FINAL

WORK PLAN

FOR THE PHASE I EVALUATION OF THE
VELSICOL SUPERFUND SITE SLURRY WALL

VELSICOL CHEMICAL CORPORATION SITE
ST. LOUIS, MICHIGAN

Prepared for:

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
ENVIRONMENTAL RESPONSE DIVISION
SUPERFUND SECTION

Knapps Centre
300 Washington Square, Mezzanine
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Prepared by:

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January 2002

W.O. No. 20083.500.001
Ms. Stephanie M. Ball  
U.S. Environmental Protection Agency  
77 West Jackson Boulevard, SR-6J  
Chicago, IL 60604-3507

RE: Final Work Plan for The Phase I Evaluation  
of the Velsicol Superfund Site Slurry Wall  
Velsicol Superfund Site –St. Louis, MI

Dear Ms. Ball:

Roy F. Weston, Inc. of Michigan would like to submit for your review three copies of the Final Work Plan for The Phase I Evaluation of the Velsicol Superfund Site Slurry Wall, for the Velsicol Superfund Site in St. Louis, Michigan.

If you have any questions or comments, please feel free to contact us.

Very truly yours,

ROY F. WESTON, INC. OF MICHIGAN

Brian J. O’Mara  
Project Manager

Enclosures

cc: Scott D. Cornelius, MDEQ (w/ 2 copies)  
Gina Bayer, EPA (w/ 1 copy)  
Rob Stryker (w/ 1 copy)  
Randall Ross (w/ 1 copy)
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Attachment C   Inorganic Analytical Service for Superfund (ILM04.1) Quick Reference Fact Sheet with Tables
SECTION 1

INTRODUCTION

Roy F. Weston, Inc. of Michigan (WESTON®) has prepared this Work Plan for the Phase I evaluation of the slurry wall at the former Velsicol Chemical Corporation (Velsicol) facility (Site), in St. Louis, Michigan in response to a request from the Michigan Department of Environmental Quality (MDEQ), Environmental Response Division (ERD), Superfund Section, under the Federal Sites Level of Effort (LOE) contract. This Work Plan has been prepared based upon: the existing draft Work Plan for the Investigation of the Velsicol Superfund Site, Slurry Wall, developed by the MDEQ-ERD dated February 2001; meetings with the MDEQ Project Manager; a review of selected site historical information and previous investigation reports; and, an initial site visit.

This Work Plan has been prepared to execute the MDEQ's primary project goal of evaluating the performance of the slurry wall at the Site. The Scope of Work (SOW) for this evaluation will be implemented in a three-phased approach. Only the Phase I activities are included in this Work Plan SOW. The primary objective of Phase I activities is to locate the slurry wall, characterize the soil and groundwater chemistry immediately inside and outside of the slurry wall area. The primary objective of Phase II activities is to evaluate the slurry wall containment effectiveness and determine the potential for vertical migration of contamination below the clay till into the underlying aquifer. The primary objective of Phase III activities will be to define the horizontal and vertical groundwater chemistry impacts at the Site, and to obtain additional groundwater elevation and flow data to completely determine whether the Site containment system (slurry wall and cap) is performing adequately.

The project goals for Phase I will be attained through completion of the following objectives:

- Organize MDEQ Site files according to Superfund Section Site File Outline Structure;
- Develop an accurate and appropriately scaled base map for the Site;
- Locate and document the location of the entire (or at least portions) of the slurry wall;
- Identify and characterize seeps at the downgradient portion of the slurry wall;
- Identify potential areas of residual wastes located outside the slurry wall boundaries along the Pine River;
INTRODUCTION

- Evaluate current groundwater elevations and flow conditions at the Site;
- Evaluate groundwater chemistry at the inside and outside boundaries of the slurry wall;
- Complete the initial evaluation of the slurry wall and cap performance; and,
- Provide recommendations for Phase II and Phase III investigations, as necessary.

These project objectives will be completed through the implementation of the investigation tasks outlined in Section 2, SOW.

1.1 BACKGROUND INFORMATION

1.1.1 Property Location

The Site is located at 324 North Street, St. Louis, Gratiot County, Michigan. The property is located near the center of Section 24, T12N, R3W (Figure 1). The former main plant site encompasses approximately 50 acres, and is bordered on the west and north by the Pine River/St. Louis Reservoir, bordered by North Avenue and Watson Street to the east, and by Washington Avenue to the south. The Site also includes a separate parcel located south of Washington Avenue across from the main plant parcel, which was formerly known as the “creamery warehouse”.

The Site includes two Superfund Operable Units. Operable Unit 1 (OU-1) consists of the 52-acre plant site which is the location of the former chemical plant manufacturing facility (Figure 2). Operable Unit 2 (OU-2) consists of contamination in sediments and fish in the St. Louis Reservoir and Pine River.

1.1.2 Site History

The Site has reportedly been used for industrial operations since the mid 1800’s and has been used at various times for a lumber mill, oil refinery, salt plant, and chemical plant. Michigan Chemical Corporation (MCC) purchased the Site in 1935 and operated a chemical manufacturing business until 1977 when MCC merged with Velsicol. MCC manufactured a wide variety of products at the Site from 1936 through 1977. These products included various salts, magnesium oxide, rare earth (radioactive) chemicals, fire retardants (polybrominated biphenyls [PBB]), and pesticides.
(hexabromobenzene [HBB], 1,1,1-Trichloro-2,2-bis(p-chlorophenyl) Ethane [DDT], and Tris (2,3-Dibromopropyl) Phosphate [TRIS]).

Former Site features included numerous manufacturing plant buildings, maintenance and warehouse buildings, offices and research and development laboratories, dozens of above ground storage tanks (ASTs), underground storage tanks (USTs), process piping, railroad sidings, lagoons and parking areas. While many of the raw materials for the chemical manufacturing were shipped to the Site via rail or truck, the Site also extracted brines from bedrock wells for use as process makeup water. Groundwater recovered during the OU-1 remedial actions was disposed of by deep well injection into the Velsicol deep well located across the Pine River from the Site.

The plant was closed in 1977 and decommissioning activities were initiated in 1978.

A comprehensive radiological survey was completed at the Site in 1981. The results of the survey indicated that the more than 95 percent of the Site (i.e., 51 of the total 52 acres) exhibited gamma measurements of less than 20 micro Roentgen per hour (µR/hr) and thus were not considered contaminated by radioactive materials based at the time on the Comprehensive Survey and Decontamination Plan, 1980. The remaining approximately 1 acre of the Site did exhibit isotopic concentrations that exceeded 20 µR/hr. Only 50 of 2200 gamma readings (approximately 2.5 percent) exceeded the criterion. No measurable personnel exposure was recorded during the course of the survey. Any residual radioactive materials were covered by the containment system cap. No alpha or beta radiation was observed during the radiological survey.

In 1982, a Consent Judgment was entered into by Velsicol, the United States Environmental Protection Agency (USEPA) and the Michigan Department of Natural Resources (MDNR), under which Velsicol constructed and implemented the “Main Plant Site Containment Program and Golf Course Site Remedial Program.” Between 1981 and 1984 and in accordance with the Consent Judgment, Velsicol submitted plans and specifications for the construction and installation of a containment system at the Plant Site for USEPA and MDNR review and approval. During the development of these plans and specifications Velsicol conducted substantial field sampling and
laboratory testing programs in accordance with the Consent Judgment in order to confirm that the construction specifications established for the components of the containment system would be met. The results of these sampling and laboratory programs were reviewed and approved by the USEPA and MDNR as the design progressed.

The remedy selected and implemented for OU-1 consisted mainly of a 2-foot thick, low-permeability slurry wall around the 52-acre main plant facility and a 3-foot thick, low permeability clay cap over the Site. Under the Consent Judgment, Velsicol must maintain groundwater levels within the slurry wall and beneath the cap ("containment system") to a maximum allowable elevation. Velsicol completed construction of the containment system in 1984.

Construction of the containment system included: 1) the emplacement of a continuous containment wall along the entire boundary of the Plant Site that was reportedly keyed a minimum of 30 inches into the underlying clay till unit and which was to achieve a permeability of $1 \times 10^{-7}$ centimeters per second (cm/s); 2) construction of a clay cap 36 inches (18 inches in some areas) thick over the Plant Site and compacted to achieve a permeability of $1 \times 10^{-7}$ cm/s; and 3) maintenance of the water table elevation within the containment system to no greater than 724.13 feet above mean sea level (ft amsl), as calculated from the average water table elevations of 14 monitoring wells located on the Plant Site.

The 1982 Consent Judgment also provided for periodic testing of the containment wall for three years after its installation. During the implementation of the Plant Site closure program in 1983 and 1984, Velsicol was required to conduct a comprehensive Quality Assurance/Quality Control (QA/QC) sampling program to monitor the installation of the various components of the containment system to ensure that the construction specifications established within the Consent Judgment would be met. According to Velsicol, the QA/QC program demonstrated that the components of the containment system were installed according to the specifications set forth in the Consent Judgment. All of the tasks outlined within the Consent Judgment were completed by 1986 under State and Federal oversight. The former main plant portion of the Site (OU-1) was then subject to an Operation and Maintenance Program which was prepared by Velsicol and approved by the USEPA, and which has been implemented since approval. Subsequent periodic testing in the
three years following construction of the containment system indicated the system was constructed as designed.

Water levels inside the containment system (slurry wall and cap) were maintained below the level set by the 1982 Consent Judgment until February 1993. In 1993 Velsicol had to remove 1.25 million gallons of water from the containment system to stay below the established level. In late 1994 Velsicol removed another 1.28 million gallons of groundwater from the system to maintain the level set in the Consent Judgment. Velsicol has not pumped water from the containment system since 1998 and lost the use of the Crumbaugh property deep injection well in which they had been disposing of the water.

Due to increasing water levels within the containment system in 1993, USEPA and MDEQ became concerned about what effect, if any, the water levels may have upon the integrity of the containment system. In early 1995, Memphis Environmental Center, Inc. (MEC) agreed to conduct an assessment of the containment system to address the concerns of the USEPA and MDEQ. Field activities were conducted during the summer of 1996, with data collection activities continuing until April of 1997. The assessment addressed all three major elements of the containment system.

The State of Michigan collected fish samples in late 1994 and noted that the average concentration of total DDT in skin off carp filet samples more than doubled since the last collection in 1989. The average concentration of total DDT in 1989 was 10.5 parts per million (ppm); in 1994 tissue concentrations were 23.3 ppm. The State of Michigan collected fish again in 1995 and found an average total DDT concentration in skin off carp filet samples of 16.1 ppm. The elevated contaminant concentrations in fish tissue coupled with the increased water flux (possibly due to elevated rainfall) into the containment system caused concern that the containment system may have failed, increasing the loading of DDT into the Pine River.

Previous studies have revealed that Site soils are contaminated with PBB, HBB, TRIS, and other contaminants; groundwater is contaminated with vinyl chloride, toluene, chlorobenzene, DDT, and
other contaminants; Pine River sediments are contaminated with PBB, HBB, and DDT; and elevated levels of PBB, DDT, and other contaminants are in fish.

Velsicol agreed to reassess the containment system to ensure that it was not a source of DDT into the Pine River. At the same time the USEPA and the MDEQ reassessed sediment contamination in the Pine River and decided to reconsider the No Action decision made in 1982.

On 11 December 1997, Velsicol submitted a work plan entitled Work Plan Post-Closure Cap Maintenance, Former Michigan Chemical Plant Site, St. Louis, MI, in which Velsicol stated it would conduct maintenance of the clay cap during the summer of 1998 by recompacting areas of the clay cap. Velsicol decided to delay the work until the USEPA completed the sediment removal project currently underway.

In 1997 Velsicol completed an assessment of the Site containment system. Velsicol’s assessment of the clay cap included collection of samples from the upper portion of the cap and analyses for permeability, grain size, and Atterberg limits. Assessment of the containment wall consisted of installation of inclinometers inside and outside the slurry wall at seven locations, installation of settlement plates at seven locations inside the slurry wall, collection of samples at nine locations for permeability analysis; installation of upper zone piezometers on the inside and outside of the wall at five locations; water level measurements and free product screening from all monitoring wells and piezometers; and a dye tracer study at the five locations where the piezometers were installed. Velsicol published a report entitled Final Containment System Assessment Report, Former Michigan Chemical Plant Site, St. Louis, Michigan, 1 October 1997 (CSA Report) detailing the containment system assessment and results.

The CSA Report concluded that the clay cap is leaking, probably because there is no frost protection layer on top of the cap. The CSA Report also concluded that 94 percent of the water that infiltrates the cap is discharged through the underlying clay till unit, rather than transmitted through the slurry wall. No obvious problems were documented in the Velsicol report and it concluded that the containment system is working as designed; however, many of the conclusions in the CSA Report
do not appear to be fully supported and the actual performance of both the cap and the slurry wall is unknown.

On 8 June 1998 the USEPA signed an Action Memorandum for a time-critical removal action (TCRA) at the Site. The removal action consisted of dredging/excavating sediments containing 3,000 ppm total DDT or greater (the hot spot), treating the sediments with a stabilizing/drying agent, and disposing the sediments off-site. The TCRA was completed in October 1999. Additional remedial actions have been undertaken since October 1999.

1.1.3 Current Conditions

The entire 52-acre, main plant parcel of the Site is now covered with shallow-rooted grass and, to restrict access, enclosed by a chain link fence. The site topography consists of fairly flat to gentle rolling areas on the entire property. All former Site manufacturing features were demolished and buried on-site or removed. Velsicol is reportedly operating and maintaining the site in accordance with an approved operation and maintenance plan requiring weekly inspections for signs of deterioration, quarterly monitoring of gas vents, measurement of groundwater levels within the contained site, and slurry wall permeability testing.

The USEPA is currently overseeing the remedial actions at the Site, which began in late 1999. Through December 2001, over 341,000 tons of stabilized sediments have been removed from the Pine River. The remedial action activities are scheduled to be complete in 2002.

1.2 PHYSIOGRAPHIC SETTING

1.2.1 Local Geology

Unconsolidated Pleistocene age glacial/lacustrine deposits and more recent Quaternary (Recent) deposits underlie the Site as the result of flooding and previous stages of the Pine River. Drilling logs from a 1979 Dames & Moore investigation (Investigation of Potential Contamination of the St. Louis Plant Site, St. Louis, MI, April, 1979) indicate the Site is underlain by a complex variety of
deposits. These deposits include fill soils, alluvium, and lacustrine deposits that typically comprise the upper 20 feet of Site soils. Water-bearing deposits within the surficial soils are identified within the upper aquifer in this report. Alluvial sands and gravels, and lacustrine silts and clays can be found as deep as 30 feet below ground surface (bgs). Borehole logs from on-site brine wells (installed by the former MCC) indicate that approximately 60 to 80 feet of clayey glacial till underlies the surficial soils described above. An extensive outwash sand unit underlies the glacial till and is approximately 5 to 30 feet thick. This outwash unit, which was identified as the lower aquifer, is separated from a deeper outwash unit by approximately 30 feet of clayey glacial till. The deeper outwash sand was reported to be over the 100 feet thick. Jurassic bedrock was encountered at 245 feet bgs beneath the Site.

Well borings from a previous investigation were advanced outside of the Site perimeter slurry wall. In addition, two well borings were placed across the river from the Site. Six borings were advanced 10 feet into the lower aquifer at depths ranging from 55 to 96 feet. One off-site boring was extended only into the shallow aquifer to a depth of 26 feet.

The upper 15 feet of Site soils consist of silty clay, silt, sand, and fill materials, which are identified as the surficial deposits. Alluvial sands and fill materials were encountered near the surface in boring locations GW-10D, GW-14D, and GW-15D. The alluvial sand was light brown to yellow in color, well sorted, medium dense, and moist to saturated. The fill materials encountered in boring location GW-10D were composed primarily of silty clay with minor amounts of sand, gravel, and a white crystalline material identified as magnesium oxide. The surficial silty clays encountered in boring locations GW-1D, GW-7D, and GW-14D were stiff, brown in color, variable in sand/gravel content, and moist to saturated. These surficial clayey soils likely represent weathered clay glacial deposits. Underlying the weathered silty clays were alluvial silts and fine sands associated with the shallow aquifer outwash deposits. These deposits were typically found between 10 and 22 feet bgs.

Underlying the surficial deposits, (i.e., depths ranging from 15 to 26 feet bgs) is a very stiff, dark gray silty clay till and shallow aquifer. This till is identified as the confining layer, which is fairly homogenous, with the exception of some thin isolated sand layers. The sand layers, typically less
than 1 foot in thickness, were encountered at depths of approximately 30 feet and 64 feet bgs. The shallow sand layer was not encountered at boring location GW-15D, and the deeper sand layer was not encountered at boring locations GW-7D and GW-10D.

The lower aquifer was not encountered in GW-7D until 96 feet bgs in comparison with the other borings where this lower aquifer was typically encountered at depths of 55 to 70 feet bgs. The lower aquifer is comprised of fine sand to silty fine sand. The variability of outwash deposit occurrence can be attributed to the complex nature of glacial depositional environments. The base of the lower aquifer could not be defined based on the CSA Report investigation borings. It is estimated that the lower aquifer is no greater than 30 feet thick, based on a review of available residential well records.

According to the percent passing values for the various sieve sizes, and utilizing description guidelines provided under the Unified Soil Classification System (USCS), the soils associated with the shallow aquifer are classified as silty to clayey sand, with trace gravel, (SC-SM). The soils identified with the deep confining till unit are classified as clayey silt, with some sand and trace gravel (ML with sand). Finally, the deep aquifer soils are classified as clayey to silty sand, with trace gravel (SC-SM).

### 1.2.2 Local Hydrogeology

According to information obtained from the MDNR and the Michigan Atlas (prepared by Western Michigan University, Department of Geology), the northern section of Gratiot County is located within the Tittabawassee River Drainage Basin. The Michigan Atlas indicated that all surface waters within this basin discharge into the Tittabawassee River, into the Saginaw River, and ultimately into Lake Huron at Saginaw Bay.

The primary surface water feature in the vicinity of the Site is the Pine River, located along the Site's western and northern boundaries. Surface water from the Site discharges directly into the
Pine River, which flows to the northeast from the Site and adjoins the Chippewa River. The Chippewa River is located east of Midland, Michigan, approximately 30 miles northeast of the Site.

The protective clay cap that covers the Site has been designed to divert Site surface water runoff to the Pine River. Surface water is concentrated into six grass-lined drainage diversion channels that extend radially outward toward the Site’s west and north perimeters. Concrete aprons and/or riprap banks were constructed along the surface water exit points to minimize surface soil erosion.

According to the Michigan Atlas, there are numerous aquifer systems within the Paleozoic age rocks. In the vicinity of the study area, these aquifers are located within the Pennsylvanian age sandstones, identified with the Saginaw and Grand River Formations. There are several deeper aquifers within the older strata in the study area; however, they are not typically utilized in the study area due to their greater depths. The atlas indicated that only 10 percent (or less) of the area’s potable wells are within the bedrock aquifers.

The remaining potable wells utilize groundwater from the Pleistocene age outwash aquifers. The outwash aquifers are interbedded within glacial till deposits, which act as aquitards between the outwash units. The Pennsylvania age sandstone aquifers are separated by the Jurassic age strata, which act as an aquitard for the bedrock aquifers. All aquifer systems described are under confining conditions, as documented by static water lever data in available residential/industrial well logs. There were no data indicating the direction of aquifer flow for the aquifer systems in the region.

Previous investigations provided information on the Site-specific hydrogeologic condition. Data collected during the drilling of the new monitoring wells indicated that there are water-bearing silts and sands with the surficial soil deposits. These uppermost water-bearing soils are associated with glaciofluvial deposits within the shallow weathered, less consolidated tills. Saturated soil conditions were encountered at various depth intervals within the surficial deposits, typically between elevations of 700 to 750 feet amsl. These soils consisted of interbedded silty to clayey sands and silty clays. For the purpose of this Work Plan, this zone of saturated shallow soils is associated with the shallow aquifer. The next water-bearing soil units, i.e., intermediate saturated zones, were
encountered from 692 to 699 feet amsl, separated from the upper saturated soils by glacial till layers. Saturated silty to clayey sands and silts within this depth interval are also glaciofluvial in origin. This zone of water-bearing soils was noted to be very isolated in extent and occurrence.

The next significant zone of water-bearing soils was documented below an elevation of 677 feet amsl at deep well locations GW-01D and GW-15D. This zone was previously identified as the lower aquifer. At deep monitoring well locations GW-7D, GW-10D, and GW-16D, the lower aquifer was encountered at slightly lower elevations, i.e. below elevation 670 feet amsl. The glaciofluvial deposits within the lower aquifer were quite variable, consisting of interbedded sands, silts, and clayey to silty sands.

Static water level measurements were collected as part of the past investigations, which indicated the shallow aquifer potentiometric levels occur from elevations 719.5 to 724.5 feet amsl. The lower aquifer potentiometric levels occur from elevations 707.5 to 714.5 feet amsl. Groundwater levels were not obtained from the saturated soil zone between elevations 692 to 699 feet amsl; therefore, it is not known whether the shallow aquifer is hydrogeologically connected with this intermediate zone.

According to the shallow aquifer potentiometric levels recorded on 9 December 1993, groundwater flow patterns are radial across the Site. Due to the presence of the peripheral slurry wall (i.e., containment wall), it seems that groundwater mounding is occurring within the property boundary. The potentiometric surface for the shallow aquifer appears to be controlled by the Site topography. The highest potentiometric levels occur along the topographic low areas of drainageways. Surface water is diverted to these areas resulting in a higher rate of recharge. This would create a mounding effect. By contrast, the potentiometric levels decrease at topographically higher areas of the Site. The horizontal hydraulic gradients range from $1 \times 10^{-2}$ ft/ft to $2 \times 10^{-3}$ ft/ft. Higher gradients occur along areas where topography increases and/or decreases abruptly. The hydraulic gradients flatten in the northeastern area of the Site where topographic relief is less pronounced.
The surface water elevation of the Pine River, which is adjacent to the Site, is approximately 720 feet amsl. Under natural conditions, the shallow aquifer groundwater from the Site would discharge directly into the river. As previously mentioned, the Site slurry wall has minimized flow into the river. Directly across the river, an off-site shallow monitoring well has a potentiometric level approximately the same as the river elevation.

The potentiometric levels recorded on 9 December 1993 for the deep aquifer indicate a northwesterly flow for the northwestern side of the Site. A drainage divide appears evident across the property and has a southeasterly flow component. The potentiometric level was highest in the vicinity of monitoring well GW-14D. The lowest potentiometric level was observed at monitoring well GW-10D. The horizontal hydraulic gradients for the deep aquifer ranged from $1 \times 10^{-2}$ ft/ft to $2.5 \times 10^{-3}$ ft/ft.

For bulk groundwater velocity estimation, an average soil porosity of 40 percent (Freeze and Cherry, 1979) was used to represent silty sands, which seem to be the representative soil type for the shallow aquifer. Rising head slug test data was used to estimate the hydraulic conductivity (K) of the aquifer for the flow equation, since it is considered more representative of aquifer conditions. Using the maximum K value obtained during rising head slug testing, the range of gradients (i) measured from the contour maps, and an assumed 40-percent porosity, the groundwater velocity of the deep aquifer can achieve flow rates from $2.3 \times 10^{-1}$ ft/day to $9.0 \times 10^{-1}$ ft/day. These rates are based on a maximum K value of $3.6 \times 10^{-1}$ ft/day, and i values of $1.0 \times 10^{-2}$ ft/ft to $2.5 \times 10^{-3}$ ft/ft.

The maximum groundwater velocity for the shallow aquifer across the Site was calculated at $1.2 \times 10^{-2}$ ft/day to $5.8 \times 10^{-2}$ ft/day. Values used to calculate shallow groundwater velocity included a maximum K value of $2.3 \times 10$ ft/day, and i values of $1.0 \times 10^{-2}$ ft/ft to $2.0 \times 10^{-3}$ ft/ft. This maximum range of velocity represents flow conditions as a result of recharge (via precipitation) into the shallow aquifer under a relatively confined (i.e., laterally at the Site boundaries and vertically) condition. Evapotranspiration would be the other primary factor affecting groundwater recharge under this scenario.
SECTION 2
PERFORMANCE EVALUATION OF SLURRY WALL CONTAINMENT SYSTEM

2.1 WORK PLAN APPROACH

As stated previously, the primary purpose of this Work Plan is to evaluate the performance of the slurry wall. A phased approach has been developed to allow for potential changes in the phases of work in order to acquire the appropriate data and findings. Each phase of work will build upon the subsequent work in order to expedite activities and achieve efficiencies between the tasks. If results indicate that the slurry wall is meeting performance criteria prior to completing all phases of work, additional work activities may not be completed. All work activities will be laid out in a SOW and submitted for approval by the MDEQ prior to commencement. This Work Plan is intended to allow flexibility regarding the placement of sampling locations, screen depths, etc. to respond to unanticipated conditions that may be encountered in the field. The MDEQ will be notified if any modifications in the SOW are conducted based on field conditions.

2.1.1 Data and Data Quality Requirements

The tasks described in this Work Plan have been developed to obtain the following data to characterize the containment system:

Subsurface soil physical characterization data (through soil borings and geophysics) for the Site area to:

- Determine if the existing slurry wall containment system is in tact, providing a barrier for groundwater flow, and functioning properly;
- Detect possible seep locations; and
- Identify any remaining contaminant source areas outside the slurry wall system.

Groundwater and surface water quality data (through piezometer well installation and seep sampling) at the Site to:
SCOPE OF WORK

- Evaluate potential releases of hazardous contaminants to groundwater from former facility processes and waste handling practices;
- Delineate the vertical and horizontal extent of groundwater contamination inside and outside the slurry wall at the site; and
- Evaluate the extent and levels of groundwater contamination inside and outside the slurry wall, and potentially discharging to the Pine River.

Soil/fill and sediment data (through soil borings, geophysics, and surface sampling) from within the facility in order to:

- Evaluate the distribution of residual contaminants from former facility operations;
- Assess the relative distribution of contaminants in surface and near-surface soils at the Site; and
- Assess the ability of the contaminants present in facility soils, sediments, and former facility waste areas to migrate into groundwater and surface water.

In addition to the above data requirements, select real-time screening data will be required for the protection of onsite field personnel. These data requirements will be described in the site Health and Safety Plan (HASP), Subsection 2.2.2, and will include ambient air monitoring with a photoionization detector (PID) and a radiation meter (RAD-Meter) during invasive tasks to monitor for volatile organic compounds (VOCs) and potential radiation exposure.

The Data Quality requirements for this investigation include Level I through Level III (as defined by USEPA) depending upon the intended use of the information. For health and safety monitoring, Level I data ("Field Screening") will be sufficient. Portable PIDs will be utilized during invasive tasks to monitor for VOCs. The PID will be operated and calibrated (at least daily during use) in accordance with manufacturers instructions. Records of calibration and maintenance will be kept onsite and made part of the project record.

For geologic characterization and geophysical investigation tasks, Level II data ("Field Analysis") will be required. All geophysical instrumentation will be calibrated, operated, and data interpreted by WESTON's Geologist/Scientist trained in the use of the equipment. Calibration and maintenance records for the equipment (during its use onsite) will be prepared, kept onsite, and will be made part of the project record. Also, all logging of soil samples collected during the soil boring program will
be performed by the WESTON Geologist/Scientist. Field personnel qualifications will be submitted to MDEQ and approved prior to any task implementation.

Because of its potential future use in the risk assessment process, all chemical analysis data will require Level III (USEPA laboratory protocol) analytical data quality. In addition, all samples to be submitted for chemical analysis will be handled in accordance with the applicable MDEQ and USEPA sample handling and preservation procedures, and managed in accordance with strict chain of custody (COC) procedures. These procedures, as well as the sample collection documentation requirements, are discussed in greater detail in Section 3.8 of this Work Plan, in addition to the site Quality Assurance Project Plan (QAPP).

2.2 PRELIMINARY ACTIVITIES

Preliminary activities will need to be completed prior to the start of field investigative activities. Preliminary activities include; a project kickoff meeting, the development of a site specific HASP, and the obtainment of site access for all properties impacted by the field investigation activities. A more detailed explanation of preliminary activities is provided in the following subsections.

2.2.1 Project Kickoff Meeting

Prior to the start of the Site activities, a project kickoff meeting will be held in the MDEQ Lansing office or at the site. The intent of the meeting will be to familiarize parties with the project and to establish clear lines of communication between the investigatory participants. MDEQ officials will chair the meeting and attendees will include the MDEQ Project Officer, USEPA, Velsicol representatives (if required), and WESTON personnel. The meeting will also serve as a forum to present the anticipated fieldwork schedule and to coordinate the fieldwork efforts.

2.2.2 Site Specific Health and Safety Plan

WESTON will develop a site specific HASP that is simultaneously effective, practical, and enforceable. To achieve this, WESTON will develop a HASP from a baseline Safety Plan and an
initial site survey. Prior to the start of any subsequent fieldwork by WESTON or subcontractors, a detailed HASP will be submitted to the MDEQ. The HASP must be read, understood, signed, and followed by all persons who perform work on or visit the site. Compliance with and effectiveness of the HASP are the responsibility of the WESTON’s Site Health and Safety Coordinator (SHSC). The HASP is designed to meet Occupational Safety and Health Act (OSHA) requirements for Hazardous Waste Operations and Emergency Response as set forth in 29 CFR 1910.120 and 1910.20. The HASP is also designed to meet Michigan OSHA requirements. The HASP will include the following elements:

- Authorized personnel and definition of responsibilities.
- Personal protective equipment on a per-task basis.
- Decontamination procedures.
- Work zone restrictions and delineation.
- Personal protection upgrade/downgrade action limits.
- Emergency information and telephone numbers.
- Incident documentation procedures.
- Contingency plans.

All site personnel will be required to show proof of 40-hour training and current annual refresher training. For the technical approach of the Work Plan an assumption of modified Level D conditions will be made with a contingency for upgrade to Level C, if necessary. Because of the past use of radiological materials at the Site, WESTON will conduct field screening with a RAD-Meter to evaluate if field personnel are exposed to radiation levels that are greater than background conditions or greater than 1 μR/hr.

2.2.3 Site Access

WESTON will coordinate all site activities with the MDEQ, USEPA and their contractor (CH2M Hill) prior to commencement of site activities. No off-site access is anticipated to be required for the Phase I activities.
2.2.4 Quality Assurance Project Plan

The MDEQ ERD requires participation of all contractors in a centrally managed quality assurance program prior to the initiation of analytical or environmental monitoring activities. This requirement applies to all environmental monitoring and measurement efforts mandated or supported by MDEQ-ERD. WESTON will prepare a Quality Assurance Project Plan (QAPP) for the Site in accordance with requirements established in the following document:

- USEPA. June 2000, Revision 0. Instructions on the Preparation of a Superfund Division QAPP, based on U.S. EPA QA/R-5.

The QAPP will also be prepared based on guidance provided by MDEQ and review of available project files, a meeting with MDEQ-ERD, and the initial Site visit by WESTON. The QAPP will specify the procedures, that must be implemented to assure that the data gathered at the Site are consistent with specific quality goals with respect to accuracy, precision, completeness, and representativeness.

2.3 PHASE I ACTIVITIES

2.3.1 Historic Site Data Review and Activities

WESTON will complete a review of selected historical data, activities, reports and supporting documents completed for the Site to assist in the development of this Work Plan and to facilitate the evaluation of the Phase I data. WESTON will review historical aerial photos taken prior to, during and immediately after completion of the OU-1 Remedial Action. WESTON will also review relevant historic reports, site maps, facility maps and other pertinent information discovered during the review of MDEQ files (See task 2.3.2). WESTON has assumed the LOE associated with this task will not exceed 215 hours. Any additional LOE required to complete this task is not within the Scope of this Work Plan.
2.3.2 MDEQ File Management Support

WESTON will provide MDEQ with a staff scientist who will review, compile and organize the various existing MDEQ files for this Site in accordance with the ERD Superfund Section File Structure Outline. WESTON has assumed the LOE required for this task will be five, 40-hour weeks of eight-hour days (i.e., 200 hours). The WESTON staff scientist will work at the direction of the MDEQ Project Manager (PM) and will input information regarding each document reviewed into an electronic file and flag historic data (i.e., groundwater elevations and analytical chemistry results) in a spreadsheet format to be provided by the MDEQ PM. The data management software that will be used for the analytical data is Enviro Data by GeoTech Computer Systems, Inc. of Englewood, Colorado. The software will meet the USEPA EDD guidance criteria.

Development and evaluation of historical groundwater elevation and chemistry data will be conducted under the Phase II SOW. The data management software that will be used for the analytical data is Enviro Data by GeoTech Computer Systems, Inc. of Englewood, Colorado. The software will meet the USEPA EDD guidance criteria.

2.3.3 Topographic Aerial Survey and Instrument Land Survey

WESTON will facilitate aerial and land surveys to develop an accurate base map of the existing Site topography, river configuration and anthropogenic features (i.e., monitoring wells, fence line, slurry wall alignment, etc.) The aerial survey will be conducted by Abrams Aerial Survey Corporation of Lansing, Michigan and will include a flyover of the Site, aerial photography, color prints and enlargements, and development of a topographic base map generated at a 1 inch equals 100 feet scale, with one foot contour intervals. All aerial photographs will be orthorectified. These data will be formatted for AutoCAD-14 software in DWG files, which will provide the topographic information for the base map. In order to complete the topographic map, WESTON will subcontract Wade-Trim of Bay City, Michigan to establish the required ground control either prior to or after completion of the flyover. The ground control will be used to tie the aerial photographic data to found points at the Site surface.
The land survey crewmembers will be 40-hour OSHA trained. In addition to establishing the ground control for the aerial photography, the land survey crew will locate the existing fence line, wells, inclinometers, catch basins and manholes. The land surveyor will also locate the locations of the geophysical trial transects, seep locations, and the locations of all of the proposed Phase I sample or borehole locations. The land survey will determine the horizontal position of each well and catch basin to within 0.1 feet and the elevation of these features to within 0.01 feet. The locations and elevations of other surface features (i.e., geophysical transect lines and boring locations) will be determined to within 0.1 feet.

The land survey elevations will be referenced to Mean Sea Level, specifically to the North American Vertical Datum (NAVD) of 1988. If the 1988 Datum is not available, the National Geodetic Vertical Datum (NGVD) 1929 Datum shall be used. The horizontal locations shall be referenced to the State Plane Coordinate System. If it is not available, an existing local grid system shall be used. All positions and coordinates of all permanent points within the control traverse shall be shown.

2.3.4 Remote Infrared Sensing Survey

WESTON will subcontract a Thermal Infrared (T-IR) aerial survey over the Site. The objective of this survey is to obtain data to evaluate whether the slurry wall is leaking or discharging groundwater directly to the Pine River. The T-IR survey will be conducted by Davis Aviation of Kent, Ohio. Remote (i.e., aerial) T-IR sensing will be used to evaluate varying radiant surface temperatures at the interface between Pine River and the Site boundary. A difference in the temperature of the Pine River and the groundwater will be evident in the T-IR images if a plume or plumes of relatively warmer groundwater seeps are entering the colder Pine River surface water near the slurry wall interface. In order for the T-IR survey to identify potential seeps at the interface, a temperature difference between the surface water body and the groundwater must exist, and a significant volume of flow must be occurring into the surface water body. The required flow needed in not quantifiable and depends on the site and environmental conditions at the time.
Ideally the T-IR survey will involve collecting data on a cold clear night to eliminate the effects of solar heating and obtain the greatest temperature contrast. This work would most likely be conducted after the autumn leaves have dropped and the nights are cold, and preferably before the river or ground has frozen. The T-IR scanner is sensitive to 0.08 degrees Celsius, therefore, only a minor temperature differential is required to identify a seep. If the surface water is 38°Fahrenheit (F) and the groundwater is 45°F or higher, any significant seeps should be identified during the survey. This technique has been used to locate problems such as the discharge of thermal effluent, vegetative stress, watershed delineation, leachate from disposal sites, and groundwater recharge via springs and seeps.

A T-IR image collection system will be placed in a typical aerial survey plane and the flight line end points will be identified on digital USGS quad sheets, and geographic coordinates will be extended for use in the aircraft GPS navigation system for all flights. All flight parameters will be established with the MDEQ prior to data acquisition. The image collection system that will be used for this survey will be the Mitsubishi IR-600 Thermal Imager. The instrument has a 512 x 512 pixel resolution and a detectable wavelength of approximately 2-6 μm.

The data delivery will consist of flight index maps showing flight lines for all coverage, flight logs showing instrument parameters from all flight lines, processed digital images, and a letter report from the T-IR subcontractor documenting the project performance. The processed digital images will be evaluated by WESTON and the T-IR subcontractor for potential seeps and any anomalies that may be shown. The results and findings will be supplied in a Technical Memorandum as discussed in Section 2.3.9.
2.3.5 Locate Slurry Wall

Prior to any subsurface activities, the exact location of the slurry wall that surrounds the site must be located. The objective is to accurately locate the entire slurry wall surrounding the site, or at a minimum the location of the slurry wall at the 24 locations where the Vertical Aquifer Sampling (VAS), described later in this Work Plan, will occur. The slurry wall location information will be used to select the VAS locations, any future work that may be conducted on site, and to have the slurry wall location on record. The existing construction documents indicate the slurry wall is approximately two-feet wide and follows the outline of the site approximately six-feet inside the perimeter fence.

The least intrusive method for locating the slurry wall so as to not damage the existing clay cap that extends over the entire site is to use non-intrusive geophysical techniques. Due to varying site conditions such as the clay cap, the metal fence surrounding the site, and the location of the Pine River, a geophysical trial test was conducted using an electromagnetic (EM)-31, EM-38, Ground-Penetrating Radar (GPR) unit, and resistivity methods. In addition, the unit used to conduct the resistivity test also has the capabilities to conduct a Self Potential (SP) test. The SP test will be used to evaluate whether it is viable to use geophysics to determine potential leaking of the slurry wall.

A geophysics trial was conducted on-site 25 September 2001 at three locations where the approximate location of the slurry wall was known. The trials were conducted near piezometers and inclinometers that had been installed adjacent to the slurry wall (see Figure 2). The locations of the existing piezometers were used as an approximate guide to conduct the trials. Each geophysical method was used to attempt to locate the slurry wall. WESTON and our geophysical subcontractor (STS Consultants, Ltd. of Lansing, MI) evaluated the data gathered on-site as they were collected. Significant interference from the perimeter fence, overlying clay cap, and apparent lack of electrical resistivity differential between the slurry wall and surrounding native soils resulted in inconclusive or less than definitive profiles of the slurry wall location. None of the geophysical methods implemented could successfully determine the
location of the slurry wall with enough accuracy and precision to the extent required for the proposed Phase I piezometer installations. Therefore, the geophysical trial was terminated.

Since the geophysical methods were not successful in locating the slurry wall, WESTON will conduct a limited Geoprobe® investigation using soil-boring observations to locate the slurry wall at each of the 24 proposed VAS locations. The approximate location of the slurry wall at each location will be identified using diagrams of the slurry wall, historic report information, and site observations. A Geoprobe® will be used to collect continuous split-spoon samples from ground surface to approximately five to 10 feet bgs at each of the 24 locations. Based on previous investigations, WESTON anticipates that the material comprising the slurry wall may be easily identifiable both visually and by ease of pushing the Geoprobe® through the slurry mixture. If the slurry wall is not identified at the initial Geoprobe® location, additional locations will be completed on the order of two-feet away from the initial profile in directions perpendicular to assumed wall orientation. If the slurry wall is not identified in a series of boreholes installed over a length of 20 to 25 feet, the proposed VAS location will be offset parallel to the wall orientation and another series of boreholes will be drilled until the containment wall is identified.

As a last option, a backhoe could be used to conduct test pits to locate the slurry wall. This approach would only be used if the Geoprobe® methodology failed, and if difficult terrain and site conditions were encountered. This method will not occur without consulting the EPA and the PRPs. To locate the top and lateral location of the slurry wall, the smallest practical transect of the clay cap would be removed to locate the slurry wall. It is anticipated that a transect of two-feet wide and approximately 25-feet maximum in length would occur. The depth of the transect would be to the top of the slurry wall, which is anticipated to be between eighteen-inches and three feet. Once the slurry wall was located it would be flagged and the location recorded to an horizontal accuracy of 1.0-foot. The removed clay cap materials would be replaced in six-inch lifts, using the existing cap materials. The materials would be reconditioned with moisture, compacted in place, and completed to their original surface elevation. For the purposes of this Work Plan, WESTON has not included costs to implement a backhoe test pit program to locate the slurry wall.
During the slurry wall investigation it may be required to dismantle portions of the chain-link fence that surrounds the entire Site property in order to conduct some of the work activities. If dismantling is required at any location, the fence will only be cut at the locations needed to conduct work and will be limited to a minimum extent as possible. Once the SOW is completed, a fence contractor will repair the dismantled fence areas to prior existing conditions.

2.3.6 Seep Sampling

Under this task, WESTON will monitor, document, and collect samples from potential seeps that occur along the Pine River and OU-1 (the former main plant) boundary interface. This task will occur while other on-site activities/tasks are occurring, such as the VAS installation and sampling mobilizations. Seep monitoring will occur during each mobilization, with one reconnaissance along the ground surface and surface water interface. If WESTON personnel are on-site for an extensive length of time, then reconnaissance along the entire length of the interface will occur every two days while on-site.

WESTON staff will walk along the interface and look for any seeps that may be occurring. If a seep is found, the date, time, location, and characteristics of the seep (color, odor, approximate flow rate, route) will be documented. Photographs will be taken and logged. Up to 15 seep samples will be collected along the interface. If additional samples could be acquired beyond 15 samples, the MDEQ will be notified and then a determination will be made if additional seep samples are required. In general, 10 of the seep samples are to be collected at different locations along the interface, and the remaining five samples can be collected of the same seep but at different time periods. The exact number and locations of the seeps will be determined based on the field findings.

The seeps will be analyzed for VOCs, Semi-Volatile Organic Compounds (SVOCs), pesticides, and PCBs-Contract Laboratory Program (CLP) Target Compound List (TCL), metals and cyanide-[CLP Target Analytical List (TAL)] (see Table 1 for a list of the parameters).
metals lists include: aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc. In addition, the samples will be analyzed for ammonia, biological oxygen demand (BOD), chemical oxygen demand (COD), chloride, sulfate, nitrate/nitrite, oil and grease, total organic carbon (TOC), total kjeldahl nitrogen (TKN), total suspended solids (TSS), and total dissolved solids (TDS). The horizontal locations of the seeps will be flagged and later surveyed to within 0.1-feet. All seep locations will be identified on the Site base map, with pertinent information documented on a table for reference.

2.3.7 Residual Contamination - Soil & Groundwater Sampling

At 10 locations between the outside of the slurry wall and the Pine River, along the Site and Pine River boundary, soil and groundwater samples will collected to evaluate if residual contamination is present beyond the slurry wall. The sample locations will be stationed every 400 feet starting at the 32+50 station from the existing slurry wall Station Grid to 72+50 (see Figure 3). At each of the 10 stations, an additional location may be sampled for soil and groundwater if there is sufficient distance between the Pine River and the first borehole location, and if the sample location is deemed necessary based on findings from the first sampling location. Therefore, a total of 20 residual contamination soil and groundwater sampling locations could be completed. The soil and groundwater sampling will be conducted utilizing a Geoprobe® unit. The first sample locations will be equal distance between the outside of the slurry wall and the Pine River. The second sample location, if necessary, will be located between the first sample location and the Pine River. The 10 locations, along the Pine River boundary of the site may be altered based on the geophysical findings and historic facility location information.

At each location, continuous soil sampling will be conducted to depth until reaching the saturated zone. At each two-foot interval, the plastic-lined cores will be field screened by cutting open the core and measuring the VOC emissions along the core length with an organic vapor analyzer (OVA) and a RAD meter. At each two-foot interval, one soil sample will be collected based on the highest OVA reading. If no OVA readings occur, a soil sample will be collected based on visual
appearance (discoloration, fill appearance), or selected randomly if the soil appears to have not been disturbed or impacted. Soil samples will be collected every two-foot interval until the saturated zone is reached. If during field screening and logging it is determined that additional samples are required (such as DNAPL or evidence from DNAPL are identified in the saturation zone), additional samples will be collected at the discretion of the on-site personnel.

At each location, one groundwater sample will be collected using a 2-foot long mill-slotted screen which will be driven to a depth of 2-feet below the top of the water table, and sampled with a peristaltic pump. The groundwater samples will be collected using a peristaltic pump with disposable tubing inserted into the Geoprobe® rods. The USEPA low-flow sampling method will be used in conjunction with a flow-through cell for measurements of redox potential (ORP), temperature, dissolved oxygen (DO), pH, and specific gravity. A description of the USEPA low-flow sampling method is included in Appendix A.

Soil samples will be preserved/extracted with methanol or collected with an EnCore sampler in accordance with the U.S. EPA Method 5035. Both the soil and groundwater samples will be analyzed for VOCs, SVOCs, pesticides, PCBs, total metals and cyanide. In addition, the groundwater samples will be analyzed for ammonia, BOD, COD, chloride, sulfate, nitrate/nitrite, oil and grease, TOC, TKN, TSS, and TDS.

At each location, detailed boring logs will be generated classifying the soil samples using the USCS, documenting all pertinent information including but not limited to odors, PID/FID readings, RAD meter readings, sample retrieval, observed evidence of contamination, and any problems encountered. When warranted, photographs of the soil and/or sampling core length will be made. Labels indicating location identification, depth, and measurement shall be included with the photograph.

All borings shall be pressure grouted with bentonite slurry. The borings will be backfilled immediately after the sampling is completed. The borings will be staked and sequentially numbered and horizontally surveyed to within 0.1 feet.
2.3.8 **VAS and Piezometer Installation**

VAS is proposed for obtaining groundwater quality samples for chemical analysis at various depths within the same borehole. VAS is performed for appropriate well screen elevations determination, three dimensional plume mapping, risk assessment, and evaluating the effectiveness of the remedial design. VAS and soil sampling will be conducted on the interior and exterior sides of the slurry wall at 24 location pairs shown on the Site Map. The final VAS sampling locations will be based on seep locations, site-specific geologic information, site historic information, and information gathered from the T-IR survey.

The VAS and installation will be conducted using a Geoprobe® unit. At each of the 24 exterior wall locations, continuous coring will be conducted to the depth of the till confining unit (approximately 30 feet bgs). The first probe per location will be used to obtain lithology and water-level information, with the subsequent probe per location used for VAS efforts.

The VAS boreholes located inside the slurry wall will be at least five feet away from the slurry wall to minimize potential damage to the slurry wall at depth. The VAS boreholes on the outside of the slurry wall are to be placed as close to the surrounding fence as possible, and will be typically five to six feet from the slurry wall location.

At each of the 24 locations, detailed boring logs will be generated classifying the soil samples using the USCS, and documenting all pertinent information including but not limited to odors, PID/FID readings, RAD meter readings, sample retrieval, observed evidence of contamination, and any problems encountered. When warranted, photographs of the soil and/or sampling core length will be made. Labels indicating location identification, depth, and measurement shall be included with the photograph.
Soil Sampling

At each location before reaching the saturated zone, each two-foot interval will be field screened by cutting open the plastic-lined core and measuring the VOC emissions along the core length with an OVA and a RAD-meter. At each two-foot interval, one soil sample will be collected based on the highest OVA reading. If no OVA readings occur, a soil sample will be collected based on visual appearance (discoloration, fill appearance), or selected randomly if the soil appears to have not been disturbed or impacted. Soil samples will be collected every two-foot interval until the saturated zone is reached. If during field screening and logging it is determined that additional samples are required (such as DNAPL or evidence from DNAPL are identified in the saturation zone), additional samples will be collected at the discretion of the on-site personnel.

Soil samples will be preserved/extracted with methanol or collected with an EnCore sampler in accordance with the USEPA Method 5035. Both the soil and groundwater samples will be analyzed for VOCs, SVOCs, pesticides, and PCBs and total metals.

VAS and Piezometer Installation

A second borehole per location will allow for the collection of the VAS information and piezometer installation. Each borehole will terminate approximately two-feet into the clay till confining layer.

All 24 exterior boreholes and up to six of the interior boreholes will be vertically sampled throughout the thickness of the shallow aquifer. The six interior boreholes will be selected based on lithology, OVA readings from the soil borings, geophysical results, and historic site information (see Figure 3 for proposed locations). A two-foot-long, mill-slotted screen will be utilized for collecting VAS samples. The mill-slotted screen will be initially driven to a depth equal to two-feet below the top of the water table and sampled with a peristaltic pump. Additional VAS samples will be collected by advancing the screen downward (from the top of the aquifer down to the clay till confining layer). Vertical samples will be collected at three equally spaced intervals (upper, middle, and lower) within the lower aquifer.
Groundwater samples will be collected from each VAS interval using a peristaltic pump with disposable tubing inserted into the Geoprobe® rods. The USEPA low-flow sampling method will be used in conjunction with a flow-through cell for measurements of ORP, temperature, dissolved oxygen, pH, and specific conductivity. The USEPA low-flow sampling method is included in Appendix A.

Groundwater samples will be submitted to a CLP laboratory for VOCs, SVOCs, pesticides, PCB-(TCLs), cyanide and total metals-(TAL). In addition, the groundwater samples will be analyzed for ammonia, BOD, COD, chloride, sulfate, nitrate/nitrite, oil and grease, TOC, TKN, TSS, and TDS. See Table 1 for the Analytical Chemistry Summary and Table 2 for the Sampling Plan Summary.

Piezometer Installation

At all 24 locations, one boring inside the slurry wall and one boring outside the wall will be used to install one-inch PVC piezometers with a five-foot long, slotted screen installed at the base of the shallow aquifer. This will establish repeatable data points at all piezometer locations.

All borings not used for piezometers shall be pressure grouted with a bentonite slurry. The borings shall be backfilled immediately after the sampling is completed. The borings will be staked and sequentially numbered starting with GP-01, etc.

Three staff gauges will be installed in the Pine River Reservoir at the locations presented in Figure 3 — one at the southwest end of the property, one in the middle of the property, and one at the northeast end (downgradient) of the Site property. In addition, two bridge locations will be marked and surveyed as measurement points for the Pine River. Washington Avenue Bridge is upgradient of the Site, and the Mill Street Bridge is downgradient of the Site.

At the conclusion of the investigation, all borings and installations will be surveyed by professional surveyor, Wade Trim of Bay City, MI. The survey will also include all various slurry wall investigative locations, seep sampling locations, residual contamination locations, VAS boreholes,
installed piezometers, and Pine River measurement points. In addition, existing monitor wells and piezometers will be resurveyed. A ground elevation accurate to the nearest 0.10-foot and an elevation for the top of the piezometer/monitor well riser to the closest 0.01-foot shall be obtained at each piezometer.

After the installation of all piezometers, three full rounds of static water levels will be collected from all newly installed piezometers, existing piezometers, monitor wells on-site, and Pine River measurement points. The first round will be collected 48-hours after the last piezometer has been installed. The second and third rounds will occur on a weekly basis after that. The depth to bottom of all piezometers and monitor wells will be collected during the first round, and only the depth to water will be collected during the second and third rounds in order to keep the potential for cross-contamination at a minimum. Subsequently, continuous water level recorders will be installed in select piezometers, stilling wells, and monitor wells (inside and outside the containment system) to measure groundwater elevation data and will be compared with meteorological data.

2.3.9 Phase I Reporting

A Technical Memorandum will be prepared detailing the Phase I activities completed at the Site. The Technical Memorandum will present the following: Geophysical trial findings; the T-IR aerial survey findings; the results of Geoprobe® borings to locate the horizontal location of the slurry wall; seep and residual contamination findings; and VAS sampling and piezometer installation results. The Technical Memorandum will include a presentation of the soil and groundwater analytical results, a comparison of analytical findings to applicable cleanup criteria, soil boring logs, piezometer construction diagrams; Site Map with site topography information, all sampling and piezometer locations, water level data, shallow groundwater contour maps, flow nets, geologic cross-sections, a groundwater quality map, and up to 15 individual groundwater parameter isoconcentration maps. The Technical Memorandum will also include a narrative of the Phase I findings, conclusions, and recommendations for subsequent investigative work, if necessary.
SECTION 3
FIELD INVESTIGATION METHODOLOGIES

3.1 GEOPHYSICAL METHODS TO LOCATE THE SLURRY WALL

WESTON conducted a limited geophysical trial in an attempt to locate the slurry wall using various non-intrusive methods on 25 September 2001. The following geophysical investigation methodologies were employed during this trial:

Ground Conductivity (EM-31 and EM-38). The conductivity of the shallow subsurface was measured using the EM-31 and EM-38 instruments. Both instruments are highly portable and permit rapid data collection. The EM-31 measures the conductivity of the upper six meters (approximately 20 feet), while the EM-38 measures the upper 1.5 meters (approximately five feet). For the trial, data were collected using these instruments along traverse lines, roughly perpendicular to the expected location of the slurry wall. Data were collected along these traverses at a close spacing (i.e. 3 feet) so that adequate coverage could be attained. These data were then plotted as cross-sections to determine if the slurry wall produces a response in the conductivity data.

Ground-Penetrating Radar. Ground-penetrating radar was also used in an attempt to locate the top of the slurry wall, but due to the presence of the low-permeability clay cap across the site, this technique did not provide the desired results. A 100 mHz antenna was used. Similar traverse lines and spacing as used in the EM-31 and EM-34 was used to collect the data.

Resistivity. The resistivity of the subsurface soil was measured along lines roughly perpendicular to the expected location of the slurry wall using a Sting/Swift Earth Resistivity meter. The Sting/Swift unit system is made by Advanced Geosciences, Inc., and includes the Sting R1 resistivity meter, the Swift control unit that enables automatic electrode switching, a smart electrode cable with 28 switches, and 28 stainless steel electrode stakes inserted into the ground. Various array types were tested (i.e., dipole-dipole, Wenner). A 28-electrode spread was utilized, with spacing between electrodes between one to five meters. To achieve the desired resolution in the upper 10 to 15 feet
of the subsurface. Data from the trials was downloaded onto a personal computer, and modeled using an inverse-square model.

**Self Potential.** SP was conducted in an attempt to locate the slurry wall. The resistivity between two porous-pot non-polarizing electrodes was measured. One electrode remained stationary while the other was moved along the survey line. The voltage between the two electrodes was measured, and the second electrode was moved down the survey line. This allowed for rapid measurement along the survey line. Data from this survey will be plotted to determine changes in the electrical potential along the SP survey line.

### 3.2 GEOPROBE® INVESTIGATIONS

The Geoprobe® method utilizes a direct push technology to sample soil and to collect discrete water samples at various depths. A Geoprobe® rig will also be utilized to conduct exploratory soil borings to a maximum depth of 10-feet in an attempt to determine the location of the slurry wall prior to completing the VAS borings and piezometer installations.

A four-foot or two-foot sampling device will be used to collect soil cores continuously to the top of the water table or base of the shallow aquifer based on task. The geologist/scientist, using the USCS, will log all soil samples. WESTON's Geologist/Scientist will monitor the Geoprobe® activities, collect samples from the continuous sampler, screen the samples with a PID, and characterize the samples. At a minimum, the following field soil descriptions and sampling information will be recorded and documented:

- Date and time;
- Weather conditions;
- Field personnel;
- Soil sampling method and equipment;
- Boring/location and identification;
- Soil name, as determined from the appropriate County Soil Survey;
- Sample number(s);
- Sample interval and depth;
• Unified Soil Classification System (USCS) soil textural classification;
• Lithology;
• Munsell soil color;
• Sedimentologic features;
• Miscellaneous observations; and,
• Evidence of contamination (e.g., discoloration, odor, PID reading, etc.)

Groundwater VAS samples may be collected utilizing the Geoprobe®. The vertical profiling will begin at the water table and continue at two deeper intervals. The groundwater samples will be collected using a stainless steel screen attached to 1.5-inch rods. A peristaltic pump and new polyethylene tubing will be used to collect each of the VAS samples. During purging, groundwater will be monitored for pH, temperature, and conductivity until the parameters have stabilized. Once the parameters have stabilized, groundwater samples will be collected directly into the sample containers (see Attachment A).

3.3 PIEZOMETER INSTALLATION AND DEVELOPMENT

At all 24 locations, one boring inside the slurry wall and one boring outside the slurry wall will be used to install one-inch PVC piezometers with five-foot long, slotted screens installed at the base of the shallow aquifer. This will establish repeatable data points at all piezometer locations.

All borings not used for piezometers shall be pressure grouted with a bentonite slurry. The borings shall be backfilled immediately after the sampling is completed. The piezometers borings will be staked and sequentially numbered starting with WPZ-01I and WPZ-01X, etc. to denote piezometers located either inside of outside of the slurry wall.

New piezometers will be allowed to set for at least 24 hours prior to development. Piezometers will be developed by alternately surging and purging using a pump. Surging will be done to increase fluid velocities in the sand pack, which will promote mobilization of fine-grained sediment in the piezometer, filter sand pack, and surrounding formation. Purging will be performed to remove the sediment from the piezometer, and introduce fresh fluid from the aquifer. A minimum of 5 well
volumes of water will be removed from each piezometers or until the water appears clear. Downhole equipment will be decontaminated between each piezometer in accordance with the protocol presented in Section 3.5.

3.4 LOW FLOW MONITORING WELL SAMPLING

The USEPA low flow sampling technique will be utilized in all groundwater sampling events unless an alternate method is approved by the MDEQ PM. Low flow sampling will minimize aquifer disturbance and wastewater generation.

The technique for low flow sampling will begin by measuring the water level in the well to the nearest 0.01-foot using an electronic water level indicator. Dedicated polyethylene or teflon tubing will be lowered to the screened interval. The tubing will be lowered so that it does not contact and disturb any sediment that may be present at the bottom of the well. After purging begins using an adjustable rate electronic pump, such as a bladder or peristaltic pump, the water level will be monitored and the pumping rate will be adjusted so that drawdown is not greater than 0.3 feet. Purging will begin at the lowest possible flow rate so that any sediment present in the well will not be disturbed. Purge water will be collected and placed in a poly-tank after sampling activities are completed, for subsequent placement into the on-site wastewater treatment plant (WWTP). During purging, groundwater will be monitored for pH, temperature, and conductivity until the parameters have stabilized (+/- 0.25 for pH, +/- 10% for conductivity, and +/- 1.0 degree Celsius for temperature). Once the parameters have stabilized, groundwater samples will be collected directly into the sample containers, see Attachment A.

Downhole equipment will be decontaminated between each monitoring well in accordance with the protocol presented in Section 3.5.
3.5 DECONTAMINATION PROCEDURES

All sampling and downhole equipment will be decontaminated prior to each use. All Geoprobe®, measuring, and sampling equipment will be properly decontaminated at an established location on-site. Decontamination methods for sampling equipment will consist of an alconox detergent wash followed by potable water rinse. A final rinse will be performed by spraying distilled water over the sampling equipment.

All Geoprobe® equipment will be decontaminated using a steam pressure washer over a tub or decontamination pad. All rods, tools, bits, etc. shall be free of potentially contaminating materials (i.e., grease, oil, paint, etc.), and shall be steam cleaned prior to use at each boring. Equipment that may potentially cross-contaminate samples, such as core barrels, etc. shall be decontaminated between each boring location. All water collected during decontamination activities will be collected and placed into the on site WWTP. The Geoprobe® shall be free of leaks, which could contaminate the investigative locations (i.e., hydraulic fluid, oil, gas, loose paint, etc.).

During low-flow groundwater sampling, the pump will be decontaminated between each sampling point in accordance with the following procedures:

- Immerse sampling pump into a tub containing trisodium phosphate solution and pump three gallons of solution through the sampling hoses.
- Immerse sampling pump into a second tub containing potable water and pump three gallons of solution through the sampling hoses.
- Immerse sampling pump into a third tub containing distilled water and pump one gallon of solution through the sampling hoses.
- Scrub sampling pump and connected hoses thoroughly with soft bristle brushes and a low trisodium phosphate solution.
- Rinse equipment with tap water by spraying until dripping.
- Rinse equipment with distilled water by spraying until dripping.

3.6 MANAGEMENT OF INVESTIGATION DERIVED WASTE

During intrusive and sampling operations all investigation derived waste (IDW), including soil
cuttings and purge/development/decontamination water, generated during field activities will be collected on site. All soils generated will be added to the sediments currently being removed from the Pine River at the Site. These sediments will be properly manifested and transported off-site for disposal. Water will be collected and discharged into the existing on-site WWTP.

The source of any water which is used for decontamination, or, if necessary, surging, or downhole purposes must be documented (i.e., fire hydrant location, etc.).

3.7 ANALYTICAL AND SAMPLE MANAGEMENT REQUIREMENTS

Further details regarding the analytical and sample management requirements will be provided in the QAPP to be prepared subsequent to this Work Plan. The following is a brief overview of information that will be provided in the QAPP. The CLP procedures will be used as a guidance where applicable.

3.7.1 Analytical Laboratory and Sample Method Requirements

All soil/sediment and surface water/groundwater samples collected will be analyzed by a CLP laboratory. Sample analytical methods, sample container requirements, preservative requirements, and holding times for each analytical parameter for water and soil/sediment samples will be provided in the QAPP. The methods utilized for the laboratory analyses are the recommended analytical methods listed in the CLP.

3.7.2 Sample Packaging and Shipping Procedures

It is MDEQ and USEPA Region V Policy to follow the Region V sample custody, or the chain-of-custody (COC) protocols as described in “NEIC Policies and Procedures,” EPA-330/9-78-001-R, revised June 1985. The COC allows for the tracing of possession and handling of individual samples from the time of field collection through the analytical laboratory analysis. This custody is in three parts; sample collection, laboratory analysis, and final evidence files. Final evidence files,
including all originals of laboratory reports, are maintained under document control in a secure area.

The sample packaging and shipment procedures summarized below will ensure that the samples will arrive at the laboratory with the COC intact.

### 3.7.2.1 Field Procedures

1. The COC will be initiated in the laboratory when the sampling containers and vials are prepared, packaged and shipped to the site conducting the sampling activities. The laboratory will list the lot number identification of the bottles on the COC or bottle shipment form. The Bottle shipment form will serve as a record of the analysis parameter, bottle type, vendor identification, bottle lot number, preservative, and the number of bottles submitted to the field by the laboratory.

2. The field sampler is personally responsible for the care and custody of the samples until they are relinquished to another individual or properly dispatched to the laboratory. As few people as possible should handle the samples. The bottle shipment form and COC will be signed and dated upon receipt and verification of the bottles. The bottle shipment will be investigated to determine any breach of the COC seals or evidence of bottle tampering.

3. Prior to the samples being collected, container labels must be filled out by the sampling personnel and applied to the bottle. Each bottle label will include, at a minimum; site name, sample identification number and location, date and time of the sample collection, samplers initials, sample preservation designation, and analysis required.

4. All bottles will be labeled with unique sample numbers using an indelible ballpoint pen.

5. The COC will be completed according to the direction listed on the back of the COC form. A copy of the COC and directions are attached to this document.

6. Upon completing the COC, the sampler will remove the pink copy of the COC (this form is provided in triplicate) and retain as a record. The remaining COC will be forwarded with the samples to the laboratory.

7. The laboratory will complete the laboratory portion of the COC during sample receipt procedures and will retain the yellow copy for internal records. The completed white original will be forwarded to the contractor with the data package requested.
When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the record. This record documents transfer of custody of samples from the sampler to another person, to the laboratory, or to/from a secure storage area.

Samples will be properly packaged for shipment and dispatched to the appropriate laboratory for analysis, with a separate signed custody record enclosed in each sample cooler. Shipping containers will be secured with strapping tape and custody seals for shipment to the laboratory. This procedure includes use of a custody seal attached to the front right and back left of the cooler. The custody seals are covered with clear plastic tape. The cooler is strapped shut with strapping tape in at least two locations.

The COC record identifying the contents will accompany all shipments.

### 3.7.2.2 Laboratory COC Procedures

The sample custodian will assign a unique number to each incoming sample for use in the laboratory. The unique number and customer number will then be entered into the sample-receiving log. The laboratory will complete the laboratory portion of the COC during sample receipt procedures and will retain the original for internal records. A completed copy will be forwarded to WESTON with the data package requested.

After the sample custodian has completed the sample log-in process, then all samples will be transferred to the appropriate storage locations. All samples will be stored within an access-controlled location and will be maintained preserved until completion of all analytical work or, at a minimum, for 30 days after receipt of the final report.
3.7.3 **QA/QC Samples**

To ensure quality throughout the project, the involvement of trained and experienced personnel will be utilized, and proven operating procedures and analytical methods for sample collection, preservation, analysis and documentation will be followed.

In addition to the quality control samples analyzed in accordance with the laboratory QA/QC Plan, several types of field quality control samples will be obtained and submitted for analysis during the course of the activities. These include:

- **Trip Blanks**: These samples are applicable to VOC analyses, and, therefore, will accompany each of the surface water and groundwater sample shipments. They will be prepared by the laboratory from ultra-pure deionized water, and will accompany the project samples through all custody changes to provide information regarding possible contamination obtained during the sample handling process and, thereby, provide a measure of analytical accuracy. Trip blank samples will be prepared for at least one of each sample parameter per sampling event, and will accompany each of the groundwater sample shipments.

- **Duplicates**: These samples are duplicate samples collected in the field and submitted to the laboratory without indication of the corresponding sample. These samples will be collected at a rate of 1 per every 10 samples with a minimum of 1 sample per sample matrix (i.e., soil, sediment, water, groundwater, waste) and will provide a measure of laboratory precision and matrix variability.

- **Sampler Blanks (Decontamination Blanks)**: These samples will be collected to evaluate the effectiveness of the field decontamination of sampling equipment. Only sampling equipment that is reused/non-dedicated will have sampler blanks collected. Sampler blanks will be prepared by pouring distilled water or laboratory supplied, ultra-pure deionized water over the sampling equipment after a decontamination procedure has been completed. This rinse water is then collected and submitted for analysis to provide an indication of possible accuracy errors that may be caused by ineffective decontamination procedures (carry-over from sample to sample). These samples will be prepared at a rate of 1 per 10 samples.

- **Matrix Spike and Matrix Spike Duplicate**: These samples are duplicate samples collected in the field and submitted to the laboratory without indication of the corresponding sample and are associated with laboratory QC. These samples will be collected at rate of 1 per every 20 samples with a minimum of 1 sample per sample matrix.
Trip blank, sampler blank, and duplicate samples will be analyzed to assess the quality of the data resulting from the field sampling program.

3.7.4 Data Validation Requirements

Validation of the laboratory analytical data generated by the CLP approved laboratory will be completed by the CLP Program Administrator. The data validation will be accomplished by comparing the contents of the data packages and QA/QC results to the requirements contained in the analytical methods. Raw data such as chromatograms, mass spectra data reports, and data station printouts will be examined to ensure that reported results are accurate. The CLP Administrator will be responsible for ensuring the accuracy of the reports.

3.8 FIELD MEASUREMENTS AND RECORD KEEPING

In order to ensure the proper coordination of all field activities, the WESTON Site Manager will oversee all field activities. The WESTON Site Manager will ensure that the SOW is adhered to, and that detailed sampling summaries, field notes, boring logs, and monitoring well/piezometer construction summaries are kept. A field logbook will be maintained to document all activities conducted during the field portion of the investigation and will include the following:

- Visual description of all sampling activities.
- Field screening data for total VOCs.
- Sample locations.
- Sample depths.
- Sample type.
- Drill and construction times.
- Boring logs.
- Type and amount of piezometer construction materials used.
- Any other pertinent information.

Entries into the logbook will contain a variety of information. At the beginning of each entry, the date, start and end time, weather conditions, names of all sampling team members present, level of
personal protection being used, documentation of adherence to protocol, any changes made to planned protocol and the signature of the person making the entry will be entered. The names of visitors to the work areas and the purpose of their visit will also be recorded in the field logbook.

Measurements made and samples collected will be recorded in the field logbook. All entries will be made in ink with no erasures. If an incorrect entry is made, the information will be crossed out with a single strike mark, initialed and dated. Whenever a sample is collected or a measurement is made, a detailed description of the location of the sampling point, which includes compass direction and distance taken from a reference point, will also be noted. All equipment used to make measurements will be identified, along with the date of calibration.

The equipment used to collect samples will be noted, along with the time of sampling, sample description, depth from which the sample was collected, volume of sample and number of containers, preservatives used (if any) and signature of sampler. Field QC samples will receive unique sample identification numbers and will be submitted to the laboratory blind to avoid laboratory bias of field QC samples.

Evidential files for the entire project will be maintained and will consist of the following:

- project work plan;
- project logbooks;
- field data records;
- sample identification documents;
- COC records;
- correspondence;
- references, literature;
- final data packages;
- miscellaneous - photos, maps, drawings, etc.; and
- final report.

The laboratory will be responsible for maintaining analytical logbooks and laboratory data. Raw laboratory data files will be inventoried and maintained by the laboratory for a period of six years, at which time the laboratory will be advised regarding the need for additional storage.
3.8.1 Photograph Identification

Photographs used in investigative reports or placed in the files shall be identified on the back of the print with the following information:

- A brief, but accurate description of what the photograph shows, including the name of the facility or site and the location.
- The date and time that the photograph was taken.
- The name of the photographer.

When photographs are taken, a record of each frame exposed shall be kept in the bound field logbook along with the information required for each photograph. If a digital camera is not used, the film shall be developed with the negatives supplied uncut. The WESTON field investigator will then enter the required information on the prints, using the photographic record from the bound field logbook, to identify each photograph. The negatives or electronic files must be maintained with the bound field logbook in the project file.

3.8.2 Identification of Physical Data

Physical data, other than samples, shall be identified by utilizing a sample tag or recording the necessary information directly on the data source. When samples are collected from vessels or containers which can be moved (drums for example), the vessel container will be marked with the field identification or sample station number for further identification, when necessary. The vessel or container may be labeled with an indelible marker (e.g., paint stick or spray paint). The vessel or container need not be marked if it already has a unique marking or serial number; however, these numbers shall be recorded in the bound field logbooks. In addition, it is suggested that the photographs of any physical data (markings, etc.) be taken and the necessary information recorded in the field logbook.
SECTION 4

PROJECT SCHEDULE AND DELIVERABLES

4.0 PROJECT SCHEDULE

The proposed project schedule for the Phase I activities of the slurry wall investigation at the Velsicol Superfund site is presented as Figure 4. The Project Schedule incorporates all project setup, historical review, field investigation, laboratory analysis, and report preparation tasks discussed in Section 2 of this Work Plan.
TABLES
### Table 1
#### Analytical Chemistry Summary
**Velsicol Superfund Site - St. Louis, MI**
**Phase I - Slurry Wall Evaluation**

<table>
<thead>
<tr>
<th>Chemical Group or Parameters</th>
<th>Laboratory Method</th>
<th>Analytes</th>
<th>Sample Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ORGANICS</strong> (also see Attachment B)</td>
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<tr>
<td>VOCs</td>
<td>EPA Method 624, CLP Methods</td>
<td>Target Compound List (&quot;TCL&quot;)</td>
<td>Seeps</td>
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<tr>
<td>SVOCs</td>
<td>EPA Method 625, CLP Methods</td>
<td>Target Compound List</td>
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<tr>
<td>PCBs/Pesticides</td>
<td>Varies, see CLP Methods</td>
<td>Target Compound List</td>
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<tr>
<td>Special Request Compounds</td>
<td>Method Development Required</td>
<td>HBB, PBB, TRIS, DDT, chlordane</td>
<td>X</td>
</tr>
<tr>
<td><strong>INORGANICS</strong> (also see Attachment C)</td>
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<tr>
<td>Metals and Cyanide</td>
<td>Varies, See CLP References</td>
<td>Target Analyte List (&quot;TAL&quot;)</td>
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<tr>
<td><strong>ADDITIONAL</strong></td>
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<td></td>
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<tr>
<td>WATER CHEMISTRY</td>
<td>Varies, See ERD and STD Target Detection Limits and Recommended Methods for Part 201, 211 and 213</td>
<td>ammonia, BOD, COD, chloride, sulfate, nitrate/nitrite, oil and grease, TOC, TKN, TSS and TDS.</td>
<td></td>
</tr>
</tbody>
</table>

X = Matrix will require analysis

GW = Groundwater

W = Water

Seeps = Surface Water

DDT = 1,1,1-Trichlor-2,2-(p-chlorophenyl) ethane

BOD = Biological Oxygen Demand

COD = Chemical Oxygen Demand

TKN = Total Kjeldahl Nitrogen

TOC = Total Organic Carbon

TSS = Total Suspended Solids

TDS = Total Dissolved Solids

HBB = Hexabromobenzene

PBB = Polybrominated biphenyls

TRIS = Tris(2,3 Dibromopropyl) Phosphate

1/18/02
## Table 2
### Sampling Plan Summary
Velsicol Superfund Site (OU-1)
Slurry Wall Investigation
St. Louis, MI

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
<th>Laboratory Analysis Summary*</th>
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<td><strong>SEEP SAMPLING</strong></td>
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<td>GW</td>
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<td>15 water samples (maximum)</td>
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<td></td>
<td>Duplicates (10%)</td>
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<tr>
<td></td>
<td>Trip Blanks (2)</td>
<td>W</td>
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<tr>
<td></td>
<td>MS/MSD</td>
<td>GW</td>
</tr>
<tr>
<td><strong>RESIDUAL CONTAMINATION - SOIL &amp; GW SAMPLING</strong></td>
<td>Soil samples every 2 feet; assume 5 samples/location (min=10, max=20)</td>
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<tr>
<td></td>
<td>GW sample at static water level</td>
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<td></td>
<td>Duplicates (10%) - Soil</td>
<td>Soil</td>
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<td></td>
<td>Duplicates (10%) - Groundwater</td>
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<tr>
<td></td>
<td>Trip Blank (2)</td>
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<tr>
<td></td>
<td>Method Blank - Groundwater</td>
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<td></td>
<td>Decontamination Blank - GW</td>
<td>W</td>
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<tr>
<td></td>
<td>MS/MSD - Soil</td>
<td>Soil</td>
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<td></td>
<td>MS/MSD - Groundwater</td>
<td>GW</td>
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<tr>
<td><strong>VAS SAMPLING</strong></td>
<td>Soil samples every 2 feet; assume 5 samples/location</td>
<td>Soil</td>
</tr>
<tr>
<td></td>
<td>VAS, 30 locations (24 outside, 6 inside)</td>
<td>GW</td>
</tr>
<tr>
<td></td>
<td>Duplicates (10%) - Soil</td>
<td>Soil</td>
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<tr>
<td></td>
<td>Duplicates (10%) - Groundwater</td>
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<td></td>
<td>Trip Blank (9)</td>
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<td>Method Blank - Groundwater</td>
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<td></td>
<td>Decontamination Blank - GW</td>
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</tr>
<tr>
<td></td>
<td>MS/MSD - Groundwater</td>
<td>GW</td>
</tr>
</tbody>
</table>

na = Not Applicable
GW = Groundwater
W = Water
Example ("1 / 2") = Minimum of 1 sample, Maximum of 2 samples collected
* Refer to Table 1 for Analyte Lists or Methods
MS = Matrix Spike
MSD = Matrix Spike Duplicate
FIGURES
SOURCE: U.S.G.S St. Louis, Michigan 7.5 Minute Quadrangle Map.
Figure 4
Project Schedule - Phase I Slurry Wall Investigation
Velsicol Superfund Site (OUI-1)
St. Louis, MI

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<td>Periodic Status Reports and Project Mgmt</td>
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Project: Phase I Schedule
Date: 11/1/02
ATTACHMENT A

LOW FLOW SAMPLING PROCEDURES
Background

The Regional Superfund Ground Water Forum is a group of ground-water scientists, representing EPA's Regional Superfund Offices, organized to exchange information related to ground-water remediation at Superfund sites. One of the major concerns of the Forum is the sampling of ground water to support site assessment and remedial performance monitoring objectives. This paper is intended to provide background information on the development of low-flow sampling procedures and its application under a variety of hydrogeologic settings. It is hoped that the paper will support the production of standard operating procedures for use by EPA regional personnel and other environmental professionals engaged in ground-water sampling. For further information contact:
I. Introduction

The methods and objectives of ground-water sampling to assess water quality have evolved over time. Initially the emphasis was on the assessment of water quality of aquifers as sources of drinking water. Large water-bearing units were identified and sampled in keeping with that objective. These were highly productive aquifers that supplied drinking water via private wells or through public water supply systems. Gradually, with the increasing awareness of subsurface pollution of these water resources, the understanding of complex hydrogeochemical processes which govern the fate and transport of contaminants in the subsurface increased. This increase in understanding was also due to advances in a number of scientific disciplines and improvements in tools used for site characterization and ground-water sampling. Ground-water quality investigations where pollution was detected, initially borrowed ideas, methods, and materials for site characterization from the water supply field and water analysis from public health practices. This included the materials and manner in which monitoring wells were installed and the way in which water was brought to the surface, treated, preserved and analyzed. The prevailing conceptual ideas included convenient generalizations of ground-water resources in terms of large and relatively homogeneous hydrologic "units". With time it became apparent that conventional water supply generalizations of
"homogeneity" did not adequately represent field data regarding pollution of these subsurface resources. The important role of "heterogeneity" became increasingly clear not only in geologic terms, but also in terms of complex physical, chemical and biological subsurface processes. With greater appreciation of the role of heterogeneity, it became evident that subsurface pollution was ubiquitous and encompassed the unsaturated zone to the deep subsurface and included unconsolidated sediments, fractured rock, and "aquitards" or low-yielding or impermeable formations. Small-scale processes and heterogeneities were shown to be important in identifying contaminant distributions and in controlling water and contaminant flow paths.

It is beyond the scope of this paper to summarize all the advances in the field of ground-water quality investigations and remediation, but two particular issues have bearing on ground-water sampling today: aquifer heterogeneity and colloidal transport. Aquifer heterogeneities affect contaminant flow paths and include variations in geology, geochemistry, hydrology and microbiology. As methods and the tools available for subsurface investigations have become increasingly sophisticated and understanding of the subsurface environment has advanced, there is an awareness that in most cases a primary concern for site investigations is characterization of contaminant flow paths rather than entire aquifers. In fact, in many cases, plume thickness can be less than well screen lengths (e.g. 3-6 m) typically installed at hazardous waste sites to detect and monitor plume movement over time. Small-scale differences have increasingly been shown to be important and there is general trend toward smaller diameter wells and shorter screens.

The hydrogeochemical significance of colloidal-size particles in subsurface systems has been realized during the past several years (Gschwend and Reynolds, 1987; McCarthy and Zachara, 1989; Puls, 1990; Ryan and Gschwend, 1990). This realization resulted from both field and laboratory studies that showed faster contaminant migration over greater distances and at higher concentrations than flow and transport model predictions would suggest.
Such models typically account for interaction between the mobile aqueous and immobile solid phases, but do not allow for a mobile, reactive solid phase. This recognition of this third "phase" as a possible means of contaminant transport that has brought increasing attention to the manner in which samples are collected and processed for analysis (Puls et al. 1990; McCarthy and Degueldre, 1993; Backhus et al. 1993; USEPA 1995). If such a phase present in sufficient mass, possesses high sorption reactivity, large surface area, and remains stable in suspension, it can serve as an important mechanism to facilitate contaminant transport in many types of subsurface systems.

Colloids are particles that are sufficiently small that the surface free energy of the particle dominates the bulk free energy. Typically, in ground water, this includes particles with diameters between 1 and 1000 nm. The most commonly observed mobile particles include: secondary clay minerals; hydrous iron, aluminum, and manganese oxides; dissolved and particulate organic materials, and viruses and bacteria. These reactive particles have been shown to be mobile under a variety of conditions in both field studies and laboratory column experiments, and as such need to be included in monitoring programs where identification of the "total" mobile contaminant loading (dissolved + naturally suspended particles) at a site is an objective. To that end, sampling methodologies must be used which do not artificially bias "naturally" suspended particle concentrations.

Currently the most common ground-water purging and sampling methodology is to purge a well using bailers or high speed pumps to remove 3 to 5 casing volumes followed by sample collection. This method can cause adverse impacts on sample quality through collection of samples with high levels of turbidity. This results in the inclusion of otherwise immobile artifactual particles which produce an overestimation of certain analytes of interest (e.g. metals or hydrophobic organic compounds). Numerous documented problems associated with filtration (Danielsson, 1982; Laxen and Chandler, 1982; Horowitz et al. 1992) make this an undesirable method of rectifying the turbidity problem, and include the
removal of potentially mobile (contaminant-associated) particles during filtration, thus artificially biasing contaminant concentrations low. Sampling-induced turbidity problems can often be mitigated by using low-flow purging and sampling techniques.

Current subsurface conceptual models have undergone considerable refinement due to the recent development and increased use of field screening tools. So-called hydraulic "push" technologies (e.g. cone penetrometer, Geoprobe®, QED HydroPunch®) enable relatively fast screening site characterization which can then be used to design and install a monitoring well network. Indeed, alternatives to conventional monitoring wells are now being considered for some hydrogeologic settings. The ultimate design of any monitoring system should however be based upon adequate site characterization and be consistent with established monitoring objectives.

If the sampling program objectives include accurate assessment of the magnitude and extent of subsurface contamination over time and/or accurate assessment of subsequent remedial performance then some information regarding plume delineation in three dimensional space is necessary prior to monitoring well network design and installation. This can be accomplished with a variety of different tools and equipment ranging from hand-operated augers to screening tools mentioned above and large drilling rigs. Detailed information on groundwater flow velocity, direction, and horizontal and vertical variability are essential baseline data requirements. Detailed soil and geologic data are required prior to and during the installation of sampling points. This includes historical as well as detailed soil and geologic logs which accumulate during the site investigation. The use of borehole geophysical techniques are also recommended. With this information (together with other site characterization data) and a clear understanding of sampling objectives, then appropriate location, screen length, well diameter, slot size etc. for the monitoring well network can decided. This is especially critical for new in situ remedial approaches or natural attenuation assessments at hazardous waste sites.
In general, the overall goal of any ground-water sampling program is to collect water samples with no alteration in water chemistry; analytical data thus obtained may be used for a variety of specific monitoring programs depending on the regulatory requirements. The sampling methodology described in this paper assumes that the monitoring goal is to sample monitoring wells for the presence of contaminants and it is applicable whether mobile colloids are a concern or not and whether the analytes of concern are metals (and metalloids) or organic compounds.

II. Monitoring Objectives and Design Considerations.

The following issues are important to consider prior to the design and implementation of any ground-water monitoring program, including those which anticipate using low-flow purging and sampling procedures.

A. Data Quality Objectives (DQO's)

Monitoring objectives include four main types: detection, assessment, corrective-action evaluation and resource evaluation, along with "hybrid" variations such as site-assessments for property transfers and water availability investigations. Monitoring objectives may change as contamination or water quality problems are discovered. However, there are a number of common components of monitoring programs which should be recognized as important regardless of initial objectives. These components include:

1) Development of a conceptual model that incorporates elements of the regional geology to the local geologic framework. The conceptual model development also includes initial site characterization efforts to identify hydrostratigraphic units and likely flow-paths using a minimum number of borings and well completions;
2) Cost-effective and well documented collection of high quality data utilizing simple, accurate, and reproducible techniques; and
3) Refinement of the conceptual model based on supplementary data collection and analysis. These fundamental components serve many types of monitoring programs and provide a basis for future efforts that evolve in complexity and level of spatial detail as purposes and objectives expand. High quality, reproducible data collection is a common goal regardless of program objective. High quality data collection implies data of sufficient accuracy, precision, and completeness (i.e. ratio of valid analytical results to the minimum sample number called for by the program design) to meet the program objectives. Accuracy depends on the correct choice of monitoring tools and procedures to minimize sample and subsurface disturbance from collection to analysis. Precision depends on the repeatability of sampling and analytical protocols. It can be assured or improved by replication of sample analyses including blanks, field/lab standards and reference standards.

B. Sample Representativeness

An important goal of any monitoring program is collection of data that is truly representative of conditions at the site. The term representativeness applies to chemical and hydrogeologic data collected via wells, borings, piezometers, geophysical and soil gas measurements, lysimeters, and temporary sampling points. It involves a recognition of the statistical variability of individual subsurface physical properties, and contaminant or major ion concentration levels, while explaining extreme values. Subsurface temporal and spatial variability are facts. Good professional practice seeks to maximize representativeness by using proven accurate and reproducible techniques to define limits on the distribution of measurements collected at a site. However, measures of representativeness are dynamic and are controlled by evolving site characterization and monitoring objectives. An evolutionary site characterization model, as shown in Figure 1, provides a systematic approach to the goal of consistent data collection.

Figure 1. Evolutionary Site Characterization Model
The model emphasizes a recognition of the causes of the variability (e.g., use of inappropriate technology such as using bailers to purge wells, imprecise or operator dependent methods) and the need to control avoidable errors.

1) Questions of scale
A sampling plan designed to collect representative samples must take into account the potential scale of changes in site conditions through space and time as well as the chemical associations and behavior of the parameters that are targeted for investigation. In subsurface systems, physical (i.e. aquifer) and chemical properties over time or space are not statistically independent. In fact, samples taken in close proximity (i.e. within distances of a few yards) or within short time periods (i.e. more frequently than monthly) are highly auto-correlated. This means that designs employing high-sampling frequency (e.g. monthly) or dense spatial monitoring designs run the risk of redundant data collection and misleading inferences regarding trends in values that aren't statistically valid. In practice, contaminant detection and assessment monitoring programs rarely suffer these "over-sampling" concerns. In corrective-action evaluation programs, it is also possible that too little data may be collected over space or time. In these cases, false interpretation of the spatial extent of contamination or underestimation of temporal concentration variability may result.

2) Target Parameters
Parameter selection in monitoring program design is most often dictated by the regulatory status of the site. However, background water quality constituents, purging indicator parameters, and contaminants, all represent targets for data collection programs. The tools and procedures used in these programs should be equally rigorous and applicable to all categories of data, since all may be needed to determine or support regulatory action.

C. Sampling Point Design and Construction
Detailed site characterization is central to all decision-making purposes and the basis for this characterization resides in identification of the geologic framework and major hydro-stratigraphic units. Fundamental data for sample point location
include: subsurface lithology, head-differences and background geochemical conditions. Each sampling point has a proper use or uses which should be documented at a level which is appropriate for the program’s data quality objectives. Individual sampling points may not always be able to fulfill multiple monitoring objectives (e.g., detection, assessment, corrective action).

1) Compatibility with Monitoring Program and Data Quality Objectives
Specifics of sampling point location and design will be dictated by the complexity of subsurface lithology and variability in contaminant and/or geochemical conditions. It should be noted that, regardless of the ground-water sampling approach, few sampling points (e.g. wells, drive-points, screened augers) have zones of influence in excess of a few feet. Therefore the spatial frequency of sampling points should be carefully selected and designed.

2) Flexibility of Sampling Point Design
In most cases "well-point" diameters in excess of 1 7/8 inches will permit the use of most types of submersible pumping devices for low-flow (minimal drawdown) sampling. It is suggested that "short" (e.g. less than 1.6 m) screens be incorporated into the monitoring design where possible so that we might expect comparable results from one device to another. "Short", of course, is relative to the degree of vertical water quality variability expected at a site.

3) Equilibration of Sampling Point
Time should be allowed for equilibration of the well or sampling point with the formation after installation. Placement of well or sampling points in the subsurface produces some disturbance of ambient conditions. Drilling techniques (e.g. auger, rotary, etc.) are generally considered to cause more disturbance than "direct-push" technologies. In either case, there may be a period (i.e. days to months) during which water quality near the point may be distinctly different from that in the formation. Proper development of the sampling point and adjacent formation to remove fines created during emplacement will shorten this water quality "recovery" period.
III. Definition of Low-Flow Purging and Sampling

It is generally accepted that water in the well casing is non-representative of the formation water and needs to be purged prior to collection of ground-water samples. However, the water in the screened interval may indeed be representative of the formation, depending upon well construction and site hydrogeology. Wells are purged to some extent for the following reasons: the presence of the air interface at the top of the water column resulting in an oxygen concentration gradient with depth, loss of volatiles up the water column, leaching from or sorption to the casing or filter pack, chemical changes due to clay seals or backfill, and surface infiltration.

Low-flow purging, whether using portable or dedicated systems, should be done using pump-intake located in the middle or slightly above the middle of the screened interval. Placement of the pump too close to the bottom of the well will cause increased entrainment of solids which have collected in the well over time. These particles are present as a result of well development, prior purging and sampling events, and natural colloidal transport and deposition. Therefore, placement of the pump in the middle or toward the top of the screened interval is suggested.

Placement of the pump at the top of the water column for sampling is only recommended in unconfined aquifers, screened across the water table, where this is the desired sampling point. Low-flow purging has the advantage of minimizing mixing between the overlying stagnant casing water and water within the screened interval.

A. Low-Flow Purging Sampling

Low-flow refers to the velocity with which water enters the pump intake and that is imparted to the formation pore water in the immediate vicinity of the well screen. It does not necessarily refer to the flow rate of water discharged at the
surface which can be affected by flow regulators or restrictions. Water level drawdown provides the best indication of the stress imparted by a given flow-rate for a given hydrological situation. The objective is to pump in a manner that minimizes stress (drawdown) to the system to the extent practical taking into account established site sampling objectives. Typically flow rates on the order of 0.1 - 0.5 L/min are used, however this is dependent on site-specific hydrogeology. Some extremely coarse-textured formations have been successfully sampled in this manner at flow rates to 1 L/min. The effectiveness of using low-flow purging is intimately linked with proper screen location, screen length, and well construction and development techniques. The reestablishment of natural flow paths in both the vertical and horizontal directions are important for correct interpretation of the data. For high resolution sampling needs, screens less than 1 m should be used. Most of the need for purging has been found to be due to passing the sampling device through the overlying casing water which causes mixing of these stagnant waters and the dynamic waters within the screened interval. Additionally, there is disturbance to suspended sediment collected in the bottom of the casing and the displacement of water out into the formation immediately adjacent to the well screen. These disturbances and impacts can be avoided using dedicated sampling equipment, which precludes the need to insert the sampling device prior to purging and sampling.

Isolation of the screened interval water from the overlying stagnant casing water may be accomplished using low-flow minimal drawdown techniques. If the pump intake is located within the screened interval most of the water pumped will be drawn in directly from the formation with little mixing of casing water or disturbance to the sampling zone. However, if the wells are not constructed and developed properly, zones other than those intended may be sampled. At some sites where geologic heterogeneities are sufficiently different within the screened interval, higher conductivity zones may be preferentially sampled. This is another reason to use shorter screened intervals, especially where high spatial resolution is a sampling objective.
B. Water Quality Indicator Parameters

It is recommended that water quality indicator parameters be used to determine purging needs prior to sample collection in each well. Stabilization of parameters such as pH, specific conductance, dissolved oxygen, oxidation-reduction potential, temperature and turbidity should be used to determine when formation water is accessed during purging. In general the order of stabilization is pH, temperature, and specific conductance, followed by oxidation-reduction potential, dissolved oxygen and turbidity. Temperature and pH, while commonly used as purging indicators, are actually quite insensitive in distinguishing between formation water and stagnant casing water; nevertheless, these are important parameters for data interpretation purposes and should also be measured. Performance criteria for determination of stabilization should be based on water-level drawdown, pumping rate and equipment specifications for measuring indicator parameters. Instruments are available which utilize in-line flow cells to continuously measure the above parameters.

It is important to establish specific well stabilization criteria and then consistently follow the same methods thereafter, particularly with respect to drawdown, flow rate and sampling device. Generally the time or purge volume required for parameter stabilization is independent of well depth or well volumes. Dependent variables are well diameter, sampling device, hydrogeochemistry, pump flow rate, and whether the devices are used in a portable or dedicated manner. If the sampling device is already in place (ie, dedicated sampling systems), then the time and purge volume needed for stabilization is much shorter. Other advantages of dedicated equipment include less purge water for waste disposal, much less decontamination of equipment, less time spent in preparation of sampling as well as time in the field, and more consistency in the sampling approach which probably will translate into less variability in sampling results. The use of dedicated equipment is strongly recommended at wells which will undergo routine sampling over time.
If parameter stabilization criteria are too stringent, then minor oscillations in indicator parameters may cause purging operations to become unnecessarily protracted. It should also be noted that turbidity is a very conservative parameter in terms of stabilization. Turbidity is always the last parameter to stabilize. Excessive purge times are invariably related to the establishment of too stringent turbidity stabilization criteria. It should be noted that natural turbidity levels in ground water may exceed 10 nephelometric turbidity units (NTU).

C. Advantages and Disadvantages of Low-Flow (Minimum Drawdown) Purging

In general, the advantages of low-flow purging include:

- samples which are representative of the 'mobile' load of contaminants present (dissolved and colloid-associated),
- minimal disturbance of the sampling point thereby minimizing sampling artifacts,
- less operator variability, greater operator control,
- reduced stress on the formation (minimal drawdown),
- less mixing of stagnant casing water with formation water,
- reduced need for filtration and therefore less time required for sampling,
- smaller purging volume which decrease waste disposal costs and sampling time,
- better sample consistency; reduced artificial sample variability

Some disadvantages of low-flow purging are:

- higher initial capital costs,
- greater set-up time in the field,
- need to transport additional equipment to and from the site,
- increased training needs,
- resistance to change on the part of sampling practitioners,
- concern that new data will indicate a "change in conditions" and trigger an "action".

IV. Low-Flow (Minimal Drawdown) Sampling Protocols
The following ground water sampling procedure has evolved over many years of experience in ground water sampling for organic and inorganic compound determinations and as such summarizes the authors (and others) experiences to date (Barcelona et al., 1984, 1994; Barcelona and Helfrich, 1986; Puls and Barcelona, 1989; Puls et. al. 1990, 1992; Puls and Powell, 1992; Puls and Paul, 1995). High-quality chemical data collection is essential in ground water monitoring and site characterization. The primary limitations to the collection of "representative" ground water samples include: mixing of the stagnant casing and "fresh" screen waters during insertion of the sampling device or ground water level measurement device; disturbance and resuspension of settled solids at the bottom of the well when using high pumping rates or raising and lowering a pump or bailer; introduction of atmospheric gases or degassing from the water during sample handling and transfer, or inappropriate use of vacuum sampling device etc.

A. Sampling Recommendations

Water samples should not be taken immediately following well development. Sufficient time should be allowed for the ground water flow regime in the vicinity of the monitoring well to stabilize and to let chemical equilibrium with the well construction materials be approached. This lag time will depend on site conditions and methods of installation but often exceeds one week. Well purging is nearly always necessary to obtain samples of water flowing through the geologic formations in the screened interval. Rather than using a general but arbitrary guideline of purging three casing volumes prior to sampling, it is recommended that an in-line water quality measurement device (e.g. flow-through cell) be used to establish the stabilization time for several parameters (e.g. pH, specific conductance, redox, dissolved oxygen, turbidity) on a well-specific basis. Data on pumping rate, drawdown, and volume required for parameter stabilization can be used as a guide for conducting subsequent sampling activities.
The following are recommendations to be considered before, during and after sampling:

- use low flow rates (<0.5 L/min), during both purging and sampling maintain minimal drawdown in the well;
- maximize tubing wall thickness, minimize tubing length; place the sampling device intake at the desired sampling point;
- minimize disturbances of the stagnant water column above the screened interval during water level measurement and sampling device insertion;
- make proper adjustments to stabilize the flow rate as soon as possible;
- monitor water quality indicators during purging;
- collect unfiltered samples to estimate contaminant loading and transport potential in the subsurface system.

B. Equipment Calibration

Prior to sampling, all sampling device and monitoring equipment should be calibrated according to manufacture's recommendations and the site Quality Assurance Project Plan (QAPP) and Field Sampling Plan (FSP). Calibration of pH should be performed with at least two buffers which bracket the expected range. Dissolved oxygen calibration must be corrected for local barometric pressure readings and elevation.

C. Water Level Measurement and Monitoring

It is recommended that a device be used which will least disturb the water surface in the casing. Well depth should be obtained from the well logs. Measuring to the bottom of the well casing will only cause resuspension of settled solids from the formation and require longer purging times for turbidity equilibration. Measure well depth after sampling is completed. The water level measurement should be taken from a permanent reference point which is surveyed in relative to ground elevation.

D. Pump Type
The use of low flow (e.g. 0.1-0.5 L/min) pumps is suggested for purging and sampling all types of analytes. All pumps have some limitation and these should be investigated with respect to application at a particular site. Bailers are inappropriate devices for low-flow sampling.

1) General Considerations
There are no unusual requirements for ground-water sampling devices when using low-flow, minimal drawdown techniques. The major concern is that the device give consistent results and minimal disturbance of the sample across a range of "low" flow rates (i.e. < 0.5 L/min). Clearly, pumping rates that cause minimal to no drawdown in one well could easily cause "significant" drawdown in another well finished in a less transmissive formation. In this sense, the pump should not cause undue pressure or temperature changes or physical disturbance on the water sample over a reasonable sampling range. Consistency in operation is critical to meet accuracy and precision goals.

2) Advantages Disadvantages of Sampling Devices
A variety of sampling devices are available for low-flow (minimal drawdown) purging and sampling and include peristaltic pumps, bladder pumps, electrical submersible pumps, and gas-driven pumps. Devices which lend themselves to both dedication and consistent operation at definable low-flow rates are preferred. It is desirable that the pump be easily adjustable and operate reliably at these lower flow rates. The peristaltic pump is limited to shallow applications and can cause degassing resulting in alteration of pH, alkalinity, and some volatiles loss. Gas-drive pumps should be of a type that does not allow the gas to be in direct contact with the sampled fluid.

Clearly, bailers and other "grab" type samplers are ill-suited for low-flow sampling since they will cause repeated disturbance and mixing of "stagnant" water in the casing and the "dynamic" water in the screened interval. Similarly, the use of inertial lift foot-valve type samplers may cause too much disturbance at the point of sampling. Use of these devices also tend to introduce uncontrolled and unacceptable operator variability.

E. Pump Installation

Dedicated sampling devices (left in the well) capable of pumping and sampling are preferred over any other type of device. Any portable sampling device should be slowly and carefully lowered to the middle of the screened interval or slightly above the middle (e.g. 1-1.5 m below the top of a 3 m screen). This is to minimize excessive mixing of the stagnant water in the casing above the screen with the screened interval zone water, and to minimize resuspension of solids which will have collected at the bottom of the well. These two disturbance effects have been shown to directly affect the time required for purging. There also appears to be a direct correlation between size of portable sampling devices relative to the well bore and resulting purge volumes and times. The key is to minimize disturbance of water and solids in the well casing.

F. Filtration

Decisions to filter samples should be dictated by sampling objectives rather than as a "fix" for poor sampling practices, and field-filtering of certain constituents should not be the default. Consideration should be given as to what the application of field-filtration is trying to accomplish. For assessment of truly dissolved (as opposed to operationally "dissolved" [ie. samples filtered with 0.45 μm filters]) concentrations of major ions and trace metals, 0.1 μm filters are recommended although 0.45 μm filters are normally used for most regulatory programs. Alkalinity samples must also be filtered if significant particulate calcium carbonate is suspected, since this material is likely to impact alkalinity titration results (although filtration itself may alter the CO2 composition of the sample and therefore affect the results).
Although filtration may be appropriate, filtration of a sample may cause a number of unintended changes to occur (e.g. oxidation, aeration) possibly leading to filtration-induced artifacts during sample analysis and uncertainty in the results. Some of these unintended changes may be unavoidable but the factors leading to them must be recognized. Deleterious effects can be minimized by consistent application of certain filtration guidelines. Guidelines should address selection of filter type, media, pore size, etc. in order to identify and minimize potential sources of uncertainty when filtering samples.

In-line filtration is recommended because it provides better consistency through less sample handling, and minimizes sample exposure to the atmosphere. In-line filters are available in both disposable (barrel filters) and non-disposable (in-line filter holder, flat membrane filters) formats and various filter pore sizes (0.1-5.0 μm). Disposable filter cartridges have the advantage of greater sediment handling capacity when compared to traditional membrane filters. Filters must be pre-rinsed following manufacturer’s recommendations. If there are no recommendations for rinsing, pass through a minimum of 1 L of ground water following purging and prior to sampling. Once filtration has begun, a filter cake may develop as particles larger than the pore size accumulate on the filter membrane. The result is that the effective pore diameter of the membrane is reduced and particles smaller than the stated pore size are excluded from the filtrate. Possible corrective measures include prefiltering (with larger pore size filters), minimizing particle loads to begin with, and reducing sample volume.

G. Monitoring of Water Level and Water Quality Indicator Parameters

Check water level periodically to monitor drawdown in the well as a guide to flow rate adjustment. The goal is minimal drawdown (<0.1 m) during purging. This goal may be difficult to achieve under some circumstances due to geologic heterogeneities within the screened interval, and may require adjustment based
on site-specific conditions and personal experience. In-line water quality indicator parameters should be continuously monitored during purging. The water quality indicator parameters monitored can include pH, redox potential, conductivity, dissolved oxygen (DO) and turbidity. The last three parameters are often most sensitive. Pumping rate, drawdown, and the time or volume required to obtain stabilization of parameter readings can be used as a future guide to purge the well. Measurements should be taken every three to five minutes if the above suggested rates are used. Stabilization is achieved after all parameters have stabilized for three successive readings. In lieu of measuring all five parameters a minimum subset would include pH, conductivity, and turbidity or DO. Three successive readings should be within ± 0.1 for pH, ± 3% for conductivity, ± 10 mv for redox potential, and ± 10% for turbidity and DO. Stabilized purge indicator parameter trends are generally obvious and follow either an exponential or asymptotic change to stable values during purging. Dissolved oxygen and turbidity usually require the longest time for stabilization. The above stabilization guidelines are provided for rough estimates based on experience.

H. Sampling, Sample Containers, Preservation and Decontamination

Upon parameter stabilization, sampling can be initiated. If an in-line device is used to monitor water quality parameters, it should be disconnected or bypassed during sample collection. Sampling flow rate may remain at established purge rate or may be adjusted slightly to minimize aeration, bubble formation, turbulent filling of sample bottles, or loss of volatiles due to extended residence time in tubing. Typically, flow rates less than 0.5 L/min are appropriate. The same device should be used for sampling as was used for purging. Sampling should occur in a progression from least to most contaminated well if this is known. Generally, volatile (e.g. solvents and fuel constituents) and gas sensitive (e.g. Fe 2+, CH 4, H 2 S/HS -, alkalinity) parameters should be sampled first. The sequence in
which samples for most inorganic parameters are collected is immaterial unless filtered (dissolved) samples are desired. Filtering should be done last and in-line filters should be used as discussed above. During both well purging and sampling, proper protective clothing and equipment must be used based upon the type and level of contaminants present.

The appropriate sample container will be prepared in advance of actual sample collection for the analytes of interest and include sample preservative where necessary. Water samples should be collected directly into this container from the pump tubing.

Immediately after a sample bottle has been filled, it must be preserved as specified in the site Quality Assurance Project Plan (QAPP). Sample preservation requirements are based on the analyses being performed (use site QAPP, Field Safety Plan [FSP], USEPA, 1992 RCRA guidance document or EPA SW-846). It may be advisable to add preservatives to sample bottles in a controlled setting prior to entering the field in order to reduce the chances of improperly preserving sample bottles or introducing field contaminants into a sample bottle while adding the preservatives.

The preservatives should be transferred from the chemical bottle to the sample container using a disposable polyethylene pipet and the disposable pipet should be used only once and then discarded.

After a sample container has been filled with ground water, a Teflon (or tin)-lined cap is screwed on tightly to prevent the container from leaking. A sample label is filled out as specified in the Field Sampling Plan (FSP). The samples should be stored inverted at 4°C.

Specific decontamination protocols for sampling devices are dependent to some extent on the type of device used and the type of contaminants encountered. Refer to the site QAPP and FSP for specific requirements.

I. Blanks

The following blanks should be collected:
(1) field blank: one field blank should be collected from each source water (distilled/deionized water) used for sampling equipment decontamination or for assisting well development procedures.

(2) equipment blank: one equipment blank should be taken prior to the commencement of field work, from each set of sampling equipment to be used for that day. Refer to site QAPP or FSP for specific requirements.

(3) trip blank: a trip blank is required to accompany each volatile sample shipment. These blanks are prepared in the laboratory by filling a 40-mL volatile organic analysis (VOA) bottle with distilled/deionized water.

V. Low-Permeability Formations and Fractured Rock

The overall sampling program goals or sampling objectives will drive how the sampling points are located, installed, and choice of sampling device. Likewise, site-specific hydrogeologic factors will affect these decisions. Sites with very low permeability formations or fractures causing discrete flow channels may require a unique monitoring approach. Unlike water supply wells, wells installed for ground-water quality assessment and restoration programs are often installed in low water-yielding settings (e.g. clays, silts). Alternative types of sampling points and sampling methods are often needed in these types of environments, because low-permeability settings may require extremely low-flow purging (<0.1 L/min) and may be technology-limited. Where devices are not readily available to pump at such low flow rates, the primary consideration is to avoid dewatering of the well screen. This may require repeated recovery of the water during purging while leaving the pump in place within the well screen.

Use of low-flow techniques may be impractical in these settings, depending upon the water recharge rates. The sampler and the end-user of data collected from such wells need to understand the limitations of the data collected, i.e. a strong potential for underestimation of actual contaminant concentrations for volatile organics, potential false negatives for filtered metals and potential false positives for unfiltered metals. It is suggested that comparisons be made between samples
recovered using low-flow purging techniques and samples recovered using passive sampling techniques (i.e. two sets of samples). Passive sample collection would essentially entail acquisition of the sample with no or very little purging using a dedicated sampling system installed within the screened interval or a passive sample collection device.

A. Low-Permeability Formations (<0.1 L/min recharge)

1. Low-Flow Purging and Sampling with Pumps
   a. "portable or non-dedicated mode" - Lower the pump (one capable of pumping at <0.1 L/min) to mid-screen or slightly above and set in place for minimum of 48 hours (to lessen purge volume requirements). After 48 hours, use procedures listed in Part IV above regarding monitoring water quality parameters for stabilization, etc., but do not dewater the screen. If excessive drawdown and slow recovery is a problem, then alternate approaches such as those listed below may be better.
   b. "dedicated mode" - Set the pump as above at least a week prior to sampling; that is, operate in a dedicated pump mode. With this approach significant reductions in purge volume should be realized. Water quality parameters should stabilize quite rapidly due to less disturbance of the sampling zone.

2. Passive Sample Collection
   Passive sampling collection requires insertion of the device into the screened interval for a sufficient time period to allow flow and sample equilibration before extraction for analysis. Conceptually, the extraction of water from low yielding formations seems more akin to the collection of water from the unsaturated zone and passive sampling techniques may be more appropriate in terms of obtaining "representative" samples. Satisfying usual sample volume requirements is typically a problem with this approach and some latitude will be needed on the part of regulatory entities to achieve sampling objectives.
B. Fractured Rock

In fractured rock formations, a low-flow to zero purging approach using pumps in conjunction with packers to isolate the sampling zone in the borehole is suggested. Passive multi-layer sampling devices may also provide the most "representative" samples. It is imperative in these settings to identify flow paths or water-producing fractures prior to sampling using tools such as borehole flowmeters and/or other geophysical tools.

After identification of water-bearing fractures, install packer(s) and pump assembly for sample collection using low-flow sampling in "dedicated mode" or use a passive sampling device which can isolate the identified water bearing fractures.

VI. Documentation

The usual practices for documenting the sampling event should be used for low-flow purging and sampling techniques. This should include, at a minimum: information on the conduct of purging operations (flow-rate, drawdown, water-quality parameter values, volumes extracted and times for measurements), field instrument calibration data, water sampling forms and chain of custody forms. See Figures 2 and 3 and "Ground Water Sampling Workshop -- A Workshop Summary" (USEPA, 1995) for example forms and other documentation suggestions and information. This information coupled with laboratory analytical data and validation data are needed to judge the "useability" of the sampling data.

VII. References


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ATTACHMENT B

ORGANIC ANALYTICAL SERVICE FOR SUPERFUND (OLM 04.2)
QUICK REFERENCE FACT SHEET WITH TABLES
Multi-Media,
Multi-Concentration,
Organic Analytical Service for Superfund (OLM04.2)

Office of Emergency and Remedial Response
Analytical Operations/Data Quality Center (5204G)

Under the legislative authority granted to the U.S. Environmental Protection Agency (EPA) under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Superfund Amendments and Reauthorization Act of 1986 (SARA), EPA develops standardized analytical methods for the measurement of various pollutants in environmental samples from known or suspected hazardous waste sites. Among the pollutants of concern to the EPA at such sites, are a series of volatile, semivolatile, and pesticide/Aroclor (pesticide PCB) compounds that are analyzed using gas chromatography coupled with mass spectrometry (GC/MS) and gas chromatography with an electron capture detector (GC/ECD). The Analytical Operations/Data Quality Center (AOC) of the Office of Emergency and Remedial Response (OERR) offers an analytical service that provides data from the analysis of water and soil sediment samples for organic compounds for use in the Superfund decision-making process. Through a series of standardized procedures and a strict chain-of-custody, the organic analytical service produces data of known and documented quality. This service is available through the Superfund Contract Laboratory Program (CLP).

DESCRIPTION OF SERVICES

The new organic analytical service is available as of September 1999. It provides a technical and contractual framework for laboratories to apply EPA CLP analytical methods for the isolation, detection, and quantitative measurement of 48 volatile, 65 semivolatile, and 28 pesticide Aroclor (pesticide PCB) target compounds in water and soil sediment environmental samples. The CLP provides the methods to be used and the specific technical, reporting, and contractual requirements, including quality assurance (QA), quality control (QC), and standard operating procedures (SOPs), by which EPA evaluates the data. This service uses GC/MS and GC/ECD methods to analyze the target compounds. Three data delivery turnarounds are available to CLP customers: 7, 14, and 21-day turnaround after laboratory receipt of the last sample in the set. In addition, there are 48 (for volatiles) and 72-hour (for semivolatiles and pesticides/Aroclors (pesticides/PCBs)) preliminary data submission options available. New options under this service include a closed system purge-and-trap method for low level volatile soil analysis and methanol preservation for medium level volatile soil analysis. In addition, users may request modifications to the specified methodologies that may include, but are not limited to, additional compounds and modified quantitation limits. A flexibility clause is also available to data users to submit samples using modified analyses to meet specific field requirements. These requirements include modified lower "California level" quantitation limits, additional analytes, and requirements to enhance method performance.

DATA USES

This analytical service provides data which EPA uses for a variety of purposes, such as determining the nature and extent of contamination at a hazardous waste site, assessing priorities for response based on risks to human health and the environment, determining appropriate cleanup actions, and determining when remedial actions are complete. The data may be used in all stages in the investigation of a hazardous waste site including site inspections, Hazard Ranking System scoring, remedial investigations/feasibility studies, remedial design, treatability studies, and removal actions. In addition, this service provides data that will be available for use in Superfund enforcement/litigation activities.

TARGET COMPOUNDS

The compounds for which this service is applicable and the corresponding quantitation limits are listed in Table 1. For water samples, the lowest quantitation limits reportable are 10 ppb for the volatile compounds, 10 ppb for the semivolatile compounds, and 0.05 ppb for the pesticide/Aroclor (pesticide PCB) compounds. For soil samples, the lowest quantitation limits reportable are 10 ppb for the volatile compounds, 330 ppb for the semivolatile compounds, and 1.7 ppb for the pesticide/Aroclor...
**Table 1. Target Compound List and Contract Required Quantitation Limits (CRQLs) For OLM04.2**

<table>
<thead>
<tr>
<th>VOLATILES</th>
<th>SEMIVOLATILES</th>
<th>PESTICIDES/AROCORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Dichlorodifluoromethane</td>
<td>SFMIVOLATILES</td>
<td>PESTICIDES/SPCBs</td>
</tr>
<tr>
<td>2. Chloromethane</td>
<td>59. Benzylalcohol</td>
<td>Water (µg/L)</td>
</tr>
<tr>
<td>3. vinyl chloride</td>
<td>60. Phenol</td>
<td>10</td>
</tr>
<tr>
<td>4. Bromomethane</td>
<td>61. 1,2-Chloroethane</td>
<td>10</td>
</tr>
<tr>
<td>5. Chloroethane</td>
<td>62. 2,4-Dichlorophenol</td>
<td>10</td>
</tr>
<tr>
<td>6. Trichlorofluoromethane</td>
<td>63. 2-Chloroethanol</td>
<td>10</td>
</tr>
<tr>
<td>7. 1,1-Dichloroethene</td>
<td>64. 2,2-Dichlorophenol</td>
<td>10</td>
</tr>
<tr>
<td>8. 1,1,2-trichloroethane</td>
<td>65. Naphthalene</td>
<td>10</td>
</tr>
<tr>
<td>9. Acetone</td>
<td>66. 4-Chloroaniline</td>
<td>10</td>
</tr>
<tr>
<td>11. Methylene Chloride</td>
<td>68. Caprolactam</td>
<td>10</td>
</tr>
<tr>
<td>12. trichloroethylene</td>
<td>69. 4-Chloro-3-methylphenol</td>
<td>10</td>
</tr>
<tr>
<td>13. Methylecholoroethane</td>
<td>70. 2-Methylnaphthalene</td>
<td>10</td>
</tr>
<tr>
<td>14. Methyl vinyl ether</td>
<td>71. 2-Nitrophenol</td>
<td>10</td>
</tr>
<tr>
<td>15. 1,1-Dichloroethane</td>
<td>72. 2-Chloroaniline</td>
<td>10</td>
</tr>
<tr>
<td>16. cis-1,2-Dichloroethene</td>
<td>73. 2,4-Dichlorophenol</td>
<td>10</td>
</tr>
<tr>
<td>17. 2-Butanone</td>
<td>74. 2,4-Dichlorophenol</td>
<td>10</td>
</tr>
<tr>
<td>18. Chloroform</td>
<td>75. 2-Chlorobenzene</td>
<td>10</td>
</tr>
<tr>
<td>19. 1,1,1-trichloroethane</td>
<td>76. 2-Chlorophenol</td>
<td>10</td>
</tr>
<tr>
<td>20. Cyclohexene</td>
<td>77. 2-Chlorophenol</td>
<td>10</td>
</tr>
<tr>
<td>21. Carbon Tetrachloride</td>
<td>78. 2,4-Dichlorophenol</td>
<td>10</td>
</tr>
<tr>
<td>22. Benzene</td>
<td>79. 2,4-Dichlorophenol</td>
<td>10</td>
</tr>
<tr>
<td>23. 1,2-Dichloroethane</td>
<td>80. 2,4-Dichlorophenol</td>
<td>10</td>
</tr>
<tr>
<td>24. Trichloroethene</td>
<td>81. 2,4-Dichlorophenol</td>
<td>10</td>
</tr>
<tr>
<td>25. Methylcyclohexane</td>
<td>82. 2,4-Dichlorophenol</td>
<td>10</td>
</tr>
<tr>
<td>26. 1,2-Dichloropropane</td>
<td>83. 2,4-Dichlorophenol</td>
<td>10</td>
</tr>
<tr>
<td>27. Bromoform</td>
<td>84. 2,4-Dichlorophenol</td>
<td>10</td>
</tr>
<tr>
<td>28. cis-1,3-Dichloropropene</td>
<td>85. 2,4-Dichlorophenol</td>
<td>10</td>
</tr>
<tr>
<td>29. 4-Methyl-2-pentanone</td>
<td>86. 2,4-Dichlorophenol</td>
<td>10</td>
</tr>
<tr>
<td>30. Toluene</td>
<td>87. 2,4-Dichlorophenol</td>
<td>10</td>
</tr>
<tr>
<td>31. trichloroethylene</td>
<td>88. 2,4-Dichlorophenol</td>
<td>10</td>
</tr>
<tr>
<td>32. 1,1,2-trichloroethane</td>
<td>89. 2,4-Dichlorophenol</td>
<td>10</td>
</tr>
<tr>
<td>33. Tetrachloroethene</td>
<td>90. 2,4-Dichlorophenol</td>
<td>10</td>
</tr>
<tr>
<td>34. 2-Hexancne</td>
<td>91. 2,4-Dichlorophenol</td>
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</tr>
<tr>
<td>35. Dichloromethanol</td>
<td>92. 2,4-Dichlorophenol</td>
<td>10</td>
</tr>
<tr>
<td>36. 1,2-Dibromoethane</td>
<td>93. 2,4-Dichlorophenol</td>
<td>10</td>
</tr>
<tr>
<td>37. Chlorobenzene</td>
<td>94. 2,4-Dichlorophenol</td>
<td>10</td>
</tr>
<tr>
<td>38. Ethylbenzene</td>
<td>95. 2,4-Dichlorophenol</td>
<td>10</td>
</tr>
<tr>
<td>39. Xylenes (Total)</td>
<td>96. Phenanthrene</td>
<td>10</td>
</tr>
<tr>
<td>40. styrene</td>
<td>97. Anthracene</td>
<td>10</td>
</tr>
<tr>
<td>41. Bromoform</td>
<td>98. Carbazole</td>
<td>10</td>
</tr>
<tr>
<td>42. Isopropylbenzene</td>
<td>99. Dim-n-butylphthalate</td>
<td>10</td>
</tr>
<tr>
<td>43. 1,1,2,2-Tetrachloroethane</td>
<td>100. Fluoranthene</td>
<td>10</td>
</tr>
<tr>
<td>44. 1,1-Dichlorobenzene</td>
<td>101. Pyrene</td>
<td>10</td>
</tr>
<tr>
<td>45. 1,4-Dichlorobenzene</td>
<td>102. Butylbenzylphthalate</td>
<td>10</td>
</tr>
<tr>
<td>46. 1,2-Dichlorobenzene</td>
<td>103. 3,3'-Dichlorobenzidine</td>
<td>10</td>
</tr>
<tr>
<td>47. 1,2-Dibromo-</td>
<td>104. Benzo[a]anthracene</td>
<td>10</td>
</tr>
<tr>
<td>48. 1,2,4-Trimethoxybenzene</td>
<td>105. Chrysene</td>
<td>10</td>
</tr>
</tbody>
</table>

* Maritime levels, quantitation limits are approximately 30 times the quantitation limits for low soils. For semivolatile medium soils, quantitation limits are approximately 30 times the quantitation limits for low soils.

'Modified "California level" quantitation limits as available under the flexibility clause.
For drinking water and groundwater type samples, use of the low concentration organic analytical service is recommended.

METHODS AND INSTRUMENTATION

For semivolatile and pesticide Aroclor (pesticide PCB) water samples, a 1-L aliquot is extracted with methylene chloride using a continuous liquid-liquid extractor or separatory funnel [for pesticides Aroclors (pesticides/PCBs) only]. For low level semivolatile soil and pesticide Aroclor (pesticides/PCBs) soil samples, a 30-g soil/sediment sample is extracted with methylene chloride/acetone using sonication, automated soxhlet, or pressurized fluid extraction techniques. For medium level semivolatile soil samples, a 1-g aliquot is extracted with methylene chloride using the techniques mentioned above for low level soil samples. For both water and soil samples, the extract is concentrated, subjected to fraction-specific cleanup procedures, and analyzed by GC/MS for semivolatiles or GC ECD for pesticides/Aroclors (pesticides PCBs).

For volatile water samples, 5 mL of water is added to a purge and trap device and purged with an inert gas at room temperature. For volatile low level soil samples, a 5-g aliquot of soil is added to a purge and trap device with 5 mL of reagent water then purged with an inert gas at 40°C; or a 5-g aliquot (pre-weighed in the field) is purged from a closed-system purge and trap device at 40°C. For volatile medium level soil samples, a measured amount is collected/extracted with methanol and an aliquot of the methanol extract is added to reagent water and purged at room temperature. For both water and soil samples, the volatiles purged from the sample are trapped on a solid sorbent. They are subsequently desorbed by rapidly heating the sorbent and then introduced into a GC/MS system. Table 2 summarizes the methods and instruments used in this analytical service.

Under the flexibility clause, EPA is seeking current CLP laboratories to perform organic analysis through a modified analysis protocol. Some modifications include, but are not limited to, a reduced CRQL of 0.5 μg/L for all non-ketone compounds, modified calibration standards, as well as additional cleanup methods.

DATA DELIVERABLES

Data deliverables for this service include hardcopy data reporting forms and supporting raw data. In addition to the hardcopy deliverable, contract laboratories must also submit the same data electronically. The laboratory must submit data to EPA within 7, 14, or 21-days (for preliminary data within 48 hours [for volatiles]) or 72 hours [for semivolatiles and pesticides/Aroclors (pesticides/PCBs)] after laboratory receipt of the last sample in a set. EPA then processes the data through an automated Data Assessment Tool (DAT). DAT is a complete CLP data assessment package that incorporates Contract Compliance Screening (CCS) and Computer-Aided Data Review and Evaluation (CADRE) review to provide EPA Regions with PC-compatible reports, spreadsheets, and electronic files within 24 to 48 hours from the receipt of the data for data validation. This automated tool facilitates the transfer of analytical data into Regional databases. In addition to the Regional electronic reports, the CLP laboratories are provided with a data assessment report that documents the instances of noncompliance. The laboratory has 10 days to reconcile defective data and resubmit the data to EPA. EPA then reviews the data for noncompliance and sends a final data assessment report to the CLP laboratory and the Region.

QUALITY ASSURANCE

The quality assurance (QA) process consists of management review and oversight at the planning, implementation, and completion stages of the environmental data collection activity. This process ensures that the data provided are of the quality required.

During the implementation of the data collection effort, QA activities ensure that the quality control (QC) system is functioning effectively and that the deficiencies uncovered by the QC system are corrected. After environmental data are collected, QA activities focus on assessing the quality of data to determine its suitability to support enforcement or remedial decisions.

Each contract laboratory prepares a quality assurance plan (QAP) with the objective of providing sound analytical chemical measurements. The QAP must specify the policies, organization, objectives, and functional guidelines, as well as the QA and QC activities designed to achieve the data quality requirements for this analytical service.

QUALITY CONTROL

The QC process includes those activities required during analytical data collection to produce data of known and documented quality. The analytical data acquired from QC procedures are used to estimate and evaluate the analytical results and to determine the necessity for, or the effect of, corrective action procedures. The QC procedures required for this analytical service are shown in Table 3.
### Table 2. Methods and Instruments

<table>
<thead>
<tr>
<th>Fraction</th>
<th>Water</th>
<th>Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volatiles</td>
<td>Purge-and-trap followed by GC/MS analysis</td>
<td>Purge-and-trap or closed-system purge-and-trap followed by GC/MS analysis</td>
</tr>
<tr>
<td>Semivolatiles</td>
<td>Continuous liquid-liquid extraction followed by GC/MS analysis</td>
<td>Sonication, automated soxhlet, or pressurized fluid extraction followed by GC/MS analysis</td>
</tr>
<tr>
<td>Pesticides/Aroclors (Pesticides/PCBs)</td>
<td>Continuous liquid-liquid or separatory funnel extraction followed by dual column GC/ECD analysis</td>
<td>Sonication, automated soxhlet or pressurized fluid extraction followed by dual column GC/ECD analysis</td>
</tr>
</tbody>
</table>

### Table 3. Quality Control

<table>
<thead>
<tr>
<th>QC Operation</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Monitoring Compounds (volatiles)</td>
<td>Added to each sample, standard, and blank</td>
</tr>
<tr>
<td>Surrogates [for semivolatiles and pesticides Aroclors (pesticides/PCBs)]</td>
<td>Added to each sample, standard, and blank</td>
</tr>
<tr>
<td>Method Blanks (volatiles)</td>
<td>Analyzed at least every 12 hours for each matrix and level</td>
</tr>
<tr>
<td>Method Blanks [semivolatiles and pesticides Aroclors (pesticides/PCBs)]</td>
<td>Prepared with each group of 20 samples or less of same matrix and level, or each time samples are extracted by the same procedure</td>
</tr>
<tr>
<td>Instrument Blank (volatiles)</td>
<td>Analyzed after a sample which contains compounds at concentrations greater than the calibration range</td>
</tr>
<tr>
<td>Instrument Blank [pesticides/Aroclors (pesticides/PCBs)]</td>
<td>Every 12 hours on each GC column used for analysis</td>
</tr>
<tr>
<td>Storage Blanks (volatiles)</td>
<td>Prepared and stored with each set of samples</td>
</tr>
<tr>
<td>GC/MS mass calibration and ion abundance patterns (volatiles and semivolatiles)</td>
<td>Every 12 hours for each instrument used for analysis</td>
</tr>
<tr>
<td>GC Resolution Check [pesticides/Aroclors (pesticides/PCBs)]</td>
<td>Prior to initial calibration, on each instrument used for analysis</td>
</tr>
<tr>
<td>Initial Calibration</td>
<td>Upon initial set up of each instrument, and each time continuing calibration fails to meet the acceptance criteria</td>
</tr>
<tr>
<td>Continuing Calibration</td>
<td>Every 12 hours for each instrument used for analysis</td>
</tr>
<tr>
<td>Internal Standards (volatiles and semivolatiles)</td>
<td>Every 12 hours for each instrument used for analysis</td>
</tr>
<tr>
<td>Matrix Spike and Matrix Spike Duplicate</td>
<td>Once every 20 or fewer samples of same fraction, matrix, and level in an SDG</td>
</tr>
</tbody>
</table>

### PERFORMANCE MONITORING ACTIVITIES

Laboratory performance monitoring activities are provided primarily by AOC and the Regions to ensure that contract laboratories are producing data of the appropriate quality. EPA performs on-site laboratory audits, data package audits, GC/MS and/or GC/ECD tape audits, and evaluates laboratory performance through the use of blind performance evaluation samples.

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ATTACHMENT C

INORGANIC ANALYTICAL SERVICE FOR SUPERFUND (ILM 04.1)
QUICK REFERENCE FACT SHEET WITH TABLES
Multi-Media, Multi-Concentration, Inorganic Analytical Service for Superfund (ILM04.1)*

Under the legislative authority granted to the U.S. Environmental Protection Agency (EPA) under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Superfund Amendments and Reauthorization Act of 1986 (SARA), EPA develops standardized analytical methods for the measurement of various pollutants in environmental samples from known or suspected hazardous waste sites. Among the pollutants that are of concern to EPA at such sites are a series of inorganic analytes and cyanide that are analyzed using inductively coupled plasma (ICP), atomic absorption (AA), and colorimetric techniques. The Analytical Operations/Data Quality Center (AOC) of the Office of Emergency and Remedial Response (OERR) offers an analytical service that provides data from the analysis of water and soil sediment samples for inorganic analytes for use in the Superfund decision-making process. Through a series of standardized procedures and a strict chain-of-custody, the inorganic analytical service produces data of known and documented quality. This service is available through the Superfund Contract Laboratory Program (CLP).

DESCRIPTION OF SERVICES

The inorganic analytical service provides a technical and contractual framework for laboratories to utilize EPA/CLP analytical methods. These methods are used in the preparation, detection, and quantitative measurement of cyanide and 23 inorganic target analytes in both water and soil sediment environmental samples. The CLP provides the methods to be used and the specific technical, reporting, and contractual requirements, including quality assurance, quality control, and standard operating procedures, by which EPA evaluates the data. This service uses ICP, AA, and colorimetric methods to analyze the inorganic target analytes and cyanide. Three data delivery turnarounds are available to CLP customers: 7, 14, and 21-day turnaround after receipt of the last sample in the set. In addition, a 72-hour preliminary data submission option also is available for all turnaround times.

DATA USES

This analytical service provides data that EPA uses for a variety of purposes. Examples include determining the nature and extent of contamination at a hazardous waste site, assessing priorities for response based on risks to human health and the environment, determining appropriate cleanup actions, and determining when remedial actions are complete. The data may be used in all stages in the investigation of a hazardous waste site including site inspections. Hazard Ranking System scoring, remedial investigations feasibility studies, remedial design, treatability studies, and removal actions. In addition, this service provides data that are available for use in Superfund enforcement litigation activities.

TARGET ANALYTES

The analytes and detection limits for which this service is applicable are listed in Table 1. The list of target analytes for this service was originally derived from the EPA Priority Pollutant List of 129 compounds. In the years since the inception of the CLP, analytes have been added to and deleted from the Target Analyte List, based on advances in analytical methods, evaluation of method performance data, and the needs of the Superfund program. Specific detection limits are highly matrix dependent.

*ILM04.1 is an interim inorganic analytical service. Further changes are expected to be released under ILM05.0 for competition during calendar year 2000.
Table 1. Target Analyte List and Contract Required Detection Limits (CRDLs) (ILM04.L)

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Analyte</th>
<th>CRDL' (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>Aluminum</td>
<td>200</td>
</tr>
<tr>
<td>Sb</td>
<td>Antimony</td>
<td>60</td>
</tr>
<tr>
<td>As</td>
<td>Arsenic</td>
<td>10</td>
</tr>
<tr>
<td>Ba</td>
<td>Barium</td>
<td>200</td>
</tr>
<tr>
<td>Be</td>
<td>Beryllium</td>
<td>5</td>
</tr>
<tr>
<td>Cd</td>
<td>Cadmium</td>
<td>5</td>
</tr>
<tr>
<td>Ca</td>
<td>Calcium</td>
<td>5000</td>
</tr>
<tr>
<td>Cr</td>
<td>Chromium</td>
<td>10</td>
</tr>
<tr>
<td>Co</td>
<td>Cobalt</td>
<td>50</td>
</tr>
<tr>
<td>Cu</td>
<td>Copper</td>
<td>25</td>
</tr>
<tr>
<td>Fe</td>
<td>Iron</td>
<td>100</td>
</tr>
<tr>
<td>Pb</td>
<td>Lead</td>
<td>3</td>
</tr>
<tr>
<td>Mg</td>
<td>Magnesium</td>
<td>5000</td>
</tr>
<tr>
<td>Mn</td>
<td>Manganese</td>
<td>15</td>
</tr>
<tr>
<td>Hg</td>
<td>Mercury</td>
<td>0.2</td>
</tr>
<tr>
<td>Ni</td>
<td>Nickel</td>
<td>40</td>
</tr>
<tr>
<td>K</td>
<td>Potassium</td>
<td>5000</td>
</tr>
<tr>
<td>Se</td>
<td>Selenium</td>
<td>5</td>
</tr>
<tr>
<td>Ag</td>
<td>Silver</td>
<td>10</td>
</tr>
<tr>
<td>Na</td>
<td>Sodium</td>
<td>5000</td>
</tr>
<tr>
<td>Tl</td>
<td>Thallium</td>
<td>10</td>
</tr>
<tr>
<td>V</td>
<td>Vanadium</td>
<td>50</td>
</tr>
<tr>
<td>Zn</td>
<td>Zinc</td>
<td>20</td>
</tr>
<tr>
<td>Cn</td>
<td>Cyanide</td>
<td>10</td>
</tr>
</tbody>
</table>

Sample concentration exceeding five times the detection limit of the instrument or method in use may be reported even though the instrument or method detection limit is greater than the CRDL. This is illustrated in the following example:

For lead:
- Method in use = ICP
- Instrument Detection Limit (IDL) = 40
- Sample Concentration = 220
- CRDL = 3

'The CRDL is the instrument detection limit obtained in pure water.

METHODS AND INSTRUMENTATION

When storing samples, the use of a cooler temperature indicator bottle and the cooler temperature must be reported on Form DC-1 and in the Sample Delivery Group (SDG) Narrative. When applying AA methods, the Contractor may analyze the sample at a dilution as long as the raw concentration or absorbance of the diluted sample falls within the upper half of the calibration range. For ICP, an undiluted analysis of the sample is required.

If an insufficient sample amount (less than 80% of the required amount) is received to perform the analyses, the Contractor must contact the Sample Management Office (SMO) to report the problem. The same is required for multi-phase samples (e.g., two-phase liquid sample and oily sludge/sandy soil sample).

Table 2 summarizes the methods and instruments used in this analytical service.

DATA DELIVERABLES

Data deliverables for this service include both hardcopy/electronic data reporting forms and supporting raw data. The laboratory must submit data to EPA within 7, 14, 21-days, or preliminary data must be submitted within 72 hours after laboratory receipt of each sample in the set. EPA then processes the data through an Automated Data Assessment Tool (DAT). DAT is a complete CLP data assessment package. DAT incorporates Contract Compliance Screening (CCS) and Computer-Aided Data Review and Evaluation (CADRE) to provide EPA Regions with PC-compatible reports, spreadsheets, and electronic files. These files can be provided to the Regions within 24 to 48 hours from the receipt of the data and can be used as a tool during the data validation process at the Region. This automated tool facilitates the transfer of analytical data into Regional databases. In addition to the Regional electronic reports, the CLP laboratories are provided with a data assessment report that documents the instances of noncompliance. The laboratory has 4 days to reconcile defective data and resubmit the data to EPA. EPA then reviews the data for noncompliance and sends a final data assessment report to the CLP laboratory and the Region.

QUALITY ASSURANCE

The quality assurance (QA) process consists of management review and oversight at the planning, implementation, and completion stages of the environmental data collection activity. This process ensures that the data provided are of the quality required.
### Table 2. Methods and Instruments

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Instrument</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al, Sh, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Ni, K, Se, Ag, Na, Ti, V, Zn</td>
<td>Inductively Coupled Plasma (ICP)</td>
<td>Acid digestion followed by ICP analysis</td>
</tr>
<tr>
<td>As, Pb, Tl, Se</td>
<td>Graphite Furnace Atomic Absorption (GFAA)</td>
<td>Acid digestion followed by GFAA analysis</td>
</tr>
<tr>
<td>Ca, Mg, Na, K</td>
<td>Flame Atomic Absorption (FAA)</td>
<td>Acid digestion followed by FAA analysis</td>
</tr>
<tr>
<td>Hg</td>
<td>Cold Vapor Atomic Absorption (CVAA)</td>
<td>Acid and permanganate oxidation followed by CVAA analysis</td>
</tr>
<tr>
<td>CN</td>
<td>Manual and Semi-automated Colorimetric</td>
<td>Distillation followed by colorimetric analysis</td>
</tr>
</tbody>
</table>

### Table 3. Quality Control

<table>
<thead>
<tr>
<th>QC Operation</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instrument Calibration</td>
<td>Daily or each time instrument is set up</td>
</tr>
<tr>
<td>Initial Calibration Verification</td>
<td>Following each instrument calibration</td>
</tr>
<tr>
<td>Initial Calibration Blank</td>
<td>Following each instrument calibration</td>
</tr>
<tr>
<td>Continuing Calibration Verification</td>
<td>Every 10 analytical samples or every 2 hours during a run and at the beginning and end of each run</td>
</tr>
<tr>
<td>Continuing Calibration Blank</td>
<td>Every 10 analytical samples or every 2 hours during a run and at the beginning and end of each run</td>
</tr>
<tr>
<td>Interference Check Sample</td>
<td>Every 20 analytical samples and at the beginning and end of each run</td>
</tr>
<tr>
<td>CRDL Standard for ICP</td>
<td>Every 20 analytical samples and at the beginning and end of each run</td>
</tr>
<tr>
<td>CRDL Standard for AA</td>
<td>At the beginning of each AA analytical run</td>
</tr>
<tr>
<td>Serial Dilution for ICP</td>
<td>For each matrix type and concentration level for each SDG</td>
</tr>
<tr>
<td>Preparation Blank</td>
<td>For each sample preparation, analysis, and matrix per batch of prepared samples</td>
</tr>
<tr>
<td>Laboratory Control Sample</td>
<td>For each sample preparation and analysis procedure for each batch</td>
</tr>
<tr>
<td>Matrix Spike Sample Analysis</td>
<td>For each matrix type, concentration level, and method for each SDG</td>
</tr>
<tr>
<td>Duplicate Sample Analysis</td>
<td>For each matrix type, concentration level, and method for each SDG</td>
</tr>
<tr>
<td>Post Digestion Spike</td>
<td>Each time matrix spike recovery is outside QC limits</td>
</tr>
<tr>
<td>Analytical Spike</td>
<td>For each analytical sample analyzed by furnace AA</td>
</tr>
<tr>
<td>Method of Standard Addition</td>
<td>When the analytical spike recovery is outside QC limits</td>
</tr>
<tr>
<td>Instrument Detection Limit Determination</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Interelement Corrections</td>
<td>Annually for ICP instruments only</td>
</tr>
<tr>
<td>Linear Range Analysis</td>
<td>Quarterly for ICP instruments only</td>
</tr>
</tbody>
</table>
During the data collection effort, QA activities ensure that the quality control (QC) system is functioning effectively and that the deficiencies uncovered by the QC system are corrected. After environmental data are collected, QA activities focus on assessing the quality of data to determine its suitability to support enforcement or remedial decisions. Each contract laboratory prepares a quality assurance plan (QAP) with the objective of providing sound analytical chemical measurements. The QAP must specify the policies, organization, objectives, functional guidelines, and QA/QC activities designed to achieve the data quality requirements for this analytical service.

QUALITY CONTROL

The QC process includes those activities required during analytical data collection to produce data of known and documented quality. The analytical data acquired from QC procedures are used to estimate and evaluate the analytical results and to determine the necessity for, or the effect of, corrective action procedures. The QC procedures required for this analytical service are shown in Table 3.

PERFORMANCE MONITORING ACTIVITIES

Laboratory performance monitoring activities are provided primarily by AOC and the Regions to ensure that contract laboratories are producing data of the appropriate quality. EPA performs on-site laboratory audits, data package audits, and evaluates laboratory performance through the use of blind performance evaluation samples.

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