities, boring locations and the cross-section selected for analyses are presented in Figure 1. Two cross-sections were identified as critical sections. Section C-C' represents a section with maximum embankment fill height at the centerline while Section D-D' represents a section with maximum exterior slope length. However, since no testing was performed on remolded samples, the embankment material was assumed to have the same strength parameters as the in situ foundation materials (conservative assumptions). This assumption resulted in the two selected cross-sections for calculation being very similar to each other and therefore only one typical critical section (D-D') is required for analysis.

Strength Parameters

The foundation soils are in situ alluvium consisting of interlayered sandy and silty clays and clayey silts and classified as ML, CL and CH according to the Unified Soil Classification System. Detailed description of these soils were described in boring logs and the geotechnical investigation report (Ref. 1). The embankment materials will be excavated from the proposed basin and ponds and therefore have the same classification as the foundation soils. The embankment fill will be compacted to 95 percent of maximum dry density as determined from the Standard Proctor Test.

Strength parameter consisting of internal friction angle and cohesion and the unit weight of the soils were obtained using average values from laboratory test results and empirical correlations. Embankment fill materials were conservatively assumed to be the same as those of the foundation materials.

**SLOPE STABILITY FOR QUARRY EQUALIZATION BASIN
AND EFFLUENT PONDS FOR LITTLE FEMME OSAGE CREEK**

The strength parameters used in each case study are shown in Table 1 and in respective cross-sections in Figures 2 through 5. Total strength parameters from consolidated undrained (CU) triaxial shear tests were used for the rapid drawdown and seismic loading cases. Effective strength parameters from the CU tests were used for the steady state cases.

Method of Analyses, Cases Studied and Conclusions

Stability of the slope under various loading conditions was analyzed using the simplified Janbu method of slices. This method applies the limit equilibrium theory and calculates the factor of safety for a mass sliding along a potential circular failure surface. STABL5, a computer program developed by Purdue University for the IBM Personal Computer was used to calculate the factors of safety.

The various loading conditions analyzed, the calculated factors of safety, and the minimum required factor of safety are shown in Table 2. The potential critical sliding surfaces are plotted in Figures 2 through 5.

Two critical cases resulting from flood conditions from the Femme Osage Creek were studied. One case was the rapid drawdown case for exterior slope facing the Little Femme Osage Creek in which the flooding is assumed to cause saturation of the embankment and that receding of water to normal elevation occurs within a short period of time (less than a year). The second case was for the interior pond slope in which the flood water level is at the maximum design flood level and the pond level is empty. A high water level at elevation 470.2 based on the 100-year flood for the Little Osage Creek presented in Horner and Shifrin, Inc., March 1990 hydrological report was used in both cases.

Long term steady state conditions with and without seismic loading were analyzed with the normal creek water at Elevation 459.0 and assuming a horizontal phreatic surface and no seepage loss through the pond liners. Therefore the pond water would have very little effect on the exterior slope stability. A pseudo-static force of 0.1g was used in the seismic case.

It should also be noted that the factor of safety for the end of construction case and other interior pond slope cases were analyzed for similar cross-section in a previous study (Ref. 2) and was found to exceed the minimum required factor of safety. Assumed soil parameters as shown in Table 1 were used (because test results were not available at the time of study). As can be seen from the table, the assumed values agree fairly well with the test results.

**SLOPE STABILITY FOR QUARRY EQUALIZATION BASIN
AND EFFLUENT PONDS FOR LITTLE FEMME OSAGE CREEK**

**TABLE 1
SUMMARY OF SOIL PARAMETERS FOR STABILITY ANALYSES**

Material	Total Stress Parameters for Rapid Drawdown Condition or Seismic Loading Condition			Effective Stress Parameters for Steady-State, Static Condition		
	<u>c (psf)</u>	<u>Ø (deg.)</u>	<u>τ_t (pcf)</u>	<u>c' (psf)</u>	<u>Ø' (deg)</u>	<u>τ_t (pcf)</u>
Engineered Fill ⁽¹⁾	400	14	115	300	25	115
Alluvium Foundation	400	14	115	300	25	115
Previous Study- Assumed Values for Engineered Fill & Alluvium	260-320	17-20	125	250-300	21-23	125

Note (1) Assume same strength parameters as foundation soil.

TABLE 2
FACTORS OF SAFETY FOR DIFFERENT LOADING CONDITIONS

	Calculated Factor of Safety	Minimum Required Factor of Safety (Ref. 3)
Long Term Steady State without Seismic Loading (Crest El. @ 459)	2.36	1.5
Long Term Steady State with Seismic Loading (pseudo-static force, k=0.1g)	1.35	1.1
Rapid Drawdown - Exterior Slope	1.65	1.2
High Flood Condition - Interior Slope (Water El. @ 470.2)	2.65	1.5

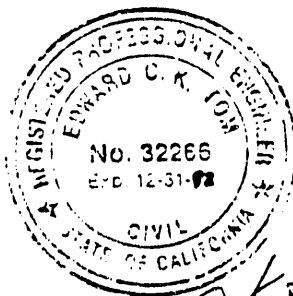
The calculated factors of safety for all cases exceed the minimum required values. The proposed embankment construction will be stable with or without the flood condition.

Erosion and Scouring Potential

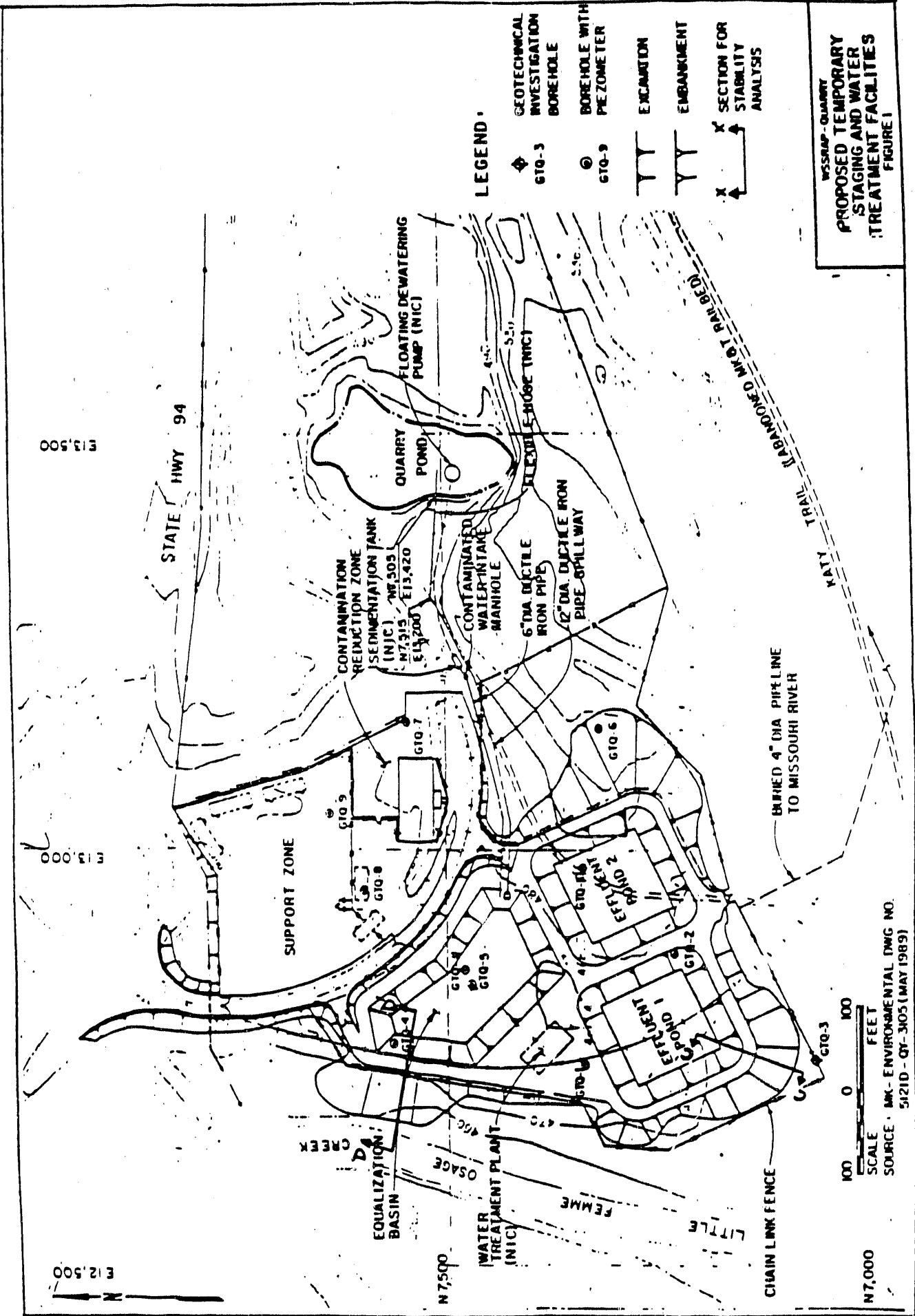
Long term erosion and scouring are not considered to be a problem because of the low water velocity adjacent to the dike not exceeding 1.5 feet per second (Horner and Shifrin Inc., March 1990). This is an acceptable velocity since the slopes will have a hearty grass surfacing due to being sodded after construction.

Attachment A - Summary of Laboratory Test Results

- Reference 1 - M-K Engineers, "WSSRAP Quarry Geotechnical Report, Draft." Rpt. No. 5121R-305-A, 17 November 1989.
- Reference 2 - M-K Engineers Preliminary Calculation, WSSRAP-Quarry, Slope Stability, November 6, 1989
- Reference 3 - U.S. Corp of Engineers "Engineer Manual, Engineering and Design - Stability of Earth and Rockfill Dams," EM 1110-2-1902, 1 April, 1970



Edward C. K. Tom
4/5/90



LEGEND

- ◆ G10-3 GEOTECHNICAL INVESTIGATION BOREHOLE
- ⊙ G10-9 BOREHOLE WITH PEZOMETER
- ⌋ EXCAVATION
- ⌋ EMBANKMENT
- X SECTION FOR STABILITY ANALYSIS

WSSRAP-Quarry
PROPOSED TEMPORARY STAGING AND WATER TREATMENT FACILITIES
 FIGURE 1

E13,500

E13,000

E12,500

STATE HWY 94

SUPPORT ZONE

CONTAMINATION REDUCTION ZONE
 SEDIMENTATION TANK (NIC)
 N7,315 E13,200
 N7,505 E13,420

QUARRY POND

CONTAMINATED WATER INTAKE MANHOLE
 6" DIA. DUCTILE IRON PIPE
 12" DIA. DUCTILE IRON PIPE-SPILLWAY

FLOATING DEWATERING PUMP (NIC)

WATER TREATMENT PLANT (NIC)

EFFLUENT POND 1

EFFLUENT POND 2

LITTLE FEMME

BARRIED 4" DIA. PIPELINE TO MISSOURI RIVER

KATY TRAIL (BARRIRED WITH RAIL BED)

CHAIN LINK FENCE

SCALE
 100 0 100 FEET

SOURCE: MK- ENVIRONMENTAL DWG NO. 5121D-QY-305 (MAY 1989)

N7,000

FIGURE 2

SECTION DD' LONG TERM NORMAL WATER TABLE (2.6.65)

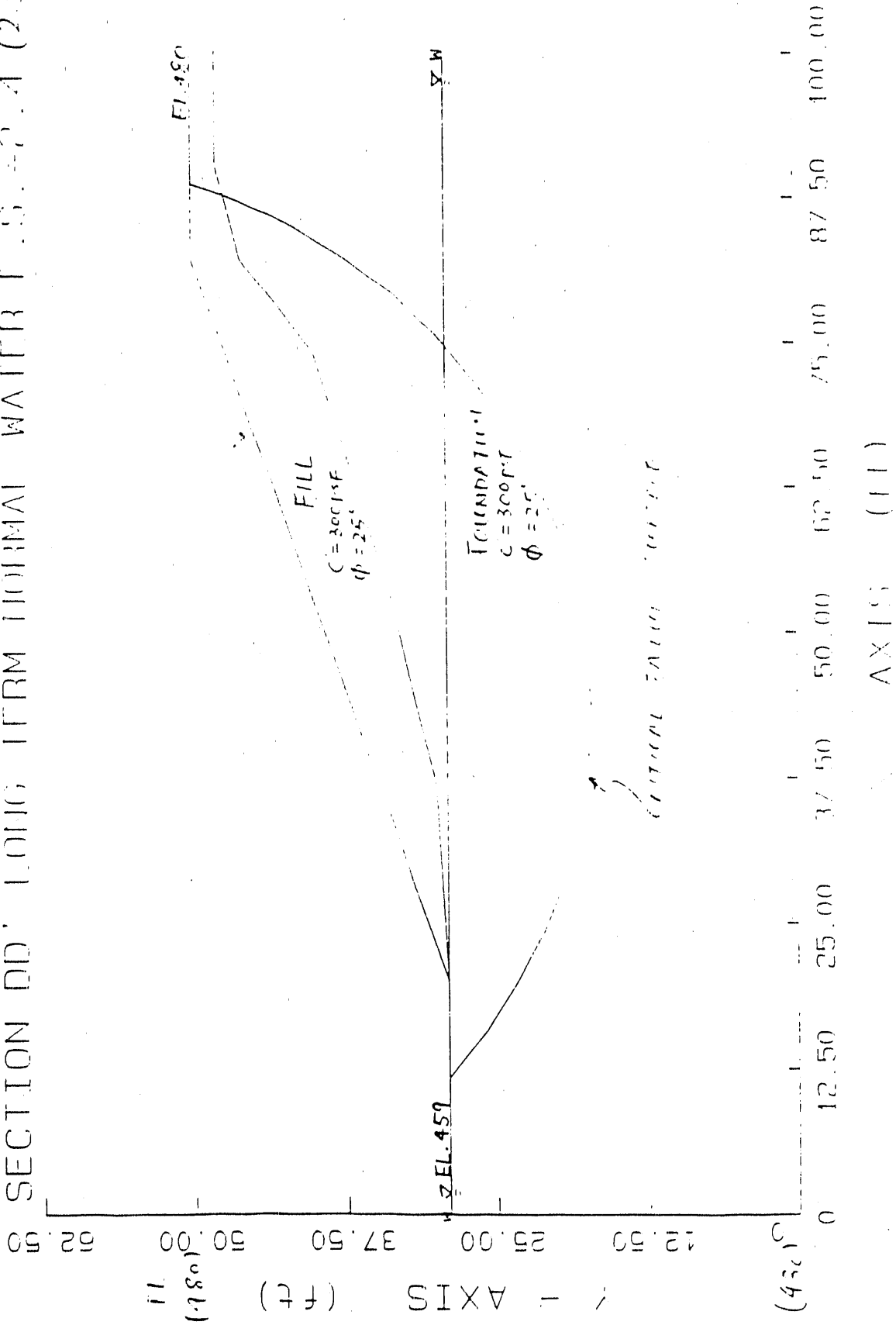
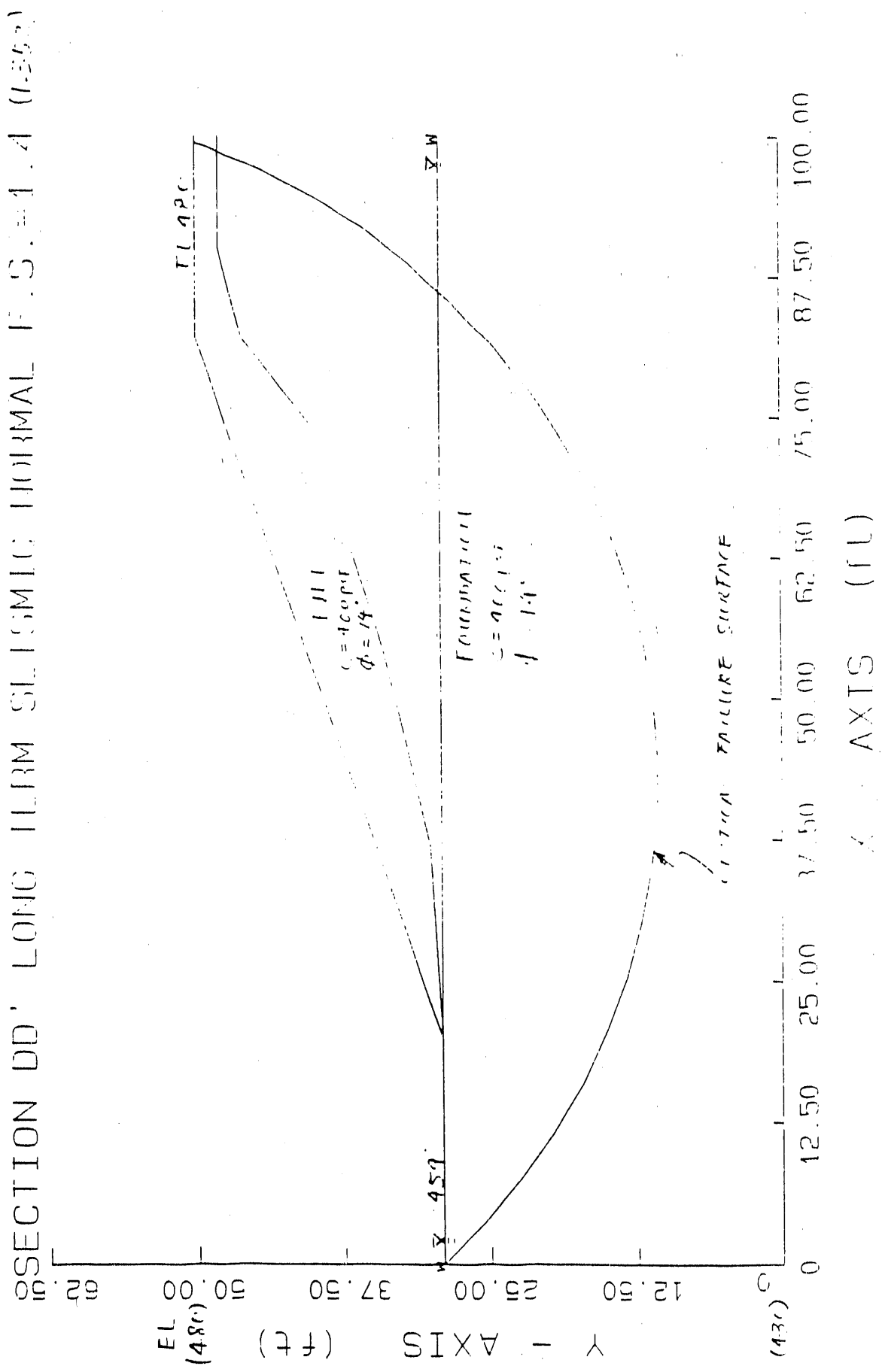


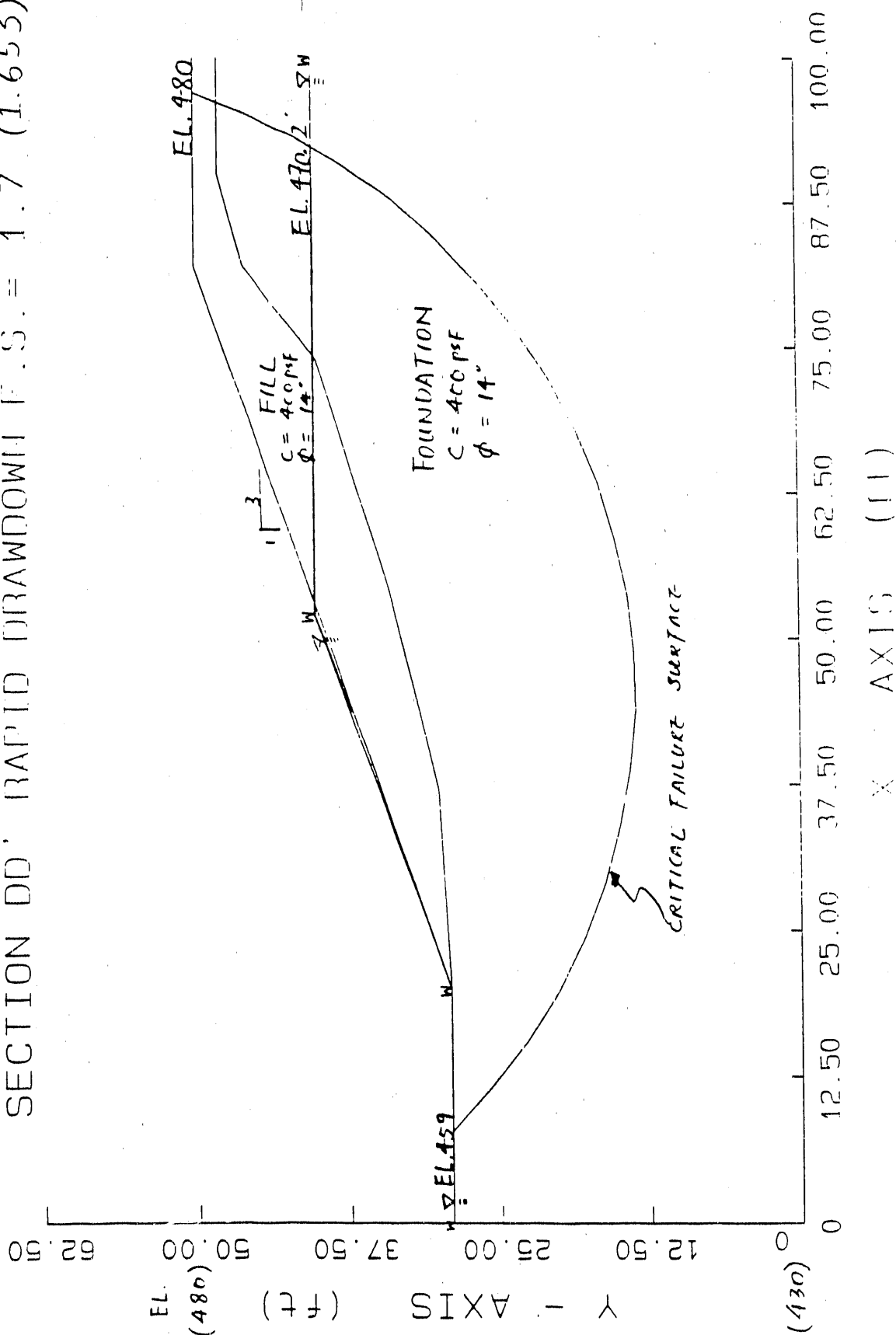
FIGURE 3



YGL 3/29/90
 EL- 4/3/90

FIGURE 4

SECTION DD' RAPID DRAWDOWN F.S. = 1.7 (1.653)

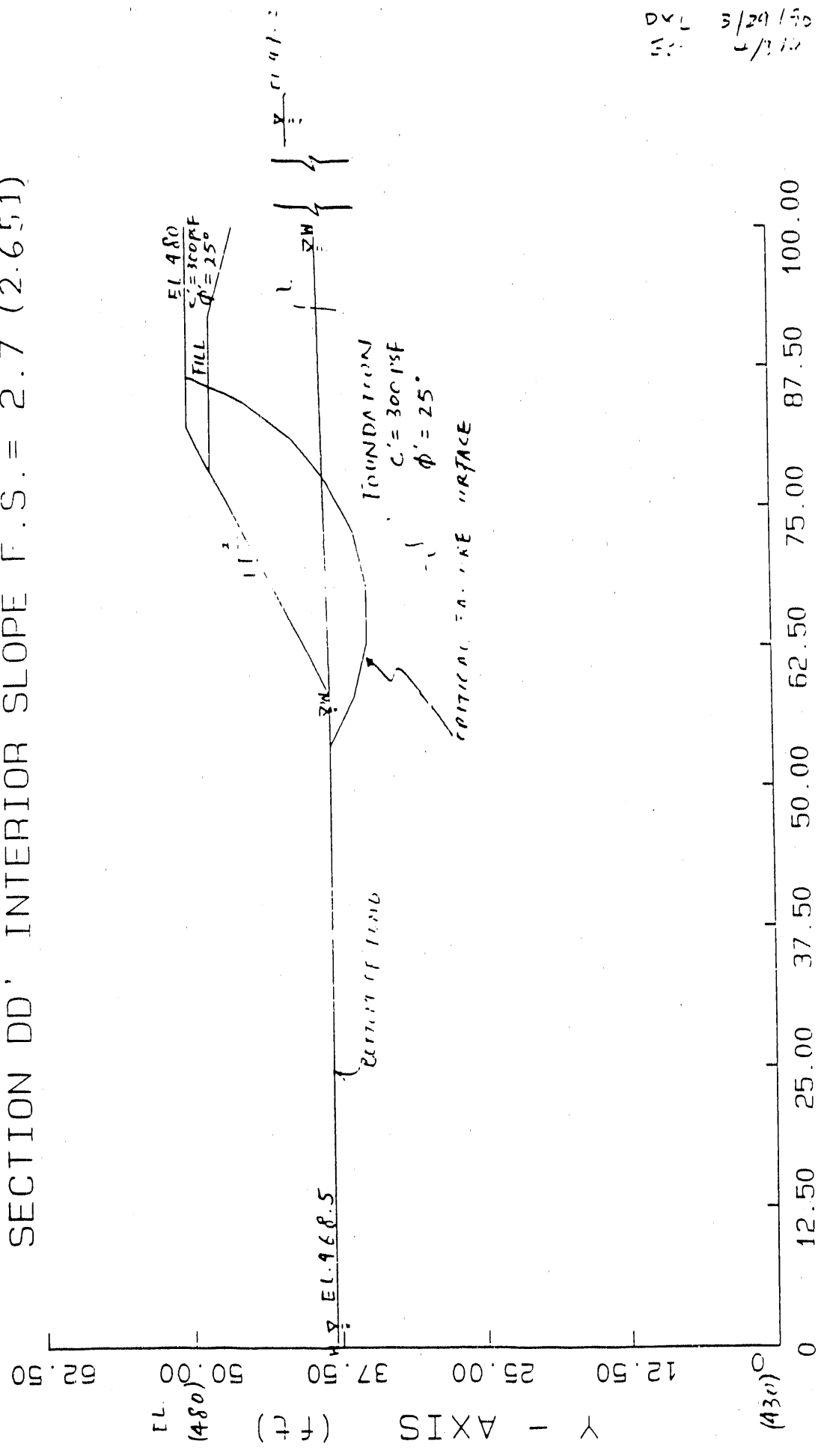


X - AXIS (ft)

DVL 5/29/50
E.S. 2/1/50

FIGURE 5

SECTION DD' INTERIOR SLOPE F.S. = 2.7 (2.65,1)



Summary of Laboratory Test Results

ATTACHMENT A

PV = 1/1000
 = 1/1000

Sheet 18 of 20
 X-11-10-189
 PXL 11/18/19

Boring No.	Sample No.	Unified Soil Class	# of Grains Sand Finer	Atterberg Plasticity Liquid Plasticity (sat) Index	Moisture Content (%)	Dry Density (pcf)	Shear Strength Total Stress (psi) c = 100 psi φ = 20°	Compressibility (cc Cr Pp) (pcf) 0.09 0000	Permeability (cm/sec) Confining Pressure (1 bar) 3.3 bar
B10-1	S102	CL	17	30	10	87	φ = 15° φ = 20°	0.37 0.09 0000	3.0 × 10 ⁻⁷ 3.7 × 10 ⁻⁶
	S104	CH	1	61	35		c = 100 psi c = 100 psi		
	S107	ML/CL	19	61	5		φ = 20° φ = 31°		
	S110	CL/ML	31	24	5		c = 0 psi c = 0 psi		
B10-2	S109	CL	32	40	10	87	φ = 000 psi	0.37 0.09 0000	3.0 × 10 ⁻⁷ 3.7 × 10 ⁻⁶
	S113	CL	2	49	27	85			
	S109	ML	15	87					
	S111	CL	12	88					
B10-3	S106	CH	2	98	81.5		φ = 15° φ = 23°	0.37 0.09 0000	3.0 × 10 ⁻⁷ 3.7 × 10 ⁻⁶
	S102	CH	0	100	10.1	93	c = 200 psi c = 200 psi		
	S107	CH	1	99	40.4	79			
	S108	CH	1	97	29.0	100	(5 × 100 psi)		
B10-4	S102	CH	1	99	37.0	72	φ = 10° φ = 13°	0.37 0.09 0000	3.0 × 10 ⁻⁷ 3.7 × 10 ⁻⁶
	S106	CH	1	99	37.0	72	c = 200 psi c = 200 psi		
	S112	ML	3	97	50.3				
	S115	CH	3	95	63.4	76			
B10-5	S102	CH	1	99	23.0	97	φ = 0.5° φ = 23°	0.37 0.09 0000	3.0 × 10 ⁻⁷ 3.7 × 10 ⁻⁶
	S104	CH	1	99	23.4		c = 1700 psi c = 000 psi		
	S106	ML	6	94	26.9	97	φ = 0.5° φ = 17°		
	S112	CH	27	73	65.0		c = 000 psi c = 000 psi		
B10-6	S102	CH	2	98	35.9	94	φ = 15.5° φ = 15°	0.37 0.09 0000	3.0 × 10 ⁻⁷ 3.7 × 10 ⁻⁶
	S104	CH	2	98	22.6		c = 250 psi c = 50 psi		
	S107	ML/CL	0.5	99.5	37.2	87			
	S109	ML	0.5	99.7	22.0	95			
B10-7	S106	CH	0.5	99.5	31.9	90		0.37 0.09 0000	3.0 × 10 ⁻⁷ 3.7 × 10 ⁻⁶
	S108	CH	0.5	99.5	31.9	90			
	S102	CH	0	100	31.6	93			
	S106	CH	6.5	93.5	29.4	88			
B10-8	S102	CH	0	100	21.7	91		0.37 0.09 0000	3.0 × 10 ⁻⁷ 3.7 × 10 ⁻⁶
	S106	CH	0.5	93.5	21.7	91			
	S111	CL	36	15	20.5	90			
	S102	CH	0	100	20.3	91			
B10-9	S106	CH	2	98	33.3	91		0.37 0.09 0000	3.0 × 10 ⁻⁷ 3.7 × 10 ⁻⁶
	S111	CL	31	23	20.5	90			
	S102	CH	0	100	20.3	91			
	S106	CH	0.5	99.5	20.5	90			

φ = 14° / φ = 25°
 c = 435 c' = 310
 Say Hard

AVG 32 89

From Ref

END

DATE FILMED

01 / 25 / 91

