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SST Deployment Demonstration and Injection Leak Testing of the HRR Long Electrode LDM System.

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Abstract: This revised test plan identifies S-102 as the target tank for completing a deployment demonstration test and an injection leak test with the high-resolution resistivity (HRR) long electrode leak detection and monitoring (LDM) system. The deployment demonstration will evaluate the performance of the HRR LDM system in an SST environment during a waste retrieval campaign. The injection test will simulate tank leaks by injecting simulated tank waste near the SST and will provide the leak detection data to quantitatively assess leak detection performance. These tests and the test data will provide the basis for continued use of the LDM system during SST waste retrievals.

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Change Justification	This revision addresses comments received from the ORP and the Washington State Department of Ecology that are within the scope of this deployment demonstration and injection leak testing: specifically the S-102 test schedules and the HRR LDM leak data processing during S-102 retrieval. This is a feasibility demonstration and does not fall under the operational readiness or startup testing umbrellas for conformance to specific procedures for test plan preparation and test practices.		

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SST Deployment Demonstration and Injection Leak Testing of the HRR Long Electrode LDM System

March 2004
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ATTACHMENTS

APPENDICES

LIST OF TERMS

ADSL	Asymmetric Digital Subscriber Line
CEES	Columbia Energy & Environmental Services, Inc., Richland, WA
CHG	CH2M HILL Hanford Group, Inc.
DOE	US Department of Energy
DST	double shell tank
Ecology	Washington State Department of Ecology
ERT	electrical resistance tomography
ERT-LET	electrical resistance tomography – long electrode technology
gph	gallons per hour.
HGI	HydroGEOPHYSICS, Inc., Tuscon, AZ
HRR	high-resolution resistivity
LDM	leak detection and monitoring
LDMM	leak detection, monitoring, and mitigation
MSDS	Material Safety Data Sheet
NEC	National Electrical Code
HAZOP	Hazard and Operability Study
MUX	multiplexer
OAT	Operational Acceptance Test
ORP	Office of River Protection
SST	single-shell tank
TBD	to be determined
UL	Underwriters Laboratory
USQ	Unreviewed Safety Question
VPN	Virtual Private Network

SST Deployment Demonstration and Injection Leak Testing of the HRR Long Electrode LDM System

1.0 Introduction

This document describes a test plan to complete a deployment demonstration test and an injection leak test with the high resolution resistivity (HRR) leak detection and monitoring (LDM) method at a single-shell tank (SST). The HRR LDM technology has been previously tested and evaluated at the 105A mock tank test site and was identified for further evaluation on SSTs during waste retrievals (RPP-10604). There are physical and electrical differences between an SST environment and the test environment at the 105A mock tank test site that will affect the performance of the HRR LDM system on an SST (PNNL-14192). In FY 2002, resistivity measurements were obtained on S-112 to obtain data to compare with the 105A mock tank data. The S-112 resistivity measurements identified two main concerns for an SST deployment which will require further investigation:

- A potential loss of leak detection sensitivity when deployed on an SST and
- An unknown false alarm risk that would falsely shut down the waste retrieval.

The deployment demonstration test (completed during an SST waste retrieval) and the injection leak test (where known volumes of waste simulant are released under an SST) will provide HRR LDM data to address these concerns.

1.1 Purpose

This document presents a test plan for completing a deployment demonstration test and an injection leak test on SST 241-S-102 with an HRR LDM (long electrode) system. The purpose of this testing is to:

- Determine the performance of the HRR LDM system in a full-scale SST environment.
- Provide data to support developing costs assessments for deployment on other SSTs (dependent on the outcome of the S-102 deployment demonstration and injection leak testing).
- Provide data to compare leak detection and monitoring performance with the current drywell logging baseline methods.
- Demonstrate that HRR LDM data can be generated to support waste retrieval operations.
- Provide a basis for future use of the HRR LDM system (dependent on the outcome of the S-102 deployment demonstration and injection leak testing).

This test plan is not intended to be an Operational Acceptance Test (OAT) for the HRR LDM system or for the current baseline gamma and neutron drywell logging methods. This is a feasibility demonstration and does not fall under the operational readiness or startup testing umbrellas for conformance to specific procedures for test plan preparation and test practices.

This does not address the "process control" issues that define the procedures and courses of action to mitigate a tank leak after a potential leaking condition has been identified.

The HRR LDM system data will not be used or treated as primary leak detection information during the S-102 retrieval (S-102 deployment demonstration test). As identified in the S-102 process control plan, the baseline gamma and neutron drywell logging system will provide the primary ex-tank leak detection data during the S-102 waste retrieval (RPP-17043).

The HRR LDM potential leak data will be part of the holistic ensemble of data that will be input to process engineering during the S-102 retrieval. Only HRR LDM data that shows or indicates a potential leaking condition with a low probability of false alarm will be considered. All potential HRR LDM leak data will be "screened" and validated, as describe in Section 3.4 below, to ensure its low false alarm probability.

1.2 Background

The River Protection Project waste retrieval projects are responsible for the safe retrieval and transfer of waste from the SSTs to the double-shell tank (DST) system. This includes providing leak detection, monitoring, and mitigation. CH2M HILL, as the prime tank farm contractor, has the responsibility for completing this SST testing and the evaluation of the HRR LDM technology.

CH2M HILL has been investigating ex-tank leak detection approaches that have the potential for improved leak detection performance capabilities, including the ability to "look" across the soil under the entire tank bottom. In January 2000, an Advanced Characterization Workshop reviewed over 20 different leak detection technologies and selected 6 of the most promising methods for further evaluation and testing. A limited demonstration test was completed in FY 2001 with the 6 methods at the 105A Mock Tank Site in the 200 East Area of the Hanford Site (PNNL-13818). In January 2002, CH2M HILL held a value engineering workshop where three of the 6 methods were selected for further development and testing (RPP-10604). The three selected methods were an HRR (long electrode) LDM method (HRR steel case resistivity LDM method), an electrical resistance tomography (ERT) point electrode method, and an ERT long electrode method. The selection process was based on a comparative evaluation that included safety, schedule, cost, technical maturity, and potential for leak detection performance.

In FY 2002 to FY 2003 (FY 02-03) a multiple-injection leak test was completed at the 105A mock tank test site (PNNL-14192) where statistical leak performance data was obtained for HRR and ERT long electrode methods and with the ERT point electrode methods. An assessment of this test data indicated that the HRR LDM method had the best potential for providing improved leak detection and monitoring on an SST. This decision was based on the size of the leak that could be reliably and repeatedly detected and on the ability to use existing tank drywell structures as electrodes.

In FY 2002, measurements were made on the S-112 tank with a resistivity based system and with a volt-ohm meter. The resulting resistivity data, when compared with the resistivity data from the mock tank test site, indicated that S-112 (and any other SST) could have a reduction in leak detection sensitivity (on the order of 1/3 to 1/5) compared with the 105A mock tank test site (PNNL-14192). The source of the degradation was tentatively identified to be from the SST's subsurface conductive infrastructure that includes buried electrical conduit, piping, and tank farm cathodic protection systems, etc. These conductive elements shunt leak measuring current away from the desired measurement volume under a tank and will reduce the potential leak detection sensitivity. It was also surmised that the electrical noise sources from waste retrieval and tank farm systems (motors, pumps, etc.) could adversely affect performance and increase the potential for false alarms. The signal-to-noise level is one of the limiting factors in the leak detection sensitivity of the HRR LDM system (RPP-14606).

On July 30, 2003, a workshop was held with Ecology and CH2M HILL to review and discuss objectives and expectations for deploying and testing the HRR LDM system as outlined in a June 2, 2003 letter from Ecology (Lyon) to ORP (Rasmussen). The objectives of this testing addresses these workshop objectives and expectations.

A deployment demonstration test (completed at an SST during waste retrieval) will provide performance data to demonstrate the HRR LDM system's ability to operate within an SST environment and the ability to be integrated, deployed, and operated with the waste retrieval system. An injection leak test (where known volumes of waste simulant will be released near an SST) will provide the calibration data needed to quantitatively assess leak performance and to provide a data processing model/protocol for future SST deployments.

2.0 Deployment Demonstration and Injection Test Objectives, Scope, and Assumptions

2.1 Test Scope and Objectives

The deployment demonstration and injection leak tests will be full-scale SST tests with an HRR LDM system, using the existing tank drywells and tank thermocouple connections as electrodes. A limited number of surface electrodes (eight surface electrodes) will also be included to support the leak detection and noise tracking. These surface electrodes will be deployed and used in a manner that would not degrade the basic HRR LDM drywell and tank thermocouple leak detection performance.

This test plan is based on completing the deployment demonstration test and the injection leak test on tank S-102. The deployment demonstration will be completed during the S-102 waste retrieval and the injection leak test will be completed after the S-102 retrieval is completed. Completing these test installations and tests on S-102 will provide data to compare performance (and cost) of the HRR LDM system to the current baseline ex-tank gamma and neutron logging methods.

2.1.1 S-102 Deployment Demonstration Test Scope and Objectives

The S-102 deployment demonstration test objectives include:

- Demonstrate HRR LDM operation within the full-scale S-102, SST environment (electrically connected infrastructure) and with the waste retrieval system using existing drywells as long electrodes, a tank thermocouple as the "mise-a-la-masse" electrode (electrical connection with the tank waste), and a limited number of surface electrodes.
- An HRR LDM system that allows baseline drywell logging to be completed on the S-102 tank drywells being used as HRR LDM electrodes. Drywell logging data will be obtained from the baseline gamma and neutron moisture probes during this HRR LDM testing (per the S-102 operations control plan). Data will also be acquired from other sources, including environmental data (rainfall, temperature, snowmelt), waste retrieval data (identification of what and when systems are operating), and surface spills/leakages that may impact performance of the resistivity based HRR LDM system.
- Development and testing of a data processing model/protocol that uses HRR LDM data to assess leak/no-leak status and to estimate leaked volumes. The schedule, provided as attachment 1, indicates that the S-102 injection leak test will be completed after the S-102 waste retrieval (deployment demonstration test) is completed.
- As agreed to between Ecology and CH2M Hill at the July 30, 2003 HRR LDM workshop, during the demonstration test the HRR LDM system data will not be used as a required or mandatory input for process control (see Section 1.1 Purpose above). However, the HRR LDM data will be analyzed for the presence of large leak indications that have a very low false alarm potential (see section 3.4 for additional information).

- Obtain basic site approvals for the SST system deployment, including the resolution of safety and hazards issues when using drywells and tank thermocouple as electrodes (National Electrical Code (NEC), UL-508, etc. as required for a tank farm deployment).
- The design, authorizations, safety assessments, installation and operational procedures, work packages, and other supporting documents required to complete this testing are expected to provide a basis for future SST deployments, depending on the outcome of the deployment demonstration and injection leak testing on S-102.

2.1.2 S-102 Injection Leak Test Scope and Objectives

The HRR LDM system for the S-102 injection leak test will be the same system used for the S-102 deployment demonstration test, assuming an acceptable HRR LDM system performance during the S-102 deployment demonstration. A leak injection system, including a metered source of simulated waste and a converted drywell, will be setup. The HRR LDM system will record data during the leak injection tests. A test matrix with a repetitive leak cycle will be completed that will provide data to statistically assess the performance of the HRR LDM system. The assessment process will be based on the methods used to assess system performance from the 105A mock tank test data (RPP-14606). The injection leak test scope and objectives include:

- Provide calibrated leak performance data to qualitatively and quantitatively evaluate leak detection performance:
  - Confirm how small a leak can be detected with a 95% probability of detection and a 5% probability of false alarm (95/5).
  - Determine the time to detect and declare a leak (leak detection) for at least two test leak rates.
  - Determine the time required to quantify (leak monitoring) a leak rate for at least two test leak rates.
  - Identify the leak position (tank quadrant a leak is coming from) using two dimensional resistivity imaging models.
- Provide calibrated leak performance data to develop a processing model/protocol for future SST deployments. Obtain data to revise (and calibrate) the data processing model/algorithm to complete deployments on other SST tank farms.
- Acquisition of authorizations, and approvals for the injection system (injection well, etc.) and injection fluid.
- Design, install, checkout, operate, and decommission a leak injection well and a fluid pumping/metering system for the leak injections.

During this injection testing, the HRR LDM measurements will be also be made with the baseline neutron moisture logging method. Because the simulated waste is not radioactive, only the neutron probe will be used during this leak injection testing.

2.2 Test Parameters and Assumptions

To complete the scope of work in this test plan, the following test parameters and assumptions are applicable:

- The HRR LDM SST system will use the tank drywells as long electrodes and the tank thermocouple as the "mise-a-la-masse" electrode (electrode that makes a connection with the leaking tank waste). The current plan is to use 8 surface electrodes to provide data to assist in leak tracking. Data from the surface electrodes will be recorded with the limitation that there would be no adverse impacts on leak detection performance with the drywell and tank thermocouple electrodes and with the acquisition of data to assess performance.
- Data will also be obtained from the baseline ex-tank gamma and neutron moisture drywell logging probes. The gamma and neutron moisture probe measurements will be used during the deployment demonstration. Only the neutron moisture probe will be used during the injection leak test as the waste simulant will not be radioactive.
- Waste retrieval will provide retrieval operating status data to assist in assessing system noise and for use in supporting the validation of potential leak conditions.
- The specific volume of interest for SST ex-tank leak detection is the cylindrical volume under the tank, between the tank's drywells.
- Statistical data will be obtained from a multiple-leak cycle injection leak test matrix (and potentially the data from the prior performance testing at the 105A mock tank) that can be used to assess the 95/5 leak detection performance (95% probability of detection and 5% probability of false alarm).
- The deployment demonstration and injection leak tests will be completed at S-102. It is assumed that the injection leak testing will be completed after the S-102 waste retrieval is completed, using the same installed HRR LDM system and electrode components that were setup for the deployment demonstration test (assuming an acceptable performance during the S-102 deployment demonstration test). The use of S-102 for the injection leak test will be re-assessed if S-102 is shown to leak during the deployment demonstration.
- Authorizations and approvals will be required for the injection well, waste simulant, and test leak volumes. Hazard and Operability Study (HAZOPs) assessments will be completed and any issues resolved to allow existing tank drywells and an electrical connection to the tank thermocouples to be used as primary HRR LDM electrodes.
- The S-Farm (and S-102 waste retrieval system) will provide support infrastructure and utilities (electrical power, Asymmetric Digital Subscriber Line (ADSL)) and space needed for the HRR LDM system.
- All test data (resistivity data) from the deployment demonstration and injection leak tests will be recorded and archived and used to potentially complete post-retrieval leak data processing (data processing for the deployment demonstration is discussed in more detail below in section 3.4).
- An S-102 tank leak is not expected to occur, based on the condition of the tank and on the retrieval methods to be used.

3.0 Deployment Demonstration Test

3.1 Deployment Demonstration Evaluation Data

The deployment demonstration test on S-102 will provide data to evaluate and assess the HRR LDM system including:

- System availability
- Time to identify, verify, and report a potential leak event
- Signal noise in quiescent and retrieval modes
- Maintenance and support of the HRR LDM system in a full-scale SST environment
- Identify equipment installation and operational issues.

3.1.1 System Availability

System availability is the actual time the system was producing meaningful leak data relative to the time that it was expected or planned to be operating and producing data. Under normal conditions, the HRR LDM system will be continuously operating, and will be shut down during the time periods when the drywells being used as electrodes are gamma and neutron logged. This planned shutdown is part of the normal expected operation and will be subtracted from the planned or expected operating time for the HRR LDM system.

The HRR LDM system operating time data will be obtained from the raw HRR LDM resistivity data that will be recorded as a function of time. The expected operating time will be obtained from the HRR LDM daily log book and from the S-102 retrieval log. The resistivity data will be reviewed and the time intervals when meaningful data was produced will be identified and tallied. System availability will be measured by comparing the time the system is providing leak data (resistivity measurements) data with the time the system was expected to be properly operating and producing leak data.

3.1.2 Time to identify, validate, and report a potential leak event

This is the time that is required to identify, validate, and report a suspected tank leaking condition. This data will only be provided if the large signal assessment indicates a "potential" leak condition (see section 3.4.1 below). The time series data will be assessed as indicated in Figure 2 for potential leak conditions. After a potential leaking condition is identified and thoroughly validated, the resistivity time-series data will be evaluated to identify the time for the on-set of the potential leaking condition as indicated from the resistivity trend features. This leak on-set time will be used to identify the time to identify, validate, and report a potential leaking event.

3.1.3 Signal to Noise During Quiescent and Retrieval Times

The HRR LDM resistivity data signal-to-noise is related to the leak detection sensitivity. The system noise is the fundamental limit for the size of a leak that the HRR LDM system can detect (RPP-14606).

Signal to noise data will be extracted from the HRR LDM time-series resistivity data for intervals where the S-102 retrieval system is operating and not operating (quiescent time). The HRR daily log and the retrieval log will be used to identify these time periods. A straight line data fit will be made to the resistivity data intervals and a statistical calculation of the standard deviation from this straight line completed. This standard deviation is a measure of the system noise. Signal-to-noise calculations will be compared for times when the retrieval system is not operating (quiescent time) and when retrieval is on-going. This will be used with other data to evaluate the impact the waste retrieval system has on the HRR LDM system.

3.1.4 Maintenance and Support Requirements

The level of maintenance and support required to keep the HRR LDM system operating is an important parameter for future planning and deployment of the HRR LDM system. Maintenance and support data is also an indicator of system weaknesses and deficiencies.

The HRR LDM daily log will be used to record the maintenance and service events that are needed to support the HRR LDM system and keep it operating. The log entry data will include time parameters for each maintenance and service event. The maintenance and support events will be analyzed and events identified according to the type of service and maintenance required. The objective is to identify repetitive or common failures of the HRR LDM system and the resources required to bring the HRR LDM system back to a satisfactory operational state.

3.1.5 Equipment Installation Issues

The resources required to install an HRR LDM system on a tank farm are important in planning for future tank and tank farm deployments. Events and issues not expected during the installation of the HRR LDM system will be documented. Documentation sources will include the HRR LDM daily log, change control documents, and written notes. The equipment installation issues will be tabulated and will include the duration and the resources required to resolve each issue.

3.2 S-102 HRR LDM Deployment Demonstration Test Setup

The basic HRR LDM system for SST leak detection is illustrated in Appendix A. The HRR LDM method is based on a 4-pole resistivity measurement system where there is an electrical driver called a transmitter (Tx) and an electrical receiver (Rx) that are each connected to a separate pair of electrodes. One electrode from each of the Tx and Rx pairs is a "remote reference electrode" that is located some distance from the SST (about 10x the maximum dimension of the largest drywell separation or for an SST, approximately 1500 ft). Figure A-1 shows that the SST drywells will be used as long electrodes and the tank thermocouple as a "mise-a-la-masse" electrode. The "mise-a-la-masse" electrode makes electrical contact with the tank waste fluid that can potentially leak from the tank.

Electrical power is applied to one of the Tx "electrode pair" (drywell and remote reference electrode) and the resulting induced voltage (Rx) is measured on all other electrode pairs (drywell and/or tank thermocouple and a remote reference electrode). When the measured voltage is divided by the driver current, a "transfer resistance" or resistivity measurement value is obtained. This process is continued using all combinations of the electrodes (drywells, tank thermocouple, surface electrodes, etc.), producing one data set. For a typical SST setup with 8 drywells, this data acquisition process is expected to take 10-15 minutes to complete. Reciprocal measurements are also recorded where a drywell is used as both a driver and receiver with respect to another drywell. As discussed later in Section 3.4.1.1, this reciprocal data is used, in part, to assess system noise and to support data quality assurance assessments.

To simplify potential flammable gas safety issues, the tank thermocouple connection will be used only as a "receiver" electrode where no driving power is applied (software limitation) or can be applied (hardware limitation) to this electrode.

Figure A-2 illustrates a conceptual layout for the two remote reference electrodes. The HRR LDM control trailer is shown as being located on the west side of S-Farm where it will be connected to electrical power and telephone (digital telephone) infrastructure (not shown in this illustration). The digital telephone will be used to provide remote access to the HRR LDM system for remote operation and data retrieval. This relieves the need to have an operator present in the control trailer and potentially reduces the cost of operation during a retrieval campaign. The remote reference electrodes are shown located to the west and south of the control trailer.

Figure A-3 shows a conceptual layout of the electrical connections that will be made to the drywells, tank thermocouple connections, and the surface electrodes for the deployment demonstration test on S-102. For the deployment demonstration, the drywells will include all of the eight S-102 drywells (40-02-01, 40-02-03, 40-02-04, 40-02-05, 40-02-07, 40-02-08, 40-02-10, 40-02-11), and drywells from adjacent tanks:

- four drywells from S-103 (40,03-01, 40-03-03, 40-03-05, 40-03-11),
- one drywell from S-106 (40-06-02),
- one drywell from S-101 (40-01-08), and
- one drywell from S-105 (40-05-10).

This will provide electrode coverage for both the S-102 deployment demonstration and the S-102 Injection Leak Test. There are additional tank infrastructure (surface routed electrical cables, buried electrical conduit, and other buried conductive features) that are not shown.

Upon completion of the S-102 retrieval and HRR LDM deployment demonstration, drywell 40-02-10 will be converted to an injection well. This will prevent this drywell from being used for future gamma and neutron logging campaigns the drywell will be decommissioned (filling it appropriately with concrete) after the testing is completed (DOE/RL-2003-13).

The electrode cables between the HRR LDM control trailer and drywells (electrodes) will be surface routed using multiple and single conductor cables, and junction boxes as illustrated in Figure A-3. Cable protection will be used where vehicle traffic will cross the electrode cables (truck mounted gamma and neutron drywell logging systems, etc.). The final cable layout will be based on the access needs to complete drywell logging with the gamma and neutron probe trucks, the drywells needed for HRR LDM coverage, and on the waste retrieval components deployed on or near S-102.

During the S-102 deployment demonstration, the baseline ex-tank leak detection will be provided by gamma and neutron moisture logging, as required in the S-102 process control document (RPP-17043). A concept for making a drywell electrical connection that would not obstruct the drywell opening for drywell logging is shown in Figure A-4 of Appendix. A. The "tapped" screw in the end (or side) of the drywell steel casing will be used to attach an electrical cable lug to the drywell (1/4 inch thick drywell casing wall). Drywell covers will be used on drywells that terminate at ground level. The cover inhibits direct access to the cable end and also identifies the drywell as being used for HRR LDM.

3.3 HRR LDM Resistivity Measurement System

The HRR LDM system for the S-102 deployment demonstration and injection leak tests will be based on the geophysical resistivity measuring methods (and basic system configuration) that was used at the FY 2002-03 105A mock tank performance testing (the basic principles of a four-pole resistivity measurement system are described above). A block diagram showing the features of this measurement system is shown in Figure A-5 of Appendix A.

The geophysical resistivity components interface to the electrodes through a series of electrical relays (multiplexer). The number of receiver channels will depend on the number of electrodes being used and the desired rate for acquisition of one data set. All of the resistivity measuring components, including the power conditioning components, will be located in the HRR LDM control trailer.

Figure A-5 shows a computer control system that has a secure virtual private network (VPN) connection to allow remote access and control. This eliminates the need for an operator to be located in the control trailer to interface with the HRR LDM system and will reduce test costs similar to that for the FY 2002-03 105A mock tank performance testing at the mock tank test site. An asymmetric digital subscriber line (ADSL) connection will be used to provide network access capability to the remote host from any approved computer with the remote VPN network access connection.

3.4 Deployment Demonstration Test Data Processing

As indicated in section 1.1 above, this HRR LDM system data will not be used or treated as primary leak detection information for process control during the S-102 retrieval (S-102 deployment demonstration test). This is necessary to reduce retrieval risks from the uncalibrated (and unvalidated) HRR LDM system data.

The HRR LDM data processing and leak assessment for S-102 deployment demonstration will be based on protocols that were used during the FY 2002-03 105A Mock Tank testing. This prior processing method provided the data on which the performance of the HRR LDM method was evaluated. Leak status, which included a leak/no-leak assessment and an estimated leak volume (if a leaking status were declared), was reported on a daily or 24 hour basis. The leak detection system operators for FY-2002-03 105A Mock Tank test did not have knowledge of the simulated leak matrix (no knowledge of when a leak test was in progress or what the leak rate was) which is similar to operating the leak detection systems on an SST during waste retrieval. The 24 hour time period is necessary to provide sufficient data for the leak assessment process (described in section 3.4.1 below) which relies on data trends to identify tank leak conditions. Further, over a 24 hour time period, a leak rate of 20 gph only results in a relatively small 480 gallon release volume. A 24 hour time period is therefore a reasonable interval to use during the S-102 deployment demonstration test.

The HRR LDM system will produce a data set (a reading from each combination of electrodes, two as the transmitter and two as the receiver) approximately every 10 to 15 minutes, with the exception of the times when it will be shutdown to accommodate drywell logging. It is currently planned to complete one drywell logging campaign every week during the deployment demonstration. This will take approximately 4-8 hours for the eight S-102 drywells specified in RPP-17043.

3.4.1 HRR LDM Data Processing Algorithm

HRR LDM processing involves identifying linear portions or "trends" within the time-series resistivity data. The HRR LDM data processing during the S-102 deployment demonstration test will consist of three basic steps.

1. Data Reduction – Acquisition, signal conditioning, trend processing.
2. Leak Detection – Assessment for large signal changes and verification of the "potential" leak/no-leak status for suspect leak signals. .

   a. When a suspected leak condition is identified, the waste retrieval daily operations log will be reviewed to potentially identify non-leak causes for the signal changes.
3. Leak Monitoring – Leak rate and volume of leak.
   a. Leak Quantification - Calculation of estimated leaked volume if a leak condition is declared.
   b. Plume Evaluation – Development of two-dimensional image(s) if a leak condition is declared.

After completing this extensive data verification and validation, probable leak conditions will be reported to S-102 retrieval operations.

3.4.1.1 Data Reduction

The logic diagram illustrating the process for acquiring and conditioning HRR LDM data is shown in Figure 1. A data set (the resistivity readings from every electrode combination used as transmitter and receiver pairs) will be obtained approximately every 10-15 minutes from the HRR LDM system. Erroneous data spikes will first be removed as part of the quality control process. This will be based, in part, on reciprocal measurements from each electrode pair (with the exception that the tank thermocouple tree may not be energized) and the average noise envelope of the data set. The quality control process will also be used to validate the operational status of the data acquisition equipment. Results from the quality control process will be stored in a database and individual raw data files will form part of the data archival record.

A linear curve fit or "trend" will be calculated from the accumulated data and normalized to a zero reference. New data points will be evaluated against a statistical envelope (95% probability of detection with a 5% probability of false alarm) that will determine:

1. If the points lie within the envelope and are part of the current trend, or
2. If the points are beyond the envelope, indicating that they:
   a. Are noise related, or
   b. Appear to represent a new data trend potentially caused by a tank leak condition.

The process will continue as new data sets are acquired. If the new trend persists, then the process for assessing a potential leak condition will be initiated. The quality control portion of data reduction will be performed continuously as each new data set is acquired.

3.4.1.2 Leak Data Processing – Leak Status Assessment

The logic diagram illustrating the process for assessing leak status is shown in Figure 2. The trend status of the accumulated data will be assessed to determine which trends represent leak events. Since all data processing is relative to a background trend, baseline data will be recorded before waste retrieval operations commence, and a *background trend* and *noise envelope* will be determined for purposes of comparison during retrieval monitoring. The background trend consists of a linear fit of the baseline data. The noise envelope for background will be determined by averaging the least-squares residual signal after the background trend is removed.

The first part of the leak detection process involves assessing (visually) the data for time-series trend changes that are similar to those that were observed during the onset of a leak at the 105A Mock Tank site. If this condition is observed, then a new trend or slope for the data set will be calculated and tracked. Individual trends will be recorded in a working database. The magnitude of change from the data points will be assessed against three threshold levels. The magnitudes of these threshold levels are based on the 105A Mock Tank data. Since the 105A Mock Tank Site does not fully simulate a tank farm environment, the threshold levels will be adjusted to compensate for observed differences in electrical noise between the two sites. The adjustment will be statistically calculated by comparing the noise envelope of baseline HRR data acquired at the 105A Mock Tank Site to the tank S-102 baseline response. This adjustment value will be further evaluated as part of the injection leak test.

As indicated in the logic diagram, the three threshold levels will be used to determine a "no leak", "inconclusive", or "potential leak" status based on repetitive occurrences of data points within these various threshold levels. For each declaration, both data reduction and data processing will be continued to provide confirmatory data for the declared status. If an inconclusive or "potential leak" status is indicated, a verification and validation process will be performed that includes:

1. Verifying changes with respect to adjacent electrodes,
2. Evaluating and assessing potential noise sources (e.g., variation in pumping speed, startup of other systems, etc.), and
3. Evaluating and assessing potential environmental changes (e.g., surface spills, snow melts, and precipitation).

The leak detection process will be performed once per day and will encompass an analysis of the data that was recorded to date (trend assessment).

3.4.1.3 Leak Monitoring

Leak Quantification

If a "potential" leak status is declared then a quantification process will be performed that relates the slope of a trend to a leak rate. The calibration of this slope can only be determined by conducting a controlled injection leak test and statistically comparing known injection parameters to processed leak trends. Until such data can be obtained, calibration parameters will be used, in part, from the HRR LDM data recorded at the 105A Mock Tank site. This volume estimate will have an error associated with it and an attempt will be made to quantify the error based on data and previous leak volume assessment algorithms.

The leak quantification process will analyze representative leak trend(s) and determine:

1. The leak onset time – the point along the time-series where the trend slope magnitude first indicated a leak event,
2. The cessation time (should one exist) – the point along the time-series where the trend slope magnitude either indicates:
   a. The cessation of a leak,
   b. A change in leak rate, or
   c. A new leak.
3. The leak rate – determined by applying the leak calibration to the current leak trend(s), and
4. The leak volume – determined by applying the leak duration to the leak rate.

<u>Plume Evaluation</u>
A two-dimensional resistivity image will be generated for a "potential leak" status condition, when there are sufficient changes in leak conditions. The image will show the resistivity changes relative to baseline resistivity data that were recorded prior to initiating the tank S-102 retrieval.

3.4.1.4 HRR Data Reporting

As indicated above, the HRR LDM data will be processed and reported on a daily or 24 hour basis. A daily informal report will be prepared addressing:

1. Operational status of monitoring system
2. Potential leak status: leak, inconclusive leak, or no leak
3. Estimated potential leak onset time (if a leak occurs)
4. Calculated potential leak rate (if a leak occurs)
5. Calculated potential leak volume (if a leak occurs)
6. Estimated potential leak cessation time (if a leak occurs)
7. Description of confidence level (if a leak occurs)
8. Two-dimensional resistivity image (if a leak and a sufficient change in leak conditions occurs)
9. If a potential leak condition is identified, retrieval events will be reviewed and included.

3.4.2 Daily Data Log

In addition to the HRR LDM data, a system daily log will be maintained to record the system status and other information related to the test environment and test systems. The log entry frequency will be related to changes in the system status but will contain at least one daily entry. System configuration modifications and changes will be identified and noted in the data log. Appendix C shows examples of the test data that will be recorded.

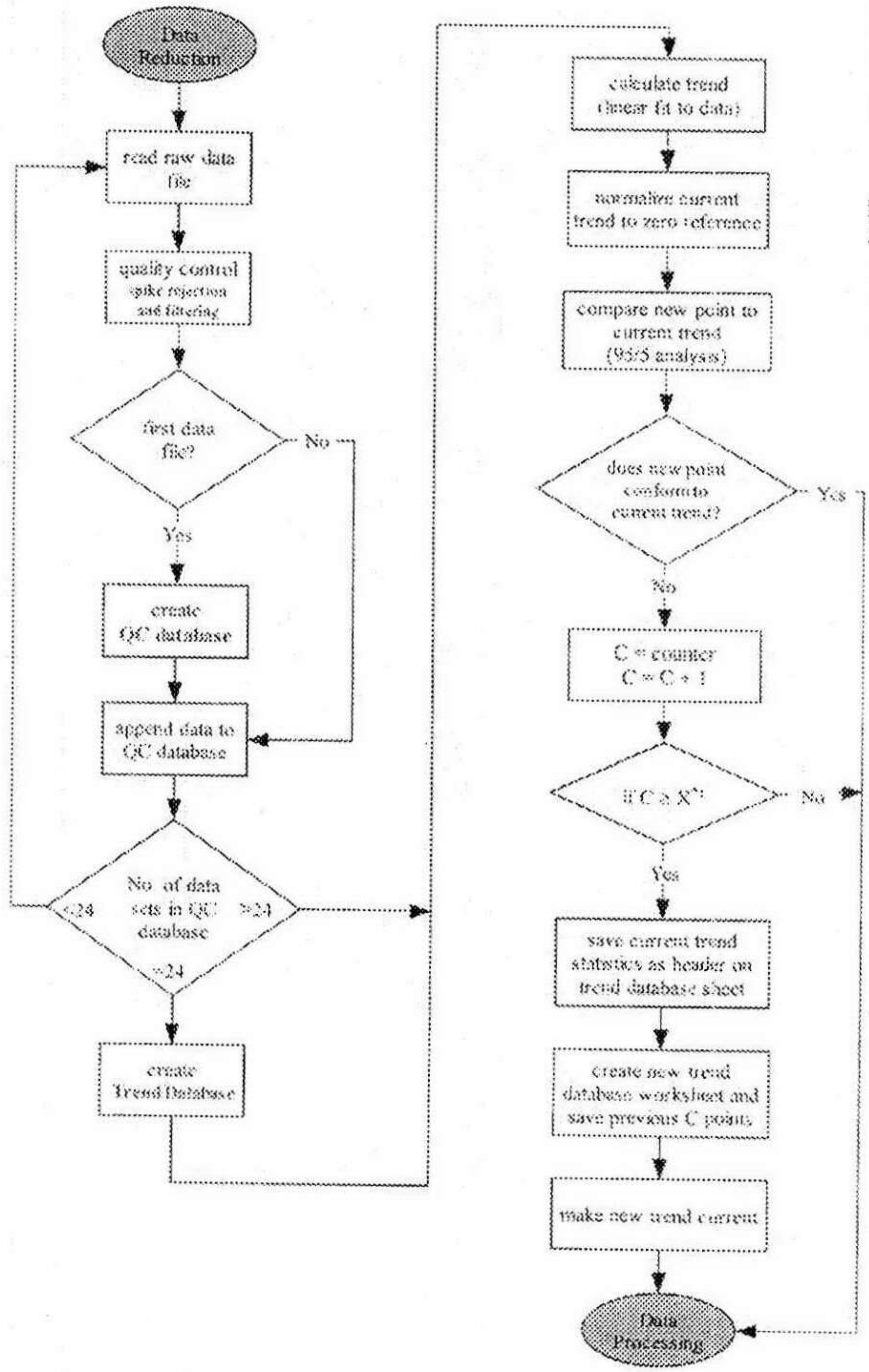
3.4.3 Data Acquisition and Archival

All data from the S-102 deployment demonstration test data will be recorded and archived for future use and for potential post-retrieval data processing when the injection leak calibration data is available. The recorded data will include data from the daily log and the daily resistivity records from the HRR LDM system. The recorded data will also be used to support the development of an HRR LDM data processing model/protocol to support future SST retrievals, depending on the outcome of the testing.

The preferred data format for the HRR LDM data archival is an amendable spread sheet file. The electronic format for data archival will be an amendable data base file. Data backup will also be identified to ensure integrity and continuity of test data. HRR LDM data will be recorded for installation and S-102 retrieval activities that include:

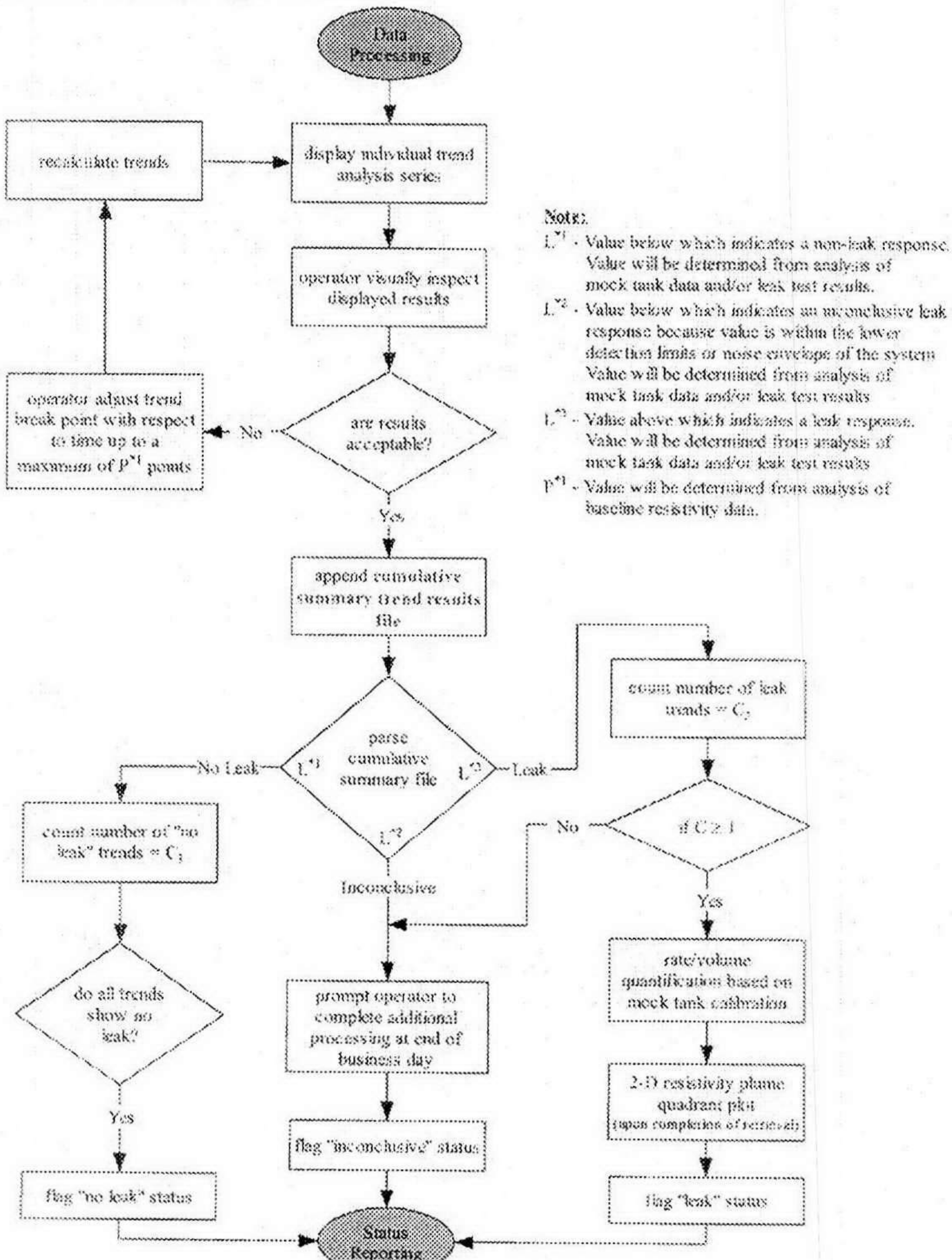
- System checkout and testing.
- Pre-retrieval baseline data.
- Waste retrieval data.
- Post-retrieval baseline data.

Figure 1. Data Reduction Flow Chart



Note:
X^{*1} - value will be determined from analysis of baseline resistivity data

Figure 2. Data Processing Flow Chart



4.0 Injection Leak Test

4.1 S-102 HRR LDM Injection Leak Test Setup

The injection leak test will be completed using the HRR LDM installation and infrastructure that was used for the S-102 deployment demonstration test. This includes the remote reference electrodes and trailer installation as shown in Figure A-2 and the drywells as discusses above in Section 3.3 for the deployment demonstration. This will provide electrode coverage (spacing and position relative to the injection leak well which will be converted drywell 40-02-10 and coverage for a prevailing plume drift which is expected to be in a Southwest direction) for the injection leak test.

Drywell 40-02-10 will be converted to an injection well with one release point that will be located just below the S-102 tank bottom elevation. The conversion to an injection well includes first perforating the drywell casing from the point of fluid injection to the bottom of the casing and then pumping in cement to fill the drywell annulus and casing that is below the point of injection. This will prevent fluid draw-down through the drywell annulus. An inflatable plug will be placed above the injection leak point and the simulated waste pumped into the injection well via a hose from the fluid injection system. After the injection leak test is completed, the upper part of the drywell will be decommissioned by perforating the remaining drywell casing and injecting cement to fill the remaining drywell and annulus volumes (DOE/RL-2003-13). This would prohibit using the drywell for gamma and neutron logging but the drywell will still be usable as an HRR LDM long electrode (the residual moisture content in the concrete is sufficient to provide good electrical connectivity to the surrounding soil).

The fluid injection system will be based on the fluid injection system (and lessons learned) from the FY 02-03 performance testing at the 105A mock tank site (PNNL-14192). A conceptual fluid injection system, shown in Figure A-8 of Appendix A, includes a liquid reservoir, fluid pumps, flow sensors, valves, and piping to connect to the injection well. This concept is based on using a metering pump, flow, and flow totalizing sensors to monitor the injected leak parameters (leak rate, leaked volume, etc.). The current plan is to locate the injection system and tank outside of the tank farm near the HRR LDM control trailer and use electrical power from the control trailer. The recorded data for the injection test will include flow, injected volume, and simulant temperature.

4.2 Sodium Thiosulfate Tank Waste Simulant

The waste simulant will be a sodium thiosulfate/water solution with a concentration between 20 and 35% (by wt) sodium thiosulfate (RPP-10904). The use of this simulant will reduce the number of potential parameters impacting the adaptation of the prior 105A mock tank test performance data and also meet a number of other criteria that are discussed in more detail below.

Sodium thiosulfate is not considered a toxic hazard if used according to MSDS and procedural requirements. The recommended disposal method is by dilution and flushing with water.

The sodium thiosulfate simulant will have electrical and physical properties similar to that of the liquid constituent of the SST waste and should migrate and spread in the soil in a manner similar to the liquid constituent of the tank waste. Sodium thiosulfate has been previously used to evaluate the transport of fluids in the vadose zone and to develop a data base for testing vadose-zone transport codes (PNNL-13679). Appendix B presents some physical properties of sodium thiosulfate and tank waste. This data shows good physical and electrical property correlation for a sodium thiosulfate solution.

The FY 2002-03 105A mock tank testing used a 35 wt% sodium thiosulfate solution as the test simulant. The only problems encountered were:

- Corrosive properties of the sodium thiosulfate which affected the injection system components, and
- The tendency for crystalline precipitation when the solution temperature was decreased (PNNL- 14192).

These problems were solved by using a corrosive resistant metering pump, flushing the injection piping after each injection campaign, and adding a fluid heating system and insulation to the fluid injection system. Since the S-102 injection leak test is expected to extend into the cold weather season, the injection system will require a heating system, including heat trace on piping and hoses.

At the present time an authorization to release up to 30,000 gallons of sodium thoisulfate/water solution has been obtained from Ecology (see Appendix E: Emails from K. Conway, Ecology to C. J. Kemp, CH2M HILL). The only issue that was raised is that the injection well should be designed to prevent drawdown of the liquid that surrounds and makes contact with the drywell. The planned conversion and decommissioning process (drywell perforation and cement injection) will prevent drawdown (DOE/RL-2003-13). The leaked fluid should not impact HRR LDM leak detection on adjacent tanks as prior leaks become part of the background (baseline) resistivity data from which new leak caused resistivity changes are detected.

4.3 S-102 Injection Leak Test Matrix

The injection leak testing will provide quantitative data from which the performance of the HRR LDM system(s) can be assessed, and will provide calibrated leak data for revising data processing model/protocol(s). The objective is data that is most representative of a tank leak condition during a waste retrieval campaign. These and other issues related to an injection leak test matrix are discussed in Appendix D.

Although the final test matrix will be refined before the injection leak test is initiated, the injection leak matrix in Appendix D (Table D-2) does illustrate some of the important test features that will provide statistical data to evaluate leak detection and leak monitoring performance. Table D-3, in Appendix D, summarizes the main features of the test matrix:

- Multiple leak starts to provide statistical data for assessing leak detection (leak detection but not quantification of a leaking condition).
- Multiple leak rates.
- Multiple leak tests at each leak rate to provide statistical data for assessing leak monitoring (estimating a leak volume).
- A balance between the need to generate statistically based test data and the need to complete the testing within a reasonable time frame and allotted injection volume.
- Injection leak rates based on historical tank leaks that have occurred with SSTs on the Hanford site and on the need to complete testing within a reasonable time frame and allotted injection volume.
- A stabilization time between leak tests (2 or 3 days), based on the HRR LDM resistivity data from the 105A mock tank testing (RPP-14606).

The plan is to run the injection leak test in an interactive manner where a test at a specific leak rate test could be terminated early if sufficient data is obtained before completing a planned injection leak volume. The decision to terminate will be based on being able to provide or estimate leak monitoring (leak volume estimate) within a 5% false alarm rate and a 95% probability of detection. The statistical basis for termination will be based on the HRR LDM leak signal data and on the HRR LDM system noise.

The time to complete the test matrix will then depend on the injection rates, the injection volumes, and the statistical performance of the HRR LDM system. Pre-test time to obtain baseline data prior and after the injection leak tests is not shown.

4.4 S-102 Injection Leak Test Data Processing

Data from the HRR LDM system will be recorded continuously, with the exception of the times when the HRR LDM system will be shutdown to accommodate drywell logging. This will produce an HRR LDM (and ERT-LET) data set from all of the electrode combinations approximately every 15 minutes. The current expectation is that a drywell logging campaign will be completed three times a week during the first testing cycle of the 10, 15, and 20 gph rates or until a plume is detected in one of the logged drywells. The logging frequency may then be reduced to a once per week frequency to provide plume growth information. A drywell logging campaign is anticipated to require approximately 4 hours for the eight drywells.

A data analysis and assessment process will be completed every 24 hours. A process for data analysis will include the following:

- Data Reduction - Acquire and Condition HRR LDM Data. This will be based on the logic diagram shown in Figure 1.

- Leak Detection - Assess and verify potential leak/no leak status from the HRR LDM data. This will be based on the logic diagram shown in Figure 2. This includes the trend analysis as well as trend coincidence between the data from various electrodes
- Leak Monitoring – Estimate a leak rate and leak volume. Develop a leak rate and leak volume estimate within the bounds of a 95% confidence level and a 5% false alarm level.
- Report leak detection, leak monitoring, and statistical conclusions to HRR LDM Technical Coordinator.
- Complete 2-dimensional image(s) – Characterize injection leak plume.

This data reduction and data processing is based on the methods that were used during the FY 2002-03 105A mock tank testing and potentially on the results of the S-102 deployment demonstration. As indicated above for the deployment demonstration test, a 24 hour time period is a reasonable interval to accumulate data for trend based assessment process (about 100 data sets are produced in a 24 hour time period for each electrode) and that a leak rate of 20 gph results in a relatively small leak volume of 480 gallons over a 24 hour time period.

Data backup will be completed to ensure integrity and continuity of test data. Data will also be recorded for activities that include:

- System checkout and testing
- Pre-test retrieval baseline data
- Completing of leak testing
- Post test baseline

The data from the S-102 injection leak test will be used to provide calibration data for the HRR LDM data processing algorithm/protocol and, potentially be used for the post-processing of the HRR LDM data from the S-102 deployment demonstration. Post processing will be used to evaluate and validate any leak response identified during the S-102 retrieval. A revised data processing algorithm will be developed to support future SST deployments depending on a decision to continue with the HRR LDM system.

5.0 Roles and Responsibilities

The CH2M HILL Hanford Group, Inc. Richland, Washington, as prime contractor to the US Department of Energy, ORP, is responsible for the S-102 deployment demonstration and injection leak testing that includes test management, technical oversight and direction, data assessment, configuration control for the test matrix and test system.

The strategy for completing this work scope includes the use of a team consisting of CH2M HILL Engineering and Tank Retrieval Projects staff and support from HydroGEOPHYSICS Inc (HGI), Tuscon, AZ, and the Columbia Energy and Environmental Services (CEES) Inc, Richland, WA. These two subcontractors will provide HRR LDM services as needed to complete the S-102 deployment demonstration test and the S-102 injection leak test.

HGI will provide the specialized HRR LDM system and technology, including their proprietary leak detection and leak data processing algorithms and will operate the system and process data for leak status. HGI also provided the previous HRR LDM system and technology that was used to complete the FY 2002-03 testing at the 105A mock tank test site (PNNL-14192).

CEES will provide the balance of components needed to package and safely deploy the HRR LDM system at a Hanford SST. These components include a control trailer for the HRR LDM system, surface and remote electrodes, and electrodes cables and junction boxes. The plan is to have CEES also provide the leak injection system and injection test consumables for the S-102 injection leak testing. CEES will provide system maintenance for the components that are located outside of the tank farm. CEES is experienced in the design and packaging of systems that meet Hanford safety standards and codes.

All of the HRR LDM system components will be provided to the Hanford Site as "drop-in" components that require no/or a minimum of field fabrication. CH2M Hill construction forces will be used for the system installation, including the cables and Yellow Jacket protection, junction boxes, surface electrodes, and electrical hookups to the drywells, tank thermocouple, and surface electrodes. CH2M Hill will also be responsible for obtaining any approvals, permits or HAZOP and safety assessments. They would be assisted by CEES in providing the design and design documentation to support these assessments and approvals. The system hardware, software, data processing, and testing will be documented and controlled through a configuration control process. This will assure that performance during the injection leak testing could be repeated in future SST deployments.

CEES and HGI will operate the HRR LDM system, record/archive and process the HRR LDM system data to identify leak status, estimate leak volume, and generate resistivity images. All data (raw or processed) will be reported to the CH2M HILL LDM technical coordinator.

6.0 S-102 Deployment Demonstration and Injection Leak Testing Schedule

The deployment demonstration test and the injection leak test will both be completed at tank S-102. The plan is to complete the deployment demonstration during the retrieval of S-102 in FY-2004 and then complete the injection leak testing using this same HRR LDM system setup on S-102.

A schedule for the S-102 deployment demonstration test and injection leak test is included as Attachment 1. This is an aggressive schedule with a first-of-kind deployment with a new system that has not been previously deployed on an SST. The schedule represents the current FY-04 funding constraints where the injection leak testing would be completed in FY-05.

The approvals and authorizations for the HRR LDM system and for the test system and injection releases are critical lead activities in the schedule. These activities include HAZOPs and safety assessments.

The schedule shows that the HRR LDM system will be ready to support an S-102 retrieval start date as early as April 8, 2004. Some of the balance of system components (electrode cables, remote reference and surface electrodes, junction boxes, etc.) could be early deliverables (not shown on the schedule) to provide some latitude for the construction forces that are anticipated to be used for the installation of these components. Electrical power and digital telephone drops, required for the HRR LDM control trailer, could also be early installations (these services will be provided by CH2M HILL).

The whole HRR LDM system for the deployment demonstration test will be installed, checked out, and baseline data recorded prior to the start of the S-102 waste retrieval campaign. The objective is to record and process HRR LDM system data during the full S-102 waste retrieval campaign, including during retrieval delays. The schedule for the deployment demonstration will depend on the S-102 waste retrieval schedule. For planning purposed, the schedule in Attachment 1 shows a 5 month time period for the completion of the S-102 waste retrieval campaign, which is based on experience with the recent S-112 waste retrieval.

The schedule shows the completion of the design and fabrication of the injection leak system test system (skid with pump, manifold, tank, etc.) in FY-04, which is dependent on the availability of funding. Having an injection leak system ready to deploy during the retrieval of S-102 will support an injection leak test start as soon as the drywell is converted to an injection well and the injection system is installed at S-102 (dependent on the availability of FY-04 funding).

After the injection leak testing is completed the injection leak system components will be decommissioned, retrieved, and disposed of. The HRR LDM electrode system will remain installed and will be available to support future SST waste retrieval campaigns. This will depend on the outcome of the S-102 deployment demonstration and injection leak tests and a decision to continue HRR LDM system SST deployments.

7.0 Deployment Demonstration and Injection Leak Test Issues

There are a number of issues that will be resolved to support the deployment demonstration and injection testing campaigns.

An initial hazards assessment was initiated in FY 02 and the safety issues identified included a potential for an electrical shock. The current assessment is that as long as the HRR LDM system's cables remain connected to the drywells being used as electrodes, there isn't any step potential electrical shock hazard. The HRR LDM system will have a "key lockout" option that will prevent electrical power from being applied to the drywells. This option is anticipated to be used when the drywells being used as HRR LDM electrodes are logged with the truck mounted gamma and neutron probes and the manually deployed neutron probe.

There is a flammable gas concern for the planned electrical connection to the tank thermocouple. This issue will be part of the hazardous operations (HAZOPs) evaluation that will be made on the HRR LDM system. If the deployment demonstration and injection leak tests are outside of the current Authorization Basis, an unreviewed safety question (USQ) review must be initiated. Regulatory approvals are needed for the injection well and for the volume of simulated waste to be injected during the testing.

8.0 Quality Control and Quality Assurance

The quality control and quality assurance for this deployment demonstration and injection leak testing will meet CH2M HILL quality assurance requirements. These requirements will be passed on to contractors and other resources that are outside of the CH2M HILL organization.

Quality assurance will be applied in a graded manner and will be applied to all tasks and activities. Configuration control will be applied to hardware, software, data processing, test systems and test configurations, and test matrixes. CH2M HILL will have final approval authority for the configuration changes that will be made after acceptance testing is completed.

Calibration requirements will be applied in a graded manner. The sensors and measurement systems that are critical to the validation and verification of the LDM systems will be identified and their calibration requirements identified in the system design documents and test implementation plans. Appendix C shows an example of some of the measurements that may require calibrated sensor systems.

9.0 Responsibility Matrix and Points of Contact

The deployment demonstration testing and injection leak testing will be completed with the support of contractors, site construction forces, and CH2M HILL technical personnel. CH2M HILL will review general system layout designs and interfaces prior to proceeding with construction and installation. The site construction force will complete the installation of in-farm and ex-farm hardware and components. Contractors will provide the HRR LDM systems and technology needed to complete the S-102 deployment demonstration and injection leak testing. This includes the following systems and components:

- HRR LDM system hardware, hardware maintenance, operation, and leak data acquisition and processing.
- Balance of system components including hardware for electrodes and cabling and fluidic injection system hardware, operation, and data acquisition.

The specific CH2M HILL points of contact for this HRR LDM testing at S-102 include the following:

Project Manager	R.E. Bauer, CH2M HILL
Responsible Manager	W. T. Thompson, CH2M HILL
HRR LDM Technical Coordinator	F.R. Reich, COGEMA-Engineering
Design Authority	G.P. Janicek CH2M HILL
Responsible Engineer	G.J. Coleman, CH2M HILL
Quality Assurance	J.F. Bores, CH2M HILL
Safety	R.E. Butler, III, CH2M HILL
Environmental Safety and Health	P.C. Miller, CH2M HILL
Systems Operations	D.J. Saueressig, CH2M HILL
Radcon	R.L. Brown, CH2M HILL
Nuclear Safety & Licensing	R.D. Smith, CH2M HILL
Regulatory Interface Point of Contact	J.J. Luke, CH2M HILL
Environmental Engineering	J.G. Field, CH2M HILL

10.0 Interfacing Elements

The HRR LDM system will be integrated with the SST waste retrieval system deployed on tank S-102. Some of the major system and test interfaces include the following:

- Electrical power.
- Telecommunications remote access connection.
- Electrical connections to the tank farm components being used as electrodes (surface, long, thermocouple, and reference).
- Interface control for conductor connections to the HRR LDM equipment.
- HRR LDM data and processed leak status information.
- Lock-out /Tag-out of HRR LDM power to the drywells for drywell logging.

A close interface will be maintained between the CH2M HILL HRR LDM Technical Coordinator and the contractors.

11.0 Final Report

Final reports summarizing the test setups, installations, test data, and HRR LDM performance will be prepared for the S-102 deployment demonstration test and for the S-102 injection leak test. The reports will address the following areas as appropriate to each specific test:

- Summaries of the test setups, test matrix, final test schedules, etc.
- Summary and descriptions of the data processing model/protocols, especially for future SST deployments.
- The resolutions for issues encountered during installation, operation, and decommissioning.
- Summary of test data and performance results. The following performance issues will be specifically addressed in the injection leak test and as appropriate in the deployment demonstration test:
    - Threshold detection levels
    - 95/5 performance parameters.
    - Time to detect leakage
    - Comparison of performance against gamma and neutron drywell moisture logging and HRR LDM methods
- Recommendations for the path forward for future SST deployments based on HRR LDM performance and on its ability to meet baseline leak detection and monitoring capability requirements.
- Recommendations for equipment setups/designs to be used in future SST deployments.
- Potential relevance of the CH2M HILL data to final closure needs for the SST that was retrieved and for future retrievals.

These final reports will also include a description of the data and the processed data that was recorded and archived.

12.0 References

DOE/RL-2003-13, Rev. 0, Auten, J.E., June 2003, *Hanford Site Well Management Plan*, Flour Hanford, Inc, Richland, Washington.

Ecology letter from J.J. Lyon to J. Rasmussen, ORP, S-112 Full Scale LDMM, HFFACO Milestone M-45-03C; S-112/C-104 F&Rs Conditional Approval Letter HFFACO Milestones M-45-03-T03 and M-45-03-T-04: and S-102 F&Rs LDMM comments/responses, HFFACO Milestone M-45-05-T16: CTS No: 03-0201, Dated June 2. 2003.

PNNL-13679, Gee, G.W. and A.L. Ward, November 2001, *Vadose Zone Transport Field Study: Status Report*, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-13818, Barnett, D. B., et., al., 2002, *Results of Tank-Leak Detection Demonstration using Geophysical Techniques at the Hanford Mock Tank Test Site-Fiscal Year 2001*, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-14192, Barnett, D.B., et. al., *Results of Performance Evaluation Testing of Electrical Leak-Detection Methods at the Hanford Mock Tank Site – FY 2002-2003*, January 2003, Prepared for the U.S. Department of Energy by Pacific Northwest National Laboratory, Richland, WA.

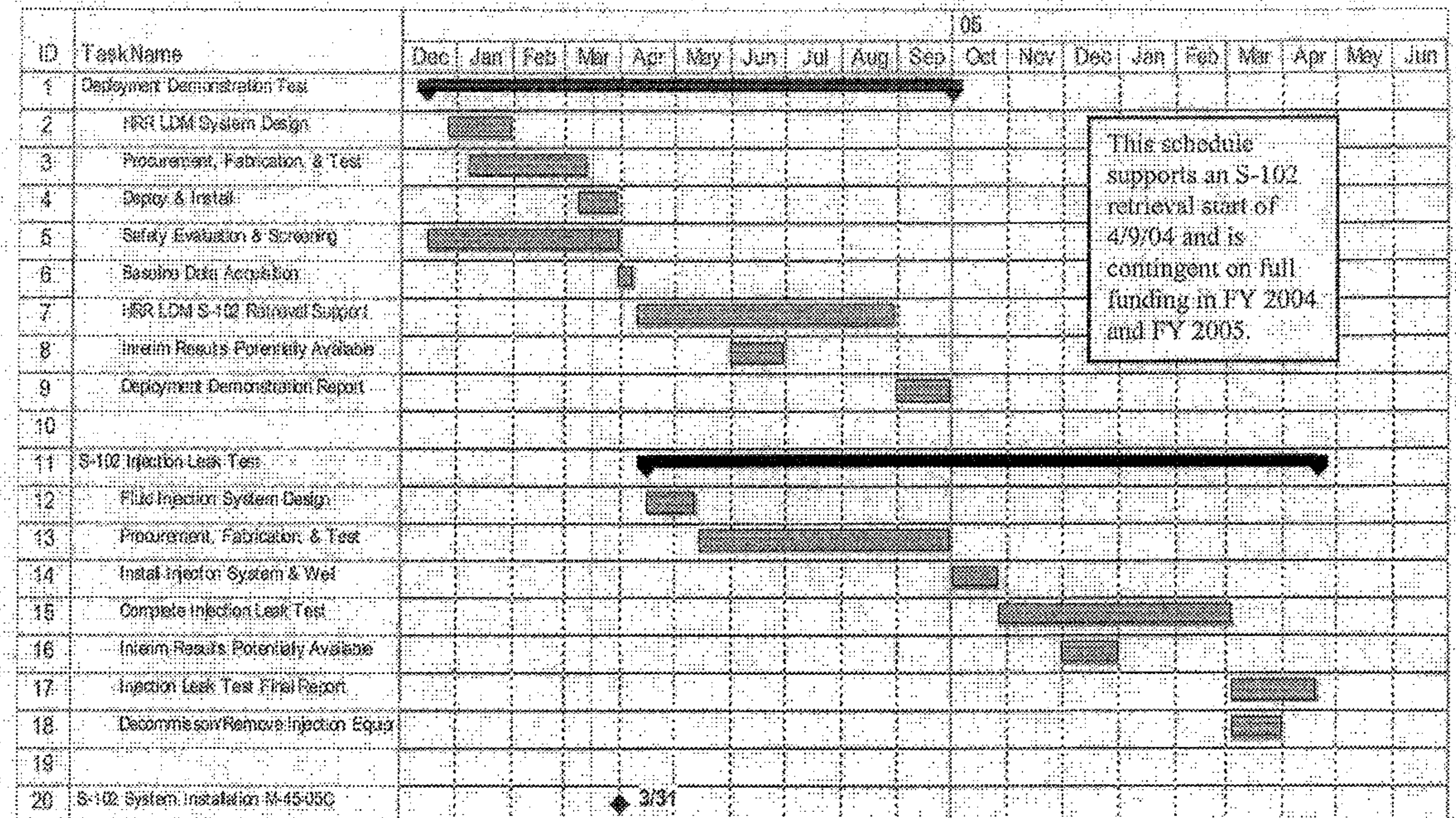
RPP-10604, Rev.1, August 2002, Boger, R.M., *Ex-Tank LDMM Technology Assessment and Down Select Report*, CH2M HILL Hanford Group, Inc. Richland, WA.

RPP-10904, Rev. 0, Boger, R.M., July 2002, Ex-Tank LDMM Performance Evaluation Test Specification, CH2M HILL Hanford Group, Inc. Richland, WA.

RPP-14606, Rev. 0, 2003, Reich, F. R., *Performance Test Assessment of HRR-SCRT, ERT-PET, and ERT-LET Ex-Tank Resistivity Leak Detection Methods – Fiscal Year 2002-2003*, CH2M HILL Hanford Group, Inc. Richland, Washington.

RPP-17043, Barton, W.B, June 2003, *Process Control Plan for Retrieval of Waste from Tank 241-S-102 by Saltcake Dissolution and Modified Sluicing*, CH2M HILL Hanford Group, Inc. Richland, WA.

Attachment 1 Draft Test Schedule



Appendix A

Tank S-102 Conceptual Deployment of HRR LDM System

Appendix A
Tank S-102 Conceptual Deployment of HRR LDM System

This appendix shows a conceptual SST installation and deployment for a high-resolution resistivity (HRR) leak detection and monitoring (LDM) system on S-102. The concepts for this S-102 deployment were taken from the following:

- S-102 deployment configuration:
  RPP-14606, Rev.0, 2003, Reich, F. R., *Performance Test Assessment of HRR-SCRT, ERT-PET, and ERT-LET Ex-Tank Resistivity Leak Detection Methods – Fiscal Year 2002-2003*, CH2M HILL Hanford Group, Inc. Richland, Washington.

- Tank waste injection simulant:
  RPP-10904, Rev. 0, Boger, R.M., Ex-Tank LDMM Performance Evaluation Test Specification, July 2002, CH2M HILL Hanford Group, Inc. Richland, W

- Geophysical resistivity measurement system:
  PNNL-14192, Barnett, D.B., et. al., *Results of Performance Evaluation Testing of Electrical Leak-Detection Methods at the Hanford Mock Tank Site – FY 2002-2003*, January 2003, Prepared for the U.S. Department of Energy by Pacific Northwest National Laboratory, Richland, WA.

A Category 3 arrangement (the type of connection normally associated with digital telephone technology) was used as the networking technique for the 105A mock tank test. The CAT 3 network relied on digital telephone access that is readily available throughout the Hanford Site. It used the Asynchronous Digital Signal Line (ADSL) technology to provide network capability to the remote host. Two ADSL lines were used which provided very sufficient network bandwidth for the two remote computers: HRR and ERT LDM system controller and the fluidic control system computer. An additional benefit of the ADSL connection was that voice telephony will be provided concurrently to the digital access without interrupting the computer connection. Two ADSL modems that were installed in the trailer at the 105A mock tank test site provided the connection points for the two computers.

Figure A-1 Conceptual HRR LDM SST tank deployment showing electrical connections to use the SST drywells as long electrodes and the tank thermocouple as the "mise-a-la-masse" electrode.

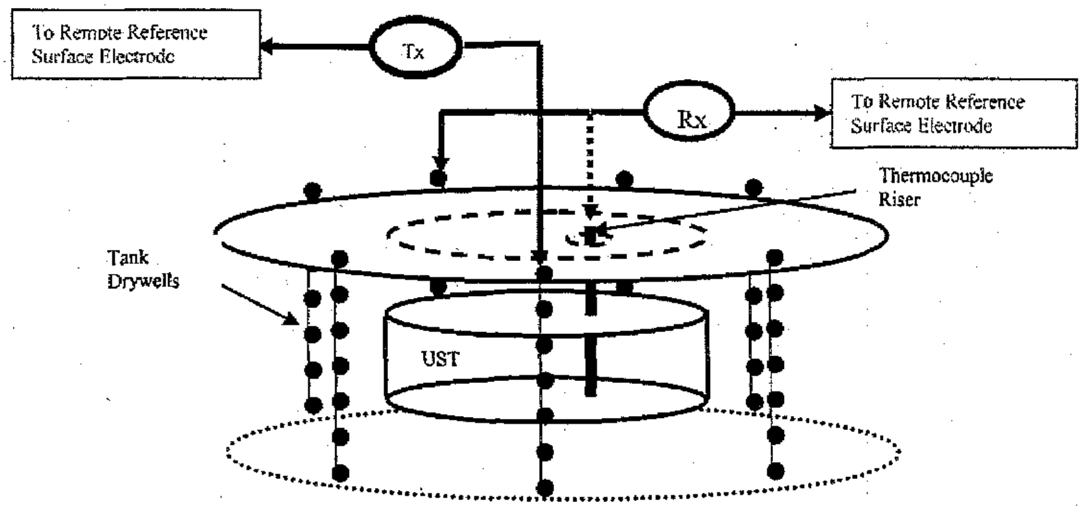


Figure A-2 Conceptual HRR LDM system installed on tank S-102 showing the locations of the two remote reference electrodes.

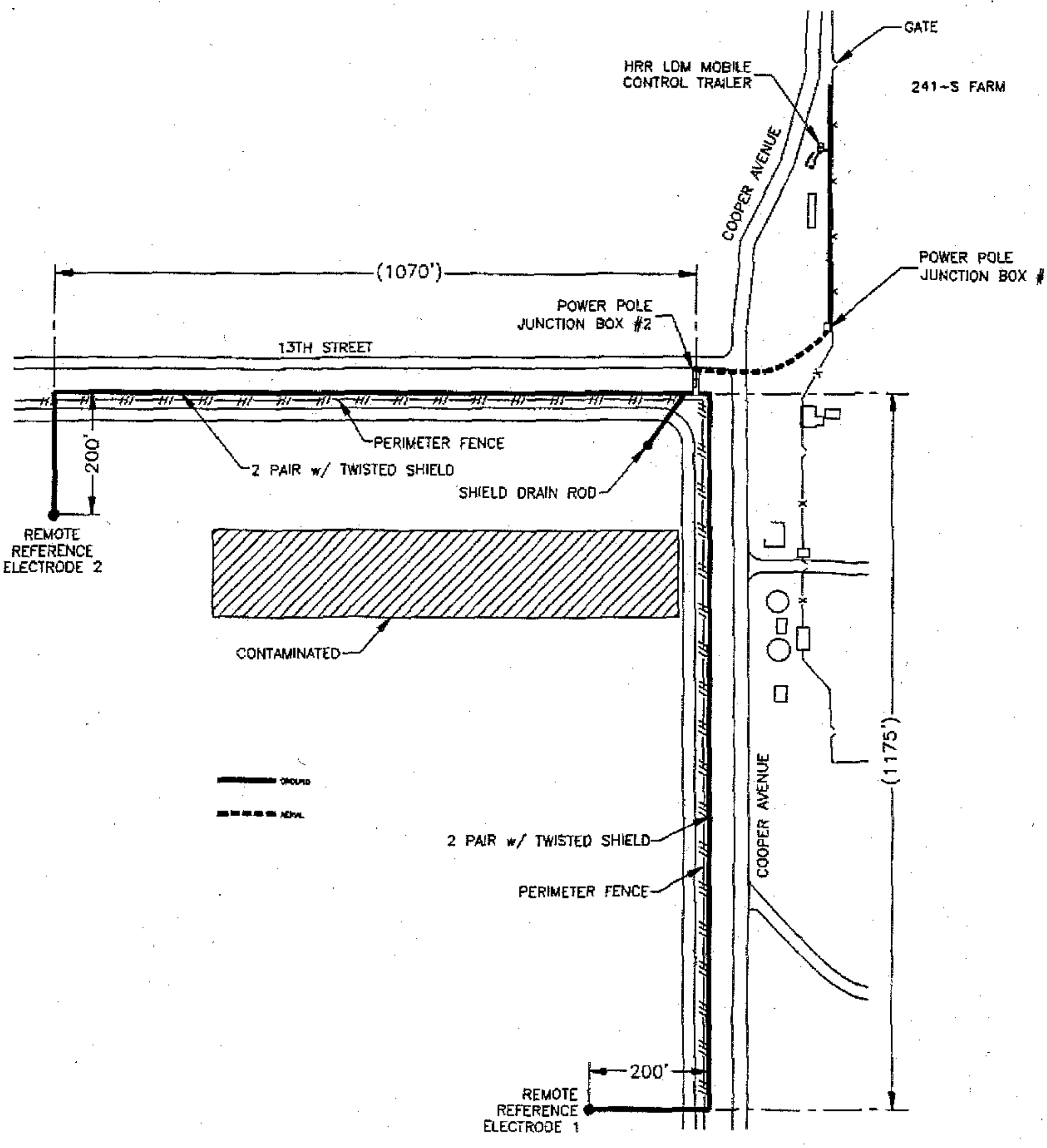


Figure A-3 Conceptual S-102 "on-tank" HRR LDM component layout showing cable routes for connecting to the tank drywells and thermocouples being used as electrodes. Also shown are the connections to 8 surface electrodes which provide supplementary HRR LDM information.

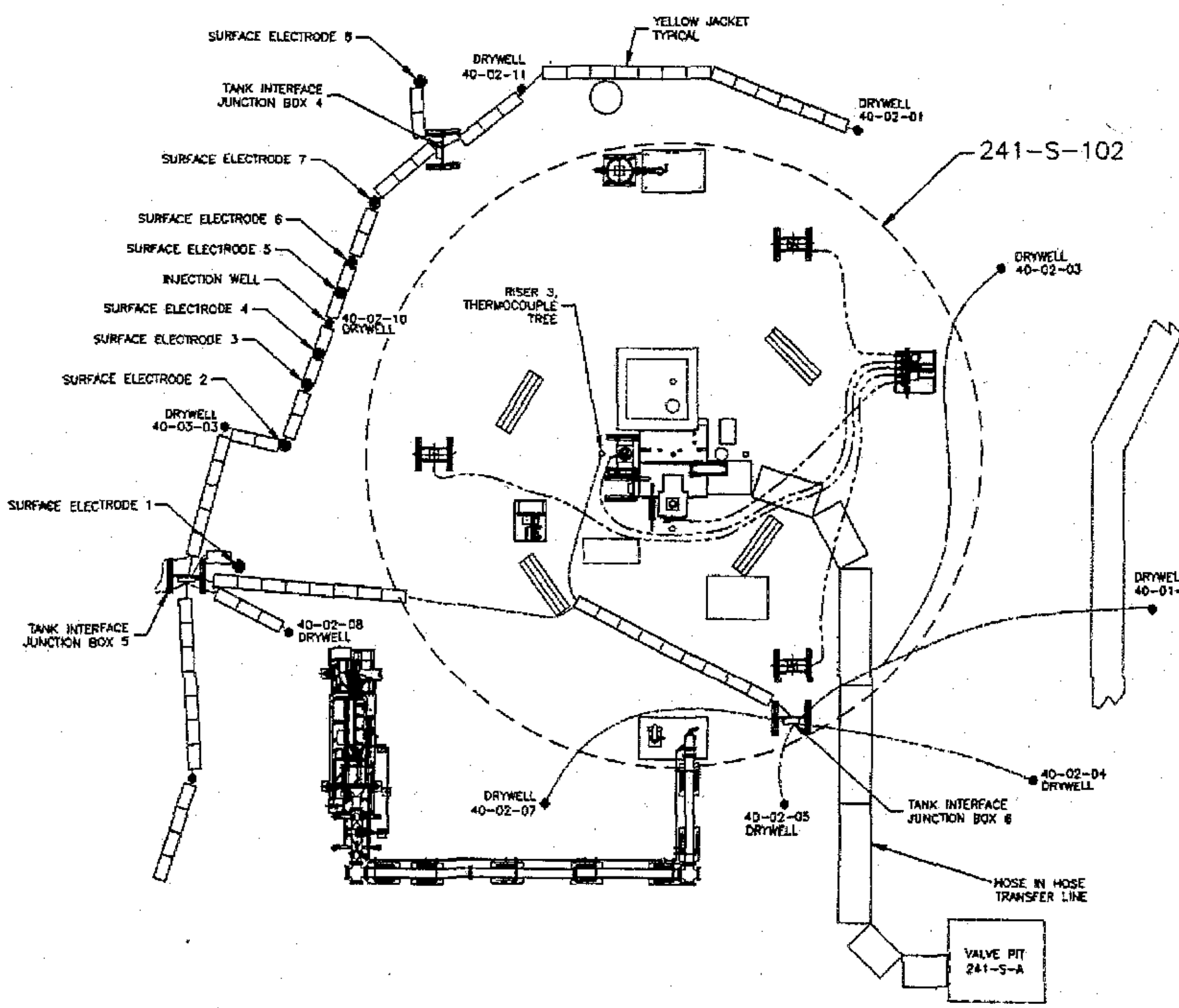


Figure A-4 Conceptual electrical connection to the steel casing of an SST drywell. This connection on the lip of the drywell will not block access to the drywell for gamma and neutron probe logging. A cable strain relief or other method of constraining the cable would protect/isolate the electrical termination physical stress.

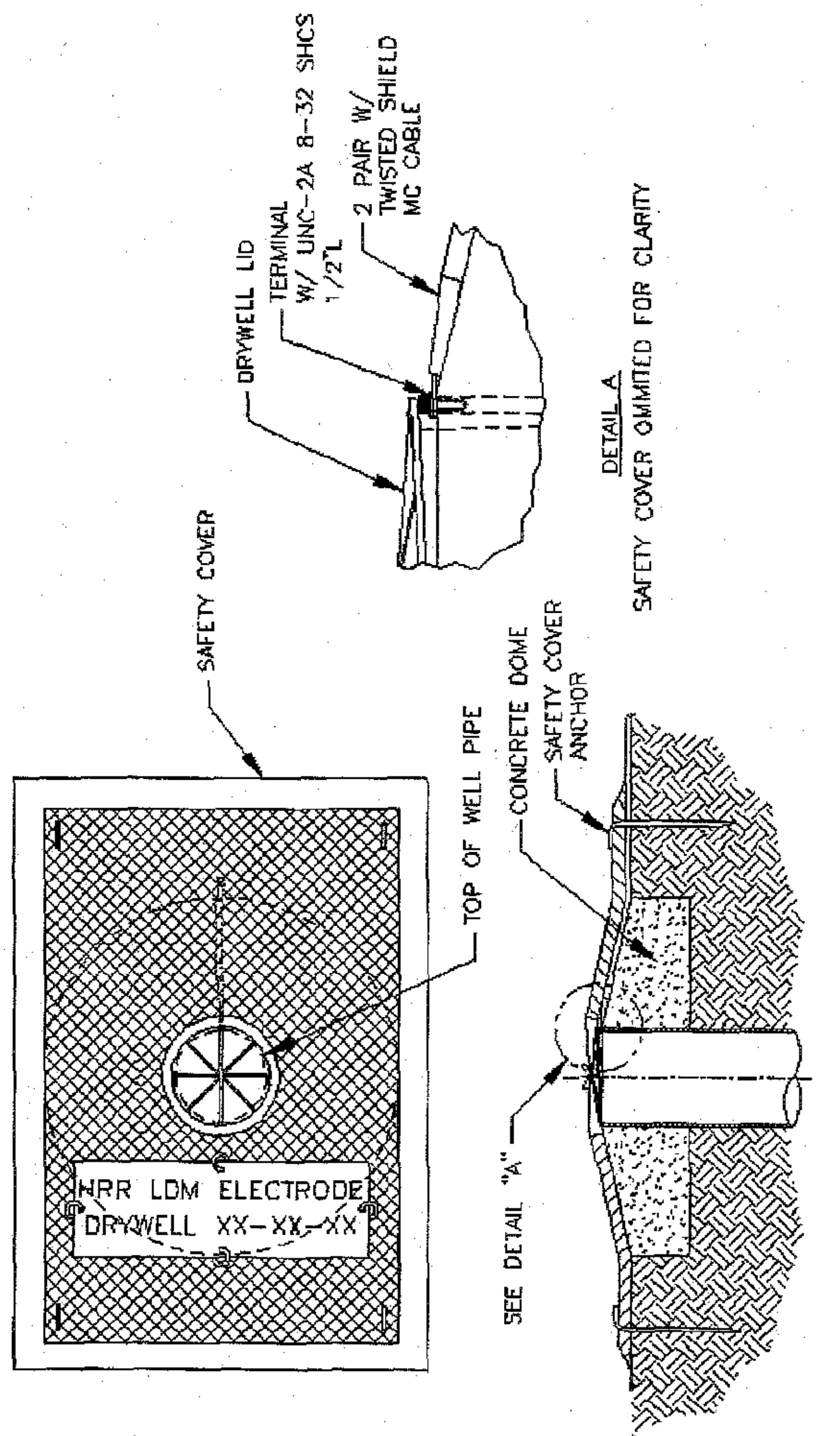


Figure A-5 Schematic of the HRR LDM system. A mechanical switch between the 120 VDC power supply and transmitter will be used for Lock-out/Tag-out to suspend electrode power during drywell logging.

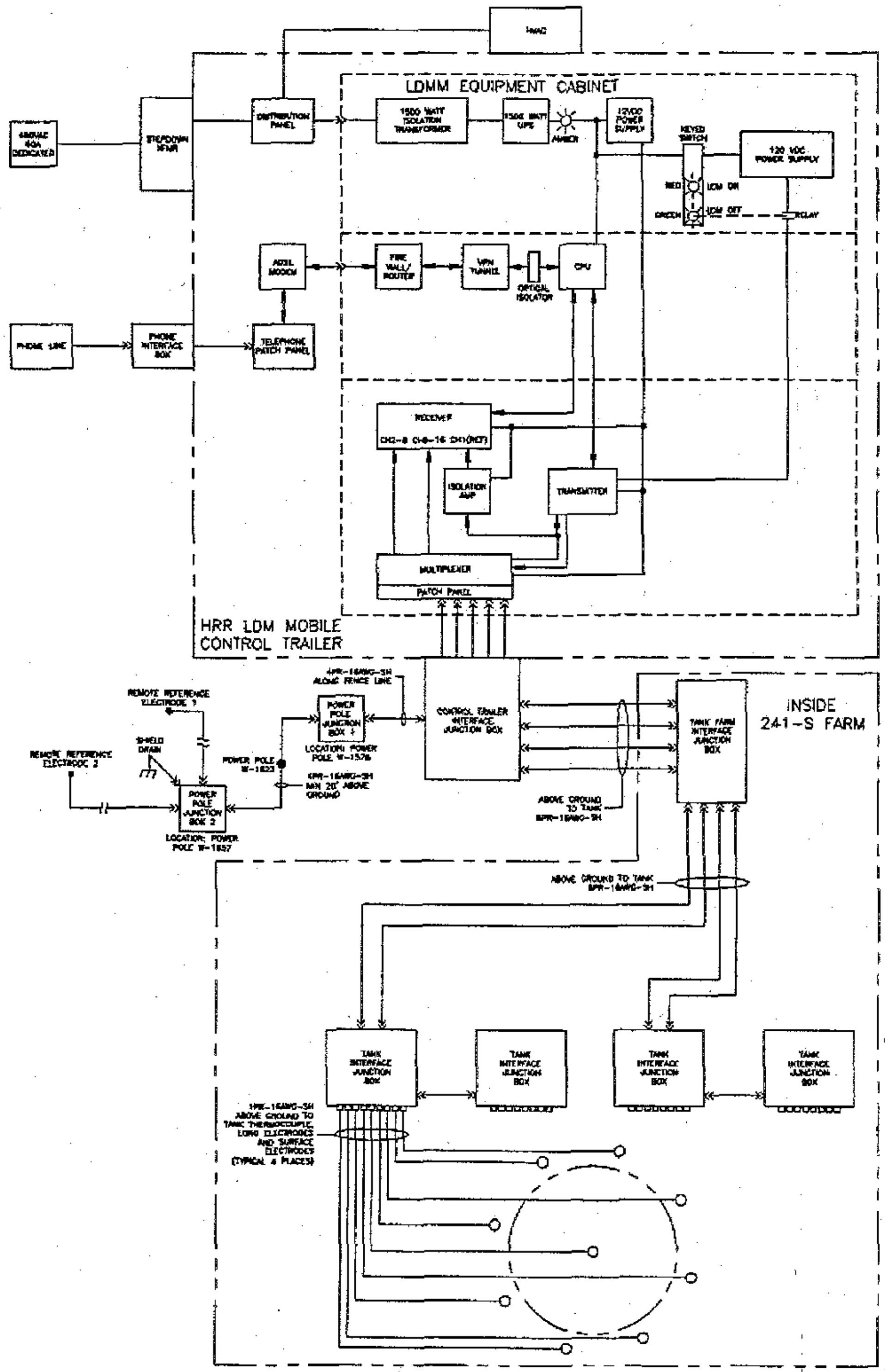


Figure A-6 S-102 injection leak test conceptual layout that includes the junction boxes, cable routes to the drywells, surface electrodes, and thermocouples that will be used as HRR LDM electrodes.

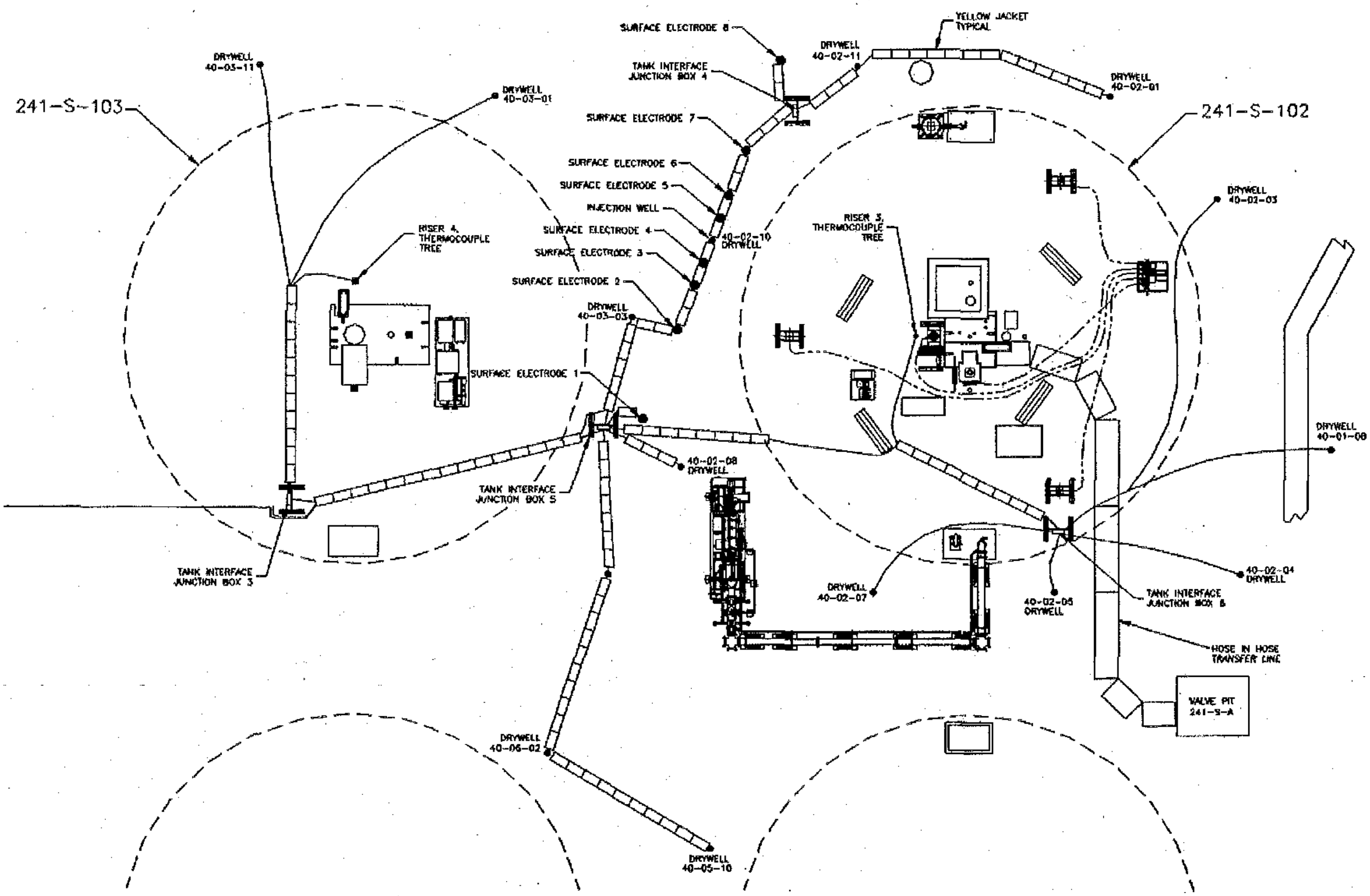
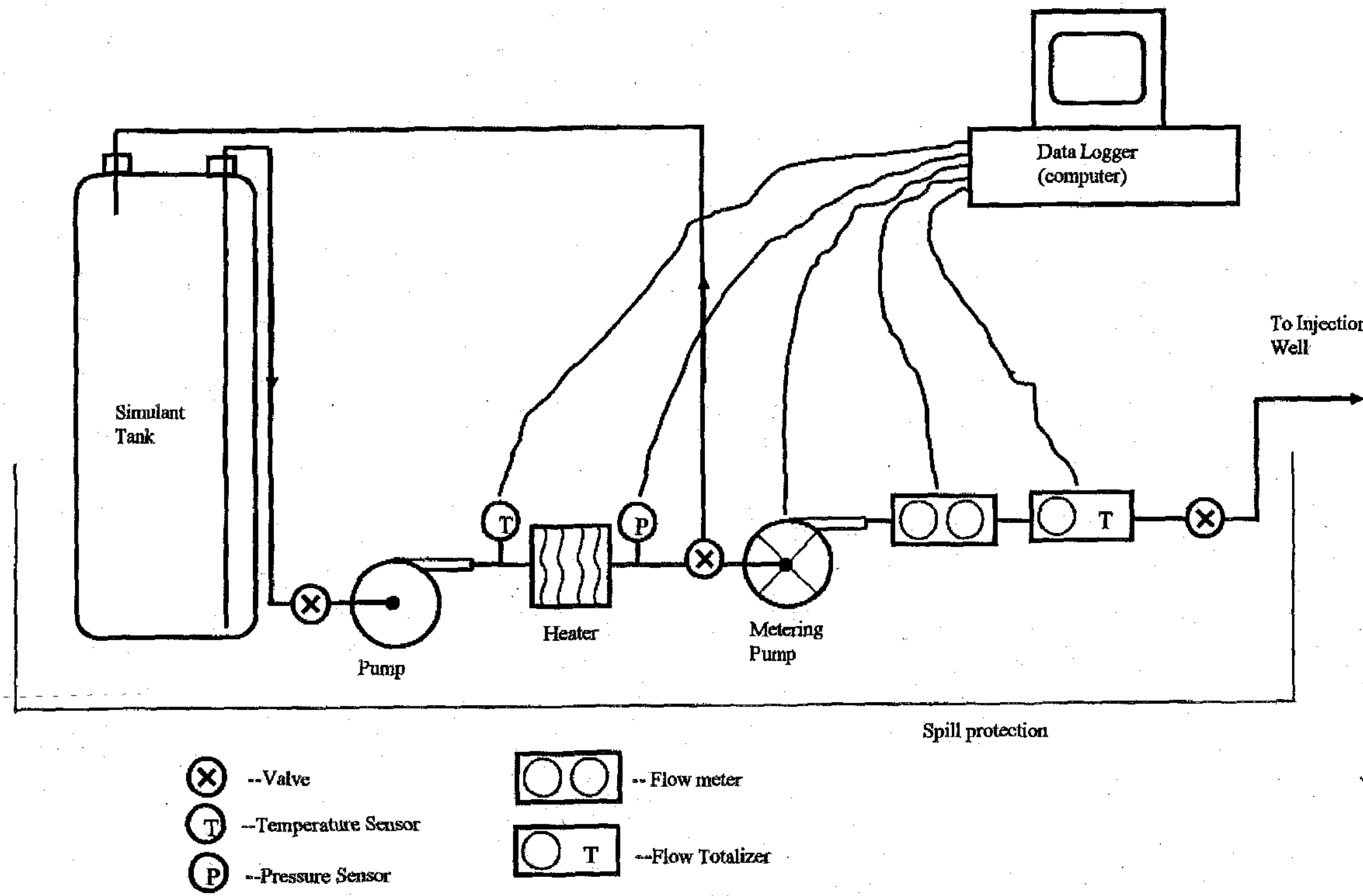


Figure A-7 Conceptual fluid injection system to "leak" known volumes of fluid into the injection well.



Appendix B

Tank Waste Injection Leak Simulant.

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Tank Waste Injection Leak Simulant

A sodium thiosulfate waste simulant, similar to that used for the FY-2002-03 105A mock tank test, is recommended for use in the injection leak testing, based on the discussions below.

B-1. FY 02-03 105A Mock Tank Waste Simulant

The following was extracted from RPP-10904, *Ex-Tank LDMM Performance Evaluation Test Specification.*

The release simulant for the FY 2002 to 2003 (FY 02-03) performance evaluation testing at the 105A mock tank test site was a 35% (wt%)sodium thiosulfate pentahydrate ($Na_2S_2O_3$ - $5H_2O$). This chemical and concentration were selected to have properties similar to those anticipated in the tank waste. The sodium thiosulfate solution is non-hazardous and non-flammable. According to an MSDS (material safety data sheet) use of safety equipment is not mandatory with this compound or water solutions. The fluid resistivity was 0.067-ohm m (15 S/m - about 5 times more conductive than sea water) and about 3000 times more conductive than the subsurface sediment.

The injection system on the 105A mock tank test used an inline water heater that was plumbed into the recirculation loop at the centrifugal pump outlet, and the solution storage tank was insulated with a blanket of 0.64-cm (0.25-in.) foam insulation. These modifications maintained the tank solution temperature at 30° to 35°C (86° to 95°F) and prevented precipitation of the sodium thiosulfate when the ambient temperature dropped.

Table B-1 presents a comparison of the properties of a 5-Molar (5M) solution of sodium nitrate and the $Na_2S_2O_3$ - $5H_2O$ solution .

Table B-1 Comparison of a 3 M sodium thiosulfate solution with waste properties.

Physical Property	(5M Sodium Nitrate)* Tank Waste Design Specification	(3M Sodium Thiosulfate Pentahydrate)* Simulated Waste
Specific gravity	1.26	1.34
Concentration	429 g/l	482 g/l
Relative viscosity	1.81	4.35
Conductivity	173 dS/m**	128dS/m

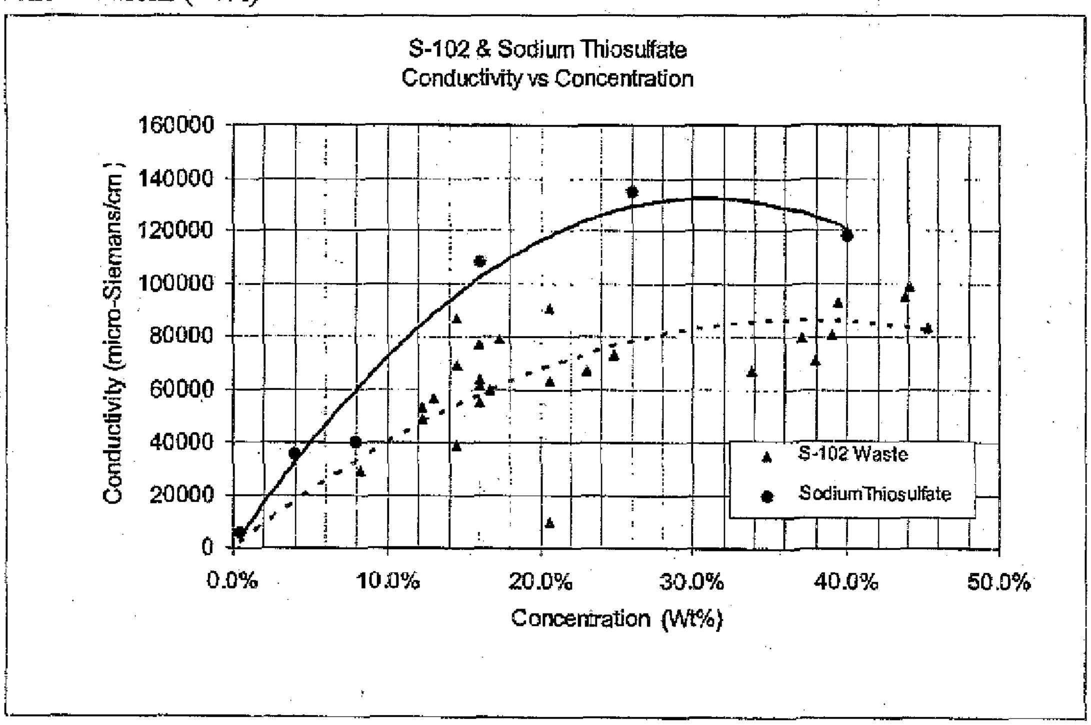
* Source: CRC, 1975.
** dS: deci-Siemans equal to one milli-mho.

B-2 S-102 Dissolved Tank Waste Conductivity Properties

The results of testing the feasibility of using conductivity as a dissolved sodium content measurement for S-102 tank waste are reported in RPP-15940. In this testing waste core samples were blended to represent the upper 2/3 and lower 1/3 of the S-102 tank wastes. Repetitive water dissolutions were then completed on a number of upper, lower, and blended upper/lower waste samples. The conductivity and dissolved waste (wt%) from the dissolution samples were measured for each dissolution test cycle (up to 5 cycles were completed to simulate multiple tank waste sluicing cycles). The results show the anticipated conductivity of the dissolved liquid waste component, as the S-102 tank wastes are systematically retrieved from the tank by water sluicing. These dissolution samples are also representative of the waste liquid that could potentially leak from the tank during the waste retrieval.

Figure B-1 shows the S-102 dissolution sample conductivities compared with the conductivity of sodium thoisulfate for a range of concentrations (S-102 data from RPP-15940, sodium thiosulfate from an informal PNNL communication). The maximum conductivity measured for all of the S-102 waste dissolution samples was 100,000 micro-Siemens/cm while the maximum conductivity for the sodium sulfate was approximately 130,000 micro-Siemens/cm.

Figure B-1 Conductivity of S-102 dissolution samples and sodium thiosulfate at different concentrations (wt%).



The conductivity data in Figure B-1 shows that the use of a sodium thiosulfate with a concentration greater than about 15% may over represent the conductivity of the tank wastes that could be leaked during waste retrieval. Therefore, it may be prudent to consider using a less concentrated solution for the injection leak testing. The use of a less concentrated solution will also reduce viscosity and specific gravity of the waste simulant, which are also over represented as shown by Table B-1. This simulant should move through move through the soil similar to water based on vadose zone transports studies performed at Sisson and Lu Site using this stimulant (PNNL-13679). This would represent a change from the solution that was used during the FY 02-03 105A mock tank performance testing that may impact the use of this previous data for the SST testing.

B-4 References:

RPP-10904, Rev. 0, Boger, R.M., *Ex-Tank LDMM Performance Evaluation Test Specification*, July 2002, CH2M HILL Hanford Group, Inc. Richland, Washington.

PNNL-13679, Gee, G. and A. Ward, 2001, *"Vadose Zone Transport Field Study: Status Report"*, Pacific Northwest National Laboratory, Richland, Washington.

RPP-15940, Callaway, W.S., *Tank 241-S-102 Core Sample Dissolution Testing Report*, June 2003, CH2M HILL Hanford Group, Inc. Richland, Washington.

Appendix C
Table of Measurement Parameters

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Measurement Parameters.

A draft listing of potential measurement parameters to be recorded during the deployment demonstration testing and injection leak testing is shown in Tables C-1 and C-2. These are recommended parameters which may be of interest, but not mandatory, to completing the deployment demonstration and injection leak tests.

All data will be recorded with a common time index to allow cross-correlation between various data sources. Cost, sensor availability, and impact on test performance assessment will be some of the factors considered for the final set of measurement parameters. Hanford weather station data may be used in place of dedicated ambient air and rainfall sensors if the data is S-Farm relevant.

A test log will also be maintained that will record the system status and other information related to the system status. The log entry frequency will be related to changes in the system status with entries expected on at least a daily basis.