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DEPARTMENT OF ENERGY
Environmental Management Los Alamos Field Office (EM-LA)
Los Alamos, New Mexico 87544

EMLA-2021-BF152-02-001 August 27, 2021

Mr. Ricardo Maestas
Acting Bureau Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505-6313

Subject: Submittal of the Aquifer Testing Guidance for the Los Alamos National Laboratory Site and the Aquifer Testing Plans for R-71 and R-72

Dear Mr. Maestas:

Enclosed please find two hard copies with electronic files of the “Aquifer Testing Guidance for the Los Alamos National Laboratory Site,” the “R-71 Aquifer Testing Plan,” and the “R-72 Aquifer Testing Plan.” These documents are being submitted to satisfy requirements listed in two New Mexico Environment Department (NMED) letters, “Amended Approval Letter for Drilling Work Plan for Chromium Groundwater Project Regional Aquifer Monitoring Well R-71” and “Amended Approval Letter for Drilling Work Plan for Chromium Groundwater Project Regional Aquifer Monitoring Well R-72,” both dated November 3, 2020. In addition to addressing certain technical topics that are beyond the scope of this submittal, each of these letters required the submittal of “a detailed aquifer performance testing plan” for the subject well. Additionally, the May 25, 2021, NMED letter, “Notice of Disapproval, Completion Report for Regional Aquifer Well R-70, Revision 1, and the Response to the New Mexico Environment Department’s Draft Comments on the Completion Report for Regional Aquifer Well R-70” stated:

> “NMED requires DOE to submit a Standard Operating Procedure (SOP) that will serve as the basis for future aquifer testing workplans. The SOP will be reviewed for comment (but not approval) by NMED and EPA and their contractors prior to receiving a work plan to conduct the next aquifer test. Because testing duration, goals and conditions may vary by future aquifer tests, NMED requires a specific workplan for each aquifer test.”

The procedure, which is called a guidance document in this submittal, provides generic field testing and analysis guidance applicable to all aquifer tests accompanying the drilling of new groundwater wells. The enclosed testing plans for R-71 and R-72 specify the testing procedures unique to these wells, such as water level measurements at nearby monitoring wells and other testing details.

The U.S. Department of Energy (DOE) Environmental Management Los Alamos Field Office (EM-LA) respectfully requests that a technical meeting be held at NMED’s earliest convenience to discuss the “Aquifer Testing Guidance for the Los Alamos National Laboratory Site,” so that issues raised in the notice of disapproval are vetted and resolved.

If you have any questions, please contact Bruce Robinson (505) 309-1361 (bruce.robinson@em-la.doe.gov) or Cheryl Rodriguez at (505) 414-0450 (cheryl.rodriguez@em.doe.gov).

Sincerely,

ARTURO
DURAN

Digitally signed by ARTURO
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Arturo Q. Duran
Compliance and Permitting Manager
Environmental Management
Los Alamos Field Office

Enclosure(s): Two hard copies with electronic files –

1. Aquifer Testing Guidance for the Los Alamos National Laboratory Site (EM2021-0481)
2. R-71 Aquifer Testing Plan (EM2021-0480)
3. R-72 Aquifer Testing Plan (EM2021-0395)

cc (letter and enclosure[s] emailed):
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Cc: Dhawan, Neelam, NMENV; Briley, Siona, NMENV; Krambis, Christopher, NMENV; Catechis, Chris, NMENV; Petersen, Michael, NMENV; Martinez, Cynthia, NMENV; Emily M. Day; Regulatory Documentation; cheryl.rodriguez@em.doe.gov; Bruce A. Robinson; Danny Katzman; Christian T. Maupin
Subject: RE: Submittal to NMED on 8/27/2021 of Aquifer Testing Guidance and R-71 and R-72 Testing Plans

Hello Ms. Maestas.
I acknowledge receipt of your email and the attached document.
Thank you.

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Subject: Submittal to NMED on 8/27/2021 of Aquifer Testing Guidance and R-71 and R-72 Testing Plans

Mr. Maestas,
Attached for submittal is a pdf file of the following:

- Submittal of the Aquifer Testing Guidance for the Los Alamos National Laboratory Site and the Aquifer Testing Plans for R-71 and R-72 (EMLA-2021-BF152-02-001, letter and enclosures)

Please acknowledge receipt of this submittal by responding to this email. Hard copies will be taken to you Monday.
Let me know if you have any questions.
Thank you.

Pamela T. Maestas
Regulatory Documentation Manager
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August 2021
EM2021-0481

Aquifer Testing Guidance for the Los Alamos National Laboratory Site

Aquifer Testing Guidance for the Los Alamos National Laboratory Site

August 2021

Responsible program director:

Steve Veenis	Steve Veenis	T2S Program Director	Water Program	8/19/21
Printed Name	Signature	Title	Organization	Date

Responsible N3B representative:

Troy Thomson	For	Acting Program Manager	N3B Environmental Remediation Program	8/19/21
Printed Name	Signature	Title	Organization	Date

Responsible DOE EM-LA representative:

Arturo Q. Duran	ARTURO DURAN Digitally signed by ARTURO DURAN Date: 2021.08.26 16:49:49 -06'00'	Compliance and Permitting Manager	Office of Quality and Regulatory Compliance	
Printed Name	Signature	Title	Organization	Date

CONTENTS

1.0 INTRODUCTION

This guidance document summarizes aquifer testing approaches planned for newly constructed monitoring, extraction, or injection wells at Los Alamos National Laboratory (LANL or the Laboratory). Hydraulic testing will be performed to obtain site-specific information on the hydraulic properties of aquifer materials. Information obtained from pumping tests will add to the understanding of the flow system and contribute to ongoing site modeling in support of groundwater characterization and modeling, contaminant plume migration prediction, and where applicable, groundwater remediation via extraction and injection wells.

This document is applicable to all sampling, extraction, and injection wells drilled at the Laboratory and will be used in conjunction with separate well-specific plans. This document outlines methods and procedures common to all tests and applies generally to intermediate or regional aquifer wells across the LANL site. As individual wells are tested, well-specific plans will be customized with detailed information pertinent to the specific subject well.

The Laboratory site has unique challenges not seen at most other environmental sites around the country. In most typical hydrogeologic settings, contaminants are relatively shallow and the aquifers are both shallow and relatively thin. This often makes it possible to install fully penetrating test wells and cost effectively provide numerous observation wells near the pumped well that exhibit significant drawdown response to pumping and thoroughly define the resulting cone of depression caused by pumping. Hydraulic testing in these environments can provide a solid, definitive data set that supports substantial and accurate determination of local aquifer properties.

The hydrogeologic setting at the Laboratory is more complex, consisting of occurrences of intermediate groundwater zones within the vadose zone, and a regionally extensive aquifer beneath the site with a thickness of 2000 to 3000 ft or greater. As such, the zone of influence of a pumping well in the regional aquifer (defined as the three-dimensional volume around the well, laterally and vertically, that is affected by pumping) expands great distances vertically throughout testing.

In addition, the sediments are highly heterogeneous as well as anisotropic, both vertically and horizontally, resulting in a complex and irregular cone of depression in response to pumping. Also, the mandated well designs typically incorporate very short well screens so that any given test is concentrated on just a tiny portion of the aquifer rather than a substantial, more representative thickness.

These unique site conditions can create challenges by complicating pumping test data sets and interpretation compared with that from other, typical aquifers of more limited depth. Nevertheless, proper implementation of hydraulic testing and data analysis can contribute to obtaining worthwhile hydraulic information about the site.

Useful outcomes associated with performing aquifer tests in either the intermediate or regional aquifers at the Laboratory can include the following:

- Information on the productivity of a well and achievable pumping or injection rates
- Information on local sediment permeability in the vicinity of the pumped well to add to a larger picture, such as a groundwater model or overall assessment of hydraulic properties in a particular area
- Development of an understanding of the relationship between geology/lithology and permeability
- Determination of aquifer properties over a broader scale wherever observation wells are available for monitoring during aquifer testing

- Determination of the degree of interconnection between the pumped well and observation wells at various locations throughout the area

2.0 GENERAL APPROACH

Constant-rate testing will be used to obtain an analyzable data set. The testing program will include (1) pretest water-level stabilization, (2) brief trial or step drawdown testing, (3) background data collection, (4) extended constant-rate testing, and (5) water-level recovery monitoring. Data will be recorded throughout the test in the pumped well (both screens in dual-screen wells) and any nearby monitoring wells close enough to be used as observation wells, including existing monitoring wells and piezometers likely to be hydraulically connected to the pumped well, whenever they are available. For the duration of the testing effort, the data collection frequency in the observation wells will be increased from the standard 2-hr readings that are normally collected to a frequency sufficient to enable analysis and modeling of the transient response.

It is important to remove the effects of barometric pressure changes on the water levels measured at the site. Therefore, barometric pressure will be monitored throughout the testing process. Barometric pressure will be compared with the background response in the observation wells to determine a unique barometric correction factor for each observation well. Barometric pressure data will be monitored at the same frequency as that used in each of the observation wells in order to simplify the process of determining the appropriate correction factors and applying them.

The existing monitoring wells in the area are equipped with vented pressure transducers. Because the aquifer is highly barometrically efficient, the resulting hydrographs from these wells have large barometrically induced water-level fluctuations, likely several times greater than the drawdown at these distant locations that will be induced by test pumping. This highlights the importance of establishing an accurate data correction protocol to remove the barometric noise. The correction factors developed for these wells will consider both barometric efficiency and any linear background trend that may be present. In most cases, the measurement interval will not exceed 15 min.

In addition to barometric pressure effects, Los Alamos County production wells can influence some of the Laboratory wells. Hydrographs will be examined for these effects and correlated with production well run times obtained from the County.

The screen(s) in the pumped well will be monitored using In-Situ Level TROLL 700 non-vented pressure transducers(s) or equivalent and will likely need little or no correction for barometric pressure effects, particularly those zones that are nearly 100 percent barometrically efficient. The pressure rating of the specific transducers used will be selected based on well-specific water levels, screen depths, and anticipated pump equipment installation depth.

Barometric pressure will be monitored using a 30-psi In-Situ Level TROLL 700 non-vented pressure transducer or equivalent maintained on-site throughout the testing. The measurements of barometric pressure may be sensitive to the ambient temperature. In addition, transducers can be damaged by temperature extremes. Therefore, the transducer should be protected from severe temperature changes to the extent practical. To minimize temperature effects, the barometric transducer will be installed in an available observation well (i.e., non-pumping well) 10 to 20 ft below land surface.

During testing, water purged from the well will be stored in tanks on-site pending proper disposition. Water handling methods will be determined on a case-by-case basis for each well.

3.0 SPECIAL CONSIDERATIONS

Because of the unique hydrogeologic setting at the Laboratory, there are a number of stringent requirements that must be met in order to achieve the highest quality data set possible. Following is a discussion of these specific considerations.

3.1 Water-Level Stabilization

Because the drawdowns in local observation wells can often be minimal, it will be important to stabilize background water levels and minimize external fluctuations to the extent practicable so that induced drawdowns in the observation wells attributable to the pumping test do not get lost in the background noise.

Active pumping and injection occur continuously in the regional aquifer beneath the LANL site, potentially affecting pumping tests in that area. Any variability in system operation can affect observed levels in the observation wells. Likewise, pump development of the screen zones in the tested well is generally performed just before test pumping activities. Once development ceases, the local water levels rebound for several days in response to pump shutdown and can affect the pumped well and observation wells.

Reasonable efforts to optimize pumping test conditions will be made on a case-by-case basis by minimizing the effect of antecedent and concurrent pumping activities. Attempts will be made to run the extraction and injection system wells at constant rates for a prescribed period of time before and during the pumping test for wells that are tested in that area.

To minimize the effects of well development rebound, the start of the extended test will be delayed so that a prescribed minimum time has elapsed between the completion of development and the start of the extended test.

In addition, for dual-screened wells, ample time will be provided between tests on each screen so that nearly complete recovery from the first test has occurred before starting the second test.

3.2 Casing Storage

In ordinary pumping tests, casing storage effects limit the usefulness of early pumping and recovery data. When pumping starts, the casing begins to dewater, contributing to the discharge rate of the pump. As time goes on, casing contribution lessens and, therefore, aquifer contribution gradually increases asymptotically, resulting in a complex variable discharge rate. Recovery data are affected similarly as the casing refills following pump shutoff—rapidly at first and more slowly over time.

The time it takes for the casing storage effect to subside is significant. For example, when a typical 5-in. monitoring well at the Laboratory is pumping 5 gallons per minute (gpm) with 10 ft of drawdown, the casing storage effect can persist for as long as 20 min. Often, by the time storage effects can be ignored, the zone of influence has already expanded through a substantial and unknown thickness of the aquifer, hindering the ability to analyze the early drawdown response and early partial penetration effects.

To eliminate this casing storage effect and to prevent drainage, pumping tests will be performed with an inflatable packer above the pump to seal inside the casing between the water level and the top of the screen. In single-screen wells, a single packer will be used above the pump. In dual-screen wells, the upper screen test will incorporate two packers, one above the screen to eliminate storage effects, and one below it to isolate it from the lower screen. The lower screen test will require a packer above the screen to isolate it from the upper screen.

Storage effects can also be caused by inadvertently entraining air in the filter pack. This can occur if the pumping water level in the well is drawn below the top of the well screen at any time. If this happens, water in the filter pack above the top of the screen will drain, allowing air to become trapped outside the blank casing just above the screen. When test pumping begins, the trapped air expands in response to pressure reduction. Likewise, when pumping stops, the trapped air compresses as water levels recover. Even when an inflatable packer is used, the change in volume associated with air expansion and compression has the same storage effect as draining a similar volume of water from the well casing in a test conducted with no packer.

Because of this, care must be taken during both *well development* and *test pumping* to avoid pulling the pumping water level into the well screen at any time, as described in section 3.3.

There is one other subtle storage effect that can occur in the pumping tests. Most of the aquifer tests at the Laboratory have shown ample gas content in the pumped water—either naturally occurring or possibly an artifact of drilling with compressed air. This gas/air can accumulate near the well bore, or even inside the well where it can be trapped beneath the inflatable packer. Similar to trapped air in the filter pack, this accumulated gas can expand and contract during initial pumping and recovery, creating a small storage effect. There is little that can be done to overcome this problem. One option may be to deflate and reinflate the packer a short time before the pumping test to release any air that might be trapped just below the packer. However, this can introduce some noise in the data set and, in dual-screen wells, can allow unwanted crossflow to occur, also inducing transient fluctuations in groundwater heads.

3.3 Pumping Rate Selection and Initial Start-Up

The pumping rate for the test will be selected based upon the yield characteristics of the pumped zone, available pumping equipment in relation to the casing size, and pumped water handling, storage, and disposal constraints. In general, attempts will be made to maximize the discharge rate whenever possible so that changes in water levels over time, both in the pumped well and observation wells, can be maximized and distinguished from whatever background fluctuations may influence the data.

As stated above, care must be taken to avoid dewatering the top of the well screen at any time during both *development* and *testing*. The discharge rate will be controlled via a valve in the discharge line at the surface to prevent exaggerated drawdown. However, when the pump is first installed and started up, the valve will have no effect as the drop pipe begins to fill. Furthermore, because the pump operates initially against minimal head when the drop pipe is empty, the discharge rate on start-up is substantially greater than the nominal capacity of the pump. The combination of a greater start-up pumping rate and the inability to control it risks dewatering the well screen and filter pack depending on the pump specifications, yield characteristics of the aquifer, and available drawdown. Therefore, special care must be taken to avoid any possibility of dewatering the screen.

In some cases, development operations may provide sufficient information on well or screen-zone yield to aid the understanding of what pumping conditions would risk dewatering the well screen. It can be especially helpful to run a pressure transducer during well development to provide drawdown information for this purpose. If this type of information is available before test pumping, it can aid testing procedure planning to ensure full screen saturation at all times during test pumping activities.

In other cases, particularly if no transducer is run during development, there may be insufficient definitive information on well yield, drawdown, and specific capacity. For dual-screened wells, even if a transducer is run during development, there may be no way to distinguish the separate yields of the individual well screens.

Depending on the available information, the subject matter expert (SME) will plan testing activities that account for maintaining complete screen saturation at all times. The set of procedures needed for a quality result may vary from one well to another depending on site-specific parameters such as depth to water, depth to the top of the well screen, depth to the top of the filter pack, well diameter, pump characteristics, relative yields of the two screens, and possible other considerations. The SME will direct the activities and make the necessary calculations to assure the optimal balance between maximizing the discharge rates for testing while avoiding dewatering the well screen.

3.4 Pump Shroud

The pump will be installed inside a shroud for the test procedures. The shroud will serve several purposes. It will allow locating the pressure transducer for the pumped zone beneath the pump, thereby minimizing electrical interference from the pump cable and, possibly, lessening the mechanical vibration associated with pump operation. The shroud will also provide cooling for the pump motor in situations where either (1) limited water height above the screen dictates placing the pump within or beneath the screen, or (2) flow rates are extremely low (unusually tight formation materials). Finally, in dual-screen wells, the shroud is essential for suspending the lower inflatable packer.

3.5 Data Collection Protocol

In general, water levels in the pumped screen will be recorded at high frequency during pump start-up and pump shut-off, and at a lesser frequency for the balance of the time. The Level TROLL 700 non-vented pressure transducer allows the option of assigning multiple data collection frequencies. Collecting dense data from the pumped screen at an early time provides an excellent snapshot of the hydraulic response immediately around the well and makes it possible to obtain a reliable estimate of the hydraulic conductivity of the screened interval. Subsequent data are typically recorded at 1-min intervals.

The measurement frequencies for the non-pumped screen in a dual-screen well do not need to be as great as for the pumped screen.

Distant observation wells will be monitored at a constant interval matching that of the on-site barometric pressure transducer. The appropriate time interval will be selected based on distances to the relevant observation wells and anticipated hydraulic response.

4.0 PLANNED SEQUENCE OF TASKS

Following is a summary of the activities that will take place as part of the aquifer performance test.

4.1 Equipment Assembly

The equipment required for pumping and testing will be arrayed at the site. Based on the well screen depth(s), depth to water, and pumping component piece lengths, a strategy will be developed for designing the pumping string, including lengths of drop pipe, packers, check valve, pump shroud, transducer cage assemblies, intermediate pipe lengths, and appropriate crossover connections to facilitate the assembly and installation. The submersible pump will be loaded into the shroud. For dual-screen wells, a nitrogen supply line pass-through will be provided for pressurizing the bottom packer.

4.2 Initial Installation

Once the pumping string has been designed, a manual water-level measurement will be made and running the pumping string will begin. As each packer is installed, the packer system will be pressurized for a prescribed period to verify that the connections are leak free before running the system to depth.

When the pump has reached the desired initial location, brief pumping will be performed to fill the drop pipe, bring water to the surface, and adjust the flow-control valve as needed. Then the pumping string will be landed at the position intended for testing and additional brief pumping may be performed to refill the drop pipe and discharge pipe.

4.3 Background Data Collection

Once the pump is in position, background data will be collected. Data collection will proceed for approximately 2.5 days—from the afternoon that the initial filling of the drop pipe is complete until the morning that the extended constant-rate test begins. During one of these days, the background data collection will be interrupted by brief pumping. The pumping will be sufficiently limited so that it will not materially affect the overall background data set in either the pumped well or observation wells.

4.4 Brief Pumping

The brief pumping will entail either a couple of short-duration constant-rate tests or a step drawdown test, or some combination of both. The short-duration constant-rate tests are useful in developing snapshots of the pressure wave expanding within the aquifer materials around the well bore immediately after starting or stopping the pump. At this early time, the height of the zone of influence may be assumed to approximate the well-screen length, thus providing an opportunity to accurately estimate the hydraulic conductivity and transmissivity of the screened interval. This type of pumping provides excellent data/information for minimal effort and should not be bypassed. It is expected that the duration of brief pumping would only be on the order of an hour or so, perhaps a little longer for step drawdown tests.

Theoretically, the extended test can provide the same type of information as the brief test. However, the very early pumping and recovery data from the extended test are often compromised. For example, during cold weather, the drop pipe must be drained overnight to prevent freezing. As a result, the pump starts up against one head condition and then encounters a different head condition once the discharge water refills the pipe and reaches the control valve. Also, because of the high gas content in the pumped water in most wells at the Laboratory, during the extended test gas can accumulate in the formation pores or within the well itself and create a storage type of effect that can compromise the very early recovery data. The brief tests provide (1) redundancy that improves the capture of very early pumping and recovery data and (2) forensic information that can be used to assess possible causes of anomalies that may be seen in the early data from the extended test.

On a rare occasion, step drawdown testing may be desired. This can occur, for example, in a sampling well in which the static water level is at or near the top of the well screen and dewatering of the screen during operation is inevitable. In this situation, steady decline of the local water table in future years could affect the performance and usability of the well. A step drawdown test can provide the information needed to assess the source of flow along the length of the screen length and provide guidance for pumping rate selection for current and future sampling.

A step drawdown test involves pumping the well for a short period of time at several different discharge rates. For the example case cited here, a suitable approach would be to start pumping at the maximum rate possible, limited by either the well capacity or the pump capacity, and reduce the rate incrementally in steps to a minimal value of roughly 30 to 40 percent of the maximum. Typically, four or five steps are adequate. At each step, the flow rate should be stabilized and measured. The duration of each step needs to be great enough to largely eliminate casing and filter pack storage effects.

Based on site-specific conditions, the SME will direct the testing activities, either short constant-rate tests or a step drawdown test, to provide optimal information.

4.5 Extended Constant-Rate Aquifer Test

The pumping duration for the extended test will be based on site-specific conditions, including availability of observation wells (or lack of it) and water handling procedures and constraints. In most cases, test lengths of 1 to 3 days will be considered, although there could be exceptions. If nearby observation wells are available for supporting cross-hole measurements, a longer test may be the preferred option. In areas where no observation wells exist, a shorter test period may be adequate.

4.6 Recovery

Following pump shutdown, recovery data will be recorded for a specified period. Typically, a minimum duration of 24 hr is adequate for the pumped well. The distant observation wells, however, are slow to respond to pumping and recovery and, therefore, a greater measurement period is appropriate. A recovery duration of approximately 3 days or more may be considered for the observation wells.

4.7 Dual-Screen Wells

In the dual-screen wells, once recovery data collection for the first pumped screen is complete, the pump will be pulled, the transducer data will be downloaded, and the transducers will be reprogrammed for the second pumping test. Then the tasks listed above will be repeated. The tasks will be timed so as to provide a suitable time of recovery from the first pumping test before initiating the second test.

5.0 EQUIPMENT REQUIREMENTS

The drilling contractor will provide specialty equipment to execute the pumping test plan. Some of the specialty equipment is listed below.

Submersible Pumps

For the 5-in. wells, the contractor should have available a variety of 4-in. submersible pumps covering a range of possible flow rates and head conditions from approximately 1 to 20 gpm to cover the possible range of well capacities encountered at the Laboratory.

For the 8-in. wells, a single 6-in.-submersible pump having the capacity to produce the expected discharge rate at prevailing head conditions will be adequate. The expected head will be the hydraulic lift plus friction loss in the drop pipe. Assuming 2-in. drop pipe, the friction loss component could range from about 100 to 400 ft of head, depending on the final discharge rate, pump depth and drop pipe wall thickness and inside diameter.

Electric Generator

An electric generator with the voltage and amperage capacity to power the selected pump will be provided.

Drop Pipe

The drop pipe used in the testing will be 2-in. stainless-steel JSL pipe. This material uses a slip-in, O-ring-fitted, spline-lock design and is less susceptible to leaks than typical threaded drop pipe.

Pressure Gauge

A pressure gauge will be provided at the well head to measure the backpressure on the pump during operation. The range of the gauge must be sufficient to handle the excess pressure that will be achieved by the pump when operating at the selected discharge rate. The pressure gauge is located first in line in the discharge assembly, i.e., ahead of all other components.

Flow-Control Valve

A stainless-steel ball valve will be installed immediately downstream from the pressure gauge to control the discharge rate as needed.

Flow Meter

A volume-totalizing flow meter will be placed in the discharge line immediately downstream from the flow-control valve to track production volume and provide the data needed to document discharge rates. In addition, at this location, a digital flow measuring and recording device will be plumbed into the discharge line to supplement the manual readings and provide an electronic record of discharge rates.

Inflatable Packer(s) and Appurtenances

Nitrogen-actuated inflatable packers will be provided that meet the anticipated pressure requirements for the well and test. Suitable nylon tubing, associated connecting fittings, and nitrogen tanks for inflating the packers will be provided.

Pump Shroud

A suitable pump shroud for housing the submersible pump and suspending additional piping beneath it will be provided along with a pass-through nitrogen line for two-packer installations.

Check Valve

The pumping string will be equipped with a check valve, which has a pressure rating well in excess of the anticipated static head in the drop pipe above the check. This will prevent water from the drop pipe draining back into the well following pump shutoff. Without a check valve, the high flux of drop-pipe water surging into the packed-off screen would corrupt the recovery data. In general, the check valve should be placed close to the pump and shroud assembly, usually within several feet.

Transducers

Level TROLL 700 non-vented pressure transducers or equivalent will be provided for testing. If the Level TROLL 700 is chosen to monitor barometric pressure, it must be a 30-psi unit. The pressure range of the downhole units (one transducer for single-screen wells, two for dual-screen wells) will be determined based on the static water level and anticipated installation depths.

Transducer Cages

The transducers will be placed in perforated metal sleeves fabricated from 1-in. pipe and strapped securely to the drop-pipe assembly.

6.0 ANALYTICAL METHODS

The key to a successful aquifer test is proper data analysis. It is vital to make a distinction between those data that support aquifer parameter characterization and those that do not, as well as which analytical methods apply and which do not.

There are two primary components to the analysis. First, the data must be pre-processed to remove water-level fluctuations not related to the pumping test being analyzed. Second, an appropriate analytical solution must be selected and applied to the drawdown data.

6.1 Data Pre-Processing

Observation wells that may be incorporated in the aquifer tests are generally monitored using vented transducers and, therefore, yield hydrographs with large background fluctuations that must be filtered out before analysis. Data from such wells will be corrected to remove extraneous background noise. The algorithm used for this will account for barometric pressure changes, well-specific barometric efficiency, and a constant linear background trend.

To accomplish this, the changes in the observed water level over time will be adjusted by a fixed percentage of the observed change in barometric pressure and replotted. This fixed percentage (equal to the barometric efficiency of the well) will be adjusted iteratively, and the data replotted, to remove sinusoidal fluctuations from the modified hydrograph, to the extent possible. The resulting modified hydrograph is expected to form a straight line except for the drawdown induced by the pumping test. If the resulting straight line is tilted (i.e., if it shows a linear background trend), that trend will be removed mathematically so that the final hydrograph is essentially horizontal. This will make it possible to observe and quantify the drawdown effects associated with running the pumping test.

Drawdown data obtained from those observation wells that show a response to pumping will be summarized in tabular form, and a map showing the resulting spatial distribution of drawdown response will be included in the well completion report.

6.2 Importance of Early Data

In many pumping tests, casing-storage effects dominate the early-time data, potentially hindering the effort to determine the transmissivity of the screened interval. The duration of casing-storage effects can be estimated using a simple, straightforward formula (Schafer 1978, 098240). Calculations have shown that typical storage effects nearly always mask the important early data in the Laboratory pumping tests, making it impossible to determine the transmissivity and hydraulic conductivity of the screened zone under ordinary circumstances.

In most instances, the use of packers has been highly successful in eliminating storage effects so that the early data can be analyzed. On occasion, however, subtle and indirect storage effects can invalidate the early test data. This primarily occurs when air is trapped in the formation, well, or filter pack. As stated earlier, dewatering a portion of the screen during development or initial pumping can allow air to become trapped in the filter pack behind the blank casing above the well screen. Also, gradual accumulation of gas or air from the formation can build up in the pore spaces around the wellbore or inside the well beneath the inflatable packer. This gradual accumulation of gas can cause transient changes in hydraulic conductivity and concomitant changes in drawdown that invalidate the application of analytical methods.

Because of this, even when inflatable packers are used, a careful analysis, including comparison of multiple pumping and recovery events for consistency, must be conducted to try to detect when this storage type effect has occurred so that only valid data are used to support determination of aquifer properties.

6.3 Summary of Analytical Methods

The exact methods that are most applicable to a specific data set vary from location to location and depend on the aquifer characteristics. Therefore, data collected and observations made during the test will drive decisions regarding which procedures and methods will be appropriate and valid. Although the analytical method most applicable to a given test cannot be specified in advance, the discussion below describes many of the analytical solutions/methods that are expected to be used in the pumping test interpretations.

The most basic solutions listed here can be solved with the use of simple Excel spreadsheets. The more complex solutions, incorporating partial penetration, delayed yield, or wellbore skin (well inefficiency) are generally computed using reputable, commercially available software such as AQTESOLVE (Advanced Aquifer Test Analysis Software) from HydroSOLVE, Inc.

Multiple Well Analysis

Ample and reasonable water-level stabilization/recovery time will be provided between well development and the pumping test and, in the case of dual-screen wells, between testing the first and second screens. However, because of the delayed hydraulic response at great distances, some observation wells might show minor, lingering effects of antecedent pumping when a particular pumping test is initiated.

If the data suggest that this is the case, a multiple well analysis will be performed within AQTESOLVE to mathematically account for the antecedent pumping.

Theis Equation

One of the most fundamental equations describing flow to a well is the Theis equation (Theis 1934-1935, 098241), which describes flow to a fully penetrating well in a confined aquifer. The following assumptions were made in deriving this solution.

- The aquifer is laterally infinite.
- The aquifer is homogeneous and of uniform thickness.
- The pumping well is fully penetrating.
- Flow is horizontal.
- The aquifer is confined.
- Flow is unsteady.
- Water is released instantaneously from storage with decline of head.
- The well diameter is arbitrarily small.

Many of these assumptions are universal in applying to most well hydraulics equations.

Wells at the Laboratory site violate the assumption of full penetration. Nevertheless, the Theis equation may have application to the very early and very late data in the pumping well. At early time, the expanding cone of depression is known to have a height roughly equal to the well screen length and, thus, the very early data may usually be analyzed using the Theis equation using an aquifer thickness equal to the screen length. At late time, if the cone of depression has fully developed and become limited by an aquitard at depth, the Theis equation can be applied. One of the challenges and limitations, however, is that the depth to the aquitard and effective aquifer thickness may not be known accurately.

Other limitations at the Laboratory site are that the Theis equation is not applicable to the very early data from observation wells and can only be used to estimate transmissivity and hydraulic conductivity, and not storage coefficient.

Cooper-Jacob Equation

The Cooper-Jacob equation (Cooper and Jacob 1946, 098236) is an approximation to the Theis equation for sufficiently large pumping times. This equation can be used for any data where the pumping time, t, is greater than approximately $5Sr^2/T$ where, in consistent units, S is storage coefficient, r is distance from the center of the pumped well, and T is transmissivity. When this condition is met, the Theis and Cooper-Jacob equations may be used interchangeably.

For the pumped well, r is small (equal to the borehole radius) and therefore the computed threshold time limitation is minimal. In other words, the Cooper-Jacob equation usually is valid for very early times in the pumped well. Conversely, at great distances, the computed threshold time is large and can invalidate the use of the Cooper-Jacob equation for much or all of the observation well data.

A specialized application of the Cooper-Jacob equation is the so-called Theis recovery method (Kruseman et al. 1991, 106681) in which residual drawdown measured during recovery is plotted versus the ratio of time since pumping started divided by the time since pumping stopped. This graphical procedure allows calculating transmissivity similar to the method using the Cooper-Jacob solution.

Hantush Equation

The Theis equation does not account for partial penetration conditions that apply to all situations at the Laboratory. Therefore, solution methods may be implemented that account for this. For confined conditions, the Hantush equation (Hantush 1961, 106003; Hantush 1961, 098237) incorporates partial penetration as well as vertical anisotropy into the solution. Applying the Hantush method allows using more of the data than does the Theis equation.

One challenge associated with the use of the Hantush solution is that the effective aquifer thickness (distance between the top of the aquifer and the underlying aquitard) must be assigned. Usually, this parameter is not known in the Laboratory tests.

Dougherty-Babu Equation

Most of the pumping test analyses are applied to data from the pumped wells that are affected by wellbore skin (well inefficiency). One way to account for this is application of the Dougherty-Babu equation (Dougherty and Babu 1984, 701557). This is similar to the Hantush equation except that it accounts for wellbore skin (well inefficiency) and may have application to certain Laboratory pumping tests.

One deficiency is that wellbore skin and storage coefficient are codependent variables. If one of them is increased or decreased, it can be compensated for by increasing or decreasing the other. Thus, a great range of combinations of these two parameters provides curve matches that are essentially indistinguishable from one another, making it difficult to obtain a unique solution.

Neuman Equation

Many of the pumping tests conducted at the Laboratory show delayed yield effects associated with unconfined conditions. The Neuman equation (Neuman 1974, 085421) provides a solution for unconfined aquifers and includes the effects of partial penetration and vertical anisotropy. As such, this solution has good application for pumping tests at the Laboratory.

Limitations include the fact that this solution approach does not work well for the pumping well. The wellbore skin renders the measured drawdown in the pumped well different than what would be predicted by the theory. This combined with other subtle anomalies, such as slight pumping rate fluctuations and formation heterogeneity, can make it difficult to obtain reliable solutions from the pumped well data. The method is better suited to application to observation wells, both distant wells and the non-pumped screen in dual-screened wells.

Moench Equation

The Moench equation (Moench 1997, 600136) is similar to the Neuman equation except that it includes the effects of wellbore skin and has better application to pumped well data than the Neuman solution. As with the Dougherty-Babu solution, codependency of skin and storage parameters can lead to multiple solutions.

Brons and Marting Method

The method of Brons and Marting (Brons and Marting 1961, 098235) incorporating a modification by Bradbury and Rothschild (Bradbury and Rothschild 1985, 098234) can be used to estimate a lower bound for hydraulic conductivity from a partially penetrating well using the observed specific capacity. This can provide a good reality check for parameter values computed from other analytical methods.

6.4 Limitations of Analytical Methods

Interpreting the pumping tests at the Laboratory is made difficult by the complex hydrogeologic setting, gas or air in the pumped water and formation pores, the restrictions on pumping well construction (particularly screen length), and the scarcity of nearby observation wells. Often, the applicable solutions methods must solve for up to five parameters simultaneously—transmissivity, storage coefficient, specific yield, anisotropy ratio, and wellbore skin. Because of the complexity of the relevant equations, slight deviations of the real-world pumping test setting from the assumptions used in deriving the applicable formulas often can result in computing incorrect and even nonsensical aquifer parameter values.

Because of this, care must be taken in the analysis to apply only appropriate methods and make sure they are applied only to appropriate portions of the data. It is vital to make a distinction between those data that support aquifer parameter characterization and those that do not. Deviations of the actual physical setting from theoretical assumptions can cause errors. For example, the saturated sediments are highly heterogeneous. When testing is performed with very short well screens, the effects of the heterogeneity are magnified in the pumping test response and the output from the extremely complex equations that are applied. Not knowing the effective aquifer thickness (depth to the underlying aquitard) further complicates the analysis. In some cases, it may be appropriate to run sensitivity analysis on aquifer thickness to document its effect.

The gas content in the groundwater can cause slight storage effects, invalidating very early data, and can induce efficiency changes in the pumped well, both up and down, that seriously alter the drawdown patterns throughout much of the test. Also, varying gas content can cause minor changes in discharge rate that complicate the analysis. Subtle rate changes of just a fraction of a percent (well within recommended guidelines) can have an effect on the calculations.

Because of this, the limitations of the analytical solutions to the actual setting must be considered when analyzing the data. Finally, in addition to the factors discussed above, aquifer heterogeneity must be considered when interpreting the drawdown data from multiple observation wells, as the effective hydraulic conductivity from the pumped well to any observation well will likely vary across the domain impacted by the pumping.

7.0 REFERENCES

The following reference list includes documents cited in this guidance. Parenthetical information following each reference provides the author(s), publication date, and ERID, ESHID, or EMID. This information is also included in text citations. ERIDs were assigned by the Laboratory's Associate Directorate for Environmental Management (IDs through 599999); ESHIDs were assigned by the Laboratory's Associate Directorate for Environment, Safety, and Health (IDs 600000 through 699999); and EMIDs are assigned by Newport News Nuclear BWXT-Los Alamos, LLC (N3B) (IDs 700000 and above). IDs are used to locate documents in N3B's Records Management System and in the Master Reference Set. The New Mexico Environment Department (NMED) Hazardous Waste Bureau and N3B maintain copies of the Master Reference Set. The set ensures that NMED has the references to review documents. The set is updated when new references are cited in documents.

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R-71 AQUIFER TESTING PLAN

1.0 INTRODUCTION

This document summarizes aquifer testing plans and requirements for well R-71 at Los Alamos National Laboratory (LANL or the Laboratory). R-71 is an 8-in. dual-screen regional aquifer well located on a narrow ridge between Sandia and Mortandad Canyons at the east end of Sigma Mesa. R-71 will be angle drilled at approximately 25° off vertical in a direction 30° east of north. Specific information, including a map of the location of the well and surrounding monitoring locations and design of the well, is provided in the "Field Implementation Plan for Regional Aquifer Well R-71" (N3B 2021, 701581). Two separate aquifer tests will be conducted on the two producing zones in R-71. This plan lays out the required equipment and time schedule for the tasks to be performed by the drilling contractor. Related and supporting information is available in the original planning document, "Aquifer Testing Guidance for the Los Alamos National Laboratory Site" (N3B 2021, 701574).

2.0 GENERAL APPROACH

Constant rate testing will be performed in each screen in R-71 to obtain an optimum/analyzable data set. Because R-71 has nearby observation wells available for monitoring during the test, at the suggestion of the New Mexico Environment Department, 72-hr pumping tests will be conducted in lieu of 24-hr tests to try to enhance the drawdown in some of these wells. The testing program for each screen zone will include (1) pretest water-level stabilization, (2) brief trial or step drawdown testing, (3) background data collection, (4) 72-hr constant rate testing, and (5) 24-hr water-level recovery monitoring. Once this sequence has been performed for the first screen tested, it will be repeated for the next screen.

It is important to remove the effects of barometric pressure changes on the water levels measured at the site. Therefore, barometric pressure will be monitored throughout the testing process.

The drilling contractor will be responsible for supplying the needed pressure transducers for the two screens in the pumped well, as well as a third transducer for monitoring barometric pressure at the site.

Table 1 shows a list of tentative observation well candidates for monitoring that are within approximately half a mile of R-71.

The distances shown in Table 1 are estimated distances from the mid-blank section (between the two screens) in R-71, tentatively assumed to be at a depth of 1290 ft (measured along the casing). Once R-71 is constructed, the final dip angle and direction, as well as the actual screen locations, will be used to recompute distances to each observation well from the center of each screen in R-71.

Water levels in the observation wells should be collected at 15-min intervals. It is expected that monitoring will continue for a few days after the final pumping test. This same measurement frequency will be used for recording barometric pressure. The Laboratory will monitor the observation wells.

3.0 SPECIAL CONSIDERATIONS

Because of the unique hydrogeologic setting at the Laboratory, there are a number of stringent requirements that must be met in order to achieve the highest quality data set possible. Following is a discussion of these specific considerations.

3.1 Water-Level Stabilization

Because the drawdowns in local observation wells are expected to be minimal, it will be important to stabilize background water levels and minimize fluctuations to the extent practicable so that induced drawdowns, in the observation wells attributable to the pumping test, do not get lost in the background noise.

Active pumping and injection occur continuously in the regional aquifer beneath Mortandad Canyon, potentially affecting pumping tests in that area. Any variability in system operation can affect observed levels in the observation wells. Therefore, attempts will be made to run the extraction and injection system wells at constant rates before and during the pumping test. It is preferred that the system remain stable for approximately 2 wk leading up to the tests as well as during the testing procedures. The Laboratory is responsible for controlling and stabilizing the extraction and injection system.

Pump development of the screen zones in the tested well generally is performed just before test pumping activities. Once development ceases, the local water levels rebound for several days in response to pump shutdown. Therefore, the schedule of activities will be structured to ensure approximately 6 days between the conclusion of development pumping and initiation of the first 72-hr pumping test.

In most previous pumping tests on the Pajarito Plateau, 5 days typically elapsed between well development and the start of the first extended pumping test, with the intervening time being used for equipment preparation, assembly and installation, background monitoring, and brief preliminary testing. Thus, the stated requirement will likely add about 1 day to the former schedule.

A minimum of 5 days will be provided between the conclusion of pumping the first screen and starting the 72-hr test on the second screen. In most previous pumping tests, this has been about the time required for recovery from the first test, which included pulling the pump, downloading and reprogramming the transducers, reinstalling the pump, and collecting background data. Thus, the stated requirement will remain consistent with other previous tests.

3.2 Casing Storage

In order to eliminate casing storage effects on the pumping test data, an inflatable packer will be installed in the pumping string above the pump, positioned below the water level and above the screen being tested. The upper screen will require two packers—one above the screen to eliminate storage effects and one below the screen to hydraulically separate it from the lower screen. Testing the lower screen will require a minimum of one packer above the screen to separate it from the upper screen. If the second packer remains in the pumping configuration for this test, it will be landed in the blank casing beneath the lower screen.

3.3 Pumping Rate Selection and Initial Start-Up

Throughout both testing and well development, care must be taken to avoid dewatering the top of the well screen at any time. If the pumping water level is pulled into the screen, the filter pack above the screen will drain, allowing air to move into the filter pack behind the blank casing above the screen and become trapped there. Expansion and contraction of the trapped air in response to pumping and recovery will cause a storage-like effect and compromise the quality of the early water-level data collected during the test.

The discharge rate will be controlled via a valve in the discharge line at the surface to prevent too much drawdown. However, when the pump is first installed and started up, the valve will have no effect as the drop pipe begins to fill. Furthermore, because the pump operates initially against minimal head when the drop pipe is empty, the discharge rate on startup is substantially greater than the nominal capacity of the pump. The combination of a greater startup pumping rate and the inability to control it risks dewatering the well screen.

Because of this, depending on the estimated capacity of the well, it may be necessary to set the pump intake above the screen for initial startup, fill the drop pipe, and adjust the flow-control valve to the desired rate. The subject matter expert (SME) will work with the driller to outline a series of steps to avoid dewatering the screen during testing activities.

3.4 Pump Shroud

The pump will be installed inside a shroud for the test procedures. The shroud will serve several purposes. It will allow locating the pressure transducer for the pumped zone beneath the pump thereby minimizing electrical interference from the pump cable and, possibly, lessening the mechanical vibration associated with pump operation. The shroud will also provide cooling for the pump motor in situations where limited water height above the screen dictates placing the pump within or beneath the screen. Finally, it is essential for suspending the lower inflatable packer.

4.0 EQUIPMENT REQUIREMENTS

The drilling contractor will provide specialty equipment to execute the pumping test plan. Some of the specialty equipment is listed below.

Submersible Pump

A 6-in. submersible pump with the capacity to produce 80 to 100 gallons per minute (gpm) at the prevailing head conditions will be adequate and appropriate based on production of wells in the area. The expected head will be the hydraulic lift plus friction loss in the drop pipe. Assuming a 2-in. drop pipe and a discharge rate of 80 to 100 gpm, the friction loss component could range from approximately 150 to 300 ft for Schedule 40 pipe and 200 to 400 ft of head for Schedule 80 pipe. The anticipated vertical lift from the pumping water level to the top of on-site storage tanks is expected to be a little more than 1200 ft. Thus, the total discharge head could range from approximately 1350 ft to more than 1600 ft, depending on discharge rate, pipe wall thickness, and specific pipe material friction factor.

A pump such as the Grundfos 40-HP model 85S400-36 would likely handle any conditions that may be encountered. A second possible choice would be model 85S400-33, which could produce approximately 80 gpm if Schedule 40 drop pipe is used.

If well yield is substantially less than anticipated, it is possible that these specific pump choices could create undesirably high gauge pressures at the surface, possibly dictating that a lower capacity pump be used. Well yield will be assessed during the development procedures and aid in the final pump selection for testing.

Electric Generator

An electric generator with the voltage and amperage capacity to power the selected pump will be provided.

Drop Pipe

The drop pipe used in the testing will be 2-in. stainless-steel JSL pipe. This material uses a slip-in, O-ring-fitted, spline-lock design and is less susceptible to leaks than typical threaded drop pipe.

Pressure Gauge

A pressure gauge will be provided at the well head to measure the backpressure on the pump during operation. The range of the gauge must be sufficient to handle the shut-in pressure that will be achieved by the pump. The pressure gauge is located first in line in the discharge assembly, i.e., ahead of all other components.

Flow-Control Valve

A stainless-steel ball valve will be installed immediately downstream from the pressure gauge to control the discharge rate as needed.

Flow Meter

A volume-totalizing flow meter will be placed in the discharge line immediately downstream from the flow-control valve to track production volume and provide the data needed to document discharge rates. At this location, other flow monitoring devices, as needed, can be plumbed into the discharge line.

Inflatable Packer(s) and Appurtenances

Nitrogen-actuated inflatable packers will be provided that meet the anticipated pressure requirements for the well and test. Suitable nylon tubing, associated connecting fittings, and nitrogen tanks for inflating the packers will be provided.

Pump Shroud

A suitable pump shroud for housing the submersible pump and suspending additional piping beneath it will be provided along with a pass-through nitrogen line for the two-packer installations.

Check Valve

The pumping string will be equipped with a check valve, which has a pressure rating well in excess of the anticipated static head in the drop pipe above the check. This will prevent water from the drop pipe draining back into the well following pump shutoff. Without a check valve, the high flux of drop-pipe water surging into the packed-off screen would corrupt the recovery data. In general, the check valve should be placed close to the pump and shroud assembly, usually within several feet, as directed by the SME during pumping-string assembly.

Transducers

Three Level TROLL 700 non-vented pressure transducers will be provided for testing. The one used to monitor barometric pressure must be a 30-psi unit. The pressure range of the two downhole units will be determined based on the static water level and anticipated installation depths of the pumping-string components.

Transducer Cages

The transducers will be placed in perforated metal sleeves fabricated from 1-in. pipe and strapped securely to the drop-pipe assembly.

5.0 ANTICIPATED SCHEDULE

To provide adequate recovery time from development pumping and the initial constant-rate pumping test, the sequence of tasks and anticipated timing are listed here. The schedule is arrayed to ensure approximately (1) 6 days of recovery between well development and initiation of the first 72-hr test, (2) 5 days between the 72-hr tests, and (3) more than 2 days of background readings for each test. It is assumed that development concludes on Day Zero, and that counting the days on the schedule goes from there.

Days 1, 2, and 3: Array and assemble components for the pumping string and discharge piping system, pressure test packers, install pump, bring water to the surface and set flow-control valve, position pump for the first test, and begin recording background water levels. (Note: if these tasks can be done more quickly, it will provide an opportunity to increase the background monitoring period accordingly.)

Day 4: Continue background monitoring, interrupted briefly by trial testing or step drawdown testing, as directed by the SME.

Day 5: Continue background monitoring.

Day 6: Pump on to begin constant-rate 72-hr test.

Day 7: Continue 72-hr test.

Day 8: Continue 72-hr test.

Day 9: Pump off to terminate 72-hr test.

Days 10 and 11: Pull pump, download and reprogram pressure transducers, reinstall pump, bring water to the surface and set flow-control valve, position pump for the second test, and begin recording background water levels.

Day 12: Continue background monitoring, interrupted briefly by trial testing or step drawdown testing, as directed by the SME.

Day 13: Continue background monitoring.

Day 14: Pump on to begin constant rate 72-hr test.

Day 15: Continue 72-hr test.

Day 16: Continue 72-hr test.

Day 17: Pump off to terminate 72-hr test.

Day 18: Pull test pump.

Days 19-plus: Continue 15-min monitoring of observation wells and barometric pressure for several days.

6.0 REFERENCES

The following reference list includes documents cited in this plan. Parenthetical information following each reference provides the author(s), publication date, and ERID, ESHID, or EMID. This information is also included in text citations. ERIDs were assigned by the Laboratory's Associate Directorate for Environmental Management (IDs through 599999); ESHIDs were assigned by the Laboratory's Associate Directorate for Environment, Safety, and Health (IDs 600000 through 699999); and EMIDs are assigned by Newport News Nuclear BWXT-Los Alamos, LLC (N3B) (IDs 700000 and above). IDs are used to locate documents in N3B's Records Management System and in the Master Reference Set. The New Mexico Environment Department (NMED) Hazardous Waste Bureau and N3B maintain copies of the Master Reference Set. The set ensures that NMED has the references to review documents. The set is updated when new references are cited in documents.

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N3B (Newport News Nuclear BWXT-Los Alamos, LLC), August 2021. "Aquifer Testing Guidance for the Los Alamos National Laboratory Site," Newport News Nuclear BWXT-Los Alamos, LLC, document EM2021-0481, Los Alamos, New Mexico. (N3B 2021, 701574)

Table 1
Distance from R-71

Well	Distance (ft)
R-62	535
CrPZ-4	1418
R-43	1520
CrPZ-5	1503
R-15	1718
CrPZ-3	2040
R-42	2276
R-72*	2325

*If available for monitoring.

R-72 AQUIFER TESTING PLAN

1.0 INTRODUCTION

This document summarizes aquifer testing plans and requirements for well R-72 at Los Alamos National Laboratory (LANL or the Laboratory). R-72 is an 8-in. dual-screen vertical well located on the plateau on the south rim above Mortandad Canyon. Specific information, including a map of the location of the well and surrounding monitoring locations and design of the well, is provided in the "Field Implementation Plan for Regional Aquifer Well R-72" (N3B 2021, 701582). Two separate aquifer tests will be conducted on the two producing zones in R-72. This plan lays out the required equipment and time schedule for the tasks to be performed by the drilling contractor. Related and supporting information is available in the original planning document, "Aquifer Testing Guidance for the Los Alamos National Laboratory Site" (N3B 2021, 701574).

2.0 GENERAL APPROACH

Constant rate testing will be performed in each screen in R-72 to obtain an optimum/analyzable data set. Because R-72 has nearby observation wells available for monitoring during the test, at the suggestion of the New Mexico Environment Department, 72-hr pumping tests will be conducted in lieu of 24-hr tests to try to enhance the drawdown in some of these wells. The testing program for each screen zone will include (1) pretest water-level stabilization, (2) brief trial or step drawdown testing, (3) background data collection, (4) 72-hr constant rate testing, and (5) 24-hr water-level recovery monitoring. Once this sequence has been performed for the first screen tested, it will be repeated for the next screen.

It is important to remove the effects of barometric pressure changes on the water levels measured at the site. Therefore, barometric pressure will be monitored throughout the testing process.

The drilling contractor will be responsible for supplying the needed pressure transducers for the two screens in the pumped well, as well as a third transducer for monitoring barometric pressure at the site.

Table 1 shows a list of tentative observation well candidates for monitoring that are within approximately half a mile of R-72.

Water levels in the observation wells should be collected at 15-min intervals. It is expected that monitoring will continue for a few days after the final pumping test. This same measurement frequency will be used for recording barometric pressure. The Laboratory will monitor the observation wells.

3.0 SPECIAL CONSIDERATIONS

Because of the unique hydrogeologic setting at the Laboratory, there are a number of stringent requirements that must be met in order to achieve the highest quality data set possible. Following is a discussion of these specific considerations.

3.1 Water-Level Stabilization

Because the drawdowns in local observation wells are expected to be minimal, it will be important to stabilize background water levels and minimize fluctuations to the extent practicable so that induced drawdowns, in the observation wells attributable to the pumping test, do not get lost in the background noise.

Active pumping and injection occur continuously in the regional aquifer beneath Mortandad Canyon, potentially affecting pumping tests in that area. Any variability in system operation can affect observed levels in the observation wells. Therefore, attempts will be made to run the extraction and injection system wells at constant rates before and during the pumping test. It is preferred that the system remain stable for approximately 2 wk leading up to the tests as well as during the testing procedures. The Laboratory is responsible for controlling and stabilizing the extraction and injection system.

Pump development of the screen zones in the tested well generally is performed just before test pumping activities. Once development ceases, the local water levels rebound for several days in response to pump shutdown. Therefore, the schedule of activities will be structured to ensure approximately 6 days between the conclusion of development pumping and initiation of the first 72-hr pumping test.

In most previous pumping tests on the Pajarito Plateau, 5 days typically elapsed between well development and the start of the first extended pumping test, with the intervening time being used for equipment preparation, assembly and installation, background monitoring, and brief preliminary testing. Thus, the stated requirement will likely add about 1 day to the former schedule.

A minimum of 5 days will be provided between the conclusion of pumping the first screen and starting the 72-hr test on the second screen. In most previous pumping tests, this has been about the time required for recovery from the first test, which included pulling the pump, downloading and reprogramming the transducers, reinstalling the pump, and collecting background data. Thus, the stated requirement will remain consistent with other previous tests.

3.2 Casing Storage

In order to eliminate casing storage effects on the pumping test data, an inflatable packer will be installed in the pumping string above the pump, positioned below the water level and above the screen being tested. The upper screen will require two packers—one above the screen to eliminate storage effects and one below the screen to hydraulically separate it from the lower screen. Testing the lower screen will require a minimum of one packer above the screen to separate it from the upper screen. If the second packer remains in the pumping configuration for this test, it will be landed in the blank casing beneath the lower screen.

3.3 Pumping Rate Selection and Initial Start-Up

Throughout both testing and well development, care must be taken to avoid dewatering the top of the well screen at any time. If the pumping water level is pulled into the screen, the filter pack above the screen will drain, allowing air to move into the filter pack behind the blank casing above the screen and become trapped there. Expansion and contraction of the trapped air in response to pumping and recovery will cause a storage-like effect and compromise the quality of the early water-level data collected during the test.

The discharge rate will be controlled via a valve in the discharge line at the surface to prevent too much drawdown. However, when the pump is first installed and started up, the valve will have no effect as the drop pipe begins to fill. Furthermore, because the pump operates initially against minimal head when the drop pipe is empty, the discharge rate on startup is substantially greater than the nominal capacity of the pump. The combination of a greater startup pumping rate and the inability to control it risks dewatering the well screen.

Because of this, depending on the estimated capacity of the well, it may be necessary to set the pump intake above the screen for initial startup, fill the drop pipe and adjust the flow control valve to the desired rate. The subject matter expert (SME) will work with the driller to outline a series of steps to avoid dewatering the screen during testing activities.

3.4 Pump Shroud

The pump will be installed inside a shroud for the test procedures. The shroud will serve several purposes. It will allow locating the pressure transducer for the pumped zone beneath the pump thereby minimizing electrical interference from the pump cable and, possibly, lessening the mechanical vibration associated with pump operation. The shroud will also provide cooling for the pump motor in situations where limited water height above the screen dictates placing the pump within or beneath the screen. Finally, it is essential for suspending the lower inflatable packer.

4.0 EQUIPMENT REQUIREMENTS

The drilling contractor will provide specialty equipment to execute the pumping test plan. Some of the specialty equipment is listed below.

Submersible Pump

A 6-in. submersible pump, with the capacity to produce 80 to 100 gallons per minute (gpm) at the prevailing head conditions will be adequate and appropriate based on production of wells in the area. The expected head will be the hydraulic lift plus friction loss in the drop pipe. Assuming a 2-in. drop pipe and a discharge rate of 80 to 100 gpm, the friction loss component could range from approximately 150 to 300 ft for Schedule 40 pipe and 200 to 400 ft of head for Schedule 80 pipe. The anticipated vertical lift from the pumping water level to the top of on-site storage tanks is expected to be a little more than 1200 ft. Thus, the total discharge head could range from approximately 1350 ft to more than 1600 ft, depending on discharge rate, pipe wall thickness, and specific pipe material friction factor.

A pump such as the Grundfos 40-HP model 85S400-36 would likely handle any conditions that may be encountered. A second possible choice would be model 85S400-33, which could produce approximately 80 gpm if Schedule 40 drop pipe is used.

If well yield is substantially less than anticipated, it is possible that these specific pump choices could create undesirably high gauge pressures at the surface, possibly dictating that a lower capacity pump be used. Well yield will be assessed during the development procedures and aid in the final pump selection for testing.

Electric Generator

An electric generator with the voltage and amperage capacity to power the selected pump will be provided.

Drop Pipe

The drop pipe used in the testing will be 2-in. stainless-steel JSL pipe. This material uses a slip-in, O-ring-fitted, spline-lock design and is less susceptible to leaks than typical threaded drop pipe.

Pressure Gauge

A pressure gauge will be provided at the well head to measure the backpressure on the pump during operation. The range of the gauge must be sufficient to handle the shut-in pressure that will be achieved by the pump. The pressure gauge is located first in line in the discharge assembly, i.e., ahead of all other components.

Flow-Control Valve

A stainless-steel ball valve will be installed immediately downstream from the pressure gauge to control the discharge rate as needed.

Flow Meter

A volume-totalizing flow meter will be placed in the discharge line immediately downstream from the flow control valve to track production volume and provide the data needed to document discharge rates. At this location other flow monitoring devices, as needed, can be plumbed into the discharge line.

Inflatable Packer(s) and Appurtenances

Nitrogen-actuated inflatable packers will be provided that meet the anticipated pressure requirements for the well and test. Suitable nylon tubing, associated connecting fittings, and nitrogen tanks for inflating the packers will be provided.

Pump Shroud

A suitable pump shroud for housing the submersible pump and suspending additional piping beneath it will be provided along with a pass-through nitrogen line for the two-packer installations.

Check Valve

The pumping string will be equipped with a check valve, which has a pressure rating well in excess of the anticipated static head in the drop pipe above the check. This will prevent water from the drop pipe draining back into the well following pump shutoff. Without a check valve, the high flux of drop-pipe water surging into the packed-off screen would corrupt the recovery data. In general, the check valve should be placed close to the pump and shroud assembly, usually within several feet, as directed by the SME during pumping-string assembly.

Transducers

Three Level TROLL 700 non-vented pressure transducers will be provided for testing. The one used to monitor barometric pressure must be a 30-psi unit. The pressure range of the two downhole units will be determined based on the static water level and anticipated installation depths of the pumping-string components.

Transducer Cages

The transducers will be placed in perforated metal sleeves fabricated from 1-in. pipe and strapped securely to the drop-pipe assembly.

5.0 ANTICIPATED SCHEDULE

To provide adequate recovery time from development pumping and the initial constant-rate pumping test, the sequence of tasks and anticipated timing are listed here. The schedule is arrayed to ensure approximately (1) 6 days of recovery between well development and initiation of the first 72-hr test, (2) 5 days between the 72-hr tests, and (3) more than 2 days of background readings for each test. It is assumed that development concludes on Day Zero, and that counting the days on the schedule goes from there.

Days 1, 2, and 3: Array and assemble components for the pumping string and discharge piping system, pressure test packers, install pump, bring water to the surface and set flow control valve, position pump for the first test, and begin recording background water levels. (Note: if these tasks can be done more quickly, it will provide an opportunity to increase the background monitoring period accordingly.)

Day 4: Continue background monitoring, interrupted briefly by trial testing or step drawdown testing, as directed by the SME.

Day 5: Continue background monitoring.

Day 6: Pump on to begin constant-rate 72-hr test.

Day 7: Continue 72-hr test.

Day 8: Continue 72-hr test.

Day 9: Pump off to terminate 72-hr test.

Days 10 and 11: Pull pump, download and reprogram pressure transducers, reinstall pump, bring water to the surface and set flow control valve, position pump for the second test, and begin recording background water levels.

Day 12: Continue background monitoring, interrupted briefly by trial testing or step drawdown testing as directed by the SME.

Day 13: Continue background monitoring.

Day 14: Pump on to begin constant rate 72-hr test.

Day 15: Continue 72-hr test.

Day 16: Continue 72-hr test.

Day 17: Pump off to terminate 72-hr test.

Day 18: Pull test pump.

Days 19-plus: Continue 15-min monitoring of observation wells and barometric pressure for several days.

6.0 REFERENCES

The following reference list includes documents cited in this plan. Parenthetical information following each reference provides the author(s), publication date, and ERID, ESHID, or EMID. This information is also included in text citations. ERIDs were assigned by the Laboratory's Associate Directorate for Environmental Management (IDs through 599999); ESHIDs were assigned by the Laboratory's Associate Directorate for Environment, Safety, and Health (IDs 600000 through 699999); and EMIDs are assigned by Newport News Nuclear BWXT-Los Alamos, LLC (N3B) (IDs 700000 and above). IDs are used to locate documents in N3B's Records Management System and in the Master Reference Set. The New Mexico Environment Department (NMED) Hazardous Waste Bureau and N3B maintain copies of the Master Reference Set. The set ensures that NMED has the references to review documents. The set is updated when new references are cited in documents.

N3B (Newport News Nuclear BWXT-Los Alamos, LLC), July 2021. "Field Implementation Plan for Regional Aquifer Well R-72," Newport News Nuclear BWXT-Los Alamos, LLC, document EM2020-0176, Los Alamos, New Mexico. (N3B 2021, 701582)

N3B (Newport News Nuclear BWXT-Los Alamos, LLC), August 2021. "Aquifer Testing Guidance for the Los Alamos National Laboratory Site," Newport News Nuclear BWXT-Los Alamos, LLC, document EM2021-0481, Los Alamos, New Mexico. (N3B 2021, 701574)

Table 1
Distance from R-72

Well	Distance (ft)
R-15	635
CrPZ-5	1121
CrPZ-4	1634
R-61	1748
CrPZ-1	1799
R-62	1810
R-33 Screen 1	2154
R-33 Screen 2	2154
R-42	2608
R-43	2723