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JUN 19 2013

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Mr. Todd Mullins
Federal Facility Agreement Manager
Kentucky Department for Environmental Protection
Division of Waste Management
200 Fair Oaks Lane, 2nd Floor
Frankfort, Kentucky 40601

Ms. Jennifer Tufts
Federal Facility Agreement Manager
U.S. Environmental Protection Agency, Region 4
61 Forsyth Street
Atlanta, Georgia 30303

Dear Mr. Mullins and Ms. Tufts:

TRANSMITTAL OF THE OPERATIONS AND MAINTENANCE PLAN FOR PHASE IIa OF THE INTERIM REMEDIAL ACTION FOR THE VOLATILE ORGANIC CONTAMINATION AT THE C-400 CLEANING BUILDING AT THE PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY (DOE/LX/07-1285&D2)

Please find enclosed for your review the *Operations and Maintenance Plan for Phase IIa of the Interim Remedial Action for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah*, DOE/LX/07-1285&D2. This is a Secondary Document as defined by the Federal Facility Agreement for the Paducah Gaseous Diffusion Plant. The U.S. Department of Energy requests receipt of approval by June 21, 2013. Receipt of approval by this date will support the planned initiation of Phase IIa operations on June 25, 2013. This plan is secondary to the *Remedial Action Completion Report for the Phase IIa Interim Remedial Action for the Volatile Organic Compound Contamination at the C-400 Cleaning Building*.

If you have any questions or require additional information, please contact David Dollins at (270) 441-6819.

Sincerely,

Jennifer Woodard

Jennifer Woodard
Federal Facility Agreement Manager
Portsmouth/Paducah Project Office

Enclosures:
1. O&M Plan—Clean Version
2. O&M Plan—Redline Version
3. Comment Response Summary
4. Additional Changes Comment Response Summary

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DOE/LX/07-1285&D2
Secondary Document

Operations and Maintenance Plan for Phase IIa of the Interim Remedial Action for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

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DOE/LX/07-1285&D2
Secondary Document

Operations and Maintenance Plan for Phase IIa of the Interim Remedial Action for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

Date Issued—June 2013

Prepared for the
U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

Prepared by
LATA ENVIRONMENTAL SERVICES OF KENTUCKY, LLC
managing the
Environmental Remediation Activities at the
Paducah Gaseous Diffusion Plant
under contract DE-AC30-10CC40020

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CONTENTS

TABLES

FIGURE

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ACRONYMS

ATS	automatic transfer switch
bgs	below ground surface
CFR	*Code of Federal Regulations*
digiTAM™	digital Temperature Acquisition Module
DNAPL	dense nonaqueous-phase liquid
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ERH	electrical resistance heating
ET-DSP™	Electro-Thermal Dynamic Stripping Process
GAC	granular activated carbon
gpm	gallons per minute
HASP	health and safety plan
IPS	inter phase synchronization
IRA	Interim Remedial Action
KAR	*Kentucky Administrative Regulations*
KPDES	Kentucky Pollutant Discharge Elimination System
LATA Kentucky	LATA Environmental Services of Kentucky, LLC
O&M	operations and maintenance plan
LED	light-emitting diode
PDP	power distribution panel
PDS	power delivery system
PGDP	Paducah Gaseous Diffusion Plant
pH	potential of hydrogen
PID	photoionization detector
PLC	programmable logic controller
PPE	personal protective equipment
ppmv	parts per million by volume
PSS	Plant Shift Superintendent
RAWP	remedial action work plan
RDR	remedial design report
RGA	Regional Gravel Aquifer
scfm	standard cubic feet per minute
SVE	soil vapor extraction
SVGTS	soil vapor and groundwater treatment system
Tc-99	technetium-99
TCE	trichloroethene
TDC	time distributed control
TDCM	time distributed control module
UCRS	Upper Continental Recharge System
VAC	volts (alternating current)
VOC	volatile organic compound
WCS	water circulation system

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EXECUTIVE SUMMARY

A phased deployment of electrical resistance heating (ERH) was implemented for the C-400 Cleaning Building Interim Remedial Action (IRA) at the Paducah Gaseous Diffusion Plant (PGDP). The first phase (Phase I) implemented the selected treatment technology in the southwest and east treatment areas. This phased deployment afforded the project the opportunity to optimize the ERH operation and the vapor and groundwater recovery and treatment system, while treating the volumes of lower contamination levels before deploying to the volume of the higher contamination levels. Phase I also allowed for the evaluation of the ERH capacity to heat the lower volume of the Regional Gravel Aquifer (RGA). While no contaminant was present in the lower RGA in the southwest treatment area, electrodes were installed to a depth up to 100 ft to evaluate the heating capability in this region of the RGA. The southeast treatment area (to be addressed in Phase II) does have contaminants in these lower regions of the RGA. The evaluation during Phase I proved that heating the Upper Continental Recharge System (UCRS) can be done quite readily utilizing ERH technology. This evaluation also proved that using ERH technology to heat the lower RGA at PGDP is challenging and will require extensive design effort to preheat the groundwater flow into the treatment volume. Based on this evaluation of the Phase I data, Phase II has been divided into two discreet treatment objectives; Phase IIa will use ERH technology to treat the southeast treatment volume in the UCRS and upper RGA, and Phase IIb will treat the lower RGA in this same treatment area (technology for Phase IIb is under evaluation at this time). Operations of Phase IIb are not included in this Operations and Maintenance (O&M) Plan. This O&M Plan is for the second phase (Phase IIa) in the southeast treatment area.

This plan outline was developed in accordance with the Federal Facility Agreement under Section 120 of the Comprehensive Environmental Response, Compensation, and Liability Act. The IRA, which includes ERH as the primary treatment technology, was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and is the response action selected in the *Record of Decision for Interim Remedial Action for the Groundwater Operable Unit for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2150&D2/R2.

The *Remedial Design Report, Certified for Construction Design Drawings and Technical Specifications Package, for the Groundwater Operable Unit for the Phase IIa Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (RDR), DOE/LX/07-1272&D2/R2, provides a detailed design of the IRA system including ERH components, with specific locations determined for subsurface components such as electrodes, extraction wells, and temperature monitoring equipment. The RDR also provides a detailed performance specification for the soil vapor and groundwater treatment system (SVGTS) that describes the influent and effluent design criteria, specifies the appropriate liquid and vapor phase treatment technology, defines the treatment process flow, and presents preliminary process monitoring and control functions.

The remediation goal for this interim action, as documented in the Record of Decision, is to operate the ERH system until monitoring indicates that heating has stabilized in the subsurface and that recovery of trichloroethene (TCE), as measured in the recovered vapor, diminishes to a point at which further recovery is at a constant rate (i.e., recovery is asymptotic). At asymptosis, continued heating would not be expected to result in further significant reduction of toxicity, mobility, or volume of the contamination zone. The criteria for ceasing operations are defined in the RDR.

This plan, developed in accordance with the Federal Facility Agreement, presents O&M activities for the ERH and SVGTS. The following information is provided as part of the plan:

- A basic description of the treatment system/subsystems and major components,
- A description of O&M including start-up, shutdown, and operator training,
- A description of potential operating problems,
- A description of routine process monitoring, and
- Laboratory testing.

References herein to any plan or procedure should be construed to refer to the most recent version of the plan or procedure in effect as of the date of this O&M Plan. If revised by LATA Environmental Services of Kentucky, LLC, or subsequent U.S. Department of Energy contractors, reference is to the revised version of such plan or procedure.

1. DESCRIPTION OF TREATMENT SYSTEM

The C-400 Cleaning Building Interim Remedial Action (IRA) at the Paducah Gaseous Diffusion Plant (PGDP) includes the design, installation, operation, and subsequent decommissioning of an electrical resistance heating (ERH) system to selectively heat discrete (vertical and horizontal) subsurface intervals resulting in the volatilization, removal, and recovery of volatile organic compounds (VOCs), primarily trichloroethene (TCE) and its degradation products, from the C-400 treatment area. The ERH system is comprised of a network of electrodes to be placed in the subsurface treatment area located to the southeast area of the C-400 Cleaning Building. Power delivery systems (PDSs) will supply power to the electrodes, which, in turn, will generate resistive heat in the subsurface soils. As a result of the resistive heating, VOCs will be volatilized and steam will be produced *in situ*; the VOCs and steam subsequently will be captured via a series of soil vapor extraction (SVE) wells. The captured vapors will be treated through a soil vapor and groundwater treatment system (SVGTS). The vapor stream will be treated such that the VOCs and steam are condensed and the VOCs are captured. A nominal amount of groundwater will be extracted to establish and maintain hydraulic control in the upper Regional Gravel Aquifer (RGA). Extracted groundwater will be treated in a SVGTS. A portion of the treated water will be injected back into the electrodes to maintain electrical conductivity and facilitate heat transfer by convection. The balance of the treated groundwater will be discharged through Kentucky Pollutant Discharge Elimination System (KPDES) Outfall 001. Section 8 contains a more detailed description of the treatment system equipment.

The *Remedial Design Report, Certified for Construction Design Drawings and Technical Specifications Package, for the Groundwater Operable Unit for the Phase IIa Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (RDR), DOE/LX/07-1272&D2/R2, provides the detailed design of the IRA system including ERH and SVGTS components, with specific locations determined for subsurface components such as electrodes, extraction wells, temperature monitoring equipment, and vacuum monitoring equipment (RDR, Section 2). The RDR also provides a detailed performance specification for the SVGTS that describes the influent and effluent design criteria (RDR, Section 3.2.9); specifies the appropriate liquid and vapor phase treatment technology (RDR, Section 4.3); defines the treatment process flow (RDR, Section 4 and Appendix F); and presents preliminary process monitoring and control functions (RDR, Sections 4.6 and 6).

A phased deployment of ERH was implemented for the C-400 Cleaning Building IRA. The first phase (Phase I) implemented the selected treatment technology in the southwest and east treatment areas. Phase I has been completed. This Operations and Maintenance (O&M) Plan is for the second phase (Phase IIa) in the southeast treatment area.

As outlined in the *Technical Performance Evaluation for Phase I of the C-400 Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1260&D1, operation of Phase I provided the opportunity to evaluate the radius of influence of the vapor recovery system, assess hydraulic containment, optimize the SVGTS, and evaluate heating performance in the RGA. Information gathered during operation of Phase I was evaluated to identify lessons learned and potential contingency actions to be implemented prior to start-up of Phase II. Evaluation of this information indicated that thermal remediation is an inefficient technology in a high permeability, high flow aquifer such as the RGA and that the cryogenic absorption system is difficult to integrate with the vapor treatment system. Based on this evaluation, Phase II has been segregated into two treatment actions near the southeast corner of the C-400 Cleaning Building, with Phase IIa implementing treatment of the Upper Continental Recharge System (UCRS) and upper RGA and Phase IIb treating the middle and lower RGA. Operations of Phase IIb are not included in this O&M Plan.

This O&M Plan was developed in accordance with the outline presented in the Federal Facility Agreement. The following sections discuss the O&M of the treatment systems. A general site plan view is shown in the RDR.

2. EQUIPMENT START-UP, SHUTDOWN, AND OPERATOR TRAINING

2.1 TECHNICAL SPECIFICATIONS GOVERNING TREATMENT SYSTEMS

The detailed design and technical specifications governing the IRA system, including ERH components with specific locations determined for subsurface components, are provided in the RDR. The RDR also provides a detailed performance specification for the SVGTS that describes the influent and effluent design criteria, specifies the appropriate liquid and vapor phase treatment technology, defines the treatment process flow, and presents preliminary process monitoring and control functions.

2.2 REQUIREMENTS FOR SERVICE VISITS

Supervisory or service personnel will be involved with the installation, start-up, and operation of the ERH system. These personnel may include on-site managers and supervisors as well as subject matter experts located off-site. Service personnel working on-site must be U.S. citizens, or, if they are a foreign national, requirements for work must be included in an approved unclassified foreign national security plan. Service personnel will have site-specific training and be required to read, or be briefed on, the *Health and Safety Plan for the C-400 Interim Remedial Action, Paducah, Kentucky* (HASP), PAD-PROJ-0068, *LATA Environmental Services of Kentucky, LLC, Worker Safety and Health Plan, Paducah Remediation Services Project*, PAD-PLA-HS-001, applicable task work instructions including hazards identification, analysis and mitigations contained therein, and other applicable project-related documents.

As part of site control, procedures have been established to ensure worker safety. Worker safety procedures are incorporated into standard operating procedures and work packages that include task work instructions, which include hazard identification, analysis, and mitigations. Engineering controls and safe work practices will be implemented to reduce and maintain employee exposure levels at or below the permissible exposure limits and published exposure limits for those hazardous substances at the site.

2.3 TRAINING SCHEDULE

Personnel training activities will be completed and documented prior to and during the system start-up period. The ERH Subcontractor will conduct system-specific training for the on-site operations staff. An Electro-Thermal Dynamic Stripping Process (ET-DSP™) technician will be on-site during normal operating hours. Additional training will be performed, as necessary, if system modifications are implemented. Training requirements will be listed in the project training matrix located in the project files. The basic training schedule includes the following:

- Required reading/briefings (work control documents, governing project documents, area logistics, basic system operations, sampling requirements, etc.) will be completed prior to starting on-site activities.

- Site-specific training [General Employee Training, radiation worker training (as applicable), etc.] will be completed prior to system start-up.

- System-specific training (operating procedures, walkdowns, on-the-job training, health and safety requirements, etc.) will be completed after batch operations and start-up.

- The following are the training required specifically for the ET-DSP™ operator:

  — Taking voltage and current measurements with a multimeter inside electrical panels and calibrating sensors;

  — Performing partial or full power down of individual breakers in advance of maintenance or adjustments to the PDS or water circulation system (WCS), and following procedures for restoring full power to the system following maintenance for breaker trip;

  — Repairing or replacing solenoid valves within the WCS if valves are deemed to be faulty;

  — Changing transformer tap settings inside the PDS to adjust electrode voltage, after full power down of PDS unit;

  — Adjusting electrode or ET-DSP™ neutral configuration by rewiring inside panels or in the well field, after power down; and

  — Replacing circuit boards or electrical components inside panels after power down.

2.4 TESTING AND START-UP

Prior to start-up of the ERH system and SVGTS, support systems such as potable water, cooling water, chilled glycol/water, boiler-produced steam, and compressed air will be tested to ensure proper operation. In addition, piping systems will be walked down to verify the correct valve alignment for operational mode.

The combined ERH system and SVGTS will be started in a logical sequence as described in this section. The general sequence of activities will be in the following order (first two activities may be conducted concurrently).

- Conduct integrated testing of SVGTS equipment or individual treatment skids using potable water and ambient air to ensure subsystems are functioning properly with motors rotating in the proper direction and speed range.

- Test ERH system to ensure operational readiness per electrical requirements in cooperation with United States Enrichment Corporation or other (future) provider of electrical power as appropriate.

- Begin batch operations to ensure VOC treatment meets design criteria based on analytical sample results. This will involve the following:

  — Start-up groundwater extraction system, pumping water from wells to the SVGTS.

  — Start-up vacuum extraction system, pulling vapor from the wells through the SVGTS, while avoiding overstressing the system with entrained water expulsions and pressure spikes.

— Start-up the ET-DSP™ system and begin heating the well field.

- Conduct batch treatment operations while collecting and containing effluent to determine if VOC discharge criteria are met.

- Begin routine operations after completing start-up activities and verifying compliance.

2.4.1 ERH System

The following sections summarize the operational phases for ERH. Initial start-up of the system involves first starting the multiphase extraction system to establish hydraulic and pneumatic control and then starting the ET-DSP™ system. Start-up activities also will be governed by project operating procedures, manufacturers' instructions, and/or task work instructions.

2.4.1.1 Groundwater extraction system start-up

To begin pumping with the submersible pumps in the extraction wells, the operating pressure in the air lines will need to be established. The valves on the air lines will be opened and then the compressed air supply valves to the individual groundwater pumps will be opened. Compressed air pressure and groundwater extraction flow rate measurement data will be collected to verify proper pump operation for each groundwater pump.

To establish hydraulic control in the southeast treatment area, the center extraction wells will be brought on line first for approximately one to two days before the outer extraction wells are started. With all extraction wells operating, balancing the extraction and reinjection rates will be done by adjusting the discharge rate of the individual extraction pumps using regulators and valves to ensure more groundwater is extracted than is reinjected. It is not anticipated that water levels will show an appreciable difference due to the high hydraulic conductivity.

During start-up, the volume of groundwater removed by the submersible pumps will be monitored to ensure that the design groundwater removal rate is achieved. It is not anticipated that adjustment to the depth of the pumps in the extraction wells will be required to achieve desired groundwater extraction rates.

During normal operations, the temperature response of the external temperature sensors will be used in addition to the groundwater extraction rates versus water injection rates to determine if hydraulic control is being maintained. Adjustments to the extraction rates from individual wells will be made based on these data. For example, the extraction rate in a well may be increased significantly more than the design rate to respond to operational conditions, such as a temperature increase in an external temperature sensor. The pumps in the extraction wells will enable this type of response.

The volume of groundwater removed from the subsurface will be monitored to achieve the design groundwater removal rate. Modifications, such as regulating the pressure of compressed air supplied to the extraction pumps, may be performed to optimize the rate of groundwater removal.

2.4.1.2 Vacuum extraction system start-up

It is anticipated that the vacuum extraction portion of the system will be started within two days after the groundwater extraction portion of the system is started. During the initial start-up of the vacuum extraction system, the valves at the vapor extraction wells and the combination vapor extraction/electrode wells will be closed and ambient air will be used for testing via bleeder valves.

The vapor recovery system will be started once hydraulic balance is achieved or if routine monitoring at the surface and in the vicinity of site workers indicates that VOC vapors are migrating to the surface. VOCs will be monitored at the surface using a photoionization detector (PID). The frequency and location of PID monitoring will be directed by the Industrial Hygiene group. Vapor flow will be adjusted at each well according to the design criteria.

Once the system is verified to be operating properly, vacuum will be applied to all the wells and slowly increased by increasing output at the vacuum pump. Flow at each extraction well will be monitored with pitot tubes, and, based on the flow, adjustments will be made at the wells to affect flow rate, and/or adjustments will be made at the vacuum blowers to increase or decrease flow rates to the system. Data will be collected to determine the initial VOC concentration in the discharge air and the maximum achievable airflow rate through the subsurface. This information will be used to help optimize system performance.

Subsequent to the initial start-up period, the vacuum will be increased, and completion of the start-up will consist of the following events:

- Measurement of subsurface vadose zone vacuum at each multiphase extraction well and vacuum monitoring well;
- Measurement of groundwater extraction rate at each multiphase extraction well;
- Measurement of vapor flow rate at each extraction point using pitot tubes and/or other appropriate measuring device;
- Measurement of total vapor extraction rate prior to treatment; and
- Measurement of total vapor and water effluent discharge flow rates.

This information will be collected and recorded at least once daily during the start-up and testing period, which may last as long as four weeks. These measurements will be used to make modifications and adjustments to the system, as necessary, to achieve the design extraction rates and to ensure hydraulic and pneumatic capture.

The vapor discharge and ambient airflow rates will be measured to determine if the system is effective in creating sufficient airflow in the subsurface. Adjustments, which may optimize the airflow, could include adjusting the level of vacuum applied to the extraction wells in various combinations, increasing the output of the vacuum blowers.

Start-up checklists will be generated for recording and tracking the parameters mentioned in this section. These checklists will be maintained in the project files.

2.4.1.3 ET-DSP™ start-up

The initial start-up of the ET-DSP™ system involves activating the various components (i.e., PDSs, water circulation components, energizing electrodes, etc.) and ensuring the components operate safely within the design parameters. Optimizing performance of the electrodes will be an ongoing process during the operations phase.

The tasks to be completed during the start-up phase by Mc^2 technical staff are listed below. Before performing any tasks, personnel must familiarize themselves with the appropriate safety protocols, procedures, and site-specific activity hazard assessments.

1. Before starting the ET-DSP™ system, review the activities to be performed with the safety supervisor and other personnel who will be working in the area. Limit the number of personnel within the area until commissioning and acceptance testing is completed.

2. Ensure that all breakers in the distribution panel are in the off (i.e., open) position, locked out, and tagged out.

3. With the distribution panel breakers to each PDS unit still in the off position (open position) and the PDS breakers locked out and tagged out, check to ensure the following:

    a. The primary side of the PDS transformers A and B are connected to the corresponding utility supply voltage,

    b. The secondary side of the PDS transformers A and B are connected to the lowest voltage tap position.

4. Confirm that there is no voltage present between the utility ground and the ET-DSP™ neutral at the PDS unit. With no voltage present, measure the resistance from the utility ground to the ET-DSP™ neutral and measure the resistance between electrodes. The resistance between the utility ground and ET-DSP™ neutral should be approximately 10 times the resistance between the electrodes. This must be repeated for each of the PDS systems on site.

5. With all electrode breakers in the off (i.e., open) position and the ESD engaged, remove the lock-out/tagout on the breakers to the PDS unit transformers that are about to be checked. Working with one PDS unit at a time, energize one transformer at a time. Confirm that the breaker energized the correct transformer within that PDS, the breaker is properly labeled, and check its primary voltage at the PDS. Energizing the PDS transformers is done by moving the breaker handles in the distribution panel to the on (i.e., closed, position). Repeat this step until all transformers in the PDS units are energized.

6. Check to ensure the phase rotation on the secondary side of each transformer in a PDS matches the phase rotation on the secondary side of the transformers in the other PDS units.

7. In each PDS unit, power up the 10 kVA 480-240/120 volts (alternating current) (VAC) transformer that is used to supply power for PDS control and power circuitry.

8. Test all ESD buttons to ensure they function properly.

9. Test network communication from the server to PDS, WCS, and remote boxes.

10. Obtain initial temperature readings from the digiTAMs™ and initial water level readings and initiate the software to monitor changes.

11. Verify operation of each PDS with the electrode breakers in the off (i.e., open, position). Manually trigger the electronic components through the server and verify the server is controlling and reading all electronic components. Disable the control software after this test is completed.

12. With the PDS transformers A and B secondary taps at the lowest voltage setting and the control software disabled, move the PDS electrode breakers to the on position (i.e., closed). Trigger the electrodes one at a time in each PDS unit through the control software and verify CT readings with a clamp-on ammeter. Calibrate the circuit, as needed. Deactivate the electrodes through the software and move the electrode breakers to the off (i.e., open) position before moving to testing the next PDS unit.

13. With the PDS transformers A and B secondary taps at the lowest voltage setting and all electrode breakers in the on position (i.e., closed), activate the control algorithm and ensure software is operating correctly.

14. Conduct a full series of step and touch potential tests for all exposed metal aboveground in the vicinity of the treatment area (i.e., within 25 ft). The measured voltage potentials may require grounding or insulating exposed metal to minimize electrical hazards.

15. Measure electrical currents in the ET-DSP™ neutral conductors. Excessive current in the ET-DSP™ neutral may require either adjustments to the grounding system or phase balancing of the PDS and electrode configuration.

16. If required, adjust the electrode and PDS configuration to optimize treatment performance. When performing acceptance testing, the transformer tap settings may be adjusted to achieve target power at the electrodes while phase balancing the system to minimize current in the neutral lines. Note that a Step and Touch Potential test must be performed each time the ET-DSP™ system is reconfigured.

17. Verify operation of each WCS unit with the valve on the main water feed line in the closed position. Manually trigger the electronic components through the server and verify the server is controlling and reading all electronic components within the WCS unit. Disable the control software after this test is completed.

18. With the valve on the main water feed line in the open position, activate the WCS control software and ensure solenoid valves and flow meters are operating correctly. Confirm the correct electrode is receiving water when its corresponding solenoid valve is triggered. Make sure the control algorithm is monitoring and recording the data from the WCS units.

19. Adjust the pump on each WCS unit to provide the required injection pressure to the well field. If an electrode is not maintaining its target power, it may be an indication that the WCS is not supplying water to that electrode.

Once operation of the control software is verified, the system may be left running under automatic control with continuous monitoring of ET-DSP™ parameters. Remote operators will adjust the system over the internet, and performance data will be available on the project Web site. On-site personnel will be required to take manual measurements, monitor the site for abnormal conditions, and perform maintenance or adjustment of on-site equipment, as needed.

2.4.2 Soil Vapor and Groundwater Treatment System Start-Up

The following is the anticipated list of parameters to be measured during system start-up. These parameters will be collected, recorded, and evaluated to ensure proper system operation:

- Vacuum at each extraction wellhead
- VOC concentration at each wellhead

- Vacuum blower suction pressure/vacuum
- Vacuum blower inlet temperature
- Vacuum blower discharge pressure
- Vacuum blower discharge temperature
- Vacuum at each vacuum monitoring wellhead
- Predilution vapor flow at the vacuum blower inlet
- Inlet and outlet of the steam carbon regeneration beds
- Inlet and outlet VOC concentration of the carbon regeneration beds
- Outlet flow of carbon adsorbers
- Outlet flow of zeolite system
- Operating time of the vacuum blower
- VOC concentration at the inlet and outlet of the vacuum blower

Testing of the SVGTS components will be required to ensure the system is operating properly. This testing will include hydrostatic tank leak tests, piping pressure tests, electrical continuity and grounding tests, flow and vacuum capacity tests, and water/vapor treatment subsystem operational tests. All of this testing will be done with potable water and ambient air.

Once testing activities are completed, system start-up with groundwater will be performed by running the system in a batch mode. The intent of these short duration "batch" runs is to ensure that the treatment system can handle the VOCs being generated during the start-up phase. The goal is to identify and correct performance problems in order to minimize their impact during full system operation.

Once the treatment system performance efficiency has been confirmed in batch mode, routine operations will begin. Influent and effluent samples will be collected to determine the treatment efficiency of the system. Batch treatment operations will be performed for at least three operational shifts to verify that the discharge criteria are being met. If the VOC concentrations are above the discharge criteria, system operations will be suspended and the situation evaluated. If the discharge criteria are being met, routine operations will commence during normal business hours for approximately one week. During this period, the system will discharge to an internal ditch that drains to KPDES Outfall 001. The system effluent will be monitored daily. If discharge criteria continue to be met, 24 hour operations will begin. If discharge criteria are not being met during the first month, system operations will be suspended and the situation evaluated. If VOC levels in the vapor stream exceed discharge criteria during normal operations, the vapor extraction will be stopped by the interlock associated with the photoacoustic analyzer monitoring the stack discharge stream. During the commissioning period of Phase IIa, the installed photoacoustic analyzer and its associated interlock to the treatment system will be tested to verify operability prior to introduction of contaminated media to the treatment system. These tests will be performed by manually inputting a false signal of stack effluent vapor VOC concentrations at 20 parts per million by volume (ppmv) and verifying automatic shutdown of the treatment system by the control system. Only in extreme conditions during normal operations will the vapor and liquid extraction be completely stopped. Influent design parameters and effluent discharge criteria for the vapor treatment system are listed in Table 1. Influent design parameters and effluent discharge criteria for the liquid treatment system are shown in Table 2.

Table 1. Vapor Treatment System Design Parameters and Discharge Criteria

Analyte/Design Parameter	Influent	Design Discharge Limit[1]
Soil vapor flow (dry air basis)	1,000 scfm	N/A
TCE concentration	20,000 ppmv	20 ppmv
Vinyl chloride concentration	30 ppmv	20 ppmv

Table 1. Vapor Treatment System Design Parameters and Discharge Criteria (Continued)

Analyte/Design Parameter	Influent	Design Discharge Limit[1]
trans-1,2-DCE concentration	50 ppmv	20 ppmv
cis-1,2-DCE concentration	50 ppmv	20 ppmv
1,1-DCE concentration	Non-detectable	20 ppmv
Soil vapor temperature	203˚F (95˚C)	N/A
Pressure/vacuum at each wellhead	15 in Hg vacuum	N/A
Air from air stripper (dry air basis)	300 scfm	N/A

[1] Using the design discharge limit as an input, the maximum off-site concentration for each pollutant was estimated utilizing the air dispersion modeling software BREEZE AERMOD GIS Pro v5.1.7 [the modeling is presented in the C-400 Phase IIa Remedial Action Work Plan (RAWP)]. Refer to the C-400 Phase IIa RAWP for additional detail.

Table 2. Liquid Treatment System Design Parameters and Discharge Criteria

Analyte/Design Parameter	Influent	Discharge Limit
Groundwater flow	20–80 gpm	N/A
Condensate flow	10 gpm max	N/A
TCE concentration	5–1,100 ppm	30 ppb
1,1-DCE concentration	154 ppb	3.2 ppb
Technetium-99 activity	10–76 pCi/L (observed in groundwater sampled during Phase I operations)	900 pCi/L
Temperature	203˚F (95˚C) maximum 185˚F (85˚C) average	89˚F (31˚C) daily max
pH	5.5–6.5	6–9
Total suspended solids	10–50 ppm	30 mg/L monthly average 60 mg/L daily max
Total residual chlorine	Plant potable water levels	0.011 mg/L monthly average 0.019 daily max

Note: Discharge limits are set forth in Section 12.2.6 of the approved C-400 Phase IIa RAWP.

Test runs on major equipment will be conducted in accordance with the manufacturers' instructions and operating procedures and are described in the following sections. Refer to the Soil Vapor and Groundwater Treatment Systems Process Flow Diagram in the RDR for equipment number references.

2.4.2.1 Vacuum blower testing

Three test runs will be conducted for vacuum blowers. The first test run is for blower B-101A, the second test run is for blower B-101B, and the third test run is for both blowers running in parallel simultaneously for maximum flow. Before initial vacuum blower testing, all main process valves in the vacuum inlet lines will be opened. Vapor inlet valves and outlet valves of the Steam Regenerated Carbon Adsorber System also will be opened. The Vapor Phase Polishing Carbon Adsorbers will be aligned such that one vessel is in the lead operating position, while the other is aligned to be in the lag position. The zeolite system also will be aligned with one vessel in the lead position and the other in the lag position. Each vacuum blower test is expected to last approximately 20 to 30 minutes. During the test runs, all piping connections, instruments, valves, vacuum levels, temperatures, and vapor flows will be checked. When the test runs of the vacuum blowers confirm the operational status of all systems, the air stripper test run will commence.

2.4.2.2 Air stripper testing

One test run will be conducted for the two air strippers (A-102A/B) and the Air Stripper Blower (B-102). The test run for the air strippers will be performed after the vacuum blower tests, because the vacuum blowers will be required to provide the motive force for the pressurized air generated by the air stripper blower (B-102) to preclude over pressurization of the vapor/liquid separators (T-101 and T-102). The air stripper test run is expected to last approximately 20 to 30 minutes. All piping connections, instruments, valves, air flow, and pressure differential will be checked during the test run. Test data will be evaluated, and any problem found will be corrected before proceeding to the next test run. When the test run confirms the operational status of the air stripper system, the steam regenerated carbon adsorber system test runs will commence.

2.4.2.3 Steam regenerated carbon adsorber system

Multiple test runs will be conducted for the steam regenerated carbon adsorber system. Tests will be performed for each alignment of the carbon adsorbers (varying lead and lag adsorber units). Operating details for the steam regenerated carbon adsorber system are provided in the manufacturer's O&M manual (*Operating and Maintenance Manual for LATA Kentucky Solvent Recovery Unit, Kevil, Kentucky*, prepared by Fusion Environmental Corporation, April 2013). Each steam regenerated carbon adsorber system test run is expected to last approximately 75 to 100 minutes and will include testing of the automatic switching between the lead-lag adsorber configurations and timing sequences of the steam regeneration cycles and the drying and cooling cycles for the adsorbers (Note: no steam will be admitted during these tests). Each adsorber configuration will be tested in a "timed switching" mode as well as in switching due to detected outlet concentration [outlet concentration will be simulated by manual input of data to the steam regenerated carbon adsorber programmable logic controller (PLC)]. During the test runs, piping connections, instruments, valves, inlet and outlet of pressure levels, temperatures, and vapor flows will be checked. Test data will be evaluated, and any problem found will be corrected before proceeding to the next sequential test run.

2.4.2.3.1 Steam boiler

Multiple test runs will be conducted for the steam boiler. Initial tests will include start up and shut down of the boiler and establishing steam pressure available at the steam regenerated carbon adsorber system preconditioning subsystem. Testing will include verification of control system functions and that all interlocking systems are programmed and operable. Test data will be evaluated, and any problem found will be corrected before proceeding to the next test run.

2.4.2.3.2 Vapor phase carbon adsorbers

Vapor phase carbon adsorbers were tested prior to and operated during Phase I operations. Testing will be performed prior to commencing Phase IIa operations, and mechanical fittings will be inspected to verify system integrity has been maintained following the lengthy down time of the system between the end of Phase I and the commencement of Phase IIa operations.

2.4.2.3.3 Zeolite adsorbers

Zeolite adsorbers were tested prior to Phase I operations. Testing will be performed prior to commencing Phase IIa operations, and mechanical fittings will be inspected to verify system integrity has been maintained following the lengthy down time of the system between the end of Phase I and the commencement of Phase IIa operations.

2.4.2.3.4 Test conclusion

Upon completion of all tests listed above, test data will be evaluated, and any problem found will be corrected before proceeding to the start-up and operation of the SVGTS. When the test run confirms the operational status of the system, the SVGTS remediation start-up and operation may commence.

2.5 SHUTDOWN

2.5.1 Operational Shutdowns

The ERH system and the SVGTS will have separate computer-based control systems. While both systems will have system interlocks designed to protect equipment and personnel and prevent release of contaminants to the environment, there are no direct interlocks between the two systems; therefore, one system will not automatically shut down the other. The system operators will be notified and will make necessary changes if problems occur in either of the units.

Two categories of shutdowns, planned and unplanned, are associated with the ERH and SVGTS. A planned system shutdown is controlled by operating procedures. An unplanned shutdown, which is a result of an off-normal condition, is initiated either automatically by the computer-based control system or by operators located on- or off-site (remotely). The ERH system can be shut down by anyone on-site by initiating an emergency shutdown via one of the emergency shutdown devices; however, only authorized operations personnel can energize the electrode field. Likewise, the SVGTS can be shut down by personnel on site by initiating one of the emergency shutdown devices. The ERH and SVGTS have separate emergency shutdown devices.

Remote ERH operators can determine if system faults or unwanted operating conditions exist inside the ERH or recovery/treatment systems. Most faults and undesired operating conditions can be corrected remotely by altering operating parameters or can be tolerated until the next scheduled site visit. More severe system faults may require system shutdown and operator call-out.

Because collection and treatment of the vapor and groundwater are vital operations, any shutdown of the SVGTS is communicated automatically to the SVGTS operations personnel. The ERH operator is contacted by the SVGTS operations personnel once the fault is evaluated to communicate the severity of the fault to the ERH operator so the ERH operator may conduct an orderly shutdown of the PDSs until the SVGTS is back online.

Except in the case of long-term shutdown, the operation of the SVGTS does not have to be adjusted due to minor problems with the ERH system. The alarms associated with ERH and SVGTS (along with the actions caused by each alarm) are identified in Table 3.

In the event of an overall site power outage, all ERH, and SVGTS equipment will shut down, and the operations staff will be contacted via the respective systems' automatic callout device using an emergency battery pack for power. The SVGTS has backup diesel generators that can be used to run the vapor recovery system at a reduced flow rate. The generators have the capacity to run one of the vacuum blowers, the steam regenerated carbon adsorber system, and the steam boiler. The groundwater recovery/treatment system, water injection, and ERH system will remain shut down. This will allow removal of roughly 400 to 500 scfm of air from the soil to minimize the potential for diffusion of VOCs from the heated soil. During power outage, the groundwater extraction/treatment system will remain shut down. When power is restored, the treatment system will be returned to normal configuration and restarted.

Table 3. System Alarms and Actions

Condition	Alarm	Action
Sitewide Power Failure		
Sitewide power failure	ERH PDS alarms SVGTS alarms	1. All equipment shuts down. 2. Operations staff is notified via autodialer. 3. Vapor recovery may be started manually at reduced rates with backup power. 4. ERH can be restarted remotely after brief (20 minute) power failures; site visit is required following extended power failures.
ERH PDS—Major Fault		
• Power failure • PDS transformer overheating • Tap switch out of position • Loss of power to controls	ERH PDS alarms	1. ERH PDS shuts down. 2. Problem seen in daily check. 3. Vapor and groundwater treatment and recovery systems remain operational. 4. Alarm cleared remotely or by site visit.
ERH PDS—Minor Fault		
• Loss of an electrical phase • Unbalanced electrical phases	No alarms	1. All systems remain operational. 2. Problem seen in daily check. 3. Remote or on-site adjustments made.
Electrode Field		
• Electrode malfunction or failure • Electrode overheating • Loss of temperature in subsurface	No alarms	1. All systems remain operational. 2. Problems seen at daily checks. 3. Perform on-site inspection.
Vapor Recovery Condenser and Chiller System		
• High-high liquid level in vapor/liquid separator T-102 • Cooling tower fault (fan failure, low water flow) • Low temp chiller fault (compressor fault, low coolant flow)	SVGTS alarms	1. Recovery/treatment operations staff is notified via autodialer. 2. Vapor recovery blowers are automatically shut down for high-high liquid level in T-102. For cooling tower and chiller faults, operations staff shut down blowers if warranted. 3. ERH control is alerted by SVGTS operations staff upon shutdown of vapor recovery blowers, and ERH operator shuts down power to electrodes. 4. Groundwater recovery/treatment shut down. 5. Site visit is required to restart systems, if fault does not autocorrect.
Vapor Recovery Blowers (Single Blower Failure)		
• Blower failure • Blower overheating	Vapor recovery blower alarms	1. Vapor treatment and ERH systems remain operational. Vapor recovery flow is automatically reset to 50% flow. 2. SVGTS operations staff is notified via autodialer. 3. Site visit is required to restart blower if fault does not autocorrect.

Table 3. System Alarms and Actions (Continued)

Condition	Alarm	Action
Vapor Recovery System (Both Blowers Fail)		
• Power failure • Blower failure • Blower overheating	Vapor Recovery blower alarms	1. Treatment/recovery system (groundwater and vapor) automatically shuts down. SVGTS operations staff is notified via autodialer. 2. ERH operator is alerted by SVGTS operations staff and ERH operator shuts down power to electrodes. 3. Condensers remain operational. 4. Site visit is required to restart systems if blower fault does not autocorrect.
Vapor Treatment System		
Failure of individual vapor treatment (vapor treatment-compressor/cooler and condensation/adsorption) skids	System alarm	1. Faulted skid is automatically shut down. SVGTS operations staff is notified via autodialer. 2. Treatment/recovery operators lower soil vapor extraction rate to match treatment skid capacity.
High VOC in outlet of carbon regeneration skid	System alarm	1. All systems remain operational. SVGTS operations staff is notified via autodialer. 2. Treatment/recovery operators trouble shoot system to identify problem.
High VOC outlet of lead or primary carbon/zeolite beds	Problem seen in routine system monitoring	1. All systems remain operational. SVGTS operator switches secondary adsorber to primary adsorption duty. 2. GAC/zeolite vessel change-out required.
High VOC outlet of vapor treatment system	System alarm	1. Vapor/groundwater extraction and treatment systems are automatically shut down. 2. SVGTS operations staff is notified via autodialer. 3. Treatment/recovery operators trouble shoot system to identify problem.
Groundwater Treatment System		
High-high level in DNAPL separator	System alarm	1. SVGTS operations staff is notified via autodialer. 2. Groundwater recovery pumps automatically shut down. Vapor recovery/treatment and ERH systems remain operational. 3. Site visit is required to troubleshoot and correct.
High-high level in TCE tank	System alarm	1. SVGTS operations staff is notified via autodialer. 2. Liquid TCE pumps (DNAPL transfer and decanter TCE condensate) automatically shut down. Vapor recovery/treatment and ERH systems remain operational. 3. Site visit is required to troubleshoot and correct.
High-high level in air stripper feed tank	System alarm	1. SVGTS operations staff is notified via autodialer. 2. Groundwater recovery pumps automatically shut down. Vapor recovery/treatment and ERH systems remain operational. 3. Site visit is required to troubleshoot and correct.

Table 3. System Alarms and Actions (Continued)

Condition	Alarm	Action
Groundwater Treatment System (continued)		
• High-low level in hot groundwater tank • Low reinjection water flow • High-low level in air stripper effluent tank • Low level in air stripper feed tank • High temperature in water discharge • High-low air flow to air stripper	System alarm	1. SVGTS operations staff is notified via autodialer. 2. Vapor recovery/treatment and ERH systems remain operational. 3. Site visit is required to troubleshoot and correct.

GAC = granular activated carbon
DNAPL = dense nonaqueous-phase liquid

2.5.2 Ceasing IRA System Operations

The criteria for ceasing IRA system operations are contained in Table 4 of the RDR.

3. DESCRIPTION OF NORMAL O&M

3.1 SYSTEM OPERATION

3.1.1 ERH System

The ET-DSP™ system is designed to require minimal on-site personnel during normal operations. Software running on the on-site server automatically controls current and water injection to the electrodes and continuously monitors operating parameters. ERH technology provider personnel in Calgary, Canada, make adjustments to electrode operation and data monitoring via the internet. On-site operators will be required to observe well field conditions, collect operational data, and perform other duties such as checking circuit breakers, visual indicators, low-voltage switches, circuit boards, network devices, or other components.

During routine operations, on-site operators will be required to observe the conditions of the site and take manual measurements. These duties may include reading gauges for pressure, temperature, or flow; taking readings from electrical and water utility meters; measuring electrical currents and voltage; reporting any abnormal conditions; and performing emergency shutdowns if necessary. ET-DSP™ operations will be carried out according to specifications in the project design, work control documents, or as required by site conditions.

3.1.2 SVGTS

Operations for the groundwater treatment system will consist of routine monitoring, inspections, sampling, and system adjustments. These activities will be governed by operating procedures, task work instructions, and manufacturers' equipment manuals.

Once the SVGTS has started, operating parameters will be monitored and recorded to ensure proper operation. Parameters such as air stripper liquid flow rate and total volume treated; air stripper air flow rate, temperature, and pressure; and groundwater VOC concentrations will be checked. Operational data collection information will be recorded manually in project log books and data collection forms governed by operating procedures. Data collected via the control system are collected and maintained in the electronic data collection system.

The off-gas emissions will be monitored by a photoacoustic analyzer that will communicate with a control system. The control system will shut down the vapor extraction and treatment system and notify operations personnel in the event of an exceedance of discharge criteria, as detected by the photoacoustic analyzer monitoring the stack effluent stream. Effluent vapor monitoring at the stack will be performed by the photoacoustic analyzer any time VOCs are being processed through the treatment system.

3.2 SYSTEM MAINTENANCE

Equipment maintenance, repair instructions, and troubleshooting are addressed in maintenance manuals supplied by the equipment vendors. Information on equipment will be retained on-site for maintenance purposes. Maintenance activities may include the servicing, repair, or replacement (if necessary) of equipment. Equipment will be maintained as recommended by the manufacturer and/or best engineering practices.

Information will also be obtained from vendors regarding equipment spare parts. This information will be evaluated to develop a list of key spare parts. The development of this list will consider availability and cost of the parts as well as their significance to system operation.

3.2.1 ERH System

Preventative maintenance for ET-DSP™ equipment is minimal, and any maintenance that arises from operating problems generally will require electrical expertise and/or in-person training on operation of the system. Maintenance tasks may be necessary to optimize ET-DSP™ performance or mitigate operating problems. Examples are as follows:

- Taking voltage and current measurements for troubleshooting;
- Performing partial or full power down of individual breakers for system adjustments;
- Replacing circuit boards or electrical components;
- Adjusting electrode or ET-DSP™ neutral configuration;
- Changing transformer tap settings inside the PDS to adjust electrode voltages; and
- Repair or replacement of faulty solenoid valves with the WCS.

On-site operators will not perform maintenance inside the PDS or electrical panels without the specific electrical training. On-site operators may be required to perform routine maintenance tasks such as the following:

- Repair hose connections and fittings if leakage is observed.

- Clean Y-strainers inside the WCS or in the well field.

- Check if the solenoid control valves within the WCS are functioning properly.

- Troubleshooting, moving, and/or replacing digiTAMs™ while taking appropriate thermal and electrical safety precautions.

- Adjust pressure regulators on the air lines supplying compressed air to the pneumatic pumps.

- Check local network and internet connections, reset the on-site server and other network devices or repair the network CAT 5 cable if it is damaged.

3.2.2 SVGTS

Maintenance required for the SVGTS will be routine and periodic to include, but not limited to, inspection of the equipment and reporting defects that could lead to equipment damage or breakdown. Any defects noted during the performance of maintenance will be reported to the C-400 Operations Manager or designee. Preventive maintenance checks will be performed by the system operator.

Routine maintenance may include lubrication of motors, blowers, and pumps; cleaning and replacement of bag filters; and replacement of the blower inlet filter, as recommended by the manufacturer.

Periodic maintenance of the air stripper will include inspections and cleaning of the column and packing if necessary. A high-pressure washer or manual cleaning of the column shell (e.g., wire brushing, scraping) should be sufficient. The estimated frequency of cleaning is once every 9 to 12 months. The manufacturer's instructions and/or best engineering practices will be followed for any required cleaning or maintenance.

Routine O&M for the Phase IIa steam regenerated carbon adsorber unit including visual inspections, system adjustments, and routine and minor corrective maintenance will be performed by on-site personnel. The steam regenerated carbon adsorber unit provider will be responsible for on-site troubleshooting (if necessary), repair/replacement/maintenance of specialized components, and major corrective maintenance during the warranty period. The system operator will take over these functions upon conclusion of the warranty period. Initial loading and any required change out of the carbon media will be performed by the system operator or their approved subcontractor.

The effluent transfer line may require periodic cleaning depending on the amount of scale that accumulates. Other infrequent, unscheduled maintenance may include replacement of worn bearings, seals, gauges, etc. The vapor extraction lines will not require frequent maintenance. The groundwater flow totalizers may require periodic cleaning.

The SVGTS will contain several types of media used in the treatment of VOC-contaminated extracted groundwater and vapors such as activated carbon, ion exchange resin, and zeolite. Maintenance activities for these media will involve periodic replacement based on system monitoring. Replacement of media is discussed further in Section 8.5 of this plan.

3.3 OPERATING CONDITIONS

Discrete interval heating and independent electrode control are critical to address the variability in conditions that are present in the subsurface at the C-400 Cleaning Building area. Power requirements and heating response will be quite different in the UCRS versus the upper RGA.

The ET-DSP™ design will allow for evaluation of operational parameters during the treatment period. Operational parameters to be measured include, but are not limited to, the following:

- Vapor recovery and treatment rates
- Subsurface temperature throughout the treatment zone
- Pressure at vapor extraction well heads
- Vacuum monitoring readings

- Water injection rate through electrodes and groundwater extraction rate
- Effluent contaminant concentration to demonstrate compliance with permit requirements

The SVGTS is designed for maximum flow rates of vapor and groundwater, which will occur if the ERH system is operated at full capacity. The SVGTS is also designed with sufficient turndown to operate during the soil heat-up period when flows are at a minimum. Operational values presented in this O&M Plan are estimated and may be adjusted based on actual operating conditions, without requiring revisions to this plan.

Vapor temperature from the extraction wells is estimated to be as high as 203°F, with a VOC concentration as high as approximately 10,000 ppmv when it enters the vapor treatment system. The VOC concentration is expected to drop to approximately 8,000 ppmv due to contaminants being removed via condensate as it travels through the main treatment line. After vapor is processed through the steam regenerated carbon beds, the polishing carbon adsorbers and zeolite system (if needed), the VOC concentration at the stack discharge will be below discharge limits.

Groundwater from the extraction wells will enter the liquid treatment system at the feed surge tank at a flow rate of approximately 30 gpm. The influent groundwater temperature may exceed 200°F, with a VOC concentration up to approximately 1,100 mg/L. Once the groundwater is processed through the air stripper, the water temperature will be approximately 150-160°F and VOC concentration is expected to drop to approximately 5 mg/L. The vapor that is stripped from the groundwater is anticipated to reach a maximum concentration near 220 ppmv. After groundwater is processed through the carbon adsorbers, it will be discharged to an on-site ditch at approximately 100°F. This ditch drains to KPDES-permitted Outfall 001. The VOC concentration will be below the discharge limit of 30 μg/L.

During operations, the steam regenerated carbon adsorption system will shift the duty of the adsorber beds based on the timed regeneration cycle. When the initial configuration is as follows:

- Adsorber bed A in the lead position,
- Adsorber bed B in the lag position, and
- Adsorber bed C in the regeneration position.

A typical run cycle is as follows: The regeneration of adsorber bed C consists of 60 minutes of steam operations followed by 10 minutes of cooling air to cool and dry the carbon media. After 70 minutes of operation in the above alignment, the control system for the steam regenerated carbon adsorption system will do the following:

- Shift adsorber bed C to the lag position,
- Shift adsorber bed B to the lead position, and
- Shift adsorber bed A to start its regeneration and cool-down cycle described above.

The steam regenerated carbon adsorption system will continue to cycle valve alignments to shift the lead, lag, regenerating carbon adsorption beds in this 70 minute timing sequence, provided no VOC concentration on the outlet of the lead or lag carbon adsorption bed indicates high VOCs.

VOC concentration in the vapor extraction and treatment train will be monitored continuously by an infrared VOC monitor in the steam regenerated carbon adsorption system. The outlet of the lead carbon adsorber will be monitored; if VOC concentration is high (greater than VOC concentration equivalent to 20 ppmv TCE), the following sequence occurs:

1. Place the standby adsorber in the lag position,
2. Shift the lag adsorber to the lead position, and
3. Shift the lead adsorber to commence the regeneration process.

The infrared VOC monitor also will monitor the outlet of the lag adsorber, the outlet of the steam regenerated carbon adsorber system. If the outlet of the steam regenerated carbon adsorber system is high (greater than VOC concentration equivalent to 20 ppmv TCE), the sequence outlined above occurs. The system operator also will receive a system alarm indicating the high VOC concentration in the outlet of the steam regenerated carbon adsorption system. The operator will monitor the trend of this outlet concentration to determine if adjustment to the regeneration timing cycle is necessary.

Off-gas from the vapor-phase polishing system will be discharged to the atmosphere through a 20-ft tall by 8-inch diameter stack. Off-gas emissions will be monitored by a photoacoustic analyzer. The analyzer will communicate with a control system to shut down the vapor extraction and treatment system, including the vacuum blowers and notify operations personnel in the event of an exceedance of discharge criteria. The set point at the stack that will cause the vapor extraction and treatment system to shut down is 20 ppmv of any VOC of concern. This is based on the air dispersion modeling results presented in the C-400 Phase IIa Remedial Action Work Plan (RAWP). The air dispersion modeling results indicate that a stack concentration of 20 ppmv results in property boundary concentrations that are significantly lower than the off-site limits; thus, the system will be shut down before emissions reach the quantities that will exceed acceptable risk levels.

Interlocks associated with off gas monitoring will not be disabled while the system is in operation unless appropriate alternate monitoring is in place. A weekly calibration check is required for the photoacoustic analyzer, which requires the unit to be placed off-line and the associated interlock disabled. When this occurs, the process display will clearly indicate that the interlock is disabled and/or the system is operating in manual mode. Alternate monitoring will include the use of a portable photoacoustic analyzer that has the same detection limit and accuracy as the stationary unit. The portable photoacoustic analyzer will have the capability to communicate clearly via visual and/or audible alarms if discharge criteria have been exceeded. This equipment will be monitored on-site at all times by trained personnel during any operational period when the off gas monitoring interlock is disabled. The operator will have the capability to shut down the aboveground treatment systems manually via a single stand-by shutdown switch. The manual shut down process will terminate these operations within a time frame comparable to an automatic system interlock shutdown of these systems. If a shutdown is required, power to the electrodes also may be shut off if the aboveground treatment system will be off-line for an extended period. The ERH operator will determine shutdown requirements based on the electrode field conditions such as the amount of energy in the formation, subsurface temperatures, and projected downtime of the aboveground treatment system.

Normal operating hours will be 0600 (6:00 a.m.) to 1630 (4:30 p.m.) Monday through Thursday. During this period, operations staff will be on-site for daily inspections and routine system O&M. Outside of normal operating hours, on-call personnel will be available to respond to off-normal conditions such as system shutdowns, plant outages, or other upset conditions. Operating hours may be extended to dual shift operation during the initial start-up phase of the project.

3.4 SCHEDULE FOR O&M TASKS

3.4.1 ERH System

The ET-DSP™ has automated data acquisition capability for monitoring essential operating parameters.

In addition, the following manual measurements will be collected and recorded (daily on regular work days during the first week of start-up and once every week thereafter):

- Voltage (phase to phase) to each electrode
- Currents supplied by each phase of the secondary sides
- Neutral current on each grounding line terminated at the PDS
- Electrical utility meter reading
- Water meter reading for the main WCS supply
- Periodic Step and Touch Potential tests at locations specified by the ERH Technology Provider

3.4.2 SVGTS

Operational inspections for the SVGTS will be performed at least twice daily on regular work days (Monday through Thursday). These inspections will confirm that the system is operational and help detect potential problems that might result in downtime. Inspection activities may include, but are not be limited to, checking the following:

- Vacuum blower operation
- Inlet vacuum pressure
- Outlet discharge pressure
- Inlet and outlet vapor flow indicators
- Inlet vacuum blower temperature
- Carbon adsorber outlet temperature
- Liquid/vapor separator water level
- Liquid/vapor separator liquid flow rate
- TCE storage tank level
- Water flow to the WCS

Operational checks will include documentation of system parameters and conditions. Inspection documentation will be recorded in project logbooks or operational data collection forms. After approximately one month of testing, routine operations are expected to commence. A summary schedule of routine O&M tasks is shown in Table 4. Sampling of vapor contaminants is covered in Section 5.2, Operational Sampling.

Table 4. Operations and Maintenance Tasks

O&M Task	**Schedule/Frequency***
Operator (technician) visit	Daily
Ensure that system is operational	Daily
Record treated water totalizer reading at the treatment system	Daily
Record blower discharge pressure	Daily
Inspect extraction vapor well heads	Daily
Measure and record pressure at vacuum monitoring wells	Daily
Measure and record vacuum at vapor extraction wells	Weekly
Inspect valves, check gauges, lubricate equipment	Quarterly
Operate sump pump (if applicable)	As required
Inspect air stripper	Semiannually (or as needed)
Replace spent vapor polishing carbon (as required)	As necessary
Replace spent liquid carbon (as required)	As necessary
Replace spent zeolite (as required)	As necessary
Replace ion exchange spent resin (not anticipated)	N/A

Table 4. Operations and Maintenance Tasks (Continued)

O&M Task	Schedule/Frequency*
Lubricate pump bearings	Per manufacturer's instructions
Clean discharge piping	As necessary
Check fail-safe shutdown interlocks	Annually

*Minimum frequency.

Waste generated from project activities will be managed in accordance with the project waste management plan. Refer to Section 12—Waste Management Plan of the RAWP.

4. POTENTIAL OPERATING PROBLEMS

This section describes operating problems that may cause a shutdown of the ERH System or the SVGTS. The discussion is limited to major problems and is not all-inclusive.

4.1 POTENTIAL OPERATING PROBLEMS AND COMMON REMEDIES

4.1.1 ERH System

Site conditions and subsurface response to system operations may vary during electrical heating and present challenges to the performance of ET-DSP™ treatment. In addition, power surges and long-term use occasionally have caused damage to PDS control and monitoring components, requiring corrective maintenance. Based on the ERH technology provider's experience at other sites and at the C-400 project during Phase I, the following operating problems have the potential to arise during treatment.

4.1.1.1 Phase imbalance

The PDS supplies 3-phase power to the electrodes, and although the electrode phases are assigned to optimize system performance, varying soil properties across the site will prevent true phase balance. The control software continuously adjusts for site variations by setting the effective current at each electrode through the Time Distributed Control Module (TDCM) and injecting water to maintain electrical conductivity around the electrodes. If reasonable phase balance cannot be maintained by the control software, the ET-DSP™ neutral current will be excessive, resulting in electrical hazard at the well field grounding points and less efficient power use. If power cannot be maintained at certain electrodes, it may be an indication of WCS malfunction and an on-site operator may need to verify water injection to the electrode well. Otherwise, a qualified person will be required on-site to reconfigure the electrode wiring and change transformer tap settings to achieve phase balance.

4.1.1.2 Over-current

The control software is designed to prevent excessive current on any group of electrodes beyond the capabilities of the system. This is done by limiting the effective current or water injection rate at the electrodes as needed. If the control software fails to limit the current, any breakers in place at the main distribution panel and inside the PDS may trip. A qualified person will be required on-site to reset the breakers and ensure the system powers up fully. If the breakers continue to trip, it may indicate a malfunction in the TDCM control circuit or WCS controller or require a decrease in transformer tap voltage.

4.1.1.3 Low power at electrodes

The PDS must be able to maintain power at the electrodes as defined in the ET-DSP™ design to achieve the treatment goals. Mc^2 remote operators will adjust control parameters and ensure the software is operating properly prior to requesting on-site action to increase current at low power electrodes. If the control software is not able to maintain current to an electrode, on-site personnel will be required to examine the system and take corrective action. The on-site person will aid the remote operator in verifying operation of the control circuit and water injection for the electrode. If a component of ET-DSP™ is malfunctioning, corrective action will be determined by Mc^2 and performed by a qualified person. The electrode power can be increased if the transformer tap voltage to the affected electrode is increased. If power at the electrode cannot meet the design specifications, the site operations group will determine what further action is required.

4.1.1.4 Grounding

If the ET-DSP™ neutral lines carry excessive current and the phases are reasonably balanced, the grounding connections to the extraction wells may require adjustment. Additional grounding may be needed if any step and touch potentials at surface are beyond safe levels and electrically insulating the component is not sufficient. A qualified technician will be required to adjust the grounding scheme as instructed by Mc^2.

4.1.1.5 Current sensors

If manual clamp meter measurements do not correspond closely with automated current readings for a given electrode, the current sensor may need recalibration. A trained operator will need to work with Mc^2 office staff to adjust the sensor to read accurately. If recalibration does not improve the accuracy, the current sensor will need corrective maintenance as determined by Mc^2.

4.1.1.6 Network communication

The control and monitoring network for ET-DSP™ may malfunction on occasion. Often the solution is simply to reset the affected network device and communication will be restored. Otherwise the affected network device or CAT5 connection will need to be replaced. On-site operators may be asked to reboot the on-site server or external modem if internet service to the site is interrupted. The internet service provider will be contacted if downtime exceeds one hour.

4.1.1.7 Water circulation system

If power at any electrode is not maintained, it may indicate a malfunction on the corresponding WCS channel and may require any of the following actions:

- The on-site operator will need to verify water injection to the electrode and initiate corrective maintenance if necessary;

- The pump may need adjustment or repair if WCS monitoring indicates insufficient pressure at the water supply;

- The WCS may be prone to network interruptions or component failure requiring action from operators or qualified persons;

- Repair any leaks occurring inside the pump cabinet or from electrode hoses; and

- Clean Y-strainers at the pump if the water supply to the unit contains debris.

4.1.1.8 DigiTAM™ sensors

DigiTAM™ temperature sensors must endure a harsh environment when installed in monitoring wells at thermal remediation sites. Malfunctioning of these sensors is possible and may require any of the following actions:

- Ensure network communication is functional and reset or repair network devices as needed.
- Verify switching function of the data channel inside the well field panel by viewing light-emitting diode (LED) indicators.
- Test communication with the sensor string using a laptop with a digiTAM™ reader.
- Remove the digiTAM™ from the well to inspect for damage and repair or replace as necessary.

4.1.2 SVGTS

Power surges and long-term use may cause damage to SVGTS equipment and control and monitoring components, requiring corrective maintenance. Based on the operating experience during Phase I at the C-400 project, the following operating problems have the potential to arise during Phase IIa operations.

4.1.2.1 Power failure

If a power failure occurs due to a utility problem or a site distribution problem, the failure will be sensed by the Automatic Transfer Switches (ATS). Each ATS will provide a signal to the respective back-up generator causing it to start automatically. Once the back-up generator is up to speed and voltage, the respective ATS shifts to provide essential 480 VAC, 60 Hz electrical power to critical electrical loads. These critical electrical loads must be restarted by a member of the operations staff. Under normal circumstances, emergency electrical power will be available in a matter of minutes. Operations personnel should contact the Plant Shift Superintendent (PSS) to report the problem and to determine the anticipated extent and duration of the outage.

After normal electrical power is restored, preparations will be made to restart the system on the normal power supply at the earliest possible time.

Any condensate or water that collects in the vapor/liquid separators will drain into the condensate sump tank where it then will be pumped to the liquid treatment system. A high-level switch will alarm if the water level increases to the point where it might reenter the gas stream. If the fault condition persists, the high-high switch also will shut down the blowers, thereby shutting down the vapor treatment system and alerting operations personnel.

4.1.2.2 Mechanical equipment failure

Mechanical failures may occur with equipment or components requiring repair, replacement, or recalibration. Once a failure is detected, the remedy will be discussed among operations personnel to determine the appropriate solution. If repair or replacement is required, the system or unit will be placed in a safe condition (i.e., shut down, taken off-line) and then isolated and locked out/tagged out as required. Repair or replacement will be performed following the manufacturer's instructions and approved task work instruction(s).

5. ROUTINE MONITORING AND LABORATORY TESTING

5.1 MONITORING TASKS

5.1.1 ERH System

Vapor recovery and groundwater extraction wells will be monitored routinely throughout heating operations to evaluate progress and to develop data plots for use, ultimately to identify when asymptosis has been achieved. The following sections describe the types of wells and instrumentation used to monitor subsurface conditions.

5.1.1.1 Multiphase extraction wells

Multiphase extraction wells are used to extract groundwater with submersible pumps and vapor by connecting the vapor screen in the vadose zone to the vacuum lines. Each multiphase extraction well has a pneumatic pump and extraction wells will have temperature and vacuum gauges installed on the well heads for monitoring well conditions.

5.1.1.2 Vapor extraction wells

Vapor extraction wells will be used to extract subsurface vapors and improve vacuum conditions in the area of the well.

5.1.1.3 Vacuum monitoring wells

Vacuum monitoring wells are designed to monitor vacuum conditions at the edge of the treatment area. If vacuum conditions at the edge of the plume are inadequate, they could be connected to the vapor extraction system, but are not designed for high flow. If this contingency is required to be implemented, the vacuum monitor well must be connected to the vapor extraction header via a throttle valve to preclude collapse of the fiberglass vacuum monitoring well screen.

5.1.1.4 Temperature monitoring

DigiTAMs™ are multi-point temperature sensing strings that are placed in monitoring wells throughout the treatment volume. Monitoring down-hole temperatures within the electrode array is crucial for optimizing ET-DSP™ for the full target area.

Temperature data will be gathered every 30 minutes from the digiTAMs™ installed in the well field. Graphical presentation of the data on the web site will consist of the following:

- Vertical temperature profiles for each digiTAM™ string;
- Temperature history, 7-day and full history, for each sensor string; and
- Horizontal temperature slices from 18 ft below ground surface (bgs) to 66 ft bgs performed at least twice per week.

5.1.2 Soil Vapor and Groundwater Treatment System

The SVGTS will be monitored by computer-controlled instrumentation as well as by on-site inspections by system operators. Routine system monitoring will include inspecting and recording information from instruments such as pressure gauges, flow totalizers, flow meters, and control panels. Additional activities will include inspections of the piping systems, storage tanks, system pumps/blowers, inline filters, filter beds, and other system equipment. Routine monitoring of the system will help confirm anticipated operating set points and/or establish normal system operating conditions.

5.1.2.1 Soil vapor extraction monitoring

Each vapor extraction wellhead will have a temperature and pressure gauge to indicate the temperature of the extracted vapor and the vacuum at each well. A pitot tube also will be installed near the wellhead to allow vapor flow to be measured and a vapor sample to be obtained. Note that obtaining a vapor sample will require use of a vacuum pump to overcome the vacuum in the vapor line.

SVE will be performed using positive displacement blowers. Positive displacement blowers are best suited for applications of high vacuum and relatively high flow. A vapor treatment system will be connected to the SVE system. Sampling ports and gauges will be supplied to measure vacuum, flow, and temperature at the blower inlet and pressure and temperature at the blower outlet. Vacuum, pressure, and temperature will be measured with a gauge, while flow is measured by pitot tubes read with water filled manometers or magnehelic gauges, or by other appropriate technology identified at installation.

5.1.2.2 Ion exchange system monitoring

During operation of the groundwater treatment system, the ion exchange vessels will be monitored for technetium-99 (Tc-99). When resin in the lead vessel becomes exhausted, the valves on the ion exchange beds will be changed to put the lag bed online as the lead bed and the exhausted resin will be replaced with fresh resin. Planning for a resin change-out in the lead resin bed will begin when the Tc-99 concentration in the lead resin bed effluent exceeds 50% concentration of Tc-99 in the treatment system influent. When Tc-99 concentration in the effluent of the lead resin bed reaches 80% of the Tc-99 concentration in the treatment system influent, the resin beds will be realigned to place the lag resin bed in the lead position and isolate the lead resin bed. The resin will be changed out in the exhausted bed, and the resin bed will be returned to service in the lag position.

5.1.2.3 Carbon adsorbers monitoring

5.1.2.3.1 Vapor phase

Vapor samples will be collected periodically from various points in the vapor treatment stream to monitor the effectiveness of the treatment units. For example, samples will be collected from the outlet of the lead steam regenerated carbon vessel as well as from the outlet of the lag vessel to determine optimum timing to switch lead/lag/regeneration duties of the vessels. These samples will be monitored real-time by installed infrared VOC monitors. Likewise, the lead vapor phase polishing carbon vessel discharge will be sampled to determine if and when a carbon change-out should be performed. Compliance with discharge criteria will be monitored at the vapor treatment system stack. These samples will be monitored real-time by the photoacoustic analyzer.

5.1.2.3.2 Liquid phase

Water samples collected upstream of aqueous-phase carbon vessels will be compared to those from the lead carbon vessel effluent to determine if and when a carbon change-out should take place. Samples will be collected routinely from the water treatment system effluent to monitor it for compliance with discharge criteria.

5.1.2.4 Infrared VOC monitors

There are two infrared VOC monitors installed in the steam regenerated carbon system. One monitors the inlet and outlet of the lead carbon adsorption vessel on a rotating frequency; the second monitors the steam regenerated carbon adsorption system outlet stream. The cycling of adsorbers occurs on a continuous basis and is operated by a PLC-based timer control. The monitor for the lead carbon adsorber transmits the indicated VOC concentration to the carbon adsorption system PLC, which controls the steam regenerating cycles of the carbon adsorbers (see Section 3.3 for regeneration cycle details). The monitor for the steam regenerated carbon adsorber system effluent transmits VOC concentrations to the PLC, which will initiate an alarm to the operator indicating the high VOC concentration condition. Data from these VOC monitors will be communicated to the SVGTS PLC to allow for system interlocks to be associated with system interlocks.

Photoacoustic analyzers will be used to monitor air quality (primarily TCE and its breakdown products) at the treatment system. Analyzer results from the permanently mounted photoacoustic analyzer are recorded during operation. The permanently mounted photoacoustic analyzer is integrated into the system for continuous monitoring of the effluent vapors. The permanent analyzer is a fixed system that analyzes the vapor as it exits the discharge stack. Discharge stack analyzer results will be recorded approximately every two minutes during operation and will be logged/recorded for future evaluation. The sample hose from the extraction point to the analyzer will be heat traced to minimize any unlikely carryover moisture from condensing in the probe and being extracted to the analyzer.

In addition to monitoring the treatment system vapor effluent, the fixed photoacoustic analyzer also will collect samples from the other vapor sample points listed in Table 5 of this plan. The photoacoustic analyzer can obtain measurements from multiple sample ports with sample lines from each port.

The analyzer system is linked to the system controls through a central PLC. Should the effluent parameter be exceeded, the PLC will shut down the SVGTS in a preprogrammed cycle and automatically make notification to the process operator that the system is in a shutdown mode. The project team will determine whether to manually shut down the ET-DSP™ system depending on the circumstances involving the high effluent reading and the projected duration of the treatment system shutdown.

The PLC also shuts down the SVGTS if it does not receive a change in photoacoustic analyzer indication in a four minute time period. This failure of photoacoustic analyzer reading to change in four minutes indicates to the PLC that the photoacoustic analyzer is not operating, and the PLC shuts down the SVGTS to preclude operation without the associated stack interlock instated protecting from the release of high VOCs in the stack effluent. The process operator is notified of the system shut down via the installed autodialer.

Data collected by the photoacoustic analyzer is transmitted automatically to the project’s data logging computer (e.g., laptop) at the time of data collection where it is stored and retrievable. Additionally, data collected by the photoacoustic analyzer are stored within the analyzer for a period of 24 hours; at that time it is overwritten by newly collected data.

Table 5. Phase IIa Operational Sampling[a]

Sample Type	Location	No. of Sample Points	Frequency	Estimated Duration (commencing upon withdrawing and treating contaminated media)	Projected No. of Samples	Parameters
Water	Multiphase Extraction Wells	22	monthly	6 months	132	VOCs, Tc-99
	Air Stripper Feed Tank	1	monthly	6 months	6	TCE, Tc-99
	Air Stripper Effluent	1	monthly	6 months	6	TCE, Tc-99
	Lead Ion Exchange Column Effluent	1	monthly	6 months	6	Tc-99
	Lead Liquid Carbon Column Effluent	1	monthly	6 months	6	TCE
	Water Treatment System Effluent	1	weekly	6 months	24	VOCs, Tc-99, TSS, Chlorine
	Start-up—System Effluent[b]	1	daily	1 week	5	VOCs, Tc-99
Vapor	Multiphase Extraction Wells	22	bi-weekly	1 month	44	VOCs
(Summa)	Extraction/Electrode (XE) Wells	39	bi-weekly	1 month	78	VOCs
	Vapor Extraction Wells	11	bi-weekly	1 month	22	VOCs
	Southeast Treatment Area Vapor Header	1	monthly	6 months	6	VOCs
	Lead Vapor Carbon Column Effluent	1	monthly	6 months	6	TCE
	Vapor Treatment System Discharge Stack	1	monthly	6 months	6	VOCs
	Start-up—Stack	1	N/A	N/A	1	VOCs
Vapor						
(photoacoustic analyzer)	Combined Outlet of Vapor Treatment Skids	1	1/hour	During Ops.	Contingent on uptime	TCE (and breakdown products)
	Lead Vapor Phase Carbon Vessel Discharge	1	1/hour	During Ops.	Contingent on uptime	TCE (and breakdown products)
	Lead Vapor Phase Zeolite Vessel Discharge	1	1/hour	During Ops.	Contingent on uptime	TCE (and breakdown products)
	Treatment System Discharge Stack	1	~ 30/hour	During Ops.	Contingent on uptime	TCE (and breakdown products)
	Vapor Header	1	daily	During Ops.	Contingent on uptime	TCE (and breakdown products)
	Grab Samples from Well Field (extraction wells, vacuum monitors, and vapor headers)	multiple	as needed (portable photoacoustic analyzer inoperable), pulsed operations	as needed (portable photoacoustic analyzer inoperable), pulsed operations	Contingent on uptime	TCE (and breakdown products)

Table 5. Phase IIa Operational Sampling[a] (Continued)

Sample Type	Location	No. of Sample Points	Frequency	Estimated Duration (commencing upon withdrawing and treating contaminated media)	Projected No. of Samples	Parameters
Vapor	Lead Steam Regenerated Carbon Adsorber Vessel Effluent	3 (1 at each adsorber vessel)	7 seconds	During Ops.	Contingent on uptime	VOCs
(infrared gas monitor)	Steam regenerated Carbon Adsorption System Effluent	1	7 seconds	During Ops.	Contingent on uptime	VOCs

[a] Sampling will occur on normal business days.
[b] Rapid turnaround time (7 days) required during start-up period.

Additionally, grab samples will be collected with a portable photoacoustic analyzer at extraction wells, discharge header, and at other locations to assist in system start-up and determine overall system performance. These grab sample locations also will be utilized during pulsed operations to aide in determining when asymptosis has been reached.

5.1.2.5 Steam regenerated carbon adsorption system

The incoming process air is forced via the process blower through all but one of the fixed-bed carbon adsorbers where the solvents are removed and from which clean air is discharged. The system will operate in a series configuration where it will enter one vessel (lead vessel) and then be routed through a secondary vessel (lag vessel) for further polishing. After a predetermined amount of time, or upon breakthrough determined by a gas analyzer, a single adsorber is taken offline for regeneration and the adsorber that has previously been offline is placed into polishing adsorption duty (lag vessel). The adsorber vessel that previously was in lag position is placed into the lead position. The vessel that previously was in the lead position starts its regeneration cycle.

The regeneration step is used to clean the activated carbon of any solvents that have been adsorbed on its surface and consists of contacting the carbon with saturated steam. As the adsorber and carbon are heated, the solvents are removed from the carbon and the steam/solvent mixture flows into a condenser where the vapors are condensed and cooled by indirect heat exchange with cooling water. The resulting condensate (solvent/water mixture) then flows (via gravity) to a decanter where it acquiesces and is physically separated and forms an aqueous and solvent phase. The two phases then will be routed (via gravity) either to storage (solvent phase) or to further treatment (aqueous phase).

After regeneration is completed, heated ambient air is introduced into the adsorber to dry and cool the activated carbon and to prepare it for subsequent adsorption of solvents. This first stream, which initially will contain free moisture, will be routed through a conditioning housing (cooling coil, demister, and heating coil) to maintain proper temperature and moisture levels to allow this stream to be routed through the polishing carbon (and, if necessary, zeolite units). Once the carbon is dry, the adsorber sits idle until required to go back online in adsorption duty to treat process emissions.

The cycling of adsorbers occurs on a continuous basis and is operated by a PLC-based timer control. An infrared gas analyzer will be provided. See Section 3.3 for regeneration cycle details.

5.2 OPERATIONAL SAMPLING

5.2.1 Required Laboratory Tests

Throughout the treatment system start-up, testing, and routine operations, vapor and water samples will be collected and analyzed to assess the progress of the IRA, to monitor the SVGTS effectiveness, and to verify compliance with discharge criteria (Figure 1). Table 6 lists the planned analytical parameters, methods, estimated detection limits, and reporting limits for laboratory analyses. Samples will be collected routinely from the water treatment system effluent to monitor for compliance with discharge criteria. After the vapor levels at the extraction wells appear to be leveling off based on photoacoustic analyzer results, summa canister samples will be collected periodically for analysis by a laboratory.

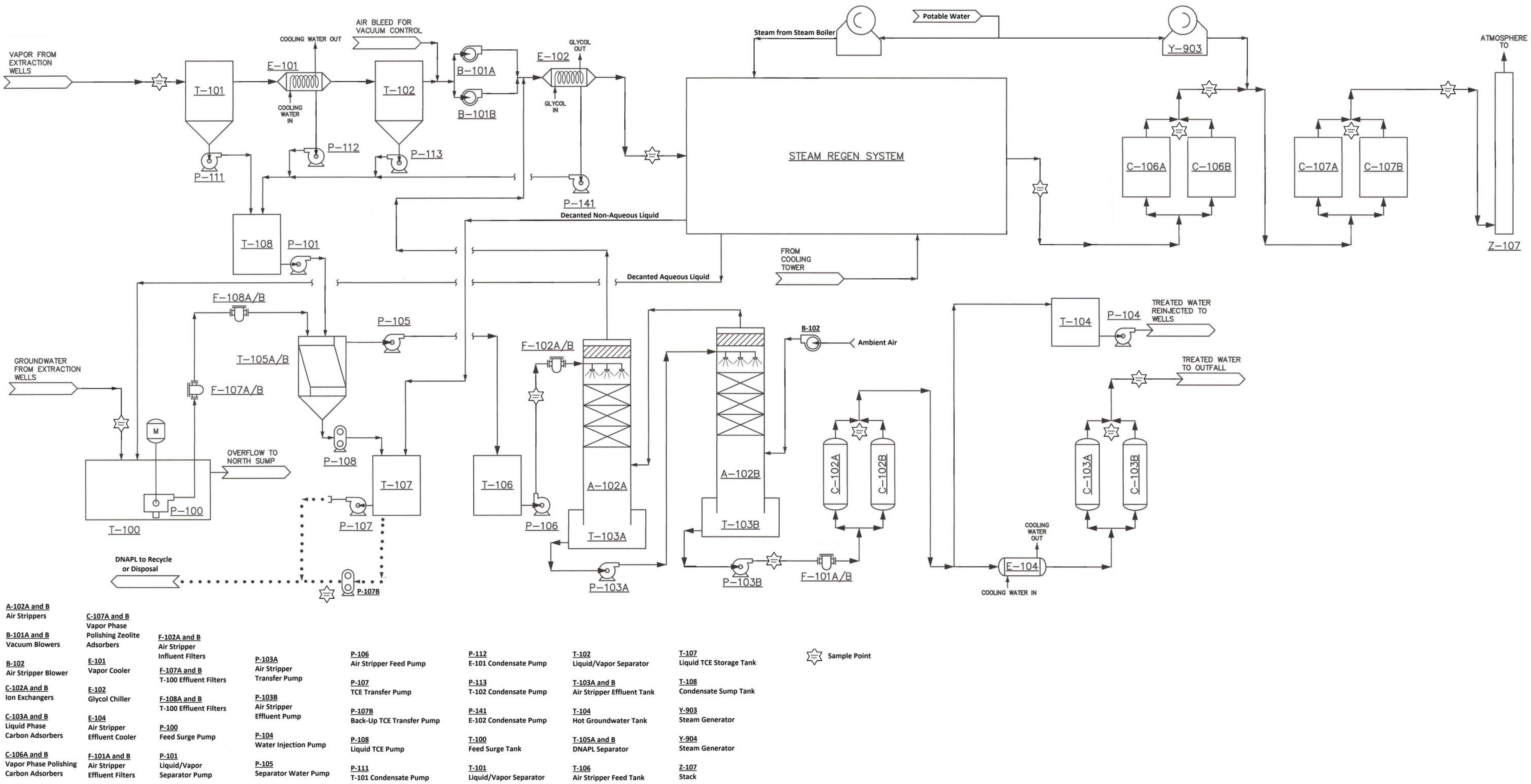

Figure 1. O&M Sampling Locations

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Table 6. Planned Analytical Parameters for Laboratory Analyses

Volatiles[a] SW-846, 8260			Estimated Detection Limit (Water)	Reporting Limit (Water)
1,1-Dichloroethene 1,2-Dichloroethene (*cis*-, *trans*-) 2-Butanone	Benzene Carbon tetrachloride Chlorobenzene	Tetrachloroethene Trichloroethene	1 µg/L	1 µg/L
Vinyl chloride			2 µg/L	2 µg/L
Volatiles, TO14			**Estimated Detection Limit (Air-Summa)**	**Reporting Limit (Air-Summa)**
1,1-Dichloroethene 1,2-Dichloroethene (*cis*-, *trans*-) 2-Butanone	Benzene Carbon tetrachloride Chlorobenzene	Tetrachloroethene Trichloroethene Vinyl chloride	1 ppbv	1 ppbv
Volatiles for Discharge, SW-846, 8260			**Estimated Detection Limit (Water)**	**Reporting Limit (Water)**
Trichloroethene			1 µg/L	1 µg/L
Radionuclide, Liquid Scintillation			**Estimated Detection Limit (Water)**	**Reporting Limit (Water)**
Technetium-99			25 pCi/L	25 pCi/L
Wet Chemistry, EPA 160.2			**Estimated Detection Limit (Water)**	**Reporting Limit (Water)**
Total suspended solids			30 mg/L	30 mg/L

[a] Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Second Edition, Final Update II, SW-846.

5.2.2 Field Measurements

Some parameters, such as vapor-phase VOCs, groundwater potential of hydrogen (pH), oxidation-reduction potential, dissolved oxygen, temperature, and specific conductivity, will be measured in the field using appropriate field instruments.

To assess the progress of the C-400 IRA, vapor samples will be collected from vapor extraction wells and vapor extraction headers coming from the treatment areas and analyzed by photoacoustic analyzers. Compliance with discharge criteria will be monitored at the vapor treatment system stack by a photoacoustic analyzer. The photoacoustic analyzers will measure the following parameters with estimated detection limits:

- trichloroethene—4 ppmv
- vinyl chloride—2 ppmv
- *cis*-1,2-dichloroethene—2 ppmv
- *trans*-1,2-dichloroethene—2 ppmv
- 1,1-dichloroethene—2 ppmv

5.2.3 Pulsed Operations Sampling

Vapor recovery and groundwater extraction wells will be monitored routinely throughout heating operations to monitor progress and to develop data plots for use ultimately in identifying when asymptosis has been achieved. TCE concentrations in recovered vapor will increase initially as the subsurface is heated. Over time, the TCE vapor concentration and mass recovery rate will decrease to an initial asymptotic level. At this point, the system will undergo a “pulsed operation,” whereby vapor recovery will be reduced or stopped for a period of time to allow the subsurface to equilibrate. When the vapor recovery flow rate is increased to previous levels, the TCE vapor concentration may rebound to a level above where it settled at asymptosis. System operations will continue until recovery again decreases to an asymptotic condition. This process may be repeated several times. The effect of pulsed operations will be evaluated by analyzing well field extracted vapor TCE levels to observe whether there is an increase that can be attributed to a rebound in TCE concentrations in the area targeted by pulsed operations. Table 7 lists the anticipated frequencies for sample collection, which may be adjusted based on observed conditions.

Table 7. Anticipated Frequencies for Sample Collection during Pulsed Operations[a]

Description	Sampling Frequency
Photoacoustic Vapor Grab Samples from Well Field (extraction wells and vapor header) in wells no longer exhibiting significant rebound	Twice per week
Groundwater samples from individual wells	Every 2 or 3 weeks
Groundwater samples from exterior monitoring wells	Every 3 weeks
Influent to the water treatment system (inlet to Feed Surge Tank (T-100)	Weekly

[a] Sampling will occur on normal business days.

5.2.4 Sample Collection

High residual heat of groundwater samples collected at extraction well heads during and after ERH operation presents additional challenge to the samplers. Groundwater sampling will be performed in accordance with procedure PAD-ENM-2101, *Groundwater Sampling*, with the additional steps that follow. The field crew will route the sample discharge stream through a coil of copper or aluminum tubing, submerged in an ice bath, to lower the groundwater temperature before collecting the sample. Groundwater samples will be collected for analysis of VOCs in 40-mL glass vials with Teflon-lined closure, filled so no headspace remains in the vial. VOC samples will be preserved with hydrochloric acid to a pH of less than 2 and cooled to 4°C ± 2°C. Additional procedures (PAD-400-0007, *1412 Photoacoustic Field Gas Monitor Operations*, and PAD-400-0019, *Sample Collection at the C-400 SVGTS*) will be utilized for the step-by-step actions required to safely collect samples.

5.3 REQUIRED QUALITY ASSURANCE/QUALITY CONTROL

Information pertaining to quality assurance/quality control, such as equipment calibration and maintenance, laboratory analyses, specific sampling and analytical procedures, personnel responsibilities, training, and corrective actions, is discussed in the RAWP, Section 5—Project Organization; Section 9—Quality Assurance Plan; and Section 10—Data Management and Implementation Plan.

6. DESCRIPTION OF ALTERNATE O&M

6.1 BACK-UP GENERATORS AND AUTOMATIC TRANSFER SWITCHES

Back-up electrical power will be provided to the site via emergency power generators. In the event of an electrical outage to the treatment system, the emergency power generators would supply electricity for critical operational equipment (such as vacuum blowers, steam regenerated carbon system, steam boiler, and condensation units). Alternate O&M of critical equipment under this temporary power source will be governed by operating procedures.

If there should be a power failure due to a site electrical distribution problem, the failure will be sensed by the ATSs. The ATSs will provide a signal to the associated back-up generator to initiate its start-up sequence. Under normal circumstances, this should be a matter of minutes. Once the generator is up to speed and voltage, the ATS will switch from its normal power supply to generator power and only the emergency power panel associated with the emergency generator will be energized. Electrical loads do not restart automatically; these loads are started manually by on-site operators. A short time delay will be utilized prior to each motor start-up to ensure that the motor in-rush current does not overload the emergency generator. The following equipment will be started in sequence.

For diesel generator #1:

a) Cooling Tower Fan
b) Cooling Tower Pump
c) Glycol Chiller
d) Glycol Chiller Pump
e) Vacuum Blower
f) Steam Regenerated Carbon System
g) Back-up Air Compressor
h) Condensate Pumps will be available for pumping condensate, as required.

For diesel generator #2:

a) Steam Boiler (Y-904)

When normal power is restored, the ATS will sense this condition. After a predetermined time delay, the ATS shifts back to its normal power supply and signals the associated diesel generator to shut down. The appropriate treatment system equipment will be restarted from the system control panel.

6.2 SYSTEM FAILURE

Should system failure (such as a trip of a vacuum blower or the air stripper blower) occur, troubleshooting activities will be performed to determine the cause of the failure. Operations personnel will ensure that the system has been shut down (as required) in an orderly fashion and verify that the treatment area is safe to perform troubleshooting activities. To diagnose and correct system problems, personnel will follow appropriate project procedures along with direction from the ERH technology provider, the front line supervisor, the site superintendent, and IRA operations manager. Operations personnel will record shutdown events, actions taken, and other pertinent information in project logbooks or operational data collection forms.

6.3 SYSTEM FAILURE VULNERABILITY AND RESOURCE REQUIREMENTS

System vulnerability for potential problems is discussed in Section 4 of this plan.

7. SAFETY PLAN

The HASP, PAD-PROJ-0068, has been developed for this IRA. This HASP was developed to identify the potential hazards associated with operation of the ERH and the SVGTS as well as to outline proper control methods to protect the workers, the public, and the environment from potential harm in accordance with PAD-WC-0018, *Work Management Program for the Paducah Environmental Remediation Project.* The HASP is maintained in the project records.

7.1 PRECAUTIONS AND REQUIRED HEALTH AND SAFETY EQUIPMENT

All safety equipment shall be inspected for serviceability by LATA Environmental Services of Kentucky, LLC, (LATA Kentucky) project personnel, initially at the start of the project and periodically thereafter. Any defective equipment immediately will be taken out of service, tagged, and replaced. In addition to other periodic inspections, fire extinguisher(s) and a first aid kit shall be available at the job site and inspected in accordance with procedures and regulations. Safety equipment inspections shall be documented on equipment tags or in the project records.

The use of appropriate personal protective equipment (PPE) is required for personnel involved in operations where exposure to hazardous conditions exist and cannot be eliminated by engineering controls or where such equipment is needed to reduce hazards. PPE will be selected and used in accordance with 10 *CFR* 851—Worker Safety and Health Program, and the requirements of LATA Kentucky procedures. PPE selection will be determined by industrial safety, industrial hygiene, and radiological controls to ensure protection of the workers from site-specific hazards posed by the task and work location.

As with typical process industrial work, field work such as collecting samples, collecting operational data, system alignments, and valve manipulations, etc., involve potential hazards to operations personnel. These hazards and associated controls will be outlined in operating procedures and manufacturer's instructions.

7.2 SYSTEM FAILURE SAFETY TASKS

In the event that system failure results in a personnel exposure to hazardous chemicals or radioactive materials, appropriate emergency response action will be taken to remove the contaminated clothing and provide care for the worker. Emergency equipment will be maintained in a readily accessible location adjacent to the active work area.

If an acute exposure to airborne chemicals occurs or is suspected and the affected personnel are unable to escape the work zone, the PSS will be contacted immediately for assistance. Rescue operations will be directed by the PSS. The United State Enrichment Corporation Fire Services and/or Hazardous Material Team are the first responders for rescue operations.

LATA Kentucky project management will be responsible for ensuring all spills of hazardous materials are properly cleaned up and disposed of, including any material generated from the spill. More comprehensive information may be found in the project HASP.

8. DESCRIPTION OF EQUIPMENT

8.1 ERH SYSTEM

Discrete interval heating and independent electrode control are critical to address the variability in conditions that are present in the subsurface at the C-400 Cleaning Building area. Power requirements and heating response will be quite different in the UCRS versus the RGA. Phase IIa concentrates on the UCRS and the upper RGA only. The ET-DSP™ technology offers a stacked electrode system to allow for electrical current to be directed among the electrodes and through the vertical extent of the contaminated soil within the treatment volume.

ERH via ET-DSP™ involves heating soil by passing current between electrodes buried in the soil, with simultaneous injection of water through the electrodes in order to maintain conductivity and to transfer heat by convection. The coupling of ERH with heat transfer by convection greatly enhances the efficiency and uniformity of heating by ERH technology. Volatilization of contaminants will be achieved as the ground temperature in the UCRS approaches the boiling point of TCE or the boiling point of the TCE/water mixture at depth below the potentiometric surface of the RGA. Vapor extraction from vapor recovery wells in the heated soil volume will remove the contaminants from the subsurface.

Water injection through the ET-DSP™ electrode helps to maintain a conductive pathway through the soil. Consequently, resistive or "cold" zones within the treatment area will be minimized. The injected makeup water supplied to electrodes also will be vaporized creating a guided steam front that strips away contaminants and carries them to extraction wells.

8.1.1 Power Distribution Panels

The power distribution panels (PDPs) contain the main equipment breaker feeder system. They are connected to the load side of the high voltage transformer. The PDPs have ABB SACE E3N-A 20 2500A/480V main breakers with up to 8 ABB SACE 5 400A/480V downstream breakers. When the 2500A breaker is engaged, a beacon light located above the panel will strobe.

8.1.2 Power Delivery System

The PDSs developed and manufactured by the ERH Technology Provider are computer-controlled to deliver the proper amount of energy to individual electrodes, both laterally and vertically. The PDSs utilize a system of time-distributed control (TDC) and inter phase synchronization (IPS) to control the power to the electrodes. This process effectively controls the amount and timing of power sent to individual electrodes. When using TDC in combination with IPS, the phases of power applied to individual electrodes may be alternated to reorient the flow of current among the electrodes to uniformly heat up the target area. This system is fully programmable and can be accessed by the ERH technology provider via the internet for remote monitoring and control.

The design configurations for the site are dynamic but, at a minimum, the PDSs will be able to deliver approximately 15 kw of power per electrode. All PDS designs include two transformers. The primary side of each transformer has tap settings allowing for a 240V or 480V utility connection. The utility connection of the PDS is made to one of the breakers at the distribution panel. The secondary side of the transformer has several output voltage settings to account for fluctuating soil conductivity due to heating effects and varying soil properties across the site. The secondary side of the transformer is connected to the electrodes via a series of breakers.

8.1.3 Stacked Electrodes

Multiple, independently controlled ET-DSP™ electrodes will be stacked in a single boring to allow for electrical current to be directed between the electrodes and through the vertical extent of the contaminated soil. The benefits of this approach are a uniform temperature distribution throughout the entire vertical profile of the soil, the ability to create preferential flow paths for steam, and the ability to reduce the number of boreholes required for installation. Ultimately the ET-DSP™ stacked electrodes will allow heating to be controlled in discrete (vertical and horizontal) intervals of the subsurface.

The electrodes are designed to conduct high current to the targeted volume of soil. A minor volume of water injection through each electrode maintains electrical conductivity of the soil, achieves convective heat transfer, and enhances displacement of the chemicals toward the extraction wells. The top electrode in the borehole has a water return line to prevent the subsurface pressure from exceeding the local fracture pressure.

Electrodes are fabricated of high temperature and chemically resistive materials. They are connected to the PDS with appropriately sized electrical cables. Each electrode is connected to a WCS using a high temperature and pressure rated hose. To enhance electrical contact with the soil, each electrode is coated with granular graphite paste over its surface. In the vadose zone, granular graphite will be used around the electrode in each borehole to improve electrical conductivity. Automated monitoring and control of the current and water flow to each electrode ensures the system is operating within its design parameters, while preset breakers prevent the electrodes from exceeding the designed amperage.

A total of 156 electrodes in 52 boreholes will be required to heat the southeast treatment area at the C-400 facility. Three electrodes will be stacked in each borehole to heat from approximately 20 ft bgs to approximately 60 ft bgs. At surface, each electrode boring is completed with a layer of bentonite placed under high-temperature grout. The bentonite separates the high-temperature grout from the sand pack. The high-temperature grout is designed to prevent the heat in the borehole from reaching the surface.

8.1.4 Time Distributed Control Module

The TDCM is the electronic controller for the PDS and gives the project engineer or operator the capability of adjusting the power output to each electrode through the on-site server. The TDCM circuitry is placed between the secondary of the PDS transformer and the electrode. The TDCM is located in a panel in the PDS unit.

8.1.5 Water Circulation System

The WCS is an internet-controlled water injection system designed to maintain moisture content in the surrounding soil during heating. If moisture content is not maintained, the soil matrix becomes highly resistive which causes a corresponding decrease in current and power at the electrode and a reduction in overall effectiveness of the ET-DSP™ system. The WCS includes a pump that boosts the water supply pressure as required. Water injection to the electrodes is controlled using a series of solenoid valve manifolds that include flow meters to monitor the volume of water to each electrode. The WCS also is automated and controlled by the server to adjust the injection rate to each electrode up to its maximum preset hourly rate.

8.1.6 Digital Temperature Acquisition Module

Subsurface temperature is one of the most important operational parameters monitored during an ERH remediation project. Temperature data need to be current and comprehensive. In order to meet this data need, a distribution of digiTAM™ sensors will be deployed in the subsurface at the C-400 Building area. DigiTAMs™ are digital temperature-sensing devices composed of long strings with imbedded sensors placed at 3-ft intervals. Each temperature sensor responds to the ET-DSP™ site computer every five minutes with a current temperature reading. ERH system operators utilize this temperature feedback to optimize system settings. Spare digiTAM™ sensors will be maintained on-site for quick replacement should one string fail. This contingency will ensure this critical data acquisition capability is maintained during the project.

8.1.7 Soil Vapor Extraction System

SVE is an established technology that is commonly used to extract volatile compounds from unsaturated soil. During SVE, a vacuum is applied to an extraction well to lower the vapor pressure in the vicinity of the well. Lowering the pressure at the extraction well induces an advective flow of soil vapors and flow of groundwater containing VOCs (primarily TCE and its degradation products) from regions of higher pressure to the extraction point. This process enhances the volatilization of contaminants from within grains of soil and promotes the diffusion of sorbed contaminants into soil pores where they can be swept and extracted along with soil vapors. In addition to using SVE in the heated zones to recover volatilized VOCs and steam, it also will be used to recover VOCs from shallow unsaturated soil in the UCRS (15 ft bgs and shallower). Although SVE and ERH systems normally will be operated concurrently, the SVE system will have the flexibility to be operated with ERH turned off.

8.1.8 Liquid Extraction System

Groundwater will be extracted via submersible pneumatic pumps during system operation to maintain hydraulic control in the treatment area and to aid in the transport of VOCs to the extraction wells. These pumps will be manufactured to withstand the expected subsurface operating temperatures. It is estimated that approximately 1.4 gpm of groundwater will be extracted from each well.

8.2 SOIL VAPOR AND GROUNDWATER TREATMENT SYSTEM

8.2.1 Liquid Treatment System

The liquid treatment system is designed to remove VOCs from entrained droplets in the vapor stream, from extracted groundwater, and from condensed steam from the vapor conditioning system. The liquid treatment system also is designed to maintain Tc-99 levels below discharge criteria. A portion of the treated water will be pumped back to the electrode field for injection through the electrodes. The balance will be discharged to a plant ditch leading to existing KPDES Outfall 001.

The liquid treatment system consists of a separator to remove TCE dense nonaqueous-phase liquid (DNAPL) from the liquid stream, an air stripper to remove the dissolved TCE from the liquid stream, ion exchange beds to remove Tc-99, a liquid-phase carbon adsorber to remove residual TCE from the liquid stream, and ancillary equipment (pumps, tanks, etc.). The individual components of the liquid treatment system are described in Section 4.4 of the RDR. Process flow diagrams and Piping and Instrumentation Diagrams are also available in the RDR.

8.2.1.1 Feed surge tank

Groundwater extracted from the treatment zone will be directed to the feed surge tank. The feed surge tank provides a degree of separation between the groundwater extraction and the liquid treatment system. This separation allows for the continued groundwater extraction in times when maintenance is required in the liquid treatment system. It also provides for the liquid treatment system to remain in operation in times when groundwater extraction is interrupted due to unforeseen circumstances. The feed surge tank is vented to the vapor treatment system to capture any potential off-gas emissions.

8.2.1.2 DNAPL separator

Extracted groundwater collected in the feed surge tank and condensate and collected water that was entrained in the vapor stream from the vapor treatment system will be processed through one of the DNAPL separators. The DNAPL separator is a plate-type separator designed to remove small droplets of pure TCE from the groundwater. The DNAPL will collect in the bottom of the separator and be pumped to a dedicated storage tank. DNAPL will be pumped from the storage tank to an appropriate container for disposition. Conductivity switches will be used to monitor the level of DNAPL in the bottom of the separator and control the DNAPL transfer pump. The DNAPL transfer pump will be designed to accommodate the high vapor pressure of hot DNAPL. The water flows through the separator plate pack and overflows into a small compartment from which it will be directed into the air stripper feed tank. The DNAPL separator has a sealed cover and is vented to the vapor treatment system to capture any potential off-gas emissions.

8.2.1.3 Air stripping system

Water exiting the DNAPL separator will enter the air stripper feed tank. From the air stripper feed tank, contaminated groundwater will be pumped into the air stripper. A level controller will adjust the feed to the air stripper to maintain the air stripper feed tank level within an operational bandwidth, as recovered groundwater flow rates change. The controller will be tuned to react slowly to changes in the feed tank level to avoid drastic changes in feed rates to the air stripper. A high-high level alarm and switch will provide protection against overflow of the air stripper feed tank by shutting down the pneumatic extraction well pumps.

The air stripper blower will provide air flow counter current to the water flow through the air strippers by drawing in ambient air and discharging to the air strippers. Air from the air strippers will be discharged to the vapor treatment system downstream of the vacuum blowers and upstream of the vapor chiller. Treated groundwater will be collected in the internal sump of the air stripper prior to overflowing into a collection tank.

8.2.1.4 Groundwater filtration

Prior to groundwater entering the air stripper system, it will pass through a set of bag filters for removal of solids that may be present in the extracted groundwater to minimize fouling or plugging of the air stripper. The bag filters will be valved so that one unit can be taken offline for bag change-outs, while the other unit remains online. Following treatment in the air strippers, the treated groundwater will pass through another set of filters to further remove solids that may have precipitated at the air stripper to minimize fouling or plugging of the liquid-phase carbon and ion exchange adsorbers.

In addition to air stripping, this water will be treated in two ion exchange adsorbers to remove Tc-99 and will be collected in a 500-gal insulated storage tank. A level controller will control the flow of treated water to the storage tank to maintain an appropriate level in the tank. Should level in the hot groundwater tank be too low, potable water will provide make-up to the tank until level is restored to an appropriate level. The flow rate of water to the electrodes will be controlled by the water circulation systems in the field. The remaining liquid flow continues downstream where it will pass through the air stripper effluent cooler. This heat exchanger will lower the temperature of the treated water to a temperature acceptable for introduction into the liquid-phase carbon adsorbers.

8.2.1.5 Ion exchange system

Based on previous investigations, Tc-99 levels in the groundwater treated through the liquid treatment system are expected to be below the 900 pCi/L target limit established by U.S. Department of Energy (DOE) for KPDES Outfall 001 discharges. As a precaution, liquid processed through the treatment system will be treated for Tc-99 prior to discharge. An ion exchange system will be placed upstream of the air stripper effluent cooler. The ion exchange system will include two ion exchange beds containing anion exchange resin. The ion exchange beds for removal of Tc-99 are included in the design to protect against discharge exceedances and to minimize Tc-99 contamination of the carbon beds downstream.

8.2.1.6 Liquid-phase carbon polishing system

The water entering the liquid treatment system may contain high levels of dissolved-phase TCE. As a result, the effluent from the air stripper may not always meet KPDES Outfall 001 discharge criteria for VOCs. The residual VOCs will be removed from the air stripper effluent in a liquid-phase carbon adsorber system. The system will contain two adsorber beds, each containing liquid-phase activated carbon. The adsorbers will act as a polishing system prior to discharge of liquid to the KPDES permitted Outfall 001.

8.2.2 Vapor Treatment System

The soil vapor produced from ERH operations will be a mixture of air, water vapor, and high levels of VOCs (primarily TCE and degradation products). The vapor produced by ERH operations is expected to be as hot as 203°F, and the composition of the gas may vary greatly. The soil vapor will consist of subsurface air and steam generated by ERH operations. The soil vapor is expected to contain TCE and other VOCs. The heterogeneous distribution of DNAPL in the soil may result in very high peak concentrations of VOCs.

The vapor treatment system is designed to process the maximum peak loading of the steam and VOCs produced by ERH operations. This system will include an SVE and vapor condensation train designed to remove the vapor from the vapor extraction wells, a steam regenerated carbon adsorber system to remove TCE, and a vapor polishing system that uses vapor-phase carbon and permanganate-impregnated zeolite to remove VOCs remaining in the soil vapor. VOCs will be recovered from the steam regenerated carbon adsorber system an organic solvent decanted from the condensate generated during the regeneration cycle.

8.2.2.1 SVE and vapor conditioning train

The SVE and vapor conditioning train will consist of vapor/liquid separators, heat exchangers, and positive displacement vacuum blowers. These components will be designed to pull the soil vapor from the extraction wells, separate gas from liquid, and then cool and condense the vapor in order to separate the steam/water. This series of operations will produce a cool, dehumidified vapor that is an acceptable feed to the steam regenerated carbon adsorber system.

Two positive displacement blowers will be fitted with variable frequency drives that will control extraction pressure and flow for the well field. The blowers will be sized to provide 100% of the design flow (50% of design flow each). Both vacuum blowers will be in operations during normal operating periods. If vapor flow is less than expected, the variable frequency drive units controlling the blower speed will be used to reduce the blower speed to an optimum while maintaining the required vacuum at the well heads. Vacuum blower operation will be optimized during initial operations due to variable permeability within the treatment zone. The soil vapor will be drawn through two liquid/vapor separators and a heat exchanger by the blowers.

The soil vapor from the SVE system may contain entrained groundwater. The first vapor/liquid separator will remove entrained water droplets from the soil vapor (primarily water that has condensed on the walls of the piping in the vapor collection manifold). The separator is a vertical knockout pot fitted with a mesh demister pad for liquid separation. Any condensate or water that collects in the separators will drain into the condensate sump tank, where it will be pumped to the liquid treatment system.

The vapor will pass through a finned-tube heat exchanger using cooling water to lower the temperature so that most of the steam from the vapor condenses. The cooling water will be cooled through the cooling tower. The heat exchanger may produce up to 5 gpm of condensate. A second vapor/liquid separator will remove liquid in the vapor that condenses in the heat exchanger. Liquid condensate from both vapor/liquid separators and heat exchanger will drain into the condensate sump tank and then will be pumped to the liquid treatment system.

After the second vapor/liquid separator, the vapor goes to the two positive displacement vacuum blowers. These blowers boost the pressure of the vapors. The heat of compression will raise the temperature of the vapor. The vapor then will flow through a second finned-tube heat exchanger to lower the temperature. This heat exchanger also will be a finned-tube unit that uses chilled glycol from a refrigerated chiller system to remove heat from the gas. The vapor then will enter the steam regenerated carbon adsorber system.

8.2.2.2 Steam regenerated carbon adsorber system

The steam regenerated carbon adsorber system will consist of multiple carbon adsorber beds, which will be aligned to operate with one in lead and one in standby with a third either in standby mode or being regenerated.

Typically, the operational cycle of the adsorber beds will be such that vapor will flow through the lead and lag beds until the system timing circuit times out to realign to the lag bed in lead and the standby bed placed in the lag duty. The lead bed will be aligned to commence its regeneration cycle. The regeneration cycle will consist of exposing the bed to saturated steam flow for a period of approximately 60-70 minutes followed by a cooldown period of approximately 20 minutes. Following the cooldown period, the bed is in a standby mode until realigned by the control system as described.

The vapor stream is monitored by an infrared gas analyzer at the outlet of the lead bed and the outlet of the lag bed. Should the analyzer detect VOC concentration equivalent to 20 ppmv TCE in the outlet of the lead bed, indicating that the lead bed is approaching a saturated condition, the realignment cycle described above will be initiated without regard to the preset timing sequence described above. This will help preclude a high level of VOCs being discharged from the system stack.

The air from the steam regenerated carbon adsorbers then will enter a two-bed vapor-phase carbon adsorber system.

8.2.2.3 Vapor-phase polishing system

The vapor-phase polishing system will consist of two sets of adsorbers that will remove low-levels of VOCs from the effluent air of the steam regenerated carbon adsorber system. Each adsorber system will be fabricated with piping and valves needed to allow either adsorber to operate as the lead or lag unit.

The first skid will contain two activated carbon adsorbers to remove residual VOCs (primarily TCE and degradation products) from the vapor stream.

The second system will be similar to the first system except that it will contain two adsorbers filled with a zeolite media that is impregnated with potassium permanganate. These adsorbers are designed to remove vinyl chloride that may be present in the effluent from the steam regenerated carbon adsorber system. Vinyl chloride does not adsorb well onto carbon. The permanganate in the zeolite medium will oxidize the vinyl chloride and is expected to keep the effluent levels below the discharge criteria of 20 ppmv. Each adsorber will contain zeolite and will be mounted with piping and valves needed to allow either adsorber to operate as the lead or lag unit. If the vinyl chloride levels in the steam regenerated carbon adsorber system discharge meet discharge criteria, the zeolite beds will not be needed. The zeolite beds will be provided with a vapor bypass line and will be used only to the extent they are needed. If the zeolite in the lead adsorber becomes exhausted and vinyl chloride breaks through the bed, the polishing adsorber will be switched to the lead position and the media in the exhausted bed will be replaced.

8.2.2.4 Discharge stack

Off-gas from the vapor-phase polishing system will be discharged to the atmosphere through a 20-ft tall by 8-inch diameter stack. Off-gas emissions will be monitored/recorded during operations by a photoacoustic analyzer approximately every two minutes so that data may be evaluated at a later date. The analyzer will communicate with a control system to shut down the vapor extraction and treatment system, including the vacuum blowers, and notify operations personnel in the event of a discharge criteria being exceeded. The set point at the stack that will cause the vapor extraction and treatment system to shut down is 20 ppmv.

8.3 EQUIPMENT IDENTIFICATION

8.3.1 ERH System

Table 8 provides the component numbers and descriptions for the ERH System.

Table 8. ERH System

Component Number	Component Description
D201—D229	Southeast Area digiTAMs™
DV201—DV210	Southeast Area Vacuum Monitoring/digiTAM™ Wells
E201—E252	Southeast Area Electrodes
V203—V205	Southeast Area Vacuum Monitoring Wells
X201—X222	Southeast Area Extraction Wells
VX201—VX211	Southeast Area Vapor Extraction Wells
V201—V205	Southeast Area Vacuum Monitoring Wells

8.3.2 Soil Vapor and Groundwater Treatment System

Table 9 provides the tag numbers and equipment names for the Soil Vapor and Groundwater Treatment System.

Table 9. Soil Vapor and Groundwater Treatment System

Tag Number	Equipment Name
A-102A&B	Air Strippers
B-101A&B	Vacuum Blowers
B-101C	Vacuum Blower

Table 9. Soil Vapor and Groundwater Treatment System (Continued)

Tag Number	Equipment Name
B102	Air Stripper Blower
C-102A&B	Ion Exchange Vessels
C-103A&B	Liquid Carbon Adsorbers
C-106A&B	Polishing Vapor Carbon Adsorbers
C-107A&B	Polishing Vapor Zeolite System
DG-1	Back-up Diesel Generator Set (800 KW)
DG-2	Back-up Diesel Generator Set (600 KW)
E-101	Vapor Cooler
E-102	Vapor Chiller
E-104	Air Stripper Effluent Cooler
F-101A&B	Air Stripper Effluent Filters
F-102A&B	Air Stripper Influent Filters
F-107A&B	Feed Bag Filters
F-108A&B	Feed Bag Filters
P-100	Feed Surge Pump
P-101	Liquid/Vapor Separator Pump
P-103A	Air Stripper Transfer Pump
P-103B	Air Stripper Effluent Pump
P-104A	Hot Groundwater Pump
P-104B	Hot Groundwater Pump
P-105	Separator Water Pump
P-106	Air Stripper Feed Pump
P-107	TCE Transfer Pump
P-107A	Back-up TCE Transfer Pump
P-108	Liquid TCE Pump
P-111	T-101 Condensate Pump
P-112	E-101 Condensate Pump
P-113	T-102 Condensate Pump
P-115	T-116 Condensate Pump
P-116	T-117 Condensate Pump
P-117	T-117 TCE Condensate Pump
R-101A	Carbon Regeneration Bed
R-101B	Carbon Regeneration Bed
R-101C	Carbon Regeneration Bed
T-100	Feed Surge Tank
T-101	Liquid/Vapor Separator 1
T-102	Liquid/Vapor Separator 2
T-103	Air Stripper Effluent Tank
T-104	Hot Groundwater Tank
T-105A&B	DNAPL Separators
T-106	Air Stripper Feed Tank
T-107	Liquid TCE Storage Tank
T-108	Condensate Sump Tank
T-111	E-101 Condensate Tank
T-116	Condenser Tank
T-117	Decanter Tank
Y-901	Cooling Tower
Y-902	Glycol Chiller
Y-904	Electric Boiler

Table 9. Soil Vapor and Groundwater Treatment System (Continued)

Tag Number	Equipment Name
Z-107	Stack
Z-901	Utility Air Compressor
Z-901B	Back-Up Instrument Air Compressor
Z-902	Air Dryer

8.4 SITE EQUIPMENT MAINTENANCE

System operational measurements and preventative maintenance will occur on a regular basis to ensure the system is functioning properly. Operational checks will include measuring critical system parameters such as soil temperature and VOC recovery. Maintenance activities will include lubrication and minor adjustment of system components. Maintenance activities will be conducted as required by the equipment manufacturers and sound engineering practice.

8.5 EQUIPMENT REPLACEMENT SCHEDULE

8.5.1 Vacuum Blower and Pumps

The operational life of blower and pumps is highly variable. Their life is estimated at approximately 5 to 6 years before the need for significant maintenance. Pump and blower bearings typically are greased every 2,000 operating hours or 3 months of use, whichever comes first. Details for preventive maintenance of individual blowers and pumps are provided in the manufacturer's operation/maintenance manual.

8.5.2 Temperature Sensing Equipment

If temperatures specified in the performance metrics are not achieved in a treatment zone within the estimated time required to heat the zone, operations personnel will attempt to determine the reason for the deviation. If there is a problem with temperature sensing equipment, it will be replaced.

8.5.3 Carbon Adsorbers

Spent carbon from the liquid phase and vapor phase carbon adsorbers will require removal and replacement periodically. Spent carbon may be sent to the carbon adsorber manufacturer or another licensed reactivation facility for recycling. It is anticipated that vapor phase polishing carbon will need to be replaced two times during Phase IIa operations, and the liquid phase carbon will require replacement once during Phase IIa.

8.5.4 Ion Exchange System

During operation of the groundwater treatment system, the effluent of the lead ion exchange vessel will be monitored for Tc-99. When the lead vessel is determined to be spent (when Tc-99 concentration in the effluent of the lead resin bed reaches 80% of the Tc-99 concentration in the treatment system influent), the valves on the ion exchange beds will be realigned to place the lag bed online as the lead bed and the exhausted resin will be replaced with fresh resin. Once the resin is replaced, the fresh resin will be placed in service as the lag ion exchange vessel. It is anticipated that resin will last the duration of the project and will not have to be replaced.

8.5.5 Polishing Zeolite System

The Polishing Zeolite Adsorbers are operated in series in a lead/lag configuration. The vapor between the lead and lag adsorbers is periodically sampled for constituents of concern. If breakthrough is detected between the adsorbers, the lead unit is taken out of service and the zeolite is replaced. The former lag unit is placed in the lead position by means of valve realignment, and the newly-replenished unit is placed in the lag position. It is anticipated that the zeolite media will not require replacement during Phase IIa operations.

8.5.6 Network Communication

The control and monitoring network for ET-DSP™ may malfunction on occasion. Often the solution is simply to reset the affected network device and communication will be restored. Otherwise the affected network device or CAT5 connection will need to be replaced according to instructions from the ERH technology provider.

8.5.7 Miscellaneous Equipment

Equipment such as filter bags in bag filters will have to be replaced on a periodic basis. The replacement periodicity will depend on the amount of suspended solids present and the resulting differential pressure on the filter system. Other infrequent, unscheduled maintenance includes replacement of worn bearings, seals, gauges, etc.

9. RECORDS AND REPORTING

Document control and records management plans will be implemented according to DOE Prime Contractor procedures. The format for any needed reports and data packages will be consistent with the approved format and style guide, as applicable. Electronic databases will be backed up according to approved information technology procedures.

Project data including field data such as vapor flow rates, vapor extraction header VOC concentration, water injection and extraction rates, etc., stack effluent photoacoustic analyzer data, and analytical data will be maintained in the project records and will be available for review. Additionally, the ERH subcontractor will maintain a project Web site throughout the project implementation that contains real-time data associated with the ERH components, thermal, energy, and process data, which also will be made available for review. These two sources will provide the necessary information to review, evaluate, and make decisions regarding project activities.

Regularly scheduled meetings will be conducted to discuss and evaluate analytical and field data generated on the project. Additionally, the overall O&M of the treatment system will be discussed to provide feedback on the progression of the IRA. This information will be used in an effort to evaluate the treatment system's effectiveness and, ultimately, to support the decision making process for ceasing operations.

9.1 DAILY OPERATING LOGS

Project logbooks, field rounds sheets, chain-of-custody forms, and field forms will be developed and maintained according to DOE Prime Contractor-approved procedures for Records Management. Detailed information can be found in the RAWP.

9.2 LABORATORY RECORDS

Fixed-base laboratories are required to report data in accordance with applicable laboratory procedures and be consistent with DOE Prime Contractor project requirements for data deliverables. Data deliverables will be reported in a format that fulfills the requirements of these procedures. For data targeted to support data validation, the laboratory will provide complete data packages that include sample report forms and quality control result summaries.

During the ERH project, a fixed-base laboratory will perform analyses for water and soil samples and for confirmation samples, as necessary. Comprehensive laboratory records will be maintained by the fixed-base laboratory.

Data generated by the laboratory will be reduced using standard methods. The analytical data will be checked for completeness and reasonableness. Laboratory data will be transferred from the laboratory electronic data deliverable to Project Environmental Measurements System.

9.3 RECORDS OF OPERATING COST

Records of project operating cost will be maintained by the DOE prime contractor project controls group. The projected operating cost for O&M of the ERH project is included in Section 10 of this plan.

9.4 REPORTING EMERGENCIES

LATA Kentucky project personnel will maintain a radio, telephone, or other reliable means of notifying emergency response personnel and the PSS. Emergency contacts for various situations are listed below:

- ***Fire:*** Fire alarm pull box, plant telephone Bell System 333, or plant radio channel 16
- ***Medical:*** Plant telephone Bell System 333 or plant radio channel 16
- ***Security:*** Plant telephone Bell System 6246 or plant radio channel 16
- ***PSS:*** Plant telephone Bell System 6211 or plant radio channel 16

If using a cell phone: 270-441-6333 for emergency calls; use 270-441-6211 for non-emergency calls. Complete guidelines for reporting information and emergency response may be found in the HASP.

9.5 PERSONNEL AND MAINTENANCE RECORDS

All personnel qualifications and training records will be recorded and maintained in accordance with PAD-TR-0702, *Conduct of Training*.

Maintenance activities will be performed in accordance with the manufacturers' instructions and conducted as both routine and corrective maintenance tasks. Maintenance records will be maintained in the project files.

9.6 REPORTS TO STATE/FEDERAL AGENCIES

Semiannual progress reports are prepared and issued at the end of each six-month period. These reports summarize the data generated by activities associated with the ERH project.

Project status meetings will be held to coincide with the Federal Facility Agreement Managers' meeting. These status meetings will be used to review the operational data, discuss trends, and evaluate the overall progress of the project in terms of meeting the remediation goals. The frequency of these meetings will vary depending on the information to be shared and may be increased as the project gets closer to completing operation.

10. PROJECTED O&M COSTS

The projected O&M cost for Phase IIa of this IRA is expected to be approximately $2.25M.

11. REFERENCE

DOE (U.S. Department of Energy) 2005. *Record of Decision for Interim Remedial Action for the Groundwater Operable Unit for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2150&D2/R2, August.