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SX Tank Farm Pore Water Extraction Experimental Test Plan

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Abstract: This document provides the instructions for performing the 241-SX pore water extraction test. The 241-SX pore water extraction test is a proof of principle test that will be performed south of the 241-SX Tank Farm to determine if pore water can be extracted from select vadose zone horizons under controlled conditions.

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LIST OF TERMS

Abbreviations and Acronyms

FY	Fiscal Year
HEPA	high-efficiency particulate air
HFFACO	Hanford Federal Facility Agreement and Consent Order
M&TE	measuring and test equipment
PM	Project Manager
PNNL	Pacific Northwest National Laboratory
WRPS	Washington River Protection Solutions, LLC
UPS	uninterruptable power supply

Units

cfm	cubic feet per minute
L/d	liters per day
mL	milliliter
mm	millimeter
psi	pounds per square inch
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 test of pore water extraction is being performed by Washington River Protection Solutions, LLC (WRPS) for the U.S. Department of Energy, Office of River Protection. This test is being conducted to meet the requirements of Ecology et al. 1989, *Hanford Federal Facility Agreement and Consent Order – Tri-Party Agreement*, Milestone M 045-20, and is described in RPP-PLAN-53808, *200 West Area Tank Farms Interim Measures Investigation Work Plan*. It is anticipated that the results of this proof of principle test will support future decision making regarding interim and final actions for soil contamination within the tank farms.

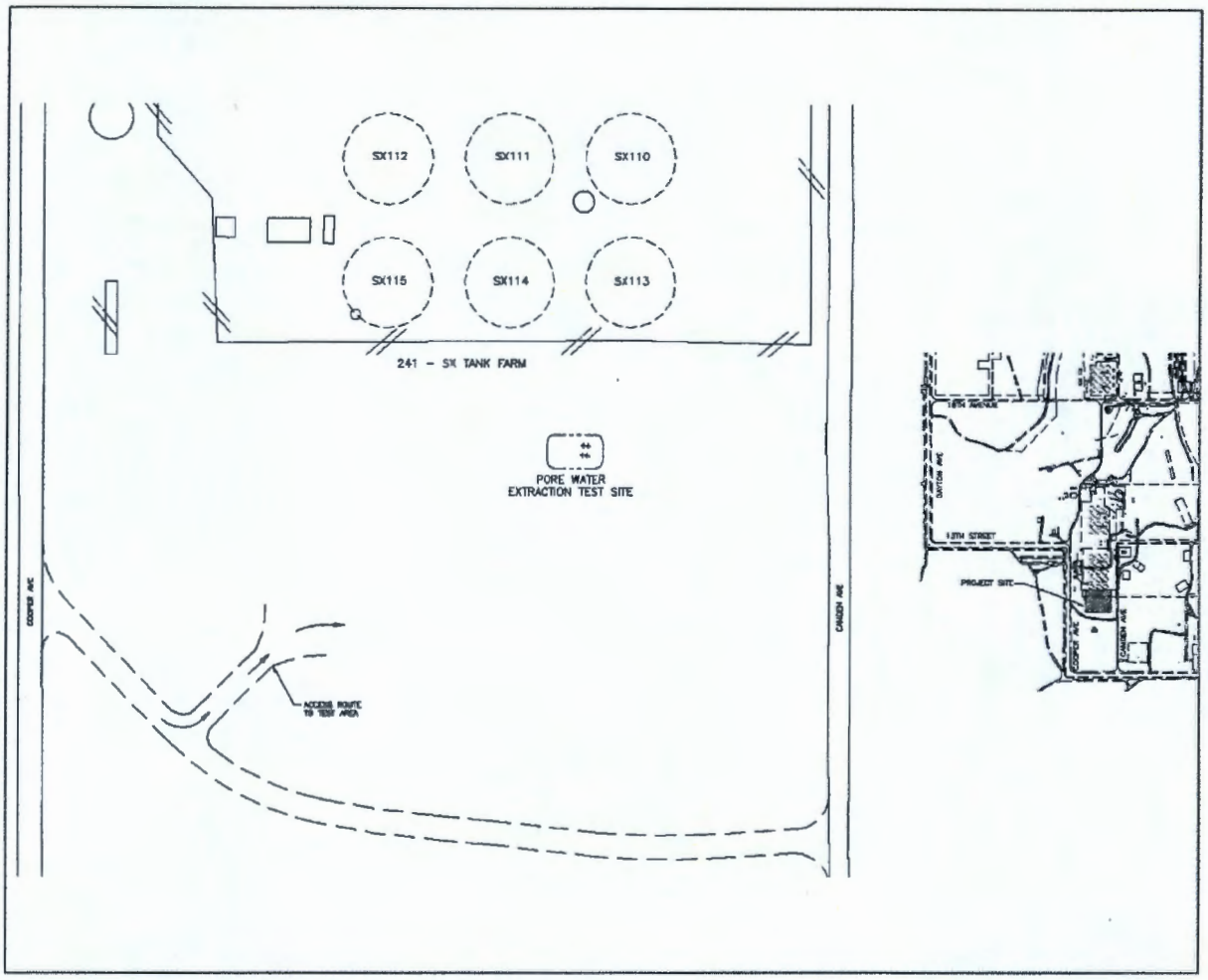
1.1 BACKGROUND

As identified in RPP-PLAN-53808, the pore water extraction test will be performed in three stages.

- The first stage proof-of-principle testing will be field activities to obtain additional information about three prospective test locations south of the 241-SX Tank Farm fence line. This first stage will involve pushing and logging these three test locations to determine if the locations have good moisture peaks (i.e., adequate moisture content) as determined by reviewing neutron log data collected from the borehole.
- The second stage of proof-of-principle testing will be pushing boreholes adjacent to the first boreholes, collecting samples, identifying a preferred test location, and designing the test equipment and associated monitoring system.
- The third stage of the proof-of-principle testing will be to procure equipment, install the test and monitoring equipment (i.e., a direct-push hole at the selected test location), and conduct the water extraction test itself.

During Fiscal Year 2013, Stages I and II were performed and activities associated with Stage III were underway (i.e., procuring and installing test and monitoring equipment at selected test location). The test location is south of 241-SX Tank Farm and shown on Figure 1. The actual pore water extraction test will be performed in Fiscal Year 2014.

Figure 1. SX Pore Water Extraction Test Site Location.



The SX Pore Water Extraction Test is designed to apply negative pressure (vacuum) via soil-gas extraction at a well to induce coincident pore water extraction. The test design is centered on using tank farm deployable equipment to address the constraints of working within a tank farm. Due to radioactive soil contamination and limitations in drilling near tanks, small diameter direct push drilling techniques applicable to tank farms are being utilized for well placement. To address space and weight limitations in working around tanks and obstacles within tank farms, the above ground portions of the test system have been constructed to allow deployment flexibility.

The pore water extraction test system consists of the following major components:

- **Vacuum system** – Consists of two vacuum pumps (P201 and P202) configured for operation independently or in parallel. It is anticipated that only one of the vacuum pumps will be required during test operations. The vacuum is connected to the well head of the extraction well. The vacuum system is used to produce a specific vacuum level (approximately -3 psig) at the well screen nominally 125 feet below ground

surface. The vacuum level is measured using a pressure transducer at the well head. Under flow conditions the line losses are accommodated by increasing the vacuum level.

NOTE: Increasing vacuum too quickly can ruin the utility of the well for the purposes of the test. Care must be taken during setup and testing to ensure that the rate and total vacuum applied to the well is controlled.

- **Water recovery system** – Consists of an air driven bladder pump installed in the extraction well. A level sensor and a pump controller are used to automatically begin operation of the pump. Expected flow rates are on the order of one gallon per day. The pump discharge line is routed to a 55-gallon drum (i.e., collection drum) located within the test trailer.
- **Extraction and monitoring well system** – Consists of four wells that are similar in construction, with the well screens centered at selected high moisture zone. Any of the wells could be used for extraction, while the remaining three wells will be used for monitoring. The water recovery system will extract water from one of the four wells designated as the extraction well. The other three wells will be used for monitoring vacuum within the formation at the depth interval of interest for the test. As the test progresses, the well being used as the extraction well may change.

NOTE: Based on the well logging results, the preferred extraction well is C8823, followed by C8824, C8826, and C8825.

It is anticipated that the testing period will be approximately six to eight weeks. As previously indicated, the goal of the test is to extract pore water and collect sufficient data over the duration of the test to evaluate the feasibility of pore water extraction.

1.2 PURPOSE AND SCOPE

The purpose of this document is to identify the activities that support the 241-SX pore water extraction test and to also provide the details that pertain to performing the tasks associated with each of these activities. The 241-SX pore water extraction test consists of the following activities:

- Test Setup
- Test Startup
- Test Operations
- Potential Additional Testing.

The document contains the following sections, which detail the tasks that will need to be performed for each activity and the personnel that are responsible for performing or overseeing these tasks:

- Safety Precautions and Limitations (Section 2.0)
- Testing (Section 3.0)
- Change Control (Section 4.0)
- Roles and Responsibilities (Section 5.0).

Tables and forms that will support the field work are provided within the sections and in the appendices of this document. The appendices contain the following information:

- Test Log (Appendix A)
- Test Exception (Appendix B)
- Equipment Calibration Certificates (Appendix C)
- Test Equipment Startup (Appendix D)
- Operational Decision Input in Response to Flow Information (Appendix E)
- Round Sheets (Appendix F)
- Personnel Log (Appendix G)
- Initial Setup Test Data Sheet (Appendix H)
- Summary Data Reports (Appendix I).

2.0 SAFETY PRECAUTIONS AND LIMITATIONS

The Field Work Supervisor or Test Director may stop testing at any time to protect personnel and equipment.

CAUTION:

Any system modification, repair, or maintenance action on the SX Pore Water Extraction Test assembly shall consider potential contamination levels and provide appropriate controls.

2.1 PERSONNEL SAFETY

All identified hazards will be addressed in the work package.

2.2 TEST SUSPENSION DUE TO SAFETY CONCERN

The Test Director or Field Work Supervisor may stop testing and place equipment in a safe condition. All suspension of testing shall be documented on the Test Log (Appendix A).

1. If directed by the Test Director, STOP all testing activities AND PLACE equipment in a safe configuration per Test Director instructions.
2. If a section of the test is suspended for any reason prior to completing all steps, the Test Director shall establish initial conditions necessary to resume testing for that section prior to resuming the test.
3. Previously completed sections need not be repeated unless directed by the Test Director to establish conditions required to resume the test.
4. Sections of this procedure may be performed out of sequence in accordance with the Test Director instructions as long as components or tests are NOT altered. Steps within each section must be performed in order.

If major changes are required (see Section 4.2). Prior to resuming testing complete a Test Exception (Appendix B) to document changes.

3.0 TESTING ACTIVITIES

Testing activities involve setup, startup, test operations, and potential additional testing. Test setup involves verifying the system components are in place; mechanical and electrical connections have been made; and the system is configured to allow startup of the test. Test setup is expected to take one to two days to complete.

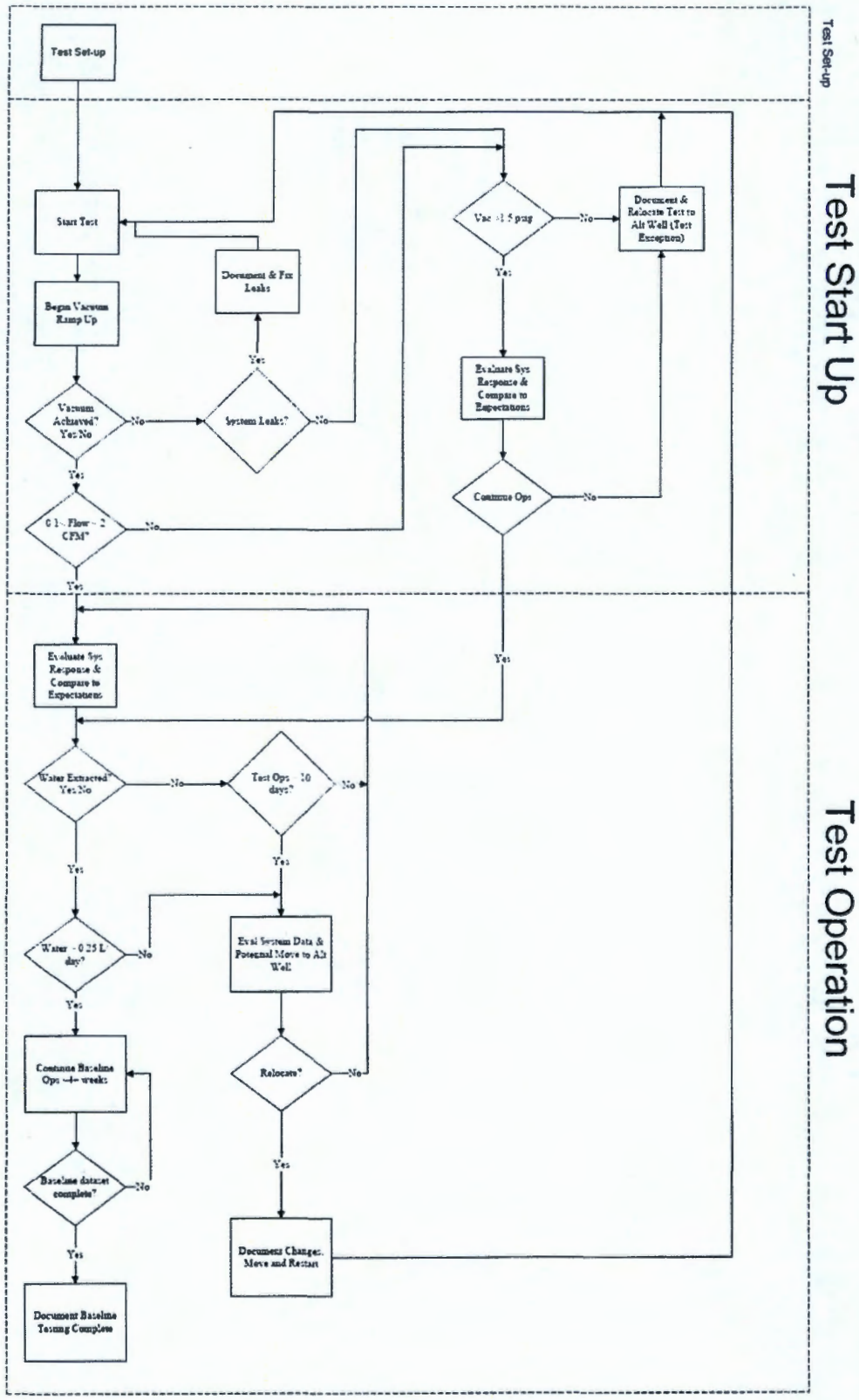
Test startup involves the controlled start of the equipment to slowly increase the vacuum level in the extraction well to the target value. Test startup is expected to take one day to complete.

Test operations involve the day to day monitoring of the test equipment and recording of the test data. Adjustments in the vacuum level may be made during test operations depending on the measured air flow rates from the extraction well.

Potential additional testing may be performed at the conclusion of testing operations to evaluate system performance under different operating conditions. The decision to proceed with additional testing will be made by the Project Manager (PM).

The SX Pore Water Extraction Test logic flow chart is depicted in Figure 2. The chart provides general guidance for troubleshooting and assessing the ability of test setup and test operations to establish conditions suitable for pore water extraction based on measured pressure and air flow values.

Figure 2. Test Logic Flow.



There are a number of variables and down-hole conditions that will affect the water and air flow rates and the potential for successfully extracting pore water. Pacific Northwest National Laboratory (PNNL) technical staff members have performed numerical modeling to examine pore water extraction under conditions that would be expected at or near the 241-SX Tank Farm. The results from these simulations can be used to evaluate operating conditions following startup of the test. Details on the testing and modeling are presented in PNNL-22662, *Field Test Design Simulations of Pore Water Extraction for the SX Tank Farm.*

Data collection during test operations will be performed using a combination of instruments connected to a data logger; and readings recorded in the test plan and on daily round sheets. The data logger will provide for continuous monitoring and recording data. The parameters logged include:

- Vacuum level in the extraction and monitoring wells
- Flow and temperature readings of the soil gas removed from the extraction well
- Nitrate concentrations in the pore water
- Water levels in the 55 gallon drums that are used to collect pore water.

Manual readings will be recorded for the inflation pressures on the well packers, differential pressure in the vacuum pump discharge line, and the bladder pump cycle counter.

Test completion is contingent on both the successful startup/operation of the test and the collection of a data set sufficient for the evaluation of pore water extraction feasibility. The minimum data set sufficient for proof-of-concept evaluation will be defined by the project team during the test. It is anticipated that a sufficient set of operating data can be acquired in the six to eight week planned test duration. This is contingent on establishing and maintaining vacuum conditions, without stopping and starting, for a period of time.

3.1 TEST SETUP

Prerequisites listed in this section must be completed prior to the commencement of testing activities.

3.1.1 System Configuration

CONFIRM system installation and equipment setup in accordance with the site plan (H-14-109845, *SX Pore Water Extraction Design Site Plan*).

_____

Test Director / Date

3.1.2 Electrical Power Requirements

CONFIRM electrical generator installation and connections are fully functional prior to execution of the test procedure.

_____

Test Director / Date

One or two portable diesel generators will be used to provide electrical power to support test operations. A plan for a refueling schedule will support continuous operation of the generator

during the entire test period. An uninterruptable power supply (UPS) is included in the equipment trailer to provide power to operate the vacuum pumps in the event that the generators require a brief shut down. The UPS will provide for continued operation of one vacuum pump, data logger, bladder pump controller, and heat trace on the discharge line of the vacuum pump for approximately 12 minutes.

3.1.3 Tools and Test Equipment

VERIFY basic tool kit to include standard and Phillips head screw drivers, standard wrenches in sizes smaller than 7/8 inches, metric wrench set 24 mm and smaller, pliers, and pipe wrenches are available at the test trailer.

Test Director / Date

3.1.4 Field Preparations

Perform steps identified in Table 1 prior to initiating test startup.

Table 1. Test Setup Steps.

NOTIFY the PM at least 2 days (48 hours) in advance of test start.	Test Director / Date
ATTACH the current, calibration records for all measuring and test equipment used to Appendix C.	Test Director / Date
VERIFY that all spill containment/drip pans are in place (for drums, generator, a small pan under any piping connections outside the trailer).	Test Director / Date
VERIFY the following design drawings have been released: H-14-109844, *SX Pore Water Extraction P&ID*; H-14-109845, *SX Pore Water Extraction Design Site Plan*; H-14-109846, *SX Pore Water One-Line and Panel Schedule*; H-14-109847, *SX Pore Water Extraction Trailer Assembly*.	Test Director / Date
VERIFY two 55-gallon drums are available in the trailer for water collection.	Test Director / Date
VERIFY well packers are pressurized to 13 psig (+/-2 psig).	Test Director / Date

3.2 TEST STARTUP

Test startup involves powering up the vacuum pump, adjusting the vacuum regulator valve, and aligning valves to slowly increase the vacuum level in the extraction well to the target level. Steps involved in starting up the test are documented in Appendix D, Test Equipment Startup.

3.3 TEST OPERATIONS

Testing is accomplished by operating the test equipment and recording data. The data is collected electronically and with the round sheets as described in Section 3.3. It also includes sampling the pore water, which is described in Section 3.3.3. Round sheet entries are marked complete by entry of the operator initials/data or by a checkmark as indicated.

Note: This is a test of an experimental method (i.e., research and development). Instrumentation or processes may require adjustment. Changes will be documented in accordance with Section 4.0.

3.3.1 Daily Operations

Energy Solutions Field Operator shall perform daily inspections and record test data on the SX Pore Water Extraction Test Daily Round Sheet (Appendix F). Daily rounds shall be performed on standard scheduled work days.

- **COMPLETE** the SX Pore Water Extraction Test Daily Round Sheet at the test site.
- **SIGN** and **DATE** completed SX Pore Water Extraction Test Daily Round Sheet.
- **FILE** completed SX Pore Water Extraction Test Daily Round Sheets in the Round Sheet Log book at the test site.
- **IF** unexpected conditions are found (e.g., water leak, equipment failure, loss of pressure on the packer), **CONTACT** the Test Director.

WRPS Test Director shall perform the following daily activity until the first sample is obtained:

- **REVIEW** operating data – download operating data from the data logger directly of from the web interface

3.3.2 Weekly Operations

WRPS Test Director shall perform weekly inspection of the test site and shall perform the following tasks:

- **REVIEW** operating data – download operating data from the data logger directly or from the web interface.
- **REVIEW** daily round sheets – review data for bladder pump cycle counter as a precursor to water arrival at the test trailer.

  Note: The bladder pump volume of water per pump cycle is approximately 29 mL with a line volume of ~760 mL. Approximately 26 pump cycles will be required for pore water to reach the trailer and another 40 cycles to fill the sample section of the discharge line before water is discharged to the collection drum.

- **REVIEW** system operations with WRPS PM (i.e., review air flow rates and vacuum readings and evaluate need for system vacuum adjustment).
- **IF** required, **ADJUST** system operating vacuum level using V203 and the values in Table 2.
- **RECORD** all adjustments made in the Test Log (Appendix A).
- **PREPARE** weekly summary report comparing test data with expected results from modeling simulations. Additional details on the expected system response (air flow/water production) are provided in Appendix E, Operational Decision Input in Response to Flow Information.
- **ATTACH** weekly summary reports in Appendix I.
- **REPORT** initial water production to WRPS PM to support planning for sampling and analysis activities.
- **ADJUST** pump controller fill and discharge times in accordance with the pump controller operation manual. An air discharge line pressure of approximately psi will be required for bladder pump operation once the discharge line has been filled.

  Note: If the discharge time setting provides for too long of a discharge period, the air pressure can put a crease in the bladder and reduce per cycle pump volumes.

Table 2. Pressure Adjustment Factor Table.

Air Flow Rate (cfm)	Pressure Adjustment (psi)
8	0.36
6	0.22
4	0.1
2	0.03
1	0

- **VERIFY** sampling is possible - based on review of test data logged, coordinate with Vadose Zone Project Sample Lead to initiate and schedule sample collection.

  NOTIFY Project Environmental Lead when collection drum is approximately half full to support planning for drum pick up and removal. Depending on water production rate the drums may remain at the test trailer for the duration of the test or they may be removed during the test.

3.3.3 Pore Water Sample Collection

Sample collection for laboratory analysis shall be performed on a weekly basis (if sufficient water is available) or as directed by the Test Director. Sample collection shall begin after sufficient water has been produced to fill the sample line In order to perform analysis, the laboratory has identified that is would be optimal to receive 1,000 mL of water (two 500 mL bottles – one with preservative and one without preservative).

WRPS Test Director shall perform the following tasks, after Test Startup has been completed:

- **REVIEW** data logger information on a daily basis to determine if and when the first sample can be collected (NOTE: 1,000 mL of water should be available prior to sample collection. Document water available on the Test Log (Appendix A).
- **IF** sufficient volume of water is available for sampling, **DOCUMENT** the water available on the Test Log Form (Appendix A) and contact:
  - Energy Solutions Field Operator
  - Vadose Zone Project Sample Lead
  - Field Work Supervisor – who will determine when sample will be collected (that day or the next day)
- **REVIEW** SX Pore Water Extraction Water Sample Collection Round Sheet (form provided in Appendix F).
- **DOCUMENT** on the Test Log (Appendix A) whether a sample could be collected on a weekly basis.

After the WPRS Test Director identifies that a sample can be collected, Energy Solutions Field Operator shall perform the following tasks:

- **ENSURE** that necessary materials are available to collect samples (e.g., sample bottles, sample labels, chains of custody, coolers).

  COLLECT sample.

  Note: Steps required to collect a water sample from the system include turning off the bladder pump and aligning valves to enable water accumulated in the sample trap to flow into the sample container. Utilize the SX Pore Water Extraction Water Sample Collection Round Sheet in Appendix F for sample collection steps.
- **DOCUMENT** sampling on the SX Pore Water Extraction Water Sample Collection Round Sheet (Appendix F).
- **SIGN** and **DATE** completed SX Pore Water Extraction Water Sample Collection Round Sheet.
- **COMPLETE** sample paperwork (e.g., Chain of Custody) and deliver sample to 222-S Laboratory.
- **IF** unexpected conditions are found (e.g., water leak, equipment failure, loss of pressure on the packer), **CONTACT** Test Director.

  The suggested approach is to fill the 500 mL sample bottle <u>without preservative first</u> with as much water is available and then fill the 500 mL sample bottle with preservative. If less than 1,000 mL of sample volume is collected, the sample volumes can be redistributed between bottles, as necessary.

NOTE: Only redistribute water from the 500 mL sample bottle without preservative into the 500 mL bottle with preservative.

Vadose Zone Sample Lead shall perform the following tasks:

- **PROVIDE** necessary sample paperwork to perform sampling (e.g., sample labels, chains of custody).
- **PROVIDE** sample bottles.
- **NOTIFY** laboratory personnel when samples will be shipped

  Work controls and prerequisites for sample collection (Industrial Hygiene and Health Physics Technician support) shall be addressed in the work package. Additionally, the following procedures will be utilized to ensure sampling guidelines are followed: TFC-OPS-WM-C-22, *Chain of Custody for Tank Farm Vadose Zone and Multi Media Sampling,* and TO-080-900-B0, *Sampling Packaging and Shipping.*

3.3.4 System Shutdown

After the WPRS Test Director or Field Work Supervisor identifies system shutdown is necessary:

- **SHUTDOWN** the system in a safe configuration.

The recommended shut-down sequence involves powering down equipment in the following order: heat trace, water pump controller, vacuum pump(s), data logger and other instrumentation. The initial valve line-up in Table D-1 or D-2 can be used as a potential safe configuration (Appendix d, Test Equipment Startup). Consideration shall be given to freeze protection, electrical isolation, and equipment/environmental safety.

3.3.5 Maintenance

With exception of generator refueling, the test equipment is not expected to require maintenance during the test period. If maintenance is required, follow the manufacturer's recommended maintenance procedures.

Note: All operating and maintenance manuals will be provided in the trailer.

3.3.6 Troubleshooting and Repair

Operations manuals for all equipment and instrumentation will be provided at the test trailer. If required, perform troubleshooting in accordance with equipment manufacturers guidelines. Additional or alternative troubleshooting may be undertaken, or troubleshooting may be discontinued and failed equipment simply replaced at the direction of the Test Director.

3.3.7 Radial HEPA Filter

The radial high-efficiency particulate air (HEPA) filter should last the duration of the test. A pressure differential over 4 inches water gauge warrants replacement of the HEPA filter.

The WPRS Test Director shall perform the following tasks:

- **REVIEW** air discharge line readings recorded on the SX Pore Water Extraction Test Daily.
- **IF** radial filter is bad, **OBTAIN** a replacement filter.

COORDINATE with the Field Work Supervisor to suspend testing operations, replace filter element, and restart test.

3.4 POTENTIAL ADDITIONAL TESTING

Additional testing may be conducted as directed by the WRPS PM following the collection of test operation data. Additional testing may involve operating the extraction test at higher vacuum levels or opening valves on the monitoring wells. The information associated with additional test shall be recorded in the Test Log (Appendix A) and on the Round Sheets (Appendix F).

4.0 CHANGE CONTROL

Changes may be made to this plan without a complete revision and re-issue, if the changes fall into one of the two categories described in Sections 4.1 and 4.2.

4.1 MINOR CHANGES

The Test Director may make pen and ink changes to this test procedure to accomplish minor corrections. Minor corrections meet the following criteria:

- Typographical and grammatical errors
- Do not change test steps (can alter test step sequence)
- Do not change acceptance criteria
- Do not change equipment configuration for form, fit, or function, and have no effect on test results.

Minor changes are not considered test exceptions and do not require the generation of a Test Exception (Appendix B).

The Test Director shall perform the following steps to accomplish minor changes:

- Cross out the affected text in ink using a single line.
- Write in the replacement text, if any, legibly in ink.
- Initial and date the change.

4.2 MAJOR CHANGES/EXCEPTIONS

Major changes to this test procedure are defined as:

- Changes to test steps
- Changes to acceptance criteria
- Changes that would affect test results (i.e., selection of a new extraction well, increasing vacuum levels).

The Test Director shall document any deviations from the test using the Test Exception (Appendix B). The WRPS PM shall review and sign concurrence for the Test Exception.

Because this test is a proof of principle test, a Quality Assurance approval of test exceptions is not required.

After the test exception has been approved, the Test Director shall implement the change using the following method:

- Document in the Test Log (Appendix A).

5.0 ROLES AND RESPONSIBILITIES

5.1 TEST DIRECTOR (OR DESIGNEE)

Test Director (Melissa Holm, 376-3740 or 308-2458) or Designee shall:

1. Verify the completion of the prerequisites in accordance with Section 5.1.
2. Approve changes in testing in accordance with Section 4.0.
3. Coordinate with the Field Work Supervisor and Shift Office.
4. Document test activities and review test paperwork in order to record data. Ensures data and information relevant to who, what, when, and how the test is executed. Data and information collected during testing shall be released as part of the test report. This includes identifying personnel involved in recording data, deviations from the test plan, equipment used, and system operating data. Daily rounds will be performed and documented by Energy Solutions Field Operator. Data and information shall be recorded in a controlled copy of the test plan using the following:
   a. Test Exceptions – Record changes in the test steps on the Test Exception (Appendix B) as defined in Section 4.0.
   b. Personnel Log – Record names, signatures, and initials of all testing personnel on the Personnel Log (Appendix G).
   c. Test Log – Record testing activities, evolutions, and deviations on the Test Log (Appendix A).
   d. Test Equipment Log – Document use of test equipment not specified in Section 3.1.3 (Tools and Test Equipment) on the Test Log (Appendix A) and if calibration is required, place calibration certificates in the Equipment Calibration Certificates (Appendix C).
   e. Initial Startup Sheets – Record test data during system startup following initial test start and after all system setting changes using the Initial Setup Test Data Sheet (Appendix H).
5. Download and save all test data collected via the data logger during test operations on a weekly basis. Compile and route summary reports to the project team to identify operating conditions and summarize actual versus predicted performance. Attach summary reports to Appendix I.
6. Obtain meteorological data (atmospheric pressure, temperature, precipitation) from the Hanford Meteorological Station (509-373-3215) over the duration of test operations.

Data shall be from a weather station near the pore water extraction test site. Meteorological data will be used in combination with data collected from the pore water extraction test setup to evaluate system performance.

7. Post status tag on the trailer door to reflect status of testing.

5.2 PROJECT MANAGER

The Project Manager Dan Parker (430-0766) shall:

1. Ensure this test procedure satisfies the project scope and objectives.
2. Review and approve test exceptions.
3. Ensure the availability of required resources and personnel to support testing activities.

5.3 PROJECT ENVIRONMENTAL LEAD

The Project Environmental Lead Becky Wiegman (373-9443) shall:

1. Ensure all necessary environmental permits are in place and any specific permit conditions are addressed.
2. Coordinate with Waste Services for the collection of drums containing pore water.

5.4 VADOSE ZONE PROJECT SAMPLE LEAD

The Vadose Zone Project Sample Lead Cindy Tabor (509-373-3981 or 513-673-2080) shall:

1. Coordinate with the test director and Energy Solutions Field Operator for sample collection.
2. Coordinate with the analytical laboratory for project analysis requirements.

5.5 ENERGY SOLUTIONS FIELD OPERATOR

Energy Solutions Field Operator shall:

1. Make daily rounds to verify the test equipment is operating properly and has not been tampered with.
2. Collect and transport pore water samples from the test site to the laboratory.
3. Complete daily rounds during test operations. Document daily rounds in logbook provided in the test trailer. An example form for the daily round sheets is provided in Appendix F.

5.6 FIELD WORK SUPERVISOR

The Field Work Supervisor shall:

1. Schedule sampling activities.
2. Coordinate with Test Director to replace radial filter elements when required.

5.7 PNNL TECHNICAL STAFF

PNNL technical staff (Mike Truex, 371-7072) shall provide consultation during test operations to compare test data against predicted system response and to provide input on test exceptions and interpretation of test data as requested.

5.8 COLUMBIA ENERGY AND ENVIRONMENTAL SERVICES, INC. TECHNICAL STAFF

Columbia Energy and Environmental Services, Inc. technical staff (Colin Henderson 947-4588) shall provide consultation on the testing equipment during test setup, startup, and operations.

5.9 ENERGY SOLUTIONS TECHNICAL STAFF

Energy Solutions technical staff (Kent Reynolds, 375-9598) shall provide consultation during test setup, startup, and operations on the well configuration, construction, operation of the well packers, and interpretation of test data.

6.0 REFERENCES

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APPENDIX A

TEST LOG

Page _____ of _____

TEST LOG

Date	Time	Entry	Initials

APPENDIX B

TEST EXCEPTION

TEST EXCEPTION

Exception No. _____

Page No. _____

Affected Section, Step(s)

Change(s)

Explanation /Justification

Concurrence

Test Director	**Signature**	**Date**
Test Engineer	**Signature**	**Date**
Other	**Signature**	**Date**
Project Manager	**Signature**	**Date**

APPENDIX C

EQUIPMENT CALIBRATION CERTIFICATES

Insert appendix here

APPENDIX D

TEST EQUIPMENT STARTUP

Perform the following steps in-order for system startup.

1. **VERIFY** valve line-up as directed in Table D1 and as shown in **Figure D1 for startup of pump P201 or Table D2 and Figure D2 for startup of P202** and document in designated locations. The system is configured to allow for parallel operation of both vacuum pumps P201 and P202. If test conditions warrant simultaneous operation of both vacuum pumps in parallel verify valve line up as shown in Table D3 and Figure D3.

NOTE: Test steps are written for initial startup using pump P201.

Table D1. Initial Valve Line-up for Operation of Vacuum Pump P201.

Control / Indicator	Description	Position	Verified (Check)
V103, V104, V105	Connection Valves at well bulkheads	Closed	
V203, V204	SMC Vacuum Regulators	Adjustment knob in full counter clockwise position	
V201, V202	Globe valves for vacuum shutoff	Closed	
V207	Vacuum cross-flow valve	Closed	
V101	Bulkhead Water Valve	Open	
V102, V106, V108	Water line sample and vent connections	Closed	
V107	Water line container valve	Open	
V306	N2 Bleed Valve	Closed	
V302, V303, V304, V305	Packer N2 Supply Valves	Closed	
V208		Open	
V209		Closed	
V210	Vacuum pump discharge	Open	
Verified by Test Director or Designee (Printed Name / Signature / Date): _____/_____/_____			

NOTE: Spring loaded relief valves V205 and V206 are preset at -5 psig. These do not require adjustment unless testing parameters are modified to operate at higher vacuum levels.

Figure D1. Initial Valve Line-Up Diagram for Operation of Vacuum Pump P201.

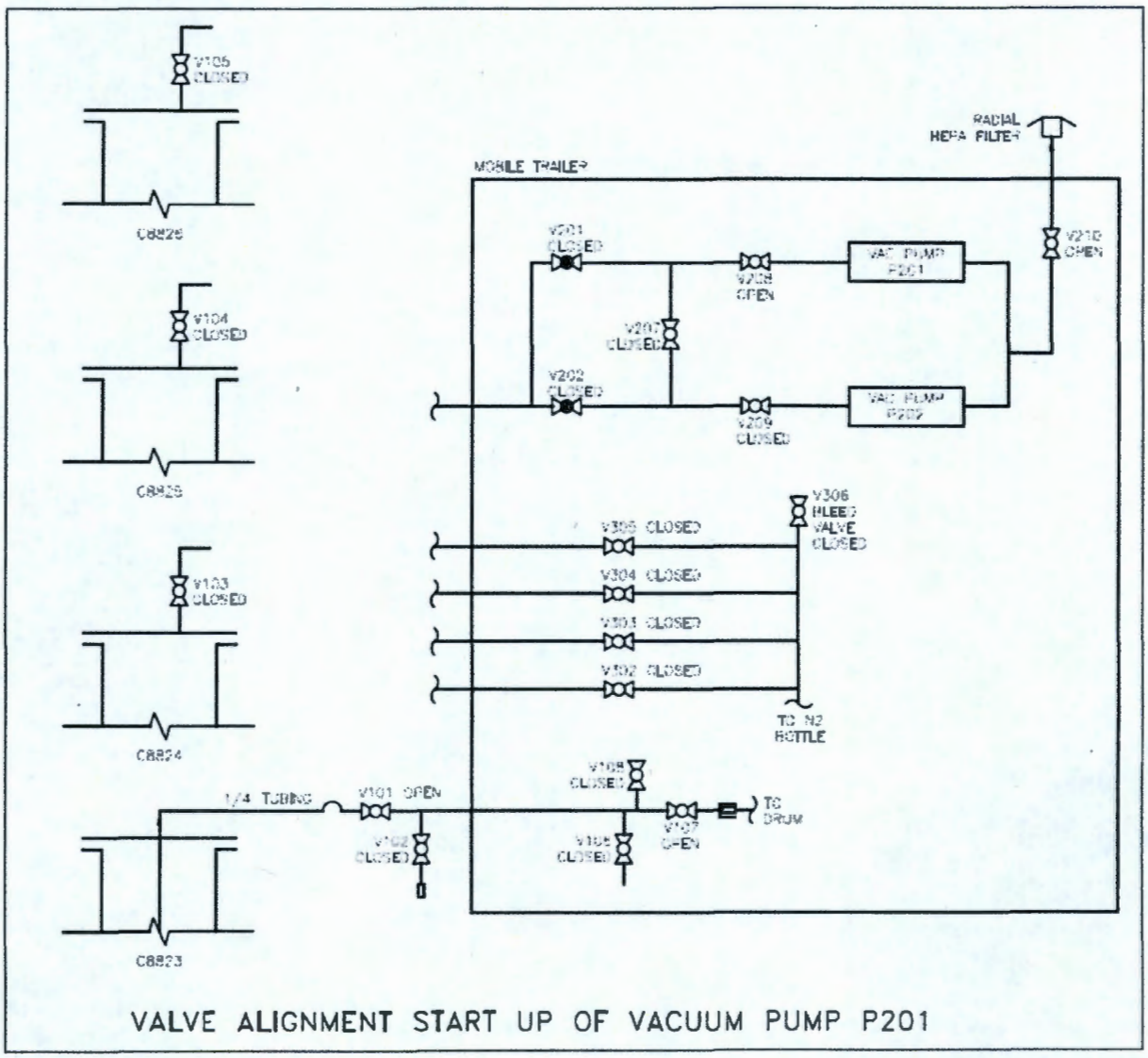


Table D2. Initial Valve Line-up for Operation of Vacuum Pump P202.

Control / Indicator	Description	Position	Verified (Check)
V103, V104, V105	Connection valves at well bulkheads	Closed	
V203, V204	SMC Vacuum Regulators	Adjustment knob in full counter clockwise position	
V201, V202	Globe valves for vacuum shutoff	Closed	
V207	Vacuum cross-flow valve	Closed	
V101	Bulkhead Water Valve	Open	
V102, V106, V108	Water line sample and vent connections	Closed	
V107	Water line container valve	Open	
V306	N2 Bleed Valve	Closed	
V302, V303, V304, V305	Packer N2 Supply Valves	Closed	
V208		Closed	
V209		Open	
V210	Vacuum pump discharge	Open	
Verified by Test Director or Designee (Printed Name / Signature / Date): _____/_____/_____			

Figure D2. Initial Valve Line-Up Diagram For Operation of Vacuum Pump P202.

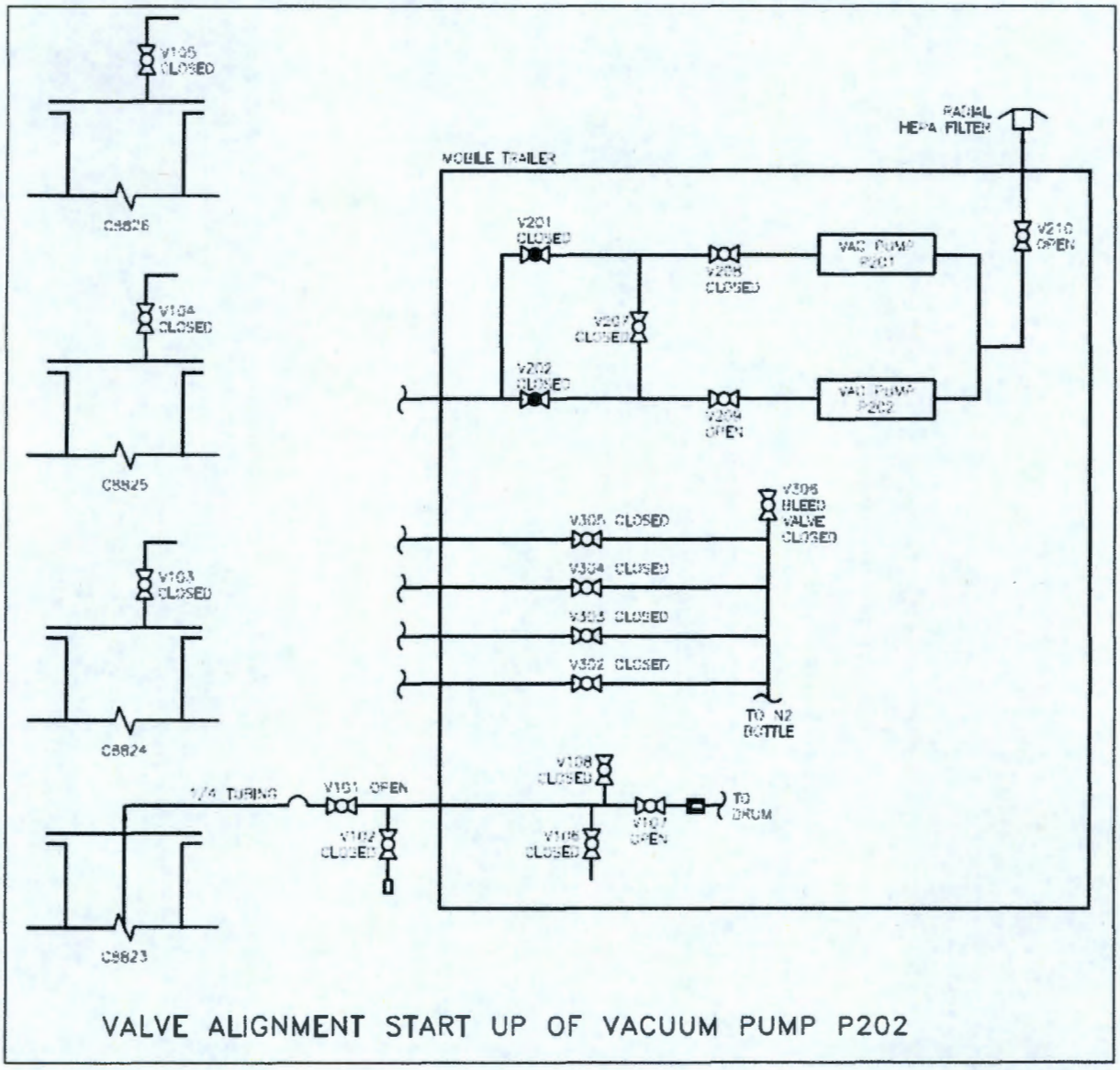
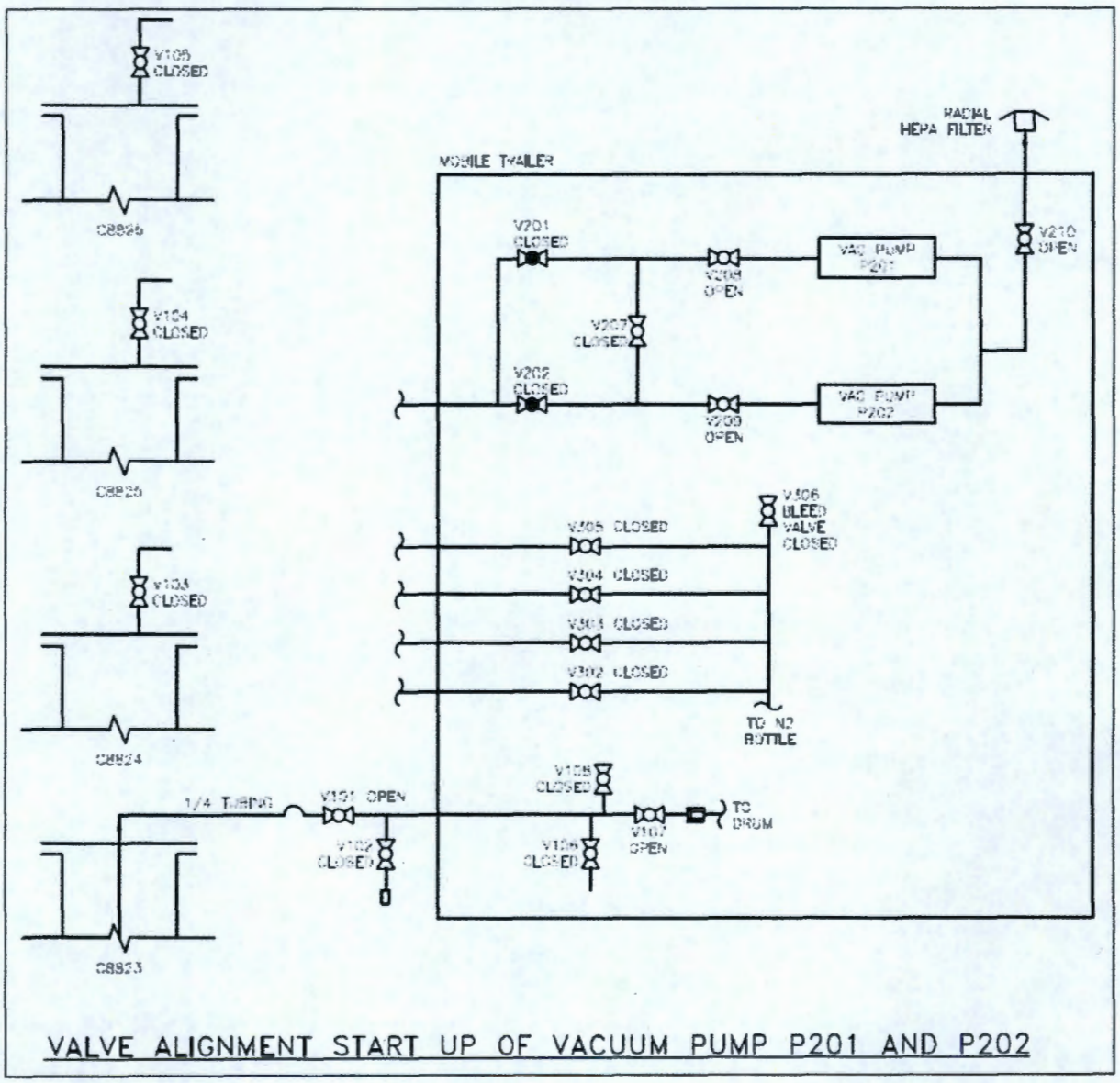


Table D3. Initial Valve Line-up for Operation of both Vacuum Pump P201 and P202 In Parallel.

Control / Indicator	Description	Position	Verified (Check)
V103, V104, V105	Connection valves at well bulkheads	Closed	
V203, V204	SMC Vacuum Regulators	Adjustment knob in full counter clockwise position	
V201, V202	Globe valves for vacuum shutoff	Closed	
V207	Vacuum cross-flow valve	Closed	
V101	Bulkhead Water Valve	Open	
V102, V106, V108	Water line sample and vent connections	Closed	
V107	Water line container valve	Open	
V306	N2 Bleed Valve	Closed	
V302, V303, V304, V305	Packer N2 Supply Valves	Closed	
V208		Open	
V209		Open	
V210	Vacuum pump discharge	Open	
Verified by Test Director or Designee (Printed Name / Signature / Date): _____/_____/_____			

Figure D3. Initial Valve Line-Up Diagram For Operation of Vacuum Pump P201and P202 in Parallel.



2. **VERIFY** data logger is powered up and that all instruments are being logged by either connecting a laptop directly to the data logger or by logging into the remote access account (directions supplied separately)

Test Director / Date

3. **TURN ON** heat trace on vacuum pump discharge line and on lines from the extraction well to the trailer.

Test Director / Date

4. **TURN ON** pump controller and ensure controller settings are at manufacturers recommendations. Set initial pump fill time to 45 seconds. Set initial discharge time to 5 seconds.
Pump controller operating manual shall be located in the trailer.

Test Director / Date

5. **TURN ON** vacuum pump P201.

Test Director / Date

6. **ADJUST** V203 until a vacuum of -0.25 psig registers on the data logger.

Test Director / Date

7. **SLOWLY OPEN** valve V201.

Test Director / Date

8. **OBSERVE** the system for 15-30 minutes for vacuum and flow to stabilize. Record data and any observations on the Initial Setup Data Sheet (see Appendix H).

Test Director / Date

9. **SLOWLY ADJUST** vacuum regulator V203 to increase the vacuum in increments of ~0.25 psig. Note on the test data sheet in Appendix H the time and indicated pressure for the vacuum line.

Test Director / Date

10. **OBSERVE** the system for 15-30 minutes for vacuum and flow to stabilize. Record data and any observations on the Initial Setup Data Sheet (see Appendix H).

Test Director / Date

11. **REPEAT** the steps 12 and 13 above until a vacuum of 3 psig is achieved. Increase the vacuum level above 3 psig based on the observed flow rate using the values in Table D4 as a guide.

Test Director / Date

NOTE: Values in Table D4 account for the line losses between the well screen and the well head.

Table D4. Pressure Adjustment Factor Table.

Air Flow Rate (cfm)	Pressure Adjustment (psi)
8	0.36
6	0.22
4	0.1
2	0.03
1	0

12. **RECORD** the time desired vacuum level is achieved on the Initial Setup Data Sheet (Appendix H).

APPENDIX E

OPERATIONAL DECISION INPUT IN RESPONSE TO FLOW INFORMATION

SX Pore Water Extraction Test Operational Decisions

- Baseline operations while ramping vacuum slowly up toward ~-3 psig (calculated at well screen) in increments of about -0.25 psig. Key data during ramp up are the extraction well air flow at the set vacuum and the vacuum measured at the monitoring wells.
    - Normal response: Progression of extraction air flow and monitoring well vacuum is comparable to simulation-based expectations leading to a vacuum of -3 psig with air flow of 0.1 to 2 cfm with air flow stable (see monitoring well vacuum plot as function of imposed extraction well vacuum) – continue operations.
    - Low air flow: Extraction air flow at applied vacuum is lower than simulation-based expectations leading to a vacuum of -3 psig with air flow <0.1 cfm. Evaluate monitoring well vacuum response trend relative to simulation results – continue operations.
    - High air flow: Extraction air flow at applied vacuum is higher than simulation-based expectations leading to flows greater than 2 cfm at or below -3 psig. Check system for leakage. Evaluate monitoring well vacuum response trend relative to simulation results – continue operations if able to reach -1.5 psig pending review of vacuum at monitoring wells (see monitoring well vacuum plot as function of imposed extraction well vacuum), or switch wells if suitable vacuum cannot be established.
- Baseline operations after ramping vacuum to steady conditions. Expect steady operations for up to 3-4 weeks to collect a suitable data set to evaluate performance.
    - Normal response – continue operations
        - Reach -3 psig with air flow of 0.1 to 2 cfm with air flow stable.
        - Water flow may be delayed up to 10 days, when started is >0.25 L/d.
        - Compare vacuum at monitoring wells to monitoring well vacuum plot as function of imposed extraction well vacuum. Consider changes over time in vacuum or flow responses due to expected wetting near well.
    - Low air flow
        - Reach -3 psig with air flow <0.1 cfm.
        - Compare vacuum at monitoring wells to monitoring well vacuum plot as function of imposed extraction well vacuum. Consider changes over time in vacuum or flow responses due to expected wetting near well.
        - Water flow may be delayed up to 10 days or more, when started is >0.25 L/d – continue operations.
        - Water flow may be delayed up to 10 days or more, when started is <0.25 L/d – evaluate water flow conditions with possibility of low permeability constrictions to water flow rate. If low flow continues or degrades, switch wells due to low permeability condition (possible from compacted zone).
    - High air flow
        - With all high air flow conditions, consideration of vacuum and flow conditions in comparison to simulation-based flow and vacuum expectations may lead to a more rapid switch to another extraction well based on projected ability to extract water.

- Cannot reach -3 psig at maximum air flow, vacuum at monitoring wells is much lower than simulation-based conditions – check system for leakage, if no issues, then:
    - Compare vacuum at monitoring wells to monitoring well vacuum plot as function of imposed extraction well vacuum. Consider changes over time in vacuum or flow responses due to expected wetting near well.
    - Consider vacuum reached and continue operations. Water flow may be delayed more than 10 days. If >-1.5 psig, continue operations to evaluate if water flow can be >0.25 L/d. Collect data for a period of time, but evaluate data to determine when to switch wells due to short circuit air flow. If <-1.5 psig then switch wells due to short circuit air flow.
- Reach -3 psig at air flow >2 cfm – check system for leakage, if no issues, then:
    - Compare vacuum at monitoring wells to monitoring well vacuum plot as function of imposed extraction well vacuum. Consider changes over time in vacuum or flow responses due to expected wetting near well.
    - Water flow may be delayed more than 10 days. If water flow is > 0.25 L/d, continue operations. If water flow is < 0.25 L/d, continue operations for a period of time to collect data and then switch wells due to short circuit air flow.

- Optional post SX Pore Water Extraction Test operational strategies (options after collecting full pore water extraction data set under baseline operational conditions).
    - Higher vacuum operation
        - If air flow at -3 psig is <8 cfm, monitoring well vacuum is reasonable compared to simulation-based results and water production has been acceptable under normal operating conditions, ramp air flow and vacuum up incrementally. Measure vacuum at monitoring wells and water production rate in 2 or 3 series of vacuum/flow steps, stopping for at least 5 days per step.
    - Desiccation parameter test
        - While desiccation cannot be fully tested with the existing test configuration, key information on the injection rate and pressure of dry air and on the vertical distribution of drying within the injection zone can be gathered.
            - Conduct a neutron moisture logging event in the selected injection well (preferably one that has only been used for monitoring in the previous testing).
            - Configure the well for injection of compressed air and provide for measurement of air flow, pressure, temperature, and relative humidity.
            - Inject air at increasing flow rates, starting at less than 1 cfm to gather information on the pressure required for injection.
            - If a stable relatively high flow rate (>5 cfm) can be obtained at moderate pressure, this operation can be continued. At the end of injection operations, conduct a neutron moisture logging event to evaluate changes from the initial moisture distribution near the well. Improved data will be obtained for longer operational periods.

APPENDIX F

ROUND SHEETS

SX Pore Water Extraction Test Daily Round Sheet

Date:_____

Step	System Component	Initials
1.	Confirm normal operation of the generator and that there are no fuel leaks.	
2.	Inspect visible portion of the water line from well head to trailer for evidence of a water line leak.	
3.	Inspect water line within equipment trailer, drums, and inspect spill containment for signs of leakage.	
4.	Record dial vacuum gauge reading on both gauges ahead of vacuum pumps P201 and P202. a. Gauge reading P201_____ b. Gauge reading P202_____	
5.	Record dial pressure gauge reading in air discharge line. a. Gauge reading _____	
6.	Confirm that the pressure gauges for the nitrogen lines routed to the well packers are reading 13 psig +/-2 psig. Adjust as necessary, leaving all isolation valves in the closed position. If any of the packers requires reinflation, monitor pressure gauge for 15-20 minutes to assess leak rate. Record packer gauge readings: 1. Well 8823:_____ 2. Well 8824:_____ 3. Well 8825:_____ 4. Well 8826:_____	
7.	Confirm inside temperature of the trailer is maintained at thermostat setting.	
8.	Confirm pump controller is powered on and functional.	
9.	Record reading on the pump cycle counter:_____	
10.	Record reading on water collection drum gauge:_____	

Record any observations relative to system operation and actions taken. Notify test director of any issues/observations that require immediate attention:

_____

_____

Rounds sheet completed by:

_____ / _____

Name-Print Sign

SX Pore Water Extraction Water Sample Collection Round Sheet

Date:_____

Step	Item	Action	Verified
1.	Bladder pump controller	Turn power switch to "off"	
2.	Valve V101	Close	
3.	Valve V108	Open	
4.	Valve V106	Place sample container under V106 outlet and open V106 to start collection and close V106 to stop water flow	
5.	Valve V106	Repeat Step 4 for multiple sample containers	
6.	Valve V108	Close when sampling is completed	
7.	Valve V101	Open	
8.	Bladder pump controller	Turn power switch to "on"	

Completed by:

_____/_____/_____

Printed Name Signed Date

APPENDIX G

PERSONNEL LOG

PERSONNEL LOG

PAGE ___/___

Name	Position / Role	Signature	Initials

APPENDIX H

INITIAL SETUP TEST DATA SHEET

Initial Setup Data Sheet

1. Identify Extraction Well:_____

2. Record following data for the extraction well:
   a. Vacuum level:_____psig
   b. Air flow rate:_____scfm
   c. Temperature of extracted air _____degrees F

3. Record vacuum level in the 3 monitoring wells
   a. Well:_____/vacuum level:_____psig
   b. Well:_____/vacuum level:_____psig
   c. Well:_____/vacuum level:_____psig

4. Record Date:_____/Time:_____

5. Notes:

Recorded by:_____

APPENDIX I

SUMMARY DATA REPORTS

Insert appendix.