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TO: Harry Allen, U.S. EPA/ERT Work Assignment Manager

THRU: Gary Buchanan, REAC Section Chief

FROM: Richard Henry, REAC Task Leader

SUBJECT: DOCUMENT TRANSMITTAL UNDER WORK ASSIGNMENT 5-932

Attached please find the following document prepared under this work assignment:

QUALITY ASSURANCE WORK PLAN, REV 2
PENTA WOOD PRODUCTS
SIREN, WI

c: Central File WA 5-932 (w/attachment)
W. Scott Butterfield (w/o attachment)

\WORKPLAN.7\QAWP-6932

QUALITY ASSURANCE WORK PLAN

REVISION 2

PENTA WOOD PRODUCTS

SIREN, WI

Prepared by
Roy F. Weston, Inc.

MARCH, 1994

U.S. EPA Work Assignment No. 5-932
Weston Work Order No. 03347-035-001-6932-01
U.S. EPA Contract No. 68-03-3482

Richard Henry 3/24/94
Richard Henry (Date)
Task Leader

W. Scott Butterfield 3/24/94
W. Scott Butterfield (Date)
Project Manager

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1.0 OBJECTIVE

The objectives of this project are to (1) determine the extent of soil and groundwater contamination associated with the Penta Wood Products (PWP) Site, Siren, Wisconsin (WI), and (2) evaluate presumptive remedial alternatives for wood preserving sites.[1] The approach to fulfilling these objectives are tailored to the guidance developed for the U.S. Environmental Protection Agency's (EPA) Superfund Accelerated Clean-up Model (SACM).

2.0 PROJECT SCOPE

2.1 Site Description

A number of investigations have been conducted at the PWP site to characterize historic activities, the extent of contamination, regional soils, geology, and hydrology, and ecological and human health risk. Memorandums and reports available to the Response Engineering and Analytical Contract (REAC) and used to develop the scope of work and the technical approach of this Quality Assurance Work Plan (QAWP) include the following:

- Report regarding the public water system of Siren, WI prepared by Jack Hunter (Siren, WI Environmental Engineer), October, 1987
- Phase II Site Evaluation Report prepared for the PWP site by Conestoga-Rovers and Associates, October, 1989
- Remedial Investigation and Corrective Action Plan for the PWP site prepared by Conestoga-Rovers and Associates, March, 1992
- Site Investigation Report for the PWP site prepared by the EPA Region V Technical Assistance Team (TAT), April, 1993
- Memorandum regarding Remedial Cost Projections for the PWP site prepared by Lisa Ende (Region V TAT), June, 1993
- Sampling report and summary of data from Wisconsin Department of Natural Resources (WDNR)/EPA sampling of the PWP site prepared by Amy Parkinson (WDNR Site Project Manager), June, 1993
- Sampling Report for a Screening Site Inspection/Pathway Sampling at the PWP site prepared by Amy Parkinson, July, 1993
- Memorandum regarding geology and well data for the PWP site prepared by Dave Johnson (WDNR Site Assessment Hydrogeologist), August, 1993
- Memorandum regarding ecological concerns at the PWP site prepared by Eileen Helmer (Region V U.S. EPA), March, 1993
- Memorandum regarding human health concerns at the PWP site prepared by Manna Muroya (EPA Region V Agency for Toxic Substances and Disease Registry {ATSDR}), March, 1993

- Briefing memo for the PWP site for presentation to the Regional Decision Team prepared by the Site Assessment Team, November, 1993

The PWP site is an inactive wood treating facility located on State Route 70, Burnett County, WI, approximately 78 miles northwest of Minneapolis, Minnesota (MN) and 60 miles south of Duluth, NM. The Village of Siren, WI is approximately 2 miles east of the site and there are three residences within 200 feet of the site; one of which is also a dairy farm. The Village of Siren has a population of approximately 3,000 people and there are 38 private wells within a one mile radius of the site. A study by the WI State Geological and Natural History Survey indicates that regional groundwater flow is to the northeast, toward several wells, wetlands, and surface water bodies.

The PWP property consists of approximately 120 acres, of which 80 acres were actively used; the remaining 40 acres are undeveloped and consist of forested areas and wetlands. The property is located in a rural agricultural and residential area and is bordered to the east, west, and north by forested areas; some of these areas are classified by the State of Wisconsin as wetlands. With the exception of a small parcel, State Route 70 forms the southern site boundary of the property. A small parcel of the PWP property is located south of State Route 70. A number of surface waterbodies are present north and west of the site. Doctor Lake and an unnamed lake are located 2,000 feet east and northeast of the site, respectively. Approximately 2,137 acres of lakes, 94 acres of bogs, and 7,500 acres of wetlands are located within a four mile radius of the site. The Amsterdam Slough Public Hunting area covers 7,233 acres and is located one mile north of the site.

Chemical treatment and ancillary wood fabrication operations began in 1953, and ceased in May, 1992 due to the inability of the facility to comply with recently enacted Resource Conservation and Recovery Act drip track regulations. Prior to 1956, wood was treated by dipping poles and timbers into an open tank of pentachlorophenol (PCP) solution or by introducing PCP into the wood under a vacuum. In 1956, a pressure treatment cylinder was installed which used a 5 to 7 percent PCP solution in a #2 fuel oil carrier. In 1975, a second pressure process was added using chemonite, a water borne salt treatment consisting of arsenate, copper II oxide, and zinc. This product is also referred to as ammoniacal-copper-arsenic (ACA).

The active portion of the site consisted of three roughly defined functional areas including a wood fabrication and white wood (untreated wood) storage area, a treated wood storage area, and a process area. A number of contaminant sources and areas of concern have been identified and include the following:

- Woodchip pile
- PCP treatment area
- Oil-water separator
- Wastewater lagoon
- Landfill areas
- Off-site soils
- Bulk storage tanks
- ACA treatment area
- Boiler water disposal lagoon
- Gully to wastewater lagoon
- On-site soils

The wood fabrication and white wood storage area is situated north of Route 70 in the western third of the property. Two sawmills, wood chipping equipment, conveyor equipment, and several storage buildings were scattered throughout this area. Woodchip storage and disposal areas are situated along the north and west border of the site and white wood was stored in the north central portion of the site. The documents reviewed have indicated that wastewater and waste woodtreating product were also disposed of in the woodchip plies. All

of the white wood, some of the buildings, and portions of the sawmills have been removed from the property.

Treated wood storage areas are located in the eastern third of the property north of Route 70. Pentachlorophenol treated wood was stored in the southeast corner of the site and ACA treated wood was stored in the northeast corner of the site. A number of storage buildings were present in the PCP storage area. Treated wood products were also stored in a small parcel south of State Route 70, however the product type was not specified in the documents available. Several above-ground storage tanks are also located in this area. All buildings and treated wood products have been removed from the treated wood storage areas; the storage tanks remain.

The chemical treatment area is located in the central third of the property north of Route 70. This area consists of a process building, a boiler building, an oil-water separator building, and a number of storage, vehicle service, and administrative buildings. Several above- and below-ground storage tanks are also present in this area with capacities ranging from 300 to 10,000 gallons. The tank contents are assumed to include chemical wood treatment products, diesel fuel, fuel oil, and gasoline.

As mentioned previously, wood products were treated in the process building with PCP since operations began in 1953, and ACA since 1975. The west side of the process building was used to treat wood with PCP and a pressure vessel extends from the side of the building. The extent of discolored soil visible in historic and recent photos suggest that product was routinely spilled from this operation. Additionally, patches of stained soil immediately west of the process building suggest that this was a drip area for PCP treated wood products. The east side of the process building was used for the ACA treatment process. A number of tanks, a treatment retort, and a small oil-water separator are present in this area.

The oil-water separator building is located immediately north of the process building. The oil-water separating unit is approximately 6 feet deep and 30 feet long. A fixed film biological treatment unit (Biotrol, Inc.) is present in this building as well. Although a number of storage buildings have been removed from the site, all process buildings in the chemical treatment area remain.

Two lagoons are present on the site. The first is a boiler water disposal lagoon, located immediately north of the process building. It is approximately 25 feet wide and 45 feet long and the lagoon walls are above grade and constructed of soil, ash from burning sludge, and treated wood scraps. This lagoon was used to dispose of non-contact boiler blow-down water. A second lagoon is located along the northeast edge of the site and is approximately three times the size of the boiler blowdown lagoon. The lagoon is situated in a slight depression and berms of mounded soil form the north and west walls of the lagoon. This lagoon was used for the disposal of process wastewater from the PCP and ACA treatment areas and excess water from the oil-water separator. Additionally, this lagoon received surface stormwater runoff through an eroded gully that drains the chemical treatment area and the treated wood product storage area.

Two landfill areas are located on the western side of the site. The first is associated with a ravine, approximately 20 to 30 feet in depth, located along the western site boundary. Woodchips, scrap wood, and some process water has been dumped into this area. A second landfill area is located along the north side of the site and was used to dispose of butt pieces of wood.

As mentioned above, all white wood and treated wood products, as well as some buildings have been removed from the site. The active portion of the site is relatively flat with a slight downward grade towards the northeast. Runoff from the site is directed toward the waste process water disposal lagoon and off-site into adjacent forested and wetland areas. Drainage pathways, erosional, and depositional areas are clearly evident across the site and in areas adjacent to the site. This is particularly true in areas adjacent to the northeastern lagoon and in the treated wood storage area.

Contaminants of concern at the PWP site have been identified by the EPA and state of WI and include PCP, arsenic, copper, zinc. Dioxins/furans are also of concern, but a limited number of analytical determinations have been performed; dioxins/furans have been detected in samples collected in the vicinity of the boiler, the boiler blowdown lagoon, and ash piles. Other contaminants detected on-site include petroleum hydrocarbons and polynuclear aromatic hydrocarbons. Although the overall pattern of contamination in the various media can be described in general terms, it is not accurate to portray the site in terms of discrete areas of high, moderate, and low contamination. The long and variable history of activities throughout the site, the pattern of accidental and intentional releases, and the natural and man-induced migration of contaminants necessitate caution when describing the extent of contamination based on sampling performed to date.

Contaminants of concern have been detected in soil and groundwater collected from active portions of the PWP property as well as areas adjacent to the property. Concentrations of PCP ranging from 1,100 to 2,700 ug/L (microgram per liter) have been detected in groundwater collected from two production wells located south of the process building. Pentachlorophenol detected in surface soils collected from various areas of the site range from non-detected and below the detection limit in soil collected from treated wood storage areas, white wood storage areas, sawmill areas, and office areas, and from 92 to 10,000 mg/kg (milligrams per liter) in the lagoons, dump areas, and chemical treatment areas. Arsenic concentrations followed a similar pattern with non-detectable to low concentrations in "non-process" areas and from 10 to 42,000 mg/kg in chemical treatment areas. Concentrations of these contaminants followed similar patterns in subsurface soil samples.

Ecological and human health concerns at the PWP site revolve around PCP and arsenic in surface soil, woodchips, and groundwater. The elevated concentrations in these media, apparent exposure routes, and available toxicity data suggest that the site represents a substantial environmental risk to human and nonhuman receptors.

2.2 Scope of Work

Site Characterization The site characterization will focus on the extent to which soil and groundwater have been contaminated with the contaminants of concern. Surface soil, subsurface soil, and groundwater in the process areas, on-site disposal areas, and off-site receptor areas will be sampled then analyzed using a combination of field and laboratory methods.

What size grid?

Sampling locations for surface and subsurface soils will be systematically positioned at nodes on a grid encompassing the entire study area. Highly contaminated areas, stained areas, suspected "hotspots" or areas otherwise requiring greater definition will be sampled at intermediate locations along the grid. The grid will also be extended to tie in any sampling locations situated in off-site contaminant migration pathways. Overburden and aquifer data focusing on geotechnical, lithological, and chemical characteristics will be determined at a number of nodes throughout the site. Soil will be sampled using a combination of manual

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What methods?

and power techniques including hand trowels and augers, a Geoprobe™, and borehole drilling equipment.

Existing production and monitor wells will be sampled and logged using downhole geophysical techniques to clarify well construction and lithology. Subsurface characteristics will be determined using geophysical, lithological, and chemical data as well as vadose zone and groundwater modeling. If necessary and where appropriate, additional monitor wells will be installed. These results will be used to predict potential contamination fate, transport, and migration patterns in the soil and groundwater, determine the volume of contaminated matrices, and evaluate the feasibility and effectiveness of pump, treat, and reinjection remedial strategies. OK

Field analytical and screening techniques will be relied on to a great extent to define the extent of contamination in soil and water. In particular, the following will be used to track the extent and migration of contamination: metals: X-ray fluorescence (XRF); organic vapors: photovac, photoionization detector (PID), flame ionization detector (FID); PCP: immuno-assay test kits; petroleum hydrocarbons: test kits. Standard laboratory analyses of contaminants of concern will be performed to confirm the field analyses on approximately 10 percent of the samples collected.

A screening level risk assessment will be performed to determine the potential for ecological impairment resulting from site contaminants. Habitats and habitat utilization on- and off-site will be evaluated with respect to the exposure pathways and the toxicity of contaminants of concern. Empirical data will be collected in the event this assessment suggests significant risk to receptors.

The information collected in the site characterization will be compiled in a comprehensive data management system. Historic site activities, significant site features, sampling, and well locations will be included in graphical presentations of contaminant data. The volume of contaminated matrices will be evaluated using this system.

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Treatability Evaluations Bench-scale evaluations aimed at PCP, ACA, and mixed PCP/ACA contaminated matrices will be performed to determine the effectiveness of various presumptive remedial technologies. The treatment of PCP contaminated soil will be evaluated using slurry-phase bioremediation, solid-phase bioremediation, and thermal desorption, followed by the base-catalyzed decomposition process. The treatment of metal contaminated soil will be evaluated using soil washing and solidification/stabilization. Groundwater treatment will be evaluated using ultraviolet radiation, carbon adsorption, and ion exchange. As mentioned above, contingencies will be included in these evaluations for soil contaminated with both PCP and metals.

An engineering evaluation of the existing wastewater treatment system (Biotrol, Inc.) will be performed to determine the existing condition of the unit. An operational plan will be developed focusing on modifications required to place the unit in operation and to determine if the unit can process the volume and quality of groundwater expected to be pumped and treated. If the Biotrol unit is beyond economic repair, or if it is not large enough to treat the proposed groundwater flow, recommendations will be made regarding expansion of the existing system or the design and construction of a new treatment system.

3.0 TECHNICAL APPROACH

3.1 Investigative Strategy

The field, laboratory, and other activities proposed to fulfill project objectives will be conducted in a phased approach. The results and information gathered during each phase will be used to design or fine tune the activities for each subsequent phase. Where technically and logistically feasible, the approach will be accelerated to achieve most project objectives within the current contract extension and to adhere to the SACM initiative. For example, multiple uses will be made of data, rapid field analytical and screening techniques will be used, and evaluation of presumptive remedial technologies will occur concurrently with the site characterization. In certain instances, it will not be technically feasible to complete a phase or task within the current contract extension period. These tasks will be identified early in the project and work will proceed on discrete activities that can reasonably expected to be completed. The goal is to complete as much as effectively possible and thus provide the framework for work to continue in the next contract period with little delay.

The project objectives will be achieved by a multidisciplinary team working on a number of activities. These activities revolve around two discrete areas including site characterization and remedial technology evaluation. The former is aimed at determining the extent and effects of soil and groundwater contamination and characterizing the physical setting of the site relative to potential contamination migration pathways, receptors, and remedial alternatives. The latter is aimed at evaluating a number of presumptive technologies and methods for site remediation. Major project tasks proposed for this project include the following:

Site Characterization
- Geophysical site characterization
- Surficial soil extent of contamination
- Subsurface soil extent of contamination
- Soil gas survey
- Vadose zone and groundwater modeling
- Groundwater extent of contamination
- Off-site extent of contamination
- Risk assessment
- Monitor well installation and slug testing
- Data management system
- Site survey and mapping

Remedial Technology Evaluation
- Soil washing
- Solidification/stabilization
- Thermal desorption
- Based catalyzed decomposition
- Slurry-phase bioremediation
- Solid-phase bioremediation
- Ultraviolet radiation
- Carbon adsorption
- Ion exchange
- Groundwater treatment design

The project objectives will be fulfilled by performing the tasks identified above in a phased approach. As discussed previously, these phases will overlap where technically and logistically feasible. To further streamline and accelerate the project, a number of assumptions based on existing site information will be made regarding the methodologies and approach.

Due to time and resource constraints related to the current REAC extension, the following activities are not planned for this contract period:

Site Characterization
- Soil gas survey
- Comprehensive modeling
- Risk assessment

Remedial Technology Evaluation
- Thermal desorption
- Based catalyzed decomposition
- Ultraviolet radiation

Data management system	Carbon adsorption
Site survey and mapping	Ion exchange
Comprehensive groundwater extent of contamination	Groundwater treatment design

3.2 Site Characterization

3.2.1 Survey and Base Map Preparation

A search will be conducted for previous survey data and site information including U.S. Geological Survey (USGS) topographic maps, site evaluations and surveys, and aerial photographs. Using this information and data, a base map will be developed in AutoCAD. Cultural features such as roads, buildings, and fences will be depicted, as well as site features such as process facilities, lagoons, stained soil, and other functional features. Background information available from U.S. Soil Conservation Service soil survey maps, U.S. Fish and Wildlife Service National Wetlands Inventory maps, and local geological maps will be included as well. The need for photogrammetric depiction of topographic contours will be determined after evaluating costs and other requirements. At a minimum, approximate elevations available from the USGS and other organizations will be depicted on the base map.

Historic information regarding the site and adjacent land use available from the state and the EPA will be plotted. Chemical contamination data from prior investigations will be posted depicting concentration and approximate sampling locations.

The soil boring, monitor well locations and elevations, and portions of the sampling grid will surveyed by a professionally licensed surveyor. This survey will be tied to the Wisconsin Coordinate System (North Zone, in feet) and elevations will be in feet above Mean Sea Level (MSL) accurate to within 0.1 feet. The precision and accuracy of the mapping will be determined.

The survey results and the AutoCAD base map will be merged to serve as the basis for the extent of contamination study, hydrogeological and engineering analysis, and graphic depiction of data. The combined map will be input into a database for future use.

3.2.2 Surficial Soil Extent of Contamination Study

3.2.2.1 Introduction

An investigation will be conducted to determine the vertical and horizontal extent of contamination (EOC) of the contaminants of concern in surficial soil. Surficial soil refers to the upper 12 inches of soil. This information will be used to determine develop a conceptual model of contaminant distribution in the surface soil, as well as migration into the groundwater, or off-site via surface runoff. Limited dioxin analysis will be conducted in those areas determined to contain high concentrations of PCP.

The extent of arsenic, copper, zinc, and PCP contamination will be determined in surface soils at two discrete intervals, 0-3 inches and 10-12 inches below the ground surface (bgs). Surface lead concentrations will also be recorded, but only as a measure of potential interferences to the XRF

analysis (Section 3.2.2.5). Surficial sampling will take place in two discrete phases: the first consisting of an on-site investigation, and the second consisting of an off-site investigation.

3.2.2.2 Sampling Grid

A sampling grid will be established to encompass the site and potential off-site sampling locations. The grid will be established along a straight North/South orientation. Its approximate dimensions will be 2,200 by 2,200 feet, with nodes demarcated at 100 foot intervals. The on-site portion of this grid is expected to cover an area measuring approximately 1,400 feet along the east and west sides, and 2,200 feet along the north and south sides. The off-site grid areas will only be partially sampled (Section 3.2.2.9), and will depend upon the results of the on-site investigation.

During the preliminary field visit, the on-site grid will be established using surveying equipment. If the ground is frozen, a portion of the grid will be delineated to facilitate grid establishment during the next field visit. The midpoint, endpoints, and several intermediary points of each grid line will be marked using four-foot long steel rebar stakes, spray-painted orange and sharpened on one end. These will be driven 1 foot into the ground using a sledge hammer, or similar tool. If necessary, an air hammer will be used to make a hole in the frozen ground before installing them. Each steel rebar stake will be safety capped, and have fluorescent colored flagging tape and an aluminum tag identifying the grid point number tied to it. If the ground is not frozen, 5-foot long wooden stakes will be used in place of the rebar, for increased visibility.

The remaining on-site grid nodes will each be marked with a 10-inch wooden spike driven to ground level and a pin flag during the following field visit. Pin flags will be labeled with the sample location code (Section 3.2.2.4) in the field with a thick indelible marker.

3.2.2.3 Sample Collection

What does XRF check for? Lead only?

Surficial soil (0 to 3 inches bgs) will be collected from each 100 foot grid node with a decontaminated stainless steel trowel as per ERT/REAC Standard Operating Procedure (SOP) #2012, Soil Sampling. Soil will be mixed to a depth of three inches over an 8 by 8-inch area. If the surface soil is dry enough, in-situ XRF readings will be made. At 10 percent of all locations, selected at random in advance, confirmation samples for laboratory analysis will be collected into 4-oz glass jars.

If the soil is saturated, then soil will be collected into a 4-oz clear glass jar at all locations for XRF analysis of arsenic, copper and zinc. This sample will be dried on-site in an oven prior to XRF analysis, and ten percent of the samples will be sent to a laboratory for confirmatory analysis. Should this be the case, each confirmation sample will consist of two XRF sample cups per location.

In either case, a second 4-oz clear glass jar will be collected at each location for PCP screening and/or analysis. A 4 ounce (oz) jar will be collected and

sent to the ERT/REAC High Hazard Laboratory for analysis of PCP by gas chromatography/mass spectroscopy (GC/MS). Should immediate information regarding PCP contaminantion be required, a 10 gram (g) aliquot will be screened on-site using enzyme immuno-assay test kits. A minimum of 10 percent of these samples will be sent to a laboratory for confirmation of PCP results by GC/MS. Each PCP confirmation sample will consist of the remaining soil in the 4-oz jar.

Subsurface soil (10 to 12 inches bgs) will be collected from alternate nodes (i.e. at 200 foot intervals). At each odd-numbered grid node, soil from 10 to 12 inches bgs will be collected using a decontaminated stainless steel bucket auger as per ERT/REAC SOP #2012, Soil Sampling. Two samples will be collected, one in a 4-oz glass jar for XRF analysis and one in a 4-ounce glass jar for PCP analysis. As described for surficial samples, a minimum of 10 percent of the samples collected for PCP and XRF analyses will be sent to a laboratory for confirmation.

It is anticipated that a total of 660 soil samples will be collected on site. Of these, 340 samples will be collected at grid nodes at the surface (0 to 3 inches bgs), and 170 grid nodes will be sampled at the subsurface (10 to 12 inches bgs). An additional 100 surface and 50 subsurface judgmental soil samples will be collected as necessary to further characterize the contamination in areas showing a higher degree of variability in XRF or PCP results. These numbers are summarized in Table 1 for planning purposes (i.e. determination of personnel required, field logistics, time frame and budget).

Table 1. Field Sampling Summary for
On-Site Surficial Extent of Contamination Study *

Sampling Approach	Analysis		
	XRF	PCP	Dioxin
Grid Nodes			
Surficial	340	340	
Subsurface	170	170	
Judgmental			
Surficial	50	50	3
Subsurface	25	25	
Total	585	585	3

* Note: This summary table is not intended as a substitute for Tables 9.1 and 9.1. It merely summarizes samples physically collected in the field on-site. It does not include off-site samples, or additional laboratory analyses which will be conducted such as MS/MSD.

The judgmental samples will be collected near suspected sources of contamination such as the process building, the oil/water separator, the lagoons, the woodchip pile, and the storage tanks. The precise location of these samples will be determined in the field upon consultation with the Work Assignment Manager. The judgmental samples will be collected as described above, although the additional XRF and PCP samples may not necessarily be taken at the same locations, since the pattern of contamination of the metals and the PCP are probably different.

Each individual sample container will be labeled with the analytical method (e.g. PCP or XRF), the date and time of sample collection, and a unique numerical location/depth code which will identify the sample location and depth (Section 3.2.2.4). Also, any other specific information pertinent to that sample, such as "lagoon sample" will be written on the container as well.

Detailed notes on each sample location and sample characteristics will be recorded on a field data sheet by one member of each sampling team. Information recorded will include general location (e.g. edge of ditch, 100 feet south of small lagoon), soil characteristics (e.g. color, texture, composition, mottling, organic material, woodchip fragments, evidence of staining or disturbance), and any other pertinent information potentially affecting results (e.g. sample taken 10 feet from junk auto).

3.2.2.4 Sample Location and Depth Code

A sample coding procedure will be used to indicate the depth and location of each sample within the grid. The code has been established to facilitate data management, and is compatible with the data reduction software used to transfer the data directly from the XRF instrument to a LOTUS spreadsheet.

This code will be used both to identify the grid nodes themselves in the field, as well as the samples collected at or near each node. The only difference between the code written on the flag or stake in the field marking each grid node, and that written on the sample container, is that the latter will also include the depth at which the sample is collected.

The coding procedure is based on a coordinate system, which assumes the origin (0N, 0E) is situated at the southwestern corner of the grid. The first four digits of the code will represent the distance in feet in a northerly direction from the origin of the grid, followed by the letter "N" for north. For example, a sample collected at a grid node located 1800 feet north of the origin will begin with the designation "1800N".

The next four digits will represent the distance in feet in an easterly direction from the origin. Thus, a location at a point 1800 feet north and 300 feet east of the origin will be identified "1800N,300E". This designation will be used to mark the stake located at that particular node on the 100-foot grid.

Actual samples collected will have a code followed by three additional digits, indicating the depth (in feet) at which the sample was collected. For

example, a sample collected at the grid node in the example above at the 1 foot depth would be identified as "1800N,300E, 1". A surface sample at the same location would be labeled as "1800N,300E, 0".

While this system was developed primarily for identifying samples collected along the grid, it will also be used to identify samples collected for depth profiles, dioxin analysis, and other judgmental purposes. For example, if a boring sampling is taken within the grid, but not necessarily on a 100-foot node, its location within the grid can still be measured and noted within 1 foot. The data collected will be incorporated into the contouring program (Section 3.2.2.8)simply by giving it a designation such as "1834N,376E, 0".

To tie depth profiles into the grid, boring samples will be labeled in the same manner, so that a sample collected from 120 feet at the location in the previous example would be labeled as "1834N,376E, 120". This same coding system will be used for all sampling throughout the site. For the sake of clarity, commas will be written on the sample bag separating the different fields. However, due to software limitations, the code itself will be entered into the computer without commas.

3.2.2.5 X-Ray Fluorescence Spectrometry

The arsenic, copper, and zinc concentration of all samples will be determined on-site using a field portable XRF instrument. The Spectrace 9000 XRF will be used as a field analytical tool to collect QA2-level data (Table 9.2). This data will be used to identify the general range of metals contamination in different areas of the site and to plot contamination contours for the three metals of concern. The concentration of lead will also be measured, to determine its potential interference with arsenic readings.

Measurements will be made using a Spectrace 9000 portable XRF spectrometer. The Spectrace 9000 XRF is a multi-element analyzer that will permit the simultaneous determination of up to 25 metals. It will be operated and calibrated as per the operating manual supplied by the manufacturer, ERT/REAC SOP #1713, Spectrace 9000 Field Portable X-Ray Fluorescence Operating Procedures and ERT/REAC SOP #1710, General Considerations for Using X-Ray Fluorescence. An instrument log book will document XRF field calibration, and energy and resolution checks as well as other field analytical data. Data disks of XRF raw and processed results will be generated and archived for future project documentation or reanalysis by the XRF if sample anomalies occur. The Spectrace 9000 will be regularly calibrated in the field by taking measurements on a set of standards. Duplicate readings will be taken on 10 percent of all samples, systematically selected.

A field portable computer will be interfaced with the Spectrace 9000 using software routines (XRFMENU) which will generate sample files with the sample location code and XRF results linked together for easier downloading for modeling and reporting purposes. Previous experience with this instrument and the contaminants of concern has shown that method detection limits (MDLs) will range from 30 to 200 parts per million by

weight (ppm w/w) for the arsenic, copper, lead, and zinc.

The Spectrace 9000 has a surface probe and battery pack that will permit analysis to be done directly on the soil surface. The XRF will be used in-situ if the soil is dry; if the soil is saturated, the soil will require drying before analysis. In the latter case, soil will be collected into a 4-oz glass jar (Section 3.2.2.3),then dried in a conventional or microwave oven. It will be sieved using a decontaminated 1 millimeter (mm) stainless steel sieve to remove pebbles, organic matter and other extraneous material. A thirty-one mm polyethylene X-ray sample cup will be labeled, filled with approximately five grams of soil, and sealed with a piece of 0.2-mm-thick polypropylene X-ray film. The sample cup will be placed directly on the XRF detector window for analysis.

A minimum of 10 percent of all XRF samples, systematically selected as described above, will be submitted to a laboratory for analysis of arsenic, copper, lead, and zinc. Each sample will consist of a 4 ounce glass jar if the XRF analyses were performed in situ, or two XRF sample cups if the XRF analyses were performed ex situ. In this manner, the laboratory analysis will be conducted on similar or the same soil that the XRF reading was taking from.

3.2.2.6 PCP Screening and Analysis

Soil collected for PCP analysis will sent to the ERT/REAC High Hazard Laboratory located at the Escambia Wood Treating Site, Brunswick, Georgia. The analysis will focus only on PCP and thus permit the use of analytical and instrument medifications to increase effieiency.

A maximum of 50 soil samples collected for PCP analysis will be screened on site using immuno-assay test kits. Immuno-assay screening will provide immediate results in the field regarding the extent of PCP contamination, and help to determine which areas of the sampling grid require further definition. Screening kits will also be used to help determine the location of samples to be submitted for dioxin analysis.

A minimum of 10 percent of all PCP screening samples will be sent to a laboratory for confirmation. For subsurface sampling, more sensitive detection limits may be required, especially for calculation of attenuation rates. In this case, a higher proportion of samples may require laboratory confirmation. However, for the sake of planning and budgetary purposes, it is presently assumed that approximately 10 percent of the subsurface samples will be sent to a laboratory for confirmation.

3.2.2.7 Dioxin Analysis

A limited number of samples will be collected for dioxin analysis. Sample locations will be determined in the field on the basis of site history, field observations, and results of PCP field screening tests. Sampling for dioxin analysis will focus on areas with the highest PCP contamination, and may also include areas where wood ash or visible staining is observed. At present, these areas are anticipated to include locations identified in the

March, 1993 ATSDR memorandum, such as the sample blowdown pond, stained soils below the former drip tracks to the PCP treatment cylinder, and soil downwind of the smokestack near the dairy farm south of State Route 70.

Each sample collected for dioxin analysis will be labeled with a unique sample location/depth code (Section 3.2.2.4). All dioxin samples will be analyzed by a subcontracted analytical laboratory for the following isomers: tetra, penta, hepta, and octa polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF). Results of these analyses will be presented showing both concentrations for each individual isomer, as well as by 2,3,7,8-tetrachorodibenzo-p-dioxin (TCDD) toxicity equivalent factors.

3.2.2.8 Data Processing, Analysis and Contouring ?

Daily printouts of XRF data will be used to post data on a site photo at a scale of approximately 1 inch = 135 feet, using acetate overlays. These data will be used in the field to determine whether additional samples are needed to further define contamination in a given area of the grid. In addition, data will be downloaded from the XRF on a daily basis, and imported into a LOTUS file compatible with GEOSOFT contouring software. Contamination contours will be generated during the field investigation to give up-to-date data on the extent of surficial contamination. The GEOSOFT program is capable of calculating the confidence interval of each contour line, box and whisker plots of data, and semivariograms; this information will also be used to determine the location of additional sampling points. Data generated for PCP will be handled in a similar fashion.

Regression analyses will be conducted on the field and laboratory data to evaluate the accuracy and precision of the field analyses and screening. Additional analysis may be conducted to determine if PCP concentrations are correlated with surface staining in the field, or if subsurface concentrations of each compound are correlated with surface concentrations.

3.2.2.9 Off-site Soil Extent of Contamination Investigation

The off-site extent of contamination study will focus on the direction of contaminant plumes identified during the on-site investigation. Off-site sampling locations will be based upon historical studies, as well as site topography, locations of contaminant sources, and potential transport pathways. Based upon a review of historic data, a potential contamination pathway exists in the northeastern portion of the site leading from a former lagoon through an erosional area into an off-site wetland. Preliminary review of an aerial photo of the site area suggests a second potential pathway exists in the southeastern portion of the site, on the south side of the highway, where some drainage apparently flows in a northeasterly direction.

At present it is anticipated that approximately 40 surficial samples and 20 subsurface samples will be collected during the off-site investigation. These numbers are summarized in Table 2 for planning purposes (i.e.

determination of personnel required, field logistics, time frame and budget). Should results of the on-site EOC investigation reveal little potential for off-site contamination, sampling could be greatly reduced, and limited to judgmental samples collected at selected locations within the off-site grid.

Table 2. Field Sampling Summary for
Off-Site Surficial Extent of Contamination Study *

Sampling Approach	Analysis	
	XRF	PCP
Judgmental		
Surficial	40	40
Subsurface	20	20
Total	60	60

* Note: This summary table is not intended as a substitute for Tables 9.1 and 9.1. It merely summarizes samples physically collected in the field on-site. It does not include off-site samples, or additional laboratory analyses which will be conducted such as MS/MSD.

3.2.2.10 Ecological Risk Assessment

Potential ecological risks resulting from site/off-site contamination will be evaluated. Preliminary fieldwork will be conducted concurrently with the off-site EOC survey, and any follow-up studies will be conducted pending results of that survey.

The preliminary (Phase I) ecological assessment will consist of identification of target receptors and habitats potentially affected by site contamination, as well as exposure pathways. Based on the results of this survey, a revised QAWP will be prepared indicating a study approach to address potential ecological risks posed by site contamination.

A species inventory and qualitative habitat assessment will be conducted in on- and off-site areas of ecological concern identified by the EPA. Particular emphasis will be placed on evaluation of two potential contaminant routes into the wetland located northeast of the site: (1) surface water flow and soil erosion from the former lagoon area, and (2) groundwater contamination.

To evaluate potential contamination from surface runoff, approximately 10 soil and 10 sediment samples will be taken along a gradient from the former lagoon into the wetland itself. These samples will be collected during the off-site EOC investigation. To evaluate potential groundwater contamination into the wetland, 10 surface water samples will be taken within the wetland at the same areas from which the sediment is collected. This will be done before collecting the sediment itself. All of these samples will be analyzed for arsenic, copper, and zinc, and PCP. These samples

should be considered of a preliminary nature, to evaluate the need for additional EOC work within the wetland area itself.

Should these samples show levels of contamination which could adversely affect the wetland biota, then toxicity testing, bioaccumulation, or tissue studies may be undertaken to evaluate the availability and toxicity of the contamination. A ecological investigation may also be warranted to evaluate concerns raised by the on-site PCP-contaminated woodchip pile[2]. Additional soil samples will be taken in this area during the surficial EOC investigation, and the need for any additional studies will be assessed based upon the analytical results.

3.2.3 Overburden Profiling Program

3.2.3.1 Introduction

The objectives of the overburden profiling program are to delineate the extent of PCP and ACA contamination in the overburden, unsaturated, and saturated zones, to determine contaminant transport characteristics, and to evaluate potential adverse impacts to ecological and human receptors. Once these objectives have been addressed, remediation alternatives such as groundwater collection, treatment, and reinjection to flush contamination from the vadose zone soils can be evaluated. To achieve these multiple objectives it is necessary to construct both unsaturated and saturated contaminant flow and transport models of the site. These objectives will be achieved by performing borehole and surface geophysical surveys, conducting a soil gas survey, installing monitoring wells and lysimeter nests, and collecting soil and groundwater samples for geotechnical and chemical analyses.

3.2.3.2 Geophysical Survey

Electromagnetic Survey The geophysical survey will be conducted as per ERT/REAC SOP #2159, General Surface Geophysics. A ground electromagnetic survey will be conducted on traverses oriented perpendicular and parallel to suspected groundwater flow. Exact locations of electromagnetic traverses will be determined after initial site inspection to avoid cultural noise interference. However, these traverses will be spaced in such a manner to best describe the geology of the site. Measurements will be taken at station spacings of 5 to 25 feet, based on the instrument used.

Electromagnetic data will be obtained using the Geonics™ EM-31 and EM-34 terrain conductivity instruments on each traverse. If it is determined that data obtained by these instruments is useful for stratigraphic mapping, the EM-31 measurements will be taken at waist height and on the ground at each sample node, and EM-34 measurements will be taken at 10, 20 and 40 meter coil separations with the coils in the vertical orientation at each sample node. Data processing will include profile plots of terrain conductivity at each coil separation.

Electromagnetic Soundings Electromagnetic soundings will be performed

along a traverse(s) perpendicular to groundwater flow, depending on site conditions. In addition, several soundings may be taken at various locations in such a way as to best describe the geology of the site and to fill in any data gaps.

Electromagnetic soundings will be collected using the Phoenix™ V-5 receiver and the Geonics™ EM-47 time-domain electromagnetic (TEM) transmitter utilizing a square transmitter loop on its side. The receiver will be centered on the station to be measured in the center of the transmitter loop.

The TEM data will be reduced to apparent resistivity versus time for data inspection and modeled using a nonlinear regression scheme to a layered-earth model. These modeled layers will be interpreted into the stratigraphic scheme of the site.

Resistivity The objective of a resistivity survey is to better define the depths, thicknesses, and continuity of strata significant to groundwater flow (such as clay versus sand layers, or grain-size variations) or to detect conductive contaminated groundwater directly.

Resistivity measurements will be taken at selected TEM sample nodes to map the subsurface electrical resistivity structure, which can be interpreted to provide geologic and hydrogeologic data and data on the physical properties of the geologic matrix or the water contained therein. The resistivity method measures the impedance to electrical current flow through lithologic material (soil, sediments, or rock), commonly in the units of ohm-meters. The resistivity of lithologic material is normally a function of porosity, permeability, water saturation, and concentration of dissolved solids in the pore fluids. The resistivity measurement can also be dominated by lithologic or rock-type variations such as sand versus clay, or sandstone versus shale.

Induced Polarization Induced Polarization (IP) soundings will be performed at selected TEM sample nodes to help better define the electrical properties of the soils. The induced polarization method is an electrical technique which measures the slow decay of voltage in the subsurface following the cessation of an excitation current pulse. Basically, an electrical current is caused to flow in the subsurface, as in the resistivity method above. This electrical current is due mainly to ion transport in the pore waters of the geologic material. During this current flow, electrochemical reactions take place between the rock matrix minerals and these ions in solution, when electrical energy is stored. After the current is turned off, the electrochemical reactions reverse, and this stored electrical energy is discharged, resulting in a secondary current flow which is measured as the induced polarization signal. Thus, in a sense, the subsurface material acts as a type of electrical capacitor.

The physical property measured by the induced polarization method is chargeability, which is measured in either millivolt-seconds per meter (milliseconds) or as a dimensionless quantity in an alternate formulation. Enhancements in chargeability occur with increased clay content and when

disseminated sulfides or graphite is present. Therefore, induced polarization is useful in combination with resistivity (since the two measurements are made simultaneously) to map the thicknesses and extent of clay and silt horizons which impede groundwater flow. In addition, given the enhanced response of rock containing disseminated sulfides or graphite, the method can be used to map some geologic units. The IP soundings will be collected with the Phoenix V-5 receiver in the IP mode of operation.

Downhole Geophysical Survey The downhole geophysical survey will be conducted as per ERT/REAC SOP #2162, Borehole Geophysics. Geophysical logs of existing and new monitoring wells will be collected using the Geonics™ EM-39 conductivity logging tool (an induction probe) and the GAMMA-39 natural gamma-ray tool. Data points will be collected at a station interval of 4 inches (0.1 meter) in these wells.

3.2.3.3 Soil Gas Survey

A soil gas sampling program will be implemented, if the petroleum hydrocarbon carrier for PCP can be detected in soil vapor, to track the migration of contaminants off-site through the unsaturated zone. Soil gas samples will initially be collected in known process areas to determine the potential success of the soil gas survey. If these results suggest that the soil gas sampling method will be successful, approximately 50 source and receptor area locations along the toe of the bluff on which the site is located will be selected for soil gas sampling.

The soil gas sampling design will be based on historic site activities, existing data, the results of soil and groundwater sampling, soil staining and discoloration, and other site reconnaissance observations. Locations will be situated in areas where the indicators described above suggest the presence and migration of PCP. Potential source areas include the two wastewater receptor lagoons, the PCP treatment building, and oil/water separator building. Potential receptor areas include those hydraulically downgradient of known contaminated areas including the toe of slope along the northern site boundary. Soil gas sampling will proceed in lateral directions until on-site analytical methods indicate that target analytes are not detected in samples.

Sample collection intervals will be determined on site based on the indicators described above. Beginning at the shallowest depth, samples will be collected using the Geoprobe at the selected intervals to a final depth that is approximately five feet above the water table or until refusal.

Soil gas samples may be collected and handled using manual methods or the Geoprobe™ as per ERT/REAC SOP #2149, Soil Gas Sampling. Soil gas samples will be analyzed on-site for volatile organic compounds (VOCs).

Based on soil gas results, proximity to a potential source, gaps in groundwater quality and soil data, a groundwater and/or soil sample may be collected at some soil gas locations. All samples will be collected over as short a time as possible to provide an instantaneous evaluation of groundwater water quality at the site.

3.2.3.4 Overburden Data Collection Methodology

Soil samples for geotechnical, lithologic and chemical analysis will be collected using a rotasonic drill rig, or the Geoprobe™. The rotasonic drill rig is a comparatively fast drilling method capable of reaching deep boring depths at a rate more quickly than speeds of conventional methods. For deep borings, well installation is relatively quick, well controlled and effective with positive placement of sand pack, seal and grout. The sample collection method provides an accurate 10 to 15 feet long continuous, relatively undisturbed soil sample. Soil samples collected from great depths in this manner minimize the risk of volatization of volatile organics and compaction of soil samples. Another unique feature of the rotasonic drilling method is that it is a clean and controlled system which generates less drilling wastes than conventional methods, and deters airborne contaminants in the breathing zone. Based on a review of the available lithologic data from the site, the rotasonic drilling method is chosen as the best drilling technology to install deep soil borings, monitor wells, and lysimeter nests.

The Geoprobe™ may be used to collect soil from 10 to 15 feet in areas where the results of the surface soil sampling effort indicate contamination. The Geoprobe™ will be operated as per to ERT/REAC SOP #2165, Geoprobe™ Operations.

Other drilling methods that were considered, but determined inappropriate for site conditions are summarized below:

Sampling at Depth with the Hollow Stem Auger Method This method was determined unsuitable due to its inability to reach great boring depths (> 120 feet). Sample collection from depths in excess of 75 feet become time consuming and inaccurate. Also, limited information from boring logs provided by the State of Wisconsin suggests that a glacial till layer exists between approximately 60-85 feet that would inhibit the advancement of the hollow stem augers beyond this depth.

Sampling at Depth with the Air Rotary Method This method is inappropriate for collecting overburden soil samples due to the introduction of forced air and disturbance to in situ soil. The threat of induced airborne contamination would increase drilling costs by upgrading levels of protection for the drilling crew. The cost of air rotary is about the same as rotasonic, however rotasonic provides more accurate data.

Sampling at Depth with the Cable Tool Method This method is certainly capable of advancing borings to the depths that will be encountered at the site. However, the method is extremely time consuming and, consequently, would inhibit completion within the current contract.

3.2.3.5 Soil Boring and Monitor Well Installation

The objective of the soil borings are to characterize lithology and determine vertical extent of soil contamination in the vicinities of each spill location at the site. Ten soil borings will be installed in the vicinity of known

contaminant plumes and in areas that may intersect contaminant migration pathways. Five of the ten soil borings will be converted to groundwater monitor wells. The areas of contaminant plumes will be determined based on existing information and soil boring locations will be chosen by the REAC Task Leader in consultation with the WAM in the field. Up to three lysimeter nests will be installed to monitor the soil pore-water in the unsaturated zone. Each lysimeter nest will monitor soil pore-water contaminant concentrations at 20 foot intervals.

At all soil boring locations, subsurface soil samples will be collected from a continuous core sampler at 10 foot intervals from ground level to the water table. The maximum depth of the boring may be determined after delineating the vertical contamination of the overburden by field analyses and screening. Soil samples will be field analyzed and screened with an XRF, PID, and FID. At soil boring locations that will be converted to monitor wells, the boring will be advanced to approximately 160 feet to allow for installation of a 20 foot well screen. Samples will be collected for field and laboratory analysis of chemical and physical parameters as described in Sections 3.2.2.5, 3.2.2.6, and 3.2.2.7. Water levels that are encountered during drilling will be noted, both at the time that they are first encountered and after they have stabilized.

The objective of converting five soil borings into groundwater monitor wells is to add to the existing monitor well network to further define the flow direction and groundwater quality at the site. Groundwater monitor wells will be installed as per ERT/REAC SOP #2150, Monitor Well Installation. Well screens for the monitor wells will be up to 20 feet in length and will be screened in the water table. Screen size and filter pack will be determined on the basis of grain size analysis of the proposed screened zone.

Up to three pressure-vacuum lysimeter nests will be installed within known contaminant spill areas. The objective of the lysimeter nests is to characterize the vertical profile of the contaminants in the unsaturated zone by collection of soil pore-water samples from each lithologic unit from the top of the static water level to the ground surface. Pressure-vacuum lysimeters will be installed at depths above 50 feet, and high pressure-vacuum lysimeters will be installed at depths below 50 feet. Soil tension will be measured using an electrical resistance block (gypsum block) attached to the lysimeter sampler above each ceramic cup. The lysimeter nest installation will consist of 2 lysimeters (as per State of Wisconsin (WDNR) regulations) per boring with an attached gypsum block on each lysimeter.

3.2.3.6 Overburden Data

The overburden data to be collected at the site will characterize the geology, identify physical parameters, and delineate contaminate plumes. The data will act as input into the conceptual model, the numerical unsaturated contaminant transport model, and the remedial action plan.

Lithologic Data A lithologic log of all borings will be recorded using the Weston GEOLIS™ lithologic information software. The GEOLIS™ software is a data collection, quality control/quality assurance, and

management system for collecting geotechnical data including soil type, color, density, blow counts, percent recovery, relative moisture content, odor, and other pertinent information. Additionally, GEOLIS™ will be used to gather monitor well construction details. The software component of GEOLIS™ will be used to perform QA/QC functions and generate data summaries of lithologic logs and well construction diagrams. Data can also be exported from the GEOLIS™ database to other software such as Geosoft, Site Planner™, GEOEAS and other software for analysis and depiction. It is anticipated that data will be recorded from approximately 1440 feet of continuous lithologic sample cores.

X-Ray diffraction may be performed on up to three clay rich soil samples to determine the physical characteristics and adsorption properties of the clay.

Geotechnical Data Geotechnical data collected from the unsaturated zone will be used to construct a one dimensional vadose zone contaminant transport model. The appropriate model will be chosen based on observed site conditions matching assumptions given in the governing equations of the model. Vadose zone models initially considered are SESOIL and VLEACH™. Geotechnical samples will be collected from representative lithologies, starting from ground level, from proposed lysimeter nest locations for a total not to exceed 9 samples.

The following soil properties of the unsaturated zone are required to construct the vadose zone contaminant transport model:

- Total effective porosity
- Cation exchange capacity
- Unsaturated hydraulic conductivity
- Annual recharge rate
- Dry bulk density
- Grain size
- Moisture content
- Soil tension

The total effective porosity, dry bulk density, grain size, cation exchange capacity, and moisture content will be determined on soil samples collected at depth. Soil tension will be measured in the field with gypsum blocks. A gypsum block is an electrical resistance block that consists of two electrodes embedded in porous material (gypsum) and is attached to a gauging device which measures the change in electrical resistivity of the gypsum due to the surrounding soil. Gypsum blocks will be nested with lysimeters in the vicinity of the contaminant plume to monitor soil tension gradients of a soil section representative of the contaminated unsaturated zone.

Unsaturated hydraulic conductivity will be estimated from the parameters collected as well as interpolation of soil-water retention curves. Annual recharge rates will be determined from existing data from local weather monitoring stations.

Chemical Data Chemical analysis for PCP, arsenic, copper, zinc and TPHC will be performed on soil samples to determine the vertical extent of contamination. Samples will be selected for analysis based on visual observations, PID and FID readings, and field screening results. Soil samples will be field screened with a PID, OVA, and enzyme immuno-assay test kits and analyzed by XRF. To delineate the vertical extent of

contamination, samples from each soil boring will be collected at 10 feet intervals for a maximum of 140 soil samples. Approximately, 125 samples will be analyzed with XRF and 15 samples will be sent to the laboratory for analysis confirmation.

The chemical parameters of the soil and contaminants that are needed for the vadose zone model are:

- o Total organic carbon of soil
- o Contaminant concentrations of soil
- o Soil pore-water samples
- o Distribution coefficient of contaminant
- o Soil/water partition coefficient of contaminants
- o Free air diffusion coefficient of contaminants
- o Aqueous solubility of contaminants
- o Henry's law constant of contaminants

The chemical parameters will be analyzed from soil samples collected from the continuous core sampler. Nested lysimeters at up to 3 locations will be used to collect soil pore-water samples at approximately 20 foot intervals in the unsaturated zone. The physical properties of the contaminant will be referenced from appropriate literature. The chemical parameters will be input for the appropriate unsaturated contaminant transport model.

3.2.4 Groundwater Monitoring Program

3.2.4.1 Introduction

The objective of the groundwater monitoring program is to determine the flow direction, quality, and characteristics of the aquifer(s) at the PWP site. The objective will be fulfilled by collecting water level data from monitor wells and by collecting groundwater samples from monitor and potable water wells. This information will assist in determining existing EOC, support of the groundwater modeling, projecting chemical fate and transport under different aquifer conditions, and evaluating the impact of different conceptual remedial pump and treat alternatives.

3.2.4.2 Water Level Measurements

Water level measurements will be collected as per ERT/REAC SOP #2151, Water Level Measurement from the existing monitor wells to define the groundwater potentiometric surface. Historical water levels will be mapped to determine seasonal variations and effects of rainfall on the aquifer. Depth to water and depth to bottom will be measured from the marked point at the top of casing (TOC) for each well. Measurements will be made with an electric water level indicator and weighted depth sounder, respectively.

3.2.4.3 Monitor Well Sampling

The existing groundwater monitoring wells and the proposed additional monitoring wells will be sampled to provide further data on the groundwater

quality of the site. The monitor wells will be sampled as per ERT/REAC SOP #2007, Groundwater Well Sampling and 2152, Monitor Well Sampling. The groundwater samples will be analyzed for PCP, arsenic, copper, zinc, and TPH. In addition, field test kits will be used to measure ammonia and nitrogen in select groundwater samples.

3.2.4.4 Potable Water Sampling

Potable water samples may be collected by the State of Wisconsin from the few neighboring residences if data indicates a potential for impact.

3.3 Remedial Option Evaluation

3.3.1 Soil Washing

Field Activities Soil will be collected from areas contaminated with approximately 500 mg/kg PCP. Enzyme immuno-assay test kits will be used in the field to determine if the targeted sampling areas are contaminated with PCP concentrations appropriate for the proposed study. Soil samples will be collected with a shovel, screened to less than 0.25 inches in size, homogenized, and placed in a 5-gallon plastic bucket. An aliquot of each soil washing treatability sample will be submitted to a laboratory for confirmation of PCP concentrations. Due to the potential for dioxin contamination, soil washing treatability studies will be conducted at the PWP site.

Treatability Study Design The soil washing study will be conducted as per ERT/REAC SOP #2173, Soils Washing Procedures. The goal of the soil washing process it to move contaminants from the solid phase (soil) to the liquid phase (wash solution). The bench-scale treatability study evaluates the effectiveness of various water-based wash solutions adjusted for pH, temperature, and surfactant concentrations and mechanical action in removing PCP and other site contaminants. Soil washing is a physical/chemical separation and volume reduction process that is generally used in conjunction with other technologies to remediate a site. Contaminants are removed (i.e. washed) from the soil matrix to form a concentrated water slurry containing the contaminants and fine soil particles. Soil washing does not destroy or reduce the toxicity of the contaminants unless it is combined with other chemical processes (i.e., oxidation). Due to the physical nature of fine soil particles binding with the chemical contaminants, they are usually not applicable to this technology. The objective of soil washing technology is to wash the contamination from the larger soil particles and then return them to the site. The fine soil particles and contaminated water are then treated by other technologies (i.e., bioremediation, carbon adsorption, etc.). The advantages of soil washing is that (1) an increased volume of clean material (the large soil particles) can be returned to the site and (2) a reduced volume of contaminated material (the wash water and fine soil particles) will require treatment by a potentially more energy intensive and costly technology (i.e., incineration, thermal desorption).

Feed and washed soil samples will be analyzed for PCP, arsenic, copper, and zinc. The slurry samples will be analyzed for PCP, arsenic, copper, and zinc. Matrix spike/matrix spike duplicates will be performed on the untreated soil and on a minimum of one sample for each additive used in the study. This will determine if any interferences are being introduced by the additives.

The following process parameters will be used for the bench-scale studies:

- o A 6:1 water:solids ratio
- o Ambient washing temperature
- o Mechanical scrubbing performed with a paddle stirrer
- o 0.1% Nonionic surfactant concentration
- o Elevated pH of 10.0

The following wash solutions will be evaluated:

- o Deionized water control (one wash and series of two washes)
- o Surfactant only wash
- o Elevated pH wash
- o Surfactant and elevated pH wash (one wash and series of two washes)
- o Surfactant and elevated pH wash followed by a deionized water rinse
- o Duplicate surfactant and elevated pH wash

The following procedure will be followed:

1. Weigh out 125 grams (g) of contaminated soil.
2. Place soil in a 1-liter clear wide mouth glass jar.
3. Add 250 milliliters (mls) deionized water (2:1 water:solids ratio) adjusted to the desired temperature, pH, and additive concentration. If adjusting the pH note the amount of acid or base required.
4. Record ambient water temperature and soil pH.
5. Place soil slurry under the paddle stirrer and set speed at approximately 50 rpm. This slow speed and low water:solids ratio will allow for an increased scrubbing action of the soil particles.
6. Allow mixing for 10 minutes.
7. Add 500 mls of distilled water and increase the speed to approximately 200 rpm for 10 minutes (enough to keep the heavier particles suspended).
8. If performing consecutive washes, cap the sample container and allow to settle for 10 minutes. Pour off the liquid fraction and repeat steps 3 to 7.
9. Pour off the liquid fraction and retain for further analysis.
10. Homogenize remaining soils, noting color and layers, and analyze for contaminants and total solids.

The following equipment and apparatus will be used:

- o Gang paddle stirrer with speed readout and control
- o Six 1-liter wide mouth glass sample jars or 1-liter beakers
- o pH meter with automatic temperature compensator probe
- o Thermometer
- o Deionized water
- o Reagents and additives

The soil washing treatability study will evaluate the effectiveness of various combinations of the following reagents and additives:

- o Surfactants (surface active agents) exhibit different combinations of detergents, foaming, wetting, emulsifying, solubilizing, and dispersing properties. Surfactants are classified depending on the charge of the larger

part of the molecule. Nonionic alkylphenol ethoxylates (i.e.,Tergitol NP-10) are highly versatile surfactants which are relatively inexpensive. Surfactants are useful for all types of contaminants.

- o Acids are used to lower the pH of the wash solution. Sulfuric, nitric, hydrochloric, and acetic acids can be used. Caution will be taken when choosing an acid to ensure that it does not interfere with analyses (i.e., hydrochloric acid and chloride analysis). Acids are generally used for metals extraction.

- o Caustics are used to increase the pH of the wash solution. A caustic which will introduce the least amount of interference is preferred (i.e., sodium hydroxide).

3.3.2 Thermal Desorption

Field Activities Soil will be collected from areas contaminated with approximately 1,500 mg/kg PCP. Enzyme immuno-assay test kits will be used in the field to determine if the targeted sampling areas are contaminated with PCP concentrations appropriate for the proposed study. Soil samples will be collected with a shovel, screened to less than 0.25 inches in size, homogenized, and placed in a 5-gallon plastic bucket. An aliquot of each thermal desorption sample will be submitted to a laboratory for confirmation of PCP concentrations.

Treatability Study Design The thermal desorption treatability study will be conducted as per ERT/REAC SOP #2176, Thermal Treatment Procedures and evaluate the Low Temperature Thermal Treatment (LT^3) unit. The LT^3 process thermally desorbs the soil and condenses the exhaust gases into a distillate. The study will be conducted at the WESTON Environmental Technology Laboratory (ETL) in Lionville, Pennsylvania. The distillate will be treated by the BCD process at a subcontracted vendor's facility.

Prior to evaluation, the following physical parameters will be determined on the soil samples for the thermal desorption studies:

- o Percent moisture
- o Grain size
- o Specific gravity
- o Soil classification and plasticity limits
- o pH
- o Heating value
- o Percent ash

Unit Clean-out Clean sand saturated with water will be processed through the system to make sure the unit is free of contamination. The condensate from this first run will be discarded. Six runs of the clean sand saturated with water will then be performed. Condensate, scrubber water, and sand (pre- and post-treatment) from each run will be collected, combined, and analyzed for total solids, PCP, arsenic, copper, zinc, and chloride.

Soil Phase As mentioned previously, contaminated soils will be screened to remove debris larger than 0.25 inches. One kilogram of soil will be weighed and combined

with 100 milliliters of water for each run. Ten runs will be made. Pre- and post-treatment soil samples will be collected from each run, composited, and analyzed for total solids, PCP, arsenic, copper, and zinc.

Distillate Phase The distillate from each run will be collected, composited, and analyzed for PCP, arsenic, copper, zinc, and dioxin. The scrubber water will be collected and analyzed for pH and chloride.

Air Sampling Samples of the exit gas from the water scrubber will be collected and analyzed for PCP, VOCs, chloride, and particulates. XAD-2 tubes, Tenax/CMS tubes, and polyurethane foam (PUF) plugs will be utilized for sample collection. Flow rates for each collection media will be monitored and recorded.

Unit Decontamination Condensate traps, the scrubber, and other accessible parts will be wiped with methanol and cleaned. Two clean soil runs will be performed at the end of the study to decontaminate the unit.

Efficiency Analysis The contaminated soil (CS) and sand (S) samples from each test and desorption units will be analyzed for the parameters summarized in Table 3.

Table 3. Analytical Parameters for Evaluation of the WESTON LT^3 Thermal Treatment Systems

Sample	Pre-treatment Solids	Post-treatment Solids	Condensate Liquid	Air
Total Solids	CS, S	CS, S	--	--
PCP	CS, S	CS, S	CS, S	CS, S
Chloride	CS, S	CS, S	CS, S	CS, S
Dioxin	CS	CS	CS	CS
As, Cu, and Zn	CS, S	CS, S	CS, S	CS, S
Particulates	--	--	--	CS
Volatile Organic Compounds	--	--	--	CS, S

3.3.3 Soil Solidification/Stabilization

Field Activities Soil will be collected from areas contaminated with a total arsenic, copper, and zinc burden of approximately 300 mg/kg. Samples will be screened in the field using XRF to ensure the targeted sampling areas are contaminated with metal concentrations appropriate for the proposed study. Soil samples will be collected with a shovel, screened to less than 0.25 inches in size, homogenized, and placed in a 5-gallon plastic bucket. An aliquot of each solidification/stabilization (S/S) sample will be submitted to a laboratory for confirmation of metal concentrations.

Since the soils may be contaminated with both PCP and ACA, several of the samples will also be screened in the field with enzyme immuno-assay test kits to ensure that the soil does not contain PCP and/or to determine the amount of PCP in the soil. These samples will also be submitted to a laboratory for confirmation of PCP concentrations.

Treatability Study Design The bench-scale S/S study will be conducted in two phases. The first will evaluate ACA contaminated soils, and the second will evaluate ACA/PCP contaminated soils. Both will be conducted on a representative sample of each type of contaminated material. The ACA contaminated soil study will be conducted at the ERT/REAC Engineering Evaluation Unit and the PCP contaminated soil study will be conducted at the WESTON Environmental Technology Laboratory, Lionville, PA.

Prior to conducting the S/S studies, the following, chemical, engineering, and geotechnical characteristics will be determined for each sample:

- o PCP
- o Metals - arsenic, copper, and zinc
- o pH
- o Percent moisture
- o Unconfined compressive strength
- o Permeability
- o TCLP for PCP
- o Grain size
- o Freeze/thaw test
- o Wet/dry test
- o Bulk density
- o TCLP for arsenic, copper, and zinc

The S/S additives utilized during the study may include fly ash or kiln dust, cement, latex, and organophillic clay. The additives will not exceed 35 percent of the total mixture. Although the actual mixtures may change during the project, the possible range of mixtures of soil and additives for the S/S treatability studies are summarized in Table 4. The samples will be cured in a concrete curing chamber.

Table 4. Possible Range of Soil and Additives Mixtures for the Solidification/Stabilization Treatability Studies

Test No.	Additive (percent by weight)				
	Soil	Fly Ash	Cement	Organophillic Clay	Total Additives
1 (Control)	90	----	10	----	10
2	80	----	20	----	20
3	70	----	30	----	30
4	75	5	20	----	25
5	75	----	20	5	25
6	70	10	10	10	30

Test No.	Additive (percent by weight)				
	Soil	Fly Ash	Cement	Organophillic Clay	Total Additives
7	80	5	10	5	20
8	70	5	20	5	30

The standard toxicity characteristics leaching procedure (TCLP) extraction procedure will be conducted on all solidified samples for analysis of PCP and arsenic. The pH of the solidified matrix will be measured prior to completing the TCLP extraction and must be less then 12 units prior to solidifying.

The following performance criteria will be used during the S/S treatability studies:

- The permeability of a friable S/S mixture must be 2 orders of magnitude less than that of the surrounding soil
- The site cleanup criteria for PCP has not been determined
- The TCLP target concentration for PCP is 100 mg/l
- The unconfined compressive strength must be least 200 pounds per square inch (psi)
- The permeability of the solidified monolith should be no greater than 1 X 10^{-6}
- Arsenic will have to pass the TCLP requirements as the specific requirement (for soil) has not been determined for the site

3.3.4 Slurry-Phase Bioremediation Studies

Cultures Indigenous cultures capable of biodegrading PCP will be developed using standard enrichment procedures with site soils as the microbe source and mineral salts-PCP as the growth medium. Non-indigenous PCP-degrading cultures may also be evaluated for their ability to remove PCP from test wastewater or soils.[3]

Nutrient Media Literature sources have been screened to identify nutrient media which have been successfully utilized to cultivate PCP-degrading cultures.[3,4,5,6] The nutrients will be prepared as sterile stock concentrates and added in suitable amounts to prepare nutrient media. Nutrient media will consist of mineral salts-PCP or inorganic nutrient-supplemented wastewater.

The mineral salts-PCP medium will be prepared by adding PCP stock solution to sterile mineral salts at a rate of 10 ml/l. Purified PCP stock solutions will be prepared by dissolving 1.0 gram of purified PCP to 100 ml of 0.046N sodium hydroxide and sterilizing the solution by filtration. The final PCP concentration in medium will be 100 mg/l.

Inorganic nutrient-supplemented wastewater will be prepared by adding inorganic nutrients to alkaline soil washing wastewater. Approximately 2 kgs of contaminated soil will be washed in 0.50N sodium hydroxide solutions at a 10 to 20 percent weight/volume (w/v) soil loading. This will yield approximately 10 liters of

wastewater which is sufficient for studies to evaluate growth performance in a shake flask and stirred tank fermenter. Wastewater solids will be removed by centrifugation and clarified wastewater stored in amber glass bottles until needed. Test wastewater will be suitably diluted with aliquots of wash solution to achieve PCP concentrations of 100 to 200 mg/l to minimize problems of toxicity.[3] Previous studies have shown that the alkaline wastewater is sterile.[7]

The alkaline wastewater will be aseptically neutralized with dilute sulfuric acid and supplemented with inorganic nutrients. The volume of the wastewater medium will be set at a desired volume with sterile deionized water. If required, the final pH will be adjusted to 7.3 to 7.5 with sterile dilute sulfuric acid or sodium hydroxide solutions.

Sampling and Analyses Cultures may be periodically sampled and analyzed for the following parameters:

- Pentachlorophenol
- Viable cell counts
- Ammonia
- Total kjeldahl nitrogen
- Inorganic phosphate
- Metals
- Sulfate
- Soil moisture
- Cation exchange capacity
- pH
- Carbon dioxide
- Nitrogen
- Nitrate
- Phosphorous
- Total phosphorous
- Chloride
- Total organic carbon
- Water holding capacity
- Particle size distribution

Decontamination of Laboratory Equipment Non-disposable contaminated glassware will be rinsed sequentially with deionized water and acetone, washed with a non-phosphate detergent (Liquinox), and rinsed with deionized water. Disposable contaminated glassware will be rinsed with acetone, and disposed of in approved receptacles.

All glassware containing liquid media with viable cultures will be sterilized in an autoclave prior to disposal with the exception of glassware containing PCP-contaminated liquids. PCP-contaminated liquids will be decanted into suitable containers as non-sterile aqueous waste and disposed of by incineration. Contaminated glassware will be washed with deionized water, rinsed with acetone, before being washed with soap and water. Solid biological waste (disposable petri dishes or pipets), not contaminated with PCP, will be sterilized in an autoclave and disposed of in labeled autoclave bags. PCP-contaminated solid waste will be stored in plastic bags in 55 gallon drums as non-sterile solid waste and disposed of by incineration.

3.3.4.1 Shake Flask Culture

The objective of this experiment is to determine whether the active culture can maintain a consistent rate and extent of PCP degradation. If active cultures are removing PCP at consistent levels over defined time periods for three consecutive passages, then attempts will be made to isolate the active culture.

Primary Enrichment Studies Standard elective enrichment studies will be conducted to develop PCP degrading cultures using site soil as the microbe source. Approximately 10 to 20 soil samples will be collected at the site and combined into composites to minimize glassware requirements. The composited soil samples will be used to inoculate mineral salts media containing purified PCP as the sole carbon and energy source.[5] Uninoculated control flasks will be included to monitor medium contamination and photodegradation of PCP. Test and control flasks will be incubated for a total of 28 days. Samples will be collected at days 0, 14, and 28 and analyzed for PCP by spectrophotometry.[5] Samples will be preserved either by freezing at -20°C or by the addition of 37 percent (v/v) formaldehyde [3.7 percent (v/v) final concentration]. The growth conditions for PCP enrichment studies are summarized in Table 5. Test cultures showing the highest rate and extent of PCP degradation will be prioritized for further evaluation in secondary enrichment studies.

Table 5. Operating Parameters Used in the Development of PCP-Degrading Enrichment Shake Flask Cultures

Operating Parameter	Parameter
Culture Volume (ml)	50 (Primary, Secondary, and Tertiary Enrichment Studies) 500 (Confirmation Growth Study) 1000 (Wastewater Growth Study)
Culture Vessel	250 ml Erlenmeyer Flask (Primary, Secondary, and Tertiary Enrichment Studies) 2000 ml Erlenmeyer Flask (Confirmation and Wastewater Growth Studies)
Nutrient Medium	Mineral Salts + PCP (Primary, Secondary, Tertiary Enrichment, and Confirmation Growth Studies) Nutrient-supplemented Wastewater (Wastewater Growth Study)
Temperature (°C)	30
Agitation Rate (rpm)	200
Inoculum	Site soils (Primary Enrichment Study) Culture Enrichments (Secondary, Tertiary Enrichment Studies) Purified Cultures (Confirmation and Wastewater Growth Studies)
Sampling Times (days)	(Purified PCP) Primary Enrichment Culture - 0, 14, 28 (Purified PCP) Secondary Enrichment Culture - 0, 4, 7 (Purified PCP) Tertiary Enrichment Culture - 0, 4, 7 (Purified PCP) Confirmation Growth Study - 0, 1, 2, 3 (Wastewater) Wastewater Growth Study - 0, 2, 4, 7, and 14

Secondary Enrichment Studies Primary enrichment cultures showing the highest rate and extent of PCP degradation will be used as the inocula in these growth studies. Aliquots of active cultures will be transferred to fresh mineral salts-PCP medium and incubated under growth conditions described above and in Table 5. Samples from test and control flasks will be collected on days 0, 4, and 7 and analyzed for relative levels of PCP. Enrichment cultures showing the highest rate and extent of PCP degradation will be studied in tertiary enrichment studies.

Tertiary Enrichment Culture Secondary enrichment cultures showing the highest rate and extent of PCP degradation will be used as the inocula in these growth studies. Aliquots of active cultures will be transferred to freshly prepared mineral salts-PCP medium and incubated under growth conditions described above and in Table 5. Samples from test and control flasks will be collected on days 0, 4, and 7.

Isolation of Purified PCP-Degrading Cultures As mentioned previously, active PCP degrading enrichment cultures will be further evaluated with the objective of isolating the PCP degrading microbe. A viable cell count evaluation will be conducted by serially diluting the culture in 10 millimolar (mM) phosphate buffer (pH 7.0) and preparing spread plates of suitable dilutions using half-strength Trypticase Soy Agar (TSA) containing a final concentration of 100 mg/l PCP as the plating medium. Individual colonies will be transferred to mineral salts-PCP indicator medium to identify isolates which produce acid when metabolizing PCP as the sole carbon source. Acid producers will be isolated using the streak plate method and half strength TSA-PCP as the plating medium; these organisms will be considered putative PCP degraders. Purified isolates will be further evaluated in shake flask culture to conclusively demonstrate PCP utilization.

Confirmation of PCP Degradation by Purified Cultures Purified isolates will be maintained on slants of half-strength TSA containing 100 ppm PCP. Seed cultures will be prepared by cultivating test isolates on a mineral salts-glutamate broth. Cultures, after reaching an absorbance value of at least 0.10 at 560 nm (A_{560nm}), will be induced to degrade PCP by the addition of a final concentration of 100 ppm PCP. After at least 80% of the PCP has been degraded, induced cells will be recovered by centrifugation, then washed and resuspended in sterile 10 mM phosphate buffer (pH 7.0). The washed cells will be inoculated into sterile mineral salts-PCP medium at a final cell count of 1×10^4 colony forming units (CFU)/ml and grown under conditions listed in Table 5. The culture will be grown over a 3 day period with samples collected at prescribed times on days 0, 1, 2, and 3. Each sample will be analyzed for PCP, chloride, culture pH, culture turbidity ($A_{560\ nm}$), and viable cell counts. PCP will be measured by spectrophotometry; however, PCP levels in the day 0 and day 3 samples will also be measured by gas chromatography to confirm spectrophotometric results. Cultures, demonstrating complete removal of PCP, stoichiometric production of chloride as a result of PCP degradation, and net increases in viable cell counts, will be considered to be legitimate PCP degraders and added to the culture library. The cultures will later be preserved at -20°C in 50 percent aqueous glycerol. Purified cultures will be routinely evaluated for their ability to remove PCP from site wastewater sources.

Growth of Purified Cultures on PCP-Contaminated Wastewater Purified PCP-degrading isolates will be grown in seed culture medium using procedures described above. Washed cells will be inoculated into shake flasks containing nutrient-supplemented wastewater medium. Concentrations of PCP, metals, inorganic nitrogen (ammonia and nitrate nitrogen), inorganic phosphate, and inorganic chloride in wastewater will be determined prior to preparing the medium. For growth studies, wastewater medium will be prepared by the addition of 900 ml of alkaline wastewater to sterile 2000 ml Erlenmeyer flasks. The wastewater will be neutralized with dilute sulfuric acid, supplemented with sterile nutrient stocks, and the culture volume set to 1000 ml with sterile deionized water. Growth parameters are summarized in Table 5. Washed cells will be added to a final cell count of 1 x 10^4 CFU/ml. Duplicate samples will be collected at days 0, 2, 4, 7, and 14. Each sample will be analyzed for levels of PCP, chloride, and viable cell counts. Cultures demonstrating removal of PCP, production of stoichiometric levels of chloride as a result of PCP degradation, and net increases in viable cell counts will be considered for further study in stirred tank fermenter.

Culture Preservation Purified or crude active cultures will be concentrated by centrifugation. Sedimented cultures will be suspended in 50% volume/volume (v/v) glycerol and frozen at -20°C for at least one month. The culture will then be thawed and recultured to check for biodegradative activity using procedures described above.

3.3.4.2 Bench-Scale Stirred Tank Fermenter Studies

Batch Culture Studies Purified PCP-degrading cultures will be evaluated as bioremediation agents by cultivating selected isolates on nutrient-supplemented wastewater in stirred tank fermenter. Procedures described above and Table 6 will be utilized in this study. Samples will be collected on days 0, 2, 4, 7, and 14. The parameters measured in these experiments will be PCP, pH/dissolved oxygen profiles, viable cell counts, inorganic phosphate, chloride, and inorganic nitrogen (ammonia and nitrate) levels. Suitable controls will be conducted to check for microbial contamination.

Table 6. Operating Parameters Used in Cultivating PCP-Degrading Cultures in Bench-Scale Fermenter Bioremediation Study

Operating Parameter	Parameter Value
Volume (liters)	2.0
Agitation (rpm)	200
Aeration (liters/minute)	0.46
Temperature (°C)	30
pH	7.0 (monitored)

Operating Parameter	Parameter Value
Dissolved Oxygen	100% (monitored)
Duration of Fermentation (days)	14
Antifoam	Polyglycol 2000
Sampling Times (days)	0, 2, 4, 7, 14

Semi-Continuous Culture Studies The objective of these experiments is to determine the minimum residence time where maximum PCP degradation can be achieved. Sampling strategies similar to those used in batch culture studies will be employed although different growth periods and sampling times will be used. Procedures described above and Table 6 will be utilized in this study.

Active cultures propagated in batch culture will be used as the inocula for succeeding fermentation cycles. Ten percent of the batch culture volume will be retained in the fermenter while the remainder of the culture will be discarded. The fermenter will be recharged with fresh wastewater to a final volume of two liters and the growth cycle reinitiated. The incubation time of each growth cycle will be sequentially reduced until a three day residence time is achieved.

Pilot-Scale Stirred Tank Fermenter Studies Purified cultures, demonstrating a consistent rate and extent of degradation of PCP in bench-scale fermenter studies, will be candidates for pilot-scale fermenter studies. Cultures cultivated in bench-scale fermenters using nutrient-supplemented wastewater as the growth medium, will be used as the inocula for the pilot-scale unit. Strategies summarized above and in Table 7 will be used in this study.

Table 7. Operating Parameters Used in Cultivating PCP-Degrading Cultures in Pilot-Scale Fermenter Bioremediation Study

Operating Parameter	Parameter Value
Volume (liters)	100-150
Agitation (rpm)	200
Aeration (liters/minute)	10-15
Temperature (°C)	30
pH	7.0 (monitored)
Dissolved Oxygen	100% saturation (monitored)
Duration of Fermentation (days)	14

Operating Parameter	Parameter Value
Antifoam	Polyglycol 2000 (controlled)
Sampling Times (days)	0, 5, 8, 14

Culture Preservation Purified or crude active cultures will be concentrated by centrifugation. Sedimented cultures will be suspended in 50% volume/volume (v/v) glycerol and frozen at -20°C for at least one month. The culture will then be thawed and recultured to check for biodegradative activity using procedures described above.

3.3.5 Solid-Phase Bioremediation Studies

Soil Amendments Amendments may be added to test soils to improve drainage and aeration properties of test soils before experiments can be initiated. The strategies used for soil conditioning will be dependent upon analytical results. Amendments such as topsoil (preferably from the site), limestone (calcium carbonate), and sand will be added to condition the soil. Sufficient limestone will be added to raise the soil pH to 7.3-7.5. Since addition of limestone can interfere with carbon dioxide measurements, amended soil will not be used in growth experiments for at least 10 days after liming the test soil. Soil permeability and drainability tests may be conducted to determine if soil properties have been improved. Other amendments include the addition of nitrogen (ammonium nitrate) and phosphorous (dibasic potassium phosphate) sources, and deionized water. The latter amendments will be added when growth experiments are initiated. Experiments will be conducted with unamended contaminated soils as controls for comparative purposes to show improvements in biodegradative activity by amended soils. Site soils, not contaminated with PCP, will also be amended in a similar fashion as contaminated soils and will be used to measure endogenous metabolic activity of site soils.

Amended test soils will be prepared in bulk and extensively analyzed to characterize the chemical and physical properties of test soils prior to initiating growth experiments. The following analyses will be performed:

- o viable cell counts
- o PCP
- o ammonia nitrogen
- o nitrate nitrogen
- o total Kjeldahl nitrogen
- o phosphate
- o total phosphorous
- o metals
- o sulfate
- o total organic carbon
- o soil moisture
- o water holding capacity
- o cation exchange capacity
- o particle size
- o pH
- o chloride

Biodegradation Experiments Solid-phase bioremediation experiments will be conducted in Biometer flasks. These flasks have been designed to allow monitoring of the rate and extent of biodegradation by measuring carbon dioxide evolution. Typically, carbon dioxide is measured cumulatively and can be monitored until metabolizable substrates are exhausted. Procedures in the use of the Biometer flasks are essentially those reported by Bartha and Pramer.[8]

In the present experiments, approximately 30 grams of amended uncontaminated or contaminated soil will be added to each flask. Test soils will be supplemented with suitable aliquots of ammonium nitrate and dibasic potassium phosphate stock solutions. Nutrient additions will be based on the level of total organic carbon present in the soil. Studies by Dibble and Bartha[9] have shown that a carbon:nitrogen (C:N) ratio of 60:1 and a carbon:phosphorous (C:P) ratio of 800:1 are optimal for solid-phase remediation systems using hydrocarbon-contaminated soil. Optimized conditions for solid-phase PCP bioremediation studies as reported by Crawford and Mohn[5] will be used in these studies. Deionized water will be added to test soils to achieve a water holding capacity (WHC) of 50 percent. After all amendments have been added, each flask will be assembled and time zero carbon dioxide measurements taken. Throughout the study, carbon dioxide levels from test flasks will be adjusted by subtracting carbon dioxide evolution values from endogenous control flasks (flasks containing amended soil but not contaminated with PCP).

Contaminated soil control flasks will contain a variety of treated and untreated soils including:

- o soils amended with calcium carbonate, sand and deionized water to a WHC of 50 percent
- o soils amended with calcium carbonate, sand, nitrogen and phosphorous supplements, and deionized water to a WHC of 50 percent and sterilized by the addition of 2 percent (w/v) mercuric chloride (sampled at week 0, 4, 8, and 12)

Uncontaminated soil control flasks will contain a variety of treated and untreated soils including:

- o soils amended with calcium carbonate, sand, nitrogen and phosphorous sources, and deionized water to a WHC of 50 percent

Control flasks will be prepared in duplicate while test flasks will be prepared in triplicate. Test and control flasks will be incubated at room temperature until there is no net increase in carbon dioxide evolution or incubated no longer than 12 weeks. Duplicate killed controls will be sampled at week 0, 4, 8, and 12 to assess abiotic losses due to photodegradation.

Existing data indicates that site soil can contain high levels of petroleum hydrocarbons. Due to the high levels of petroleum hydrocarbons found in soil, the carbon dioxide evolved during biodegradation experiments will be produced primarily from hydrocarbons. PCP concentrations will be relatively low (approximately 100 to 300 ppm) due to the toxic nature of the compound. It is assumed that if the flasks are monitored until there is no net increase in carbon dioxide production, then resident hydrocarbons and PCP have both been removed.

Sampling Trapping of carbon dioxide using potassium hydroxide solutions will be carried out by procedures used in studies reported by Bartha and Pramer[8]. Samples for measurement of soil PCP will be collected by emptying test soils from each Biometer flask into 8 ounce amber glass bottles fitted with Teflon lined caps. Each flask will be washed with rinses of deionized water and methylene chloride with rinsates being added to respective test bottles. Test samples will be sterilized by the

addition of 2 percent w/v mercuric chloride.

Decontamination of Laboratory Equipment All non-disposable contaminated glassware and disposable contaminated glassware will be decontaminated or disposed of as described previously (Section 3.3.4). All glassware containing liquid media with viable cultures will be disposed of as described previously (Section 3.3.4).

3.3.6 Groundwater Remediation

Field Activities Treatability studies will be performed to evaluate feasible groundwater remediation technologies. These results, in conjunction with results obtained from the aquifer test and the groundwater modeling will be used to determine the volume and characteristics of the contaminated groundwater. The maximum flow of contaminated groundwater that can be treated in the Biotrol unit will also be determined.

Contaminated groundwater collected from the existing wells will be composited into 5-gallon samples for the treatability studies. If a representative sample can not be collected from the existing wells, samples will be collected from new monitor wells after installation, development, and characterization. During site activities, enzyme immuno-assay test kits will be used to screen potential treatability samples to ensure that PCP concentrations are approximately 10 mg/L (the solubility of PCP).

Prior to the initiation of the constant rate pumping test, a groundwater sample will be collected from the pumping well. Samples of the pumped water will be collected at 8 hour intervals for the initial 24-hour period, then at 24-hour intervals for the (expected) remaining 48-hour time period. In addition to these samples, the cumulatively collected groundwater will be sampled to evaluate the groundwater quality under pumping conditions. The results obtained from this test will be compared to the results obtained from the prior sampling. If the results are not similar, then treatability tests may be conducted to determine if the treatment system engineered earlier can be used to treat the water from the pump test.

Treatability Study Design The treated water discharge criteria will be determined so the appropriate detection limits can be specified to the analytical laboratories. It is anticipated that the discharge of criteria for PCP will be 1 part per billion (ppb). Data on discharge criteria for other compounds will be specified by the Work Assignment Manager.

Treatability samples will be analyzed for the following parameters:

o	PCP	o	Chloride
o	TPHC	o	Sulfate
o	Dioxin/Furans	o	Ammonia
o	Metals	o	Alkalinity
o	Total dissolved solids	o	Total suspended solids
o	Total organic carbon	o	Chemical oxygen demand
o	Silica	o	Conductivity
o	pH	o	Nitrate
o	Total hardness (titration)	o	Calcium hardness (titration)

Treatability studies will be conducted on representative composite groundwater

samples collected from contaminated areas at the site. Three 5-gallon composite samples of groundwater will be collected and submitted to subcontract laboratories for the following evaluations:

- Ultraviolet (UV) radiation with:
  - Only ozone
  - Only hydrogen peroxide
  - Both ozone and hydrogen peroxide
  - Other additives or catalyst
- Carbon adsorption
- Ion Exchange

The results of the treatability studies will be compared against the local discharge requirements or requirements specified by the Work Assignment Manager. The UV radiation vendor will demonstrate that the technology can meet the cleanup criteria by actual observed data. Interpolated verification of cleanup goals will not be accepted. The carbon adsorption vendor will determine the amount of carbon required to treat 1,000 gallons of water. A treatability and technology evaluation report will be prepared including a cost-benefit analysis of the appropriate treatment technologies including the costs of energy, chemicals, and capital equipment.

As part of the treatability study, a sample of the free product will be collected during the initial hydrogeological work if detected in any of the existing monitoring wells. The free product samples will be analyzed for the following parameters:

- PCP
- TPHC
- Oil and grease
- pH
- Saybolt viscosity
- Specific gravity
- Percent water
- Dioxin/furan
- Heating value
- Priority pollutant metals
- Total suspended solids
- Flash point
- Percent sulphur
- Total chloride
- Percent ash
- Free liquids
- Water reactive (yes or no)

Treatment System Design The preliminary design work will be completed prior to obtaining the best estimate of the total flow to be treated in the plant. The total flow will be obtained during the pump test.

An engineering evaluation of the existing Biotrol treatment system will be performed to determine the existing condition of the unit. An operational plan will be developed focusing on modifications required to place the unit in operation and to determine if the unit can process the volume and quality of groundwater expected to be pumped and treated. If the Biotrol unit is beyond economic repair, or it is not large enough to treat the proposed groundwater flow, recommendation will be made regarding expansion of the existing system or the design and construction of a new treatment system.

The final treatment system design may include the following drawings:

- Process flow diagram
- Piping and instrumentation diagram

- o Equipment arrangement
- o Extraction well piping and instrumentation
- o Recovery well detail
- o Facility legend
- o Facility piping plan
- o Electrical site plan
- o Electrical symbol legend and general notes
- o Electrical single line drawing
- o Power and control plan
- o Electrical schematic diagram and instrumentation details

The treatment system design may also include the following documents:

- o Major equipment list
- o Description and function of major equipment
- o Preliminary cost estimate of treatment system
- o Sump pumps with control panel specifications
- o Lift pump with control panels specifications
- o Dual pump recovery system specifications
- o Instrumentation general specifications
- o Instrumentation functional specifications
- o Instrumentation equipment specifications
- o Instrumentation control panel specifications
- o Instrumentation installation specifications

As-built drawings will be completed after the system installation. Conference calls and/or meetings will be conducted between involved parties during the project and prior to determining the final design of the system. Home office assistance may be obtained for conceptual and final design of the treatment system and WESTON personnel may be on site to oversee the installation of the system.

3.4 Standard Operating Procedures

The following ERT/REAC SOPs will be followed for all field, laboratory and office activities unless otherwise specified in the QAWP:

SOP	Title
2001	General Field Sampling Guidelines
2002	Sample Documentation
2003	Sample Storage, Preservation and Handling
2004	Sample Packaging and Shipment
2005	Quality Assurance/Quality Control Samples
2006	Sampling Equipment Decontamination
2056	Photoionization Detector (PID) HNU
2057	Monitoring of Organic Vapors with a Flame Ionization Detector
2060	RAM-1 Operation
2101	Field pH Measurement
2107	Photovac 10A10 Portable Gas Chromatograph Operation
2108	Photovac 10S50, 10S55, and 10S70 Gas Chromatograph Operation
2109	Photovac GC Analysis for Soil, Water, and Air/Soil Gas
2129	Slam Bars

2156 Well Development
2157 Controlled Pumping Test
2158 Slug Tests
2161 Terrain Conductivity Meter
2170 Investigation-Derived Waste Management
2175 Shake Flask Test Procedures
2177 Landfarm Simulation Study Procedures
2178 Composting Procedures
2179 Fermentation Procedures
3001 REAC Health and Safety Program Policy and Implementation
4006 Logbook Documentation
4007 Photodocumentation of Site Activities by REAC Personnel
4010 Chain of Custody Procedures

3.5 Waste Residuals Disposal

All of the treated and untreated samples will be maintained by REAC or the subcontract laboratory for 60 days after the issuance of the final report. If no additional testing has been requested at the end of the 60 days, arrangements will be made for disposal.

4.0 PROJECT MANAGEMENT AND REPORTING

The REAC Task Leader will maintain contact with the U.S. EPA/ERT Work Assignment Manager to provide information on the technical and financial progress of this project. This communication will commence with the issuance of the work assignment and project scoping meeting. Activities under this project will be reported in status or trip reports and other deliverables (e.g., analytical reports, final reports) identified in Section 8.0. Activities will also be summarized in appropriate format for inclusion in REAC Monthly and Annual Reports.

WESTON personnel performing work under this work assignment have received the WESTON Conflict of Interest Policy and Operating Practice and been informed of their obligation to report personal conflicts of interest. Each employee has agreed to this policy by signing a statement related to conflict of interest responsibilities. In addition, WESTON has conducted a search of its conflict of interest data base in reference to this work assignment and has found no actual or potential conflict of interest with the acceptance of this task. Lastly, WESTON recognizes the continuing obligation to identify and report any actual or potential conflicts of interest arising at anytime during performance of this work assignment.

5.0 PROJECT SCHEDULE

The work assignment for this project was received on December 27, 1993. The existing data and information necessary to develop an understanding of the site and the site setting was identified and reviewed and technical scoping meetings were held with the Work Assignment Manager and other individuals. A REAC project team was assembled and the QAWP was prepared to address the Work Assignment objectives. Also during this period, the equipment and other resources needed to conduct site activities were specified and assembled. It is anticipated that field and other activities will be initiated immediately following approval of this QAWP. The tentative schedule for field, laboratory, and other activities is summarized in Table 8.

Table 8. Proposed Penta Wood Products Project Schedule

Task	Start Date	End Date
Groundwater sampling from existing wells	3/28	3/31
Soil sampling for remedial technology evaluation	3/30	3/31
Biotrol unit engineering evaluation	3/28	3/31
Sampling grid layout	3/28	3/31
Geophysics	3/28	3/31
Remedial technologies evaluation: solidification/stabilization	4/4	5/6
Remedial technologies evaluation: slurry-phase bioremediation	4/4	5/16
Remedial technologies evaluation: solid-phase bioremediation	4/4	5/20
Soil boring, monitor well and lysimeter installation	4/11	4/25
Lysimeter purge and sample	4/17	4/24
Slug tests	4/11	4/27
Monitor well development and sampling	4/19	4/24
Geophysics	4/18	4/22
On-site surficial soil sampling and field analysis	4/11	4/17
Off-site surficial soil sampling and analysis	4/18	4/20
Remedial technology evaluation: soil washing	4/11	4/13
Preliminary modeling	5/2	5/9

6.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

Richard Henry is the REAC Task Leader/Quality Control (QC) Coordinator for this work assignment. The Task Leader is the primary REAC point of contact with the U.S. EPA Work Assignment Manager and is responsible for the development and completion of the QAWP, project team organization, and supervision of all project tasks, including reporting and deliverables. In addition, the QC Coordinator is responsible for ensuring field adherence to the WP/QAWP and recording any deviations from the QAWP.

The REAC QA Officer is Christine Andreas, the Health and Safety Officer is Tom Mignone, the O&A Section Chief is Gary Buchanan, and the S&A Section Chief is Vinod Kansal. These individuals are responsible for auditing and guiding the project team, reviewing/auditing the deliverables and proposing corrective action, if necessary, for nonconformity to the WP/QAWP or HASP. The REAC project team consists of numerous individuals including subtask leaders, field and laboratory technicians, and office support personnel. The following REAC subtask leaders are the key members of this team and are responsible for the development and implementation of the activities specified

below:

Personnel	Responsibility
Paul Bovitz	Surficial soil EOC; risk assessment
Dan Crouse	Remedial technology evaluation
Michael Druger	Groundwater/subsurface soil EOC; aquifer characterization
Larry Kaelin	Field analytics
Ferrell Miller	Bioremedial technology evaluation
Noel Rogers	Geophysical characterization
Ty Willingham	Data management and depiction

While not specifically identified, activities such as video documentation, photodocumentation, computer graphics and support, statistics, word processing and report preparation and purchasing support may be required in order to accomplish the objectives of this project.

7.0 MANPOWER AND COST PROJECTIONS

7.1 Cost Summary

The estimated costs (including labor, travel, materials and equipment, subcontractor, and analytical) to complete this project are summarized in the attached cost summary sheet and Table 9. As mentioned previously, REAC does not anticipate completing monitor well network design and installation in the current contract extension; hence the costs are not included in the attached estimate.

7.2 Travel Summary

Preliminary Site Visit

Travel to PWP site, Siren, WI

- Number of trips: 1
- Number of days 5
- Number of personnel 7
- Airfare (per person) $ 900 round trip
- Per diem (per person) $ 66 per day
- Other Costs $ 1500

Field Activities

Travel to PWP site, Siren, WI

- Number of trips: 1
- Number of days 14
- Number of personnel 16
- Airfare (per person) $ 900
- Per diem (per person) $ 66 per day
- Other Costs $ 7500

Table 9 Estimated Resource Requirements for Site Characterization and Remedial Technology Evaluation

Activity	Hours					Dollars			
	O&A	S&A	Other	HOS	Total	S/C	Travel	Other	Total
Site Characterization									
Preliminary visit	225	70	15	-	310	-	5420	1500	6920
Geophysical study	85	-	25	410	520	-	2975	700	3675
Surface soil EOC[1]	550	585	60	-	1195	4950	15450	8165	28565
Subsurface soil EOC[1]	420	355	40	-	815	4125	11150	7250	22525
Off-site EOC[1]	210	230	15	-	455	28750	4280	3450	36480
Risk assessment[2]	-	-	-	-	-	-	-	-	-
Soil borings	160	310	10	60	540	17575	3350	1950	22875
Lysimeter study	260	310	10	60	640	45800	3550	17500	66850
Groundwater study	920	490	20	60	1490	56050	8850	4800	69700
Soil gas study[2]	-	-	-	-	-	-	-	-	-
Data management[2]	-	-	-	-	-	-	-	-	-
Modeling[3]	40	-	-	10	50	-	-	100	100
Photogrametric map & DTM[3]	5	-	5	-	10	1000	-	100	1100
Site survey[2]	-	-	-	-	-	-	-	-	-
Subtotal	2875	2350	200	600	6025	158250	55025	45515	258790
Remedial Technology Evaluation									
Soil washing	200	145	20	-	365	4950	2500	3050	10500
Solidification/stabilization	180	490	5	65	740	11400	600	2650	14650
Thermal desorption[2]	-	-	-	-	-	-	-	-	-
Base-catalyzed decomposition[2]	-	-	-	-	-	-	-	-	-
Bioremediation	390	440	25	425	1280	33550	4850	5625	44025
Groundwater[2]	-	-	-	-	-	-	-	-	-
Subtotal	770	1075	50	490	2385	49900	7950	11325	69175
Total	3645	3425	250	1090	8410	208150	62975	56840	327965

1. Resource estimates based on 2 ERT Technical Assistance Team members providing XRF analytical support during the field investigation
2. Activity deferred until next contract period
3. Activity partially deferred until next contract period

Bench-scale remedial technologies evaluation: solidification/stabilization studies

Travel to the ETL, Lionville, Pennsylvania

- Number of trips: 3
- Number of days 1
- Number of personnel 2
- Per diem $ 250
- Other Costs $ 200

Bench-scale remedial technologies evaluation: engineering parameter analysis of soil samples

Travel to the ETL, Lionville, Pennsylvania

- Number of trips: 2
- Number of days 1
- Number of personnel 2
- Per diem $ 175
- Other Costs $ 125

Confirmatory laboratory analyses of PCP

Travel to the high hazard laboratory, Brunswick, Georgia

- Number of trips: 1
- Number of days 35
- Number of personnel 2
- Airfare (per person) $ 750
- Per diem (per person) $ 67 per day
- Other Costs $ 2500

8.0 DELIVERABLES AND TASKS

The following deliverables will be provided under this project:

ITEM	DATE
Preliminary Analytical Report	5/13/94
Preliminary Report - Geophysical Assessment	5/20/94
Preliminary Report - Surficial Soil Extent of Contamination	5/20/94
Preliminary Report - Aquifer Characterization	5/23/94
Final Analytical Report	5/23/94
Preliminary Report - Subsurface Soil Extent of Contamination	5/23/94
Preliminary Report - Remedial Technology Evaluation	5/23/94
Preliminary Report - Bioremediation	5/23/94

All project deliverable and task dates are estimates based on the information available at the time of the QAWP completion. New information, additional tasks, changes in scope, and events outside the control of REAC may result in revisions to these dates.

9.0 QUALITY ASSURANCE

The following QA objectives and protocols apply, as per Tables 9.1 and 9.2:

The following QA Protocols for QA1 data are applicable to all sample matrices and include:

1. Provide sample documentation in the form of field logbooks, the appropriate field

data sheets and chain of custody forms.

2. All instrument calibration and/or performance check of the procedures or methods will be summarized and documented in the field/personal or instrument log notebook.
3. The detection limit will be determined and recorded, along with the data, where appropriate.

The following QA Protocols for QA2 data are applicable to all sample matrices and include:

1. Provide sample documentation in the form of field logbooks, the appropriate field data sheets and chain of custody forms. Chain of custody sheets are optional for field screening locations.
2. All instrument calibration and/or performance check of the procedures or methods will be summarized and documented in the field/personal or instrument log notebook.
3. The detection limit will be determined and recorded, along with the data, where appropriate.
4. Document sample holding times; this includes documentation of sample collection and analysis dates.
5. Provide initial and continuing instrument calibration data.

6a. For soil, sediment and water samples, include rinsate blanks, field blanks and trip blanks at the rate specified in Table 9.1, footnotes 2 and 3, respectively.

6b. For air samples, include lot blanks, field blanks, collocated samples, trip blanks, and breakthrough samples at the rate specified in Table 9.2, footnotes 1-7, respectively.

6c. For soil gas samples, include duplicate samples, zero air samples, field standards, ambient air samples, and matrix spikes at the rate specified in Table 9.1, footnotes 2-6, respectively.

7. Performance Evaluation (PE) samples are optional, if available.
8. a. Definitive Identification - confirm the identification on 10% of the screened (field or lab) or 100% of the unscreened samples via an EPA-approved method; provide documentation such as chromatograms, mass spectra, etc.
   b. Quantitation - provide documentation for quantitative results from screening and EPA-approved verification methods (for screened samples) or just quantitative results (in the case of unscreened samples).
   c. Analytical Error - determine the analytical error by calculating the precision, accuracy and coefficient of variation on a subset of the screened or all of the unscreened samples using an EPA-approved method.

Numbers of samples to be collected for this project/event are entered onto Table 9.1, Field Sampling Summary, and Table 9.2, QA/QC Analysis and Objectives Summary, to facilitate ready identification of analytical parameters desired, type, volume and number of containers needed, preservation requirements, number of samples required and associated number, and type of QA/QC samples required based on the QA level.

All project deliverables will receive an internal peer review prior to release, as per guidelines established in the REAC Administrative Procedures.

REFERENCES

(1) Foster Wheeler, Inc., 1992, Contaminants and Remedial Options at Wood Preserving Sites, Risk Reduction Engineering Laboratory, Office of Research and Development, U.S. EPA, Cincinnati, OH.

(2) Helmer, E., 1993, Memorandum regarding ecological concerns at the PWP site, U.S. EPA, Region V.

(3) Crawford, R.L., and Mohn, W.W. "Microbiological Removal of Pentachlorophenol from Soil Using a *Flavobacterium*," Enzyme and Microbial Technology, Vol. 7, 1985, pp. 617-620.

(4) Edgehill, R.U., and Finn, R.K. "Isolation, Characterization, and Growth Kinetics of Bacteria Metabolizing Pentachlorophenol," European Journal of Applied Microbiology and Biotechnology, Vol. 16, 1982, pp. 179-184.

(5) Saber, D.L., and Crawford, R.L. "Isolation and Characterization of *Flavobacterium* Strains that Degrade Pentachlorophenol," Applied and Environmental Microbiology, Vol. 50, No. 6, December, 1985, pp. 1512-1518.

(6) Topp, E., R.L. Crawford, and R.S. Hanson. "Influence of Readily Metabolizable Carbon on Pentachlorophenol-degrading *Flavobacterium sp.*",Applied and Environmental Microbiology, Vol. 54, No. 10, October, 1988, pp. 2452-2459.

(7) Roy F. Weston, Inc./REAC. 1993. Preliminary Report, Treatability Study: Larry's Post and Woodtreating, Columbia Heights, Montana. Work Assignment # 3-563, Work Order # 03347-034-001-5563.

(8) Bartha, R., and Pramer, D. "Features of a Flask and Method for Measuring the Persistence and Biological Effects of Pesticides in Soil," Soil Science, Vol. 100; No. 1, 1966, pp. 68-70

(9) Dibble, J.T., and Bartha, R. "Effect of Environmental Parameters on the Biodegradation of Oil Sludge," Applied and Environmental Microbiology, Vol. 27, No. 4, 1979, pp. 729-739.

Table 9.1. Field Sampling Summary
Surface Soil EOC

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
Dioxin	<1 ppb	S	8-ounce clear glass jar (1)	4°C	7 days	3	NA	0	NA	0	3
As, Cu, Zn, Pb (XRF)	30 mg/kg	S	4-oz clear glass jar (1)	4°C	6 mon	645	NA	NA	NA	NA	645
As, Cu, Pb, Zn (lab analysis)	1 mg/kg	S	XRF Sample cup (2 per location)	4°C	6 mon	65	NA	7	NA	7	72
PCP (test kits)	5 mg/kg	S	4-oz amber glass (1)	4°C	7 days	50	NA	NA	NA	NA	50
PCP (lab analysis)	1 mg/kg	S	4-oz amber glass (1)	4°C	7 days	645	NA	NA	NA	15	660

* Matrix: S-Soil

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "N/A".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "N/A". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "N/A". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "N/A".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.2. QA/QC Analysis and Objectives Summary
Surface Soil EOC

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix *	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
As, Cu, Pb, Zn	S	SW-846	8	0	0.5 mg/kg	QA2
PCP	S	EPA 8270 (modified)	12	0	0.5 mg/kg	QA2
Dioxin	S	EPA 8290	0	0	0.5 µg/kg	QA1

* Matrix: S-Soil

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.

Table 9.1. Field Sampling Summary
Overburden Characterization

Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	QC Extra's				Total Field Samples[6]
							Rinsate Blanks[2]	Field/Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	
Volumetric Water Content	NA	S	(1) 32 oz plastic/glass	4°C	7 days	9	NA	NA/NA	NA	NA	9
pH	6 - 9 units	S	(1) 4 oz plastic/glass	4°C	ASAP	9	NA	NA/NA	NA	NA	9
Cation Exchange Capacity	NA	S	(1) 23 oz plastic/glass	4°C	NA	9	NA	NA/NA	NA	NA	9
Water Holding Capacity	NA	S	(1) 32 oz plastic/glass	4°C	NA	9	NA	NA/NA	NA	NA	9
Grain Size	NA	S	(1) 32 oz plastic/glass	NA	NA	9	NA	NA/NA	NA	NA	9
Total Organic Carbon	NA	S	(1) 4 oz plastic/glass	4°C	28 days	9	NA	NA/NA	NA	NA	9
Total Effective Porosity	NA	S	(1) 8 oz plastic/glass	4°C	28 days	9	NA	NA/NA	NA	NA	9
Dry Bulk Density	NA	S	(1) 32 oz plastic/glass	4°C	24 hours	9	NA	NA/NA	NA	NA	9
FOC	NA	S	(1) 4 oz plastic/glass	4°C	28 days	9	NA	NA/NA	NA	NA	9
X-ray Diffraction	NA	S	(1) 4 oz plastic/glass	4°C	28 days	3	NA	NA/NA	NA	NA	3

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one or one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.1. (cont'd) Field Sampling Summary
Overburden Characterization

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
PCP (lab analysis)	1 mg/kg	S	4 oz amber glass (1)	4°C	7/40 day	50	NA	5	NA	5	55
PCP (test kits)	5 mg/kg	S	4 oz amber glass (1)	4°C	immediate	10	NA	NA	NA	NA	10
PCP	1 mg/l	W	32 oz amber glass (2)	4°C	7/40 day	50	5	3	NA	5	58
As, Cu, Pb, Zn (XRF)	30 mg/kg	S	4 oz glass (1)	4°C	6 mon	50	NA	5	NA	5	55
As, Cu, Pb, Zn (lab analysis)	1 mg/kg	S	XRF Sample cup (2 per location)	4°C	6 mon	5	NA	NA	NA	1	5
As, Cu, Zn	see attached	W	1 l plastic (1)	HNO_3 to pH<2 4°C	6 mon	50	5	3	NA	5	58
TPHC	1 ppm	S	8 oz glass (1)	4°C	28/14 day	50	NA	5	NA	NA	55
Dioxin	1 ppb	S	8 oz glass (1)	4°C	7/40 day	2	0	0	NA	0	2

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one or one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.2. QA/QC Analysis and Objectives Summary - Soil
Overburden Characterization

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix*	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
Volumetric Water Content	S	EPA 160.3	NA	NA	1%	QA1
pH	S	SW 846-9045	NA	NA	0.1 unit	QA1
Cation Exchange Capacity	S	SW-846-9081	NA	NA	1 PPM	QA1
Water Holding Capacity	S	ASTM 2980	NA	NA	1 %	QA1
Grain Size	S	ASTM D422-63	NA	NA	NA	QA1
Total Organic Carbon	S	SW 846-9060	NA	NA	1 ppm	QA2
Total Effective Porosity	S	To be determined	NA	NA	NA	QA1
Bulk Dry Density	S	ASTM D2937-83	NA	NA	NA	QA1
FOC	S	To be determined	NA	NA	NA	QA1
X-ray Diffraction	S	To be determined	NA	NA	NA	QA1

* Matrix: S-Soil, W-Water

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.

Table 9.2. (cont'd) QA/QC Analysis and Objectives Summary
Overburden Characterization

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix*	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
PCP	W	625/CLP	5	N/A	0.2 ppm	QA2
PCP	S	8250 or 8270/SW-846	5	N/A	1 ppm	QA2
Arsenic, Copper, Zinc	W	EPA-600/CFR 40	1	N/A	See attached list	QA2
Arsenic, Copper, Zinc	S	SW-846	5	N/A	See attached list	QA2
Dioxin	S	8280/SW-846	0	N/A	1 ppt	QA2

* Matrix: S-Soil, W-Water

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.

Table 9.1. Field Sampling Summary
Remedial Option Evaluation: Soil/Water Characterization

Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	QC Extra's				Total Field Samples[6]
							Rinsate Blanks[2]	Field/Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	
Moisture	NA	S	32 oz glass (1)	4°C	7 days	3	NA	NA/NA	NA	NA	3
pH	6 - 9 units	S	4 oz glass (1)	4°C	ASAP	3	NA	NA/NA	NA	NA	3
Cation Exchange Capacity	NA	S	32 oz glass (1)	4°C	NA	3	NA	NA/NA	NA	NA	3
Water Holding Capacity	NA	S	32 oz glass (1)	4°C	NA	3	NA	NA/NA	NA	NA	3
Grain Size	NA	S	32 oz glass (1)	NA	NA	3	NA	NA/NA	NA	NA	3
Total Organic Carbon	NA	S	4 oz glass (1)	4°C	28 days	3	NA	NA/NA	NA	NA	3
Nitrogen Ammonia	NA	S	8 oz glass (1)	4°C	28 days	3	NA	NA/NA	NA	NA	3
Total Kjeldahl Nitrogen	NA	S	32 oz glass (1)	4°C	24 hours	3	NA	NA/NA	NA	NA	3
Total Phosphorus	NA	S	4 oz glass (1)	4°C	28 days	3	NA	NA/NA	NA	NA	3
Nitrate/Nitrogen	NA	S	4 oz glass (1)	4°C	28 days	3	NA	NA/NA	NA	NA	3

* Matrix: S-Soil, W-Water.

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one or one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.1. (cont'd) Field Sampling Summary
Remedial Option Evaluation: Soil/Water Characterization

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
Calcium	NA	S	8 oz glass (1)	4°C	6 mon	3	NA	NA/NA	NA	1	3
Magnesium	NA	S	8 oz glass (1)	4°C	6 mon	3	NA	NA/NA	NA	1	3
Sodium	NA	S	8 oz glass (1)	4°C	6 mon	3	NA	NA/NA	NA	1	3
Potassium	NA	S	4 oz glass (1)	4°C	6 mon	3	NA	NA/NA	NA	1	3
Zinc	NA	S	8 oz glass (1)	4°C	6 mon	3	NA	NA/NA	NA	1	3
Manganese	NA	S	8 oz glass (1)	4°C	6 mon	3	NA	NA/NA	NA	1	3
Copper	NA	S	8 oz glass (1)	4°C	6 mon	3	NA	NA/NA	NA	1	3
Iron	NA	S	8 oz glass (1)	4°C	6 mon	3	NA	NA/NA	NA	1	3
% Sulfur	NA	S	8 oz glass (1)	4°C	NA	3	NA	NA/NA	NA	NA	3

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one or one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.1. (cont'd) - Field Sampling Summary
Remedial Option Evaluation: Soil/Water Characterization

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
PCP	to be determined	S	8 oz. glass (1)	4°C	7/40 day	20	NA	1/NA	NA	2	20
PCP Immuno-Assay	to be determined	W	2 oz amber glass (1)	4°C	Immediate	20	NA	NA/NA	NA	NA	20
PCP Immuno-Assay	to be determined	S	2 oz glass (1)	4°C	Immediate	50	NA	NA/NA	NA	NA	50

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40 ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.2. QA/QC Analysis and Objectives Summary
Remedial Option Evaluation: Soil/Water Characterization

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix*	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
Moisture	S	EPA 160.3	NA	NA	1%	QA1
pH	S	SW 846-9045	NA	NA	0.1 unit	QA1
Cation Exchange Capacity	S	SW-846-9081	NA	NA	1 ppm	QA1
Water Holding Capacity	S	ASTM 2980	NA	NA	1 %	QA1
Grain Size	S	ASTM D422-63	NA	NA	NA	QA1
Total Organic Carbon	S	SW 846-9060	NA	NA	1 ppm	QA1
Nitrogen Ammonia	S	EPA 350.1/350.3	NA	NA	1 ppm	QA1
Total Kjeldahl Nitrogen	W	EPA 351.2/351.3	NA	NA	1 ppm	QA1
Total Phosphorus	S	EPA 365.1/365.2	NA	NA	1 ppm	QA1
Nitrate/Nitrogen	S	EPA 353.2	NA	NA	1 ppm	QA1
Calcium	S	EPA 215.1	1	NA	See attached list	QA1
Magnesium	S	EPA 242.1	1	NA	See attached list	QA1
Sodium	S	EPA 273.1	1	NA	See attached list	QA1

* Matrix: S-Soil, W-Water

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.

Table 9.2. (cont'd) QA/QC Analysis and Objectives Summary
Remedial Option Evaluation: Soil/Water Characterization

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix*	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
Potassium	S	EPA 258.1	1	NA	See attached list	QA1
Zinc	S	EPA 289.1	1	NA	See attached list	QA1
Manganese	S	EPA 243.1	1	NA	See attached list	QA1
Copper	S	EPA 220.1	1	NA	See attached list	QA1
Iron	S	EPA 236.1	1	NA	See attached list	QA1
% Sulfur	S	ASTM D-3177 Method A	NA	NA	See attached list	QA1
PCP	S	8270/SW-846	2	NA	10 ppb	QA2

* Matrix: S-Soil, W-Water

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.

Table 9.1. Field Sampling Summary
Remedial Option Evaluation: Soil Washing

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
PCP	1 ppb	W	1 l amber (1)	4°C	7/40 day	20	NA	NA	NA	2	20
PCP	30 ppm	S	4 oz glass (1)	4°C	7/40 day	20	NA	NA	NA	2	20
As, Cu, & Zn	See attached list	W	1 L polyethylene (1)	4°C, pH < 2 HNO_3	6 mon	20	NA	NA	NA	2	20
As, Cu, & Zn	See attached list	S	8 oz glass (1)	4°C	6 mon	20	NA	NA	NA	2	20

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of one 40 ml vial filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.2. QA/QC Analysis and Objectives Summary
Remedial Option Evaluation: Soil Washing

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix*	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
PCP	W	625/CLP	2	NA	0.2 ppm	QA2
PCP	S	8250 or 8270/SW-846	2	NA	1 ppm	QA2
As, Cu, & Zn	W	EPA-600/CFR 40	2	NA	See attached list	QA2
As, Cu, & Zn	S	SW-846	2	NA	See attached list	QA2

* Matrix: S-Soil, W-Water

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.

Table 9.1. Field Sampling Summary
Remedial Option Evaluation: Thermal Desorption

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
PCP	1 ppm	W	1 l amber (1)	4°C	7/40 day	2	NA	NA	NA	1	2
PCP	30 ppm	S	4 oz glass (1)	4°C	7/40 day	4	NA	NA	NA	1	4
Chloride	1 ppm	W	4 oz glass (1)	4°C	28 day	3	NA	NA	NA	1	3
Chloride	1 ppm	S	4 oz glass (1)	4°C	7/40 day	4	NA	NA	NA	1	4
Dioxin	1 ppb	S	4 oz glass (1)	4°C	7/40 day	2	NA	NA	NA	0	2
As, Cu, & Zn	See attached list	W	1 L polyethylene (1)	4°C, pH < 2 HNO_3	6 mon	2	NA	NA	NA	1	2
As, Cu, & Zn	See attached list	S	8 oz glass (1)	4°C	6 mon	4	NA	NA	NA	1	4
Heating Value (BTU)	NA	S	8 oz glass (1)	NA	NA	1	NA	NA	NA	NA	1
Percent Ash	NA	S	8 oz glass (1)	NA	NA	1	NA	NA	NA	NA	1
Soil Classification	NA	S	8 oz glass (1)	NA	N/a	1	NA	NA	NA	NA	1
Specific Gravity	NA	S	8 oz glass (1)	NA	NA	1	NA	NA	NA	NA	1

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of one 40 ml vial filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.2. QA/QC Analysis and Objectives Summary
Remedial Option Evaluation: Thermal Desorption

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix*	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
PCP	W	625/CLP	1	NA	0.2 ppm	QA2
PCP	S	8250 or 8270/SW-846	1	NA	1 ppm	QA2
Chloride	W	EPA 325.3	1	NA	1 ppm	QA2
Chloride	S	SM 4500	1	NA	1 ppm	QA2
Dioxin	S	8280/SW-846	0	NA	1 ppt	QA1
As, Cu, & Zn	W	EPA-600/CFR 40	1	NA	See attached list	QA2
As, Cu, & Zn	S	SW-846	1	NA	See attached list	QA2
Heating Value (BTU)	S	ASTM D240	NA	NA	1 BTU	QA1
Percent Ash	S	ASTM D2974	NA	NA	1 %	QA1
Soil Classification	S	ASTM D2487-90	NA	NA	NA	QA1
Specific Gravity	S	Method 213E	NA	NA	1 unit	QA1

* Matrix: S-Soil, W-Water

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.

Table 9.1. Field Sampling Summary
Remedial Option Evaluation: Thermal Desorption (Air)

Analytical Parameter	Action Level[1]	Sampling Media	Suggested Holding Times	Flow Rate	Volume Min - Max	Subtotal Number Samples
PCP	NA	XAD-2 Tube	1 week	2 l/min	1000 l	2
HCl	NA	Silica Gel Tube 600 mg	----	0.2-0.5 l/m	3 l 100 l	2
Particulates	NA	Tared 37 mm 5 um PVC Filter	Indefinite	1.5-2 l/m	25 @ 15 mg/m^3 133 @ 15 mg/m^3	1
As, Cu, & Zn	NA	0.8 um filter (MCE)	6 mths	1-4 l/m	5 l 2000 l	2
VOA	NA	Tenax/CMS	1 week	20 ml/min	5 l	2

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of one 40 ml vial filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.2. QA/QC Analysis and Objectives Summary
Remedial Option Evaluation: Thermal Desorption (Air)

Analytical Parameter	Analytical Method	Estimated Limit of Detection[1]	Lot Blanks[2]	Field Blanks[3]	Collocated Samples[4]	Trip Blanks[5]	Breakthrough[6]	PE Samples[7]	QA Objective[8]
PCP	NIOSH 5506, 5515	0.3 - 0.5 ug/sample	1	1	NA	NA	NA	NA	QA2
HCl	NIOSH 7903	1-4 ug/sample	1	1	NA	NA	NA	NA	QA2
Particulates	NIOSH 0500	0.2 mg	1	1	NA	NA	NA	NA	QA2
As, Cu, & Zn	NIOSH 7300	0.005-5 mg/m^3	1	1	NA	NA	NA	NA	QA2
VOA	TO1	0.3 - 0.5 ug/sample	1	1	NA	NA	NA	NA	QA2

1. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
2. Required for all QA levels at a minimum rate of 10% of the total samples, or one (1) per sampling event per lot.
3. Mandatory for QA2 and QA3 at a minimum rate of 5% of the total samples or one (1) per sampling event. Certain methods may require a greater frequency.
4. Required for all QA levels at a minimum rate of 5% of the total samples or one (1) per sampling event.
5. Mandatory for QA2 and QA3 at a minimum rate of 5% of the total samples or one (1) per sampling event.
6. Recommended for QA2 and QA3. Rate is method dependent. Requirement for use is based on deviations from accepted protocol and atmospheric conditions.
7. Performance evaluation samples are optional for QA2 but mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
8. Enter the QA objective desired: QA1, QA2, or QA3.

Table 9.1. Field Sampling Summary
Remedial Option Evaluation: Solidification

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
PCP	30 ppm	S	8 oz glass (1)	4°C	7/40d	4	NA	NA/NA	NA	1	4
PCP by TCLP	100 mg/l	W	8 oz glass (1)	4°C	7/40d	25	NA	NA/NA	NA	4	25
As, Cu, & Zn	See attached list	S	8 oz glass (1)	4°C	6 mon	4	NA	NA/NA	NA	1	4
As, Cu, & Zn by TCLP	As - 5 mg/l Cu - Not det Zn - Not det	W	1 liter glass or polyethylene (1)	HNO_3 to pH<2 4°C	6 mon	25	NA	NA/NA	NA	4	25

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40 ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.1. (cont'd) Field Sampling Summary
Remedial Option Evaluation: Solidification

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
Percent Moisture	NA	S	plastic/glass	4°C	7 days	2	NA	NA/NA	NA	NA	2
pH	NA	S	plastic/glass (4 oz)	4°C	ASAP	2	NA	NA/NA	NA	NA	2
Permeability	No greater than 1 X 10^{-6}	X	plastic/glass	4°C	NA	12	NA	NA/NA	NA	NA	12
Grain Size	NA	S	plastic/glass	NA	NA	2	NA	NA/NA	NA	NA	2
Bulk Density	NA	S	plastic/glass (4 oz)	4°C	NA	2	NA	NA/NA	NA	NA	2
Freeze/Thaw	NA	X	plastic/glass (8 oz)	4°C	NA	12	NA	NA/NA	NA	NA	12
Wet/Dry	NA	X	plastic/glass	4°C	NA	12	NA	NA/NA	NA	NA	12
Unconfined Compressive Strength	50 - 200 psi	X	Cemented Soil	NA	NA	25	NA	NA/NA	NA	NA	25

* Matrix: S-Soil, W-Water, X-Solidification Sample

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one or one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40 ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.2. QA/QC Analysis and Objectives Summary
Remedial Option Evaluation: Solidification

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix*	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
PCP	S	8250 or 8270/ SW-846	1	NA	1 ppm	QA2
PCP by TCLP	W	625/CLP	4	NA	1 ppm	QA2
As, Cu, & Zn	S	SW-846	1	NA	See attached list	QA2
As, Cu, & Zn by TCLP	W	EPA-600/CFR 40	4	NA	See attached list	QA2

* Matrix: S-Soil, W-Water

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.

Table 9.2. (cont'd) QA/QC Analysis and Objectives Summary
Remedial Option Evaluation: Solidification

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix*	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
Percent Moisture	S	EPA 160.3	NA	NA	NA	QA1
pH	S	SW 846-9045	NA	NA	0.1 units	QA1
Permeability	S	SW 846	NA	NA	NA	QA1
Grain Size	S	ASTM D422-63	NA	NA	NA	QA1
Bulk Density	S	ASTM D2937-83	NA	NA	NA	QA1
Freeze/Thaw	X	ASTM D4842-88	NA	NA	NA	QA1
Wet/Dry	X	ASTM D4843-88	NA	NA	NA	QA1
Unconfined Compressive Strength	X	ASTM D-1633	NA	NA	10 Psi	QA1

* Matrix: S-Soil, W-Water, X-Solidification Sample

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.

Table 9.1. Field Sampling Summary
Remedial Option Evaluation: Groundwater Treatability

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
PCP	10 ppb	W	32 oz amber glass (2)	4°C	7/40d	2	NA	NA	NA	1	2
Chloride	1 ppm	W	32 oz glass jar (1)	4°C	7/14d	2	NA	NA	NA	1	2
Sulfate	1 ppm	W	32 oz glass jar (1)	4°C	7/14d	2	NA	NA	NA	NA	2
Alkalinity	1 ppm	W	32 oz glass jar (1)	4°C	7/14d	2	NA	NA	NA	NA	2
Silica	1 ppm	W	32 oz glass jar (1)	4°C	7/14d	2	NA	NA	NA	NA	2
Conductivity	$\frac{1\ \mu mho\text{-}Equiv^{(7)}}{cm}$	W	32 oz glass jar (1)	4°C	7/14d	2	NA	NA	NA	NA	2
Total Suspended Solids	1 ppm	W	32 oz glass jar (1)	4°C	7/14d	2	NA	NA	NA	NA	2
Total Dissolved Solids	1 ppm	W	32 oz glass jar (1)	4°C	7/14d	2	NA	NA	NA	NA	2
Total Organic Carbon	1 ppm	W	32 oz glass jar (1)	4°C	7/14d	2	NA	NA	NA	NA	2
Chemical Oxygen Demand	1 ppm	W	32 oz glass jar (1)	4°C	7/14d	2	NA	NA	NA	NA	2

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40 ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of one 40 ml vial filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.
7. Equiv - Equivalency.

Table 9.1. (cont'd) Field Sampling Summary
Remedial Option Evaluation: Groundwater Treatability

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
Nitrate	1 ppm	W	32 oz glass jar (1)	4°C	7/14d	2	NA	NA	NA	NA	2
Ammonia	1 ppm	W	32 oz plastic jar (1)	H_2SO_4 to pH<2, 4°C	7/14d	2	NA	NA	NA	NA	2
pH	6 - 9 units	W	8 oz glass (1)	4°C	Immediate	2	NA	NA	NA	NA	2
Hardness by Titration (Total)	To be Determined	W	32 oz glass (1)	4°C	7/14/d	2	NA	NA	NA	NA	2
Hardness by Titration (Calcium)	To be Determined	W	32 oz glass (1)	4°C	7/14/d	2	NA	NA	NA	NA	2
Metals [7]	To be Determined	W	1 liter glass or polyethylene (1)	HNO_3 to pH<2 4°C	6 mon	2	NA	NA	NA	1	2
Dissolved Iron	To be Determined	W	500 ml polyethylene (1)	0.45 micron HNO_3 to pH<2 4°C	6 mon	2	NA	NA	NA	1	2

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40 ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of one 40 ml vial filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.
7. Al, As, Ca, Cd, Cr (tot), Cu, Fe, Pb, Mg, Mn, Hg, Na, and Zn.

Table 9.2. QA/QC Analysis and Objectives Summary
Remedial Option Evaluation: Groundwater Treatability

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix*	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
PCP	W	625/CLP	1	NA	10 ppb	QA2
Chloride	W	EPA 325.3	1	NA	1.0 ppm	QA1
Sulfate	W	EPA 375.3	NA	NA	1.0 ppm	QA1
Alkalinity	W	EPA 310.1	NA	NA	1.0 ppm	QA1
Silica	W	EPA 370.1	NA	NA	1.0 ppm	QA1
Conductivity	W	EPA 120.1	NA	NA	1.0 $\frac{1\ \mu mho\text{-}Equiv^{(5)}}{cm^2}$	QA1
Total Suspended Solids	W	EPA 160.2	NA	NA	1.0 ppm	QA1
Total Dissolved Solids	W	EPA 160.1	NA	NA	1.0 ppm	QA1
Total Organic Carbon	W	EPA 415.1	NA	NA	1.0 ppm	QA1
Chemical Oxygen Demand	W	EPA 410.1	NA	NA	1.0 ppm	QA1
Nitrate	W	EPA 352.1	NA	NA	1.0 ppm	QA1
Ammonia	W	EPA 350.2	NA	NA	1.0 ppm	QA1
pH	W	Std Mthds 423	NA	NA	NA	QA1
Hardness	W	Std Mthds 314	NA	NA	1.0 ppm	QA1
Metals[6]	W	EPA-600/CFR 40	1	NA	See Attached TAL Table	QA2
Dissolved Iron	W	EPA-600/CFR 40	1	NA	See Attached TAL Table	QA2

* Matrix: S-Soil, W-Water

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.
5. Equiv. = Equivalency
6. Al, As, Ca, Cd, Cr (tot), Cu, Fe, Pb, Mg, Mn, Hg, Na, and Zn.

Table 9.1. Field Sampling Summary
Remedial Option Evaluation: Free Product

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
PCP	1 ppm	X	32 oz amber glass (2)	4°C	7/40d	1	NA	NA	NA	1	1
Heating Value (BTU)	1 ppm	X	8 oz glass (1)	4°C	7/40d	1	NA	NA	NA	NA	1
TPHC	1 ppm	X	100 ml glass	4°C, 5 ml HCl		1	NA	NA	NA	NA	1
TAL Metals	.5 ppm	X	1 liter glass or polyethylene (1)	HNO_3 to pH<2 4°C	6 mon	1	NA	NA	NA	1	1
Oil & Grease	1 ppm	X	16 oz. glass (1)	4°C	7/40d	1	NA	NA	NA	NA	1
pH	6 - 9 units	X	16 oz. glass (1)	4°C	7/40d	1	NA	NA	NA	NA	1
Saybolt Viscosity	NA	X	16 oz. glass (1)	4°C	7/40d	1	NA	NA	NA	NA	1
Specific Gravity	NA	X	16 oz. glass (1)	4°C	7/40d	1	NA	NA	NA	NA	1
Percent Water	NA	X	16 oz. glass (1)	4°C	7/40d	1	NA	NA	NA	NA	1
Dioxin/Furan	1 ppt	X	16 oz. glass (1)	4°C	7/40d	1	NA	NA	NA	0	1

* Matrix: S-Soil, W-Water, X-Free Product

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40 ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of one 40 ml vial filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.1. (cont'd) Field Sampling Summary
Remedial Option Evaluation: Free Product

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
Total Suspended Solids	NA	X	4 oz glass (1)	4°C	7/40 d	1	NA	NA	NA	NA	1
Percent Sulfur	NA	X	8 oz glass (1)	4°C	7/40d	1	NA	NA	NA	NA	1
Total Chloride	NA	X	8 oz glass (1)	4°C	6 mon	1	NA	NA	NA	1	1
Percent Ash	NA	X	8 oz glass (1)	4°C	NA	1	NA	NA	NA	NA	1
Water Reactive (yes or no)	NA	X	8 oz glass (1)	4°C	7/40d	1	NA	NA	NA	NA	1

* Matrix: S-Soil, W-Water, X-Free Product

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40 ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of one 40 ml vial filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.2. QA/QC Analysis and Objectives Summary
Remedial Option Evaluation: Free Product

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix*	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
PCP	X	625/CLP	1	NA	500 ppm	QA2
Heating Value (BTU)	X	ASTM D240	NA	NA	1 BTU/Pound	QA1
TPH	X	EPA 418.1	NA	NA	50 ppm	QA2
Metals[5]	X	EPA-600/CFR 40	1	NA	See Attached TAL Table	QA2
Oil & Grease	X	USEPA Method 413.1	NA	NA	25 ppm	QA1
pH	X	USEPA Method 9040	NA	NA	NA	QA1
Saybolt Viscosity	X	ASTM Method D445	NA	NA	NA	QA1
Specific Gravity	X	Method 213E	NA	NA	NA	QA1
Percent Water	X	Karl-Fisher Analysis	NA	NA	0.005%	QA1
Dioxin/Furan	X	Method 8280	0	NA	1 ppb	QA2

* Matrix: S-Soil, W-Water, X-Other

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.
5. Arsenic, antimony, beryllium, cadmium, total chromium, copper, lead, mercury, nickel, selenium, silver, silver, thallium, and zinc.

Table 9.2. (cont'd) - QA/QC Analysis and Objectives Summary
Remedial Option Evaluation: Free Product

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix*	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
Total Suspended Solids	X	Method 2540 D	NA	NA	1 ppm	QA1
Percent Sulfur	X	ASTM D-12964	NA	NA	1 %	QA2
Total Chloride	X	EPA 325.3	NA	NA	1 ppm	QA2
Percent Ash	X	ASTM D-2974	NA	NA	1 %	QA1
Water Reactive (yes or no)	X	SW 846 Chapter 8-3	NA	NA	Yes or No	QA1

* Matrix: S-Soil, W-Water, X-Free Product

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.

Table 9.1. Laboratory Sampling Summary
Bioremediation Evaluation

							QC Extra's				
Analytical Parameter	Level of Sensitivity[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
PCP	ND[7]	W/S	1 oz./8 oz. amber glass (2)	4°C,HCHO	7/40 days	51	NA	NA	NA	8	51
Ammonia Nitrogen	ND	W/S	1 oz./8 oz. amber glass (2)	H_2SO_4, pH<2, -20°C,HCHO	28 days	12	NA	NA	NA	2	12
Nitrate Nitrogen	ND	W/S	1 oz./8 oz. amber glass (2)	H_2SO_4,pH<2, -20°C,HCHO	28 days	12	NA	NA	NA	2	12
Total Kjeldahl Nitrogen	ND	S	1 oz. amber glass (2)	H_2SO_4, pH<2, $HgCl_2$, 4°C	48 hours	2	NA	NA	NA	1	2
Phosphate	ND	W/S	1 oz./8 oz. amber glass (2)	H_2SO_4,pH<2, -20°C,HCHO	48 hours	12	NA	NA	NA	2	12
Total Phosphorous	ND	S	1 oz./8 oz. amber glass (2)	H_2SO_4, pH<2, $HgCl_2$,4°C	28 days	2	N/D	N/D	N/D	1	2
Trace Metals	ND	W/S	1 oz./8 oz. amber glass (2)	HNO_3,pH<2 -20°C,HCHO	6 mos	2	NA	NA	NA	1	2
Chloride	ND	W	1 oz. amber glass (2)	4°C	28 days	32	NA	NA	NA	4	32

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.
7. Not determined

Table 9.1. (cont'd) Laboratory Sampling Summary
Bioremediation Evaluation

							QC Extra's				
Analytical Parameter	Level of Sensitivity[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
Sulfate	ND	S	8 oz. amber glass (2)	4°C	28 days	2	NA	NA	NA	NA	2
Total Organic Carbon	ND	S	8 oz. amber glass (2)	4°C, H_2SO_4, pH<2	28 days	2	NA	NA	NA	NA	2
Soil Moisture	ND	S	8 oz. amber glass (2)	4°C	7 days	2	NA	NA	NA	NA	2
Water Holding Capacity	ND	S	8 oz. amber glass (2)	4°C	NA	2	NA	NA	NA	NA	2
Cation Exchange Capacity	ND	S	8 oz. amber glass (2)	4°C	NA	2	NA	NA	NA	NA	2
Particle Size Distribution	ND	S	8 oz. amber glass (2)	4°C	NA	2	NA	NA	NA	NA	2
pH	ND	S	8 oz. amber glass (2)	4°C	NA	2	NA	NA	NA	NA	2

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.
7. Not determined

Table 9.2. QA/QC Analysis and Objectives Summary
Boremediation Evaluation

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix *	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
PCP	W	SW 846-8270	8	0	1.0 ppm	QA-2
Ammonia Nitrogen	W	Method 350.1/350.3 EPA-600/4-79-020	2	0	0.010-0.030 ppm	QA-2
Nitrate Nitrogen	W	Method 353.2 EPA-600/4-79-020	2	0	0.10 ppm	QA-2
Total Kjeldahl Nitrogen	S	Method 351.2 EPA-600/4-79-020	1	0	1.0 ppm	QA-2
Phosphate	W	Method 365 EPA-600/4-79-020	2	0	0.010 ppm P	QA-2
Total Phosphorous	S	Method 365.1 EPA-600/4-79-020	1	0	0.010 ppm P	QA-2
Trace Metals	W	SW-846-6010	1	0	0.010-0.20 ppm	QA-2
Chloride	W	Method 325 EPA-600-4-79-020	4	0	1.0 ppm	QA-2
Sulfate	S	SW-846-9035-38	NA	0	1.0 ppm	QA-2
Total Organic Carbon	S	SW-846-9060	NA	0	1.0 ppm	QA-2
Soil Moisture	S	Method 106.3 EPA-600-4-79-020	NA	NA	NA	QA-1
Water Holding Capacity	S	ASTM 2980	NA	NA	NA	QA-1
Cation Exchange Capacity	S	SW-846-9081	NA	NA	NA	QA-1
Particle Size Distribution	S	ASTM D422-63	NA	NA	NA	QA-1
pH	S	SW-846-9045	NA	NA	NA	QA-1

* Matrix: S-Soil, W-Water

1. Ensure that sufficient environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective.
2. For QA-2 (optional) and for QA-3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory MS/MSD may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the level of sensitivity.
4. Enter QA Objective desired: QA-1, QA-2, or QA-3.

TARGET COMPOUND LIST (TCL) AND QUANTITATION LIMITS (QLs)[1]

Volatiles	CAS Number	Quantitation Limits[2] Water ug/L	Low Soil/Sediment[3] ug/Kg
Chloromethane	74-87-3	10	10
Bromomethane	74-83-9	10	10
Vinyl Chloride	75-01-4	10	10
Chloroethane	75-00-3	10	10
Methylene Chloride	75-09-2	5	5
Acetone	67-64-1	10	10
Carbon Disulfide	75-15-0	5	5
1,1-Dichloroethane	75-35-4	5	5
1,1-Dichloroethene (DCE)	75-34-3	5	5
1,2-Dichloroethane (total)	540-59-0	5	5
Chloroform	67-66-3	5	5
1,2-Dichloroethane	107-06-2	5	5
2-Butanone	78-93-3	10	10
1,1,1-Trichloroethane	71-55-6	5	5
Carbon Tetrachloride	56-23-5	5	5
Bromodichloromethane	75-27-4	5	5
cis-1,3-Dichloropropene	10061-01-5	5	5
Trichloroethene (TCE)	79-01-6	5	5
Dibromochloromethane	124-48-1	5	5
1,1,2-Trichloroethane	79-00-5	5	5
Benzene	71-43-2	5	5
trans-1,3-Dichloropropene	10061-02-6	5	5
Bromoform	75-25-2	5	5
4-Methyl-2-pentanone	108-10-1	10	10
2-Hexanone	591-78-6	10	10
Tetrachloroethene (PCE)	127-18-4	5	5
Toluene	108-88-3	5	5
1,1,2,2-Tetrachloroethane	79-34-5	5	5
Chlorobenzene	108-90-7	5	5
Ethyl Benzene	100-41-4	5	5
Styrene	100-42-5	5	5
Xylenes (total)	1330-20-7	5	5

TARGET COMPOUND LIST (TCL) AND QUANTITATION LIMITS (QLs)[1]

Volatiles (Cont'd)	CAS Number	Quantitation Limits[2] Water ug/L	Low Soil/Sediment[3] ug/Kg
Dichlorofluoromethane	75-43-4	10	10
Trichlorofluoromethane	75-69-4	5	5
trans-1,2-Dichloroethene	156-60-5	5	5
2,2-Dichloropropane	594-20-7	5	5
cis-1,2-Dichloroethene	156-59-2	5	5
1,1-Dichloropropene	563-58-6	5	5
1,2-Dichloropropane	78-87-5	5	5
Dibromomethane	74-95-3	10	10
1,3-Dichloropropane	142-28-9	5	5
1,2-Dibromomethane	106-93-4	5	5
1,1,1,2-Tetrachloroethane	630-20-6	5	5
p-Xylene	106-42-3	5	5
m-Xylene	108-38-3	5	5
o-Xylene	95-47-6	5	5
Isopropylbenzene	98-82-8	5	5
1,2,3-Trichloropropane	96-18-4	5	5
Bromobenzene	108-86-1	5	5
n-Propylbenzene	103-65-1	5	5
2-Chlorotoluene	95-49-8	5	5
4-Chlorotoluene	106-43-4	5	5
1,3,5-Trimethylbenzene	25551-13-7	5	5
tert-Butylbenzene	98-06-6	5	5
1,2,4-Trimethylbenzene	25551-13-7	5	5
sec-Butylbenzene	135-98-8	5	5
1,3-Dichlorobenzene	541-73-1	5	5
p-Isopropyltoluene	99-87-6	5	5
1,4-Dichlorobenzene	106-46-7	5	5
1,2-Dichlorobenzene	95-50-1	5	5
n-Butylbenzene	104-51-8	5	5
1,2-Dibromo-3-Chloropropane	96-12-8	5	5
1,2,4-Trichlorobenzene	120-82-1	5	5
Naphthalene	91-20-3	5	5
Hexachlorobutadiene	87-68-3	10	10
1,2,3-Trichlorobenzene	12002-48-1	10	10

(1) Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

(2) Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, on a dry weight basis will be higher.

(3) Medium Soil/Sediment QLs for Volatile TCL Compounds are 125 times the individual Low Soil/Sediment QL.

TARGET COMPOUND LIST (TCL) AND QUANTITATION LIMITS (QL)[1]

Semivolatile	CAS Number	Quantitation Limits[2] Water ug/L	Low Soil/Sediment[3] ug/Kg
Phenol	108-95-2	10	330
bis (2-Chloroethyl) ether	111-44-4	10	330
2-Chlorophenol	95-57-8	10	330
1,3-Dichlorobenzene	541-73-1	10	330
1,4-Dichlorobenzene	106-46-7	10	330
Benzyl alcohol	100-51-6	10	330
1,2-Dichlorobenzene	95-50-1	10	330
2-Methylphenol	95-48-7	10	330
bis (2-Chloroisopropyl) ether	108-60-1	10	330
4-Methylphenol	106-44-5	10	330
N-Nitroso-di-n-propylamine	621-64-7	10	330
Hexachloroethane	67-72-1	10	330
Nitrobenzene	98-95-3	10	330
Isophorone	78-59-1	10	330
2-Nitrophenol	88-75-5	10	330
2,4-Dimethylphenol	105-67-9	10	330
bis (2-Chloroethoxy) methane	111-91-1	10	330
2,4-Dichlorophenol	120-83-2	10	330
1,2,4-Trichlorobenzene	120-82-1	10	330
Naphthalene	91-20-3	10	330
4-Chloroaniline	106-47-8	10	330
Hexachlorobutadiene	87-68-3	10	330
4-Chloro-3-methylphenol	59-50-7	10	330
2-Methylnaphthalene	91-57-6	10	330
Hexachlorocyclopentadiene	77-47-4	10	330
2,4,6-Trichlorophenol	88-06-2	10	330
2,4,5-Trichlorophenol	95-95-4	50	1700
2-Chloronaphthalene	91-58-7	10	330
2-Nitroaniline	88-74-4	50	1700
Dimethylphthalate	131-11-3	10	330
Acenaphthylene	208-96-8	10	330
2,6-Dinitrotoluene	606-20-2	10	330
3-Nitroaniline	99-09-2	50	1700
Acenaphthene	83-32-9	10	330
2,4-Dinitrophenol	51-28-5	50	1700
4-Nitrophenol	100-02-7	50	1700
Dibenzofuran	132-64-9	10	330
2,4-Dinitrotoluene	121-14-2	10	330
Diethylphthalate	84-66-2	10	330
4-Chlorophenyl-phenyl ether	7005-72-3	10	330
Fluorene	86-73-7	10	330
4-Nitroaniline	100-01-6	50	1700

TARGET COMPOUND LIST (TCL) AND QUANTITATION LIMITS (QL)[1]

Semivolatile (Cont'd)	CAS Number	Quantitation Limits[2] Water ug/L	Low Soil/Sediment[3] ug/Kg
4,6-Dinitro-2-methylphenol	534-52-1	50	1700
N-nitrosodiphenylamine	86-30-6	10	330
4-Bromophenyl-phenyl ether	101-55-3	10	330
Hexachlorobenzene	118-74-1	10	330
Pentachlorophenol	87-86-5	50	1700
Phenanthrene	85-01-8	10	330
Anthracene	120-12-7	10	330
Carbazole	86-74-8	10	330
Di-n-butylphthalate	84-74-2	10	330
Fluoranthene	206-44-0	10	330
Pyrene	129-00-0	10	330
Butylbenzylphthalate	85-68-7	10	330
3,3-Dichlorobenzidine	91-94-1	20	6700
Benzo (a) anthracene	56-55-3	10	330
Chrysene	218-01-9	10	330
bis (2-Ethylhexyl) phthalate	117-81-7	10	330
Di-n-octylphthalate	117-84-0	10	330
Benzo (b) fluoranthene	205-99-2	10	330
Benzo (k) fluoranthene	207-08-9	10	330
Benzo (a) pyrene	50-32-8	10	330
Indeno (1,2,3-cd) pyrene	193-39-5	10	330
Dibenz (a,h) anthracene	53-70-3	10	330
Benzo (g,h,i) perylene	191-24-2	10	330

(1) Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

(2) Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment on a dry weight basis will be higher.

(3) Medium Soil/Sediment QLs for SemiVolatile TCL Compounds are 60 times the individual Low Soil/Sediment QL.

INORGANIC TARGET ANALYTE LIST (TAL)

Analyte	Range of Detection Limits Water, µg/l	Soil, mg/kg
Aluminum	250	25-50
Antimony	5-10	0.5-1.0
Arsenic	5-10	0.5-1.0
Barium	5-25	0.5-1.0
Beryllium	5-10	1.0-2.5
Cadmium	5-10	0.5-1.0
Calcium	25-50	2.5-5.0
Chromium	10-50	5
Cobalt	25-50	2.5-5.0
Copper	25	2.5-5.0
Iron	50-100	5-10
Lead	5-50	5
Magnesium	25-50	2.5-5.0
Manganese	25-50	2.5-5.0
Mercury	0.2-0.4	0.04
Nickel	25-50	2.5-5.0
Potassium	25-50	2.5-5.0
Selenium	5-10	0.5-1.0
Silver	10-25	1.0-2.5
Sodium	25-100	5-10
Thallium	5-10	0.5-1.0
Vanadium	10-25	1.0-2.5
Zinc	10-25	1.0-5.0

QUALITY ASSURANCE WORK PLAN

PHASE II

PENTA WOOD PRODUCTS

SIREN, WI

Prepared by
Roy F. Weston, Inc.

August 1994

U.S. EPA Work Assignment No. 0-026
Weston Work Order No. 03347-040-001-0026-01
U.S. EPA Contract No. 68-C4-0022

for Michael J. Druger (Date) 9/1/94
Task Leader

for Ralph M. Shapot (Date) 9/1/94
Program Manager

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1.0 OBJECTIVE

Phase I of this project was completed by the Response Engineering and Analytical Contract (REAC) during February through May 1994 under U.S. Environmental Protection Agency/Environmental Response Team (U.S. EPA/ERT) Work Assignment 5-932. The objectives for Phase II this project are: 1) provide sufficient hydrogeologic information to complete the preliminary design of a groundwater extraction, treatment, and soil flushing system; 2) select effective soil and groundwater remediation technologies for use in the preliminary design of a groundwater extraction, treatment, and soil flushing system; 3) determine the potential for ecological impairment resulting from site contaminants; and 4) delineate "hot spots" of soil contamination at the site in support of soil removal and treatment activities.

The purpose of the groundwater extraction system is to prevent further migration of contaminated groundwater from the site and remove contaminated groundwater for treatment. The treatment system will reduce contaminants to acceptable levels. The soil flushing system will use the treated water to promote removal of contaminants from the vadose zone by inducing flow towards the extraction well system and/or by promoting biodegradation. To select effective soil and groundwater remediation technologies, REAC will complete evaluation of soil and groundwater remedial technologies that started during Phase I of the project. The data collected from this phase will be used in preparing a preliminary groundwater treatment and soil flushing system design. To determine the potential for ecological impairment resulting from site contaminants, REAC will perform a preliminary ecological risk assessment. REAC will conduct soil sampling and provide analytical services to delineate "hot spots" of soil contamination at the site in support of soil removal and treatment activities.

2.0 PROJECT SCOPE

2.1 Site Description

The Penta Wood Products (PWP) property consists of approximately 120 acres, 80 of which were actively used for wood treatment. The remaining 40 acres are undeveloped and consist of forested areas and wetlands. The property is located in a rural agricultural and residential area and is bordered to the east, west, and north by forested areas; some of these areas are classified by the State of Wisconsin as wetlands (with the exception of), State Route 70 forms the southern site boundary of the property, a small parcel of PWP property located south of State Route 70. A number of surface water bodies are present north and west of the site. Doctor Lake and an unnamed lake are located 2,000 feet east and northeast of the site, respectively. Approximately 2,137 acres of lakes, 94 acres of bogs, and 7,500 acres of wetlands are located within a four mile radius of the site. The Amsterdam Slough Public Hunting area covers 7,233 acres and is located one mile north of the site.

Chemical treatment and ancillary wood fabrication operations began at the site in 1953. Operations ceased in May 1992 due to the inability of the facility to comply with recently enacted Resource Conservation and Recovery Act (RCRA) drip track regulations. Prior to 1956, wood was treated by dipping poles and timbers into an open tank of pentachlorophenol (PCP) solution or by introducing PCP into the wood under a vacuum. In 1956, a pressure treatment cylinder was installed which used a 5 to 7 percent PCP solution in a #2 fuel oil carrier. In 1975, a second pressure process was added using chemonite, a water borne salt treatment consisting of arsenate, copper II oxide, and zinc. This product is also referred to as ammoniacal-copper-arsenate (ACA).

Ecological and human health concerns at the PWP site revolve around PCP and arsenic in surface soil, wood chips, and groundwater. The elevated concentrations in these media, apparent exposure routes, and available toxicity data suggest that the site represents a substantial environmental risk to human and nonhuman receptors.

2.2 Previous Investigations

A number of investigations have been conducted at the PWP site to characterize historic activities, the extent of contamination, regional soils, geology, hydrology, and ecological and human health risks. Memorandums and reports available to REAC and used to develop the scope of work and the technical approach of this Quality Assurance Work Plan QAWP include the following:

- Report regarding the public water system of Siren, WI prepared by Jack Hunter (Siren, WI Environmental Engineer). October 1987
- Phase II Site Evaluation Report prepared for the PWP site by Conestoga-Rovers and Associates. October 1989
- Remedial Investigation and Corrective Action Plan for the PWP site prepared by Conestoga-Rovers and Associates. March 1992
- Site Investigation Report for the PWP site prepared by the EPA Region V Technical Assistance Team (TAT). April 1993
- Memorandum regarding Remedial Cost Projections for the PWP site prepared by Lisa Ende (Region V TAT). June 1993
- Sampling report and summary of data from Wisconsin Department of Natural Resources (WDNR)/EPA sampling of the PWP site prepared by Amy Parkinson (WDNR Site Project Manager). June 1993
- Sampling Report for a Screening Site Inspection/Pathway Sampling at the PWP site prepared by Amy Parkinson. July 1993
- Memorandum regarding geology and well data for the PWP site prepared by Dave Johnson (WDNR Site Assessment Hydrogeologist). August 1993
- Memorandum regarding ecological concerns at the PWP site prepared by Eileen Helmer (Region V U.S. EPA). March 1993
- Memorandum regarding human health concerns at the PWP site prepared by Manna Muroya (EPA Region V Agency for Toxic Substances and Disease Registry (ATSDR). March 1993
- Briefing memo for the PWP site for presentation to the Regional Decision Team prepared by the Site Assessment Team. November 1993
- Results of the REAC investigation at the site during March through May 1994. This investigation included extensive surface soil sampling; installation of nine soil borings, six monitor wells and three lysimeters; two complete rounds of groundwater sampling; one round of soil-pore liquid sampling; and treatability studies.

2.3 Wastewater Lagoon

The contaminant source of concern for Phase II is the wastewater lagoon located along the northeast edge of the site. The lagoon is situated in a slight depression and berms of mounded soil form the north and west walls of the lagoon. This lagoon was used for the disposal of process wastewater from the PCP and ACA treatment areas and excess water from the oil-water separator. Additionally, this lagoon received surface stormwater runoff through an eroded gully that drains the chemical treatment area and the treated wood product storage area.

Contaminants of concern at the PWP site have been identified by the U.S. EPA and State of Wisconsin and include PCP, arsenic (As), copper (Cu), and zinc (Zn). Other contaminants detected on-site include petroleum hydrocarbons and polynuclear aromatic hydrocarbons.

2.4 Summary of REAC Phase I Project Activities

Previous survey data, site information, and aerial photographs were used to develop a base map. The soil boring, monitor well and lysimeter locations, as well as portions of the sampling grid were surveyed by REAC and ERT field staff. The base map and survey results were merged to serve as the basis for the extent of contamination study, hydrogeological and engineering analysis, and graphic depiction of data.

An investigation was conducted to determine the vertical and horizontal extent of contamination for contaminants of concern in surficial soil. This information will be used to develop a conceptual model of contaminant distribution in the surface soil, as well as to determine potential migration of contaminants into the groundwater or off-site via surface runoff.

The extent of arsenic, copper, zinc, and PCP contamination was determined by sampling along a grid at several discrete depths below the ground surface. A sampling grid was established to encompass the site and off-site sampling locations. Soil was collected from each 100-foot grid node as well as intermediate and discretionary nodes as per the March 24, 1994 QAWP.

Soil samples were collected into 4-oz clear glass jars for on-site analyses of arsenic, copper and zinc by X-Ray Fluorescence Spectrometry (XRF), and for off-site analysis of PCP at the ERT/REAC High Hazard Laboratory in Brunswick, GA. Additionally, *in-situ* XRF readings were made at select locations. Where immediate information regarding PCP contamination was required, a 10 gram (g) soil aliquot was screened on-site using enzyme immuno-assay test kits.

Evaluation of remedial options for the PWP site were initiated. Critical soil washing and solidification/stabilization (s/s) studies were completed, and preliminary results were issued[1]. Bulk soil samples were also collected at the PWP site for use in a thermal desorption/base catalyzed decomposition (BCD) treatability study, which will be subcontracted to a qualified vendor. Bioremediation enrichment culture studies were conducted to screen soil for the presence of PCP-degrading microbes. Literature sources were reviewed to identify nutrient media that were successfully used to cultivate PCP-degrading microbes.

2.5 Scope of Work

2.5.1 Hydrogeologic Investigation

To accomplish the objectives of the hydrogeologic investigation, REAC plans the following steps:

1) Install additional monitor wells to better define the extent of contamination and provide hydrogeologic data; collect geotechnical samples to obtain critical data for use in contaminant modeling; and conduct infiltration tests to provide data for use in designing an infiltration gallery for use in the soil flushing system.

2) Conduct an aquifer pumping test to obtain the hydrogeologic data needed to design an optimal groundwater containment and recovery well field. During the pump test, the performance of the treatment system will be evaluated. A pilot scale infiltration system will be used to dispose of treated water in a clean area of the site.

3) The hydrogeologic, chemical, and geotechnical data will be used to model contaminant behavior in the vadose zone and groundwater flow and contaminant transport. The purpose of this effort is to optimize the placement and design of groundwater extraction wells and the infiltration system for use in soil flushing.

4) Based on the results of the modelling effort, a groundwater treatment system and treated water infiltration system for use in soil flushing will be designed.

To implement the steps outlined above, the proposed hydrogeologic investigation scope of work includes:

1) updating the existing base map,
2) conducting geophysical surveys, if appropriate,
3) installing monitor well and recovery wells,
4) collecting geotechnical, chemical, and lithologic data,
5) conducting small scale vadose zone infiltration tests,
6) characterizing the aquifer using aquifer tests, geochemical analysis, conducting additional groundwater sampling in September and November 1994, and conducting weekly rounds of water level measurements,
7) conducting a pilot test of the infiltration system, and
8) constructing a vadose zone and groundwater flow and contaminant transport model.

Each of these items are discussed in detail in Subsection 3.1.

2.5.2 Remedial Technology Evaluation

The purpose of the evaluation is to select effective soil remediation and groundwater treatment technologies. The remedial technology evaluation scope of work includes bench-scale and pilot-scale studies of the effectiveness of various technologies for treating PCP -, ACA -, and mixed PCP/ACA - contaminated soil and groundwater.

The remedial technology evaluation will include:

1) Soil

- thermal desorption followed by base catalyzed decomposition
- slurry-phase bioremediation
- solid-phase bioremediation
- soil flushing
- solidification/stabilization

2) Groundwater

- ultraviolet radiation
- carbon adsorption
- clay adsorption
- ion exchange
- chelating and dispersing agents for reducing the availability of soluble metals
- filtration

3) Groundwater treatment system preliminary design

REAC engineering and geosciences personnel will implement a pilot scale groundwater recovery and treatment system. This pilot test will be used to determine aquifer characteristics for design of a groundwater recovery well system and to determine if *in-situ* soil flushing of PCP contaminated soil is feasible.

2.5.3 Ecological Risk Assessment

A screening level risk assessment will be performed to determine the potential for ecological impairment resulting from site contaminants. Habitats, habitat utilization on- and off-site, exposure pathways, and the toxicity of contaminants of concern (PCP, As, and Cu) will be evaluated to determine risk to receptors. Empirical data will be collected in the event this assessment suggests significant risk to receptors.

Additional surface and shallow subsurface soil sampling will be conducted to delineate and further characterize isolated contaminated areas and contaminant migration pathways identified during Phase I of this project. The results of this sampling will be used to help identify additional soil for removal and/or remediation.

3.0 TECHNICAL APPROACH

3.1 Hydrogeologic Investigation

3.1.1 Updating Existing Basemap

Consistent and accurate survey data is imperative at this site due to the gentle sloping nature of the groundwater potentiometric surface. Therefore, after installation, all existing and newly installed soil boring and monitor well locations and elevations will be surveyed by a professionally licensed subcontractor with

northing and easting coordinates tied to the Wisconsin Coordinate System (North Zone, in feet). Elevation data will be in feet above Mean Sea Level (MSL) accurate to within a 10th of a foot.

A basemap of the site and as surrounding buffer area will be prepared photogrametrically using black and white aerial photography of the site obtained in April 1994. The basemap will include site topography (at 2 foot and 5 foot contour intervals) and existing site features visible in the photography. The basemap will provide a "snap shot" on pre-remedial conditions at the site and will be used to present the results of the hydrogeologic and engineering investigations and preliminary design work.

3.1.2 Geotechnical, Chemical, and Lithologic Data Collection

The overburden profiling program will provide geotechnical, lithologic, and chemical data to delineate the vertical and horizontal extent of PCP and ACA contamination in the unsaturated and saturated zones in the known contaminated areas. The overburden profiling program will consist of installing monitor wells and soil borings in the vicinities of known soil contamination, collecting representative soil and groundwater samples at regular intervals for chemical and geotechnical analysis, and conducting geophysical surveys to map the characteristics of the semi-confined aquifer. This data will be used to construct both the unsaturated and saturated contaminant flow and transport models of the site.

Geotechnical, lithologic and soil samples will be collected at regular intervals from the screened zone of the monitor well and from the weathered and non-weathered zones of the semi-confining layer. Samples from the deep monitor well will be collected from the base of the lower sand aquifer to verify aquifer thickness. Samples from the semi-confining layer will be collected from all newly installed wells to estimate vertical hydraulic conductivity. Infiltration tests will be conducted in the vadose zone containing PCP contaminated soils. These tests will determine the average infiltration rate for the design of proposed infiltration galleries in the vicinity of the lagoon. Soil samples will also be collected using a modified California split spoon or Shelby tube as per ERT/REAC SOP #2012, Soil Sampling. When split spoon sampling is performed to gain geologic information, all work will be performed as per with American Society for Testing and Materials (ASTM) D 1586-67 (reapproved 1974).

3.1.2.1 Geotechnical Data

In order to develop vadose zone and groundwater contaminant transport model, the following soil properties of the unsaturated and saturated zones are required:

- Total effective porosity
- Unsaturated hydraulic conductivity
- Dry bulk density
- Cation exchange capacity
- Soil moisture release curve
- Vertical and horizontal hydraulic conductivity
- Matric potential
- Recharge rate

- Annual precipitation Data
- Moisture Content
- Grain Size
- pH

Total effective porosity, dry bulk density, cation exchange capacity, grain size, soil moisture release curve, pH, and moisture content will be obtained from soil samples collected at depth using either the hollow stem auger or the rotasonic drilling methods. Samples for analysis will be geotechnical collected from either the Shelby tube or the continuous core sampler at 5 to 10 feet intervals for a total of up to 25 samples.

Matric potential will be measured in the field with gypsum blocks. During Phase I (April 1994), gypsum blocks were nested with lysimeters in the vicinity of the contaminant plume to monitor matric potential gradients of a soil section representative of the contaminated unsaturated zone.

The results of the geotechnical sample analysis will be used to estimate unsaturated hydraulic conductivity. Annual recharge rates will be determined based on existing data from local weather monitoring stations. During monitor well installations, vertical hydraulic conductivity will be measured in samples collected from the overburden soil, as well as the confining layer using a modified California split spoon or by field measurement of infiltration rates as outlined in Subsection 3.1.5.

3.1.2.2 Chemical Data

Chemical analyses of soil samples for PCP, ACA, and total petroleum hydrocarbons (TPH) will be performed to determine the vertical extent of contamination. Sample collection will be based on visual and the use of field screening. Soil samples will be screened using a photoionization detector (HNu) and an organic vapor analyzer (OVA). It is anticipated that a maximum of 75 soil samples, collected at 5 to 10 feet intervals from both the unsaturated and saturated zones, will be analyzed for PCP, ACA, and TPH.

The appropriate chemical parameters of the soil and contaminants that are required for the vadose zone and groundwater contaminant transport models are:

- Total organic carbon content of soil (soil sample)
- Soil-pore liquid samples (from existing lysimeters)
- Distribution coefficient of contaminant (literature)
- Soil water partitioning coefficient of contaminant (literature)
- Free air diffusion coefficient of contaminant (literature)
- Aqueous solubility of contaminant (literature)
- Henry's law constant of contaminant (literature)

The chemical parameters will be analyzed from soil samples collected from either the split spoon or the continuous core sampler. Previously installed nested lysimeters at three locations will be used to collect soil-pore liquid samples from the unsaturated zone. The physical properties of the contaminant will be referenced from literature.

3.1.2.3 Lithologic Data

A detailed lithologic log of all borings will be recorded using lithologic information system (GEOLIS™). WESTON's geologic and GEOLIS™ is a data collection and management system that is used to record and present data including soil type, color, blow counts, percent recovery, relative moisture content, odor, well construction details, and other pertinent information.

3.1.3 Geophysical Surveys

Geophysical surveys may be conducted to define the extent of the upper semi-confining unit and determine the base of the semi-confined aquifer. The base of the semi-confined aquifer is believed to be approximately 275 to 300 feet below ground surface (bgs). This information is necessary to construct an accurate vadose zone and groundwater flow and transport model of the site. Methods under consideration include seismic and electromagnetic surveys.

Geophysical data collected during Phase I will be analyzed and interpreted to assist in constructing the geological model of the PWP site. If further geophysical investigation of the PWP site is needed, the following geophysical survey methods may be used:

3.1.3.1 Electromagnetic Survey

The geophysical survey will be conducted as per ERT/REAC SOP #2159, General Surface Geophysics. A ground electromagnetic survey will be set up on traverses oriented perpendicular and parallel to suspected groundwater flow. Exact locations of electromagnetic traverses will be determined after initial site inspection to avoid cultural noise interference. However, these traverses will be spaced in such a manner to best describe the geology of the site. Measurements will be taken at station spacings of 5 to 25 feet, based on the instrument used.

Electromagnetic data will be obtained using the Geonics™ EM-31 and EM-34 terrain conductivity instruments on each traverse. If it is determined that data obtained by these instruments is useful for stratigraphic mapping, the EM-31 measurements will be taken at waist height and on the ground at each sample node, and EM-34 measurements will be taken at 10, 20 and 40 meter coil separations with the coils in the vertical orientation at each sample node. Data processing will include profile plots of terrain conductivity at each coil separation.

3.1.3.2 Electromagnetic Sounding

Electromagnetic sounding will be performed along a traverse(s) perpendicular to groundwater flow, depending on site conditions. In addition, several soundings may be taken at various locations in such a way as to best describe the geology of the site and to fill in any data gaps. Electromagnetic sounding will be collected using the Phoenix™ V-5 receiver and the Geonics™ EM-47 time-domain electromagnetic (TEM) transmitter utilizing a square transmitter loop on its side. For data collection on each station, the receiver will be centered within the transmitter loop.

The TEM data will be reduced to apparent resistivity versus time for data inspection and modeled using a nonlinear regression scheme to a layered-earth model. These modeled layers will be interpreted into the stratigraphic scheme of the site.

3.1.3.3 Resistivity

The objective of a resistivity survey is to better define the depths, thicknesses, and continuity of strata significant to groundwater flow (such as clay versus sand layers, or grain-size variations) or to detect conductive contaminated groundwater directly.

Resistivity measurements will be taken at selected TEM sample nodes to map the subsurface electrical resistivity structure, which can be interpreted to provide geologic and hydrogeologic data and data on the physical properties of the geologic matrix or the water contained therein. The resistivity method measures the impedance to electrical current flow through lithologic material (soil, sediments, or rock), commonly in the units of ohm-meters. The resistivity of lithologic material is normally a function of porosity, permeability, water saturation, and concentration of dissolved solids in the pore fluids. The resistivity measurement can also be dominated by lithologic or rock-type variations such as sand versus clay, or sandstone versus shale.

3.1.3.4 Induced Polarization

Induced Polarization (IP) soundings will be performed at selected TEM sample nodes to help better define the electrical properties of the soils. The induced polarization method is an electrical technique which measures the slow decay of voltage in the subsurface following the cessation of an excitation current pulse. Basically, an electrical current is caused to flow in the subsurface, as in the resistivity method above. This electrical current is due mainly to ion transport in the pore waters of the geologic material. During this current flow electrical energy is stored by electrochemical reactions between the rock matrix minerals and ions in solution. After the current is turned off, the electrochemical reactions reverse, and this stored electrical energy is discharged, resulting in a secondary current flow which is measured as the induced polarization signal. Thus, in a sense, the subsurface material acts as a type of electrical capacitor.

The physical property measured by the induced polarization method is chargeability, which is measured in either millivolt-seconds per meter (milliseconds) or as a dimensionless quantity in an alternate formulation. Enhancements in chargeability occur with increased clay content and when disseminated sulfides or graphite is present. Therefore, induced polarization is useful in combination with resistivity (since the two measurements are made simultaneously) to map the thicknesses and extent of clay and silt horizons which impede groundwater flow. In addition, given the enhanced response of rock containing disseminated sulfides or graphite, the method can be used to map some geologic units. The IP sounding will be collected with the Phoenix V-5 receiver in the IP mode of operation.

3.1.3.5 Shallow Seismic Reflection

The shallow seismic reflection method involves introducing a sonic shock wave (shot) through the medium and measuring its arrival time from the reflecting surface to a series of electromechanical transducers (geophones) attached to a seismograph. The seismograph records the time of arrival of all waves, using the moment the shot is set off as time zero. This method produces high resolution mapping of the bedrock-unconsolidated contact at intermediate depths (typical minimum of 10 to 30 meters), and high resolution mapping of stratigraphy and rock type at greater depths (more than 70 meters). This method will be employed to locate and map the base of the semi-confined aquifer.

Data will be collected using a EG&G Geometrics Model 2401 signal enhancing seismograph or equivalent instrument, using appropriate geophones and cables. The actual spread geometries will depend on the estimated depth to the target layers. Field data will be digitally recorded for computer processing and selection of first arrivals. Geophone locations will be marked with pin flags and their locations will be surveyed. Energy will be provided at shot points with 1,000-grain black powder charges buried at a depth of 3 feet below groundsurface (BGS). If these charges provide insufficient energy, an explosives subcontractor will be hired to provide larger sheets.

The geometry of each geophone array must be accurately depicted in the field logbook. The array sketch must be annotated with the line number and spread number. Other important information that must be documented as follows:

- Distances between surveyed reference grid nodes and shot point and/or geophone locations must be measured. At least two points (geophones or shot points) along each spread should be measured/ tied to the reference grid.
- Source type (e.g., sledge hammer, weight drop, and explosives). Note changes in source type, if applicable.
- Geophone and shot point identification or number.
- Spread configuration.
- Intersection points for orthogonal reflection survey lines.
- Depth (BGS) of shot (when using explosives) and shot point (Y-) offset distance from spread, if possible.
- File name of shot point record.
- Data acquisition/field processing settings on the seismograph.
- Cultural information (e.g., buried pipelines or utilities, and power lines).

3.1.4 Monitor Well and Recovery Well Installation

Additional monitor wells will be installed to characterize lithology, determine vertical and horizontal extent of soil contamination, locate the base of the semi-confined aquifer, construct one recovery well, and set up a pump test observation network at the site. Groundwater monitor wells will be installed as per ERT/REAC SOP #2150, Monitor Well Installation and the Wisconsin Department of Natural

Resources (WDNR) Chapter (NR141). The unconfined aquifer monitor well screens will be 10 feet in length, and the semi-confined aquifer monitor well screens will be between 15 to 30 feet in length. The recovery well screen size and filter pack will be determined on the basis of grain size analysis of the proposed screened zone.

A total of five monitor wells (four unconfined and two semi-confined) and one recovery will be installed. An unconfined monitor well will be installed in close proximity to existing monitor wells: MW-06, MW-10, MW-14, and the proposed semi-confined recovery well. One semi-confined aquifer monitor well, will be placed between existing wells MW-08 and MW-12. The recovery well MW-18; will be placed in the former lagoon area. The purpose of these well installations is to determine the horizontal of PCP contamination (MW-17), the vertical extent of contamination (MW-18), and the thickness of the semi-confined aquifer (MW-18). MW-18 will be constructed as the recovery well for the PCP contaminated groundwater at the former lagoon area. It will also be used as the discharge well for the proposed constant rate pump test as described in subsection 3.1.6.2.

At all well locations, subsurface soil samples will be collected at a minimum of 5 foot intervals from ground level to the water table. The maximum depth of the unconfined monitor wells will be at the depth to the semi-confining layer (approximately 120 feet). At semi-confined monitor well, MW017, a 15-foot screen will be installed in the first water bearing unit below the semi-confining layer. A well screen up to 30 feet in length will be installed at MW-18 and its total depth will depend on the depth of the semi-confined aquifer. To ensure that this well performs as an optimal recovery well, the screen and filter pack must be carefully selected. To provide the data needed to make this selection, soil samples will be collected for grain size analysis from likely screened intervals. The boring will be completed and the grain size of the samples will be analyzed to provide data for the design of the well screen and sand pack. The final completion depth of the well will then be determined, the borehole backfilled to the appropriate depth, and the well constructed using 6-inch, Schedule 80 PVC casing and screen. The completion depth of this well is expected to be in the range of 170 feet.

Soil samples will be field screened with an HNu and a OVA. Samples will be collected for field and laboratory analysis of chemical and physical parameters as described in Subsection 3.1.2. Water levels that are encountered during drilling will be noted, both at the time that they are first encountered and after they have stabilized.

3.1.5 Infiltration Tests

Two infiltration test methods will be used to determine the vertical hydraulic conductivity (K_v), and the saturated, horizontal hydraulic conductivity (K_h) of the vadose zone. Eight infiltration tests in four borings will be performed in the vicinity of the area of the proposed infiltration galleries. The infiltration tests will be conducted as described in ASTM D5126-90 and in Boutwell.

The infiltration tests will be conducted at depths of 20, 60, and at the top of the till unit (approximately 100 to 120 feet BGS). These depths were chosen based on the following rationale:

- 20 feet: assumed ground surface or near ground surface after removal of contaminated soil
- 60 feet: midway between post removal ground surface and top of till
- 100 feet: top of semi-confining till unit

3.1.6 Aquifer Characterization

The objective of aquifer characterization is to obtain data to construct a preliminary groundwater flow and transport model for optimizing future remediation technology. Slug tests or pumping tests may be conducted and results used to estimate hydraulic conductivity. Aquifer characteristics that may be obtained from pumping tests include hydraulic conductivity, transmissivity, specific yield for the unconfined aquifer, and storage coefficient for the semi-confined aquifer.

3.1.6.1 Groundwater Monitoring

The objective of the groundwater monitoring program is to determine the flow direction, quality, and characteristics of the aquifer(s) at the PWP site. The objective will be fulfilled by collecting water level data from monitor wells and by collecting groundwater samples from pre-existing and newly installed monitor wells. This information will assist in determining the extent of contamination, support of the groundwater modelling, projecting chemical fate and transport under different aquifer conditions, and evaluating the impact of different conceptual remedial pump and treat alternatives.

Water Level Measurements

To provide data needed for groundwater flow modelling, REAC proposes that water level measurements be collected weekly from all wells. New wells will be added to this program as they are installed. Ideally, these measurements should be collected by personnel onsite. Alternatively, a data logging system could be used to collect water levels automatically from selected wells.

Water level measurements will be collected as per ERT/REAC SOP #2151, Water Level Measurement, from the existing monitor wells to define the groundwater potentiometric surface. Historical water levels will be mapped to determine seasonal variations and effects of rainfall on the aquifer. Depth to water and depth to bottom will be measured from the marked point at the top of casing (TOC) for each well. Measurements will be made with an electric water level indicator and weighted depth sounder, respectively.

Monitor Well Sampling

To provide data for use in vadose zone and groundwater flow modelling and treatment system design, REAC proposes conducting complete rounds of groundwater sampling in September and November 1994. All existing and newly installed wells would be included in this sampling effort. The monitor wells will be sampled as per ERT/REAC SOP #2007, Groundwater Well Sampling and ERT/REAC SOP #2152, Monitor Well Sampling. Analytical parameters for September 1994 would include PCP, ammonia, metals (aluminum, arsenic, barium, berylium, cobolt, chromium, copper, manganese, lead, nickel, vandium, iron, zinc) major ions (magnesium, calcium, sodium, potassium, sulfate, chloride, alkalinity, nitrate), volatile organic carbons (VOCs) and tritium. VOCs may be dropped from the second round after comparison with previous results.

To ensure good quality data for geochemical analysis of groundwater at the site, REAC plans to filter samples for metals and major ions analyses. Unfiltered samples will also be analyzed for metals so that unfiltered and filtered results may be compared. In addition, major ion and alkalinity analysis will be performed at one laboratory. These steps are planned to try to eliminate charge balance errors found in earlier analysis.

To obtain a detailed vertical profile on the distribution of contaminants at the wastewater lagoon, the recovery well may be sampled using the multi-layer sampler (MLS). The MLS is a groundwater sampling tool that can be applied for both discrete hydrochemical sampling as well as for obtaining groundwater velocity profiles. The MLS is based on dialysis membrane technology. The sampler consists of discreet sampling cells, placed at pre-determined depth intervals, which collect representative water samples. The sampler is placed into the screened well, where it remains until equilibrium is reached. Equilibium is achieved when groundwater has diffused into the cell, across the membrane, displacing the analyte free water. The time to equlibrium is a function of the analytes and membrane. Once equilibrium is reached, the MLS is lifted out of the well and the individual cells are removed from the sampler and sent to the laboratory.

Geochemical Analysis

The results of the major ion and tritium analysis will be used to describe site groundwater geochemistry, and aid in the definition of site hydrogeology and groundwater contaminant transport. Major ion analysis (Ca, Mg, Na, K, SO_4, Cl, alkalinity, and NO_3) will be analyzed using Schoeller and trilinear diagrams. These analyses will classify the type(s) of groundwater at the site. Tritium (an isotope of hydrogen) serves as an age indicator of the groundwater and acts as a natural tracer in the groundwater flow system. These analyses will help REAC construct a more complete and accurate groundwater flow and contaminant transport model of the site.

3.1.6.2 Aquifer Testing

Recovery and injection remedial strategies have been proposed for both the unconfined and the semi-confined aquifers. To evaluate recovery and

injection system alternatives, the unconfined and semi-confined aquifers will be characterized with constant rate drawdown tests and slug tests. The methods of testing are outlined as follows:

Slug Tests

A series of slug tests will be conducted on the newly installed monitor wells as per ERT/REAC SOP #2158, Slug Tests. During the slug tests, water levels will be monitored with a pressure transducer/data logger system. Hydraulic conductivities will be estimated using appropriate data analysis methods.

Pre-Test Monitoring

To measure ambient water level fluctuations at the site, a Geoguard T.U.B.E.R.™ and/or a HERMIT™ data logger system will be used to monitor water levels at 15-minute intervals in the pumping well for at least a week prior to performing the pumping test. This background data will be used to determine the effect of local fluctuations on the aquifer.

Step Drawdown Test

Prior to conducting the pumping test, a step drawdown test will be performed to determine:

- The maximum anticipated drawdown, and
- The anticipated volume of water produced at certain discharge rates and the drawdown associated with those flow rates.

The step drawdown test will be performed by progressively increasing the flow rate at one to two hour intervals. The generated drawdown versus time data will be plotted on semi-logarithmic graph paper, with the constant rate test discharge rate determined from this graph. Additionally, the aquifer data will be evaluated using the appropriate aquifer data analysis methods.

Constant Rate Pumping Test

The constant rate test is an accurate and reliable procedure to determine aquifer characteristics through controlled pumping. The aquifer characteristics that will be obtained from the pumping test results include transmissivity (T) and specific yield (S_y).

Following the collection of the step drawdown data, the aquifer will be allowed to re-establish it's initial water levels before beginning the constant rate pumping test. At the beginning of the pumping test and throughout the test, a constant discharge from the pumping well will be maintained. The rate will be obtained from the step test data and will be established quickly at the onset of the constant rate pumping test. During the constant rate test, the pumping well and piezometers will be monitored as per a previously set schedule. The drawdown phase of the constant test is estimated to be 72 to 96 hours (3 to 4 days). After completion of the drawdown phase of the test, the pump will be shut off and the recovery phase of the test will

begin. During this phase, water levels in the pumping and observation wells will be monitored until at least 90% recovery of the initial static level has been achieved.

All discharged groundwater from the pumping well will be processed for PCP removal through a carbon filtration unit and staged in a large holding tank or basin. The treated groundwater will be released upon compliance with the State of Wisconsin's guidelines for release of treated groundwater.

Groundwater Sampling

Prior to the initiation of the pumping test, a groundwater sample will be collected from the pumping well. Samples of the pumped water will be collected at 8-hour intervals for the initial 24-hour period, then at 24-hour intervals for the (expected) remaining 48-hour period. In addition to these samples, the cumulatively collected groundwater will be sampled for treatment options and/or disposal purposes. These samples will be analyzed for select metals, PCP, and VOCs.

Water Level Measurements

Water levels will be measured as per ERT/REAC SOP #2151, Water Level Measurement. Individual pressure transducers will be placed in each monitoring well used during the pumping test. The transducers will be coupled to an on-site data logger.

Calculations

The aquifer properties to be determined include transmissivity, specific yield, storage, leakance of the semi-confining unit, and hydraulic conductivity. Reference texts which will be consulted for the accepted analytical methods may include Applied Hydrogeology[3], Groundwater and Wells[4], Analysis and Evaluation of Pumping Test Data[5], Groundwater[6], and Physical and Chemical Hydrogeology[7].

3.1.7 Vadose and Groundwater Flow and Transport Modeling

To estimate the extent of the contaminant plumes and evaluate remedial recovery system alternatives, groundwater flow and contaminant transport modeling will be conducted for both the saturated aquifer and the vadose zone of the site. This will be accomplished by developing conceptual models of the site based on available data. The modeling software will be selected after reviewing the available data and information.

The modeling will be used to:

- Assess vertical distribution of contaminants in the vadose zone,
- Estimate contaminant migration direction in groundwater,
- Evaluate locations for additional soil borings and monitoring wells, and
- Evaluate the effectiveness of proposed remedial alternatives

3.1.7.1 Vadose Zone Modeling

The movement of PCP and ACA from the ground surface to the water table will be modeled using appropriate vadose zone modeling software.

Information collected from soil borings, geophysical surveys, and soil property tests will be used to construct a conceptual vadose zone model. Appropriate modeling software will be selected based on the data and information available at that stage. The analytical results of borehole soil samples will be used to calibrate the constructed model.

The calibrated model will be used to analyze the plume migration pattern in the vadose zone, assess the plume impact to groundwater in the future, and to assist in evaluating certain recovery system alternatives.

3.1.7.2 Groundwater Flow and Contaminant Transport Modeling

Similar to the vadose zone modeling, a conceptual model for the site semi-confined aquifer will be developed utilizing available information on the site topography, geology, hydrogeology, potentiometric data, and the extent of soil and groundwater contamination. An appropriate groundwater flow and contaminant transport model will be selected based on analysis of the conceptual hydrogeologic model. It is possible that separate models may be used for the flow and transport components. The model will be constructed and calibrated based on available information. In the future, the model could be further verified when a remedial system becomes operational.

The following site specific information will be collected for the modeling:

- Aquifer hydraulic conductivity,
- Aquifer base level,
- Annual infiltration rate,
- Aquifer porosity, and
- Bulk density of aquifer porous media

The calibrated groundwater flow and contaminant transport model will be used to:

- Simulate the groundwater flow system at the site,
- Assess the potential plume impact to off-site receptors (i.e., wetlands, water supply wells), and
- Evaluate proposed remediation design.

3.1.7.3 Geochemical Modelling

To evaluate the form of chermonite present in the groundwater, the geochemical model WATEQ4F[8] will be used to model the thermodynamic speciation of the organic ions and complex species in groundwater from PWP. This model can calculate equilibrium speciation and saturation indices for mineral species and estimate element concentrations that have not been determined analytically. The model also calculates charge balance of the sampled water, percent carbindoxide (pCO_2) and the reductionoxidation (Redox) potential.

3.2 Soil Treatability and Technology Evaluation

3.2.1 Thermal Desorption/Base Catalyzed Dechlorination

Field Activities - During Phase I REAC activities, a bulk soil sample was collected from the site for use in the thermal desorption/BCD study. This sample contained approximately 1,000 mg/kg PCP and is in storage at WESTON's Environmental Technology Laboratory (ETL), located in Lionville, Pennsylvania.

The thermal desorption/BCD treatability study will be subcontracted out to a qualified treatability testing laboratory. Prior to testing, the samples will be screened to remove particles greater than 0.25 inches in diameter. An aliquot of each soil sample will be submitted for confirmatory analytical testing.

Prior to evaluation, the following physical parameters will be determined on the soil samples used for the thermal desorption/BCD studies:

- Percent moisture
- Grain size
- Specific gravity
- Percent ash
- pH
- Heating value
- Soil classification and plasticity limits

Unit Clean-out - Clean sand saturated with water will be processed through the system to make sure the unit is free of contamination. The condensate from this first run will be discarded. Six runs of the clean sand saturated with water will then be performed. Condensate, scrubber water, and sand (pre- and post-treatment) from each run will be collected, and analyzed for total solids, PCP, As, Cu, Zn, and chloride.

Soil Phase - Contaminated soils will be screened to remove debris larger than 0.25 inches. One kilogram of soil will be weighed and combined with 100 milliliters of water for each run. Ten runs will be made. Pre- and post-treatment soil samples will be collected from each run, and analyzed for total solids, PCP, As, Cu, and Zn.

Distillate Phase The distillate from each run will be collected, and analyzed for PCP, arsenic, copper, zinc, and dioxin. The scrubber water will be collected and analyzed for pH and chloride.

Air Sampling Samples of the exit gas from the water scrubber will be collected and analyzed for PCP, VOCs, chloride, and particulates. XAD-2 tubes, Tenax/CMS tubes, and polyurethane foam (PUF) plugs will be utilized for sample collection. Flow rates for each collection media will be monitored and recorded.

Unit Decontamination Condensate traps, the scrubber, and other accessible parts will be wiped with methanol and cleaned. Two clean soil runs will be performed at the end of the study to decontaminate the unit.

Efficiency Analysis The contaminated soil (CS) and sand (S) samples from each test and desorption units will be analyzed for the parameters summarized in Table 3.1.

Table 3.1. Analytical Parameters for Evaluation of the WESTON LT^3 Thermal Treatment Systems

Sample	Pre-treatment Solids	Post-treatment Solids	Condensate Liquid	Air
Total Solids	CS, S	CS, S	--	--
PCP	CS, S	CS, S	CS, S	CS, S
Chloride	CS, S	CS, S	CS, S	CS, S
Dioxin	CS	CS	CS	CS
As, Cu, and Zn	CS, S	CS, S	CS, S	CS, S
Particulates	--	--	--	CS
Volatile Organic Compounds	--	--	--	CS, S

3.2.2 Slurry-Phase Bioremediation Studies

Cultures - During Phase I REAC activities, enrichment culture studies were conducted to screen soils for the presence of PCP-degrading microbes. Results showed that 12 of 13 soil samples screened demonstrated PCP-degrading activity. The Penta Drain 1B soil sample was found to have the highest PCP degradative activity. Two microbial cultures were identified in this enrichment culture and have been purified. As part of Phase II activities, studies to confirm that both cultures are authentic PCP degraders are in progress. Further studies with the remaining 11 enrichment cultures will not be conducted since these enrichment cultures were considerably less active in removing PCP. Non-indigenous cultures may be evaluated for their ability to remove PCP from test wastewater samples[9]. Slurry phase anaerobic dechlorination studies will be subcontracted out to a qualified treatability laboratory.

Nutrient Media - During Phase I REAC activities, literature sources were screened to identify nutrient media which have been successfully utilized to cultivate PCP-degrading microbes[10,11,12,13]. The nutrients will be prepared as sterile stock concentrates and added in suitable amounts to prepare nutrient media. PCP sources will consist of purified PCP stock solutions or PCP-contaminated wastewater. PCP concentrations will be adjusted to levels ranging from 100-300 mg/l.

Wastewater Medium Preparation - Contaminated soils will be washed with alkaline solutions to prepare PCP contaminated wastewater. Soil slurries (10-20% w/v) will be prepared in sodium hydroxide solutions ranging from 0.010-0.50N and stirred overnight. Solids will be removed by centrifugation and clarified wastewater stored in amber glass bottles until needed. Wastewater samples will be analyzed for levels of PCP and metals. Further treatment steps may be necessary to lower levels of toxic

metals. Test wastewater will be suitably diluted to 100-300 mg/l to minimize problems of toxicity[14].

Sterile alkaline wastewater will be aseptically neutralized with dilute acid (sulfuric or hydrochloric acid) and supplemented with inorganic nutrients. The volume of the wastewater medium will be set to a desired volume with sterile deionized water. The final pH of the wastewater medium will be adjusted to 7.3-7.5, if required.

Sampling and Analysis - Cultures may be periodically sampled and analyzed for the following analytes:

- PCP
- viable cell counts
- ammonia
- total kjeldahl nitrogen
- nitrate
- phosphate
- total phosphorous
- metals
- chloride
- pH

Decontamination of Laboratory Equipment Non-disposable contaminated glassware will be rinsed sequentially with deionized water and acetone, washed with a non-phosphate detergent (Liquinox), and rinsed with deionized water. Disposable contaminated glassware will be rinsed with acetone and disposed of in approved receptacles.

All glassware containing liquid media with viable cultures will be sterilized in an autoclave prior to disposal with the exception of liquids containing PCP. PCP-contaminated liquids will be decanted into suitable containers as non-sterile aqueous waste and disposed of by incineration. Contaminated glassware will be cleaned as discussed above. Solid biological waste (disposable petri dishes or pipets), not contaminated with PCP, will be sterilized in an autoclave and disposed of in labeled autoclave bags. PCP contaminated solid waste will be stored in plastic bags in 55 gallon drums as non-sterile solid waste and disposed of by incineration.

3.2.2.1 Shake Flask Culture

Confirmation of PCP Degradation by Purified Cultures The objective of these studies is to confirm that the cultures isolated from the Penta Drain 1B enrichment culture can degrade PCP. Operating parameters used to conduct these studies are summarized in Table 3.2. Purified isolates will be maintained on slants of one-tenth strength Trypticase Soy Agar (TSA) supplemented with PCP to a final concentration of 100 ppm. Seed cultures will be prepared by cultivating test isolates on mineral salts-glutamate broth. Cultures, having grown to turbidity values of 0.10 at 560 nm ($A_{560\ nm}$), will be induced to degrade PCP by adding purified PCP stock solution to a final concentration of 100 ppm. After at least 80 percent of the added PCP has been degraded, induced cells will be recovered by centrifugation, washed, and resuspended in 10 millimolar (mM) phosphate buffer (pH 7.0). The washed cells will be inoculated into sterile mineral salts-PCP medium at a final cell count of 1×10^4 colony forming units (CFU)/ml and grown under conditions listed in Table 3.3. Each test culture will be grown over a 3-4 day period with samples collected at prescribed times. Each sample will be analyzed for PCP, chloride, culture pH, and viable cell count. PCP will be measured by spectrophotometry; however, samples collected at the beginning and end of

the growth experiment will be further analyzed by gas chromatography to confirm results obtained by the spectrophotometric method. Cultures, demonstrating complete removal of PCP, stoichiometric production of chloride as a result of PCP degradation, and net increases in viable cell counts will be considered authentic PCP degraders and added to the culture library. The cultures will be preserved at -20°C in 50 percent v/v aqueous glycerol.

Table 3.2. Operating Parameters Used in the Development of PCP-Degrading Enrichment Shake Flask Cultures

Operating Parameter	Parameter
Culture Volume (ml)	50 (Primary, Secondary, and Tertiary Enrichment Studies) 500 (Confirmation Growth Study) 1000 (Wastewater Growth Study)
Culture Vessel	250 ml Erlenmeyer Flask (Primary, Secondary, and Tertiary Enrichment Studies) 2000 ml Erlenmeyer Flask (Confirmation and Wastewater Growth Studies)
Nutrient Medium	Mineral Salts + PCP (Primary, Secondary, Tertiary Enrichment, and Confirmation Growth Studies) Nutrient-supplemented Wastewater (Wastewater Growth Study)
Temperature (°C)	30
Agitation Rate (rpm)	200
Inoculum	Site soils (Primary Enrichment Study) Culture Enrichments (Secondary, Tertiary Enrichment Studies) Purified Cultures (Confirmation and Wastewater Growth Studies)
Sampling Times (days)	(Purified PCP) Primary Enrichment Culture - 0, 14, 28 (Purified PCP) Secondary Enrichment Culture - 0, 4, 7 (Purified PCP) Tertiary Enrichment Culture - 0, 4, 7 (Purified PCP) Confirmation Growth Study - 0, 1, 2, 3 (Wastewater) Wastewater Growth Study - 0, 2, 4, 7, and 14

Growth of Purified Cultures on PCP-Contaminated Wastewater Authentic PCP-degrading cultures will be grown in seed culture medium as described in confirmation studies discussed above. Washed cells will be inoculated into shake flasks containing nutrient-supplemented wastewater medium. Wastewater medium will be analyzed for PCP, metals, inorganic nitrogen (ammonia and nitrate nitrogen), Total Kjeldahl nitrogen, inorganic phosphate, total phosphorous, and chloride prior to initiating growth experiments. The procedures, operating parameters, and target analytes in growth experiments will be identical to those used in confirmation experiments. Due to the nature of the wastewater matrix, PCP will be analyzed solely by gas chromatography. Cultures, demonstrating removal of

PCP, production of stoichiometric amounts of chloride as a result of PCP degradation, and net increases in viable cell counts will be considered for further study in stirred tank fermenter.

3.2.2.2 Bench-Scale Stirred Tank Fermenter Studies

Batch Culture Studies Purified PCP-degrading cultures will be evaluated as bioremediation agents by cultivating selected isolates on nutrient-supplemented wastewater in stirred tank fermenter. Procedures described herein and Table 3.3 will be utilized in this study. Samples will be collected on days 0, 2, 4, 7, and 14. The parameters measured in these experiments will be PCP, pH/dissolved oxygen profiles, viable cell counts, inorganic phosphate, chloride, and inorganic nitrogen (ammonia and nitrate) levels. Suitable controls will be conducted to check for microbial contamination.

Table 3.3. Operating Parameters Used in Cultivating PCP-Degrading Cultures in Bench-Scale Fermenter Bioremediation Study

Operating Parameter	Parameter Value
Volume (liters)	2.0
Agitation (rpm)	200
Aeration (liters/minute)	0.46
Temperature (°C)	30
pH	7.0 (monitored)
Dissolved Oxygen	100% (monitored)
Duration of Fermentation (days)	14
Antifoam	Polyglycol 2000
Sampling Times (days)	0, 2, 4, 7, 14

Semi-Continuous Culture Studies - The objective of these experiments is to determine the minimum residence time where maximum PCP degradation can be achieved. Sampling strategies similar to those used in batch culture studies will be employed although different growth periods and sampling times will be used. Procedures described above and in Table 3.3 will be utilized in this study.

Active cultures propagated in batch culture will be used as the inocula for succeeding fermentation cycles. Ten percent of the batch culture volume will be retained in the fermenter while the remainder of the culture will be discarded. The fermenter will be recharged with fresh wastewater to a final volume of two liters and the growth cycle reinitiated. The incubation time of each growth cycle will be sequentially reduced until a 3 day residence time is achieved.

Pilot-Scale Stirred Tank Fermenter Studies - Purified cultures, demonstrating a consistent rate and extent of degradation of PCP in bench-scale fermenter studies, will be candidates for pilot-scale fermenter studies. Cultures cultivated in bench-scale fermenters using nutrient-supplemented wastewater as the growth medium, will be used as the inocula for the pilot-scale unit. Strategies summarized above and in Table 3.4 will be used in this study.

Table 3.4. Operating Parameters Used in Cultivating PCP-Degrading Cultures in Pilot-Scale Fermenter Bioremediation Study

Operating Parameter	Parameter Value
Volume (liters)	100-150
Agitation (rpm)	200
Aeration (liters/minute)	10-15
Temperature (°C)	30
pH	7.0 (monitored)
Dissolved Oxygen	100% saturation (monitored)
Duration of Fermentation (days)	14
Antifoam	Polyglycol 2000 (controlled)
Sampling Times (days)	0, 5, 8, 14

3.2.3 Solid-Phase Bioremediation Studies

Soil Amendments - Amendments may be added to test soils to improve drainage and aeration properties of test soils before experiments can be initiated. The strategies used for soil conditioning will be dependent upon analytical results. Amendments such as topsoil (preferably from the site), limestone (calcium carbonate), and sand will be added to condition the soil. Sufficient limestone will be added to raise the soil pH to 7.3-7.5. Since addition of limestone can interfere with carbon dioxide measurements, amended soil will not be used in growth experiments for at least 10 days after liming the test soil. Soil permeability and drainability tests may be conducted to determine if soil properties have been improved. Other amendments include the addition of nitrogen (ammonium nitrate) and phosphorous (dibasic potassium phosphate) sources, and deionized water. The latter amendments will be added when growth experiments are initiated. Experiments will be conducted with unamended contaminated soils as controls for comparative purposes to show improvements in biodegradative activity by amended soils. Site soils, not contaminated with PCP, will also be amended in a similar fashion as contaminated soils and will be used to measure endogenous metabolic activity of site soils.

Amended test soils will be extensively analyzed to characterize the chemical and physical properties of test soils prior to initiating growth experiments. The following analyses will be performed:

- viable cell counts
- PCP
- ammonia nitrogen
- nitrate nitrogen
- total Kjeldahl nitrogen
- phosphate
- total phosphorous
- metals
- TPH
- hydraulic conductivity
- sulfate
- total organic carbon
- soil moisture
- water holding capacity
- cation exchange capacity
- particle size
- pH
- chloride
- bulk density
- soil ash content

Biodegradation Experiments - Solid-phase bioremediation experiments will be conducted in Biometer flasks. These flasks have been designed to allow monitoring of the rate and extent of biodegradation by measuring carbon dioxide evolution. Typically, carbon dioxide is measured cumulatively and can be monitored until metabolizable substrates are exhausted. Procedures in the use of the Biometer flasks are essentially those reported by Bartha and Pramer[15].

In the present experiments, approximately 30 grams of amended uncontaminated or contaminated soil will be added to each flask. Test soils will be supplemented with suitable aliquots of ammonium nitrate and dibasic potassium phosphate stock solutions. Nutrient additions will be based on the level of total organic carbon present in the soil. Studies by Dibble and Bartha[16] have shown that a carbon:nitrogen (C:N) ratio of 60:1 and a carbon:phosphorous (C:P) ratio of 800:1 are optimal for solid-phase remediation systems using hydrocarbon-contaminated soil. Optimized conditions for solid-phase PCP bioremediation studies as reported by Crawford and Mohn[10] will be used in these studies. Deionized water will be added to test soils to achieve a water holding capacity (WHC) of 50 percent. After all amendments have been added, each flask will be assembled and time zero carbon dioxide measurements taken. Throughout the study, carbon dioxide levels from test flasks will be adjusted by subtracting carbon dioxide evolution values from endogenous control flasks (flasks containing amended soil but not contaminated with PCP).

Contaminated soil control flasks will contain a variety of treated and untreated soils including:

- soils amended with calcium carbonate, sand and deionized water to a WHC of 50 percent, and

- soils amended with calcium carbonate, sand, nitrogen and phosphorous supplements, and deionized water to a WHC of 50 percent and sterilized by the addition of mercuric chloride (sampled at week 0, 4, 8, and 12)

Uncontaminated soil control flasks will contain a variety of treated and untreated soils including: soils amended with calcium carbonate, sand, nitrogen and phosphorous sources, and deionized water to a WHC of 50 percent.

Control flasks will be prepared in duplicate while test flasks will be prepared in triplicate. Test and control flasks will be incubated at room temperature until there is no net increase in carbon dioxide evolution or incubated no longer than 12 weeks. Duplicate killed controls will be sampled at week 0, 4, 8, and 12 to assess abiotic losses due to photodegradation.

Existing data indicates that site soil can contain high levels of petroleum hydrocarbons. Due to the high levels of petroleum hydrocarbons found in soil, the carbon dioxide evolved during biodegradation experiments will be produced primarily from hydrocarbons. PCP concentrations will be relatively low (approximately 100 to 300 ppm) due to the toxic nature of the compound. It is assumed that if the flasks are monitored until there is no net increase in carbon dioxide production, then resident hydrocarbons and PCP have both been removed.

Sampling - Trapping of carbon dioxide using potassium hydroxide solutions will be carried out by procedures used in studies reported by Bartha and Pramer[13]. Samples for measurement of soil PCP will be collected by emptying test soils from each Biometer flask into 8 ounce amber glass bottles fitted with Teflon lined caps. Each flask will be washed with rinses of deionized water and methylene chloride with rinsates being added to respective test bottles. Test samples will be sterilized by the addition of 2 percent w/v mercuric chloride.

Decontamination of Laboratory Equipment - All non-disposable contaminated glassware and disposable contaminated glassware will be decontaminated or disposed of as described in Section 3.2.4. All glassware containing liquid media with viable cultures will be disposed of as described in Section 3.2.4.

Pilot scale solid phase bioremediation tests will be conducted at the PWP site. The tests will be set up in one of the existing on-site buildings following steam cleaning of the cement floor. Ten soil windrow piles will be situated in a herringbone pattern within the building. Each windrow soil pile will be treated with various combinations of soil amendments and nutrients. Various types of PCP-degrading organisms may also be screened (i.e., bacterial cultures, white rot fungi, etc.). Unamended control piles will be included in the study, as well as bioaugmentation using expanded cellulose; anaerobic reductive dechlorination; high temperature and moderate temperature composting; and land farming using various nutrient additions. Each soil windrow will be placed in a cell with approximate dimensions of 8 ft (width) x 4 feet (height) x 16 feet (length). Each cell will consist of a base containing approximately 6 inches of wood chips or gravel. A 4-inch PVC perforated pipe will be buried in the base for aeration. A 10-mil plastic sheet will be placed on the concrete floor beneath the cell base for leachate collection and protection against spills. A single ply of geotextile filter fabric will be placed on top of the wood chip/gravel base in each cell. Approximately 250 cubic feet of contaminated soil/amendment mixtures will be placed into each cell.

A dedicated computer (located onsite and linked, via modem, to REAC in Edison, NJ) will be used to monitor temperature, oxygen content, moisture content and aeration rate of each soil/amendment mixture. Moisture will be provided by placing a perforated garden hose inside each pile. Water will be pumped to each cell from a water tank in order to maintain soil moisture levels at desired levels. Aeration will be provided by dedicated 0.5 horsepower air vacuum/blowers connected to the perforated pipes in each cell base by means of a main air supply pipe. Soil and

leachate samples will be collected periodically for approximately 1 year for analysis of the parameters listed in Table 9.1, Field Sampling Summary - Remedial Option Evaluation: Plot Scale Solid Phase Bioremediation.

Leachate will be collected in a floor drain located at one end of each cell. A sump pump placed in a well located at one end of the drain will be used to pump the leachate to the Biotrol unit. The leachate will be analyzed for the same parameters as the soil samples.

3.2.4 Soil Flushing

Column Studies - A soil flushing study will be conducted to determine whether this technology can be applied to PCP-contaminated soils in the lagoon area at the PWP site. A representative bulk sample of PCP-contaminated soil will be collected from the lagoon area and screened to remove particles larger than 0.25 inch in diameter. The screened bulk soil sample will then be homogenized and placed in a 5 gallon plastic bucket. An initial characterization sample will be submitted for physical and chemical analysis. Four representative aliquots of soil will be placed into four columns and compacted evenly. Distilled water (or chemical flushing fluids made using distilled water) will be percolated through the columns. Periodic leachate sampling will be conducted to determine the number of pore volumes of flushing solution needed to achieve treatment criteria as well as the relative effectiveness of the flushing solutions used. Flushing solutions will be analyzed for parameters listed in Table 9.1, Field Sampling Summary - Remedial Option Evaluation: Soil Flushing Column Study.

Soil samples (both untreated and chemical flushing-solution treated) will be collected for analysis. For each flushing treatment, the percent PCP removal efficiency will be determined as a function of pore volume number. Soil samples will be analyzed for parameters listed in Table 9.1 (see above).

Pilot Study - A pilot scale in-situ soil flushing study will be conducted on-site during pump test activities to determine the feasibility of constructing a full-scale soil flushing system for the remediation of PCP-contaminated soil. The pilot-scale system will include groundwater recovery wells, a water treatment system, and an effluent discharge system. Sufficient water storage capacity will be provided to hold the entire volume of water generated during a 4-day pump test conducted at up to 60 gallons per minute (gpm) (maximum volume of up to 400,000 gallons). If needed, the area on which the storage tanks are to be set up will be graded to insure a level surface. The treated groundwater discharge area will be located in a gravel drainage field constructed to prevent site soil erosion. A bottomless cylindrical tank may be placed around the discharge location to provide additional erosion protection. This will also allow an estimation of the rate at which water can effectively infiltrate site soils. Data obtained during operation of the pilot scale soil flushing system will be used to determine whether construction of a full scale flushing system is a viable remediation option at the PWP site.

Water samples collected during the test will be analyzed for parameters listed in Table 9.1, Field Sampling Summary - Remedial Option Evaluation: Groundwater Treatability.

If data collected from the pilot scale washing system indicate that soil washing techniques will not be a viable treatment option, alternative remediation technologies will be evaluated. Additional bench or pilot-scale soil washing treatments may also be evaluated pending Quality Assurance/Quality Control (QA/QC) validation of results of bench-scale soil washing tests conducted during Phase I activities. These soil washing test results have not yet been validated using proper QA/QC procedures.

3.2.5 Soil Solidification/Stabilization

A concrete pad will be constructed using ACA-contaminated soils (approximately 2 acre-feet) excavated from the Wood Storage Drip area. This pad will be used as a base for solid phase biotreatment activities and is expected to bear heavy equipment traffic. Engineering assistance will be provided, if needed, with respect to collecting and analyzing confirmatory soil samples in order to select areas within the site from which to excavate soil used for pad construction. Assistance in the design and placement of the concrete pad will also be provided if needed.

Confirmatory untreated and cement-treated soil samples will be analyzed for parameters listed in Table 9.1, Field Sampling Summary - Remedial Option Evaluation: S/S - Concrete Pad Construction.

3.3 Groundwater Treatability and Technology Evaluation

Treatability studies will be performed to evaluate feasible groundwater remediation technologies. These results, in conjunction with results obtained from the aquifer test and groundwater modeling will be used to determine the volume and characteristics of the contaminated groundwater. The maximum flow of contaminated groundwater that can be treated in the Biotrol unit will also be determined.

Contaminated groundwater collected from the existing wells will be composited into 5-gallon samples for the treatability studies. If a representative sample can not be collected from the existing wells, samples will be collected from new monitor wells after installation, development, and characterization. During site activities, enzyme immuno-assay test kits will be used to screen potential treatability samples to ensure that PCP concentrations are at least 10 mg/L (the solubility of PCP).

Prior to the initiation of the constant rate pumping test, a groundwater sample will be collected from the pumping well. Samples of the pumped water will be collected at 8-hour intervals for the initial 24-hour period, then at 24-hour intervals for the (expected) remaining 48-hour time period. In addition to these samples, the cumulatively collected groundwater will be stored and sampled to evaluate the groundwater quality under pumping conditions. The results obtained from this test will be compared to the results obtained from the prior sampling. Treatability tests may be conducted to determine if the treatment system engineered earlier can be used to treat the water from the pump test.

Treatability Study Design The treated water discharge criteria will be determined so the appropriate detection limits can be specified to the analytical laboratories. Data on discharge criteria for other compounds will be specified by the Work Assignment Manager.

Treatability studies will be conducted on representative composite groundwater samples collected from contaminated areas at the site and on leachate samples from solid phase bioremediation samples. Three 5-gallon composite samples of groundwater will be collected and submitted to subcontract laboratories for the following evaluations:

- Ultraviolet (UV) radiation with:
  - Only ozone
  - Only hydrogen peroxide
  - Both ozone and hydrogen peroxide
  - Other additives or catalyst
- Carbon adsorption
- Ion Exchange
- Clay absorption
- Ultra-filtration

Shake tests using groundwater and various dosages of carbon, clay or ion exchange resin will be conducted to generate adsorption isotherms. Based on the adsorption isotherm data, column tests will be conducted utilizing the optimum carbon/liquid, clay/liquid, or resin/liquid ratio to further define carbon, clay or ion exchange resin performance levels. UV radiation studies will be conducted using jar tests in conjunction with UV radiation exposure. Chemical treatment addition, if required, will be by means of direct addition to the jar test samples. Laboratory ultrafiltration studies will also be performed with a small bench scale unit to determine whether this technology can be used to reduce PCP levels.

Treatability samples will be analyzed for the parameters listed in Table 9.1, Field Sampling Summary - Remedial Option Evaluation: Adsorption Study. The results of the treatability studies will be compared against the local discharge requirements or the requirements specified by the Work Assignment Manager.

Free-Product Analysis

As part of the treatability study, a sample of free product will be collected if detected in any of the existing monitoring wells. The free product samples will be analyzed for the parameters listed in Table 9.1, Field Sampling Summary - Remedial Option Evaluation: Free Product.

3.4 Groundwater Treatment and Soil Flushing System Design

The preliminary design work of a groundwater treatment system will be completed using the results of the groundwater treatability and technology evaluation; aquifer pumping test and vadose zone, groundwater flow, and contaminant transport modeling; and soil flushing studies.

The preliminary design work will include:

- process flow diagram
- piping and instrumentation diagram
- equipment arrangement
- extraction well piping and instrumentation
- recovery well detail
- facility legend
- facility piping plan
- electrical site plan

- electrical symbol legend and general notes
- electrical single line drawing
- power and control plan
- electrical schematic diagram and instrumentation details

The preliminary design may also include the following documents:

- major equipment list
- description and function of major equipment
- preliminary cost estimate of treatment system
- sump pumps with control panel specifications
- lift pump with control panel specifications
- dual pump recovery system specifications
- instrumentation general specifications
- instrumentation functional specifications
- instrumentation equipment specifications
- instrumentation control panel specifications
- instrumentation installation specifications

As-built drawings will be completed after the system installation. Conference calls and/or meetings will be conducted between involved parties during the project and prior to determining the final design of the system. Home office assistance may be obtained for conceptual and final design of the treatment system and WESTON personnel may be on site to oversee the installation of the system.

3.5 Ecological Risk Assessment

The objective of the ecological risk assessment will be achieved by completion of the following generalized tasks:

- Existing data, reports, and analytical results pertinent to the site will be reviewed. In particular, the memoranda regarding ecological concerns at the site prepared by Eileen Helmer (Region V, U.S. EPA) will be reviewed in light of the project scope.

- A screening level ecological risk assessment will be conducted focusing on contaminants of concern, exposure pathways, receptor organisms, and endpoints that may be unique to the site. Data from the site document mentioned above, previous ERT/REAC evaluations, and the primary literature will be used to identify assessment variables.

- An empirical field investigation will be performed to compliment and fine tune the risk assessment variables developed from existing data and the literature. The investigation will involve additional sampling and analysis of soil, sediment, water, and is likely to involve sampling and analysis of biological matrices.

Potential ecological risks stemming from the site will be evaluated as per the Office of Emergency Response and Removal (OERR) Draft Ecological Risk Assessment Guidance. Exposure and toxicity data for the highest detected concentrations of contaminants of concern will be integrated and used to estimate the potential risk associated with the site. The principal activities in this assessment include selecting contaminants of concern, estimating the exposure concentration(s), deriving toxicological endpoint concentration(s), and assessing the risk.

Existing data concerning the extent and magnitude of contamination at the PWP site will be reviewed and summarized with respect to the ecological risk assessment. From this, contaminants of concern will be selected on the basis of criteria that provide an appropriate level of conservatism and include the frequency of detection, distribution, concentration, biological availability, and toxicity. Although Ar, Cu, Zn, and pentachlorophenol were detected throughout the site, they may not all be carried through the risk assessment.

The exposure assessment establishes pathways and estimates exposure concentrations of contaminants of concern. The pathways and estimated exposure concentrations will be based on measured concentrations, estimates of chemical fate and transport, and will reflect life history characteristics of the selected biological indicator organisms.

The toxicity assessment evaluates the concentrations of contaminants of concern that are known to or are likely to result in adverse effects to organisms. Toxicological endpoint concentrations will be based on literature values derived using standard test species that are taxonomically related to the biological indicator organisms. As eluded to above, it may be necessary to measure concentrations of contaminants in ecological significant matrices (e.g., tissue) or key receptor organisms, or conduct laboratory toxicity evaluations of soil, sediment, or water. It is anticipated that further delineation or characterization of isolated "hot spots" in peripheral on- and off-site areas will be performed as part of the risk assessment. The approximate number and type of samples are summarized in the Table 3.5.

Table 3.5 Field Sampling Summary for Ecological Assessment*

Analysis	Matrix			
	Water	Sediment	Soil	Tissue
Metals				
As, Cu, Zn by XRF	NA	25	50	NA
As, Cu, Zn by AA	15	15	25	10
PCP	15	15	25	10
Toxicity	10	10	10	NA

* Note: This table merely summarizes the number and type of samples and analyses that may be required to support the ecological risk assessment and is used for planning, budgeting, and scheduling purposes. It does not include additional laboratory analyses which will be conducted such as MS/MSD.

The risk characterization is primarily an integration of the exposure and toxicity assessment results. The estimated exposure concentrations will be compared to toxicological endpoint concentration for each contaminant of concern. The quotient method, which compares the estimated exposure concentration with the selected toxicological endpoint concentration, will be used in this assessment.

The hazard quotient enables the relative toxicity of individual contaminants of concern to be determined; higher quotients are associated with greater potential toxicity. Cumulative toxicity, or the toxicity associated with chemical mixtures, is an important component of this risk characterization and will be addressed by summing all toxicity quotients resulting in an estimate of total risk for the site. This sum will be used as an index of potential injury or

hazard to receptors from site contaminants. In addition, individual scores will be used to identify the dominant contaminants contributing to the overall risk.

Other components of this risk assessment will include an identification of biological indicator organisms and an analysis of uncertainty. Biological indicator organisms will be selected from species known to inhabit the site or the general vicinity of the site. Among these, endangered or threatened species will be considered. The uncertainty analyses reflects data gaps and assumptions made as part of the exposure and toxicity assessment and the risk characterization.

Additional judgmental samples will be collected and analyzed near isolated "hotspots" and/or areas of ecological concern. The precise location of these samples will be determined in the field upon consultation with the Work Assignment Manager. The additional XRF and PCP samples may not necessarily be taken at the same location, since the pattern of contamination of the metals and the PCP may be different. The judgmental samples will be collected as site conditions dictate as per the following ERT/REAC Standard Operating Procedures (SOP):

- SOP #2001, General Field Sampling Guidelines
- SOP #2002, Sample Documentation
- SOP #2003, Sample Storage, Preservation and Handling
- SOP #2004, Sample Packaging and Shipment
- SOP #2006, Sampling Equipment Decontamination
- SOP #2012, Soil Sampling
- SOP #2013, Surface Water Sampling
- SOP #2016, Sediment Sampling

4.0 PROJECT MANAGEMENT AND REPORTING

The REAC Task Leader, Mike Druger, will maintain contact with the U.S. EPA/ERT Work Assignment Manager, Harry Allen, to provide information on the technical and financial progress of this project. This communication will commence with the issuance of the work assignment and project scope meeting. Activities under this project will be reported in status or trip reports and other deliverables (e.g., analytical reports, final reports) identified in Section 8.0. Activities will also be summarized in appropriate format for inclusion in REAC Monthly and Annual Reports.

WESTON and C.C. Johnson & Malhorta, P.C. (CCJM) personnel performing work under this work assignment have received the REAC Conflict of Interest Plan and been informed of their obligation to report personal conflicts of interest. Each employee has agreed to this policy by signing a statement related to conflict of interest responsibilities. In addition, WESTON and CCJM will conduct searches of corporate conflict of interest data bases in reference to this work assignment. Any actual or potential conflict of interest associated with this work assignment will be brought to the attention of the Contract and Project Officers. Lastly, WESTON recognizes the continuing obligation to identify and report any actual or potential conflict of interest arising at any time during performance of this work assignment.

5.0 PROJECT SCHEDULE

The work assignment for this project was received on June 13, 1993. A REAC project team was assembled and the QAWP was prepared to address the Work Assignment objectives. Also during this period, the equipment and other resources needed to conduct site activities were specified and assembled. It is anticipated that field and other activities will be initiated immediately following approval of this QAWP. The tentative schedule for field, laboratory, and other activities is summarized in Table 5.1.

Table 5.1 Proposed Penta Wood Products Project Schedule

Task	Start Date	End Date
Geophysical Surveys	8/94	10/94
Soil boring, monitor well, and recovery well installation	8/94	9/94
Monitor well development	8/94	9/94
Groundwater sampling from existing wells	8/94	11/94
Aquifer tests	8/94	9/94
Remedial technology evaluation: slurry-phase bioremediation	8/94	10/95
Remedial technology evaluation: solid-phase bioremediation	8/94	10/95
Remedial technology evaluation: thermal desorption/BCD	8/94	11/94
Remedial technology evaluation: soil flushing	8/94	9/94
Remedial technology evaluation: carbon adsorption	8/94	10/94
Remedial technology evaluation: clay adsorption	8/94	10/94
Concrete pad construction	9/94	10/94
Pilot scale solid phase bioremediation	10/94	10/95
Pilot scale soil flushing	9/94	5/95
Groundwater Flow Modeling	9/94	11/94
Final Report - Site characterization	8/94	2/95
Ecological Risk Assessment	8/94	11/94

6.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

Tom Mignone is the REAC Project Manager/Quality Control (QC) Coordinator for this work assignment. The Project Manager is the primary REAC point of contact with the U.S. EPA Work Assignment Manager and is responsible for the development and completion of the QAWP, project team organization, and supervision of all project tasks, including reporting and deliverables. In addition, the QC Coordinator is responsible for ensuring field adherence to the QAWP and recording any deviations from the QAWP.

The REAC QA Officer is Christine Andreas, the Health and Safety Officer is Tom Mignone, and the Analytical Section Leader is Vinod Kansal. These individuals are responsible for auditing and guiding the project team, reviewing/auditing the deliverables and proposing corrective action, if necessary, for nonconformity to the QAWP or HASP. The REAC project team consists of subtask leaders, field and laboratory technicians, and office support personnel. The following REAC subtask leaders are the key members of this team and are responsible for the development and implementation of the activities specified below:

Personnel	Responsibility
Rich Henry	Surficial soil EOC; Ecological risk assessment
Mike Mohn	Remedial technology evaluation
Michael Druger	Hydrogeologic investigation
Ferrell Miller	Bioremedial technology evaluation
Noel Rogers	Geophysical characterization

While not specifically identified, activities such as video documentation, photodocumentation, computer graphics and support, statistics, word processing and report preparation and purchasing support may be required in order to accomplish the objectives of this project.

7.0 MANPOWER AND COST PROJECTIONS

7.1 Cost Summary

The estimated costs (including labor, travel, materials and equipment, subcontractor, and analytical) to complete this project are summarized in the attached cost summary sheet and Table 7.1.

9.0 QUALITY ASSURANCE

QA objectives and protocols are summarized in Tables 9.1 and 9.2

As specified in Table 9.2, the following QA Protocols for QA1 data are applicable:

1. Sample documentation in the form of field logbooks, the appropriate field data sheets, and chain of custody forms will be provided.
2. All instrument calibration and/or performance check procedures/methods will be summarized and documented in the field/personal or instrument log notebook.
3. Detection limit(s) will be determined and recorded, along with the data, where appropriate.

As specified in Table 9.2, the following QA Protocols for QA2 data are applicable:

1. Sample documentation in the form of field logbooks, the appropriate field data sheets, and chain of custody forms will be provided. Chain of custody sheets are optional for field screening locations.
2. All instrument calibration and/or performance check procedures/methods will be summarized and documented in the field/personal or instrument log notebook.
3. Detection limit(s) will be determined and recorded, along with the data, where appropriate.
4. Sample holding times will be documented; this includes documentation of sample collection and analysis dates.
5. Initial and continuing instrument calibration data, will be provided.

6a. For **soil, sediment and water samples**, rinsate blanks, field blanks, and trip blanks will be included at the rate specified in Table 9.1, footnotes 2 and 3, respectively.

6b. For **air samples**, lot blanks, field blanks, collocated samples, trip blanks, and breakthrough samples will be included at the rate specified in Table 9.2, footnotes 1-7, respectively.

6c. For **soil gas samples**, duplicate samples, zero air samples, field standards, ambient air samples, and matrix spikes will be included at the rate specified in Table 9.1, footnotes 2-6, respectively.

7. Performance Evaluation (PE) samples are optional, if available.
8. Choose any one or any combination of the following three options:

   a. **Definitive Identification** - the identification on 10% of the screened (field or lab) or 100% of the unscreened samples will be confirmed via an EPA-approved method; documentation such as chromatograms, mass spectra, etc will be provided.

   b. **Quantitation** - documentation for quantitative results from screening and an EPA-approved verification methods (for screened samples) or just quantitative results (in the case of unscreened samples) will be provided.

   c. **Analytical Error** - the analytical error will be determined by calculating the precision, accuracy, and coefficient of variation on a subset of the screened or all of the unscreened samples using an EPA-approved method.

Numbers of samples to be collected for this project/event are presented in Table 9.1, Field Sampling Summary, and Table 9.2, QA/QC Analysis and Objectives Summary. These tables identify analytical parameters desired; type, volume and number of containers needed; preservation requirements; number of samples to be collected; and associated number and type of QA/QC samples based on the QA level.

All project deliverables will receive an internal peer review prior to release, per guidelines established in the REAC Administrative Procedures.

Field monitoring equipment will be calibrated and used as per the manufacturers instructions and recommendations. All calibration data will be documented in site log books.

Documentation of site activities and observations will be in the form of field logbooks and the appropriate field data sheets completed with information to sufficiently describe the site and any conditions which may have a bearing on the final data interpretation.

Habitat assessments, and field collections will be performed by the same person(s) to ensure consistency and all field procedures and observations will be documented.

All project deliverables will receive an internal peer review prior to release, as per guidelines established in REAC Administrative Procedures.

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Table 9.1. Field Sampling Summary
Overburden Characterization

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
Moisture Content	NA	S	(1) 32 oz plastic/glass	4°C	7 days	24	NA	NA/NA	NA	NA	24
pH	6 - 9 units	S	(1) 4 oz plastic/glass	4°C	ASAP	24	NA	NA/NA	NA	NA	24
Cation Exchange Capacity	NA	S	(1) 32 oz plastic/glass	4°C	NA	24	NA	NA/NA	NA	NA	24
Capillary-Moisture Tension	NA	S	(1) 32 oz plastic/glass	4°C	NA	24	NA	NA/NA	NA	NA	24
Grain Size	NA	S	(1) 32 oz plastic/glass	NA	NA	30	NA	NA/NA	NA	NA	30
Total Organic Carbon	NA	S	(1) 4 oz plastic/glass	4°C	28 days	24	NA	NA/NA	NA	NA	24
Specific Gravity	NA	S	(1) 32 oz plastic/glass	4°C	28 days	24	NA	NA/NA	NA	NA	24
Dry Bulk Density	NA	S	(1) 32 oz plastic/glass	4°C	28 days	30	NA	NA/NA	NA	NA	30
Permeability	NA	S	(1) 32 oz plastic/glass	4°C	28 days	20	NA	NA/NA	NA	NA	20

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one or one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.1. (cont'd) Field Sampling Summary
Overburden Characterization

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
PCP (lab analysis)	1 mg/kg	S	4 oz amber glass (1)	4°C	7/40 day	60	NA	6	NA	6	72
As, Cu, Zn (lab analysis)	1 mg/kg	S	XRF Sample cup (2 per location)	4°C	6 mon	5	NA	NA	NA	1	5

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one or one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.1. Field Sampling Summary - Groundwater: August and November 1994 Sampling

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix *	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/Trip Blanks[3]	PE Samples[4]	Total Matrix Spike[5]	Total Field Samples[6]
VOA	See Attached Table	GW	40 mL vial (3)	4°C **	7 day	44	4	4/9	0	5	61
PCP	1 ug/L	GW	32 oz. AGJ (1)	4°C	7 day	55	4	8/NA	0	6	67
Ammonia	100 µg/L	GW	1 L Poly (1)	4°C pH<2 H_2SO_4	28d	44	4	4/NA	0	5	52
Filtered: Alkalinity (as $CaCO_3$)	10 mg/L	GW	250 mL Poly (1)	4°C	14d	44	4	4/NA	0	NA	52
Tritium (fill completely)	<1 TU	GW	1 L Poly (1)	4°C	6 mon	44	4	4/NA	0	NA	52
Filtered: Al, As, Ba, Be, Co, Cr, Cu, Fe, Mn, Pb, Ni, V, Zn	See Attached Table	GW	500 mL Poly (1)	4°C pH<2 HNO_3	6 mon	44	4	4/NA	0	5	52
Unfiltered: Al, As, Ba, Be, Co, Cr, Cu, Fe, Mn, Pb, Ni, V, Zn	See Attached Table	GW	500 mL Poly (1)	4°C pH<2 HNO_3	6 mon	44	4	4/NA	0	5	52
Filtered, Major Cations (Ca, Mg, Na, K)	See Attached Table	GW	500 mL Poly (1)	4°C pH<2 HNO_3	6 mon	44	4	4/NA	10	5	62
Filtered: Chloride Sulfate Nitrate	1mg/L 1mg/L 0.4 mg/L	GW	1 L Poly (1)	4°C	Cl 28 d NO_3 48Hr. SO_4 28 d	44	4	4/NA	0	5	52

TU = Tritium Unit

* Matrix: S-Soil W-Water O-Oil, DS-Drum Solid, DL-Drum Liquid, SD-Sediment, PW-Potable Water, GW-Groundwater, SW-Surface Water, SL-Sludge, X-other

** If residual chlorine is present, preserve with 0.008% $Na_2S_2O_3$.

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "N/A."
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous filed blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "N/A". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "N/A". Each aqueous trip blank consists of two 40 mL vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 mL vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "N/A".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.1. Field Sampling Summary
Remedial Option Evaluation: Thermal Desorption

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
PCP	1 ppm	W	1 l amber (1)	4°C	7/40 day	2	NA	NA	NA	1	2
PCP	30 ppm	S	4 oz glass (1)	4°C	7/40 day	4	NA	NA	NA	1	4
Chloride	1 ppm	W	4 oz glass (1)	4°C	28 day	3	NA	NA	NA	1	3
Chloride	1 ppm	S	4 oz glass (1)	4°C	7/40 day	4	NA	NA	NA	1	4
Dioxin	1 ppb	S	4 oz glass (1)	4°C	7/40 day	2	NA	NA	NA	0	2
As, Cu, & Zn	See attached list	W	1 L polyethylene (1)	4°C, pH < 2 HNO_3	6 mon	2	NA	NA	NA	1	2
As, Cu, & Zn	See attached list	S	8 oz glass (1)	4°C	6 mon	4	NA	NA	NA	1	4
Heating Value (BTU)	NA	S	8 oz glass (1)	NA	NA	1	NA	NA	NA	NA	1
Percent Ash	NA	S	8 oz glass (1)	NA	NA	1	NA	NA	NA	NA	1
Soil Classification	NA	S	8 oz glass (1)	NA	N/a	1	NA	NA	NA	NA	1
Specific Gravity	NA	S	8 oz glass (1)	NA	NA	1	NA	NA	NA	NA	1

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of one 40 ml vial filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.1. Field Sampling Summary
Remedial Option Evaluation: Thermal Desorption (Air)

Analytical Parameter	Action Level[1]	Sampling Media	Suggested Holding Times	Flow Rate	Volume Min - Max	Subtotal Number Samples
PCP	NA	XAD-2 Tube	1 week	2 l/min	1000 l	2
HCl	NA	Silica Gel Tube 600 mg	----	0.2-0.5 l/m	3 l 100 l	2
Particulates	NA	Tared 37 mm 5 um PVC Filter	Indefinite	1.5-2 l/m	25 @ 15 mg/m^3 133 @ 15 mg/m^3	1
As, Cu, & Zn	NA	0.8 um filter (MCE)	6 mths	1-4 l/m	5 l 2000 l	2
VOA	NA	Tenax/CMS	1 week	20 ml/min	5 l	2

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of one 40 ml vial filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.1. Laboratory Sampling Summary
Bioremediation Evaluation

							QC Extra's				
Analytical Parameter	Level of Sensitivity[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
PCP	ND[7]	W/S	1 oz./8 oz. amber glass (2)	4°C,HCHO	7/40 days	51	NA	NA	NA	8	51
Ammonia Nitrogen	ND	W/S	1 oz./8 oz. amber glass (2)	H_2SO_4, pH<2, -20°C,HCHO	28 days	12	NA	NA	NA	2	12
Nitrate Nitrogen	ND	W/S	1 oz./8 oz. amber glass (2)	H_2SO_4,pH<2, -20°C,HCHO	28 days	12	NA	NA	NA	2	12
Total Kjeldahl Nitrogen	ND	S	1 oz. amber glass (2)	H_2SO_4, pH<2, $HgCl_2$, 4°C	48 hours	2	NA	NA	NA	1	2
Phosphate	ND	W/S	1 oz./8 oz. amber glass (2)	H_2SO_4,pH<2, -20°C,HCHO	48 hours	12	NA	NA	NA	2	12
Total Phosphorous	ND	S	1 oz./8 oz. amber glass (2)	H_2SO_4, pH<2, $HgCl_2$,4°C	28 days	2	N/D	N/D	N/D	1	2
Trace Metals	ND	W/S	1 oz./8 oz. amber glass (2)	HNO_3,pH<2 -20°C,HCHO	6 mos	2	NA	NA	NA	1	2
Chloride	ND	W	1 oz. amber glass (2)	4°C	28 days	32	NA	NA	NA	4	32

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.
7. Not determined

Table 9.1. (cont'd) Laboratory Sampling Summary
Bioremediation Evaluation

							QC Extra's				
Analytical Parameter	Level of Sensitivity[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
Sulfate	ND	S	8 oz. amber glass (2)	4°C	28 days	2	NA	NA	NA	NA	2
Total Organic Carbon	ND	S	8 oz. amber glass (2)	4°C, H_2SO_4, pH<2	28 days	2	NA	NA	NA	NA	2
Soil Moisture	ND	S	8 oz. amber glass (2)	4°C	7 days	2	NA	NA	NA	NA	2
Water Holding Capacity	ND	S	8 oz. amber glass (2)	4°C	NA	2	NA	NA	NA	NA	2
Cation Exchange Capacity	ND	S	8 oz. amber glass (2)	4°C	NA	2	NA	NA	NA	NA	2
Particle Size Distribution	ND	S	8 oz. amber glass (2)	4°C	NA	2	NA	NA	NA	NA	2
pH	ND	S	8 oz. amber glass (2)	4°C	NA	2	NA	NA	NA	NA	2

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.
7. Not determined

Table 9.1. Field Sampling Summary
Remedial Option Evaluation: Soil/Water Characterization

Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	QC Extra's				
							Rinsate Blanks[2]	Field/Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
Moisture	NA	S	32 oz glass (1)	4°C	7 days	3	NA	NA/NA	NA	NA	3
pH	6 - 9 units	S	4 oz glass (1)	4°C	ASAP	3	NA	NA/NA	NA	NA	3
Cation Exchange Capacity	NA	S	32 oz glass (1)	4°C	NA	3	NA	NA/NA	NA	NA	3
Water Holding Capacity	NA	S	32 oz glass (1)	4°C	NA	3	NA	NA/NA	NA	NA	3
Grain Size	NA	S	32 oz glass (1)	NA	NA	3	NA	NA/NA	NA	NA	3
Total Organic Carbon	NA	S	4 oz glass (1)	4°C	28 days	3	NA	NA/NA	NA	NA	3
Nitrogen Ammonia	NA	S	8 oz glass (1)	4°C	28 days	3	NA	NA/NA	NA	NA	3
Total Kjeldahl Nitrogen	NA	S	32 oz glass (1)	4°C	24 hours	3	NA	NA/NA	NA	NA	3
Total Phosphorus	NA	S	4 oz glass (1)	4°C	28 days	3	NA	NA/NA	NA	NA	3
Nitrate/Nitrogen	NA	S	4 oz glass (1)	4°C	28 days	3	NA	NA/NA	NA	NA	3

* Matrix: S-Soil, W-Water.

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one or one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.1. (cont'd) Field Sampling Summary
Remedial Option Evaluation: Soil/Water Characterization

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
Calcium	NA	S	8 oz glass (1)	4°C	6 mon	3	NA	NA/NA	NA	1	3
Magnesium	NA	S	8 oz glass (1)	4°C	6 mon	3	NA	NA/NA	NA	1	3
Sodium	NA	S	8 oz glass (1)	4°C	6 mon	3	NA	NA/NA	NA	1	3
Potassium	NA	S	4 oz glass (1)	4°C	6 mon	3	NA	NA/NA	NA	1	3
Zinc	NA	S	8 oz glass (1)	4°C	6 mon	3	NA	NA/NA	NA	1	3
Manganese	NA	S	8 oz glass (1)	4°C	6 mon	3	NA	NA/NA	NA	1	3
Copper	NA	S	8 oz glass (1)	4°C	6 mon	3	NA	NA/NA	NA	1	3
Iron	NA	S	8 oz glass (1)	4°C	6 mon	3	NA	NA/NA	NA	1	3
% Sulfur	NA	S	8 oz glass (1)	4°C	NA	3	NA	NA/NA	NA	NA	3

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one or one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.1. (cont'd) - Field Sampling Summary
Remedial Option Evaluation: Soil/Water Characterization

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
PCP	to be determined	S	8 oz. glass (1)	4°C	7/40 day	20	NA	1/NA	NA	2	20
PCP Immuno-Assay	to be determined	W	2 oz amber glass (1)	4°C	Immediate	20	NA	NA/NA	NA	NA	20
PCP Immuno-Assay	to be determined	S	2 oz glass (1)	4°C	Immediate	50	NA	NA/NA	NA	NA	50

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40 ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.1. Field Sampling Summary
Remedial Option Evaluation: Groundwater Treatability

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
PCP	10 ppb	W	32 oz amber glass (2)	4°C	7/40d	20	NA	NA	NA	2	20
Chloride	1 ppm	W	32 oz glass jar (1)	4°C	7/14d	2	NA	NA	NA	1	2
Sulfate	1 ppm	W	32 oz glass jar (1)	4°C	7/14d	2	NA	NA	NA	NA	2
Alkalinity	1 ppm	W	32 oz glass jar (1)	4°C	7/14d	2	NA	NA	NA	NA	2
Silica	1 ppm	W	32 oz glass jar (1)	4°C	7/14d	2	NA	NA	NA	NA	2
Conductivity	$\frac{1\ \mu mho\text{-}Equiv^{(7)}}{cm^2}$	W	32 oz glass jar (1)	4°C	7/14d	2	NA	NA	NA	NA	2
Total Suspended Solids	1 ppm	W	32 oz glass jar (1)	4°C	7/14d	2	NA	NA	NA	NA	2
Total Dissolved Solids	1 ppm	W	32 oz glass jar (1)	4°C	7/14d	2	NA	NA	NA	NA	2
Total Organic Carbon	1 ppm	W	32 oz glass jar (1)	4°C	7/14d	2	NA	NA	NA	NA	2
Chemical Oxygen Demand	1 ppm	W	32 oz glass jar (1)	4°C	7/14d	2	NA	NA	NA	NA	2

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40 ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of one 40 ml vial filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.
7. Equiv - Equivalency.

Table 9.1. Field Sampling Summary
Remedial Option Evaluation: Soil Flushing Column Study

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
PCP	1 ppm	W	1 l amber (1)	4°C	7/40 day	45	NA	NA	NA	5	45
As, Cu, Zn, Fe	See Attached List	W	1 L Polyethylene (1)	4°C HNO_3 pH< 2	6 mon	8	NA	NA	NA	1	8
Total Hardness	NA	W	32 oz glass (1)	4°C	7/40 day	8	NA	NA	NA	1	8
TPH	NA	W	16 oz glass (1)	H_2SO_4 pH<2 4°C	28 day	8	NA	NA	NA	1	8
BOD	NA	W	32 oz glass (1)	4°C	24 hr	8	NA	NA	NA	1	8
TOC	NA	W	32 oz glass	4°C, pH <2 H_2SO_4	7/14 d	8	NA	NA	NA	1	8
Total Iron (filtered)	To Be Determined	W	1 L polyethylene (1)	0.45 micron, HNO_3 to pH <2 4°C	6 mon	8	NA	NA	NA	1	8
Alkalinity	NA	W	8 oz glass (1)	4°C	7/40 d	8	NA	NA	NA	NA	8
TSS	NA	W	8 oz glass (1)	4°C	7/40 d	8	NA	NA	NA	NA	8
TDS	NA	W	8 oz glass (1)	4°C	7/40 d	8	NA	NA	NA	NA	8
pH	NA	W	16 oz glass (1)	4°C	7/40 d	45	NA	NA	NA	NA	45
Conductivity	NA	W	16 oz glass (1)	4°C	7/40 d	8	NA	NA	NA	NA	8
COD	NA	W	32 oz glass (1)	4°C	7/40 d	8	NA	NA	NA	NA	8
Ca Hardness	NA	W	32 oz glass (1)	4°C	7/40 d	8	NA	NA	NA	NA	8

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of one 40 ml vial filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.1 (Cont'd). Field Sampling Summary
Remedial Option Evaluation: Soil Flushing Column Study

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
PCP TCLP	See Attached List	S	8 oz. glass (1)	4°C	7/14 day	10	NA	NA	NA	1	10
PCP	30	S	4 oz glass (1) (1)	4°C HNO_3 pH< 2	7/40 day	10	NA	NA	NA	1	10
As, Cu, Zn, Fe	Se Attached List	S	8 oz glass (1)	4°C	6 mon	10	NA	NA	NA	1	10
TPH	NA	S	4 oz glass (1)	4°C	7/40 day	10	NA	NA	NA	1	10
Cation Exchange Capacity	NA	S	32 oz glass (1)	4°C	NA	10	NA	NA	NA	1	10
pH	NA	S	8 oz glass (1)	NA	NA	10	NA	NA	NA	NA	10
TOC	NA	S	4 oz glass (1)	NA	NA	10	NA	NA	NA	NA	10

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of one 40 ml vial filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.1. Laboratory Sampling Summary
Bioremediation Evaluation - Pilot Scale Solid Phase

							QC Extra's				
Analytical Parameter	Level of Sensitivity[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
PCP	ND[7]	W/S	1 oz./8 oz. amber glass (2)	4°C,HCHO	7/40 days	240	NA	NA	NA	24	240
Ammonia Nitrogen	ND	W/S	1 oz./8 oz. amber glass (2)	H_2SO_4, pH<2, -20°C,HCHO	28 days	40	NA	NA	NA	4	40
Nitrate Nitrogen	ND	W/S	1 oz./8 oz. amber glass (2)	H_2SO_4,pH<2, -20°C,HCHO	28 days	40	NA	NA	NA	4	40
Total Kjeldahl Nitrogen	ND	W/S	1 oz. amber glass (2)	H_2SO_4, pH<2, $HgCl_2$, 4°C	48 hours	40	NA	NA	NA	4	40
Phosphate	ND	W/S	1 oz./8 oz. amber glass (2)	H_2SO_4,pH<2, -20°C,HCHO	48 hours	40	NA	NA	NA	4	40
Total Phosphorous	ND	W/S	1 oz./8 oz. amber glass (2)	H_2SO_4, pH<2, $HgCl_2$,4°C	28 days	40	N/D	N/D	N/D	4	40
Trace Metals	ND	W/S	1 oz./8 oz. amber glass (2)	HNO_3,pH<2 -20°C,HCHO	6 mos	40	NA	NA	NA	4	40
Chloride	ND	W/S	1 oz. amber glass (2)	4°C	28 days	40	NA	NA	NA	4	40

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.
7. Not determined

Table 9.1. (cont'd) Laboratory Sampling Summary
Bioremediation Evaluation - Pilot Scale Solid Phase

							QC Extra's				
Analytical Parameter	Level of Sensitivity[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
Sulfate	ND	W/S	8 oz. amber glass (2)	4°C	28 days	40	NA	NA	NA	24	40
Total Organic Carbon	ND	W/S	8 oz. amber glass (2)	4°C, H_2SO_4, pH<2	28 days	40	NA	NA	NA	24	40
Soil Moisture	ND	S	8 oz. amber glass (2)	4°C	7 days	40	NA	NA	NA	24	40
Water Holding Capacity	ND	S	8 oz. amber glass (2)	4°C	NA	40	NA	NA	NA	NA	40
Cation Exchange Capacity	ND	S	8 oz. amber glass (2)	4°C	NA	40	NA	NA	NA	NA	40
Particle Size Distribution	ND	S	8 oz. amber glass (2)	4°C	NA	40	NA	NA	NA	NA	40
pH	ND	W/S	8 oz. amber glass (2)	4°C	NA	40	NA	NA	NA	NA	40

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.
7. Not determined

Table 9.1. Field Sampling Summary
Remedial Option Evaluation: Adsorption/Filtration Study

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
PCP	1 ppm	W	1 l amber (1)	4°C	7/40 day	40	NA	NA	NA	4	40
TOC	30 ppm	W	4 oz glass (1)	4°C pH< 2 HNO_3	7/40 day	40	NA	NA	NA	4	40
TSS	NA	W	8 oz glass (1)	4°C	7/40 day	2	NA	NA	NA	1	2
TDS	NA	W	8 oz glass (1)	4°C	7/40 day	2	NA	NA	NA	1	2

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of one 40 ml vial filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.1. Field Sampling Summary
S/S - Concrete Pad Construction

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
PCP	1 ppm	S, X	4 oz. glass (1)	4°C	7/40 day	20	NA		NA	2	20
As, Cu, Zn	See Attached List	S, X	8oz glass (1)	4°C	6 mon	20	NA	NA	NA	2	20
TCLP (PCP, As, Cu, Zn)	See Attached List	S, X	8 oz glass (1)	4°C	7/14 day	20	NA	NA	NA	2	20
pH	NA	S, X	plastic/glass 4 oz glass (1)	4°C	ASAP	20	NA	NA	NA	NA	20
Percent Moisture	NA	S,X	plastic/glass 4 oz glass (1)	4°C	NA	20	NA	NA	NA	NA	20
Bulk Density	NA	S,X	plastic/glass 4 oz glass (1)	NA	NA	20	NA	NA	NA	NA	20
UCS	50-200 psi	X	NA	NA	NA	20	NA	NA	NA	NA	20
Wet/Dry	NA	X	8 oz glass (1)	NA	NA	10	NA	NA	NA	NA	20
Freeze/Thaw	NA	X	8 oz glass (1)	NA	NA	10	NA	NA	NA	NA	20
Hydraulic Cond.	NA	X	8 oz glass (1)	NA	NA	20	NA	NA	NA	NA	20
TPH	NA	S	4 oz glass (1)	4°C	7/40 d	10	NA	NA	NA	1	10
Grain Size	NA	S,X	plastic/glass 4 oz.	NA	NA	10	NA	NA	NA	NA	20

* Matrix: S-Soil, W-Water, X-Other

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40 ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of one 40 ml vial filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.
7. Al, As, Ca, Cd, Cr (tot), Cu, Fe, Pb, Mg, Mn, Hg, Na, and Zn.

Table 9.1. (cont'd) Field Sampling Summary
Remedial Option Evaluation: Groundwater Treatability

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
Nitrate	1 ppm	W	32 oz glass jar (1)	4°C	7/14d	2	NA	NA	NA	NA	2
Ammonia	1 ppm	W	32 oz plastic jar (1)	H_2SO_4 to pH<2, 4°C	7/14d	2	NA	NA	NA	NA	2
pH	6 - 9 units	W	8 oz glass (1)	4°C	Immediate	2	NA	NA	NA	NA	2
Hardness by Titration (Total)	To be Determined	W	32 oz glass (1)	4°C	7/14/d	2	NA	NA	NA	NA	2
Hardness by Titration (Calcium)	To be Determined	W	32 oz glass (1)	4°C	7/14/d	2	NA	NA	NA	NA	2
Metals [7]	To be Determined	W	1 liter glass or polyethylene (1)	HNO_3 to pH<2 4°C	6 mon	2	NA	NA	NA	1	2
BOD	1 ppm	W	32 oz glass (1)	4°C	24 hr	2	NA	NA	NA	1	2
TPH	1 ppm	W	32 oz glass (1)	4°C	28 d	2	NA	NA	NA	1	2
Dissolved Iron	To be Determined	W	500 ml polyethylene (1)	0.45 micron HNO_3 to pH<2 4°C	6 mon	2	NA	NA	NA	1	2

* Matrix: S-Soil, W-Water

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40 ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of one 40 ml vial filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.
7. Al, As, Ca, Cd, Cr (tot), Cu, Fe, Pb, Mg, Mn, Hg, Na, and Zn.

Table 9.1. Field Sampling Summary
Remedial Option Evaluation: Free Product

Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	QC Extra's				
							Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
PCP	1 ppm	X	32 oz amber glass (2)	4°C	7/40d	1	NA	NA	NA	1	1
Heating Value (BTU)	1 ppm	X	8 oz glass (1)	4°C	7/40d	1	NA	NA	NA	NA	1
TPHC	1 ppm	X	100 ml glass	4°C, 5 ml HCl		1	NA	NA	NA	NA	1
TAL Metals	.5 ppm	X	1 liter glass or polyethylene (1)	HNO_3 to pH<2 4°C	6 mon	1	NA	NA	NA	1	1
Oil & Grease	1 ppm	X	16 oz. glass (1)	4°C	7/40d	1	NA	NA	NA	NA	1
pH	6 - 9 units	X	16 oz. glass (1)	4°C	7/40d	1	NA	NA	NA	NA	1
Saybolt Viscosity	NA	X	16 oz. glass (1)	4°C	7/40d	1	NA	NA	NA	NA	1
Specific Gravity	NA	X	16 oz. glass (1)	4°C	7/40d	1	NA	NA	NA	NA	1
Percent Water	NA	X	16 oz. glass (1)	4°C	7/40d	1	NA	NA	NA	NA	1
Dioxin/Furan	1 ppt	X	16 oz. glass (1)	4°C	7/40d	1	NA	NA	NA	0	1

* Matrix: S-Soil, W-Water, X-Free Product

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40 ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of one 40 ml vial filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.1. (cont'd) Field Sampling Summary
Remedial Option Evaluation: Free Product

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
Total Suspended Solids	NA	X	4 oz glass (1)	4°C	7/40 d	1	NA	NA	NA	NA	1
Percent Sulfur	NA	X	8 oz glass (1)	4°C	7/40d	1	NA	NA	NA	NA	1
Total Chloride	NA	X	8 oz glass (1)	4°C	6 mon	1	NA	NA	NA	1	1
Percent Ash	NA	X	8 oz glass (1)	4°C	NA	1	NA	NA	NA	NA	1
Water Reactive (yes or no)	NA	X	8 oz glass (1)	4°C	7/40d	1	NA	NA	NA	NA	1

* Matrix: S-Soil, W-Water, X-Free Product

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "NA".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "NA". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "NA". Each aqueous trip blank consists of two 40 ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of one 40 ml vial filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.1. Field Sampling Summary
Ecological Risk Assessment

							QC Extra's				
Analytical Parameter	Action Level[1]	Matrix*	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	Rinsate Blanks[2]	Field/ Trip Blanks[3]	PE Samples[4]	Total Matrix Spikes[5]	Total Field Samples[6]
Dioxin	<1 ppb	S	8-ounce clear glass jar (1)	4°C	7 days	3	NA	0	0	0	3
As, Cu, Zn, Pb (XRF)	30 mg/kg	S	4-oz clear glass jar (1)	4°C	6 mon	75	NA	NA	0	NA	75
As, Cu, Zn (lab analysis)	1 mg/kg	S	XRF Sample cup (2 per location)	4°C	6 mon	40	NA	NA	0	4	40
PCP (test kits)	5 mg/kg	S	4-oz amber glass (1)	4°C	7 days	10	NA	NA	0	NA	10
PCP (lab analysis)	1 mg/kg	S	4-oz amber glass (1)	4°C	7 days	40	NA	NA	0	4	40
As, Cu, Zn (lab Analysis)	See attached table	W	1-liter poly (1)	pH <2 HNO_3 4°C	6 mon	15	NA	3	0	2	18
PCP	1µg/L	W	32-oz amber glass (1)	4°C	7 day	15	NA	3	0	2	18
As, Cu, Pb, Zn (lab analysis)	500 ug/kg	T	8-oz glass (1)	0°C	6 mon	10	NA	NA	0	NA	10
PCP	500 ug/kg	T	8-oz glass (1)	0°C	7 day	10	NA	NA	0	NA	10

* Matrix: S-Soil/Sediment, T-tissue

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank required per type of sampling device per day. For QA1, enter "N/A".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "N/A". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "N/A". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "N/A".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

Table 9.2. QA/QC Analysis and Objectives Summary - Soil
Overburden Characterization

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix*	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
Moisture Content	S	ASTMD2216-90	NA	NA	1%	QA1
pH	S	SW 846-9045	NA	NA	0.1 unit	QA1
Cation Exchange Capacity	S	SW-846-9081	NA	NA	1 PPM	QA1
Capillary-Moisture Tension	S	ASTMD2325-68	NA	NA	1 %	QA1
Grain Size	S	ASTM D422-63	NA	NA	NA	QA1
Total Organic Carbon	S	SW 846-9060	NA	NA	1 ppm	QA2
Specific Gravity	S	ASTMD854-83	NA	NA	NA	QA1
Bulk Dry Density	S	ASTM D2937-83	NA	NA	NA	QA1
Permeability	S	ASTMD2434-68	NA	NA	NA	QA1

* Matrix: S-Soil, W-Water

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.

Table 9.2. QA/QC Analysis and Objectives Summary - Groundwater Sampling August and November 1994

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix *	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
VOA	GW	EPA 624/CLP	5	0	See Attached Table	QA2
PCP	GW	SW-846/8270	6	0	1µg/L	QA2
Ammonia	GW	EPA 350.2	5	0	100µg/L	QA2
Filtered: Alkalinity (as $CaCO_3$)	GW	EPA 310.1	NA	0	10 mg/L	QA2
Tritium	GW	Enrichment/LSC[5]	NA	0	<1 TU	QA2
Filtered: Al, As, Ba, Ca, Cr, Cu, Fe, K, Mg, Mn, Na, Zn	GW	EPA-200	5	0	See Attached Table	QA2
Unfiltered: Al, As, Ba, Ca, Cr, Cu, Fe, K, Mg, Mn, Na, Zn	GW	EPA-200	5	0	1 mg/L	QA2
Major Cations (Ca, Mg, Na, K)	GW	EPA-200	5	0	See Attached Table	QA2
Filtered: Chloride	GW	EPA 300.0	5	0	1 mg/L	QA2
Filtered: Sulfate	GW	EPA 300.0	5	0	1 mg/L	QA2
Filtered: Nitrate	GW	EPA 300.0	5	0	0.4 mg/L	QA2

TU = Tritium Unit, 1 TU = 3.2 pCi/L

* Matrix: S-Soil W-Water O-Oil, DS-Drum Solid, DL-Drum Liquid, SD-Sediment, PW-Potable Water, GW-Groundwater, SW-Surface Water, SL-Sludge, X-other

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.
5. Enrichment process by electrolysis, measurement using a low-level gas counting system or liquid scintillation counting (LSC).

Table 9.2. (cont'd) QA/QC Analysis and Objectives Summary
Overburden Characterization

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix*	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
PCP	S	8250 or 8270/SW-846	6	N/A	1 ppm	QA2
Arsenic, Copper, Zinc	S	SW-846	6	N/A	See attached list	QA2

* Matrix: S-Soil, W-Water

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.

Table 9.2. QA/QC Analysis and Objectives Summary
Remedial Option Evaluation: Thermal Desorption

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix*	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
PCP	W	625/CLP	1	NA	0.2 ppm	QA2
PCP	S	8250 or 8270/SW-846	1	NA	1 ppm	QA2
Chloride	W	EPA 325.3	1	NA	1 ppm	QA2
Chloride	S	SM 4500	1	NA	1 ppm	QA2
Dioxin	S	8280/SW-846	0	NA	1 ppt	QA1
As, Cu, & Zn	W	EPA-600/CFR 40	1	NA	See attached list	QA2
As, Cu, & Zn	S	SW-846	1	NA	See attached list	QA2
Heating Value (BTU)	S	ASTM D240	NA	NA	1 BTU	QA1
Percent Ash	S	ASTM D2974	NA	NA	1 %	QA1
Soil Classification	S	ASTM D2487-90	NA	NA	NA	QA1
Specific Gravity	S	Method 213E	NA	NA	1 unit	QA1

* Matrix: S-Soil, W-Water

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.

Table 9.2. QA/QC Analysis and Objectives Summary
Remedial Option Evaluation: Thermal Desorption (Air)

Analytical Parameter	Analytical Method	Estimated Limit of Detection[1]	Lot Blanks[2]	Field Blanks[3]	Collocated Samples[4]	Trip Blanks[5]	Breakthrough[6]	PE Samples[7]	QA Objective[8]
PCP	NIOSH 5506, 5515	0.3 - 0.5 ug/sample	1	1	NA	NA	NA	NA	QA2
HCl	NIOSH 7903	1-4 ug/sample	1	1	NA	NA	NA	NA	QA2
Particulates	NIOSH 0500	0.2 mg	1	1	NA	NA	NA	NA	QA2
As, Cu, & Zn	NIOSH 7300	0.005-5 mg/m^3	1	1	NA	NA	NA	NA	QA2
VOA	TO1	0.3 - 0.5 ug/sample	1	1	NA	NA	NA	NA	QA2

1. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
2. Required for all QA levels at a minimum rate of 10% of the total samples, or one (1) per sampling event per lot.
3. Mandatory for QA2 and QA3 at a minimum rate of 5% of the total samples or one (1) per sampling event. Certain methods may require a greater frequency.
4. Required for all QA levels at a minimum rate of 5% of the total samples or one (1) per sampling event.
5. Mandatory for QA2 and QA3 at a minimum rate of 5% of the total samples or one (1) per sampling event.
6. Recommended for QA2 and QA3. Rate is method dependent. Requirement for use is based on deviations from accepted protocol and atmospheric conditions.
7. Performance evaluation samples are optional for QA2 but mandatory for QA3 at one per parameter per matrix. For QA1, enter "NA".
8. Enter the QA objective desired: QA1, QA2, or QA3.

Table 9.2. QA/QC Analysis and Objectives Summary
Bioremediation Evaluation

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix *	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
PCP	W	SW 846-8270	8	0	1.0 ppm	QA-2
Ammonia Nitrogen	W	Method 350.1/350.3 EPA-600/4-79-020	2	0	0.010-0.030 ppm	QA-2
Nitrate Nitrogen	W	Method 353.2 EPA-600/4-79-020	2	0	0.10 ppm	QA-2
Total Kjeldahl Nitrogen	S	Method 351.2 EPA-600/4-79-020	1	0	1.0 ppm	QA-2
Phosphate	W	Method 365 EPA-600/4-79-020	2	0	0.010 ppm P	QA-2
Total Phosphorous	S	Method 365.1 EPA-600/4-79-020	1	0	0.010 ppm P	QA-2
Trace Metals	W	SW-846-6010	1	0	0.010-0.20 ppm	QA-2
Chloride	W	Method 325 EPA-600-4-79-020	4	0	1.0 ppm	QA-2
Sulfate	S	SW-846-9035-38	NA	0	1.0 ppm	QA-2
Total Organic Carbon	S	SW-846-9060	NA	0	1.0 ppm	QA-2
Soil Moisture	S	Method 106.3 EPA-600-4-79-020	NA	NA	NA	QA-1
Water Holding Capacity	S	ASTM 2980	NA	NA	NA	QA-1
Cation Exchange Capacity	S	SW-846-9081	NA	NA	NA	QA-1
Particle Size Distribution	S	ASTM D422-63	NA	NA	NA	QA-1
pH	S	SW-846-9045	NA	NA	NA	QA-1

* Matrix: S-Soil, W-Water

1. Ensure that sufficient environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective.
2. For QA-2 (optional) and for QA-3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory MS/MSD may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the level of sensitivity.
4. Enter QA Objective desired: QA-1, QA-2, or QA-3.

Table 9.2. QA/QC Analysis and Objectives Summary
Remedial Option Evaluation: Soil/Water Characterization

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix*	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
Moisture	S	EPA 160.3	NA	NA	1%	QA1
pH	S	SW 846-9045	NA	NA	0.1 unit	QA1
Cation Exchange Capacity	S	SW-846-9081	NA	NA	1 ppm	QA1
Water Holding Capacity	S	ASTM 2980	NA	NA	1 %	QA1
Grain Size	S	ASTM D422-63	NA	NA	NA	QA1
Total Organic Carbon	S	SW 846-9060	NA	NA	1 ppm	QA1
Nitrogen Ammonia	S	EPA 350.1/350.3	NA	NA	1 ppm	QA1
Total Kjeldahl Nitrogen	W	EPA 351.2/351.3	NA	NA	1 ppm	QA1
Total Phosphorus	S	EPA 365.1/365.2	NA	NA	1 ppm	QA1
Nitrate/Nitrogen	S	EPA 353.2	NA	NA	1 ppm	QA1
Calcium	S	EPA 215.1	1	NA	See attached list	QA1
Magnesium	S	EPA 242.1	1	NA	See attached list	QA1
Sodium	S	EPA 273.1	1	NA	See attached list	QA1

* Matrix: S-Soil, W-Water

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.

Table 9.2. (cont'd) QA/QC Analysis and Objectives Summary
Remedial Option Evaluation: Soil/Water Characterization

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix*	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
Potassium	S	EPA 258.1	1	NA	See attached list	QA1
Zinc	S	EPA 289.1	1	NA	See attached list	QA1
Manganese	S	EPA 243.1	1	NA	See attached list	QA1
Copper	S	EPA 220.1	1	NA	See attached list	QA1
Iron	S	EPA 236.1	1	NA	See attached list	QA1
% Sulfur	S	ASTM D-3177 Method A	NA	NA	See attached list	QA1
PCP	S	8270/SW-846	2	NA	10 ppb	QA2

* Matrix: S-Soil, W-Water

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.

Table 9.2. QA/QC Analysis and Objectives Summary
Remedial Option Evaluation: Soil Flushing Study

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix*	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
PCP	W	SW 846-8270	5	NA	1 ppm	QA2
As, Cu, Zn, Fe	W	EPA 600/CFR-40	1	NA	See Attached List	QA2
Total Hardness	W	STD MTHDS 314	NA	NA	1 ppm	QA1
Oil and Grease	W	EPA 413	1	NA	1 ppm	QA2
BOD	W	EPA 405.1	1	NA	1 ppm	QA2
TOC	W	EPA 415.1	NA	NA	1 ppm	QA1
Total Iron (filtered)	W	EPA 600/CFR 40	1	NA	1 ppm	QA2
Alkalinity	W	EPA 310.1	NA	NA	1 ppm	QA1
TSS	W	EPA 160.2	1	NA	1 ppm	QA1
TDS	W	EPA 160.1	NA	NA	1 ppm	QA1
pH	W	SW 846-9045	NA	NA	NA	QA1
Conductivity	W	EPA 120.1	NA	NA	NA	QA1
COD	W	EPA 410.1	NA	NA	1 ppm	QA1
Ca Hardness	W	STD MTHDS 314	NA	NA	1ppm	QA1

* Matrix: S-Soil, W-Water

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq$10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.

Table 9.2 (Cont'd). QA/QC Analysis and Objectives Summary
Remedial Option Evaluation: Soil Flushing Study

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix*	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
PCP TCLP	S	SW 600/CFR 40	1	NA	1 ppm	QA2
PCP	S	SW 846-8270	1	NA	10 ppb	QA2
As, Cu, Zn, Fe	S	SW-846	1	NA	See Attached List	QA2
TPH	S	EPA 418.1	1	NA	1 ppm	QA2
Cation Exchange Capacity	S	SW 846-9081	1	NA	1 ppm	QA1
pH	S	SW 846-9060	NA	NA	0.1 unit	QA1
TOC	S	SW 846-9060	1	NA	1 ppm	QA1

* Matrix: S-Soil, W-Water

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.

Table 9.2. QA/QC Analysis and Objectives Summary - Soil
S/S - Concrete Pad Construction

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix*	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
PCP	S,X	SW 846-8270	2	NA	1 ppm	QA2
As, Cu, Zn	S,X	SW 846	2	NA	1 ppm	QA2
TCLP (PCP, As, Cu, Zn)	S,S	EPA 600/CFR 40	2	NA	1 ppm	QA2
pH	S,S	SW-846-9045	NA	NA	1 %	QA1
Percent Moisture	S,S	EPA 160.3	NA	NA	NA	QA1
Bulk Density	S,X	ASTM D2037-83	NA	NA	NA	QA1
UCS	X	ASTM D-1633	NA	NA	NA	QA1
Wet/Dry	X	ASTM D4843-88	NA	NA	NA	QA1
Freeze/Thaw	X	ASTM-D4842-88	NA	NA	NA	QA1
Hydraulic Conductivity	X	SW 846	NA	NA	NA	QA1
TPH	S	EPA 418.1	1	NA	NA	QA2
Grain Size	S	ASTM D422-63	NA	NA	NA	QA1
Oil and Grease	S	SW 846-9070	NA	NA	NA	QA2

* Matrix: S-Soil, W-Water

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.

Table 9.2. QA/QC Analysis and Objectives Summary
Bioremediation Evaluation - Pilot Scale Solid Phase

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix *	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
PCP	S	SW 846-8270	25	0	1.0 ppm	QA-2
Ammonia Nitrogen	S	Method 350.1/350.3 EPA-600/4-79-020	4	0	0.010-0.030 ppm	QA-2
Nitrate Nitrogen	S	Method 353.2 EPA-600/4-79-020	4	0	0.10 ppm	QA-2
Total Kjeldahl Nitrogen	S	Method 351.2 EPA-600/4-79-020	4	0	1.0 ppm	QA-2
Phosphate	S	Method 365 EPA-600/4-79-020	4	0	0.010 ppm P	QA-2
Total Phosphorous	S	Method 365.1 EPA-600/4-79-020	4	0	0.010 ppm P	QA-2
Trace Metals	S	SW-846-6010	4	0	0.010-0.20 ppm	QA-2
Chloride	S	Method 325 EPA-600-4-79-020	4	0	1.0 ppm	QA-2
Sulfate	S	SW-846-9035-38	4	0	1.0 ppm	QA-2
Total Organic Carbon	S	SW-846-9060	4	0	1.0 ppm	QA-2
Soil Moisture	S	Method 106.3 EPA-600-4-79-020	NA	NA	NA	QA-1
Water Holding Capacity	S	ASTM 2980	NA	NA	NA	QA-1
Cation Exchange Capacity	S	SW-846-9081	NA	NA	NA	QA-1
Particle Size Distribution	S	ASTM D422-63	NA	NA	NA	QA-1
pH	S	SW-846-9045	NA	NA	NA	QA-1
Hydraulic Conductivity	S	SW 846	NA	NA	NA	QA-1
Bulk Density	S	ASTM D2937-83	NA	NA	NA	QA-1
Percent Ash	S	To be determined	NA	NA	NA	QA-1

* Matrix: S-Soil, W-Water

1. Ensure that sufficient environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective.
2. For QA-2 (optional) and for QA-3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory MS/MSD may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the level of sensitivity.
4. Enter QA Objective desired: QA-1, QA-2, or QA-3.

Table 9.2. QA/QC Analysis and Objectives Summary
Remedial Option Evaluation: Adsorption/Filtration Study

Analytical Parameter	Matrix*	Analytical Method Ref.	Matrix Spikes		QA/QC	
			Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
PCP	W	SW 846-8270	4	NA	1 ppm	QA2
TOC	W	EPA 415.1	4	NA	1 ppm	QA1
TSS	W	EPA 160.2	1	NA	1 PPM	QA1
TDS	W	EPA 160.1	1	NA	1 ppm	QA1

* Matrix: S-Soil, W-Water

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.

Table 9.2. QA/QC Analysis and Objectives Summary
Remedial Option Evaluation: Groundwater Treatability

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix*	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
PCP	W	625/CLP	3	NA	10 ppb	QA2
Chloride	W	EPA 325.3	1	NA	1.0 ppm	QA1
Sulfate	W	EPA 375.3	NA	NA	1.0 ppm	QA1
Alkalinity	W	EPA 310.1	NA	NA	1.0 ppm	QA1
Silica	W	EPA 370.1	NA	NA	1.0 ppm	QA1
Conductivity	W	EPA 120.1	NA	NA	1.0 $\frac{1\ \mu mho\text{-}Equiv^{(5)}}{cm^2}$	QA1
BOD	W	EPA 405.1	1	NA	1.0 ppm	QA2
TPH	W	EPA 418.1	1	NA	1.0 ppm	QA2
Total Suspended Solids	W	EPA 160.2	NA	NA	1.0 ppm	QA1
Total Dissolved Solids	W	EPA 160.1	NA	NA	1.0 ppm	QA1
Total Organic Carbon	W	EPA 415.1	NA	NA	1.0 ppm	QA1
Chemical Oxygen Demand	W	EPA 410.1	NA	NA	1.0 ppm	QA1
Nitrate	W	EPA 352.1	NA	NA	1.0 ppm	QA1
Ammonia	W	EPA 350.2	NA	NA	1.0 ppm	QA1
pH	W	Std Mthds 423	NA	NA	NA	QA1
Hardness	W	Std Mthds 314	NA	NA	1.0 ppm	QA1
Metals[6]	W	EPA-600/CFR 40	1	NA	See Attached TAL Table	QA2
Dissolved Iron	W	EPA-600/CFR 40	1	NA	See Attached TAL Table	QA2

* Matrix: S-Soil, W-Water

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.
5. Equiv. = Equivalency
6. Al, As, Ca, Cd, Cr (tot), Cu, Fe, Pb, Mg, Mn, Hg, Na, and Zn.

Table 9.2. QA/QC Analysis and Objectives Summary
Remedial Option Evaluation: Free Product

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix*	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
PCP	X	625/CLP	1	NA	500 ppm	QA2
Heating Value (BTU)	X	ASTM D240	NA	NA	1 BTU/Pound	QA1
TPH	X	EPA 418.1	NA	NA	50 ppm	QA2
Metals[5]	X	EPA-600/CFR 40	1	NA	See Attached TAL Table	QA2
Oil & Grease	X	USEPA Method 413.1	NA	NA	25 ppm	QA1
pH	X	USEPA Method 9040	NA	NA	NA	QA1
Saybolt Viscosity	X	ASTM Method D445	NA	NA	NA	QA1
Specific Gravity	X	Method 213E	NA	NA	NA	QA1
Percent Water	X	Karl-Fisher Analysis	NA	NA	0.005%	QA1
Dioxin/Furan	X	Method 8280	0	NA	1 ppb	QA2

* Matrix: S-Soil, W-Water, X-Other

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.
5. Arsenic, antimony, beryllium, cadmium, total chromium, copper, lead, mercury, nickel, selenium, silver, silver, thallium, and zinc.

Table 9.2. (cont'd) - QA/QC Analysis and Objectives Summary
Remedial Option Evaluation: Free Product

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix*	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
Total Suspended Solids	X	Method 2540 D	NA	NA	1 ppm	QA1
Percent Sulfur	X	ASTM D-12964	NA	NA	1 %	QA2
Total Chloride	X	EPA 325.3	NA	NA	1 ppm	QA2
Percent Ash	X	ASTM D-2974	NA	NA	1 %	QA1
Water Reactive (yes or no)	X	SW 846 Chapter 8-3	NA	NA	Yes or No	QA1

* Matrix: S-Soil, W-Water, X-Free Product

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.

Table 9.2. QA/QC Analysis and Objectives Summary
Ecological Risk Assessment

			Matrix Spikes		QA/QC	
Analytical Parameter	Matrix *	Analytical Method Ref.	Lab[1]	Additional[2]	Detection Limits[3]	QA Objective[4]
As, Cu, Pb, Zn	S	SW-846	4	0	0.5 mg/kg	QA2
PCP	S	EPA 8270 (modified)	4	0	0.5 mg/kg	QA2
Dioxin	S	EPA 8290	0	0	0.5 µg/kg	QA1
As, Cu, Zn	W	EPA-200	2	0	1 ug/L	QA2
PCP	W	SW-846/8270	2	0	See attached table	QA2
As, Cu, Zn	T	T18182	0	0	500 ug/kg	QA2
PCP	T	T1805L	0	0	500 ug/kg	QA2

* Matrix: S-Soil

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of ≥10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.

TARGET COMPOUND LIST (TCL) AND QUANTITATION LIMITS (QLs)[1]

Volatiles	CAS Number	Quantitation Limits[2] Water ug/L	Low Soil/Sediment[3] ug/Kg
Chloromethane	74-87-3	10	10
Bromomethane	74-83-9	10	10
Vinyl Chloride	75-01-4	10	10
Chloroethane	75-00-3	10	10
Methylene Chloride	75-09-2	5	5
Acetone	67-64-1	10	10
Carbon Disulfide	75-15-0	5	5
1,1-Dichloroethane	75-35-4	5	5
1,1-Dichloroethene (DCE)	75-34-3	5	5
1,2-Dichloroethane (total)	540-59-0	5	5
Chloroform	67-66-3	5	5
1,2-Dichloroethane	107-06-2	5	5
2-Butanone	78-93-3	10	10
1,1,1-Trichloroethane	71-55-6	5	5
Carbon Tetrachloride	56-23-5	5	5
Bromodichloromethane	75-27-4	5	5
cis-1,3-Dichloropropene	10061-01-5	5	5
Trichloroethene (TCE)	79-01-6	5	5
Dibromochloromethane	124-48-1	5	5
1,1,2-Trichloroethane	79-00-5	5	5
Benzene	71-43-2	5	5
trans-1,3-Dichloropropene	10061-02-6	5	5
Bromoform	75-25-2	5	5
4-Methyl-2-pentanone	108-10-1	10	10
2-Hexanone	591-78-6	10	10
Tetrachloroethene (PCE)	127-18-4	5	5
Toluene	108-88-3	5	5
1,1,2,2-Tetrachloroethane	79-34-5	5	5
Chlorobenzene	108-90-7	5	5
Ethyl Benzene	100-41-4	5	5
Styrene	100-42-5	5	5
Xylenes (total)	1330-20-7	5	5

TARGET COMPOUND LIST (TCL) AND QUANTITATION LIMITS (QLs)[1]

Volatiles (Cont'd)	CAS Number	Quantitation Limits[2] Water ug/L	Low Soil/Sediment[3] ug/Kg
Dichlorofluoromethane	75-43-4	10	10
Trichlorofluoromethane	75-69-4	5	5
trans-1,2-Dichloroethene	156-60-5	5	5
2,2-Dichloropropane	594-20-7	5	5
cis-1,2-Dichloroethene	156-59-2	5	5
1,1-Dichloropropene	563-58-6	5	5
1,2-Dichloropropane	78-87-5	5	5
Dibromomethane	74-95-3	10	10
1,3-Dichloropropane	142-28-9	5	5
1,2-Dibromomethane	106-93-4	5	5
1,1,1,2-Tetrachloroethane	630-20-6	5	5
p-Xylene	106-42-3	5	5
m-Xylene	108-38-3	5	5
o-Xylene	95-47-6	5	5
Isopropylbenzene	98-82-8	5	5
1,2,3-Trichloropropane	96-18-4	5	5
Bromobenzene	108-86-1	5	5
n-Propylbenzene	103-65-1	5	5
2-Chlorotoluene	95-49-8	5	5
4-Chlorotoluene	106-43-4	5	5
1,3,5-Trimethylbenzene	25551-13-7	5	5
tert-Butylbenzene	98-06-6	5	5
1,2,4-Trimethylbenzene	25551-13-7	5	5
sec-Butylbenzene	135-98-8	5	5
1,3-Dichlorobenzene	541-73-1	5	5
p-Isopropyltoluene	99-87-6	5	5
1,4-Dichlorobenzene	106-46-7	5	5
1,2-Dichlorobenzene	95-50-1	5	5
n-Butylbenzene	104-51-8	5	5
1,2-Dibromo-3-Chloropropane	96-12-8	5	5
1,2,4-Trichlorobenzene	120-82-1	5	5
Naphthalene	91-20-3	5	5
Hexachlorobutadiene	87-68-3	10	10
1,2,3-Trichlorobenzene	12002-48-1	10	10

(1) Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

(2) Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, on a dry weight basis will be higher.

(3) Medium Soil/Sediment QLs for Volatile TCL Compounds are 125 times the individual Low Soil/Sediment QL.

TARGET COMPOUND LIST (TCL) AND QUANTITATION LIMITS (QL)[1]

Semivolatile	CAS Number	Quantitation Limits[2] Water ug/L	Low Soil/Sediment[3] ug/Kg
Phenol	108-95-2	10	330
bis (2-Chloroethyl) ether	111-44-4	10	330
2-Chlorophenol	95-57-8	10	330
1,3-Dichlorobenzene	541-73-1	10	330
1,4-Dichlorobenzene	106-46-7	10	330
Benzyl alcohol	100-51-6	10	330
1,2-Dichlorobenzene	95-50-1	10	330
2-Methylphenol	95-48-7	10	330
bis (2-Chloroisopropyl) ether	108-60-1	10	330
4-Methylphenol	106-44-5	10	330
N-Nitroso-di-n-propylamine	621-64-7	10	330
Hexachloroethane	67-72-1	10	330
Nitrobenzene	98-95-3	10	330
Isophorone	78-59-1	10	330
2-Nitrophenol	88-75-5	10	330
2,4-Dimethylphenol	105-67-9	10	330
bis (2-Chloroethoxy) methane	111-91-1	10	330
2,4-Dichlorophenol	120-83-2	10	330
1,2,4-Trichlorobenzene	120-82-1	10	330
Naphthalene	91-20-3	10	330
4-Chloroaniline	106-47-8	10	330
Hexachlorobutadiene	87-68-3	10	330
4-Chloro-3-methylphenol	59-50-7	10	330
2-Methylnaphthalene	91-57-6	10	330
Hexachlorocyclopentadiene	77-47-4	10	330
2,4,6-Trichlorophenol	88-06-2	10	330
2,4,5-Trichlorophenol	95-95-4	50	1700
2-Chloronaphthalene	91-58-7	10	330
2-Nitroaniline	88-74-4	50	1700
Dimethylphthalate	131-11-3	10	330
Acenaphthylene	208-96-8	10	330
2,6-Dinitrotoluene	606-20-2	10	330
3-Nitroaniline	99-09-2	50	1700
Acenaphthene	83-32-9	10	330
2,4-Dinitrophenol	51-28-5	50	1700
4-Nitrophenol	100-02-7	50	1700
Dibenzofuran	132-64-9	10	330
2,4-Dinitrotoluene	121-14-2	10	330
Diethylphthalate	84-66-2	10	330
4-Chlorophenyl-phenyl ether	7005-72-3	10	330
Fluorene	86-73-7	10	330
4-Nitroaniline	100-01-6	50	1700

TARGET COMPOUND LIST (TCL) AND QUANTITATION LIMITS (QL)[1]

Semivolatile (Cont'd)	CAS Number	Quantitation Limits[2] Water ug/L	Low Soil/Sediment[3] ug/Kg
4,6-Dinitro-2-methylphenol	534-52-1	50	1700
N-nitrosodiphenylamine	86-30-6	10	330
4-Bromophenyl-phenyl ether	101-55-3	10	330
Hexachlorobenzene	118-74-1	10	330
Pentachlorophenol	87-86-5	50	1700
Phenanthrene	85-01-8	10	330
Anthracene	120-12-7	10	330
Carbazole	86-74-8	10	330
Di-n-butylphthalate	84-74-2	10	330
Fluoranthene	206-44-0	10	330
Pyrene	129-00-0	10	330
Butylbenzylphthalate	85-68-7	10	330
3,3-Dichlorobenzidine	91-94-1	20	6700
Benzo (a) anthracene	56-55-3	10	330
Chrysene	218-01-9	10	330
bis (2-Ethylhexyl) phthalate	117-81-7	10	330
Di-n-octylphthalate	117-84-0	10	330
Benzo (b) fluoranthene	205-99-2	10	330
Benzo (k) fluoranthene	207-08-9	10	330
Benzo (a) pyrene	50-32-8	10	330
Indeno (1,2,3-cd) pyrene	193-39-5	10	330
Dibenz (a,h) anthracene	53-70-3	10	330
Benzo (g,h,i) perylene	191-24-2	10	330

(1) Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

(2) Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment on a dry weight basis will be higher.

(3) Medium Soil/Sediment QLs for SemiVolatile TCL Compounds are 60 times the individual Low Soil/Sediment QL.

INORGANIC TARGET ANALYTE LIST (TAL)

Analyte	Range of Detection Limits Water, µg/l	Soil, mg/kg
Aluminum	250	25-50
Antimony	5-10	0.5-1.0
Arsenic	5-10	0.5-1.0
Barium	5-25	0.5-1.0
Beryllium	5-10	1.0-2.5
Cadmium	5-10	0.5-1.0
Calcium	25-50	2.5-5.0
Chromium	10-50	5
Cobalt	25-50	2.5-5.0
Copper	25	2.5-5.0
Iron	50-100	5-10
Lead	5-50	5
Magnesium	25-50	2.5-5.0
Manganese	25-50	2.5-5.0
Mercury	0.2-0.4	0.04
Nickel	25-50	2.5-5.0
Potassium	25-50	2.5-5.0
Selenium	5-10	0.5-1.0
Silver	10-25	1.0-2.5
Sodium	25-100	5-10
Thallium	5-10	0.5-1.0
Vanadium	10-25	1.0-2.5
Zinc	10-25	1.0-5.0