Drilling Work Plan for Regional Aquifer Wells MW-14 (R-64) and MW-10 (R-65)

Primary Purpose	Regional aquifer wells R-64 and R-65 (formerly designated MW-14 and MW-10, respectively in the Technical Area 21 [TA-21] Network Analysis) are being installed to monitor water quality in the regional aquifer downgradient of moderate- to high-priority potential release sites at TA-21, as required by the New Mexico Environment Department's (NMED's) Approval with Modifications, Technical Area 21 Monitoring Well Network Evaluation and Recommendations, Los Alamos National Laboratory, dated December 2, 2010 (NMED 2010, 111462). The proposed locations for wells R-64 and R-65 are shown in Figure 1. Well R-64 will be installed first, and it will provide new water-level measurements that will be used to update the water-table map for TA-21. After the water-table map is updated, the location of well R-65 may be adjusted to optimize monitoring of potential contaminants downgradient of high-priority potential release sites at TA-21. Wells R-64 and R-65 are both located on the north edge of DP Mesa and are separated by a distance of about 310 ft. Therefore, the geologic and hydrologic conditions encountered by the two wells are expected to be similar. The two boreholes are expected to penetrate the top of regional saturation at a depth of approximately 1259 ft within Miocene pumiceous sediments of the upper Santa Fe Group. The target borehole total depths (TDs) are approximately 1380 ft. Because of their proximity to potential breakthrough locations at TA-21, both wells will be completed with a single screen set near the top of regional saturation. Figures 2 and 3 show the predicted geology and conceptual well design for wells R-64 and R-65, respectively. Final well designs will be based on data acquired during drilling, including information from lithological logs of cuttings, water-level measurements, video logs, geophysical logs, and drillers' observations. Well design documents will be submitted to NMED for approval.
Conceptual Model	Wells R-64 and R-65 are located at the facility boundary downgradient of moderate- to high-priority potential release sites at TA-21. Transport in the vadose zone is considered to be vertical with potential contaminants arriving at the regional aquifer within hypothesized arrival areas directly below the surface release sites. These arrival areas are referred to as potential "breakthrough locations." Contaminant impacts on the regional aquifer are most easily detected by monitoring groundwater near the water table immediately downgradient of the potential breakthrough locations. Based on current regional aquifer water-table maps, the hydraulic gradient should transport potential contaminants generally towards the east or northeast. However, advective transport of contaminants may not be perpendicular to the equipotential water-table lines (i.e., parallel to the direction of the hydraulic gradients) because of aquifer anisotropy and heterogeneity. Additionally, possible infiltration mounding beneath nearby Los Alamos and Pueblo Canyons may affect the hydraulic gradients locally. There are uncertainties about water-table depth and groundwater flow direction at TA-21 because of the low spatial density of regional aquifer wells in the area. Information to construct water-table maps is largely derived from widely spaced observations at wells R-2, R-7, R-6, and R-4.
Drilling Approach	Drilling will be conducted with methods selected to optimize the potential for completing the wells without the use of drilling additives in, or immediately above, the target zone of saturation. A combination of open-hole and casing-advance methods will be used. Each interval of open hole or casing advance will be optimized to meet the well objectives. Casing will be used to advance the borehole when open-hole drilling is not possible and to secure the borehole through unstable zones or any perched horizons.

Potential Drilling Fluids, Composition, and Use	Fluids and additives may be used to facilitate drilling. These fluids and additives are consistent with those previously used in the drilling program at Los Alamos National Laboratory (LANL or the Laboratory) and have been characterized geochemically. Fluids and additives previously authorized for use by NMED include • potable water, 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. No drilling fluids will be used within 100 ft of the regional aquifer except potable municipal water.
Well Objectives for R-64 and R-65	• The primary objective is to monitor water quality at the top of the regional aquifer downgradient of moderate- to high-priority potential release sites at TA-21. • A secondary objective is to establish water levels and gradients in the regional aquifer in this area for water-table maps and thereby to enable optimization of the monitoring network. • Another secondary objective is to determine if perched-intermediate groundwater occurs beneath the mesa at TA-21. • A third secondary objective is to define the hydrostratigraphy of the site, characterizing rock units that can impact contaminant pathways in the vadose zone and the regional aquifer.
Potential Groundwater Occurrence and Detection	*Perched Water:* East of wells R-64 and R-65, perched water was encountered in well R-6 and subsequently targeted for emplacement of intermediate well R-6i (Figure 1). The perched water at well R-6i occurs in Puye Formation sediments above Cerros del Rio lavas. A comparable perched interval occurs in intermediate well LAOI-3.2/3.2a farther east, at the confluence of Los Alamos and DP canyons. Attempts to place another intermediate well (LADP-5) at a location between well R-6i and the proposed locations for wells R-64 and R-65 failed to encounter perched water to the total borehole depth of 720 ft. Borehole LADP-5 was plugged and abandoned. Borehole LADP-4, located in DP Canyon north of wells R-64 and R-65, was drilled to a total depth of 800 ft and did not encounter perched groundwater. Data obtained at boreholes LADP-4 and LADP-5 indicate that Cerros del Rio lavas do not extend far enough to the west to be encountered at wells R-64 and R-65 and that perched water associated with basalts is unlikely at the two proposed wells. Perched groundwater might occur above permeability barriers within the stratified deposits of the Puye Formation. Perched water of this type occurs at well R-7, located in Los Alamos Canyon southwest of the R-64 and R-65 locations (Figure 1). South and southwest of wells R-64 and R-65, perched groundwater occurs in Los Alamos Canyon at wells LADP-3 and LAOI(A)-1.1 in the Guaje Pumice Bed. Flow in these groundwater occurrences appears to be controlled by the Guaje Pumice Bed that dips southward away from TA-21. This conclusion is supported by observations that deep boreholes on DP Mesa did not encounter perched groundwater in the Guaje Pumice Bed. Drilling at wells R-64 and R-65 will be halted at a depth of 1159 ft, approximately 100 ft above the regional aquifer, to evaluate whether perched groundwater occurs above or within the Guaje Pumice Bed or the Puye Formation.

Potential Groundwater Occurrence and Detection (cont.)	*Regional Groundwater:* In wells R-64 and R-65 the regional groundwater is expected to occur at a depth of 1259 ft, within Miocene pumiceous sediments of the upper Santa Fe Group. Methods for groundwater detection may include drillers' observations, water-level measurements, borehole video, and borehole geophysics.
Core Sampling	No core collection or sampling is planned.
Perched Groundwater Screening Sampling	Groundwater screening samples will be collected during drilling if perched groundwater is encountered in the vadose zone and if such zones produce sufficient water for sampling. Screening samples of perched groundwater will be analyzed for cations/metals (dissolved and total) and anions (dissolved) by the Earth and Environmental Sciences Division's Geochemistry and Geomaterials Research Laboratory and for tritium by off-site laboratories.
Regional Groundwater Characterization Sampling	Groundwater samples will be collected from the completed wells between 10 and 60 d after well development, in accordance with the Compliance Order on Consent. These samples will be analyzed for the full suite of constituents including radionuclides, metals/cations, general inorganic chemicals, high explosives, volatile organic compounds, and stable isotopes. Subsequent groundwater samples will be collected according to guidance in the Laboratory's Interim Facility-Wide Groundwater Monitoring Plan (LANL 2010, 109830).
Geophysical Testing	The Laboratory's borehole video camera and 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 well screens. The logs will be collected by Schlumberger, Inc. For open-hole conditions, the logs will include accelerator porosity sonde (neutron porosity), array induction, combined magnetic resonance, natural and spectral gamma, and formation micro-imager 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 define the top of regional saturation and to characterize the hydraulic properties of saturated rocks in the regional aquifer. The suites run and timing of geophysical logging will depend on borehole conditions.
Well Completion Design	Figures 2 and 3 show the conceptual well designs for wells R-64 and R-65, respectively.
Well Development	The wells 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 clay minerals introduced as annular fill 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). • If it is not possible to bring the water-quality parameters within measurement limits specified below, the use of chemical well development may be discussed with NMED. No chemicals will be added without approval from NMED.

Well Development (cont.)	• Chemicals that may be used include the addition of sodium acid pyrophosphate and AQUA-CLEAR PFD to remove clay minerals 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 Testing	Hydraulic testing will be deferred until both R-64 and R-65 are installed. The need for hydraulic testing and the test configuration will be based on hydrogeologic conditions encountered during drilling.
Investigation-Derived Waste Management	Investigation-derived waste (IDW) will be managed in accordance with standard operating procedure (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 Laboratory requirements. The primary waste streams will include drill cuttings, drilling water, development water, purge water, decontamination water, and contact waste. 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 (November 2006). 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 for 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 d 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 R-64 will be completed by July 15, 2011. The final location for well R-65 will be selected and the drill pad prepared after water levels at the completed R-64 well are allowed to stabilize for a month. Rapid turnaround groundwater analyses collected after well development may also be used to select the R-65 well location. The approximate completion date for R-65 is September 30, 2011.

REFERENCES

The following list includes all documents cited in this plan. Parenthetical information following each reference provides the author(s), publication date, and ER ID. This information is also included in text citations. ER IDs are assigned by the Environmental Programs Directorate's Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the master reference set.

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau and the 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), June 2010. "2010 Interim Facility-Wide Groundwater Monitoring Plan," Los Alamos National Laboratory document LA-UR-10-1777, Los Alamos, New Mexico. (LANL 2010, 109830)

NMED (New Mexico Environment Department), December 2, 2010. "Approval with Modifications, Technical Area 21 Monitoring Well Network Evaluation and Recommendations," New Mexico Environment Department letter to G.J. Rael (DOE-LASO) and M. Graham (LANL) from J.P. Bearzi (NMED-HWB), Santa Fe, New Mexico. (NMED 2010, 111462)

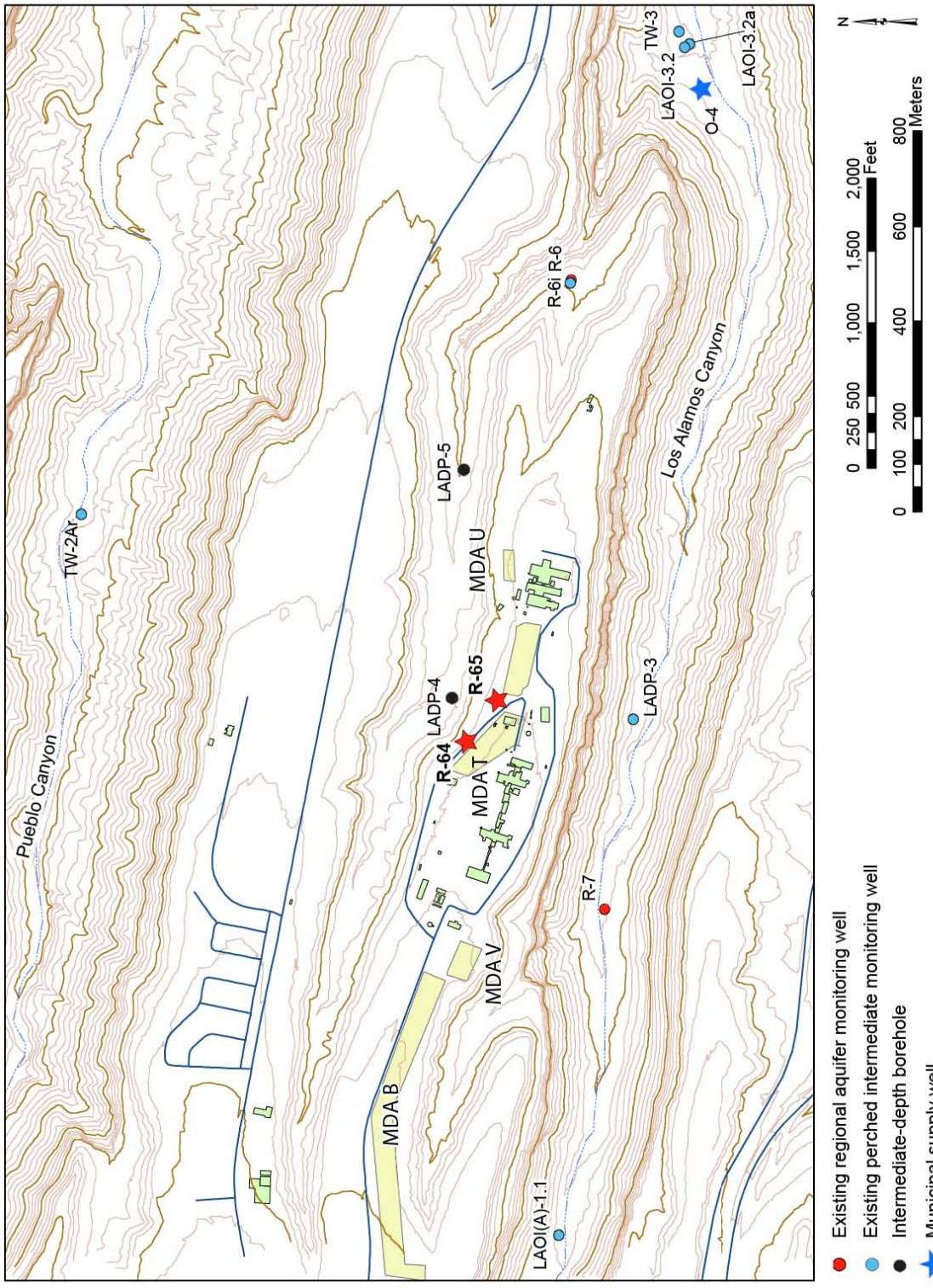

Figure 1 Proposed locations for wells R-64 and R-65

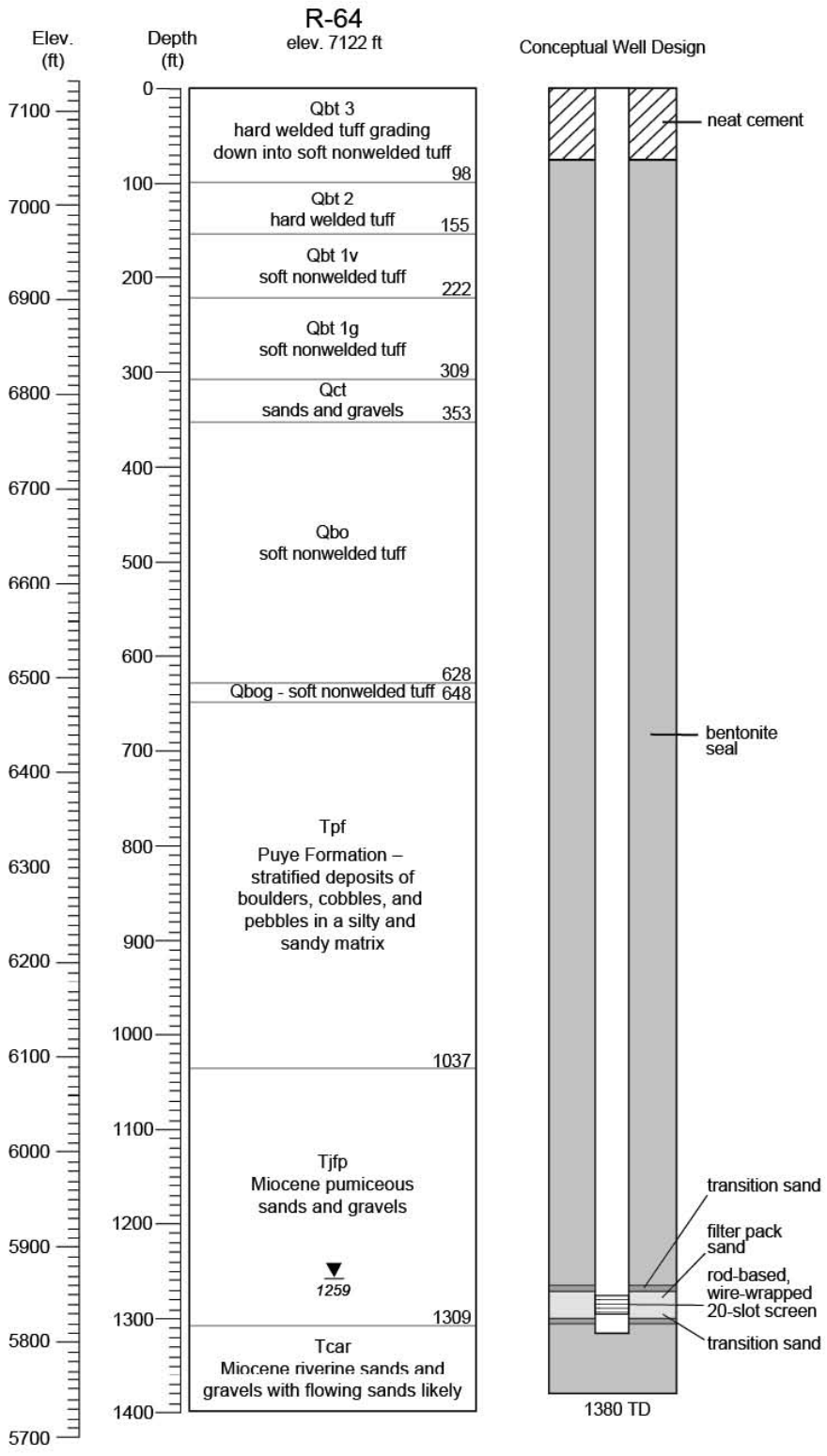

Figure 2 Predicted geology and conceptual well design for well R-64

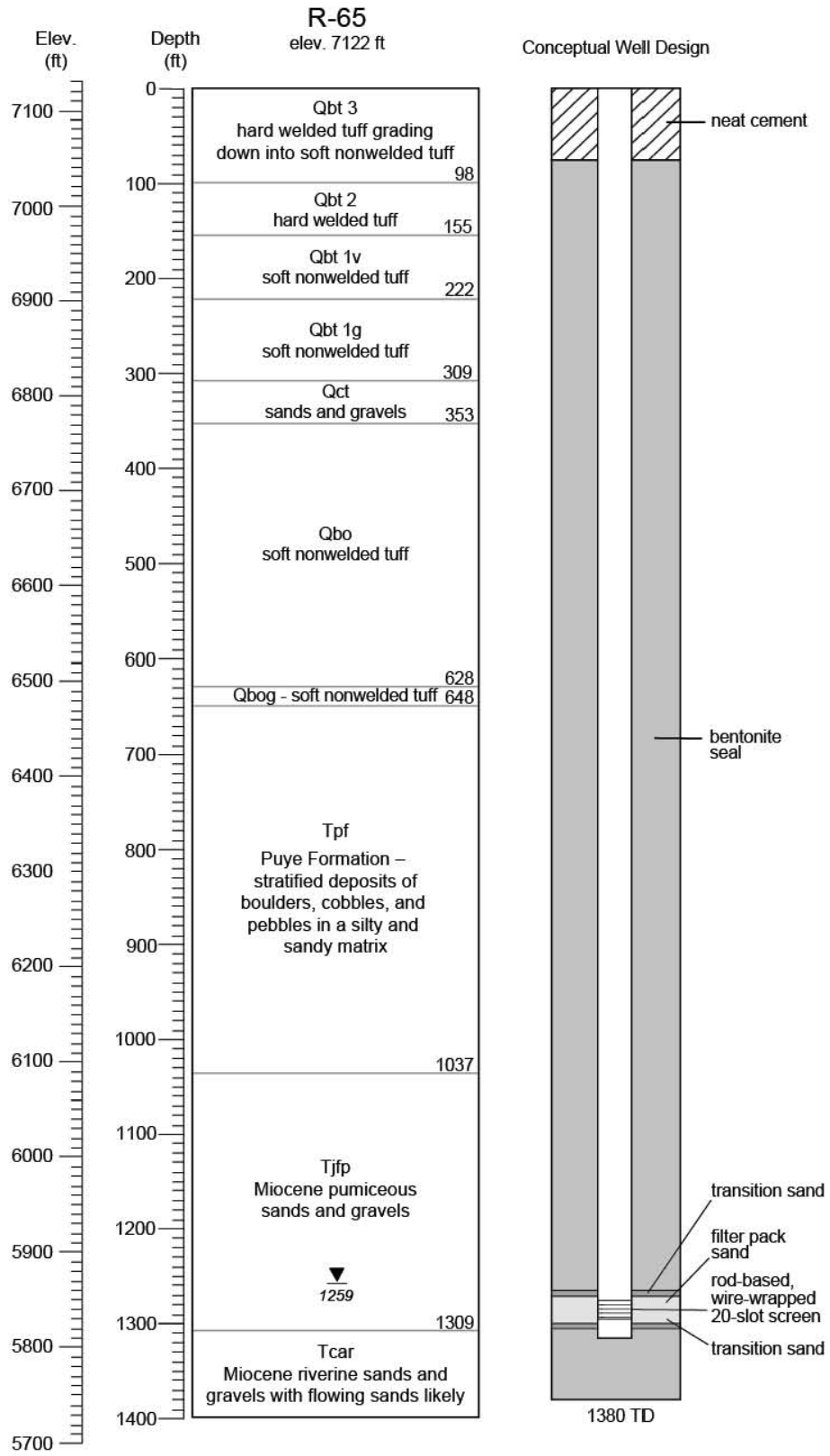

Figure 3 Predicted geology and conceptual well design for well R-65