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John Kieling, Bureau Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505-6303

Subject: Completion Report for Groundwater Extraction Well CrEX-3

Dear Mr. Kieling:

Enclosed please find two hard copies with electronic files of the Completion Report for Groundwater Extraction Well CrEX-3 in accordance with the guidance in Appendix F, Section II, of the June 2016 Compliance Order on Consent Order.

If you have any questions, please contact Stephani Swickley at (505) 606-1628 (sfuller@lanl.gov) or Cheryl Rodriguez at (505) 665-5330 (cheryl.rodriguez@em.doe.gov).

Sincerely,

Bruce Robinson, Program Director
Environmental Remediation Program
Los Alamos National Laboratory

Sincerely,

David S. Rhodes, Director
Office of Quality and Regulatory Compliance
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BR/DR/SS:sm

Enclosures: Two hard copies with electronic files – Completion Report for Groundwater Extraction Well CrEX-3 (EP2016-0077)

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LA-UR-16-26486
September 2016
EP2016-0077

Completion Report for Groundwater Extraction Well CrEX-3

Los Alamos
NATIONAL LABORATORY
EST. 1943

Prepared by the Associate Directorate for Environmental Management

EP2016-0077

Completion Report for Groundwater Extraction Well CrEX-3

September 2016

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EXECUTIVE SUMMARY

This well completion report describes the drilling, well construction, development, aquifer testing, and dedicated pumping system installation for groundwater extraction well CrEX-3, located within Los Alamos National Laboratory (LANL or the Laboratory), New Mexico. The CrEX-3 extraction well is intended to remove hexavalent chromium–contaminated groundwater from within the regional aquifer in Mortandad Canyon at the Laboratory. The well was drilled and constructed in accordance with the New Mexico Environment Department's (NMED's) approval of the "Drilling Work Plan for Groundwater Extraction Well CrEX-3."

The CrEX-3 borehole was drilled using dual-rotary air-drilling methods to a total depth of 1004.5 ft below ground surface (bgs). Fluid additives used included potable water and foam. Foam-assisted drilling was used to total depth.

The following geologic formations were encountered at CrEX-3: Quaternary alluvium, Otowi Member of the Bandelier Tuff, Guaje Pumice Bed of the Otowi Member, the Cerros del Rio volcanics, the Puye Formation, and Miocene Pumiceous Sediments.

Well CrEX-3 was completed as a single-screen well within the regional aquifer. The screened interval is set between 909.6 and 948.8 ft bgs within Puye Formation sediments. The static depth to water after well installation was measured at 898.5 ft bgs.

The well was completed in accordance with an NMED-approved well design. The well was developed and the regional aquifer groundwater met target water-quality parameters. Aquifer testing indicates regional groundwater extraction well CrEX-3 will perform effectively in meeting the planned objectives. A pumping system and transducer were installed in the screened interval.

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Acronyms and Abbreviations

amsl	above mean sea level
ASTM	American Society for Testing and Materials
bgs	below ground surface
btoc	below top of casing
Consent Order	Compliance Order on Consent
DTW	depth to water
EES	Earth and Environmental Sciences (Laboratory group)
EM	Environmental Management
ENV-CP	Environmental Protection Division–Environmental Compliance Programs
ESH	Environment, Safety, and Health (Laboratory directorate)
gpm	gallons per minute
hp	horsepower
I.D.	inside diameter
LANL	Los Alamos National Laboratory
NAD	North American Datum
NC	not collected
NMED	New Mexico Environment Department
NTU	nephelometric turbidity unit

O.D.	outside diameter
PVC	polyvinyl chloride
TA	technical area
TD	total depth
WCSF	waste characterization strategy form

1.0 INTRODUCTION

This completion report summarizes borehole drilling, well construction, well development, aquifer testing, and dedicated pumping system installation for groundwater extraction well CrEX-3. The report is prepared in accordance with the guidance in Appendix F, Section II, of the June 2016 Compliance Order on Consent (the Consent Order). The CrEX-3 groundwater extraction borehole was drilled between February 17 and March 19, 2016, and was completed between April 3 and April 11, 2016, at Los Alamos National Laboratory (LANL or the Laboratory) for the Environmental Management (EM) Directorate.

Well CrEX-3 is located in Mortandad Canyon (Figure 1.0-1), just east of the centroid of the hexavalent chromium contamination in the groundwater beneath the canyon. The objective of the extraction well is to remove chromium-contaminated groundwater at the top of the regional aquifer for treatment.

The CrEX-3 borehole was drilled to a total depth (TD) of 1004.5 ft below ground surface (bgs). During drilling, cuttings samples were collected at 10-ft intervals from ground surface to TD. An extraction well was installed with a screened interval between 909.6 ft and 948.8 ft bgs within Puye Formation volcaniclastic sediments. The depth to water (DTW) of 898.5 ft bgs was recorded on April 19, 2016, after well installation.

Post-installation activities included well development, aquifer testing, surface completion, geodetic surveying, and pumping system installation. Future activities will include site restoration and waste management.

The information presented in this report was compiled from field reports and daily activity summaries. Records, including field reports, field logs, and survey information are on file at the EM Records Processing Facility. This report contains brief descriptions of activities and supporting figures, tables, and appendixes associated with the CrEX-3 project.

2.0 ADMINISTRATIVE PLANNING

The following documents were prepared to guide activities associated with the drilling, installation, and development of extraction well CrEX-3:

- “Drilling Work Plan for Groundwater Extraction Well CrEX-3” (LANL 2015, 601001);
- “Storm Water Pollution Prevention Plan CrEX-3 Well Pad and Construction Support Activities” (LANL 2015, 601729);
- “[Integrated Work Document for] Implementation of the Drilling Work Plan for Groundwater Extraction Well CrEX-1” (Yellow Jacket Drilling 2014, 600131);
- “Spill Prevention Control and Countermeasures Plan for the ADEP Groundwater Monitoring Well Drilling Operations, Los Alamos National Laboratory, Revision 6” (North Wind Inc. 2011, 213292); and
- “Waste Characterization Strategy Form for Chromium Well CrEX-1” (LANL 2014, 254859).

3.0 DRILLING ACTIVITIES

This section describes the drilling approach and provides a chronological summary of field activities conducted at extraction well CrEX-3.

3.1 Drilling Approach

The drilling method, equipment, and drill-casing were selected to drill CrEX-3 to the required depth. Further, the drilling approach ensured that a sufficiently sized drill casing was used to meet the required 3-in.-minimum annular thickness of the filter pack around an 8.62-in.–outside-diameter (-O.D.) well screen.

Dual-rotary drilling methods using a Foremost DR-24HD drill rig were employed to drill the CrEX-3 borehole. The drill rig was equipped with dual-tube reverse-circulation drilling rods, tricone bits, downhole hammer bits, deck-mounted air compressor, auxiliary compressors, and general drilling equipment. Three sizes of A53 grade B flush-welded mild carbon-steel casing (20-in.-O.D., 18-in.-O.D., 14-in. and 10-in.–inside-diameter [I.D.]) were used for drilling CrEX-3.

The dual-rotary drilling technique at CrEX-3 used filtered compressed air and fluid-assisted air to evacuate cuttings from the borehole during drilling. Drilling fluids, other than air, used in the borehole included potable water and a mixture of potable water with Baroid Quik Foam foaming agent. The fluids were used to cool the bit and help lift cuttings from the borehole. Foaming agents were used during the entire drilling effort to assist in lifting cuttings to the surface.

3.2 Chronological Drilling Activities for the CrEX-3 Well

The Foremost DR-24HD drill rig, drilling equipment, and supplies were mobilized to the CrEX-3 drill site from February 11 to 17, 2016. The equipment and tooling were decontaminated before mobilization to the site. On February 17, at 0630, following on-site equipment inspections, drilling of the extraction well borehole began when the boring was begun for the 24.0-in. surface conductor casing. At 60.0 ft bgs, the 24.0-in. casing was removed and 60.0 ft of 20.0-in. surface conductor casing was set and cemented in place.

From February 19 to 21, the 18.0-in. casing was advanced from 60.0 ft to 328.5 ft bgs, at the top of the Cerros del Rio basalt. From February 24 to March 1, the borehole was drilled open-hole through the basalt using a 17¼-in. hammer bit. Drilling continued open hole through the Cerros del Rio basalt to 695 ft bgs.

Beginning on March 4, a 15.0-in. borehole was advanced to 810.0 ft bgs. The 14.0-in. casing began to bind in the borehole and became stuck at 748.0 ft bgs. While trying to free the casing, it parted at 182.0 ft bgs. The New Mexico Office of the State Engineer gave approval to leave the 14-in. casing in place from 182.0 ft to 748.0 ft bgs and to continue drilling to TD.

Beginning on March 13, the 15.0-in. borehole was advanced with 10.0-in. casing and a 15.0-in. underreaming bit from 810.0 ft bgs, and TD was reached at 1004.5 ft bgs on March 19.

4.0 SAMPLING ACTIVITIES

This section describes the cuttings and groundwater sampling activities for extraction well CrEX-3. No groundwater samples were collected during drilling. All sampling activities were conducted in accordance with applicable quality procedures.

4.1 Cuttings Sampling

Cuttings samples were collected from the CrEX-3 extraction well borehole at 10.0-ft intervals from ground surface to the TD of 1004.5 ft bgs. At each interval, the drillers collected approximately 500 mL of bulk cuttings from the discharge cyclone, placed them in canvas or plastic bags, labeled them, and stored them on-site. Radiological control technicians screened the cuttings before they were removed from the site. All screening measurements were within the range of background values. The cuttings samples were delivered to the Laboratory's archive facility at the conclusion of drilling activities.

Section 5.1 of this report summarizes the stratigraphy encountered at well CrEX-3.

5.0 GEOLOGY AND HYDROGEOLOGY

A brief description of the geologic and hydrogeologic features encountered at CrEX-3 is presented below. The Laboratory's geology task leader and geologists examined the cuttings to determine the geologic contacts and hydrogeologic conditions. Drilling observations, video logging, geophysics, and water-level measurements were used to characterize groundwater occurrences.

5.1 Stratigraphy

Rock units for the CrEX-3 borehole are presented below in order of youngest to oldest in stratigraphic occurrence. Lithologic descriptions are based on binocular microscope analysis of drill cuttings collected from the discharge hose. Figure 5.1-1 illustrates the stratigraphy at CrEX-3.

Alluvium, Qal (0–90 ft bgs)

The poorly consolidated and moderately sorted alluvium consists of abundant minerals and minor rock fragments mixed with fine-grained matrix and coated with light grayish brown silt and clay. The bulk of the weathered sediments consist of abundant quartz and feldspar grains and minor amounts of dark minerals. Minor amounts of dacite, pumice, and altered tuff fragments were also noted. The sediments become lighter in color with depth and are dominated by quartz sand with minor feldspars and rock fragments. Partially rusted iron filings form orange aggregates of minerals throughout this section.

Otowi Member of the Bandelier Tuff, Qbo (90–300 ft bgs)

Poorly sorted, unconsolidated, and light brownish-gray pumice-rich sandy gravel mixed with dacite fragments forms the uppermost ash-flow tuff. The pumice clasts are partially rounded and lightly coated with silt of pulverized glass. In some cases, the amount of dacite is greater than the pumice fraction. Most of the pumice clasts are grayish except for few wood chip–like rusty fragments noted in the middle part of the ash-flow tuff sequence. Quartz and feldspar minerals represent a significant fraction of the ash-flow tuff. In the lowermost part of the ash-flow tuff deposit, the pumice clasts are light gray and are more abundant than the dark gray dacite fragments and the crystal-rich and glassy matrix.

Guaje Pumice Bed of the Otowi Member of the Bandelier Tuff, Qbog (300–310 ft bgs)

The unit consists of white pumice mixed with significant amounts of quartz and feldspar grains and subordinate amount of dacite fragments. The pumice clasts are poorly sorted, subangular to subrounded, and dense compared with the pumices from the overlying ash-low tuff. At least two types of light to medium and pinkish-gray dacite fragments are commonly present with the white pumice of the Guaje Pumice Bed.

Cerros del Rio Volcanics, Tb4 (310–680 ft bgs)

The upper Puye Formation sediment horizon commonly present within the transition zone between the Guaje Pumice Bed of the Bandelier Tuff and the Cerros del Rio basaltic sequence is absent. Instead, a mixture of partially weathered basalt, white pumice, and a few sandstone fragments was encountered. The typical clay-rich alluvial or fluvial deposit is absent. The Cerros del Rio volcanic sequence consists of several lava flows. The uppermost flow is slightly weathered (oxidized) vesicular basalt that transitions to dark gray microcrystalline and porphyritic flow that contains coarse and fractured olivine, pyroxene, and plagioclase. Vesicle walls are coated with vapor-phase minerals, and white amygdules were also noted in some of the lava fragments. The next flow is medium gray, fine grained, and consists of sparsely vesicular and platy fragments. A partially altered grayish-brown and sparsely vesicular lava with phenocrysts of plagioclase and pyroxene caps a reddish to reddish-brown scoria bed that was intersected in the middle section of the volcanic sequence. The scoria fragments are oxidized and contain plagioclase and pyroxene minerals. More of the grayish-brown lava underlies the scoria bed. It is the thickest flow and it is underlain by another scoria bed. A few rounded fragments of light pinkish-gray silty clay occur with the scoria fragments, and some vesicles are filled with it. Medium brown, sparsely vesicular lava underlies the scoria bed. The flow is fine-grained, sparsely vesicular with phenocrysts of olivine, plagioclase, and pyroxene minerals and forms the basal flow. More silty clay fragments were also noted within the lava fragments.

Puye Formation, Tpf (680–965 ft bgs)

Several types of poorly sorted and clast-supported light to medium-gray dacite fragments mixed with minor basalt clasts define the transition zone from the Cerros del Rio volcanic sequence to the Puye Formation sediments. In most cases, the dacite fragments are lightly coated with silt from pulverized sandstone clasts present as minor fraction within the Puye Formation. Moreover, scoria-like orange glassy fragments were noted in the uppermost part of the deposit. These fragments were noted in the 710 to 720–ft interval. In the deeper section of the Puye Formation, the cuttings contain minor fraction of fine-grained minerals and silt matrix that partially form aggregates of rusty clumps of iron filings. Minor white pumice fragments mixed with sandstone clasts in a sandy matrix occur in the lowermost part of the Puye Formation. The matrix contains rusty aggregates of silt and clay.

Miocene Pumiceous Sediments, Tjfp (965–1004.5 ft bgs)

Reworked, poorly sorted, and subrounded white pumice fragments form the bulk of the Miocene pumiceous deposit. Minor coarse dacite fragments and light brownish-gray silty sand represent a minor fraction of the deposit.

5.2 Groundwater

Drilling at CrEX-3 proceeded without any groundwater indications until 901.0 ft bgs as noted by the drilling crew. The borehole was then advanced to the TD of 1004.5 ft bgs. The water level was 901.0 ft bgs on March 19, 2016, before well installation. The DTW in the completed well was 898.4 ft bgs on April 19.

6.0 BOREHOLE LOGGING

Between March 2 and March 3, 2016, a 14.0-in. casing string was installed to a depth of 330.0 ft bgs and then laboratory video and gamma logs were run (Table 6.0-1). Video was run from the surface to 670.0 ft bgs. A gamma log was conducted from 696.0 ft bgs to the surface.

On March 8, a video survey was recorded in the cased borehole from ground surface to 740.0 ft bgs to observe the break in the 14.0-in. casing at about 183.0 ft bgs and the condition of the casing to TD.

On March 19, a gamma log was run from TD of 1004.5 ft to ground surface to aid in designing the well.

On May 8, a video and gamma log were run to document the condition of the completed well. The camera failed at 916.0 ft bgs so only the top of the screened interval is visible. This video will be rerun at the next opportunity—when the pump is removed from the well. Logging was conducted with Laboratory logging equipment and staff (Appendixes C and D).

7.0 WELL INSTALLATION CrEX-3 EXTRACTION WELL

The CrEX-3 well was installed between March 22 and April 11, 2016.

7.1 Well Design

The CrEX-3 well was designed in accordance with the objectives outlined in the “Drilling Work Plan for Groundwater Extraction Well CrEX-3” (LANL 2015, 601001). The drill cuttings and driller’s logs as well as the results of the downhole geophysics and DTW were reviewed. The objectives in setting the screen were to

- obtain key information regarding chromium mass removal, including the orientation and size of the capture zone established from an extended period of pumping to support assessments of mass removal;
- explore the operational extraction approach that achieves the greatest rate of chromium mass removal;
- optimize the removal of only chromium-contaminated water; and
- avoid drawing chromium contamination downwards within the aquifer.

A secondary objective of keeping the well screen entirely within the Puye Formation was developed based on analytical results from recently installed core holes in the vicinity as drilling was completed. The contact between the Puye Formation and the underlying Miocene Pumiceous unit was logged at 965.0 ft bgs.

Extraction well CrEX-3 was designed with a screened interval between 910.0 ft and 950.0 ft bgs to test mass-removal strategies that involve characterization of the hydraulic and contaminant response to pumping, particularly in the centroid, and to remove chromium-contaminated groundwater near the top of the regional aquifer within the Puye Formation. The well design was submitted to NMED on March 21, 2016, and approved later that day. The final CrEX-3 design and NMED’s approval are included in Appendix A.

7.2 Well Construction

From March 20 to 22, 2016, the stainless-steel well casing, screens, and tremie pipe were decontaminated, and well construction materials were mobilized to the site.

The CrEX-3 extraction well was constructed of 8.0-in.-I.D./8.63-in.-O.D. type A304 passivated stainless-steel beveled casing fabricated to American Society for Testing and Materials (ASTM) A312 standards. The screened section utilized two 10.0-ft lengths and one 20.0-ft length of 8.0-in.-I.D. 0.040-in. slot, rod-based wire-wrapped screens to make up the 40.0-ft-long screen interval. Stainless-steel centralizers (two sets of four) were welded to the well casing approximately 2.0 ft above and below the screened interval. All individual casing and screen sections were welded together using compatible stainless-steel welding rods. A 2.0-in. steel tremie pipe was used to deliver backfill and annular fill materials downhole during well construction. A 10.0-ft-long stainless-steel sump was placed below the bottom of the well screen.

The well casing was welded together and installed into the borehole from March 23 to 24.

On March 25 as the 10.0-in. drill casing was being extracted from the borehole, the drill crew lost control of the 10.0-in. casing and it fell 90.0 ft back into the borehole. With no way to get ahold of the 10.0-in. casing with the 8.0-in. well steel in the borehole, the 8.0-in. well had to be removed, plasma cut into 20.0-ft sections, and taken off-site to be rebeveled. From March 28 to 30, the 8.0-in. well was removed from the borehole.

On April 1, the 10.0-in. drill casing was removed from the borehole. From April 3 to 5, the 8.0-in. stainless-steel casing and screens were reinstalled in the open borehole. Backfilling began on April 6 and was completed on April 11.

Figure 7.2-1 presents an as-built schematic showing construction details for the completed well. Table 7.2-1 presents the annular fill materials used in CrEX-3.

The lower bentonite backfill was installed between April 6 and 7 from 975.0 ft to 956.3 ft bgs using 20.1 ft^3 of ¼-in. coated bentonite pellets. The filter pack was installed between April 7 and 8 from 956.3 ft to 901.5 ft bgs using 53.5 ft^3 of 10/20 silica sand. The filter pack was surged to promote compaction. The fine sand collar was installed above the filter pack from 901.5 ft to 899.5 ft bgs using 3.0 ft^3 of 20/40 silica sand. From April 8 to 10, the bentonite seal was installed from 899.5 ft to 59.5 ft bgs using 767.2 ft^3 of 3/8-in. bentonite chips. On April 11, a cement seal was installed from 59.5 ft to 8.0 ft bgs. The cement seal used 86.7 ft^3 of Portland Type I/II/V cement.

8.0 POST-INSTALLATION ACTIVITIES

Following well installation at CrEX-3, the well was developed and aquifer pumping tests were conducted. A temporary pumping system was installed. The wellhead surface completion will be constructed as part of the treatment system piping and infrastructure project in fall 2016. A geodetic survey will be performed once the surface completion vault and piping are installed. Site-restoration activities will be completed following the final disposition of contained drill cuttings and groundwater, per the NMED-approved land application decision trees.

8.1 Well Development

The well was developed between April 19 and May 2, 2016. Initially, the screened interval was swabbed and bailed from April 19 to 26 to remove formation fines in the filter pack and well sump. Bailing continued until water clarity visibly improved. From April 27 to May 2, final well development was then performed with a submersible pump.

The swabbing tool employed was a 7.5-in.-O.D., 1-in.-thick nylon disc attached to a weighted steel rod. The wireline-conveyed tool was drawn repeatedly across the screened interval, causing a surging action across the screen and filter pack.

The first bailing tool employed was a 6.0-in.-O.D. by 20.0-ft-long carbon steel, bottom-filling, bailer with an approximate volume of 30 gal. The tool was repeatedly lowered by wireline, filled, withdrawn from the well, and emptied into the cuttings pit. After 1 d of bailing, it was determined that 5.3 ft of material remained in the sump. Bailing switched to a 4-in. by 20-ft-long carbon steel sand bailer and was bailed on April 26 until the sump was cleaned out. Approximately 3200 gal. of groundwater was removed during bailing activities.

After bailing, a 30-horsepower (hp), 6-in. Franklin submersible pump was installed in the well for the final stage of well development. The screened interval was pumped from top to bottom and from bottom to top in 2-ft increments each day and night from April 27 to May 2. Approximately 68,205 gal. of groundwater was purged with the submersible pump during well development.

8.1.1 Well Development Field Parameters

The field parameters of turbidity, temperature, and pH were monitored via a flow-through cell at CrEX-3 during well development. The field parameter measurements toward the end of development on May 3, 2016, were pH of 8.01, temperature of 17.39°C, and turbidity of 2.52 nephelometric turbidity units (NTU). Field water-quality parameters are presented in Table 8.1-1.

8.2 Aquifer Testing

Step testing was conducted on May 3, 2016. The well was pumped in four steps at 25.6 gallons per minute (gpm), 38.1 gpm, 51.3 gpm, and 64.0 gpm in 1-h increments. A total of 11,700 gal. of water was removed during the step testing. A 24-h aquifer test was conducted between May 4 and 5, followed by a 24-h recovery period. The average pumping rate for the 24-h test was approximately 51.1 gpm. A 30-hp pump was used for the aquifer tests. A total of approximately 74,985 gal. of groundwater was purged during aquifer testing. Turbidity, temperature, and pH were measured during the aquifer tests. The CrEX-3 aquifer test results and analysis are presented in Appendix D.

8.3 Pumping System Installation

A dedicated pumping system for CrEX-3 was installed on May 8, 2016. The system uses a 6-in. Franklin Electric submersible pump and 30-hp motor. The pump control panel includes a variable-frequency drive that will allow for flow control via motor speed manipulation. The pump riser pipe consists of 3.0-in. threaded and coupled American Petroleum Institute 5L galvanized steel. Two 1.0-in.-I.D. schedule 80 polyvinyl chloride (PVC) tubes are installed along with, and banded to, the pump column. A dedicated In-Situ Level Troll 500 transducer is installed in one of the tubes, and the second tube will be used for manual water-level measurements. Both PVC tubes are equipped with a 0.5-ft section of 0.010-in. slotted screen and a closed bottom.

Pumping system details for CrEX-3 are presented in Figure 8.3-1a. Figure 8.3-1b presents technical notes for the well.

8.4 Wellhead Completion

A reinforced concrete subsurface vault will be installed at the CrEX-3 wellhead in fall 2016. The vault will be slightly elevated above ground surface and will provide long-term structural integrity for the well. A brass monument marker will be embedded in the vault. Six steel bollards, covered by high-visibility plastic sleeves, will be set at the outside edges of the pad to protect the well from accidental vehicle damage. They are designed for easy removal to allow access to the well. Figure 8.3-1a shows details of the current wellhead completion.

8.5 Geodetic Survey

A provisional survey of the top of the stainless-steel well was performed on June 9, 2016. The temporary survey data will be used for water-level monitoring until the surface completion is constructed and the final survey is performed. Current survey data for CrEX-3 are presented on Table 8.5-1.

A licensed professional land surveyor will conduct a geodetic survey once the wellhead is completed. The survey data will conform to Laboratory Information Architecture project standards IA-CB02, “GIS Horizontal Spatial Reference System,” and IA-D802, “Geospatial Positioning Accuracy Standard for A/E/C and Facility Management.” All coordinates will be expressed relative to New Mexico State Plane Coordinate System Central Zone 83 (North American Datum [NAD] 83); elevation will be expressed in feet above mean sea level (amsl) using the National Geodetic Vertical Datum of 1929. Survey points will include ground-surface elevation near the concrete pad, the top of the monument marker in the concrete pad, the top of the well casing, and the top of the protective casing.

8.6 Waste Management and Site Restoration

Waste generated from the CrEX-3 project includes drilling fluids, drill cuttings, and contact waste. A summary of the waste characterization samples collected during drilling, construction, and development of the CrEX-3 well is presented in Table 8.6-1. All waste streams produced during drilling and development activities were sampled in accordance with the “Waste Characterization Strategy Form for Chromium Well CrEX-1” (LANL 2014, 254859). Development water was land-applied under a temporary permission to discharge (NMED 2014, 600128).

Fluids produced during drilling and containerized in the pit will be evaporated on-site. Evaporation activities began in June 2016.

Analytical results for fluids produced during well development and pump testing will be reviewed with the goal of land application. Data will be reviewed manually and within the automated waste determination program per the waste characterization strategy form and ENV-RCRA-QP-010, Land Application of Groundwater. If it is determined that drilling fluids are nonhazardous but cannot meet the criteria for land application, the drilling fluids will be reevaluated for treatment and disposal at one of the Laboratory’s wastewater treatment facilities or other authorized disposal facility. If analytical data indicate the drilling fluids are hazardous/nonradioactive or mixed low-level waste, the drilling fluids will be to an off-site treatment, storage, and disposal facility.

Cuttings produced during drilling were sampled, and analytical results will be reviewed with the goal of land application. Once the fluids are evaporated or removed from the pit, a composite volatile organic analyte sample of the cuttings will be collected and evaluated against land-application criteria (ENV-RCRA-QP-011, Land Application of Drill Cuttings). If cuttings meet land-application criteria, materials will be spread across the pad area, and the site will be reseeded as required for site reclamation.

Characterization of contact waste will be based upon acceptable knowledge, referencing the analyses of the waste samples collected from the drilling fluids, drill cuttings, and decontamination fluids. A waste profile form will be completed, and the contact wastes will be removed from the site following land application of the pit-contained drill cuttings. The pit liner will be included in the contact waste disposal materials.

Site restoration activities are conducted by Maintenance and Site Services personnel at the Laboratory. Activities include evaporating drilling fluids, removing cuttings from the pit, and managing the development/pump test fluids in accordance with applicable procedures. The polyethylene liner will be removed following land application of the cuttings, and the containment area berms will be removed and leveled. Activities also include backfilling and regrading the containment area, as appropriate.

9.0 DEVIATIONS FROM PLANNED ACTIVITIES

Drilling and well construction at CrEX-3 were performed as specified in "Drilling Work Plan for Groundwater Monitoring Well CrEX-3" (LANL 2014, 254824). One significant deviation from the plan occurred. The broken string of 14.0-in. casing left in the borehole between 182.0 ft and 748.0 ft bgs. The bottom of the broken casing is approximately 150.0 ft above the top of the regional aquifer. Because no perched-intermediate water was encountered at this location and the casing is set in the bentonite backfill, it will not act as a conduit and will not compromise the well in any way.

10.0 ACKNOWLEDGMENTS

Yellow Jacket Drilling drilled and installed extraction well CrEX-3.

11.0 REFERENCES AND MAP DATA SOURCES

11.1 References

The following list includes all documents cited in this report. Parenthetical information following each reference provides the author(s), publication date, and ER ID or ESH ID. This information is also included in text citations. ER IDs were assigned by the Environmental Programs Directorate's Records Processing Facility (IDs through 599999), and ESH IDs are assigned by the Environment, Safety, and Health (ESH) Directorate (IDs 600000 and above). IDs are used to locate documents in the Laboratory's Electronic Document Management System and, where applicable, in the master reference set.

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau and the ESH Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

LANL (Los Alamos National Laboratory), February 28, 2014. "Waste Characterization Strategy Form for Chromium Well CrEx-1," Los Alamos National Laboratory, Los Alamos, New Mexico. (LANL 2014, 254859)

LANL (Los Alamos National Laboratory), March 2014. "Drilling Work Plan for Groundwater Extraction Well CrEX-1," Los Alamos National Laboratory document LA-UR-14-21478, Los Alamos, New Mexico. (LANL 2014, 254824)

LANL (Los Alamos National Laboratory), November 2015. "Drilling Work Plan for Groundwater Extraction Well CrEX-3," Los Alamos National Laboratory document LA-UR-15-28592, Los Alamos, New Mexico. (LANL 2015, 601001)

LANL (Los Alamos National Laboratory), December 16, 2015. "Storm Water Pollution Prevention Plan, CrEX-3 Well Pad and Construction Support Activities, Los Alamos National Laboratory," Los Alamos National Laboratory, Los Alamos, New Mexico. (LANL 2015, 601729)

NMED (New Mexico Environment Department), August 8, 2014. "Temporary Permission to Discharge, Treated Ground Water from Aquifer Testing at Pilot Pumping Well CrEX-1 (AI: 856, PRD20140007)," New Mexico Environment Department letter to A. Dorries (LANL) and G. Turner (DOE) from J. Schoeppner (NMED-GWQB), Santa Fe, New Mexico. (NMED 2014, 600128)

North Wind Inc., July 2011. "Spill Prevention Control and Countermeasures Plan for the ADEP Groundwater Monitoring Well Drilling Operations, Los Alamos National Laboratory, Revision 6," plan prepared for Los Alamos National Laboratory, Los Alamos, New Mexico. (North Wind, Inc., 2011, 213292)

Yellow Jacket Drilling, June 27, 2014. "Integrated Work Document for Drilling and Installation of LANL Well [CrEX-1]," Los Alamos, New Mexico. (Yellow Jacket Drilling 2014, 600131)

11.2 Map Data Sources

Point Feature Locations of the Environmental Restoration Project Database; Los Alamos National Laboratory, Waste and Environmental Services Division, EP2008-0109; 12 April 2010.

Hypsography, 100 and 20 Foot Contour Interval; Los Alamos National Laboratory, ENV Environmental Remediation and Surveillance Program; 1991.

Surface Drainages, 1991; Los Alamos National Laboratory, ENV Environmental Remediation and Surveillance Program, ER2002-0591; 1:24,000 Scale Data; Unknown publication date.

Paved Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Dirt Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Technical Area Boundaries; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Division; 4 December 2009.

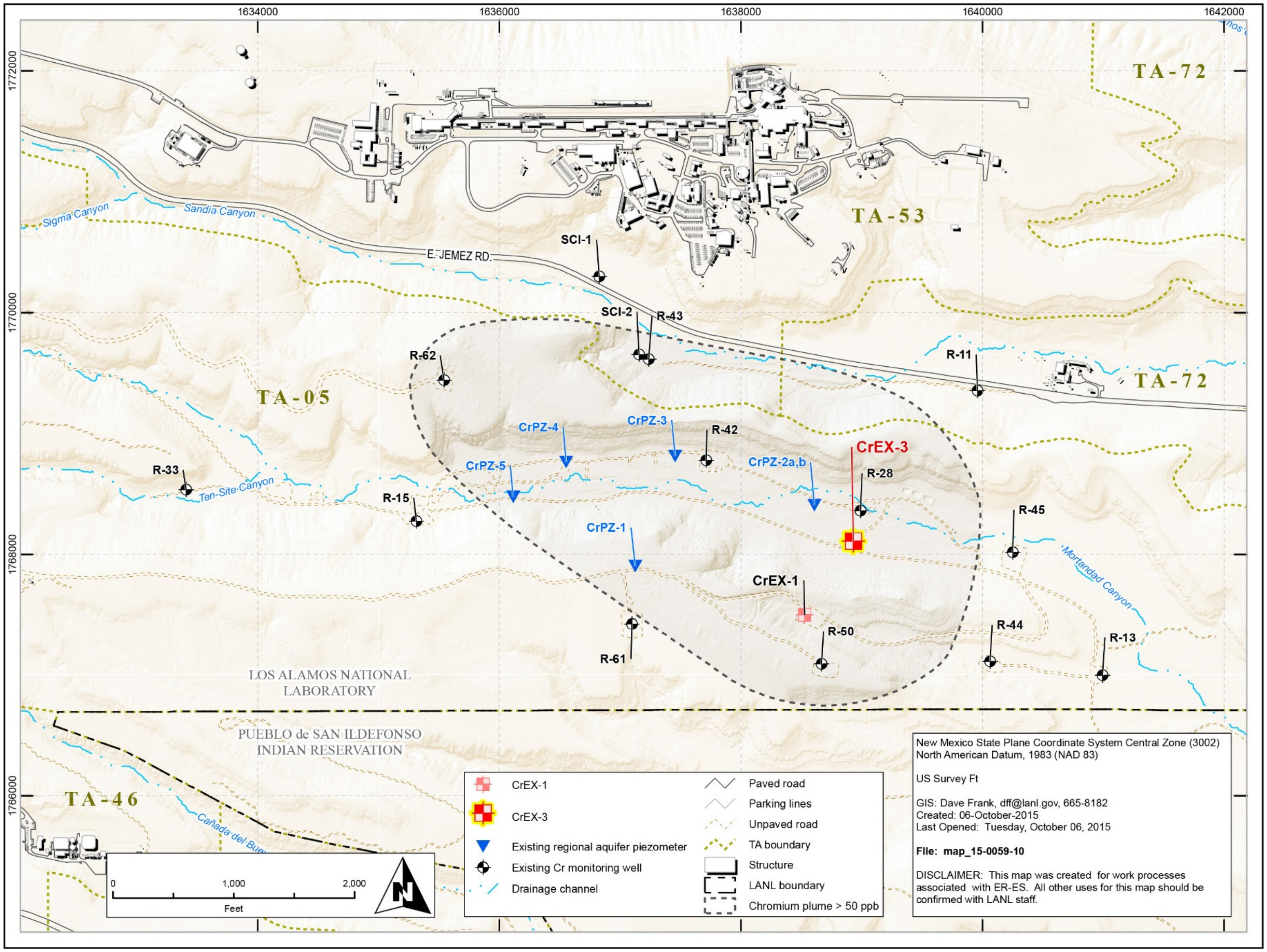


Figure 1.0-1 Location of extraction well CrEX-3

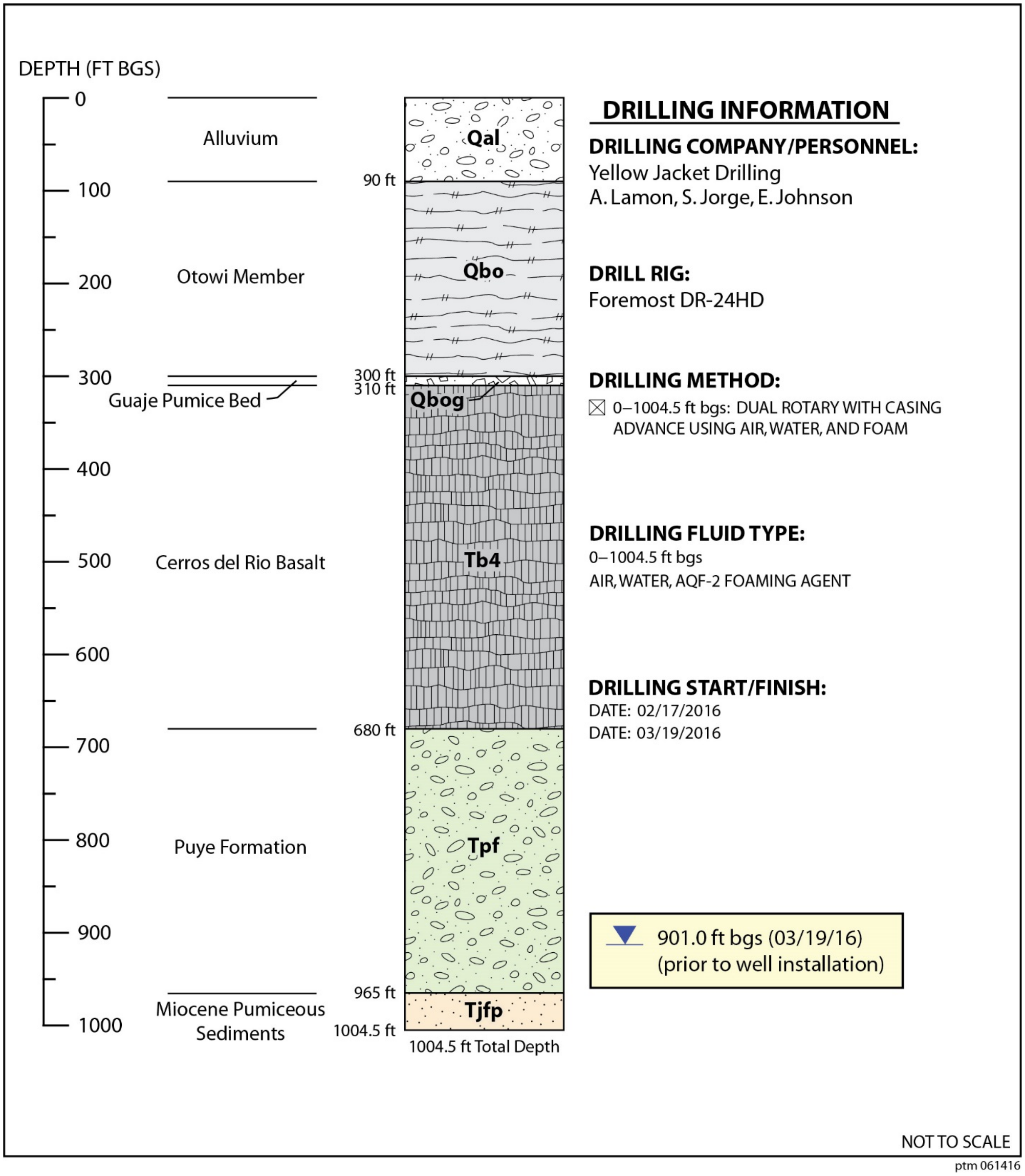


Figure 5.1-1 Extraction well CrEX-3 borehole stratigraphy

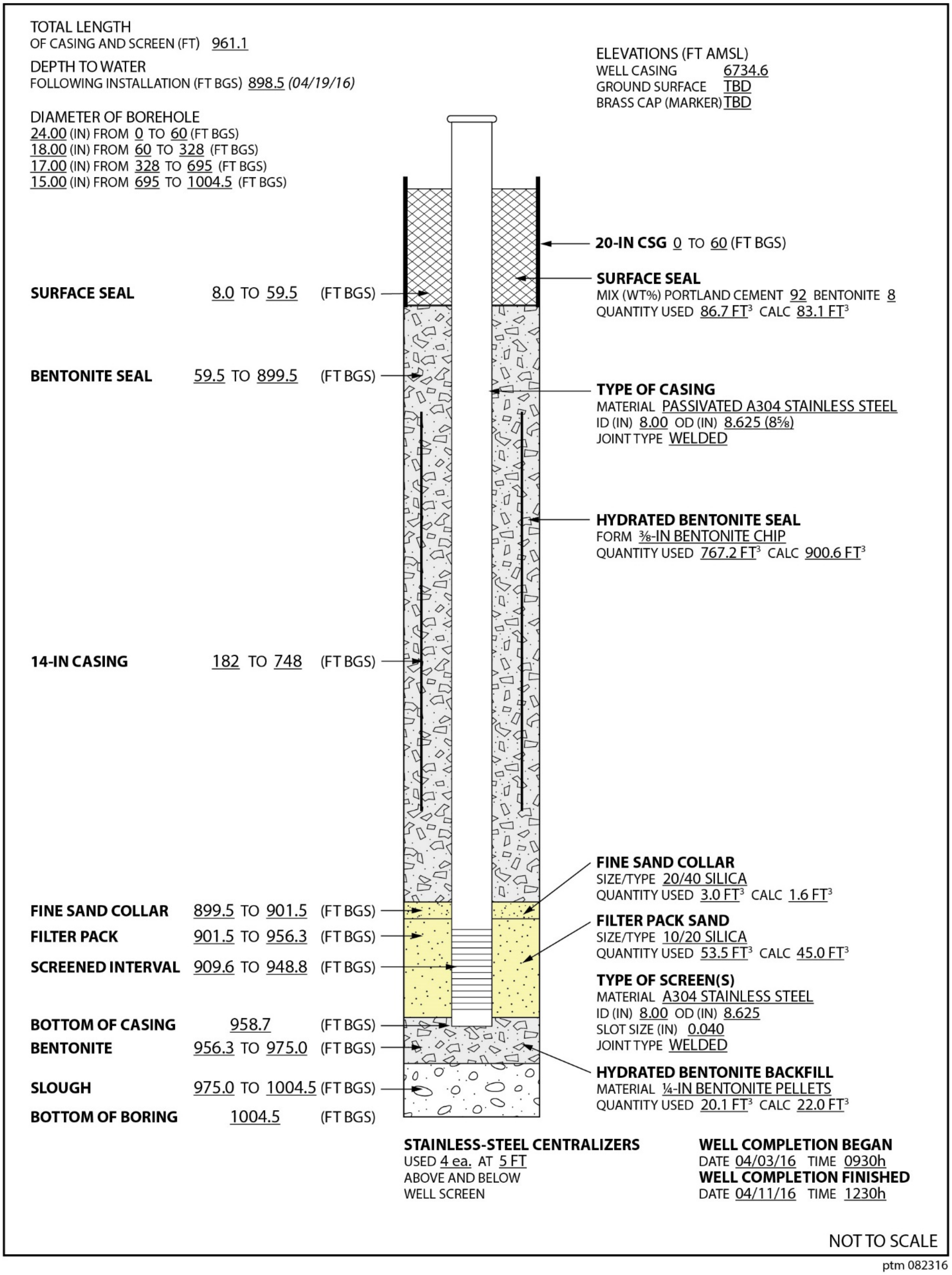


Figure 7.2-1 Extraction well CrEX-3 as-built well construction diagram

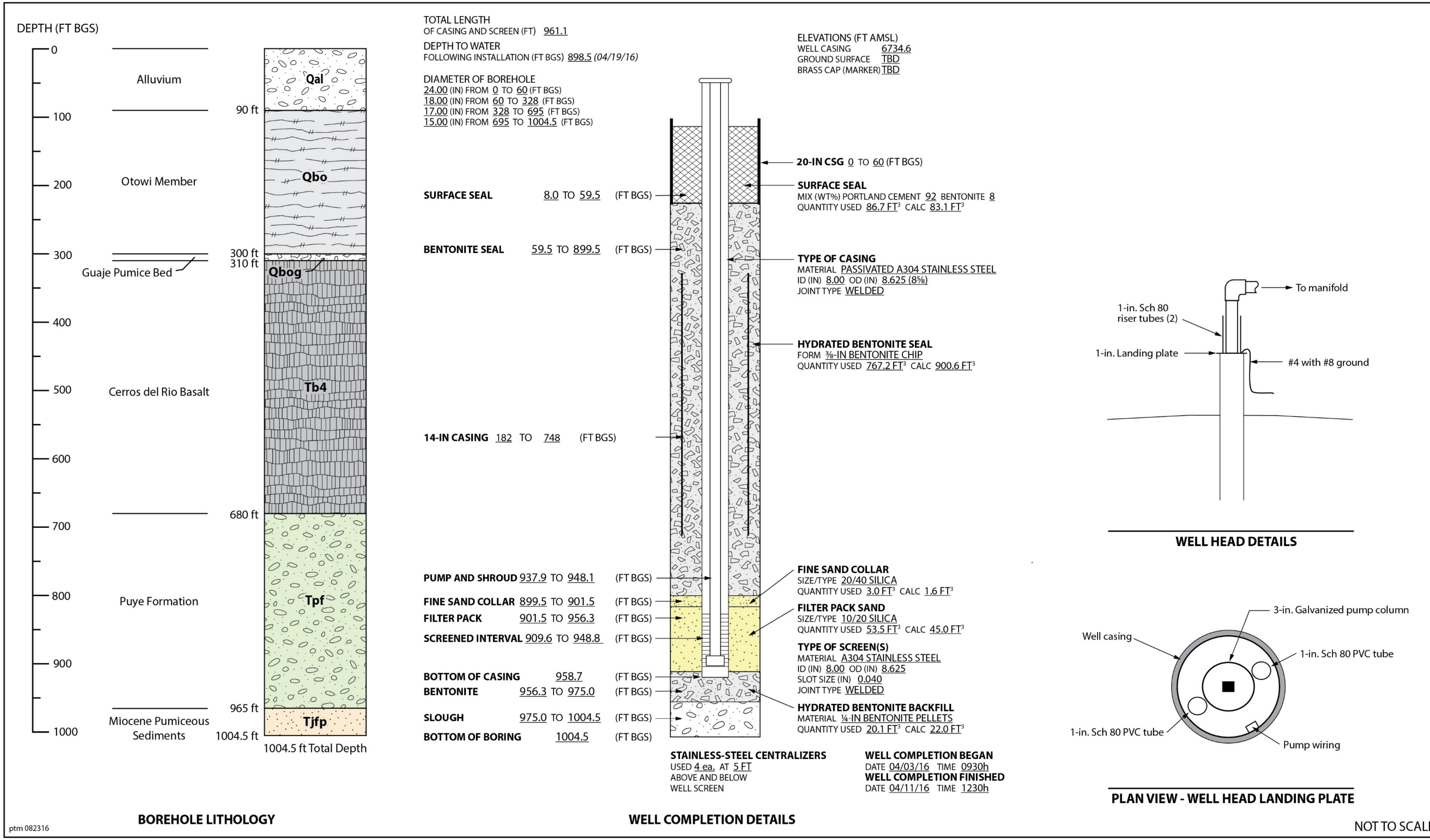


Figure 8.3-1a Extraction well CrEX-3 as-built diagram with borehole lithology and technical well completion details

CrEX-3 TECHNICAL NOTES:

SURVEY INFORMATION*

Brass Marker

Northing:	TBD
Easting:	TBD
Elevation:	TBD

Well Casing (top of stainless steel)

Northing:	TBD
Easting:	TBD
Elevation:	6734.6 ft amsl

BOREHOLE GEOPHYSICAL LOGS

LANL: Natural gamma ray

DRILLING INFORMATION

Drilling Company
Yellow Jacket Drilling, Inc.

Drill Rig
Foremost DR-24HD

Drilling Methods
Dual rotary fluid-assisted air rotary

Drilling Fluids
Air, potable water, AQF-2 Foam

MILESTONE DATES

Drilling

Start:	02/17/2016
Finished:	03/19/2016

Well Completion

Start:	04/03/2016
Finished:	04/11/2016

Well Development

Start:	04/19/2016
Finished:	05/02/2016

WELL DEVELOPMENT

Development Methods
Performed swabbing, bailing, and pumping
Total Volume Purged: 71,405 gal.

Parameter Measurements (Final)

pH:	7.91
Temperature:	20.7°C
Turbidity:	0.81 NTU

AQUIFER TESTING

24-h Constant-Rate Pumping Test

Water Produced:	74,985 gal.
Average Flow Rate:	51.1 gpm
Performed on:	05/04/16–05/05/16

DEDICATED SAMPLING SYSTEM

Pump (Shrouded)
Make: Franklin Electric
Model: 70SR30F66-3263

Motor
Make: Franklin Electric
Model: Submersible Sand Fighter
30 hp, 3 phase, 460 V

Pump Column
Flomatic model # 80DI check valves at 239, 471, and 725 ft bgs

Transducer Tubes
2 × 1.0-in. flush threaded schd. 80 PVC tubing
0.020-in. slot screens at 944.1–744.6 ft bgs

Transducer
Make: In-Situ Level TROLL
Model: LT 500
PSIG range: Max 30 PSI / 69 ft
S/N: 458444

NOTE:
* Coordinates based on New Mexico State Plane Grid Coordinates, Central Zone (NAD83); Elevation expressed in feet amsl using the National Geodetic Vertical Datum of 1929.

Figure 8.3-1b As-built technical notes for extraction well CrEX-3

Table 6.0-1
Logging Runs

Date(s)	Type of Log	Depth (ft bgs)	Description
03/03/2016	Video	0–670	LANL video from ground surface to 670.0 ft bgs. Observe open-hole interval.
03/03/2016	Gamma log	0-696	LANL gamma log through open-hole section.
03/08/2016	Video	0–740	LANL video to confirm condition of broken 14.0-in. drill casing.
03/19/2016	Gamma log	0–1004	LANL gamma log at drilling TD.
05/08/2016	Gamma log	1–960	LANL as-built gamma log to confirm position of bentonite backfill and sand pack materials.
05/08/2016	Video	0-960	LANL video to confirm screen condition. Not recorded due to camera failure.

Table 7.2-1
CrEX-3 Extraction Well Annular Fill Materials

Material	Volume
Upper surface seal: cement slurry	86.7 ft^3
Upper bentonite seal: bentonite chips	767.2 ft^3
Fine sand collar: 20/40 silica sand	3.0 ft^3
Filter pack: 10/20 silica sand	53.5 ft^3
Backfill: bentonite pellets	20.1 ft^3

Table 8.1-1
Field Water-Quality Parameters and Well Performance for Development of Well CrEX-3

Date	Time	Pumping Rate (gpm)	Depth to Water (ft btoc[a])	Draw Down (ft)	Cumulative Purge Volume (gal.)	pH	Turbidity (NTU)	Temp (deg C)
Well Development								
04/30/2016	8:18	0.0	901.54	0.00	29,130	NC[b]	NC	NC
	8:30	30.0	NC	NC	NC	NC	NC	NC
	8:40	30.0	909.79	8.25	29,440	7.83	5.82	18.17
	8:50	0.0	910.10	8.56	29,770	8.04	15.10	19.14
	9:00	0.0	910.21	8.67	30,095	7.99	11.30	19.02
	9:05	0.0	NC	NC	NC	NC	NC	NC
	9:10	40.0	NC	NC	30,495	NC	NC	NC
	9:20	40.0	913.20	11.66	30,865	7.95	10.10	19.18
	9:30	40.0	913.40	11.86	31,350	7.95	8.35	18.88
	9:40	40.0	913.58	12.04	31,780	7.94	7.63	18.81
	9:50	40.0	913.62	12.08	32,210	7.94	6.70	18.35
	9:56	50.0	NC	NC	32,470	NC	NC	NC
	10:20	50.0	916.39	14.85	33,690	7.94	6.37	17.77
	10:30	50.0	916.52	14.98	34,195	7.93	5.66	19.45
	10:40	50.0	916.58	15.04	34,710	7.93	5.47	19.07
	10:46	60.0	NC	NC	35,040	NC	NC	NC
	11:00	60.0	921.82	20.28	35,950	7.94	8.77	19.93
	11:10	60.0	922.10	20.56	36,595	7.92	6.80	19.68
	11:20	60.0	922.35	20.81	37,240	7.91	NC	19.66
	11:30	0.0	NC	NC	37,890	NC	NC	NC
	12:15	0.0	NC	NC	NC	NC	NC	NC
	12:50	0.0	NC	NC	NC	NC	NC	NC
	16:00	35.0	901.60	0.06	41,810	NC	NC	NC
	16:05	35.0	910.20	8.66	41,810	7.90	2.48	19.75
	16:30	35.0	911.13	9.59	42,000	7.89	3.06	19.55
	16:50	35.0	911.38	9.84	42,965	7.89	2.70	19.08
	17:10	35.0	911.57	10.03	43,740	7.90	3.06	20.17
	17:15	0.0	NC	NC	44,510	NC	NC	NC
05/1/2016	7:54	0.0	901.65	0.00	44,700	NC	NC	NC
	8:00	30.0	NC	NC	44,700	NC	NC	NC
	8:15	25.6	909.70	8.05	NC	NC	NC	NC
	8:30	25.6	910.00	8.35	44,730	7.96	3.40	18.45
	8:35	38.1	NC	NC	NC	NC	NC	NC
	9:13	38.1	911.79	10.14	NC	7.93	3.28	19.19
	9:25	38.1	911.80	10.15	NC	7.92	2.99	19.20

Table 8.1-1 (continued)

Date	Time	Pumping Rate (gpm)	Depth to Water (ft btoc[a])	Draw Down (ft)	Cumulative Purge Volume (gal.)	pH	Turbidity (NTU)	Temp (deg C)
	9:30	42.5	NC	NC	NC	NC	NC	NC
	9:45	42.5	913.23	11.58	NC	7.91	2.63	19.05
	10:00	42.5	913.36	11.71	NC	7.92	1.94	19.38
	10:05	51.3	NC	NC	NC	NC	NC	NC
	10:20	51.3	915.84	14.19	NC	7.92	2.73	18.63
	10:45	51.3	916.11	14.46	NC	7.92	1.91	19.27
	10:50	66.3	NC	NC	NC	NC	NC	NC
	11:05	66.3	921.00	19.35	NC	7.93	3.39	18.82
	11:20	66.3	921.34	19.69	NC	7.93	2.83	19.15
	11:30	66.3	921.50	19.85	NC	7.93	2.91	18.72
	11:35	0.0	NC	NC	NC	NC	NC	NC
05/02/2016	11:08	0.0	901.90	0.00	NC	NC	NC	NC
	11:23	25.0	NC	NC	NC	NC	NC	NC
	11:35	25.0	NC	NC	45,030	NC	NC	NC
	11:40	25.0	907.70	5.80	45,165	7.98	3.13	16.69
	11:48	25.0	907.84	5.94	NC	8.01	2.52	17.39
	11:50	0.0	NC	NC	45,430	NC	NC	NC
	13:08	0.0	901.86	-0.04	45,430	NC	NC	NC
	13:10	38.1	NC	NC	45,430	NC	NC	NC
	13:40	38.1	990.00	88.10	46,570	NC	NC	NC
	13:50	38.1	909.10	7.20	46,960	NC	NC	NC
	13:51	42.5	NC	NC	46,998	NC	NC	NC
	14:05	42.5	910.20	8.30	47,595	NC	NC	NC
	14:10	42.5	NC	NC	47,805	NC	NC	NC
	14:11	51.3	NC	NC	NC	NC	NC	NC
	14:30	51.3	912.35	10.45	48,820	NC	NC	NC
	14:50	51.3	912.62	10.72	49,850	NC	NC	NC
	15:00	51.3	912.68	10.78	50,360	NC	NC	NC
	15:01	66.3	912.62	10.72	NC	NC	NC	NC
	15:30	66.3	918.05	16.15	52,330	NC	NC	NC
	15:45	66.3	918.33	16.43	53,330	NC	NC	NC
	15:46	57.0	NC	NC	NC	NC	NC	NC
	16:32	57.0	916.26	14.36	56,080	NC	NC	NC
	16:45	57.0	NC	NC	56,775	NC	NC	NC
	16:46	64.0	NC	NC	NC	NC	NC	NC
	17:00	64.0	917.94	16.04	57,730	NC	NC	NC

Table 8.1-1 (continued)

Date	Time	Pumping Rate (gpm)	Depth to Water (ft btoc[a])	Draw Down (ft)	Cumulative Purge Volume (gal.)	pH	Turbidity (NTU)	Temp (deg C)
	17:10	64.0	918.04	16.14	58,365	NC	NC	NC
	17:11	73.5	NC	NC	NC	NC	NC	NC
	17:30	73.5	921.11	19.21	59,830	NC	NC	NC
	17:40	73.5	921.29	19.39	60,560	NC	NC	NC
	17:41	0.0	NC	NC	60,630	NC	NC	NC
Step Test								
05/03/2016	8:12	0.0	901.84	0.00	NC	NC	NC	NC
	8:16	0.0	901.84	0.00	60,635	0	NC	NC
	8:20	0.0	901.84	0.00	60,635	NC	NC	NC
	8:25	0.0	901.84	0.00	60,635	NC	NC	NC
	8:28	0.0	901.84	0.00	60,635	NC	NC	NC
	8:30	25.6	NC	NC	60,635	NC	NC	NC
	8:35	25.6	907.55	5.71	60,785	8.02	NC	10.00
	8:40	25.6	907.85	6.01	60,940	7.96	1.72	18.13
	8:35	25.6	907.92	6.08	61,095	8.04	2.46	19.40
	8:50	25.6	908.07	6.23	61,250	8.02	2.33	19.48
	8:55	25.6	908.16	6.32	61,410	8.00	2.01	19.48
	9:00	25.6	908.21	6.37	61,570	7.98	2.01	20.02
	9:10	25.6	908.29	6.45	61,890	7.95	1.85	19.70
	9:20	25.6	908.34	6.50	62,220	7.94	1.68	19.53
	9:30	25.6	908.39	6.55	62,560	7.94	1.68	19.47
	9:31	38.1	NC	NC	NC	NC	NC	NC
	9:36	38.1	909.39	7.55	62,785	7.93	1.54	19.65
	9:41	38.1	909.48	7.64	62,975	7.93	1.67	19.10
	9:46	38.1	909.52	7.68	63,170	7.93	1.34	19.51
	9:51	38.1	909.55	7.71	63,365	7.93	1.52	19.76
	9:56	38.1	909.59	7.75	63,560	7.93	0.50	19.67
	10:01	38.1	909.60	7.76	63,755	7.93	1.50	19.44
	10:11	38.1	909.65	7.81	64,640	7.93	1.51	19.69
	10:21	38.1	909.67	7.83	64,530	7.93	1.37	19.18
	10:31	38.1	909.74	7.90	64,915	7.93	1.37	19.36
	10:32	51.3	NC	NC	NC	NC	NC	NC
	10:33	51.3	911.61	9.77	65,000	7.93	1.79	20.10
	10:38	51.3	912.41	10.57	65,260	7.93	1.54	20.03
	10:43	51.3	912.56	10.72	65,515	7.91	1.53	19.91
	10:48	51.3	912.68	10.84	65,770	7.92	1.81	19.86

Table 8.1-1 (continued)

Date	Time	Pumping Rate (gpm)	Depth to Water (ft btoc[a])	Draw Down (ft)	Cumulative Purge Volume (gal.)	pH	Turbidity (NTU)	Temp (deg C)
	10:53	51.3	912.75	10.91	66,030	7.92	1.67	19.90
	10:58	51.3	912.84	11.00	66,280	7.92	1.76	19.94
	11:03	51.3	912.90	11.06	66,530	7.92	1.61	20.14
	11:13	51.3	913.00	11.16	67,040	7.92	1.23	20.21
	11:23	51.3	913.09	11.25	67,550	7.92	1.54	20.12
	11:33	51.3	913.14	11.30	68,060	7.93	1.38	20.12
	11:34	64.0	NC	NC	NC	NC	NC	NC
	11:39	64.0	916.33	14.49	68,430	7.92	1.31	20.09
	11:44	64.0	916.64	14.80	68,750	7.92	1.97	20.03
	11:49	64.0	916.76	14.92	69,075	7.91	1.63	19.33
	11:54	64.0	916.81	14.97	69,395	7.93	1.91	20.23
	11:59	64.0	916.97	15.13	69,710	7.92	1.72	20.27
	12:04	64.0	917.03	15.19	70,030	7.92	1.66	20.12
	12:14	64.0	917.13	15.29	70,670	7.91	1.51	19.99
	12:24	64.0	917.16	15.32	71,310	7.91	1.45	20.20
	12:34	64.0	917.30	15.46	71,955	7.91	1.72	20.47
	12:39	64.0	917.32	15.48	72,270	7.91	1.60	20.51
	12:40	0.0	NC	NC	72,335	NC	NC	NC
24-h Aquifer Test								
05/04/2016	13:05	0.0	901.90	0.00	72,335	NC	NC	NC
	13:15	0.0	901.90	0.00	72,335	NC	NC	NC
	13:25	0.0	901.90	0.00	72,335	NC	NC	NC
	13:28	0.0	901.92	0.02	72,335	NC	NC	NC
	13:30	NC	NC	NC	72,335	NC	NC	NC
	13:31	NC	909.40	7.50	NC	NC	NC	NC
	13:32	NC	910.44	8.54	NC	NC	NC	NC
	13:33	NC	910.87	8.97	NC	NC	NC	NC
	13:34	NC	911.15	9.25	NC	NC	NC	NC
	13:35	NC	911.37	9.47	72,610	NC	NC	NC
	13:36	NC	911.46	9.56	NC	NC	NC	NC
	13:37	NC	911.62	9.72	NC	NC	NC	NC
	13:38	NC	911.73	9.83	NC	NC	NC	NC
	13:39	NC	911.82	9.92	NC	NC	NC	NC
	13:40	NC	911.91	10.01	72,870	7.93	3.40	19.69
	13:42	NC	912.04	10.14	NC	NC	NC	NC
	13:44	NC	912.15	10.25	NC	NC	NC	NC

Table 8.1-1 (continued)

Date	Time	Pumping Rate (gpm)	Depth to Water (ft btoc[a])	Draw Down (ft)	Cumulative Purge Volume (gal.)	pH	Turbidity (NTU)	Temp (deg C)
	13:46	NC	912.23	10.33	NC	NC	NC	NC
	13:48	NC	912.34	10.44	NC	NC	NC	NC
	13:50	NC	912.40	10.50	73,375	7.97	1.47	21.20
	13:55	NC	912.66	10.76	NC	NC	NC	NC
	14:00	NC	912.69	10.79	73,875	7.93	1.44	21.43
	14:05	NC	912.79	10.89	NC	NC	NC	NC
	14:10	NC	912.88	10.98	NC	NC	NC	NC
	14:15	NC	912.99	11.09	NC	NC	NC	NC
	14:20	NC	913.05	11.15	74,910	7.92	1.02	21.12
	14:30	NC	913.12	11.22	75,430	7.91	0.99	21.18
	14:40	51.2	913.23	11.33	75,945	7.91	0.79	21.23
	14:50	NC	913.28	11.38	76,465	7.92	0.79	20.85
	15:00	NC	913.30	11.40	76,955	7.92	0.79	20.99
	15:15	NC	913.35	11.45	77,765	7.92	1.32	21.17
	15:30	NC	913.38	11.48	78,540	7.92	0.55	21.26
	15:45	NC	913.37	11.47	79,315	7.91	0.55	21.38
	16:00	NC	913.42	11.52	80,085	7.92	0.66	20.43
	16:15	NC	913.44	11.54	80,860	7.92	0.54	21.03
	16:30	NC	913.45	11.55	81,630	7.91	0.54	21.18
	16:45	NC	913.45	11.55	82,400	7.91	0.47	21.13
	17:00	NC	913.49	11.59	83,180	7.91	0.42	21.41
	17:30	NC	913.44	11.54	84,730	7.92	0.41	20.83
	18:00	NC	913.49	11.59	86,330	7.91	0.00	21.27
	18:30	NC	913.48	11.58	87,790	7.90	0.39	21.44
	19:00	NC	913.46	11.56	89,360	7.90	0.74	21.29
	19:30	NC	913.46	11.56	90,880	7.90	0.74	20.36
	20:00	NC	913.46	11.56	92,440	7.91	0.24	19.63
	20:30	NC	913.45	11.55	93,960	7.91	0.36	19.50
	21:00	NC	913.44	11.54	95,440	7.91	0.31	19.24
	21:30	NC	913.44	11.54	97,060	7.91	0.31	19.75
	22:00	NC	913.43	11.53	98,460	7.91	0.45	19.02
	22:30	NC	913.40	11.50	100,000	7.92	0.45	18.82
	23:00	NC	913.40	11.50	101,530	7.92	0.58	18.66
	23:30	NC	913.50	11.60	103,000	7.92	0.76	18.82

Table 8.1-1 (continued)

Date	Time	Pumping Rate (gpm)	Depth to Water (ft btoc[a])	Draw Down (ft)	Cumulative Purge Volume (gal.)	pH	Turbidity (NTU)	Temp (deg C)
05/05/2016	0:00	NC	913.35	11.45	104,550	7.91	0.90	19.04
	0:30	NC	913.35	11.45	106,050	7.92	0.01	18.60
	1:00	NC	913.35	11.45	107,560	7.92	1.50	18.45
	1:30	NC	913.30	11.40	109,100	7.92	1.25	18.47
	2:00	NC	913.26	11.36	110,540	7.90	1.38	23.68
	2:30	NC	913.21	11.31	112,150	7.92	1.35	19.15
	3:00	NC	913.19	11.29	113,570	7.94	0.26	18.64
	3:30	NC	913.15	11.25	115,140	7.98	0.45	18.70
	4:00	NC	913.12	11.22	116,660	7.98	0.48	19.26
	4:30	NC	913.11	11.21	118,100	7.96	0.46	18.95
	5:00	NC	913.80	11.90	119,690	7.99	0.87	19.06
	5:30	NC	913.60	11.70	121,120	7.94	1.01	18.55
	6:00	53.0	913.05	11.15	122,680	7.93	0.43	18.64
	6:30	53.0	913.03	11.13	124,190	7.92	0.43	18.07
	7:00	53.0	913.00	11.10	125,710	7.91	0.58	18.61
	7:30	53.0	912.99	11.09	127,240	7.90	0.74	19.26
	8:00	NC	912.97	11.07	128,785	7.91	0.55	19.77
	8:30	NC	912.97	11.07	130,330	7.91	0.54	19.78
	9:00	NC	912.97	11.07	131,880	7.90	0.50	19.88
	9:30	NC	912.90	11.00	133,420	7.90	0.50	20.10
	10:00	NC	912.86	10.96	134,975	7.90	1.35	20.14
	10:30	NC	912.83	10.93	136,515	7.91	0.67	20.45
	11:00	NC	912.79	10.89	138,060	7.89	0.98	20.63
	11:30	NC	912.75	10.85	139,610	7.90	0.62	20.91
	11:45	NC	912.72	10.82	140,640	7.91	0.62	20.73
	12:00	NC	912.65	10.75	142,700	7.90	0.67	21.10
	12:30	NC	912.60	10.70	144,250	7.90	0.89	21.49
	13:00	NC	912.60	10.70	145,025	7.90	0.68	21.29
	13:15	NC	912.60	10.70	145,530	7.91	0.82	21.24
	13:25	NC	NC	NC	145,790	7.90	0.82	21.25
	13:30	NC	912.17	10.27	141,155	7.91	0.81	20.70
	13:32	NC	NC	NC	NC	NC	NC	NC
	13:35	NC	912.50	10.60	146,045	NC	NC	NC
	13:40	NC	912.50	10.60	146,295	NC	NC	NC
	13:45	NC	912.49	10.59	146,550	NC	NC	NC
	13:50	NC	912.49	10.59	146,805	NC	NC	NC

Table 8.1-1 (continued)

Date	Time	Pumping Rate (gpm)	Depth to Water (ft btoc[a])	Draw Down (ft)	Cumulative Purge Volume (gal.)	pH	Turbidity (NTU)	Temp (deg C)
	13:55	NC	912.49	10.59	147,065	NC	NC	NC
	13:58	NC	912.50	10.60	147,215	NC	NC	NC
	14:00	NC	NC	NC	147,320	NC	NC	NC
	14:01	0.0	904.40	2.50	147,320	NC	NC	NC
	14:02	0.0	903.30	1.40	147,320	NC	NC	NC
	14:03	0.0	903.02	1.12	147,320	NC	NC	NC
	14:04	0.0	902.78	0.88	147,320	NC	NC	NC
	14:05	0.0	902.70	0.80	147,320	NC	NC	NC
	14:06	0.0	902.65	0.75	147,320	NC	NC	NC
	14:08	0.0	902.55	0.65	147,320	NC	NC	NC
	14:10	0.0	902.10	0.20	147,320	NC	NC	NC
	14:12	0.0	902.08	0.18	147,320	NC	NC	NC
	14:14	0.0	902.04	0.14	147,320	NC	NC	NC
	14:16	0.0	902.03	0.13	147,320	NC	NC	NC
	14:18	0.0	902.01	0.11	147,320	NC	NC	NC
	14:20	0.0	902.00	0.10	147,320	NC	NC	NC
	14:25	0.0	901.98	0.08	147,320	NC	NC	NC

[a] ft btoc = Feet below top of casing.

[b] NC = Not collected.

Table 8.5-1
CrEX-3 Survey Coordinates

Identification	Northing	Easting	Elevation
CrEX-3 top of stainless-steel well casing	1768184.223	1638949.276	6734.601

Notes: All coordinates are expressed as New Mexico State Plane Coordinate System Central Zone (NAD 83); elevation is expressed in ft amsl using the National Geodetic Vertical Datum of 1929. Provisional survey conducted. Will be resurveyed when vault is installed.

Table 8.6-1
Summary of Waste Characterization Samples Collected during Drilling, Construction, and Development of CrEX-3

Event ID	Sample ID	Date Collected	Description	Sample Matrix
10595	WSTMO-16-110685	02/19/2016	CrEX-3 drill cuttings (top) VOC	Solid
10595	WSTMO-16-110687	02/19/2016	CrEX-3 drill cuttings trip blank VOC	Solid
10595	WSTMO-16-110684	02/26/2016	CrEX-3 drill cuttings (middle) VOC	Solid
10595	WSTMO-16-110689	02/26/2016	CrEX-3 drill cuttings trip blank VOC	Solid
10595	WSTMO-16-110686	03/16/2016	CrEX-3 drill cuttings (bottom) VOC	Solid
10595	WSTMO-16-110688	03/16/2016	CrEX-3 drill cuttings trip blank VOC	Solid
10623	WSTMO-16-114806	06/06/2016	CrEX-3 drill cuttings (comprehensive)	Solid
10594	WSTMO-16-110675	02/19/2016	CrEX-3 drilling fluids (top) VOC	Liquid
10594	WSTMO-16-110681	02/19/2016	CrEX-3 drilling fluids trip blank VOC	Liquid
10594	WSTMO-16-11079	02/19/2016	CrEX-3 drilling field dup. VOC	Liquid
10594	WSTMO-16-110677	02/26/2016	CrEX-3 drilling fluid VOC	Liquid
10594	WSTMO-16-110682	02/26/2016	CrEX-3 drilling fluid trip blank VOC	Liquid
10594	WSTMO-16-110680	02/26/2016	CrEX-3 drilling fluid dup. VOC	Liquid
10594	WSTMO-16-110676	03/16/2016	CrEX-3 drilling fluid VOC	Liquid
10594	WSTMO-16-110683	03/16/2016	CrEX-3 drilling fluid trip blank VOC	Liquid
10594	WSTMO-16-110678	03/16/2016	CrEX-3 drilling fluid dup. VOC	Liquid
10624	WSTMO-16-114780	06/06/2016	CrEX-3 drilling fluid VOC	Liquid
10624	WSTMO-16-4788	06/06/2016	CrEX-3 drilling fluid dup. VOC	Liquid
10624	WSTMO-16-114781	06/06/2016	CrEX-3 drilling fluid dup. VOC	Liquid

Appendix A

Final Well Design and
New Mexico Environment Department Approval

From: Katzman, Danny
Sent: Monday, March 21, 2016 11:52 AM
To: White, Stephen Spalding; Branch, John Phillip; Thomson, Jim
Subject: FW: CrEX-3 well design proposal

From: Dale, Michael, NMENV <Michael.Dale@state.nm.us>
Sent: Monday, March 21, 2016 10:26:52 AM
To: Katzman, Danny
Cc: Shen, Hai; Swickley, Stephani Fuller; Everett, Mark Capen; Ball, Ted; Wear, Benjamin, NMENV; Kulis, Jerzy, NMENV; Longmire, Patrick; Fellenz, David Richard; Green, Megan; Yanicak, Stephen M; Granzow, Kim P
Subject: RE: CrEX-3 well design proposal

Danny,

New Mexico Environment Department (NMED) hereby approves the installation of the regional-aquifer injection well CrEX-3 as proposed in your e-mail, with attachment, that was received today, March 21, 2016 at 9:34 AM. This approval is based on information available to NMED at the time of the approval. LANL must provide the results of groundwater sampling, any modifications to the well design as proposed in the above-mentioned e-mail, and any additional information relevant to the installation of the well as soon as such data or information become available. In addition, please provide NMED reasonable-time (e.g., 1 -2 days) notification prior to the initiation of well development and aquifer testing at CrEX-3. Please call if you have any questions concerning this approval.

Thank you,

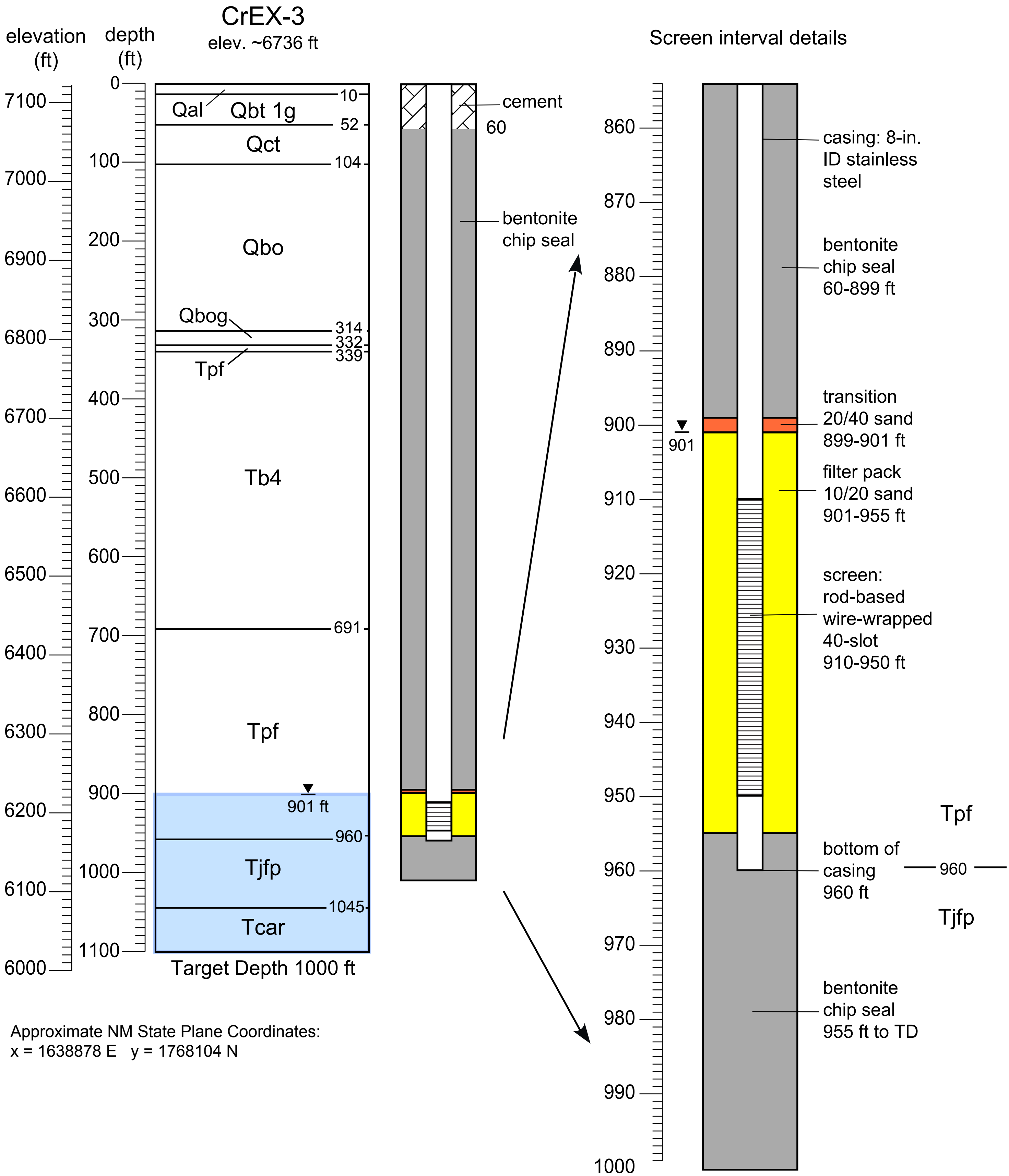
Michael R. Dale
New Mexico Environment Department
1183 Diamond Drive, Suite B
Los Alamos, NM 87544
LANL MS M894
Cell Phone: (505) 231-5423
Office Phone (505) 476-3078

From: Katzman, Danny [katzman@lanl.gov]
Sent: Monday, March 21, 2016 9:34 AM
To: Dale, Michael, NMENV
Cc: Shen, Hai; Swickley, Stephani Fuller; Everett, Mark Capen; Ball, Ted
Subject: CrEX-3 well design proposal

Michael- thanks for joining us in the CrEX-3 well-design discussion on Sunday.
Here's a summary of what I believe we agreed to as the design and basis. Please verify in a response to this email.

A first-order objective for CrEX-3 is to test mass-removal strategies which involves characterization of the hydraulic and contaminant response to pumping, particularly in the centroid. In order to achieve this, the team agreed that the well design should position the well screen entirely within the Puye formation and comfortably above the Miocene Pumiceous contact estimated at ~960' bgs. Based on analytical results from nearby corehole (CrCH-2) and R-28, it also appears that contamination is also predominantly within the upper 50 ft of the water table which is at ~901' bgs in the CrEX-3 borehole. Based on this information, we recommend that CrEX-3 be designed with a 40' screen with the slots set at 910' (9 ft below the water table). Primary filter pack will extend from 901-910' with an additional 2' of transition sand on top. See the attached figure for additional detail.

Let us know if you have any questions.
Thanks.
Danny



Approximate NM State Plane Coordinates:
x = 1638878 E y = 1768104 N

Appendix B

Borehole Video Logging
(on DVD included with this document)

Appendix C

Geophysical Logs
(on CD included with this document)

Appendix D

Aquifer Testing Report

D-1.0 INTRODUCTION

This appendix describes the hydraulic analysis of pumping tests conducted from May 3 to 5, 2016, at extraction well CrEX-3, located in Mortandad Canyon at Los Alamos National Laboratory (LANL or the Laboratory). The CrEX-3 tests were conducted to (1) characterize the hydrogeologic properties of the aquifer materials screened by the well and (2) estimate the hydraulic properties of the Puye Formation. The water-level depth was 901 ft below ground surface (bgs) before well installation. The screen interval is between 909.6 ft and 948.8 ft bgs, with a screen length of 39.2 ft. Two separate pumping activities were conducted at CrEX-3: (1) on May 3, 2016, from 8:22 to 14:59, a step-pumping test was conducted using four different pumping rates; (2) from May 3, 15:02, to May 5, 14:00, a 24-hr pumping test was performed. These pumping activities provide important information about the hydraulic properties of the well. Discussed below are model analyses performed of the water-level data observed during these pumping events. In these analyses, a partially penetrated confined/unconfined aquifer that is homogeneous and anisotropic is assumed. The thickness of the aquifer affected by the pumping test is assumed to be uniform and equal to 64 ft. The total thickness of the regional aquifer is substantially larger (>1000 ft); however, because of partial penetration effects (CrEX-3 is installed at the top of the aquifer) and aquifer anisotropy, the pumping at CrEX-3 does not interrogate the entire aquifer thickness. The results presented below are sensitive to the assumption of aquifer thickness. The software AQTESOLV (Duffield 2007, 601723) is used to interpret the pumping test data. Two theoretical models built in the software AQTESOLV, (Theis 1934-1935, 098241) and (Neuman 1974, 085421), are applied for parameter estimation.

D-2.0 INTERPRETATION OF OBSERVED WATER-LEVEL DATA

D-2.1 Step Test (Test 1)

After well development, a pumping test was executed using for four pumping steps. Each step had duration of 1 h, and the pumping rate was continuously increased. The rates during the four steps were 25.6, 38.1, 51.3, 64.0 gallons per minute (gpm). The total water pumped was 11,700 gal. in 4 h, followed by a recovery period. The observed multistep water-level depths were converted to drawdowns (in ft) and then used to estimate the parameters. First, the variable-rate Theis model (Theis 1934–1935, 098241) was used to fit the multistep observation data. The multistep variable pumping rates and parameter estimation results are shown in Tables D-2.1-1 and D-2.1-2. The estimated hydraulic conductivity is 6.0 m/d, and the storage coefficient is 1.0E-6. The computed drawdowns during the first step and the recovery time do not fit very well in the observed data (Figure D-2.1-1).

Then, the variable-rate Neuman model (Neuman 1974, 085421) was used to fit the observed data. By considering the delayed gravity response of the unconfined aquifer, the Neuman model can simulate well the multistep pumping test processes and the computed drawdowns fit the observed data very well. The estimated parameters are listed in Table D-2.1-3 in which the conductivity is 1.8 m/d, storage coefficient is 0.00084, and specific yield is 0.35, which is limited to the possibly maximum porosity of the Puye Formation during the parameter-estimation process. The parameter β coefficient is 0.0067, and in this model, the ratio of K_z/K_r is equal to 0.49. The objective function (or sum of squares) is reduced from 1067.6, obtained from the Theis model, to 175.9. The result shown in Figure D-2.1-2 is better fitted with the Theis model.

D-2.2 24-h Pumping Test (Test 2)

After the well fully recovered from the step test, a constant-rate pumping test was conducted for about 24 h from May 4, 2016, at 13:28 to May 5, at 13:58, and the total water pumped was 74,985 gal. with a constant pumping rate of 51.1 gpm. The observed water depths during the pumping period were converted to displacements or drawdowns (in ft) and then used to estimate the parameters. First, the constant-rate Theis model (Theis 1934-1935, 098241) was used to fit the observed data. The test data and parameter estimation processes are presented in Tables D-2.2-1 and D-2.2-2. The estimated hydraulic conductivity is 6.8 m/d and the storage coefficient is very small (1.0E-6). As discussed above, the Theis model does not consider the delayed water-release mechanisms of the unconfined aquifer and does fit the observed data (Figure D-2.2-1).

Then, the constant-rate Neuman model (Neuman 1974, 085421) was used to fit the observed data. The Neuman model considers the delayed gravity response of the unconfined aquifer and the computed drawdowns fit the observations very well. The estimated parameters are listed in Table D-2.2-3: the hydraulic conductivity is 2.7 m/d, storage coefficient is 0.00071, and specific yield is 0.35. The parameter β is 0.001, which corresponds to a K_z/K_r ratio of 0.1. The objective function (or sum of squares) is reduced from 3405.1, obtained from the Theis model, to 365.9. The drawdowns modeled from the constant-rate Neuman model match the observations perfectly (Figure D-2.2-2).

D-3.0 SUMMARY

Multistep and constant-rate pumping tests were conducted on CrEX-3 to gain an understanding of the hydraulic characteristics of the saturated Puye Formation. Two sets of water-depth observations were made using the data obtained from the pumping tests and were used for parameter estimations with different analytical models: the Theis and the Neuman models. The estimated parameters from the tests are summarized in Table D-3.0-1. Because the Neuman model considers the delayed gravity response of the unconfined aquifer, the computed drawdowns for the three tests always fit the data much better that those computed from the Theis model. Therefore, the estimated parameters from the Neuman model are more reliable than those from Theis model. The Neuman model can minimize the objective functions for the two test data, decrease parameter estimation variances, and thus reduce the uncertainty of the estimated parameters. In Table D-3.0-1, the estimated hydraulic conductivities have an increased trend over time. Similarly, the anisotropy ratio increases, which reflects increases in the lateral hydraulic conductivity (Kr). These observations may be the result of continued well development during pumping that increases the well efficiency. However, the difference in the estimated permeabilities between the step test and the 24-h test is small, suggesting the well is well developed, and this difference may be caused by scaling effects. That is, a much larger aquifer volume is interrogated during the 24-h test compared with the step test.

It is important to note that estimated hydraulic parameters are sensitive to assumed aquifer thickness. If the aquifer thickness were assumed to be higher, the estimated hydraulic conductivity would be lower. However, despite the uncertainties, the estimated hydraulic conductivity values for CrEX-3 are consistent with hydraulic conductivity estimates observed at other investigation wells which range between 0.6 m/d and 40 m/d.

Because of better matching of observed data to the model, the aquifer estimates using Neuman model are preferred. In summary, the hydraulic conductivity at CrEX-2 is 2.7 m/d, the storage coefficient is 7.1×10^{-3}, the specific yield is 0.35, and the anisotropy ratio between vertical and lateral hydraulic conductivity is 0.1. These estimates are reasonable and consistent with previous estimates and previous site information.

D-4.0 REFERENCES

The following list includes all documents cited in this appendix. Parenthetical information following each reference provides the author(s), publication date, and ER ID or ESH ID. This information is also included in text citations. ER IDs were assigned by the Environmental Programs Directorate's Records Processing Facility (IDs through 599999), and ESH IDs are assigned by the Environment, Safety, and Health (ESH) Directorate (IDs 600000 and above). IDs are used to locate documents in the Laboratory's Electronic Document Management System and, where applicable, in the master reference set.

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau and the ESH Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

Duffield, G.M., June 16, 2007. "AQTESOLV for Windows, Version 4.5, User's Guide," HydroSOLVE, Inc., Reston, Virginia. (Duffield 2007, 601723)

Neuman, S.P., April 1974. "Effect of Partial Penetration on Flow in Unconfined Aquifers Considering Delayed Gravity Response," *Water Resources Research,* Vol. 10, No. 2, pp. 303-312. (Neuman 1974, 085421)

Theis, C.V., 1934-1935. "The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Ground-Water Storage," *American Geophysical Union Transactions,* Vol. 15-16, pp. 519-524. (Theis 1934-1935, 098241)

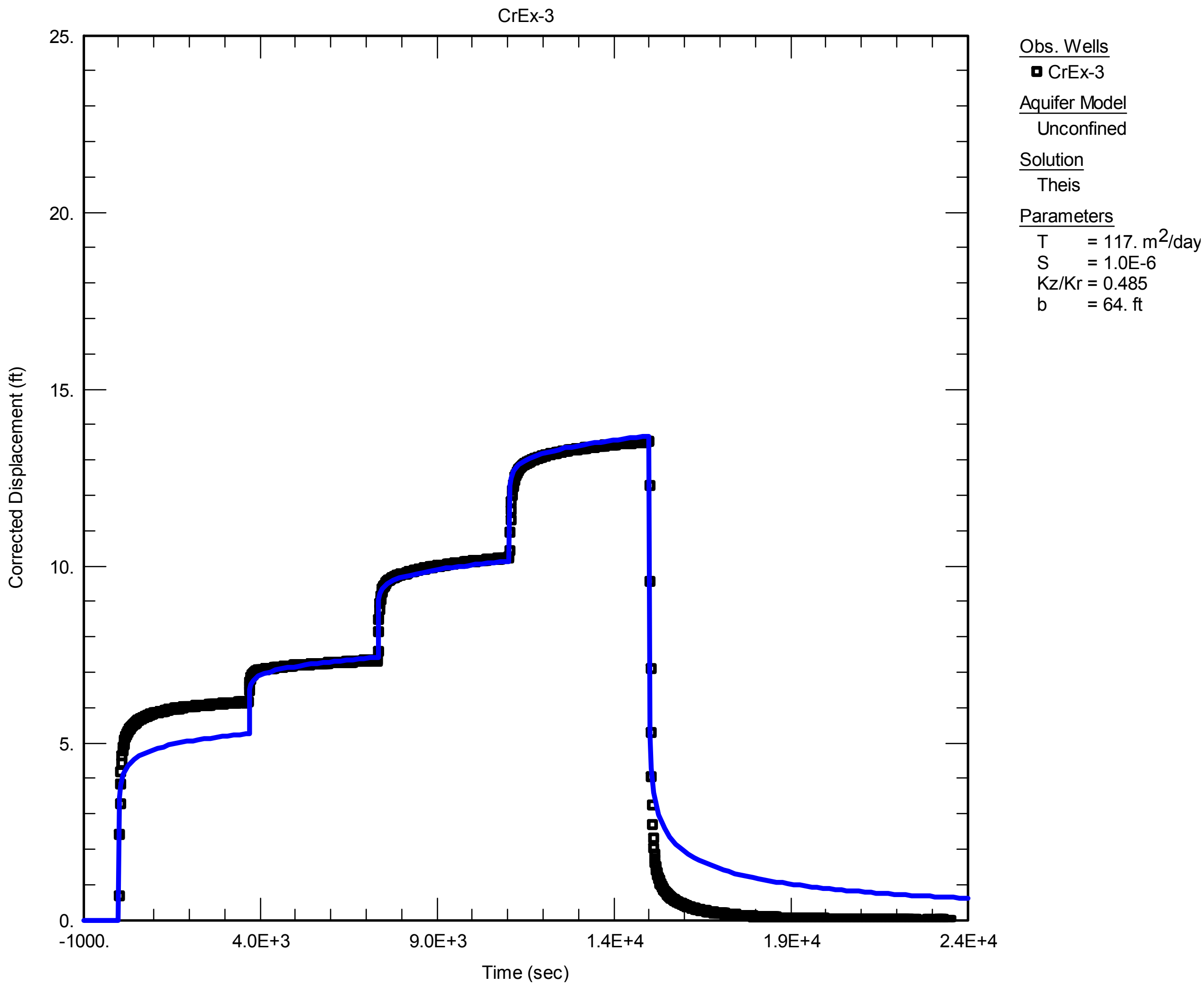


Figure D-2.1-1 Fitting results using step-test data and Theis model (data are shown as black squares; the blue line is the model)

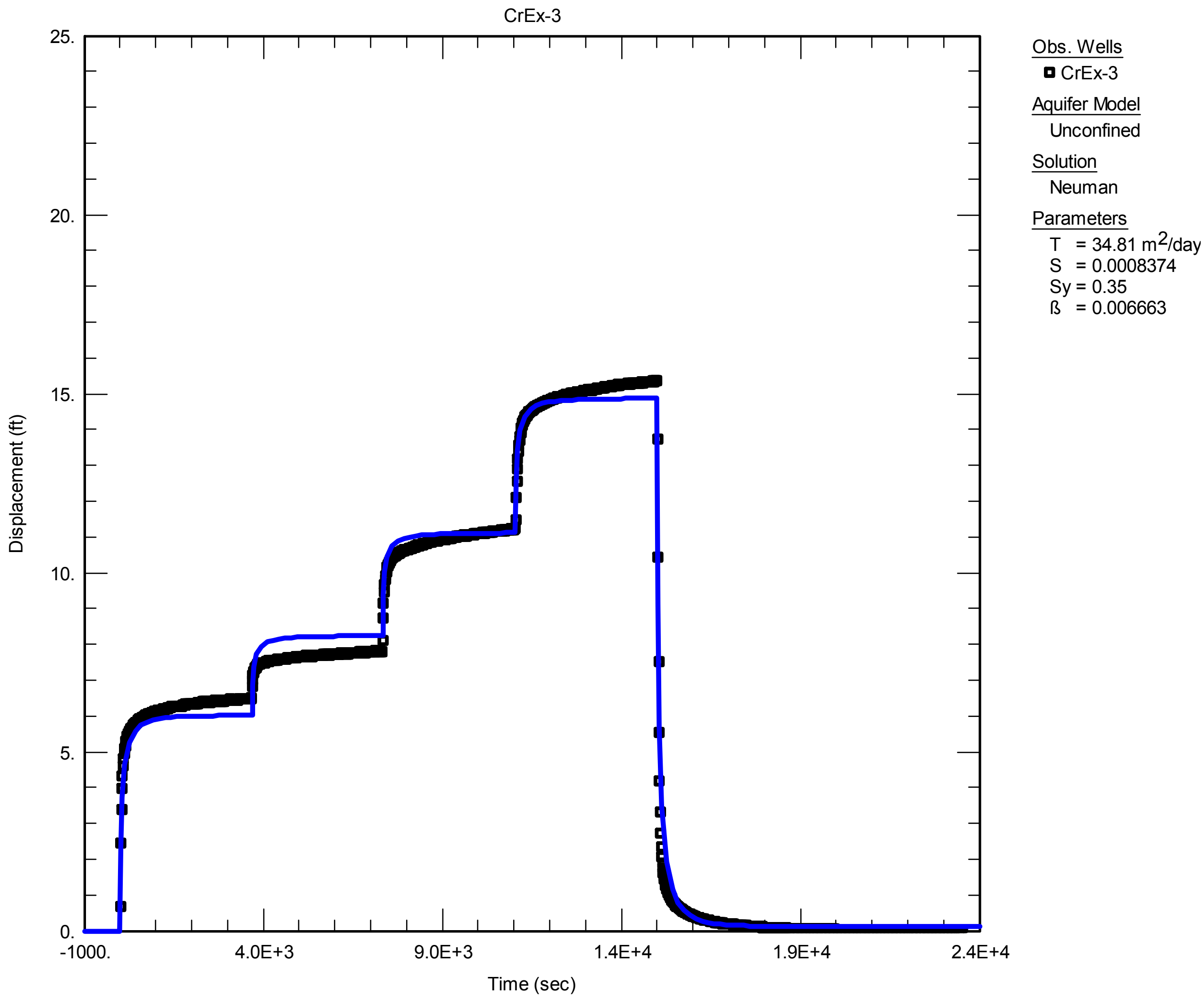


Figure D-2.1-2 Fitting results using step-test data and Neuman model (data are shown as black squares; the blue line is the model)

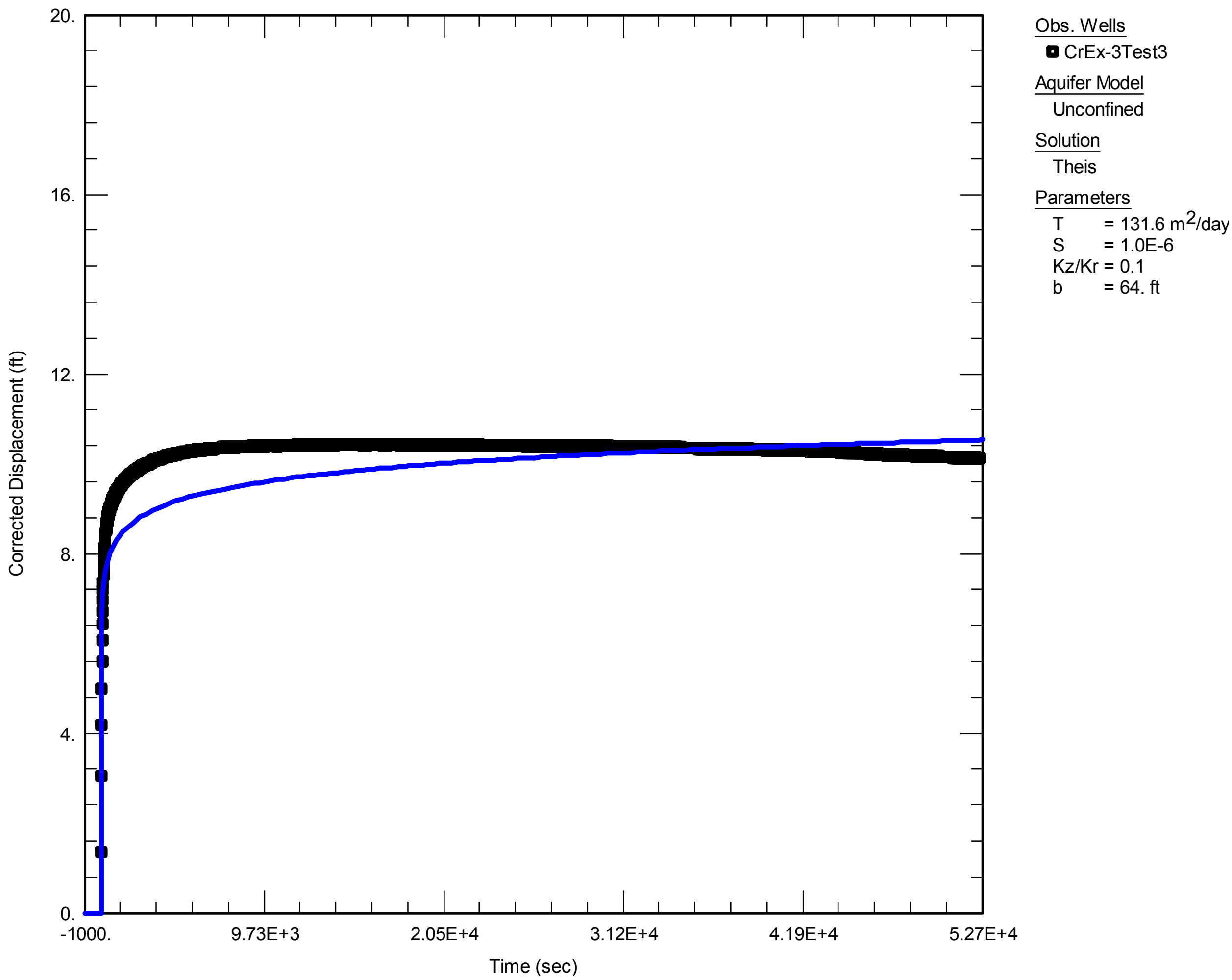


Figure D-2.2-1 Fitting results using 24-h test data and Theis model (data are shown as black squares; the blue line is the model)

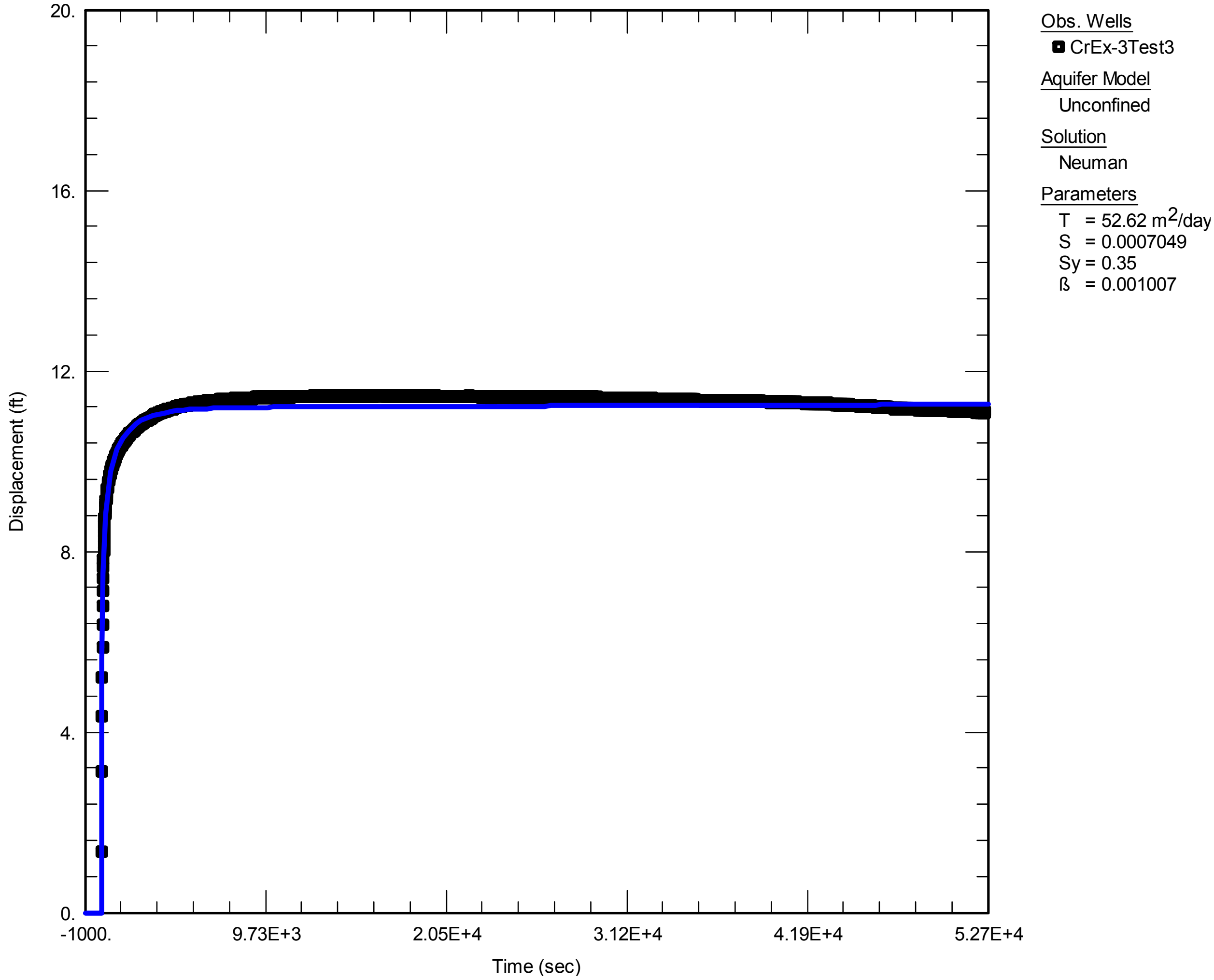


Figure D-2.2-2 Fitting results using 24-h test data and Neuman model (data are shown as black squares; the blue line is the model)

Table D-2.1-1
Hydrogeologic Information Used in AQTESOLV to Interpret Step-Test Data

Data Set: E:\EP2016\AquiferTest\Crex3_CrEx-3\CrEx3_Test2_pumpingTest_newRate_unconfined_Theis.aqt
Title: CrEx-3
Date: 06/09/16
Time: 15:24:35

PROJECT INFORMATION

Company: LANL
Client: zd
Project: ep
Location: Puye
Test Date: 2015
Test Well: CrEx3

AQUIFER DATA

Saturated Thickness: 64. ft
Anisotropy Ratio (Kz/Kr): 0.485

PUMPING WELL DATA

No. of pumping wells: 1

Pumping Well No. 1: CrEx-3

X Location: 0. ft
Y Location: 0. ft

Casing Radius: 8.5 ft
Well Radius: 7.5 ft

Partially Penetrating Well
Depth to Top of Screen: 12. ft
Depth to Bottom of Screen: 51.2 ft

No. of pumping periods: 5

Pumping Period Data

Time (sec)	Rate (gal/sec)	Time (sec)	Rate (gal/sec)	Time (sec)	Rate (gal/sec)
0.	0.4646	7350.	0.855	1.5E+4	0.
3690.	0.635	1.104E+4	1.143		

OBSERVATION WELL DATA

No. of observation wells: 1

Observation Well No. 1: CrEx-3

X Location: 0. ft
Y Location: 0. ft

Radial distance from CrEx-3: 0. ft

Partially Penetrating Well
Depth to Top of Screen: 12. ft
Depth to Bottom of Screen: 51.2 ft

No. of Observations: 1568

Observation Data

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
15.	0.664	7860.	10.6	1.571E+4	0.573
30.	2.456	7875.	10.61	1.572E+4	0.564
45.	3.384	7890.	10.61	1.574E+4	0.555

Table D-2.1-2
Estimated Parameters Using Step-Test Data and Theis Model

Pumping Test
Aquifer Model: Unconfined
Solution Method: Theis

VISUAL ESTIMATION RESULTS

Estimated Parameters

Parameter	Estimate	
T	114.9	m^2/day
S	1.0E-6	
Kz/Kr	0.485	
b	64.	ft

K = T/b = 5.892 m/day (0.00682 cm/sec)
Ss = S/b = 1.562E-8 1/ft

AUTOMATIC ESTIMATION RESULTS

Estimated Parameters

Parameter	Estimate	Std. Error	Approx. C.I.	t-Ratio	
T	117.	2.685	+/- 5.265	43.58	m^2/day
S	1.0E-6	3.397E-7	+/- 6.661E-7	2.944	
Kz/Kr	0.485	not estimated			
b	64.	not estimated			ft

C.I. is approximate 95% confidence interval for parameter
t-ratio = estimate/std. error
No estimation window

K = T/b = 5.997 m/day (0.006942 cm/sec)
Ss = S/b = 1.562E-8 1/ft

Parameter Correlations

	T	S
T	1.00	-0.99
S	-0.99	1.00

Residual Statistics

for weighted residuals

Sum of Squares .... 1067.6 ft^2
Variance .... 0.6818 ft^2
Std. Deviation....... 0.8257 ft
Mean .... -0.2071 ft
No. of Residuals 1568
No. of Estimates 2

Table D-2.1-3
Estimated Parameters with the Variable-Rate Neuman Model for the Puye Formation

Aquifer Model: Unconfined
Solution Method: Neuman

Estimated Parameters

Parameter	Estimate	Std. Error	Approx. C.I.	t-Ratio	
T	34.81	1.592	+/- 3.122	21.87	m^2/day
S	0.0008374	5.714E-5	+/- 0.0001121	14.65	
Sy	0.35	0.06385	+/- 0.1252	5.482	
ß	0.006663	0.001127	+/- 0.002211	5.909	

C.I. is approximate 95% confidence interval for parameter
t-ratio = estimate/std. error
No estimation window

K = T/b = 1.785 m/day (0.002065 cm/sec)
Ss = S/b = 1.308E-5 1/ft

Parameter Correlations

	T	S	Sy	ß
T	1.00	-0.93	-0.75	-1.00
S	-0.93	1.00	0.77	0.93
Sy	-0.75	0.77	1.00	0.74
ß	-1.00	0.93	0.74	1.00

Residual Statistics

for weighted residuals

Sum of Squares . . . . 175.9 ft^2
Variance . . . . 0.1125 ft^2
Std. Deviation. . . . . . . 0.3354 ft
Mean . . . . -0.0407 ft
No. of Residuals 1568
No. of Estimates 4

Table D-2.2-1
Hydrogeologic Information Used in AQTESOLV to Interpret 24-h Pumping Test

Data Set: E:\EP2016\AquiferTest\Crex3_CrEx-3\CrEx3_test3_pumpingTest_unconfined_Theis.aqt
Date: 06/11/16
Time: 11:16:34

PROJECT INFORMATION

Company: LANL
Client: zd
Project: ep
Location: Puye
Test Date: 2016
Test Well: CrEx3

AQUIFER DATA

Saturated Thickness: 64. ft
Anisotropy Ratio (Kz/Kr): 0.1

PUMPING WELL DATA

No. of pumping wells: 1

Pumping Well No. 1: CrEx-3Test3

X Location: 0. ft
Y Location: 0. ft

Casing Radius: 8.5 ft
Well Radius: 7.5 ft

Partially Penetrating Well
Depth to Top of Screen: 12. ft
Depth to Bottom of Screen: 51.2 ft

No. of pumping periods: 2

Pumping Period Data

Time (sec)	Rate (gal/sec)	Time (sec)	Rate (gal/sec)
0.	0.8517	5.265E+4	0.8517

OBSERVATION WELL DATA

No. of observation wells: 1

Observation Well No. 1: CrEx-3Test3

X Location: 0. ft
Y Location: 0. ft

Radial distance from CrEx-3Test3: 0. ft

Partially Penetrating Well
Depth to Top of Screen: 12. ft
Depth to Bottom of Screen: 51.2 ft

No. of Observations: 7405

Observation Data

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
10.	1.357	2.47E+4	11.41	4.939E+4	11.13
20.	3.129	2.471E+4	11.42	4.94E+4	11.12
30.	4.334	2.472E+4	11.41	4.941E+4	11.12
40.	5.206	2.473E+4	11.42	4.942E+4	11.13
50.	5.867	2.474E+4	11.43	4.943E+4	11.14

Table D-2.2-2
Estimated Parameters Using 24-h Pumping Test Data and Theis Model

Aquifer Model: Unconfined
Solution Method: Theis

Estimated Parameters

Parameter	Estimate	Std. Error	Approx. C.I.	t-Ratio	
T	131.6	1.592	+/- 3.121	82.66	m^2/day
S	1.0E-6	2.117E-7	+/- 4.148E-7	4.725	
Kz/Kr	0.1	not estimated			
b	64.	not estimated			ft

C.I. is approximate 95% confidence interval for parameter
t-ratio = estimate/std. error
No estimation window

K = T/b = 6.748 m/day (0.00781 cm/sec)
Ss = S/b = 1.562E-8 1/ft

Parameter Correlations

	T	S
T	1.00	-1.00
S	-1.00	1.00

Residual Statistics

for weighted residuals

Sum of Squares . . . . 3405.1 ft^2
Variance . . . . 0.46 ft^2
Std. Deviation. . . . . . . 0.6782 ft
Mean . . . . 0.04649 ft
No. of Residuals 7405
No. of Estimates 2

Table D-2.2-3

Estimated Parameters Using 24-h Pumping Test Data and Neuman Model

Diagnostic Statistics

Estimation failed to converge! Maximum iterations reached.

Aquifer Model: Unconfined
Solution Method: Neuman

Estimated Parameters

Parameter	Estimate	Std. Error	Approx. C.I.	t-Ratio	
T	52.62	1.137	+/- 2.228	46.29	m^2/day
S	0.0007049	4.32E-5	+/- 8.467E-5	16.32	
Sy	0.35	0.0456	+/- 0.08937	7.676	
ß	0.001007	0.000114	+/- 0.0002234	8.84	

C.I. is approximate 95% confidence interval for parameter
t-ratio = estimate/std. error
No estimation window

K = T/b = 2.697 m/day (0.003122 cm/sec)
Ss = S/b = 1.101E-5 1/ft

Parameter Correlations

	T	S	Sy	ß
T	1.00	-0.97	-0.69	-1.00
S	-0.97	1.00	0.71	0.97
Sy	-0.69	0.71	1.00	0.67
ß	-1.00	0.97	0.67	1.00

Residual Statistics

for weighted residuals

Sum of Squares . . . . 365.9 ft^2
Variance . . . . 0.04943 ft^2
Std. Deviation. . . . . . . 0.2223 ft
Mean . . . . -0.009738 ft
No. of Residuals 7405
No. of Estimates 4

Table D-3.0-1
Summary of the Parameter Estimates

Model	Parameter (units)	Step Test	24-h Test
	Groundwater volume pumped (gal.)	11,700	74,985
Theis	Hydraulic conductivity (m/d)	6.0	6.8
	Storage coefficient (−)	1.00E-06	1.00E-06
	Anisotropy ratio Kz/Kr (−)	0.49	0.1
Neuman	Hydraulic conductivity (m/d)	1.8	2.7
	Storage coefficient (−)	0.00084	0.00071
	Anisotropy ratio Kz/Kr (−)	0.49	0.1
	Specific yield (−)	0.35	0.35