Drilling Work Plan for Perched-Intermediate Pumping Well CdV-16-4ip

Primary Purpose	Perched-intermediate pumping well CdV-16-4ip is being installed as part of a hydrologic testing program to evaluate the properties of the deep-perched groundwater zone at Consolidated Unit 16-021(c)-99 (260 Outfall), located in Technical Area 16 (TA-16) in the southwest corner of Los Alamos National Laboratory. The "p" in the well name indicates this well is designed for pump testing. The tests will provide field-scale measurements of aquifer parameters for the deep-perched system that will be used to assess the potential for pumping and treatment of contaminated deep-perched groundwater associated with the 260 Outfall. Details of the hydrologic testing program are presented in the "Hydrologic Testing Work Plan for Consolidated Unit 16-021(c)-99" (LANL 2010, 108534). The proposed site for well CdV-16-4ip is east of the main cluster of observation wells that include multiple well screens at R-25 and single well screens at R-25b, R-25c, and CdV-16-1(i) (Figure 1). This location is selected to optimize the spatial distribution of potential pressure responses from the observation wells. The distances of the observation wells from the pumping well range between 372 and 483 ft (Figure 2). The depth to the top of the perched-intermediate groundwater is expected to be approximately 715 ft. The target depth for the CdV-16-4ip borehole is approximately 1150 ft. The well is tentatively designed with two screens, each 40 to 60 ft in length, within the perched groundwater zone (Figure 2). It is anticipated that the upper screen will be placed near the top of saturation in the Otowi Member of the Bandelier Tuff; the deeper screen will target a deeper productive zone in the underlying sedimentary deposits of the Puye Formation. Actual well screen lengths and positions will be based on data collected during drilling, including information from lithologic logs of cuttings, water-level measurements, video logs, geophysical logs, and driller's observations. Figures 2 and 3 show the predicted geology and proposed well design for well CdV-16-4ip. A final well design will be based on hydrogeological conditions encountered during drilling, and a revised well design document will be submitted to the New Mexico Environment Department (NMED) for approval before well construction.
Conceptual Model	The deep-perched zone in the vicinity of TA-16 is up to 420 ft thick and occurs within the Otowi Member of the Bandelier Tuff and the underlying Puye Formation. This perched zone is believed to be recharged along the Jemez mountain-front via the Pajarito fault zone and along canyon bottoms. Surface geophysics, water-level data, and stream-flow data indicate a component of the deep-perched groundwater may originate as recharge associated with infiltration along upper Cañon de Valle downgradient of the 260 Outfall. Based on existing data, the perched groundwater zone extends from west to east for more than 1.3 mi (2 km) and from north to south for approximately 0.6 mi (1 km). The perched zone has been detected at R-26 screen 1; R-25b; R-25 screens 1, 2, 4; CdV-16-1(i); CdV-16-2(i)r (Figure 1); and R-47i, a little farther east. The deep-perched zone was not observed at R-18 and R-48, defining its north-south extent. Water-level data indicate groundwater within the deep-perched system generally flows from west to east. There is some evidence of a southerly component of flow within the Otowi Member of the Bandelier Tuff in the vicinity of R-25, possibly because of recharge along Cañon de Valle. Water-level data from multiple screens in R-25 indicate that water levels within the deep-perched system are lower with depth, indicating significant vertical anisotropy, with vertical hydraulic conductivities perhaps orders of magnitude lower than horizontal hydraulic conductivities in some strata.

Conceptual Model (cont.)	Data from wells and drilling in the TA-16 area indicate the perched groundwater system is characterized by a series of saturated horizons separated by unsaturated strata, as observed at screens 3 and 4 of R-25. Because the Puye Formation consists of stratified alluvial fan deposits, its hydraulic properties are expected to be highly heterogeneous. The specific nature of vertical connection between the perched groundwater system and the regional aquifer is not known.
Drilling Approach	A combination of open-hole and casing-advance methods will be employed. Each interval of open-hole or casing-advance will be optimized to meet well objectives. Casing will be used to protect open-hole intervals below, to advance the borehole when open-hole drilling is not possible, and to secure the borehole through unstable zones. Surface casing will be advanced to a depth of 700 ft, and an attempt will be made to drill an open borehole to the target depth of 1150 ft. Drilling fluids will include municipal water and AQF-2 foam. An attempt will be made to minimize the use of drilling fluids below 700 ft to minimize the adverse effects on the groundwater chemistry. However, the primary goal of the drilling is to install a pumping well for aquifer testing rather than for groundwater-quality monitoring. Characterization of the perched zone and final design of the pumping well are best served by maintaining a stable open-hole environment while drilling through the perched groundwater zone so open-hole geophysical logs can be collected. Open-hole geophysical logs will provide better characterization of the perched zone than cased-hole logs. If borehole conditions become unstable, the borehole may be advanced to total depth using drill casing, limiting geophysical analyses to a cased-hole suite.
Potential Drilling Fluids, Composition, and Use	Fluids and additives that may be used to facilitate drilling are consistent with those previously used in the drilling program at Los Alamos National Laboratory (LANL) and have been characterized geochemically. Fluids and additives previously authorized for use by NMED include • potable water from municipal water supply to aid in delivery of other drilling additives and cool the drill bit; • QUIK-FOAM, a blend of alcohol ethoxy sulfates, used as a foaming agent; and • AQF-2, an anionic surfactant, used as a foaming agent. Complete records will be maintained detailing the type, amount, and volume of drilling fluid used, depth of drilling fluid added to the borehole, amount in storage in the borehole, and recovery volume of drilling fluid. No chemicals, other than those listed above, will be added without approval from NMED.
Hydrogeologic and Geochemical Objectives	The primary objective is to install a pumping well as part of a hydrologic testing program to evaluate properties of the deep-perched groundwater zone at TA-16. Key objectives of the pumping tests include the following: • acquiring field-scale measurements of hydrogeologic properties, such as formation transmissivity and storage coefficient, necessary to evaluate the viability of the pump-and-treat remedial alternative for groundwater remediation • evaluating lateral and vertical hydraulic connectivity within the perched zone • providing data regarding concentrations of contaminants in the vicinity of the test well • potentially evaluating heterogeneity/anisotropy of the flow medium • evaluating boundary conditions to assess the lateral extent of the deep-perched zone to provide information about the hydraulic connectivity between the deep-perched zone and the regional aquifer

Groundwater Occurrence and Detection	Perched groundwater is known to occur at wells at R-26, R-25b, R-25, CdV-16-1(i), CdV-16-2(i)r, and R-47i. Based on information from these wells, the perched zone at CdV-16-4ip is expected to occur within the tuffs of the Otowi Member and in sedimentary deposits of the underlying Puye Formation. The depth to the top of perched saturation is expected to be approximately 715 ft. Methods for groundwater detection may include driller's observations, water-level measurements, borehole video, and borehole geophysics.
Core Sampling	No core collection is planned.
Perched Groundwater Screening Sampling	No groundwater screening samples will be collected during drilling of the CdV-16-4ip borehole because drilling foam will be used. Screening samples may be collected during well development.
Groundwater Characterization Sampling	Groundwater characterization samples will be collected during testing in accordance with "Hydrologic Testing Work Plan for Consolidated Unit 16-021(c)-99" (LANL 2010, 108534).
Geophysical Testing	LANL's borehole video camera, natural gamma, and induction tools will be used in the open borehole if conditions allow. A full suite of geophysical logs will be run, if required, for proper placement of the screens. The logs will be collected by Schlumberger, Inc., and for open-hole conditions will include accelerator porosity sonde (neutron porosity), array induction, combined magnetic resonance, natural and spectral gamma, and formation microimager logs. In cased portions of the borehole, neutron porosity, triple lithodensity, elemental capture, natural gamma, and spectral gamma logs will be collected. These logs will be used to characterize the hydraulic properties of saturated rocks in the regional aquifer. The geophysical logs also will be used to select the well-screen depths. The suite and timing of geophysical logging will depend on borehole conditions.
Well Completion Design	Figures 2 and 3 show the proposed well design and predicted geology for well CdV-16-4ip. The upper well screen will be placed within the Otowi Member near the top of the perched zone, and a deeper screen will be placed in Puye Formation approximately 150 to 200 ft below the upper screen. The well screens for this pumping well will be 40 to 60 ft in length. Because of uncertainties about the thicknesses and lateral extent of the perched-intermediate groundwater, it is possible the proposed screen 2 for CdV-16-4ip (Figure 2) may not intercept enough water to warrant the placement of a screen in the deeper zone. Therefore, the final well design will be based on field data collected during drilling, including geophysical logs, drill cuttings, water-level measurements, and driller's observations.
Well Development	The well may be developed by both mechanical and chemical means. Mechanical means include swabbing, bailing, and pumping. Chemical means include the use of additives to remove clays, and/or chlorination to kill bacteria introduced during well completion. • After initial swabbing and bailing, a submersible pump will be used to complete the development process. • Water-quality parameters will be measured in a flow-through cell. The parameters to be monitored are pH, specific conductance, dissolved oxygen, temperature, turbidity, oxidation-reduction potential, and total organic carbon (TOC).

Well Development (cont.)	• If LANL is unable to bring the water-quality parameters to measure within the limits specified below, the use of chemical well development may be discussed with NMED. No chemicals will be added without approval from NMED. • Chemical means that may be used include sodium acid pyrophosphate and AQUACLEAR PFD to remove clays and/or chlorination to kill bacteria introduced during well completion. Well development will be considered complete when target water-quality parameters are met. The target water-quality parameters are turbidity <5 nephelometric turbidity units, TOC <2 ppm, and other parameters stable.
Hydraulic Isolation of Screens	The screen intervals will be isolated from one another as much as possible. During pump development an inflatable packer will be used to focus efforts on the target screen. While resting the aquifer before and between aquifer tests, the packer will remain inflated. After testing an isolation packer (inflatable or mechanical) will remain between the screens.
Hydraulic Testing	Details of the hydrologic testing program are presented in "Hydrologic Testing Work Plan for Consolidated Unit 16-021(c)-99."
Investigation-Derived Waste Management	Investigation-derived waste (IDW) will be managed in accordance with Standard Operating Procedure (SOP) EP-SOP-5238, Characterization and Management of Environmental Program Waste (http://www.lanl.gov/environment/all/qa/adep.shtml). This SOP incorporates the requirements of applicable U.S. Environmental Protection Agency and NMED regulations, U.S. Department of Energy orders, and LANL requirements. The primary waste streams include drill cuttings, drilling water, development water, purge water, decontamination water, and contact waste. Where Resource Conservation and Recovery Act constituents are detected and duplicate samples are collected during the same sampling event and one is a nondetect and the other is detected, LANL assumes the detection is the result of laboratory or field contamination. The detection will not be used for waste determination and/or land application. Drill cuttings will be managed in accordance with the NMED-approved Notice of Intent (NOI) Decision Tree for Land Application of IDW Solids from Construction of Wells and Boreholes (November 2007). Drilling, purge, and development waters will be managed in accordance with the NMED-approved NOI Decision Tree for Drilling, Development, Rehabilitation, and Sampling Purge Water (March 2010). Initially, drill cuttings and drilling water will be stored in lined pits. The cuttings may or may not contain residue of drilling/well completion additives (e.g., drilling foam and bentonite clay). The contents of the pits will be characterized with direct sampling following completion of drilling activities, and waste determinations will be made from validated data. If validated analytical data show these wastes cannot be land-applied, they will be removed from the pit, containerized, and placed in accumulation areas appropriate to the type of waste. Cuttings, drilling water, development water, and purge water that cannot be land-applied and are designated as hazardous waste will be sent to an authorized treatment, storage, or disposal facility within 90 days of containerization. Development water, purge water, and decontamination water will be containerized separately at their point of generation, placed in an accumulation area appropriate to the type of waste, and directly sampled. Contact waste will be containerized at the point of generation, placed in an appropriate accumulation area, and characterized using acceptable knowledge of the media with which it came in contact.
Schedule	Well CdV-16-4ip is proposed for completion by September 30, 2010, as presented in LANL's Proposed Integrated Well-Installation Schedule of October 14, 2009 (LANL 2009, 107088), and approved by NMED in a letter dated November 2, 2009 (NMED 2009, 107353).

REFERENCES

LANL (Los Alamos National Laboratory), October 14, 2009. "Submittal of a Proposed Integrated Well-Installation Schedule," Los Alamos National Laboratory letter (EP2009-0496) to J.P. Bearzi (NMED-HWB) from M.J. Graham (LANL) and G.J. Rael (DOE-LASO), Los Alamos, New Mexico. (LANL 2009, 107088)

LANL (Los Alamos National Laboratory), February 2010. "Hydrologic Testing Work Plan for Consolidated Unit 16-021(c)-99," Los Alamos National Laboratory document LA-UR-10-0404, Los Alamos, New Mexico. (LANL 2010, 108534)

NMED (New Mexico Environment Department), November 2, 2009. "Proposed Integrated Well-Installation Schedule, Los Alamos National Laboratory," New Mexico Environment Department letter to D. Gregory (DOE-LASO) and D. McInroy (LANL) from J.P. Bearzi (NMED-HWB), Santa Fe, New Mexico. (NMED 2009, 107353)

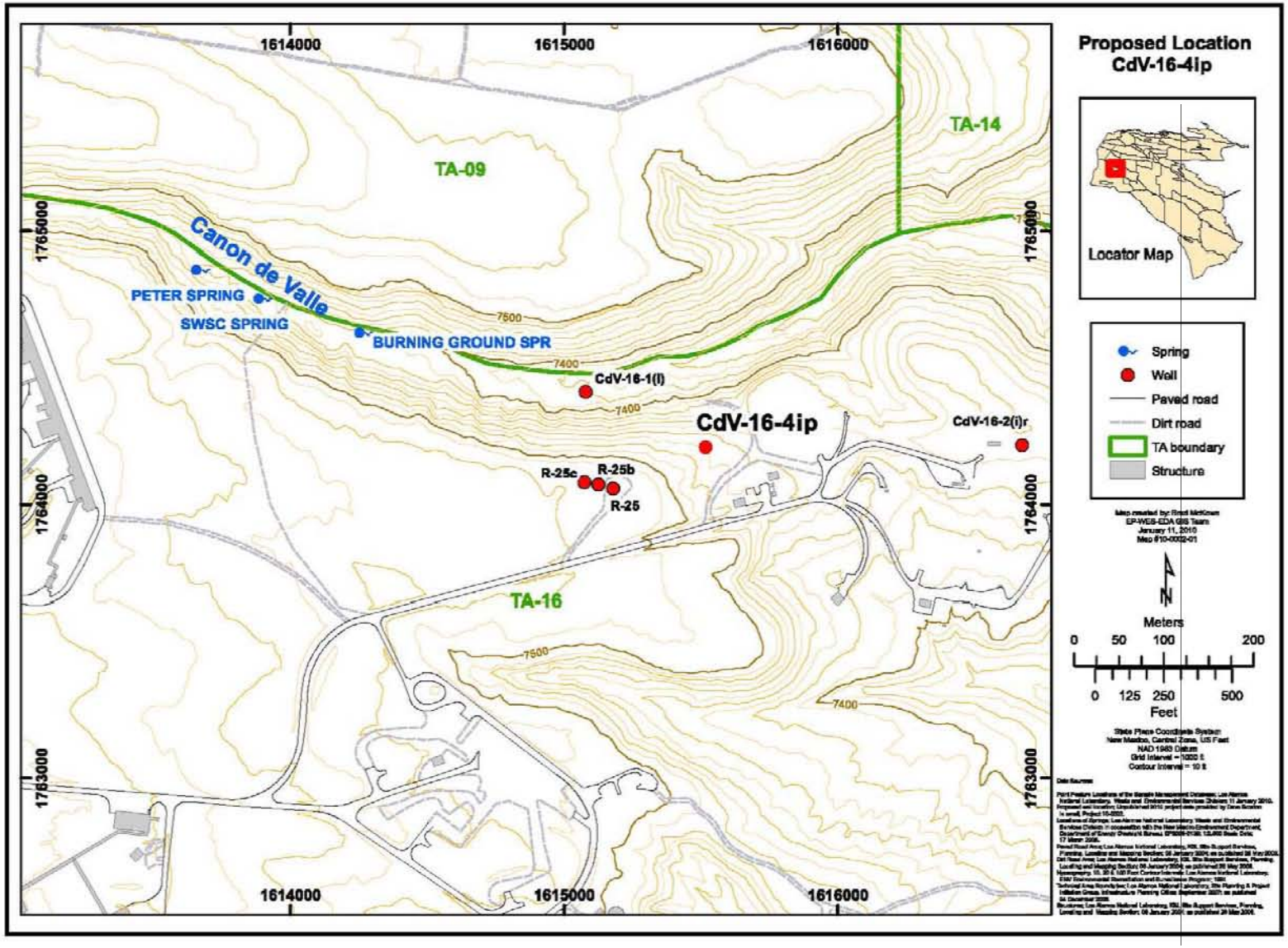

Figure 1 **Proposed location of well CdV-16-4ip**

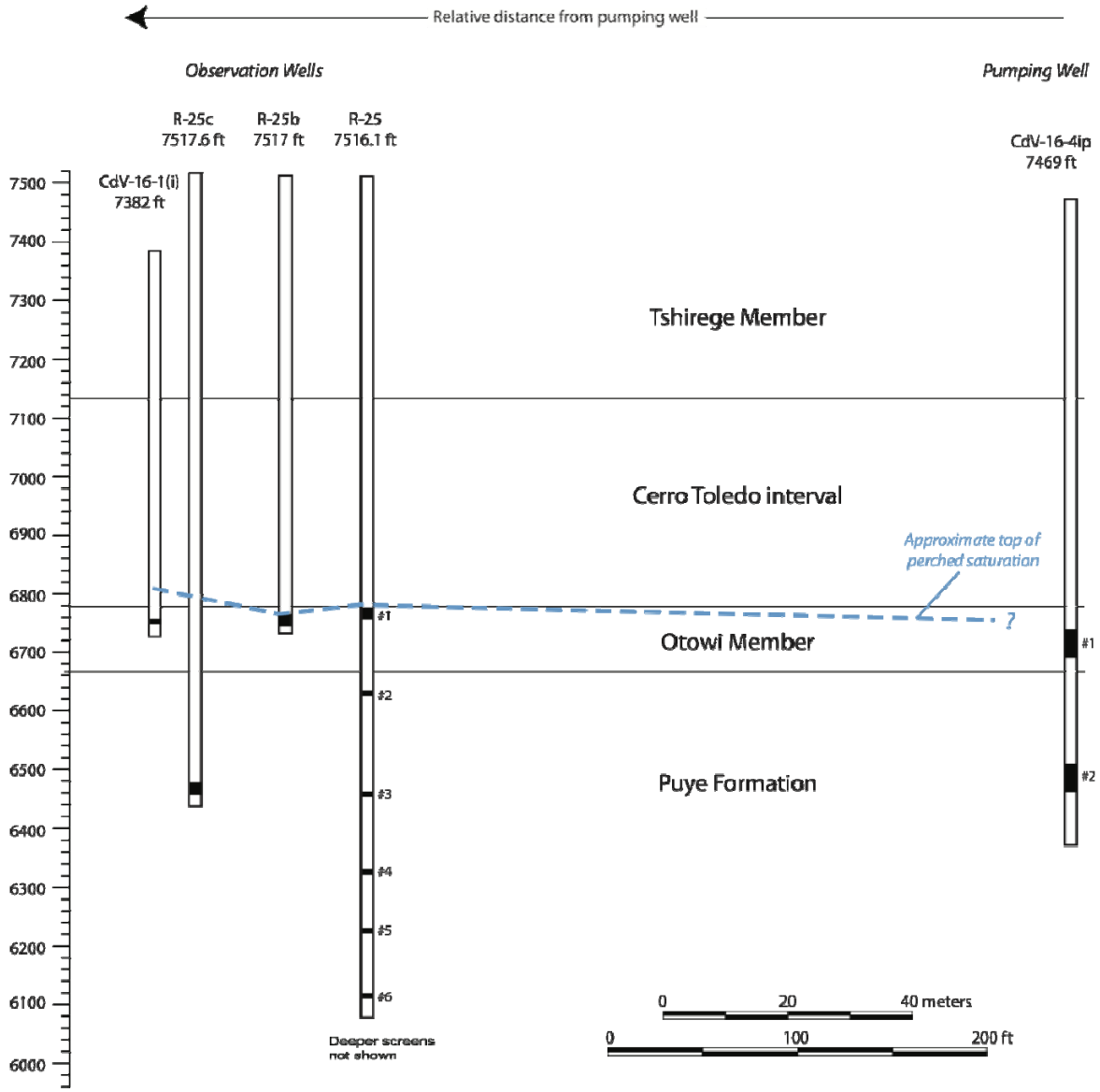

Figure 2 **Conceptual layout of pumping test showing the depths of observation well screens relative to pumping well screens**

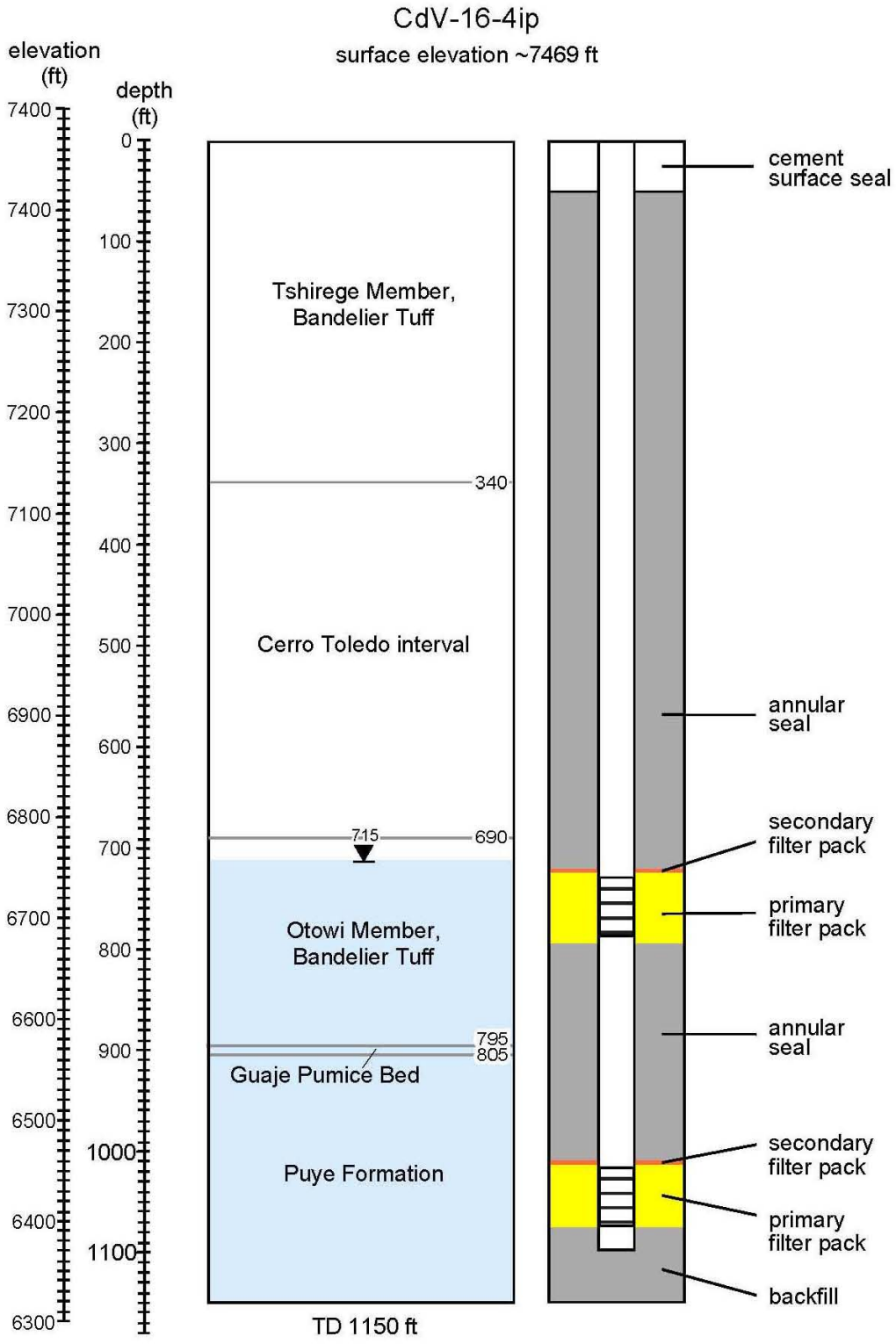

Figure 3 Predicted geology and proposed well design for well CdV-16-4ip