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Sandia National Laboratories

Sandia National Laboratories, New Mexico Environmental Restoration Operations

Installation of Groundwater Monitoring Wells TAV-MW15 and TAV-MW16

May 2017

U.S. DEPARTMENT OF ENERGY

United States Department of Energy
Sandia Field Office

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA-0003525.

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TABLE OF CONTENTS

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LIST OF FIGURES

Figure

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LIST OF TABLES

Table

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LIST OF APPENDICES

Appendix

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ACRONYMS AND ABBREVIATIONS

°C	degree(s) Celsius
µmhos	micromhos
ARCH	Air rotary casing hammer
ARDH	Air rotary downhole hammer
ARG	Ancestral Rio Grande
bgs	below ground surface
btoc	below top of casing
cm	centimeter
CSS	Colorado Silica Sand
ER	Environmental Restoration
FOP	Field Operating Procedure
ft	feet or foot
gal	gallon(s)
HWB	Hazardous Waste Bureau
ID	inside diameter
MW	monitoring well
NMED	New Mexico Environment Department
NMOSE	New Mexico Office of the State Engineer
NTU	nephelometric turbidity unit(s)
OD	outside diameter
pH	potential of hydrogen
POD	point of diversion
PVC	polyvinyl chloride
SNL/NM	Sandia National Laboratories, New Mexico
TA-V	Technical Area V
TAV	Technical Area V (well designation only)
TAVG	Technical Area V Groundwater
TD	total depth
Temp.	temperature
Work Plan	*Revised Treatability Study Work Plan for In-Situ Bioremediation at the Technical Area-V Groundwater Area of Concern*

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1.0 INTRODUCTION

This report documents the installation of two groundwater monitoring wells at the Technical Area V Groundwater (TAVG) Area of Concern at Sandia National Laboratories, New Mexico (SNL/NM). SNL/NM is managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA-0003525.

Well installation activities were conducted in accordance with the New Mexico Environment Department (NMED) Hazardous Waste Bureau (HWB)-approved work plan *Revised Treatability Study Work Plan for In-Situ Bioremediation at the Technical Area-V Groundwater Area of Concern* (Work Plan) (SNL/NM March 2016). The Work Plan was approved by NMED HWB prior to the start of field work (NMED May 2016).

Project activities were performed from November 2016 through January 2017 by SNL/NM Environmental Restoration (ER) Operations personnel, and the SNL/NM drilling contractor Cascade Drilling LP. Drilling activities began with borehole drilling and sampling on November 30, 2016. Well construction and development fieldwork was completed on January 31, 2017. Land surveys to establish the location coordinates and elevations of the two wells were completed on March 23, 2017, and transmitted to SNL/NM personnel on April 17, 2017.

1.1 Project Objectives

The objectives of the field program were to install and develop two TAVG monitoring wells TAV-MW15, and TAV-MW16. The Work Plan (SNL/NM March 2016) specified that the wells be installed south of the Technical Area V (TA-V) boundary (Figure 1-1). The purpose of the wells was to define the extent of trichloroethylene and nitrate concentrations, and the potentiometric surface along the southern boundary.

Monitoring well TAV-MW15 was installed on December 19, 2016 through January 10 2017. Monitoring well TAV-MW16 was installed on November 29 through December 19, 2016. (Table 1-1).

Table 1-1
Summary of Primary Field Activities Conducted during November 2016 to January 2017

Well	Type of Monitoring Well	Casing TD (ft bgs)	Primary Field Activity
TAV-MW15	Groundwater, PVC	546	Well Installation, Land Surveying
TAV-MW16	Groundwater, PVC	557	Well Installation, Land Surveying

bgs = Below ground surface.
ft = Feet.
MW = Monitoring Well.
PVC = Polyvinyl chloride.
TAV = Technical Area-V
TD = Total Depth.

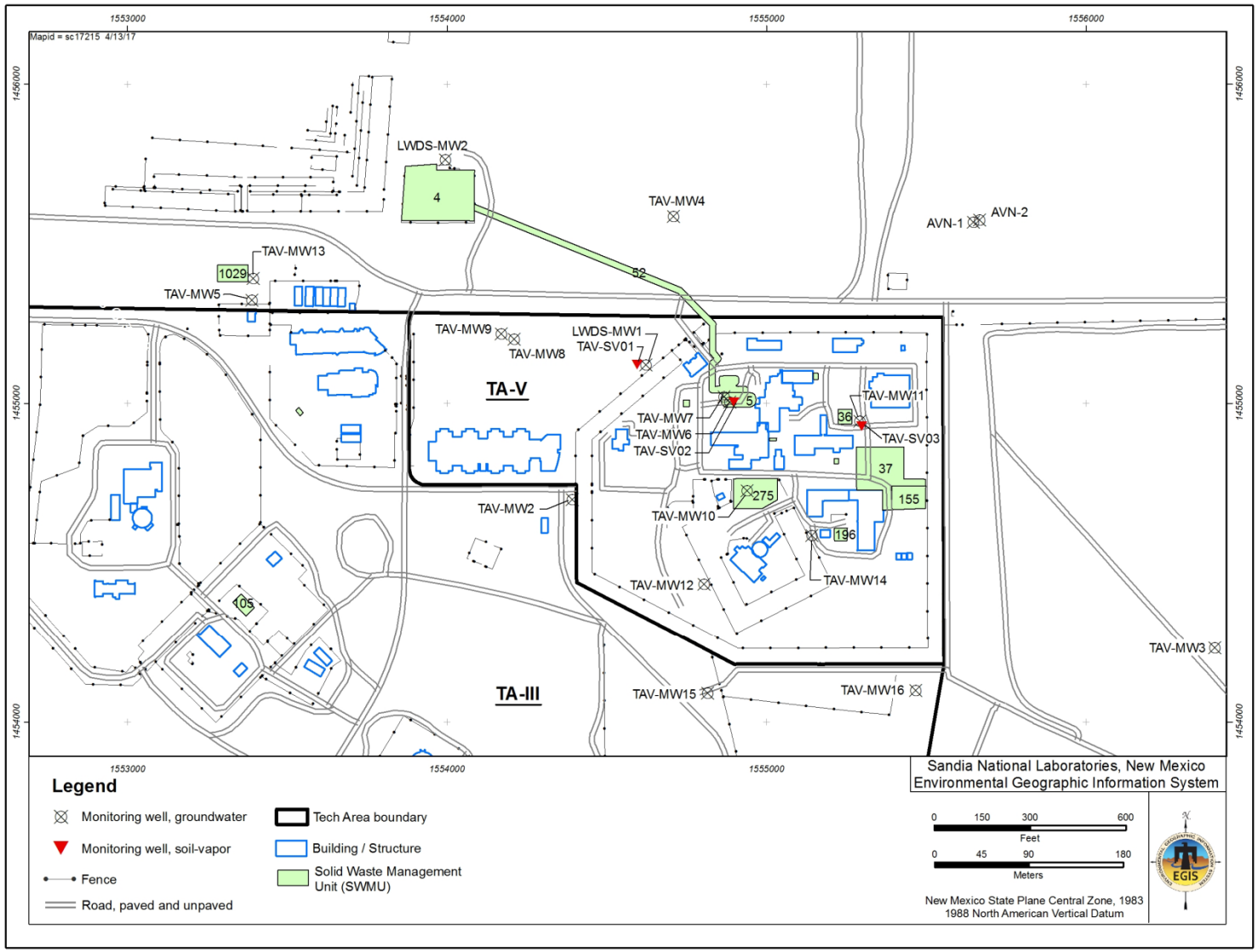

Figure 1-1
Location Map of Monitoring Wells at the Technical Area V Groundwater Area of Concern

1.2 Report Organization

This report is organized by field activity:

- Chapter 2.0 describes the drilling activities including drilling, well installing, and well development.
- Chapter 3.0 describes the construction of the concrete pad and well heads.
- Chapter 4.0 describes the land surveying of elevations and coordinates.
- Chapter 5.0 lists the variances from the Work Plan.
- Chapter 6.0 lists the references cited in this report.

The following appendices provide supplemental information:

- Appendix A provides the lithologic logs.
- Appendix B provides photographs of the lithologic cuttings.
- Appendix C provides the photographs of the core samples.
- Appendix D contains the well construction data sheets.
- Appendix E presents the well construction diagrams.
- Appendix F provides the well development forms.

This report satisfies reporting requirements for both the NMED HWB and the New Mexico Office of the State Engineer (NMOSE) as described in the Work Plan (SNL/NM March 2016). The Compliance Order on Consent (NMED April 2004) also specifies 27 reporting elements for the installation of a monitoring well. The NMOSE requirements and guidance are provided in “Rules and Regulations Governing Well Driller Licensing; Construction, Repair, and Plugging of Wells” (NMOSE August 2005). The two new wells are permitted by NMOSE as Point of Diversion (POD) 126 (TAV-MW15) and POD 127 (TAV-MW16) of Permit File RG-900065 (NMOSE July 2016a, NMOSE July 2016b).

Additional field documentation consisting of pages from the field logbook and safety records are on file at the Sandia Records Center.

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2.0 MONITORING WELL DRILLING, INSTALLATION, AND DEVELOPMENT

All drilling and monitoring well installation operations were performed by Cascade Drilling LP, and supervised by SNL/NM ER Operations personnel. The boreholes for monitoring wells TAV-MW15 and TAV-MW16 (Figure 1-1) were drilled using the air-rotary casing hammer (ARCH) method with a Speedstar 50K drilling rig and associated equipment. Continuous coring samples were collected using an air rotary downhole hammer (ARDH) from approximately 10 feet above the static water table to the boreholes total depth (TD).

Applicable Sandia Field Operating Procedures (FOPs) and Administrative Operating Procedure are listed in Table 2-1. The most current version of the procedure was used.

Table 1-1
Applicable Sandia National Laboratories, New Mexico Procedures

Procedure Number	Procedure Title
FOP 05-04	Groundwater Monitoring Waste Management
FOP 12-11	Drilling Methods, Designing, and Installing Groundwater Monitoring Wells
FOP 94-01	Safety Meetings, Inspections, and Pre-Entry Briefings
FOP 94-05	Borehole Lithologic Logging
FOP 94-25	Documentation of Field Activities
FOP 94-41	Well Development
FOP 94-57	Decontaminating Drilling and Associated Field Equipment
AOP 08-05	Monitoring Well Installation, Decommissioning, and Planning

The following sections describe the borehole drilling and well construction activities.

2.1 Monitoring Well Drilling and Installation

The drilling equipment (i.e., rig, bits, collars, pipe, and drive casing) was decontaminated with a high-pressure water sprayer (steam cleaner) prior to the start of drilling operations. Decontamination was done at the Environmental Resources Field Operations decontamination pad in Technical Area III.

The first 200 feet of each borehole was advanced with a tricone bit, and 11.75-inch outside diameter (OD) drive casing was advanced to keep the alluvium from sloughing into the borehole. From 200 feet below ground surface (bgs) to TD the bit and casing was changed to an 8.5 inch tricone bit, and 9.625-inch OD drive casing.

The lithologic descriptions are based upon drill cuttings collected at the cyclone air discharge port, and are provided in Appendix A. Photographs of the collected lithologic cuttings are provided in Appendix B. The lithology for both boreholes consisted primarily of unconsolidated uniform fine grained sand, with intermittent gravel layers. Near the water table the lithology became more varied, and layers of cemented fine grained sand, Ancestral Rio Grande (ARG) sediments, and clay rich zones were encountered. A photograph and description of the ARG sample from TAV-MW15 is provided in Appendix C, Figure C-6.

Five samples of continuous core were collected at both boreholes, from approximately 10 feet above the static water table to TD. The core was obtained with ARDH drill that advanced a 5-foot long, 4-inch diameter acetate lined core barrel. One hundred percent of the core was consistently recovered (Tables 2-1 and 2-2). Core samples less than 5 feet long were due to refusal (it was not possible continue coring). After the core samples had been collected ARCH drilling resumed advancing the borehole. All core samples were photographed in their entirety (Appendix C) before segments were removed for laboratory analysis. The remaining core was sealed and stored at the ER Field Office. The core will be stored for at least six months as specified in the Work Plan (SNL/NM March 2016).

All well materials were installed through the temporary steel drive casing. The well annulus above the screen was grouted to the surface. The well was constructed of nominal 5-inch (inside diameter of 4.767 inches and OD of 5.563 inches), Schedule 80 polyvinyl chloride (PVC), flush-threaded, blank casing and 25-foot 0.020-inch slot, Schedule 80 PVC screen. The sump consisted of a 5-foot length of Schedule 80 PVC, flush treaded, blank casing with a threaded bottom cap.

Table 2-2
Depth of Continuous Core Samples Collected from TAV-MW15

Core Run	Anticipated Depth to Water (ft bgs)	Cored Interval (ft bgs)	Core Recovery
1		510 – 515	100%
2	519	515 – 519	100%
3		520 – 525	100%
4		525 – 529	100%
5		530 – 535	100%

bgs = Below ground surface.
ft = Feet.

Table 2-3
Depth of Continuous Core Samples Collected from TAV-MW16

Core Run	Anticipated Depth to Water (ft bgs)	Cored Interval (ft bgs)	Core Recovery
1		520 – 525	100%
2		525 – 530	100%
3	535	530 – 535	100%
4		535 – 540	100%
5		540 – 543	100%

bgs = Below ground surface.
ft = Feet.

The threaded bottom cap contained a solid 5-inch long PVC plug placed in the bottom of the sump to reduce the possibility of dislodging the end cap during future well development and sampling activities. PVC centralizers were placed above and below the screen section, and at 100-foot intervals on the blank casing. A summary of the well construction is provided by the well construction data sheets in Appendix D, and Well Construction Diagrams in Appendix E.

Colorado Silica Sand (CSS) (# 10-20) was used as the primary sand pack in the annulus around the screen and extended approximately 5 feet above the top of the screen. A 5-foot thick secondary sand pack using No. 60 CSS was placed above the primary sand pack. A 30-foot thick bentonite chip plug consisting of 3/8-inch Holeplug™ bentonite chips was placed above the secondary filter pack. The chips were hydrated with approximately 50 gallons of water, and the plug was allowed to set (hydrate) before the first lift of bentonite grout was pumped into the well annulus with a hose.

Bentonite grout (consisting of Quik Grout™ granulated bentonite and water) was used to fill the remainder of the well annulus to the surface. The first lift of approximately 100 feet of grout (consisting of ten 50-pound bags of Quik Grout™ plus 300 gallons of water) was pumped into the well annulus with a hose and allowed to set for 24 hours. The subsequent lifts of grout were then pumped into the annulus with a hose in approximate 100-foot lifts until the annulus was filled to the surface. A one hour hold time was observed between the installation of each 100-foot layer of bentonite grout.

While drilling and installing well materials, environmentally sensitive protocols were used to ensure that each monitoring well would produce representative groundwater samples of the water-bearing zone. For example, two vegetable-based compounds, manufactured by Matex Chemical Control, were used. “ES Thread Compound” was used on the drive-casing and drill-pipe threads. The casing hammer and the downhole hammer used “RDO 302 ES Hammer Oil.” Drilling waste, including vadose zone and saturated zone cuttings, was disposed of according to applicable state and federal regulations, as specified in the project-specific waste management plan (SNL/NM October 2016).

2.1.1 Drilling and Installation of Monitoring Well TAV-MW15

The borehole for monitoring well TAV-MW15 was spudded in alluvium southwest of TA-V in Technical Area III (Figure 1-1 and Figure 2-1). Drilling progressed primarily through damp uniform fine grained sand, with intermittent layers of gravels and cobbles (Appendices A and B). The gravels and cobbles were predominantly composed of sub-angular to sub-rounded limestone with occasional quartzite fragments.

Approximately 10 feet above the anticipated water level a 5-foot long and 4-inch diameter continuous core was collected, and coring continued until TD was reached. The anticipated water level was interpolated from the Annual Groundwater Monitoring Report, Plate 1 *SNL/NM Monitoring Well Locations and Base-Wide Potentiometric Surface Map of the Regional Aquifer for the Kirtland Air Force Base Vicinity July 2015* (SNL/NM June 2016). As shown in Table 2-1, five core samples were collected from 510 to 535 ft bgs, and photos of the continuous core samples are provided in Appendix C. After the core samples were collected, ARCH drilling resumed to advance the borehole. During drilling and development the depth to water was relatively constant at approximately 517.5 ft bgs.

The top of the well screen for monitoring well TAV-MW15 was set in alluvial sediments at 516 ft bgs, and was located approximately 2 ft above the static water level. CSS #10-20 sand was installed from 511 to 550 ft bgs. A bailer was used to settle the primary sand pack, and then CSS #60 sand was installed from 506 to 511 ft bgs. A bentonite chip seal of 3/8-inch Baroid Holeplug ® was placed from 476 to 506 ft bgs. Baroid Quik-Grout®) was installed from 476 to approximately 20 ft bgs. Quickrete ® concrete was then installed from 20 ft bgs to the ground surface.

2.1.2 Drilling and Installation of Monitoring Well TAV-MW16

The borehole for monitoring well TAV-W16 was spudded in alluvium southeast of TA-V (Figure 1-1 and Figure 2-2). Drilling progressed primarily through damp uniform fine grained sand, with intermittent layers of gravels and cobbles. The gravels and cobbles were predominantly composed of sub-angular to sub-rounded limestone with occasional quartzite fragments (Appendices A and B).

Figure 2-1
Drill Rig and Air Compressor at the Location of Monitoring Well TAV-MW15 at the Technical Area V Groundwater Area of Concern. (View to the northwest, December 19, 2016)

Figure 2-2
Drill Rig, Pipe Truck, and Air Compressor, at the Location of Monitoring Well TAV-MW16 at the Technical Area V Groundwater Area of Concern. (View to the west, December 1, 2016.)

Approximately 10 feet above the anticipated water level, 5-foot long and 4-inch diameter continuous core samples were collected until TD was reached. As shown in Table 2-2, five core samples were collected from 520 to 543 ft bgs, and photos of the continuous core samples are provided in Appendix C. After the core samples were collected ARCH drilling was used to advance the borehole. During drilling and development, the depth to water was relatively constant at approximately 528.5 ft bgs.

The top of the well screen for monitoring well TAV-MW16 was set in alluvial sediments at 527 ft bgs, and was located approximately 2 ft above the static water level. CSS #10-20 sand was installed from 522 to 563 ft bgs. A bailer was used to settle the primary sand pack, and then CSS #60 sand was installed from 517 to 522 ft bgs. A bentonite chip seal of 3/8-inch Baroid Holeplug ® was placed from 487 to 517 ft bgs. Baroid Quik-Grout® was installed from 487 to approximately 25 ft bgs. Bentonite 3/8-inch chips were installed and hydrated from 16 to 25 ft bgs. Quickrete ® concrete was then installed from 16 ft bgs to the ground surface.

2.2 Well Development

Monitoring well TAV-MW15 was developed on January 17 and 18, 2017, and TAV-MW16 was developed on January 11 and 12, 2017. The development work followed the standard practice to remove sediment and fine-sized particles from the well sump and screen slots. Work was conducted using a development (pump hoist) rig operated by Cascade Drilling LP. Water produced during well development was disposed of according to applicable state and federal regulations, as specified in the project specific waste management plan (SNL/NM October 2016).

The Well Development FOP 94-41, Revision 2, (SNL/NM July 2016) and the Work Plan (SNL/NM March 2016) defined the well-development steps and objectives. Five saturated wellbore volumes is the minimum volume of water required to be removed from a monitoring well when the borehole was drilled without the use of drilling mud. The FOP defines the adequacy of well development at the point where the minimum wellbore volume has been removed, and representative groundwater is obtained.

Representative groundwater is indicated when potential of hydrogen (pH), temperature, and specific conductivity measurements are within 10 percent for 3 consecutive wellbore volumes, and the water is visibly clear of suspended solids with a turbidity of less than 5 nephelometric turbidity units (NTU).

Calculation of a wellbore volume takes into consideration the groundwater contained in the well screen and the groundwater present in the adjacent saturated sand pack. The sand pack is assumed to have a porosity of 30 percent. The calculated wellbore volume for monitoring wells TAV-MW15 and TAV-MW16 was 46 gallons at the time of development.

2.2.1 Well Development at Monitoring Well TAV-MW15

Well development began with an aluminum bailer operated on a winch line. The first 2.5 gallon bail contained approximately 50 percent mud and sediment, and the remainder was muddy water. Approximately 30 gallons of muddy sediment and muddy water was bailed, and became progressively cleaner. When bailing started, there was approximately 3 feet of sediment in the borehole sump from 543 to 546 ft bgs. The 4-inch diameter bailer passed freely inside the

casing indicating that the casing and screen were not significantly bent or crooked. A swab was then used to agitate water in and out of the screen slots. Bailing then resumed, and the recovered water was muddy with a little sediment settling out. The majority of the sediment remained suspended in the water. A total of 15 gallons of slightly cloudy water was bailed after swabbing. An electrical submersible pump was then installed using 21-ft lengths of 1 inch galvanized pipe. The bottom of the pump was set just above the flush threaded end cap at the bottom of the casing. Approximately 25 gallons of cloudy water was pumped. Pumping stopped and water in the 1 inch pipe was allowed to flow down the wellbore to surge and clean out the bottom of the casing. Pumping then resumed, and as summarized in Table 2-3 and documented on the field forms (Appendix F), approximately 345 gallons (7.5 wellbores) of groundwater was pumped and geochemical parameters were measured for each wellbore volume. The combined (bailed and pumped) purge volume was 390 gallons, which is equivalent to approximately 8.5 wellbore volumes.

Table 2-4
Summary of Water Quality Parameters Measured During the Pumping Phase of Well Development at Monitoring Well TAV-MW15

Date	Time	Groundwater Volume (gal.)	Wellbore Volumes, (approx.)	Temp. (°C)	Specific Conductivity (µmhos/cm)	pH	Turbidity (NTU)
01/18/17	13:51	325	7.1	21.247	785.1	7.32	108.05
01/18/17	13:59	335	7.3	21.386	790.8	7.34	62.35
01/18/17	14:06	350	7.6	21.171	787.4	7.35	48.63
01/18/17	14:10	355	7.7	21.199	786.7	7.35	106.08
01/18/17	14:14	360	7.8	21.075	785.8	7.34	61.32
01/18/17	14:22	370	8.0	21.403	793.2	7.34	44.59
01/18/17	14:26	375	8.2	21.704	806.2	7.33	41.20
01/18/17	14:30	380	8.3	22.157	811.7	7.33	5.36
01/18/17	14:33	385	8.4	22.259	811.5	7.32	3.22
01/18/17	14:36	390	8.5	22.252	809.3	7.32	4.52

approx. = Approximate.
°C = Degree(s) Celsius.
cm = centimeter.
gal. = Gallons.
µmhos = Micromhos.
MW = Monitoring well.
NTU = Nephelometric turbidity unit(s).
pH = Potential of hydrogen.
TAV = Technical Area V
Temp. = Temperature.

All measured water quality parameters showed less variability than specified in the Work Plan (SNL/NM March 2016). Representative groundwater samples are expected to be collected from the monitoring well in future sampling events. The final turbidity measurement was 4.52 NTU and the groundwater was visibly clear.

2.2.2 Well Development at Monitoring Well TAV-MW16

Well development began using an aluminum bailer operated on a winch line. Approximately 20 gallons of moderately cloudy water and a minor amount of fine grained sand settled out. The water became progressively clearer as bailing progressed. The 4-inch diameter bailer passed freely inside the casing indicating that the casing and screen were not significantly bent or crooked. A swab was used to agitate water in and out of the screen slots. Bailing resumed, and the water from the first bail was cloudy, and ¼ inch of fine grained sand was deposited. A total of 24 gallons of slightly cloudy water was bailed after swabbing. An electrical submersible pump was then installed using 21-ft lengths of 1 inch galvanized pipe. The bottom of the pump was set just above the flush threaded end cap at the bottom of the wellbore. As summarized in Table 2-4 and documented on the field forms (Appendix F), approximately 285 gallons (6.3 wellbores) of groundwater was pumped and geochemical parameters were measured for each wellbore volume. The combined (bailed and pumped) purge volume was 330 gallons, which is equivalent to approximately 7.3 wellbore volumes.

Table 2-5
Summary of Water Quality Parameters Measured During the Pumping Phase of Well Development at Monitoring Well TAV-MW16

Date	Time	Groundwater Volume (gal.)	Wellbore Volumes, (approx.)	Temp. (°C)	Specific Conductivity (µmhos/cm)	pH	Turbidity (NTU)
01/12/17	14:22	285	6.3	22.507	889.7	7.24	33.80
01/12/17	14:27	290	6.4	22.301	884.2	7.25	27.24
01/12/17	14:32	295	6.6	22.283	878.7	7.25	24.38
01/12/17	14:37	300	6.7	22.088	874.7	7.26	23.31
01/12/17	14:43	305	6.8	22.038	878.4	7.26	25.26
01/12/17	14:48	310	6.9	21.920	876.1	7.27	18.60
01/12/17	14:54	315	7.0	22.239	882.8	7.26	9.62
01/12/17	14:59	320	7.1	22.841	874.2	7.26	5.79
01/12/17	15:04	325	7.2	23.033	895.4	7.26	4.01
01/12/17	15:10	330	7.3	23.438	889.0	7.25	3.74

approx. = Approximate.
°C = Degree(s) Celsius.
cm = centimeter
gal. = Gallons.
µmhos = Micromhos
MW = Monitoring well.
NTU = Nephelometric turbidity unit(s).
pH = Potential of hydrogen.
TAV = Technical Area V
Temp. = Temperature.

All measured water quality parameters showed less variability than the requirements specified in the Work Plan (SNL/NM March 2016). Representative groundwater samples are expected to be collected from the monitoring well in future sampling events. The final turbidity measurement was 3.74 NTU and the groundwater was visibly clear.

3.0 CONSTRUCTION OF CONCRETE PADS

As a protective measure, concrete pads were built for the two new monitoring wells.

3.1 Concrete Pads for New Monitoring Wells TAV-MW15 and TAV-MW16

A concrete well pad, stovepipe (10-inch inside diameter [ID] steel protective casing), and bollards (3-inch diameter steel guard posts) were used to complete the two new monitoring wells TAV-MW15 and TAV-MW16. The stovepipes were capped with aluminum locking covers, and Torquer® T5 plastic well caps were installed on the top of each PVC casing. Concrete pads 4-ft by 4-ft square, and approximately 6 inches thick were installed with a gentle slope to direct precipitation away from the stovepipes. A brass marker stamped with the well identification number was placed on the surface of each concrete pad. A sign listing contact information was attached to each stovepipe. Three bollards were placed around each concrete pad. The bollards and stovepipes were painted high-visibility yellow.

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4.0 LAND SURVEYING

Land surveying was conducted on March 25, 2017 to determine northing and easting coordinates and precision elevations (vertical accuracy of 0.01 ft) for the two monitoring wells. Donald Cordova of Survey Control Inc. performed the work that was overseen by New Mexico-registered surveyor, Stephen Toler of Surveying Control Inc. The coordinates and elevations are listed on Table 4-1 and on the well construction diagrams (Appendix E). The northing and easting coordinates are provided in New Mexico Central Zone State Plane coordinates based upon the North American Datum of 1983. The elevations are based upon the North American Vertical Datum of 1988. The top of the PVC casing elevation is the measuring point that will be used for subsequent water level measurements.

Table 4-1
Survey Coordinates and Elevations for Monitoring Wells TAV-MW15 and TAV-MW16

Well	Easting, X	Northing, Y	Ground Surface Elevation (ft amsl)	Top of PVC Casing Elevation (ft amsl)
TAV-MW15	1,554,816.10	1,454,085.45	5,435.1	5,437.3
TAV-MW16	1,555,468.68	1,454,093.47	5,446.1	5,448.3

amsl = Above mean sea level.
ft = Feet.
MW = Monitoring Well.
PVC = Polyvinyl chloride.
TAV = Technical Area V.

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5.0 VARIANCES FROM THE WORK PLAN

There were no variances (significant deviations) from the requirements as specified in the Work Plan (SNL/NM March 2016).

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6.0 REFERENCES

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NMED, see New Mexico Environment Department.

NMOSE, see New Mexico Office of the State Engineer.

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SNL/NM, see Sandia National Laboratories/New Mexico.

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APPENDIX A
Lithologic Logs for Monitoring Wells
TAV-MW15 and TAV-MW16

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-MW15	
BORING NUMBER: —	COORDINATES: -106.535832 34.996356	DATE: Dec. 19, 2016
ELEVATION —	GWL: Depth Date/Time	DATE STARTED: —
ENGINEER/GEOLOGIST: LWM	Depth Date/Time	DATE COMPLETED: —
DRILLING METHOD Arch.		PAGE: 1 OF 4

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
20'				5-10 ft med-small gravel hard ground. <consolidation?> sub angular to subrounded. mostly limestone & qtzite			
			→	20' uniform fine grained sand w/ few pieces of gravel mostly limestone & qtzite. Color of sand is moderate yellowish brown 10YR 5/4. Slightly wet.			
				25-30' very hard ground.			
40'			→	40' large-med subrounded-subang. gravels. Mostly limestone. @ 40' transitioned to mostly fine grained uniform sand - moderate yellowish brown 10YR 5/4 slightly wet. occasional gravel obs, could be remnants from hard ground @ 25-30'			Gravels 2"-1" in size.
				50-ft hard ground.			
60'				Uniform fine grained sand, moderately yellowish brown 10YR 5/4, slightly moist. Large-med cobbles and gravels 2"-1" subangular to subrounded, mostly limestone.			
				65-75' Hard ground. gravels ½-⅛" mostly limestone, some qtzite. subangular to subrounded.			

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-MW15	
BORING NUMBER:	COORDINATES:	DATE: Dec. 19, 2016.
ELEVATION	GWL: Depth Date/Time	DATE STARTED: —
ENGINEER/GEOLOGIST: LCM	Depth Date/Time	DATE COMPLETED: —
DRILLING METHOD Aircts		PAGE: 2 OF 4

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
80'				At 80 cuttings returned to predominantly uniform fine grained sand. Moderately yellowish brown 10YR 5/4, slightly moist. Occassional med ¾-½" subrounded gravel. limestone.			
100'				Dominantly large-medium cobbles and gravels 2-½", subangular to subrounded limestone. Hammer penetrated relatively easy, and not much chatter on drill. 10-20% fine grained sand. w/ color of moderate yellowish brown. 10YR 5/4.			
120'				Similar to 80'. Predominantly. fine grained sand, moderately yellowish brown 10YR 5/4, slightly moist. Contains 5-10% gravels 1-½" in size, subangular to subrounded mostly limestone.			

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-MW15	
BORING NUMBER:	COORDINATES:	DATE: Dec. 19, 2016.
ELEVATION	GWL: Depth Date/Time	DATE STARTED: —
ENGINEER/GEOLOGIST: Lum	Depth Date/Time	DATE COMPLETED: —
DRILLING METHOD Arcts		PAGE: 3 OF 4

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
140'				Uniform fine grained sand, color has lightened to Dark Yellowish orange 10YR 6/6. moisture content has decreased and is drier. too. Few pieces of gravel ½-¼" size, subangular to subrounded limestones. Penetration rate of hammer has slowed since 100', gravel zone may be dragging on casing. Since 100+ has been dominantly fine grained sand.			Drier samples due to greater depth? or in situ variations.
160			160'	Uniform fine grained sand, color is dark yellowish orange 10YR 6/6. 5-10% cobbles and gravels, broken pieces, or subangular to subrounded. mostly limestone			
180				Uniform fine grained sand, color is dark yellowish orange 10YR 6/6 5-10% gravels, subrounded, limestone.			

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-MW15	
BORING NUMBER:	COORDINATES:	DATE: Dec. 19, 2016.
ELEVATION	GWL: Depth Date/Time	DATE STARTED: Dec 19, 2016
ENGINEER/GEOLOGIST: Lum	Depth Date/Time	DATE COMPLETED: Dec 20, 2016
DRILLING METHOD Arch.		PAGE: 4 OF 4

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
200'				Uniform fine grained sand, color is dark yellowish orange 10YR 6/6 5-10% gravels 1-½, subrounded limestones.			Dec. 19, 2016
220'				Uniform fine grained sand. color is moderate yellowish brown 10YR 5/4.			Dec. 20, 2016 ↓
				235' - nit gravel layer med-to small pebbles ½-⅛", mostly limestone, few qtzite.			
240				Same as 220 w/ residue of gravel layer from 235- 5-10%.			

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-LWLS	
BORING NUMBER: —	COORDINATES: —	DATE: Dec. 20, 2016
ELEVATION —	GWL: Depth Date/Time	DATE STARTED:
ENGINEER/GEOLOGIST: Lum	Depth Date/Time	DATE COMPLETED:
DRILLING METHOD ARctt.		PAGE: 1 OF 3

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
260'				255 tft gravel layer, 1 - 1/4 subrounded limestone			
			→	260' Primarily uniform fine grained sand color is moderate yellowish brown 10YR 5/4. has 5-10% gravels, 1 - 1/4" in size, subrounded, mostly limestone.			
280'				same as 260' with no coarse fraction.			
				290-295 gravel layer, 1"- 1/4" subrounded gravels, mostly limestone. had to hammer a bit 10-15 strokes.			
300'				same as 260 with small amount of gravels 5-7% from gravel layer @ 290-295'. Color of sand f. grained is moderately yellowish brown. 10 YR 5/4.			
				310' NFT gravel layer medium to fine grained 1/2 - 1/8" subrounded limestones. Needed to hammer 5-7 times.			

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-MW15.	
BORING NUMBER:	COORDINATES:	DATE: Dec. 20, 2016.
ELEVATION	GWL: Depth Date/Time	DATE STARTED:
ENGINEER/GEOLOGIST: Lum	Depth Date/Time	DATE COMPLETED:
DRILLING METHOD Aecd		PAGE: 2 OF 3

DEPTH (.)	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
320				Uniform fine grained sand, slightly moist. color is moderately yellowish brown 10YR 5/4.			
				330' hit a thin gravel layer			
340				Same as 320'			
				350' hit a hard gravel layer 1-2 ft. thick.			350' now have to hammer, casing not sliding down.
360				Same as 320'			
				365-375 hit hard ground, multiple thin gravel layers have been encountered. 1"- 1/8" subrounded limestone pebbles.			

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-MW15	
BORING NUMBER: —	COORDINATES: —	DATE: Dec. 20, 2016.
ELEVATION —	GWL: Depth Date/Time	DATE STARTED: Dec. 20, 2016
ENGINEER/GEOLOGIST: Lum	Depth Date/Time	DATE COMPLETED: Dec. 21, 2016
DRILLING METHOD Arch.		PAGE: 3 OF 3

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
380'				Primarily uniform fine grained sand, color is Dark Yellowish orange 10YR 6/6, slightly damp. Maybe drying out due to air recirc. thru. 5-10% gravels 1"- ½", subrounded, limestone. Multiple layers encountered 365-375'.			
400			~5%	uniform fine grained sand color is moderate yellowish brown 10YR 5/4. Sample is slightly damp and holds together when squeezed 5% clay content.			Dec 20 2016
				~410 thin gravel zone 1-2' thick, mostly limestone.			
420'				same as 400'. <Dec. 21, 2016>.			Dec. 21, 2016

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TAV	SITE NUMBER: TAV-MW15	
BORING NUMBER: —	COORDINATES: —	DATE: Dec. 21, 2016.
ELEVATION —	GWL: Depth Date/Time	DATE STARTED:
ENGINEER/GEOLOGIST: Lum	Depth Date/Time	DATE COMPLETED:
DRILLING METHOD Aecus		PAGE: 1 OF 2

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
440'			→	Gravel layer 1"-⅛ gravels, subrounded to subangular, primarily limestone, with some qtzite. 50:50 mix, matrix is uniform fine grained sand moderate yellowish brown 10YR 5/4, sand is slightly damp. Because of high conc. coarse fraction sample will no longer hold together when squeezed.			
460'			→	Same as 440'. Predominantly a gravel with some uniform fine grained sand. Sand will now hold together, but mixture (in sample bag) will not.			
480'				Uniform fine grained sand, slightly damp. holds together indicating some clay (5%) color is in between Dark yellowish orange 10YR 6/6 & Moderate yellowish brown 10YR 5/4.			

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-MW15	
BORING NUMBER: —	COORDINATES: —	DATE: Dec. 21, 2016
ELEVATION —	GWL: Depth Date/Time	DATE STARTED:
ENGINEER/GEOLOGIST: Lum	Depth Date/Time	DATE COMPLETED:
DRILLING METHOD ARGT.		PAGE: 2 OF 2

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
500				Uniform fine grained sand, slightly damp. holds together indicating some clay (5%). color is in between Dark Yellowish orange 10YR 6/6 & Moderate yellowish brown 10YR 5/4. Coarse fraction in matrix increasing med-coarse sand, ~5%.			
				-> 510. similar to 500 with increasing clay content.			
520'				Mostly uniform fine grained sand, slightly moist, some clay, color is dark yellowish orange 10YR 6/6. Increasing fraction med-coarse sand. 5-10%, and gravels 10+5. coarse fractions mostly limestone, some qtzite, occasional granite pieces obs.			

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-MW16 / 34.996383	
BORING NUMBER: —	COORDINATES: -106.533658	DATE: 11-30-2016
ELEVATION —	GWL: Depth Date/Time	DATE STARTED: 11-30-2016
ENGINEER/GEOLOGIST: Lum	Depth Date/Time	DATE COMPLETED: —
DRILLING METHOD ARCH		PAGE: 1 OF 3

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
20'	cuttings			Uniform Fine grained sand. Moderately wet. Color is grayish orange 10YR 7/4. 5-10% gravels 1/8" – 3/4" angular to subangular primarily composed of limestone			
40'	cuttings			Uniform. Fine grained sand. Slightly wet. Color is grayish-orange 10YR 7/4. 10-15% gravels, subangular primarily composed of limestone. 1/8" – 1". Size of grains mac graded, not binomial like 20' sample.			
60'	cuttings.			Uniform. Fine grained sand. Slightly wet. Color is grayish orange 10YR 7/4. Texture, size dist is more heterogeneous. 40-50% sand, 5-15% fine grained 30-40% gravels 1/8" - 1", Channel deposit?			

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-MW16		
BORING NUMBER: —	COORDINATES: —	DATE: 11-30-2016	
ELEVATION —	GWL: Depth	Date/Time	DATE STARTED: 11-30-2016
ENGINEER/GEOLOGIST: Lum.	Depth	Date/Time	DATE COMPLETED: —
DRILLING METHOD ARCH.			PAGE: 2 OF 3

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
80'	cuttings.			Uniform fing grained sand. Slightly wet. Color is greyish orange. 10 YR 7/4. very minor coarse component <5% likely remnants from gravels encountered above ~60'			
100'	cuttings.			same as 80', no coarse fragments.			
120'	cuttings.			same as 80', no coarse fragments.			

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV - MW16		
BORING NUMBER: —	COORDINATES: —	DATE: 11-30-2016.	
ELEVATION —	GWL: Depth Date/Time	DATE STARTED: 11-30-2016	
ENGINEER/GEOLOGIST: LUM	Depth Date/Time	DATE COMPLETED: 12-1-2016	
DRILLING METHOD ARCH.		PAGE: 3 OF 3	

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
	H0'	cuttings.		same as 80'. Starting to obs gravels. 1/8 - 1" subangular to subrounded. Mostly limestone.			
160'	cuttings.			Uniform fine grained sand. Slightly wet. Color is grayish-orange. 10 YR 7/4. Coarse component has increased to 10-15%. and size 1/8"-1".			11-30-2016
180'	cuttings.			Uniform fine grained sand. slightly wet. color is grayish-orange 10YR 7/4. No coarse component.			12-1-2016.

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-MW16		
BORING NUMBER: —	COORDINATES: —	DATE: Dec. 1, 2016	
ELEVATION —	GWL: Depth	Date/Time	DATE STARTED: —
ENGINEER/GEOLOGIST: LUM	Depth	Date/Time	DATE COMPLETED: —
DRILLING METHOD ARCH.			PAGE: 1 OF 2

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
200'	Cuttings.			Uniform fine grained sand slightly wet. Color is greyish-orange. 10YR 7/4. Sand is approx 60%. Remaining is ⅛-¼ small grained coarse fragments. Primarily limestone w/ some qtz. No coarse fraction ½-1" cobbles. Air lift?			Gravel layer ended ~ 5' after 200'.
220	Cuttings.			Uniform fine grained sand. Slightly wet. Color is darker Moderate yellowish brown 10YR 5/4. 5-10% ⅛-¼" rock, mostly limestone.			230-235' gravel or cobbles encountd.
240'	Cuttings.			Uniform fine grained sand. Slightly wet. Color appears lighter - grayish orange 10YR 7/4 Approximately 10% gravels ⅛-¼" in size, mostly limestone.			

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-MW16		
BORING NUMBER: —	COORDINATES: —		DATE: Dec 1, 2016
ELEVATION —	GWL: Depth	Date/Time	DATE STARTED: —
ENGINEER/GEOLOGIST: Lum	Depth	Date/Time	DATE COMPLETED: —
DRILLING METHOD ARCH			PAGE: 2 OF 2

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
260	Cuttings.			Mixture uniform fine grained sand - greyish orange. Mix with coarser grained gravels 1/8 - 1.5" mostly limestone.	10YR 7/4		240'+ gravel + cobbles. 250' large cobbles encountered.
280	Cuttings.			@ 270' dropped out of gravel and cobble zone. Predominantly uniform fine grained sand Greyish-orange 10YR 7/4. 5-10 gravels 1/8 - 1/2". Mostly limestone.			
300	Cuttings.			Uniform fine grained sand Greyish orange 10YR 7/4. 5-10% gravels 1/8 - 1/4"			

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-MW16.	
BORING NUMBER: —	COORDINATES: —	DATE: Dec 2, 2016
ELEVATION —	GWL: Depth Date/Time	DATE STARTED: -
ENGINEER/GEOLOGIST: Lum	Depth Date/Time	DATE COMPLETED: —
DRILLING METHOD ARCH.		PAGE: 1 OF 3

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
320'	cuttings.			Same as 300'. Same uniform fine grained sand grayish orange 10YR 7/4. Slight increase in gravels ~10% - ½" size.			
340	cuttings.			Gravel encountered starting @ ~335'. still 50% fine grained sand, but 40-50% gravels. ⅛" - ¾" in size. Mostly limestone. 350' not gravel layer ~ 355' dropping back to sand.			
360	cuttings.			same as 340'.			

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-MW16		
BORING NUMBER: —	COORDINATES: —		DATE: Dec. 2, 2016
ELEVATION —	GWL: Depth	Date/Time	DATE STARTED: —
ENGINEER/GEOLOGIST: Lum	Depth	Date/Time	DATE COMPLETED: —
DRILLING METHOD Aect			PAGE: 2 OF 3

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
380	cuttings.			Primarily uniform fine grained sand. Grayish-orange 10YR 7/4. <5% small gravels 1/8-1/4".			
				395' Hit 'hard' gravel layer large pieces 1/4 upt to 1 1/2"			
400	cuttings.			50% uniform fine grained sand. Grayish-orange 10YR 7/4. 50% cobble-gravels mostly limestone.			
420	cuttings.			@ 415' hit gravel layer with few large pieces. Mostly 1/8-1/4" rounded grains. ~~40-5~~ 50-60%. Remainder 40-50% is same uniform fine grained sand. Grayish orange 10YR 7/4.			

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-MW16	
BORING NUMBER: —	COORDINATES: —	DATE: Dec 2, 2016.
ELEVATION —	GWL: Depth Date/Time	DATE STARTED: Dec. 2, 2016
ENGINEER/GEOLOGIST: Lum	Depth Date/Time	DATE COMPLETED: Dec 6, 2016
DRILLING METHOD ARCH		PAGE: 2 OF 3

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
440'	Cuttings.			Fine grained sand with few (10%) small pebbles ~ 1/8" or less. Color is Moderate yellowish brown 10YR 5/4. Slightly moist. Sample darker than others and did not lighten when dried. Increased clay content? ~ 10%. Samples hold together < slightly when compressed.			12-2-2016 450' hard gravel layer hit.
460	Cuttings.			Just like 440'. Fine sand w/ thin gravel layers. Stopped on Dec. 5, 2016. 10% clay content.			12-5-2016
480	Cuttings.			Predominantly fine grained sand. 10YR 5/4, slightly moist. Increase % gravel-cobble layers ~ 30-40% thin, with hard penetration for drive casing. Poor rise small 1/8 - 1/2" gravels. 20% clay content. Reached depth Dec. 6, 2016			12-6-2016
				~ 495' clay content increasing ~ 20% samples holding together. Still dominantly sand. Volcanic clasts ops. 1/8 - 1/4 size. Gravels subrounded to subangular. Still predominantly limestone.			

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-MW16	
BORING NUMBER: —	COORDINATES: —	DATE: Dec 6, 2016
ELEVATION —	GWL: Depth Date/Time	DATE STARTED:
ENGINEER/GEOLOGIST: Lum	Depth Date/Time	DATE COMPLETED:
DRILLING METHOD Arctic.		PAGE: 3 OF 3

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
500	cuttings.			Predominantly fine grained sand, moist sample, color 10YR 5/4. Clay content increasing, clumps and holds shape when compressed ~20% clay. Thin gravel layers ⅛-¼ subangular to subrounded. Distinct volcanic white/black rock still predominantly limestone.			
520	cuttings.			Same as 500' less gravels ~5% Clay content may be increasing Trip out to start coring. Core taken 520-525'. Core barrel stuck.			

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-MW16	
BORING NUMBER: —	COORDINATES: —	DATE: Dec. 7, 2016
ELEVATION —	GWL: Depth Date/Time	DATE STARTED: 12-7-2016
ENGINEER/GEOLOGIST: LUM	Depth Date/Time	DATE COMPLETED: 12-8-2016
DRILLING METHOD ARCH/CORING		PAGE: 1 OF 1

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
523	CORE			Fine grained silty-sand with clay content (5-10%). Does not hold shape well when compressed ~5% clay. Color is Moderate yellowish brown 10YR 5/4. Occasional gravels found subrounded limestone 1/2-1/8" in size. Limestone			collected Dec. 7, 2016
528	CORE			Same as 523. Appears to have more clay content (10%?) holds shape when compressed. No gravels or coarse fraction in sample.			collected Dec. 4, 2016
533				Heterogeneous gravel bag deposit Consists of gravel 3/4-1/8 with subangular to subrounded outline. Limestone, volcanics (speckled black and white), quartz, and feldspar. Coarse, medium sands grains of quartz, feldspar. Fine grained silty sand still present w/ same color Moderate yellowish brown 10YR 5/4 present. Gravels - 15%-20% Sands - 40%, fine silt/clay - 30% 50%			collected Dec. 8, 2016

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-MW16	
BORING NUMBER: —	COORDINATES: —	DATE: Dec. 8, 2016
ELEVATION —	GWL: Depth Date/Time	DATE STARTED: —
ENGINEER/GEOLOGIST: Lum	Depth Date/Time	DATE COMPLETED: —
DRILLING METHOD Arch / Core		PAGE: 1 OF 1

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
538				Same as 528. Consists of fine grained clayey silt. Color is Moderate Yellowish Brown 10YR 5/4. No coarse fraction obs.			collected Dec. 8, 2016.
552				Same as 533, w/ gravels, sand, and fine grained silty, and clay. Large clasts are mostly limestone, but obs. qtz, feldspar grains. and volcanic clasts. + metamorphic greenstone (chlorite) clasts.			Dec. 8, 2016

NOTES:

APPENDIX B
Photographs of Lithologic Cuttings from
Monitoring Wells TAV-MW15 and TAV-MW16

Figure B-1: Photograph of cuttings from monitoring well TAV-MW15. From left to right cuttings shown are from 20, 40, 60, 80, 100, and 120 feet below ground surface.

Figure B-2: Photograph of cuttings from monitoring well TAV-MW15. From left to right cuttings shown are from 100, 120, 140, 160, 180, and 200 feet below ground surface.

Figure B-3: Photograph of cuttings from monitoring well TAV-MW15. From left to right cuttings shown are from 220, 240, 260, 280, 300, 320, and 340 feet below ground surface.

Figure B-4: Photograph of cuttings from monitoring well TAV-MW15. From left to right cuttings shown are from 280, 300, 320, 340, 360, 380, and 400 feet below ground surface.

Figure B-5: Photograph of cuttings from monitoring well TAV-MW15. From left to right cuttings shown are from 420, 440, 460, 480, and 500 feet below ground surface.

Figure B-6: Photograph of cuttings from monitoring well TAV-MW16. From right to left cuttings shown are from 20, 40, 60, 80, 100, 120, 140, and 160 feet below ground surface.

Figure B-7: Photograph of cuttings from monitoring well TAV-MW16. From right to left cuttings shown are from 140, 160, 180, 200, 220, 240, 260, 280 and 300 feet below ground surface.

Figure B-8: Photograph of cuttings from monitoring well TAV-MW16. From right to left cuttings shown are from 300, 320, 340, 360, 380, 400, 420, and 440 feet below ground surface.

Figure B-8: Photograph of cuttings from monitoring well TAV-MW16. From right to left cuttings shown are from 380, 400, 420, 440, 460, 480, 500, and 520 feet below ground surface.

APPENDIX C
Photographs of Continuous Core Samples from
Monitoring Wells TAV-MW15 and TAV-MW16

Figure C-1: Photograph of continuous core sample from monitoring well TAV-MW15. From right to left the sample was from 510 to 515 feet below ground surface.

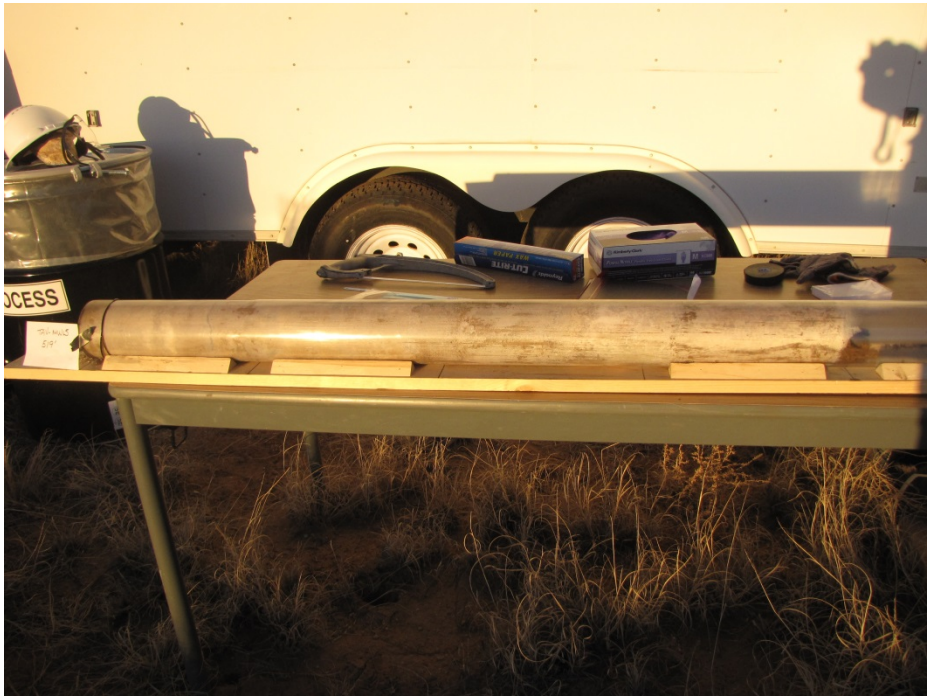


Figure C-2: Photograph of continuous core sample from monitoring well TAV-MW15. From right to left the sample was from 515 to 519 feet below ground surface.

Figure C-3: Photograph of continuous core sample from monitoring well TAV-MW15. From right to left the sample was from 520 to 525 feet below ground surface.

Figure C-4: Photograph of continuous core sample from monitoring well TAV-MW15. From right to left the sample was from 525 to 529 feet below ground surface.

Figure C-5: Photograph of continuous core sample from monitoring well TAV-MW15. From right to left the sample was from 530 to 535 feet below ground surface.

Figure C-6: Photograph of washed Ancestral Rio Grande (ARG) sediments from TAV-MW15 at 529 feet that were recovered from the drill bit of the core barrel.

Rock clasts as large as one inch in diameter were found, with the average clast approximately ½ to ¼ inch in diameter. Grains are sub-rounded to sub-angular. The larger clasts are predominantly limestone and granite with some quartzite.

The lithologies in the ARG sediment was very varied and was comprised of approximately 40% limestone, 30% granite, and the remaining consisting of quartz, feldspar, volcanics, and some shale.

Figure C-7: Photograph of continuous core sample from monitoring well TAV-MW16. From right to left the sample was from 520 to 525 feet below ground surface.

Figure C-8: Photograph of continuous core sample from monitoring well TAV-MW16. From right to left the sample was from 525 to 530 feet below ground surface.

Figure C-9: Photograph of continuous core sample from monitoring well TAV-MW16. From right to left the sample was from 530 to 535 feet below ground surface.

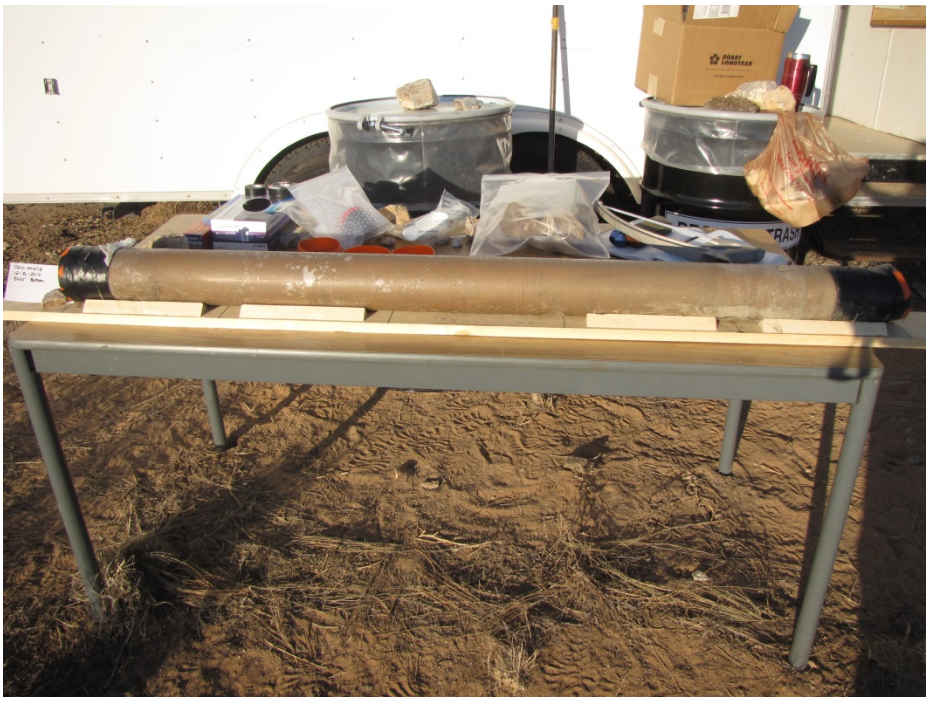


Figure C-10: Photograph of continuous core sample from monitoring well TAV-MW16. From right to left the sample was from 535 to 540 feet below ground surface.

Figure C-11: Photograph of continuous core sample from monitoring well TAV-MW16. From right to left the sample was from 540 to 543 feet below ground surface.

APPENDIX D
Well Construction Data Sheets for
Monitoring Wells TAV-MW15, and TAV-MW16

Well Construction Data for TAV-MW15

Technical Area V Groundwater Area of Concern, Sandia National Laboratories/New Mexico

Items Required by the Order[a] section VIII.D	Comments (acronyms are defined in footnotes)
1. Well name/number	Groundwater monitoring well TAV-MW15.
2. Date of well construction	Drilling began on December 19, 2016. Construction completed on January 10, 2017. Development completed on January 18, 2017. Land surveying conducted on March 25, 2017.
3. Drilling method	Air rotary casing hammer to 550 ft bgs.
4. Drilling contractor and name of driller	Cascade Drilling LP, Keith Jacobs, as supervised by Bryan Nydoske (NM License #WD-1210), using a GEFCo Speed Star 50K-CH rig.
5. Borehole diameter and well casing diameter	Borehole: From 0 to 200 ft bgs a tricone bit with 11.75-inch drive casing. From 200 ft bgs to 550 ft bgs, 8.5-inch tricone bit with 9.625-inch diameter drive casing.
	Well casing: 4.75 inches ID, 5.5 inches OD, PVC.
6. Well depth	545.81 ft bgs (548.05 ft minus 2.24 ft stickup).
7. Casing length	548.05 ft (from bottom of sump to top of well casing).
8. Casing materials	Well casing: schedule 80 PVC. Centralizers: at the top and bottom of the screened interval 517 and 542 ft bgs, and at 100 ft intervals.
9. Casing and screen joint type	Flush-threaded, 2 threads per inch, with neoprene o-rings.
10. Screened interval(s)	515.8 to 540.8 ft bgs, with sump from 540.8 to 545.8 ft bgs.
11. Screen materials	Schedule 80 PVC, 515.8 to 540.8 ft bgs.
12. Screen slot size and design	Twenty-slot (0.020-inch slotted screen with vertical spacing of 0.125-inches), 515.8 to 540.8 ft bgs.
13. Filter pack material and gradation	Primary: #10-20 CSS silica sand.
	Secondary: #60 CSS silica sand.
14. Filter pack volume (calculated and actual)[b]	Calculated: 17.4 ft^3, both sand packs and rathole.
	Actual Used: 23.0 ft^3, both sand packs and rathole.
15. Filter pack placement method	Gravity feed through drive casing.
16. Filter pack interval(s)	Primary: 510.8 to 550 ft bgs of #10-20 sand.
	Secondary: 505.8 to 510.8 ft bgs of #60 sand.
17. Annular sealant composition	Halliburton Baroid Quik-Grout® bentonite grout, and Halliburton Baroid Holeplug® bentonite chips, 3/8-inch grade.
18. Annular sealant placement method	Grout: gravity feed through drive casing. Chips: gravity feed through drive casing and subsequently hydrated with water gravity feed into drive casing.
19. Annular sealant volume (calculated and actual)	Calculated: Bentonite grout: 216.7 ft^3 (1620.8 gals). Bentonite chips: 11.4 ft^3.
	Actual Used: Bentonite grout: 260.7 ft^3 (1950 gals). Bentonite chips: 12.5 ft^3.

Well Construction Data for TAV-MW15 (Concluded)

Technical Area V Groundwater Area of Concern, Sandia National Laboratories/New Mexico

Items Required by the Order[a] section VIII.D	Comments (acronyms are defined in footnotes)
20. Annular sealant interval(s)	Bentonite grout: 20 to 476 ft bgs.
	Bentonite chips: 476 to 506 ft bgs.
21. Surface sealant composition	Quikrete® concrete.
22. Surface seal placement method	Gravity feed into annulus.
23. Surface sealant volume (calculated and actual)	Calculated: 10.5 ft^3 (78.9 gals).
	Actual Used: 40.1 ft^3 poured concrete 3 to 20 ft bgs (300 gals).
24. Surface sealant interval	Ground surface to 20 ft bgs.
25. Surface seal and well apron design and construction	4-ft by 4-ft by 6-inch thick concrete pad, with steel mesh reinforcement
26. Well development procedure and turbidity measurements	Bail, swab, bail and submersible pump (see Table 2-3 and Attachment E for turbidity measurements).
27. Well development purge volume(s) and stabilization parameter measurements	Bail 45 gallons. Pump 345 gals with parameter measurements. Total purge volume was 390 gallons, corresponding to 8.5 wellbores. See Table 2-3 and Attachment E for field parameter measurements. One wellbore volume was calculated to be 43 gallons assuming 30% porosity in saturated sand pack.
28. Type and design and construction of protective casing	Monument (stovepipe) completion with 6-ft length of 10-inch diameter steel casing (from 3 ft bgs to 3 ft above ground surface).
29. Well cap and lock	Royer Inc. 2-piece aluminum locking well cap and padlock. Three steel bollards.
30. Ground surface elevation	5,435.08 ft amsl, adjacent to concrete pad.
31. Survey reference point elevation on well casing	5,437.32 ft amsl, for measuring water levels.
32. Top of monitoring well casing elevation	5,437.32 ft amsl, same as above.
33. Top of protective steel casing elevation	5,437.79 ft amsl, top of aluminum locking cover.
34. Name of geologist	Clinton C. Lum.
35. Initial water level	517.82 ft bgs, pre-development water level, January 3, 2017. 517.5 ft bgs measured just before well development January 17, 2017.
36. Final water level	517.5 ft bgs, after development January 26, 2017
37. Date of well development	January 17 and 18, 2017.

[a]New Mexico Environment Department, April 2004. "Compliance Order on Consent," New Mexico Environment Department, Santa Fe, New Mexico.

[b]Filter pack volume defined as the total volume of filter pack sand placed in well, both adjacent to the well casing, screen, and sump and below the sump (if applicable).

amsl = Above mean sea level.
bgs = Below ground surface.
btoc = Below top of casing.
CSS = Colorado Silica Sand Inc. (Oglebay Norton Industrial Sands).
ft = Feet or foot.
ft^3 = Cubic foot (cubic feet).
gals = Gallons.
ID = Inside diameter.
OD = Outside diameter.
PVC = Polyvinyl chloride.
Rathole = Extra hole drilled at the bottom of the borehole to allow for slough.

Well Construction Data for TAV-MW16

Technical Area V Groundwater Area of Concern, Sandia National Laboratories/New Mexico

Items Required by the Order[a] section VIII.D	Comments (acronyms are defined in footnotes)
1. Well name/number	Groundwater monitoring well TAV-MW16
2. Date of well construction	Drilling began on November 30, 2016. Construction completed on January 5, 2017. Development completed on January 12, 2014. Land surveying conducted on March 25, 2017
3. Drilling method	Air rotary casing hammer to 557 ft bgs.
4. Drilling contractor and name of driller	Cascade Drilling LP, Keith Jacobs as supervised by Bryan Nydoske (NM License #WD-1210), using a. GEFCo Speed Star 50K-CH rig.
5. Borehole diameter and well casing diameter	Borehole: From 0 to 200 ft bgs a tricone bit with 11.75-inch drive casing. From 200 ft bgs to 557 ft bgs, 8.5-inch tricone bit with 9.625-inch diameter drive casing.
	Well casing: 4.75 inches ID, 5.5 inches OD, PVC.
6. Well depth	556.86 ft bgs (559.15 ft minus 2.29 ft stickup)
7. Casing length	559.43 ft (from bottom of sump to top of well casing)
8. Casing materials	Well casing: schedule 80 PVC. Centralizers: at the top and bottom of the screened interval 527 and 552 ft bgs, and 100 ft intervals.
9. Casing and screen joint type	Flush threaded, 2 threads per inch, with neoprene o-rings.
10. Screened interval(s)	527 to 552 ft bgs, with sump from 552 to 557 ft bgs
11. Screen materials	Schedule 80 PVC
12. Screen slot size and design	Twenty slot (0.020-inch slotted screen with vertical spacing of 0.125-inches), 527 to 552 ft bgs
13. Filter pack material and gradation	Primary: #10-20 CSS silica sand
	Secondary: #60 CSS silica sand
14. Filter pack volume (calculated and actual)[b]	Calculated: 16.6 ft^3, both sand packs and rathole
	Actual Used: 17.0 ft^3, both sand packs and rathole
15. Filter pack placement method	Gravity feed through drive casing.
16. Filter pack interval(s)	Primary: 522 to 563 ft bgs of #10-20 sand.
	Secondary: 517 to 522 ft bgs of #60 sand
17. Annular sealant composition	Halliburton Baroid Quik-Grout® bentonite grout, and Halliburton Baroid Holeplug® bentonite chips, 3/8-inch grade.
18. Annular sealant placement method	Grout: gravity feed through drive casing. Chips: gravity feed through drive casing and hydrated with water gravity feed into drive casing.
19. Annular sealant volume (calculated and actual)	Calculated: Bentonite grout: 217.8 ft^3 (1628.9 gals) Bentonite chips: 17.0 ft^3
	Actual Used: Bentonite grout: 374.3 ft^3 (2800 gals) Bentonite chips: 13.5 ft^3
20. Annular sealant interval(s)	Bentonite grout: 25 to 563 ft bgs
	Bentonite chips: 16 to 25 ft bgs, and 487 to 517 ft bgs
21. Surface sealant composition	Quikrete® concrete
22. Surface seal placement method	Gravity feed into annulus

Well Construction Data for TAV-MW16 (Concluded)

Technical Area V Groundwater Area of Concern, Sandia National Laboratories/New Mexico

Items Required by the Order[a] section VIII.D	Comments (acronyms are defined in footnotes)
23. Surface sealant volume (calculated and actual)	Calculated: 8.1 ft^3 (60.3 gallons)
	Actual Used: 20.1 ft^3, poured concrete 3 to 16 ft bgs (150 gallons)
24. Surface sealant interval	Ground surface to 10 ft bgs
25. Surface seal and well apron design and construction	4-ft by 4-ft by 6-inch-thick concrete pad, with steel mesh reinforcement.
26. Well development procedure and turbidity measurements	Bail, swab, bail, and submersible pump (see Table 2-4 and Attachment E for turbidity measurements)
27. Well development purge volume(s) and stabilization parameter measurements	Bailed 44 gals. Pumped 286 gals with parameter measurements. Total purge volume was 330 gals, corresponding to 7.3 wellbores. (See Table 2-4 and Attachment E for field parameter measurements.) One wellbore volume was calculated to be 46 gals assuming 30% porosity in saturated sand pack.
28. Type and design and construction of protective casing	Monument (stovepipe) completion with 6-ft length of 10-inch-diameter steel casing (from 3 ft bgs to 3 ft above ground surface).
29. Well cap and lock	Royer Inc. 2-piece aluminum locking well cap and padlock. Three steel bollards.
30. Ground surface elevation	5,446.05 ft amsl, adjacent to concrete pad
31. Survey reference point elevation on well casing	5,448.34 ft amsl, for measuring water levels
32. Top of monitoring well casing elevation	5,448.34 ft amsl, same as above
33. Top of protective steel casing elevation	5,449.09 ft amsl, top of aluminum locking cover
34. Name of geologist	Clinton C Lum
35. Initial water level	528.93 ft bgs, pre-development water level, December 9, 2016. 528.55 ft bgs, just before well development January 11, 2016.
36. Final water level	528.74 ft bgs, after well development January 26, 2014.
37. Date of well development	January 11 and 12, 2017

[a]New Mexico Environment Department, April 2004. "Compliance Order on Consent," New Mexico Environment Department, Santa Fe, New Mexico.

[b]Filter pack volume defined as the total volume of filter pack sand placed in well, both adjacent to the well casing, screen, and sump and below the sump (if applicable).

amsl = Above mean sea level.
bgs = Below ground surface.
btoc = Below top of casing.
CSS = Colorado Silica Sand Inc. (Oglebay Norton Industrial Sands).
ft = Feet or foot.
ft^3 = Cubic foot (cubic feet).
gals = Gallons.
ID = Inside diameter.
OD = Outside diameter.
PVC = Polyvinyl chloride.
Rathole = extra hole drilled at the bottom of the borehole to allow for slough.

APPENDIX E
Well Construction Diagrams for
Monitoring Wells TAV-MW15 and TAV-MW16

Well Name: TAV-MW15
Project Name: TAV GW
NMOSE Well File Code: RG-90065
Owner Name: SNL/NM
Date Drilling Started: DEC 19, 2016
Date Well Dev. Completed: JAN 18, 2017

Drilling Contractor: CASCADE DRILLING LP.
Drilling Method: AIR ROTARY CASING/HAMMER
Borehold Depth (FBGS): 550.00
Casing Depth (FBGS): 545.80
Geo Location: TA-V
Completion Zone: ALLUVIAL SEDIMENTS
Completion Formation: SANTA FE GROUP

Survey Data

Survey Date: APR 05, 2017
Surveyed By: SURVEYING CONTROL, INC.
State Plane Coordinates: NAD 83
(X) Easting: 1554816.10
(Y) Northing: 1454085.45

Surveyed Evaluations (FAMSL)

Protective Casing: 5437.79
Top of Inner Well Casing: 5437.32
Concrete Pad: 5435.51
Ground Surface: 5435.1

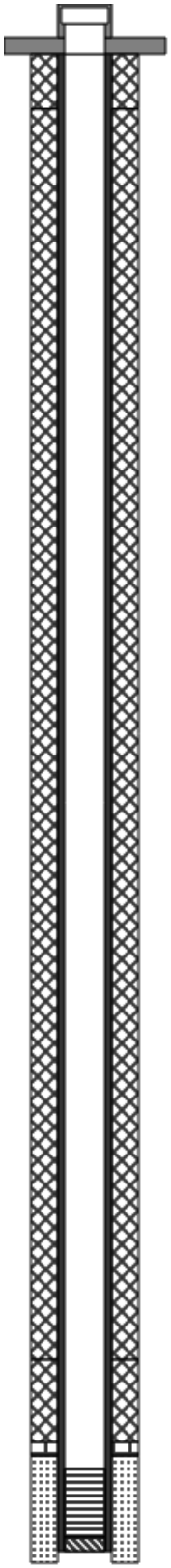
Calculated Depths and Elevations

Initial Depth to Water (FBGS) 517.80
Date Initial Depth Measured: JAN 03, 2017
Last Measured Water Elevation (FAMSL): 4917.71
Date Last Measured: APR 04, 2017

Miscellaneous Information

Screen Slot Size (in.):
Date Updated: 02-MAY-17
Date Printed from EDMS: MAY 03, 2017

Comments:



Completion Data Measured Depths (FBGS)

Casing Stickup: 2.2

Interval	Material	Srt	Stp	LEN	ID	OD
SEAL	CEMENT	0.0	20.0	20.0		
BOREHOLE		0.0	550.0	550.0		
CASING	SCHEDULE 80 PVC	0.0	545.8	545.8	4.75	5.5
SEAL	BENTONITE GROUT	20.0	476.0	456.0		
SEAL	BENTONITE CHIPS	476.0	506.0	30.0		
SECONDARY PACK	#60 SAND	506.0	511.0	5.0		
PRIMARY PACK	#10-20 SAND	511.0	550.0	39.0		
SCREEN	SCHEDULE 80 PVC	515.8	540.8	25.0	4.75	5.5
SUMP	SCHEDULE 80 PVC	540.8	545.8	5.0	4.75	5.5

Well Name: TAV-MW16
Project Name: TAV-GW
NMOSE Well File Code: RG-90065
Owner Name: SNL/NM
Date Drilling Started: NOV 30, 2016
Date Well Dev. Completed: JAN 12, 2017

Drilling Contractor: CASCADE DRILLING LP
Drilling Method: AIR ROTARY CASING/HAMMER
Borehold Depth (FBGS): 563.00
Casing Depth (FBGS): 556.90
Geo Location: TA-V
Completion Zone: ALLUVIAL SEDIMENTS
Completion Formation: SANTA FE GROUP

Survey Data

Survey Date: APR 05, 2017
Surveyed By: SURVEYING CONTROL, INC.
State Plane Coordinates: NAD 83
(X) Easting: 1555468.68
(Y) Northing: 1454093.47

Surveyed Evaluations (FAMSL)

Protective Casing: 5449.09
Top of Inner Well Casing: 5448.34
Concrete Pad: 5446.51
Ground Surface: 5446.1

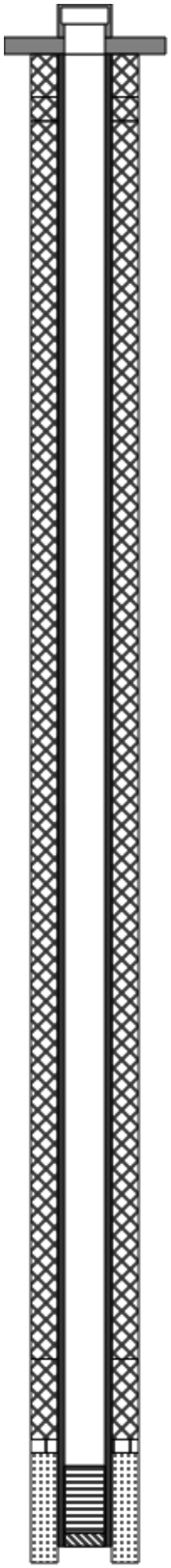
Calculated Depths and Elevations

Initial Depth to Water (FBGS) 528.90
Date Initial Depth Measured: DEC 09, 2016
Last Measured Water Elevation (FAMSL): 4917.16
Date Last Measured: APR 04, 2017

Miscellaneous Information

Screen Slot Size (in.):
Date Updated: 02-MAY-17
Date Printed from EDMS: MAY 03, 2017

Comments:



Completion Data Measured Depths (FBGS)

Casing Stickup: 2.3

Interval	Material	Srt	Stp	LEN	ID	OD
BOREHOLE		0.0	563.0	563.0		
CASING	SCHEDULE 80 PVC	0.0	556.9	556.9	4.75	5.5
SEAL	CEMENT	0.0	16.0	16.0		
SEAL	BENTONITE CHIPS	16.0	25.0	9.0		
SEAL	BENTONITE GROUT	25.0	487.0	462.0		
SEAL	BENTONITE CHIPS	487.0	517.0	30.0		
SECONDARY PACK	#60 SAND	517.0	522.0	5.0		
PRIMARY PACK	#10-20 SAND	522.0	563.0	41.0		
SCREEN	SCHEDULE 80 PVC	526.9	551.9	25.0	4.75	5.5
SUMP	SCHEDULE 80 PVC	551.9	556.9	5.0	4.75	5.5

APPENDIX F
Well Development Forms for Monitoring Wells
TAV-MW15 and TAV-MW16

Well Development Log

Well Name: TAN - MW16	Date: Jan 11, 2017
Initial Water Level (fbgs) : 528.5'	Personnel: Clinton Lum, Guy Henniner.
Final Water Level: Not measured.	Well Bore Volume[1] (gals): ~~29~~ 46 gallons
Total Depth (fbgs): 557' bottom casing.	5x well bore volume (gals): ~~146~~ 230 gallons. C.L 3-28-17
	10x well bore volume (gals): 460 gallons.

Describe the Well Development Method(s): Bailer to remove sediment. Swabbed hole for 30 minutes. Bailed 20 gallons (40 gallons total). Bailed another 4 gallons. Pulled 20 gallons. Set submersible pump just above end cap. Pumped 285 gallons of water. Bailed and pumped total of 330 gallons.

Comments:

[1]May use the following gal/ft for each respective diameter well to calculate well bore volume or use the formula

$$[d(ft)/2]^2 \times \pi \times [7.5\ gal/ft^3] = gal/ft$$

For other well diameters (d = diameter).

Well Diameter (in.)	Gals/ft
2.0	0.16
4.0	0.65
4.5	0.83
5.0	1.05
6.0	1.47

FIELD MEASUREMENT LOG FOR GROUNDWATER SAMPLE COLLECTION

Project Name: TA-V	
Well I.D.: TAV-MW16	Date: Jan. 12, 2016
Method: Portable pump X	Dedicated pump _____ Pump depth: 557'

Pump located @ pump.

PURGE MEASUREMENTS

Depth to Water (ft)	Time 24 hr	Vol. (L/gal)	Temp (°C)	SC (µS/cm)	ORP (mV)	pH	Turbidity (NTU)	DO (%)	DO (mg/L)
528.5	14:22	285	22.507	889.7	140.5	7.24	33.80	58.9	5.08
|	14:27	290	22.301	884.2	149.3	7.25	27.24	59.1	5.13
|	14:32	295	22.283	878.7	145.4	7.25	24.38	59.0	5.12
|	14:37	300	22.088	874.7	142.8	7.26	23.31	60.0	5.22
|	14.43	305	22.038	878.4	138.8	7.26	25.26	58.6	4.94
|	14.46	310	21.920	876.1	136.4	7.27	18.60	49.8	4.35
|	14:54	315	22.239	882.8	133.4	7.26	9.62	45.7	3.96
|	14.59	320 @	22.841	874.2	130.4	7.26	5.79	46.4	3.98
|	15:04	325	23033	895.4	129.1	7.26	4.01	45.9	3.92
=	15:10	330	23.438	899.0	127.5	7.25	3.74	46.3	3.93

Comments: 3 barrels x 40 gallons = 280 gallons
@ barrels = 320 gallons @ 15 14:59. (time).

Well Development Log

Well Name: TAV-MW15	Date: Jan. 18, 2017
Initial Water Level (fbgs): 517.8'	Personnel: Clinton Lum, Guy Hennigan.
Final Water Level: Not measured.	Well Bore Volume[1] (gals): 46 gallons
Total Depth (fbgs): 546'	5x well bore volume (gals): 230 gallons.
	10x well bore volume (gals): 460 gallons.

Describe the Well Development Method(s): Bailed to removed sediment. TOBI 30 gallons. Estimate removed approx 3 feet of sediment from sump. Surged for 45 minutes. Bailed 15 gallons. Set up submersible pump just above end cap. Pumped 345 gallons. TOBI purge volume (bail + pump) was 390 gallons.

Comments:

[1]May use the following gal/ft for each respective diameter well to calculate well bore volume or use the formula

$$[d(ft)/2]^2 \times \pi \times [7.5\ gal/ft^3] = gal/ft$$

For other well diameters (d = diameter).

Well Diameter (in.)	Gals/ft
2.0	0.16
4.0	0.65
4.5	0.83
5.0	1.05
6.0	1.47

FIELD MEASUREMENT LOG FOR GROUNDWATER SAMPLE COLLECTION

Project Name: TA-V	
Well I.D.: TAV-MW15.	Date: Jan. 18, 2017
Method: Portable pump X	Dedicated pump _____ Pump depth: 557'

PURGE MEASUREMENTS

Depth to Water (ft)	Time 24 hr	Vol. (L/gal)	Temp (°C)	SC (µS/cm)	ORP (mV)	pH	Turbidity (NTU)	DO (%)	DO (mg/L)
	13:51	325 (9)	21.247	785.1	157.4	7.32	108.05	84.2	7.47
	13:55	330	21.390	789.7	153.1	7.33	122.13	83.1	7.33
	13:59	335	21.386	790.8	148.8	7.34	62.35	84.5	7.45
	14:02	340	21.360	790.2	148.0	7.34	49.37	84.7	7.47
	14:06	350	21.171	787.4	146.0	7.35	48.63	85.2	7.54
	14:10	355	21.199	786.7	143.5	7.35	106.08	82.6	7.32
	14:14	360	21.075	785.8	141.3	7.34	61.32	83.0	7.37
	14:18	365	21.078	784.8	140.2	7.34	69.79	81.8	7.26
	14:22	370 (10)	21.403	793.2	140.1	7.34	44.59	82.1	7.24
	14:26	375	21.704	806.2	143.9	7.33	41.20	83.4	7.30
	14:30	380	22.157	811.7	147.4	7.33	5.36	84.7	7.36
	14:33	385	22.259	811.5	149.4	7.32	3.22	85.0	7.38
	14:36	390	22.252	809.3	149.1	7.32	4.52	85.6	7.43

Comments: @ 14:30 Time and 380 gallons changed to Hach turbidity meter. Sonde turb. is reading 40-60 NTU. 14:41 sprayed, sprayed Sonde turb now reading 0.75 NTU.