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Work Plan for Hydrologic Testing of R-66

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EXECUTIVE SUMMARY

This work plan describes the following activities and hydrologic tests to be conducted at proposed regional aquifer well R-66.

- New regional aquifer monitoring well R-66 is planned for installation at a location near regional aquifer monitoring well TW-3 and municipal water-supply well O-4. The new well will be designed as a monitoring well to detect any contamination in the shallow section of the regional aquifer near well O-4. The new well will have a screen 20–30 ft below the regional water table.
- A single-hole step-drawdown test of brief duration will be conducted to define the pumping rate for the cross-hole constant rate pumping test, to measure the well's specific capacity, and to estimate the lower bound of hydraulic conductivity.
- A cross-hole constant rate pumping test will be conducted on R-66, during which pressure responses will be monitored in the pumping well and TW-3. The pumping test will be conducted for a minimum of 1 and up to 3 d, with possible pumping rates on the order of 20 gallons per minute, depending on the formation transmissivity.
- The estimates of hydraulic conductivity for aquifer properties near R-66 and TW-3 will be compared based on the cross-hole pumping and single-hole tests.
- An evaluation will be made of the comparability of hydraulic conductivity estimates from specific capacity, single-hole, and cross-hole pumping tests conducted across Los Alamos National Laboratory.

CONTENTS

1.0 INTRODUCTION

New regional monitoring well R-66 is planned for installation at a location near regional aquifer monitoring well TW-3 and municipal water-supply well O-4. The new well will be designed as a monitoring well to detect any contamination in the shallow section of regional aquifer near well O-4. This work plan proposes hydrologic testing to collect additional data on properties of the shallow portion of the regional aquifer near municipal water-supply well O-4. Figure 1.0-1 shows the location of water-supply well O-4 and monitoring wells nearby including TW-3 and the proposed location for R-66.

This work plan provides details regarding proposed hydrologic tests to be conducted at the site and was developed to meet the requirements of the New Mexico Environment Department's (NMED's) Approval with Modifications for the Drilling Work Plan for Regional Well R-66 (Test Well 3r) (NMED 2011, 201630) and an email of clarification (Dale 2011, 206375).

The hydrologic tests described in this work plan are designed to provide a better understanding of the shallow regional aquifer near municipal water-supply well O-4 and to collect field-scale measurements of hydrogeologic properties based on single-hole and cross-hole pumping tests. These properties include formation transmissivity and storage coefficient as well as the relative degree of interconnectivity between the deep and shallow regional aquifer systems. Results from these tests will be used as a basis of comparison to evaluate the applicability of single-well pumping tests conducted on the other wells at Los Alamos National Laboratory (LANL).

Section 1 of this work plan provides background information. Section 2 presents an updated conceptual model and summarizes available hydrologic data for the test site. Section 3 provides the details for the proposed testing, including the location and design of the test well and a description of the aquifer testing to be conducted. A schedule for the proposed activities is presented in section 4, and references are provided in section 5.

2.0 CONCEPTUAL MODEL

The shallow section of the regional aquifer in the vicinity of the regional water-supply well O-4 is predominantly unconfined, with the water table located within Miocene sedimentary rocks that include axial riverine deposits and Jemez alluvial fan deposit. Because these sedimentary deposits are interbedded, they are combined as a single unit (Tcar) in the sitewide geologic framework model. Most regional monitoring wells near O-4 have screens installed near the regional water table. Water levels in regional monitoring wells near O-4 show little influence from transient effects of deeper water-supply pumping at O-4 and the other municipal wells nearby. The water level at TW-3 does not appear to be affected by the transients in the water-supply pumping at O-4 despite the two wells being separated by a distance of only 407 ft (LANL 2006, 091450). The TW-3 water level seems to have been declining at a constant rate of 0.8 ft/yr since 1992 (Koch and Schmeer 2010, 201566). The nonpumping water level at O-4 is relatively steady without any long-term decline (Koch and Schmeer 2011, 201566). The cause for the TW-3 water-level decline is uncertain. In addition, the regional water level at TW-3 is about 15 ft higher than the O-4 water level, suggesting vertical hydraulic disconnection between the shallow and the deep section of the regional aquifer.

The deep section of the regional aquifer pumped by O-4 appears to be confined. The total thickness of the regional aquifer near O-4 is not known. O-4 is pumping groundwater through a 1460-ft-long screen placed within the Miocene sediments (Tcar), but thick Miocene basalts occur just below the top of the screen. The top of the well screen is about 300 ft below the regional water table.

A water-table map of the regional aquifer near O-4 is presented in Figure 2.0-1. The water-table contours indicate groundwater generally flows from west to east upgradient of O-4. The flow directions downgradient of O-4 are uncertain and potentially influenced by local recharge along Los Alamos Canyon.

The data summarized in Table 2.0-1 reflect localized hydraulic properties in the vicinity of the wells tested. Field-scale hydraulic properties of the regional aquifer near O-4 based on cross-well drawdown responses between pumping and observation wells have not been estimated. The multiwell tests proposed between R-66 and TW-3 of this work plan will provide field scale measurements of aquifer transmissivity and storage coefficient.

3.0 FIELD-TEST DESIGN

One of the primary objectives of the aquifer tests is to characterize the hydrogeologic properties of the shallow portion of the regional aquifer near regional water-supply well O-4. The aquifer tests will allow estimation of the large-scale hydraulic conductivity and storage coefficient (specific yield) of the regional aquifer. The hydrogeologic information collected at R-66 may also provide information on the vertical hydraulic connectivity between the deep and the shallow sections of the regional aquifer based on the water-level fluctuations at R-66 and their correlation to the water-supply pumping at O-4.

The proposed R-66 pumping well location, shown in Figure 1.0-1, is east of the regional water-supply well O-4. This location was selected because of the area’s topography and the location of existing infrastructure. Pressures will also be monitored at wells R-6, R-4, and R-8 during the test, but these wells are probably too far from R-66 (more than 1400 ft) to produce a measurable response to pumping.

Well R-66 will be drilled up to a depth of 900 ft below ground surface (bgs) with a goal to place a 20-ft-long screen submerged about 20 ft below the regional water table. At the R-66 location, the regional water table is expected to be about 800 ft bgs. Drilling will be performed using fluid-assisted air-rotary drilling methods. Drilling fluids will include municipal water and AQF-2 foam to a depth of 700 ft; an attempt will be made to use only municipal water for circulation below 700 ft to minimize the effects of drilling fluids on the groundwater chemistry and formation hydraulic properties. Surface casing will be installed to a depth of 700 ft; however, an attempt will be made to drill open hole to 450 ft so the perched groundwater zone can be characterized by open-borehole 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.

Characterization of R-66 will include a lithologic log prepared from drill cuttings, water-level measurements in the borehole during drilling and in the completed well, groundwater samples collected during well development, driller’s observations about drilling conditions and water production, borehole video and geophysical logs, and aquifer tests conducted in the completed well. Details of these characterization activities were included in a separate drilling work plan submitted for well R-66 (LANL 2011, 111601).

R-66 will be constructed as a 5-in.-inside-diameter stainless-steel well with one 20-slot, wire-wrapped well screen, 20 ft in length. The screen will be located near the top of regional saturation in the Miocene deposits. The depth of the well screen will be selected based on characterization data collected during drilling. The scope of work included in this work plan includes evaluating the aquifer properties with a step-drawdown test, results from the pumping well, results from observation wells, and comparison of these results with aquifer parameters estimated from other single well tests conducted at LANL.

3.1 Specific Capacity Test

A single-hole step-drawdown test will be performed at R-66 before the cross-hole pumping test is conducted. The test will include up to three pumping periods (steps) performed at a series of different pumping rates depending on the formation transmissivity. The pumping rates will be increased progressively, starting will the lowest pumping rate on the order of 3 to 5 gallons per minute (gpm). The pumping rate at the final stage will utilize the maximum pumping rate that can be produced by the pump and the screened formation. The test will be applied to define the optimum pumping rate for the cross-hole constant rate pumping test, The test data will be used to measure the well's specific capacity and to estimate the lower bound of hydraulic conductivity.

3.2 Cross-Hole Pumping Test

The design of the pumping tests is based on the following assumptions about the hydrogeological properties of the regional aquifer.

- Hydraulic conductivity estimates for the regional aquifer near O-4 range between 5 and 60 ft/d (Table 2.0-1).
- The specific storage of the regional aquifer is not known. A range of storage coefficient values characterizing different flow conditions (S = 0.003 and 0.0003) was used to evaluate the range of possible drawdown responses during the proposed pumping tests.
- The total thickness of the shallow portion of the regional aquifer is about 100 ft (~30 m).
- Transmissivity of the shallow portion of the regional aquifer is assumed to be 500 ft^2/d based on conservative (lower) hydraulic conductivity and saturated-thickness estimates.
- Based on the well diameter, a pump with capacity of up to 30 gpm can be used during the pumping test. The goal during the pumping tests is to maintain pumping drawdown above the well screen at R-66. The actual pumping rate will be selected based on the local aquifer properties encountered at the well. The analyses below assume that the pumping will be conducted at rate of 20 gpm.

Pumping drawdowns are predicted below based on these assumptions and applying a Theis analytical solution for a confined, uniform, and isotropic infinite aquifer (Freeze and Cherry 1979, 088742). The Theis solution may not be representative of the actual hydrogeologic conditions but provides an approximate estimate of the expected groundwater flow conditions during the pumping test.

The predicted drawdown versus time curves at distances 0.3048, 6.096, and 60.96 ft from the pumping well are shown in Figures 3.2-1 and 3.2-2 for two different specific yield values, respectively. The predicted drawdown versus distance from the pumping well curves after 1, 3, and 10 d of pumping are shown in Figures 3.2-3 and 3.2-4. As the storage coefficient value decreases (i.e., approaches unconfined values), the radius of influence is diminished. The figures suggest that 1 d of pumping may not be sufficient to cause drawdown responses at TW-3. The projected drawdown calculations indicate that up to a 3-d pumping test may be sufficient to produce drawdown responses at TW-3. The predicted pumping drawdowns and the design of the pumping test will be reevaluated based on the hydrogeological observations made during drilling and development of R-66.

Because of the lateral distances between R-66 and the other nearby monitoring wells, pumping drawdowns during testing are expected at TW-3 only. Pressures will also be monitored at well R-6, R-4, and R-8, but these wells are probably too far from R-66 (more than 1400 ft) to produce a measurable response to pumping.

3.3 Comparison of Results with Other Pumping Tests at LANL

In general, the specific capacity and single-hole pumping tests provide information about the local hydrodynamic properties of the aquifer in close vicinity of the pumped screen. Typically it is assumed the hydraulic conductivity estimates from single-hole pumping tests are representative of aquifer properties within about 10 ft around the tested screen. The cross-hole pumping tests provide information about hydrodynamic properties of the aquifer in the area between the pumped and monitored screens. In this way, the cross-hole pumping tests yield potentially more information on the large-scale aquifer properties (Freeze and Cherry 1979, 088742). In addition, most of the regional aquifer screens respond to water-supply pumping. The observed pressure transients can be correlated with the pumping transients. The collected transient data can be viewed as a series of cross-hole pumping tests where the municipal wells are the pumping wells and the monitoring wells and the observation wells. These cross-hole pumping tests also provide estimates of the large-scale aquifer properties (Harp and Vesselinov 2010, 111220).

The report summarizing the result of the pumping test will present a comparison between estimates of hydrodynamic properties of the aquifer obtained based on (1) specific capacity tests (2) short-term single-hole pumping tests, (3) long-term cross-hole pumping, and (4) pressure transients from transients in the water-supply pumping. The data will be presented for the monitoring wells in the study area: TW-3, R-66, R-6, R-4, and R-8. The comparisons will evaluate the comparability of hydraulic conductivity estimates from pumping tests conducted across LANL.

4.0 SCHEDULE

The proposed pumping test well R-66 is scheduled to be completed by October 30, 2011, consistent with NMED's letter of September 12, 2011, approving LANL's proposed request to change the R-65 and R-66 completion schedules (LANL 2011, 206229; NMED 2011, 206381). The activities proposed in this work plan will be completed by November 30, 2011 followed by a stand-alone report to be submitted by February 29, 2012.

5.0 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.

Dale, M., August 29, 2011. RE: R-66 testing work plan question. E-mail message to M. Everett (LANL) from M. Dale (NMED), Santa Fe, New Mexico. (Dale 2011, 206375)

Freeze, R.A., and J.A. Cherry, January 1979. *Groundwater*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey. (Freeze and Cherry 1979, 088742)

Harp, D.R., and V.V. Vesselinov, June 2010. "Identification of Pumping Influences in Long-Term Water Level Fluctuations," *Ground Water,* online publication, pp. 1-12. (Harp and Vesselinov 2010, 111220)

Koch, R.J., and S. Schmeer, March 2011. "Groundwater Level Status Report for 2010, Los Alamos National Laboratory," Los Alamos National Laboratory report LA-14437-PR, Los Alamos, New Mexico. (Koch and Schmeer 2010, 201566)

LANL (Los Alamos National Laboratory), January 2006. "Investigation Report for the TA-16-340 Complex [Consolidated Units 13-003(a)-99 and 16-003(n)-99 and Solid Waste Management Units 16-003(o), 16-026(j2), and 16-029(f)]," Los Alamos National Laboratory document LA-UR-06-0153, Los Alamos, New Mexico. (LANL 2006, 091450)

LANL (Los Alamos National Laboratory), January 2011. "Drilling Work Plan for Test Well 3r (R-66)," Los Alamos National Laboratory document LA-UR-11-0184, Los Alamos, New Mexico. (LANL 2011, 111601)

LANL (Los Alamos National Laboratory), September 2, 2011. "Proposed Exchange in the R-65 and R-66 Schedules," Los Alamos National Laboratory letter (EP2011-0301) to J. Kieling (NMED-HWB) from M.J. Graham (LANL) and G.J. Rael (DOE-LASO), Los Alamos, New Mexico. (LANL 2011, 206229)

NMED (New Mexico Environment Department), March 31, 2011. "Approval with Modifications, Drilling Work Plan for Regional Well R-66 (Test Well 3r)," New Mexico Environment Department letter to G.J. Rael (DOE-LASO) and M.J. Graham (LANL) from J.P. Bearzi (NMED-HWB), Santa Fe, New Mexico. (NMED 2011, 201630)

NMED (New Mexico Environment Department), September 12, 2011. "Approval, Proposed Exchange in the R-65 and R-66 Schedules," New Mexico Environment Department letter to G.J. Rael (DOE-LASO) and M.J. Graham (LANL) from J.E. Kieling (NMED-HWB), Santa Fe, New Mexico. (NMED 2011, 206381)

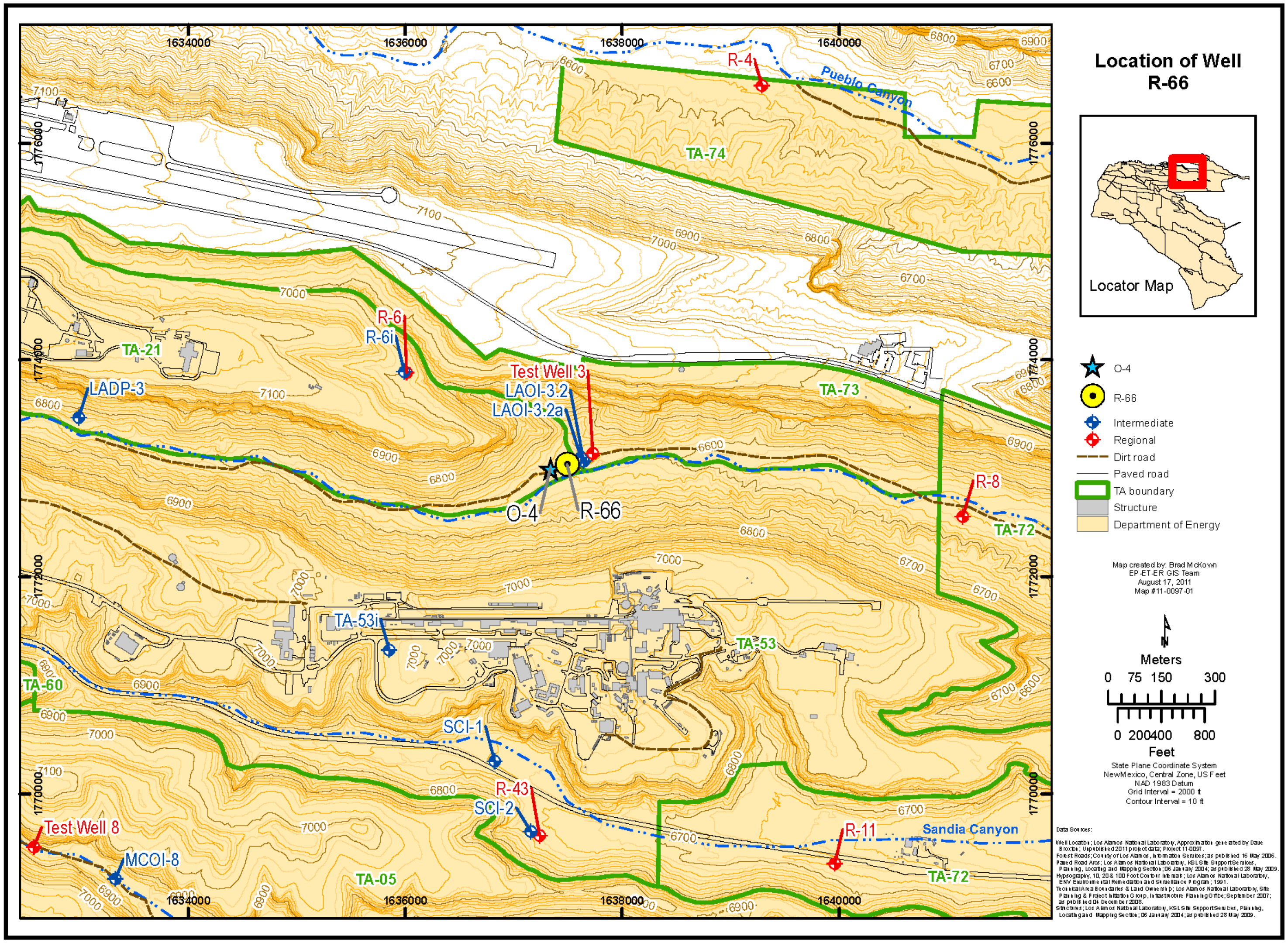

Figure 1.0-1 Location of regional water-supply well O-4 and nearby monitoring wells, including TW-3, and proposed location for well R-66

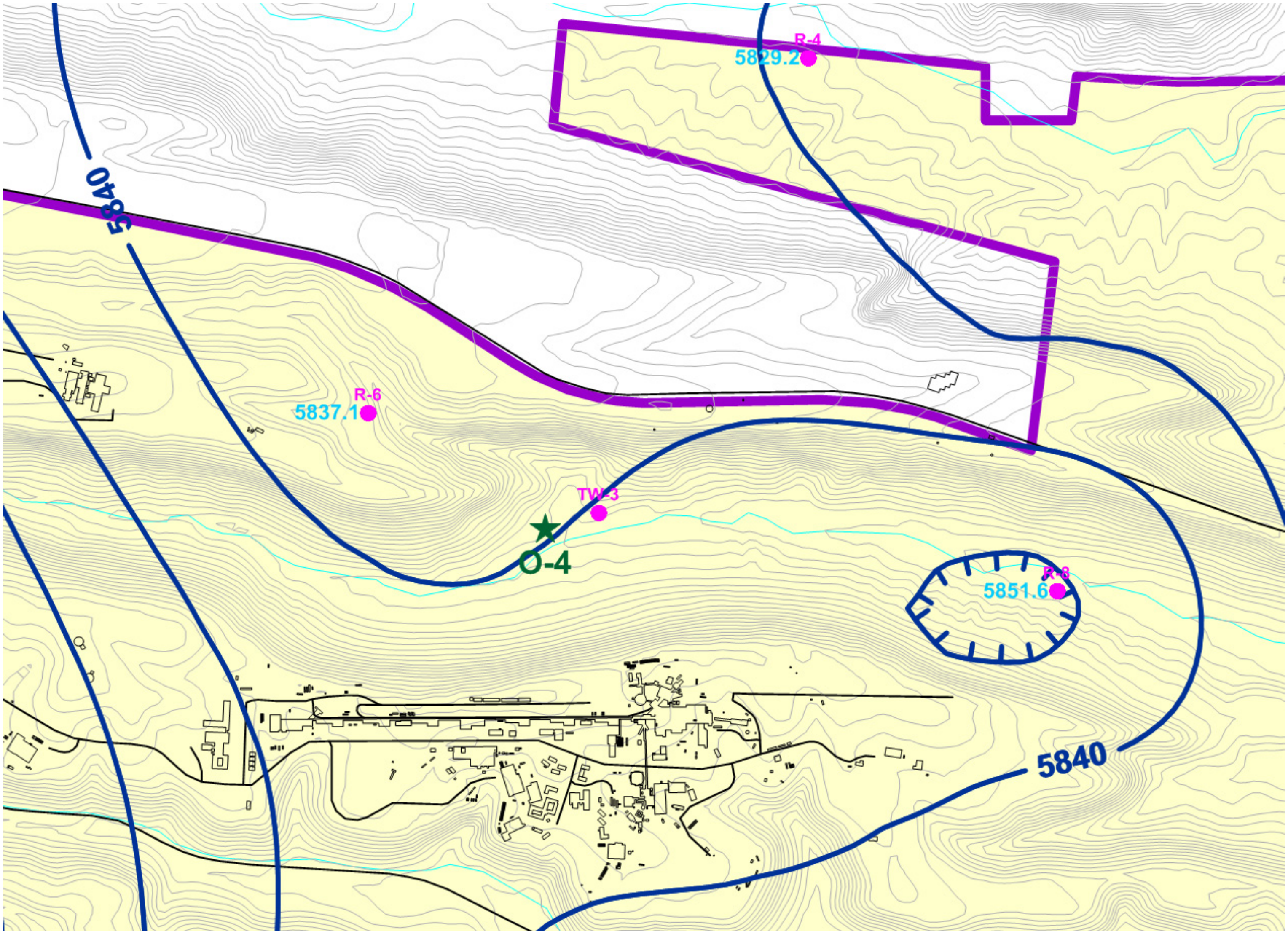

Figure 2.0-1 Water table map of the regional aquifer near O-4 based on February 2011 water-level data collected at the shallowest screens of the regional monitoring wells

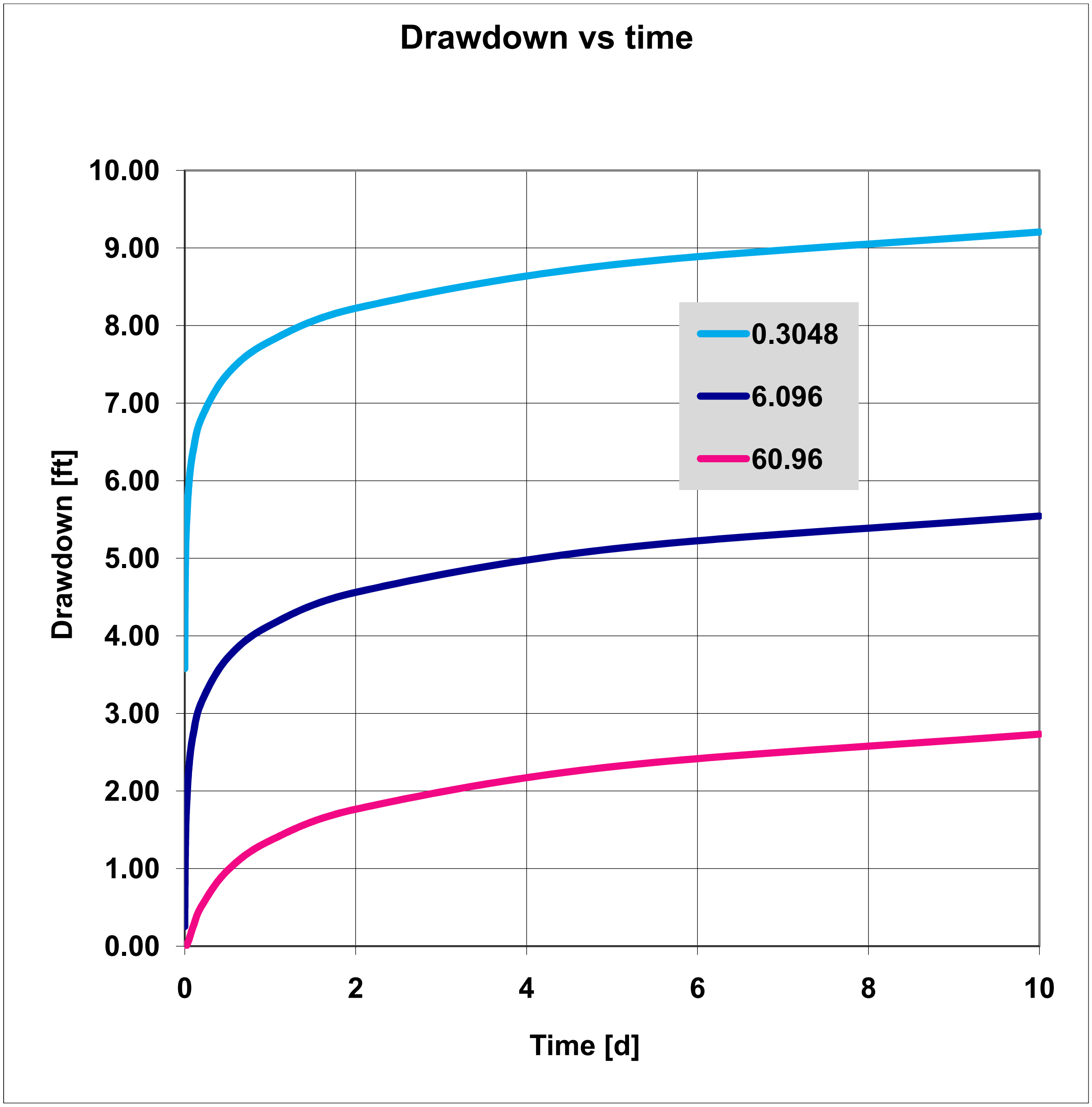

Figure 3.2-1 **Predicted drawdown versus time at distances 0.3048, 6.096, and 60.96 ft from the pumping well based on Theis analytical solution. The "0.3048 ft" curve represents approximately the expected drawdown at the pumping well. Model parameters: pumping rate Q = 20 gpm, transmissivity T = 500 ft^2/d, storage coefficient S = 0.003.**

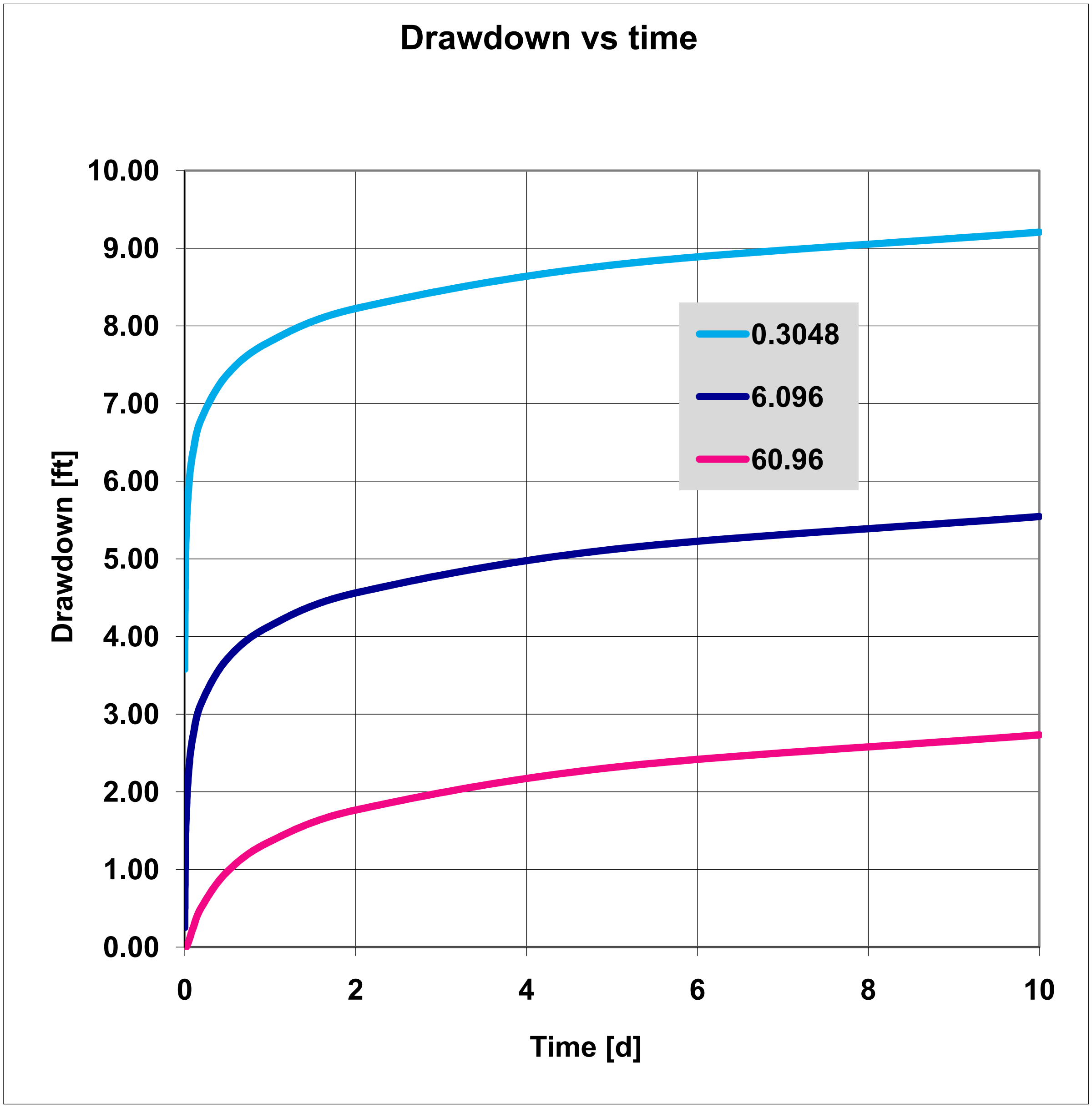

Figure 3.2-2 Predicted drawdown versus time at distances 0.3048, 6.096, and 60.96 ft from the pumping well based on Theis analytical solution. The "0.3048 ft" curve represents approximately the expected drawdown at the pumping well. Model parameters: pumping rate Q = 20 gpm, transmissivity T = 500 ft^2/d, storage coefficient S = 0.0003.

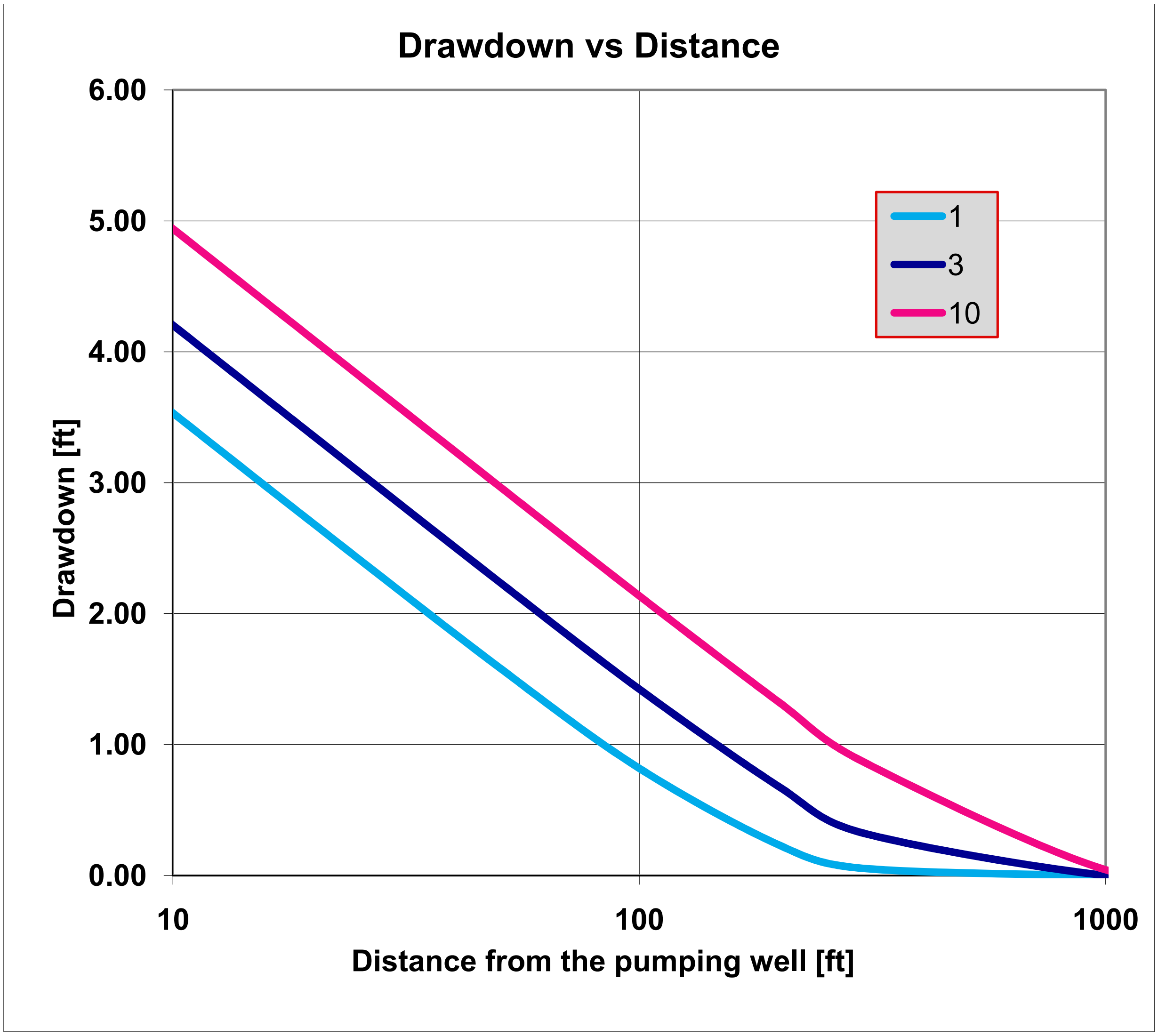

Figure 3.2-3 **Predicted drawdown versus distance from the pumping well 1, 3, and 10 d after the pumping test commenced based on Theis analytical solution. Model parameters: pumping rate Q = 20 gpm, transmissivity T = 500 ft^2/d, storage coefficient S = 0.003.**

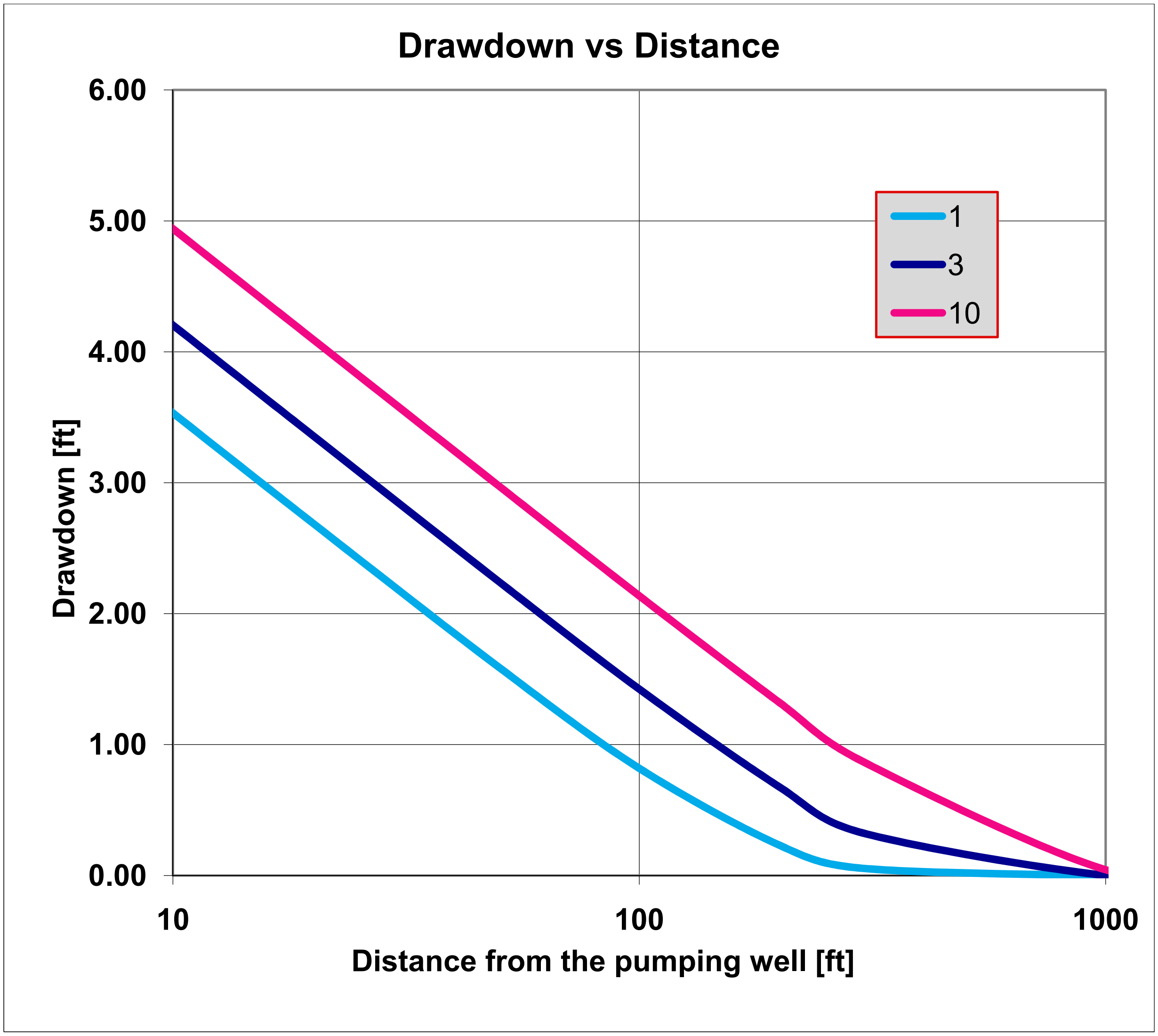

Figure 3.2-4 Predicted drawdown versus distance from the pumping well 1, 3, and 10 d after the pumping test commenced based on Theis analytical solution. Model parameters: pumping rate Q = 20 gpm, transmissivity T = 500 ft^2/d, storage coefficient S = 0.0003.

Table 2.0-1
Hydraulic Conductivity Estimates
for Regional Monitoring Wells
in the Vicinity of Water-Supply Well O-4

Well	Geologic Unit	k [ft/d]
TW-3	Tcar	No test
R-1	Tjfp	5
R-4	Tpf	12
R-6	Tcar	60
R-7	Tjfp	No test
R-8	Tcar	No test
R-43	Tcar	10