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14-TF-0054

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Ms. Jane A. Hedges, Program Manager
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Ms. Hedges:

TRANSMITTAL OF RPP-RPT-56596, *PORE-WATER EXTRACTION PROOF-OF-PRINCIPLE FIELD TEST REPORT*, REV. 0

This letter transmits RPP-RPT-56596, *Pore-Water Extraction Proof-of Principle Field Test Report*, Rev. 0, in completion of Hanford Federal Facility Agreement and Consent Order Target M-045-22-T03. The attached report documents the results of the field testing of pore-water extraction testing and provides recommendations for additional testing and development of this technology. The status and results of the pore-water extraction testing have been discussed at ongoing monthly status meeting with Washington State Department of Ecology staff over the past year.

Per Hanford Federal Facility Agreement and consent Order Milestone M-045-22, the attached report will support a determination by the U.S. Department of Energy, Office of River Protection and the Washington State Department of Ecology concerning the continuation of soil desiccation/contaminant removal testing, or other interim measures.

If you have any questions, please contact me, or your staff may contact Doug Hildebrand on (509) 373-9626.

Thomas W. Fletcher, Assistant Manager
for Tank Farms

TF:RDH

Attachment

Distribution – Page 2

M-045-22-T03

cc w/attach:
TPA Administrative Record
Environmental Portal, LMSI
WRPS Correspondence

cc w/o attach:
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ATTACHMENT 1

14-TF-0054

RPP-RPT-56596
***PORE-WATER EXTRACTION PROOF-OF-PRINCIPLE FIELD TEST REPORT*, REV. 0**

DOCUMENT RELEASE FORM

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(b) Reviewer (Optional, Print/Sign): J.C. Henderson [signature] Date: 5/2/14 Date: ______

Date: ______ Date: ______

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RPP-RPT-56596, Rev. 0

Pore-Water Extraction Proof-of-Principle Field Test Report

Author Name: DL Parker, MJ Holm, JC Henderson
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Richland, WA 99352
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Key Words: pore-water extraction, proof-of-principle test, vadose zone, interim measure, soil remediation, direct push, small diameter, pore water, 241-SX Tank Farm

Abstract: A proof-of-principle test was conducted near the 241-SX Tank Farm to evaluate pore-water extraction as a potential remediation technology. The test system was designed using tank farm deployable equipment. Vacuum was applied to a sealed vadose zone well in an effort to extract pore water from a high-moisture zone of interest. If successful, this technology has the potential to remove some mobile contaminants from the unsaturated zone.

APPROVED
By Janis D. Aardal at 1:18 pm, May 05, 2014

Release Approval Date

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EXECUTIVE SUMMARY

A proof-of-principle pore-water extraction test was conducted near the 241-SX Tank Farm. The goal of the test was to determine if contaminated pore water could be extracted from the vadose zone. The test was one step in evaluating pore-water extraction as a potential remediation technology for removing contaminated pore water from the vadose zone. The system was designed and built to address the constraints of working within a tank farm. Small-diameter, direct-push techniques were used for borehole advancement and well placement. The direct-push technique displaces soil rather than bringing potentially contaminated soil to the surface. Additionally, the equipment used is relatively lightweight when compared to other drilling techniques. Direct-push methods have been successfully used in the tank farms to mitigate worker exposures to radioactive soil contamination and accommodate weight limitations for equipment deployed near underground waste storage tanks. The small-diameter boreholes required the design or selection of equipment that could be deployed in the available space.

The proof-of-principle test applied vacuum (approximately -3 psig) to a sealed well screen and established a pressure gradient suitable to initiate pore-water flow through the well screen and into the extraction well. Pore water was successfully extracted from the vadose zone during the test. The pore water was analyzed and found to contain soluble contaminants. Extracted pore water was collected in a well sump and then pumped to the surface using a small-diameter, air-driven bladder pump. The volume of pore water removed was well below expectations. Low water production from the extraction wells may result from several factors. Hydraulic conductivity in the compacted zone adjacent to the well screen may be low, and the as-constructed configuration of the well could also result in conditions that impede water flow. Well configuration is important to facilitate water flow from the formation through the well screen. Excessive silt intrusion into the extraction well sump was discovered at the completion of testing; this likely inhibited the water production rates and interfered with the operation of test equipment.

During test planning, the project team made a decision to utilize the same size boreholes that are routinely used for tank farm characterization activities. This provided a high degree of confidence in the ability of existing tooling and equipment to advance the boreholes to the required depth near the 241-SX Tank Farm. This also limited the space available within the borehole to construct the extraction and monitoring wells and required the design of prototype equipment and non-standard methods for well construction. Limited space also prevented inspection and verification of down-hole conditions. The use of prototype equipment and non-standard methods resulted in reliability issues with using the wells for either pore water extraction or vacuum monitoring purposes.

Recommendations are provided for additional development and testing aimed at improving the ability to construct the down-hole portion of the extraction wells and improve water production. If successful, additional pore-water extraction field testing is recommended.

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Abbreviations and Acronyms

ETF	Effluent Treatment Facility
HEPA	high-efficiency particulate air
ORP	U.S. Department of Energy, Office of River Protection
SX Tank Farm	241-SX Tank Farm
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
WRPS	Washington River Protection Solutions, LLC

Units

μg	microgram
bgs	below ground surface
ft	foot
ft^3	cubic feet
gal	gallon
hp	horsepower
in.	inch
L	liter
mA	milliamp
mL	milliliter
pCi	picocurie
ppm	parts per million
psig	pounds per square inch gauge
scfm	standard cubic feet per minute

Pressure Unit Conversions

-1 psig = -6894 Pascal = -27.7 inches (0.7 meters) of water = -2.04 inches (5.2 centimeters) of mercury (Hg) = 6.8% absolute vacuum

-3 psig = -20685 Pascal = -83 inches (2.1 meters) of water = -6.1 inches (15.5 centimeters) of mercury (Hg) = 21.4% absolute vacuum

1.0 INTRODUCTION

A proof-of-principle, pore-water extraction test was performed by Washington River Protection Solutions, LLC (WRPS) for the U.S. Department of Energy, Office of River Protection (ORP). The test was performed to meet the requirements of Milestone M-045-20 of the Ecology et al. (1989), *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement). The basis for the test is defined in RPP-PLAN-53808, *200 West Area Tank Farms Interim Measures Investigation Work Plan*. The purpose of the proof-of-principle test was to determine if more extensive testing is warranted.

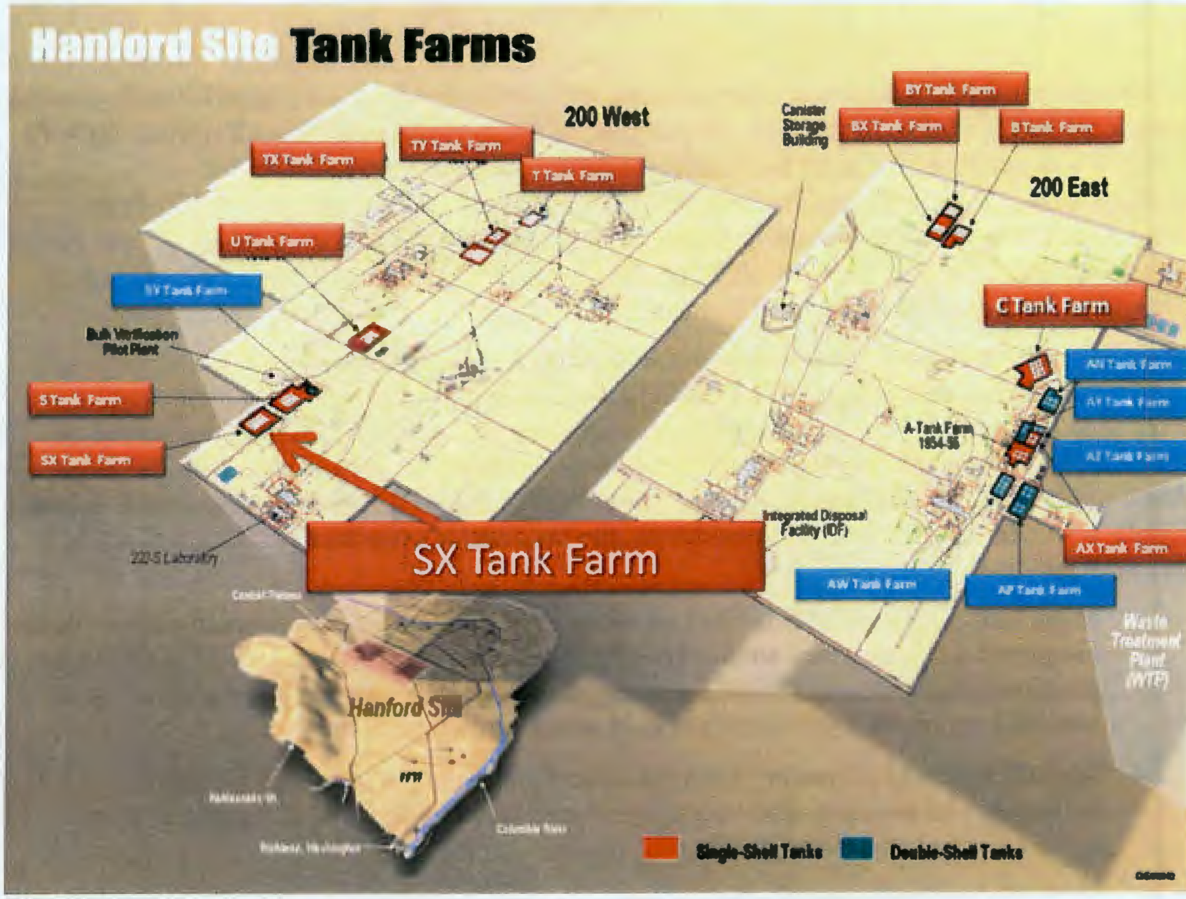
The goal of the proof-of-principle test was to determine if contaminated pore water could be extracted from the vadose zone. Tank farm deployable equipment and direct-push techniques were used to determine if an extraction well could be constructed and if equipment could be successfully deployed in small-diameter boreholes. Testing was performed in the 200 West Area, south of the 241-SX Tank Farm (SX Tank Farm). The SX Tank Farm location is shown in Figure 1. As described in RPP-PLAN-53808, the pore-water extraction test was performed in three stages:

- Stage I involved conducting field activities to obtain additional information about three prospective test locations south of the SX Tank Farm fence line. Each of the three test locations were evaluated for sedimentary deposits of the correct nature with adequate moisture content for application of pore water extraction techniques.
- Stage II involved advancing boreholes directly adjacent to the Stage I boreholes, collecting soil samples, selecting the preferred test location, and designing the test equipment and associated monitoring system.
- Stage III involved procuring equipment; constructing four test wells configured for use as either monitoring or extraction wells, installing the test and monitoring equipment (i.e., pump and level indicator in the well selected for pore-water extraction); and conducting the pore-water extraction test.

Stages I and II were completed in fiscal year 2013. As detailed in RPP-RPT-56849, *Completion Report for 241-SX Tank Farm Direct Push Pore Water Extraction,* in Stage I, three potential locations were evaluated for the possible placement of pore water extraction and monitoring boreholes. Stage I field work resulted in two candidate locations for further evaluation in Stage II. Fieldwork completed during Stage II resulted in selecting the preferred area for locating the four boreholes and constructing the monitoring and extraction wells during Stage III.

As the testing defined in RPP-PLAN-53808 progressed, it became clear that additional testing of a larger-diameter (3.75-in. outside diameter rather than 2.625-in. outside diameter), direct-push methodology was needed to more fully evaluate the pore-water extraction technology. Therefore, the scope of testing was expanded beyond that defined in RPP-PLAN-53808 to include development testing of larger-diameter, direct-push technology for extraction and monitoring well construction. Testing of a larger-diameter, direct-push methodology is described in Section 9.0 of this report, and the results of that testing as of February 2014 are incorporated into the recommendations presented in Section 10.0 of this report.

Figure 1. Pore-Water Extraction Test Site Location.



This test report documents the proof-of-principle test results. Activities associated with locating wells, subsurface characterization, and constructing the wells for Stages I, II, and III are reported in RPP-RPT-56849. Stage III pore-water extraction testing activities, including test results and recommendations for follow-on testing, are provided in this report.

Development and submittal of this test report is required under Tri-Party Agreement Target Milestone M-045-22-T03. Per Target Milestone M-045-22-T03 and Tri-Party Agreement Milestone M-045-22, this test report is to provide the results from the initial proof-of-principle test and provide a recommendation for further testing or for performing interim barrier construction. Per Milestone M-045-22, this test report is to be considered in reaching a decision on future interim measures.

2.0 BACKGROUND

Laboratory tests have demonstrated the ability to extract water from some types of unsaturated soil under specific operational conditions of applied gas-phase vacuum (PNNL-20507, *Pore-Water Extraction Intermediate-Scale Laboratory Experiments and Numerical Simulations*; PNNL-21882, *Pore-Water Extraction Scale-Up Study for the SX Tank Farm*). Pore-water extraction, for purposes of this test, is the removal of water from unsaturated soil by means of applying suction (vacuum) at a well and then pumping the collected pore water to the surface for collection and disposal. Removal of pore water from the vadose zone soils is in response to the applied pressure gradient, but is limited by the capillary forces in the porous media. Pore-water extraction can only occur when moisture content in the soil is above a threshold that is a function of the soil hydraulic properties (PNNL-21882).

Elevated moisture conditions corresponding to the range for which pore-water extraction was successful in the laboratory have been observed in the vadose zone beneath some of the tank farms, especially in higher silt content layers. Numerical simulations were conducted to help define equipment and operational parameters associated with conducting the proof-of-principle test of pore-water extraction near the SX Tank Farm (PNNL-22662, *Field Test Design Simulations of Pore-Water Extraction for the SX Tank Farm*). Base case and sensitivity cases were analyzed to identify a range of potential air flow and water production rates. With a target vacuum level of -3 psig, expected nominal air flow rates of approximately 0.4 ft^3/minute and water production of approximately 4 gal/day were identified through numerical modeling simulations.

The modeling effort was based on information collected in laboratory studies and from field characterization information collected at the test site. Numerical simulations were used to evaluate pore-water extraction performance as a function of the test site properties and for the type of extraction well configuration that can be constructed using the direct-push technology. The output of the simulations included rates of water and air extraction as a function of operational conditions for use in supporting field equipment design. The simulations also investigated the impact of subsurface heterogeneities in sediment properties and moisture distribution on pore-water extraction performance.

3.0 TEST OBJECTIVES

As discussed in RPP-PLAN-53808, the primary test objective of this initial proof-of-principle testing was to determine if contaminated pore water could be extracted from the soil using equipment suitable for deployment within the tank farms. Principle test questions to be addressed included the following:

1. Can soluble contaminants in liquid-phase pore water be removed using small-diameter, direct-push boreholes?
2. What equipment configuration and operating parameters are required to extract liquid-phase, pore-water-containing contaminants through a direct-push borehole?

3. If liquid-phase, water-containing contaminants cannot be removed, can vapor-phase moisture be removed using the small-diameter boreholes placed with the direct-push unit?

The focus of this initial proof-of-principle testing was on pore-water extraction, with vapor-phase moisture extraction to be pursued only if liquid water could not be removed. It should be noted, as discussed in RPP-PLAN-53808, soil vapor extraction has been successfully performed using direct-push boreholes near the 216-Z-9 crib in the 200 West Area.

4.0 TEST DESIGN

Design of the monitoring and extraction wells and the belowgrade portion of the system was based on using standard tank farm direct-push techniques for borehole construction. To this end, this test used standard-size drive casing (2.625-in. outside diameter and 1.875-in. inside diameter) placed with a direct-push hydraulic hammer. Direct-push technology is used throughout the tank farms for subsurface investigations that include geophysical logging, instrument placement, and sample collection activities. Direct-push technology is used at the Hanford Site tank farms because of its low cost to implement relative to other well construction techniques; ability to provide rapid borehole advancement; and because neither soil cuttings nor drilling fluids are generated during borehole advancement, thereby mitigating worker exposure to radiologically contaminated soil and reducing waste disposal costs. In addition, the direct-push hydraulic hammer unit operating footprint is small compared to other drilling equipment and can be placed in locations where placement of a larger drill rig would be problematic.

The aboveground test equipment was designed and configured as a mobile system for field deployment. The aboveground portion of the system is contained within a small 7-ft wide × 14-ft long utility trailer to provide a controlled environment for the equipment as well as a convenient deployment platform. The aboveground equipment includes the vacuum system, the pump controller, the data logger, and storage drums for the pore water.

Commercial off-the-shelf equipment, coupled with established methods for construction, were used where possible to control costs and allow the test to be performed on schedule. Where commercially available equipment was not available, specially manufactured or modified components were used.

The general location of the test area is specified in Milestone M-045-20, and was chosen due to the presence of relatively shallow moist geologic layers containing mobile contaminants such as technetium-99 and nitrate. The specific area south of SX Tank Farm was chosen for the test to allow greater operational flexibility than would be possible working within the tank farm (Figure 2).

Figure 2. Pore-Water Extraction Test Site Location.

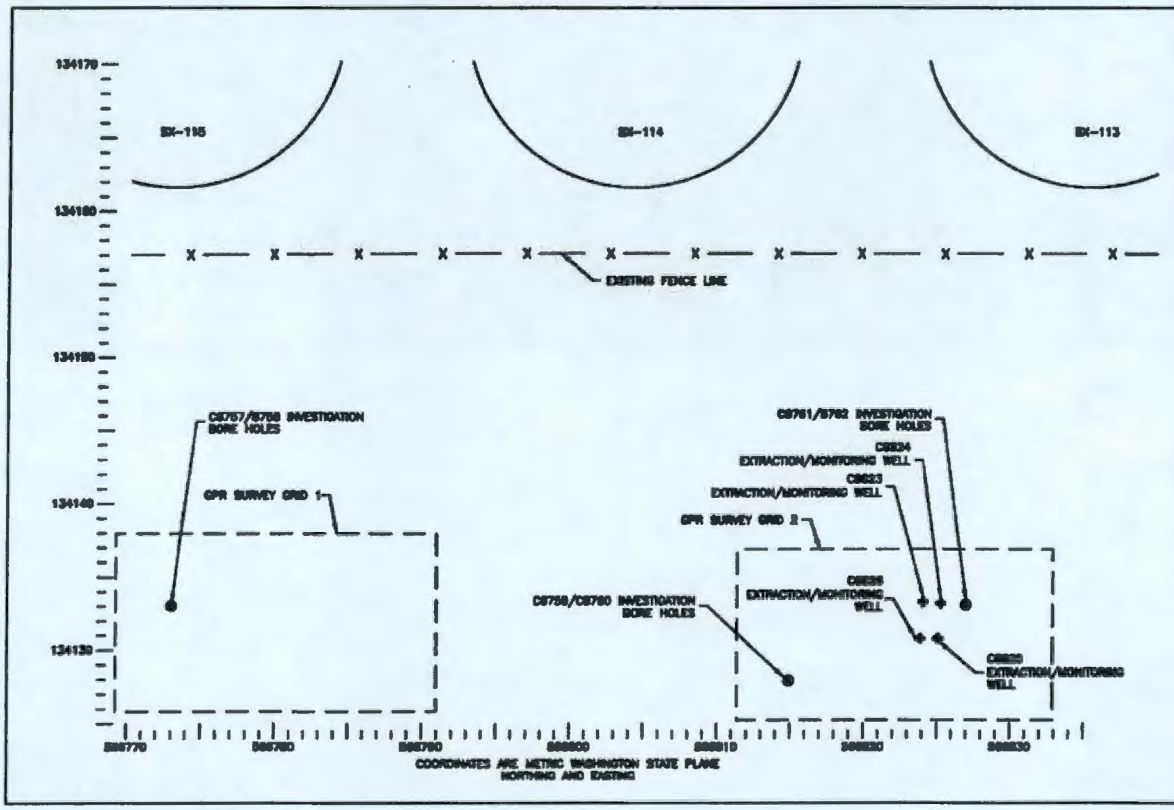
4.1 INVESTIGATION SITES

In accordance with Stages I and II of RPP-PLAN-53808, three investigation sites were planned south of SX Tank Farm; however, refusal of the direct-push unit occurred several times at the western most site and it was abandoned. The locations of the three investigation sites are shown in Figure 3. A borehole for geophysical logging (i.e., moisture and gamma) and a borehole for soil sampling were pushed at the remaining two sites. The second borehole was pushed adjacent to each logging borehole and three soil samples were collected from each sampling borehole.

Note: *RPP-PLAN-54366, Field Sampling and Analysis Plan for SX Pore Water Extraction Test Project Stage 1 – Soil Sampling, indicated that each sample borehole would be sampled at two intervals (i.e., six samples from three investigation sites). It was decided that six samples would still be collected – three sample intervals per each of the two investigation sites.*

The sample intervals from each site were selected based on the logging results and other information available about the location (see February 12, and February 21, 2013, meeting minutes in Appendix A). The samples were analyzed on a "quick-turnaround" basis for moisture content, nitrate, and technetium. (Refer to RPP-RPT-55107 for analysis results.) Additional tests (i.e., falling head test) were performed at the investigation sites to gain additional hydrogeologic property information to assist in selecting the test location.

Figure 3. Investigation Site and Well Locations for Stages I, II, and III.



4.2 WELL LOCATION DESIGN AND CONSTRUCTION

After reviewing available information, the best test location was determined to be between the center and eastern most investigation sites. This decision was documented in a meeting with ORP and the Washington State Department of Ecology (see the April 17, 2013 meeting minutes in Appendix B).

The benefits of selecting this location are as follows:

- More promising sediment type (sandy silt as opposed to silty sand), higher moisture content sediment layers, and slightly thicker silt layers
  - Greater than 2-ft-thick moisture layer
  - Greater than approximately 30% volumetric moisture content
  - Estimated pore water nitrate concentrations of 44 to 90 mg/L
- Avoids the edge of the tank farm excavation slope, and keeps the test area within the Stage I investigation area
- Test area is close to the tank farm and within the thicker silt beds (because the beds thin toward the south).

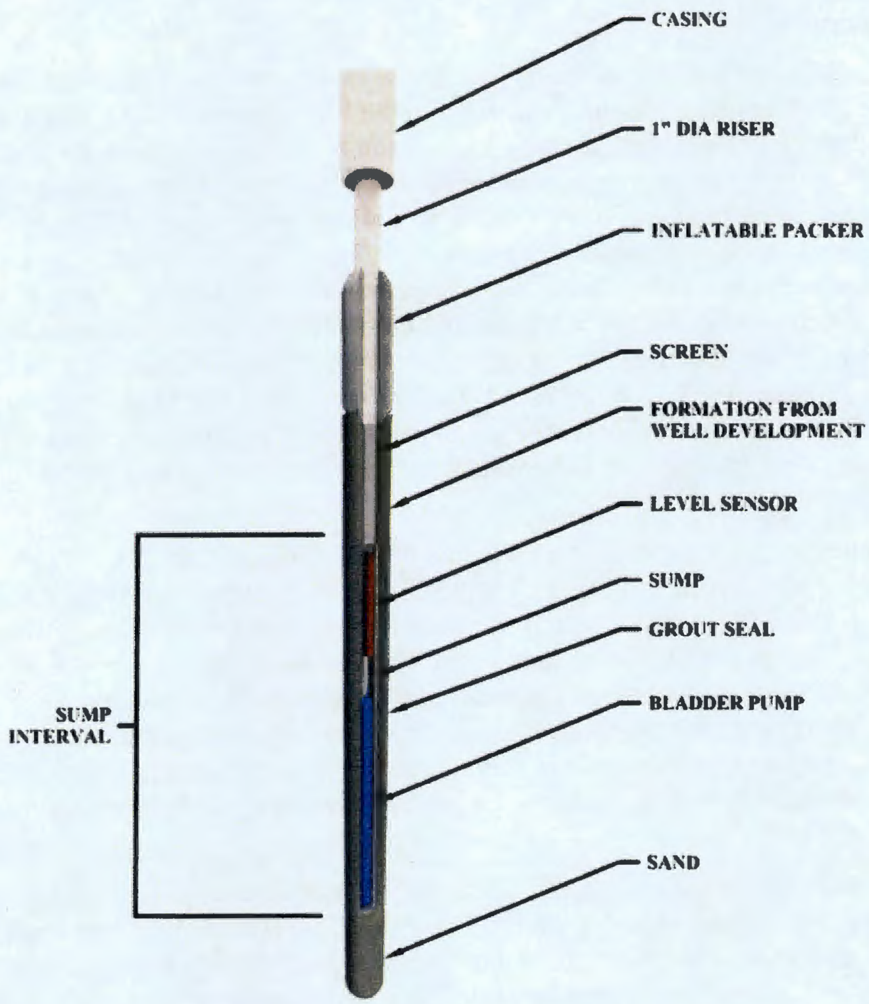
Following selection of the final test location, four monitoring/extraction wells were constructed in a 4 ft × 8 ft "box." The identification numbers for the four wells are C8823, C8824, C8825, and C8826 (see Figure 3). By orienting the four wells in a rectangular pattern, the distance from the extraction well to the remaining three monitoring wells would be the same regardless of which well was used for extraction. This provided three monitoring points with varying distances from the extraction well, necessary for actual radius of influence calculations, while maintaining the flexibility to relocate the extraction well within the "box" if failure at one location is encountered. The distances were selected based on predicted zone of measurable vacuum influence based on the numerical modeling results (PNNL-22662, *Field Test Design Simulations of Pore Water Extraction for the SX Tank Farm*). Note that the measurable vacuum response distance is smaller than the potential radial influence of pore-water extraction from a well. As a risk mitigation measure, all four wells were constructed so that they could function as extraction wells or monitoring wells.

To construct the monitoring and extraction wells, a 2.625-in. outside diameter, 1.875-in. inside diameter drive casing was driven to a depth of approximately 150 ft below ground surface (bgs). Based on geophysical logs from nearby wells, the target zone for extraction was between 120 and 130 ft bgs. A core sampler was used to remove material through the target zone in order to limit the amount of compaction around the well screen. Nominally, the bottom 60 ft of each borehole was logged using a neutron-neutron moisture tool and spectral gamma sensor to identify the specific target extraction zone in each borehole. A target moisture content of 25% by volume was established through laboratory testing and was used in selecting target extraction zones.

Well screen placement was based on logging information. A moisture peak at a depth of about 128 to 129 ft bgs in well C8823 appeared the most promising for well screen placement. This depth interval has high volumetric moisture content and adequate thickness for the placement of a well screen. The well screen length was discussed as it relates to the moisture interval and subsequent dimensions needed for sealing above and below the screened interval. Based on this discussion, a 12-in.-long well screen was selected. (Refer to the August 1, 2013 meeting notes in Appendix A.)

Four sets of identical riser, packer, screen, and sump assemblies were installed within the driven borehole casings. A screen and packer assembly that would fit inside of the drive casing and still allow for a 1-in.-diameter riser pipe was developed. Figure 4 depicts the general down-hole configuration following installation of the pump and level sensor. The riser pipe had a nominal 1-in. inside diameter and the screens and sumps had a 1.33-in. inside diameter. Each well has a sump approximately 4 ft deep below a 1-ft, 10-slot screen. Through mock-up and testing of different combinations, the project developed a sump/screen/packer design that would fit inside of the drive casing. To seal the well screen, a custom inflatable packer was developed for use above the screen and a technique was developed to seal below the screen with grout. Details on the well construction and development are provided in RPP-RPT-56849. A summary of well construction and development is provided in the following paragraphs.

Figure 4. Extraction Well Down-Hole Configuration.



Note: monitoring well configurations are the same but do not include the level sensor or bladder pump.

A number of mock-up tests using clear plastic tubing, grout, and simulated packer assemblies were conducted at an offsite test facility to estimate the grout required to provide the lower seal. Figure 5 shows the grout level just below the well screen in the mock-up test. The grout delivery system for the bottom seal was modified and tested several times, and a design was chosen to provide the best chances of successfully achieving a grout seal at the bottom of the well screen.

Figure 5. Mock-Up Test

The direct-push well construction technique displaces the soil as the casing is pushed to depth and results in a compacted zone around the casing. To reduce the thickness of this compacted soil through the target depth interval for pore-water extraction, a core barrel sampling tool was used to remove soil ahead of the primary casing. After moisture logging was completed, the wells were constructed with the screens centered at the depth corresponding to the highest measured moisture content.

After the well assemblies were grouted into the boreholes, it was determined that two of the wells (C8825 and C8826) had grout in the sumps with grout either partially or fully blocking the screen. While grout was not observed in the other two well sumps, the height of grout outside the well in the annular space was not known because it could not be measured after well emplacement. Due to these conditions, two of the wells (C8823 and C8824) were candidates for use as either extraction or monitoring wells, while the other two wells (C8825 and C8826) were suitable only as monitoring wells.

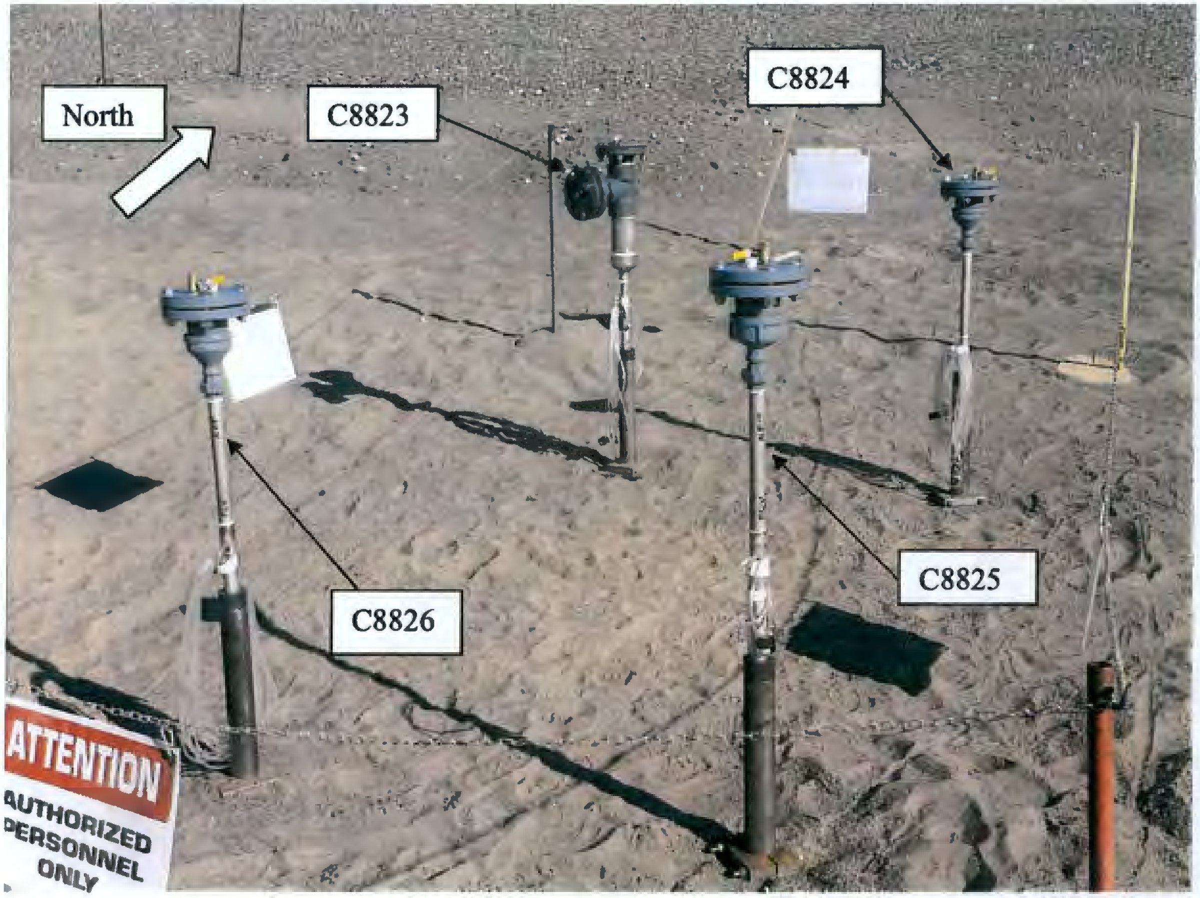
Based on as-built well configurations, geology, and the moisture logging results, the extraction well priority (highest to lowest) was C8823, C8824, C8826, and C8825. The priority was established prior to initiating testing to reach agreement on which well to use for the initial equipment installation and the subsequent well in the event well C8823 was not suitable for use as an extraction well.

The wells were then developed by surging and pumping in an effort to break down the compacted material resulting from pushing the casing through the soil and to establish contact between the formation and the well screen. Well development was performed on the four wells in order of least desirable wells for extraction purposes being developed first (i.e., in the order of C8826, C8825, C8823, C8824). This allowed the well development process, to be refined before the higher priority extraction wells were developed.

Falling head tests were performed in each of the wells between surge and pump efforts to assess the effectiveness of the well development. Development efforts for all four boreholes showed no effect in breaking down the compacted zone or increasing the effective permeability as had been observed previously in the C8761 test borehole (RPP-RPT-56849). Development efforts were also balanced against over-developing the wells, potentially resulting in channeling of the formation and loss of the well for extraction purposes.

The aboveground portion of the extraction well assembly provided the necessary interfaces with the above grade portion of the extraction system. The extraction well included pipe fittings and bulkhead type fittings to maintain a seal on the well while providing pass-through connections for the compressed air and water lines connected to the bladder pump; connection for the vacuum line; and e-tape for the water level sensor. The extraction well head assembly also included provisions for a pressure transducer and thermocouple probe. The three monitoring wells included pipe fittings to maintain a seal on the wells while providing penetrations for pressure transducers and valves for potential use during test operations. Valves were included on the monitoring wells to provide a means for allowing atmospheric air into the well or injecting air under pressure. The above grade portion of the four wells prior to connecting the vacuum line and instrumentation is shown in Figure 6.

Figure 6. Above Grade Portion of Monitoring and Extraction Wells.



4.3 EXTRACTION SYSTEM DESCRIPTION

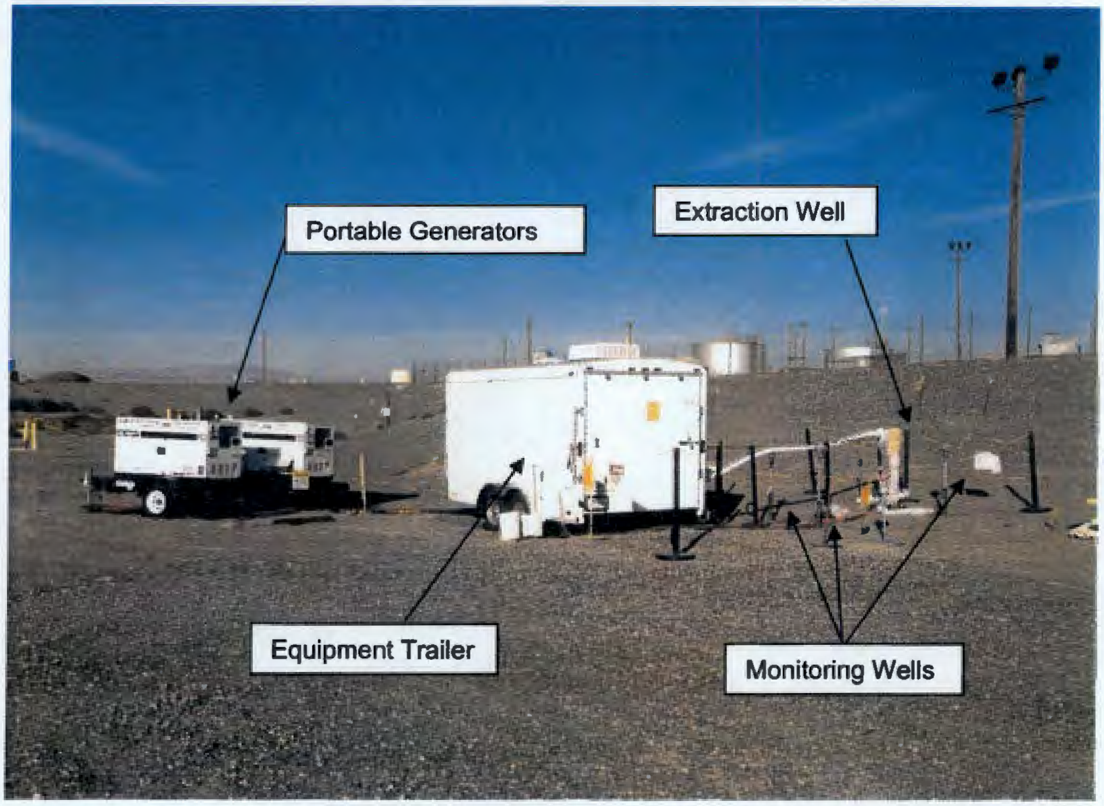
The extraction system design is documented on released engineering drawings. Configuration control of the test system was maintained during testing by revising the design drawings and documenting all system modifications using established procedures for engineering change control. The following design drawings document the above grade portion of the system:

- H-14-109843, *SX Pore Water Extraction Process Flow Diagram*
- H-14-109844, *SX Pore Water Extraction P&ID*
- H-14-109845, *SX Pore Water Extraction Site Plan*
- H-14-109846, *SX Pore Water One-Line and Panel Schedule*
- H-14-109847, *SX Pore Water Extraction Trailer Assembly*
- H-14-109848, *SX Pore Water Instrument Enclosure*
- H-14-109849, *SX Pore Water Pump Bulkhead Assembly.*

4.3.1 Above Grade Extraction Equipment

The above grade portion of the system included the equipment trailer that contained the vacuum pumps and other equipment required to establish a controlled vacuum in the well, water collection system for the extracted pore water, and instrumentation to monitor parameters of interest during test operations (Figure 7).

Figure 7. Pore-Water Extraction Above Grade Test Setup.

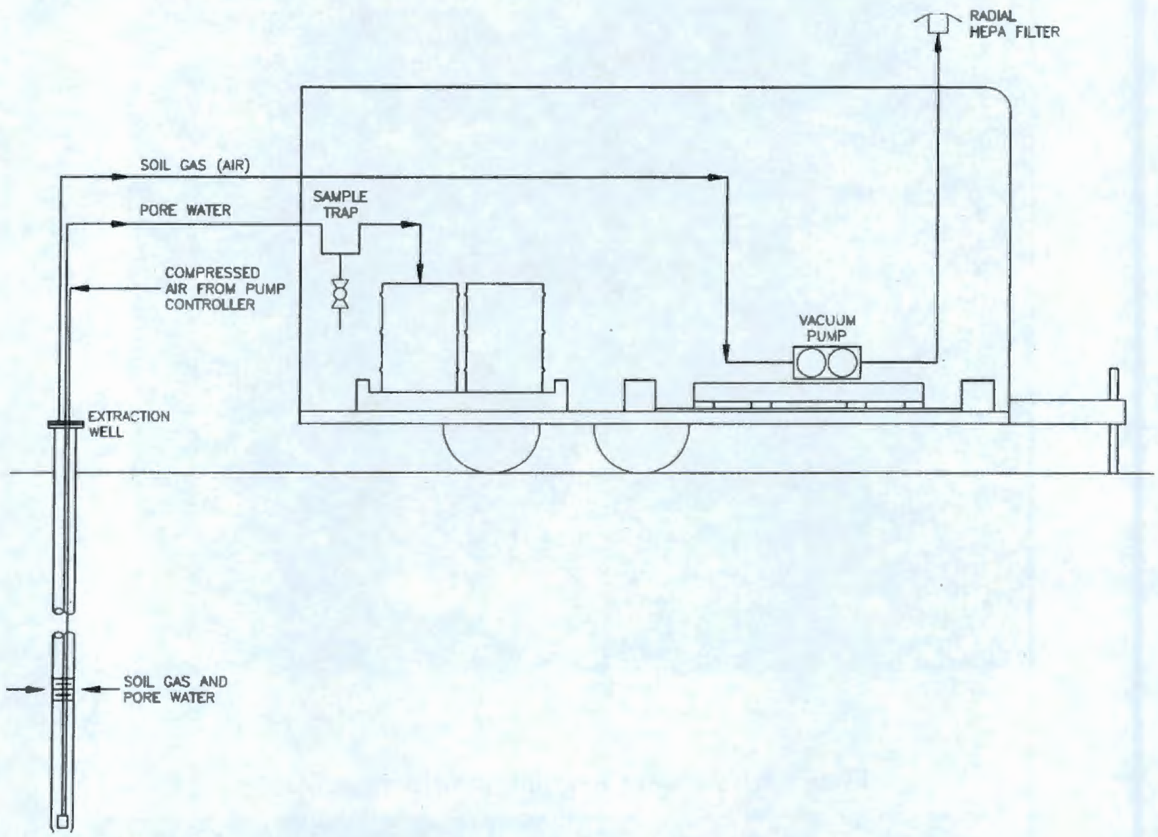


Two 0.75 hp Gast Manufacturing, Inc. rotary vane vacuum pumps, each having an 8 scfm free-flow capacity, combined with adjustable vacuum regulators provided the capability to impose a vacuum on the well over a range of flow rates. Vacuum lines were configured with valves to allow for operation of either vacuum pump independently or operation of both pumps in parallel for higher air flows. The inside of the test trailer is shown in Figure 8 and Figure 9. Figure 8 shows the two vacuum pumps on the bench and the vacuum line routing on the wall. Figure 9 shows adjustment of the vacuum regulator used to set the vacuum level applied to the extraction well. The air stream extracted from the well was treated as potentially contaminated and was routed to the outside of the trailer and through a high-efficiency particulate air (HEPA) filter prior to discharging to the atmosphere. Additionally, the collection drum was fitted with a HEPA drum filter to control emissions from air displaced from the drum. A simplified flow diagram of the system is provided in Figure 10.

Figure 8. Test Trailer Prior to Deployment.

Figure 9. Vacuum Regulator Adjustment.

Figure 10. SX Tank Farm Pore-Water Extraction Test Simplified Flow Diagram.



Two portable generators were used for the test. One generator was used to provide power while the other was maintained as a backup. An uninterruptable power supply was included in the design to provide for continued operation of the vacuum pump and data logger when the main power supply was moved from one generator to another. This allowed for generator servicing without disruption of test operations.

A nitrogen supply was included in the design to provide for inflation of the well packers. A regulator, valves, and pressure gauges allowed for inflating each of the well packers individually. The rear of the test trailer showing the nitrogen supply along with the water collection drum on a spill pallet is shown in Figure 11.

Figure 11. Test Trailer Rear View.

The above grade equipment was housed in a 7-ft wide × 14-ft long dual axle utility trailer with heat and air conditioning. These features, along with heat trace and insulation on the water line routed from the extraction well into the test trailer, provided a mobile deployment platform and allow for year-round test operations. Figure 12 shows the above grade portion of the extraction well insulated and wrapped for cold weather operation.

Figure 12. Extraction Well with Heat Trace and Insulation.

4.3.2 Belowgrade Extraction Equipment

The 1 in. inside diameter of the well riser limited the commercially available pump options for the test. A Geotech Environmental Equipment, Inc. 0.85-in.-diameter × 24-in.-long, air-driven bladder pump was selected for use and was installed in the extraction well sump to pump water to the surface. The bladder pump was operated by a Geotech pump controller at the surface. The pump controller has a self-contained air compressor that provides compressed air to the pump to compress the pump bladder and push water into the discharge line. A check valve on top of the pump prevents water in the discharge line from draining back so that each pump cycle pushes approximately 2 oz of water into the discharge line. The bladder pump and controller were configured with a water level meter located near the top of the well sump. The pumping system was configured to operate in a drawdown mode where the level meter signaled the pump controller to cycle the pump when the water level in the sump rose to where it was in contact with the level meter.

4.3.3 Monitoring and Instrumentation Equipment

Monitoring instruments were included in the system design to collect data for use in assessing system operations. Eleven instruments were included in the system design. The primary parameters of interest for pore-water extraction testing were vacuum level in the extraction well and corresponding air flow from the extraction well. Pressure transducers were installed in the system at the well head and near the vacuum pumps to measure vacuum levels. The vacuum level measured at the well head was used for control of the extraction process. A comparison of vacuum levels at the two locations allowed for comparison to identify vacuum leaks. Air flow was measured using two thermal mass flow meters.

Thermal mass flow meters were selected because they measure flow independent of pressure and automatically compensate for changes in temperature. To accurately measure air flow over the potential range of air flows anticipated, two different flow meters were used in the system. Solenoid valves were installed to direct vacuum air flow through either the 0.25-in. flow meter or the 0.5-in. flow meter. When vacuum air flow rate was below 2 scfm, the 0.25-in. diameter, in-line flow meter was used for process monitoring. When vacuum air flow was greater than 2 scfm, solenoid valves swapped positions so that the 0.5 in.-diameter, in-line flow meter was used for process monitoring. Flow meters were equipped with local read out as well as a 4 to 20 mA output sent to the data logger for collection.

Instrumentation to monitor nitrate concentrations and volumes of extracted pore water were included in the design. A nitrate sensor was included in the water line between the well and the collection drum within the trailer. The piping was configured to provide a trap that would remain full of water and keep the membrane of the sensor wet throughout the test. The nitrate sensor was included in the system design to provide real-time data on any water extracted from the well and to help guide sampling activities. A radar drum level gauge was installed in the collection drum to monitor the amount of pore-water accumulated in the drum.

Data from all 11 instruments was sent to the data logger for storage and future access. Data collected for each instrument included the date and time stamp, tag identification, I/O (input/output) type, raw value collected by instrument, scaled value, engineering units of scaled value, and description of tag.

4.4 ENVIRONMENTAL PLANNING

Environmental planning for the onsite testing activities addressed both air emissions and management of water extracted from the well during test operations. Air permitting considerations addressed construction of the wells and operation of the system that included discharge of the air drawn from the extraction well by the vacuum pumps. Management of the extracted pore-water involved classification and defining a path for disposal.

Direct-push of the four boreholes was covered under ALARACT 18, *Environmental Restoration Program ALARACT Demonstration for Drilling*, and operation of the vacuum extraction system was covered under Washington State Department of Health NOC 904, *SX Farm Pore Water Extraction Test Project* (FF-01, 2014, *Radioactive Air Emissions License for the Department of Energy Richland Office Hanford Site*). Estimated emissions for the project were determined to be two orders of magnitude below the de minimis levels for all toxic air pollutants; therefore, agreement was reached with the Washington State Department of Ecology that the SX Pore Water Extraction Test Project was exempt from New Source Review.

RPP-RPT-54393, *241-SX Tank Farm Proof-of-Principle Test Pore Water Extraction Water Management Evaluation*, was developed to evaluate options for the storage and disposal of the pore-water extracted during the test. The option selected was to handle the extracted pore water as engineering test material until no further sampling was necessary, and then dispose of the water at the Effluent Treatment Facility (ETF). The drum was labeled and staged as engineering test material until completion of the test.

5.0 TEST OPERATIONS

With the potential to encounter radiological contamination during test operations, the area around the wells and the test trailer was designated as a Radiological Buffer Area. Personnel access was controlled and radiological surveys were routinely performed during test operations, system modification, and water sampling activities in accordance with work controls defined in the work package.

Test operations were initiated on well C8823 in early October 2013. Test operations were performed in accordance with RPP-PLAN-55319, *SX Tank Farm Pore Water Extraction Experimental Test Plan*. The target vacuum level during test operations was -3 psig at the well screen. Based on the modeling simulation results, the test plan identified target vacuum levels and air flow rates. Threshold values were also identified to allow for switching to an alternate extraction well in the event that the target vacuum level could not be established or the air flow was too high. Initial operation at well C8823 showed vacuum level and air flow within the established operational targets.

Operational issues were encountered with the bladder pump and the inflatable well packer in well C8823 following start up. The bladder pump was configured with a level sensor and pump controller to operate in a drawdown mode (i.e., when the water level in the sump reached the level sensor the pump controller cycles the bladder pump and continues operating until the water level drops below the level sensor). The system did not operate in a drawdown mode and the pump controller cycled continuously throughout the test. Continued cycling of the bladder pump would not affect the ability of the system to extract pore water but would likely shorten pump life. Section 5.2 discusses the findings at test completion, during equipment removal it was discovered there was a significant volume of saturated silt that may have affected the performance of the level sensor. Additionally, the inflatable packer failed and would not maintain the required inflation pressure. Troubleshooting was performed and attempts were made to establish a seal above the screen using bentonite pellets. Those efforts were initially successful and following restart allowed the system to reach target vacuum levels. However, with time the measured air flow steadily increased, suggesting that the integrity of the seal could not be maintained. Without a seal the vacuum levels necessary for pore-water extraction could not be maintained. Alternatively, the increased airflow may have been air channeling in the soil formation along the well bore, outside of the influence of the seal. These issues led to a decision to relocate the extraction equipment to well C8824 in early November 2013. Well C8824 was used as the extraction well for the remainder of test operations.

Operational issues were also encountered with the inflatable packers in monitoring wells C8825 and C8826. The inflatable packers in those two wells required routine re-inflation during the test, indicating that there was a slow leak in the nitrogen supply line or the packer itself. Inflation pressure was monitored during daily rounds and adjusted to a target pressure of 13 psig ± 2 psig as necessary between test start-up and November 26, 2013. During this time period, packer inflation pressure in the wells fell to between 3 and 4 psig in a 24-hour period. The loss of pressure in the packers makes evaluating the radius of influence via the vacuum levels difficult to assess. System modifications were made to provide a separate nitrogen supply for the two monitoring wells on November 26. This involved adding additional nitrogen bottles, a pressure regulator, and valves to connect the tubing running to the packers. Following the system modification, the nitrogen supply to the packers was regulated at 12 psig. One or both of the packers failed around December 2 when the nitrogen bottles were found to be empty. These monitoring well packers were not re-inflated for the remainder of the test.

Following the nitrogen supply modification on November 26, the primary nitrogen supply was dedicated to maintaining the inflation pressure on the extraction well packer. Nitrogen supply to the extraction well packer was left at a regulated pressure of 11 to 12 psig throughout the test to maintain the seal above the well screen. There was no evidence of any leakage from the extraction well packer throughout the test at well C8824.

5.1 TEST OPERATIONS ON EXTRACTION WELL C8823

A summary of the test operations using well C8823 as the extraction well is provided in Table 1. A number of operational issues were encountered in attempting to achieve a steady vacuum of -3 psig on well C8823. Because well C8823 was the preferred extraction well, additional troubleshooting steps and potential remedies were attempted in an effort to establish operating conditions suitable for pore-water extraction.

Table 1. Test Operations Summary, Extraction Well C8823.

Date	Summary of Test Status	Sample Collected (approximate sample volume)
10/8/13	Test setup and collection of "equipment blank" sample.	Yes – Equipment blank (~1000 mL)
10/9/13	Test operations started on well C8823, vacuum ramp up initiated. Did not complete ramp up prior to end of shift.	No
10/10/13	Completed vacuum ramp up to -3 psig on extraction well and obtained operational vacuum and air flow targets. Issue identified with bladder pump continuing to cycle. Ramped system down at end of the day.	No
10/14/13	Troubleshot equipment and found the instrument cable between the bladder pump controller and level reel was broken. Extraction well packer failed and drained the nitrogen supply bottle.	No
10/16/13	System placed in standby for potential Government shutdown.	No
10/23/13	Added approximately 7 cups of bentonite pellets and 0.5 gal. of distilled water to well C8823 annulus in attempt to seal off the screened interval.	No
10/28/13	Vacuum system modifications made and vacuum ramped up.	No
10/31/13	Vacuum leak discovered at the extraction well head assembly. Vacuum system ramped down, leak sealed and left to cure over the weekend. Added approximately 2 cups of bentonite pellets and 1.5 gal. of distilled water to well C8823 annulus.	No
11/4/13	Troubleshot pump controller with spare water level meter, controller function verified. Ramped up vacuum on extraction well.	No
11/7/13	Decision made to relocate pump and reconfigure system to use well C8824 as the extraction well. Ramped system vacuum down to 0 psig.	No

As noted in Section 4.3.3, the primary parameters of interest for pore-water extraction testing were the applied vacuum level and the corresponding air flow from the extraction well. Plots of vacuum level and air flow are provided throughout this section to illustrate system response to the applied vacuum level. Pressure and air flow plots were used throughout test operations to evaluate system performance relative to target values and identify changes over time.

Between October 10 and October 14, the inflatable well packer installed in well C8823 failed. The inflatable well packer had been left inflated on October 10, but when the team returned to the test site on October 14, the well packer was deflated and the nitrogen bottle that connected to the well packer was empty. Subsequent attempts to re-inflate the well packer were unsuccessful. The loss of the inflatable well packer eliminated the upper seal above the well screen and rendered well C8823 unusable as an extraction well.

A number of options were evaluated to establish a seal above the well screen so that well C8823 could continue to be used as an extraction well. A potential fix of using bentonite pellets was selected as the preferred option. The bentonite pellets chosen were small enough to be placed into the annular space but too large to pass the packer assembly. The expectation was that the bentonite pellets could be dropped into the annular space between the riser and the outer casing to come to rest on and around the packer assembly.

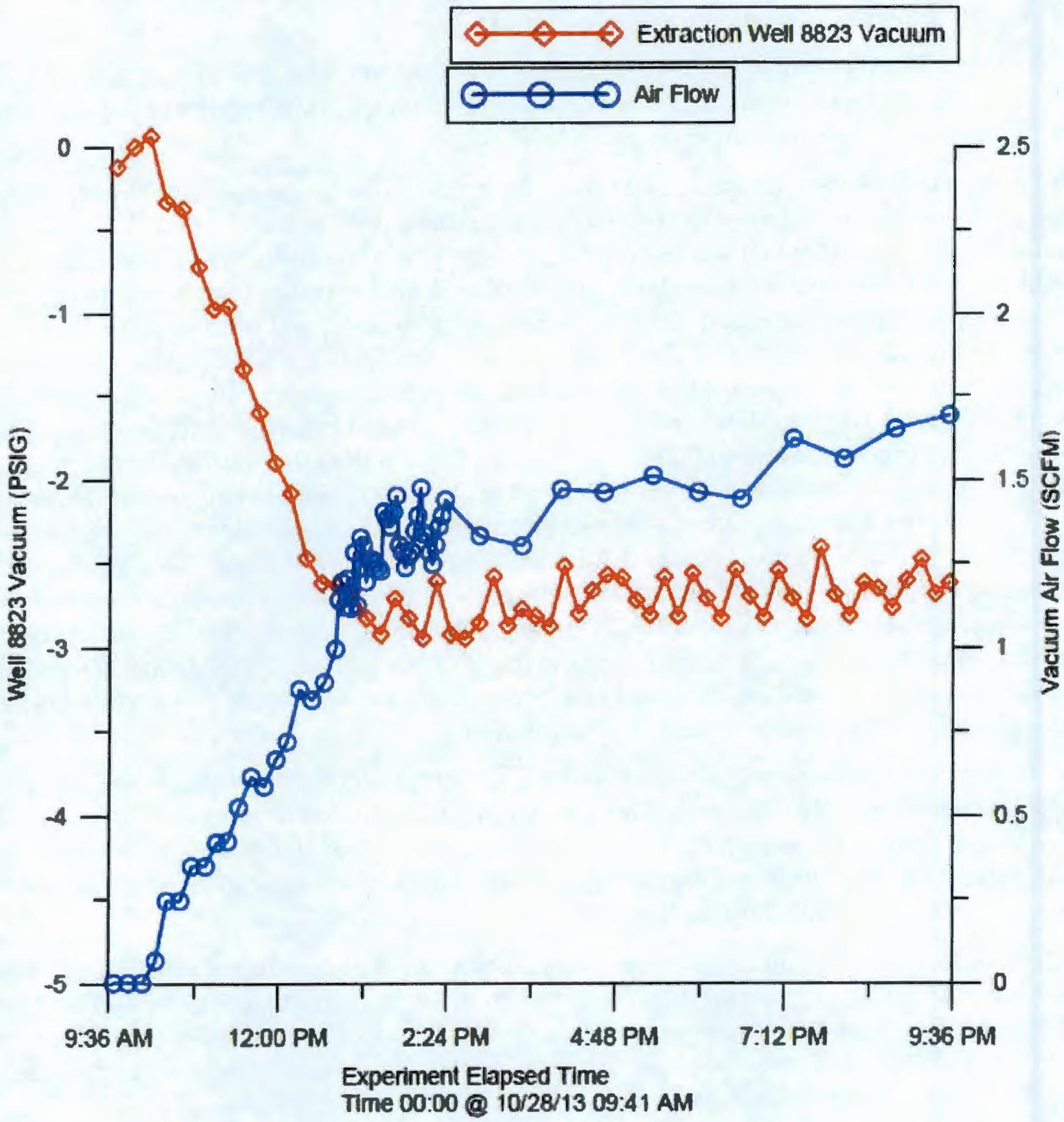
On October 23, approximately 7 cups of bentonite pellets were placed and hydrated with approximately 0.5 gal. of deionized water. The system was allowed to set without a vacuum so the pellets would have time to hydrate.

On October 28, the vacuum system was reconfigured to allow for operation of the bladder pump with a vacuum applied to the well then the test operations were restarted. One downside of the vacuum system modification was the influence of the pump controller vent cycle on the main vacuum system flow and pressure data. The bladder pump controller has a small air compressor that is used to apply compressed air to the outside of the bladder and push water up the discharge line to the surface. At the end of a cycle, the pump controller triggers a solenoid valve that vents the compressed air to the atmosphere and relieves the pressure on the outside of the pump bladder, allowing water to flow into the pump cavity. Normal pump operation requires that the pump be submerged in water so that the head pressure from the water pushes water into the pump. The vacuum applied to the well reduces the absolute pressure at the bottom of the well sump below atmospheric pressure. Under these conditions the applied vacuum prevents water from flowing into the pump cavity so that it can be pumped to the surface. To compensate for the vacuum applied to the well, the pump controller was modified to vent the bladder pump into a vacuum reservoir that was in turn tied into the main vacuum system. The vacuum reservoir added to the system was sized to minimize the impact from venting the bladder pump and associated air line into the main vacuum line connected to the extraction well. This modification was successfully tested prior to field implementation.

On October 31, a vacuum leak was discovered at the extraction well head assembly where the water line penetrated the well head. This penetration was sealed with silicone sealant and allowed to cure over the weekend. The test was restarted on November 4. After ramping up the vacuum on both October 28 and November 4, it appeared that the bentonite pellets were effective at creating a seal (Figure 13 and Figure 14).

A graph of the well vacuum and air flow for the first 12 hours following ramp up of the system on October 28 is shown in Figure 13. The graph shows the slow ramp up of the vacuum applied to the well going from 0 to -3 psig over approximately 2 hours. The effect of the bladder pump controller venting into the vacuum system can be seen in the variability in both the pressure and flow data following system ramp up.

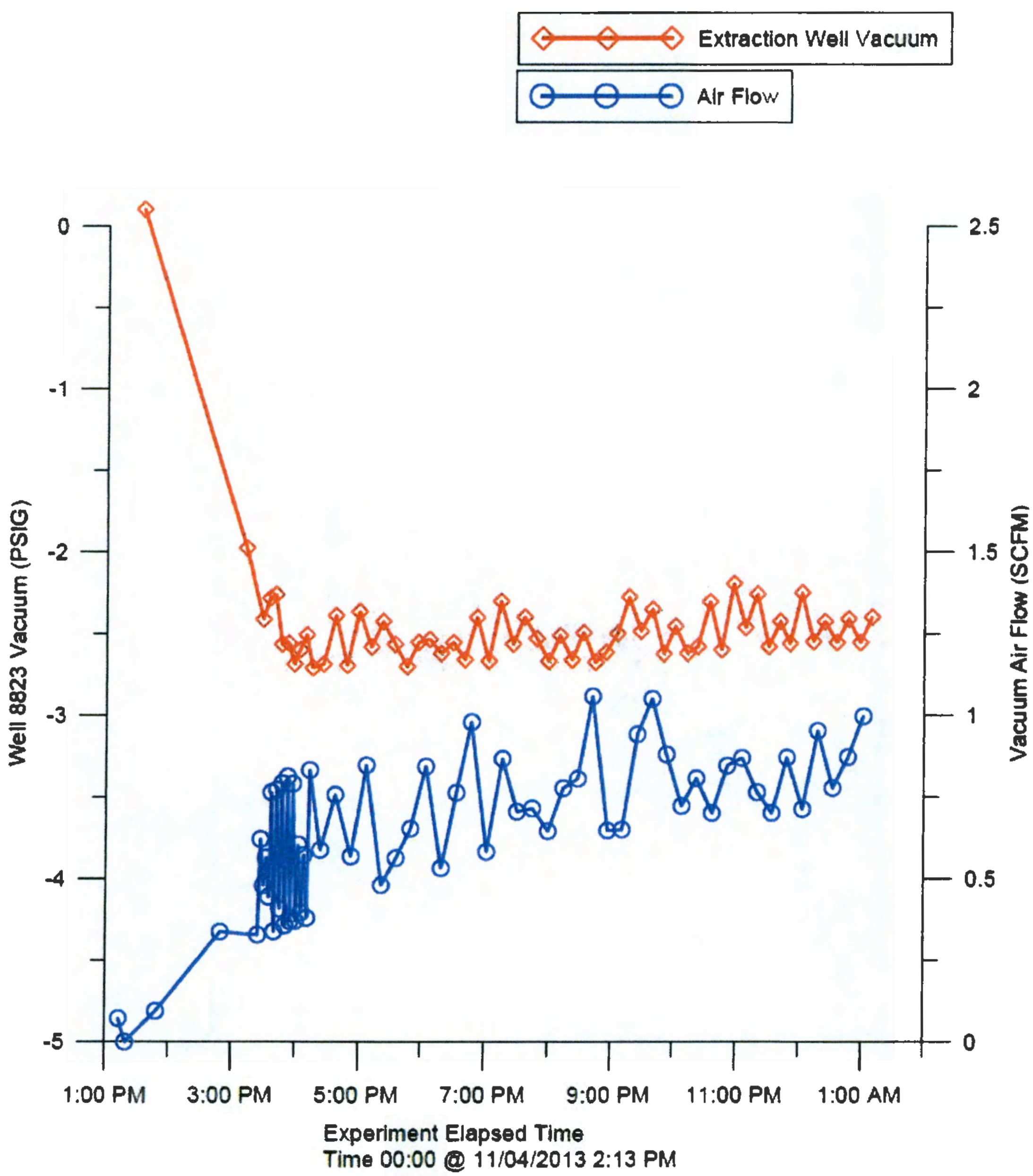
Figure 13. Extraction Well C8823 Pressure and Flow Plot Ramp Up (10-28-2013).



Comparison of the measured flow rate to the predicted flow rate cannot be made while the bladder pump controller is cycling and venting compressed air into the vacuum reservoir. The air added to the vacuum system from the pump controller causes a pressure pulse, causing the vacuum regulator to increase the air flow until the target vacuum level is reestablished. This masks the steady state vacuum level and the volume of soil gas extracted from the well. Direct comparisons of measured versus predicted vacuum levels and gas flow rates can be made when the pump controller was turned off.

A vacuum leak was subsequently found at the well head resulting in repair and restart of the test on November 4. A graph of the extraction well vacuum and air flow for the first 12 hours following ramp up on November 4 is shown in Figure 14.

Figure 14. Extraction Well C8823 Pressure and Flow Plot Ramp Up (11-4-2013).



However, as test operations continued, a slow loss of vacuum and increase in air flow occurred after the target vacuum level of -3 psig was applied. This is illustrated in Figure 15 where the air flow from the extraction well goes from approximately 0.5 scfm to over 2 scfm between November 5 and November 7. Evaluation of the vacuum and air flow data led the project team to conclude that the well could not be used as an extraction well. A decision to move the extraction equipment to well C8824 was made on November 17. Figure 16 shows the bladder pump being removed from well C8823.

Figure 15. Extraction Well C8823 Pressure and Flow Plot.

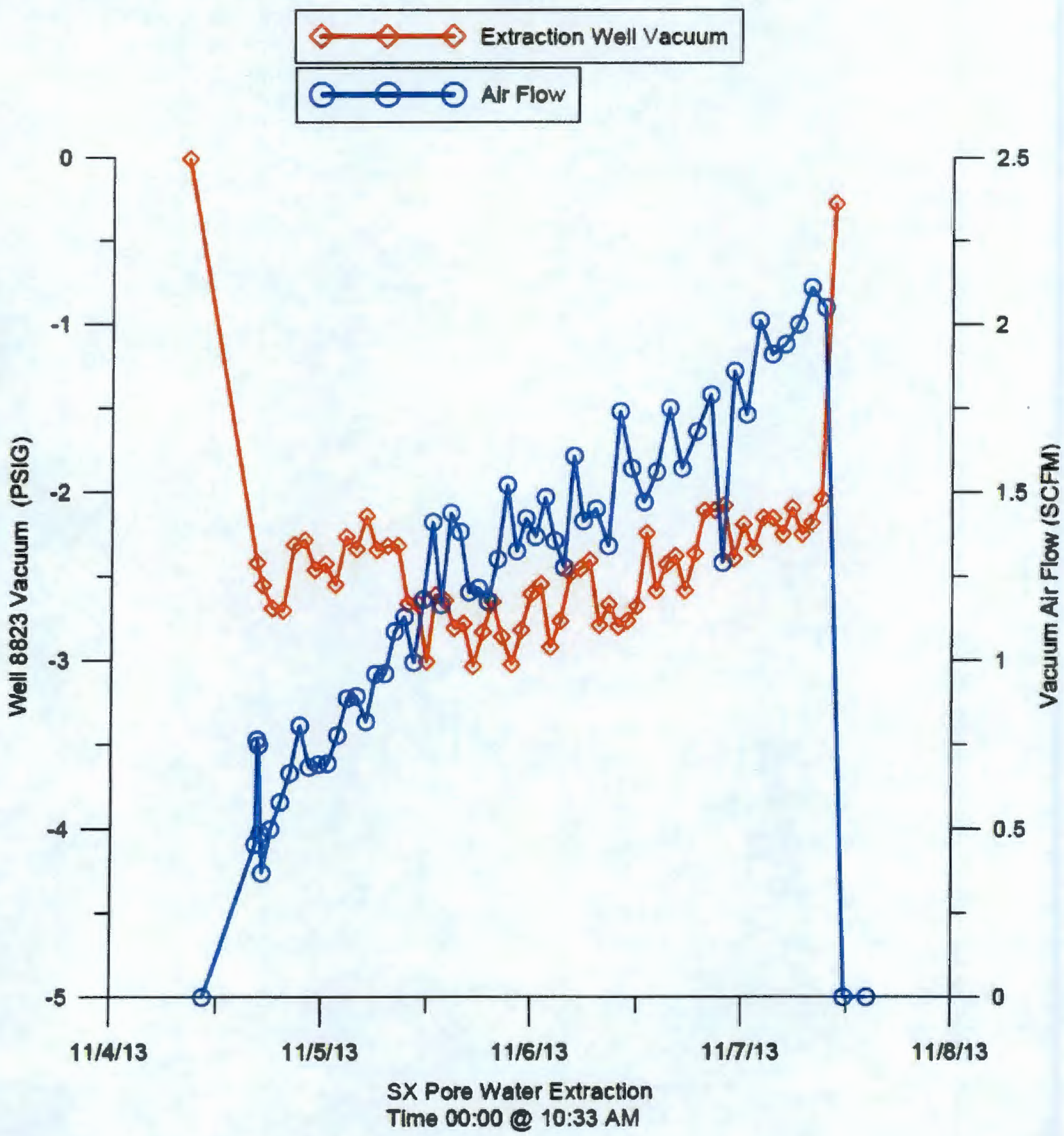


Figure 16. Bladder Pump Removal from Well C8823.

5.2 TEST OPERATIONS ON EXTRACTION WELL C8824

Pore-water extraction testing was performed using well C8824 beginning on November 11, 2013, and continued through the duration of test operations. A summary of the test operations using well C8824 as the extraction well is provided in Table 2.

Table 2. Test Operations Summary, Extraction Well C8824. (2 sheets)

Date	Summary of Test Status	Sample Collected (approximate sample volume)
11/7/13	Removed bladder pump and well head assembly from well C8823 and installed on well C8824, replaced water level meter, sealed well head assembly and left to cure.	No
11/11/13	Ramped up vacuum on extraction well C8824. Obtained operational vacuum and air flow targets.	Yes – Collected Sample 1. Note sample volume from well C8823 (volume ~1000 mL).
11/12-12/9	System operated at steady state. Extraction well vacuum at -3 psig with air flow of about 0.3-0.5 ft^3/min.	Yes – Collected Sample 2 on 11/18 (volume ~100 mL). Collected Sample 3 on 12/2 (volume ~200 mL).
11/26/13	Modified nitrogen supply to add separate nitrogen bottle, regulator and manifold for inflating packers on monitoring wells C8825 and C8826.	No
12/9/13	Troubleshot bladder pump operation by ramping down vacuum level and observing water movement in discharge tubing during pump cycling events. Very little movement observed; potential causes identified as (1) no water present to pump or (2) problem with the pump.	Yes – Attempted sample collection (volume ~15 mL). Sample saved and combined with Sample 4 taken on 12/18.
12/10/13	Reconfigured vacuum reservoir and isolated pump controller vent line from the primary vacuum line in the trailer. Removed and replaced of the bladder pump in the well. Water level in bottom of extraction well sump measured at 7.2 in. This indicates that the pump was lowering the water level in the sump below the level probe and that the continuous cycling of the pump controller was a result of either the level meter or the controller not functioning as designed. System reassembled and well head resealed with silicone and left to cure.	No
12/11/13	Ramped up the vacuum to approx. -3.6 psig in an effort to improve water production. Powered up the bladder pump controller, the pump continued to cycle on a frequency that indicated a problem with using the pump controller in the draw down mode. The bladder pump was powered off. Decision made to not leave the pump controller powered on in the draw down mode. Follow on pump operation will be performed by powering up the pump controller, operating for a period of time, and then powering off.	No
12/12-12/18	Steady state operation with well vacuum at -3.6 psig.	No
12/13/13	Cycled the bladder pump approximately 15 cycles, observed some water movement in tubing.	No
12/18/13	Ramped up system vacuum to -4.3 psig, collected sample, and cycled the bladder pump.	Yes – collected Sample 4 (~650 mL).

Table 2. Test Operations Summary, Extraction Well C8824. (2 sheets)

Date	Summary of Test Status	Sample Collected (approximate sample volume)
12/18/13 – 1/7/14	Steady state operation with extraction well vacuum at -4.3 psig. System experienced a loss in vacuum (from -4.3 to -3.8 psig) and an increase in air flow on 12/20. The change is characteristic of a vacuum leak but no leak was found in above grade piping. Periodically cycled the bladder pump and watched for indications of water movement in pump discharge line tubing.	No
1/7/14	Increased vacuum from approximately -3.8 psig at the well to approximately -4.2 psig.	No
1/9/14	Cycle bladder pump and attempt to collect a sample.	Yes – Collected Sample 5 (~90 mL)
1/20/14	Test operations stopped.	Yes – Collected Sample 6 (~200 mL)

Problems with operation of the bladder pump controller led to replacing the pump and water level meter when the extraction equipment was moved from well C8823 to well C8824. The drawdown function of the pump controller with the new level meter was verified before installation in the well. However, following startup of the test, the pump controller cycled continuously based on the fill and discharge time settings and did not function in a drawdown mode as intended. A plot of the vacuum and flow for the first 12 hours following ramp up on extraction well C8824 is shown in Figure 17. In accordance with RPP-PLAN-55319, the applied vacuum was slowly increased from 0 to -3 psig over approximately 2 hours.

Figure 17. Initial Ramp Up of Vacuum in Well C8824 (11-11-2013).

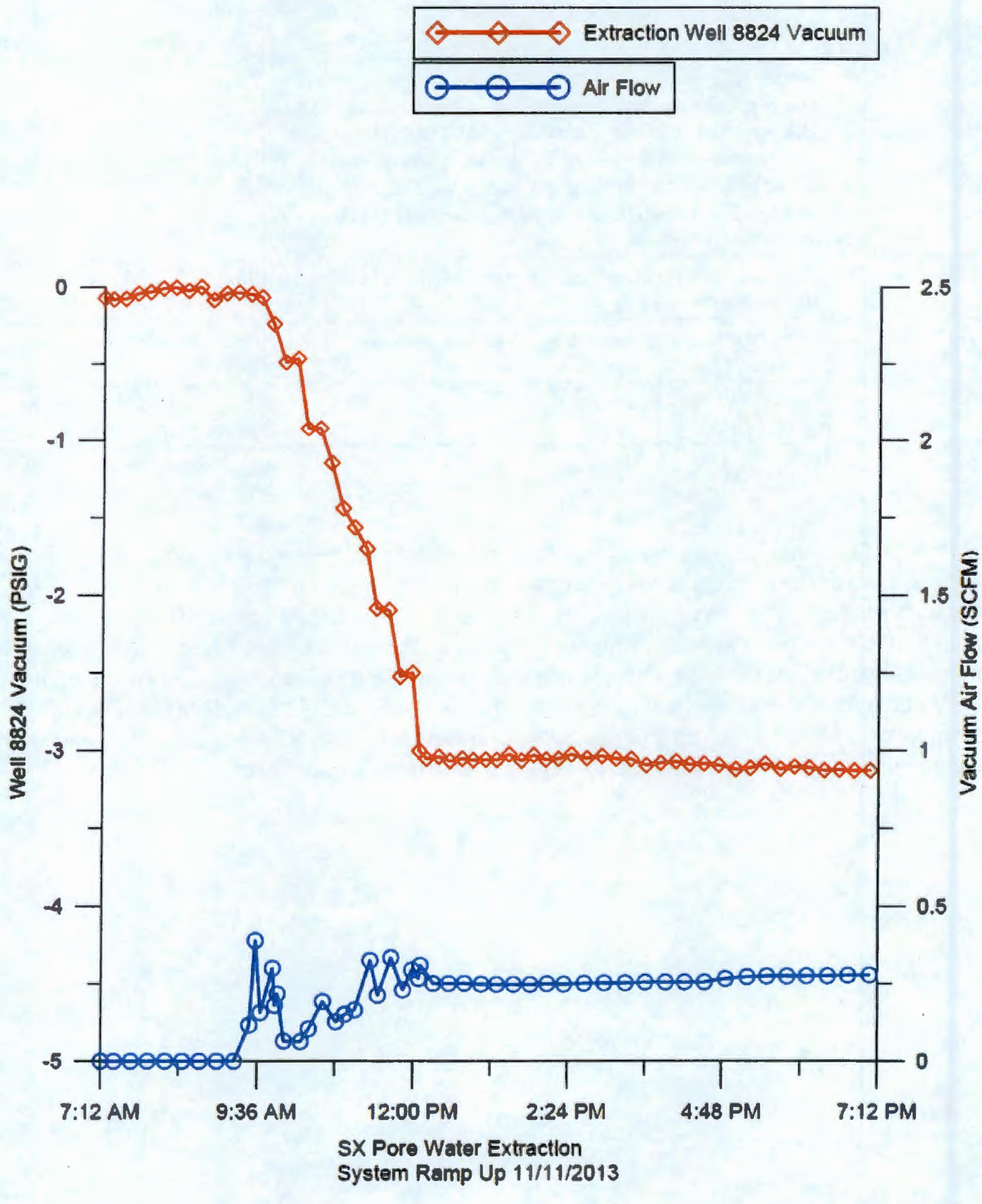


Figure 18 shows a two-week plot of pressure and flow data from November 11 to November 24. The pressure and flow data between November 11 and November 15 are relatively constant and do not show any influence of the pump controller cycling. At the time, it appeared that the pump was not cycling because the water level had not reached the level meter. When the battery was replaced in the level reel on November 15, however, the pump resumed cycling on a regular interval. This indicates that the 9 volt battery was likely low on power and did not allow the pump controller to cycle. As shown in Figure 18 and Figure 19, the extraction well vacuum and flow fluctuated with the pump controller operation after November 15.

Figure 18. Extraction Well C8824 Pressure and Flow Plot (11-11 to 11-24-2013).

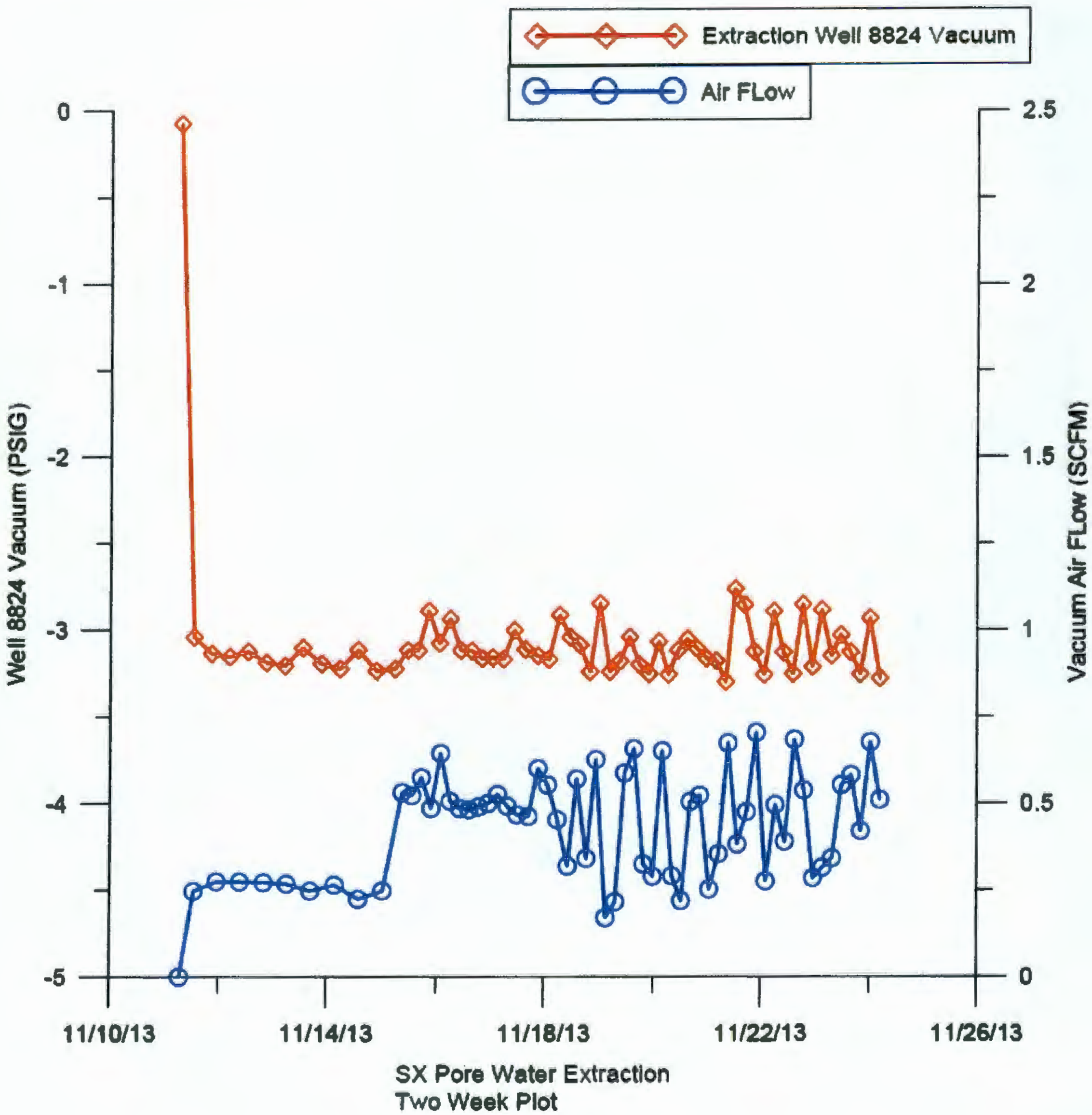


Figure 19. Extraction Well C8824 Pressure and Flow Plot (11-24 to 11-29-2013).

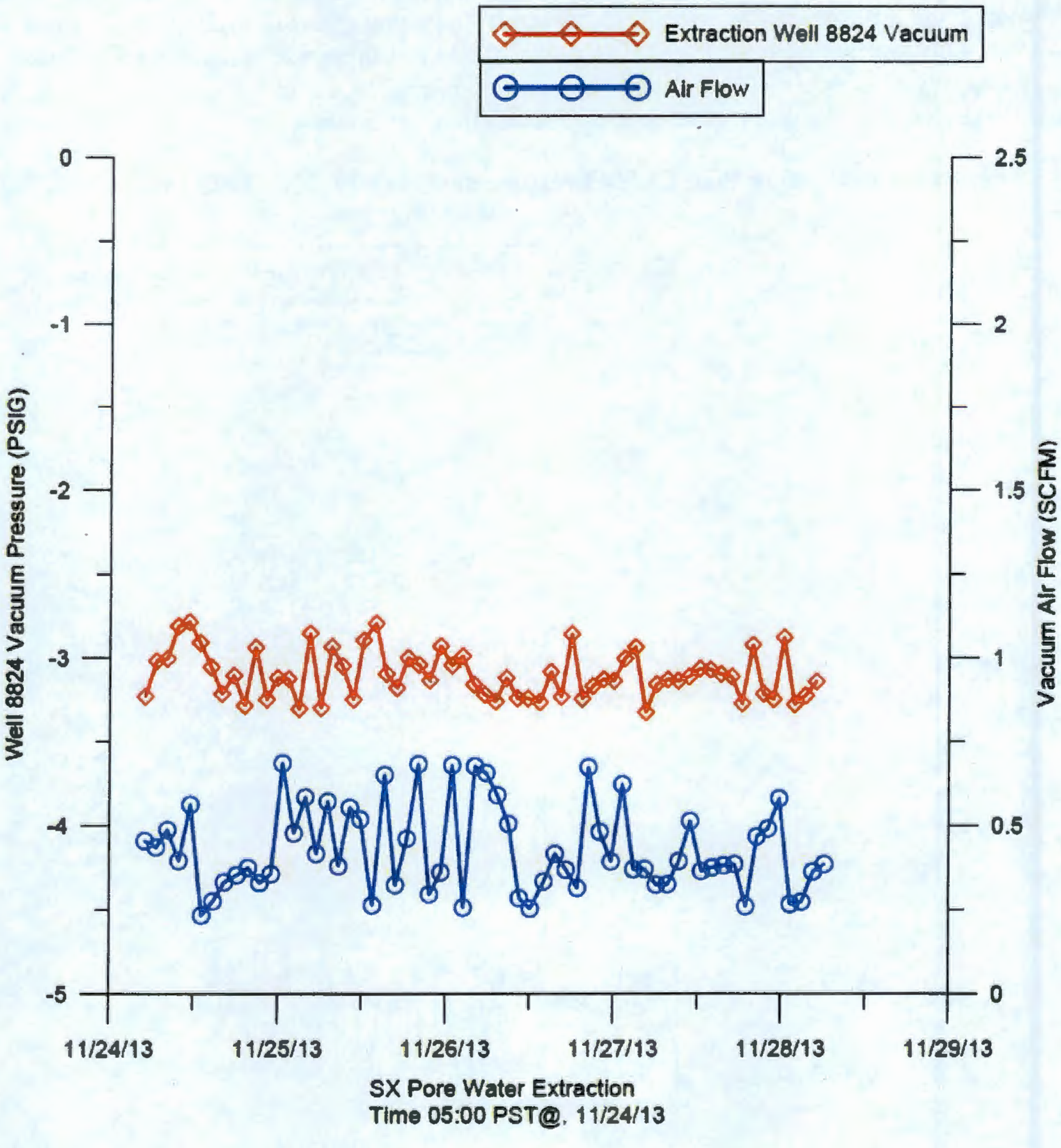
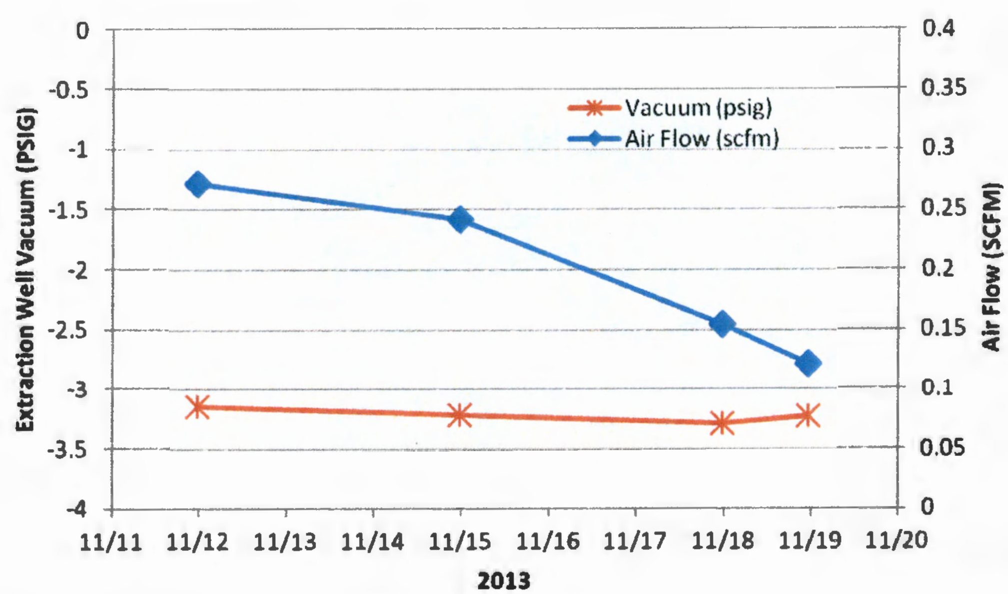


Figure 20 shows a subset of the flow and pressure data extracted from the logs to assess the change in air flow following system startup. These data points were selected at times when the bladder pump controller was not operating to eliminate the influence of the pump controller venting on the vacuum data. As shown in Figure 20, there is a trend of decreasing air flow at nearly constant vacuum. This is aligned with the conceptual model for pore-water extraction where the pore water migrates toward the well screen, increasing water saturation near the well and reducing the available pore space for air flow.

Figure 20. Extraction Well C8824 Air Flow and Vacuum at Select Times.



Concerns over the continued cycling of the bladder pump and the lack of water production led to ramping the vacuum down on December 10 to troubleshoot the system and modify the vacuum system. The bladder pump was removed from the well and visually inspected. The water depth remaining in the well sump was measured at 7 in. Taking into consideration the geometry of the well sump and the water displaced by the pump, 7 in. of water would not reach the level sensor. The pump controller was, however, still cycling the bladder pump. Two possibilities for this were that (1) the level sensor may have picked up some sediment as it passed the well screen causing it to continually respond as if it were in water or (2) the pump controller or level reel electronics were not functioning properly.

The vacuum system was modified to isolate the pump controller vent line from the primary vacuum line. This was done to eliminate the vacuum fluctuations observed in the extraction well when operating the pump controller. The pump controller vent line was isolated from the primary well vacuum system by reconfiguring the vacuum system to route the compressed air from the pump controller directly to the second vacuum pump. With this configuration, operation of the second vacuum pump was required when the bladder pump was operated. This modification allowed a steady vacuum to be maintained in the extraction well and eliminated the potential affect of the vacuum fluctuations on pore-water extraction.

After restart of the test on December 10, 2013, test operations were continued until January 20, 2014. Figure 21 shows (1) the target vacuum level and corresponding air flow rate for reference for December 10 through December 22, (2) the increased vacuum level applied to the extraction well on December 18 and the corresponding increase in air flow, and (3) a decrease in vacuum and an increase in flow on December 20, which was not in response to a change in a system setting and that could be the result of a small vacuum leak or this could correspond to the silt moving into the well.

Figure 21. Target Vacuum Level and Corresponding Air Flow Rate.

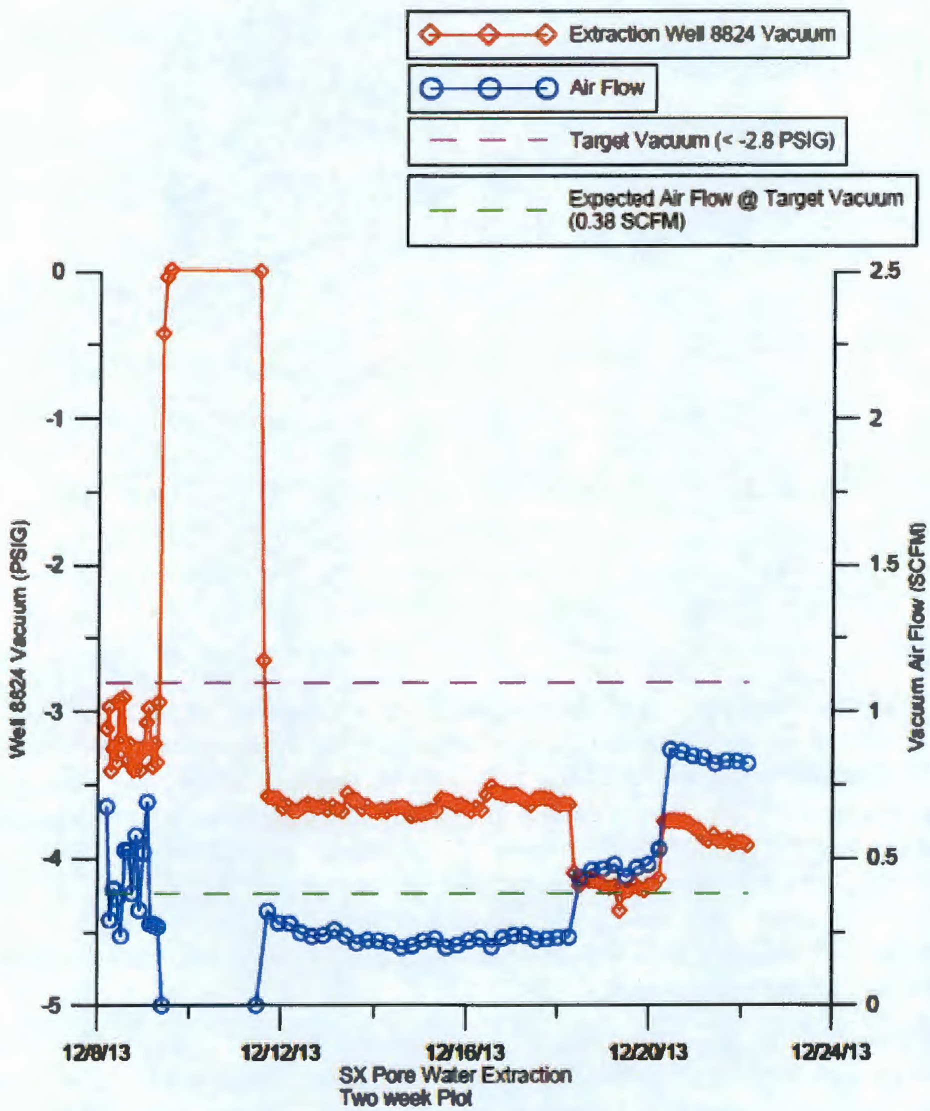
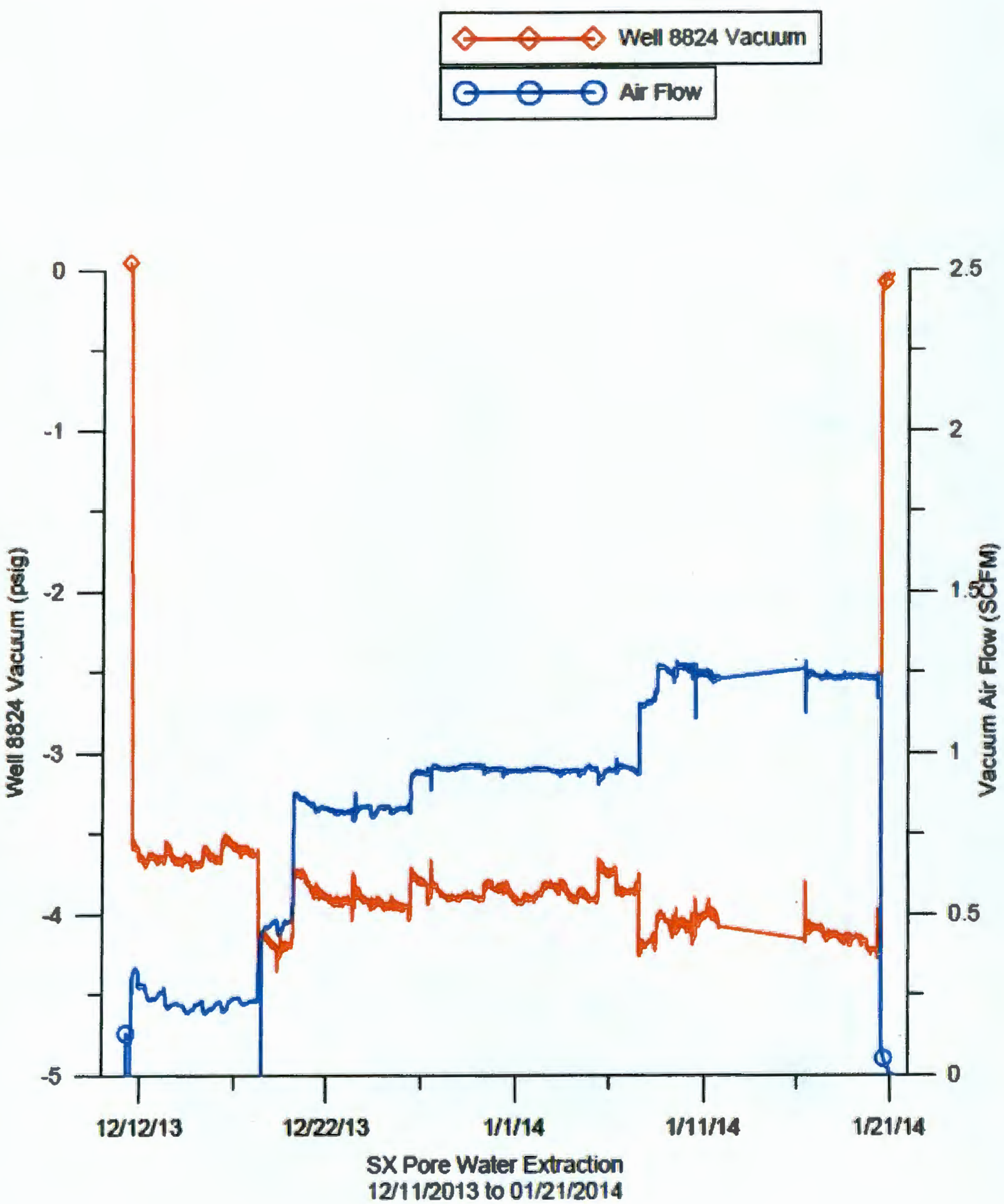


Figure 22 provides a summary plot of the vacuum and flow levels between December 10 and January 20.

Figure 22. Summary Vacuum and Flow Levels.



Following completion of test operations, the system was shut down and the pump assembly was removed from the extraction well to allow for future well decommissioning. When the pump was removed, signs of silt and mud were visible on the water level meter probe and on the outside of the bladder pump. Following pump removal, a water level meter was used to measure the water level and estimate the depth of silt in the well sump. The water level was measured using a conductivity probe. The water level was 16 in. below the screen/top of the sump, indicating that there were 32 in. of water/silt in the well sump. The volume displaced by the pump would raise the water level approximately 9 in., so prior to pump removal the estimated water level was still approximately 7 in. below the screen/top of sump. The sludge depth was estimated at 24 in. by using the weight of the level meter probe to find the solids level in the sump. This volume of silt would have filled the bottom of the well sump and covered most of the bladder pump. Subsequent inspection of the bladder pump intake screen found silt buildup on the inside of the pump screen (Figure 23).

Figure 23. Bladder Pump Screen After Removal from Extraction Well.

6.0 TEST DATA ANALYSIS AND REVIEW

Pore water samples collected during the proof-of-principle test were transported to the Hanford Site 222-S Laboratory for analysis. Samples were collected, managed, and controlled in accordance with existing procedures. To support test objectives, the sample analysis was limited to nitrate and technetium-99 as the constituents of concern. Sample results were provided as "quick turnaround sample results" to support the testing schedule and are provided in Table 3. These results are preliminary, have not been released in a final data package, and are subject to change.

Table 3. Preliminary Pore-Water Extraction Sample Analysis Results.

Sample	Source	Estimated Sample Volume (mL)	Nitrate (µg/mL), (mg/L)	Technetium (pCi/mL)
Equip Blank	N/A	~1000	ND	ND
Sample 1	C8823	~1000	0.658	0.0408
Sample 2	C8824	~100	0.531	ND
Sample 3	C8824	~200	0.396	0.0253
Sample 4	C8824	~650	0.551	0.0301
Sample 5	C8824	~90	0.225	0.0624*
Sample 6	C8824	~200	0.765	0.0770

*Result is estimated (result is above the method detection limit but below the estimated quantitation limit).

ND = not detected.

Based on the as-built geometry of the wells, the volume of the sump in well C8823 is 0.28 gal (1050 mL) and the volume of the sump in well C8824 is 0.34 gal (1280 mL).[1] Well C8823 has approximately 9.7 in. of grout in the bottom of the sump. Taking into the account the volume displaced by the bladder pump, the available volume in C8823 is 0.22 gal (820 mL) and the available volume in C8824 is 0.28 gal (1050 mL). The estimated volume in the bladder pump and in the discharge tubing between the pump and the trailer is 0.20 gal (750 mL). It is assumed that the well sump remained full or nearly full of development water prior to starting test operations on both well C8823 and well C8824. Based on the above, any sample volume in excess of 0.02 gal (80 mL) for well C8823 and 0.08 gal (300 mL) for well C8824 represents pore-water extracted from the formation.

Sample 1 consists of water removed from well C8823. This sample was collected immediately after relocating the extraction equipment from well C8823 to well C8824. This sample was held up in the system piping and there was no extraction performed on well C8824 prior to collection of Sample 1. Based on the well sump and equipment volumes, the estimated volume of pore water removed from well C8823 is 0.24 gal (0.92 L).

Samples 2 through 6 consist of water pumped out of well C8824. Based on the well sump and equipment volumes, the estimated volume of pore water removed from well C8824 is 0.33 gal

[1] The laboratory analysis sample volumes and sample results were reported in metric units. For parallel unit comparisons with the rest of this document, English unit conversions for those reported volumes have been added.

(1.24 L). The extraction rate for both wells was significantly below the expected water production rate for base case conditions of approximately 4 gal/day (15 L/day) and sensitivity case conditions with a compacted zone adjacent to the well screen of 0.08 gal/day (0.32 L/day) (PNNL-22662).

Calculated nitrate concentrations in pore water from soil samples collected from exploratory wells C8760 and C8762, located near the pore-water extraction test site, ranged from 44 ppm to 90 ppm (44 mg/L to 90 mg/L). Nitrate concentrations in pore-water extracted during the proof-of-principle test were expected to fall within this range. Nitrate concentrations in the samples collected were substantially below the expected concentration. This is believed to be in part due to the volume of deionized water used for well development. Well development records show a total of 49 gal (185 L) of deionized water put into well C8823 and a total of 34.5 gal (130 L) removed over a number of surge and pump efforts. The volume difference was 14.5 gal (55 L). Similarly, in well C8824 a total of 46 gal (174 L) was put into the well and 33 gal (125 L) was removed. The net volume difference was 13 gal (49 L). This excess water would remain in the formation surrounding the well screen. This excess volume would be expected to create a zone around the well screen with low nitrate concentrations. If sufficient pore-water were recovered, nitrate concentrations would be expected to trend upward and approach the levels observed in the pore-water from pre-test soil samples.

7.0 TEST PERFORMANCE EVALUATION

Pore water was successfully extracted from the vadose zone during the test. The pore water was analyzed and found to contain soluble contaminants. The volume of water produced from both of the wells used for pore-water extraction was low. Water production rates remained well below expected values throughout the test. Problems with the test equipment were encountered during test operations requiring the system to be shut down to make changes. The potential for problems to occur was anticipated during test planning. Changes made to support continued testing included making hardware modifications to the system, adding bentonite pellets to the extraction well to establish a seal above the well screen, and switching extraction wells. Steady-state vacuum levels were established for two three-day periods (a cumulative six days) on the highest priority extraction well C8823 before conditions changed and the project team switched to well C8824. Steady-state vacuum levels were established for a four-week period followed by a six-week period (an approximate cumulative 10 weeks) on well C8824. As described in PNNL-22662, the time required to reach steady-state conditions for water production is on the order of 40 days; however, measureable water production was expected within the first few days after the vacuum is established. Even though the two operating periods on well C8823 were short, the water production was lower than expected.

Target vacuum levels were established and maintained for longer periods of time on extraction well C8824. Corresponding air flow rates measured during the test were in line with modeling-based expectations. As shown in Figure 19, the vacuum and air flow response over time during steady vacuum operation is an indicator of moisture migration toward the screened interval and associated higher water saturation near the well. Thus, air flow as a function of applied vacuum showed good agreement with predictive modeling throughout the test indicating that the test setup successfully established the conditions suitable for pore-water extraction.

Low water production from the extraction wells may result from several factors. The hydraulic conductivity in the compacted zone adjacent to the well screen may be low. Additionally, the as-constructed configuration of the well could also result in conditions that impede water flow. Well configuration is important to facilitate water flow from the formation through the well screen.

During test planning, the project team made a decision to utilize the same size boreholes that are routinely used for tank farm characterization activities. This provided a high degree of confidence in the ability of existing tooling and equipment to advance the boreholes to the required depth at the SX Tank Farm. This also limited the space available within the borehole to construct the extraction and monitoring wells and required the design of prototype equipment and non-standard methods for well construction. Limited space also prevented inspection and verification of down-hole conditions outside of the riser pipe. The use of prototype equipment and non-standard methods resulted in reliability issues with using the wells for either pore-water extraction or vacuum monitoring purposes.

Commercial well packers of the right size were not available; prototype packers were designed and fabricated to fit within the available space. During test operations, three out of the four packers failed. The loss of the inflatable packer followed by higher air flow in the preferred extraction well C8823 led to switching the equipment to well C8824 for continued extraction attempts. There were no issues with the inflatable packer in extraction well C8824 during the balance of testing. The inflatable packers in the two monitoring wells failed during the test, preventing the collection of pressure monitoring data; however, this did not impact the pore-water extraction process.

Even with extensive mock-up testing and attention to detail, there were consistency issues realized after the well sumps were grouted in the boreholes. The objective of grouting the well sumps in place was to use just enough grout in the bottom of the hole so that the grout would rise to a level just below the screen after the well string was lowered into place. Any uncertainties in down-hole conditions or unexpected changes in conditions due to soil sloughing into the well would affect the final results. If the grout level were to rise above the screen, it could plug off the available open area for pore water to flow in; if the grout level were too low, it would leave an open area below the well screen where water could accumulate and not move through the well screen. Grout was observed to intrude into the well sump in three of the four constructed wells.

Efforts to develop the extraction wells by surging and pumping the wells to break down the compacted zone of the formation were not successful, although this technique appeared to have been successful in testing the planned well development method in the nearby investigation borehole as a part of Stage II. Development efforts were halted when no measureable improvements were observed in the falling head test data. Depending on the cause or causes, incomplete development of the well could have limited water migration through the well screen and into the sump.

An accumulation of silt was discovered in the extraction well after completing the test. The silt reduced the ability to remove extracted pore water and may have impeded the flow of water into the well. On December 10, 2013, after approximately four weeks of test operations, testing was suspended to troubleshoot the pump controller. The pump was removed from the well and the water level was measured in the well sump. There was no silt accumulation observed in the well at that time. After completing the test in late January 2014, the pump and level probe were removed from the well during demobilization and silt was observed on the outside of both items. The accumulation of silt in the extraction well observed after completing the test occurred sometime following the December 11, 2013 restart of testing. It is unclear if the silting occurred throughout the test or after the vacuum level was increased in an effort to improve water production.

Laboratory testing of pore-water extraction using high-silt-content material conducted by Pacific Northwest National Laboratory, which like the field test did not have a "filter pack" protecting the well, resulted in limited extraction of silt This silt extraction may have been due to high water saturation conditions in the high-silt material and loss of its structural integrity. It is unknown whether the flow-cell packing conditions could have contributed to the unstable silt material condition. Multiple other flow cell experiments were conducted with no silt extraction observed. In the field, use of a filter pack around the well screen may help limit silt intrusion into the well.

The utility of pore-water extraction as a remediation technology is limited unless water production can be increased. While the conditions for pore-water extraction were established during the test, the water production rates were very low. The technology shows promise if the issues impacting water production can be resolved through additional design and testing. There are a number of improvements that affect the extraction process that should be considered for future development testing. These include: (1) larger-diameter boreholes to provide flexibility for constructing well seals, (2) methods to minimize the compaction zone and ensure connectivity between the formation and the well screen, (3) options such as a filter pack to reduce silt intrusion into the extraction well, and (4) improvements in the water pumping equipment.

Soil desiccation using the direct-push wells was not pursued in the test design because it was secondary to determining if contaminated pore water could be extracted. Differences in the down-hole well configuration and test hardware that would be required to establish the higher flows needed for desiccation were not compatible with the design air flow and vacuum ranges used for pore-water extraction. It should be noted that, as discussed in RPP-PLAN-53808, soil vapor extraction has been successfully performed using direct-push boreholes near the 216-Z-9 crib in the 200 West Area.

8.0 LESSONS LEARNED

There were a number of lessons learned in setting up and operating the proof-of-principle test. The test configuration used both commercial equipment adapted for use and prototype equipment built specifically for the test. The project team recognized early on that well construction would be a challenge using the proven direct-push equipment. These challenges were realized during the test. The inside diameter of the drive casing constrained the available space for the riser pipe, well sump, screen, and packer assembly.

The limited space in the direct-push boreholes caused (1) difficulties with installation of a seal below the well screen (grout) and above the well screen (packers) and (2) precluded installation of a filter pack around the well screen. These issues impacted performance of the well for pore-water extraction.

The limited space required design and fabrication of prototype inflatable packer assemblies to seal the annular space above the well screens. Three of the four inflatable packers failed during the test. The inflatable packer on the extraction well C8824 worked well throughout the test.

Limited options were available for the well pump. An air-driven bladder pump was the only commercially available pump found that could fit down the 1-in.-diameter well. The air driven bladder pump is not intended for operation in a well that is under a vacuum. The pump controller required modification during the test to tie the vent into the vacuum system. Efforts to break down the compacted zone in the formation around the well screen were not successful based on the falling head test data. The approach to developing these types of wells was tested on the exploratory boreholes and worked well; however, concerns over potential silting of the wells led to the selection of smaller slot size on the extraction wells. The smaller slot size on the extraction wells may have limited the ability of the development effort to break down the compacted zone. Also, the difference in the inside diameter of the screen (1.33 in.) and the riser (1 in.) limited the ability to surge and effect the formation outside of the screen. The lesson learned is that changes to the test configuration deployed in the field from those developed through prototype and mockup testing may impact system performance.

A nitrate sensor was installed in the water line to provide real time nitrate concentration data during test operations. Lack of water production impacted operation of the meter. The Foxcroft Equipment and Services Company, Inc., FX-300 nitrate analyzer meter used in the system requires a steady flow of water past the sensor head. The low and intermittent flow of water produced during testing was not sufficient for the nitrate sensor to function. The nitrate meter used in the test is not suitable for this type of application.

A radar-type drum level gauge was installed to monitor and record the water level in the collection drum. With the collection drum empty, the gauge was sensitive to movement of the test trailer and the level readings jumped from zero to near full as test personnel were moving around in the trailer. It is not clear if the gauge would have stabilized with some water in the drum. Future testing should consider an alternative type of gauge.

The web-based data logger worked well throughout the test and provided real-time remote access to the test data during operations. The remote access to the test data reduced the amount of time required for test personnel to be present at the test site to monitor test operations and allowed test personnel to verify operations and monitor key test parameters.

9.0 LARGER-DIAMETER, DIRECT-PUSH TESTING

During construction of the four extraction and monitoring wells near the SX Tank Farm, it was recognized that larger-diameter boreholes would provide the necessary room to utilize conventional down-hole construction tooling and techniques. The ability to drive the larger-diameter casing at the SX Tank Farm is uncertain; however, the potential benefits warranted additional development and testing. Therefore, in addition to the test work scope defined in RPP-PLAN-53808, tooling redesign and supplemental development testing was initiated to determine if larger-diameter drive casings could be pushed to target depths suitable for pore-water extraction. The larger-diameter, direct-push casing selected for testing has an outside diameter of 3.75 in. rather than the 2.625-in. outside diameter pipe used for the monitoring and extraction wells. The larger-diameter drive casing provides space for construction of seals and a filter pack around the well screen. One drawback to the larger-diameter drive casing is the increased sidewall compaction resulting from soil displacement as the casing is pushed through the soil.

A development and testing plan was prepared that included four pushes at a test site adjacent to the Energy*Solutions* shop located on Energy Northwest property, and if successful, four pushes near the SX Tank Farm, adjacent to the pore-water monitoring and extraction wells. As of February 28, 2014, two of four planned pushes have been successfully completed to the target depths at the Energy Northwest test site. The testing completed to date has provided valuable information on the tooling design, and design modifications have been implemented to improve performance. A mock well completion was performed to demonstrate construction of an extraction well; this included placing a screen and riser, placing grout and other completion materials, and demonstrating the ability to measure depths during these activities to ensure desired well construction is achievable.

Current plans include completion of two additional pushes at the Energy Northwest test site, followed by relocation of the equipment to the pore-water extraction test site south of the SX Tank Farm. At the SX Tank Farm pore-water extraction test site, four larger-diameter pushes to a target depth of 135 ft or greater are planned. If the larger-diameter casings can be driven to depth south of the SX Tank Farm, additional testing may be recommended to evaluate down-hole construction methods and well development methods.

10.0 RECOMMENDATIONS

The proof-of-principle, pore-water extraction testing showed that it was possible to extract pore water from the unsaturated zone under the right conditions. The well design and construction and the extraction equipment were successfully operated to establish a vacuum level suitable for pore-water extraction. To assess whether the system can be made practical by increasing the water production, the following testing and development efforts are recommended:

- Complete additional testing on larger-diameter wells to determine if they can provide usable extraction and monitoring wells. Testing would address whether the increased thickness of compressed zone caused by the larger outer diameter drill string can be adequately mitigated to allow pore water and air to pass through.
- Perform proof-of-principle, pore-water extraction cold testing at a location suitable to pore-water extraction to assess ability of system to produce sufficient water. This is contingent on finding a suitable location with appropriate sediment properties and moisture conditions.
- Identify additional test sites in or near a tank farm suitable for pore-water extraction (e.g., high-moisture zone, favorable geology, contamination).
- Define extraction system design improvements to support future field testing.
- Evaluate and test options for constructing a filter pack and breaking down the compacted zone across the screened interval.
- Evaluate options for improving extraction well design and construction methods that would use the standard 2.5-in.-diameter, direct-push wells. In the event that the larger-

diameter drive casings cannot be reliably pushed to target depths in some locations, the smaller-diameter pushes could potentially still be of use if they could be made to function adequately.

- Evaluate alternative pumps and controllers. Planned testing with the larger-diameter drive casing will still use a 1-in.-nominal-diameter riser pipe. Alternative pump types or controls should be evaluated and tested prior to further field deployment.
- Conduct a field test incorporating the above design improvements at a location deemed appropriate for pore-water extraction.

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APPENDIX A

EXTRACTION TEST MEETING MINUTES

SX POREWATER EXTRACTION TEST MEETING MINUTES
FISCAL YEAR 2013

This package contains summary notes from the following meetings:

- February 12, 2013, Sample Selection Meeting for Location C8760
- February 21, 2013, Sample Selection Meeting for Location C8762
- August 1, 2013, Extraction Well and Screen Depth Selection Meeting

R Douglas Hildebrand	[signature]	8-28-2013
DOE Project Manager (print)	DOE Project Manager (signature)	Date
Maria Skorska	[signature]	9-8-13
Ecology Project Manager (print)	Ecology Project Manager (signature)	Date

MEETING NOTES

SX Pore-Water Extraction Test – Location C8760 Sample Depths

MEETING DATE: February 12, 2013

LOCATION: Washington State Department of Ecology, Richland Office

ATTENDEES:

Mike Barnes (Ecology)	Dan Parker (WRPS)
Maria Skorska (Ecology)	Harold Sydnor (WRPS)
Joe Caggiano (Ecology)	Mike Truex (PNNL)
Kent Reynolds (Energy Solutions)	Cindy Tabor (WRPS)
R.D. Hildebrand (DOE)	Mart Oostrom (PNNL)
Melissa Holm (WRPS)	Les Fort (WRPS)
Ann Shrum (WRPS)	Susan Eberlein (WRPS)

BACKGROUND: This meeting was part of the continuing effort to ensure communication between Ecology and DOE representatives regarding the field work associated with interim measures. Specifically, discussion pertained to the proof of principle test south of SX that is being performed to determine if vadose zone pore-water extraction using tank farm-deployable equipment is a viable technology for remediation within a tank farm.

The purpose of this meeting was to discuss and reach agreement on the intervals to be sampled at location C8760.

DISCUSSION: Cindy Tabor discussed the field status of the project and identified that the first location, C8757, was pushed three times and met refusal at 11.5 feet below ground surface (ft bgs). It was identified that these three attempts were approximately 3 to 4 feet apart and that ground penetration radar was performed prior to the selection of C8757's location. It was also briefly identified that the reason for refusal might be that concrete was placed in the area. After refusal was met three times, a decision was made to move to the next location, C8759 (the location being discussed in this meeting).

Cindy Tabor also identified that per RPP-PLAN-53808, 200 West Area Tank Farms Interim Measures Investigation Work Plan, a total of three prospective test locations were to sampled, each location having two sample intervals. However since one test location could not be evaluated due to refusal (C8757), meeting attendees might want to consider sampling three intervals at the remaining two test locations. Six samples would then still be collected for the project, as originally planned.

Regarding sample selections for C8759/C8760, Cindy Tabor provided the following information to the meeting attendees:

- A location map showing current and prior direct push efforts in the area near C8759/C8760.
- Field plots and processed spectral gamma and moisture logs for C8759
- Gamma and moisture logs from prior direct push efforts in the area near C8759/C8760
- Analytical results from prior direct push efforts in the area near C8759/C8760
- Information from a nearby ground water well, Well 299-W23-19, located SW of Tank 241-SX-115.

Kent Reynolds explained the use of the logs and noted that the gross gamma logs can indicate geologic change. Generally speaking a lower count rate indicates courser grained material, while a higher count rate indicates finer grained material. It was noted that the moisture logs showed a range of approximately five to 40 percent by volume.

Information from prior investigations in the area of C8759/C8760 was discussed.

- Location C7169/C7170 is approximately 140 ft from C8759/C8760. The highest nitrate concentration in C7170 was 990 µg/g at a depth of 113 to 115 ft bgs. This depth interval would equate to a depth of approximately 104 ft bgs at C8759/C8760.

- Location C7167/C7168 is approximately 96 ft from C8759/C8760. The surface elevation difference between C7167 and C8759/C8760 is approximately 11 ft. The highest nitrate concentration in C7168 was 1,950 µg/g at a depth of 129-131 ft bgs. This depth interval would equate to a depth of approximately 117 ft bgs at C8759/C8760.

- The highest nitrate concentration of 24,000 mg/L in Well 299-W23-19 was at 130 ft bgs. This depth interval would equate to a depth of approximately 120 ft bgs at C8759/C8760.

Based on the available data, two sample depth intervals, approximately 104 to 106 ft bgs, and approximately 122.5 to 124.5 ft bgs, were proposed for discussion:

The interval of 104 to 106 ft bgs showed estimated volumetric moisture content of only 22 percent. Because this moisture was less than the recommended moisture level identified by PNNL (Mike Truex indicated that ~25 percent or more was recommended based on information in PNNL-21882), this sample depth was eliminated as a potential choice.

The interval of 122.5 to 124.5 ft bgs showed estimated volumetric moisture content of 35 percent. This depth is similar to the depths in C7168 and Well 299-W23-19 where higher nitrate and Tc-99 concentrations have occurred. The geology of the interval was also discussed - Cold Creek upper (PPLu) with a uniform grain size above and finer grain below the higher moisture interval, which indicates that it would be a good area to sample.

Additionally, an interval of approximately 140 ft bgs was briefly discussed but was dismissed due to the higher known contamination at the approximately 122.5 to 124.5 ft bgs.

CONCLUSIONS: The consensus agreement was that the interval of approximately 122.5 to 124.5 ft bgs was most promising and that characterizing the area above and below this interval would provide valuable information for test design. It was agreed, therefore; that three cores would be taken "back to back" from approximately 121 to 127 ft bgs (Refer to Table 1 for the summary of rationale). This approach would provide information essential to determining how best to design and set the packer/screen assemblies.

Table 1. Sample Depth for C8760

Location Log Hole/Sample Hole	Sample Depth (ft bgs)	Reason
C8759/C8760	121 – 127 (3 consecutive sample intervals)	• Cold Creek upper (upper Plio-Pleistocene unit [PPLu]) - uniform grain size above and finer grain below a higher moisture interval • 35% moisture (within PNNLs criteria): 122.5 – 122.4 ft bgs • Similar zone to C7168 and 299-W23-19 where higher nitrate and Tc-99 concentrations have occurred

Stratigraphic info
Higher moisture per Processed Log (highest moisture is 40%)
Historical Information

MEETING NOTES

SX Pore-Water Extraction Test – Location C8762 Sample Depths

MEETING DATE: February 21, 2013

LOCATION: Washington State Department of Ecology, Richland Office

ATTENDEES:

Mike Barnes (Ecology)	Dan Parker (WRPS)
Melissa Holm (WRPS)	Harold Sydnor (WRPS)
Marcel Bergeron (WRPS)	Mike Truex (PNNL)
Jacob Throolin (WRPS)	Cindy Tabor (WRPS)
R.D. Hildebrand (DOE)	Susan Eberlein (WRPS)
Les Fort (WRPS)	

BACKGROUND: This meeting was part of the continuing effort to ensure communication between Ecology and DOE representatives regarding the field work associated with interim measures. Specifically, discussion pertained to the proof of principle test south of SX Tank Farm that is being performed to determine if vadose zone pore-water extraction using tank farm-deployable equipment is a viable technology for remediation within a tank farm.

The purpose of this meeting was to discuss and reach agreement on the intervals to be sampled at location C8762.

DISCUSSION: Cindy Tabor led the discussion and provided information to the meeting attendees. Information included:

- A location map showing current and prior direct push efforts in the area near C8761/C8762.
- Field plots and processed spectral gamma and moisture logs for C8759 and C8761.
- Gamma and moisture logs from prior direct push efforts in the area near C8761/C8762.
- Analytical results from prior direct push efforts in the area near C8761/C8762
- Information from a nearby ground water well, Well 299-W23-19, located SW of Tank 241-SX-115.

Information from prior investigations in the area of C8761/C8762 was discussed.

- C7167/C7168 are located approximately 95 ft from C8761/C8762. The surface elevation difference between C7167 and C8761/C8762 is approximately 11 ft. The highest nitrate concentration in C7167/C7168 of 1,950 µg/g was at a depth of 129-131 ft bgs. This depth interval would equate to a depth of approximately 117 ft bgs at C8761/C8762.
- The highest nitrate concentration of 24,000 mg/L in Well 299-W23-19 was at 130 ft bgs. This depth would equate to a depth of approximately 120 ft bgs at C8761/C8762.

The interval of approximately 127 to 128 ft bgs showed estimated volumetric moisture content of approximately 30 to 40 percent. This is within the range PNNL's has recommended based on their studies (~25 percent or more based on information in PNNL-21882). The interval is similar to intervals in nearby boreholes where higher nitrate and Tc-99 concentrations have occurred. The geology of the interval was also discussed - Cold Creek upper (PPLu) with a uniform grain size above and finer grain below the higher moisture interval, which indicates that it would be a good area to sample.

CONCLUSIONS: The consensus agreement was that the interval of approximately 127 to 128 ft bgs was most promising. Obtaining additional information concerning the interval up to approximately 123 ft bgs would be useful in test design. It was agreed, therefore; that three cores would be taken "back to back" from approximately 123 – 129 ft bgs (Refer to Table 1 for the summary of rationale).

Table 1. Sample Depth for C8762

Location Log Hole/Sample Hole	**Sample Depth (ft bgs)**	**Reason**
C8761/C8762	123 – 129 (3 consecutive sample intervals)	• Cold Creek upper (PPLu) - uniform grain size above and below higher moisture intervals • Highest moisture peaks overall 30 – 40 % (within PNNLs criteria) • Similar zone to where higher nitrate and Tc-99 concentrations have occurred

Stratigraphic info
Higher moisture per Processed Log (highest moisture is 40%)
Historical Information

MEETING NOTES

SX Pore-Water Extraction Test – Extraction Well and Screen Depth Selection

MEETING DATE: August 1, 2013

LOCATION: Washington State Department of Ecology, Richland Office

ATTENDEES:

Mike Barnes (Ecology)	Dan Parker (WRPS)
Maria Skorska (Ecology)	Harold Sydnor (WRPS)
Joe Caggiano (Ecology)	Mike Truex (PNNL)
Kent Reynolds (Energy Solutions)	Cindy Tabor (WRPS)
R.D. Hildebrand (DOE)	Becky Wiegman (WRPS)

BACKGROUND: This meeting was part of the continuing effort to provide a communication avenue between Ecology and DOE representatives to discuss the field work associated with interim measures. Specifically, discussion pertained to the proof of principle test south of SX that is being performed to determine if vadose zone pore-water extraction using tank farm-deployable equipment is a viable technology for remediation within a tank farm.

The purpose of this meeting was to discuss the four locations pushed for the test and agree upon the:

- Priority of locations to be used for the extraction well
- Depths for the placement of well screens.

DISCUSSION: Cindy Tabor led the discussion and provided information packets to the meeting attendees. Each packet contained:

- A location map showing the four extraction/monitoring well locations (C8823 – C8826) and a nearby characterization borehole (C8761/C8762).
- Field Plots and Processed Spectral Gamma and Moisture logs for borehole C8761
- Field Plots and Processed Spectral Gamma and Moisture Plots for boreholes C8823 – C8826
- Analytical, Soil and Moisture information – Sampled from 123-129 feet below ground surface (ft bgs) for borehole C8762

It was agreed that a moisture peak at a depth of about 128 to 129 ft bgs in well C8823 appeared the most promising for well screen placement. This depth interval has high volumetric moisture content and adequate thickness for the placement of a well screen. Kent Reynolds explained the well screen and packer placement process and how that process would be applied to this borehole. The well screen length was discussed as it relates to the bed thickness needed for sealing above and below the screened interval. Geological and analytical results from the characterization borehole (C8761/C8762) nearby were discussed (Table 1):

Table 1. C8762 Laboratory Analytical and Geological Information

Depth (ft bgs)	Nitrate (ug/g)	Technetium-99 (pCi/g)	Geologic and Moisture
123-125	8.22	ND	Clayey Silt to Sandy Silt Slightly moist to moist
125-127	5.01	ND	Silty Sand to Sand Very slightly moist to slightly moist
127-129	13.8	ND	Sandy Silt to Silty Sand Slightly moist to moist

ND = Not Detected

Mr. Reynolds discussed the apparent difference in depth of the high-moisture peak between the borehole C8825 and the other three boreholes. Mr. Reynolds noted that it is unclear whether the high-moisture peak in borehole C8825 correlates with the same unit represented by the high-moisture peaks in C8823, C8824, and C8826. It was agreed that without other information, it is not possible to tell.

The use of nitrate rather than technetium-99 in pore water as a tracer was discussed. Dan Parker explained that nitrate is an acceptable constituent to use for the test as identified in the 200 West Area Tank Farms Interim Measures Investigation Work Plan (RPP-Plan-53808). Mike Truex confirmed that nitrate will behave like technetium as it is also an anion.

It was agreed that the most promising location for the extraction well was C8823. Dr. Skorska asked if it would be possible to move to another extraction well later during the testing to determine if pore-water extraction works as well at other locations. Mr. Parker responded that such a test is not planned and is not currently in the baseline; however, such a test could be recommended in the test report. Mr. Parker noted that the initial test should lead to recommendations for further testing or barrier construction. The project team will be developing and tracking recommendations for further testing as they arise.

The use of other locations for the extraction well was further discussed if the initial extraction well location fails to produce water. The three remaining locations, which will be used as monitoring wells, are being configured so that any of them, if successfully built and developed, could be used as an extraction well. It was also explained that the monitoring wells are being configured to monitor vacuum and that the spacing of the wells was determined based on PNNL modeling.

CONCLUSIONS: The priority of locations to be used as the extraction well and the approximate top of screen elevations for each of the four well locations was discussed and agreed upon:

- Extraction well priority (highest to lowest) is C8823, C8824, C8826, and C8825. For example, if C8823 proves unusable as an extraction well, the next well in the list (i.e., C8824) will be used as the extraction well.
- Approximate top of the screen depths and elevations for each well are provided below.

Table 2. Extraction Well Screen Placement Information

Well	Approximate Top of Screen Elevation (ft above mean sea level) / Depth (ft bgs)	Rationale
C8823	526.6 / 128	Screen will be centered on moisture peak to provide the best chances for sealing above and below the screen
C8824	526.8 / 128	
C8825	527.3 / 127	
C8826	526.9 / 127	

APPENDIX B

INTERIM MEASURES MEETING NOTES

MEETING NOTES

200 West Tank Farms Interim Measures Investigations

MEETING DATE: April 17, 2013

LOCATION: Washington State Department of Ecology, Richland Office

ATTENDEES:

Jim Alzheimer (Ecology)	R.D. Hildebrand (DOE)
Mike Barnes (Ecology)	Dan Parker (WRPS)
Joe Caggiano (Ecology)	Julie Robertson (Freestone Environmental Services)
Susan Eberlein (WRPS)	Maria Skorska (Ecology)
Les Fort (WRPS)	Cindy Tabor (WRPS)
Dan Glaser (WRPS)	Becky Wiegman (WRPS)

BACKGROUND: This meeting was part of the continuing effort to provide a communication avenue between Ecology and DOE representatives to discuss the documents, field work, and results of interim measures investigations being undertaken at the 241-TX, 241-SX, and 241-U Tank Farms. A list of open and unresolved actions and the status of those actions will be tracked and resolutions documented as part of the meeting notes.

DISCUSSION:

Prior Meeting Notes: The March 20, 2013 meeting notes were signed by DOE at the meeting and submitted for Ecology signature. The February meeting notes were reported to have been submitted to the Administrative Record.

Status of the Work Plan: The *200 West Area Tank Farms Interim Measures Work Plan* (RPP-PLAN-53808, Revision 1) was approved by Ecology on March 27, 2013. TPA Change Control Form M-45-12-05, which provides completion dates for interim milestone M-045-22 and three associated targets, was signed by DOE on March 18, 2013, and by Ecology on April 1, 2013.

Status of the TX Farm SAP: The *Sampling and Analysis Plan for Soil Samples in Support of Interim Measure Planning at the 241-TX Tank Farm* (RPP-PLAN-54376, Rev. 0) was transmitted to Ecology on March 11, 2013. Ecology noted one comment that requires a change to the plan. The meeting attendees discussed options for formally providing the comment within the timeframe required by Section 9.0 of the TPA Action Plan.

Status of Ongoing Field Work: WRPS distributed a simple graphic illustrating the anticipated vadose zone field work schedule through the first quarter of fiscal year 2015. The general sequence has direct push fieldwork being performed first at SX Farm (Stage I/II), then C Farm, then back at SX Farm (Stage III installation of extraction and monitoring boreholes), and then TX Farm. In parallel, SGE work will be conducted first at U Farm and then at C Farm. All actions were reported to be on schedule.

- Direct Push Work: At SX Farm, WRPS reported that Stage I and II field work (pushing two logging and two sample holes) was completed. At the 241-C-200 Tanks, four boreholes have been pushed to total depth, and logging is underway. WRPS estimated that work at the C-200 Tanks will be complete near the end of May 2013. It was identified that characterization field work at TX Farm and south of SX Farm (Stage III) will be performed simultaneously, as two hydraulic hammer units and other necessary resources will be available to support field work. Work at these farms is scheduled to begin in June 2013.
- Surface Geophysical Exploration Work: Field work at U Farm is scheduled to begin in late April or early May 2013. Work at C Farm is estimated to begin at the end of July 2013.
- SX Farm Field Test Location: The approved Work Plan, RPP-PLAN-53808, Revision 1, identifies that a field test location decision will be provided by April 30, 2013. WRPS provided a description of the field test location selected by the project team and reasons for the selection. The field test location was described as a 4-ft by 8-ft rectangle located approximately six feet west of existing borehole C8761. One borehole will be pushed into each corner of the rectangle through a zone of elevated moisture that is estimated to exist at approximately 123 ft to 125 ft bgs (based on information from recently installed boreholes at SX Farm). Each of the four boreholes will be designed for use as either a monitoring or extraction well. The benefits of selecting this location are as follows:
  - More promising sediment type (sandy mud as opposed to muddy sand), higher moisture content beds, and slightly thicker beds.
    - There is a greater than 2-ft thick moisture bed in this area.
    - Moisture greater than ~30% volumetric moisture content is present.
    - Nitrate concentrations estimated in pore water of 44 to 90 mg/L.
  - Avoids edge of tank farm excavation slope, and keeps the test area within the area for which data has been gathered.
  - Test area close to tank farm water source, and within the thicker beds (i.e., the beds seem to thin toward the south).

  Based on the information provided by WRPS, the meeting attendees agreed that the selected location appears suitable for the SX Farm test. The attendees also agreed to document the agreement in these signed meeting notes rather than by formal letter.

Data Status: WRPS reported that quick-turn results have been assembled and evaluated to inform the SX Farm test location decision. Available results were also provided to the WRPS organization responsible for preparing a radioactive air permit application. A radioactive air permit will be required to perform the test.

New Topics: DOE reported the receipt of an email containing draft comments from the Nez Perce on the Work Plan (RPP-PLAN-53808, Revision 0). The meeting attendees discussed the comments, which provide valuable input to the planning of the Phase II RFI/CMS investigations of the 200 West Tank Farms. However, the attendees agreed that Work Plan RPP-PLAN-53808 was prepared to fulfill a TPA milestone covering a different scope of work from that required to complete a Phase II investigation. The parties agreed there would be value in working together to informally engage with the Nez Perce to discuss and acknowledge the value of their comments. Pending receipt of finalized comments, DOE will hold a meeting with Ecology and the Nez Perce to discuss the draft comments.

Next Meeting: The meeting attendees noted multiple conflicts with the proposed May 2013 meeting date. **ACTION**: Cancel proposed May 2013 meeting. WRPS/DOE will provide an email status report in lieu of the May meeting.

ACTIONS: Refer to the following table. A date-based numbering system is used to track the actions. Actions will be removed from the list after DOE and Ecology have agreed to close the action.

R Douglas Hildebrand	[signature]	5-20-2013
DOE Project Manager (print)	DOE Project Manager (signature)	Date
Michael W Barnes	[signature] for	5-22-2013
Ecology Project Manager (print)	Ecology Project Manager (signature)	Date

Item #	Topic/Title	Actionee	Description	Status
2013-03-20-1	Provide revised WP to Ms. Skorska	Tabor/Hendrickson	Provide Ms. Skorska with paper and electronic copies of WP	closed
2013-03-20-2	Provide date for completing TX data package	Tabor	Provide date when completed TX data package will be given to Ecology to support evaluation of recommendations.	Closed. Action will be addressed in response to action 2013-03-20-3.
2013-03-20-3	Respond to Rev. 0 TX SAP	Barnes	Prepare letter formally responding to DOE submission of Rev. 0 TX SAP, requesting date for provision of TX data package.	In process.
2013-04-17-1	Provide May 2013 Status by email	Eberlein/Hildebrand	Cancel May 2013 meeting and provide email status report in lieu of meeting.	New.