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Date: MAY 26 2015
Refer To: ADESH-15-080
LAUR: 15-23197
Locates Action No.: U1500012/U1500873

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

Subject: Submittal of the Completion Report for Chromium Project Coreholes 1 through 5

Dear Mr. Kieling:

Enclosed please find two hard copies with electronic files of the Completion Report for Chromium Project Coreholes 1 through 5.

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,

Alison M. Dorries, Division Leader
Environmental Protection Division
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Sincerely,

Christine Gelles, Acting Manager
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AD/CG/DM/SS:sm

Enclosures: Two hard copies with electronic files – Completion Report for Chromium Project Coreholes 1 through 5 (EP2015-0068)

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LA-UR-15-23197
May 2015
EP2015-0068

Completion Report for Chromium Project Coreholes 1 through 5

Los Alamos
NATIONAL LABORATORY
EST. 1943

Prepared by the Environmental Programs Directorate

EP2015-0068

Completion Report for Chromium Project Coreholes 1 through 5

May 2015

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EXECUTIVE SUMMARY

This completion report summarizes the drilling, core collection, and installation of piezometers for Chromium Project coreholes 1 through 5 (CrCH-1 through CrCH-5), located in Mortandad Canyon within Technical Area 05 at Los Alamos National Laboratory. The work plan to install these coreholes with piezometers was approved by the New Mexico Environment Department in September 2014.

These coreholes were drilled to collect samples within the Puye Formation, mixed Miocene deposits, Miocene pumiceous sediments, and Miocene riverine deposits beneath Mortandad Canyon in the area of the chromium contamination plume. Activities conducted during drilling and later with core material focused on evaluating chromium concentrations in vadose-zone porewater within the regional aquifer and on investigating the potential for natural attenuation of chromium within regional aquifer materials.

All five coreholes were drilled using air rotary, casing advance for the upper part of each borehole, until the Cerros del Rio volcanic series was penetrated. Drilling beneath the Cerros del Rio volcanic series was undertaken using a sonic coring system to total depth, planned for penetrating 100 ft into the regional aquifer. This depth was not achieved in all cases, given the physical limits of the sonic drilling rig were reached before the planned total depth could be reached.

The coreholes were completed as groundwater piezometers constructed of 2-in.–inside diameter stainless-steel casing and screens. Bailing was conducted to remove sediment from the piezometers and to establish hydrologic connection with the aquifer.

Geologic formations encountered during drilling included, in descending stratigraphic order, Tshirege Member of the Bandelier Tuff, Cerro Toledo interval, Otowi Member of the Bandelier Tuff (including the Guaje Pumice Bed), upper Puye Formation, Cerros del Rio volcanic series, the lower Puye Formation, Miocene pumiceous sediments, and Miocene riverine deposits.

The regional water table occurs within the Puye Formation and Miocene pumiceous sediments at depths ranging from 907.3 ft to 1114 ft below ground surface, as measured in the completed piezometers.

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Acronyms and Abbreviations

amsl	above mean sea level
bgs	below ground surface
ESH	Environment, Safety, and Health
I.D.	inside diameter
LANL	Los Alamos National Laboratory
NAD	North American Datum
NMED	New Mexico Environment Department
NTU	nephelometric turbidity unit
O.D.	outside diameter
SWL	static water level
TA	technical area
TD	total depth

1.0 INTRODUCTION

This completion report summarizes the drilling, core collection, and installation of piezometers for Chromium Project coreholes 1 through 5 (CrCH-1 through CrCH-5) located in Mortandad Canyon within Technical Area 05 at Los Alamos National Laboratory (LANL or the Laboratory). These coreholes were drilled and piezometers installed from August 19, 2014, to March 16, 2015.

The work plan for installing six coreholes was approved by the New Mexico Environment Department (NMED) in its September 26, 2014, letter, "Approval With Modifications Drilling Work Plan for Chromium Project Coreholes" (LANL 2014, 259151; NMED 2014, 525201). During execution of this work and planning for the installation of regional groundwater monitoring well R-67, NMED agreed that the coring planned for the sixth corehole, CrCH-6, could be combined with the air-rotary drilling at the location chosen for regional groundwater monitoring well R-67. The drilling work plan for combined groundwater monitoring well R-67 and CrCH-6 that included this approach was submitted on to NMED on March 6, 2015 (LANL 2015, 600265). The Laboratory received approval with modifications from NMED on April 2, 2015 (NMED 2015, 600341). Information on coring at R-67 will be included in the R-67 well completion report.

CrCH-1 through CrCH-5, shown in Figure 1.0-1, were drilled to achieve the following objectives.

- Collect core samples for the purpose of evaluating the degree of attenuation (reduction and/or adsorption) of contaminant chromium that has occurred within the lower Puye Formation in the vadose zone and within the upper 100 ft of the regional aquifer (Puye Formation and Miocene pumiceous unit). This objective specifically supports the geochemistry studies proposed in the "Interim Measures Work Plan for the Evaluation of Chromium Mass Removal" (LANL 2013, 241096). This evaluation is being conducted to assess whether natural attenuation of chromium is an existing process within the regional aquifer plume area and to characterize the attenuation mechanism(s) and capacity that might remain within different portions of the plume (centroid versus periphery) in the regional aquifer.
- Collect core for the purpose of evaluating evidence of vadose-zone infiltration pathways for chromium. The approach for this objective includes detailed analysis of core solids and pore water to characterize the presence of contaminant chromium and the association of chromium with various solids phases.
- Characterize the stratification of chromium concentrations in the upper 100 ft of the regional aquifer. This objective will provide potentially important information to guide pumping-well design and pumping strategies to optimize the mass removal of chromium.
- Install piezometers in the coreholes for pressure monitoring, potential field testing for cross-hole tracer studies, and field tests that may involve introducing amendments to stimulate attenuation of chromium in the regional aquifer.

Results from these investigations will be presented in a separate report at a later date.

Characterization during drilling included collection of cuttings samples at 10-ft intervals from ground surface to the base of the Cerros del Rio basalts for lithologic evaluation. Once the borehole had been advanced through the volcanic rocks using air-rotary methods, the dual-rotary rig was demobilized and a sonic rig capable of continuously coring was mobilized to the site. Core was collected using sonic drilling techniques in Lexan-lined 5-ft core barrels where feasible, based on geologic conditions. Core was collected from beneath the volcanic rocks up to 100 ft into the regional aquifer or until the limits of the drilling equipment, whichever was shallower.

Following completion of coring, each corehole was completed as a 2-in.-inside diameter (I.D.) stainless-steel groundwater piezometer with a 0.040-slot screen set near the water table. CrCH-2 was completed with dual piezometers installed in the corehole.

Post-installation activities included surface completion, removing sediment from the piezometer with a bailer to facilitate hydrologic connection to the aquifer, and geodetic surveying. The construction aspect of these piezometers (i.e., deep 2-in. completions) prohibits typical development techniques, particularly high-volume pumping. The piezometer design and the inability to conduct traditional development techniques may affect their use as sampling locations that produce fully representative water-quality data. Future activities will include site restoration and waste management.

Periodic water-quality sampling from the piezometers will be conducted using either by BESST, Inc., or Bennett Sample Pump systems.

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 in the Laboratory's Electronic Document Management System. This report contains brief descriptions of activities and supporting figures, tables, and appendixes associated with the corehole drilling and piezometer installation project.

2.0 ADMINISTRATIVE PREPARATION

The following documents were prepared to guide activities associated with drilling the coreholes and installing the piezometers:

- "Drilling Work Plan for Chromium Project Coreholes" (LANL 2014, 259151);
- IWDs [Integrated Work Documents] for Drilling Using the SONIC and Dual Rotary Drilling Methods," Yellow Jacket Drilling, Inc. (Yellow Jacket Drilling 2014, 600347);
- "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 Project Coreholes" (LANL 2014, 254859).

3.0 GEOLOGY AND HYDROLOGY

This section describes the geology and hydrology penetrated by the coreholes. Geologic unit descriptions note the intervals for each corehole where the units were encountered. The groundwater section describes the groundwater encountered in each corehole.

3.1 Stratigraphy

The stratigraphy and contacts presented below are based on lithologic descriptions of cuttings and core samples collected during drilling. Cuttings samples were collected from the discharge cyclone during air-rotary drilling from the surface to the base of the Cerros del Rio volcanic series and core samples were collected during sonic drilling through the subbasalt Puye Formation to the total depth (TD) of the corehole. Corehole geophysical logs and video logs provided additional information about lithologic properties and helped to refine geologic contacts. Geologic units are described below in order of youngest to oldest geologic units. All depths are presented in feet below ground surface (bgs). Figures 3.1-1 through 3.1-5 illustrate the stratigraphy at the coreholes.

Quaternary Alluvium, Qal

The Quaternary alluvium consists of moderately to well-sorted nonindurated sandy silt and clay and gravely silt and clayey sands. Fragments include intermediate composition volcanics, felsic crystals, and pumice fragments. Qal is present from 0.0 to 140.0 ft in CrCH-2, from 0.0 to 108.0 ft in CrCH-3, from 0.0 to 115.0 ft in CrCH-4, and from 0.0 to 65.0 ft in CrCH-5; it is not present in CrCH-1.

Unit 2, Tshirege Member of the Bandelier Tuff, Qbt 2

Unit 2 of the Tshirege Member of the Bandelier Tuff consists of light purplish-gray to medium gray, moderately to partly welded, crystal-rich, devitrified ash-flow tuff. Vapor-phase crystallization is pervasive. Sanidine and quartz phenocrysts are abundant and gray to green lava lithic clasts are common. Welding decreases down-section, and the basal contact is placed at the transition to the poorly welded ash-flow tuffs of unit Qbt 1v. Qbt 2 is present from 0.0 to 60.0 ft in CrCH-1; it is not present in CrCH-2, CrCH-3, CrCH-4, and CrCH-5.

Unit 1v, Tshirege Member of the Bandelier Tuff, Qbt 1v

Unit 1v of the Tshirege Member of the Bandelier Tuff consists of light gray, poorly welded, crystal-rich, devitrified ash-flow tuff. Vapor-phase crystallization is pervasive. Cuttings are fines-depleted because of drilling circulation, and sanidine and quartz phenocrysts are highly concentrated. The contact between unit 1v and the underlying unit 1g is placed at the first appearance of vitric pyroclasts downhole. The contact coincides with an abrupt increase in the borehole gamma-ray response at the top of unit 1g. Qbt 1v is present from 60.0 to 170.0 ft in CrCH-1; it is not present in CrCH-2, CrCH-3, CrCH-4, and CrCH-5.

Unit 1g, Tshirege Member of the Bandelier Tuff, Qbt 1g

Unit 1g of the Tshirege Member of the Bandelier Tuff consists of grayish-orange-pink to pale orange nonwelded, crystal-rich, vitric ash-flow tuff. White to pale orange, lustrous, glassy pumices are characteristic of unit 1g. Cuttings are fines-depleted, resulting in high concentrations of sanidine and quartz phenocrysts and dacite lithic clasts. The contact between unit 1g and the underlying Cerro Toledo interval was difficult to determine based on drill cuttings alone, and the contact is based on a decrease in borehole gamma-ray response downhole. Qbt 1g is present from170.0 to 220.0 ft in CrCH-1; it is not present in CrCH-2, CrCH-3, CrCH-4, and CrCH-5.

Cerro Toledo Interval, Qct

The Cerro Toledo interval consists of light gray to light brownish-gray, poorly to well-sorted tuffaceous sand and gravel deposits that occur between the Tshirege and Otowi Members of the Bandelier Tuff. Cuttings contain abundant subangular to rounded pumice clasts with quartz and feldspar phenocrysts that are generally finer grained than those in the Bandelier Tuff. Cuttings also contain minor light brown to grayish pink lava clasts and trace rounded obsidian. Qct is present from 220 to 260 ft in CrCH-1, from 115.0 to 130.0 ft in CrCH-4, and from 65.0 to 145.0 ft in CrCH-5; it is not present in CrCH-2 and CrCH-3.

Otowi Member of the Bandelier Tuff, Qbo

The Otowi Member of the Bandelier Tuff consists of white to light gray, lithic-rich, pumiceous, nonwelded ash-flow tuff. White, gray, and pinkish-brown glassy pumices contain large (>2 mm) phenocrysts of sanidine and quartz. Cuttings are fines-depleted, resulting in high concentrations of sanidine and quartz phenocrysts and a variety of intermediate lava lithic clasts. The contact with the underlying Guaje Pumice Bed is placed at an abrupt downhole increase in borehole gamma-ray response that is commonly associated with this contact in nearby wells. Qbo is present from 260 to 580 ft in CrCH-1, from 140.0 to 320.0 ft in CrCH-2, from 108.0 to 372.0 ft in CrCH-3, from 130.0 to 410.0 ft in CrCH-4, and from 145.0 to 425.0 ft in CrCH-5.

Guaje Pumice Bed of the Otowi Member of the Bandelier Tuff, Qbog

The Guaje Pumice Bed is a stratified pumice- and ash-fall deposit that contains dense white pumices, abundant quartz and sanidine phenocrysts, and dark intermediate lava lithic clasts. Because of the fines-depleted nature of the cuttings, it is difficult to distinguish these pumice- and ash-fall deposits from the overlying ash-flow tuffs based on cuttings alone. Qbog is present from 580.0 to 600.0 ft in CrCH-1, from 320.0 to 340.0 ft in CrCH-2, from 372.0 to 390.0 ft in CrCH-3, from 410.0 to 430.0 ft in CrCH-4, and from 425.0 to 445.0 ft in CrCH-5.

Puye Formation, Tpf

A thin sequence of fluvial sediments assigned to the Puye Formation overlies the Cerros del Rio volcanic series at these locations. These deposits consist of light orangish-gray silty sandstones consisting of quartz, feldspar, minor white pumices, and trace mafic minerals. The sandstones are interbedded with gravels containing clasts of subangular to subrounded dacite in a matrix of lithic sand. Tpf is present from 600.0 to 625.0 ft in CrCH-1, from 340.0 to 350.0 ft in CrCH-2, from 390.0 to 400.0 ft in CrCH-3, from 430.0 to 460.0 ft in CrCH-4, and from 445.0 to 460.0 ft in CrCH-5.

Cerros del Rio Volcanic Series, Tb4

The Cerros del Rio volcanic series is a thick sequence of medium to dark gray, massive to vesicular, basaltic lava flows and scoria deposits separated by porous zones of interflow breccias. The basalts are sparsely porphyritic with phenocrysts of olivine, pyroxene, and plagioclase. Borehole videos show the basalts are variably intersected by complex fracture systems. Pink clay fills many of the fractures. Tb4 is present from 625.0 to 902.0 ft in CrCH-1, from 350.0 to 680.0 ft in CrCH-2, from 400.0 to 690.0 ft in CrCH-3, from 460.0 to 720.0 ft in CrCH-4, and from 460.0 to 735.0 ft in CrCH-5.

Puye Formation, Tpf

The Puye Formation is a gray to reddish-brown silty sandy conglomerate. The unit is poorly to moderately sorted and largely consists of stacked beds of subangular to subrounded boulders, cobbles, and gravels supported by a matrix of lithic sand and silts. Lithic sand and thin silt deposits are intercalated with the coarser deposits. Clasts in these deposits consist of dacitic detritus shed from the Tschicoma Formation exposed in the highlands west of the Pajarito Plateau. Tpf is present from 902.0 to 1144.0 ft in CrCH-1, from 680.0 to 938.0 ft in CrCH-2, from 690.0 to 922.5 ft in CrCH-3, from 720.0 to 945.0 ft in CrCH-4, and from 735.0 to 1013.0 ft in CrCH-5.

Miocene Pumiceous Sediments, Tjfp

Miocene pumiceous sediments form an unassigned unit that consists of light brown and very light gray to pinkish-gray tuffaceous silty sand with multicolored dacitic and rhyolitic gravel. Core from this unit contain abundant, reworked, subrounded white vitric pumice and gray perlite and devitrified rhyolite lava clasts. Pumice clasts contain small sparse quartz, sanidine, and biotite phenocrysts. Tjfp is present from 1144.0 to 1158.0 ft (TD) in CrCH-1, from 938.0 to 987.0 ft (TD) in CrCH-2, from 922.5 to 1001.0 ft in CrCH-3, from 945.0 to 1047.0 ft (TD) in CrCH-4, and from 1013.0 to 1016.0 ft (TD) in CrCH-5.

Miocene Riverine Deposits, Tcar

Miocene riverine deposits consist of gray-brown to medium-brown fine-to-medium silty sand and subrounded to rounded gravel with a silty sandy matrix. The sand and silt fractions are dominated by rounded and frosted quartz with subordinate feldspars and intermediate volcanic clasts. The gravel fraction consists of clasts of dark, intermediate-composition lavas and <10% Precambrian quartzite. These deposits are probably correlative with the Hernandez Member of the Chamita Formation. Tcar is present from 1001.0 to 1023.0 ft (TD) in CrCH-3; it was not present in CrCH-1, CrCH-2, CrCH-4, and CrCH-5.

3.2 Groundwater

The section below describes the detections of groundwater within each corehole.

Groundwater was encountered during drilling in CrCH-1 at 1113.6 ft bgs on October 12, 2014. Groundwater was measured in the open borehole at 1114.0 ft bgs on October 14, 2014, before piezometer construction. Groundwater was measured in the constructed piezometer at 1113.0 ft bgs on January 11, 2015, during development. Groundwater was measured in the completed and bailed piezometer at 1112.9 ft bgs on April 6, 2015.

Groundwater water was encountered during drilling in CrCH-2 at approximately 900.0 ft bgs on December 12, 2014. Groundwater was measured in the open borehole at 907.3 ft bgs on December 23, 2014, before piezometer construction. Groundwater was measured in in the constructed upper piezometer at 901.6 ft bgs on January 29, 2015, during development. Groundwater was measured in the constructed lower piezometer at 904.1 ft bgs on January 29, 2015. Groundwater was measured in the completed and bailed upper piezometer at 903.3 ft bgs on April 2, 2015. Groundwater was measured in the completed and bailed lower piezometer at 903.4 ft bgs on April 2, 2015.

Groundwater water was encountered during drilling in CrCH-3 at approximately 923.0 ft bgs on November 15, 2014. Groundwater was measured in the open borehole at 931.0 ft bgs on December 3, 2014, before piezometer construction. Groundwater was measured in the constructed piezometer at 929.6 ft bgs on December 22, 2014, during development. Groundwater was measured in the completed and bailed piezometer at 929.2 ft bgs on April 6, 2015.

Groundwater water was encountered during drilling in CrCH-4 at approximately 947.0 ft bgs on January 16, 2015. Groundwater was measured in the constructed piezometer at 951.0 ft bgs on February 26, 2015. Groundwater was measured in the constructed piezometer at 946.6 ft bgs on March 18, 2015, during development. Groundwater was measured in the completed and bailed piezometer at 946.8 ft bgs on April 6, 2015.

Groundwater was encountered during drilling in CrCH-5 at 951.0 ft bgs on February 6, 2015. Groundwater was measured in the constructed piezometer at 966.0 bgs on February 9, 2015.

Groundwater was measured in the constructed piezometer at 965.5 ft bgs on March 17, 2015, during development. Groundwater was measured in the completed and bailed piezometer at 965.3 ft bgs on April 6, 2015.

3.3 Regional Aquifer Groundwater Elevation

Based on the depth to groundwater measured in April 2015, all of which were taken after the piezometers were installed and bailed, the water level in this area varies from 5834.3 ft (CrPZ-2b) to 5837.9 ft (CrPZ-4) above mean sea level (amsl).

4.0 DRILLING APPROACH

The upper part of each corehole was drilled using a Foremost DR-24 HD dual-rotary drilling rig. The dual-rotary system allows for drilling with conventional air/mist/foam methods with the drill string while simultaneously rotating and advancing casing with a cutting shoe. The Foremost DR-24 HD drill rig was equipped with 5.5-in.–outside diameter (O.D.) dual-wall reverse-circulation drill pipe, tricone bits, downhole hammer bits, and general drilling equipment. Casing sizes used in drilling activities included 24-in., 16-in., 12-in., 10-in., and 8-in. nominal diameters. Not all these casing sizes were used in each borehole. The dual-rotary and standard rotary (open-hole) techniques used filtered compressed air and fluid-assisted air to evacuate cuttings from the borehole.

Drilling fluids, including compressed air, municipal water, and a mixture of municipal water with Baroid brand QUIK-FOAM foaming agent, were used, as necessary, to advance the borehole through the Cerros del Rio volcanic series (basalt). The fluids were used to cool the bit and help lift cuttings from the borehole.

After penetrating the Cerros del Rio volcanic series (basalt), the drilling subcontractor switched to rotosonic drilling using a Terrasonic TSi 150T drill rig. The TSi 150T drill rig used a 5-in.-diameter, 5-ft-long core barrel assembly with Lexan liners to collect core samples from the borehole to TD. The sonic rig used 7-in.-diameter casing inside the dual-rotary 8-in. casing to the bottom of the 8-in. casing. A 6-in.-diameter sonic drill casing inside the 7-in. casing was advanced directly behind the sonic core barrel assembly to clean out the corehole and keep it open. This casing size allowed the piezometer to be constructed with the desired 2-in.-minimum annular thickness of the filter pack around a 2.375-in.-O.D. screen.

5.0 COREHOLE 1

The following sections describe the drilling, sampling, logging, construction, and post-installation activities at CrCH-1.

5.1 Chronology of Drilling Activities

Drilling equipment and supplies were mobilized from CrEX-1 to CrCH-1 on August 18, 2014, and were prepared for drilling. Drilling of the CrCH-1 borehole began on August 19, 2014, when a 16-in.-O.D. surface casing was installed with a 24-in.-diameter tricone bit. The 24-in.-diameter borehole was advanced to 60.0 ft bgs and the 16-in. casing set to that depth and cemented in place. The surface casing was set in unit 2 of the Tshirege Member of the Bandelier Tuff.

From August 22 to August 26, 2014, a 13.41-in.-diameter borehole was drilled to 585.0 ft bgs (near the top of the Cerros del Rio volcanic series) using casing-advance methods, including the use of potable water and foam. This portion of the borehole was cased with 12-in.-I.D. casing. Five feet of this casing, plus the casing shoe, were cut off and left in the borehole from 580.0 to 585.0 ft bgs.

From August 26 to August 31, 2014, 11.42-in.-diameter borehole was advanced from 585.0 to 905.0 ft bgs (near the bottom of the Cerros del Rio volcanic series) using casing-advance methods, including the use of potable water and foam. This portion of the borehole was cased with 10-in.-I.D. casing to 886.0 f bgs.

On August 31, 2014, the drillers lost track of the casing and drill string tallies and began rotating the drill bit inside the casing at approximately 866.0 ft bgs, shearing off the 10-in. casing. The 10-in. casing above 866.0 ft bgs was retracted from the borehole. A video log of the borehole showed that a 20-ft length of the 10-in. casing remained in the borehole from 866.0 to 886.0 ft bgs. Because the casing was sitting upright in the borehole and the top was open, the decision was made to install 8-in.-diameter casing through this zone and drill ahead through the remainder of the Cerros del Rio volcanic series. On September 11 and 12, 2014, 8-in. casing was installed to a depth of 886.0 ft bgs. The drill string was then tripped into the borehole and on September 13, 2014, drilling proceeded to 944.0 ft bgs. At this point, the DR rig demobilized from CrCH-1 to begin drilling at CrCH-2.

On September 16, 2014, the TSi 150T arrived on-site, set up, and began drilling. By September 30, 2014, the borehole had been advanced to 1096.0 ft bgs with nearly 100% core recovery. At that point, a hydraulic cylinder on the drill rig broke and the rig was down for 8 d, awaiting parts and repair. On October 8, 2014, drilling resumed. Sonic drilling continued to a depth of 1158.0 ft bgs, which was the physical limit of the equipment. At this point, a portion of the sonic core barrel assembly was lost off the drill string and had to be fished out of the borehole. Fishing continued for the lost core barrel assembly until October 21, 2014, when the assembly was recovered.

5.2 Sampling Activities

The following sections summarize the sampling activities for CrCH-1. All sampling activities were conducted in general accordance with applicable standard operating procedures.

5.2.1 Geologic Sampling

Samples of bulk rotary cuttings were collected at 10-ft intervals from ground surface to 944.0 ft bgs and used for lithologic logging.

Core samples were collected using the sonic core barrel at approximately 4-ft intervals from 967.0 to 1136.5 ft bgs in CrCH-1. Samples cohesive enough to remain intact were stored in the Lexan liners inside the core barrel for each sampling run. Samples that did not remain intact in the Lexan liners were placed into plastic sleeves. Table 5.2-1 presents a summary of all core samples collected at CrCH-1.

5.2.2 Groundwater Sampling

Groundwater samples were collected using a SimulProbe sampling device from 1120.0 and 1140.0 ft bgs. Table 5.2-2 presents a summary of all groundwater sample collected at CrCH-1. The SimulProbe is a downhole sampling device that allows the collection of in situ groundwater. The sampler is driven into the undisturbed formation at the bottom of the borehole and a port is opened to allow groundwater to flow into the sample collection chamber. Samples were collected from near the water table to TD in approximately

20-ft intervals to characterize stratification of chromium and related contaminants within the regional aquifer.

5.3 Borehole Logging

The following sections describe the corehole logging conducted at CrCH-1. Table 5.3-1 presents a summary of all logging conducted at CrCH-1.

5.3.1 Video Logging

Laboratory personnel ran a video survey of the borehole from the surface to 862.0 ft bgs on September 3, 2014. The purpose of this survey was to locate the top of the 10-in. drill casing. Laboratory personnel ran a second video survey of the borehole from the surface to 902.0 ft bgs on September 7, 2014. The purpose of this survey was to locate the top and bottom of the the 10-in. drill casing. Laboratory personnel ran a video survey of the piezometer from the surface to TD of 1138.0 ft bgs on November 14, 2014, to locate a potential obstruction that was causing the bailer to hang up within the piezometer. A slight deviation in the piezometer casing was noted at approximately 850.0 ft bgs.

Table 5.3-1 provides a description of the completed logs. The video logs are provided on DVD in Appendix A of this report.

5.3.2 Geophysical Logging

On January 8, 2015, the Laboratory ran a natural gamma ray survey in the constructed CrCH-1 piezometer from a TD of 1138.0 ft bgs to the surface to collect lithologic information. Table 5.3-1 shows the depths of coverage for each type of log. The Laboratory geophysical logs are included in Appendix B of this report (on CD).

5.4 Piezometer Design and Construction

On October 15, 2014, a piezometer design was sent to NMED for review and approval. Approval of the design was received on October 17, 2014 (see Appendix C).

The CrCH-1 piezometer (CrPZ-1) was designed in accordance with the objectives and steps outlined in the work plan, approved with modifications by NMED (LANL 2014, 259151; NMED 2014, 525201). The core and drillers logs were reviewed as well as the depth to water. The objective in setting the screen was to establish a piezometer at the top of the regional aquifer. Therefore, the 10-ft long screened interval was set from 1122.9 to 1132.9 ft bgs with the water level measured at 1118.9 ft bgs.

CrPZ-1 was constructed of 2.0-in.-I.D./2.375-in.-O.D. passivated-type A304 stainless-steel flush-threaded casing. The screened interval consists of a 10-ft length of 2.0-in.-I.D. rod-based, 0.040-in. slot, wire-wrapped screen from 1122.9 to 1132.9 ft bgs. Casing and screen were steam-pressure washed before installation. A 1.25-in.-I.D. steel flush-threaded tremie pipe string, also decontaminated before use, was used to deliver annular fill materials and potable water downhole during piezometer construction. Figure 5.4-1 illustrates the final piezometer construction details.

Piezometer construction began on October 25, 2014. Before the piezometer was constructed, the bottom of the borehole was measured at a depth of 1145.0 ft bgs. The borehole had sloughed in from 1158 to 1145.0 ft bgs. The piezometer was lowered into the borehole on October 25, 2014, and the screened interval was placed from 1122.9 to 1132.9 ft bgs.

The primary filter pack (consisting of 10/20 sand) was placed via tremie pipe on October 26, 2014. The filter pack was installed from a depth of 1145.0 to 1117.5 ft bgs and swabbed to promote settling. Transition sand consisting of 20/40 sand was placed via tremie pipe from depths of 1117.5 to 1115.5 ft bgs. Bentonite was placed via tremie pipe above the secondary filter pack in multiple lifts as the 6-in. sonic casing was removed from 1115.5 to 950.0 ft bgs, slightly below the depth of the 8-in. casing set by the DR drill rig. The sonic rig then demobilized on October 31, 2014. The DR drill rig mobilized to the site on November 4, 2014, and began pulling the 8-in. casing and completing construction of the piezometer. Bentonite was placed in multiple lifts from 950.0 to 585.0 ft bgs as the 8-in. casing was retracted. The remainder of the 8-in. casing was then removed from the borehole. From November 6 to 7, 2014, bentonite was placed via tremie pipe from depths of 585.0 to 61.0 ft bgs as the 12-in. casing was removed. The remaining 12-in. casing was then removed from the borehole. On November 8, 2014, a grout mixture of 92% cement and 8% bentonite was emplaced from a depth of 61.0 to 4.0 ft bgs as the piezometer was completed. Table 5.4-1 presents a summary of the annular fill materials used to construct CrPZ-1.

5.5 Post-Installation Activities

The surface-completion and surface pad were completed on March 23, 2015. A geodetic survey was completed on March 26, 2015. Site restoration activities will be completed following the final disposition of contained drill cuttings and groundwater, per the NMED-approved waste disposal decision trees.

5.5.1 Bailing

CrPZ-1 was bailed from November 15 to 18, 2014, and again from January 10 to 11, 2015. All water was removed using a bailer on a wire line. A total of 132.75 gal. was removed during these two efforts. Water-quality parameters observed on January 11, 2015, at the end of bailing were temperature of 16.3°C, specific conductance of 285 μS/cm, dissolved oxygen of 8.6 ppm, pH of 8.2, and turbidity of 760 nephelometric turbidity units (NTU).

Limited low-flow purging will be conducted with either a BESST Blatymidi sampling system or a Bennett pump during the spring of 2015. The pumping effort is ongoing and had not been completed at the time of this report.

5.6 Deviations from Planned Activities

One deviation from the “Drilling Work Plan for Chromium Project Coreholes” (LANL 2014, 259151; NMED 2014, 525201) occurred. The sonic rig was not physically capable of penetrating 100.0 ft into the aquifer at the CrCH-1 location as was planned. Water was encountered at 1118.0 ft bgs, and the sonic rig reached its maximum capability at 1158.0 ft bgs. Therefore, the stratification of chromium in the full upper 100.0 ft .0 of the aquifer could not be evaluated, as stated in the work plan objectives.

6.0 COREHOLE 2

The following sections describe the drilling, sampling, logging, construction, and post-installation activities at CrCH-2.

6.1 Chronology of Drilling Activities

Drilling equipment and supplies were mobilized from CrCH-1 to CrCH-2 on September 13 and 14, 2014, and prepared for drilling. Drilling of the CrCH-2 borehole began on September 15, 2014. A 24-in.-diameter borehole was advanced to 60.0 ft bgs and a 16-in. steel casing set to 57.0 ft bgs and cemented in place. The surface casing was set in alluvium.

From September 18 to 21, 2014, a 13.41-in.-diameter borehole was drilled to 580.0 ft bgs (within the Cerros del Rio volcanic series) using casing-advance methods, including the use of potable water and foam. This portion of the borehole was cased with 12-in.-I.D. casing. Five feet of this casing, plus the casing shoe, were cut off and left in the borehole from 575.0 to 580.0 ft bgs.

From September 23 to 25, 2014, a 9.33-in.-diameter borehole was advanced from 580.0 to 700.0 ft bgs (through the Cerros del Rio volcanic series) using casing-advance methods, including the use of potable water and foam. This portion of the borehole was cased with 8-in.-I.D. casing to 700.0 ft bgs. The DR rig demobilized from CrCH-2 to CrCH-3 to begin drilling at that corehole on September 27 and 28, 2014.

On December 3, 2014, the TSi 150T arrived on-site, set up, and began drilling. Between December 4 and December 9, 2014, the borehole was advanced from 700.0 to 839.0 ft bgs. Lexan core barrel liners were not used in this portion of the borehole because of the presence of dacitic boulders that tended to create enough frictional heat with the sonic core barrel to melt the liners. Sonic drilling continued to a depth of 987.0 ft bgs, which was the physical limit of the equipment.

The DR rig returned to CrCH-2 on January 6, 2015. The borehole was previously cored to 987.0 ft bgs but had caved in to approximately 934.0 ft bgs. The DR rig cleaned out the hole and advanced the 8-in. casing to 979.0 ft bgs between January 8 and 10, 2015, in preparation for piezometer construction.

6.2 Sampling Activities

The following sections summarize the sampling activities for CrCH-2. All sampling activities were conducted in general accordance with applicable standard operating procedures.

6.2.1 Geologic Sampling

Bulk rotary cuttings samples were collected at 10-ft intervals from ground surface to 700.0 ft bgs and used for lithologic logging.

Samples were collected using the sonic core barrel at approximately 4-ft intervals from 703.0 to 987.0 ft bgs in CrCH-2. Samples cohesive enough to remain intact were stored in the Lexan liners inside the core barrel for each sampling run. Samples that did not remain intact in the Lexan liners were placed into plastic sleeves. Table 6.2-1 presents a summary of all core samples collected at CrCH-2.

6.2.2 Groundwater Sampling

Groundwater samples were collected using the SimulProbe sampling device at 913.0, 934.0, 953.0, 973.0, and 982.0 ft bgs. Table 6.2-2 presents a summary of all groundwater samples collected at CrCH-2.

6.3 Borehole Logging

The following sections describe the borehole logging conducted at CrCH-2. Table 6.3-1 presents a summary of all logging conducted at CrCH-2.

6.3.1 Video Logging

Laboratory personnel ran a video survey of the borehole from the surface to 930.0 ft bgs on December 23, 2014. The purpose of this survey was to observe the cased and open borehole, to collect information on the casing depths, to confirm the standing water level, and to observe the borehole geology.

Table 6.3-1 provides a description of the completed logs. Video logs are provided on DVD in Appendix A of this report.

6.3.2 Geophysical Logging

On December 23, 2014, the Laboratory ran a natural gamma ray and an induction survey in the borehole from 934.0 ft bgs to the surface to collect lithologic and hydrologic information. Table 6.3-1 shows the depths of coverage for each type of log. The Laboratory geophysical logs are included in Appendix B of this report (on CD).

6.4 Piezometer Design and Construction

A two-piezometer design was sent to NMED for review and was approved on January 8, 2015 (see Appendix C).

The CrCH-2 piezometers (CrPZ-2a and CrPZ-2b) were designed in accordance with the objectives and steps outlined in the work plan, approved with modifications by NMED (LANL 2014, 25951; NMED 2014, 525201). The core and drillers logs were reviewed as well as the depth to water. The objective in setting the upper screen was to establish a piezometer at the top of the regional aquifer. Therefore, the 10-ft-long screened interval was proposed from 909.0 to 919.0 ft bgs with the water level measured at 904.0 ft bgs. The objective in setting the lower screen was to enable characterization of the vertical chromium concentration profile and to facilitate cross-hole testing with regional monitoring well R-28. A 20-ft-long screened interval was proposed from 944.0 to 964.0 ft bgs.

CrPZ-2a and CrPZ-2b were constructed of 2.0-in.-I.D./2.375-in.-O.D. passivated type A304 stainless-steel flush-threaded casing. The screened intervals consist of 2.0-in.-I.D. rod-based, 0.040-in. slot, wire-wrapped screen. Casing and screen were steam-pressure washed before installation. A 1.25-in.-I.D. steel flush-threaded tremie pipe string, also decontaminated before use, was used to deliver annular fill materials and potable water downhole during piezometer construction. Figure 6.4-1 illustrates the final construction details.

Piezometer construction began on January 11, 2015. Before the piezometer was constructed, the bottom of the borehole was measured at a depth of 975.3 ft bgs. The deeper piezometer, CrPZ-2b, was lowered into the borehole on January 12, 2015, and the screened interval was placed from 944.0 to 964.0 ft bgs. The upper piezometer, CrPZ-2a, was lowered into the borehole on January 13, 2015, and the screened interval was placed from 909.8 to 919.8 ft bgs.

The bottom of the corehole was backfilled with bentonite from the measured TD of 975.3 to 968.3 ft bgs. The lower primary filter pack (consisting of 10/20 sand) was placed via tremie pipe on January 12, 2015. The filter pack was installed from a depth of 968.3 to 940.0 ft bgs and swabbed to promote settling of the filter pack. The transition sand consisting of 20/40 sand was placed via tremie pipe from depths of 940.0 to 938.0 ft bgs. The corehole sloughed in between 938.0 and 935.3 ft as casing was being retracted. Bentonite was placed via tremie pipe above the slough in multiple lifts from 935.3 to 925.3 ft bgs. The upper primary filter pack (consisting of 10/20 sand) was placed via tremie pipe on January 13, 2015. The filter pack was placed from a depth of 925.3 to 904.0 ft bgs and swabbed to promote settling. The transition sand consisting of 20/40 sand was placed via tremie pipe from depths of 904.0 to 902.0 ft bgs. Bentonite was placed via tremie pipe above the transition sand in multiple lifts from 902.0 to 881.0 ft bgs as the 8-in. casing was retracted. The remaining 8-in. casing was then removed from the borehole. From January 16 to 17, 2015, bentonite was placed via tremie pipe in multiple lifts from 881.0 to 60.0 ft bgs as the 12-in. casing was retracted. The remaining 12-in. casing was then removed from the borehole. On January 19, 2015, a grout mixture of 92% cement and 8% bentonite was emplaced from a depth of 60 to 2.0 ft bgs as the piezometer was completed. Table 6.4-1 presents a summary of the annular fill materials used to construct CrPZ-2a and CrPZ-2b.

6.5 Post-Installation Activities

The surface completion and pad were completed on March 17, 2015. A geodetic survey was completed on March 26, 2015. Site restoration activities will be completed following the final disposition of contained drill cuttings and groundwater, per the NMED-approved waste disposal decision trees.

6.5.1 Bailing

CrPZ-2a was bailed from January 20 to February 2, 2015. All water was removed from this piezometer using a bailer on a wire line. A total of 164 gal. was purged. Water-quality parameters observed on February 3, 2015, at the end of bailing, were temperature of 17.3 C, specific conductance of 227 µS/cm, dissolved oxygen of 9.0 ppm, pH of 7.5, and turbidity of 5762 NTU.

CrPZ-2b was bailed from February 3 to 6, 2015. All water was removed from this piezometer using a bailer on a wire line. A total of 166 gal. was purged. Water-quality parameters observed on February 3, 2015, at the end of bailing, were temperature of 17.7°C, specific conductance of 241 µS/cm, dissolved oxygen of 7.7 ppm, pH of 6.8, and turbidity of 176 NTU.

Limited low-flow purging will be conducted with a Bennett pump during the spring of 2015. The pumping effort is ongoing and had not been completed at the time of this report.

6.6 Deviations from Planned Activities

The significant deviation from planned activities for CrCH-2 was the construction of two piezometers rather than one, as presented in the original corehole work plan (LANL 2014, 25951). The objective in setting the upper screen was to establish a piezometer at the top of the regional aquifer in accordance with NMED's approval with modifications to the work plan (LANL 2014, 25951; NMED 2014, 525201). The objective in setting the lower screen was to enable characterization of the vertical chromium concentration profile and to facilitate cross-hole testing with regional monitoring well R-28.

7.0 COREHOLE 3

The following sections describe the drilling, sampling, logging, construction, and post-installation activities at CrCH-3.

7.1 Chronology of Drilling Activities

Dual-rotary drilling equipment and supplies were mobilized from CrCH-2 to CrCH-3 on September 27 and 28, 2014, and prepared for drilling. Drilling of the CrCH-3 borehole began on September 28, 2014. A

24-in.-diameter borehole was advanced to 60.0 ft bgs and a 16-in. steel casing set to that depth and cemented into place. The surface casing was set in alluvium.

From October 2 to 8, 2014, an 11.42-in.-diameter borehole was drilled to 695.0 ft bgs (bottom of the Cerros del Rio volcanic series) using casing-advance methods, including the use of potable water and foam. This portion of the borehole was cased with 10-in.-I.D. casing. Five feet of this casing, plus the casing shoe, were cut off and left in the borehole from 685.0 to 690.0 ft bgs. From October 8 to 9, 2014, 8-in.-I.D. casing was installed in the borehole to 695.0 ft bgs. The DR rig demobilized from CrCH-3 to CrCH-4 to begin drilling at that corehole on October 10, 2014.

On October 31, 2014, the TSi 150T arrived on-site, set up, and began drilling. Between October 31 and November 25, 2014, the borehole was advanced from 700.0 to 1023.0 ft bgs.

The DR rig returned to CrCH-3 on December 4, 2014. The borehole was previously cored to 1023.0 ft bgs but had caved in to approximately 990.0 ft bgs. The DR rig constructed the lower portion of the piezometer in the open portion of the borehole.

7.2 Sampling Activities

The following sections summarize the sampling activities for CrCH-3. All sampling activities were conducted in general accordance with applicable standard operating procedures.

7.2.1 Geologic Sampling

Bulk rotary cuttings samples were collected at 10-ft intervals from ground surface to 700.0 ft bgs and used for lithologic logging.

Samples were collected using the sonic core barrel at approximately 4-ft intervals from 700.0 ft bgs to 1023.0 ft bgs in CrCH-3. Samples cohesive enough to remain intact were stored in the Lexan liners inside the core barrel for each sampling run. Samples that did not remain intact in the Lexan liners were placed into plastic sleeves. Table 7.2-1 presents a summary of all core samples collected at CrCH-3.

7.2.2 Groundwater Sampling

Groundwater samples were collected using a SimulProbe sampling device at 963.0, 983.0, 1003.0, and 1023.0 ft bgs. Table 7.2-2 presents a summary of all groundwater samples collected at CrCH-3.

7.3 Borehole Logging

The following sections describe the borehole logging conducted at CrCH-3. Table 7.3-1 presents a summary of all logging conducted at CrCH-3.

7.3.1 Video Logging

Laboratory personnel ran a video survey of the borehole from the surface to 935.0 ft bgs on December 3, 2014. The purpose of this survey was to observe the cased and open borehole, to collect information on the casing depths, to confirm the static water level, and to observe the borehole geology. On December 24, 2014, Laboratory personnel ran a video of the borehole from the surface to 975.0 ft bgs to verify screen placement depth and the static water level.

Table 7.3-1 provides a description of the completed logs. Video logs are provided on DVD in Appendix A of this report.

7.3.2 Geophysical Logging

On December 3, 2014, the Laboratory ran a natural gamma ray and an induction survey in the CrCH-3 borehole from 992.0 ft bgs to the surface to collect lithologic and hydrologic information. On December 24, 2014, Laboratory personnel ran a natural gamma ray survey from 975.0 to 875.0 ft bgs of the completed piezometer to confirm the placement position of the filter pack and backfill.

Table 7.3-1 shows the depths of coverage for each type of log. The Laboratory geophysical logs are included in Appendix B of this report (on CD).

7.4 Piezometer Design and Construction

A piezometer design for CrCH-3 was sent to NMED for review and was approved on December 3, 2014 (see Appendix C).

The CrCH-3 piezometer was designed in accordance with the objectives and steps outlined in the work plan approved with modifications by NMED (LANL 2014, 25951; NMED 2014, 525201). The core and drillers logs were reviewed as well as the depth to water. The objective in setting the screen was to establish a piezometer at the top of the regional aquifer. A 20-ft-long screened interval was proposed from 941.0 to 961.0 ft bgs with the water level measured at 931.0 ft bgs.

The CrCH-3 piezometer (CrPZ-3) was constructed of 2.0-in.-I.D./2.375-in.-O.D. passivated-type A304 stainless-steel flush-threaded casing. Figure 7.4-1 illustrates the final piezometer construction details. The screened interval consists of a 20-ft length of 2.0-in.-I.D. rod-based, 0.040-in. slot, wire-wrapped screen from 939.4 to 959.4 ft bgs. Casing and screen were steam-pressure washed before installation. A 1.25-in.-I.D. steel, flush-threaded tremie pipe string, also decontaminated before use, was used to deliver annular fill materials and potable water downhole during piezometer construction.

Piezometer construction began on December 5, 2014. Before the piezometer was constructed, the bottom of the borehole was measured at a depth of 990.0 ft bgs. The borehole had sloughed in from 1023.0 to 990 ft bgs. The piezometer was lowered into the borehole on December 5, 2014, and the screened interval was placed from 939.4 to 959.4 ft bgs.

The primary filter pack (consisting of 10/20 sand) was placed via tremie pipe on December 6, 2014. The filter pack was placed from a depth of 966.0 to 934.0 ft bgs and swabbed to promote settling. The transition sand, consisting of 20/40 sand, was placed via tremie pipe from depths of 934.0 to 932.0 ft bgs. Bentonite was placed via tremie pipe above the secondary filter pack in multiple lifts from 932.0 to 695 ft bgs. The DR drill rig completely removed the 8-in. casing on December 6 and 7, 2014. Bentonite was placed in multiple lifts from 695.0 to 61.0 ft bgs as the 10-in. casing was retracted. The remainder of the 10-in. casing was then removed from the borehole on December 9, 2014. On December 9, 2014, a grout mixture of 92% cement and 8% bentonite was emplaced from a depth of 61.0 to 1.0 ft bgs as the piezometer was completed. Table 7.4-1 presents a summary of the annular fill materials used to construct CrPZ-3.

7.5 Post-Installation Activities

The surface completion and pad were completed on March 17, 2015. A geodetic survey was completed on March 26, 2015. Site restoration activities will be completed following the final disposition of contained drill cuttings and groundwater, per the NMED-approved waste disposal decision trees.

7.5.1 Bailing

CrPZ-3 was bailed from December 15 to 22, 2014. All water was removed from this piezometer using a bailer on a wire line. A total of 108 gal. was removed. Water-quality parameters observed on December 22, 2014, were temperature of 16.4°C, specific conductance of 274 µS/cm, dissolved oxygen of 8.5 ppm, pH of 7.6, and turbidity of 57.5 NTU.

Limited low-flow purging will be conducted with a Bennett pump during the spring of 2015. The pumping effort is ongoing and had not been completed at the time of this report.

7.6 Deviations from Planned Activities

No deviations from the work plan objectives occurred at CrCH-3.

8.0 COREHOLE 4

The following sections describe the drilling, sampling, logging, construction, and post-installation activities at CrCH-4.

8.1 Chronology of Drilling Activities

Drilling equipment and supplies were mobilized from CrCH-2 to CrCH-4 on October 11, 2014, and prepared for drilling. Before drilling CrCH-4, the engine on the DRrig failed and the rig had to demobilize for a complete engine replacement. Drilling of the CrCH-4 borehole began on November 11, 2014, with a 24-in.-diameter tricone bit and dual-rotary drilling method. The 24-in.-diameter borehole was advanced to 56.0 ft bgs and a 16-in. casing set to that depth and cemented into place. The surface casing was set in alluvium.

From November 13 to 23, 2014 an 11.42-in.-diameter borehole was drilled to 754.8 ft bgs (into of the Cerros del Rio volcanic series) using casing-advance methods, including the use of potable water and foam. This portion of the borehole was cased with 10-in.-I.D. casing. The casing was retracted from 754.8 to 730.0 ft bgs, and the casing was cut at 725.0 ft bgs. Five feet of this casing, plus the casing shoe, were cut off and left in the borehole from 725.0 to 730.0 ft bgs.

On November 24, 2014, the borehole was cased with 8-in.-I.D. casing to 736.0 ft bgs.

On December 16, 2014, the TSi 150T arrived on-site, set up, tripped 685.0 ft of 7-in. casing and 730.0 ft bgs of 6-in casing into the borehole, and began drilling. By December 21, 2014, the borehole had been advanced to 824.0 ft bgs with nearly 100% core recovery. Work then stopped for the winter holiday break. On January 7, 2015, crews returned to work, but the sonic rig had problems with the hydraulic system. On January 11, 2015, the rig was repaired and drilling resumed. Sonic drilling continued to a depth of 1047.0 ft bgs. At the completion of drilling, the 7-in. casing extended to 710.0 ft bgs and the 6-in. casing to 1030.0 ft bgs. All the 6-in. and 7-in. casing was removed by the sonic rig during piezometer construction. The 8-in. and 10-in. casing were removed by the DR rig during piezometer construction.

8.2 Sampling Activities

The following sections summarize the sampling activities for CrCH-4. All sampling activities were conducted in general accordance with applicable standard operating procedures.

8.2.1 Geologic Sampling

Bulk rotary cuttings samples were collected at 10-ft intervals from ground surface to 728.0 ft bgs and used for lithologic logging.

Samples were collected using the sonic core barrel at approximately 4-ft intervals from 728.0 ft to 1047.0 ft bgs in CrCH-4. Samples cohesive enough to remain intact were stored in the Lexan liners inside the core barrel for each sampling run. Samples that did not remain intact in the Lexan liners were placed into plastic sleeves. Table 8.2-1 presents a summary of all core samples collected at CrCH-4.

8.2.2 Groundwater Sampling

Groundwater samples were collected using a SimulProbe sampling device at 967.0, 987.0, 1007.0, 1027.5, and 1047.0 ft bgs. Table 8.2-2 presents a summary of all groundwater samples collected at CrCH-4.

8.3 Borehole Logging

The following sections describe the borehole logging conducted at CrCH-4. Table 8.3-1 presents a summary of all logging conducted at CrCH-4.

8.3.1 Video Logging

Laboratory personnel ran a video survey of the piezometer from the surface to 1002.6 ft bgs on January 29, 2015. The purpose of this survey was to verify screen placement depth, static water level, and the TD of the piezometer.

Table 8.3-1 provides a description of the completed logs. The video logs are provided on DVD in Appendix A of this report.

8.3.2 Geophysical Logging

On January 29, 2015, the Laboratory ran a natural gamma ray survey in the constructed CrPZ-4 piezometer from 1000.0 ft bgs to the surface to collect lithologic information. Table 8.3-1 shows the depths of coverage for each type of log. The Laboratory geophysical logs are included in Appendix B of this report (on CD).

8.4 Piezometer Design and Construction

On January 22, 2015, a piezometer design was sent to NMED for review and approval. Approval of the design was received on January 22, 2015 (see Appendix C).

The CrCH-4 piezometer (CrPZ-4) was designed in accordance with the objectives and steps outlined in the work plan, approved with modifications by NMED (LANL 2014, 25951; NMED 2014, 525201). The core and drillers logs were reviewed as well as the depth to water. The objective in setting the screen was to establish a piezometer at the top of the regional aquifer. A 20-ft-long screened interval was set from 957.0 to 977.0 ft bgs with the water level measured at 947.0 ft bgs.

The CrPZ-4 piezometer was constructed of 2.0-in.-I.D./2.375-in.-O.D. passivated-type A304 stainless-steel flush-threaded casing. Figure 8.4-1 illustrates the final piezometer construction details. The screened interval consists of a 20-ft length of 2.0-in.-I.D. rod-based, 0.040-in. slot, wire-wrapped screen from 957.0 to 977.0 ft bgs. Casing and screen were steam-pressure washed before installation. A 1.25-in.-I.D. steel, flush-threaded tremie pipe string, also decontaminated before use, was used to deliver annular fill materials and potable water downhole during piezometer construction.

Piezometer construction began on January 23, 2015.

Before the piezometer was constructed, the bottom of the borehole was measured at a depth of 1023.0 ft bgs. The borehole had sloughed in from 1047.0 to 1023.0 ft bgs. The piezometer was lowered into the borehole on October 25, 2014, and the screened interval was placed from 957.0 to 977.0 ft bgs.

The primary filter pack (consisting of 10/20 sand) was placed via tremie pipe on January 24, 2015. The filter pack was placed from a depth of 983.7 to 951.8 ft bgs and swabbed to promote settling. The transition sand consisting of 20/40 sand was placed via tremie pipe from depths of 951.8 to 948.2 ft bgs. Bentonite was placed via tremie pipe above the secondary filter pack in multiple lifts as the 7-in. sonic casing was removed, from 948.2 to 724.7 ft bgs, slightly below the depth of the 8-in. casing installed by the DR drill rig. The sonic drill rig then demobilized on January 26, 2015. The DR rig mobilized to the site on March 6, 2015, and began pulling the 8-in. casing and completing construction of the piezometer. Bentonite was placed in multiple lifts from 724.7 to 455.0 ft bgs as the 10-in. casing was retracted. On March 10, 2015, bentonite was placed via tremie pipe from depths of 455.0 ft to 66.0 ft bgs as the 12-in. casing was removed. The remaining 12-in. casing was then removed from the borehole. On March 13, 2015, a grout mixture of 92% cement and 8% bentonite was emplaced from a depth of 66.0 to 2.0 ft bgs as the piezometer was completed. Table 8.4-1 presents a summary of the annular fill materials used to construct CrPZ-4.

8.5 Post-Installation Activities

The surface completion pad were completed on March 17, 2015. A geodetic survey was completed on March 26, 2015. Site restoration activities will be completed following the final disposition of contained drill cuttings and groundwater, per the NMED-approved waste disposal decision trees.

8.5.1 Bailing

CrPZ-4 was bailed from March 18 to March 21, 2015. All water was removed from this piezometer using a bailer on a wire line. A total of 254 gal. was removed. Water-quality parameters observed on March 21, 2015 at the end of bailing, were temperature of 16.8°C, specific conductance of 88 µS/cm, dissolved oxygen of 8.2 ppm, pH of 7.7, and turbidity of 834 NTU.

Limited low-flow purging will be conducted with a Bennett pump during the spring of 2015. The pumping effort is ongoing and had not been completed at the time of this report.

8.6 Deviations from Planned Activities

No deviations from the work plan objectives occurred at CrCH-4.

9.0 COREHOLE 5

The following sections describe the drilling, sampling, logging, construction, and post-installation activities at CrCH-5.

9.1 Chronology of Drilling Activities

Dual-rotary drilling equipment and supplies were mobilized from CrCH-2 to CrCH-5 on December 2, 2014, and prepared for drilling. Drilling of the CrCH-5 borehole began on December 3, 2014. A 24-in.-diameter borehole was advanced to 55.0 ft bgs and a 16-in. steel casing set to that depth and cemented into place. The surface casing was set in alluvium.

From December 11 to 16, 2014, an 11.42-in.-diameter borehole was drilled to 755.0 ft bgs (bottom of the Cerros del Rio volcanic series) using casing-advance methods, including the use of potable water and foam. The upper portion of the borehole was cased with 10-in.-I.D. casing to 531.0 ft bgs. Five feet of this casing, plus the casing shoe, were cut off and left in the borehole from 526.0 ft to 531.0 ft bgs. On December 17, 2014, 8-in.-I.D. casing was installed in the borehole to 750.0 ft bgs. The DR rig demobilized from CrCH-5 to CrCH-2 to begin piezometer construction at that corehole on December 18, 2014.

On January 26, 2015, the TSi 150T arrived on-site, set up, and began work. The 7-in. casing was run into the borehole to 750.0 ft bgs. The 6-in. casing was run into the borehole at 740.0 ft bgs. Between January 26 and February 9, 2015, the corehole was advanced from 750.0 to 1010.0 ft bgs. Groundwater water was encountered at approximately 966.0 ft bgs on February 7, 2015. Sonic drilling continued to a depth of 1016.0 ft bgs.

9.2 Sampling Activities

The following sections summarize the sampling activities for CrCH-5. All sampling activities were conducted in general accordance with applicable procedures.

9.2.1 Geologic Sampling

Bulk rotary cuttings samples were collected at 10-ft intervals from ground surface to 750.0 ft bgs and used for lithologic logging.

Samples were collected using the sonic core barrel at approximately 4-ft intervals from 756.0 to 1016.0 ft bgs in CrCH-5. Samples cohesive enough to remain intact were stored in the Lexan liners inside the core barrel for each sampling run. Samples that did not remain intact in the Lexan liners were placed into plastic sleeves. Table 9.2-1 presents a summary of all core samples collected at CrCH-5.

9.2.2 Groundwater Sampling

Groundwater samples were collected using a SimulProbe sampling device at 971.0, 991.0, and 1011.0 ft bgs, Table 9.2-2 presents a summary of all groundwater samples collected at CrCH-5.

9.3 Borehole Logging

The following sections describe the borehole logging conducted at CrCH-5. Table 9.3-1 presents a summary of all logging conducted at CrCH-5.

9.3.1 Video Logging

Laboratory personnel ran a video survey of the borehole from the surface to 796.5 ft bgs on January 29, 2015. The purpose of this survey was to locate the dropped sonic core barrel assembly. On February 9, 2015, Laboratory personnel ran two video surveys from the surface to 798.0 and 970.6 ft bgs to collect information on casing depths, the static water level, and the geology in the uncased part of the borehole.

Table 9.3-1 provides a description of the completed logs. The video logs are provided on DVD in Appendix A of this report.

9.3.2 Geophysical Logging

On February 9, 2015, the Laboratory ran natural gamma ray and induction logs in the constructed CrPZ-5 piezometer from the TD of 988.6 ft bgs to the surface to collect lithologic and hydrologic information. Table 9.3-1 shows the depths of coverage for each type of log. The Laboratory geophysical logs are included in Appendix B of this report (on CD).

9.4 Piezometer Design and Construction

A piezometer design was sent to NMED for review and was approved on February 10, 2015 (see Appendix C).

The CrCH-5 piezometer (CrPZ-5) was designed in accordance with the objectives and steps outlined in the Work Plan, approved with modifications by NMED (LANL 2014, 25951; NMED 2014, 525201). The core and drillers logs were reviewed as well as the depth to water. The objective in setting the screen was to establish a monitoring point at the top of the regional aquifer. A 20-ft-long screened interval was proposed from 976.0 to 996.0 ft bgs with the water level measured at 966.0 ft bgs.

The CrPZ-5 piezometer was constructed of 2.0-in.-I.D./2.375-in.-O.D. passivated-type A304 stainless-steel flush-threaded casing. The screened interval consists of a 20-ft length of 2.0-in.-I.D. rod-based, 0.040-in. slot, wire-wrapped screen from 976.0 to 996.0 ft bgs. Casing and screen were steam-pressure washed before installation. A 1.25-in.-I.D. steel, flush-threaded tremie pipe string, also decontaminated before use, was used to deliver annular fill materials and potable water downhole during piezometer construction. Figure 9.4-1 illustrates the final construction details.

Piezometer construction began on February 11, 2015, with the sonic rig. Before the piezometer was constructed, the bottom of the borehole was measured at a depth of 1010.0 ft bgs. The piezometer was lowered into the borehole on February 11, 2015, and the screened interval was placed from 976.0 to 996.0 ft bgs.

The primary filter pack (consisting of 10/20 sand) was placed via tremie pipe on February 11, 2015. The filter pack was placed from a depth of 1001.0 to 970.5 ft bgs and swabbed to promote settling. The transition sand consisting of 20/40 sand was placed via tremie pipe from depths of 970.5 to 968.5 ft bgs. Bentonite was placed via tremie pipe above the secondary filter pack in multiple lifts from 968.5 to 751.0 ft bgs on February 12, 2015.

The DR rig returned to CrPZ-5 to finish piezometer construction on March 11, 2015. The DR rig completely removed the 8-in. casing on March 11, 2015. Bentonite was placed in multiple lifts from 746.0 to 539.0 ft bgs. All of the 10-in. casing was then removed from the borehole on March 13, 2015. Bentonite was again placed in multiple lifts from 539.0 to 64.0 ft bgs. On March 16, 2015, a grout mixture of

92% cement and 8% bentonite was emplaced from a depth of 64.0 to 3.0 ft bgs as the piezometer was completed. Table 9.4-1 presents a summary of the annular fill materials used to construct CrPZ-5.

9.5 Post-Installation Activities

The surface completion and pad were completed on March 23, 2015. A geodetic survey was completed on March 26, 2015. Site restoration activities will be completed following the final disposition of contained drill cuttings and groundwater, per the NMED-approved waste disposal decision trees.

9.5.1 Bailing

CrPZ-5 was bailed from March 17 to March 22, 2015. All water was removed from this piezometer using a bailer on a wire line. A total of 493 gal. was removed. Water-quality parameters observed on March 22, 2015 at the end of bailing were temperature of 18.1°C, specific conductance of 141 µS/cm, dissolved oxygen of 7.4 ppm, pH of 7.4, and turbidity of 4966 NTU.

Limited low-flow purging will be conducted with a Bennett pump during the spring of 2015. The pumping effort is ongoing and had not been completed at the time of this report.

9.6 Deviations from Planned Activities

One deviation from the “Drilling Work Plan for Chromium Project Coreholes” (LANL 2014, 259151; NMED 2014, 525201) occurred at CrPZ-5. The sonic rig was not physically capable of penetrating 100.0 ft into the aquifer at the CrCH-5 location as planned. Water was encountered at 966.0 ft bgs, and the sonic rig reached its maximum capability at 1010.0 ft bgs.

10.0 PIEZOMETER INSTRUMENTATION

The piezometers will initially be outfitted with dedicated water-level transducers for continuous water-level monitoring during periods when a chromium extraction well(s) is in operation. Water-quality sampling may be conducted on an as-needed basis most likely using either the BESST, Inc., or Bennett Sample Pump systems.

11.0 SURFACE PAD INSTALLATIONS

Reinforced concrete surface pads, 10 ft × 10 ft × 9 in. thick, were installed at all the piezometers from March 17 to 23, 2015. Each concrete pad is slightly elevated above ground surface and crowned to promote runoff. The pads will provide long-term structural integrity for the piezometers. A brass monument marker was embedded in the northwest corner of each pad. A 16-in.-O.D. steel protective casing with a locking lid was installed around the stainless-steel piezometer riser. A 0.5-in. weep hole was drilled near the base of the protective casing at each piezometer to prevent water accumulation inside the protective casing. Pea gravel was emplaced between the protective casing and piezometer casing to a height of 1.0 ft above the weep hole. Four steel bollards, covered by high-visibility plastic sleeves, were set at the outside edges of each pad to protect the piezometer from accidental vehicle damage. Bollards are designed for easy removal to allow access to the piezometer. Appendix D shows details of the surface pad completions.

12.0 SURVEY ACTIVITIES

A licensed professional land surveyor conducted geodetic surveys at each piezometer on March 26, 2015. (Table 12.0-1). The survey data 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 are expressed relative to New Mexico State Plane Coordinate System Central Zone 83 (North American Datum [NAD] 83); elevations are expressed in feet amsl using the National Geodetic Vertical Datum of 1929. For each piezometer survey points included ground-surface elevation near the concrete pad, the top of the monument marker in the concrete pad, the top of the piezometer casing, and the top of the protective casing. The survey data are provided in Table 12.0-1.

13.0 WASTE MANAGEMENT

Waste generated from the chromium coreholes project includes drilling fluids, purged groundwater, drill cuttings, decontamination water, compressor water, and contact waste. A summary of the waste characterization samples collected during drilling, construction, and development of the chromium coreholes piezometers are presented in Table 13.0-1. All waste streams produced during drilling and development activities were sampled in accordance with the "Chromium Well CrEx-1 Waste Characterization Strategy Form" (LANL 2014, 600344).

Analytical results for fluids produced during development and pump testing will be reviewed with the goal of land-application. Data will be reviewed manually and within the automated waste disposition 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 evaporated. If analytical data indicate the drilling fluids are hazardous/nonradioactive or mixed low-level waste, the drilling fluids will be either treated on-site or disposed of at an authorized facility. Development water was discharged under Temporary Permission to Discharge, permit (AL: 856, PRD20140007).

Cuttings produced during drilling were sampled and analytical results will be reviewed with the goal of land-application. If cuttings meet land-application criteria, the pit liner will be removed, cuttings will be left in the pit, and a layer of base course will cover the cuttings.

Decontamination fluids used for cleaning the piezometer steel were containerized and staged at the CrEx-1 well pad. This fluid waste was sampled and a waste profile form will be completed as soon as the analytical data is received. This decontamination water waste will be shipped for disposal at a Laboratory-approved off-site disposal facility.

Characterization of contact waste will be based upon acceptable knowledge, referencing the analyses of the waste samples collected from the drill 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 drill cuttings. The pit liners will be included in the contact waste disposal materials.

Site restoration activities are conducted by Maintenance and Site Services personnel at the Laboratory. They include evaporating drilling fluids and removing cuttings from the pit and managing the development/pump test fluids in accordance with applicable procedures. The polyethylene liners 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.

14.0 ACKNOWLEDGMENTS

Yellow Jacket Drilling drilled coreholes 1 through 5, installed the piezometers, conducted the bailing and installed the surface completions.

Laboratory personnel ran downhole video, natural gamma, and induction logging equipment and conducted the surveying and waste management activities.

15.0 REFERENCES AND MAP DATA SOURCES

15.1 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 EP 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), April 2013. "Interim Measures Work Plan for the Evaluation of Chromium Mass Removal," Los Alamos National Laboratory document LA-UR-13-22534, Los Alamos, New Mexico. (LANL 2013, 241096)

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), February 28, 2014. "Waste Characterization Strategy Form for Chromium Well CrEx-1 [with complete Attachment 4]," Los Alamos National Laboratory, Los Alamos, New Mexico. (LANL 2014, 600344)

LANL (Los Alamos National Laboratory), July 2014. "Drilling Work Plan for Chromium Project Coreholes," Los Alamos National Laboratory document LA-UR-14-24829, Los Alamos, New Mexico. (LANL 2014, 259151)

LANL (Los Alamos National Laboratory), March 2015. "Drilling Work Plan for Combined Groundwater Monitoring Well R-67 and CrCH-6," Los Alamos National Laboratory document LA-UR-15-21004, Los Alamos, New Mexico. (LANL 2015, 600265)

NMED (New Mexico Environment Department), September 26, 2014. "Approval with Modifications, Drilling Work Plan for Chromium Project Coreholes," New Mexico Environment Department letter to P. Maggiore (DOE-NA-LA) and J.D. Mousseau (LANL) from J.E. Kieling (NMED-HWB), Santa Fe, New Mexico. (NMED 2014, 525201)

NMED (New Mexico Environment Department), April 2, 2015. "Approval with Modifications, Drilling Work Plan for Combined Groundwater Monitoring Well R-67 and CrCH-6," New Mexico Environment Department letter to P. Maggiore (DOE-NA-LA) and M. Brandt (LANL) from J.E. Kieling (NMED-HWB), Santa Fe, New Mexico. (NMED 2015, 600341)

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, August 12, 2014. "IWDs [Integrated Work Documents] for Drilling Using the SONIC and Dual Rotary Drilling Methods," Los Alamos, New Mexico. (Yellow Jacket Drilling 2014, 600347)

15.2 Map Data Sources

Coarse Scale Drainage Arcs; Los Alamos National Laboratory, Water Quality and Hydrology Group of the Risk Reduction and Environmental Stewardship Program; as published 03 June 2003.

Dirt Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 19 March 2008; as published 04 January 2008.

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

Inactive Outfalls; Los Alamos National Laboratory, Water Quality and Hydrology Group of the Environmental Stewardship Division at Los Alamos National Laboratory Los Alamos New Mexico; 01 September 2003.

Paved Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 19 March 2008; as published 04 January 2008.

Penetrations; Los Alamos National Laboratory, Environment and Remediation Support Services, ER2006-0664; 1:2,500 Scale Data, 01 July 2006.

Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 19 March 2008; as published 04 January 2008.

Technical Area Boundaries; Los Alamos National Laboratory, Site Planning and Project Initiation Group, Infrastructure Planning Division; 19 September 2007.

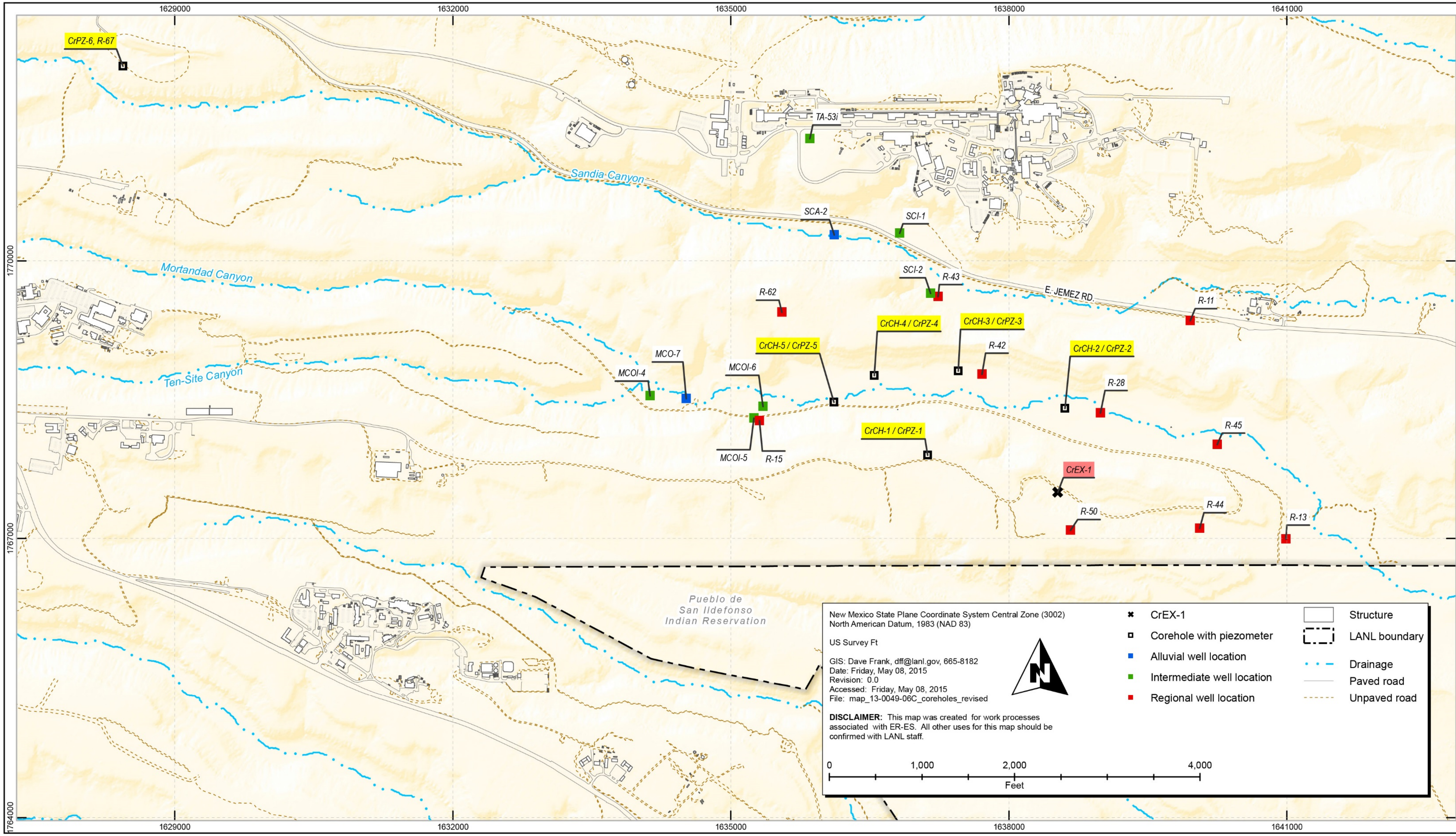


Figure 1.0-1 Locations of coreholes 1 to 5

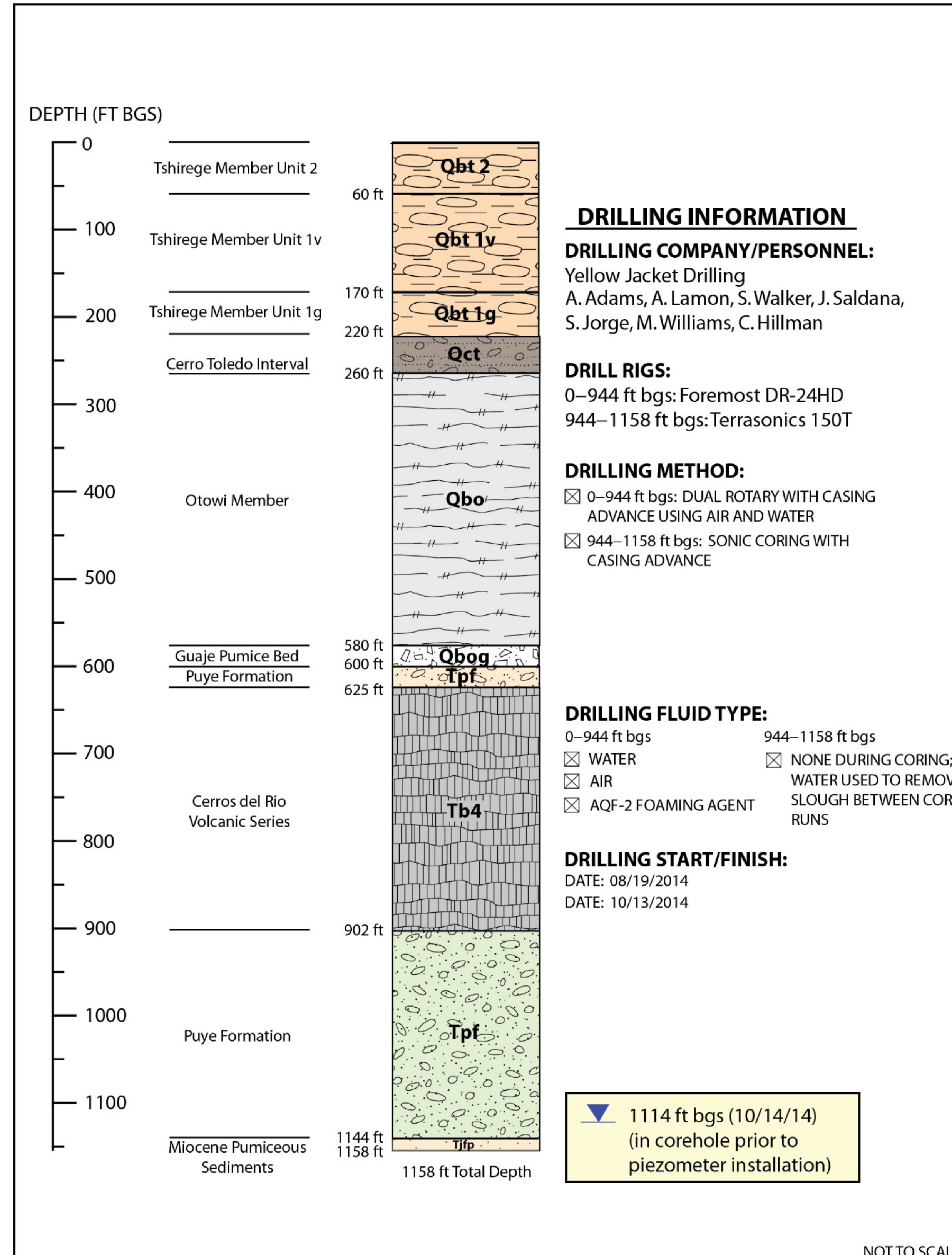


Figure 3.1-1 Borehole stratigraphy for CrCH-1

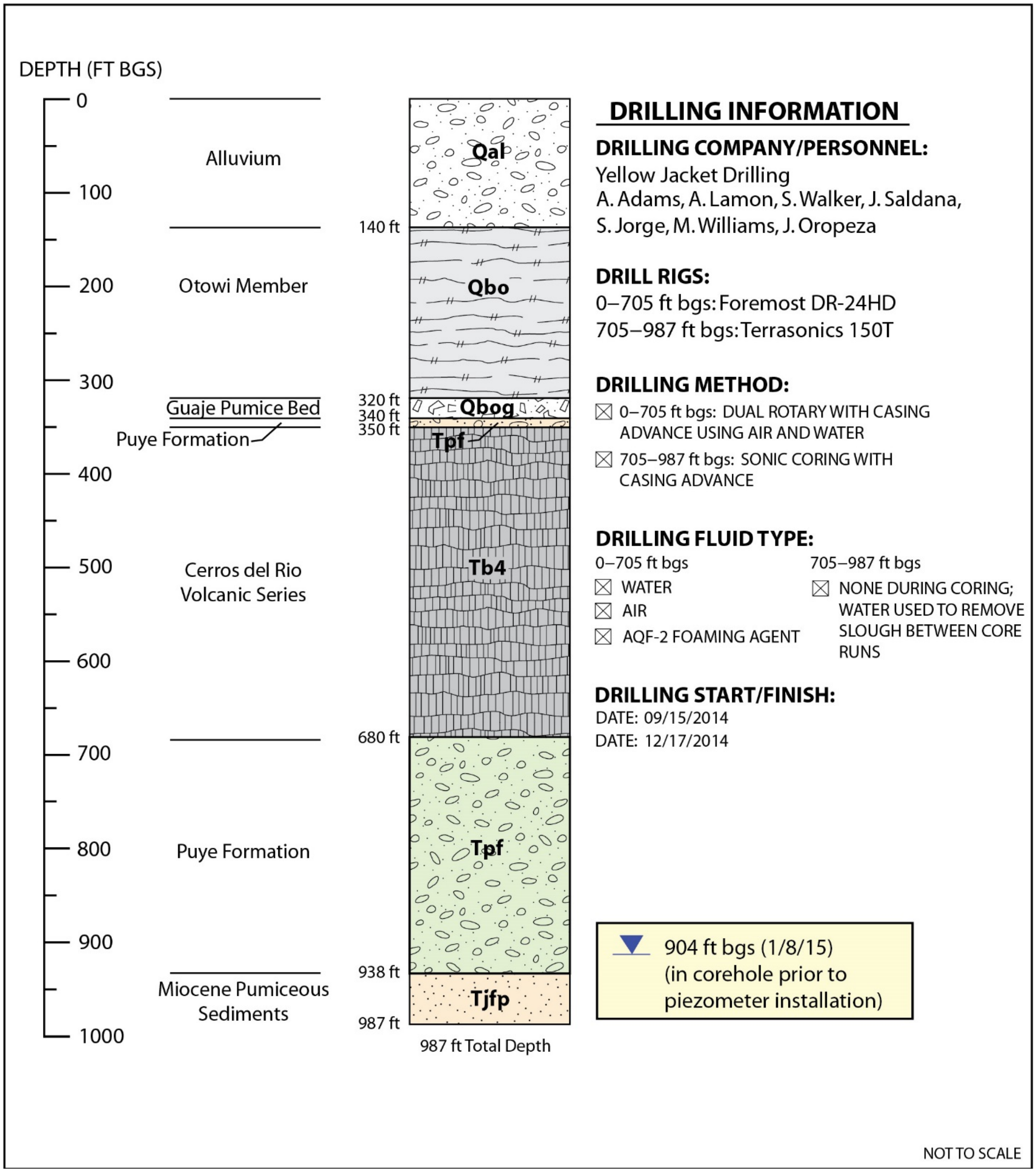


Figure 3.1-2 Borehole stratigraphy for CrCH-2

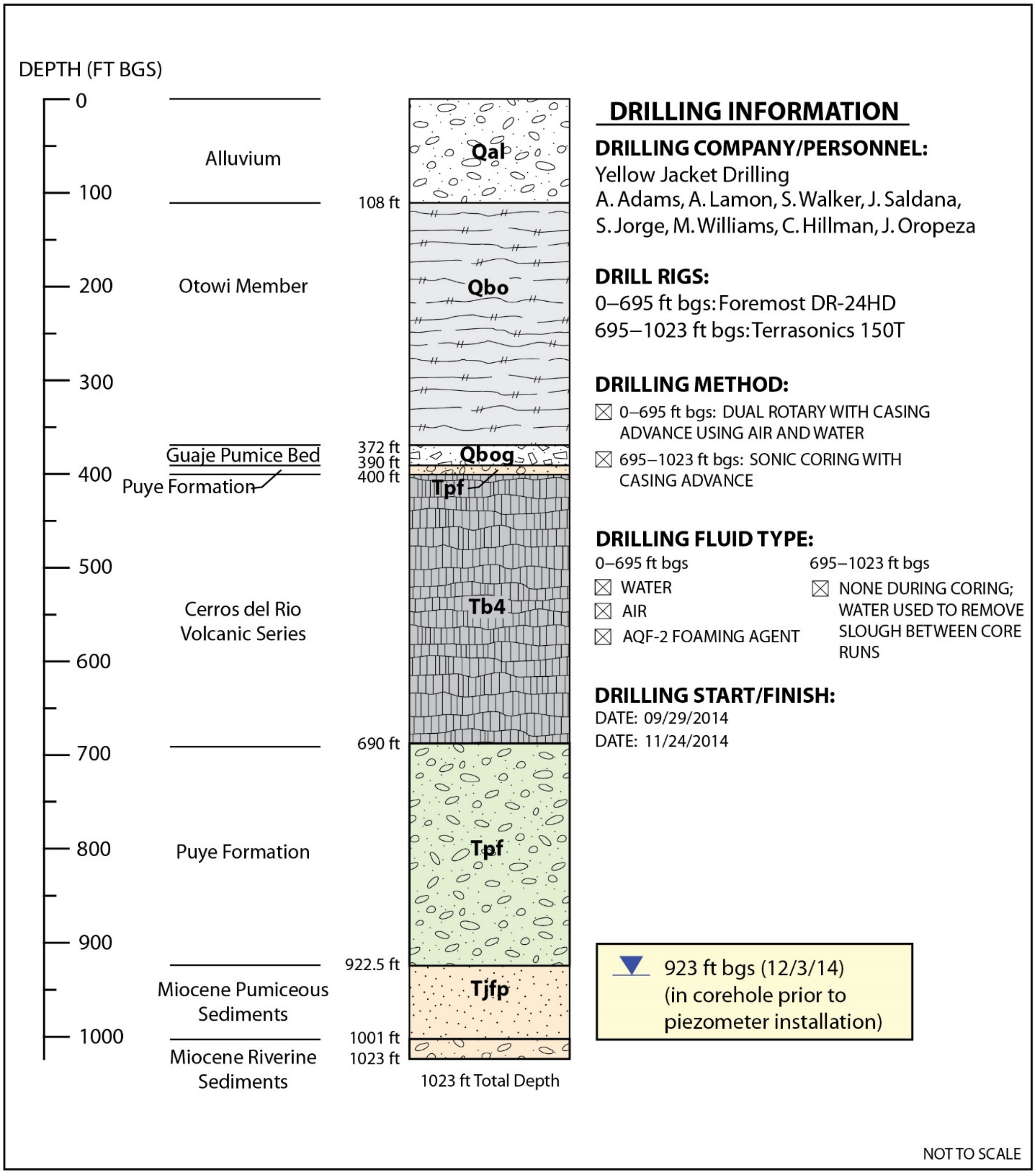


Figure 3.1-3 Borehole stratigraphy for CrCH-3

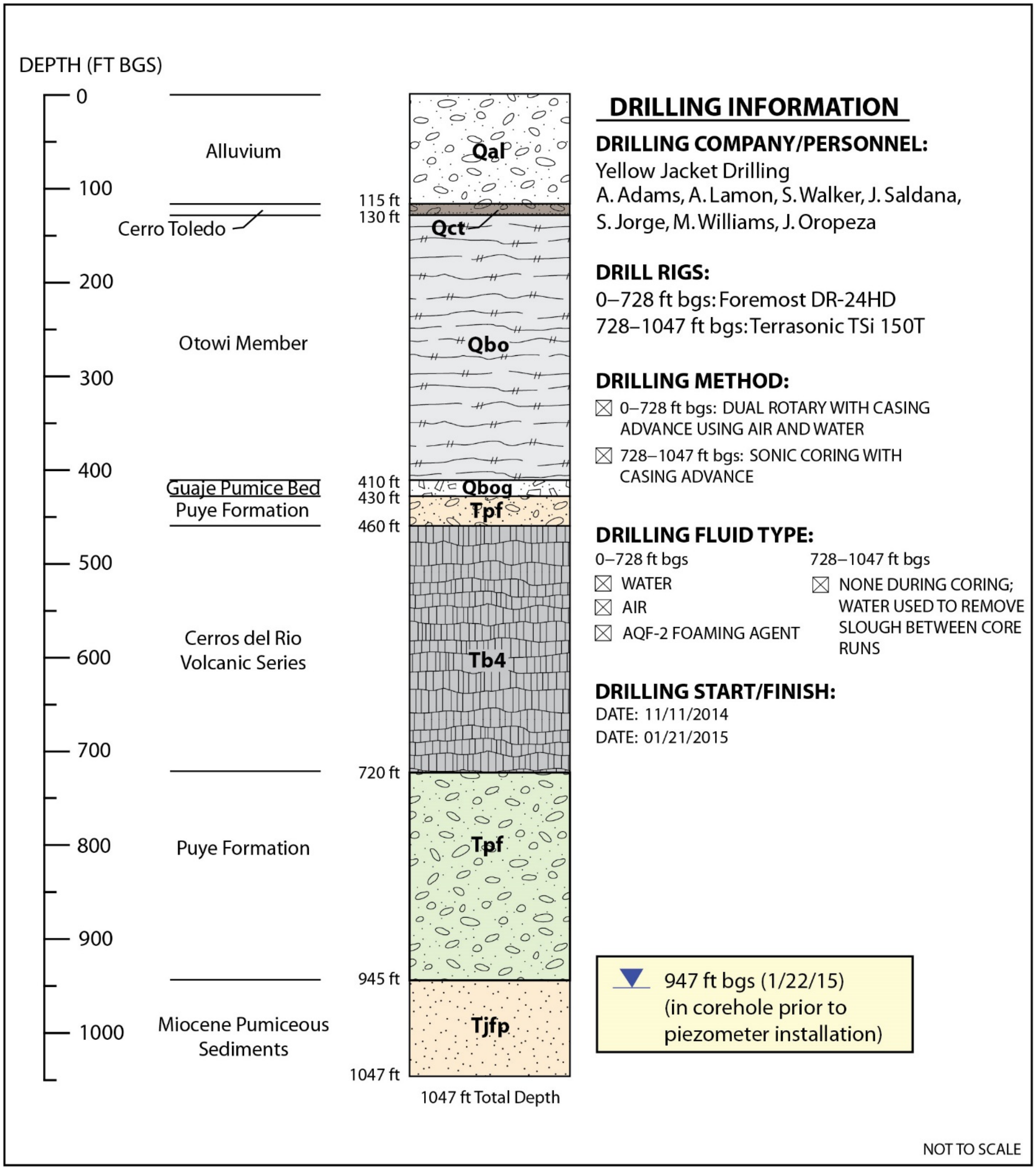


Figure 3.1-4 Borehole stratigraphy for CrCH-4

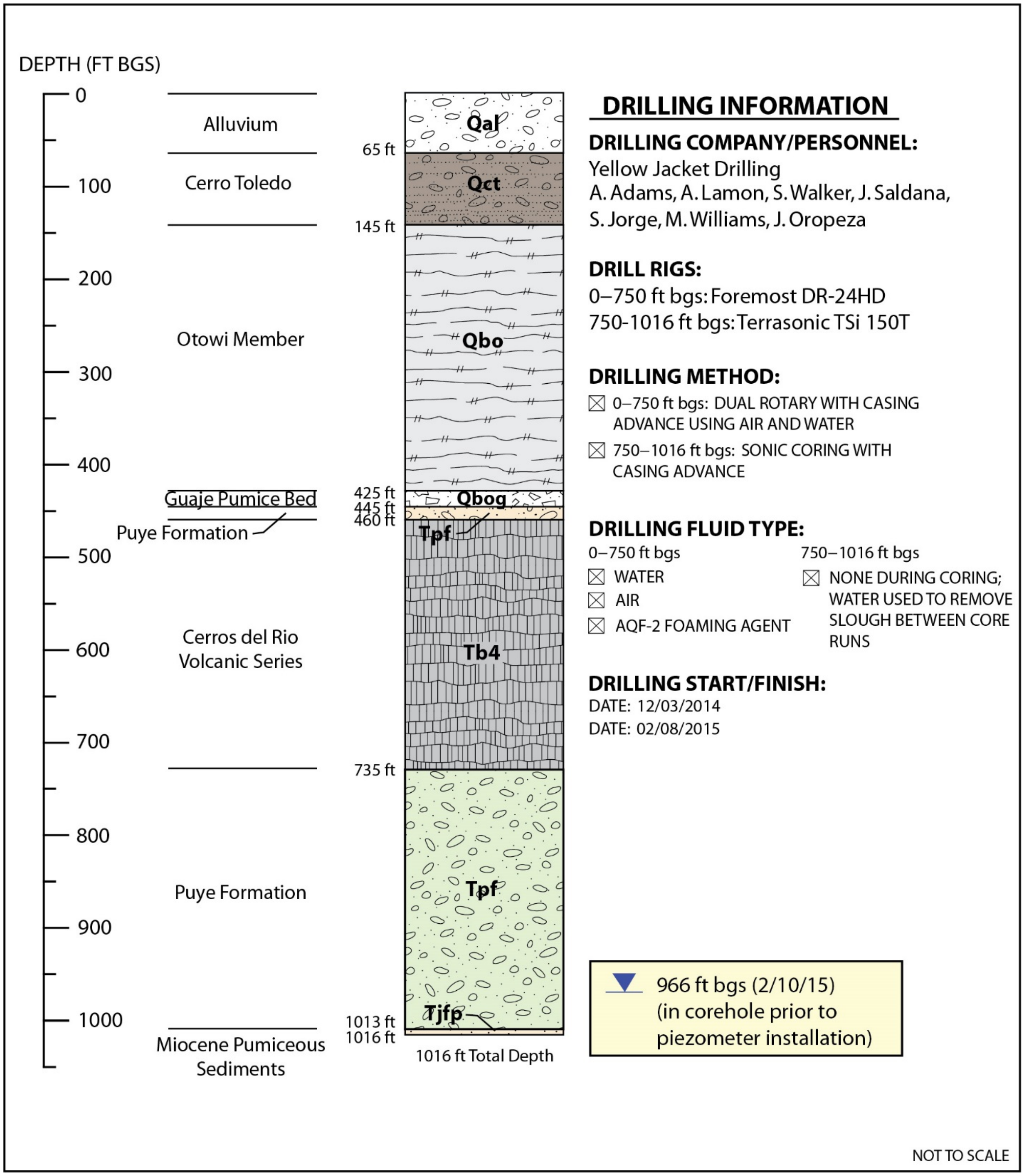


Figure 3.1-5 Borehole stratigraphy for CrCH-5

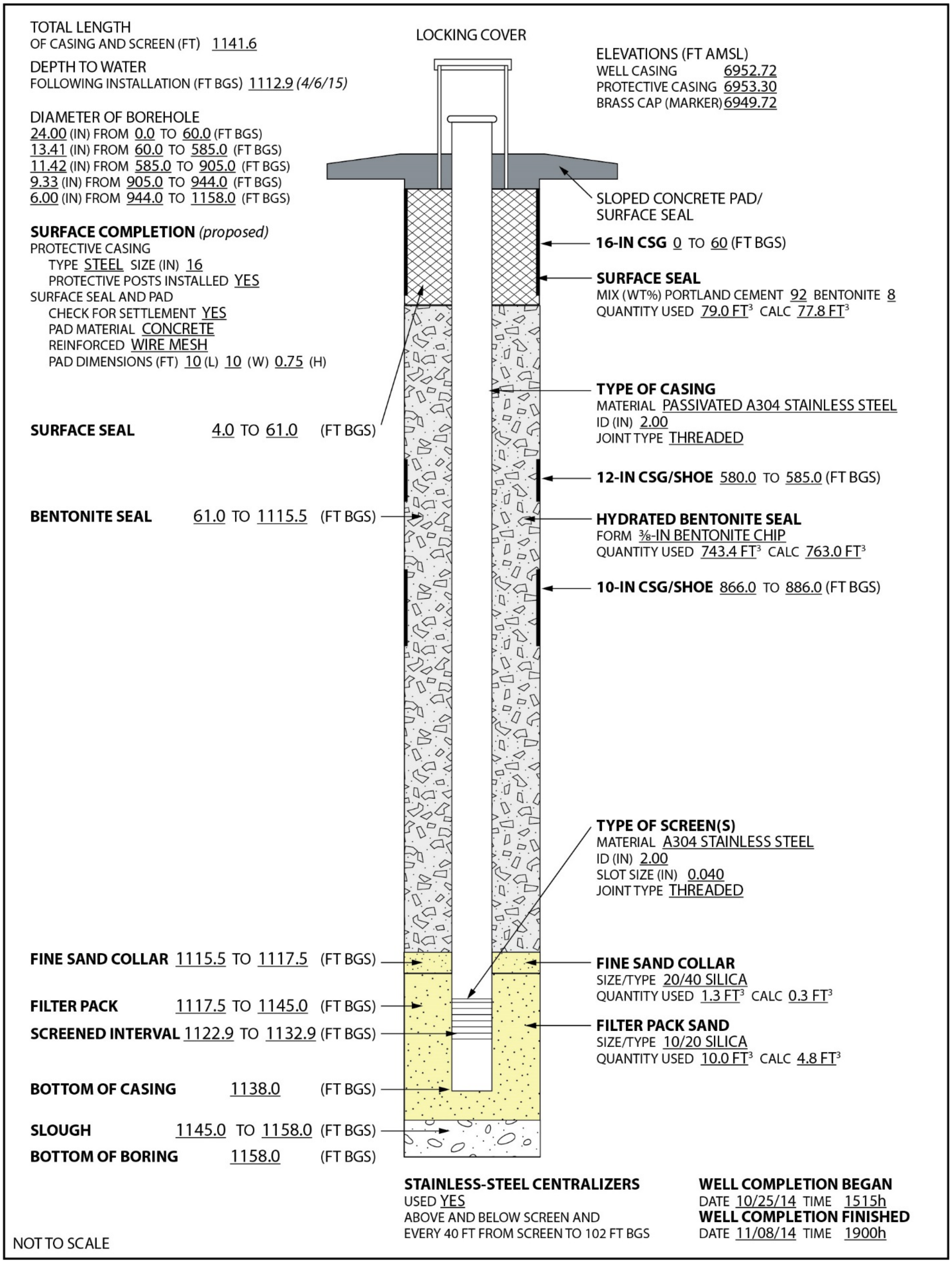


Figure 5.4-1 As-built construction diagram for CrPZ-1

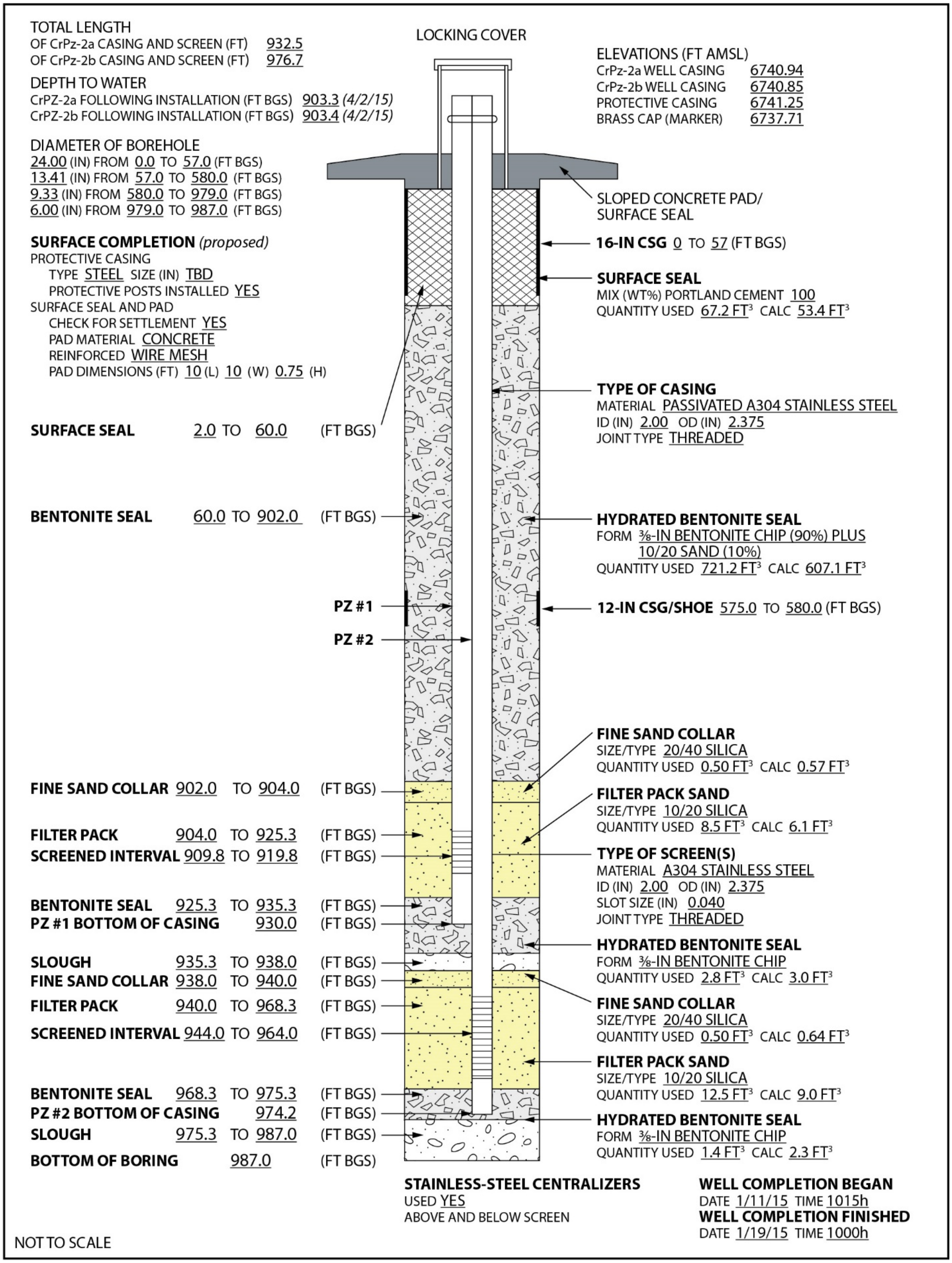


Figure 6.4-1 As-built construction diagram for CrPZ-2a and CrPZ-2b

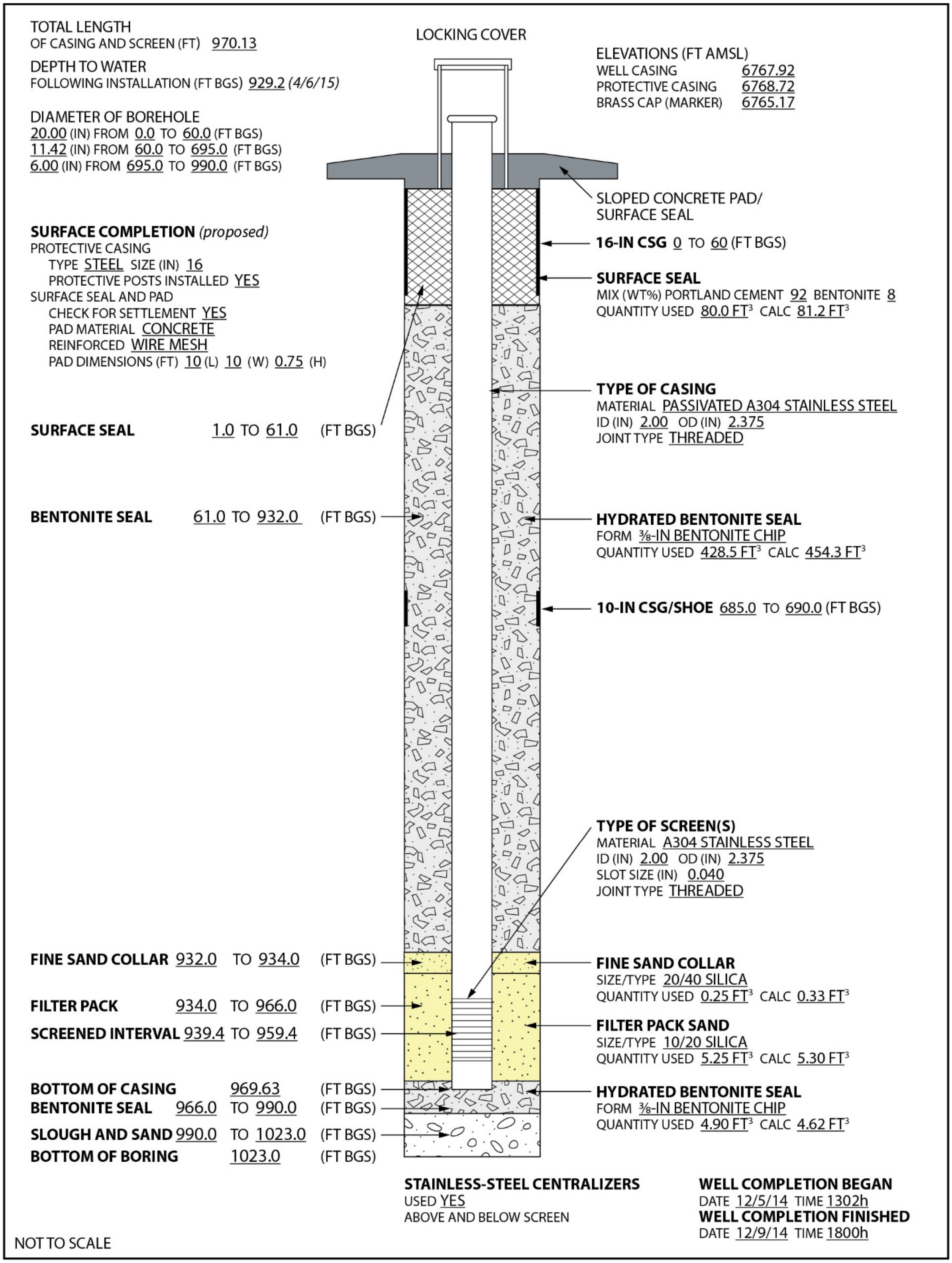


Figure 7.4-1 As-built construction diagram for CrPZ-3

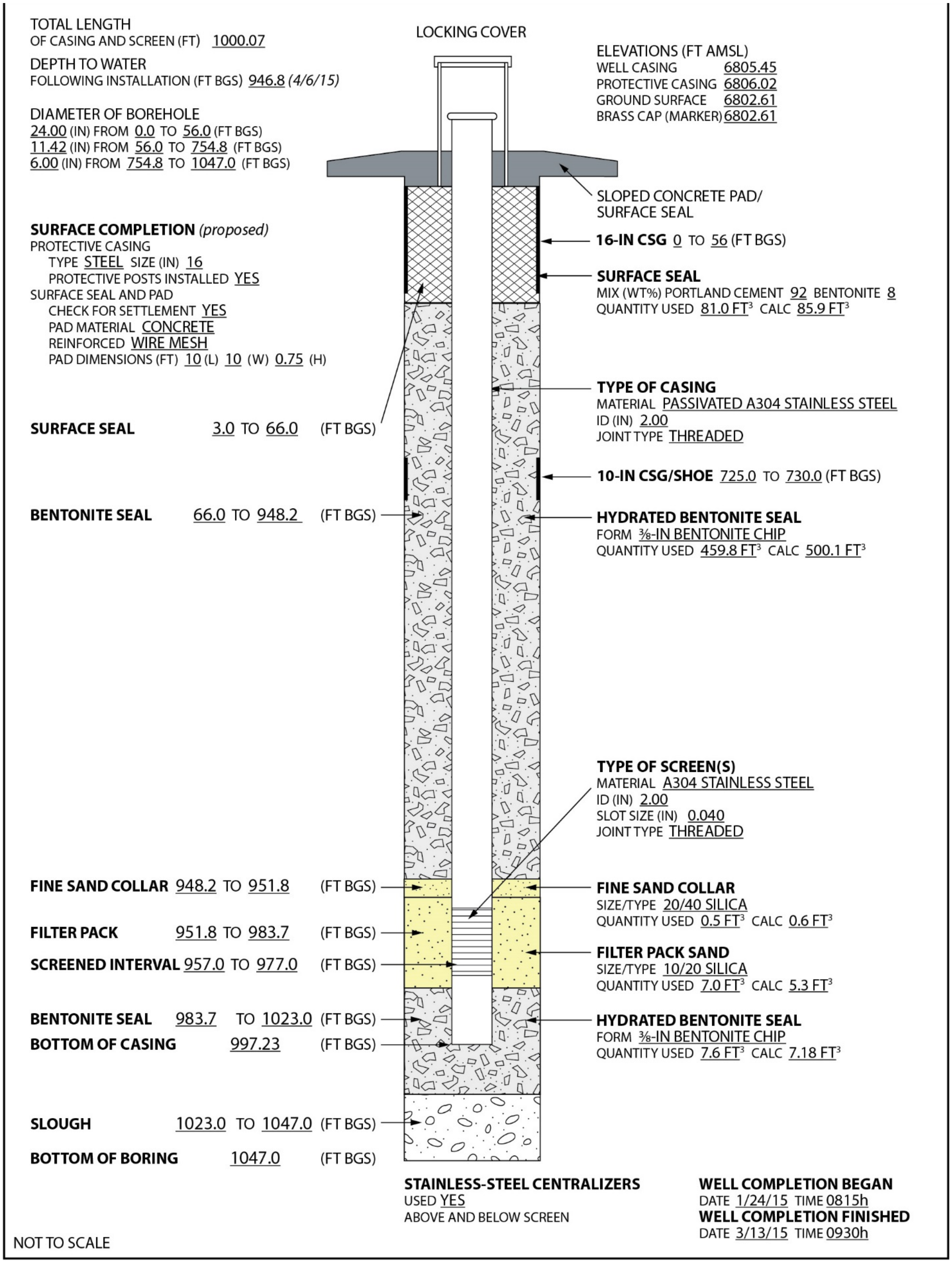


Figure 8.4-1 As-built construction diagram for CrPZ-4

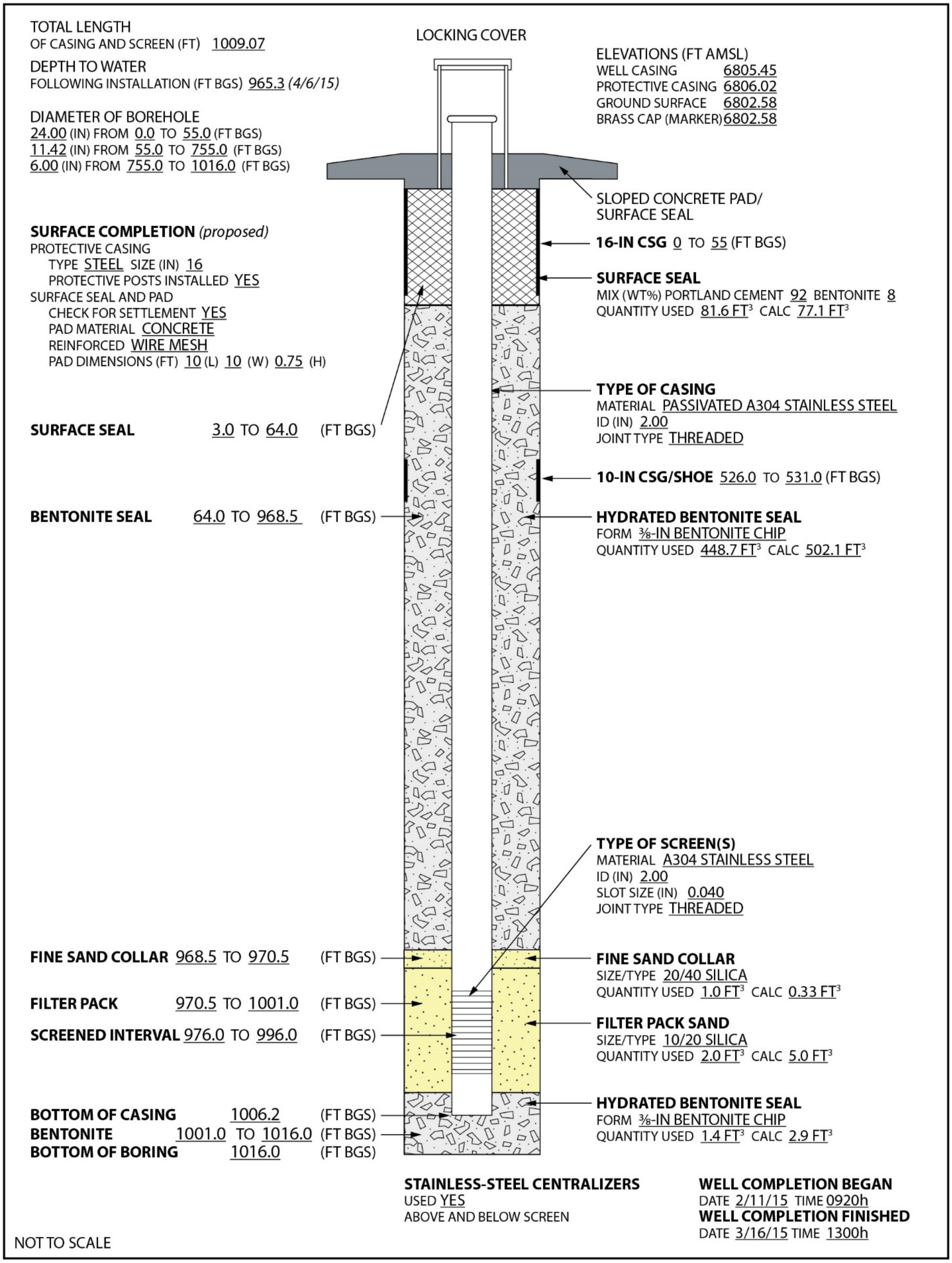


Figure 9.4-1 As-built construction diagram for CrPZ-5

Table 3.3-1
Measured Groundwater Elevations

Corehole	Measured on 3/2/15 and 3/6/15 (ft amsl)
CH-1	5836.8
CH-2	5834.4
CH-3	5836
CH-4	5837.9
CH-5	5837.24

Table 5.2-1
Core Samples Collected at CrCH-1

Container	Run No.	Sample Identification	Upper Depth (ft)	Lower Depth (ft)	Moisture Content (%)	Pore Water (mL)	Free Water (mL)
Tube	1	n/a*	945	948	No Recovery – Melted liner		
Tube	2	n/a	955	956.5	No Recovery – Melted liner		
Tube	3	n/a	966	968	No Recovery		
Tube	4	CH1-14-972	967	972	n/a	n/a	90.0
Tube	5	CH1-14-977	972	977	n/a	n/a	450.0
Tube	6	CH1-14-981	977	981	n/a	n/a	n/a
Tube	7	CH1-14-983	981	983	n/a	n/a	340.0
Tube	8	CH1-14-986	983	986	n/a	n/a	300.0
Tube	9	CH1-14-989	986	989	9.9	<0.1	40.0
Tube	10	CH1-14-992	989	992	13.38	<0.1	n/a
Tube	11	CH1-14-993	992	993	5.8	n/a	n/a
Tube	12	CH1-14-996.5	993	996.5	6.57	n/a	n/a
Tube	13	CH1-14-1000	996.5	1000	5.47	n/a	n/a
Tube	14	CH1-14-1003	1000	1003	11.38	<0.1	n/a
Tube	15	CH1-14-1003 T	1003	1006	14.73	<.1	n/a
		CH1-14-1006	1003	1006	4.99	n/a	n/a
Tube	16	CH1-14-1006 T	1006	1009	7.81	<0.1	n/a
		CH1-14-1009	1006	1009	5.4	n/a	
Tube	17	CH1-14-1009 T	1009	1012	10.45	<0.1	n/a
		CH1-14-1012	1009	1012	6.44	n/a	
Tube	18	CH1-14-1012 T	1012	1015	13.34	<0.1	40.0
		CH1-14-1015	1012	1015	7.46	<0.1	
Tube	19	CH1-14-1015 T	1015	1018	12.92	<0.1	n/a
		CH1-14-1018	1015	1018	6.66	<0.1	

Table 5.2-1 (continued)

Container	Run No.	Sample Identification	Upper Depth (ft)	Lower Depth (ft)	Moisture Content (%)	Pore Water (mL)	Free Water (mL)
Tube	20	CH1-14-1018 T	1018	1021	12.33	1.1	n/a
		CH1-14-1021	1018	1021	10.55	n/a	
Tube	21	CH1-14-1021 T	1021	1024	7.55	0.2	n/a
		CH1-14-1024	1021	1024	6.04	n/a	
Tube	22	CH1-14-1024 T	1024	1027	10.17	0.6	n/a
		CH1-14-1027	1024	1027	7.16	n/a	
Tube	23	CH1-14-1027 T	1027	1030	11.32	0.3	15.0
		CH1-14-1030	1027	1030	6.68	n/a	
Tube	24	CH1-14-1030 T	1030	1033	10.61	0.2	n/a
		CH1-14-1033	1030	1033	8.17	n/a	
Tube	25	CH1-14-1033 T	1033	1036	9.27	0.7	n/a
		CH1-14-1036	1033	1036	7.26	n/a	
Tube	26	CH1-14-1036 T	1036	1041	6.95	0.3	n/a
		CH1-14-1041	1036	1041	12.38	n/a	
Tube	27	CH1-14-1041 T	1041	1044	12.6	2.0	<0.1
		CH1-14-1046	1041	1044	9.73	0.8	
Tube	28	CH1-14-1046 T	1044	1047	6.74	n/a	n/a
		CH1-14-1047	1044	1047	9.56	<0.1	
Tube	29	CH1-14-1047 T	1047	1050	10.05	n/a	n/a
		CH1-14-1050	1047	1050	5.47	n/a	
Tube	30	CH1-14-1050 T	1050	1053	10.2	n/a	n/a
		CH1-14-1053	1050	1053	4.9	n/a	
Tube	31	CH1-14-1053 T	1053	1056	9.67	n/a	n/a
		CH1-14-1056	1053	1056	6.51	n/a	
Tube	32	CH1-14-1056 T	1056	1057.5	4.46	n/a	n/a
		CH1-14-1057.5	1056	1057.5	3.61	n/a	
Tube	33	CH1-14-1057.5 T	1057.5	1060.5	9.14	<0.1	n/a
		CH1-14-1060.5	1057.5	1060.5	10.74	n/a	
Tube	34	CH1-14-1061 T	1060.5	1064	12.27	<0.1	n/a
		CH1-14-1064	1060.5	1064	9.68	n/a	
Tube	35	CH1-14-1064 T	1064	1067	9.77	n/a	n/a
		CH1-14-1067	1064	1067	14.17	<0.1	
Tube	36	CH1-14-1067 T	1067	1070	9.3	n/a	n/a
		CH1-14-1070	1067	1070	4.73	n/a	
Tube	37	CH1-14-1070 T	1070	1074	11.65	n/a	n/a
		CH1-14-1074	1070	1074	7.88	n/a	
Tube	38	CH1-14-1074 T	1074	1077	8.3	n/a	n/a

Table 5.2-1 (continued)

Container	Run No.	Sample Identification	Upper Depth (ft)	Lower Depth (ft)	Moisture Content (%)	Pore Water (mL)	Free Water (mL)
		CH1-14-1077	1074	1077	9.71	n/a	
Tube	39	CH1-14-1077 T	1077	1080	8.81	n/a	n/a
		CH1-14-1080	1077	1080	10.02	n/a	
Tube	40	CH1-14-1080 T	1080	1082	11.57	<0.1	n/a
		CH1-14-1082	1080	1082	11.03	n/a	
Tube	41	CH1-14-1082 T	1082	1085	11.72	n/a	n/a
		CH1-14-1085	1082	1085	8.47	<0.1	
Tube	42	CH1-14-1085 T	1085	1086	14.5	n/a	n/a
		CH1-14-1086	1085	1086	9.34	n/a	
Tube	43	CH1-14-1086 T	1086	1087	7.73	n/a	n/a
		CH1-14-1087	1086	1087	8.13	n/a	
Tube	44	CH1-14-1087 T	1087	1090	9.38	n/a	n/a
		CH1-14-1090	1087	1090	16.69	n/a	
Tube	45	CH1-15-1090 T	1090	1093.5	14.25	<0.1	n/a
Tube	45	CH1-15-1093.5	1090	1093.5	8.3	n/a	
Tube	46	CH1-15-1093.5 T	1093.5	1097	9.7	0.4	n/a
		CH1-15-1097	1093.5	1097	13.46	n/a	
Tube	47	CH1-15-1097 T	1097	1099	11.29	<0.1	n/a
		CH1-15-1099	1097	1099	5.96	<0.1	
Tube	48	CH1-15-1099 T	1099	1102.5	12.13	0.4	n/a
		CH1-15-1102.5	1099	1102.5	8.53	n/a	
Tube	49	CH1-15-1102.5 T	1102.5	1105.5	11.39	0.3	n/a
		CH1-15-1105.5	1102.5	1105.5	9.23	<0.1	
Tube	50	CH1-15-1105.5 T	1105.5	1108.5	12.99	0.5	n/a
		CH1-15-1108.5	1105.5	1108.5	11.59	n/a	
Tube	51	CH1-15-1108.5 T	1108.5	1111.5	10.53	n/a	n/a
		CH1-15-1111.5	1108.5	1111.5	10.73	1.4	
Tube	52	CH1-15-1111.5 T	1111.5	1114.5	13.98	0.4	n/a
		CH1-15-1114.5	1111.5	1114.5	10.55	n/a	
Tube	53	CH1-15-1114.5 T	1114.5	1117.5	23.84	4.5	n/a
		CH1-15-1117.5	1114.5	1117.5	13.73	2.9	
Tube	54	CH1-15-1117.5 T	1117.5	1120	23.83	5.0	40.0
		CH1-15-1120	1117.5	1120	14.17	n/a	
Tube	55	CH1-15-1120 T	1120	1122.5	16.98	3.2	0.5
		CH1-15-1122.5	1120	1122.5	10.48	n/a	
Tube	56	CH1-15-1122.5 T	1122.5	1125.5	15.37	3.9	12.0
		CH1-15-1125.5	1122.5	1125.5	19.02	2.0	

Table 5.2-1 (continued)

Container	Run No.	Sample Identification	Upper Depth (ft)	Lower Depth (ft)	Moisture Content (%)	Pore Water (mL)	Free Water (mL)
Tube	57	CH1-15-1125.5 T	1125.5	1128.5	22.42	2.0	3.5
		CH1-15-1128.5	1125.5	1128.5	13.63	5.1	
Tube	58	CH1-15-1128.5 T	1128.5	1131.5	15.83	3.8	2.0
		CH1-15-1131.5	1128.5	1131.5	12.82	0.8	
Tube	59	CH1-15-1131.5 T	1131.5	1134.5	19.48	2.5	n/a
		CH1-15-1134.5	1131.5	1134.5	13.71	1.0	
Tube	60	CH1-15-1134.5 T	1134.5	1136.5	24.63	8.5	3.5
		CH1-15-1134.5	1134.5	1136.5	13.48	0.5	

*n/a = Not applicable.

Table 5.2-2
Groundwater Samples
Collected at CrCH-1

Corehole No.	Collection Depth (ft bgs)
1	1120
1	1140

Table 5.3-1
Borehole Logging CrCH-1

Corehole No.	Date	Log Type	Depth Interval (ft)	Purpose
1	9/3/14	Video	0–862	Locate top of parted casing
	9/7/14	Video	0–902	Locate parted casing string
	11/14/14	Video	0–TD	Not recorded; run in piezometer casing to locate potential obstruction
	1/8/15	Gamma Ray	1138–0	Collect stratigraphic information

Table 5.4-1
Annular Fill Materials for CrCH-1

Material	Volume (ft^3)
Surface seal: 92% Portland cement, 8% bentonite	79.0
Upper seal: 0.375-in. bentonite chips and 20/40 sand	743.4
Piezometer screen transition sand collar: 20/40 silica sand	1.3
Piezometer screen primary filter pack sand: 10/20 silica sand	10.0

Table 6.2-1
Core Samples Taken at CrCH-2

Container	Run No.	Sample Identification	Upper Depth (ft)	Lower Depth (ft)	Moisture Content (%)	Pore Water (mL)	Free Water (mL)
Tube	1	CH2-15-703 T	703	707	n/a*	12.30	n/a
		CH2-15-707 M	703	707	n/a	6.50	
		CH2-15-707	703	707	14.29	2.50	
Tube	2	CH2-15-716 T	716	720	n/a	5.70	n/a
		CH2-15-720 M	716	720	n/a	3.20	
		CH2-15-720	716	720	9.11	0.30	
Bag	3	CH2-15-724 M	720	724	9.84	1.60	n/a
Bag	4	CH2-15-728 M	724	728	18.13	n/a	n/a
Bag	5	CH2-15-730 M	728	730	26.27	11.30	n/a
Bag	6	CH2-15-734 M	730	734	16.45	6.80	n/a
Bag	7	CH2-15-738 M	734	738	15.43	5.10	n/a
Bag	8	CH2-15-741 M	738	741	11.56	n/a	n/a
Bag	9	CH2-15-744 M	741	744	8.96	n/a	n/a
Bag	10	CH2-15-745 M	744	745	23.94	n/a	n/a
Bag	11	CH2-15-747.5 M	745	747.5	9.42	n/a	n/a
Bag	12	CH2-15-750 M	747.5	750	0.77	n/a	n/a
Bag	13	CH2-15-756 M	750	756	10.20	n/a	n/a
Bag	14	CH2-15-757.5 M	756	757.5	9.71	3.80	n/a
Bag	15	CH2-15-758.5 M	757.5	758.5	11.82	5.20	n/a
Bag	16	CH2-15-762.5 M	758.5	762.5	8.70	2.69	n/a
Bag	17	CH2-15-766.5 M	762.5	766.5	11.51	3.90	n/a
Bag	18	CH2-15-770 M	766.5	770	10.02	1.70	n/a
Bag	19	CH2-15-773 M	770	773	14.25	2.60	n/a
Bag	20	CH2-15-777 M	773	777	9.13	n/a	n/a
Bag	21	CH2-15-780 M	777	780	11.90	1.90	n/a
Bag	22	CH2-15-783.5 M	780	783.5	8.01	n/a	n/a
Bag	23	CH2-15-787 M	783.5	787	7.81	n/a	n/a
Bag	24	CH2-15-792 M	787	792	11.47	n/a	n/a
Tube	25	CH2-15-797	792	797	19.35	11.40	n/a
Bag	26	CH2-15-802 M	797	802	11.57	n/a	n/a
Tube	27	CH2-15-802 T	802	805	7.77	n/a	n/a
		CH2-15-805	802	805	7.51	n/a	
Bag	28	CH2-15-807.5 M	805	807.5	14.58	8.40	n/a
Bag	29	CH2-15-811 M	807.5	811	15.58	7.80	n/a
Bag	30	CH2-15-815.5 M	811	815	19.67	12.00	n/a
Bag	31	CH2-15-819 M	815	819	12.27	2.60	n/a

Table 6.2-1 (continued)

Container	Run No.	Sample Identification	Upper Depth (ft)	Lower Depth (ft)	Moisture Content (%)	Pore Water (mL)	Free Water (mL)
Bag	32	CH2-15-822 M	819	822	6.81	n/a	n/a
Bag	33	CH2-15-824 M	822	824	14.90	4.10	n/a
Bag	34	CH2-15-827 M	824	827	5.78	n/a	n/a
Tube	35	CH2-15-827 T	827	831	n/a	1.80	n/a
		CH2-15-831	827	831	11.42	n/a	
Tube	36	CH2-15-835	831	835	3.26	n/a	n/a
Tube	37	CH2-15-835 T	835	839	n/a	1.60	n/a
		CH2-15-839	835	839	6.85	n/a	
Bag	38	CH2-15-843 M	839	843	5.82	n/a	n/a
Tube	39	CH2-15-847	843	847	6.67	n/a	n/a
Tube	40	CH2-15-847 T	847	851	n/a	1.90	n/a
		CH2-15-851	847	851	15.07	n/a	
Tube	41	CH2-15-855	851	855	7.04	n/a	n/a
Tube	42	CH2-15-859	855	859	7.34	n/a	n/a
Tube	43	CH2-15-859 T	859	863	n/a	2.10	n/a
		CH2-15-863	859	863	18.93	4.70	
Tube	44	CH2-15-867	863	867	9.16	n/a	n/a
Tube	45	CH2-15-867 T	867	871	n/a	7.08	n/a
		CH2-15-871	867	871	6.97	n/a	
Bag	46	CH2-15-875 M	871	875	13.49	n/a	n/a
Tube	47	CH2-15-879	875	879	7.00	n/a	n/a
Tube	48	CH2-15-883	879	883	10.75	n/a	n/a
Bag	49	CH2-15-887 M	883	887	8.06	n/a	n/a
Bag	50	CH2-15-892 M	887	892	16.21	1.30	n/a
Tube	51	CH2-15-892 T	892	896	n/a	4.40	n/a
		CH2-15-896	892	896	8.39	n/a	
Tube	52	CH2-15-896 T	896	900	n/a	3.80	47.0
		CH2-15-900	896	900	23.69	6.20	
Bag	53	CH2-15-904 M	900	904	11.25	n/a	n/a
Tube	54	CH2-15-908	904	908	39.95	15.10	n/a
Bag	55	CH2-15-915 M	908	913	17.96	5.70	n/a
Tube	56	CH2-15-917	913	917	16.21	4.80	400
Bag	57	CH2-15-921 M	917	921	13.51	6.60	370
Tube	58	CH2-15-925	921	925	9.81	2.20	460
Bag	59	CH2-15-929 M	925	929	25.38	6.30	600
Bag	60	CH2-15-934 M	929	934	18.87	7.50	500
Bag	61	CH2-15-939 M	934	939	27.74	8.20	250

Table 6.2-1 (continued)

Container	Run No.	Sample Identification	Upper Depth (ft)	Lower Depth (ft)	Moisture Content (%)	Pore Water (mL)	Free Water (mL)
Bag	62	CH2-15-942 M	939	942	33.69	8.80	600
Bag	63	CH2-15-946 M	942	946	25.79	8.10	n/a
Bag	64	CH2-15-950 M	946	950	22.15	7.40	490
Bag	65	CH2-15-953 M	950	953	26.70	n/a	500
Tube	66	CH2-15-957	953	957	22.09	5.20	210
Tube	67	CH2-15-962	957	962	15.48	6.80	500
Tube	68	CH2-15-967	962	967	25.63	5.40	520
Bag	69	CH2-15-970 M	967	970	25.18	9.70	240
Bag	70	CH2-15-973 M	970	973	28.74	8.90	300
Bag	71	CH2-15-978 M	973	978	19.25	4.20	225
Bag	72	CH2-15-982 M	978	982	25.68	12.00	n/a
Bag	73	CH2-15-987 M	982	987	36.83	6.90	n/a

*n/a = Not applicable.

Table 6.2-2
Groundwater Samples
Collected at CrCH-2

Corehole No.	Collection Depth (ft bgs)
2	913
2	934
2	953
2	973
2	982

Table 6.3-1
Borehole Logging CrCH-2

Corehole No.	Date	Log Type	Depth Interval (ft)	Purpose
2	12/23/14	Video	0–930	Cased and open hole; collect information on casing depths, static water level (SWL), and general geology
CrPZ-2	12/23/14	Gamma Ray and Induction	934–0	Collect stratigraphic and hydrologic data

Table 6.4-1
Annular Fill Materials for CrCH-2

Material	Volume (ft^3)
Surface seal: 92% Portland cement, 8% bentonite	67.2
Upper seal: 0.375-in. bentonite chips and 20/40 sand	721.2
Upper screen transition sand collar: 20/40 silica sand	0.5
Upper screen primary filter pack sand: 10/20 silica sand	8.5
Separating seal: 0.375-in. bentonite seal	2.8
Slough	0.75
Lower screen transition sand collar: 20/40 silica sand	0.5
Lower screen primary filter pack sand: 10/20 silica sand	12.5
Lower seal: 0.375-in. bentonite chips	1.4

Table 7.2-1
Core Samples Collected at CrCH-3

Container	Run No.	Sample Identification	Upper Depth (ft)	Lower Depth (ft)	Moisture Content (%)	Pore Water (mL)	Free Water (mL)
Tube	1	CH3-15-703.5	700	703.5	16.91	n/a*	n/a
Tube	2	CH3-15-706.5	703.5	706.5	7.66	n/a	n/a
Tube	3	CH3-15-710	706.5	710	15.99	n/a	n/a
Tube	4	CH3-15-713.5	710	713.5	14.15	n/a	230
Tube	5	CH3-15-716.5	713.5	716.5	26.36	4.20	n/a
Tube	6	CH3-15-719.5	716.5	719.5	20.28	3.50	230
Tube	7	CH3-15-724.5	721	724.5	14.46	1.87	100
Tube	8	CH3-15-728	724.5	728	8.07	n/a	n/a
Tube	9	CH3-15-731	728	731	6.48	n/a	25
Tube	10	CH3-15-734	731	734	24.19	4.80	n/a
Tube	11	CH3-15-737	734	737	9.4	n/a	n/a
Tube	12	CH3-15-740	737	740	12.65	n/a	n/a
Tube	13	CH3-15-740 T	740	743.5	16.56	1.20	n/a
		CH3-15-743.5	740	743.5	9.78	n/a	
Tube	14	CH3-15-743.5 T	743.5	746.5	10.16	n/a	n/a
		CH3-15-746.5	743.5	746.5	12.26	n/a	
Tube	15	CH3-15-746.5 T	746.5	749.5	12.78	0.40	n/a
		CH3-15-749.5	746.5	749.5	13.43	n/a	
Tube	16	CH3-15-749.5 T	749.5	752.5	9.25	n/a	n/a
		CH3-15-752.5	749.5	752.5	10.71	n/a	
Tube	17	CH3-15-752.5 T	752.5	756	12.22	0.40	n/a
		CH3-15-756	752.5	756	7.99	n/a	

Table 7.2-1 (continued)

Container	Run No.	Sample Identification	Upper Depth (ft)	Lower Depth (ft)	Moisture Content (%)	Pore Water (mL)	Free Water (mL)
Tube	18	CH3-15-756 T	756	759.5	13.63	1.03	n/a
		CH3-15-759.5	756	759.5	11.57	0.05	
Tube	19	CH3-15-759.5 T	759.5	763	11.23	n/a	n/a
		CH3-15-763	759.5	763	6.3	n/a	
Tube	20	CH3-15-763 T	763	766	12.62	n/a	n/a
		CH3-15-766	763	766	5.78	n/a	
Tube	21	CH3-15-766 T	766	769	12.46	0.92	n/a
		CH3-15-769	766	769	9.65	n/a	
Tube	22	CH3-15-769 T	769	772.5	15.16	2.97	n/a
		CH3-15-772.5	769	772.5	10.14	n/a	
Tube	23	CH3-15-772.5 T	772.5	776	10.47	0.70	n/a
		CH3-15-776	772.5	776	14.24	1.20	
Tube	24	CH3-15-776 T	776	779	15.27	2.96	n/a
		CH3-15-779	776	779	11.27	n/a	
Tube	25	CH3-15-779 T	779	782.5	11.58	1.42	n/a
		CH3-15-782.5	779	782.5	8.65	n/a	
Tube	26	CH3-15-782.5 T	782.5	786	8.86	2.40	n/a
		CH3-15-786	782.5	786	8.98	n/a	
Tube	27	CH3-15-786 T	786	789.5	9.4	n/a	n/a
		CH3-15-789.5	786	789.5	8.25	n/a	
Tube	28	CH3-15-789.5 T	789.5	792.5	10.62	2.20	n/a
		CH3-15-792.5	789.5	792.5	8.28	n/a	
Tube	29	CH3-15-792.5 T	792.5	795.5	12.11	1.81	n/a
		CH3-15-795.5	792.5	795.5	8.25	n/a	
Tube	30	CH3-15-795.5 T	795.5	798.5	10.85	1.78	n/a
		CH3-15-798.5	795.5	798.5	10.45	n/a	
Tube	31	CH3-15-798.5 T	798.5	801.5	11.82	2.54	n/a
		CH3-15-801.5	798.5	801.5	14.47	n/a	
Tube	32	CH3-15-801.5 T	801.5	829.5	12.24	2.96	n/a
		CH3-15-805	801.5	805	7.44	n/a	
Tube	33	CH3-15-805 T	805	808	39.1	4.20	n/a
		CH3-15-808	805	808	9.01	n/a	
Tube	34	CH3-15-808 T	808	811	13.2	3.10	n/a
		CH3-15-811	808	811	11.18	0.56	
Tube	35	CH3-15-811 T	811	814	11.03	n/a	n/a
		CH3-15-814	811	814	5.24	n/a	

Table 7.2-1 (continued)

Container	Run No.	Sample Identification	Upper Depth (ft)	Lower Depth (ft)	Moisture Content (%)	Pore Water (mL)	Free Water (mL)
Tube	36	CH3-15-814 T	814	818	5.08	n/a	n/a
		CH3-15-818	814	818	6.34	n/a	
Tube	37	CH3-15-818 T	818	822	10.14	1.50	n/a
		CH3-15-822	818	822	8.12	n/a	
Tube	38	CH3-15-822 T	822	825	17.08	2.20	n/a
		CH3-15-825	822	825	8.32	n/a	
Tube	39	CH3-15-825 T	825	827	14.47	4.30	n/a
		CH3-15-827	825	827	15.76	n/a	
Tube	40	CH3-15-827 T	827	829.5	20.04	4.70	n/a
		CH3-15-829.5	827	829.5	11.39	n/a	
Tube	41	CH3-15-829.5 T	829.5	834	11.28	n/a	n/a
		CH3-15-834	829.5	834	7.05	n/a	
Tube	42	CH3-15-834 T	834	837.5	12.24	4.80	n/a
		CH3-15-837.5	834	837.5	9.11	n/a	
Tube	43	CH3-15-837.5 T	837.5	841.5	7.06	n/a	n/a
		CH3-15-841.5	837.5	841.5	9.09	n/a	
Tube	44	CH3-15-841.5 T	841.5	845	10.35	n/a	n/a
		CH3-15-845	841.5	845	10.46	n/a	
Tube	45	CH3-15-845 T	845	848	16.54	4.33	n/a
		CH3-15-848	845	848	5.59	n/a	
Tube	46	CH3-15-848 T	848	851	15.13	n/a	n/a
		CH3-15-851	848	851	8.14	n/a	
Tube	47	CH3-15-851 T	851	854	9.33	n/a	n/a
		CH3-15-854	851	854	12.8	n/a	
Tube	48	CH3-15-854 T	854	857	7.47	n/a	n/a
		CH3-15-857	854	857	8.83	n/a	
Tube	49	CH3-15-857 T	857	861	10.2	0.89	n/a
		CH3-15-861	857	861	9.1	n/a	
Tube	50	CH3-15-861 T	861	865	6.53	n/a	n/a
		CH3-15-865	861	865	6.06	n/a	
Tube	51	CH3-15-865 T	865	869	7.45	n/a	n/a
		CH3-15-869	865	869	14.34	2.89	
Tube	52	CH3-15-869 T	869	872	9.57	n/a	n/a
		CH3-15-872	869	872	6.35	n/a	
Tube	53	CH3-15-872 T	872	876	5.18	n/a	n/a
		CH3-15-876	872	876	5.22	n/a	

Table 7.2-1 (continued)

Container	Run No.	Sample Identification	Upper Depth (ft)	Lower Depth (ft)	Moisture Content (%)	Pore Water (mL)	Free Water (mL)
Tube	54	CH3-15-876 T	876	880	13.64	n/a	n/a
		CH3-15-880	876	880	14.97	4.60	
Tube	55	CH3-15-880 T	880	884	12.07	n/a	n/a
		CH3-15-884	880	884	9.05	n/a	
Tube	56	CH3-15-884 T	884	888	12.35	3.40	n/a
		CH3-15-888	884	888	7.17	n/a	
Tube	57	CH3-15-888 T	888	891	6.76	n/a	n/a
		CH3-15-891	888	891	11.15	n/a	
Tube	58	CH3-15-891 T	891	895	14.17	n/a	n/a
		CH3-15-895	891	895	7.82	n/a	
Tube	59	CH3-15-895 T	895	899	10.26	2.00	n/a
		CH3-15-899	895	899	12.77	n/a	
Tube	60	CH3-15-899 T	899	903	17.01	4.97	n/a
		CH3-15-903	899	903	9.91	n/a	
Tube	61	CH3-15-903 T	903	907	6.24	n/a	n/a
		CH3-15-907	903	907	12.73	n/a	
Tube	62	CH3-15-907 T	907	911	11.49	n/a	n/a
		CH3-15-911	907	911	7.41	2.29	
Tube	63	CH3-15-911 T	911	913	12.02	2.97	n/a
		CH3-15-913	911	913	11.81	n/a	
Tube	64	CH3-15-913 T	913	916	9.93	1.30	n/a
		CH3-15-916	913	916	9.23	2.80	
Tube	65	CH3-15-916 T	916	920	19.87	9.40	n/a
		CH3-15-920	916	920	16.32	n/a	
Tube	66	CH3-15-920 T	920	923	14.12	3.67	n/a
		CH3-15-923	920	923	10.6	n/a	
Tube	67	CH3-15-923 T	923	927	11	n/a	n/a
		CH3-15-927	923	927	13.02	n/a	
Tube	68	CH3-15-927 T	927	930	24.41	n/a	n/a
		CH3-15-930	927	930	24.39	3.10	
Tube	69	n/a	930	932	No Recovery – Dropped sample		
Tube	70	n/a	930	931	n/a		
Tube	71	CH3-15-931 T	931	933	19.56	6.10	n/a
		CH3-15-933	931	933	22.79	n/a	
Tube	72	CH3-15-933 T	933	936	22.85	9.48	n/a
		CH3-15-936	933	936	20.87	7.15	

Table 7.2-1 (continued)

Container	Run No.	Sample Identification	Upper Depth (ft)	Lower Depth (ft)	Moisture Content (%)	Pore Water (mL)	Free Water (mL)
Tube	73	CH3-15-936 T	936	940	27.14	12.20	n/a
		CH3-15-940	936	940	19.68	9.45	
Tube	74	CH3-15-940 T	940	944	29.01	9.60	n/a
		CH3-15-943	940	944	22.33	n/a	
Tube	75	CH3-15-944 T	944	947	28.39	10.10	n/a
		CH3-15-947	944	947	22.76	6.31	
Tube	76	CH3-15-947 T	947	951	26.31	5.22	280
		CH3-15-951	947	951	23.75	n/a	
Tube	77	CH3-15-951 T	951	955	35.64	18.50	410
		CH3-15-955	951	955	20.77	n/a	
Tube	78	CH3-15-955 T	955	959	18.25	5.57	450
		CH3-15-959	955	959	23.92	4.45	
Tube	79	CH3-15-959 T	959	963	26.82	10.60	n/a
		CH3-15-963	959	963	34.22	8.90	
Tube	80	CH3-15-963 T	963	967	25.65	14.00	400
		CH3-15-967	963	967	28.84	3.68	
Tube	81	CH3-15-967 T	967	971	32.53	6.77	n/a
		CH3-15-971	967	971	26.67	11.85	
Tube	82	CH3-15-971 T	971	975	28.8	n/a	500
		CH3-15-975	971	975	30.53	10.83	
Tube	83	CH3-15-975 T	975	980	28.61	n/a	n/a
		CH3-15-980	975	980	39.24	9.04	
Tube	84	CH3-15-980 T	980	983	28.28	n/a	600
		CH3-15-983	980	983	24.59	8.75	
Tube	85	CH3-15-983 T	983	987	30.82	n/a	500
		CH3-15-987	983	987	16.19	n/a	
Tube	86	CH3-15-987 T	987	991	26.41	n/a	n/a
		CH3-15-991	987	991	26.07	n/a	
Tube	87	CH3-15-991 T	991	995	19.62	n/a	600
		CH3-15-995	991	995	32.49	7.50	
Tube	88	CH3-15-995 T	995	999	24.16	n/a	240
		CH3-15-999	995	999	19.07	3.10	
Bag	89	CH3-15-999 T	999	1003	19.17	n/a	430
		CH3-15-1003	999	1003	12.28	n/a	
Tube	90	CH3-15-1003 T	1003	1007	19.83	n/a	120
		CH3-15-1007	1003	1007	14.11	2.79	

Table 7.2-1 (continued)

Container	Run No.	Sample Identification	Upper Depth (ft)	Lower Depth (ft)	Moisture Content (%)	Pore Water (mL)	Free Water (mL)
Tube	91	CH3-15-1007 T	1007	1008	18.26	n/a	n/a
		CH3-15-1008	1007	1008	21.19	10.52	
Tube	92	CH3-15-1008 T	1008	1012	21.61	n/a	510
		CH3-15-1012	1008	1012	18.46	10.30	
Bag	93	CH3-15-1012 T	1012	1015	24.07	n/a	150
		CH3-15-1015	1012	1015	14.64	9.70	
Bag	94	CH3-15-1015 T	1015	1019	9.88	n/a	550
		CH3-15-1019	1015	1019	14.47	4.60	
Bag	95	CH3-15-1019 T	1019	1023	9.53	n/a	380
		CH3-15-1023	1019	1023	9.87	2.30	

*n/a = Not applicable.

Table 7.2-2
Groundwater Samples
Collected at CrCH-3

Corehole No.	Collection Depth (ft bgs)
3	963
3	983
3	1003
3	1023

Table 7.3-1
Borehole Logging CrCH-3

Corehole No.	Date	Log Type	Depth Interval (ft)	Purpose
3	12/3/14	Video	0–935	Cased and open hole; collect information on casing depths, SWL, and general geology
	12/3/14	Gamma Ray and Induction	992–0	Collect stratigraphic and hydrologic data
	12/24/14	Video	0–975	Run in piezometer casing; verify screen placement and SWL
	12/24/14	Gamma Ray	975–875	Collect data on filter pack placement

Table 7.4-1
Annular Fill Materials for CrCH-3

Material	Volume (ft^3)
Surface seal: 92% Portland cement, 8% bentonite	80.0
Upper seal: 0.375-in. bentonite chips and 20/40 sand	438.9
Piezometer screen transition sand collar: 20/40 silica sand	0.3
Piezometer screen primary filter pack sand: 10/20 silica sand	5.3
Lower seal: 0.375-in. bentonite chips	4.9

Table 8.2-1
Core Samples Collected at CrCH-4

Container	Run No.	Sample Identification	Upper Depth (ft)	Lower Depth (ft)	Moisture Content (%)	Pore Water (mL)	Free Water (mL)
Bags (2)	1	CH4-15-736 M	728	736	21.83	4.00	n/a*
		CH4-15-736 T	728	736	n/a	1.60	n/a
Tube	2	CH4-15-741	736	741	10.71	n/a	n/a
Tube	3	CH4-15-746	741	746	6.12	n/a	n/a
Tube	4	CH4-15-751	746	752	5.44	n/a	n/a
Bag	5	CH4-15-756 M	752	756	4.31	n/a	n/a
Bag	6	CH4-15-761 M	756	761	11.64	3.10	n/a
Bag	7	CH4-15-767 M	761	767	4.86	n/a	n/a
Bag	8	CH4-15-770 M	767	770	9.78	1.60	n/a
Bag	9	CH4-15-775 M	770	775	28.34	14.00	n/a
Bag	10	CH4-15-780 M	775	780	9.56	4.80	n/a
n/a	11	n/a	780	786	No Recovery		
Bag	12	CH4-15-790 M	786	790	12.96	6.40	n/a
n/a	13	n/a	790	792	No Recovery		
n/a	14	n/a	790	807	No Recovery		
n/a	15	n/a	790	797	No Recovery		
Bag	16	CH4-15-807 M	790	807	4.10	n/a	n/a
Bag	17	CH4-15-810 M	807	810	13.53	1.52	n/a
Bag	18	CH4-15-821 M	820	821	14.03	6.80	n/a
Bag	19	CH4-15-824 M	821	824	21.00	15.90	n/a
n/a	20	n/a	n/a	n/a	n/a	n/a	n/a
Bag	21	CH4-15-827 M	824	827	8.02	n/a	n/a
Bag	22	CH4-15-832 M	827	832	23.68	5.47	n/a
Bag	23	CH4-15-837 M	832	837	7.92	n/a	n/a
Bag	24	CH4-15-839 M	837	839	9.09	n/a	n/a
		CH4-15-842 M	839	842	9.84	n/a	

Table 8.2-1 (continued)

Container	Run No.	Sample Identification	Upper Depth (ft)	Lower Depth (ft)	Moisture Content (%)	Pore Water (mL)	Free Water (mL)
Tube	25	CH4-15-846	842	846	7.10	n/a	n/a
Tube	26	CH4-15-850	846	850	6.17	0.30	n/a
Bag	27	CH4-15-853 M	850	853	5.26	n/a	n/a
Tube	28	CH4-15-857	853	857	10.22	n/a	n/a
Tube	29	CH4-15-862	857	862	14.36	1.02	n/a
Tube	30	CH4-15-865	862	865	9.01	0.40	n/a
Bag	31	CH4-15-868 M	865	868	10.63	n/a	n/a
Tube	32	CH4-15-873	868	873	6.75	n/a	n/a
Tube	33	CH4-15-877	873	877	8.42	n/a	n/a
Bag	34	CH4-15-881 M	877	881	7.89	n/a	n/a
Tube	35	CH4-15-886	881	886	0.64	n/a	n/a
Tube	36	CH4-15-890	886	890	12.75	n/a	n/a
Bag	37	CH4-15-892 M	890	892	12.58	n/a	n/a
n/a	38	n/a	892	898	No Recovery		
Tube	39	CH4-15-902	898	902	5.84	n/a	n/a
Tube	40	CH4-15-906	902	906	10.47	n/a	n/a
Tube	41	CH4-15-910	906	910	16.93	n/a	n/a
Bag	42	CH4-15-914 M	910	914	8.70	n/a	n/a
Tube	43	CH4-15-918	914	918	11.94	0.60	n/a
Tube	44	CH4-15-922	918	922	12.81	2.70	n/a
Tube	45	CH4-15-926	922	926	7.62	n/a	n/a
Bag	46	CH4-15-930 M	926	930	7.66	n/a	n/a
Bag	47	CH4-15-934 M	930	934	9.59	n/a	n/a
Tube	48	CH4-15-939	934	938	5.79	n/a	n/a
Tube	49	CH4-15-942	938	942	6.75	n/a	n/a
Bag	50	CH4-15-947.5 M	942.5	947.5	22.84	n/a	n/a
Tube	51	CH4-15-952	947.5	952	26.90	7.20	n/a
Tube	52	CH4-15-957	952	957	24.57	5.20	280
Bag	53	CH4-15-962 M	957	962	26.40	11.10	n/a
Bag	54	CH4-15-967 M	962	967	20.42	2.90	250
Bag	55	CH4-15-972 M	967	972	24.28	6.90	380
Bag	56	CH4-15-977 M	972	977	43.84	7.30	400
Bag	57	CH4-15-982 M	977	982	22.43	6.00	500
Bag	58	CH4-15-987 M	982	987	24.34	6.50	450
Bag	59	CH4-15-992 M	987	992	34.73	7.20	150
Bag	60	CH4-15-997 M	992	997	21.70	8.40	230
Bag	61	CH4-15-1002 M	997	1002	32.90	8.30	600

Table 8.2-1 (continued)

Container	Run No.	Sample Identification	Upper Depth (ft)	Lower Depth (ft)	Moisture Content (%)	Pore Water (mL)	Free Water (mL)
Bag	62	CH4-15-1007 M	1002	1007	20.67	10.30	n/a
Bag	63	CH4-15-1012 M	1007	1012	22.09	n/a	400
Bag	64	CH4-15-1017 M	1012	1017	24.02	n/a	500
Bag	65	CH4-15-1022 M	1017	1022	23.05	8.50	220
Bag	66	CH4-15-1027 M	1022	1027	19.21	4.70	n/a
n/a	67	n/a	1027	1032	No Recovery		
Bag	68	CH4-15-1032 M	1027	1032	23.00	10.00	n/a
Bag	69	CH4-15-1037 M	1032	1037	18.17	n/a	n/a
Bag	70	CH4-15-1042 M	1037	1042	37.19	8.20	450
Bag	71	CH4-15-1047 M	1042	1047	34.12	n/a	350

*n/a = Not applicable.

Table 8.2-2
Groundwater Samples
Collected at CrCH-4

Corehole No.	Collection Depth (ft bgs)
4	967
4	987
4	1007
4	1027.5
4	1047

Table 8.3-1
Borehole Logging CrCH-4

Corehole No.	Date	Log Type	Depth Interval (ft)	Purpose
4	1/29/15	Video	0–1002.58	Run in piezometer casing; verify screen placement and SWL
	1/29/15	Gamma Ray	1000–0	Collect stratigraphic information

Table 8.4-1
Annular Fill Materials for CrCH-4

Material	Volume (ft^3)
Surface seal: 92% Portland cement, 8% bentonite	81.0
Upper seal: 0.375-in. bentonite chips and 20/40 sand	450.8
Piezometer screen transition sand collar: 20/40 silica sand	0.5
Piezometer screen primary filter pack sand: 10/20 silica sand	7.0
Lower seal: 0.375-in. bentonite chips	7.6

Table 9.2-1
Core Samples Taken at CrCH-5

Container	Run No.	Sample Identification	Upper Depth (ft)	Lower Depth (ft)	Moisture Content (%)	Pore Water (mL)	Free Water (mL)
n/a*	1	n/a	n/a	n/a	No Recovery		
Bag	2	CH5-15-762 M	756	762	21.79	1.27	n/a
Bag	3	CH5-15-767 M	762	767	14.29	2.86	n/a
Bag	4	CH5-15-772 M	767	772	18.15	2.40	n/a
Bag	5	CH5-15-777 M	772	777	25.43	1.98	n/a
Bag	6	CH5-15-780 M	776	780	12.11	n/a	n/a
Bag	7	CH5-15-784 M	780	784	10.65	n/a	n/a
Bag	8	CH5-15-789 M	784	789	16.11	n/a	n/a
Bag	9	CH5-15-794 M	789	794	4.31	n/a	n/a
Bag	10	CH5-15-801 M	794	801	9.33	n/a	n/a
Bag	11	CH5-15-804 M	801	804	7.89	n/a	n/a
Bag	12	CH5-15-807 M	804	807	7.92	n/a	n/a
Bag	13	CH5-15-812 M	807	812	7.26	n/a	n/a
Bag	14	CH5-15-817 M	812	817	5.61	n/a	n/a
Bag	15	CH5-15-821 M	817	821	10.64	n/a	n/a
Bag	16	CH5-15-825 M	821	825	12.26	n/a	n/a
n/a	17	n/a	825	830	No Recovery		
Bag	18	CH5-15-835 M	830	835	10.54	n/a	n/a
Bag	19	CH5-15-840 M	835	840	15.44	2.83	n/a
Bag	20	CH5-15-845 M	840	845	14.31	n/a	n/a
Bag	21	CH5-15-850 M	845	850	5.39	n/a	n/a
Bag	22	CH5-15-855 M	850	855	14.48	0.44	n/a
Bag	23	CH5-15-860 M	855	860	12.67	n/a	n/a
Bag	24	CH5-15-865 M	860	865	12.65	n/a	n/a
Bag	25	CH5-15-870 M	865	870	18.94	0.87	n/a
Bag	26	CH5-15-875 M	870	875	12.01	n/a	n/a

Table 9.2-1 (continued)

Container	Run No.	Sample Identification	Upper Depth (ft)	Lower Depth (ft)	Moisture Content (%)	Pore Water (mL)	Free Water (mL)
Bag	27	CH5-15-880 M	875	880	6.91	n/a	n/a
Bag	28	CH5-15-885 M	880	885	7.62	n/a	n/a
Bag	29	CH5-15-890 M	885	890	7.26	n/a	n/a
Bag	30	CH5-15-895 M	890	895	5.67	n/a	n/a
Bag	31	CH5-15-899 M	895	899	13.25	n/a	n/a
Bag	32	CH5-15-903 M	899	903	11.61	n/a	n/a
Bag	33	CH5-15-906.5 M	903	906.5	10.55	n/a	n/a
Bag	34	CH5-15-910 M	906.5	910	11.19	n/a	n/a
Bag	35	CH5-15-915 M	910	915	9.45	n/a	n/a
Bag	36	CH5-15-920 M	915	920	9.96	n/a	n/a
Bag	37	CH5-15-925 M	920	925	5.63	n/a	n/a
Bag	38	CH5-15-930 M	925	930	7.82	n/a	n/a
Bag	39	CH5-15-935 M	930	935	11.09	n/a	n/a
Bag	40	CH5-15-940 M	935	940	7.44	n/a	n/a
Bag	41	CH5-15-945 M	940	945	7.3	n/a	n/a
Bag	42	CH5-15-950 M	945	950	8.8	n/a	n/a
Bag	43	CH5-15-955 M	950	955	9.53	n/a	n/a
Bag	44	CH5-15-960 M	955	960	8.97	n/a	n/a
Bag	45	CH5-15-965 M	960	965	13.61	1.64	n/a
Bag	46	CH5-15-970 M	965	970	12.3	4.60	n/a
Bag	47	CH5-15-975 M	970	975	12	3.16	n/a
Bag	48	CH5-15-980 M	975	980	23.36	10.86	n/a
Bag	49	CH5-15-985 M	980	985	28.01	2.74	n/a
Bag	50	CH5-15-990 M	985	990	18.34	7.14	190
Bag	51	CH5-15-994 M	990	994	24.51	7.71	n/a
Bag	52	CH5-15-998 M	994	998	11.53	5.33	n/a
Bag	53	CH5-15-1002 M	998	1002	35.08	6.95	n/a
		CH5-15-1005 M	1002	1005	26.66	7.79	
Bag	54	CH5-15-1010 M	1005	1010	28.92	2.84	250
Bag	55	CH5-15-1016 M	1010	1016	11.32	3.50	n/a

*n/a = Not applicable.

Table 9.2-2
Groundwater Samples
Collected at CrCH-5

Corehole No.	Collection Depth (ft bgs)
5	971
5	991
5	1011

Table 9.3-1
Borehole Logging CrCH-5

Corehole No.	Date	Log Type	Depth Interval (ft)	Purpose
5	1/29/15	Video	0–796.42	Locate top of fish
	2/9/15	Video	0–798	Run #1 uncentralized; assess casing joints
	2/9/15	Video	0–970.5	Run #2 centralized; cased and open hole; collect information on casing depths, SWL, and general geology
	2/9/15	Gamma Ray and Induction	988.6–0	Collect stratigraphic and hydrologic data

Table 9.4-1
Annular Fill Materials for CrCH-5

Material	Volume (ft^3)
Surface seal: 92% Portland cement, 8% bentonite	81.6
Upper seal: 0.375-in. bentonite chips and 20/40 sand	403.5
Piezometer screen transition sand collar: 20/40 silica sand	1
Piezometer screen primary filter pack sand: 10/20 silica sand	2.0
Lower seal: 0.375-in. bentonite chips	1.4

Table 12.0-1
Survey Coordinates for Piezometers 1 to 5

Point No.	Northing	Easting	Elevation	Description
758	1767944.04	1637133.15	6949.70	CrCH-1 brass cap
			6953.30	Top of protective casing
761	1767940.70	1637136.03	6952.72	Top of piezometer casing
765	1768408.05	1638619.59	6737.71	CrCH-2 brass cap
			6741.25	Top of protective casing
762	1768404.39	1638621.69	6740.94	Top of CrPZ-2a piezometer casing
763	1768404.87	1638621.76	6740.85	Top of CrPZ-2b piezometer casing
766	1768747.27	1637438.36	6765.17	CrCH-3 brass cap
			6768.72	Top of protective casing
768	1768744.16	1637441.17	6767.92	Top of piezometer casing
769	1768723.50	1636478.23	6784.71	CrCH-4 brass cap
			6788.21	Top of protective casing
771	1768720.69	1636481.24	6787.51	Top of piezometer casing
772	1768435.06	1636003.32	6802.58	CrCH-5 brass cap
			6806.02	Top of protective casing
774	1768432.11	1636006.33	6805.45	Top of piezometer casing

Table 13.0-1
Summary of Waste Characterization Samples Collected during Drilling, Construction, and Development of Piezometers 1 to 5

Event ID	Sample ID	Date Collected	Description	Sample Matrix
CrCH-1				
6864	WSTMO-14-86608	08/22/2014	Drilling fluids (top)	Fluid
6864	WSTMO-14-86610	08/22/2014	Drilling fluids (top) field duplicate	Fluid
6864	WSTMO-14-86615	08/22/2014	Drilling fluids (top) trip blank	Fluid
6864	WSTMO-14-86608	09/17/2014	Drilling fluids (composite middle and bottom)	Fluid
6864	WSTMO-14-86611	09/17/2014	Drilling fluids field duplicate	Fluid
6864	WSTMO-14-86614	09/17/2014	Drilling fluids trip blank	Fluid
6863	WSTMO-14-86604	10/29/2014	Drilling fluids (composite)	Fluid
6863	WSTMO-14-86605	10/29/2014	Drilling fluids (composite)	Fluid
6863	WSTMO-14-86606	10/29/2014	Drilling fluids field duplicate	Fluid
6861	WSTMO-14-86597	08/22/2014	Drill cuttings (top)	Soil
6861	WSTMO-14-86602	08/22/2014	Drill cuttings field duplicate	Soil
6861	WSTMO-14-86599	08/25/2014	Drill cuttings(middle)	Soil
6861	WSTMO-14-86600	08/25/2014	Drill cuttings field duplicate	Soil
6861	WSTMO-14-86598	09/17/2014	Drill cuttings(bottom)	Soil
6861	WSTMO-14-86601	09/17/2014	Drill cuttings field duplicate	Soil
6862	WSMTO-14-86603	10/08/2014	Drill cuttings (composite)	Soil
CrCH-2				
6902	WSTMO-14-87089	09/15/2014	Drilling fluids (top)	Fluid
6902	WSTMO-14-87094	09/15/2014	Drilling fluids field duplicate	Fluid
6902	WSTMO-14-87095	09/15/2014	Drilling fluids trip blank	Fluid
9115	WSTMO-15-93332	03/09/2015	Drilling fluids (composite middle and bottom)	Fluid
9115	WSTMO-15-93333	03/09/2015	Drilling fluids field duplicate	Fluid
9115	WSTMO-15-93334	03/09/2015	Drilling fluids trip blank	Fluid
6899	WSTMO-14-87081	10/29/2014	Drilling fluids (composite)	Fluid
6899	WSTMO-14-87080	10/29/2014	Drilling fluids (composite)	Fluid
6899	WSTMO-14-87082	10/29/2014	Drilling fluids field duplicate	Fluid
6901	WSTMO-14-87085	09/15/2014	Drill cuttings (top)	Soil
6901	WSTMO-14-87088	09/15/2014	Drill cuttings trip blank	Soil
6901	WSTMO-14-87084	09/18/2014	Drill cuttings (middle and bottom)	Soil
6901	WSTMO-14-87084	09/18/2014	Drill cuttings trip blank	Soil
6898	WSTMO-14-87077	10/08/2014	Drill cuttings (composite)	Soil

Table 13.0-1 (continued)

Event ID	Sample ID	Date Collected	Description	Sample Matrix
CrCH-3				
9116	WSTMO-15-93335	03/09/2015	Drilling fluids (composite top, middle, and bottom)	Fluid
9116	WSTMO-15-93336	03/09/2015	Drilling fluids field duplicate	Fluid
9116	WSTMO-15-93337	03/09/2015	Drilling fluids trip blank	Fluid
6936	WSTMO-14-87592	10/29/2014	Drilling fluids (composite)	Fluid
6936	WSTMO-14-87593	10/29/2014	Drilling fluids (composite)	Fluid
6936	WSTMO-14-87594	10/29/2014	Drilling fluids field duplicate	Fluid
6939	WSTMO-14-87605	10/02/2014	Drill cuttings (top)	Soil
6939	WSTMO-14-67508	10/02/2014	Drill cuttings trip blank	Soil
6939	WSTMO-14-87606	10/06/2014	Drill cuttings (middle)	Soil
6939	WSTMO-14-87609	10/06/2014	Drill cuttings trip blank	Soil
6939	WSTMO-14-87607	11/03/2014	Drill cuttings (bottom)	Soil
6939	WSTMO-14-87610	11/03/2014	Drill cuttings trip blank	Soil
6937	WSTMO-14-87595	10/08/2014	Drill cuttings (composite)	Soil
CrCH-4				
6962	WSTMO-15-89299	11/14/2014	Drilling fluids (top)	Fluid
6962	WSTMO-15-89302	11/14/2014	Drilling fluids field duplicate	Fluid
6962	WSTMO-15-89304	11/14/2014	Drilling fluids trip blank	Fluid
6962	WSTMO-15-89300	11/17/2014	Drilling fluids (middle)	Fluid
6962	WSTMO-15-89301	11/17/2014	Drilling fluids field duplicate	Fluid
6962	WSTMO-15-89305	11/17/2014	Drilling fluids trip blank	Fluid
6962	WSTMO-15-89306	11/19/2014	Drilling fluids (bottom)	Fluid
6962	WSTMO-15-89298	11/19/2014	Drilling fluids field duplicate	Fluid
6962	WSTMO-15-89303	11/19/2014	Drilling fluids trip blank	Fluid
6958	WSTMO-15-89289	03/09/2015	Drilling fluids (composite)	Fluid
6958	WSTMO-15-89288	03/09/2015	Drilling fluids (composite)	Fluid
6958	WSTMO-15-89290	03/09/2015	Drilling fluids field duplicate	Fluid
6960	WSTMO-15-89292	11/14/2014	Drill cuttings (top)	Soil
6960	WSTMO-15-89297	11/14/2014	Drill cuttings trip blank	Soil
6960	WSTMO-15-89294	11/17/2014	Drill cuttings (middle)	Soil
6960	WSTMO-15-89295	11/17/2014	Drill cuttings trip blank	Soil
6960	WSTMO-15-89293	11/19/2014	Drill cuttings (bottom)	Soil
6960	WSTMO-15-89296	11/19/2014	Drill cuttings trip blank	Soil
6959	WSTMO-15-89291	01/29/2015	Drill cuttings (composite)	Soil

Table 13.0-1 (continued)

Event ID	Sample ID	Date Collected	Description	Sample Matrix
CrCH-5				
7032	WSTMO-15-91250	12/03/2014	Drilling fluids (top)	Fluid
7032	WSTMO-15-91265	12/03/2014	Drilling fluids field duplicate	Fluid
7032	WSTMO-15-91251	12/03/2014	Drilling fluids trip blank	Fluid
7032	WSTMO-15-91252	12/12/2014	Drilling fluids (middle)	Fluid
7032	WSTMO-15-91266	12/12/2014	Drilling fluids field duplicate	Fluid
7032	WSTMO-15-91253	12/12/2014	Drilling fluids trip blank	Fluid
7032	WSTMO-15-91254	12/15/2014	Drilling fluids (bottom)	Fluid
7032	WSTMO-15-91267	12/15/2014	Drilling fluids field duplicate	Fluid
7032	WSTMO-15-91255	12/15/2014	Drilling fluids trip blank	Fluid
7033	WSTMO-15-91259	03/09/2015	Drilling fluids (composite)	Fluid
7033	WSTMO-15-91258	03/09/2015	Drilling fluids (composite)	Fluid
7033	WSTMO-15-91260	03/09/2015	Drilling field duplicate	Fluid
7032	WSTMO-15-91244	12/03/2015	Drill cuttings (top)	Soil
7032	WSTMO-15-91245	12/03/2014	Drill cuttings field duplicate	Soil
7032	WSTMO-15-91246	12/12/2014	Drill cuttings (middle)	Soil
7032	WSTMO-15-91247	12/12/2014	Drill cuttings field duplicate	Soil
7032	WSTMO-15-91248	12/15/2014	Drill cuttings (bottom)	Soil
7032	WSTMO-15-91249	12/15/2014	Drill cuttings field duplicate	Soil
7034	WSTMO-15-91261	02/03/2015	Drill cuttings composite	Soil
Other CrCH Project Waste Samples				
9182	WSTMO-15-95586	04/06/2015	Decontamination water (composite)	Fluid
9182	WSTMO-15-95587	04/06/2015	Decontamination water (composite)	Fluid
9182	WSTMO-15-95588	04/06/2015	Decontamination water trip blank	Fluid
6996	WST05-15-90481	11/05/2014	Compressor water (composite)	Fluid
6996	WST05-15-90482	11/05/2014	Compressor water trip blank	Fluid

Appendix A

Borehole Video Logging
(on DVDs included with this document)

Appendix B

Geophysical Logging
(on CD included with this document)

Appendix C

Final Well Designs and New Mexico Environment Department Approvals for Piezometers 1 to 5

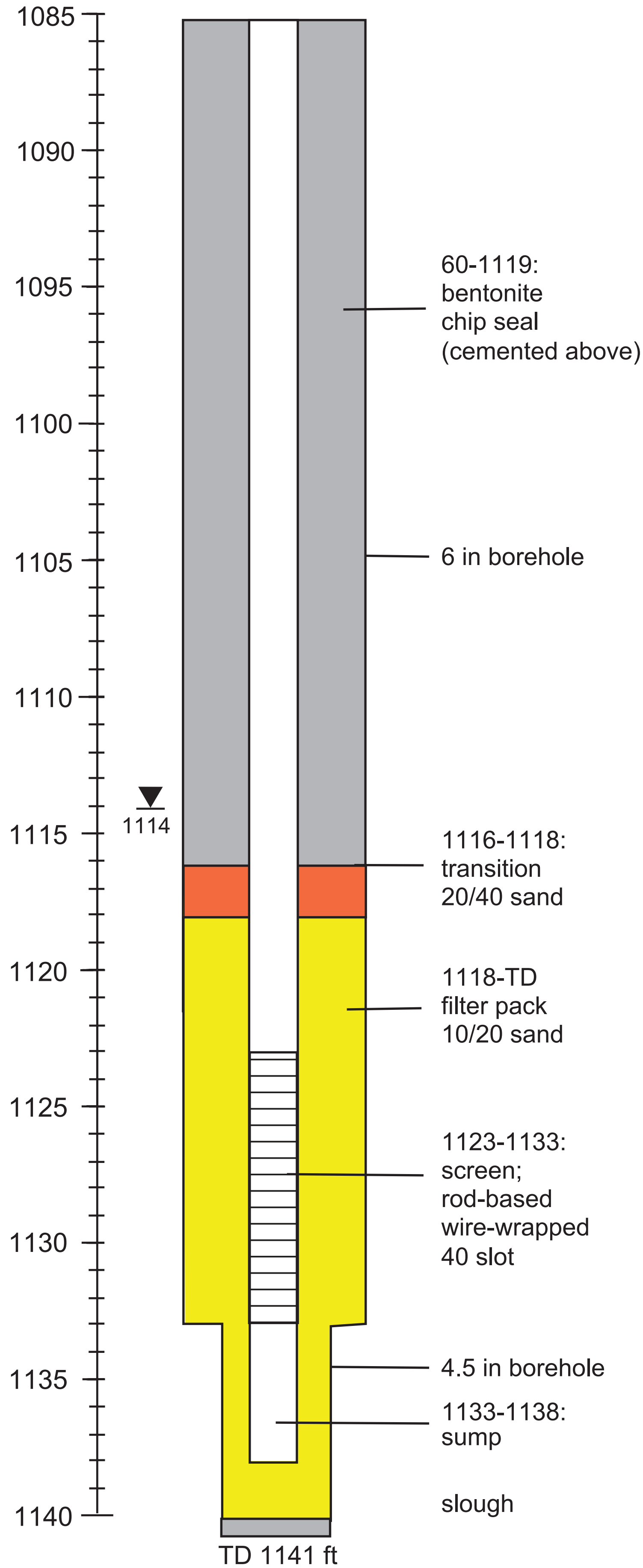
Chromium Corehole #1 (CrCH-1) Proposed Well Design – 2" Diameter Stainless Steel Well

Introduction

Due to limitations with the sonic drill rig, the current downhole casing cannot be advanced deeper than 1133 ft bgs. The proposed well design is therefore constrained by the present borehole configuration. The drilling subcontractor advanced 6-in casing to 1133 ft bgs with the 4.5-in coring depth to 1141 ft bgs. Static water level (SWL) has been established at 1114 ft bgs by multiple measurements at this depth and by bailing down this water level and monitoring recharge.

Construction

The proposed construction details are shown on the attached figure. A minimum hole diameter of 6 inches is needed to successfully construct this well with a 2-inch annulus around the well screen. With a SWL of 1114 ft bgs and bottom of 6-in borehole at 1133 ft, a 10-ft screen length with 9 ft of submergence is proposed. Nine feet of screen submergence should allow for adequate drawdown during of pumping at nearby well CrEX-1. Because of space constraints within the borehole, the annulus around the sump will be filled with sand in the 4.5-in-diameter portion of the well.


1085
1090
1095
1100
1105
1110
1115
1120
1125
1130
1135
1140
1114
60-1119:
bentonite
chip seal
(cemented above)
6 in borehole
1116-1118:
transition
20/40 sand
1118-TD
filter pack
10/20 sand
1123-1133:
screen;
rod-based
wire-wrapped
40 slot
4.5 in borehole
1133-1138:
sump
slough
TD 1141 ft

From: Dale, Michael, NMENV <Michael.Dale@state.nm.us>
Sent: Wednesday, October 15, 2014 7:33 PM
To: Broxton, David E
Cc: Katzman, Danny; Swickley, Stephani Fuller; Douglass, Craig R; Wear, Benjamin, NMENV; Cobrain, Dave, NMENV; Kulis, Jerzy, NMENV; Shen, Hai; Longmire, Patrick; Yanicak, Stephen M; Mayer.Richard@epamail.epa.gov; Everett, Mark Capen
Subject: RE: CrCH-1 Proposed Well Design

Dave,

NMED hereby approves the installation of the well (CrCH-1) as proposed in your E-mail below. 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 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 becomes available. Please call if you have any questions concerning this approval.

Thank you,

Michael 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) 661-2673

From: Broxton, David E [broxton@lanl.gov]
Sent: Wednesday, October 15, 2014 2:25 PM
To: Dale, Michael, NMENV
Cc: Katzman, Danny; Swickley, Stephani Fuller; Douglass, Craig R
Subject: CrCH-1 Proposed Well Design

Michael,

Attached for your review and approval is the proposed CrCH-1 well design and justification. Please copy all of the addressees on this email with your response.

Thank you.

Chromium Corehole #2 (CrCH-2) Proposed Piezometer Design

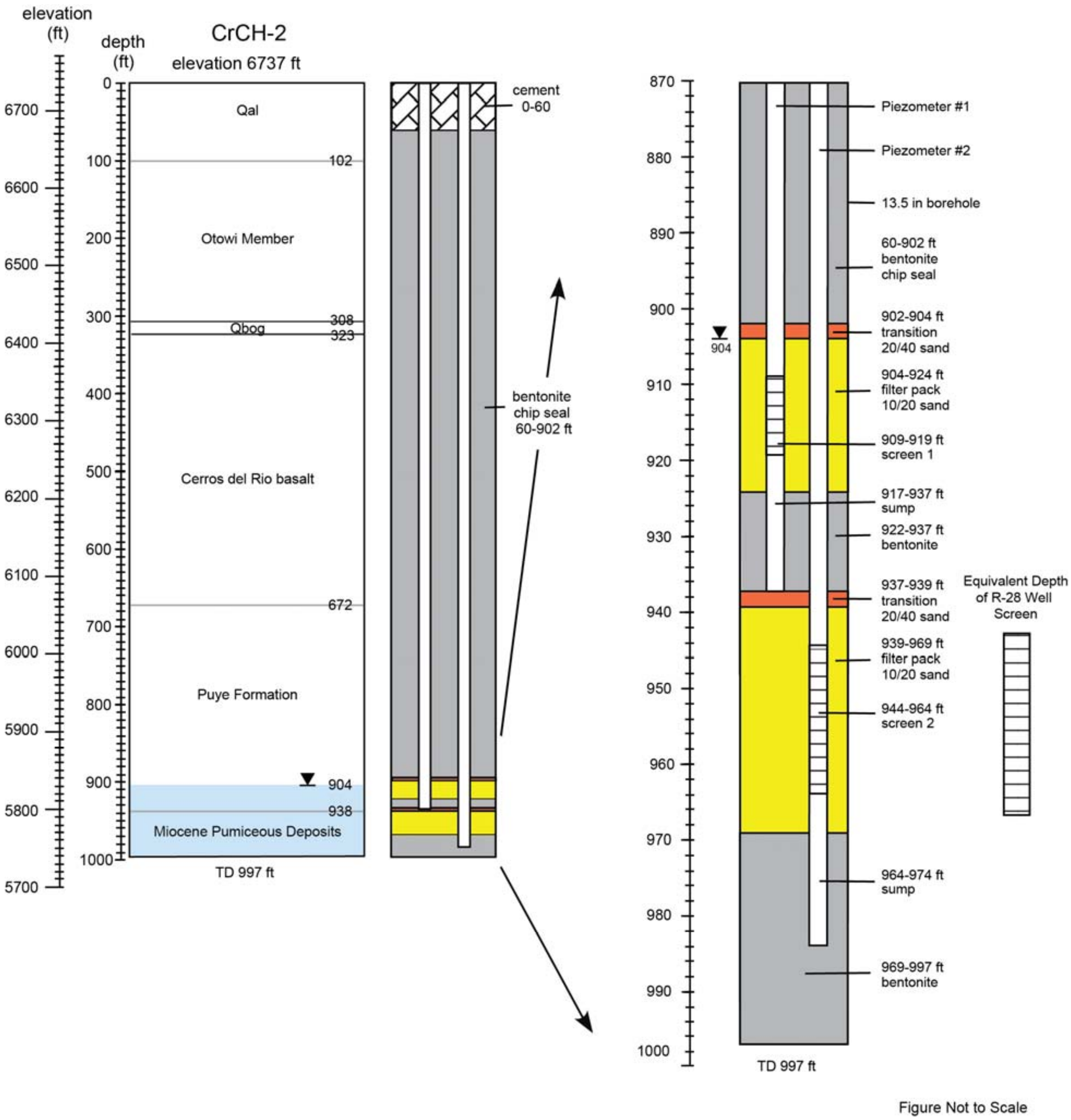
Introduction

The sonic drill rig has advanced to a depth of approximately 83 feet (987 ft, bgs) beneath the water table in the regional aquifer. Coring was terminated when the drillers became concerned about getting the tools stuck within an interval of the Miocene pumiceous deposits containing hard dacitic clasts. Sonic core was collected continuously over the interval 702-987 ft bgs. Static water level (SWL) was measured at 904 ft bgs by multiple measurements with the corehole advanced to 987 ft. As previously discussed with NMED, the LANL/DOE team proposes constructing a two-piezometer installation at this location.

Construction

The proposed construction details for a two-piezometer design are shown on the attached figure. The sonic corehole will be reamed out with 8-in casing-advance methods deep enough and large enough diameter to accommodate the two-piezometer design. Based on the measured SWL of 904 ft bgs, a 10-ft screen length with 5 ft of submergence and a 20-ft screen at a depth equivalent to the screen at R-28 are proposed. The 5-ft submergence for the upper screen is closer to the top of the aquifer than typical installations; however in this case, a longer bentonite seal between the two piezometers is preferred over a longer screen at the water table. The 10-year average water level decline at R-28 is 0.6 ft per year, therefore the upper screen will provide useful head data for approximately 25 years. Modeling also suggests that drawdown from a likely nearby extraction well would also not draw water beneath the screen 1 position. Installing two piezometers at this location will meet both NMED's requirement to collect groundwater screening data from the top of the aquifer and LANL/DOE's interest in both documenting the vertical chromium concentration profile and conducting cross-hole investigations with R-28 in support of remedy selection.

Note the recommendation for a smaller thickness of transition sand than was directed by NMED in the September 2014 Approval with Modification. The proposed transition sand thickness of 2 ft is sufficiently protective and minimizes the sand pack above the aquifer. The thoroughness of well development is greatly improved when the entire sand pack is submerged within the aquifer.



elevation (ft)
depth (ft)
CrCH-2
elevation 6737 ft
6700
6600
6500
6400
6300
6200
6100
6000
5900
5800
5700
0
100
200
300
400
500
600
700
800
900
1000
Qal
102
Otowi Member
308
Qbog
323
Cerros del Rio basalt
672
Puye Formation
904
938
Miocene Pumiceous Deposits
TD 997 ft
cement 0-60
bentonite chip seal 60-902 ft
870
880
890
900
910
920
930
940
950
960
970
980
990
1000
904
Piezometer #1
Piezometer #2
13.5 in borehole
60-902 ft bentonite chip seal
902-904 ft transition 20/40 sand
904-924 ft filter pack 10/20 sand
909-919 ft screen 1
917-937 ft sump
922-937 ft bentonite
937-939 ft transition 20/40 sand
939-969 ft filter pack 10/20 sand
944-964 ft screen 2
964-974 ft sump
969-997 ft bentonite
Equivalent Depth of R-28 Well Screen
TD 997 ft
Figure Not to Scale

From: Dale, Michael, NMENV <Michael.Dale@state.nm.us>
Sent: Thursday, January 08, 2015 2:22 PM
To: Everett, Mark Capen
Cc: Cobrain, Dave, NMENV; Wear, Benjamin, NMENV; Kulis, Jerzy, NMENV; Shen, Hai; Katzman, Danny; Yanicak, Stephen M
Subject: RE: Chromium project CrCH-2 proposed completion design

Mark,

NMED hereby approves the installation of the well/piezometer CrCH-2 as proposed in your e-mail with attachment as noted below. 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. Please call if you have any questions concerning this approval.

Michael 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) 661-2673

From: Everett, Mark Capen [meverett@lanl.gov]
Sent: Thursday, January 08, 2015 1:26 PM
To: Dale, Michael, NMENV; Kulis, Jerzy, NMENV; Wear, Benjamin, NMENV; Cobrain, Dave, NMENV
Cc: Swickley, Stephani Fuller; Katzman, Danny; Williams, Deborah L; Grieggs, Tony; Dorries, Alison Marie; Ball, Ted; Rodriguez, Cheryl L; Shen, Hai
Subject: Chromium project CrCH-2 proposed completion design

Michael,

As discussed, here is our proposed design for a two-piezometer completion at corehole CrCH-2. Please respond to this e-mail with your concurrence or give a call to discuss further.

Thanks,

Mark Everett, PG
CAP-ES LANL
(505) 667-5931 (o)
(505) 231-6002 (c)

Chromium Corehole #3 (CrCH-3) Proposed Piezometer Design

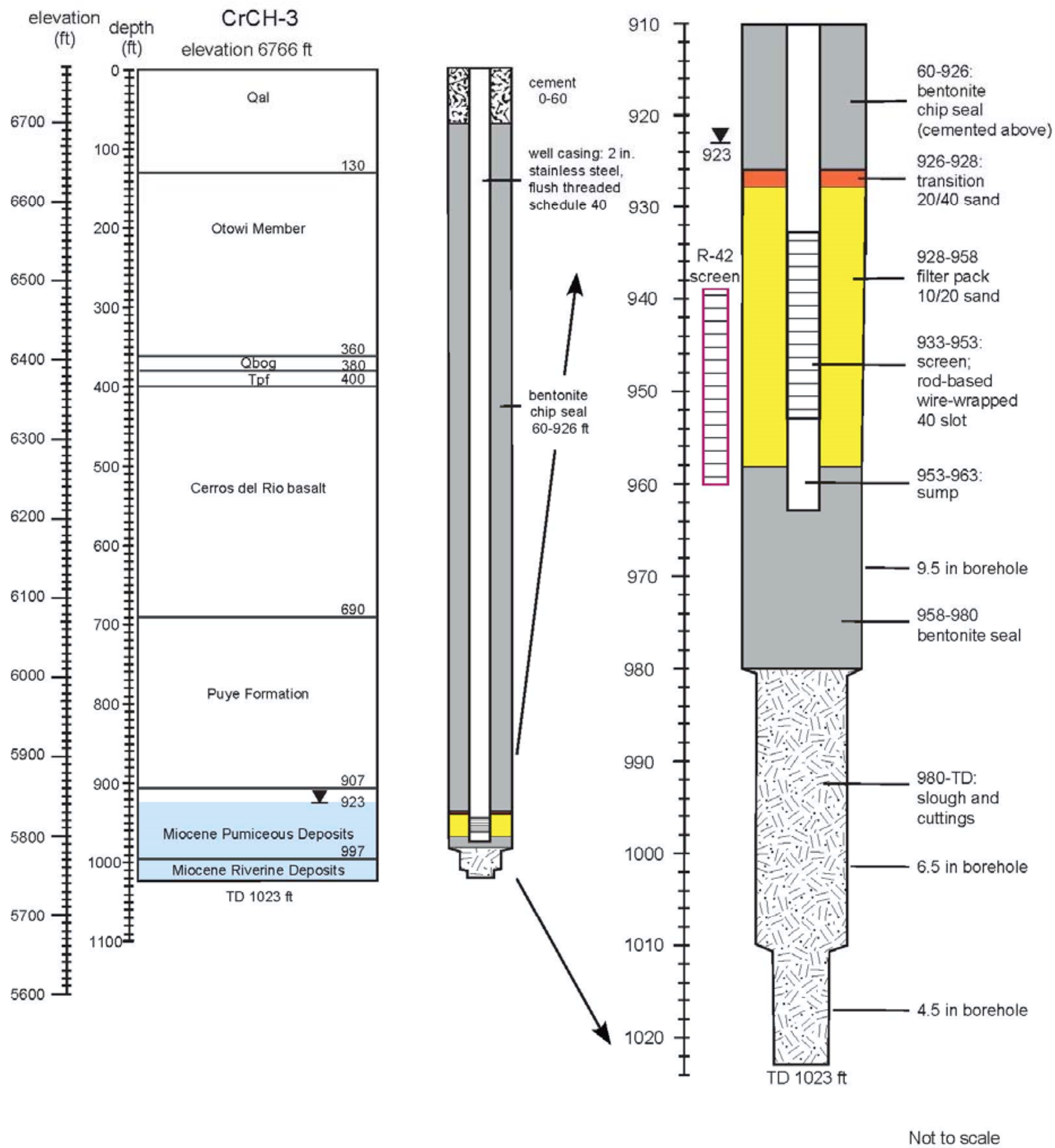
Introduction

The sonic drill rig has advanced to the target depth of approximately 100 feet (1,023 ft, bgs) beneath the water table in the regional aquifer. Sonic core was collected continuously over the interval 700-1023 ft bgs. Static water level (SWL) was measured at 923 ft bgs by multiple measurements with the corehole advanced to 932 ft.

Construction

The proposed construction details are shown on the attached figure. With a SWL of 923 ft bgs, a 20-ft screen length with 10 ft of submergence is proposed. Ten feet of screen submergence should allow for representative monitoring at the top of the regional aquifer, allow for potential drawdown associated with future extraction well pumping, and sufficiently overlap with the screen in R-42 for crosshole testing.

Note the recommendation for a smaller thickness of transition sand than was directed by NMED in the September 2014 Approval with Modification. The proposed transition sand thickness of 2 ft is sufficiently protective and increases the likelihood that filter pack will remain below the water table.



CrCH-3
elevation 6766 ft
elevation (ft)
depth (ft)
Qal
130
Otowi Member
360
Qbog
380
Tpf
400
Cerros del Rio basalt
690
Puye Formation
907
923
Miocene Pumiceous Deposits
997
Miocene Riverine Deposits
TD 1023 ft
cement 0-60
well casing: 2 in. stainless steel, flush threaded schedule 40
bentonite chip seal 60-926 ft
923
R-42 screen
60-926: bentonite chip seal (cemented above)
926-928: transition 20/40 sand
928-958 filter pack 10/20 sand
933-953: screen; rod-based wire-wrapped 40 slot
953-963: sump
9.5 in borehole
958-980 bentonite seal
980-TD: slough and cuttings
6.5 in borehole
4.5 in borehole
TD 1023 ft
Not to scale

From: Dale, Michael, NMENV <Michael.Dale@state.nm.us>
Sent: Wednesday, December 03, 2014 10:59 AM
To: Everett, Mark Capen
Cc: Wear, Benjamin, NMENV; Cobrain, Dave, NMENV; Kulis, Jerzy, NMENV; Shen, Hai; Longmire, Patrick; Katzman, Danny; Yanicak, Stephen M; Granzow, Kim P
Subject: FW: Chromium corehole CrCH-3 completion proposal

Mark,

NMED hereby approves the installation of the well/piezometer CrCH-3 as proposed in your e-mail with attachment as noted below. 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. Please call if you have any questions concerning this approval.

Thank you,

Michael
New Mexico Environment Department
1183 Diamond Drive, Suite B
Los Alamos, NM 87544
LANL MS M894
Cell Phone: (505) 231-5423
Office Phone (505) 661-2673

From: Dale, Michael Ray [mdale@lanl.gov]
Sent: Wednesday, December 03, 2014 10:43 AM
To: Dale, Michael, NMENV
Subject: FW: Chromium corehole CrCH-3 completion proposal

From: Everett, Mark Capen
Sent: Wednesday, December 03, 2014 7:03 AM
To: Dale, Michael Ray
Cc: Shen, Hai; Rodriguez, Cheryl L; Roberts, Kathryn Margaret; Swickley, Stephani Fuller; Rich, Kent; Ball, Ted; Katzman, Danny; Jerzy Kulis (jerzy.kulis@state.nm.us); Dave Cobrain (dave.cobrain@state.nm.us)
Subject: Chromium corehole CrCH-3 completion proposal

Michael,

As we briefly discussed yesterday, here is our proposed design for completion of CrCH-3. Please respond with your concurrence or give a call so we can discuss it further.

Thanks,

Mark Everett, PG
CAP-ES LANL
(505) 667-5931 (o)
(505) 231-6002 (c)

Chromium Corehole #4 (CrCH-4) Proposed Piezometer Design

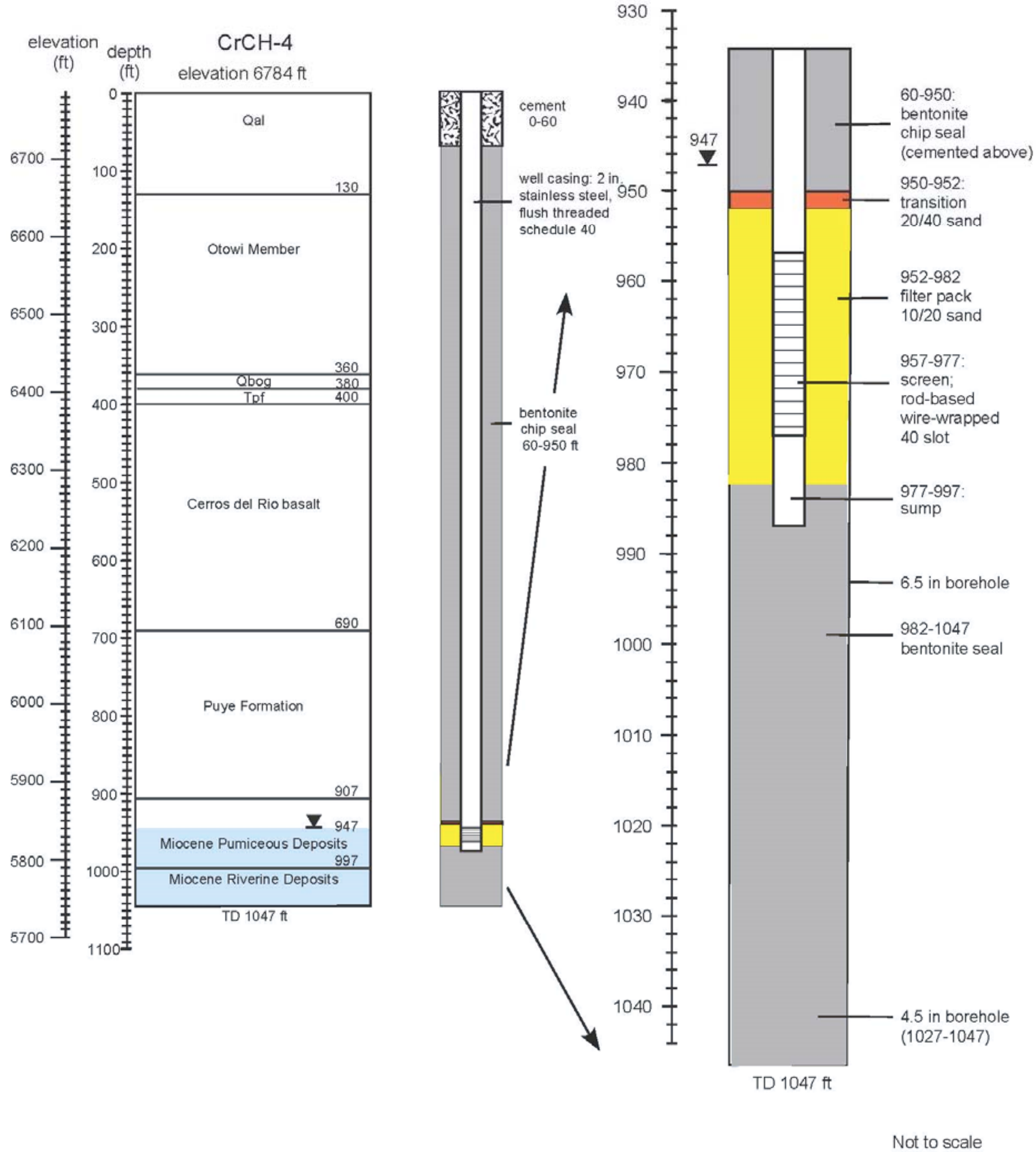
Introduction

The sonic drill rig has advanced to the target depth of approximately 100 feet (1,047 ft, bgs) beneath the water table in the regional aquifer. Sonic core was collected continuously over the interval 733-1047 ft bgs. Static water level (SWL) was measured at 947 ft bgs by multiple measurements with the corehole advanced to 1047 ft.

Construction

The proposed construction details are shown on the attached figure. With a SWL of 947 ft bgs, a 20-ft screen length with 10 ft of submergence is proposed. Ten feet of screen submergence should allow for representative monitoring at the top of the regional aquifer and allow for potential drawdown associated with future extraction well pumping.

Note the recommendation for a smaller thickness of transition sand than was directed by NMED in the September 2014 Approval with Modification. The proposed transition sand thickness of 2 ft is sufficiently protective and increases the likelihood that filter pack will remain below the water table.



elevation (ft)
depth (ft)
CrCH-4
elevation 6784 ft
Qal
130
Otowi Member
360
Qbog
380
Tpf
400
Cerros del Rio basalt
690
Puye Formation
907
947
Miocene Pumiceous Deposits
997
Miocene Riverine Deposits
TD 1047 ft
cement 0-60
well casing: 2 in. stainless steel, flush threaded schedule 40
bentonite chip seal 60-950 ft
947
60-950: bentonite chip seal (cemented above)
950-952: transition 20/40 sand
952-982 filter pack 10/20 sand
957-977: screen; rod-based wire-wrapped 40 slot
977-997: sump
6.5 in borehole
982-1047 bentonite seal
4.5 in borehole (1027-1047)
TD 1047 ft
Not to scale

From: Dale, Michael, NMENV <Michael.Dale@state.nm.us>
Sent: Thursday, January 22, 2015 3:12 PM
To: Everett, Mark Capen
Cc: Cobrain, Dave, NMENV; Wear, Benjamin, NMENV; Kulis, Jerzy, NMENV; Rodriguez, Cheryl L; Shen, Hai; Yanicak, Stephen M
Subject: RE: CrCH-4 proposed completion design

Mark,

NMED hereby approves the installation of the well/piezometer CrCH-4 as proposed in your e-mail with attachment as noted below. 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. Please call if you have any questions concerning this approval.

Thank you,

Michael 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) 661-2673

____

From: Everett, Mark Capen [meverett@lanl.gov]
Sent: Thursday, January 22, 2015 12:24 PM
To: Dale, Michael, NMENV; Kulis, Jerzy, NMENV; Cobrain, Dave, NMENV; Wear, Benjamin, NMENV
Cc: Shen, Hai; Rodriguez, Cheryl L; Swickley, Stephani Fuller; Ball, Ted; Dorries, Alison Marie; Grieggs, Tony; Saladen, Michael Thomas
Subject: CrCH-4 proposed completion design

Michael,

As we briefly discussed today, here is our proposed design for completion of CrCH-4. Please respond with your concurrence or give a call so we can discuss it further.

Thanks,

Mark Everett, PG
CAP-ES LANL
(505) 667-5931 (o)
(505) 231-6002 (c)

Chromium Corehole #5 (CrCH-5) Proposed Piezometer Design

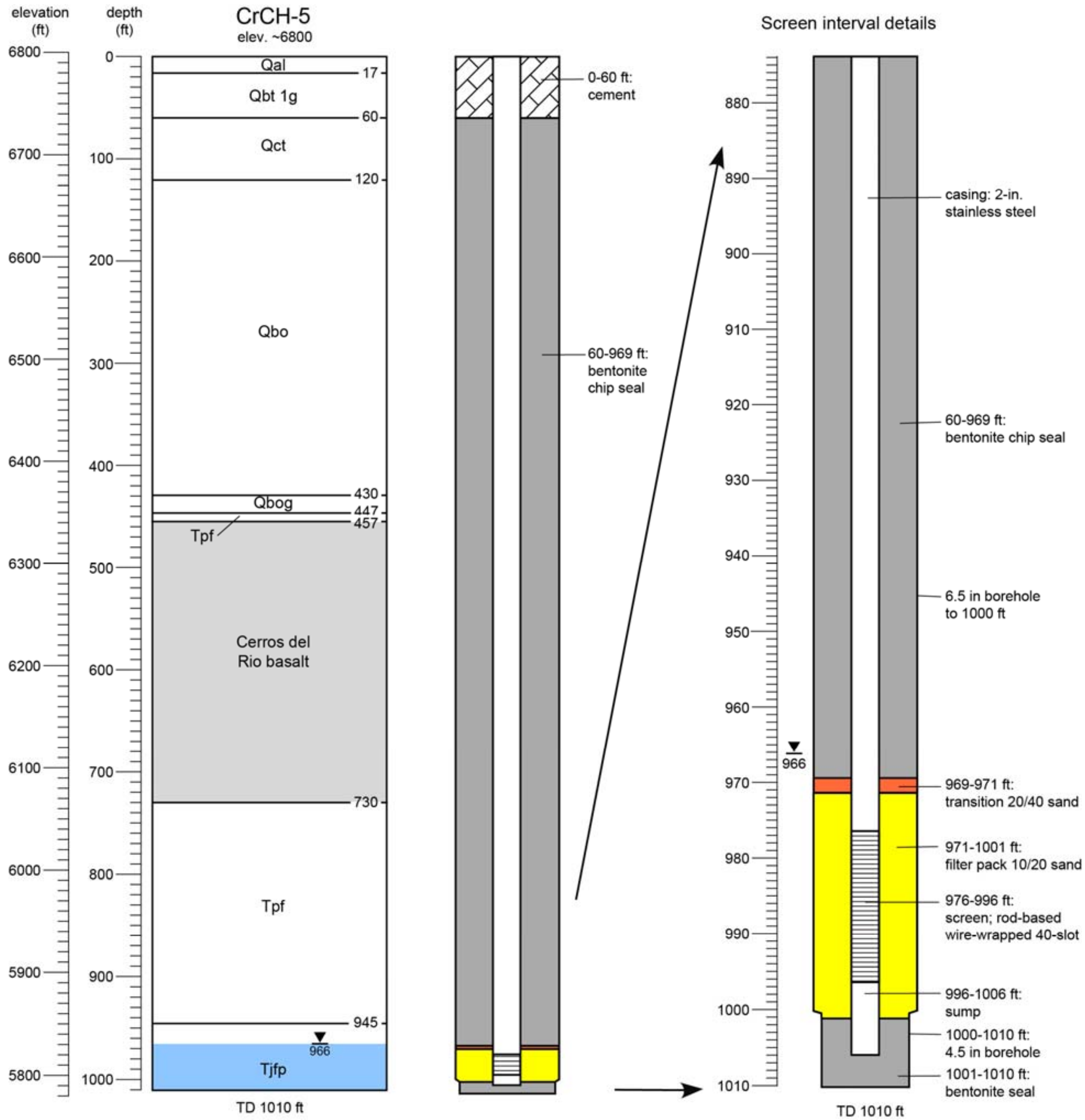
Introduction

The sonic drill rig has advanced to a depth of approximately 44 feet (1,010 ft, bgs) beneath the water table in the regional aquifer. The corehole was stopped when the casing became tight in the hole and extensive efforts to improve downhole conditions were unsuccessful. Sonic core was collected continuously over the interval 750-1010 ft bgs. Static water level (SWL) was measured at 966 ft bgs by multiple measurements with the corehole advanced to 1010 ft.

Construction

The proposed construction details are shown on the attached figure. With a SWL of 966 ft bgs, a 20-ft screen length with 10 ft of submergence is proposed. Ten feet of screen submergence should allow for representative monitoring at the top of the regional aquifer and allow for potential drawdown associated with future extraction well pumping.

Note the recommendation for a smaller thickness of transition sand than was directed by NMED in the September 2014 Approval with Modification. The proposed transition sand thickness of 2 ft is sufficiently protective and increases the likelihood that filter pack will remain below the water table.



elevation (ft)
depth (ft)
CrCH-5
elev. ~6800
Qal
Qbt 1g
Qct
Qbo
Qbog
Tpf
Cerros del Rio basalt
Tpf
Tjfp
966
TD 1010 ft
0-60 ft: cement
60-969 ft: bentonite chip seal
Screen interval details
casing: 2-in. stainless steel
60-969 ft: bentonite chip seal
6.5 in borehole to 1000 ft
969-971 ft: transition 20/40 sand
971-1001 ft: filter pack 10/20 sand
976-996 ft: screen; rod-based wire-wrapped 40-slot
996-1006 ft: sump
1000-1010 ft: 4.5 in borehole
1001-1010 ft: bentonite seal
TD 1010 ft

From: Dale, Michael, NMENV <Michael.Dale@state.nm.us>
Sent: Tuesday, February 10, 2015 4:04 PM
To: Everett, Mark Capen
Cc: Cobrain, Dave, NMENV; Wear, Benjamin, NMENV; Kulis, Jerzy, NMENV; Rodriguez, Cheryl L; Shen, Hai
Subject: RE: Chromium project CrCH-5 proposed completion design

Mark,

NMED hereby approves the installation of the well/piezometer CrCH-5 as proposed in your e-mail with attachment as noted below. 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 CrCH-5 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. Please call if you have any questions concerning this approval.

Thank you,

Michael 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) 661-2673

From: Everett, Mark Capen [meverett@lanl.gov]
Sent: Tuesday, February 10, 2015 12:51 PM
To: Dale, Michael, NMENV; Kulis, Jerzy, NMENV; Wear, Benjamin, NMENV; Cobrain, Dave, NMENV
Cc: Swickley, Stephani Fuller; Katzman, Danny; Williams, Deborah L; Grieggs, Tony; Dorries, Alison Marie; Ball, Ted; Rodriguez, Cheryl L; Shen, Hai
Subject: Chromium project CrCH-5 proposed completion design

Michael,

Here is our proposed design for the piezometer completion at core hole CrCH-5. Please respond to this e-mail with your concurrence or give a call to discuss further.

Mark Everett, PG
CAP-ES LANL
(505) 667-5931 (o)
(505) 231-6002 (c)

Appendix D

Details of Surface Pad Completions and Technical Notes

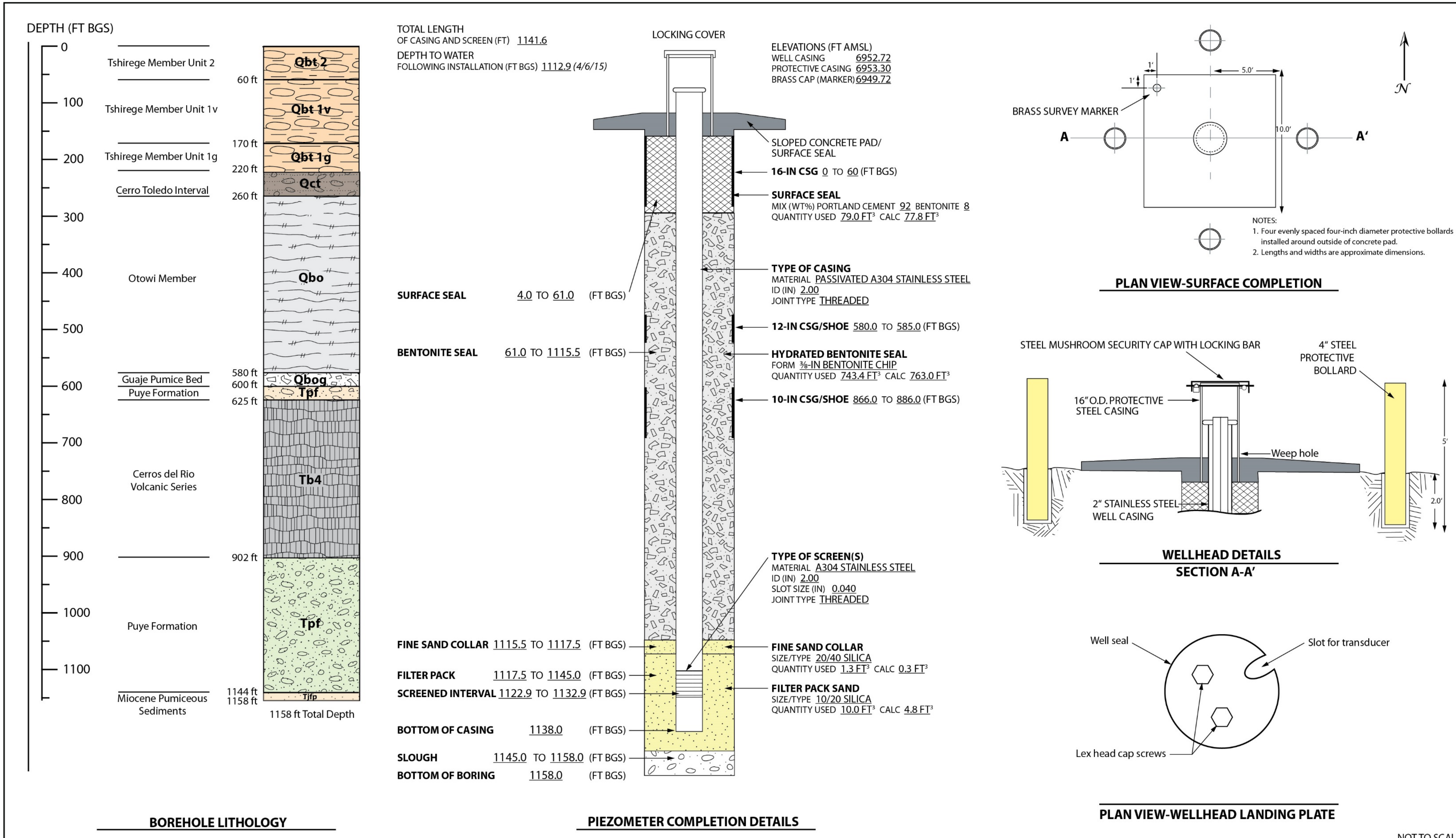


Figure D-1a Details of the surface pad completion for CrPZ-1

CrCH-1 TECHNICAL NOTES:

SURVEY INFORMATION*

Brass Marker
Northing: 1767944.04
Easting: 1637133.15
Elevation: 6949.70

Well Casing (top of stainless steel)
Northing: 1767940.70
Easting: 1637136.03
Elevation: 6952.72

BOREHOLE GEOPHYSICAL LOGS

LANL: Natural gamma ray

DRILLING INFORMATION

Drilling Company
Yellow Jacket Drilling, Inc.

Drill Rig
Foremost DR-24HD
Terrasonic TSi 150T

Drilling Methods
Dual rotary: 0 ft to 944 ft bgs
Sonic: 944 ft to 1158 ft bgs

Drilling Fluids
Dual rotary: Air, potable water, AQF foam
Sonic: Potable water

MILESTONE DATES

Drilling
Start: 08/19/2014
Finished: 10/08/2014

Well Completion
Start: 10/25/2014
Finished: 11/08/2014

Well Development
Start: 11/15/2014
Finished: 11/18/2014

WELL DEVELOPMENT

Development Methods
Bailing
Total Volume Purged: 132.75 gal.

Parameter Measurements (Final)
pH: 8.2
Temperature: 16.3°C
Specific Conductance: 285 μS/cm
Turbidity: 760 NTU

DEDICATED SAMPLING SYSTEM

Transducer
Make: In-Situ, Inc.
Model: Level TROLL 500
PSIG range: 30 PSIG range (vented)
S/N: TBD

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 D-1b Technical notes for CrPZ-1

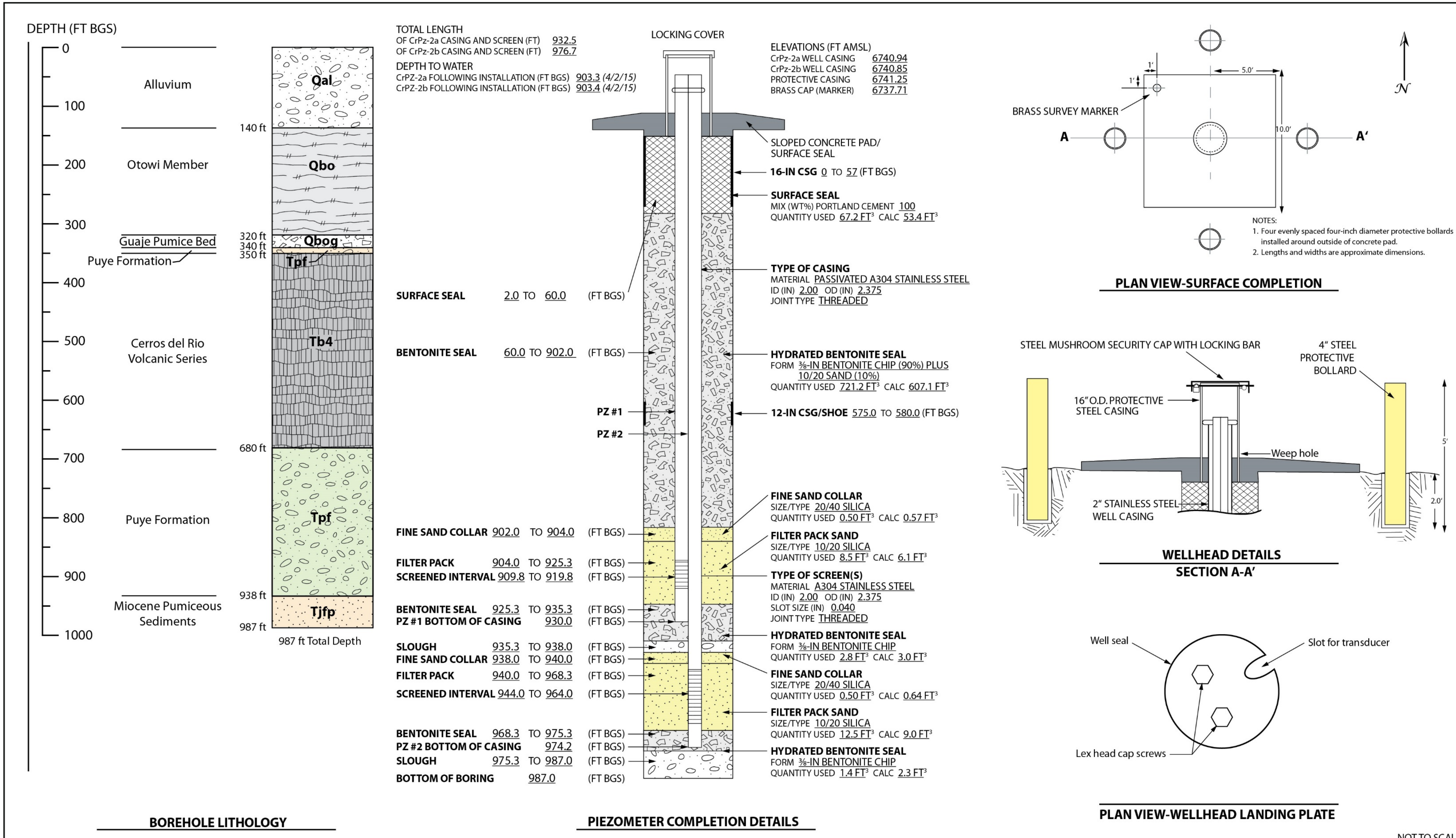


Figure D-2a Details of the surface pad completion for CrPZ-2a and CrPZ-2b

CrCH-2 TECHNICAL NOTES:

SURVEY INFORMATION*

Brass Marker
Northing: 1768408.05
Easting: 1638619.59
Elevation: 6737.71

Well Casing (top of stainless steel)
CrPz-2a
Northing: 1768404.39
Easting: 1638621.69
Elevation: 6740.94

CrPz-2b
Northing: 1768404.87
Easting: 1638621.76
Elevation: 6740.85

BOREHOLE GEOPHYSICAL LOGS

LANL: Natural gamma ray and induction

DRILLING INFORMATION

Drilling Company
Yellow Jacket Drilling, Inc.

Drill Rig
Foremost DR-24HD
Terrasonic TSi 150T

Drilling Methods
Dual rotary: 0 ft to 700 ft bgs
Sonic: 700 ft to 987 ft bgs

Drilling Fluids
Dual rotary: Air, potable water, AQF foam
Sonic: Potable water

MILESTONE DATES

Drilling
Start: 09/15/2014
Finished: 12/17/2014

Well Completion
Start: 01/11/2015
Finished: 01/19/2015

Well Development
Start: 01/20/2015
Finished: 02/02/2015

WELL DEVELOPMENT

Development Methods
Bailing
Total Volume Purged: 166 gal.

Parameter Measurements (Final)
CrPz-2a
pH: 7.5
Temperature: 17.3°C
Specific Conductance: 227 µS/cm
Turbidity: 5762 NTU

CrPz-2b
pH: 6.8
Temperature: 17.7°C
Specific Conductance: 240 µS/cm
Turbidity: 176 NTU

DEDICATED SAMPLING SYSTEM

Transducer
Make: In-Situ, Inc.
Model: Level TROLL 500
PSIG range: 30 PSIG range (vented)
S/N: TBD

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 D-2b Technical notes for CrPZ-2a and CrPZ-2b

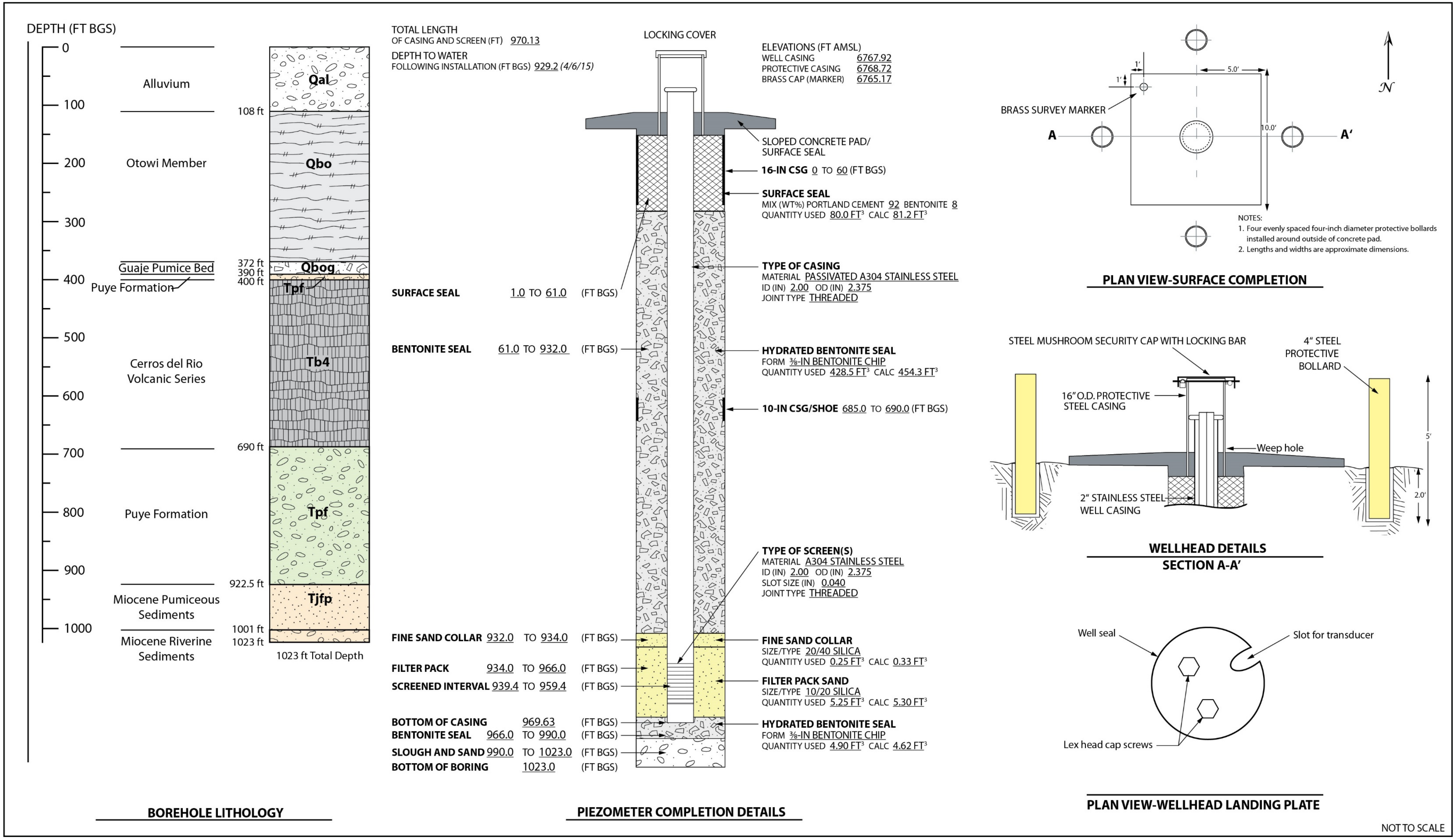


Figure D-3a Details of the surface pad completion for CrPZ-3

CrCH-3 TECHNICAL NOTES:

SURVEY INFORMATION*

Brass Marker
Northing: 1768747.27
Easting: 1637438.36
Elevation: 6765.17

Well Casing (top of stainless steel)
Northing: 1768744.16
Easting: 1637441.17
Elevation: 6767.92

BOREHOLE GEOPHYSICAL LOGS

LANL: Natural gamma ray and induction

DRILLING INFORMATION

Drilling Company
Yellow Jacket Drilling, Inc.

Drill Rig
Foremost DR-24HD
Terrasonic TSi 150T

Drilling Methods
Dual rotary: 0 ft to 695 ft bgs
Sonic: 695 ft to 1023 ft bgs

Drilling Fluids
Dual rotary: Air, potable water, AQF foam
Sonic: Potable water

MILESTONE DATES

Drilling
Start: 09/29/2014
Finished: 11/24/2014

Well Completion
Start: 12/05/2014
Finished: 12/09/2014

Well Development
Start: 12/15/2014
Finished: Ongoing

WELL DEVELOPMENT

Development Methods
Bailing
Total Volume Purged: 108 gal.

Parameter Measurements (Final)
pH: 7.6
Temperature: 16.4°C
Specific Conductance: 274 µS/cm
Turbidity: 57.5 NTU

DEDICATED SAMPLING SYSTEM

Transducer
Make: In-Situ, Inc.
Model: Level TROLL 500
PSIG range: 30 PSIG range (vented)
S/N: TBD

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 D-3b Technical notes for CrPZ-3

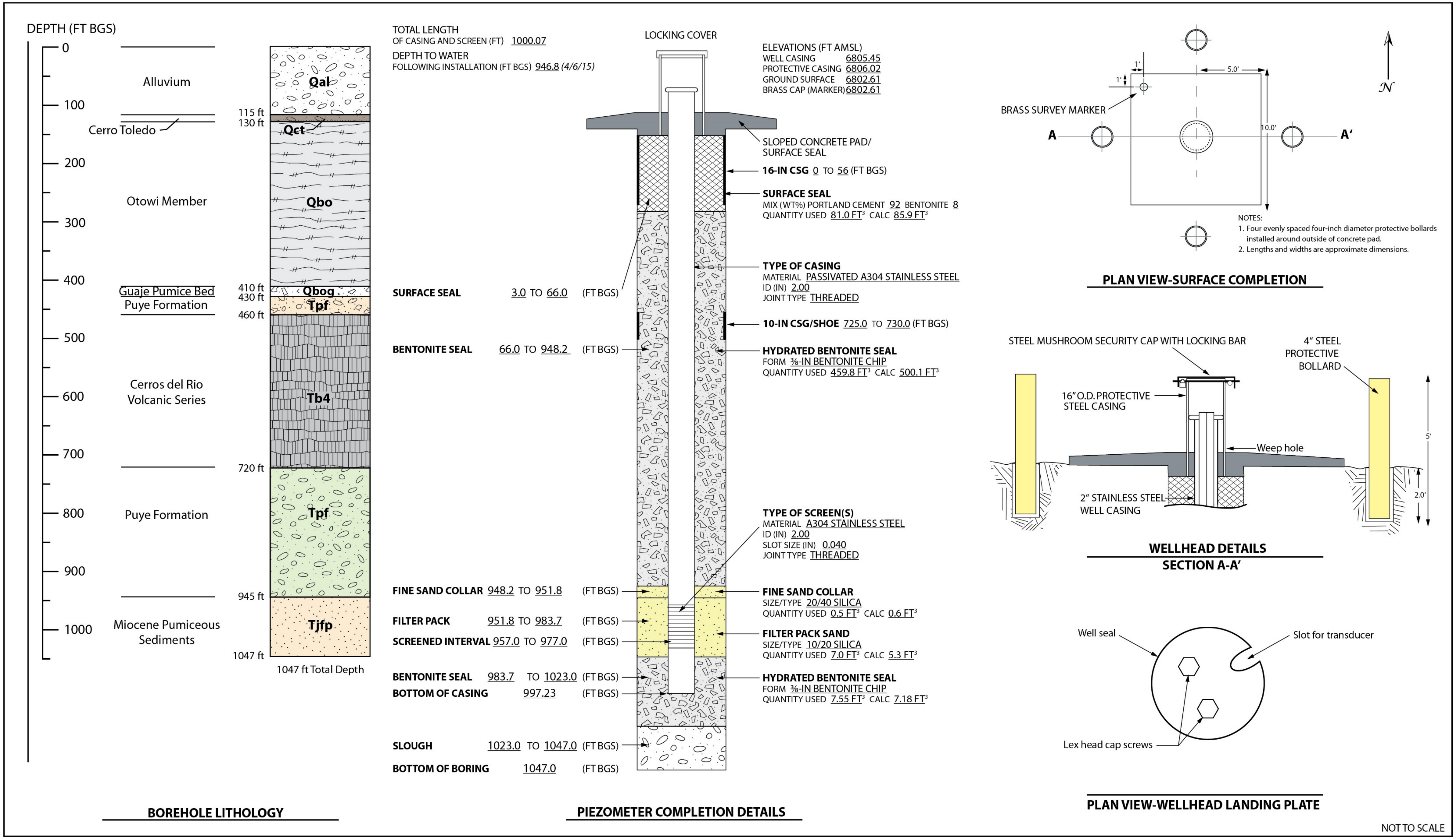


Figure D-4a Details of the surface pad completion for CrPZ-4

CrCH-4 TECHNICAL NOTES:

SURVEY INFORMATION*

Brass Marker
Northing: 1768723.50
Easting: 1636478.23
Elevation: 6784.71

Well Casing (top of stainless steel)
Northing: 1768720.69
Easting: 1636481.24
Elevation: 6787.51

BOREHOLE GEOPHYSICAL LOGS

LANL: Natural gamma ray

DRILLING INFORMATION

Drilling Company
Yellow Jacket Drilling, Inc.

Drill Rig
Foremost DR-24HD
Terrasonic TSi 150T

Drilling Methods
Dual rotary: 0 ft to 754.8 ft bgs
Sonic: 754.8 ft to 1047 ft bgs

Drilling Fluids
Dual rotary: Air, potable water, AQF foam
Sonic: Potable water

MILESTONE DATES

Drilling
Start: 11/11/2014
Finished: 01/21/2015

Well Completion
Start: 01/24/2015
Finished: 03/13/2015

Well Development
Start: 03/18/2015
Finished: Ongoing

WELL DEVELOPMENT

Development Methods
Bailing
Total Volume Purged: 254 gal.

Parameter Measurements (Final)
pH: 7.7
Temperature: 16.8°C
Specific Conductance: 88 μS/cm
Turbidity: 834 NTU

DEDICATED SAMPLING SYSTEM

Transducer
Make: In-Situ, Inc.
Model: Level TROLL 500
PSIG range: 30 PSIG range (vented)
S/N: TBD

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 D-4b Technical notes for CrPZ-4

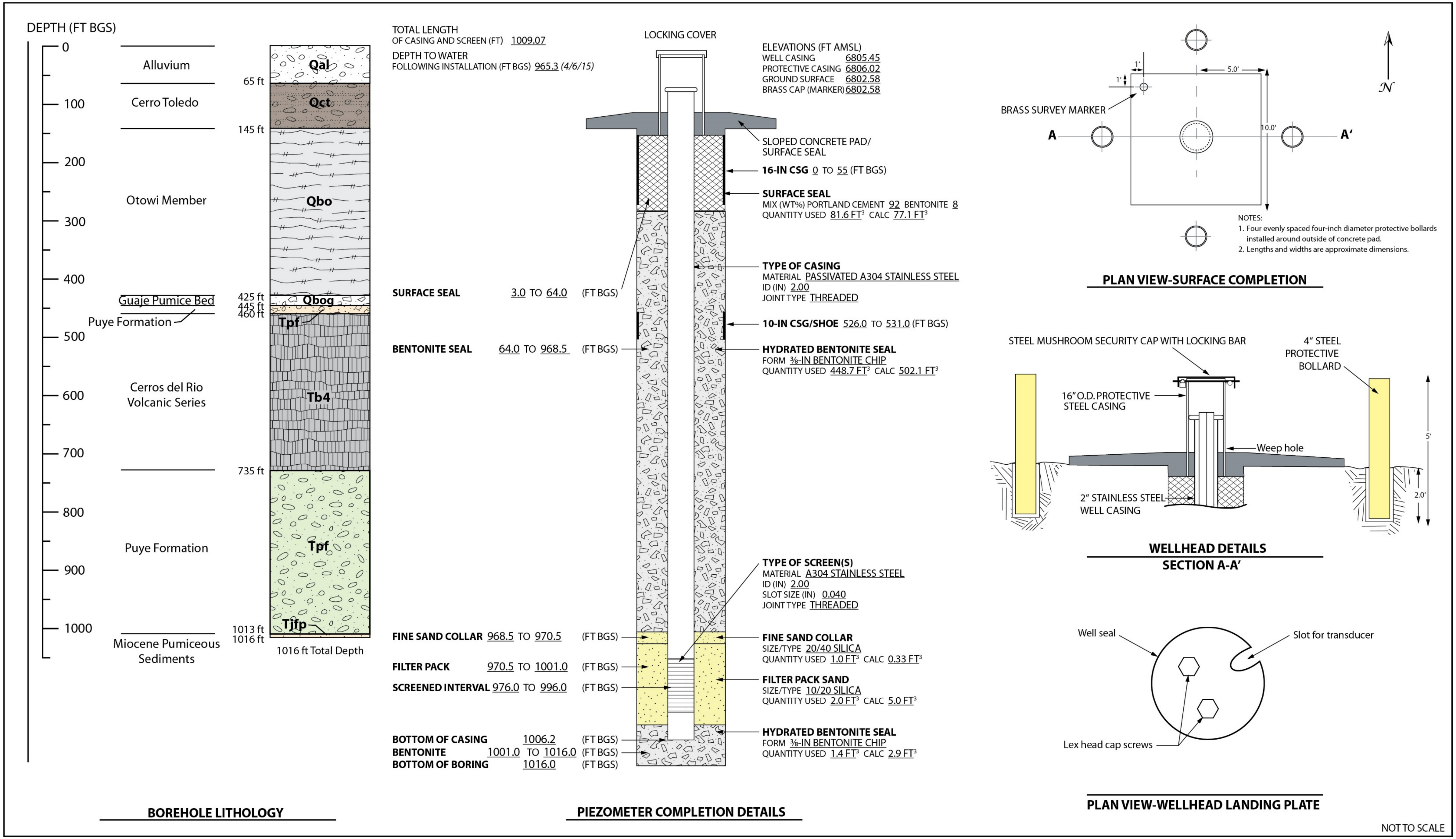


Figure D-5a Details of the surface pad completion for CrPZ-5

CrCH-5 TECHNICAL NOTES:

SURVEY INFORMATION*

Brass Marker
Northing: 1768435.06
Easting: 1636003.32
Elevation: 6802.58

Well Casing (top of stainless steel)
Northing: 1768432.11
Easting: 1636006.33
Elevation: 6805.45

BOREHOLE GEOPHYSICAL LOGS

LANL: Natural gamma ray and induction

DRILLING INFORMATION

Drilling Company
Yellow Jacket Drilling, Inc.

Drill Rig
Foremost DR-24HD
Terrasonic TSi 150T

Drilling Methods
Dual rotary: 0 ft to 755 ft bgs
Sonic: 755 ft to 1016 ft bgs

Drilling Fluids
Dual rotary: Air, potable water, AQF foam
Sonic: Potable water

MILESTONE DATES

Drilling
Start: 12/03/2014
Finished: 02/08/2015

Well Completion
Start: 02/11/2015
Finished: 03/16/2015

Well Development
Start: 03/17/2015
Finished: Ongoing

WELL DEVELOPMENT

Development Methods
Bailing
Total Volume Purged: 493 gal.

Parameter Measurements (Final)
pH: 7.4
Temperature: 18.1°C
Specific Conductance: 141 µS/cm
Turbidity: 4966 NTU

DEDICATED SAMPLING SYSTEM

Transducer
Make: In-Situ, Inc.
Model: Level TROLL 500
PSIG range: 30 PSIG range (vented)
S/N: TBD

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 D-5b Technical notes for CrPZ-5