Final

RFI Work Plan, Dow Hanging Rock Facility, Ironton, Ohio

USEPA ID OHD 039 128 913

Prepared for

The Dow Chemical Company

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CH2MHILL®

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Acronyms and Abbreviations

°F	degrees Fahrenheit
AOC	area of concern
BAZ	biologically active zone
BERA	baseline ecological risk assessment
bgs	below ground surface
BTAG	Biological Technical Assistance Group
COPC	constituent of potential concern
COPEC	constituent of potential ecological concern
CSM	conceptual site model
Dow	The Dow Chemical Company
DQO	data quality objective
Eco-SSL	ecological soil screening level
ELCR	excess lifetime cancer risk
ERA	ecological risk assessment
ESL	ecological screening level
facility	The Dow Chemical Company Hanging Rock Facility in Ironton, Ohio
FSP	field sampling plan
gpm	gallons per minute
GSI	groundwater-surface water interface
HDPE	high-density polyethylene
HHRA	human health risk assessment
HQ	hazard quotient
NWI	National Wetlands Inventory
ODNR	Ohio Department of Natural Resource
Ohio EPA	Ohio Environmental Protection Agency
PR	preliminary review
QA	quality assurance

QAPP	quality assurance project plan
QC	quality control
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RFI	Resource Conservation and Recovery Act facility investigation
RSL	regional screening level
SERA	screening ecological risk assessment
SLERA	screening level ecological risk assessment
SWI	Scioto Water Incorporated
SWMU	solid waste management unit
TCA	trichloroethane
USEPA	United States Environmental Protective Agency
USFWS	United States Fish and Wildlife Service
VSI	visual site inspection

SECTION 1

Introduction

1.1 Purpose and Objectives

This Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) work plan describes the investigation activities associated with The Dow Chemical Company (Dow) Hanging Rock Facility in Ironton, Ohio (facility). The primary objective is to satisfy the U.S. Environmental Protective Agency (USEPA) requirement under Section II.F.2 RFI of the Part B permit. Implementation of this work plan will address this objective by providing the data necessary to perform an initial site characterization, improve the understanding of fate and transport of constituents at the facility, and provide initial data for future human health and ecological risk assessments (HHRAs and ERAs, respectively). In addition, this document presents a description of current conditions.

Figure 1-1 shows the facility location, and Figure 1-2 shows the facility boundary, areas of concern (AOCs), and solid waste management unit (SWMU) locations. Sources of information used to prepare this RFI work plan include the following:

- *Preliminary Review, Visual Site Inspection Report* (PR/VSI), A.T. Kearney 1989
- *Preliminary Assessment, Visual Site Inspection*, Tetra Tech 2000
- RCRA permit, modified August 2010
- Site visit conducted by CH2M HILL in October 2010

This RFI will be completed using a phased approach. In the first phase of investigation, as discussed in this work plan, soil samples will be collected from the AOCs and SWMUs requiring further investigation. In addition, monitoring wells will be installed across the facility to provide an understanding of the facility hydrogeology, including subsurface stratigraphy and groundwater flow direction. At selected locations, deep borings will be advanced to bedrock to determine the stratigraphy to bedrock. Subsequent phases of investigation will be based on information obtained in this first phase.

1.2 Report Organization

This report contains the following sections:

- Section 1, *Introduction,* provides a general overview of this work plan and regulatory background for the facility.
- Section 2, *Facility Description,* provides a description of the facility and historical ownership/operations.
- Section 3, *Preliminary Conceptual Site Model of Current Conditions,* discusses physical conditions encountered at the facility.
- Section 4, *Investigation Approach*, provides the details of the Phase I RFI.

- Section 5, *Human Health Risk Assessment Approach*, provides the approach for the HHRA.
- Section 6, *Ecological Risk Assessment Approach,* provides the approach for the ERA.
- Section 7, *References*, lists the references cited in this report.

1.3 Regulatory Overview

The facility submitted an RCRA Part A permit application in 1980 and was issued an Ohio Hazardous Waste Facility Installation and Operation Permit in 1981 (A.T. Kearney 1989). This permit was modified in 1986 to include a hazardous waste storage tank. In 1989, Dow applied for an RCRA permit modification to include additional storage process using containers. A PR/VSI was conducted on behalf of USEPA in 1989 (A.T. Kearney 1989), and a follow-up investigation was completed in 2000 (Tetra Tech 2000).

In 2005, USEPA issued an RCRA permit for the facility. Subsequent negotiations between Dow and USEPA were resolved, and a revised permit was issued in August 2010. The investigation discussed in this work plan is in accordance with the requirements of the 2010 RCRA permit.

SECTION 2

Facility Description

2.1 Physical Description of the Facility

The facility is located at 925 County Road 1A in Lawrence County, approximately 4 miles northwest of Ironton, Ohio. The facility is between the old and new State Route 52. The facility occupies only a small portion of the 750-acre parcel. The property owned by Dow is bordered on the north by wooded hills; on the west by farmland; on the south by the Ohio River; and on the east by farmland and residences. Big Thief Creek flows east to west through the southern portion of Dow's property and discharges into the Ohio River about 1,000 feet south of the property boundary.

2.2 Facility Operational and Waste Management History

2.2.1 Facility Operational History

Dow began operating at the facility in 1957 and currently employs about 100 people at the facility. Available historical aerial photographs taken between 1952 and 2010 are presented in Appendix A. The 1952 aerial shows the land being used primarily as pasture or farmland. By 1960, a small portion of the facility appears in the aerial photograph (Appendix A). The facility area subsequently expanded, as shown in the 1979 and 1988 aerials. The 2005 aerial shows development on the portions of the property that are owned or leased by others (Figure 1-2, Appendix A). Additional information on past land uses, owners, and operators is not available. Facility buildings are used for manufacturing operations, as well as warehouse and office space. Five water wells are located onsite; two are used for fire protection and supplemental process water.

The facility manufactures and ships polymeric beads and foam, most of which are intermediate products used or combined with other materials offsite by other companies. Three plants currently operate at the facility: Styron plant, Styrofoam plant, and Ethafoam plant. The Styron plant, which began operation in 1968, is owned and operated by American Styrenics.

2.2.2 Facility Waste Management

Some of the wastes produced at the facility are characteristic hazardous waste; others contain only small quantities of hazardous constituents (Tetra Tech 2000). Most hazardous wastes historically were generated by the Styron plant as a result of cross contamination of product and heat transfer fluids, process sampling, residuals from process upsets and cleaning, and condensate collection from the process bypass stream.

Most of the wastes generated in the three plants are characteristic hazardous wastes D001 and D018, including waste oils, DOWTHERM fluid, and methylene chloride waste (Tetra Tech 2000). D001 and D018 wastes reportedly are stored in 55-gallon drums at satellite accumulation areas onsite or transferred directly to the hazardous waste storage area.

Solid waste generated include partially polymerized styrene, ethylbenzene, polystyrene, rubber, and acrylonitrile wastes; laboratory wastes; and solvent-contaminated materials such as boots, gloves, rags, and feed filters. The drums are stored in the hazardous waste storage area for less than 90 days and are transferred to the hazardous waste container loading area before being transported for disposal to Green Valley Landfill in Smithfield, Kentucky.

The liquid wastes consist of styrene, ethylbenzene, acrylonitrile, oil solutions, and solvent-contaminated lubricating oils. The drums are stored in the hazardous waste storage area for less than 90 days and are transferred for incineration to Safety-Kleen in Bridgeport, New Jersey.

2.3 Solid Waste Management Units and Areas of Concern

This section briefly presents descriptions of the SWMUs and AOCs identified in the RCRA permit as requiring additional information (*Final May 2006/Modified August 2010, OHD 039 128 913)*. The two SWMUs and four AOCs contained in the 2011 request for determination for Class 2 Permit Modification are not included in this work plan. Both the Tetra Tech preliminary assessment/VSI and the A.T. Kearney PR/VSI were used to summarize the SWMUs and AOCs listed below. Figure 1-2 shows the approximate location of each SWMU and AOC. Photographs of the SWMUs and AOCs taken during CH2M HILL's 2010 site visit are included in Appendix B.

2.3.1 SWMU 1 – Former Flaring Pad

The former flaring pad was located in the area of the present maintenance building. The flaring pad reportedly operated from 1957 through 1968. The flaring pad was a concrete pad smaller than the current maintenance building, with a tank used to burn waste using an aspiration system. Byproducts from the Styrofoam process containing styrene, partially polymerized polystyrene, and ethylbenzene were burned on the flaring pad. SWMU 1 was located southwest of Building 505. The pad was drained to the process sewer in that area of the site (Dow 2007).

2.3.2 SWMU 11 – Satellite Accumulation Area - Ethafoam Plant

SWMU 11 is a 10-foot-square roofed concrete container storage area. Valves, drums of raw material, and hazardous waste were stored in this area. The containers and valves were stored on pallets. In 2007, the pad was inspected to be in good condition and any spills would be directed to the process sewer (Dow 2007). No other information was available for this area.

2.3.3 SWMU 12 – Former Methylene Chloride Cleaning Tank

The former methylene chloride cleaning tank was adjacent to the tank farm on Street A in the northwestern corner of the Styron plant. The tank was 10 feet high, 4 feet in diameter, and was staged on top of railroad ties. The tank was placed on a 10-foot-square concrete pad that had a 6–inch-high curb. The tank was surrounded by sand and covered by 1 inch of Styrofoam (Dow 2007). The tank was used for cleaning partially polymerized polystyrene from equipment used in the polystyrene process. Equipment would be bolted to the tank, and methylene chloride would be pumped through the equipment. The spent

methylene chloride then would be pumped into a delivery truck for offsite disposal, and the excess methylene chloride was drummed and taken to the hazardous waste container storage area. The cleaning process took 5 to 7 days, and the methylene chloride was contained during the process. Use of the tank was discontinued in 1993, and the tank was removed and replaced in 1998 (Tetra Tech 2000).

2.3.4 SWMU 15 – Two Section Septic Tank System

This unit is south of the main office building under a grassy area in front of the building. The unit is 16 feet by 20 feet, constructed of concrete, and has a capacity of 2,600 gallons. The unit has been in operation since 1957 and has received septic wastewater and process wastewater. Before 1976, water was discharged to the stormwater drainage system (SWMU 18). After 1976, water was discharged to the wastewater treatment system.

2.3.5 SWMU 17 – Stormwater Drainage System

This unit surrounds the Styron plant and is comprised of drainage ditches, sewer lines, and roof drains from the Styrofoam and Ethafoam plants. The system consists of 3-foot-deep, natural clay, gravel-lined ditches, grates, and concrete sewer lines. The system discharges into the surface drainage ditch to Big Thief Creek (SWMU 18). The drainage ditches have been present since 1957. Stormwater runoff from the Styron, Styrofoam, and Ethafoam plants and the tank farm flows through this drainage system.

2.3.6 SWMU 18 – Drainage Ditch to Big Thief Creek

This unit, which operated from 1957 to 1992, is a grass and gravel-lined surface water drainage ditch that ranges from 3 to 5 feet deep. It received water from the stormwater drainage system and fire pond. In 1988, a styrene spill occurred in the drainage ditch in the vicinity of the styrene storage tanks. Another spill occurred when process wastewater flowing into the aerated skimmer basin exceeded the pumping capacity to the treatment plant, and the untreated process water discharged directly to the surface drainage ditch to Big Thief Creek. The PR/VSI reported that analysis of the drainage ditch and outfall waters had small but measurable amounts of 1,1,1-trichloroethane (1,1,1-TCA); benzene; ethylbenzene; 1,3- and 1, 4-dimethylbenzene; styrene; isopropylbenzene; toluene; and xylenes (A.T. Kearney 1989). The ditch currently receives treated water from the wastewater treatment system.

2.3.7 SWMU 19 – Drainage Ditch to North

This unit is a slight depression leading from the northern part of the Styron plant to a ditch that runs along the railroad adjacent to State Route 52. The ditch receives stormwater runoff from the northernmost part of the Styron plant.

2.3.8 SWMU 24 – Process Sewer Line

The unit is constructed of preformed cement pipes packed with oakum caulking. The system receives discharges from most onsite sumps, including forklift wash water, cooling tower and boiler blowdown, and stormwater from the SWMU 17. A 150-foot portion of the sewer line was voluntarily investigated, excavated, and removed as part of the closure of the former drum storage area (Radian 1997). Post-excavation sampling demonstrated compliance with industrial and residential soil cleanup standards developed in accordance with *Closure Plan Review Guidance for RCRA Facilities* (Ohio Environmental Protection

Agency [Ohio EPA] 1993). The closure plan for this portion of the process sewer line was approved by Ohio EPA on September 30, 1996 (Radian 1997). A copy of the approval letter is included in Appendix C.

The area was restored and backfilled with clean soil. A new collection sump was installed, and a portion of the process sewer line was replaced (Radian 1997). The remainder of the sewer line has not been investigated.

2.3.9 SWMU 25-28 – Former Wastewater Treatment System

The wastewater treatment system consisted of an aerator, clarifier, chlorinator, and two tertiary sand filters. The system was installed in 1976 and was constructed of concrete and built into the ground. Process wastewater from the aerator skimmer basin and sanitary wastewater from the septic tank flowed into the 15,000-gallon packaged wastewater treatment plant, consisting of an aerator and clarifier (Dow 2007). The clarified water was routed to one of two sand filters, sent to the chlorinator, and discharged to the fire pond. The system treated approximately 11,000 gallons of water per day. The units were removed in 1992.

2.3.10 SWMU 29 – Former Used Filter Sand Pile

A pile of used filter sand was stored temporarily on the ground just a few feet west of the tertiary sand filters. The sand was stored there pending transport to a landfill. The PR/VSI reported this activity was not a common practice (A.T. Kearney 1989). The sand was used to polish wastewater after treatment in the aerated skimmer and the treatment plant (Dow 2007). The unit became inactive when the wastewater treatment system was replaced in 1992. The general area has been excavated and regraded since the sand was placed onto the ground. No other information is available for this unit.

2.3.11 SWMU 36 – Former 250-gallon Pressurized Storage Tanks

Twenty 250-gallon pressurized storage tanks were located throughout the facility that were used to store liquid wastes such as solvents, oils, or liquid process wastes. The tanks were discontinued in 1995. The tanks had cradles built into them in order to move them with forklifts. No other information is available for these units. Because the tanks were moved around the Styron plant, and cannot be represented by specific locations, this SWMU will not be investigated during this RFI.

2.3.12 SWMU 37 – Fire Protection Collection Basin

This unit consists of a 250,000-gallon-capacity concrete basin located north of the wastewater treatment system. The unit, which began operation in 1992, primarily receives stormwater, although it would receive spills if they occurred inside a diked area (Dow 2007).

The basin is constructed of concrete with high-density polyethylene (HDPE) lining the outer wall of the concrete. Joints are provided with an HDPE water-stop, and all inlet and exit piping was extrusion welded to the HDPE liner (Dow 2007). The concrete basin is intact and competent (Exhibit 1, Appendix B). Given the nature of the basin's use and design, no investigation is necessary. This SWMU will not be investigated during this RFI.

2.3.13 AOC D – Underground Catalyst Storage Tank

A former 10,000-gallon steel tank housed in an underground concrete vault in the Styron plant was used to store the catalyst 1,1-Di(tert-butylperoxy)cyclohexane, an organic peroxide. This peroxide is typically found as a percent solution in mineral oil and ethylbenzene (Dow 2007). The tank was taken out of service in December 1999 (Tetra Tech 2000). There are no known releases from this AOC, and the tank has been removed.

2.4 Facility Water Usage

Five water supply wells are located onsite. The facility reports that Well 5 is used as needed for the wastewater treatment plant, and Well 2 is used for fire protection. The remaining three wells are not used. Boring logs for the wells are presented in Appendix D.

2.5 Surrounding Land Use and Descriptions

Land use in the vicinity of the facility is predominantly agricultural. The Dow-owned property, including land leased by others, is bordered to the north by State Route 52, to the south by the Ohio River, and to the east and west by farmland. The nearest residential area is located directly east of the Dow-owned property.

2.5.1 Area Water Supply

Scioto Water Incorporated (SWI) supplies drinking water to most of the residents within the vicinity of the facility. This water is purchased from the City of Portsmouth, Ohio. In a January 27, 2011, telephone conversation, City of Portsmouth personnel said the Dow facility also purchased water from the City. The water supplied to the facility as well as water sold to SWI is from the City's filtration plant located on the Ohio River near New Boston, Ohio, which is approximately 15 miles upstream of the facility. During the field investigation, it will be determined if any of the surrounding residences have drinking water wells.

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SECTION 3

Preliminary Conceptual Site Model of Current Conditions

3.1 Geology and Hydrogeology

This section contains a discussion of regional geology, bedrock, unconsolidated soils, and local hydrogeology at the facility.

3.1.1 Regional Geology

The facility is in the Ironton Plateau physiographic region of the Allegheny Plateau province. The Ironton Plateau is characterized by moderately high relief (300 feet) dissected plateaus. Coarse-grained, coal-bearing rock sequences are more common in this region than other regions of the Allegheny Plateau province. The geology of the Ironton plateau region consists of Pennsylvanian age sedimentary units of the Allegheny Formation and the Pleistocene age Minford Clay, silt-loam and sand and gravel (Ohio Department of Natural Resource [ODNR] 2006).

The only source of information on the subsurface geology at the facility is from well logs obtained from ODNR dating to 1955. Appendix D contains six well logs obtained from ODNR (2011). Figure 3-1 shows the locations of the water wells from the ODNR logs, and the known locations of the five facility wells. It is unclear how the facility wells relate to the ODNR logs, as the coordinates do not correlate. The facility is underlain primarily by a combination of unconsolidated and bedrock geologic material. The unconsolidated material includes clay, sand, and gravel, and the bedrock consists of the shale unit of the Allegheny Formation.

In general, low-permeability clay soil was encountered in the wells from ground surface to depths ranging between 10 and 28 feet below ground surface (bgs). The clay unit appears to be thicker toward the Ohio River to the south and thinner north of the facility. Underlying the clay layer is the coarse-grained sand and gravel unit that generally extends to the top of bedrock between 70 and 80 feet bgs.

Soils in the vicinity of the facility are of the Elkinsville, Weibachsville, and Sciotoville silt loam group (United States Department of Agriculture, Natural Resources Conservation Service 2011). These soils are characterized as gently sloping, moderately well drained, with low to moderate permeability.

3.1.2 Bedrock

The ODNR well logs describe bedrock as occurring between 75 and 80 feet bgs. Bedrock encountered in most of the wells is described as blue to gray shale. One of the well logs (ODNR Well ID 233182) located north of the facility described the bedrock as sandstone. It is likely that both the shale and sandstone are members of the Pennsylvanian age Allegheny Formation.

3.1.3 Unconsolidated Soils

The unconsolidated soil described on the ODNR logs includes up to 28 feet of clay underlain by 55 to 70 feet of coarse-grained sand and gravel. The clay layer is believed to be Ohio River floodplain deposits. The sand and gravel layer beneath the clay is likely alluvial deposits deposited by the Ohio River and colluvium formed when loose material rolled from the top of the moderate grade slope of the Ironton Plateau and built up at the bottom of a low-grade slope. A glacial map of Ohio (ODNR Division of Geological Survey 2005) indicated the continental glaciations in Ohio did not extent as far south as the location of the facility.

3.1.4 Local Hydrogeology – Unconsolidated Deposits

The main sources of information on site hydrogeology are the ODNR logs for water wells installed at or near the facility. Water level information from the onsite facility well logs indicates that depth to static water level ranges from 16 to 35 feet bgs. The depth to groundwater is shallower closer to the Ohio River and deeper further north of the facility. The well logs indicated the upper clay layer is partially saturated at locations where the depth to water level is shallow, i.e., close to the Ohio River. The sand and gravel unit is saturated in the vicinity of the facility. The groundwater flow direction could not be interpreted from the available well logs because the well logs did not have ground surface elevation that could be used to determine the groundwater elevation at the wells location.

The sand and gravel unit is the major aquifer for the surrounding area and supplies all the process water for the facility. The sand and gravel aquifer occurs under confined conditions. The clay unit appears to act as an upper confining unit, and the shale and sandstone bedrock acts as the lower confining unit to the sand and gravel aquifer. The clay layer underlying the facility may retard surface drainage in the area from significantly contributing to the sand and gravel aquifer. The main source of recharge for the sand and gravel aquifer likely is through underflow from upgradient portions of the aquifer.

The facility lies in an area that has been described to contain permeable deposits of sand and gravel beneath the floodplain adjacent to the Ohio River (Schmidt 1995). The sand and gravel deposits in this area are capable of yielding between 100 and 500 gallons per minute (gpm). Pumping test data obtained from well logs for water wells installed at the facility indicate the wells were pumped at between 150 and 350 gpm for 24 to 48 hours, and a drawdown of between 8 and 9 feet was recorded. One of the wells closer to the Ohio River was pumped at 217 gpm for 74 hours, and drawdown of 25 feet was recorded. None of the water wells onsite is installed in bedrock; however, Groundwater Resources of Lawrence and Gallia counties (Schmidt 1995) described bedrock under the facility as alternating layers of shale and thin sandstone capable of yielding less than 2 gpm at depth of less than 125 feet.

3.2 Hydrology

Surface water generally drains south toward the Ohio River. Ditches control most of the surface water drainage at the facility, and one drainage ditch in the northwest portion of the facility drains to the north. SWMU 18 flows into Big Thief Creek, which discharges to the Ohio River. The section of the Ohio River by the facility flows from west to east.

3.3 Meteorology and Climate

Ironton, Ohio, is approximately 13 miles northwest of Huntington, West Virginia. Precipitation in the Huntington/Ironton area averages approximately 41 inches annually. Records for this area indicate March through August are the wettest months (greater than 3.5 inches per month) while October, November, and February are the driest (less than 3 inches per month). The average annual snowfall for the area is 25.9 inches. The average daily temperature is 55.2 degrees Fahrenheit (°F). The coldest month is January when the average daily temperature is 32.8 °F. The hottest month is July when the average daily temperature is 75.4 °F. Winds typically are from the south to south-southeast at an average speed of 6.5 miles per hour.

3.4 Ecological Setting

The identified terrestrial and aquatic habitats were based on observations made by a CH2M HILL ecologist during a November 2010 site walk. A complete ecological survey (i.e., bird survey, plant, and/or animal survey) was not conducted as part of this site walk.

3.4.1 Terrestrial Habitats

Terrestrial habitats on the active portion of the facility are limited to open grasslands. Small scrub/shrub and woody habitats were found around the perimeter of the facility as well as to the south. The dominant large woody species within the terrestrial habitats included oak, sycamore, maple, and pine. Smaller scrub/shrub species observed included multi-flora rose, honeysuckle, poison ivy, and various shrubs. Several species of birds were noted during the site walk and included the American robin, dove, blue jay, and crow. Other birds were observed, but could not be identified. The only mammals observed during the site walk were squirrels; however, the grassy, scrub/shrub, and woody habitats likely could support other smaller mammalian species such as rabbit, voles, shrew, woodchuck, and mice. In addition, larger mammals such as raccoon, fox, and deer may be found passing through the scrub/shrub and/or woody areas, but given the small riparian buffer, it is unlikely that the larger mammals would use these habitats as a significant source of food and/or shelter.

3.4.2 Aquatic Habitats

The only onsite aquatic habitats identified during the site walk included a drainage ditch to the north and a drainage ditch flowing south to Big Thief Creek. The drainage ditch to the north is a relatively small grass-lined ditch approximately 3 feet wide, and at the time of the site walk, only approximately 6 inches of water was present in the ditch. The drainage ditch to Big Thief Creek ranges from 4 to 10 feet wide (the widest portions were found at the southern extent of the ditch). Portions of this ditch are gravel lined, and water depths ranged from about 6 to 24 inches during the site walk. Fish were not observed in either ditch during the site walk, and it is unlikely that either ditch could support a viable fish community.

Offsite aquatic features include Big Thief Creek and the Ohio River, both of which are south of the drainage ditch to Big Thief Creek. In addition, during a desktop survey of the National Wetlands Inventory (NWI) database, several small wetlands were identified within

the vicinity of the facility (Appendix E). The closest wetlands were adjacent to the southern extent of the drainage ditch to Big Thief Creek and along Big Thief Creek. These wetlands were identified by NWI as freshwater emergent and/or freshwater forested/shrub wetlands. No formal wetland delineation was conducted during the site walk to confirm the presence of wetlands.

3.4.3 Special Habitats

No existing or proposed state nature preserves are at the facility, and no known unique ecological sites, geologic features, breeding or non-breeding animal concentrations, champion trees, state parks, state forests, scenic rivers, or wildlife areas are within the project area. The U.S. Fish and Wildlife Service (USFWS) maintain records and databases of rare and endangered species for the state. USFWS lists the Indiana bat (*Myotis sodalist)*, running buffalo clover (*Trifolium stoloniferum),* fanshell mussel (*Cyprogenia stegaria),* and pink mucket pearly mussel (*Lamsilis abupta*) as endangered species, and sheepnose mussel (*Plethobasus cyphyus*) and snuffbox mussel (*Epioblasma triquetra)* as proposed endangered species in Lawrence County. These species were not observed onsite during the site walk in November 2010, and given the limited habitats present, it is unlikely that these species would be present onsite.

3.5 Summary of Previous Site Investigations

In 1988, a styrene monomer spill occurred in the diked pump area near the styrene storage tanks. As part of the cleanup, impacted soil was excavated and disposed of. Post-excavation sampling was not completed as part of the cleanup. The facility also monitored Outfall 011 in Big Thief Creek for styrene, and none was detected.

In 1989, A.T. Kearney and DPRA Inc. conducted a PR/VSI at the facility. The PR/VSI was to identify potential for release of hazardous waste or constituents from the SWMUs and AOCs at the facility and to make recommendations where necessary. The PR/VSI report recommended follow-up activities in SWMUs and AOCs where either potential exist for release of hazardous material, or where there were documented release and no documentation of proper cleanup of the release (A.T. Kearney 1989).

In 1990, two 12,000-gallon waste fuel tanks were removed. As part of the tanks closure process, impacted soil in the area around the former tank locations was excavated, and the excavation was backfilled with clean soil.

As part of USEPA Region 5 Environmental Priorities Initiatives, Tetra Tech conducted a PR/VSI of the facility in 2000 to characterize the facility's actual and potential release of hazardous material from onsite SWMUs and AOCs. No AOC was evaluated during this PR/VSI (Tetra Tech 2000).

3.6 Preliminary Physical Conceptual Site Model

This conceptual site model (CSM) is based on limited information available at the time of preparing this work plan. The main source of geological information is well logs for water wells installed at the facility (ODNR 2011). The CSM will be refined as more information about the facility becomes available.

The facility is near the Ohio River, and sections of the facility south of old State Route 52 are on the 100-year floodplain of the Ohio River (Federal Emergency Management Agency 2011). Sections north of old State Route 52 are outside the floodplain. The stratigraphy consists of approximately 30 feet of clayey soils underlain by approximately 50 feet of sand and gravel. The clay layer is thicker toward the Ohio River and thinner northward toward State Route 52. The unconsolidated deposits are underlain by shale bedrock. The sand and gravel deposits form a regional aquifer.

The groundwater flow patterns at the facility have not been studied.

Surface water generally drains south toward the Ohio River. Most of the surface water drainage at the facility is controlled by ditches, and one drainage ditch in the northwest portion of the facility drains to the north, to an offsite ditch.

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SECTION 4

Investigation Approach

4.1 Project Objectives

The investigation objective is to determine if releases have occurred at the SWMUs and AOCs identified for further investigation (Table 4-1). If a release has occurred, this investigation will evaluate the risk to human health and the environment and will identify a path forward. USEPA has identified one SWMU, SWMU 36, as requiring additional investigation; however, soil samples cannot be taken at this unit because information on the size and location at the facility does not exist. Instead, in a subsequent phase of investigation, sitewide groundwater will be investigated and potential impacts from this site will be considered.

This investigation is designed to be completed in phases. For the first phase, surface soil, subsurface soil, and sediment will be investigated. Based on the results of the investigation, additional media, including groundwater, may be investigated.

4.2 Data Quality Objectives

Data quality objectives (DQOs) were established during the work planning process. DQOs assess the type, quality, and quantity of data necessary to achieve the project objectives. The DQOs were developed to generate the information necessary to meet the RFI objectives and are presented in the quality assurance project plan (QAPP; Appendix H).

The overall decision criteria for the investigation are as follows:

- If no exceedances of screening levels in surface or subsurface soil are detected at any AOC or SWMU, no additional investigations will be performed at that site.
- If no exceedances in sediment are detected at SWMU 18, no additional investigations will be performed.
- If exceedances are detected in any media investigated, the AOC or SWMU will be evaluated for risk and additional investigations may be performed to delineate the extent of impact.
- The information obtained from the installation of monitoring wells will be used to determine the site subsurface geology as well as provide an understanding of groundwater flow.

4.3 Field Investigations

This section presents sampling activities that will be performed. The investigation will take place in a phased approach, with Phase I activities focused on determining the presence or absence of contamination and evaluating the hydrogeological setting. Further investigations may be warranted to determine the nature and extent of constituents and fate

and transport mechanisms. Risk assessments will be conducted later after collecting adequate data. Phase I investigation tasks are described in the following sections.

4.4 Soil and Sediment Sampling

Soil borings will be advanced at the SWMUs and AOCs that have been identified for further investigation. For this work plan, it is assumed that borings will be advanced to 10 feet bgs to support evaluation of potential exposure pathways; however, deeper borings may be necessary and will be determined based on conditions encountered in the field. Soil samples will be collected from up to four intervals from 0 to 10 feet bgs; the samples will be analyzed for volatile and semivolatile organic compounds and RCRA metals.

Figures 4-1 through 4-11 present the proposed sample locations for each SWMU and AOC. The proposed samples are summarized in Table 4-1.

Sediment samples will be collected from SWMU 18 (Figure 4-7). Additional details are in the field sampling plan (FSP; Appendix F).

Because of the lack of information regarding the location of SWMUs 36 and 37, these areas will not be investigated during this phase of the RFI. These areas will be investigated in a subsequent phase of the RFI, when sitewide groundwater impacts are evaluated.

4.5 Monitoring Well Installation

To evaluate site stratigraphy and groundwater flow direction, eight monitoring wells will be installed across the facility (Figure 4-13). The monitoring wells will be set in the shallow water-bearing zones. At three of these locations (MW-01, MW-07, and MW-0), the borings will be extended to bedrock to further delineate site stratigraphy. Additional details are in the FSP (Appendix F).

4.6 Data Validation

Data review, verification, and validation are the processes by which data, generated in support of a project, are reviewed against the data quality assurance (QA)/quality control (QC) requirements. The data are evaluated for precision and accuracy against the analytical protocol requirements. Nonconformance or deficiencies that could affect the precision or accuracy of the reported result are identified and noted. The effect on the result then is considered when assessing whether the result is sufficient to achieve DQOs.

All data collected as part of this investigation will be consistent with the QAPP and will be validated by CH2M HILL. Deficiencies discovered as a result of data verification, review, or validation, as well as corrective actions implemented in response, will be documented and submitted in the form of a written report.

Data from the RFI sampling events will be evaluated for quality with respect to reporting limits and laboratory qualifiers. During the data evaluation step, the following procedures will be used:

- Rejected ("R" qualified) data will be excluded from the risk assessment.

- A value reported as estimated ("J" qualified) will be included in the risk assessment if it is the only value provided for a sample, or if it is the highest reported result from a set of reported values from dilutions and/or reanalysis, given these two conditions.
- For duplicate samples, the maximum concentration between the two samples will be used as the sample concentration.
- The sample quantitation limits will be compared to screening levels for constituents that are 100 percent nondetected in an environmental matrix; results of the comparison will be provided in an appendix to the HHRA and discussed in the uncertainty section of the HHRA. Additional details are provided in the QAPP (Appendix H).

4.7 Data Evaluation

Surface soil, subsurface soil, and sediment analytical results will be screened against USEPA industrial soil regional screening levels (RSLs; USEPA 2010). Groundwater samples will not be collected during the Phase I RFI; the monitoring wells installed will be used to determine groundwater flow direction and to understand the site geology. The soil and sediment screening will be used to provide a preliminary evaluation of the nature and extent of contamination in soil and sediment. Data obtained in this phase may be used to identify constituents of potential concern (COPCs), but further investigations may be necessary for sufficient delineation in soil and to investigate other media such as groundwater.

Available documentation indicates that chromium has not been utilized in the manufacturing process at the site. Trivalent chromium can occur naturally in soil and groundwater. It unlikely that hexavalent chromium would be present in soil at the site; therefore, the soil and sediment results will be screened against the USEPA RSL for trivalent chromium.

The data collected in Phase I will be summarized in a report, and HHRA and ERA interim deliverables will be included. These are discussed in more detail in their respective sections and will be used to determine the need for and scope of future investigation phases.

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SECTION 5

Human Health Risk Assessment Approach

The primary purpose of the HHRA is to determine whether additional risk evaluation, data collection, or mitigation is warranted. If it is determined that facility-specific cumulative risks for a receptor population are within USEPA's risk management range of $1x10^{-6}$ to $1x10^{-4}$ for carcinogenic compounds, and the facility-specific cumulative hazard index is less than 1, then no further risk evaluation will be recommended. If either of these is exceeded, then additional evaluation and/or action would be warranted.

The HHRA will provide an evaluation of the potential current and future risks to human health posed by detected constituents at the facility in accordance with USEPA guidance for conducting HHRAs. The overall approach for the HHRA will follow USEPA Risk Assessment Guidance for Superfund (RAGS), Part A (USEPA 1989). In general, this is a four-step evaluation process that includes the following:

1. Data evaluation and identification of COPCs
2. Exposure assessment
3. Toxicity assessment
4. Risk characterization

For the first phase of investigation, only data evaluation and identification of COPCs for each sampled medium will be completed, which is discussed in detail below. If additional data are collected in subsequent investigation phases, the combined dataset will be reevaluated and used in subsequent steps of the HHRA.

5.1 Data Evaluation and Identification of COPCs

Soil (surface and subsurface) and groundwater samples will be addressed in the HHRA as follows:

- Soil samples collected from discrete depths between 0 and 10 feet bgs during the Phase I RFI (and potentially during Phase II, if further delineation is needed) will be used in the HHRA. Surface soil from 0 to 2 feet bgs will be used to evaluate the current industrial scenario and current trespasser/recreational user scenario. Because future invasive activities may disturb soil in the shallow subsurface (0 to 10 feet bgs) and bring current subsurface soil to the ground surface where contact may occur, soil from the 0- to 10-foot bgs interval will be used to evaluate reasonably foreseeable future scenarios.
- Groundwater samples collected during the Phase II RFI will be used to evaluate applicable current and future groundwater exposure scenarios.

5.1.1 Selection of Chemicals of Potential Concern

The COPC screening process will be conducted for soil on a site-specific basis (by SWMU or AOC); in future investigations, groundwater will be screened on a sitewide or site-specific basis, as appropriate, based on results of groundwater sampling. The maximum detected

concentration of each detected constituent will be compared to its screening level. If the maximum detected concentration exceeds its screening level, it will be retained as a COPC for further evaluation in the HHRA. For constituents with at least 20 samples and a frequency of detection of less than 5 percent, a weight of evidence approach will be used to determine if the chemical is related to the investigated area. The magnitudes and locations (clustering) of the detected concentrations and potential source of the chemical will be evaluated. If the detected results for a given chemical show no clustering, the concentrations are not substantially elevated relative to the detection limit, and the chemical was not historically used in the area where detected, the detected results will be considered sporadic, and the chemical will be eliminated as a COPC.

For constituents that are not detected in all samples within an environmental medium, the maximum reporting limit for each constituent will be compared to its screening level to determine if a weight of evidence evaluation, as described above, is warranted to determine COPC status. The COPC selection process will be discussed in the RFI and presented in RAGS, Part D, Table 2 (USEPA 2001).

5.1.2 Screening Levels for Soil and Sediment

Surface soil, subsurface soil, and sediment analytical results will be screened against the USEPA RSLs for chemical constituents at Superfund sites (USEPA 2010). The RSLs based on noncarcinogenic health endpoints will be reduced by a factor of 10 (i.e., adjusted to a hazard quotient [HQ] = 0.1) to account for the potential presence of multiple constituents affecting the same target organ, while no adjustment will be made for the RSLs based on carcinogenic health endpoints (i.e., the RSLs will be based on a target excess lifetime cancer risk [ELCR] of $1x10^{-6}$). For those constituents with more than one RSL (e.g., carcinogenic-based RSL, noncarcinogenic-based RSL [HQ = 0.1]), the lowest value will be selected as the final RSL for that constituent. The industrial RSLs will be used for selecting soil COPCs for onsite areas, and the residential RSLs will be used for selecting soil and sediment COPCs for offsite and public accessible areas. A detected constituent in soil that has no RSL will be compared to an RSL for a surrogate chemical, if available.

5.1.3 Screening Levels for Groundwater

Groundwater data will be screened against the tap water RSLs (USEPA 2010). Similar to the approach for soil described above, the RSLs based on noncarcinogenic health endpoints will be reduced by a factor of 10 (adjusted to an HQ = 0.1) to account for the potential presence of multiple constituents affecting the same target organ, while no adjustment will be made for the RSLs based on carcinogenic health endpoints (i.e., the RSLs will be based on a target ELCR of $1x10^{-6}$).

5.2 Baseline HHRA

As described in Section 4, the RFI is designed to be completed in phases. For Phase I, surface and subsurface soil and sediment will be investigated. The human health evaluation of Phase I data will only include a screening assessment (i.e., comparison of analytical data collected during Phase I to media-specific screening values). Based on the results of the screening assessment from the Phase I dataset, recommendations will be made for further

evaluation of the Phase I data, additional data collection, and/or no further action with respect to human health risk.

If warranted after the Phase II field investigation, a draft HHRA report will be prepared and incorporated into the draft RFI report. The report will include a discussion of potential uncertainties inherent in the estimates of potential cancer risks and noncancer health hazards presented in the risk assessment.

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SECTION 6

Ecological Risk Assessment Approach

This section describes the proposed ERA to be conducted on surface soil, surface water, and sediment data collected as part of the proposed RFI activities. The ERA will consist of a screening ecological risk assessment (SERA) (Steps 1 and 2 of the ERA process) and the first step (Step 3) of the baseline ecological risk assessment (BERA). The ERA will follow the procedures set forth in the following ERA guidance documents:

- USEPA. 1992. Framework for Ecological Risk Assessment. EPA/630/R-92/001.
- USEPA. 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments.* Interim Final. EPA/540/R-97/006.
- USEPA. 1998. *Guidelines for Ecological Risk Assessment.* EPA/630/R-95/002F.
- Ohio Environmental Protection Agency (Ohio EPA). 2008. *Ecological Risk Assessment Guidance Document.* DERR-00-RR-031. Division of Emergency and Remedial Response.

The overall objective of the ERA will be to determine whether constituents of potential ecological concern (COPECs) are present at the facility, and if present, whether additional action or evaluation is warranted. As described in Section 4, the RFI is designed to be completed in phases. For Phase I, surface and subsurface soil and sediment will be investigated. The proposed ERA for Phase I data will only include a screening assessment (i.e., comparison of analytical data collected during Phase I to media-specific screening values). Based on the results of the screening assessment from the Phase I dataset, recommendations will be made for further evaluation of the Phase I data, additional data collection, and/or no further action with respect to ecological risk.

Below is a summary of the main components of the ERA:

- **Problem Formulation:** Involves (1) compiling and reviewing existing information on the ecological setting; (2) compiling and reviewing available analytical and biological data; (3) developing a CSM that identifies and evaluates potential source areas, transport pathways, fate and transport mechanisms, exposure media, exposure pathways and routes, and receptors; and (4) developing assessment and measurement endpoints for critical exposure pathways.
- **Screening Assessment:** This step completes the SERA and involves an evaluation of the potential for adverse effects to both lower trophic level receptors (plants and invertebrate) from direct exposure to facility soil and the potential for adverse effects to upper trophic level receptors (i.e., birds and mammals) from the investigation of prey that have accumulated constituents via the food web. Preliminary COPECs will be identified by direct comparison of constituent concentrations detected in soil to USEPA Region 5 ecological screening levels (ESLs) and/or USEPA ecological soil screening levels (Eco-SSLs); USEPA Region 5 ESLs for sediment; and Ohio EPA water quality criteria and/or USEPA Region 5 ESLs for surface water. Those constituents that

exceeded the screening levels will be retained for further analysis. (Note, this step is the final step of the ERA for the proposed Phase I dataset.)

- **Refined Risk Characterization:** This characterization completes the first step (Step 3) of the BERA. This section will include refinements of the conservative assumptions employed in the SERA. (This step and subsequent steps will only be conducted if warranted based on the ecological screening assessment results and, as a result, will not be included as part of the Phase I RFI report.)
- **Risk Evaluation:** This section will include an evaluation of the outcomes of the SERA and Step 3 of the BERA. The risk evaluation helps identify which refined COPCs are most likely to pose unacceptable risks to receptor populations considering several lines of evidence (i.e., a weight-of-evidence approach).
- **Uncertainty Evaluation:** This section will include a presentation and discussion of the potential uncertainties of the inputs to the ERA.
- **Ecological Risk Conclusions:** The section will summarize the outcome of the ERA.

As described in Section 4, the RFI is designed to be completed in phases. For Phase I, surface and subsurface soil and sediment will be investigated. The proposed ERA for Phase I data will only include a screening assessment (i.e., comparison of analytical data collected during Phase I to media-specific screening values). Based on the results of the screening assessment from the Phase I dataset, recommendations will be made for further evaluation of the Phase I data, additional data collection, and/or no further action with respect to ecological risk.

Based on limited facility history knowledge and observations by a CH2M HILL ecologist during a November 2010 site visit, it was determined that portions of the facility contain habitats and biota (i.e., potential ecological receptors) and exhibit potentially complete exposure pathways for such receptors. Further detailed below are the preliminary screening level problem formulation for the facility and subsequent selection of ecologically relevant SWMUs/AOCs and the rationale for excluding other SWMUs/AOCs from ERA considerations.

6.1 Screening Level Problem Formulation

As presented above, the screening level problem formulation is the first step of the ERA process and was conducted as part of this work plan in an effort to establish the goals, scope, and focus the ecological investigations of the various SWMUs/AOCs at the facility. The problem formulation presented below involved the following:

- Compiling and reviewing existing information on the ecological setting
- Compiling and reviewing available analytical and biological data
- Developing a CSM that identifies and evaluates potential source areas, transport pathways, fate and transport mechanisms, exposure media, exposure pathways and routes, and receptors
- Developing assessment and measurement endpoints for critical exposure pathways

Two main questions were addressed in the problem formulation:

1. Are habitats and biota (i.e., potential ecological receptors) present?
2. Do complete exposure pathways exist for such receptors?

If the answer is "No" to both these questions, then exposure pathways are considered incomplete, and the ERA process terminates at Step 1 with a conclusion of negligible (acceptable) risk. Step 1 of the ERA process for each SWMU and AOC is presented in Section 6.2.

6.2 Selection of Ecologically Relevant Sites

As a preliminary step to the problem formulation, a determination was first made as to which SWMUs or AOCs could be considered ecologically relevant (i.e., contain habitat, ecological receptors, and potentially complete exposure pathways) and warrant further evaluation via the ERA process. To make this determination, the following three basic questions were asked of each site:

1. Are habitats and biota present onsite or directly adjacent?
2. Are exposure pathways potentially complete (i.e., might receptors be exposed to contaminated media, if present)?
3. Should the ERA process continue?

The answers to these questions relative to the observed conditions are summarized in Table 6-1. The answers to Questions 1 and 2 are based largely on observations made during a site visit in November 2010 by a CH2M HILL ecologist to evaluate the general ecological setting at the facility and localized habitats at specific SWMUs and AOCs. In addition, facility history information summarized in earlier sections of this document also was used to help answer Question 2, if the answer to Question 1 was "Yes." Based on this, the following SWMUs and AOC were identified as ecologically relevant:

- SWMU 18 – Drainage Ditch to Big Thief Creek
- SWMU 19 – Drainage Ditch to North
- SWMU 29 – Former Used Filter Sand Pile

Nine sites do not warrant further evaluation within the ERA because they are within or near the current and/or former process areas of the facility; surrounded by buildings, pavement, and/or roads; enclosed partially or completely by fencing or berms; and contain no viable habitats. Therefore, the answer to Question 1 for each of these sites is "No", and so it follows that no receptors or receptor groups are expected to use these sites; thus, there is no potential for complete exposure pathways. As such, ERAs will not be conducted for the following sites, and they are not considered or discussed further:

- Four other sites (SWMUs 25, 26, 27, and 28) that have viable habitats (adjacent terrestrial grasslands) but are located within process areas
- Areas that are either paved or covered with gravel and could not support viable terrestrial receptors

For SWMU 37, the answer to Question 1 also was "Yes" because of a small fire pond. This unit consists of a concrete basin with a 25,000-gallon capacity located north of the wastewater treatment system. The unit receives untreated process water from the process sewer system. Given the nature of this basin (i.e., concrete structure), this SWMU could not likely support aquatic life (other than opportunistic aquatic insects such as fly larvae), and as a result, further evaluation of SWMU 37 is not warranted with respect to ecological risk.

6.3 Preliminary Ecological Conceptual Site Model

Based on the environmental setting discussion above and facility history, a preliminary ecological CSM was developed to describe the potential sources, pathways and exposure routes, and potential receptors for the four sites containing habitats and potentially complete exposure pathways (Table 6-1). Based on the preliminary CSM, a series of assessment endpoints, risk hypotheses, and measurement endpoints also were developed. Figure 6-2 presents the generalized CSM that is applicable for SWMUs 18, 19, and 29.

6.3.1 Potential Source Areas

Potential source areas include:

- Former spills, releases, and discharges to drainage ditches (SWMUs 18 and 19) from stored materials and/or process waste streams
- Former spills and or releases from stored materials to ground surface (SWMU 29)

6.3.2 Potential Transport Pathways and Exposure Media

A transport pathway describes the mechanisms whereby facility-related constituents, once released, may be transported from a source to ecologically relevant media where receptor exposures may occur. The primary mechanisms for transport from the source areas identified above may include:

- Leaching of constituents from soil or waste materials by infiltrating precipitation and transport to surface water bodies by groundwater
- Leaching of constituents from soil or waste materials by precipitation and transport by surface runoff by overland flow to surface water bodies
- Uptake by biota from surface soil, sediment, or surface water and trophic transfer to upper trophic level receptors

Because of where ecological receptors reside and forage, the following exposure media of interest were identified:

- Surface sediment
- Surface soil

Although surface water is present within the drainage ditch to Big Thief Creek and in the drainage ditch to the north, surface water is not considered a media of concern at this point in the ERA. Evaluation of surface soil and sediment data collected in Phase I will be evaluated to determine the need for collection of surface water.

Groundwater is considered only as a transport medium, since there are no ecological exposures to groundwater until it discharges to surface water bodies. In these areas, upwelling or venting situations can occur where groundwater passes through the shallow subsurface sediment on its way into the surface water body. The hydrological interface is referred to as the groundwater-surface water interface (GSI) and the shallow subsurface sediment environment is considered the biologically active zone (BAZ) since the majority of benthic macroinvertebrates is expected to reside here. The BAZ is the key point of potential exposure at GSI situations. Potential exposures are from constituents in migrating groundwater, sediment, and/or surface water. Additionally, deep-rooted terrestrial plants might be exposed to perched groundwater in some situations.

Groundwater exposures at the GSI will not be addressed during the initial evaluation because little is known about the linkage, or lack thereof, between facility-related groundwater and aquatic habitats. Information gained during Phase I of the investigation (soil and groundwater dynamics) will be used to determine if the GSI should be addressed in subsequent phases of investigation and ERAs.

Air also will not be formally addressed in the ERAs, because that medium is not likely to result in significant contributions to total exposure.

6.4 Exposure Pathways and Routes

An exposure pathway links a source with one or more receptors through exposure by one or more media and exposure routes. Exposure, and thus potential risk, can occur only if complete exposure pathways exist. An exposure route describes the specific mechanisms by which a receptor is exposed to a constituent present in an environmental medium.

Figure 6-2 presents an assessment of the significance of exposure routes for various receptor groups with potential site exposure. Exposure routes were classified as any of the following:

- **Complete and significant pathway—**Potential exists for a constituent, if present, to reach a receptor by the proposed route, and there is a high potential the receptor will receive a significant proportion of the constituent dose by the proposed route.
- **Complete and insignificant pathway—**Potential exists for a constituent, if present, to reach a receptor by the proposed route, and there is low potential the receptor will receive a significant proportion of the constituent dose by the proposed route.
- **Incomplete pathway—**There is no potential for a constituent, if present, to reach a receptor by the proposed route.

As noted, terrestrial and aquatic habitats are associated with the facility. For the sites with terrestrial habitats, only those exposure routes considered "complete and significant" or "complete and significance unknown" will be addressed via the ERA process; however, investigation Phase I, proposed in this work plan, is focused on soil and sediment at specific sites. Therefore, even though it is possible that ecological exposures to transported constituents into surface water exist, this pathway will not be addressed at this time in the ERA process. Rather, information gained during the terrestrial ERA process and evaluation of sediment in the ERA and groundwater investigation component of the initial

investigation phase will be used to determine if surface water pathway should be addressed in subsequent phases of investigation and ERAs.

For lower trophic level receptors in the terrestrial and aquatic habitats (e.g., soil invertebrates and marcroinvertebrate communities in sediment), direct contact is considered the primary exposure route. Terrestrial plants are exposed mainly through their root surfaces during water and nutrient uptake to chemicals present in surface soil.

Upper trophic level receptors (e.g., mammals and birds) may be exposed to constituents through:

- Inhalation of gaseous constituents or of constituents adhered to particulate matter
- Incidental ingestion of contaminated abiotic media (soil) during feeding activities
- Ingestion of contaminated water
- Ingestion of contaminated plant and/or animal tissues for constituents which have entered food webs
- Direct (dermal) contact with contaminated abiotic media

Given the small size of the drainage ditches, it is unlikely that these aquatic habitats can support a viable fish community, and it is likely limited to a macroinvertebrate community and insectivorous/herbivorous birds and mammals. As a result, the ERA will only evaluate potential receptors likely to be present within the ditches.

Some volatile chemicals may be present in soil and particulate resuspension may occur at some sites, but inhalation typically will not represent a significant exposure route because the contribution to the total dose from the inhalation route generally is insignificant for upper trophic level ecological receptors relative to ingestion pathways. Exposure to constituents present in surface soil by dermal contact may occur but is unlikely to represent a major exposure pathway for most receptors because fur and feathers minimize transfer of constituents across dermal tissue.

6.4.1 Receptors of Potential Concern

Because of the complexity of natural systems, it is not practical to assess directly the potential impacts to ecological receptors present. Therefore, specific receptor species (e.g., American robin) or species groups (e.g., macroinvertebrates) were selected as surrogates to evaluate potential risks to larger components of the ecological community (such as herbivorous birds) used to represent the assessment endpoints (e.g., survival and reproduction of herbivorous birds). The following criteria were used to select receptor species:

- Those known to occur, or are likely to occur, on the facility
- Those having a particular ecological, economic, or aesthetic value
- Those that are representative of taxonomic groups, life history traits, or trophic levels in the habitats present at the facility for which complete exposure pathways are likely to exist

- Those that can be expected, because of toxicological sensitivity or potential exposure magnitude, to represent potentially sensitive populations at the facility

Section 3.4 summarizes the ecological setting of the facility as observed during the site visit. The following upper trophic level receptors were selected for evaluation based upon the criteria listed above and from the site observations:

- Red-tailed hawk (*Buteo jamaicensis*)—avian terrestrial carnivore
- Mallard duck (*Anas platyrhynchos*)—avian semi-aquatic herbivore
- Marsh wren (*Cistothorus palustris*)—avian semi-aquatic insectivore
- Mourning dove (*Zenaida macroura*)—avian terrestrial herbivore
- American robin (*Turdus migratorius)*—avian terrestrial insectivore
- Short-tailed shrew (*Blarina brevicauda*)—mammalian terrestrial insectivore
- White-tailed deer (*Odocoileus virginianus*)—mammalian terrestrial herbivore
- White-footed mouse (*Peromyscus leucopus*)—mammalian terrestrial herbivore
- Red fox (*Vulpes vulpes*)—mammalian terrestrial carnivore
- Muskrat (*Ondatra zibethicus*)—mammalian semi-aquatic herbivore

Upper trophic level receptor species quantitatively evaluated in the ERA process will be limited to birds and mammals, the taxonomic groups with the most available information regarding exposure and toxicological effects. Lower trophic level receptor species will be evaluated based upon those taxonomic groupings for which medium-specific screening values have been developed. As such, specific species of aquatic biota are not chosen as receptors because of the limited information available for specific species and because aquatic biota (e.g., macroinvertebrates) will be evaluated on a community level by comparison of medium-specific constituents with corresponding screening values.

Amphibians and reptiles also are applicable receptor groups. Individual species of reptiles and amphibians, however, are not selected for evaluation because of the general lack of available toxicological information for these taxonomic groups for direct effects (reptiles) and effects from exposures by food webs (reptiles and amphibians). Potential risks to amphibians and reptiles from food web exposures will be generally evaluated using other fauna (birds and mammals) as surrogates. However, potential risks to these groups from direct exposure to soil will not be evaluated because amphibians and reptiles more commonly occur in association with aquatic habitats, which are not being addressed in these ERAs.

6.4.2 Endpoints and Risk Hypotheses

Problem formulation includes the selection of ecological endpoints and risk hypotheses based upon the CSM. Two types of endpoints—assessment endpoints and measurement endpoints—are defined as part of the ERA process (USEPA 1997). An assessment endpoint is an explicit expression of the environmental component or value that is to be protected. A measurement endpoint is a measurable ecological characteristic that is related to the component or value chosen as the assessment endpoint. The considerations for selecting assessment and measurement endpoints are summarized in USEPA (1997) and discussed in detail in Suter (1989, 1990, 1993). Risk hypotheses are testable hypotheses about the relationship among the assessment endpoints and their predicted responses when exposed to constituents.

Endpoints define ecological attributes to be protected (assessment endpoints) and measurable characteristics of those attributes (measurement endpoints) that can be used to gauge the degree of adverse effect that has occurred or may occur. Assessment endpoints most often relate to attributes of biological populations or communities. They are intended to focus the risk assessment on particular components of the ecosystem that could be adversely affected by constituents attributable to a site (USEPA 1997). Assessment endpoints contain an entity (e.g., a heron population) and an attribute of that entity (e.g., survival rate). Individual assessment endpoints usually encompass a group of species or populations (the receptor) with a common characteristic, such as specific exposure route or constituent sensitivity, with the receptor then used to represent the assessment endpoint in the risk evaluation.

Assessment and measurement endpoints may involve ecological components from any level of biological organization, from individual organisms to the ecosystem itself. Effects on individual organisms are important for some receptors, such as rare and endangered species. Population- and community-level effects typically are more relevant to ecosystems. Population- and community-level effects usually are difficult to evaluate directly without long-term and extensive study. However, measurement endpoint evaluations at the individual level, such as an evaluation of the effects of constituent exposure on reproduction, can be used to predict effects on an assessment endpoint at the population or community level.

Table 6-2 summarizes the specific assessment endpoints, risk hypotheses, measurement endpoints, and associated receptors that will be used in the ERA process. Revisions to assessment endpoints assessment endpoints, risk hypotheses, measurement endpoints, and associated receptors may need to be made following the Phase I sampling efforts based on visual observations of species within the drainage ditches and onsite.

6.5 ERA Deliverables

Following the Phase I investigation (consisting of soil and sediment sampling), preliminary screening of detected constituents will be conducted for each ecologically relevant site at the facility (SWMU 18, 19, and 29) and results will be presented as part of the Phase I technical memorandum. For this screening, surface soil screening values for lower trophic level receptors (terrestrial and aquatic receptors) will be identified for detected constituents. USEPA Eco-SSLs, if available, will be used as the primary basis for identification of these screening values. For detected constituents without Eco-SSLs, USEPA Region 5 RCRA ESLs (USEPA 2003) will be used. For chemicals without ESLs and Eco-SSLs, USEPA Region 3 Biological Technical Assistance Group (BTAG) screening values will be used as a tertiary source (USEPA 1995). For sediment, detected constituents will be compared to sediment ESLs. Constituents detected in sediment without ESLs will be compared to BTAG sediment screening values, where available. Other literature values may be used in cases where the primary, secondary, or tertiary values are not available.

Detected concentrations at each site will be compared to these surface soil and sediment screening values to evaluate whether surface soil at each of these sites has been delineated sufficiently. If soil or sediment delineation has not been achieved in Phase I, additional soil samples will be recommended for collection during the Phase II RFI in an effort to complete

the delineation, and a screening level ecological risk assessment (SLERA) will be prepared and presented via subsequent deliverables (i.e., Phase II technical memorandum). If it is determined that Phase I delineation is sufficient a particular site or sites, an SLERA will be presented for each delineated site via the Phase I technical memorandum. If bioaccumulative constituents are detected, the SLERA might also include upper trophic level assessment (i.e., food web exposure modeling) for the appropriate receptors indicated above. The overall approach, including the effects and exposure assessments, will be detailed in the ERA section of the Phase I technical memorandum.

If a Phase II investigation is conducted, SLERAs will be conducted and presented in the Phase II technical memorandum, or most appropriate deliverable, for each delineated ecologically relevant site. As done for Phase I SLERAs, lower trophic and upper trophic level assessment (i.e., food web exposure modeling) will be conducted and presented for Phase II SLERAs. The overall approach, including the effects and exposure assessments, will be detailed in the ERA section of the Phase II technical memorandum.

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SECTION 7

References

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Tables

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TABLE 4-1
Proposed Sampling Locations, Types and Analysis
Dow Hanging Rock, Ironton, OH

SWMU	Description	Number of Proposed Borings	Samples to Collect	Samples per Boring	Proposed Analytes
1	Former Flaring Pad	9	Surface/subsurface soil	4	VOCs, SVOCs, RCRA metals
11	Satellite Accumulation Area-Ethafoam Plant	5	Surface/subsurface soil	4	VOCs, SVOCs, RCRA metals
12	Former Methylene Chloride Cleaning Tank	2	Surface/subsurface soil	4	VOCs, SVOCs, RCRA metals
15	Two-Section Septic Tank System	4	Surface/subsurface soil	4	VOCs, SVOCs, RCRA metals
17	Storm Water Drainage System	3	Surface/subsurface soil	4	VOCs, SVOCs, RCRA metals
18	Drainage Ditch to Big Thief Creek	5	Sediment	1	VOCs, SVOCs, RCRA metals
19	Drainage Ditch to North	2	Surface/subsurface soil	4	VOCs, SVOCs, RCRA metals
24	Process Sewer Line	7	Surface/subsurface soil	4	VOCs, SVOCs, RCRA metals
25-28	Former Wastewater Treatment System	4	Surface/subsurface soil	4	VOCs, SVOCs, RCRA metals
29	Former Used Filter Sand Pile	2	Surface/subsurface soil	4	VOCs, SVOCs, RCRA metals
36	Former 250-gallon Pressurized Storage Tanks	TBD	NA	0	VOCs, SVOCs, RCRA metals
37	Fire Protection Collection Basin	TBD	NA	0	VOCs, SVOCs, RCRA metals
AOC	**Description**	**Number of Proposed Borings**			**Proposed Analytes**
D	Underground Catalyst Storage Tank	2	Surface/subsurface soil	4	VOCs, SVOCs, RCRA metals

Notes:

TBD = This site will be evaluated during a later phase when sitewide groundwater is investigated.

VOC = volatile organic compound

SVOC = semivolatile organic compound

RCRA metals = Resource Conservation and Recovery Act metals

Up to four samples will be collected from each proposed boring

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TABLE 6-1
Determination of Need for Ecological Risk Assessment
Dow Hanging Rock, Ironton, Ohio

	Question 1:		Question 2:	Question 3:
Site	**Are habitats and biota present onsite or directly adjacent?**	**Where/Habitat Type**	**Are exposure pathways potentially complete?**	**Should the ecological risk assessment (ERA) process continue?**
SWMU 1 - Former Flaring Pad	No			No
SWMU 11 - Satellite Accumulation Area - Ethafoam Plant	No			No
SWMU 12 - Former Methylene Chloride Cleaning Tank	No			No
SWMU 15 - Two-Section Septic Tank System	No			No
SWMU 17 - Stormwater Drainage System	No			No
SWMU 18 - Drainage Ditch to Big Thief Creek	Yes	onsite/aquatic	Yes	Yes
SWMU 19 - Drainage Ditch to North	Yes	onsite/aquatic	Yes	Yes
SWMU 25 - 28 - Former Wastewater Treatment System	Yes	adjacent/terrestrial (grassland)	No	No
SWMU 29 - Former Used Filter Sand Pile	Yes	onsite/terrestrial (grassland)	Yes	Yes
SWMU 36 - Former 250-gallon Pressurized Storage Tank	Yes	adjacent/aquatic (fire pond)	No	No
SWMU 37 - Fire Protection Collection Basin	Yes	onsite/Aquatic (collection basin)	No	No
AOC D - Underground Catalyst Storage Tank	No			No

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TABLE 6-2
Assessment Endpoints, Risk Hypotheses, and Measurement Endpoints
Dow Hanging Rock, Ironton, Ohio

Assessment Endpoint	Risk Hypothesis	Measurement Endpoint	Receptor
Terrestrial Habitats			
Survival, growth, and reproduction of terrestrial soil invertebrate communities	Are site related PCOC concentrations in surface soils sufficient to adversely affect soil invertebrate communities?	Comparison of constituent concentrations in surface soils with soil screening values	Soil invertebrates (earthworms)
Survival, growth, and reproduction of terrestrial plant communities	Are site-related PCOC concentrations in surface soils sufficient to adversely affect terrestrial plant communities?	Comparison of constituent concentrations in surface soils with soil screening values	Terrestrial plants
Survival, growth, and reproduction of terrestrial reptile populations	Are site-related PCOC concentrations in surface soil sufficient to adversely affect terrestrial reptile populations?	Comparison of constituent concentrations in surface soils with soil screening values	Reptiles
	Are Facility-related constituent concentrations in surface soil sufficient to cause adverse effects (on growth, survival, or reproduction) to terrestrial reptile populations?	Evidence of potential risk to other upper trophic level terrestrial receptors evaluated in the ERA	
Survival, growth, and reproduction of avian terrestrial herbivore populations	Are site-related constituent concentrations in surface soils sufficient to cause adverse effects (on growth, survival, or reproduction) to avian receptor populations that may consume terrestrial plants from the site?	Comparison of modeled dietary intakes using surface soil concentrations with literature-based ingestion screening values; ratios >1 based upon the NOAEL-LOAEL range indicate an effect	Mourning dove
Survival, growth, and reproduction of avian terrestrial insectivore populations	Are site-related PCOC concentrations in surface soils sufficient to cause adverse effects (on growth, survival, or reproduction) to avian receptor populations that may consume terrestrial plants and soil invertebrates from the site?	Comparison of modeled dietary intakes using surface soil concentrations with literature-based ingestion screening values; ratios >1 based upon the NOAEL-LOAEL range indicate an effect	American robin
Survival, growth, and reproduction of avian terrestrial carnivore populations	Are site-related PCOC concentrations in surface soils sufficient to cause adverse effects (on growth, survival, or reproduction) to avian receptor populations that may consume small mammals from the site?	Comparison of modeled dietary intakes using surface soil concentrations with literature-based ingestion screening values; ratios >1 based upon the NOAEL-LOAEL range indicate an effect	Red-tailed hawk

TABLE 6-2
Assessment Endpoints, Risk Hypotheses, and Measurement Endpoints
Dow Hanging Rock, Ironton, Ohio

Assessment Endpoint	Risk Hypothesis	Measurement Endpoint	Receptor
Survival, growth, and reproduction of mammalian terrestrial herbivore populations	Are site-related PCOC concentrations in surface soils sufficient to cause adverse effects (on growth, survival, or reproduction) to mammalian receptor populations that may consume terrestrial plants from the site?	Comparison of modeled dietary intakes using surface soil concentrations with literature-based ingestion screening values; ratios >1 based upon the NOAEL-LOAEL range indicate an effect	White-tailed deer
Survival, growth, and reproduction of mammalian terrestrial invertivore populations	Are site-related PCOC concentrations in surface soils sufficient to cause adverse effects (on growth, survival, or reproduction) to mammalian receptor populations that may consume soil invertebrates from the site?	Comparison of modeled dietary intakes using surface soil concentrations with literature-based ingestion screening values; ratios >1 based upon the NOAEL-LOAEL range indicate an effect	Short-tailed shrew
Survival, growth, and reproduction of mammalian terrestrial omnivore populations	Are site-related PCOC concentrations in surface soils sufficient to cause adverse effects (on growth, survival, or reproduction) to mammalian receptor populations that may consume terrestrial plants and soil invertebrates from the site?	Comparison of modeled dietary intakes using surface soil concentrations with literature-based ingestion screening values; ratios >1 based upon the NOAEL-LOAEL range indicate an effect	White-footed mouse
Survival, growth, and reproduction of mammalian terrestrial carnivore populations	Are site-related PCOC constituent concentrations in surface soils sufficient to cause adverse effects (on growth, survival, or reproduction) to mammalian receptor populations that may consume small mammals from the site?	Comparison of modeled dietary intakes using surface soil concentrations with literature-based ingestion screening values; ratios >1 based upon the NOAEL-LOAEL range indicate an effect	Red fox
Aquatic Habitats			
Survival, growth, and reproduction of aquatic and benthic invertebrate communities	Are site-related PCOC concentrations in sediment sufficient to adversely affect aquatic and benthic invertebrate communities?	Comparison of constituent concentrations in sediment with medium-specific screening values	Aquatic and benthic invertebrates
Survival, growth, and reproduction of aquatic plant communities	Are site-related PCOC concentrations in sediment sufficient to adversely affect aquatic plant communities?	Comparison of constituent concentrations in sediment with medium-specific screening values	Aquatic and wetland plants
Survival, growth, and reproduction of amphibian populations	Are site-related constituent concentrations in sediment sufficient to cause adverse effects (on growth, survival, or reproduction) to amphibian populations?	Comparison of constituent concentrations in sediment with medium-specific screening values Evidence of potential risk to other upper trophic level aquatic receptors evaluated in the ERA	Amphibians
Survival, growth, and reproduction of aquatic reptile	Are site-related PCOC concentrations in sediment sufficient to cause adverse effects	Comparison of constituent concentrations in sediment with medium-specific screening values	Reptiles

TABLE 6-2
Assessment Endpoints, Risk Hypotheses, and Measurement Endpoints
Dow Hanging Rock, Ironton, Ohio

Assessment Endpoint	Risk Hypothesis	Measurement Endpoint	Receptor
populations	(on growth, survival, or reproduction) to aquatic reptile populations?	Evidence of potential risk to other upper trophic level aquatic receptors evaluated in the ERA	
Survival, growth, and reproduction of avian aquatic omnivore populations	Are site-related PCOC concentrations in sediment sufficient to cause adverse effects (on growth, survival, or reproduction) to avian receptor populations that may consume aquatic/wetland prey from the site?	Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion screening values; ratios >1 based upon the NOAEL-LOAEL range indicate an effect	Marsh wren
Survival, growth, and reproduction of mammalian aquatic omnivore populations	Are site-related PCOC concentrations in sediment sufficient to cause adverse effects (on growth, survival, or reproduction) to mammalian receptor populations that may consume aquatic/wetland prey from the site?	Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion screening values; ratios >1 based upon the NOAEL-LOAEL range indicate an effect	Raccoon
Survival, growth, and reproduction of avian aquatic herbivore populations	Are site-related PCOC concentrations in sediment sufficient to cause adverse effects (on growth, survival, or reproduction) to avian receptor populations that may consume aquatic plants from the site?	Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion screening values; ratios >1 based upon the NOAEL-LOAEL range indicate an effect	Mallard duck
Survival, growth, and reproduction of mammalian aquatic herbivore populations	Are site-related PCOC concentrations in sediment sufficient to cause adverse effects (on growth, survival, or reproduction) to mammalian receptor populations that may consume aquatic plants from the site?	Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion screening values; ratios >1 based upon the NOAEL-LOAEL range indicate an effect	Muskrat

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Figures

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N

0 20 40
Miles

FIGURE 1-1
Site Location
Dow Hanging Rock
Ironton, Ohio

CH2MHILL

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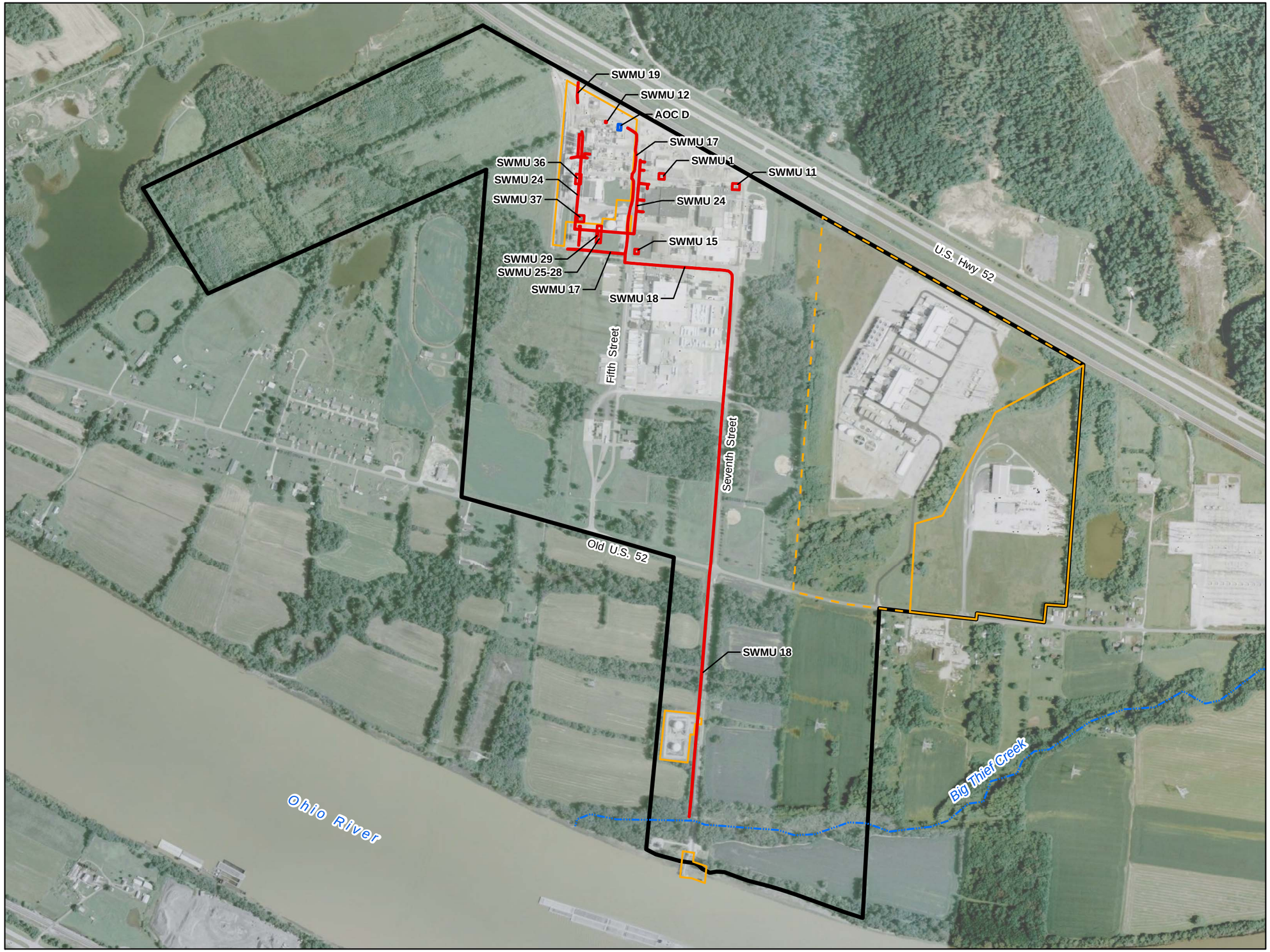

LEGEND

- Approximate Site Boundary
- Property Owned or Leased by Others (Dashed = Assumed Boundary)
- AOC
- SWMU
- Big Thief Creek

N

FIGURE 1-2
Site Layout
Dow Hanging Rock
Ironton, Ohio

CH2MHILL

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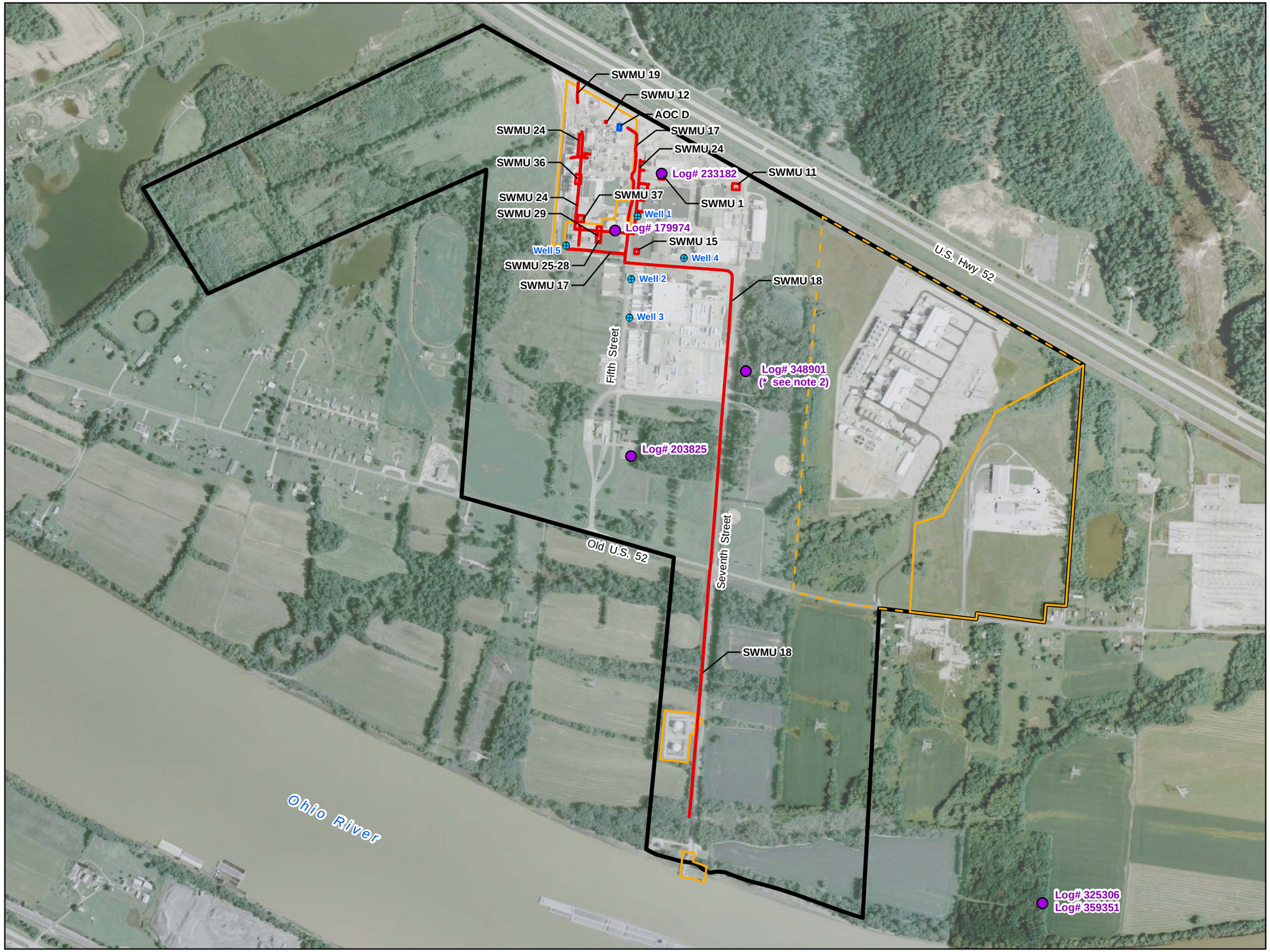


LEGEND

- Approximate Site Boundary
- Property Owned or Leased by Others (Dashed = Assumed Boundary)
- AOC
- SWMU
- ODNR Boring Log
- Approximate Water Well Location (no boring logs available)

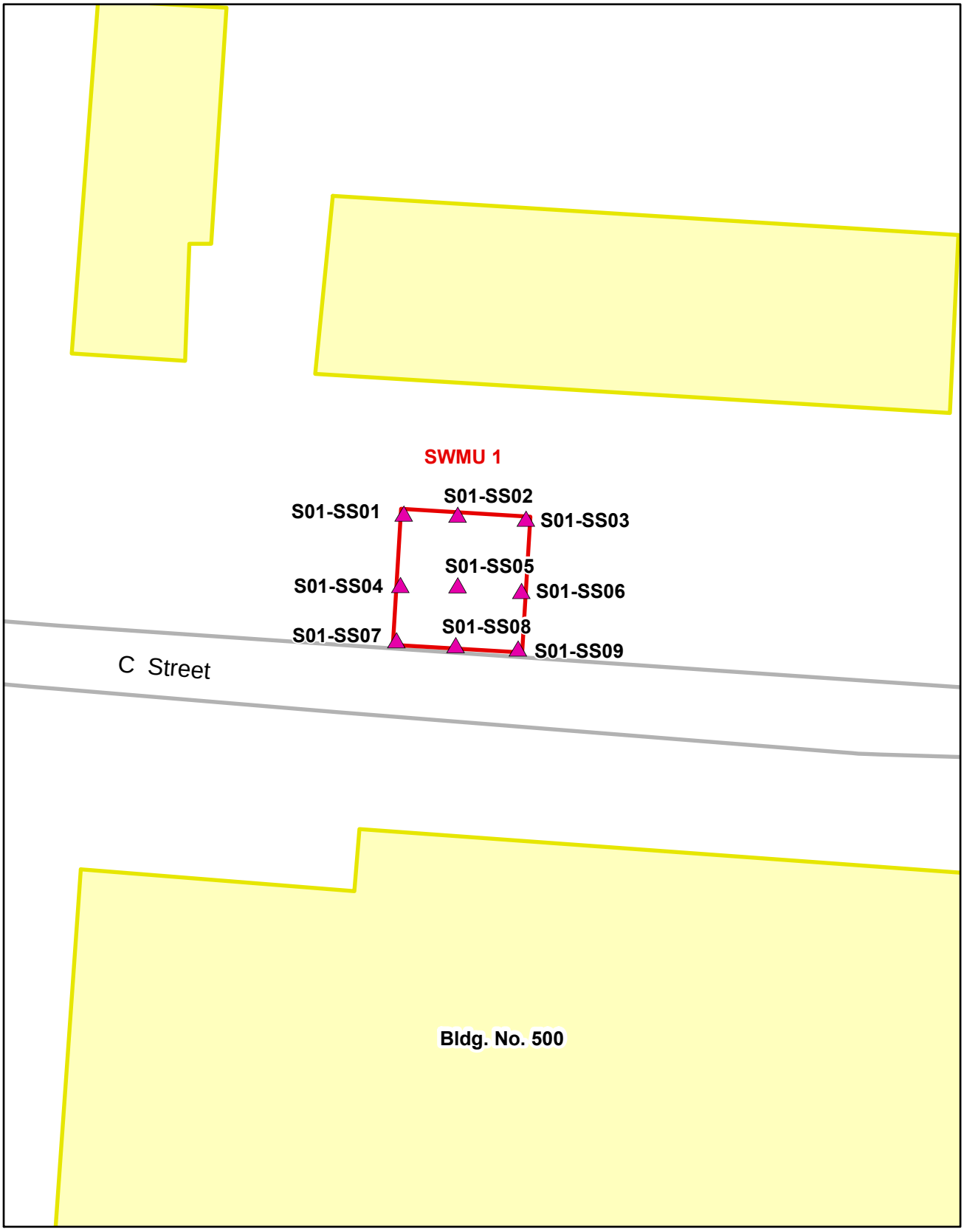
Notes:
1. ODNR = Boring logs from the Ohio Department of Natural Resources
2. * Exact location unknown, well placed based on drawing on log.

N

FIGURE 3-1
Borings and Wells Identified Near Dow Hanging Rock Facility
Dow Hanging Rock

CH2MHILL

RDD \\BALDUR\PROJ\DOW_HANGING_ROCK_404798\MAPFILES\PROPOSED_LOCS\FIG3-1_SURVEY_WELLS.MXD MSCHROCK 10/18/2011 2:19:22 AM



LEGEND

- SWMU
- Building
- Edge of Road
- Proposed Soil Boring

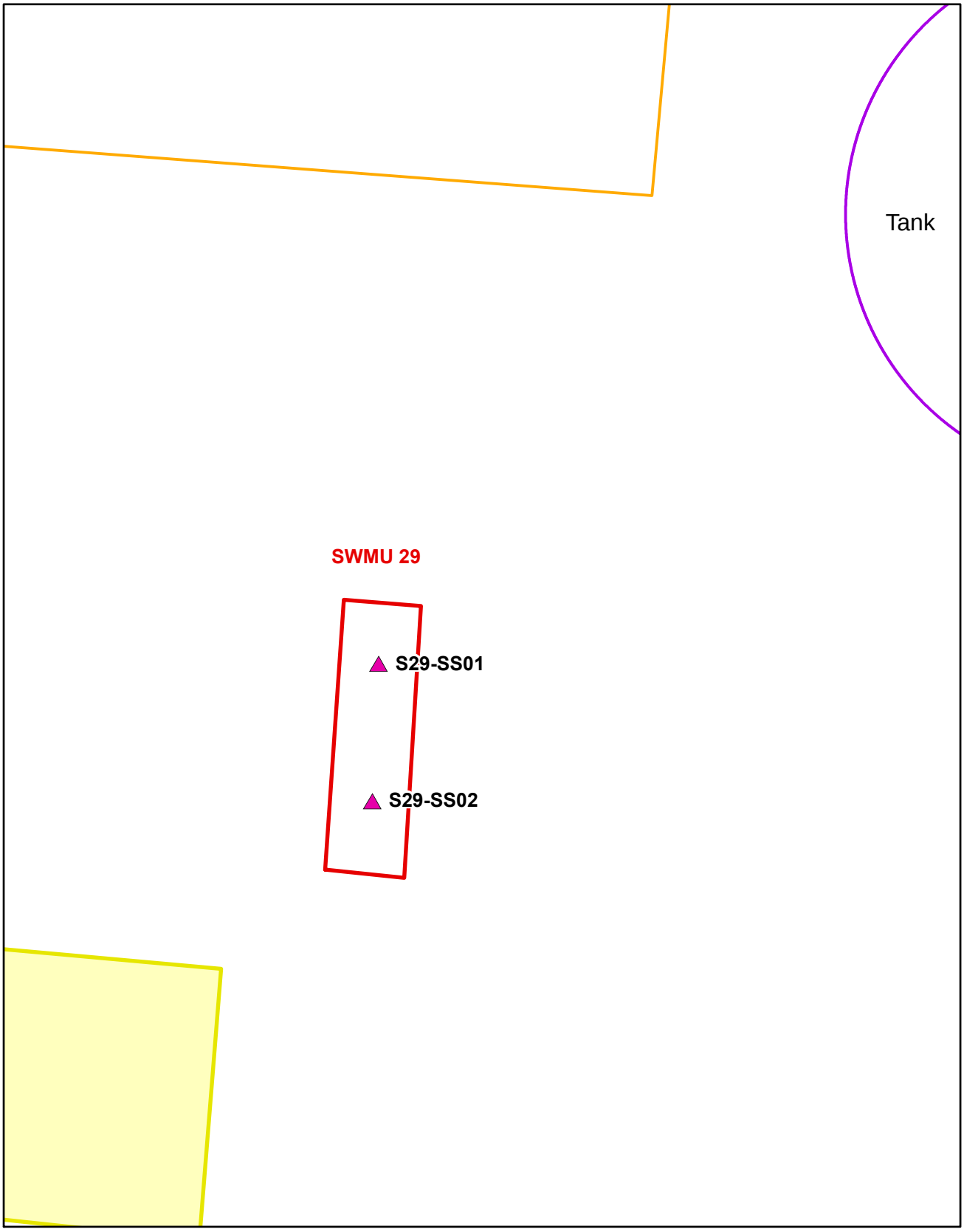
N

0 25 50
Feet

FIGURE 4-1
SWMU 1 – Proposed Sample Locations
Dow Hanging Rock
Ironton, Ohio

CH2MHILL

RDD \\BALDUR\PROJ\DOW_HANGING_ROCK_404798\MAPFILES\PROPOSED_LOCS\FIG4-1_SWMU_1_PROPOSED.MXD MSCHROCK 10/19/2011 10:58:00 PM



LEGEND

- SWMU
- Property Owned or Leased by Others (Dashed = Assumed Boundary)
- Edge of Road
- Proposed Soil Boring

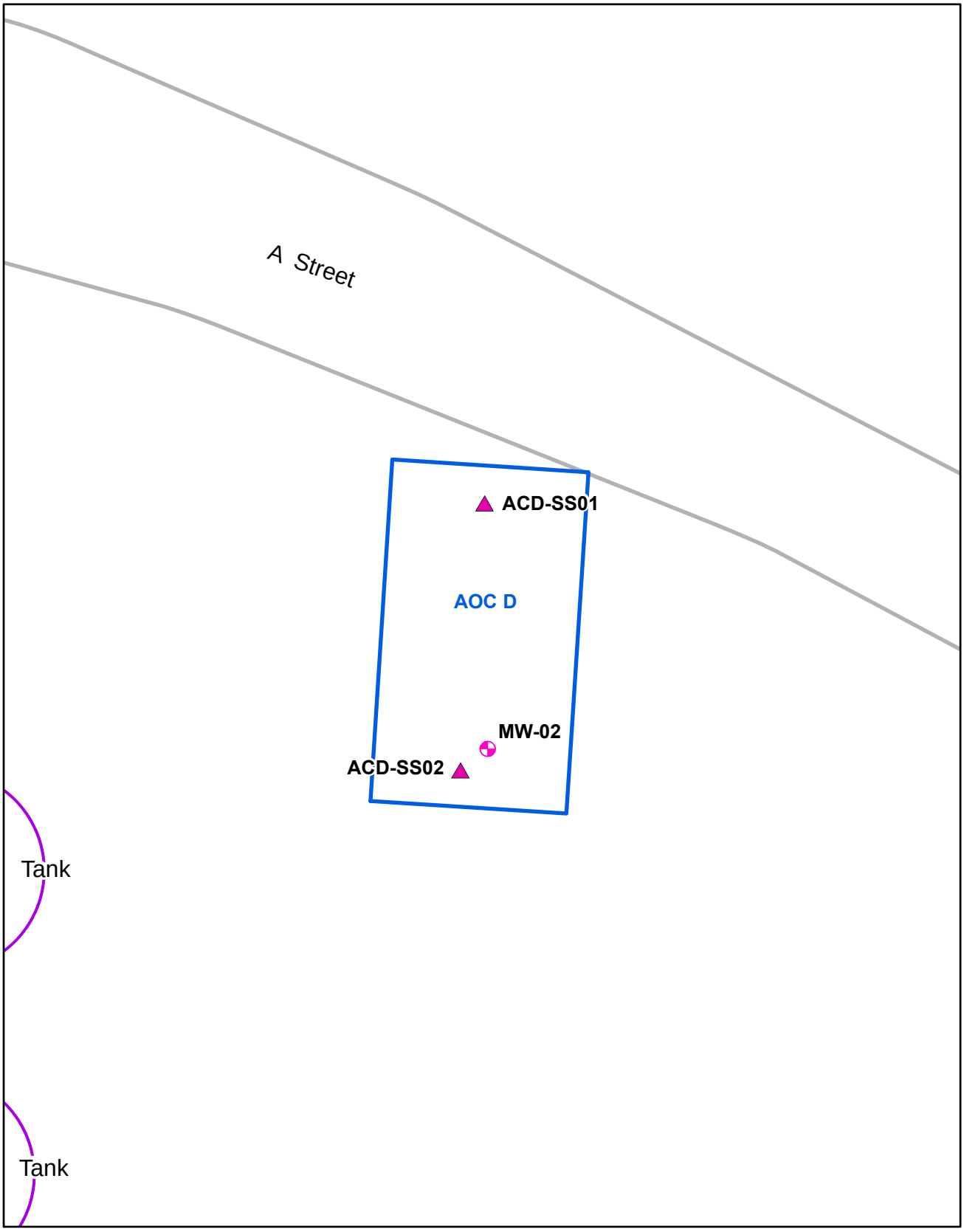
N

0 10 20
Feet

FIGURE 4-10
SWMU 29 – Proposed Sample Locations
Dow Hanging Rock
Ironton, Ohio

CH2MHILL

RDD \\BALDUR\PROJ\DOW_HANGING_ROCK_404798\MAPFILES\PROPOSED_LOCS\FIG4-10_SWMU_29_PROPOSED.MXD MSCHROCK 10/24/2011 2:20:17 PM



LEGEND

- AOC
- Tank
- Edge of Road
- Proposed Monitoring Well
- Proposed Soil Boring

Note:
1. Soil boring locations will be based on utility clearance.

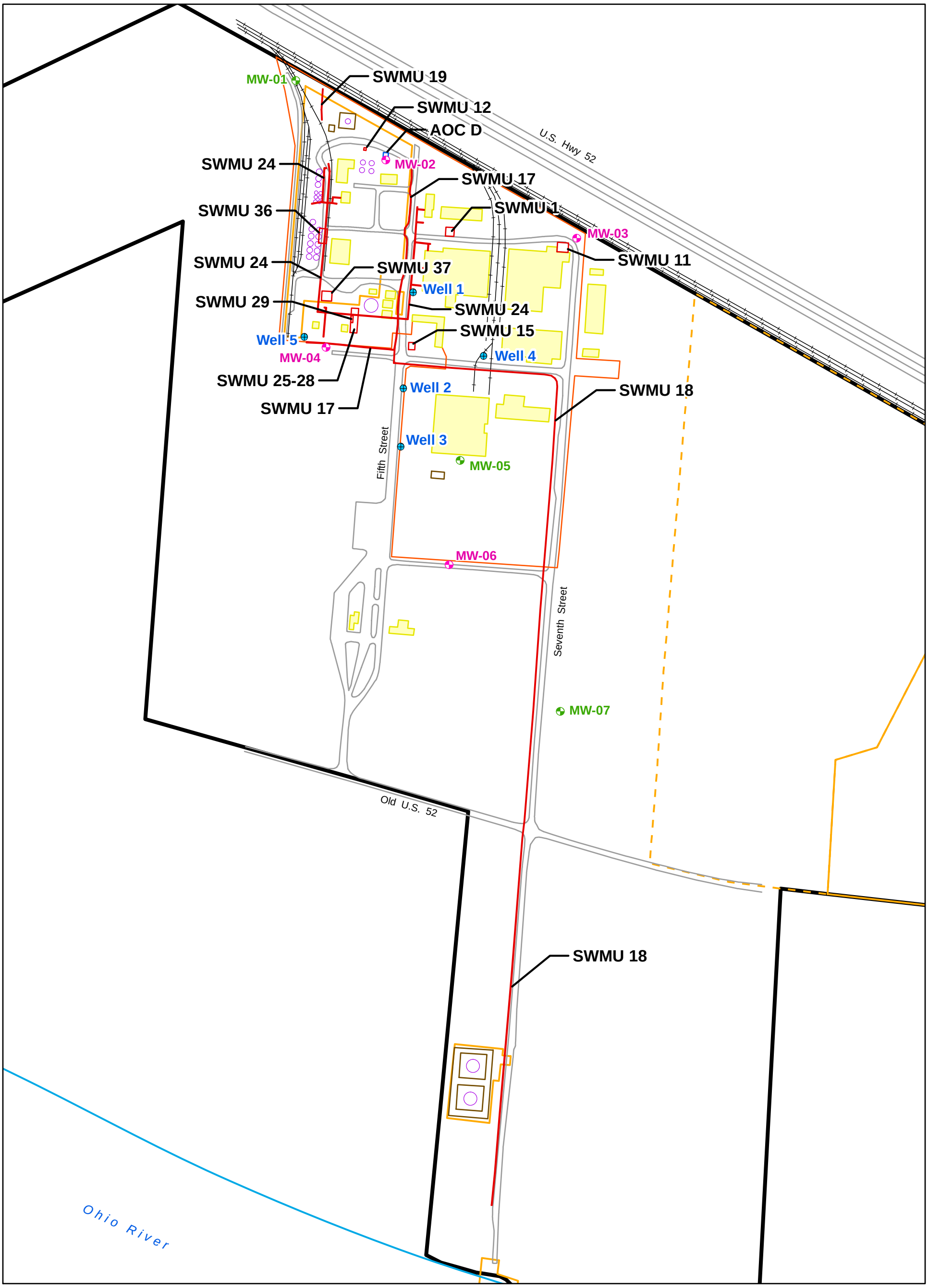
N

0 10 20
Feet

FIGURE 4-11
AOC D – Proposed Sample Locations
Dow Hanging Rock
Ironton, Ohio

CH2MHILL

RDD \\BALDUR\PROJ\DOW_HANGING_ROCK_404798\MAPFILES\PROPOSED_LOCS\FIG4-11_AOC_D_PROPOSED.MXD MSCHROCK 10/19/2011 11:20:50 PM



LEGEND

- Proposed Monitoring Well
- Proposed Monitoring Well / Deep Boring
- Approximate Water Well Location
- Approximate Site Boundary
- Property Owned or Leased by Others (Dashed = Assumed Boundary)
- AOC
- SWMU
- Railroad
- Miscellaneous Structure
- Tank
- Building
- Fence
- Edge of Road

N

0 250 500
Feet

FIGURE 4-12
Current and Proposed Wells
Dow Hanging Rock
Ironton, Ohio

CH2MHILL

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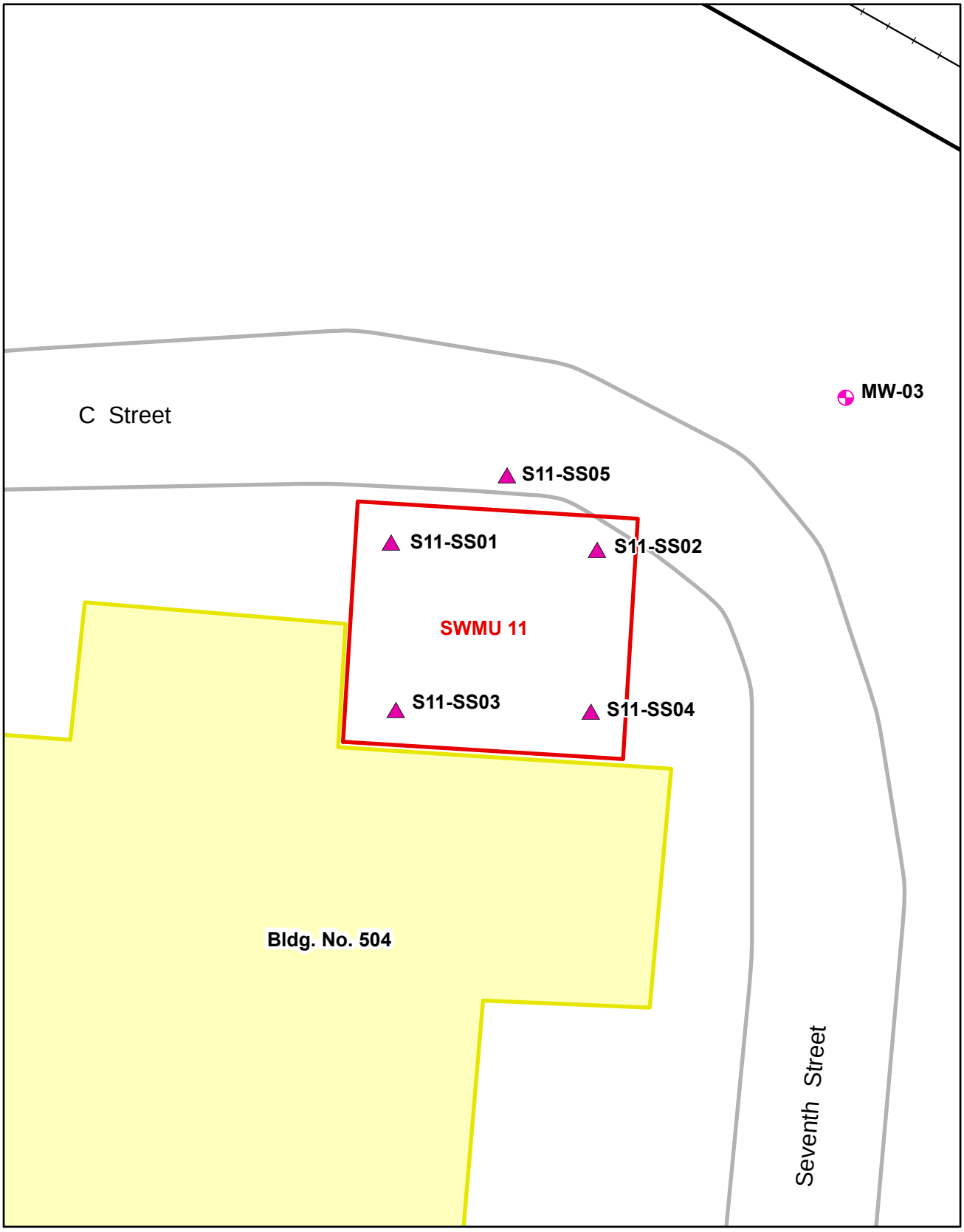


LEGEND

- Approximate Site Boundary
- SWMU
- Building
- Railroad
- Edge of Road
- Proposed Monitoring Well
- Proposed Soil Boring

Note:
1. Sample locations will be biased toward cracks in the concrete and a sump located onsite.

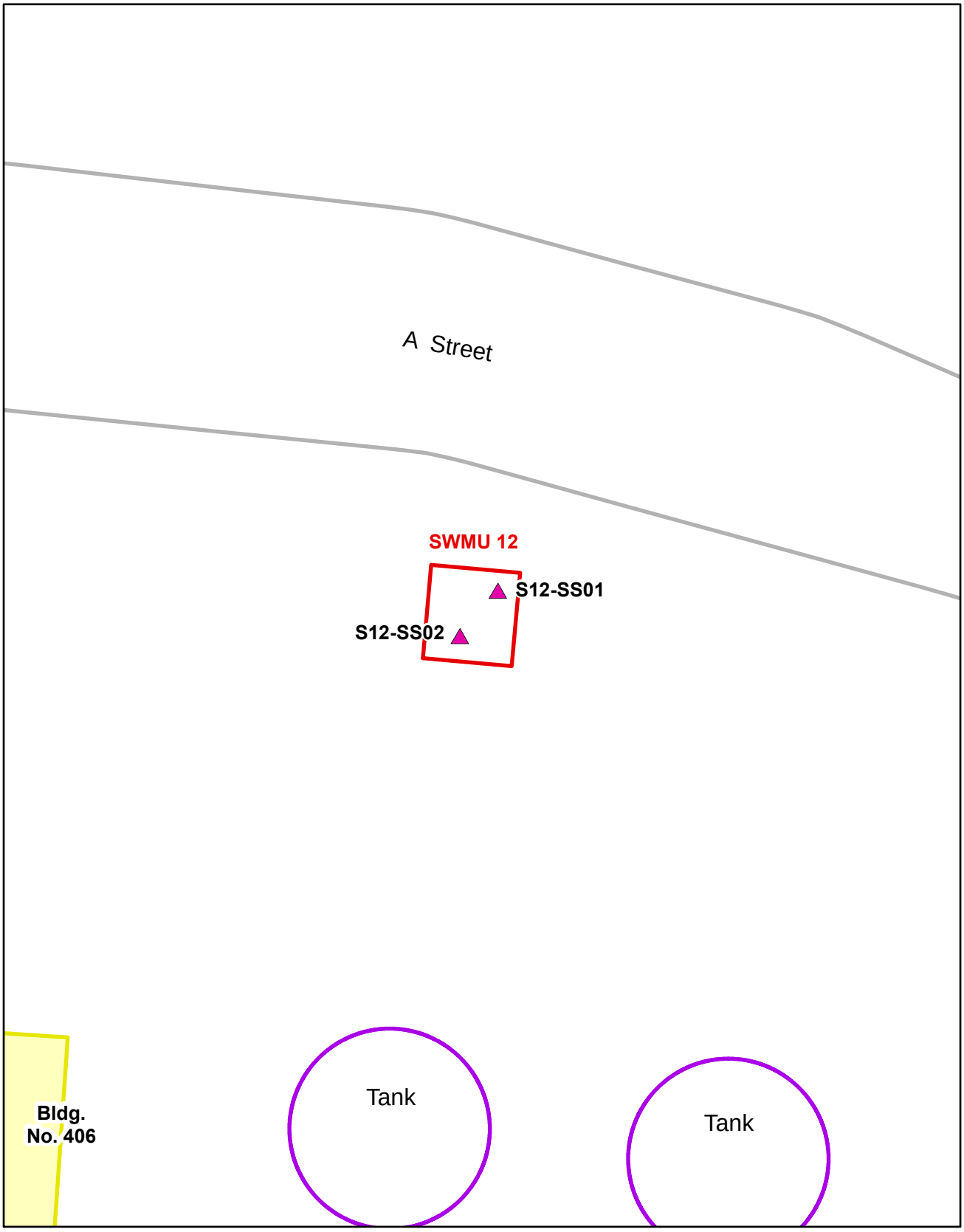
N

0 15 30
Feet

FIGURE 4-2
SWMU 11 – Proposed Sample Locations
Dow Hanging Rock
Ironton, Ohio

CH2MHILL

RDD \\BALDUR\PROJ\DOW_HANGING_ROCK_404798\MAPFILES\PROPOSED_LOCS\FIG4-2_SWMU_11_PROPOSED.MXD MSCHROCK 10/19/2011 10:58:21 PM



LEGEND

- SWMU
- Tank
- Edge of Road
- Proposed Soil Boring

Note:
1. If possible, borings will be located within the containment area.

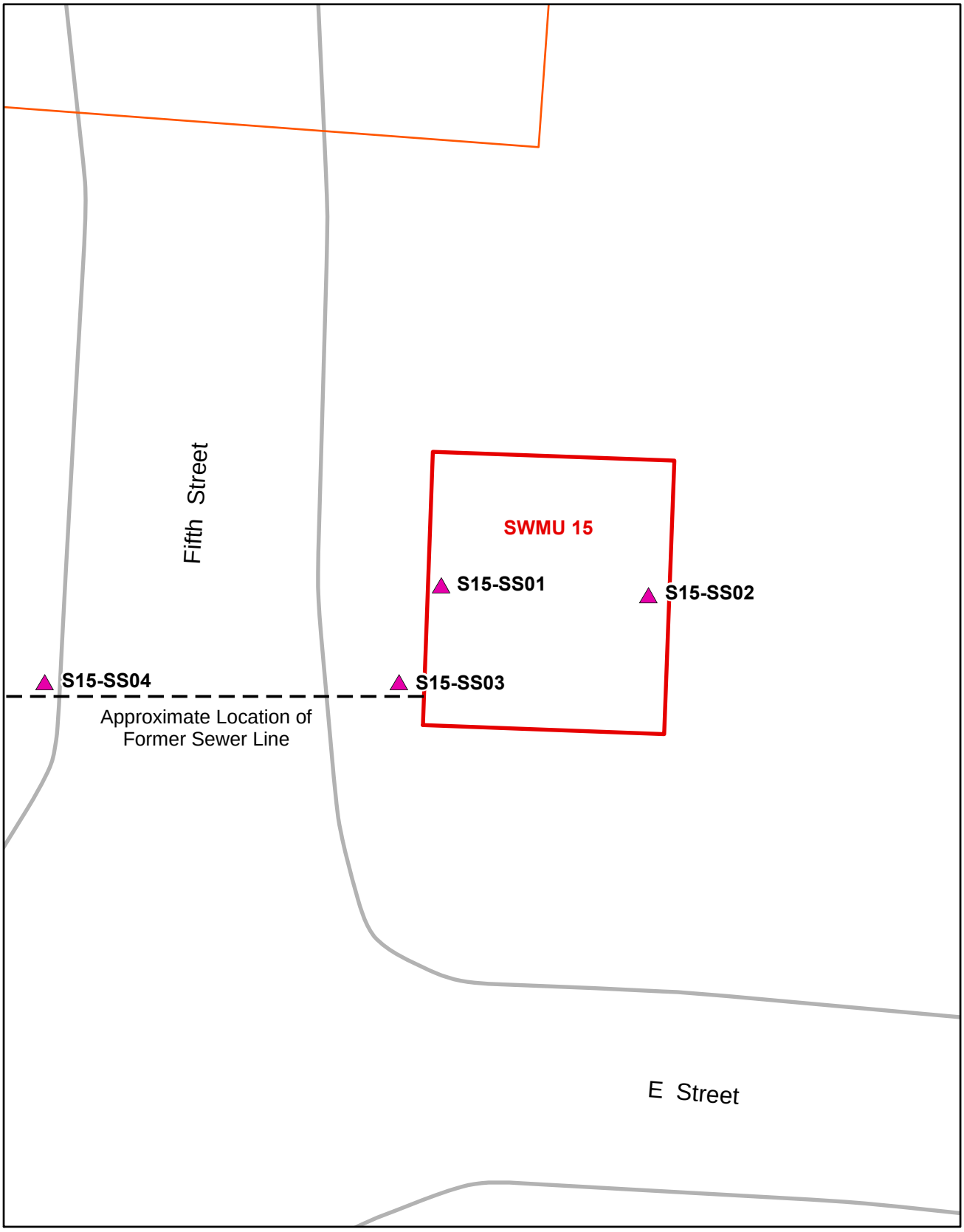
N

0 10 20
Feet

FIGURE 4-3
SWMU 12 – Proposed Sample Locations
Dow Hanging Rock
Ironton, Ohio

CH2MHILL

RDD \\BALDUR\PROJ\DOW_HANGING_ROCK_404798\MAPFILES\PROPOSED_LOCS\FIG4-3_SWMU_12_PROPOSED.MXD MSCHROCK 10/19/2011 10:57:23 PM



LEGEND

- SWMU
- Former Sewer
- Fence
- Edge of Road
- Proposed Soil Boring

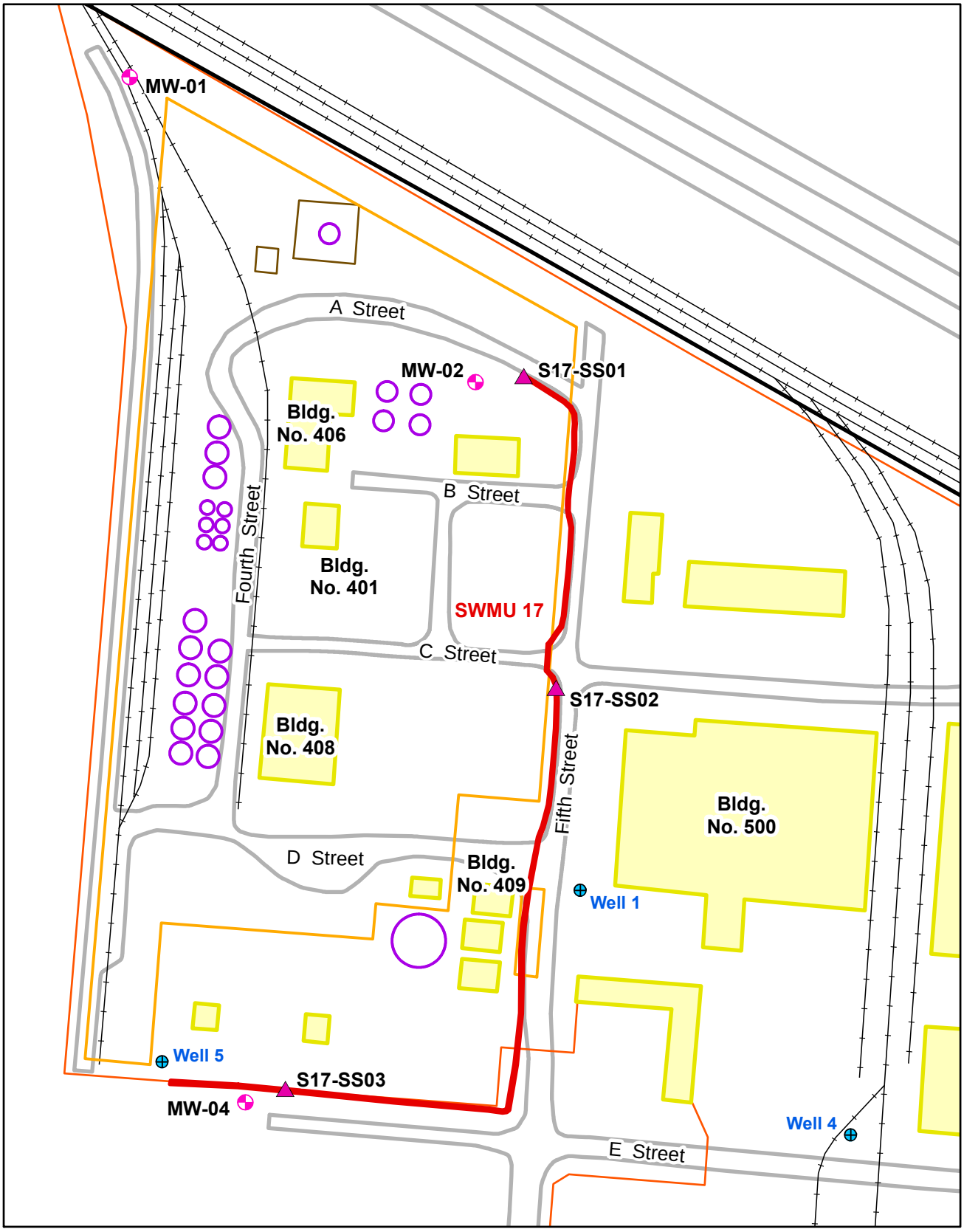
N

0 10 20
Feet

FIGURE 4-4
SWMU 15 – Proposed Sample Locations
Dow Hanging Rock
Ironton, Ohio

CH2MHILL

RDD \\BALDUR\PROJ\DOW_HANGING_ROCK_404798\MAPFILES\PROPOSED_LOCS\FIG4-4_SWMU_15_PROPOSED.MXD MSCHROCK 10/19/2011 10:59:05 PM



LEGEND

- SWMU
- Building
- Approximate Site Boundary
- Property Owned or Leased by Others
- Tank
- Railroad
- Fence
- Edge of Road
- Proposed Monitoring Well
- Proposed Soil Boring
- Approximate Water Well Location

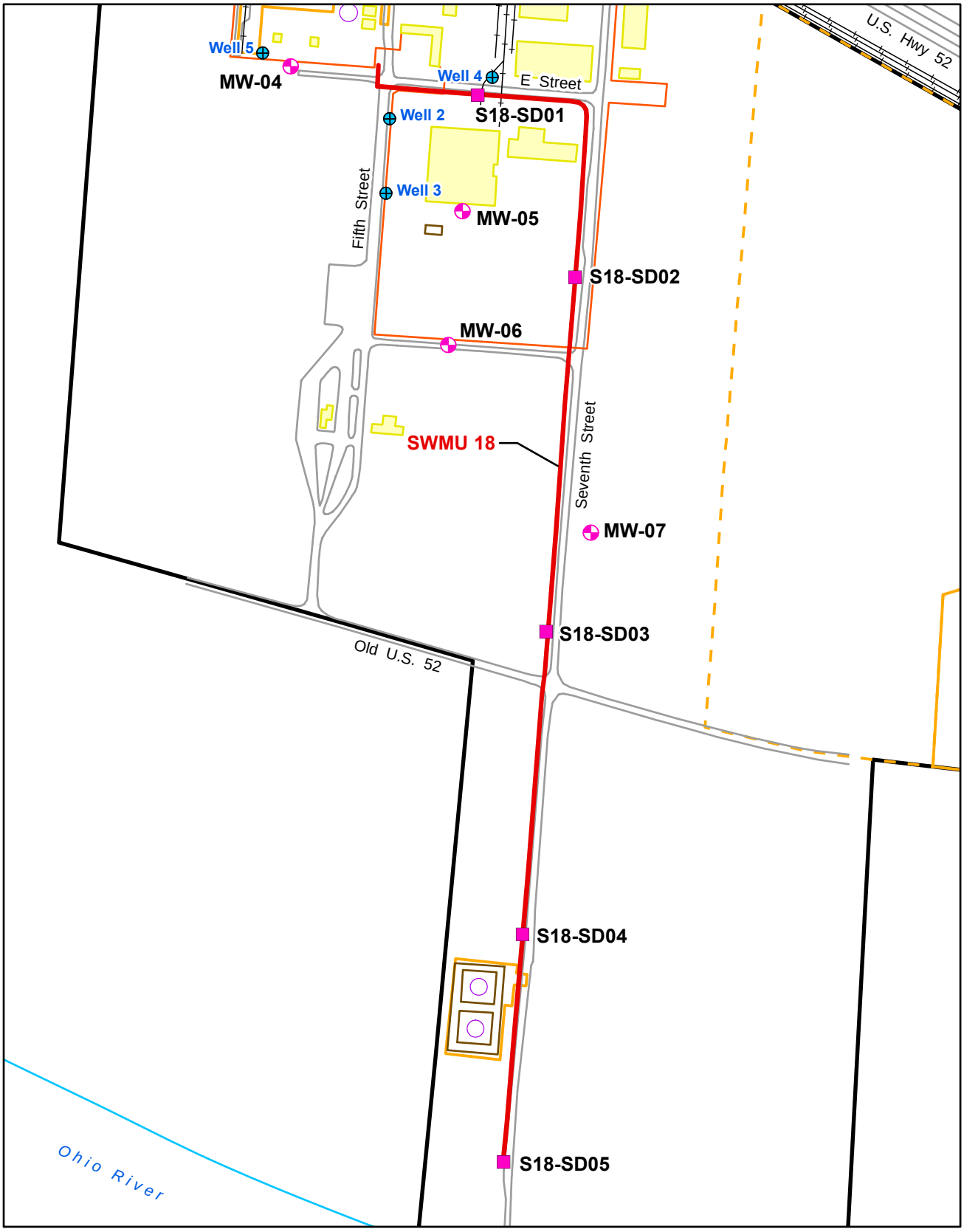
N

0 50 100 200
Feet

FIGURE 4-5
SWMU 17 – Proposed Sample Locations
Dow Hanging Rock
Ironton, Ohio

CH2MHILL

RDD \\BALDUR\PROJ\DOW_HANGING_ROCK_404798\MAPFILES\PROPOSED_LOCS\FIG4-5_SWMU_17_PROPOSED.MXD MSCHROCK 10/19/2011 10:55:36 PM



LEGEND

- Approximate Site Boundary
- Property Owned or Leased by Others (Dashed = Assumed Boundary)
- SWMU
- Building
- Tank
- Miscellaneous Structure
- Railroad
- Fence
- Edge of Road
- Approximate Water Well Location
- Proposed Monitoring Well
- Proposed Sediment

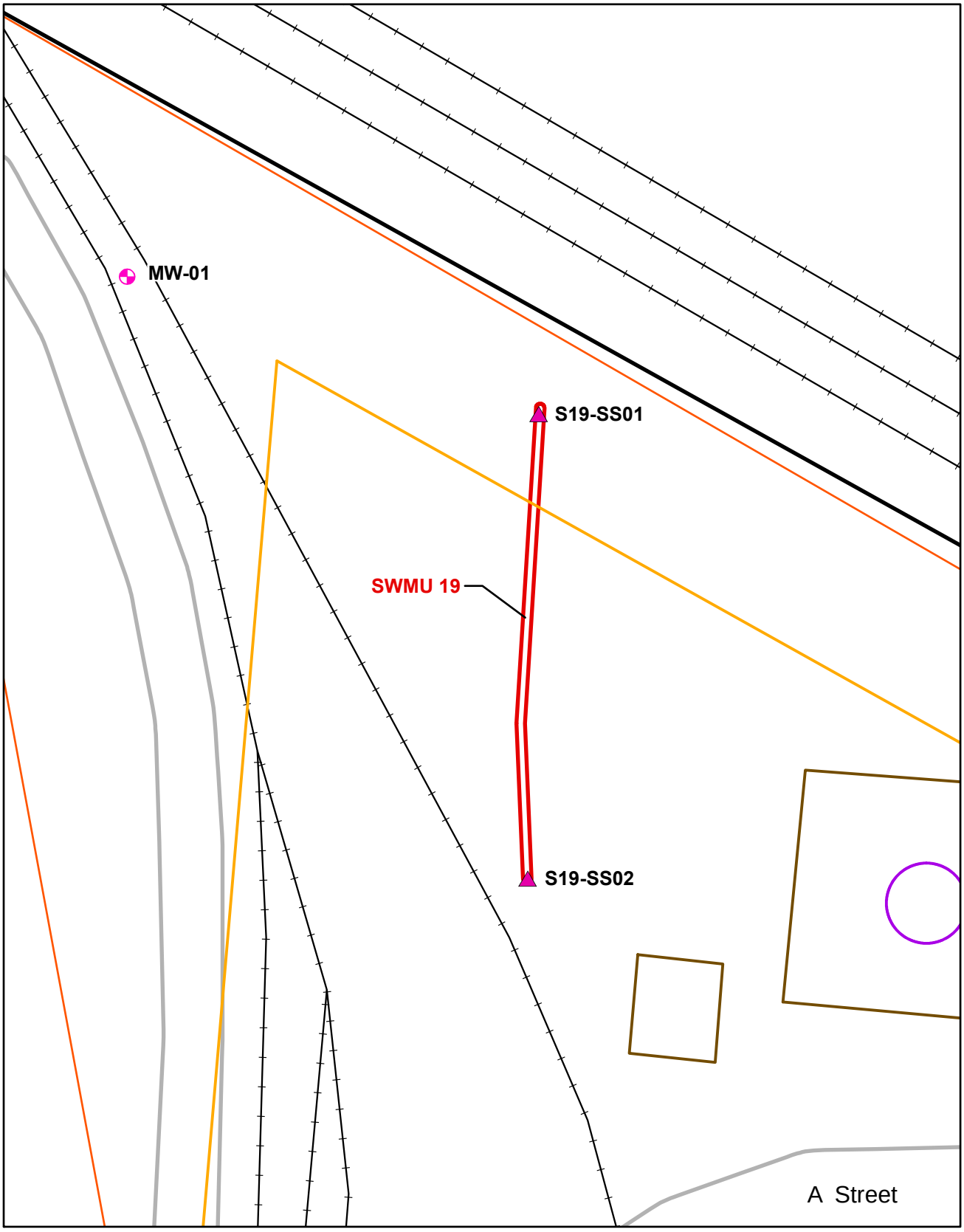
N

0 300 600
Feet

FIGURE 4-6
SWMU 18 – Proposed Sample Locations
Dow Hanging Rock
Ironton, Ohio

CH2MHILL

RDD \\BALDUR\PROJ\DOW_HANGING_ROCK_404798\MAPFILES\PROPOSED_LOCS\FIG4-6_SWMU_18_PROPOSED.MXD MSCHROCK 10/19/2011 11:04:26 PM



LEGEND

- Approximate Site Boundary
- Property Owned or Leased by Others
- SWMU
- Miscellaneous Structure
- Tank
- Railroad
- Fence
- Edge of Road
- Proposed Monitoring Well
- Proposed Soil Boring

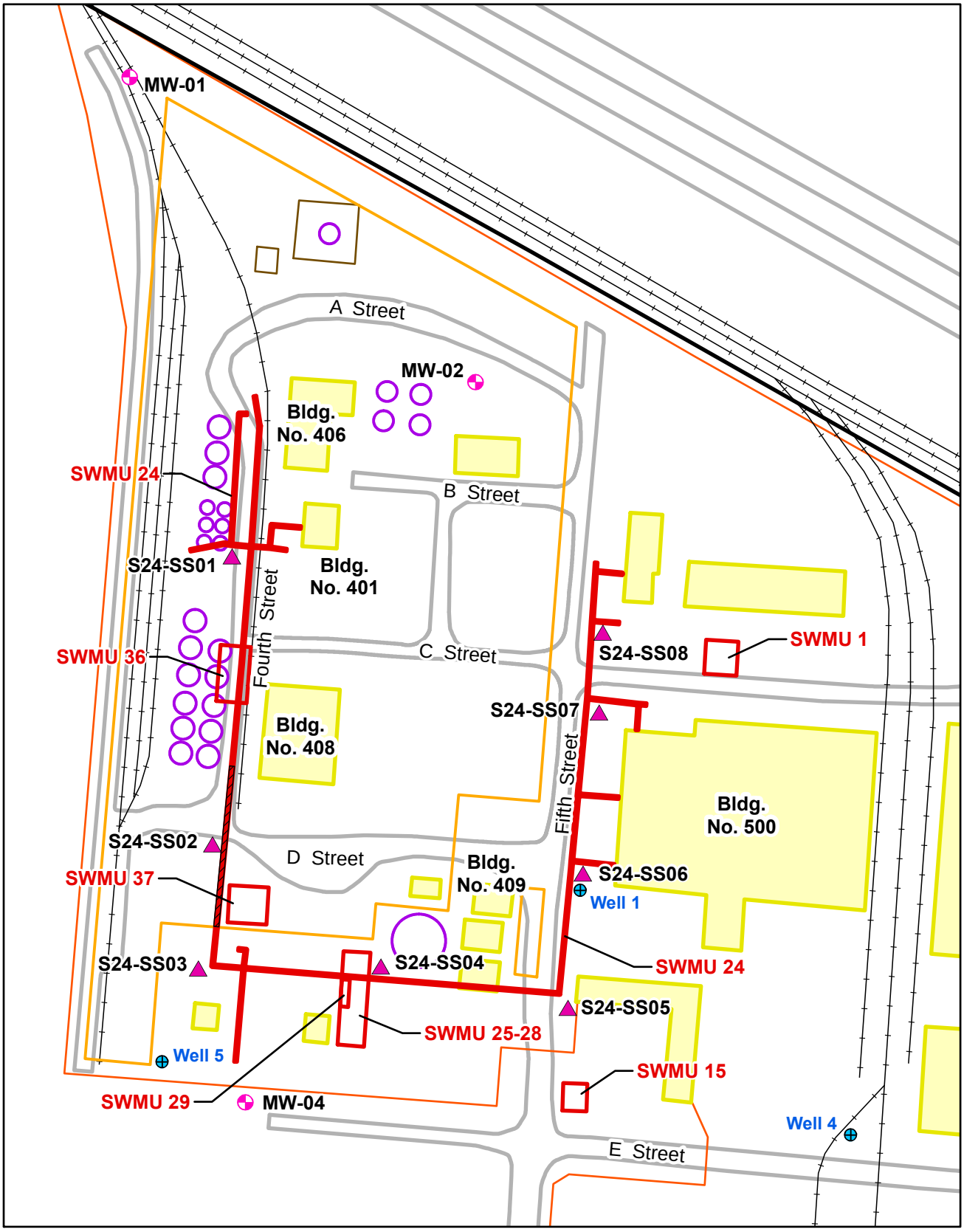
N

0 25 50
Feet

FIGURE 4-7
SWMU 19 – Proposed Sample Locations
Dow Hanging Rock
Ironton, Ohio

CH2MHILL

RDD \\BALDUR\PROJ\DOW_HANGING_ROCK_404798\MAPFILES\PROPOSED_LOCS\FIG4-7_SWMU_19_PROPOSED.MXD MSCHROCK 10/19/2011 11:09:08 PM



LEGEND

- Proposed Monitoring Well
- Proposed Soil Boring
- Approximate Location of Process Sewer Line Voluntary Closure Excavation Area
- SWMU
- Property Owned or Leased by Others
- Approximate Site Boundary
- Tank
- Building
- Railroad
- Fence
- Edge of Road
- Approximate Water Well Location

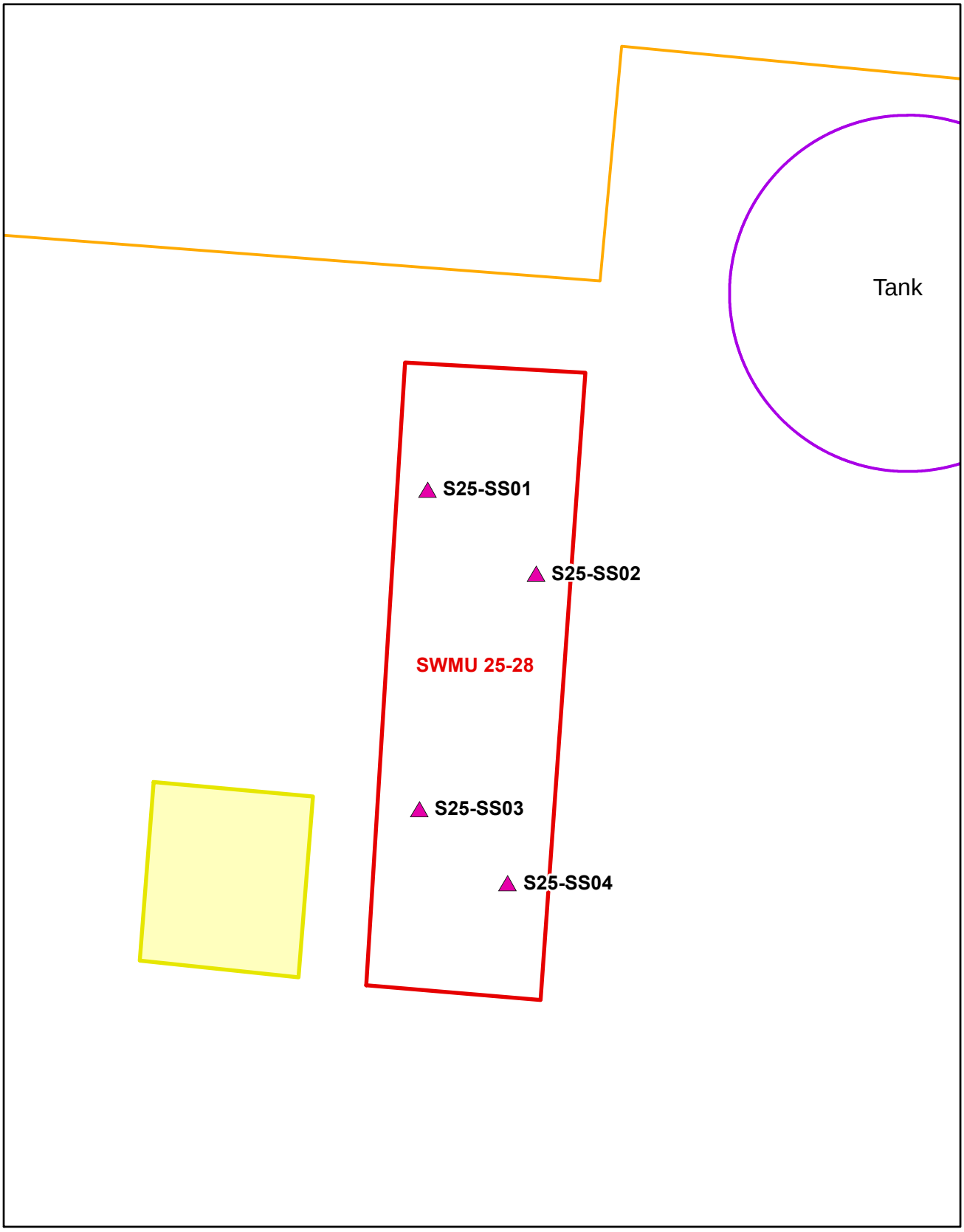
N

0 50 100 200
Feet

FIGURE 4-8
SWMU 24 – Proposed Sample Locations
Dow Hanging Rock
Ironton, Ohio

CH2MHILL

RDD \\BALDUR\PROJ\DOW_HANGING_ROCK_404798\MAPFILES\PROPOSED_LOCS\FIG4-8_SWMU_24_PROPOSED.MXD MSCHROCK 10/19/2011 11:10:17 PM



LEGEND

- SWMU
- Property Owned or Leased by Others
- Building
- Proposed Soil Boring
- Approximate Water Well Location

Note:
1. Samples will be taken from areas not used as parking lots.

N

0 15 30
Feet

FIGURE 4-9
SWMU 25-28 – Proposed Sample Locations
Dow Hanging Rock
Ironton, Ohio

CH2MHILL

RDD \\BALDUR\PROJ\DOW_HANGING_ROCK_404798\MAPFILES\PROPOSED_LOCS\FIG4-9_SWMU_25-28_PROPOSED.MXD MSCHROCK 10/24/2011 2:15:45 PM

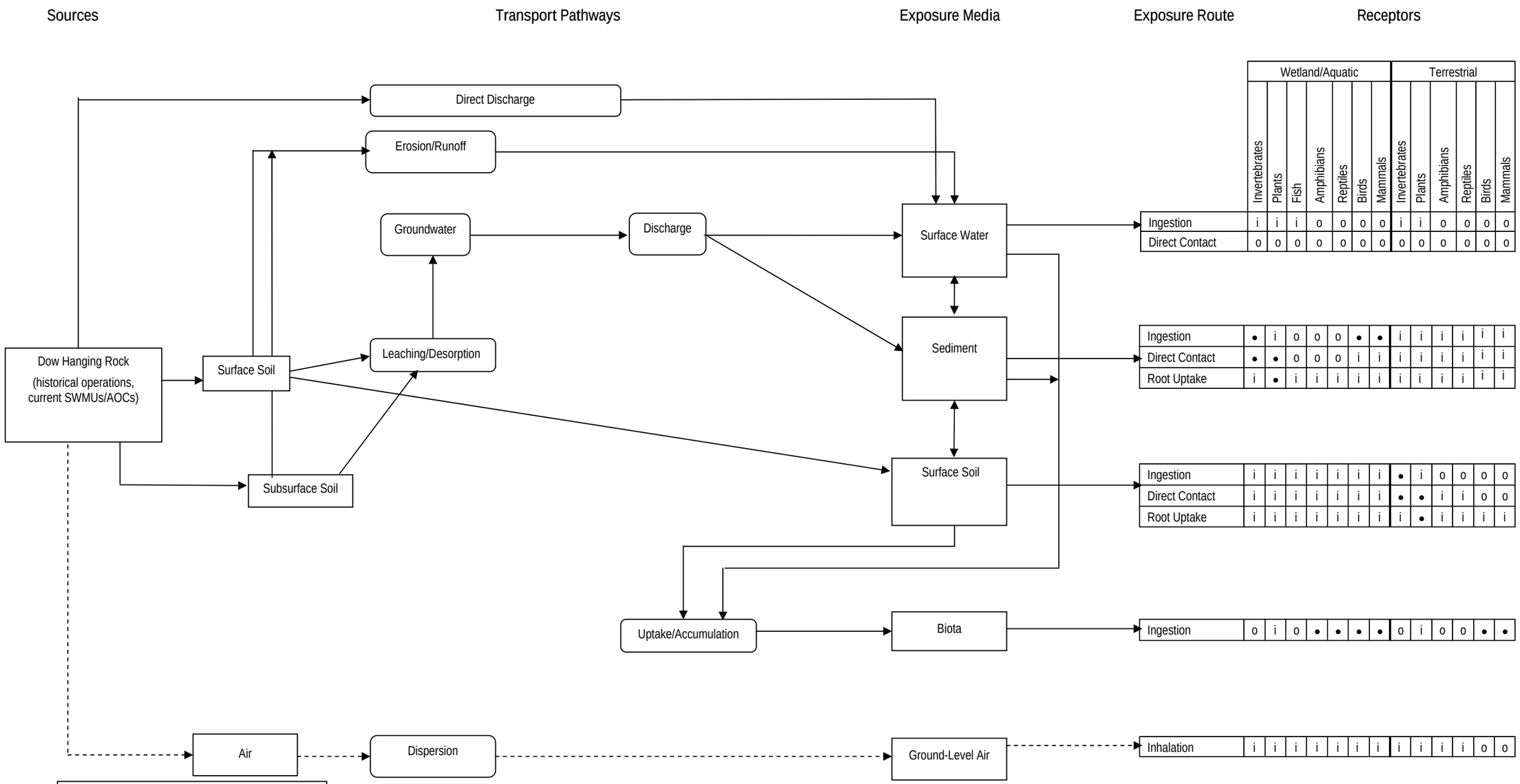


Figure 6-1
Preliminary Conceptual Site Model
RCRA Facility Investigation
Dow Hanging Rock
Ironton, Ohio

Appendix A
Historical Aerial Photographs

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Statewide Aerial

StatewideAerial.com
1-888-748-1971

Statewide Aerial Order ID:
10930.S157.1344

Completed: 9/30/2011

AERIAL PHOTO SEARCH

for the site:

HANGING ROCK (404798)
925 COUNTY ROAD 1A
IRONTON, OHOH 45638

38.573636 | -82.790565

Search Results Summary

Date	Source	Scale	Comment
2010	National Agriculture Information Program (NAIP)	700	
2005	National Agriculture Information Program (NAIP)	700	
1995	US Geological Survey (USGS)	700	
1988	National Aerial Photography Program (NAPP)	700	
1971	US Geological Survey (USGS)	700	
1960	US Geological Survey (USGS)	700	
1952	US Geological Survey (USGS)	700	

Date:	Scale:	Source:	JobID:	Project Number:
2010	1"=700'	NAIP	10930.S157.1344	404798
Site Location:				Comment:
925 COUNTY ROAD 1A IRONTON,OH				

Statewide Aerial

Date:	Scale:	Source:	JobID:	Project Number:
2005	1"=700'	NAIP	10930.S157.1344	404798
Site Location:				Comment:
925 COUNTY ROAD 1A IRONTON,OH				

Statewide Aerial

Date:	Scale:	Source:	JobID:	Project Number:
1995	1"=700'	USGS	10930.S157.1344	404798
Site Location:				Comment:
925 COUNTY ROAD 1A IRONTON,OH				

Statewide Aerial

Date:	Scale:	Source:	JobID:	Project Number:
1988	1"=700'	NAPP	10930.S157.1344	404798
Site Location:				Comment:
925 COUNTY ROAD 1A IRONTON,OH				

Statewide Aerial

Date:	Scale:	Source:	JobID:	Project Number:
1971	1"=700'	USGS	10930.S157.1344	404798
Site Location:				Comment:
925 COUNTY ROAD 1A IRONTON,OH				

Statewide Aerial

Date:	Scale:	Source:	JobID:	Project Number:
1960	1"=700'	USGS	10930.S157.1344	404798
Site Location:				Comment:
925 COUNTY ROAD 1A IRONTON,OH				

Statewide Aerial

Date:	Scale:	Source:	JobID:	Project Number:
1952	1"=700'	USGS	10930.S157.1344	404798
Site Location:				Comment:
925 COUNTY ROAD 1A IRONTON,OH				

Statewide Aerial

Appendix B
Photo Log

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Photograph 1: AOC D: Looking down at underground catalyst storage tank

Photograph 2: Looking west at culvert from under access road discharging to Big Thief Creek

Photograph 3: Big Thief Creek looking west from access road

Photograph 4: Looking east at Big Thief Creek from access road

Photograph 5: Another view looking west at Big Thief Creek from access road

Photograph 6: SWMU 1: Looking north at approximate area of SWMU 1

Photograph 7: SWMU 5: Looking south into SWMU 5

Photograph 8: SWMU 11: Looking down at vault used to clean out (vacuum) SWMU 11 area

Photograph 9: SWMU 11: Looking east at floor drain inside SWMU 11

Photograph 10: SWMU 11: Looking down at crack on the floor of SWMU 11

Photograph 11: SWMU 11: Looking at the floor of SWMU 11

Photograph 12: SWMU 12: Looking down at the valve at the side of the methylene chloride cleaning tank

Photograph 13: SWMU 12: Looking down at liquid draining from valve at the side of methylene chloride tank

Photograph 14: SWMU 12: Sump in the floor of SWMU 12 area

Photograph 15: SWMU 12: Looking north in SWMU methylene chloride cleaning tanks in background

Photograph 16: SWMU 12: Looking at floor of SWMU 12; cracks on floor and rust from pipes and valves

Photograph 17: SWMU 15: Looking west at the panel in SWMU 15

Photograph 18: SWMU 15: Looking east at the in SWMU 15

Photograph 19: SWMU 17: Looking down at a swale draining into a drainage pipe at the northeast corner of American Styrenic facility

Photograph 20: SWMU 17: Storm drain along SWMU 17

Photograph 21: SWMU 17: Looking south at swale part of SWMU 17

Photograph 22: SWMU 17: Different view of Photograph 21

Photograph 23: SWMU 17: SWMU 17 section at the southeast corner of American Styrenic facility

Photograph 24: SWMU 18: Looking west at SWMU 18 from west of Building 502

Photograph 25: SWMU 18: Closer view of Photograph 24

Photograph 26: SWMU 18: Another closer view of Photograph 24

Photograph 27: SWMU 18: Pool of water in SWMU 18 south of Building 502

Photograph 28: SWMU 18: Pool of water in SWMU 18 midway between Buildings 502 and 507

Photograph 29: SWMU 18: Pool of water in SWMU 18 southeast of Building 507

Photograph 30: SWMU 18: Pool of water in SWMU 18; left of picture is toward Big Thief Creek

Photograph 31: SWMU 18: Closer look of Photograph 30

Photograph 32: SWMU 18 Beginning of SWMU 18 west of Building 502

Photograph 33: SWMU 19

Photograph 34: SWMU 19: Looking south to opening to drainage ditch

Photograph 35: SWMU 19: Swale between drainage ditch to the north and south of SWMU 19

Photograph 36: SWMU 19: Looking north to opening to drainage ditch

Photograph 37: SWMU 25-28: Looking east at the former waste water treatment area; system has been demolished and area regraded

Photograph 38: SWMU 25-28: Swale at the southern edge of the former waste water treatment plant area

Photograph 39: SWMU 36: Looking north in SWMU 36

Photograph 40: SWMU 36

Photograph 41: SWMU 37: SE corner of the fire protection collection system reservoir

Photograph 42: SWMU 37: Pump used to transfer liquid collected from fire protection system

Photograph 43: SWMU 37: Sludge from cleaning out the fire protection system collection reservoir

Photograph 44: SWMU 37: Looking down at liquid collected in the fire protection system reservoir

Photograph 45: Water Well #5: Looking east

Photograph 46: Looking at the stamp plate on water well #5

Exhibit 1: SWMU 37. Photographs show drained basin. Basin is competent, with no visible cracks.

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Appendix C
Closure Approval Letter

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OhioEPA
State of Ohio Environmental Protection Agency

STREET ADDRESS
1800 WaterMark Drive
Columbus, OH 43215-1099

TELE: (614) 644-3020 FAX: (614) 644-2329

MAILING ADDRESS
P.O. Box 1049
Columbus, OH 43216-1049

CLOSURE PLAN APPROVAL

CERTIFIED MAIL

Re: *CLOSURE PLAN*
Dow Hanging Rock Plant
OHD 039 128 913

September 30, 1996

Mr. Dennis Stanley
The Dow Chemical Company
Hanging Rock Plant
925 County Road 1A
Ironton, Ohio 45638

Dear Mr. Stanley:

On August 9, 1996, the Dow Chemical Company, Hanging Rock Plant, (Dow) submitted to Ohio EPA an amended closure plan for the former drum storage area located at 925 County Road 1A, Ironton, Ohio. An addendum to the amended closure plan was received on September 25, 1996. The amended closure plan was submitted pursuant to Rule(s) 3745-66-12 of the Ohio Administrative Code (OAC) in order to demonstrate that Dow's proposal for closure complies with the requirements of OAC Rules 3745-66-11 and 3745-66-12.

The public was given the opportunity to submit written comments regarding the amended closure plan of Dow in accordance with OAC Rule 3745-66-12. No comments were received by Ohio EPA in this matter.

Based upon review of Dow's submittal and subsequent revisions, I conclude that the amended closure plan for the hazardous waste facility at 925 County Road 1A, Ironton, Ohio, as modified herein, meets the performance standard contained in OAC Rule 3745-66-11 and complies with the pertinent parts of OAC Rule(s) 3745-66-12.

The amended closure plan submitted to Ohio EPA on August 9, 1996 for Dow is hereby approved with the following modification(s):

OHIO E.P.A.

SEP 30 96

ENTERED DIRECTOR'S JOURNAL

I certify this to be a true and accurate copy of the official document as filed in the records of the Ohio Environmental Protection Agency.

By: Kim Yoder Date 9/30/96

George V. Voinovich, Governor
Nancy P. Hollister, Lt. Governor
Donald R. Schregardus, Director

Printed on Recycled Paper

1. Section 3.1.2, Page 3-2, Table 7 of the Addendum to the Amended Closure Plan: This table is hereby stuck from the closure plan as it does not represent the correct soil clean-up levels established for the site. Dow has provided the correct risk-based soil clean-up levels for both an industrial scenario and a residential scenario in Attachment A of the Addendum to the Amended Closure Plan. These values shall be the established soil clean-up levels.

2. The statement in section 3.1.1 of the regarding potential exposure pathways for soil is hereby struck from the text. The inhalation, ingestion, and dermal pathways for soil have been considered when establishing the risk-based standards. A mult-constituent, multi-pathway, cumulative and additive exposure scenario have been used to establish clean-up standards for both the industrial and residential scenario for the site. Any text that indicates otherwise is hereby struck from the text.

Please be advised that approval of this amended closure plan does not release Dow from any responsibilities as required under the Hazardous and Solid Waste Amendments of 1984 regarding corrective action for all releases of hazardous waste or constituents from any solid waste management unit, regardless of the time at which waste was placed in the unit.

Notwithstanding compliance with the terms of the amended closure plan, the Director may, on the basis of any information that there is or has been a release of hazardous waste, hazardous constituents, or hazardous substances into the environment, issue an order pursuant to Section 3734.20 et seq of the Revised Code or Chapters 3734 or 6111 of the Revised Code requiring corrective action or such other response as deemed necessary; or initiate appropriate action; or seek any appropriate legal or equitable remedies to abate pollution or contamination or to protect public health or safety or the environment.

Nothing here shall waive the right of the Director to take action beyond the terms of the amended closure plan pursuant to the Comprehensive Environmental Response, Compensation and Liability Act of 1980, 42 U.S.C. §9601 et seq., as amended by the Superfund Amendments and Reauthorization Act of 1986, Pub. L. 99-499 ("CERCLA") or to take any other action pursuant to applicable Federal or State law, including but not limited to the right to issue a permit with terms and conditions requiring corrective action pursuant to Chapters 3734 or 6111 of the Revised Code; the right to seek injunctive relief, monetary penalties and punitive damages, to undertake any removal, remedial, and/or response action relating to the facility, and to seek recovery for any costs incurred by the Director in undertaking such actions.

Strict compliance with each and every provision of this approved closure plan, especially including the modifications specified herein, is expected. The Ohio EPA will monitor such compliance. The Director expressly reserves the right to take action, pursuant to Chapters 3734 and 6111 of the Revised Code, and other applicable law, to enforce such compliance

OHIO E.P.A.
SEP 30 '96
ENTERED DIRECTOR'S JOURNAL

I certify this to be a true and accurate copy of the official document as filed in the records of the Ohio Environmental Protection Agency.

By: [signature] Date 9/30/96

and to seek appropriate remedies in the event of noncompliance with the provisions and modifications of this approved closure plan.

You are notified that this action of the Director is final and may be appealed to the Environmental Board of Review pursuant to Section 3745.04 of the Ohio Revised Code. The appeal must be in writing and set forth the action complained of and the grounds upon which the appeal is based. It must be filed with the Environmental Board of Review within thirty (30) days after notice of the Director's action. A copy of the appeal must be served on the Director of the Ohio Environmental Protection Agency within three (3) days of filing with the Board. An appeal may be filed with the Environmental Board of Review at the following address: Environmental Board of Review, 236 East Town Street, Room 300, Columbus, Ohio 43266-0557.

When closure is completed, the Ohio Administrative Code Rule 3745-66-15 requires the owner or operator of a facility to submit to the Director of the Ohio EPA certification by the owner or operator and an independent, registered professional engineer that the facility has been closed in accordance with the approved closure plan. The certification by the owner or operator shall include the statement found in OAC 3745-50-42(D). These certifications should be submitted to: Ohio Environmental Protection Agency, Division of Hazardous Waste Management, Attn: Thomas Crepeau, Data Management Section, P.O. Box 1049, Columbus, Ohio 43216-1049.

Sincerely,

Donald R. Schregardus
Director

dowappSM.oo

cc: Tom Crepeau, DHWM Central File, Ohio EPA
Montee Suleiman, DHWM, Ohio EPA
Harriet Croke, Ohio Permit Section, USEPA - Region V
Michael Moschell, SEDO, Ohio EPA

I certify this to be a true and accurate copy of the official document as filed in the records of the Ohio Environmental Protection Agency.

By: _____ Date 9/30/96

OHIO E.P.A.

SEP 30 96

ENTERED DIRECTOR'S JOURNAL

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Appendix D
Boring Logs

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WELL LOG AND DRILLING REPORT

ORIGINAL

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1500 Dublin Road
Columbus, Ohio

No. 179974

County Lawrence Township ~~Ironton~~ Section of Township 7

Owner Dow Chemical Company Address Ironton, Ohio

Location of property Just west of Hanging Rock, Ohio, off State Route 52

CONSTRUCTION DETAILS

Casing diameter 12" Length of casing 60'
Type of screen Cook Length of screen 15'
Type of pump Furnished by others
Capacity of pump
Depth of pump setting
Date of completion 2-31-61

BAILING OR PUMPING TEST

Pumping rate 225 G.P.M. Duration of test 24 hrs.
Drawdown 9 ft. Date 2-15-61
Developed capacity 225 GPM
Static level—depth to water 35 ft.
Pump installed by others

WELL LOG

Formations Sandstone, shale, limestone, gravel and clay	From	To
Clay and Surface	0 Feet	15 Ft.
Dry Mud and Pea Gravel	15'	25'
Coarse Gravel	25'	31'
Coarse Sand & Pea Gravel	31'	35'
Medium Sand	35'	44'
Coarse Sand	44'	60'
Coarse Sand, Some Gravel	60'	65'
Coarse Sand, Pea Gravel	65'	70'
Coarse Gravel & Coarse Sand	70'	75'
Rock	75'	

chem. analysis
7-13-61

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.

N.

about 1000 ft. north from Ohio River and about 300 ft. south of plant site.

W. E.

S.

10A

See reverse side for instructions

Drilling Firm Diehl Pump & Supply Co. Date April 10, 1961

Address 3985 Race Road, Cincinnati 11, Ohio Signed Edw. B. Wagner
Diehl Pump + Supply Co., Inc.

Water Well Log and Drilling Report

Ohio Department of Natural Resources
Division of Water
Phone: 614-265-6740 Fax: 614-265-6767

Well Log Number: 179974

View Image of Original Well Log

ORIGINAL OWNER AND LOCATION

Original Owner Name: *DOW CHEMICAL COMPANY*

County: *LAWRENCE* **Township:** *HAMILTON* **Section Number:** *7*

Address: *SR 52* **Lot Number:**

City: **State:** *OH* **Zip Code:**

Location Number: *10* **Location Map Year:** *1980* **Location Area:**

Latitude: *38.576328* **Longitude:** *-82.792256*

CONSTRUCTION DETAILS

Borehole Diameter: 1: **Borehole Depth: 1:** *75 ft.* **Depth to Bedrock:**

2: **2:**

Casing Diameter: 1: *12 in.* **Casing Length: 1:** *60 ft.* **Casing Thickness: 1:**

2: **2:** **2:**

Casing Height Above Ground: **Aquifer Type:** *ROCK*

Date of Completion: *4/10/1961* **Total Depth:** *75 ft.* **Well Use:**

Driller's Name: *DIEHL PUMP & SUPPLY CO INC*

Screen Diameter: **Slot Size:** **Screen Length:**

Type: **Material:**

Set Between:

Gravel Pack Material/Size: **Vol/Wt Used:**

Method of Installation: **Placed:**

Grout Material/Size: **Vol/Wt Used:**

Method of Installation: **Placed**

WELL TEST DETAILS

Static Water Level: *35 ft.* **Test Rate:** *225 gpm* **Associated Reports**

Drawdown: *9 ft.* **Test Duration:** *24 hrs.* *NONE*

COMMENTS: *NONE*

WELL LOG

Formations	From	To
CLAY	0	15
SURFACE	15	15
MIXED MUD & GRAVEL	15	25
COARSE GRAVEL	25	31
MIXED SAND & GRAVEL	31	35
MEDIUM SAND	35	44
COARSE SAND	44	60
COARSE SAND & GRAVEL	60	65
MIXED SAND & GRAVEL	65	70
ROCK	70	75
COARSE SAND & GRAVEL	75	75

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Well log questions - Web site questions - Web policies

Water Well Log and Drilling Report

Ohio Department of Natural Resources
Division of Water
Phone: 614-265-6740 Fax: 614-265-6767

Well Log Number: 203820

View Image of Original Well Log

ORIGINAL OWNER AND LOCATION

Original Owner Name: *DOW CHEMICAL COMPANY*

County: *LAWRENCE* **Township:** *HAMILTON* **Section Number:** *7*

Address: *SR 549* **Lot Number:**

City: **State:** *OH* **Zip Code:**

Location Number: **Location Map Year:** *1980* **Location Area:**

Latitude: **Longitude:**

CONSTRUCTION DETAILS

Borehole Diameter: 1: **2:** **Borehole Depth: 1:** *79 ft.* **2:** **Depth to Bedrock:**

Casing Diameter: 1: *6 in.* **2:** **Casing Length: 1:** *80 ft.* **2:** **Casing Thickness: 1:** **2:**

Casing Height Above Ground: **Aquifer Type:** *SAND AND GRAVEL*

Date of Completion: *10/22/1955* **Total Depth:** *79 ft.* **Well Use:**

Driller's Name: *HYDRO GROUP, INC.-RANNEY DIVISION*

Screen Diameter: **Slot Size:** **Screen Length:**

Type: **Material:**

Set Between:

Gravel Pack Material/Size: **Vol/Wt Used:**

Method of Installation: **Placed:**

Grout Material/Size: **Vol/Wt Used:**

Method of Installation: **Placed**

WELL TEST DETAILS

Static Water Level: *43 ft.* **Test Rate:** **Associated Reports**

Drawdown: **Test Duration:** *NONE*

COMMENTS: *NONE*

WELL LOG

Formations	From	To
BROWN CLAY	0	14
BROWN GRAVEL & CLAY	14	24
HARDPAN	24	24
BROWN MIXED SAND & GRAVEL	24	38
BROWN MIXED SAND & GRAVEL	38	57
BROWN MIXED SAND & GRAVEL	57	68
BROWN MIXED SAND & GRAVEL	68	79

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Well log questions - Web site questions - Web policies

Water Well Log and Drilling Report

Ohio Department of Natural Resources
Division of Water
Phone: 614-265-6740 Fax: 614-265-6767

Well Log Number: 203823

View Image of Original Well Log

ORIGINAL OWNER AND LOCATION

Original Owner Name: *DOW CHEMICAL COMPANY*

County: *LAWRENCE* **Township:** *HAMILTON* **Section Number:** *7*

Address: *SR 549* **Lot Number:**

City: **State:** *OH* **Zip Code:**

Location Number: **Location Map Year:** *1980* **Location Area:**

Latitude: **Longitude:**

CONSTRUCTION DETAILS

Borehole Diameter: 1: **2:** **Borehole Depth: 1:** *93 ft.* **2:** **Depth to Bedrock:**

Casing Diameter: 1: *6 in.* **2:** **Casing Length: 1:** *84 ft.* **2:** **Casing Thickness: 1:** **2:**

Casing Height Above Ground: **Aquifer Type:** *CLAY & SHALE*

Date of Completion: *10/20/1955* **Total Depth:** *93 ft.* **Well Use:**

Driller's Name: *HYDRO GROUP, INC.-RANNEY DIVISION*

Screen Diameter: **Slot Size:** **Screen Length:**

Type: **Material:**

Set Between:

Gravel Pack Material/Size: **Vol/Wt Used:**

Method of Installation: **Placed:**

Grout Material/Size: **Vol/Wt Used:**

Method of Installation: **Placed**

WELL TEST DETAILS

Static Water Level: *42 ft.* **Test Rate:** **Associated Reports**

Drawdown: **Test Duration:** *NONE*

COMMENTS: *NONE*

WELL LOG

Formations	From	To
BROWN CLAY	0	12
HARDPAN	12	20
BROWN PEA GRAVEL & CLAY	20	20
WHITE MIXED SAND & GRAVEL	20	41
BROWN MIXED SAND/GRAVEL/BOULDERS	41	64
BROWN MIXED SAND & GRAVEL	64	81
BROWN MIXED SAND & GRAVEL	81	84
BROWN FINE SAND & GRAVEL	84	86
HARDPAN	86	92
GRAY FINE GRAVEL & CLAY	92	92
GRAY SOFT CLAY & SHALE	92	93

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Well log questions - Web site questions - Web policies

Water Well Log and Drilling Report

Ohio Department of Natural Resources
Division of Water
Phone: 614-265-6740 Fax: 614-265-6767

Well Log Number: 203825

View Image of Original Well Log

ORIGINAL OWNER AND LOCATION

Original Owner Name: *DOW CHEMICAL COMPANY*

County: *LAWRENCE* **Township:** *HAMILTON* **Section Number:** *7*

Address: *BLACK TOP RD* **Lot Number:**

City: **State:** *OH* **Zip Code:**

Location Number: *11* **Location Map Year:** *1980* **Location Area:**

Latitude: *38.571371* **Longitude:** *-82.791694*

CONSTRUCTION DETAILS

Borehole Diameter: 1: **2:** **Borehole Depth: 1:** *84 ft.* **2:** **Depth to Bedrock:**

Casing Diameter: 1: *12 in.* **2:** **Casing Length: 1:** *76 ft.* **2:** **Casing Thickness: 1:** **2:**

Casing Height Above Ground: **Aquifer Type:** *HARDPAN*

Date of Completion: *10/24/1955* **Total Depth:** *84 ft.* **Well Use:**

Driller's Name: *HYDRO GROUP, INC.-RANNEY DIVISION*

Screen Diameter: **Slot Size:** **Screen Length:**

Type: **Material:**

Set Between:

Gravel Pack Material/Size: **Vol/Wt Used:**

Method of Installation: **Placed:**

Grout Material/Size: **Vol/Wt Used:**

Method of Installation: **Placed**

WELL TEST DETAILS

Static Water Level: *40 ft.* **Test Rate:** *350 gpm* **Associated Reports**

Drawdown: **Test Duration:** *48 hrs.* *NONE*

COMMENTS: *NONE*

WELL LOG

Formations	From	To
SURFACE	0	10
CLAY	10	10
BROWN MIXED CLAY	10	18
MIXED GRAVEL	18	22
MIXED SAND & GRAVEL	22	42
MIXED GRAVEL/SAND/ROCK	42	47
MIXED SAND & GRAVEL	47	81
MIXED SAND/GRAVEL/BOULDERS	81	84
HARDPAN	84	84

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Well log questions - Web site questions - Web policies

Water Well Log and Drilling Report

Ohio Department of Natural Resources
Division of Water
Phone: 614-265-6740 Fax: 614-265-6767

Well Log Number: 233182

View Image of Original Well Log

ORIGINAL OWNER AND LOCATION

Original Owner Name: *DOW CHEMICAL CO.*

County: *LAWRENCE* **Township:** *HAMILTON* **Section Number:** *15*

Address: *GILRUTH LN* **Lot Number:**

City: **State:** *OH* **Zip Code:**

Location Number: *9* **Location Map Year:** *1980* **Location Area:**

Latitude: *38.577771* **Longitude:** *-82.79084*

CONSTRUCTION DETAILS

Borehole Diameter: 1: **Borehole Depth: 1:** *80 ft.* **Depth to Bedrock:**
2: **2:**

Casing Diameter: 1: *26 in.* **Casing Length: 1:** *70 ft.* **Casing Thickness: 1:**
2: **2:** **2:**

Casing Height Above Ground: **Aquifer Type:** *SANDSTONE*

Date of Completion: *8/4/1958* **Total Depth:** *80 ft.* **Well Use:**

Driller's Name: *LAYNE-OHIO, COLS*

Screen Diameter: **Slot Size:** **Screen Length:**

Type: **Material:**

Set Between:

Gravel Pack Material/Size: **Vol/Wt Used:**

Method of Installation: **Placed:**

Grout Material/Size: **Vol/Wt Used:**

Method of Installation: **Placed**

WELL TEST DETAILS

Static Water Level: *39 ft.* **Test Rate:** *200 gpm* **Associated Reports**

Drawdown: *8 ft.* **Test Duration:** *NONE*

COMMENTS: *NONE*

WELL LOG

Formations	From	To
CLAY	0	20
SAND & GRAVEL	20	39
PEA SAND & GRAVEL	39	45
FINE SAND	45	55
GRAY SAND	55	80
SANDSTONE	80	80

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Well log questions - Web site questions - Web policies

WELL LOG AND DRILLING REPORT

ORIGINAL

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1562 W. First Avenue
Columbus, Ohio 43212

PLEASE USE PENCIL OR TYPEWRITER

DO NOT USE INK.

№ 325306

County Lawrence Township Hamilton Section of Township 15

Owner Dow Chemical Co. Address Ironton, Ohio

Location of property South of old highway 52 at Dow's Hanging Rock Plant

CONSTRUCTION DETAILS

Casing diameter 12" Length of casing 42'

Type of screen Cook Length of screen 12'

Type of pump

Capacity of pump

Depth of pump setting

Date of completion Oct., 1966

BAILING OR PUMPING TEST

Pumping Rate G.P.M. Duration of test hrs.

Drawdown ft. Date

Static level-depth to water 21 ft.

Quality (clear, cloudy, taste, odor)

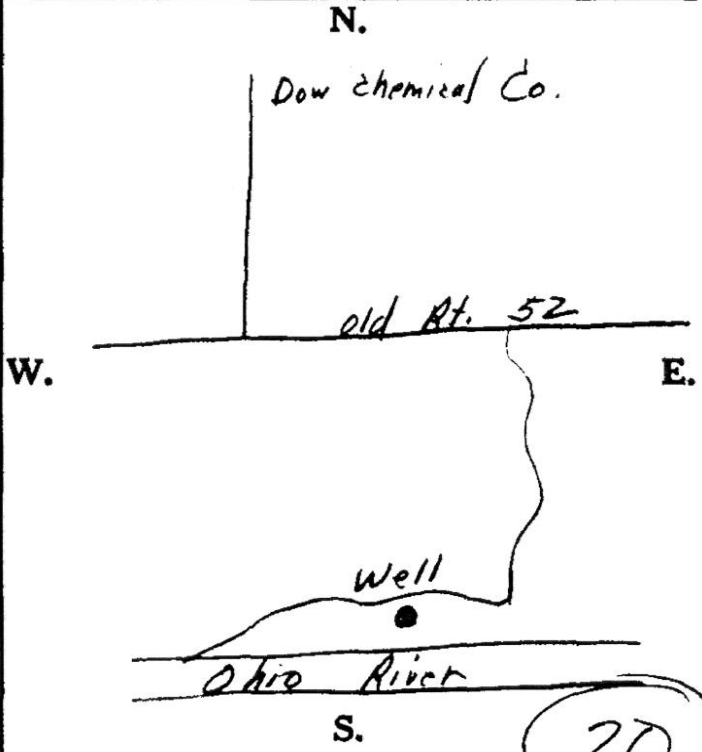
Pump installed by

WELL LOG*

Formations Sandstone, shale, limestone, gravel and clay	From	To
Clay	0 Feet	17 Ft.
Sandy clay	17	28
Brown sand + coal + gravel	28	35
Brown sand + gravel	35	49
Gray sand + gravel	49	54
Gravel + clay	54	74
Weathered shale	74	75

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

20

Drilling Firm George H. Mayhew & Assoc. Date Feb. 1, 1967

Address Powell, Ohio Signed George H. Mayhew

*If additional space is needed to complete well log, use next consecutive numbered form.

Water Well Log and Drilling Report

Ohio Department of Natural Resources
Division of Water
Phone: 614-265-6740 Fax: 614-265-6767

Well Log Number: 325306

View Image of Original Well Log

ORIGINAL OWNER AND LOCATION

Original Owner Name: *DOW CHEMICAL CO.*
County: *LAWRENCE* **Township:** *HAMILTON* **Section Number:** *15*
Address: *SR 52* **Lot Number:**
City: **State:** *OH* **Zip Code:**
Location Number: *20* **Location Map Year:** *1980* **Location Area:**
Latitude: *38.561166* **Longitude:** *-82.779873*

CONSTRUCTION DETAILS

Borehole Diameter: 1: **Borehole Depth: 1:** *75 ft.* **Depth to Bedrock:**
2: **2:**
Casing Diameter: 1: *12 in.* **Casing Length: 1:** *42 ft.* **Casing Thickness: 1:**
2: **2:** **2:**
Casing Height Above Ground: **Aquifer Type:** *SHALE*
Date of Completion: *2/1/1967* **Total Depth:** *75 ft.* **Well Use:**
Driller's Name:
Screen Diameter: **Slot Size:** **Screen Length:**
Type: **Material:**
Set Between:
Gravel Pack Material/Size: **Vol/Wt Used:**
Method of Installation: **Placed:**
Grout Material/Size: **Vol/Wt Used:**
Method of Installation: **Placed**

WELL TEST DETAILS

Static Water Level: *21 ft.* **Test Rate:** **Associated Reports**
Drawdown: **Test Duration:** *NONE*
COMMENTS: *NONE*

WELL LOG

Formations	From	To
CLAY	0	17
SANDY CLAY	17	28
COAL	28	35
BROWN SAND & GRAVEL	35	35
BROWN SAND & GRAVEL	35	49
GRAY SAND & GRAVEL	49	54
GRAVEL & CLAY	54	74
SHALE	74	75

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Well log questions - Web site questions - Web policies

WELL LOG AND DRILLING REPORT

ORIGINAL

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1562 W. First Avenue
Columbus, Ohio 43212

PLEASE USE PENCIL OR TYPEWRITER
DO NOT USE INK.

№ 348901

County LAWRENCE Township Hamilton Section of Township 7

Owner THE DOW CHEMICAL CO Address MIDLAND, MICHIGAN

Location of property HANGING ROCK PLANT

CONSTRUCTION DETAILS

Casing diameter 12" Length of casing 76'

Type of screen BRONZE Length of screen 20'

Type of pump

Capacity of pump

Depth of pump setting

Date of completion

BAILING OR PUMPING TEST

Pumping Rate 151 G.P.M. Duration of test 24 hrs.

Drawdown 8 ft. Date DEC 27, 1965

Static level-depth to water 29.1 ft.

Quality (clear, cloudy, taste, odor) CLEAR

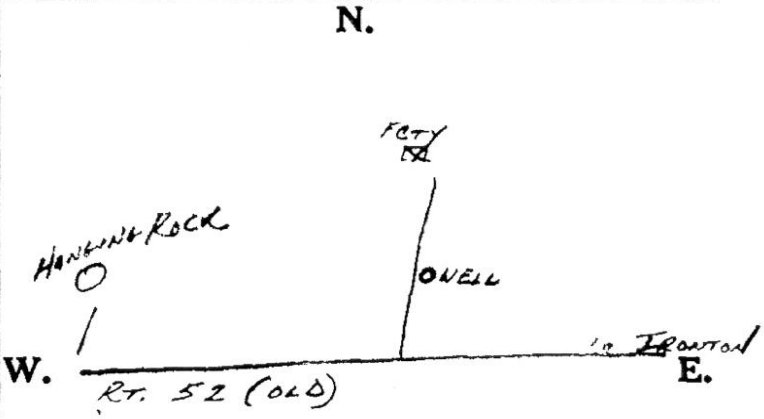
Pump installed by

WELL LOG*

Formations Sandstone, shale, limestone, gravel and clay	From	To
CLAY & SURFACE	0 Feet	16 Ft.
DRY MILL & PEA GRAVEL	16	23
COARSE GRAVEL & SAND	23	32
SAND & GRAVEL	32	35
MEDIUM SAND	35	45
COARSE SAND	45	50
COARSE SAND & GRAVEL	50	55
COARSE SAND & GRAVEL	55	60
COARSE GRAVEL & PEA GRAVEL	60	65
COARSE GRAVEL & SAND	65	74
PEA GRAVEL FINE SAND	74	76
SHALE	76	—

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



S.

See reverse side for instructions

A

Drilling Firm DIEHL PUMP & SUPPLY Date MARCH 4, 1966

Address 3985 RACE ROAD CINTI. Signed Jackie Schramm

*If additional space is needed to complete well log, use next consecutive numbered form.

Water Well Log and Drilling Report

Ohio Department of Natural Resources
Division of Water
Phone: 614-265-6740 Fax: 614-265-6767

Well Log Number: 348901

View Image of Original Well Log

ORIGINAL OWNER AND LOCATION

Original Owner Name: *THE DOW CHEMICAL CO.*

County: *LAWRENCE* **Township:** *HAMILTON* **Section Number:** *7*

Address: *SR 52* **Lot Number:**

City: **State:** *OH* **Zip Code:**

Location Number: **Location Map Year:** *1980* **Location Area:**

Latitude: **Longitude:**

CONSTRUCTION DETAILS

Borehole Diameter: 1: **Borehole Depth: 1:** *76 ft.* **Depth to Bedrock:**
2: **2:**

Casing Diameter: 1: *12 in.* **Casing Length: 1:** *76 ft.* **Casing Thickness: 1:**
2: **2:** **2:**

Casing Height Above Ground: **Aquifer Type:** *SHALE*

Date of Completion: *3/4/1966* **Total Depth:** *76 ft.* **Well Use:**

Driller's Name: *DIEHL PUMP & SUPPLY CO INC*

Screen Diameter: **Slot Size:** **Screen Length:**

Type: **Material:**

Set Between:

Gravel Pack Material/Size: **Vol/Wt Used:**

Method of Installation: **Placed:**

Grout Material/Size: **Vol/Wt Used:**

Method of Installation: **Placed**

WELL TEST DETAILS

Static Water Level: *30 ft.* **Test Rate:** *151 gpm* **Associated Reports**

Drawdown: *8 ft.* **Test Duration:** *24 hrs.* *NONE*

COMMENTS: *NONE*

WELL LOG

Formations	From	To
CLAY	0	16
SURFACE	16	16
MIXED MUD & GRAVEL	16	23
COARSE SAND & GRAVEL	23	32
SAND & GRAVEL	32	35
MEDIUM SAND	35	45
COARSE SAND	45	50
COARSE SAND & GRAVEL	50	60
MIXED SAND & GRAVEL	60	65
COARSE SAND & GRAVEL	65	74
MIXED SAND & GRAVEL	74	76
SHALE	76	

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WELL LOG AND DRILLING REPORT

ORIGINAL

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1562 W. First Avenue
Columbus, Ohio 43212

PLEASE USE PENCIL OR TYPEWRITER
DO NOT USE INK.

№ 359351

County Lawrence Township Hamilton Section of Township 15

Owner Dow Chemical Co. Address Hanging Rock, Ohio

Location of property Old US 52 6000' west of Glendale

CONSTRUCTION DETAILS

Casing diameter 12" Length of casing 41'

Type of screen Cook - Everdur Type 50 slot Length of screen 12'

Type of pump none

Capacity of pump

Depth of pump setting

Date of completion

BAILING OR PUMPING TEST

Pumping Rate 217 G.P.M. Duration of test 74 hrs.

Drawdown 25' ft. Date 9-16-66 - start

Static level-depth to water 514.75 ft.
Ground elev — 530±

Quality (clear, cloudy, taste, odor) cloudy - high iron content

Pump installed by

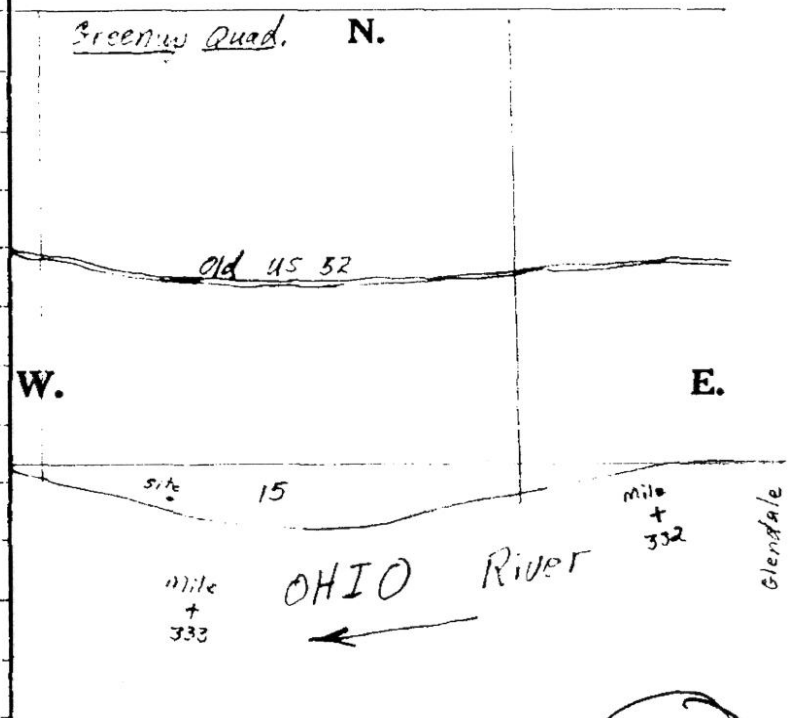
WELL LOG*

Formations Sandstone, shale, limestone, gravel and clay	From	To
Clay & silt	0 Feet	19 Ft.
sandy clay	19 Ft.	28 ft.
Fine sand with clay lenses	28 Ft.	34 Ft.
Brown Sand & Gravel	34 Ft.	50 Ft.
Compact Gray sand & gravel (40% gravel)	50 Ft.	54 Ft.
Blue Clay grading to weathered shale	54 Ft.	75 Ft.

S = 0.225
T = 20,600 gpd/ft
P = 1130 gpd/ft²

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

20

Drilling Firm Ranney Water Systems, Inc. Date December 15, 1967

Address 926 East Broad Street, Columbus, O. Signed

*If additional space is needed to complete well log, use next consecutive numbered form.

Water Well Log and Drilling Report

Ohio Department of Natural Resources
Division of Water
Phone: 614-265-6740 Fax: 614-265-6767

Well Log Number: 359351

View Image of Original Well Log

ORIGINAL OWNER AND LOCATION

Original Owner Name: *DOW CHEMICAL CO.*
County: *LAWRENCE* **Township:** *HAMILTON* **Section Number:** *15*
Address: *USRT 52* **Lot Number:**
City: **State:** *OH* **Zip Code:**
Location Number: *20* **Location Map Year:** *1980* **Location Area:**
Latitude: *38.561166* **Longitude:** *-82.779873*

CONSTRUCTION DETAILS

Borehole Diameter: 1: **Borehole Depth: 1:** *75 ft.* **Depth to Bedrock:**
2: **2:**
Casing Diameter: 1: *12 in.* **Casing Length: 1:** *41 ft.* **Casing Thickness: 1:**
2: **2:** **2:**
Casing Height Above Ground: **Aquifer Type:** *CLAY & SHALE*
Date of Completion: *12/15/1967* **Total Depth:** *75 ft.* **Well Use:**
Driller's Name: *HYDRO GROUP, INC.-RANNEY DIVISION*
Screen Diameter: **Slot Size:** **Screen Length:**
Type: **Material:**
Set Between:
Gravel Pack Material/Size: **Vol/Wt Used:**
Method of Installation: **Placed:**
Grout Material/Size: **Vol/Wt Used:**
Method of Installation: **Placed**

WELL TEST DETAILS

Static Water Level: *16 ft.* **Test Rate:** *217 gpm* **Associated Reports**
Drawdown: *25 ft.* **Test Duration:** *74 hrs.* *NONE*

COMMENTS: *NONE*

WELL LOG

Formations	From	To
SILT & CLAY	0	19
SANDY CLAY	19	28
FINE SAND & CLAY	28	34
GRAY SAND & GRAVEL	34	50
GRAY SAND & GRAVEL	50	54
BLUE CLAY & SHALE	54	75

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Appendix E
National Wetlands Inventory

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U.S. Fish and Wildlife Service

National Wetlands Inventory

National Wetlands Inventory

Jan 27, 2011

Wetlands

- Freshwater Emergent
- Freshwater Forested/Shrub
- Estuarine and Marine Deepwater
- Estuarine and Marine
- Freshwater Pond
- Lake
- Riverine
- Other

This map is for general reference only. The US Fish and Wildlife Service is not responsible for the accuracy or currentness of the base data shown on this map. All wetlands related data should be used in accordance with the layer metadata found on the Wetlands Mapper web site.

User Remarks:

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Appendix F
Field Sampling Plan

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Final

Field Sampling Plan Dow Hanging Rock, Ironton, Ohio

Prepared for

The Dow Chemical Company

November 2011

CH2MHILL®

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Appendix

A Standard Operating Procedures

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Acronyms and Abbreviations

AOC	area of concern
bgs	below ground surface
DOT	United States Department of Transportation
Dow	The Dow Chemical Company
DPT	direct push technology
facility	The Dow Chemical Company Hanging Rock Facility located in Ironton, Ohio
FSP	field sampling plan
GPS	global positioning system
GW	groundwater
HASP	health and safety plan
ID	identification
IDW	investigation-derived waste
MS	matrix spike
MSD	matrix spike duplicate
NGVD	National Geodetic Vertical Datum
OUPS	Ohio Underground Protective Services
PID	photoionization detector
PVC	polyvinyl chloride
QAPP	quality assurance project plan
QC	quality control
RCRA	Resource Conservation and Recovery Act
RFI	Resource Conservation and Recovery Act facility investigation
SB	soil boring
SOP	standard operating procedure
SS	surface soil
SVOC	semi volatile organic compound
SWMU	solid waste management unit
VOC	volatile organic compound

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SECTION 1

Introduction

CH2M HILL prepared this Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) field sampling plan (FSP) for The Dow Chemical Company (Dow) Hanging Rock Facility located in Ironton, Ohio (facility). This RFI FSP serves as an appendix to the RFI work plan and supports the investigative tasks covered under Phase I of the RFI as described in the RFI work plan.

The facility is an industrial property used for the manufacture of Styrofoam and Styron and is located in southern Ohio on the west bank of the Ohio River, in the town of Ironton. The property covers 750 acres and is bounded by the Ohio River on the south, U.S. Highway 52 on the north and farmland and residential properties to the east and west.

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SECTION 2

Field Activities

This section presents sampling activities that will be performed to address the data quality objectives outlined in the work plan. Appendix A contains standard operating procedures (SOPs) for these activities. Only activities proposed for Phase I of the investigation are included in this document. Additional phases, or additional sampling, will be addressed in an addendum(s) to the FSP.

2.1 Direct Push Technology Soil Sampling

Soil borings will be advanced to a depth of at least 10 feet below ground surface (bgs) using direct push technology (DPT) at the solid waste management units (SWMUs) and areas of concern (AOCs) identified in the work plan. Figures of soil sampling locations are presented in the work plan (Figures 4-1 through 4-12). Details of sample depths and number of samples are presented in Table 4-1 of the work plan.

Soil samples will be analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and RCRA metals. Soil samples will be sent to an approved laboratory, which will be selected prior to commencement of the fieldwork.

Soil samples will be collected from the DPT soil borings for laboratory analysis from up to four depth intervals in the unsaturated zone. The objective of the soil sampling is to accurately delineate the vertical extent of any impacts to the soil at the boring locations from previous releases from the SWMUs and AOCs. In general, samples will be collected from the following intervals:

- 0 to 2 feet bgs
- 3 to 5 feet bgs
- Interval with the most evidence of contamination if a contaminated interval encountered
- 8 to 10 feet bgs (or 2 feet above the water table or at the bottom of the boring)

An additional sample may be collected from a boring if an elevated photoionization detector (PID) reading is observed, or other signs of potential impacts are observed. The field geologist will determine the presence of a water table based on the presence of saturated soil. The field geologist also will use field screening techniques such as observation, staining, or other available information to select exact soil sampling intervals. The field geologist will screen the soil using a PID for organic vapors. If signs of potential impacts extend to the bottom of the boring, the boring will be extended until signs of impact are no longer observed. These impacts may include soil staining or elevated PID readings. If deepened, an additional sample will be collected from the bottom of the boring.

The soil samples collected for VOC analysis will be collected first. For the 0- to 2-foot bgs interval, VOC samples will be taken from 1.5 to 2 feet bgs to minimize volatilization due to sample exposure to the atmosphere. Soil samples will be collected using the standard DPT

sampling procedures described in the SOP, *Direct-Push Technology Soil Sample Collection* (Appendix A).

2.2 Surface Soil Sampling

Surface soil samples will be collected using a DPT, using techniques described in the SOP, *Surface Soil Sampling* (Appendix A). Soil samples will be analyzed for VOCs, SVOCs, and RCRA metals. Equipment will be decontaminated according to the SOP, *Field Sampling Equipment Decontamination,* presented in Appendix A.

2.3 Deep Soil Boring

Up to three deep borings will be installed across the site (Figure 4-13 in the work plan) to characterize the local geology to bedrock. A CH2M HILL field geologist will determine when top of bedrock and thus final depth is reached in each boring. Deep borings will be installed using sonic drilling technology and will be continuously logged. Deep boring will completed at the location of the planned monitoring wells so a monitoring well can be installed in the boring after the lithology has been logged to top of bedrock and the bore hole has been backfilled to the desired well depth.

On completing the deep boring, the borehole shall be backfilled to the desired depth of the monitoring well to be installed at that location following the steps below.

- Bentonite-cement slurry or hydrated bentonite chips will be placed from the bottom of the borehole to five foot below the desired bottom of the monitoring well.
- A silica sand filter pack will be installed from the top of the bentonite seal to the desired bottom of the monitoring well.
- The monitoring well will be installed as detailed in Section 2.4.

2.4 Monitoring Well Installation

Up to seven groundwater monitoring wells will be installed at the facility (Figure 4-13 in the work plan). The monitoring wells will be installed at the water table or uppermost water bearing zone. A CH2M HILL field geologist will determine the exact depth of the wells. Monitoring wells will be installed using sonic drilling technology and will be continuously logged. Soil samples will be retained from each borehole for laboratory analysis to characterize the nature and extent of any contaminant at the monitoring well location. Soil recovered from the borings will be continuously screened and logged using field screen techniques outlined in Section 2.1. Soil samples will be collected and retained for laboratory analysis as outlined in Section 2-1. A PID also will be used for monitoring sample locations for VOCs as a health and safety precaution, and the readings will be documented on the boring log.

The placement of the well screens will vary and will be determined by the CH2M HILL geologist. Each monitoring well will be constructed with 2-inch-diameter Schedule 40 polyvinyl chloride (PVC) screen and riser. Monitoring well screens will be machine slotted 0.01-inch, 10 feet in length. A silica sand filter pack will be placed in the annular space of the well screen from the bottom of the boring extending to an approximate depth of 2 feet

above the top of the screen. A 2-foot bentonite seal layer will be placed above the top of the sand pack. After the bentonite has been hydrated, a cement-bentonite grout will be placed in the remaining annular space. The monitoring wells will be completed flush to ground surface with watertight steel vaults in the process area and at other locations as directed by Dow. The remaining monitoring wells will be aboveground completions with locking, protective casings. A locking watertight cap will be placed on the PVC casings, and the wells will be clearly marked.

2.5 Sediment Sampling

Sediment samples will be collected from the bottom of the drainage ditches at the facility to evaluate impacts to the sediment from the operational activities conducted at the facility. Sediment samples will be collected from the soft bed of the drainage ditch using either a scoop sampler, hand trowel, or other equivalent device. Sampling will be conducted in accordance with the SOP, *Sediment Sampling* (Appendix A).

If water is flowing in the ditch or creek from which sediment is to be collected, the sampling will be designed to start from downstream and work upstream to prevent contamination of unsampled areas.

After collecting the sediment samples, the following will be noted:

- Sample location sketch on the figure with permanent (immovable) site features
- Station location coordinates recorded with global positioning system (GPS) instrument
- Station depth
- Gross characteristics of the sediment
  - Texture
  - Color
  - Biological structures (e.g., shells, tubes, macrophytes)
  - Presence of debris (e.g., wood chips, wood fibers, human artifacts)
  - Presence of oily sheen
  - Odor (e.g., hydrogen sulfide, oil, creosote)

All sediment samples will be analyzed for VOCs, SVOCs, and RCRA metals.

2.6 Soil Boring Documentation

To ensure a detailed description of subsurface conditions, soil samples from borings and monitoring wells will be collected continuously. Soil samples will be logged using the Unified Soil Classification System in accordance with American Society for Testing and Materials D2488 (visual-manual method for field description). The boring log will include observations on soil type, grain size distribution, changes in lithology, stained soil or chemical odor, soil moisture, PID reading, depth to the water table, depth intervals of samples collected for laboratory analysis, and total depth of boring (see SOP, *Soil Boring Logging*, in Appendix A).

2.7 Well Development

All newly installed monitoring wells will be allowed to sit for at least 48 hours before development to allow the seals and grout to set. The wells will be developed according to the *OEPA Technical Guidance Manual for Hydrogeologic Investigations and Groundwater Monitoring* (Appendix A).

The monitoring wells will be developed by surging (with a surge block) and pumping. The CH2M HILL geologist will coordinate and observe all development activities.

CH2M HILL will monitor field parameters (specific conductance, temperature, pH, dissolved oxygen, oxidation-reduction potential, and turbidity) during development. Wells will be developed according to the SOP in Appendix A. If water was added during the well installation process, at least that much water will be removed during development. Development water will be containerized in 55-gallon drums and stored at the staging area, as outlined in Section 3.5.

2.8 Soil Boring Abandonment

Soil borings will be abandoned in accordance with applicable Ohio requirements. A bentonite-cement slurry or hydrated bentonite chips will be placed from the bottom to the top of the hole using a tremie pipe or by hand. Abandoned soil borings will be checked 24 hours after abandonment to ensure curing occurred properly. If settling has occurred, solid bentonite will be added to fill the hole to the ground surface.

2.9 Water Level Measurements

Depth to water and depth to bottom measurements will be collected from all monitoring wells within 24 hours. The depth to water measurements will be used to calculate groundwater elevations, which will be used to evaluate groundwater flow.

2.10 Utility Clearance

Before drilling each boring or monitoring well, the utilities at each soil boring location will be cleared by Ohio Underground Protective Services (OUPS). The facility will be notified before any drilling, and a representative will consult any available facility drawings. In addition, a private utility locator will be contracted to locate buried utilities at the DPT soil boring and monitoring well locations.

2.11 Surveying

An Ohio-certified surveyor will perform surveying of the monitoring well locations and the existing water wells located onsite. The locations will be tied to the same elevation datum (National Geodetic Vertical Datum [NGVD] 1988) as the topographic maps of the area. The borings will be surveyed horizontally to the nearest 0.1 foot and vertically to the nearest 0.1 foot. The monitoring wells will have top of well casing and ground elevation surveyed horizontally to the nearest 0.1 foot and vertically to the nearest 0.1 foot. Well coordinates will be recorded in Ohio State Plane coordinates.

Field personnel will record the coordinates of the soil boring and sediment sampling locations with a handheld GPS unit with submeter accuracy.

2.12 Well Survey

The Ohio Department of Natural Resources website will be accessed for well logs of wells within 1 mile of the facility. In addition, the Ohio Wellhead Protection Program and the Ohio Source Water Assessment and Protection Program also will be investigated to determine whether the site and surrounding area falls within the boundaries of one of these areas.

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SECTION 3

Sample Management and Quality Assurance

This section contains information about project requirements related to analytical methods, equipment, field quality control (QC), sample nomenclature, equipment decontamination, investigation-derived waste (IDW), data validation, and health and safety.

3.1 Sample Containers, Preservation, and Hold Times

The quality assurance project plan (QAPP) presents details on the required analytical methods, sample containers, preservation, and hold times to be used for this investigation.

3.2 Sample Identification

CH2M HILL has devised a sample numbering system that will be used to identify each sample, including duplicates and blanks. The method of sample identification (ID) used depends on the type of sample collected and the sample container type.

The field analysis data will be recorded in bound field logbooks or recorded on data sheets along with sample identity information while in the custody of the sampling team.

Labels for samples sent to a laboratory for analysis will be written in indelible ink. The following information is typically included on the sample label:

- Site name or identifier
- Sample ID number
- Date and time of sample collection
- Sample matrix or matrix identifier (SS=surface soil, SB=soil boring, SD=sediment)
- Type of analyses to be conducted

Each analytical sample will be assigned a unique number as described below.

Soil is as follows: **S01-SS01-XXXX-12DD11**

Where:

A or S=AOC or SWMU sample is taken from (ACD=AOC D, S01=SWMU 1)

SS = Soil
SD = Sediment
XXXX = Sample Depth (for groundwater, 0000)
12DD11 = Month, day and year sample was collected
FD = Field Duplicate
EB=Equipment blank
TB = Trip Blank
MS/MSD=Matrix Spike/Matrix Spike Duplicate

Examples:

- Duplicates will be blind. The duplicates will be numbered consecutively when more than one duplicate is collected in a day. The first field duplicate collected on April 25, 2011, would be **HGR- 042511-FD01.**
- A sample collected at SWMU 01 at location 05 from 8 to 9 feet on April 25, 2012, would be **S01-SS05-0809-042511.**
- A matrix spike/matrix duplicate sample collected at location 05 from 8 to 9 feet bgs on April 25, 2011, would be **S01-SS05-0809-042511MS/MSD.**
- **A trip blank will be collected each day samples are collected and shipped.** A trip blank collected on April 25, 2011, would be labeled **042511TB.**

The sample ID numbers will be tracked electronically from collection through laboratory analysis and into the final reports. The sample number will be checked to make sure it matches with is entered on the chain-of-custody form.

3.3 Field Quality Control

A description of the field QC samples and the frequency of collection are provided below. Field QC samples will be collected in accordance with the facility QAPP and will include the following:

- Trip blank: Samples used to monitor potential VOC contamination introduced during sample shipping and handling. One trip blank will be included with each cooler containing samples for VOC analysis (aqueous and solid phase).
- Equipment rinsate blanks: Samples of American Society for Testing and Materials Type II water passed through and over the surface of decontaminated sampling equipment. One equipment rinsate blank will be collected for every 20 field samples or per event if less than 20 samples collected.
- Temperature blanks: Shipped with each cooler to the offsite laboratory containing samples requiring preservation at approximately 4 degrees Celsius. The temperature blanks are not to be analyzed for analytical parameters. One temperature blank will be shipped with each cooler.
- Field duplicates: Samples collected to monitor the precision of the field sampling process. One field duplicate will be collected for every 20 field samples (per matrix) or per event if less than 20 samples collected (per matrix).
- MS/MSD: Spike recovery is used to evaluate potential matrix interferences, as well as accuracy. The duplicate spike results (MS and MSD) are compared to evaluate precision. One MS/MSD sample set will be collected for every 20 field samples or per event if less than 20 samples collected.

3.4 Equipment Decontamination

Sampling equipment that is reused in the field will be decontaminated in accordance with the procedures described in the SOP, *Field Sampling Equipment Decontamination* (Appendix A). Excess media and decontamination materials and liquids will be disposed of in accordance with the procedures described in Section 3.5. A decontamination pad will be constructed at a location designated by the facility.

3.5 Investigation-Derived Waste

The generation of three types of IDW is anticipated during this investigation: liquid, soil, and solid.

Liquid IDW consisting of decontamination fluids and water generated during well development will be containerized in U.S. Department of Transportation (DOT)-approved 55-gallon steel drums.

Soil IDW consisting of soil removed from the soil borings during DPT activities and monitoring well installation and excess soil from sediment sampling will be containerized in DOT-approved 55-gallon drums. Each IDW drum will be staged as directed by Dow and will be identified with a "PENDING ANALYSIS" label. The label will indicate the location, depth intervals contained, and the date the waste was generated.

Solid IDW consisting of personal protective equipment, sampling expendables (e.g., tubing, liners, etc.), plastic, and related consumable material will be contained in trash bags and disposed of in an approved dumpster designated by Dow and the site safety coordinator.

The first two categories of IDW will be characterized for disposal at the end of this phase of the project or within 45 days of the date of generation, and will be transported and disposed of by a Dow-approved contractor following proper characterization.

3.6 Data Validation

All field and analytical data collected under this field effort will be validated in accordance with the facility QAPP.

3.7 Health and Safety

A site-specific health and safety plan (HASP) has been prepared in accordance with 29 Code of Federal Regulations 1910.120 in a manner that meets regulatory requirements and supports Dow's health and safety program. The HASP addresses worker health and safety, required training, record keeping, and emergency procedures. The HASP is included as Appendix C of the work plan.

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Appendix A
Standard Operation Procedures

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STANDARD OPERATING PROCEDURE

General Guidance for Monitoring Well/Piezometer Installation

Purpose and Scope

To provide site personnel with a review of the well/piezometer installation procedures that will be performed. These procedures are to be considered general guidelines only and are in no way intended to supplement or replace the contractual specifications in the driller's subcontract.

Monitoring well installations are planned for shallow unconsolidated aquifers.

Equipment and Materials

1. Drilling rig (hollow stem auger, sonic, air hammer, air rotary, or mud rotary)
2. Well-construction materials (i.e., surface casing, screens, riser, casing, caps, bottom plugs, centering guides, sand, bentonite, grout, and surface-finish materials)
3. Development equipment

Procedures and Guidelines

1. Wells will be installed in accordance with standard MDNR procedures.

2. The threaded connections will be water-tight.

3. Well screens generally will be constructed of 10-slot or 20-slot Schedule 40 PVC and will be 5 to 10 feet in length depending on saturated thickness of unconsolidated sediments. The exact slot size and length will be determined by the field team supervisor. Stainless steel may be required under certain contaminant conditions.

4. A record of the finished well construction will be compiled.

5. All soils and liquids generated during well installations will be drummed for proper disposal.

Monitoring Well Installation

- Monitoring wells in unconsolidated materials will be installed in at least 6-inch-diameter boreholes to accommodate well completion materials in designated locations.
- Monitoring wells in unconsolidated materials will be constructed of 2-inch-diameter, factory manufactured, flush-jointed, Schedule 40 PVC screen with threaded bottom plug and riser.
- Screens will be filter packed with a properly sized and graded, thoroughly washed, sound, durable, well-rounded basalt or siliceous sand. When using hollow-stem augers, the filter pack will be installed by slowly pouring the sand into the annular space while simultaneously raising the augers and using a weighted tape to sound for the sand surface. For rotary-drilled wells, the height of the sand pack also will be sounded with a weighted tape.
- The primary filter sand pack (typically Morie #2) will extend from 1 to 2 feet below the base to 2 feet above the top of the screen; filter pack will be allowed to settle and hydrate before final measurement is taken. For wells deeper than 30 feet, the filter pack will be placed using a tremie pipe and flowing water.
- A secondary filter sand pack (typically Morie #00) 1-foot thick will be placed above the primary sand pack.
- Annular well seals will consist of 2 feet of pelletized or granular bentonite clay placed above the filter pack. If necessary the pellets will be hydrated using potable water. For wells installed using hollow-stem augers, the bentonite will be poured into the annular space while slowly raising the augers and sounding for the top of the bentonite with a weighted tape. A high-solids bentonite slurry introduced with a side-discharging tremie pipe will be used for the bentonite seals in wells greater than 30 feet deep. For rotary-drilled wells, the height of the well seal also will be

sounded with a weighted tape. High-solids slurries will have solids content of at least 20 percent.

- The top of the annular seal will be measured after the bentonite seal has been allowed to hydrate and before the grout is applied. The seal will be allowed to hydrate for at least 30 minutes before work in the well continues.
- The annular space above the bentonite seal will be filled to grade with a bentonite-cement slurry grout mixture.
- The grout mixture consists of 94 pounds (lbs) of cement (1 bag) per 6 gallons of water and 2 to 3 lbs of powdered bentonite per bag of cement to reduce shrinkage.
- The grout mix will be carefully applied to avoid disturbing the bentonite seal; the method of grout placement must force grout from the bottom of the space to be grouted to the surface.
- After allowing the grout to settle and set up overnight, additional grout will be added to maintain grade.
- A protective steel casing equipped with keyed alike locking caps will be grouted in place for each new well; the casing will extend at least 2 feet above grade and 3 feet below grade, and will be painted a bright color.

Well Development

- New monitoring wells will be developed after the well has been completely installed and the grout has hardened (at least 24 hours)
- The well will be developed by surging and pumping.
- Equipment placed in the well will be decontaminated before use.
- If information is available, begin developing in the least-contaminated well first.
- Development will include surging the well by abruptly stopping flow and allowing water in the well column to fall back into the well.
- Pipes and pumps must not be fitted with foot valves or other devices that might inhibit the return flow of water to the well.
- Surging should continue throughout the development process.
- The air-lift method may be used to pump materials out of the well. The air compressor will be fitted with filters to remove all oil and the air lift hose used will be made of inert materials.
- Well development will continue until the water produced is free of turbidity, sand, and silt. Monitor purge water until turbidity is below 50 NTU or until 10 well volumes have been purged, whichever comes first.

- Development water will be considered hazardous and placed in sealed 55-gallon U.S. DOT approved steel drums. CH2M HILL will label and date the drums, and transport the drums to a designated site for storage.

Attachments

1) Well completion diagram

2) Well development log

Key Check and Items

- Ensure that all equipment is properly decontaminated as needed.

- Only new, sealed materials (e.g., screens, risers, and sand) will be used in constructing the well.

- Care shall be taken when making downhole measurements to ensure that proper heights of sand, seal, and grout are achieved.

PROJECT NUMBER	WELL NUMBER SHEET OF

WELL DEVELOPMENT LOG

PROJECT : LOCATION :
DEVELOPMENT CONTRACTOR : LOGGER :
DEVELOPMENT METHOD AND EQUIPMENT USED :
START :
END :

START WATER LEVELS :
WELL DEPTH:
WELL VOLUME:
MAXIMUM DRAWDOWN DURING DEVELOPMENT:
TOTAL QUANTITY OF WATER DISCHARGED:
DISPOSITION OF DISCHARGE WATER:

Time	Water Volume Discharged (gal)	Water Level (ft BTOC)	Turbidity (NTU)	Temperature (°C)	pH	Specific Conductivity (mS/cm)	Remarks (color, odor, sheen, sediment, etc.)

PROJECT NUMBER	WELL NUMBER SHEET OF

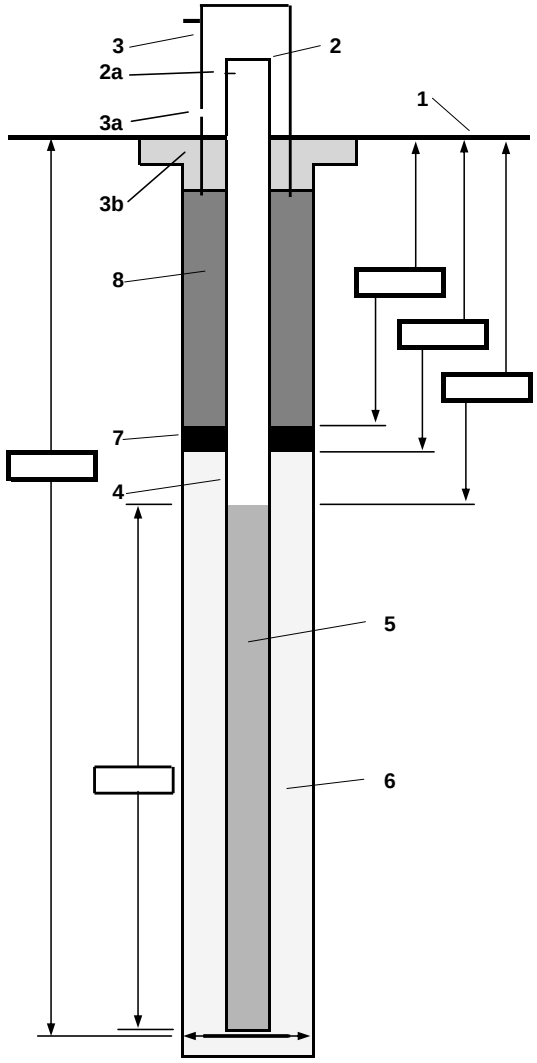
WELL COMPLETION DIAGRAM

PROJECT : LOCATION :

DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT USED :

WATER LEVELS : START : END : LOGGER :



1- Ground elevation at well _____

2- Top of casing elevation _____
   a) vent hole? _____

3- Wellhead protection cover type _____
   a) weep hole? _____
   b) concrete pad dimensions _____

4- Dia./type of well casing _____

5- Type/slot size of screen _____

6- Type screen filter _____
   a) Quantity used _____

7- Type of seal _____
   a) Quantity used _____

8- Grout
   a) Grout mix used _____
   b) Method of placement _____
   c) Vol. of well casing grout _____

Development method _____

Development time _____

Estimated purge volume _____

Comments _____

PROJECT NUMBER	WELL NUMBER SHEET OF

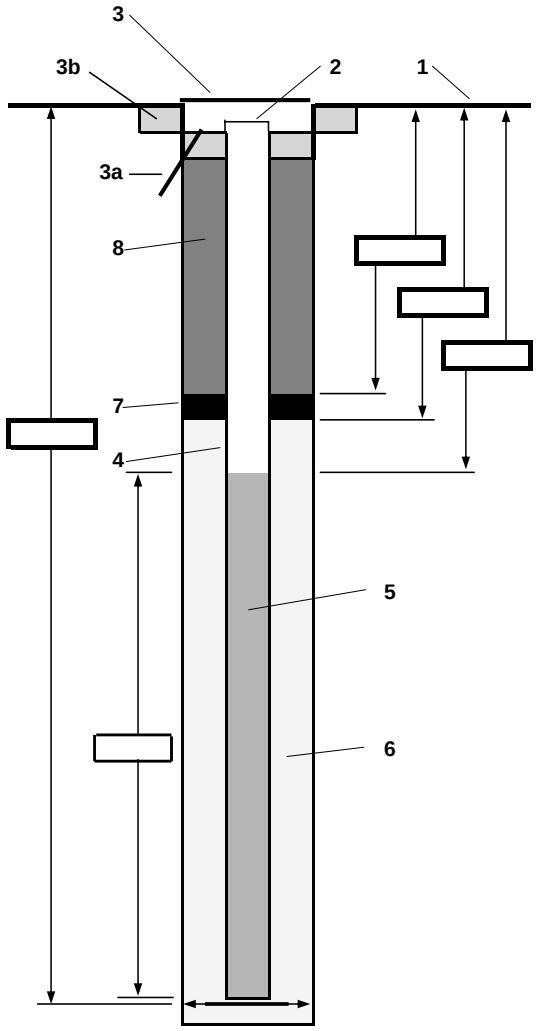
WELL COMPLETION DIAGRAM

PROJECT : LOCATION :

DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT USED :

WATER LEVELS : START : END : LOGGER :



1- Ground elevation at well _____

2- Top of casing elevation _____

3- Wellhead protection cover type _____
   a) drain tube? _____
   b) concrete pad dimensions _____

4- Dia./type of well riser _____

5- Type/slot size of screen _____

6- Type screen filter _____
   a) Quantity used _____

7- Type of seal _____
   a) Quantity used _____

8- Grout
   a) Grout mix used _____
   b) Method of placement _____
   c) Vol. of well casing grout _____

Development method _____

Development time _____

Estimated purge volume _____

Comments _____

PROJECT NUMBER	WELL NUMBER SHEET OF

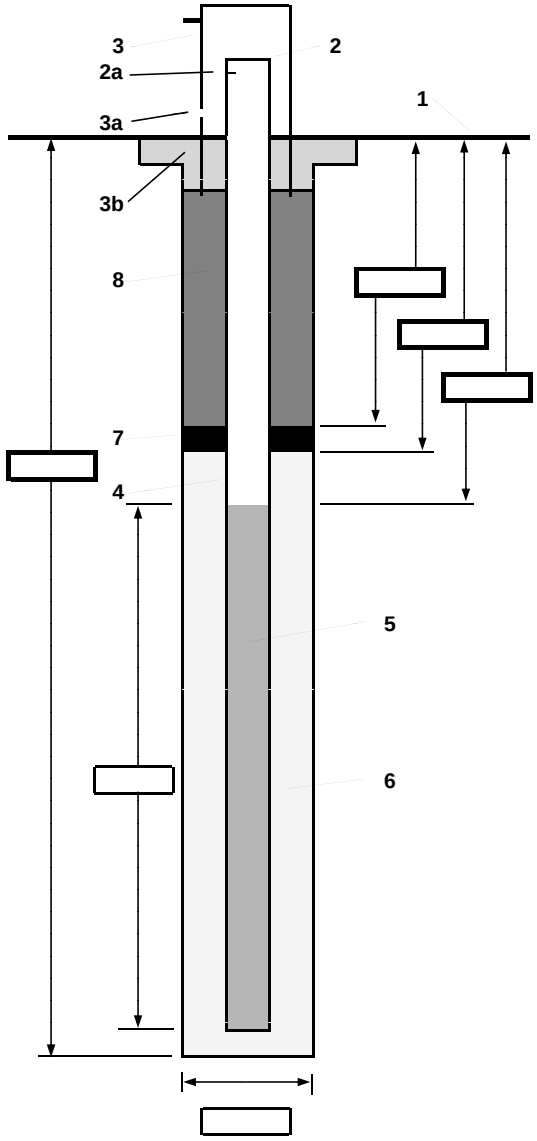
WELL COMPLETION DIAGRAM

PROJECT : LOCATION :

DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT USED :

WATER LEVELS : START : END : LOGGER :



1- Ground elevation at well _____

2- Top of casing elevation _____
   a) vent hole? _____

3- Wellhead protection cover type _____
   a) weep hole? _____
   b) concrete pad dimensions _____

4- Dia./type of well casing _____

5- Type/slot size of screen _____

6- Type screen filter _____
   a) Quantity used _____

7- Type of seal _____
   a) Quantity used _____

8- Grout
   a) Grout mix used _____
   b) Method of placement _____
   c) Vol. of well casing grout _____

Development method _____

Development time _____

Estimated purge volume _____

Comments _____

PROJECT NUMBER	WELL NUMBER SHEET OF

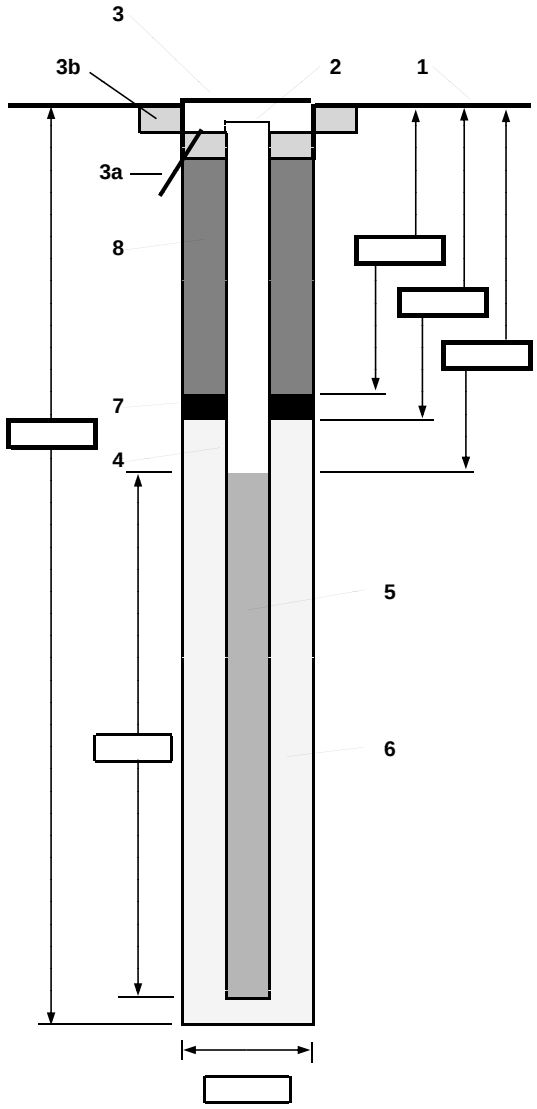
WELL COMPLETION DIAGRAM

PROJECT : LOCATION :

DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT USED :

WATER LEVELS : START : END : LOGGER :



1- Ground elevation at well _____

2- Top of casing elevation _____

3- Wellhead protection cover type _____
   a) drain tube? _____
   b) concrete pad dimensions _____

4- Dia./type of well riser _____

5- Type/slot size of screen _____

6- Type screen filter _____
   a) Quantity used _____

7- Type of seal _____
   a) Quantity used _____

8- Grout
   a) Grout mix used _____
   b) Method of placement _____
   c) Vol. of well casing grout _____

Development method _____

Development time _____

Estimated purge volume _____

Comments _____

PROJECT NUMBER	WELL NUMBER SHEET OF

WELL DEVELOPMENT LOG

PROJECT : LOCATION :

DEVELOPMENT CONTRACTOR : LOGGER :

DEVELOPMENT METHOD AND EQUIPMENT USED :

START :

END :

START WATER LEVELS :

WELL DEPTH:

WELL VOLUME:

MAXIMUM DRAWDOWN DURING DEVELOPMENT:

TOTAL QUANTITY OF WATER DISCHARGED:

DISPOSITION OF DISCHARGE WATER:

Time	Water Volume Discharged (gal)	Water Level (ft BTOC)	Turbidity (NTU)	Temperature (°C)	pH	Specific Conductivity (mS/cm)	Remarks (color, odor, sheen, sediment, etc.)

STANDARD OPERATING PROCEDURE

Sediment Sampling

Purpose

This standard operating procedure (SOP) practice describes collecting and handling sediment samples during field operations using sediment scoop samplers.

Scope and Applicability

This sediment sampling procedure is applicable to collecting representative surficial sediment samples using a sediment scoop sampler and hand trowel. Refer to the specific requirements of the project and sample handling procedures described in the work plan when using this SOP during field activities.

Example Equipment / Materials

- Scoop sediment sampler or hand trowel
- Stainless steel spoon or spatula for sediment sample transfer
- Stainless steel bowls or pans
- Measuring tape
- Logbook and waterproof and permanent marker
- Personal protection equipment (rubber or latex gloves, boots, hip waders, etc.)
- Samples bottles
- Cooler with ice
- Paper towel or Kimwipes

Scoop Sediment Sampler

A scoop sampler consists of a glass jar, a high-density polyethylene wide-mouth jar, or a stainless steel scoop, typically clamped to a pole. The pole may be made of wood or plastic and be either fixed length or telescoping. If the water body can be sampled from the shore or if it can be waded into, the easiest and "cleanest" way to collect a sample is to use the scoop sampler because it reduces the potential for cross-contamination. This method is performed by reaching over or wading into the water body and, while facing upstream into the current, gently lowering the scoop into the water until it is resting on the substrate. Ensure the area upstream, which is to be sampled, is undisturbed.

In a single, smooth action, sweep the scoop sampler along the bottom, moving it upstream and then out of the water column. Do not return the scoop to collect additional sample volume from the same location until the collected sample is removed from the scoop. When performing replicate sampling for additional volume, avoid sampling areas previously sampled.

The scoop sampler method is effective in shallow water environments (less than 1 foot deep) and when collecting for small volumes of sample. The scoop sampler method is also effective in areas that have small pockets of sample material, such as pockets of sand on a cobble beach. It is difficult not to disturb fine-grained materials at the sediment/water interface. It is usually effective in fine-grained substrates and only samples the top 3 to 5 centimeters.

Hand Trowel

A hand trowel is a tool with a pointed, scoop-shaped metal blade and a handle. It is used for breaking up earth and digging small holes in soft sediments.

If the surface water body can be waded, the easiest way to collect a sediment sample is by using a stainless steel scoop or hand trowel. The sampling method is accomplished by wading into the surface water body and while facing upstream (into the current), scooping the sample along the bottom of the surface water body in the upstream direction. Excess water may be removed from the scoop or spoon. However, this may result in the loss of some fine-particle material associated with the bottom of the surface water body.

This method can be used to collect consolidated sediments but is limited somewhat by the depth of the aqueous layer. Accurate, representative samples can be collected with this procedure, depending on the care and precision demonstrated by the sample team member. In surface water bodies that are too deep to wade, but are less than 8 feet deep, a scoop sediment sampler or spoon attached to a piece of conduit can be used either from the banks if the surface water body is narrow or from a boat. The sediment is placed into a glass pan and homogenized. A stainless steel or plastic scoop or lab spoon will suffice in most applications. Care should be exercised to avoid the use of devices plated with chrome or other materials. Plating is particularly common with garden trowels. Follow these procedures to collect sediment samples with a scoop or trowel:

- Using a pre-cleaned stainless steel scoop or trowel, remove the desired thickness of sediment from the sampling area.
- Transfer the sample into an appropriate sample or homogenization container

Typical Procedures / Guidelines

- Make a sketch of the sample area, showing nearby features and permanent structures that can be used to locate the sample points on a map. Whenever possible, include measured distances from such identifying features. Include depth and width of waterway, rate of flow, type and consistency of sediment, and point and depth of sample removal (e.g., along shore, mid-channel).
- Start downstream and work upstream to prevent contamination of unsampled areas.
- Collect the sediment sample using the appropriate sampling method as described in the work plan/field sampling plan.

- Ensure all field observations are recorded completely and correctly. After the sample is judged acceptable, the following observations should be recorded:
  - Station location indicated on the global positioning system instrument
  - Station depth
  - Gross characteristics of the sediment
    - Texture
    - Color
    - Biological structures (e.g., shells, tubes, macrophytes)
    - Presence of debris (e.g., wood chips, wood fibers, human artifacts)
    - Presence of oily sheen
    - Odor (e.g., hydrogen sulfide, oil, creosote)
- Before subsamples of the surficial sediments are taken, the overlying water must be removed. The preferred method of removing this water is by slowly siphoning it off near one side of the sampler. This can be done using a peristaltic pump, or in a similar siphoning-type device. Methods such as decanting the water or slightly cracking the grab to let the water run out are not recommended because they may result in unacceptable disturbance or loss of fine-grained surficial sediment and organic matter.
- Once the overlying water has been removed, the surficial sediment can be subsampled. When subsampling surficial sediments, unrepresentative material should be removed in the field and noted on the field log sheet.
- Transfer sample into sample jars as specified in the work plan/field sampling plan and quality assurance project plan using a stainless steel spoon or utensil. Never touch the sediment sample because gloves may introduce organic contamination into the sample.
- Fill out necessary chain-of-custody forms.
- Decontaminate all sampling implements and protective clothing according to prescribed procedures.

Key Checks / Items

- Start downstream, work upstream.
- Log exact locations using permanent features.
- Work safely. Beware of hidden hazards under the water.

A hand trowel

3

STANDARD OPERATING PROCEDURE

Logging of Soil Borings

Purpose and Scope

This standard operating procedure (SOP) provides guidance to obtain accurate and consistent descriptions of soil characteristics during soil-sampling operations. The characterization is based on visual examination and manual tests, not on laboratory determinations.

Equipment and Materials

- Indelible pens
- Tape measure or ruler
- Field logbook
- Spatula
- HCl, 10 percent solution
- Squirt bottle with water
- Rock- or soil-color chart (e.g., Munsell)
- Grain-size chart
- Hand lens
- Unified Soil Classification System (USCS) index charts and tables to help with soil classification (attached)

Procedures and Guidelines

This section covers several aspects of the soil characterization: instructions for completing the CH2M HILL soil boring log Form D1586 (attached), field classification of soil, and standard penetration test procedures.

Instructions for Completing Soil Boring Logs

- Soil boring logs will be completed in the field logbooks or on separate soil boring log sheets. Information collected will be consistent with that required for Form D1586 (attached), a standard CH2M HILL form, or an equivalent form that supplies the same information.

- The information collected in the field to perform the soil characterization is described below.

- Field personnel should review completed logs for accuracy, clarity, and thoroughness of detail. Samples also should be checked to see that information is correctly recorded on both jar lids and labels and on the log sheets.

Heading Information

- **Boring/Well Number.** Enter the boring/well number. A numbering system should be chosen that does not conflict with information recorded for previous exploratory work done at the site. Number the sheets consecutively for each boring.
- **Location.** If station, coordinates, mileposts, or similar project layout information is available, indicate the position of the boring to that system using modifiers such as "approximate" or "estimated" as appropriate.
- **Elevation.** Elevation will be determined at the conclusion of field activities.
- **Drilling Contractor.** Enter the name of the drilling company and the city and state where the company is based.
- **Drilling Method and Equipment.** Identify the bit size and type, drilling fluid (if used), and method of drilling (e.g., rotary, hollow-stem auger). Information on the drilling equipment (e.g., CME 55, Mobile B61) also is noted.
- **Water Level and Date.** Enter the depth below ground surface to the apparent water level in the borehole. The information should be recorded as a comment. If free water is not encountered during drilling or cannot be detected because of the drilling method, this information should be noted. Record date and time of day (for tides, river stage) of each water level measurement.
- **Date of Start and Finish.** Enter the dates the boring was begun and completed. Time of day should be added if several borings are performed on the same day.
- **Logger.** Enter the first initial and full last name.

Technical Data

- **Depth Below Surface**. Use a depth scale that is appropriate for the sample spacing and for the complexity of subsurface conditions.
- **Sample Interval.** Note the depth at the top and bottom of the sample interval.
- **Sample Type and Number.** Enter the sample type and number. SS-1 = split spoon, first sample. Number samples consecutively regardless of type. Enter a sample number even if no material was recovered in the sampler.
- **Sample Recovery.** Enter the length to the nearest 0.1 foot of soil sample recovered from the sampler. Often, there will be some wash or caved material above the sample; do not include the wash material in the measurement. Record recovery in feet.
- **Standard Penetration Test Results.** In this column, enter the number of blows required for each 6 inches of sampler penetration and the "N" value, which is the sum of the blows in the middle two 6-inch penetration intervals. A typical standard penetration test involving successive blow counts of 2, 3, 4, and 5 is recorded as 2-3-4-5 and (7). The standard penetration test is terminated if the sampler encounters refusal. Refusal is a penetration of less than 6 inches with a blow count of 50. A partial penetration of 50 blows for 4 inches is recorded as 50/4 inches. Penetration by the weight of the slide hammer only is recorded as "WOH."

- Samples should be collected using a 140-pound hammer and 2-inch diameter split spoons. Samples may be collected using direct push sampling equipment. However, blow counts will not be available. A pocket penetrometer may be used instead to determine relative soil density.
- Sample also may be collected using a 300-pound hammer or 3-inch-diameter split-spoon samples at the site. However, use of either of these sample collection devices invalidates standard penetration test results and should be noted in the comments section of the log. The 300-pound hammer should only be used for collection of 3-inch-diameter split-spoon samples. Blow counts should be recorded for collection of samples using either a 3-inch split-spoon, or a 300-pound hammer. An "N" value need not be calculated.

Soil Description

The soil classification should follow the format described in the "Field Classification of Soil" subsection below.

Comments

Include all pertinent observations (changes in drilling fluid color, rod drops, drilling chatter, rod bounce as in driving on a cobble, damaged Shelby tubes, and equipment malfunctions). In addition, note if casing was used, the sizes and depths installed, and if drilling fluid was added or changed. You should instruct the driller to alert you to any significant changes in drilling (changes in material, occurrence of boulders, and loss of drilling fluid). Such information should be attributed to the driller and recorded in this column.

Specific information might include the following:

- The date and the time drilling began and ended each day
- The depth and size of casing and the method of installation
- The date, time, and depth of water level measurements
- Depth of rod chatter
- Depth and percentage of drilling fluid loss
- Depth of hole caving or heaving
- Depth of change in material
- Health and safety monitoring data
- Drilling interval through a boulder

Field Classification of Soil

This section presents the format for the field classification of soil. In general, the approach and format for classifying soils should conform to ASTM D 2488, Visual-Manual Procedure for Description and Identification of Soils (attached).

The Unified Soil Classification System is based on numerical values of certain soil properties that are measured by laboratory tests. It is possible, however, to estimate these values in the field with reasonable accuracy using visual-manual procedures (ASTM D 2488). In addition, some elements of a complete soil description, such as the presence of cobbles or boulders, changes in strata, and the relative proportions of soil types in a bedded deposit, can be obtained only in the field.

Soil descriptions should be precise and comprehensive without being verbose. The correct overall impression of the soil should not be distorted by excessive emphasis on insignificant details. In general, similarities rather than differences between consecutive samples should be stressed.

Soil descriptions must be recorded for every soil sample collected. The format and order for soil descriptions should be as follows:

- Soil name (synonymous with ASTM D 2488 Group Name) with appropriate modifiers. Soil name should be in all capitals in the log, for example "POORLY-GRADED SAND."
- Group symbol, in parentheses, for example, "(SP)."
- Color, using Munsell color designation
- Moisture content
- Relative density or consistency
- Soil structure, mineralogy, or other descriptors

This order follows, in general, the format described in ASTM D 2488.

Soil Name

The basic name of a soil should be the ASTM D 2488 Group Name on the basis of visual estimates of gradation and plasticity. The soil name should be capitalized.

Examples of acceptable soil names are illustrated by the following descriptions:

- A soil sample is visually estimated to contain 15 percent gravel, 55 percent sand, and 30 percent fines (passing No. 200 sieve). The fines are estimated as either low or highly plastic silt. This visual classification is SILTY SAND WITH GRAVEL, with a Group Symbol of (SM).
- Another soil sample has the following visual estimate: 10 percent gravel, 30 percent sand, and 60 percent fines (passing the No. 200 sieve). The fines are estimated as low plastic silt. This visual classification is SANDY SILT. The gravel portion is not included in the soil name because the gravel portion was estimated as less than 15 percent. The Group Symbol is (ML).

The gradation of coarse-grained soil (more than 50 percent retained on No. 200 sieve) is included in the specific soil name in accordance with ASTM D 2488. There is no need to further document the gradation. However, the maximum size and angularity or roundness of gravel and sand-sized particles should be recorded. For fine-grained soil (50 percent or more passing the No. 200 sieve), the name is modified by the appropriate plasticity/elasticity term in accordance with ASTM D 2488.

Interlayered soil should each be described starting with the predominant type. An introductory name, such as "Interlayered Sand and Silt," should be used. In addition, the relative proportion of each soil type should be indicated (see Table 1 for example).

Where helpful, the evaluation of plasticity/elasticity can be justified by describing results from any of the visual-manual procedures for identifying fine-grained soils, such as reaction to shaking, toughness of a soil thread, or dry strength as described in ASTM D 2488.

Group Symbol

The appropriate group symbol from ASTM D 2488 must be given after each soil name. The group symbol should be placed in parentheses to indicate that the classification has been estimated.

In accordance with ASTM D 2488, dual symbols (e.g., GP-GM or SW-SC) can be used to indicate that a soil is estimated to have about 10 percent fines. Borderline symbols (e.g., GM/SM or SW/SP) can be used to indicate that a soil sample has been identified as having properties that do not distinctly place the soil into a specific group. Generally, the group name assigned to a soil with a borderline symbol should be the group name for the first symbol. The use of a borderline symbol should not be used indiscriminately. Every effort should be made to first place the soil into a single group.

Color

The color of a soil must be given. The color description should be based on the Munsell system. The color name and the hue, value, and chroma should be given.

Moisture Content

The degree of moisture present in a soil sample should be defined as dry, moist, or wet. Moisture content can be estimated from the criteria listed on Table 2.

Relative Density or Consistency

Relative density of a coarse-grained (cohesionless) soil is based on N-values (ASTM D1586 [attached]). If the presence of large gravel, disturbance of the sample, or non-standard sample collection makes determination of the in situ relative density or consistency difficult, then this item should be left out of the description and explained in the Comments column of the soil boring log.

Consistency of fine-grained (cohesive) soil is properly based on results of pocket penetrometer or torvane results. In the absence of this information, consistency can be estimated from N-values. Relationships for determining relative density or consistency of soil samples are given in tables 3 and 4.

Soil Structure, Mineralogy, and Other Descriptors

Discontinuities and inclusions are important and should be described. Such features include joints or fissures, slickensides, bedding or laminations, veins, root holes, and wood debris.

Significant mineralogical information such as cementation, abundant mica, or unusual mineralogy should be described.

Other descriptors may include particle size range or percentages, particle angularity or shape, maximum particle size, hardness of large particles, plasticity of fines, dry strength,

dilatancy, toughness, reaction to HCl, and staining, as well as other information such as organic debris, odor, or presence of free product.

Equipment and Calibration

Before starting the testing, the equipment should be inspected for compliance with the requirements of ASTM D 1586. The split-barrel sampler should measure 2-inch or 3-inch O.D., and should have a split tube at least 18 inches long. The minimum size sampler rod allowed is "A" rod (1-5/8-inch O.D.). A stiffer rod, such as an "N" rod (2-5/8-inch O.D.), is required for depths greater than 50 feet. The drive weight assembly should consist of a 140-pound or 300-pound hammer weight, a drive head, and a hammer guide that permits a free fall of 30 inches.

Attachments

Soil Boring Log, CH2M HILL Form D1586, and a completed example

ASTM D 2488 *Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)*

ASTM 1586 *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils*

Tables 1 through 4

Key Checks and Preventive Maintenance

- Check entries to the soil-boring log and field logbook in the field; because the samples will be disposed of at the end of fieldwork, confirmation and corrections cannot be made later.
- Check that sample numbers and intervals are properly specified.
- Check that drilling and sampling equipment is decontaminated using the procedures defined in SOP *Decontamination of Drilling Rigs and Equipment*.

STANDARD OPERATING PROCEDURE

Soil Sampling

Purpose

To provide general guidelines for the collection and handling of direct-push samples during field operations.

Scope and Applicability

The method described for direct soil sampling is applicable for soil sampling at and below ground surface using mechanized drilling equipment (i.e., direct push technology [DPT] or hollow stem auger). Equipment and responsibilities of the drilling subcontractors are described in the contracting documentation.

Note that particular handling and filling procedures are required for soil samples collected for volatile organic compound (VOC) analysis. Please refer to *VOC Soil Sampling* standard operating procedure (SOP) for specific procedures for collecting VOC samples.

Equipment / Materials

Provided by the Drilling Operator

- Drill rig and appropriate equipment

Health and Safety

- Photoionization detector (PID) and/or flame ionization detector (FID)
- Sampling gloves as specified in the health and safety plan

Decontamination

- Decontamination solutions (as specified in the *Field Sampling Equipment Decontamination* SOP)
- Brushes and containment basins

Sampling (as appropriate)

- Plastic sheeting
- Sample containers
- Sampling bowls and spoons
- Encore VOC sampling equipment (refer to *VOC Soil Sampling* SOP)
- Camera and film
- Sample table and plastic cover
- Plastic trash bags
- Indelible marking pens
- Black permanent ink pen (Sharpie or similar)

- Field sampling logbook
- Duct tape
- Sampling form

Sample Packing

- Appropriate packing cartons and filler
- Labels
- Chain-of-custody documents
- Coolers for sample shipping and cooling
- Knife
- Double-bagged ice
- Strapping tape
- Sealable baggies

Procedures / Guidelines

Acquire and Log the Soil Sample

1. *Prepare the Sampling Station*: Set up the sample table adjacent to the well and cover the tabletop with clear sheet plastic to minimize contamination of the table. Tape the plastic onto the table and record the sample location, site, anticipated sample time, and field sample number onto the plastic using an indelible pen. Fill out the sample labels and place on the appropriate sample containers. Labels must be waterproof to prevent water damage. The following information must be included on the sample label:

   - Site name
   - Field identification or sample station number
   - Date and time of sample collection
   - Designation of the sample as grab or composite
   - Type of sample (matrix) and a brief description of the sampling location
   - Printed full name of the sampler
   - Sample preservative used
   - Type of analyses to be performed

   If a sample is split with another party, sample labels with identical information should be attached to each of the sample containers.

2. *Take a Station Photograph*: Position the labeled sample containers and required trip blanks on the sample table so the sampling information on the plastic is legible and then take a photograph of the sampling setup. Only take photographs if this is necessary and allowed by client site representatives.

3. *Position Rig*: Have the drilling subcontractor position the rig over the approved sample location. Place plastic sheeting under rig to prevent any fluids released from the rig from reaching the ground. Record sample location, time, and date of sampling in field logbook.

4. *Collect Sample*: After the equipment operator removes the sample barrel from the drive casing, he/she will remove the liner/casing from the sample barrel, split it lengthwise, and will turn it over to the team geologist.
5. *Open and Log Sample*: Log the core and record the data on a standard log sheet or logbook. Conduct PID readings and record the data on the boring log form. Photograph the soil sample, if appropriate.
6. *Take Headspace*: Perform the headspace analysis for volatile organic vapors on a representative sample from the sample barrel that has been placed in a resealable plastic bag in accordance with the *Air Monitoring with the OVM Instrument* or *Air Monitoring with the MultiRae Instrument* SOPs. Record the data on the soil logging form or in the field logbook.

   After filling the resealable plastic bag, wait 5 minutes. If the ambient temperature is less than 50 degrees Fahrenheit (°F), move the sample into a warm place (greater than 50°F) and let the sample equilibrate for 5 minutes. After 5 minutes, take the reading by breaking the resealable plastic bag seal just enough to insert the probe of the PID/FID, inserting the probe, and recording the result.
7. *Take the Soil Sample*: Take the VOC portion of the soil sample first directly from the sample core, using the EnCore procedure, if necessary (refer to the *VOC Soil Sampling* SOP). After the EnCore VOC samples have been taken and placed in the cooler on ice, take the remaining analytical sample.

   Samples for the remaining analytical suite can be collected after homogenizing the sample core in a decontaminated, stainless steel bowl. Use a decontaminated spoon and place a representative portion of the entire sample length in each sample container. Tightly pack the sample and screw on the container lid. Immediately place the samples in a cooler with ice. Do not leave the sample exposed to the sun or extreme temperatures.
8. *Decontaminate Tools*: Decontaminate the pan or bowl, and media transfer tools before using to collect another sample. Refer to the *Field Sampling Equipment Decontamination* SOP.
9. *Driller Decontamination*: The driller is responsible for decontaminating drilling tools, such core barrels. Refer to the *Field Sampling Equipment Decontamination* SOP, as appropriate. Document the procedure used by the drillers for decontamination in the logbook.
10. *Record Keeping*:
    - Record sample description, depth, and time and date of sampling in field logbook.
    - Fill out the chain-of-custody form.
11. *Manage Investigation-Derived Waste (IDW)*: Discard the unused sample in accordance with IDW requirements

Warning: Do not let the liners sit in the sun or in a warm environment. If a liner filled with soil cannot be sampled immediately, it must be cooled with ice until the sampling can proceed.

Quality Control Samples

Quality control (QC) samples that are collected with soil samples include duplicates, matrix spike (MS)/matrix spike duplicates (MSDs), trip blanks, and equipment blanks. Of these, trip blanks and equipment blanks are aqueous and do not require extra soil volume. The MS/MSD sample will be submitted to the laboratory with the original sample, and the duplicate will be submitted to the laboratory as a separate sample. The number of sampling locations that require an MS/MSD or duplicate sample should be predetermined.

Key Checks / Items

- Make sure the soil samples are kept at a temperature of approximately 4 degrees Celsius if they cannot be immediately sampled.
- Determine if a QC sample will be required at a sampling location. If a QC MS/MSD or duplicate soil sample will be needed, then additional sample volume will be required. Additional sample volume may be acquired by pushing another soil sample.
- Ensure plastic sheeting is placed under the rig to prevent any released fluids from the rig from reaching the ground.
- Ensure that all tools that may come into contact with the sample, a team member, other equipment, or non-contaminated environment are properly decontaminated.
- Collect rinse water investigation-derived waste from decontamination activities.

STANDARD OPERATING PROCEDURE

VOC Soil Sampling

Purpose

This technical practice contains guidelines for collecting and handling soil volatile organic compound (VOC) samples using EnCore sampling techniques.

Scope and Applicability

The method described for EnCore sampling is applicable for soil sampling of VOCs following SW 846 Method 5035 (Closed-System Purge and Trap and Extraction for Volatile Organics in Soil and Waste Samples).

Technical Practice Details

General

The EnCore sampler is a disposable volumetric sampling device developed to assist in taking VOC soils and sediment samples with minimal handling. The sampler has three components: the coring body, the plunger, and the cap. A reusable T-handle is used to assist in pushing the sampler into the material. The airtight sealing cap prevents the loss of volatiles. No chemicals (such as methanol) are to be used in the sampling process.

Equipment / Materials

- EnCore samplers
- EnCore T-handle
- Latex or surgical gloves
- Stainless steel pan or bowl
- Field logbook
- Sealing plastic bags
- Decontamination solutions and equipment
- Air monitoring devices (such as photoionization detectors [PIDs])

Procedures / Guidelines

The following procedures and guidelines refer to the macro sample as a "soil sample." "VOC sample" or "VOC soil" refers to the sample extracted from the macro sample by the EnCore sampler.

Acquire the Soil Sample

The taking of soil samples will vary slightly depending on the method of collection. Follow the directions specified in this standard operating procedure (SOP) for the specific sampling methodology.

1. Have the drilling subcontractor/sample technician position the sampling equipment over the surveyed and flagged sample location.
2. The driller/sampler will collect the desired soil sample using a hand auger, split spoon, or other approved method.
3. Collect the VOC sample using the EnCore system from the collected soil sample.
4. Log the core/sample and record the data on a standard log sheet or field logbook. Conduct PID readings and record the data on the core sampling log. Photograph the soil sample, if appropriate.

Collecting VOC Soil Samples

The following procedure describes the use of the EnCore sampling system for collecting VOC soil samples.

Before taking a VOC Sample (Preparation)

- Hold coring body and push plunger rod down until small o-ring rests against tabs. This will assure that plunger moves freely.
- Depress locking lever on T-handle. Place coring body, plunger-end first, into open end of T-handle, aligning the two slots on the coring body with the two locking pins in the T-handle. Twist coring body clockwise to lock pins in slots. Check to ensure sampler is locked in place. Sampler is ready for use.

Taking a VOC Sample

- Turn T-handle so that the T faces up and coring body down. This positions the plunger bottom flush with the bottom of the coring body (ensure plunger bottom is in position. Using T-handle, push sampler into soil until coring body is completely full. When full, small O-ring will be centered in T-handle viewing hole. Remove sampler from sediment or soil. Wipe excess material from coring body exterior.
- Cap coring body while it is still on T-handle. Push cap over flat area of ridge and twist to lock **cap** in place. **Cap must be seated to seal sampler**.

NOTE: The VOC sample must be collected as quickly as possible to minimize the loss of volatiles.

Preparing EnCore Sampler for Shipment

- Remove the capped sampler by depressing locking lever on T-handle while twisting and pulling sampler from T-handle.
- Lock plunger by rotating extended plunger rod fully counter-clockwise until the **wings** rest firmly against tabs.
- Attach completed circular label (from EnCore sampler bag) to cap on coring body.

- Return full sampler to zipper bag. Seal bag and put in a sample cooler and cool with ice.
- Fill out the chain-of-custody form, and process the sample for delivery to the laboratory.
- Decontaminate sample barrel, pan or bowl, and media transfer tools before using to collect another sample.
- Collect rinse water from decontamination activities and appropriately.

NOTE: Do not leave the samples in the sun or in a warm environment for any significant length of time. Soil samples shall be cooled with ice until the sample is processed.

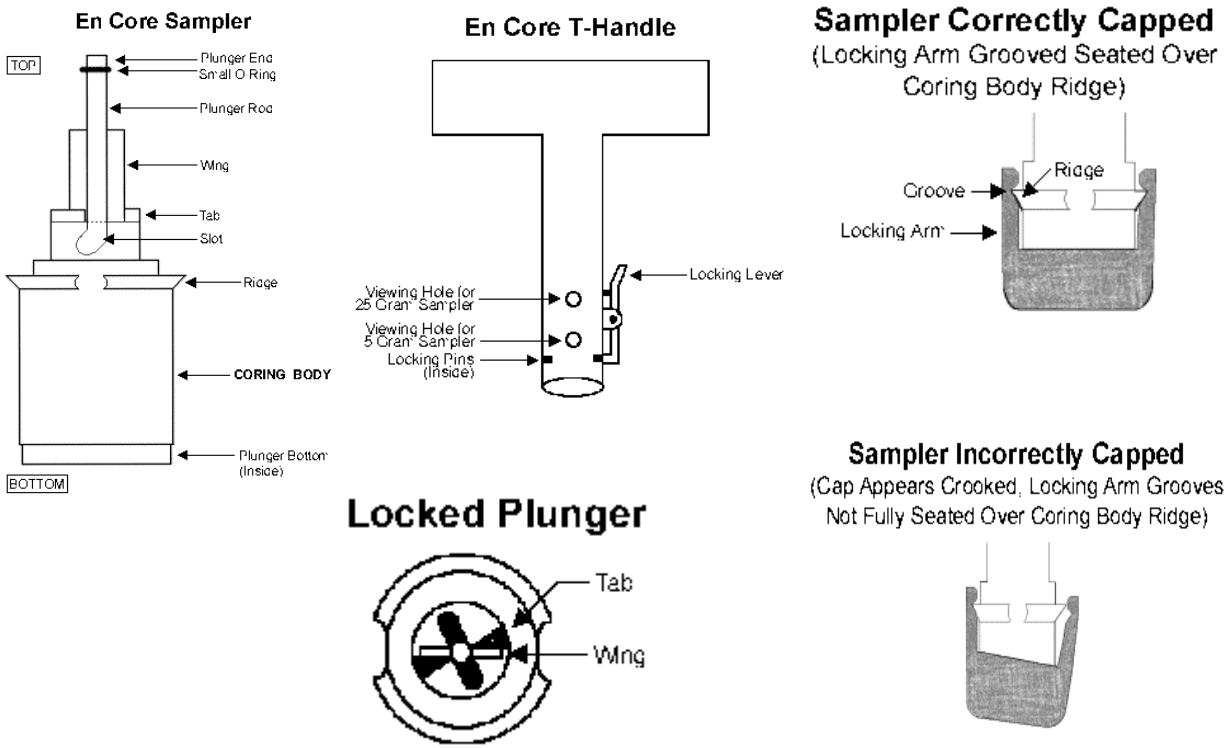
Quality Control Samples

Quality control (QC) samples that are collected with soil samples include duplicates, matrix spike (MS)/matrix spike duplicates (MSDs), trip blanks, and equipment blanks. Of these, trip blanks and equipment blanks are aqueous and do not require soil volume. If a duplicate or MS/MSD sample is required at a sampling location, then a second sample aliquot shall be collected. The MS/MSD sample will be submitted to the laboratory with the original sample. Duplicates will be submitted to the laboratory as separate samples.

Key Checks/Items

- Make sure the samples are kept at a temperature of approximately 4 degrees Celsius before and after they are processed for delivery to the laboratory.
- Determine if a QC sample will be required at a sampling location. If a QC MS/MSD or duplicate soil sample will be needed, then additional sample volume will be required. Additional sample volume is acquired by pushing another soil sample.
- Ensure all tools that may come in contact with the sample, are properly decontaminated.
- Collect rinse water from decontamination activities and manage appropriately.

EXHIBIT 1
Using the En Core T-Handle
The Hoover Company, Plant No. 1, North Canton, Ohio



STANDARD OPERATING PROCEDURE

Field Sampling Equipment Decontamination

Purpose

To provide general guidelines for decontamination of soil sampling equipment, monitoring equipment, and sample containers used in potentially contaminated environments.

Equipment and Materials

- Demonstrated analyte-free deionized or distilled water.
- Potable water.
- Deionized or distilled water.
- Alconox (or other phosphate free detergent) and water solution.
- Methanol. DO NOT USE ACETONE.
- Large plastic pails or tubs for detergent and water, scrub brushes, squirt bottles for detergent, methanol and water, plastic bags, and sheets.
- U.S. Department of Transportation (DOT)-approved 55-gallon drum for disposal of waste.

Procedures and Guidelines

Sampling Equipment Decontamination

Soil, surface water, and sediment sampling equipment not to be steam cleaned (such as drilling equipment) will be decontaminated by personnel wearing disposable latex gloves or vinyl gloves using the following procedure:

1. Remove loose soil and gross contamination.
2. Rinse with potable water.
3. Wash all equipment surfaces that contacted the potentially contaminated soil or water with Alconox solution, using a brush as needed to remove particulate matter and surface films.
4. Rinse with potable water.
5. If organic contamination is suspected, rinse twice with methanol solution and air dry. DO NOT USE ACETONE.
6. Rinse with deionized or distilled water and air dry.

7. Wrap the equipment with aluminum foil, if appropriate, to prevent contamination if the equipment is to be stored or transported.
8. Collect all decontamination fluids and dispose of in a DOT-approved 55-gallon drum.

Monitoring Equipment Decontamination

1. Wrap soil contact points in plastic to reduce need for subsequent cleaning.
2. Wipe surfaces that had possible contact with contaminated materials with a paper towel wet with detergent solution; if organic contamination is suspected, wipe with a towel wet with methanol solution; and wipe three times with a towel wet with deionized or distilled water.
3. Dispose of used paper towels in a DOT-approved 55-gallon drum.

Sample Container Decontamination

The outer surface of sample containers filled in the field must be decontaminated before being packed for shipment or handled by personnel without dermal hand protection.

1. Wipe container with a paper towel dampened with detergent solution after the containers have been sealed.
2. Wipe container with a paper towel dampened with potable water.
3. Dispose of used paper towels in a DOT-approved 55-gallon drum.

Key Checks and Items

- Clean with solutions of detergent, methanol, and deionized or distilled water.
- Do not use acetone for decontamination.
- Drum all contaminated rinsate and materials.
- Decontaminate sample bottles before relinquishing them to anyone.
- Document any deviations from above procedure.

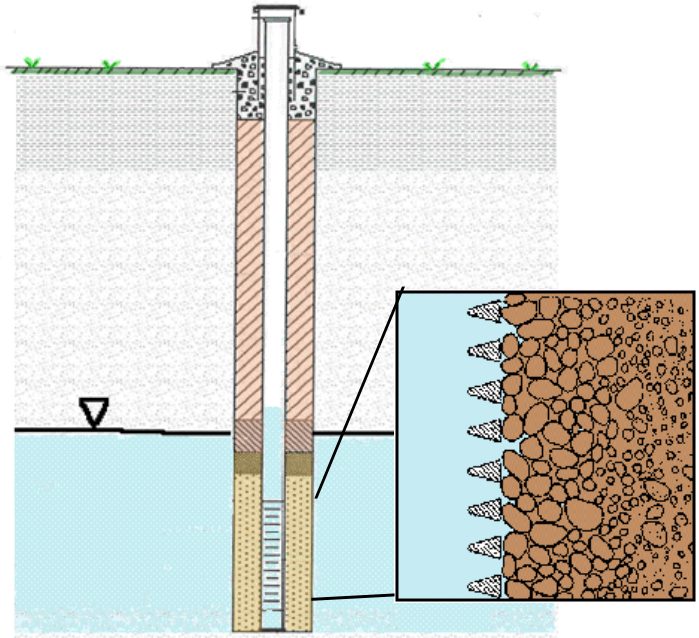
State of Ohio
Environmental Protection Agency

Division of Drinking and Ground Waters

Technical Guidance Manual for Ground Water Investigations

Chapter 8

Monitoring Well Development, Maintenance, and Redevelopment



February 2009

Governor : Ted Strickand
Director : Chris Korleski

TECHNICAL GUIDANCE MANUAL FOR GROUND WATER INVESTIGATIONS

CHAPTER 8

MONITORING WELL DEVELOPMENT, MAINTENANCE, AND REDEVELOPMENT

February 2009
Revision 2

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PREFACE

This document is part of a series of chapters incorporated in Ohio EPA's *Technical Guidance Manual for Hydrogeologic Investigations and Ground Water Monitoring* (TGM), which was originally published in 1995. DDAGW now maintains this technical guidance as a series of chapters rather than as an individual manual. The chapters can be obtained at http://www.epa.state.oh.us/ddagw/tgmweb.htm.

The TGM identifies technical considerations for performing hydrogeologic investigations and ground water monitoring at potential or known ground water pollution sources. The purpose is to enhance consistency within the Agency and inform the regulated community of the Agency's technical recommendations and the basis for them. In Ohio, the authority over pollution sources is shared among various Ohio EPA divisions, including the Emergency and Remedial Response (DERR), Hazardous Waste Management (DHWM), Solid and Infectious Waste (DSIWM), and Surface Water (DSW), as well as other state and local agencies. DDAGW provides technical support to these divisions.

Ohio EPA utilizes ***guidance*** to aid regulators and the regulated community in meeting laws, rules, regulations and policy. Guidance outlines recommended practices and explains their rationale. The Agency may not require an entity to follow methods recommended by this or any other guidance document. It may, however, require an entity to demonstrate that an alternate method produces data and information that meet the pertinent requirements. The procedures used to meet requirements usually should be tailored to the specific needs and circumstances of the individual site, project, and applicable regulatory program, and should not comprise a rigid step-by-step approach that is utilized in all situations.

MAJOR TECHNICAL CHANGES

Ohio EPA Technical Guidance Manual for Hydrogeologic Investigations and Ground Water Monitoring (TGM) was finalized in 1995 and Chapter 8 (Monitoring Well Development, Maintenance, and Redevelopment was revised in February 2004. This guidance document represents the second revision to Chapter 8. Listed below are the major changes from February 2004.

1. Revised the water quality indicator parameter values used to evaluate whether the well has been properly developed.

2. Added a recommendation for a time interval between development and sampling of one week.

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CHAPTER 8
MONITORING WELL DEVELOPMENT, MAINTENANCE, AND REDEVELOPMENT

The goal of ground water sampling is to obtain a sample that represents the current ground water conditions. Well development, well maintenance, and re-development (as needed) are critical to any ground water sampling program. The well development procedure and maintenance of the well should be documented.

Due to the effects of installation, the ground water entering a monitoring well may not be representative of natural conditions with respect to yield, chemical characteristics, and amount of suspended particulate matter. To allow for the collection of representative samples or physical properties (e.g., hydraulic conductivity), wells must be developed properly. Development involves stressing the formation so that a graded filter pack is created around the screen and particulate matter and fluids (when used) remaining from well drilling and construction are removed. Development restores hydraulic conditions and enhances yield of the saturated zone, stabilizes chemical changes that may have occurred during drilling and construction, and produces a well that is capable of yielding a sample of acceptably low turbidity (Panko and Barth, 1988; Aller et al., 1991, Izraeli et al., 1992).

Proper development creates a graded filter pack around the well screen. When pumping is first initiated, natural materials in a wide range of grain sizes are drawn into the well, producing very turbid water. As pumping continues, natural materials are drawn into the filter, producing an effective filter pack through a sorting process. This sorting process begins when the largest particles are retained by the filter pack, resulting in a layer of coarse particles against the screen. With continued pumping this process produces a progressively finer layer until an effective graded filter pack is produced (Izraeli, et al., 1992).

As indicated above, a key aspect of development is that it can reduce sample turbidity by removing fine particulate matter (clay and silt) from the filter pack and the geologic formation near the well intake, enhancing inflow to the well. Additionally, it can increase the life of wells by reducing or eliminating the potential for filling with fine particles or organic matter. Such "silting up" reduces yield and can result in anaerobic activity (NCASI, 1981). It is essential that filtration not be viewed as a substitute for proper development.

FACTORS AFFECTING DEVELOPMENT

Several factors may affect the performance and selection of a method or combination of methods for monitoring well development. These include, but may not be limited to, site hydrogeologic environment, well design, drilling method employed (Aller et al., 1991), and intended use of the well.

HYDROGEOLOGIC ENVIRONMENT

Ground water moves more easily through permeable, consolidated formations and "clean", coarse-grained sand and gravel; therefore, development may be accomplished quickly and easily. In contrast, flow through relatively impermeable silty or clayey material is slow or

limited; consequently, the process can be difficult. Well development should be applied with great care to wells installed in predominantly fine-grained formations (e.g., silts and clays). Rigorous development techniques may actually increase the turbidity of the ground water.

The ease of development is usually less predictable for unconsolidated formations than for rock. In general, more difficulty may be encountered when materials are unconsolidated. If a borehole is not stable, even distribution of the filter pack around the screen may not be achieved, hindering development (Aller et al., 1991). If materials are silt and clay, drilling may cause smearing along the borehole wall, which also causes problems. On the other hand, drilling causes minimal damage to homogeneous sand and gravel, and development is not affected (Hackett, 1987).

Different types of formations may be developed more effectively by using certain techniques. For example, a highly stratified, coarse-grained deposit is handled best by methods that concentrate energy on small parts of the formation. If the deposit is rather uniform, techniques that apply the same force over the entire length of the well screen can produce satisfactory results. Techniques that withdraw water quickly can reduce the hydraulic conductivity of formations containing a significant amount of silt and clay (Driscoll, 1986). Development of fine-grained materials generally should be accomplished by gentle action (Gass, 1989).

WELL DESIGN

Typical monitoring well design (e.g., small diameter, artificial filter pack, and limited screen open area) makes development difficult. Generally, wells should be designed to keep entrance velocities low enough to avoid degassing and/or alteration of water quality (Gass, 1986). The thickness of the pack has considerable effect on the procedure because it reduces the amount of energy imparted to the borehole wall. The pack should be as thin as possible if development is to be effective at removing fine particulates. Conversely, it should be thick enough to ensure adequate borehole support and good distribution of material around the screen. Generally, a minimum of two inches is sufficient.

Selection of the proper screen slot size and configuration is also essential for successful development. Slots are chosen to permit removal of fine material from the formation (see Chapter 7). Large slots may filter too much material and cause settlement and damage. Alternatively, it may not be possible to develop or sample properly if the slots are too small. According to Driscoll (1986), development works best when screens have both maximum open area and a slot configuration that permits the forces to be directed efficiently into the formation. In general, screens that are continuous slot, wire-wound facilitate easier development because they have the greatest open area (Gass, 1986).

Large diameter wells (i.e., four inches or larger) are much easier to develop due to equipment availability. However, the high cost of construction materials has resulted in the installation of smaller wells with machine-slotted screens (Gass, 1986). The equipment available for small diameter wells (e.g., direct push pre-packed wells) may be limited to small capacity bailers, inertial lift pumps, and small diameter bladder pumps.

DRILLING METHODS

The drilling process influences not only choice of development procedures, but also the intensity with which the procedures should be applied (Aller et al., 1991). All drilling methods impair the ability of a formation to transmit water to a borehole or well. Problems that can occur include: 1) the use of air rotary drilling to penetrate consolidated rock can cause fine particles to build up on the borehole walls and may plug fractures and pore spaces, 2) driving casing or using augers can cause smearing of fine-grained particulates between the casing/screen and the natural formation, 3) mud rotary can cause mudcakes to build up on the borehole wall, and 4) all drilling methods potentially can compact sediments. Development should rectify these problems to enhance yield and allow collection of representative samples.

Drilling fluid of any type can affect ground water quality; therefore, their use is discouraged. If a fluid is used, development should remove any that has infiltrated into the formation to allow in-situ ground water quality to return to pre-installation conditions.

PRESENCE OF NON-AQUEOUS PHASE LIQUIDS

Prior to development, the well should be checked for the presence of non-aqueous phase liquids (NAPL). If present, consideration should be given to the degree the well should be developed or even if the well should be developed. Care will need to be taken so that development does not spread the NAPL across the entire screened interval (through the entire sand pack and along the adjacent formation.)

INTENDED USE

The development technique may also depend on the intended use of a well. Wells intended for hydraulic testing (e.g., pump tests and slug tests) may need to be developed at higher rates to allow for the accurate determination of hydraulic conductivity and yield. Rates may need to be similar to the expected pumping rates anticipated during the aquifer tests. When the well will not be sampled for quality, other methods, such as jetting, may be acceptable (See Driscoll, 1986).

OTHER FACTORS

Site accessibility and ***type and availability of equipment*** should be considered during the selection of an appropriate method or combination of methods. The need for ***proper disposal of contaminated discharge water*** also can drive selection. ***Time and cost*** may dictate selection; however, methods that minimize time and cost often prove to be inadequate. Cost/benefit analysis generally favors proper and complete development. If it is inadequate, time and cost for drilling, well installation, ground water sampling, and sample analysis may be wasted on data that is not representative

Development should be applied cautiously to wells that are known or ***suspected to contain contaminants***, particularly those that pose a hazard through inhalation or direct contact. Appropriate safety precautions should be taken to protect field personnel. Also, it should be

noted that contaminated water and sediments removed during development may need to be drummed and disposed of properly.

DEVELOPMENT PROCEDURE

The general approach to development involves dislodging and removing fine-grained material and drilling fluids out of the ground water zone and into the well, and then from the well itself. This section describes development procedures, including predevelopment (measures taken during installation and construction), time and duration of development, and development methods.

PREDEVELOPMENT

Whenever possible, steps should be taken during well installation and construction to remove drilling cuttings and fluids prior to placement of the screen, filter pack, and annual seal. This may include removing water from the borehole prior to installation of the well screen and surging and removal of water after the sand pack has been installed, prior to installing the annular seal.

Typically, the water in the borehole is highly turbid and viscous from the drill cuttings. Removing this fluid prior to installing the screen and sand pack may make subsequent development efforts easier. An additional advantage to this technique is that the potential for "bridging" the sand pack during installation may be reduced because the viscosity of the water due to sediments in the boring is greatly reduced.

After the screen and sand pack are in place the well may be surged gently prior to installing the bentonite seal and grout (note that the augers/casing should be at the top of the sand pack during this process to prevent overlying material from falling into the sand pack). Surging at this time is advantageous in that it will be more effective in removing fines from the well and formation and grading and stabilizing the sand pack when the weight of the overlying grout is not present. Additional sand may need to be added to compensate for settling of the sand pack and ensure that sufficient separation exists between the annular seal and well intake. If surging is performed only after the well is completely installed (i.e., the grout is in place), there is a greater chance that the sand pack could settle and create a void between the sand pack and annular seal. If the annular seal sinks into the void space, the well could become contaminated with grout and may need to be replaced.

Mechanically surging the well using the drill rig is likely to be more effective and is much easier than trying to do it manually after the well is installed. Care should be taken not to place to large a force on the well that may cause it to collapse.

DEVELOPMENT CRITERIA

Development should not be implemented until the seal has cured and settled. Ideally, a time of 48 hours is required for neat cement and bentonite grout mixtures (Gaber and Fisher, 1988). However, the time required varies with site conditions and grout type.

The duration of development varies with the type of formation, screen length, height of the water column, thickness of filter pack, and method used. The most frequent mistake is to "give up" before the well has been adequately developed. Adequate development may take less than two hours to more than three days.

Development should proceed until the following criteria are met:

1. Water can enter as readily as hydraulic conditions allow.

2. A representative sample can be collected. In general, representative conditions can be assumed when the water is visually clear of sediments (e.g., turbidity. 10 NTU) and pH, and specific conductance have stabilized over at least three successive well volumes. Other criteria such as temperature, oxidation-reduction potential or dissolved oxygen may also be useful to determine whether a well can produce a representative sample. Stability criteria of water quality parameters listed in Table 8.1 can be used to determine when development objectives have been met. The duration, along with pH, temperature, specific conductivity measurements, and turbidity should be recorded on the well development record (See section on Development Documentation).

   In some instances, collection of a sample with a turbidity of 10 NTU is difficult or unattainable. If a well does not provide a sediment-free sample, development can stop when all of the following conditions are met:

   - Several procedures have been tried,

   - Proper well construction has been verified,

   - Turbidity has stabilized within 10% over three successive well volumes, and

   - Conductivity, and pH have stabilized over at least three successive well volumes. (It should be noted that pH, temperature, and conductivity may not stabilize if water quality has been degraded).

3. The sediment thickness remaining in the well is less than 1 percent of the screen length or less than 0.1 feet for screens equal to or less than 10 feet.

4. A minimum of three times the standing water volume in the well (to include the well screen, casing, plus saturated annulus, assuming 30 percent annular porosity) should be removed. In addition to the "three times standing water volume" criteria, further volumetric removal should be considered if fluids were utilized during well drilling and installation.

Table 8.1. Water-Quality Indicator Parameters (ASTM Standard D6771-02).

Parameter	Stabilization Criteria
pH	Difference of ±0.2
specific electric conductance	Difference of ± 3%
temperature	Difference of ± 0.5 ºC
turbidity	±10% (when turbidity is greater than 10 NTUs)
oxidation -reduction potential (ORP)	± 20 millivolts
dissolved oxygen (DO)	10% or ±0.2 mg/L, whichever is greater

METHODS

In general, methods to develop monitoring wells include pumping, overpumping, surging, bailing, and backwashing. The most effective approach(s) generally is a combination of one or more methods that allow for water movement in both directions through the screen. A technique that allows for reversing the flow helps to minimize bridging in the formation and filter pack.

Other methods exist, such as airlifting, air surging, jetting with water or air, or adding chemicals. Although various chemicals, including acids, surfactants, chelating agents, wetting agents, disinfectants, and dry ice have been employed for water supply wells, their use for monitoring wells is generally not appropriate. The addition of air, water, or chemicals may affect sample analysis in unpredictable ways. Air forced into a formation can reduce its permeability (Kraemer et al., 1991) and can cause volatilization of organics, if present. Water should be added only on rare occasions (i.e., when an insufficient amount exists to provide enough energy to develop the wells adequately). If water is added, it should be chemically analyzed for potential impact on in-situ ground water quality.

The following provides a general description of methods commonly used. The advantages and disadvantages of each are summarized and procedures are provided.

Pumping and Overpumping

A widely accepted technique is to pump a well using an intake that is raised and lowered (without excessive surging) throughout the length of the screened interval (Puls and Powell, 1992). Methods that rely totally on pumping may not sufficiently stabilize the formation or the filter pack material. Although visibly clear water may eventually be discharged, any subsequent activity that agitates the water column can cause considerable turbidity (ASTM Standard D5521-05). Utilizing pumps in which the pumping action creates gentle surging or pumps that can be fitted with a surge block may enhance development. Backwashing may also be combined with pumping to create a surging action.

The recommended approach is to begin pumping at the top of the screen with low pumping rates and incrementally work down the well screen. The process should then be repeated in reverse, from the bottom of the well to the top. When there is no improvement in turbidity, the well should be allowed to equilibrate and then the process should be repeated at higher pumping rates. Alternate pumping and equilibration cycles should continue until the water is

free of sediments and no additional sediment accumulates in the bottom of the well. According to Keely and Boateng (1987), however, some settlement and further loosening of fines can occur after the first attempt. Accordingly, a final series of cycles may need to be conducted 24 hours later.

Monitoring well development should begin at low rates (e.g., 100 ml/min) and end at rates at least ten times the sampling rate; however, in most cases, higher rates will be needed. In particular, higher rates may be needed when the well is being used in hydraulic tests to determine hydraulic characteristics of the formation. Overpumping at a rate that substantially exceeds water removal during purging and sampling increases influx of fine particles, thereby opening screen slots, pore spaces, and fractures. High rates may not be advisable when wells are in a pristine area and adjacent to a contaminant plume because of the potential to draw in contaminants. Other disadvantages of pumping and overpumping include bridging of particles against the screen and the need for proper disposal of contaminated water.

Development by pumping is most effective in coarse-grained, unconsolidated deposits and rock formations. However, it generally has limited application in highly conductive formations because it is difficult to pump monitoring wells at sufficient rates to create the high entrance velocities necessary for removal of fine particulates (Barcelona et al., 1985). The pumps utilized should be capable of pumping at low to high rates and be controlled by valving. Small diameter pumps that offer a wide range have recently been developed.

Monitoring wells can be developed by using either a centrifugal or submersible pump. A centrifugal pump may be effective for low-yielding wells; however, it can be utilized only if the depth to water is less than approximately 25 feet. The use of a submersible pump is not limited by water level, but is affected by well diameter, construction material of the impeller, and type and concentration of contaminants. According to Kraemer et al. (1991), the presence of fine-grained materials can clog or damage pumps with plastic impellers. The bladder of squeeze-type pumps also may be damaged by fines. It is recommended that a bailer be initially used to remove accumulated sediments. Prior to well development, the pumps should be decontaminated in a manner consistent with the procedures described in Chapter 6 for drilling and subsurface sampling equipment.

Surging

Surging involves pulling and pushing water into and out of a well intake by using a plunger or block. This process destroys bridging and can be effective for small diameter monitoring wells. A surge block is a device with a flexible gasket that is close in size to the well diameter (Figure 8.1). It is attached to a rod that is raised and lowered. Water is forced out of the intake on the downstroke, breaking up the bridged sediments and enabling water and sediments to flow back into the well on the upstroke. The surge block should fit with a minimum clearance of one-fourth inch (Barcelona et al., 1985). It should be of sufficient weight to overcome the inertia and drag of the cable reel and friction of the discs against the casing on the downstroke. Also, it should be of sufficient density to overcome the effects of buoyancy (Schalla and Landick, 1986).

Prior to surging, wells should be bailed or pumped to make sure that water will enter the well. If water does not enter the well, then surging should not be conducted. The negative pressure on the upstroke can cause the well to collapse.

For screen lengths of five feet or less, surging above the screen is effective for the entire screen length (Gass, 1986). For lengths greater than five feet, surging should be initiated above the screen and worked gradually downward at 2-3 feet intervals as water begins to easily move in and out of the well screen. To minimize damage, surging should start slowly and increase in force during the process. High differential pressures may cause collapse of the well screen or casing or may damage the filter pack (e.g., channels or voids may form near the screen if the pack sloughs away) (Keely and Boateng, 1987). A significant amount of fines can accumulate in the well during surging. These fines can be forced back into the formation and also make it impossible to remove the surge block. Therefore, it is necessary to withdraw the block at intervals and remove the sediment with a sand pump or bailer.

According to a study by Paul et al. (1988), surging of wells screened in fine-grained sediments should be avoided because it increases turbidity, does not improve hydraulic response significantly, and is unnecessarily costly. However, gentle surging action to agitate the sand pack may assist in improving the turbidity of low-yielding saturated zones.

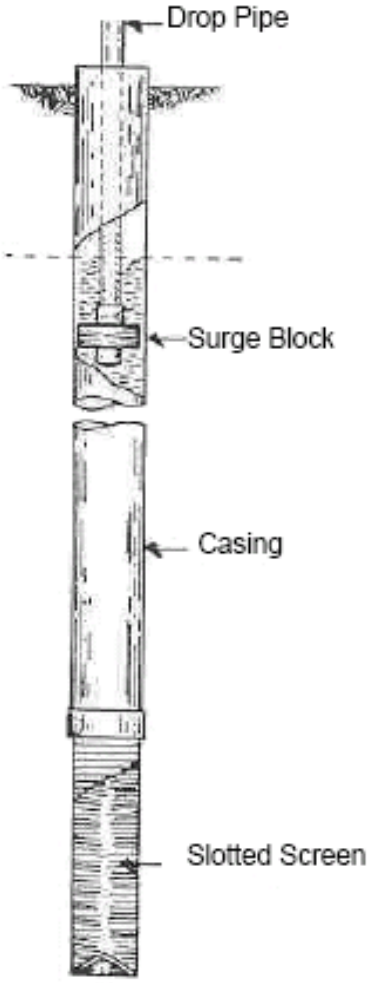

Figure 8.1 Development with a surge block (Source: "Monitoring Well Development" by T.E. Gass. *Water Well Journal*, Vol. 40, No. 1, p. 53 (Figure 1). 1986. Reprinted from Water Well Journal with permission from National Ground Water Association. Copyright 1986).

Backwashing

Backwashing or rawhiding (Gass, 1986) involves allowing water that is pumped to the top of a well to flow back through the pump and out through the well intake. Backwashing breaks up the bridged particles, allowing them to be pumped and removed; however, it may not be forceful enough to obtain favorable results. The method may only develop materials opposite the upper part of the intake or preferentially develop the most permeable zones in stratified deposits. Also, it may allow potentially contaminated water to enter uncontaminated zones. Thus, the technique may not be appropriate for areas of known or suspected contamination.

Bailing

In some instances, a bailer with a check valve at the bottom may be an effective method of development (Lapham, et. al., 1997). The bailer is rapidly lowered down the well until it hits the water column. The impact of the bailer on the water surface will initially force water into the formation. The withdrawal of the bailer causes water to flow back into the well. A stainless steel bailer is recommended to have sufficient weight to create the surging action. A bailer can also be fitted with a flange to serve as a surging tool.

To properly develop the well, rapid motions along the entire length of the intake should be done to create an inward and outward thrust of water that breaks up bridges that may have formed adjacent to the well intake. To enhance the removal of particulates accumulated at the bottom of the well, rapid short strokes near the bottom can be used to agitate and suspend sediments, thus allowing them to be removed. Development by bailing should be limited to gentle action in low-yielding wells (Gass, 1989). If a well is de-watered, it should be allowed to recover and bailing should be resumed.

Development by bailing is very labor-intensive. Depending on the volume of water that must be removed, it may be useful to rig a tripod and pulley to aid in the lifting of the bailer from the well (Kraemer et al., 1991). As with surging, care should be taken not to cause collapse of the well casing or screen.

Air-lift Pumping and Air Surging

Other techniques commonly utilized are air lift pumping and air surging. These methods may induce and trap air in the formation outside the well intake and alter ground water quality. Furthermore, if ground water is highly contaminated, the methods can expose field personnel to hazardous materials. Use is not recommended unless the technique does not introduce air into the well screen and it can be demonstrated that the quality of water to be sampled will not be affected. Air from the compressor should be filtered to insure that oil is not introduced into the well (Barcelona et al., 1985). Generally, air techniques may be effective at removing debris, but cause very little positive effect beyond the well screen (Gass, 1986).

One method that does not introduce air is ***two pipe air-lift pumping*** (Figure 8.2). Air is injected through the inner pipe at high pressure to bubble out into the surrounding outer pipe. The bubbles reduce the unit weight of the water, causing the column of water and sediments to be lifted upward, allowing ground water from the formation to flow into the well (Gass, 1986).

To avoid injecting air into the screened interval, Aller et al. (1991) recommended that the bottom of the pipe be no more than ten feet from the top of the screen. Scalf et al. (1981) indicated that the use of air is restricted by the submergence factor, which equals the height of water in feet above the bottom of the pipe while pumping (blowing water out) divided by the total length of the pipe. The submergence factor should be on the order of at least twenty percent. This may be difficult to achieve with many shallow wells.

Development by ***air surging*** involves applying air intermittently to allow water to fall back down the casing and create a backwashing or surging action to break up any bridging (Keely and Boateng, 1987). This method is not recommended because it causes mixing of aerated water with the water in the well (Aller et al., 1991). Schalla and Landick (1986) have developed an air-vented surge plunger for developing small-diameter wells that does not introduce air into the formation unless the unit is lowered into the screened interval.

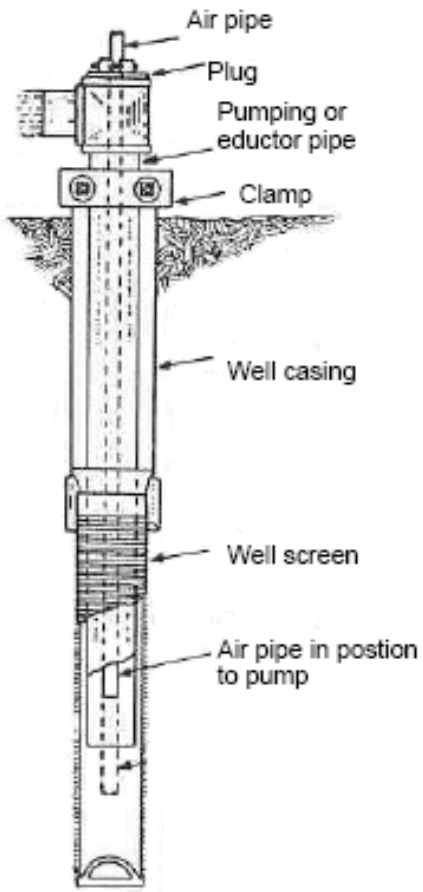

Figure 8.2: Two pipe air-lift system (Source: "Monitoring Well Development" by T.E. Gass. *Water Well Journal*, Vol. 40, No. 1, p. 54 (Figure 4). 1986. Reprinted from Water Well Journal with Permission from National Ground Water Association. Copyright 1986).

Inertial Lift Pump

Inertial lift pumps are constructed of a ball valve at the end of a flexible tube that runs to the surface. The sampler is lowered to the bottom of the well and the ball valve opens, allowing water to enter the tube. As well development begins the water column in the tubing is equal to that in the well. The tube is then lifted and dropped in a continuous up-and-down motion. As the tube is lifted, the water column is lifted in the tubing a distance equal to the stroke length. Lowering the tube allows the check valve to open, allowing water to enter the tubing.

The ball valve seats on the upstroke, capturing the water that has entered the tubing. This cycle continues with each up and down movement until water moves up and out of the tubing.

Inertial lift pumps are inexpensive, fairly portable, and easy to operate. They are particularly useful for development of small diameter wells (e.g., direct push pre-packed wells), since the tubing is available in sizes small enough to fit in small diameter wells. A potential drawback to inertial lift pumps is that in fine-grained formations over-surging can cause the well screen to become clogged with fines; therefore, it may be necessary to perform additional purging with a non-surging pump device to reduce turbidity (ASTM Standard D6724-04). Inertial lift pumps may be ineffective in removing large volumes of water and are not effective development tools for wells larger than 2 inches ID (ASTM Standard D6725-04).

Use of an inertial lift pump that is close in size to the inner diameter of the well can create a surging action in the well, while the pump simultaneously purges the well, removing the fines that are loosened by the surging action. Attachable surge blocks are available for some inertial lift pumps; however, this can increase the risk of clogging.

WELL DEVELOPMENT DOCUMENTATION

Well development documentation is important to show that representative samples can be obtained. Development method(s), time spent on development, volume of water removed, depth of the well, depth to top of the screen, diameter of the well, visual appearance (clarity), turbidity, pH, and specific electrical conductance of discharge water at various intervals should be recorded on a form or log (Lapham, et. al., 1997). Figure 8.3 provides an example of a well development record.

Information on recovery rates and estimated yield should also be documented. This information may be helpful in planning for sampling events and in sampling techniques.

TIME INTERVAL BETWEEN DEVELOPMENT AND SAMPLING

Prior to sampling a well, sufficient time should be allowed for equilibration with the formation after development. The intent is to provide time for the newly installed well and backfill materials to equilibrate to their new environment and for that environment to stabilize after disturbance. Though a significant volume of water may be pulled through the well during development, the well and granular backfill surfaces over which this water passes are not likely to be at chemical equilibrium with the ground water zone. The time for a well to stabilize depends on the characteristics of the ground water zone and the method of development; however, there is no rigorous scientific analysis to substantiate a time frame. A recommended "rule –of –thumb" is one week. Several weeks may be needed for lower permeability formations (< 1X 10-6 cm/sec) (Izraeli, et al, 1992; Byrnes et al., 1994; USACE, 1998). See section on "Development Criteria" for additional information on when a well can be considered properly developed.

Figure 8.3 EXAMPLE RECORD OF WELL DEVELOPMENT

Site Name:	Initial Well Depth:	Final Well Depth:
Well ID:	Well Diameter:	Screen Length:
Developers:	Static Water Level:	Total Purged Volume:
Start Date: End Date:	Weather Conditions:	
General Comments (e.g., presence of NAPLS):	General Development Method(s):	

Date	Time	Method	Pumping Rate (gal/min)	Volume Purged (gal)	Temp. (ºC)	Spec. Cond. (µS/cm)	pH	Turbidity (NTU)	Other	Comments (e.g., clarity of water and success of development)

Field Parameter and Stability Guidance: pH (±0.2 standard units); Temperature (±0.5 ºC); specific conductance (±3%, µS/cm); turbidity (±10% when turbidity is greater than 10 NTU); dissolved oxygen (10% or ±0.2 mg/L, whichever is greater); oxidation-reduction potential (±20 ml/g)

NTU- nephelometric unit, µS/cm- microsiemens per centimeter

WELL MAINTENANCE CHECKS AND REDEVELOPMENT

During the course of their active lives, monitoring wells should be checked to confirm that the well is still intact and fine particles have not accumulated. Unlike water supply wells, monitoring wells remain predominantly unpumped. There is no continuous removal of fines over an extended period. According to Kraemer et al. (1991), no matter how complete development appears to be, there is a high probability (especially for wells completed in fine-grained formations) that introduction of pumps or bailers will create a surge rendering the water somewhat turbid. In addition to sediments accumulating in the well, the casing and screen can become corroded or plugged by chemical or bio-chemical precipitates, and thus cause a loss of hydraulic connection. Metal well casings are subject to degradation over time from exposure to corrosive ground waters (pH of less than 6.0). Polyvinyl chloride (PVC) casing can dissolve in the presence of PVC solvent or if a pure organic product reaches the well in high concentrations from chemical spills or leaking storage tanks. A deteriorating well structure or a well that is “silting up” can cause a bias to the data that might be difficult to detect or might even be interpreted as trends in ground water quality. To provide a representative sample, these wells should be restored. Restoration typically involves redevelopment.

It is recommended that performance be evaluated during the life of a well. This may include, but not be limited to, noting a significant drop in yield during purging, noting increased turbidity, measuring total well depth to determine if sediments have been deposited, and using a camera to determine if incrustation of the screen or damage to the well casing has occurred. Comparison of water-level fluctuations over time in the well can indicate a possible change in hydraulic connection of the well to the aquifer. For example, a long-term decline in the water level in a well could indicate gradual plugging of the well screen. Slug tests or injection, pressure, or partial-vacuum tests can also be conducted as part of the continual evaluation of the well (Stallman, 1983; Lohman, 1972; Driscoll, 1986; Bedinger and Reed, 1988). These tests help evaluate whether there is still good hydraulic connection between the well screen and the ground water zone.

Well maintenance records should be kept including, but not limited to, periodic checks on depths; trends in water levels, yield changes and turbidity; the external physical condition of the well, its protective casing, the surface seal; and other criteria utilized to monitor the integrity of the well. At minimum, wells should be redeveloped when 20% of the well screen is occluded by sediments (U.S. EPA, 1988), or records indicate a change in yield and turbidity.

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Appendix G
Health and Safety Plan

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Health and Safety Plan

The Dow Chemical Company

Dow Hanging Rock, Ironton, Ohio

November 2011

CH2MHILL®

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1 Introduction

1.1 CH2M HILL Policy and Commitment

CH2MHILL

HSSE Target Zero World-Class Performance

Health, Safety, Security, and Environment Policy

Protection of people and the environment is a CH2M HILL core value. It is our vision to create a culture within CH2M HILL that empowers employees to drive this value into all global operations and achieve excellence in health, safety, security, and environment (HSSE) performance. CH2M HILL deploys an integrated, enterprise-wide behavior-based HSSE management system to fulfill our mission and the expectations of our clients, staff, and communities based on the following principles:

- We require all management and supervisory personnel to provide the leadership and resources to inspire and empower our employees to take responsibility for their actions and for the actions of their fellow employees to create a safe, healthy, secure, and environmentally-responsible workplace.
- We provide value to clients by tailoring HSSE processes to customer needs and requiring all CH2M HILL employees and subcontractors to deliver projects with agility, personal service, and responsiveness and in compliance with HSSE requirements and company standards to achieve health, safety, security, and pollution prevention excellence. Our performance will aspire to influence others and continually redefine world-class HSSE excellence.
- We systematically evaluate our design engineering and physical work environment to verify safe and secure work conditions and practices are established, consistently followed, and timely corrected.
- We continually assess and improve our HSSE program to achieve and maintain world-class performance by setting and reviewing objectives and targets, reporting performance metrics, and routinely reviewing our progress.
- We care about the safety and security of every CH2M HILL employee and expect all employees to embrace our culture, share our core value for the protection of people and the environment, understand their obligations, actively participate, take responsibility, and "walk the talk" on and off the job.

The undersigned pledge our leadership, commitment, and accountability for making this policy a reality at CH2M HILL.

Dated the 1st day of October 2009.

Lee A. McIntire
Chief Executive Officer

Garry Higdon
President, Energy Division

Jacqueline Rast
President, Major Programs Group

Robert C. Allen
Chief Human Resources Officer

Mark Lasswell
President, Transportation Business Group

Catherine Santee
Chief Financial Officer

Bob Gerd
President, Facilities & Infrastructure Division

Margaret McLean
Chief Legal Officer

Thomas G. Searle
President, International Division

Bill Dehn
Senior Vice President, Special Projects

Michael E. McKelvy
President, Government, Environment, and Nuclear Division

Nancy R. Tuor
Vice-Chair, International

Keith Christopher
Senior Vice President, Health, Safety, Security, and Environment

1.1.1 Safe Work Policy

It is the policy of CH2M HILL to perform work in the safest manner possible. Safety must never be compromised. To fulfill the requirements of this policy, an organized and effective safety program must be carried out at each location where work is performed.

CH2M HILL believes that all injuries are preventable, and we are dedicated to the goal of a safe work environment. To achieve this goal, every employee on the project must assume responsibility for safety.

Every employee is empowered to:

- Conduct their work in a safe manner.
- Stop work immediately to correct any unsafe condition that is encountered.
- Take corrective actions so that work may proceed in a safe manner.

Safety, occupational health, and environmental protection will not be sacrificed for production. These elements are integrated into quality control, cost reduction, and job performance, and are crucial to our success.

1.1.2 Health and Safety Commitment

CH2M HILL has embraced a philosophy for health and safety excellence. The primary driving force behind this commitment to health and safety is simple: employees are CH2M HILL's most significant asset and CH2M HILL management values their safety, health, and welfare. Also, top management believes that all injuries are preventable. CH2M HILL's safety culture empowers employees at all levels to accept ownership for safety and take whatever actions are necessary to eliminate injury. Our company is committed to world-class performance in health and safety and also understands that world-class performance in health and safety is a critical element in overall business success.

CH2M HILL is committed to the prevention of personal injuries, occupational illnesses, and damage to equipment and property in all of its operations; to the protection of the general public whenever it comes in contact with the Company's work; and to the prevention of pollution and environmental degradation.

Company management, field supervisors, and employees plan safety into each work task in order to prevent occupational injuries and illnesses. The ultimate success of CH2M HILL's safety program depends on the full cooperation and participation of each employee.

CH2M HILL management extends its full commitment to health and safety excellence.

1.2 Project-Specific Health, Safety, and the Environment Goals

All management and employees are to strive to meet the project-specific Health, Safety, and the Environment (HSE) goals outlined below. The team will be successful only if everyone makes a concerted effort to accomplish these goals. The goals allow the project to stay focused on optimizing the health and safety of all project personnel and, therefore, making the project a great success.

The Project has established eleven specific goals and objectives:

- Create an injury-free environment.
- Have zero injuries or incidents.
- Provide management leadership for HSE by communicating performance expectations, reviewing and tracking performance, and leading by example.
- Ensure effective implementation of the HSP through education, delegation, and team work.
- Ensure 100 percent participation in HSE compliance.
- Continuously improve our safety performance.
- Maintain free and open lines of communication.
- Make a personal commitment to safety as a value.
- Focus safety improvements on high-risk groups.
- Continue strong employee involvement initiatives.
- Achieve health and safety excellence.

1.3 Applicability

This HSP applies to:

- All CH2M HILL staff, including subcontractors and tiered subcontractors of CH2M HILL working on the site.
- All visitors to the construction site in the custody of CH2M HILL (including visitors from the Client, the Government, the public, and other staff of any CH2M HILL company).

This HSP does not apply to the third-party contractors, their workers, their subcontractors, their visitors, or any other persons not under the direct control or custody of CH2M HILL.

This HSP defines the procedures and requirements for the health and safety of CH2M HILL staff and visitors when they are physically on the work site. The work site includes the project area (as defined by the contract documents) and the project offices, trailers, and facilities thereon.

This HSP will be kept onsite during field activities and will be reviewed as necessary. The HSP will be amended or revised as project activities or conditions change or when supplemental information becomes available. The HSP adopts, by reference, the Enterprise-wide Core Standards (CS) and Standard Operating Procedures (SOPs), as appropriate. In addition, the HSP may adopt procedures from the project Work Plan and any governing regulations. If there is a contradiction between this HSP and any governing regulation, the more stringent and protective requirement shall apply.

All CH2M HILL staff and subcontractors must sign the employee sign-off form included in this document as Attachment 1 to acknowledge review of this document. Copies of the signature page will be maintained onsite by the Safety Coordinator (SC).

2 Project Details

2.1 Approval

This site-specific Health and Safety Plan (HSP) has been written for use by CH2M HILL only. CH2M HILL claims no responsibility for its use by others unless that use has been specified and defined in project or contract documents. The plan is written for the specific site conditions and identified scope(s) of work and must be amended if those conditions or scope(s) of work change.

By approving this HSP, the Responsible Health and Safety Manager (RHSM) certifies that the personal protective equipment has been selected based on the project-specific hazard assessment.

RHSM Approval: Jason Kearns **Date**: 10/17/2011

2.2 Project and Site Information

Project Number	404798	
Client	The Dow Chemical Company	
Project /Site Name	Hanging Rock Facility	
Site Address	925 County Road 1A Ironton, OH 45638	
Site Status	☐ Active ☐ Legacy	
Dates of Site Work	From: 11/1/2011	To: 11/1/2012
Date HASP Prepared	12/15/2010, 10/17/2011	
Site Access Requirements	• Read, sign and submit the "Dow Proprietary Agreement" • Have negative result in Drug Testing program that meets CH2M HILL's requirements • CH2M HILL Staff only: Attend and participate in the following training to be delivered by the CH2M HILL HSM: "HSE Chartering for Working on Dow" • Subcontractors and CH2M HILL staff: Attend site-specific H&S chartering delivered by CH2M HILL • Comply with background check requirements.	
Prevailing Weather/Climate:	Average temperatures range from 32° F in winter to 92° F in summer. Rainfall ranges from 3 to 5 inches per month, with more rainfall during summer months than winter months.	

Site History/Description:	The facility is a manufacturing plant built in 1957. It is about 4 miles Northwest of Ironton in Lawrence county Ohio. The Facility currently manufacture and ships polymeric beads and foams
Description Project Work:	A Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) must be completed to thoroughly evaluate the nature and extent of any realease of hazardous waste and hazardous constituent from all SWMUs and Areas of Concern identified. The tasks associated with this investigation are as follows: • Mobilization / Demobilization • Direct Push Technology (DPT) Drilling • Sonic Drilling • Soil Sampling • Groundwater Grab Sampling • Surface Soil Sampling • Sediment Sampling • MW Installation • Well Development • Groundwater Sampling • Decontamination • Investigation-Derived Waste (IDW) Management

2.3 Contact Information

	Name	**Telephone**
Dow Remediation Leader	Tim King	304.747.3763
Dow Site/Facility Contact	Mike Ratliff	740.533.4026 (o) 740.646.4530 (m)
Site Manager/Project Manager	Lisa Cundiff	314.335.3010 (o) 618.610.6120 (m)
Assistant Project Manager	Rachel Grand	314.335.3018 (o) 314.599.3414 (m)
Field Team Leader /Safety Coordinator	Osaguona Ogbebor	937.220.2904 (o) 937.212.1942 (m)
H&S Manager	Jason Kearns	304.747.2511 (o) 304.382.9629 (m)
Environmental Manager	Cindy Lang	248.223.6056 (o) 734.735.7128 (m)
CH2M HILL Dow Program HS&E Director	Jeanne Burgess	508.280.3653

2.4 Site Map

(To be inserted)

2.5 Task Management Requirements

Task	Subcontractor Oversight?			Hazwoper Regulated (Y/N)	Active Sites Permit/ Procedure Required?
	Continuous	Effective	NA		
Mobilization / Demobilization		Y		N	N
DPT Drilling	Y			Y	Y
Sonic Drilling	Y			Y	Y
Soil Sampling	Y			Y	Y
Groundwater Grab Sampling	Y			Y	Y
Surface Soil Sampling			X	Y	Y
Sediment Sampling			X	Y	Y
MW Installation	Y			Y	Y
Well Development	Y			Y	Y
Groundwater Sampling			X	Y	Y
Decontamination	Y			Y	Y
IDW Management			X	Y	Y

Refer to project documents (i.e., Work Plan) for detailed task information. Tasks other than those listed above require an approved amendment or revision to this plan before tasks begin. Refer to the "Site Control" section of this HSP for procedures related to "clean" tasks that do not involve hazardous waste operations and emergency response (HAZWOPER).

Under specific circumstances, the training and medical monitoring requirements of federal or state Hazwoper regulations are not applicable. It must be demonstrated that the tasks can be performed without the possibility of exposure in order to use non-Hazwoper-trained personnel. **Prior approval from the Responsible Health and Safety Manager (RHSM) is required before these tasks are conducted on regulated hazardous waste sites.**

2.5.1 Activity Hazard Analysis

An Activity Hazard Analysis (AHA) must be performed for each task. An AHA defines the activity being performed, the hazards posed and control measures required to perform the work safely. Workers must be briefed on the AHA before doing the work and their input is solicited prior, during, and after the performance of work to further identify the hazards posed and control measures required. The AHA shall identify the work tasks required to perform each activity, along with potential HSE hazards and recommended control measures for each hazard. In addition, a listing of the equipment to be used to perform the activity, inspection requirements and training requirements for the safe operation of the equipment listed must be identified. The following hazard controls and applicable CH2M HILL CSs and SOPs should be used as a basis for preparing AHAs.

AHAs must be prepared for CH2M HILL activities and included as an attachment to this HSP.

2.5.2 Subcontractor Activity Hazard Analysis

CH2M HILL subcontractors are required to provide AHAs specific to their scope of work on the project for acceptance by CH2M HILL. Each subcontractor shall submit AHAs for their field activities, as defined in their work plan/scope of work, along with their project-specific safety plan/procedures. Additions or changes in field activities, equipment, tools, or material used to perform work or hazards not addressed in existing AHAs requires either a new AHA to be prepared or an existing AHA to be revised.

In the order listed below, the RHSM considers the various methods for mitigating the hazards. Employees are trained on this hierarchy of controls during their hazardous waste training and reminded of them throughout the execution of projects.

- Elimination of the hazards (e.g., use remote sampling methodology to avoid going into a confined space)
- Substitution (e.g., reduce exposure to vapors by using of a geoprobe instead of test pitting)
- Engineering controls (e.g., ventilate a confined space to improve air quality)
- Warnings (e.g., establish exclusion zones to keep untrained people away from hazardous waste work)
- Administrative controls (e.g., implement a work-rest schedule to reduce chance of heat stress)
- Use of PPE (e.g., use of respirators when action levels are exceeded)

2.6 Subcontractors

(Reference CH2M HILL SOP HSE-215 Contracts, Subcontracts and HS&E Management Practices)

Subcontractor:	
Contact:	
Subcontractor:	
Contact:	
Subcontractor:	
Contact:	

Subcontractors are responsible for the health and safety procedures (known as AHAs) specific to their work, and are required to submit AHAs to CH2M HILL for review before the start of fieldwork. Subcontractors must comply with the established health and safety plan(s). CH2M HILL should continuously endeavor to observe subcontractors' safety performance. This endeavor should be reasonable, and include observing for hazards or unsafe practices that are both readily observable and occur in common work areas. CH2M HILL is not responsible for exhaustive observation for hazards and unsafe practices. In addition to this level of

observation, the SC is responsible for confirming CH2M HILL subcontractor performance against both the subcontractor's safety plan and applicable self-assessment checklists.

Health and safety-related communications with CH2M HILL subcontractors should be conducted as follows:

- Verify that subcontractor(s) have briefed the project team on the hazards and precautions related to their work.
- When apparent non-compliance/unsafe conditions or practices are observed, notify the subcontractor's safety representative and request corrective action. The subcontractor is responsible for determining and implementing necessary controls and corrective actions.
- When repeat non-compliance/unsafe conditions are observed, notify the subcontractor's safety representative and stop affected work until adequate corrective measures are implemented.
- When an apparent imminent danger exists, immediately remove all affected CH2M HILL employees and subcontractors, notify subcontractor's safety representative, and stop affected work until adequate corrective measures are implemented. Notify the Project Manager and HS&E Manager as appropriate.
- Document all oral health and safety-related communications in project field log books, daily reports, or other records.

2.7 Contractors (Third Parties, Client Contractors)

(Reference CH2M HILLCH2M HILL SOP HSE-215, *Contracts, Subcontracts and HSE Management Practices*)

Subcontractor:	
Contact:	
Subcontractor:	
Contact:	

Client Contractors

This HSP does not cover contractors that are contracted directly to the client or the owner. CH2M HILLCH2M HILL is not responsible for the health and safety or means and methods of the contractor's work, and we must never assume such responsibility through our actions (e.g., advising on health and safety issues). In addition to these instructions, CH2M HILLCH2M HILL team members should review contractor safety plans so that we remain aware of appropriate precautions that apply to us. Self-assessment checklists are to be used by the SC and CH2M HILLCH2M HILL team members to review the contractor's performance ONLY as it pertains to evaluating CH2M HILLCH2M HILL exposure and safety. The RHSM is the only person who is authorized to comment on or approve contractor safety procedures.

Health and safety-related communications with contractors should be conducted as follows:

- Request the contractor to brief CH2M HILLCH2M HILL team members on the precautions related to the contractor's work.
- When an apparent contractor non-compliance/unsafe condition or practice poses a risk to CH2M HILLCH2M HILL team members:
  - Notify the contractor safety representative.
  - Request that the contractor determine and implement corrective actions.
  - If necessary, stop affected CH2M HILLCH2M HILL work until contractor corrects the condition or practice.
  - Notify the client, Project Manager, and RHSM as appropriate.

If apparent contractor non-compliance/unsafe conditions or practices are observed, inform the contractor safety representative (CH2M HILL's obligation is limited strictly to informing the contractor of the observation—the contractor is solely responsible for determining and implementing necessary controls and corrective actions).

If an apparent imminent danger is observed, immediately warn the contractor employee(s) in danger and notify the contractor safety representative (CH2M HILL's obligation is limited strictly to immediately warning the affected individual(s) and informing the contractor of the observation—the contractor is solely responsible for determining and implementing necessary controls and corrective actions).

Document all verbal health and safety-related communications in project field logbook, daily reports, or other records.

2.8 Evacuation

In the event of an emergency evacuation, workers will assemble in the pre-determined assembly areas. The SC will be the Incident Coordinator until Dow or professional emergency responders take control of the situation. The SC will notify personnel when it is safe to return to work.

In the case of an alarm the following evacuation procedures will be executed:

- Evacuation routes and assembly areas (and alternative routes and assembly areas) are specified on the cover page of this document.
- The SSC will designate evacuation route(s) and assembly area(s) before work begins and are discussed with the field team at the Pre-Job Meeting. Every worker on site will sign the HASP acknowledging evacuation procedures.
- Safety Equipment worn during evacuation will be standard PPE directed by AHA, unless otherwise directed by the nature of the emergency response. The SSC will determine the appropriate evacuation safety equipment needed dependent upon response. Will use multi-ray in the work area for organics and vapors. Use radio for communication. (Standard clothing or PPE (at a minimum includes: hard hat, safety glasses with side shields, non-

impervious sturdy leather steel toe work boot (ankle), [safety shoes/boot preferred], hearing protection, and safety vests.) Additional PPE may be required by contractor to conduct work based on the contractors Activity Hazard Analysis. FRC is also required for all who visit the job site as well as for the workers).

- Personnel will assemble at the assembly area(s) upon hearing the emergency signal for evacuation.
- The SSC and a "buddy" will remain on the site after the site has been evacuated (if safe) to assist local responders and advise them of the nature and location of the incident.
- The SSC will account for all personnel in the onsite assembly area.
- The SSC will write up the incident as soon as possible after it occurs and submit a report to the Corporate Director of Health and Safety.

2.9 Project-specific Emergency Equipment and Supplies

The SC is responsible for verifying that the emergency equipment listed below is onsite and available and that all personnel involved in the project know the location of emergency equipment. The SC should mark the locations of emergency equipment on the site map and post the map.

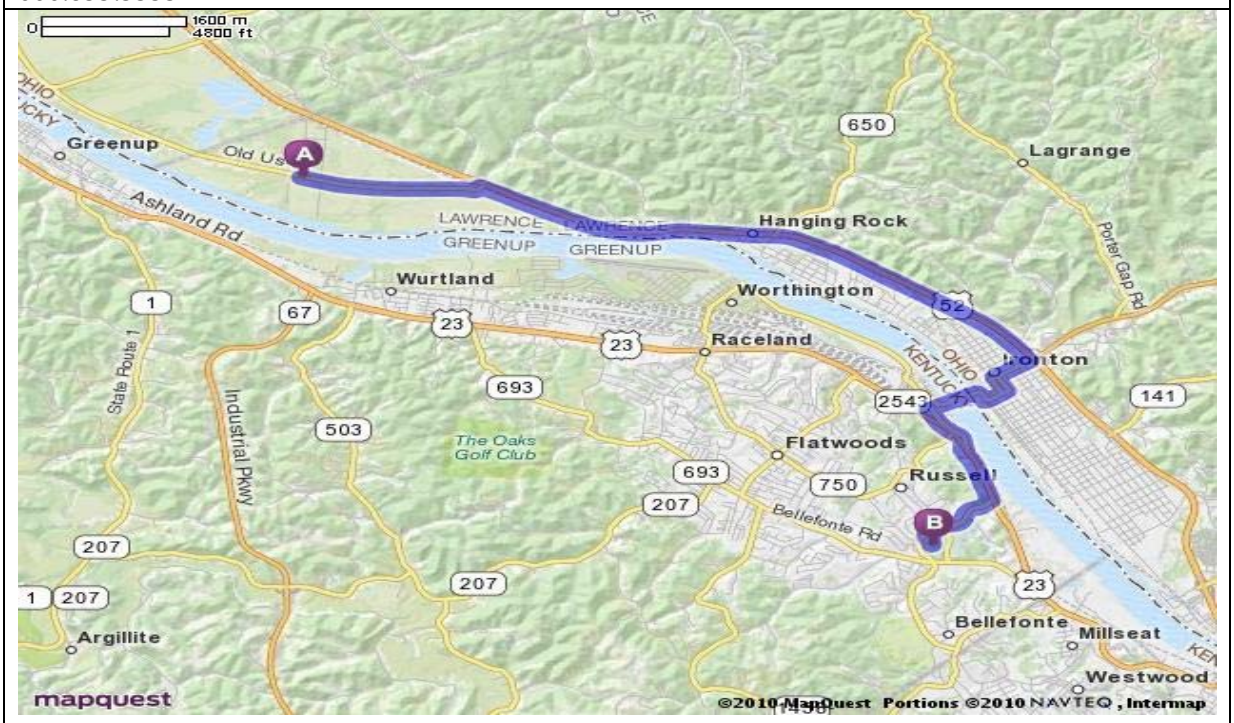
Emergency Equipment and Supplies	Location
Fire extinguisher (A, B, and C classes)	Support Zone/Heavy Equipment
First aid kit	Support Zone/Field Vehicle
Eye wash	Support and Decon Zone/Field Vehicle
Potable water	Support and Decon Zone/Field Vehicle
Bloodborne pathogen kit	Support Zone/Field Vehicle
Cell Phone	Safety Coordinator

2.10 Emergency Contacts

24-hour CH2M HILL Injury Reporting– 1-866-893-2514 24-hour CH2M HILL Serious Incident Reporting Contact – 720-286-4911	
Facility Emergency Response #: Contact Site Emergency Personnel by dialing 4055 from any grey phone on site. The site will contact outside emergency services if additional assistance is needed.	**CH2M HILL- Medical Consultant** WorkCare Dr. Peter Greaney M.D. 300 S. Harbor Blvd, Suite 600 Anaheim , CA 92805 800-455-6155/866-893-2514 714-978-7488
Utilities Emergency Phone Numbers First contact Site Emergency Personnel Contact Ohio Utility Protection Service (OUPS) for all utility emergencies. OUPS will contact the appropriate utility company. For any suspected site . For utility emergencies at active sites, contact safe work permit writer.	
CH2M HILL Responsible Health and Safety Manager (RHSM) Name: Jason Kearns Phone: 304.747.2511 (o)/304.382.9629 (m)	**CH2M HILL Director – Health, Safety, Security & Environment** Andy Strickland/DEN (720) 480-0685 (cell) or (720) 286-2393 (office)
CH2M HILL Project Environmental Manager Name: Cindy Lang Phone: 248.223.6056 (o)/734.735.7128 (m)	
CH2M HILL Human Resources Department Name: Tammy Wyatt Phone: 864.599.4270 (o) / 770.352.1494 (m)	**CH2M HILL Worker's Compensation:** Contact Business Group HR dept. to have form completed or contact Jennifer Rindahl after hours: (720)891-5382
CH2M HILL Safety Coordinator (SC) Name: Osaguona Ogbebor Phone: 937.220.2904 (o)/937.212.1942 (m)	**CH2M HILL Project Manager** Name: Rachel Grand Phone: 314.335.3018 (o)/913.940.1589 (m)
Media Inquiries Corporate Strategic Communications Name: John Corsi Phone: (720) 286-2087	**Automobile Accidents** Rental: Jennifer Rindahl/DEN: 720-286-2449
Federal Express Dangerous Goods Shipping Phone: 800/238-5355	**CHEMTEL (hazardous material spills)** **Phone: 800/255-3924**
Facility Alarms:	Evacuation Assembly Area(s):
Facility/Site Evacuation Route(s):	

2.11 Directions to Local Hospital

Our Lady of Bellfonte Hospital
St. Christopher Drive
Ashland, KY 41101
606.833.3333



1. Start at **925 COUNTY ROAD 1A, IRONTON** going toward **OLD US-52** - go **1.6** mi
2. Turn Right to take ramp onto **OHIO RIVER SCENIC BYWY(US-52 E)** - go **5.2** mi
3. Take ramp toward **OH-93/IRONTON/JACKSON** - go **0.1** mi
4. Turn Right on **PARK AVE/PARK ST** - go **0.5** mi
5. Turn Left on **S 2ND ST** - go **0.2** mi
6. Turn Right on **ADAMS ST**
7. Turn Right on **CAMPBELL AVE** - go **0.1** mi
8. Bear Left on **VERNON ST**
9. Continue on **IRONTON BRIDGE RD** - go **0.3** mi
10. Bear Left on **MAIN ST** - go **< 0.1** mi
11. Turn Left on **BELLEFONTE ST(KY-244)** - go **0.6** mi
12. Bear Left on **US 23 HWY(US-23 S)** - go **0.7** mi
13. Turn Right on **ASHLAND DR(KY-1725)** - go **0.4** mi
14. Bear Right on **ST CHRISTOPHER DR(KY-1093)** - go **0.2** mi
15. Arrive at **SAINT CHRISTOPHER DR, ASHLAND**

2.12 Safe Behavior Observations

Safe Behavior Observations (SBOs) shall be conducted by SC or designee for specific work tasks or operations comparing the actual work process against established safe work procedures identified in the project-specific HSP and AHAs. SBOs are a tool to be used by supervisors to provide positive reinforcement for work practices performed correctly, while also identifying and eliminating deviations from safe work procedures that could result in a loss. The SC or designee shall perform SBOs/SWOs at the frequency indicated in the table below. The SC or designee shall complete the SBO form (attached to this HSP) for the task/operation being observed and submit them weekly to the regional point of contact. Safe Behavior Observations must be submitted at least every two weeks to the region contact. Completed documents can be scanned and e-mail to:

CH2MHILL ES COM Safe Behavior Observations (SafeBehaviorObservations@ch2m.com)

Activity	Frequency of Observation	Observation Performed By
All	One per week when onsite	Safety Coordinator, Construction Manager, Project Manager, Site Manager, & Health and Safety Manager

2.13 Project Activity Self-Assessment Checklists

In addition to the hazard controls specified in this document, Project Activity Self-Assessment Checklists are contained as an attachment to this HSP. The Project-Activity Self–Assessment Checklists are based upon minimum regulatory compliance and some site-specific requirements may be more stringent. The objective of the self-assessment process is to identify gaps in project safety performance, and prompt for corrective actions in addressing these gaps. The self-assessment checklists, including documented corrective actions, shall be made part of the permanent project records and maintained by the SC.

The self-assessment checklists will also be used by the SC in evaluating the subcontractors and any client contractors' compliance on site.

The self-assessment checklists for the following tasks and exposures are required when the task or exposure is initiated and weekly thereafter while the task or exposure is taking place. The checklists shall be completed by the SC or other CH2M HILL representative and maintained in project files.

Activity	Checklists	Frequency
Mobilization / Demobilization	PPE Checklist	Initially when conducting work and when there is a new user.
	Lifting Checklist	Initially when conducting work and when there is a new user conducting lifting task.
DPT Drilling	Drilling Checklist	Initially, when there is a new driller, and weekly thereafter.
	Hand and Power Tool Checklist	Before the initial use of a hand and power tools and weekly thereafter.
	Methylene Chloride	Before conducting work in area where methylene chloride is expected be a contaminant.

Activity	Checklists	Frequency
Sonic Drilling	Drilling Checklist	Initially, when there is a new driller, and weekly thereafter.
	Hand and Power Tool Checklist	Before the initial use of a hand and power tools and weekly thereafter.
	Methylene Chloride	Before conducting work in area where methylene chloride is expected be a contaminant.
Soil Sampling	Drilling Checklist	Initially, when there is a new driller, and weekly thereafter.
	Hand and Power Tool Checklist	Before the initial use of a hand and power tools and weekly thereafter.
	Methylene Chloride	Before conducting work in area where methylene chloride is expected be a contaminant.
Groundwater Grab Sampling	Drilling Checklist	Initially, when there is a new driller, and weekly thereafter.
	Hand and Power Tool Checklist	Before the initial use of a hand and power tools and weekly thereafter.
	Methylene Chloride	Before conducting work in area where methylene chloride is expected be a contaminant.
Surface Soil Sampling	Hand and Power Tool Checklist	Before the initial use of a hand and power tools and weekly thereafter.
Sediment Sampling	Hand and Power Tool Checklist	Before the initial use of a hand and power tools and weekly thereafter.
MW Installation	Drilling Checklist	Initially, when there is a new driller, and weekly thereafter.
	Hand and Power Tool Checklist	Before the initial use of a hand and power tools and weekly thereafter.
	Methylene Chloride	Before conducting work in area where methylene chloride is expected be a contaminant.
Decontamination	Pressure Washing Checklist	Each time before the use of pressure washing equipment.
Spotting	Vehicle / Equipment Spotting PTHA Card	For daily routine backing task, this documents will be reviewed weekly. However for more hazardous backing tasks, such as the backing of delivery trucks into position, this document will be reviewed.
Forklift Use	Forklift Checklist	Initially, when there is a new operator, and weekly thereafter.
Skid Steer Use	Earthmoving Equipment Checklist	Initially, when there is a new operator, and weekly thereafter.

2.14 Utility Locate Procedure

Do not begin subsurface construction activities (e.g., trenching, excavation, drilling, etc.) until a check for underground utilities and similar obstructions has been conducted. The use of as-built drawings and utility company searches must be supplemented with a geophysical or other survey by a qualified, independent survey contractor to identify additional and undiscovered buried utilities.

Examples of the type of geophysical technologies include:

Ground Penetrating Radar (GPR), which can detect pipes, including gas pipes, tanks, conduits, cables, etc., both metallic and non-metallic, at depths up to 30 feet (9.1 meters) depending on equipment. Sensitivity for both minimum object size and maximum depth detectable depends on equipment selected, soil conditions, etc.

Radio Frequency (RF), involves inducing an RF signal in the pipe or cable and using a receiver to trace it. Some electric and telephone lines emit RF naturally and can be detected without an induced signal. This method requires knowing where the conductive utility can be accessed to induce RF field if necessary.

Dual RF, a modified version of RF detection using multiple frequencies to enhance sensitivity but with similar limitations to RF.

Ferromagnetic Detectors, are metal detectors that will detect ferrous and non-ferrous utilities. Sensitivity is limited, e.g. a 100 mm iron disk to a depth of about one meter or a 25 mm steel paper clip to a depth of about 20 cm.

Electronic markers, are emerging technologies that impart a unique electronic signature to materials such as polyethylene pipe to facilitate location and tracing after installation. Promising for future installations but not of help for most existing utilities already in place.

2.14.1 Procedure

The following procedures shall be used to identify and mark underground utilities during subsurface construction activities on the project:

The survey contractor shall determine the most appropriate geophysical technique or combinations of techniques to identify the buried utilities on the project, based on the survey contractor's experience and expertise, types of utilities anticipated to be present, and specific site conditions.

The survey contractor shall employ the same geophysical techniques used on the project to identify the buried utilities, to survey the proposed path of subsurface construction work, and to confirm no buried utilities are present.

Identify customer specific permit and/or procedural requirements for excavation and drilling activities. For military installations contact the Base Civil Engineer and obtain the appropriate form to begin the clearance process.

Contact utility companies or the state/regional utility protection service at least two (2) working days prior to excavation activities to advise of the proposed work, and ask them to establish the location of the utility underground installations prior to the start of actual excavation. By law, everyone contact Ohio Utility Protection Services, 1-800-362-2764 or 8-1-1, at least 48 hours but no more than 10 working days (excluding weekends and legal holidays) before beginning any digging or excavation work. This regulation also applies to smaller or personal projects to include but not limited to digging fencepost holes, anchoring supports for decks and swing sets, planting trees, removing tree roots and driving landscaping stakes into the ground.

Schedule the independent survey.

Obtain utility clearances for subsurface work on both public and private property.

Clearances are to be in writing, signed by the party conducting the clearance.

Underground utility locations must be physically verified by hand digging using wood or fiberglass-handled tools when any adjacent subsurface construction activity (e.g., mechanical drilling, excavating) work is expected to come within 5 feet (1.5 meters) of the marked underground system. If subsurface construction activity is within 5 feet (1.5 meters) and

parallel to a marked existing utility, the utility location must be exposed and verified by hand digging every 100 feet (30.5 meters).

Protect and preserve the markings of approximate locations of facilities until the markings are no longer required for safe and proper excavations. If the markings of utility locations are destroyed or removed before excavation commences or is completed, the PM must notify the utility company or utility protection service to inform them that the markings have been destroyed.

Conduct a site briefing for employees regarding the hazards associated with working near the utilities and the means by which the operation will maintain a safe working environment. Detail the method used to isolate the utility and the hazards presented by breaching the isolation.

2.14.2 Proximity to Power Lines

No work is to be conducted within 50 feet (15.2 meters) of overhead power lines without first contacting the utility company to determine the voltage of the system. No aspect of any piece of equipment is to be operated within 50 feet (15.2 meters) of overhead power lines without first making this determination.

Operations adjacent to overhead power lines are PROHIBITED unless one of the following conditions is satisfied:

Power has been shut off, positive means (such as lockout) have been taken to prevent the lines from being energized, lines have been tested to confirm the outage, and the utility company has provided a signed certification of the outage.

The minimum clearance from energized overhead lines is as shown in the table below, or the equipment will be repositioned and blocked to ensure that no part, including cables, can come within the minimum clearances shown in the table.

MINIMUM DISTANCES FROM POWERLINES

Powerlines Nominal System Kv	Minimum Required Distance, Feet (Meters)
0-50	10 (3.0)
51-100	12 (3.7)
101-200	15 (4.6)
201-300	20 (6.1)
301-500	25 (7.6)
501-750	35 (10.7)
751-1000	45 (13.7)

(These distances have been determined to eliminate the potential for arcing based on the line voltage.)

The power line(s) has been isolated through the use of insulating blankets which have been properly placed by the utility. If insulating blankets are used, the utility will determine the minimum safe operating distance; get this determination in writing with the utility representative's signature.

All inquiries regarding electric utilities must be made in writing and a written confirmation of the outage/isolation must be received by the PM prior to the start of work.

2.14.3 Site-Specific Utility Locate Procedures

The following site-specific procedures are to be followed before intrusive work is conducted. It is the SC's role to ensure that utility clearance has been performed according to UCC Dow standards this plan before allowing intrusive work to start.

The clearance will be provided by: ☐ Private ☒ Public ☒ Dow

The following methods will be used to identify the areas that need to be cleared to the party completing the clearance:

☒ Paint ☒ Pin Flags ☐ Stakes ☒ Marked on Drawing ☐ Other

The following methods will be used to identify the location of utilities:

☒ Visual observation ☐ Ground penetrating radar or similar equipment

☒ Drawings ☐ Other Texas Dig TESS procedures

The following methods will be used to communicate the location of utilities:

☒ Paint ☐ Pin Flags ☐ Stakes ☒ Marked on Drawing ☐ Other

These locations are cleared for foot diameter from the identified utility.

The following marking colors are associated with utilities as follows:

red	electric power lines, cables, conduit, and lighting cable
yellow	gas, oil, steam, petroleum, or gaseous materials
orange	communication, alarm or signal lines, cables, or conduit
blue	water, irrigation, and slurry lines
green	sewers and drain lines
pink	temporary survey markings
white	proposed excavation

Prior to using heavy equipment the following methods must be employed:

☐ Hand dig 5 ft ☐ Air Knife ☒ Probing ☐ Other ☐ N/A

Explain "other" or "N/A" _____

2.15 Contaminants of Concern

The table below summarizes the potential contaminants of concern (COC) and their occupational exposure limit and signs and symptoms of exposure. The table also includes the

maximum concentration of each COC and the associated location and media that was sampled (e.g., groundwater, soil boring, surface soil). These concentrations were used to determine engineering and administrative controls described in the "Project-Specific Hazard Controls" section of this HSP, as well as PPE and site monitoring requirements.

Contaminants of Concern

Contaminant	Location and Maximum[a] Concentration (ppm)	Exposure Limit[b]	IDLH[c]	Symptoms and Effects of Exposure	PIP[d] (eV)
Ethyl Benzene	GW: SB: SS:	100 ppm	800	Eye, skin, and mucous membrane irritation; headache; dermatitis; narcotic; coma	8.76
Methylene Chloride	GW: SB: SS:	25 ppm	2,300 ppm	Weakness, tingling & numbness, vertigo, nausea	11.35
Styrene	GW: SB: SS:	50 ppm	700	Dizziness. Drowsiness. Headache. Nausea. Vomiting. Weakness. Unconsciousness. Redness. Pain	8.40

Footnotes:

[a] Specify sample-designation and media: SB (Soil Boring), A (Air), D (Drums), GW (Groundwater), L (Lagoon), TK (Tank), SS (Surface Soil), SL (Sludge), SW (Surface Water).
[b] Appropriate value of PEL, REL, or TLV listed.
[c] IDLH = immediately dangerous to life and health (units are the same as specified "Exposure Limit" units for that contaminant); NL = No limit found in reference materials; CA = Potential occupational carcinogen.
[d] PIP = photoionization potential; NA = Not applicable; UK = Unknown.

Potential Routes of Exposure		
Dermal: Contact with contaminated media. This route of exposure is minimized through use of engineering controls, administrative controls and proper use of PPE.	**Inhalation:** Vapors and contaminated particulates. This route of exposure is minimized through use of engineering controls, administrative controls and proper use of respiratory protection when other forms of control do not reduce the potential for exposure.	**Other:** Inadvertent ingestion of contaminated media. This route should not present a concern if good hygiene practices are followed (e.g., wash hands and face before drinking or smoking).

2.16 Air Monitoring Specifications

(Reference CH2M HILL SOP HSE-207, *Exposure Monitoring for Airborne Chemical Hazards*)

When performing site monitoring, record all the information, such as in a field logbook. Note date and time, describe monitoring location (e.g., in breathing zone, at source, etc. and site location), and what the reading is. If any action levels are reached, note it in the field logbook and note the action taken.

Exposure records (air sampling) must be preserved for the duration of employment plus 30 years. Ensure that copies of the field log book are maintained in the project file.

Copies of all project exposure records (e.g., copies of field logbook pages where air monitoring readings are recorded and associated calibration) shall be sent to the regional SPA for retention and maintained in the project files.

2.16.1 Action Levels

Instrument	Tasks	Action Levels[a]		Frequency [b]
FID/PID: TVA 1000	DPT Drilling Sonic Drilling Soil Sampling Groundwater Grab Sampling Surface Soil Sampling MW Installation Well Development Groundwater Sampling	Background > BG - 5 ppm > 5 ppm	Level D Level C Stop Work and contact HSM	Continuous during task.
CGI: MSA model 260 or 261 or equivalent	DPT Drilling Sonic Drilling Soil Sampling Groundwater Grab Sampling MW Installation Well Development Groundwater Sampling	0-10% : 10-25% LEL: >25% LEL:	No explosion hazard Potential explosion hazard Explosion hazard; evacuate or vent	Continuous during task.
Dust Monitor:	All Tasks	No Visible Airborne Dust Visible Airborne Dust	Level D Level D. Institute Dust Suppression Techniques	Continuous during all tasks.
Noise-Level Monitor [d]	All Tasks	Conversations can be held at distances of 3 feet without shouting Conversations cannot be held at a distances of 3 feet without shouting	No action required Hearing protection required	Continuous during all tasks.

[a] Action levels apply to sustained breathing-zone measurements above background.
[b] The exact frequency of monitoring depends on field conditions and is to be determined by the SC; generally, every 5 to 15 minutes if acceptable; more frequently may be appropriate.
[c] If the measured percent of O_2 is less than 10, an accurate LEL reading will not be obtained. Percent LEL and percent O_2 action levels apply only to ambient working atmospheres, and not to confined-space entry. More-stringent percent LEL and O_2 action levels are required for confined-space entry.
[d] Noise monitoring and audiometric testing also required.

2.16.2 Integrated Personal Air Sampling

Sampling, in addition to real-time monitoring, may be required by other OSHA regulations where there may be exposure to certain contaminants. Air sampling typically is required when

site contaminants include lead, cadmium, arsenic, asbestos, and certain volatile organic compounds. Contact the RHSM immediately if these contaminants are encountered.

2.17 PPE Requirements

(Reference CH2M HILL- SOP HSE-117, *Personal Protective Equipment*)

PPE must be worn by employees when actual or potential hazards exist and engineering controls or administrative practices cannot adequately control those hazards.

A PPE assessment has been conducted by the RHSM based on project tasks (see PPE specifications below). Verification and certification of assigned PPE by task is completed by the RHSM that approved this plan. Below are items that need to be followed when using any form of PPE:

- Employees must be trained to properly wear and maintain the PPE.
- In work areas where actual or potential hazards are present at any time, PPE must be worn by employees working or walking through the area.
- Areas requiring PPE should be posted or employees must be informed of the requirements in an equivalent manner.
- PPE must be inspected prior to use and after any occurrence to identify any deterioration or damage.
- PPE must be maintained in a clean and reliable condition.
- Damaged PPE shall not be used and must either be repaired or discarded.
- PPE shall not be modified, tampered with, or repaired beyond routine maintenance.

The table below outlines PPE to be used according to task based on project-specific hazard assessment. If a task other than the tasks described in this table needs to be performed, contact the RHSM so this table can be updated.

Project-Specific PPE Requirements [a]

Task	Level	Body	Head	Respirator [b]
Mobilization / Demobilization	D	Work clothes; Safety toed leather work boots Gloves (Kevlar-Cut resistance rating of 4 and abrasion rating of 3)	Hardhat [c] Safety glasses with side shields Ear protection [d] Goggles	None required
Decontamination IDW Management	Modified D	Work clothes or cotton coveralls. Street clothes cannot be outer-most layer. Polycoated Tyvek is required if there is the potential to not keep work clothes free of dirt or contamination. **Boots:** Safety-toed leather work boots. **Gloves:** Inner surgical-style nitrile & outer chemical-resistant nitrile gloves. Gloves (Kevlar-Cut resistance rating of 4 and abrasion rating of 3)	Hardhat [c] Safety glasses with side shields Ear protection [d] Goggles	None required
Work near vehicular traffic ways or earth moving equipment.	All	Appropriate level of ANSI/ISEA 107-2004 high-visibility safety vests.	Work near vehicular traffic ways or earth moving equipment.	
Equipment decontamination if using pressure washer	Modified D with splash protection	**Coveralls:** Polycoated Tyvek® **Boots:** 16-inch-high steel-toed rubber boots **Gloves:** Inner surgical-style nitrile & outer chemical-resistant nitrile gloves.	Hardhat [c] Splash shield [c] over safety glasses with side shields or splash goggles Ear protection [d]	None required.
DPT Drilling Sonic Drilling Soil Sampling Groundwater Grab Sampling Sediment Sampling Soil Sampling MW Installation Well Development Groundwater Sampling	C	**Coveralls:** Polycoated Tyvek® **Boots:** Safety -toe, chemical-resistant boots OR Safety -toe, leather work boots with outer rubber boot covers **Gloves:** Inner surgical-style nitrile & outer chemical-resistant nitrile gloves.	Hardhat [c] Splash shield [c] Ear protection [d] Spectacle inserts	APR, full face, (MSA Advantage 1000 or similar) w/ (GME-P100 cartridge or similar)
NOT AUTHORIZED WITHOUT CONTACTING HSM.	B	**Coveralls:** Polycoated Tyvek® **Boots:** Safety -toe, chemical-resistant boots OR Safety -toe, leather work boots with outer rubber boot covers **Gloves:** Inner surgical-style nitrile & outer chemical-resistant nitrile gloves.	Hardhat [c] Splash shield [c] Ear protection [d] Spectacle inserts	Positive-pressure demand self-contained breathing apparatus (SCBA); MSA Ultralite, or equivalent.

Reasons for Upgrading or Downgrading Level of Protection (with approval of RHSM)	
Upgrade[f]	**Downgrade**
• Request from individual performing tasks. • Change in work tasks that will increase contact or potential contact with hazardous materials. • Occurrence or likely occurrence of gas or vapor emission. • Known or suspected presence of dermal hazards. • Instrument action levels in the "Site Monitoring" section exceeded.	• New information indicating that situation is less hazardous than originally thought. • Change in site conditions that decrease the hazard. • Change in work task that will reduce contact with hazardous materials.

[a] Modifications are as indicated. CH2M HILL will provide PPE only to CH2M HILL employees.
[b] No facial hair that would interfere with respirator fit is permitted.
[c] Hardhat and splash-shield areas are to be determined by the SC.
[d] Ear protection should be worn when conversations cannot be held at distances of 3 feet (1 meter) or less without shouting.
[e] See cartridge change-out schedule.
[f] Performing a task that requires an upgrade to a higher level of protection (e.g., Level D to Level C) is permitted only when the PPE requirements have been approved by the RHSM, and an SC qualified at that level is present.

2.18 Respiratory Protection

(Reference CH2M HILL SOP HSE-121, *Respiratory Protection*)

Implement the following when using respiratory protection:

- Respirator users must have completed appropriate respirator training within the past 12 months. Level C training is required for air-purifying respirators (APR) use and Level B training is required for supplied-air respirators (SAR) and self-contained breathing apparatus (SCBA) use. Specific training is required for the use of powered air-purifying respirators (PAPR).
- Respirator users must complete the respirator medical monitoring protocol and been approved for the specific type of respirator to be used.
- Tight-fitting facepiece respirator (negative or positive pressure) users must have passed an appropriate fit test within past 12 months.
- Respirator use shall be limited to those activities identified in this plan. If site conditions change that alters the effectiveness of the specified respiratory protection, the RHSM shall be notified to amend the written plan.
- Tight-fitting facepiece respirator users shall be clean-shaven and shall perform a user seal check before each use.
- Canisters/cartridges shall be replaced according to the change-out schedule specified in this plan. Respirator users shall notify the SC or RHSM of any detection of vapor or gas breakthrough. The SC shall report any breakthrough events to the RHSM for schedule upgrade.
- Respirators in regular use shall be inspected before each use and during cleaning
- Respirators in regular use shall be cleaned and disinfected as often as necessary to ensure they are maintained in a clean and sanitary condition.

- Respirators shall be properly stored to protect against contamination and deformation.
- Field repair of respirators shall be limited to routine maintenance. Defective respirators shall be removed from service.
- When breathing air is supplied by cylinder or compressor, the SC or RHSM shall verify the air meets Grade D air specifications.

The SC or designee shall complete the H&S Self-Assessment Checklist – Respiratory Protection included in as attachment to this plan to verify compliance with CH2M HILL's respiratory protection program.

2.18.1 Respirator Change-Out Schedule

Contaminant	Change-Out Schedule
Methylene Chloride	Canisters may only be used for emergency escape and must be replaced after use

2.19 Decontamination

The SC must establish and monitor the decontamination procedures and their effectiveness. Decontamination procedures found to be ineffective will be modified by the SC. The SC must ensure that procedures are established for disposing of materials generated on the site. Personnel and equipment leaving the exclusion zone must be decontaminated.

Personnel	Sample Equipment	Heavy Equipment
Boot wash/rinse Glove wash/rinse Outer-glove removal Body-suit removal Inner-glove removal Respirator removal (if applicable) Hand wash/rinse Face wash/rinse Shower as soon as possible Dispose of PPE consistent with facility requirements or project waste management plan. Dispose of personnel rinse water consistent with facility requirements or project waste management plan.	Wash/rinse equipment Contain waste materials for disposal consistent with facility requirements or project waste management plan.	Power wash Steam clean Dispose of equipment rinse water to facility or sanitary sewer, or contain for offsite disposal

No eating, drinking, or smoking is permitted in contaminated areas and in exclusion or decontamination zones. The SC should establish areas for eating, drinking, and smoking.

The following figure illustrates a conceptual establishment of work zones, including the decontamination line. Work zones are to be modified by the SC to accommodate task-specific requirements.

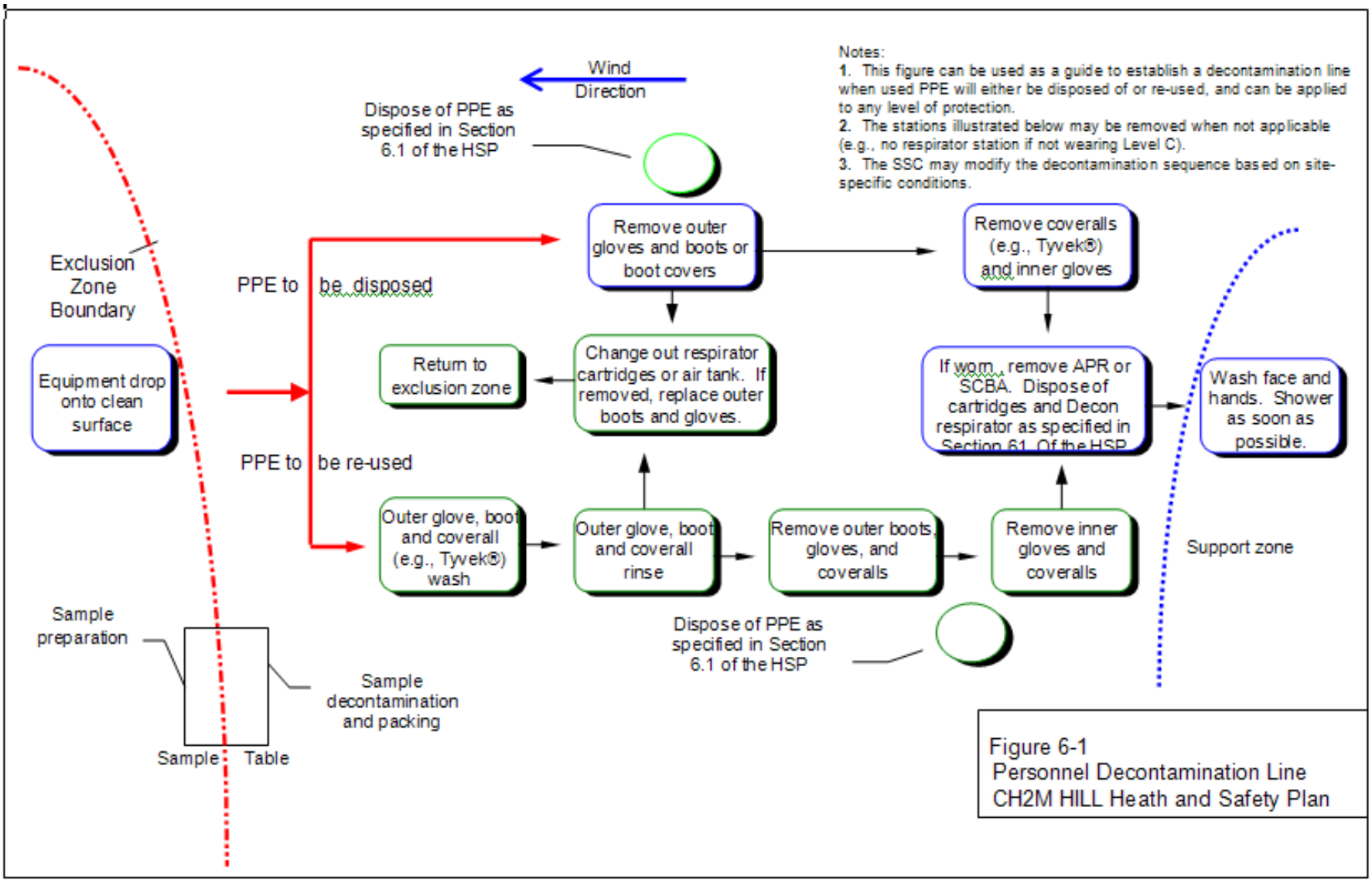


Figure 6-1
Personnel Decontamination Line
CH2M HILL Heath and Safety Plan

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2.20 Project-Specific Training Requirements

Task	Dow Program Chartering	HWW: Hazardous Waste Worker*	CSW: Construction Site Worker*	Excavation	Confined Space	Isolation of Energy/LOTO	Fall Protection	Energized Electrical Safety	Job o r Site-specific Medical Surveillance.	Site HS&E Chartering	Waste Management Trainng (SC Only)	Dangerous Goods Shipping (SC Only)	Methylene Chloride	Other:
Mobilization / Demobilization	X									X				
DPT Drilling	X	X							X	X	X	X	X	
Sonic Drilling	X	X							X	X	X	X	X	
Soil Sampling	X	X							X	X	X	X	X	
Groundwater Grab Sampling	X	X							X	X	X	X	X	
Surface Soil Sampling	X	X							X	X	X	X	X	
Sediment Sampling	X	X							X	X	X	X	X	
MW Installation	X	X							X	X	X	X	X	
Well Development	X	X							X	X	X	X	X	
Groundwater Sampling	X	X							X	X	X	X	X	
Decontamination	X	X							X	X	X		X	
IDW Management	X	X							X	X			X	

X – Required

O – May be required depending on project-specifics, see AHA

2.21 Health and Safety Plan Sign-off Form

Name	**Company**	**Signature** (indicating review of Project-Specific and General Requirements sections of this HASP)	**Date**	**Tasks** (Initial AHAs Reviewed)												
				HASP Review	Mobilization / Demobilization	DPT Drilling	Sonic Drilling	Soil Sampling	Groundwater Grab Sampling	Surface Soil Sampling	Sediment Sampling	MW Installation	Well Development	Groundwater Sampling	Decontamination	IDW Management

3 Dow Program Requirements

3.1 Daily Safety Briefings

CH2M HILL requires that the SC conduct and document daily safety meetings to discuss with the field team the task to be performed that day and the potential hazards and mitigation measures. The Safety Briefing Record SBR shall be used to document daily safety meetings.

At the start of each day's activities, the crew supervisor completes the SBR, provided as an attachment to this HSP, with input from the work crew, during their daily safety meeting. The day's tasks, personnel, tools and equipment that will be used to perform these tasks are listed, along with the hazards posed and required HSE procedures, as identified in the HSP & AHA. The use of SBR promotes worker participation in the hazard recognition and control process while reinforcing the task-specific hazard and required HSE procedures with the crew each day.

Safety Briefing Record
Dow Program - March 2008

CH2MHILL

Location/Project:	Date of Meeting: ____/____/____ Time: Start: ____:____ End ____:____
Safety Coordinator: FTL/CM:	Other CH2M HILL employees present:

Subcontractors Involved in Tailgate Meeting:

1. _____ # workers _____
2. _____ # workers _____
3. _____ # workers _____

Scope of Today's Work:

Hazards & Controls
(Check box to indicate topic is applicable, and topic was considered and/or discussed)

Today's Weather and Impact on Work Activities:

☐ Key Hazards & Controls Discussed:

☐ Personal Protective Equipment: PPE Requirements discussed:	☐ Safety-related permits required: ☐ Safe Work Permit (Active) ☐ Utility locate clearance ☐ Confined space ☐ Energized electrical ☐ Other: _____

Identifying information – include site & project name/number.

Identify both, if different.

Include the names of each contractor and lower-tier subcontractor (use additional forms if necessary).

Include number of workers for each subcontractor.

Adequately describe the scope of work for the day/activities covered by this tailgate meeting.

Briefly describe the hazards and controls that were discussed during the safety meeting.

☐ Req'd Notifications or Communications:	☐ Alarms & Evacuation:
☐ Change Conditions:	☐ "Lessons Learned" generated or shared:

Is a **Safe Work Observation** required for today? (see HASP for req'd frequency) ☐ Yes ☐ No

If yes, today's SWO will be performed by:

Describe a key observation/near miss from yesterday's work:

Crew Attendance & Participation

Comments: Safety focus for today, interventions, observations, feedback, near misses, etc:

Name	Comments	Signature

Facilitator's Signature: _____ ___/___/___ Hours Worked Today:_____

Indicate if a Safe Behavior Observation will be completed consistent with requirements in the HASP.

The PM, SC and/or FTL should share an observation each day from the previous days work.

Meeting facilitator (or designee) should capture the input of each employee attending the tailgate meeting.

Each attendee is expected to contribute to the meeting through shared observations, interventions, near miss reporting.

Each attendee is to sign the meeting form.

Meeting facilitators sign and date form to complete the meeting record.

At the end of the work day, record the total hours worked for all project workers on-site during the day.

Send completed forms to the HSM at least weekly. Forms may be scanned and e-mailed.

3.2 Interventions

Interventions are encouraged. Interventions should be performed when an unsafe condition is observed, unsafe behavior is occurring, or if something is happening that should be positively reinforced. When intervening with another person, staff must talk to the person about how to be safer and/or correct the unsafe situation. Interventions should be documented on the Safety Briefing Record in the Crew Attendance & Participation section.

3.3 Safe Behavior Observation

Safe Behavior Observations (SBOs) prompt the recognition of safe behaviors through positive reinforcement, as well as identify and correct "at risk" behaviors. The observers will watch the work activity for 10-15 minutes, observing what is being done safely and what could be done more safely. SBOs should be conducted by persons knowledgeable of the work being observed. If an unsafe condition or at-risk behavior is observed, the observer should intervene immediately. At the end of the observation period, the observer will discuss with the team their findings, including improving how the work is being conducted. The observer should inquire into the causes of any at-risk behaviors or unsafe conditions. The observer will document their observations, as well as steps taken, on a Safe Behavior Observation form. Key observations from Safe Behavior Observations should be discussed at the next tailgate safety meeting.

3.4 Active Site Requirements

Work at Dow Chemical Active sites (those sites where Dow has active operations) may be covered by Dow Global Standards and other site-specific requirements.

3.4.1 Safe Work Permits

All work must be conducted under a SWP or a safe work procedure unless specifically exempted from the standard. CH2M HILL workers accepting safe work permits must be trained on the safe work permit standard. It is the responsibility of the SWP acceptor"

- To accept a Safe Work Permit and to ensure that the hazards of the work, area and/or equipment have been reviewed with the Personnel Issuing a Safe Work Permit and understood.
- To ensure that the hazards of the work, area and/or equipment have been reviewed with all personnel working under the Safe Work Permit and understood.
- To notify the Personnel Issuing a Safe Work Permit of any changing conditions or if he/she will be leaving the work site.
- To maintain the Safe Work Permit and any additional permits and/or checklists at the work site.
- To ensure that any additional requirements, permits and/or checklists that are needed based upon the scope of the work are appropriately addressed.
- To sign-off the Safe Work Permit upon closure.

3.4.2 Hot Work

Requirements are based on classification of work into low or high energy hot work and designation of work areas as restricted, flammable, general or exempt.

- **High Energy Ignition Source** (High Energy Hot Work): Includes activities that generate open flames and/or sparks and activities that could provide an ignition source after an immediate removal of the energy supply (for example: welding, cutting, grinding metals, fired heaters, etc.)

- **Low Energy Ignition Source** (Low Energy Hot Work): Includes activities that generate heat or have the potential to generate sparks and activities that generally do not provide an ignition source after a removal of the energy supply (for example: electrical/battery operated tools, non-intrinsically safe portable equipment - including mobile phones and pagers, cameras, abrasive blasting, air driven tools, soldering irons, internal combustion engines and motor vehicles, extension cords, or the use of hand tools that could generate sparks - like chisels and hammer wrenches, etc.)

3.4.3 Isolation of Energy Sources

Required when work on or servicing equipment could result in exposure to energy sources including chemical, electrical, thermal, mechanical, springs, pneumatic, hydraulic, pressure, gravity, and radiation. All people doing work under the isolation of energy sources (Red Tag Isolation) shall have control of all isolating devices (shall have the control over the removal of any and all Red Tags associated with their work). One or more of the following shall be used for the isolation of energy sources:

- A Master Red Tag System (uses an operations Red Tag controlled by all people doing work under the isolation).
- An Individual Red Tag System (uses personal Red Tags, each controlled by an individual person doing work under the isolation).
- An Energy Control Operating Procedure.

3.4.4 Confined Space Entry

Required when any part of body breaks the plane of an opening to a confined spaced. All Confined Space Entries shall have:

- A Safe Work Permit
- A Confined Space Entry Permit
- A Confined Space Entry Operating Procedure

3.4.5 Pressure Washing and Hydroblasting

Required when pressure washing (mechanically sprayed water at >150 psig) and hydroblasting. Pressure Washing requires either a Pressure Washing Operating Procedure or a Safe Work Permit. When a Safe Work Permit is used, the pressure washing crew must complete the Dow Pressure Washing Checklist.

3.4.6 Line and Equipment Opening

Required for any line or equipment opening attached to a Dow process (including sampling ports). A L&EO Checklist, either by itself or as part of the Safe Work Permit shall be used to identify and document the potential hazards and safeguards of a line or equipment opening.

There are specific training requirements for:

- People who prepare and/or conduct line or equipment openings.
- People who Issue Safe Work Permits for line or equipment openings.

3.4.7 Electrical Safe Work Practices

Requires training commensurate with task when working on or near energized electrical equipment.

Other requirements may include site-specific indoctrination or orientation training, basic safety orientation training, background checks, etc.

4 Hazard Controls

This section must be reviewed by all staff working on the project. In addition, each individual must review the task-specific AHA(s) for the work they will be performing.

4.1 Project-Specific Hazard Controls

This section provides safe work practices and control measures used to reduce or eliminate potential hazards. These practices and controls are to be implemented by the party in control of either the work or the particular hazard. Each person onsite is required to abide by the hazard controls. Consult the appropriate CH2M HILL SOP to ensure all requirements are implemented. CH2M HILL employees and subcontractors must remain aware of the hazards affecting them regardless of who is responsible for controlling the hazards. CH2M HILL employees and subcontractors who do not understand any of these provisions should contact the RHSM for clarification.

4.1.1 Arsenic

(Reference CH2M HILL, SOP HSE-501, Arsenic)

Arsenic is considered a "Confirmed Human Carcinogen." CH2M HILL is required to control employee exposure to arsenic when exposures are at or above 5.0 micrograms per cubic meter (µg/m3), or if there is the possibility of skin or eye irritation from arsenic. The elements of the CH2M HILL arsenic program include the following:

- Exposure monitoring
- Methods of control, including PPE and respirators
- Medical surveillance
- Training on hazards of arsenic and control measures (includes project-specific training and the computer-based training on CH2M HILL's Virtual Office, Arsenic Exposure)
- Recordkeeping requirements
- If air monitoring indicates there is potential exposure at the action level concentrations, notify the RHSM to ensure the above have been adequately addressed. Full implantation of SOP HSE-501, Arsenic, will be required. Other exposure control measures include:
- Do not enter regulated work areas unless training, medical monitoring, and PPE requirements established by the competent person have been met.
- Do not eat, drink, smoke, chew tobacco or gum, or apply cosmetics in regulated areas.

- Avoid skin and eye contact with liquid and particulate arsenic or arsenic trichloride.
- Respiratory protection and other exposure controls selection shall be based on the most recent exposure monitoring results obtained from the competent person.
- Review the fact sheet included as an attachment to this HSP.

4.1.2 Asbestos

(Reference CH2M HILL SOP HSE-502, Asbestos)

Asbestos is a cancer-causing mineral that was included in many building materials. When disturbed harmful asbestos fibers can be released and inhaled and ingested by workers. Materials suspected of containing asbestos shall be treated as asbestos unless documentation and/or testing results indicate otherwise. Where the presence of asbestos is suspected, if at all possible, design all operations to avoid contact.

When there is a risk of disturbing asbestos and making it friable (able to release fibers when the materials are crushed, abraded or cut) the activity becomes regulated. The asbestos standard for construction regulates asbestos exposure for the following activities:

- Demolishing or salvaging structures where asbestos is present in concentrations greater than 1 percent
- Removing or encapsulating asbestos-containing materials (1% or greater asbestos content)
- Constructing, altering, repairing, maintaining, or renovating asbestos-containing structures or substrates
- Installing asbestos containing products
- Cleaning up asbestos spills/emergencies
- Transporting, disposing, storing, containing and housekeeping involving asbestos or asbestos containing products on a construction site

CH2M HILL is required to control employee exposure to asbestos when exposures are at or above 0.1 fibers per cc (f/cc) by implementing a program that meets the requirements of the OSHA Asbestos standard, 29 Code of Federal Regulations (CFR) 1926.1101. The elements of the CH2M HILL asbestos program include the following:

- Exposure monitoring;
- Methods of control, including PPE and respirators;
- Medical Surveillance;
- Training on hazards of asbestos and control measures;
- Record keeping requirements.

If air monitoring indicates there is potential exposure at the action level concentrations, notify the RHSM to ensure the above have been adequately addressed. Other exposure control measures include:

- Do not enter regulated work areas unless training, medical monitoring, and PPE requirements established by the competent person have been met.

- Do not eat, drink, smoke, chew tobacco or gum, or apply cosmetics in regulated areas.
- Avoid skin and eye contact with liquid and particulate arsenic or arsenic trichloride.
- Respiratory protection and other exposure controls selection shall be based on the most recent exposure monitoring results obtained from the competent person.
- Review the fact sheet included as an attachment to this HSP.
- Do not disturb waste or other materials labeled "Danger - Asbestos Fibers."

Subcontractors performing asbestos abatement activities are required to obtain state or special licenses and permits and have a written compliance/abatement plan that has been reviewed and accepted by CH2M HILL before work begins. Subcontractors are required to provide proof that all asbestos workers medically qualified, training and a competent person has been appointed before work begins.

4.1.3 Benzene

(Reference CH2M HILL SOP HSE-503, Benzene)

Benzene is considered a "Confirmed Human Carcinogen." CH2M HILL is required to control employee workplace exposure to benzene when personal exposures is at or above 0.5 parts per million (ppm) as an 8-hour time-weighted average (TWA) or above 5.0 ppm short term exposure limit (STEL), by implementing a program that meets the requirements of the Occupational Safety and Health Administration (OSHA) Benzene standard, 29 CFR 1910.1028. The elements of the CH2M HILL benzene program include the following:

- Exposure monitoring
- Methods of control, including personal protective equipment (PPE) and respirators
- Medical surveillance
- Training on hazards of benzene and control measures (includes project-specific training and the computer-based training on CH2M HILL's Virtual Office, Benzene)
- Record keeping requirements
- If air monitoring indicates there is potential exposure at the action level concentrations above, notify the RHSM to ensure the above have been adequately addressed. Other exposure control measures include:
- Do not enter regulated work areas unless training, medical monitoring, and PPE requirements established by the competent person have been met.
- Do not eat, drink, smoke, chew tobacco or gum, or apply cosmetics in regulated areas.
- Respiratory protection and other exposure controls selection shall be based on the most recent exposure monitoring results obtained from the competent person.
- Review the fact sheet included as an attachment to this HSP.

4.1.4 Compressed Gas Cylinders

(Reference CH2M HILL SOP HSE-403, Hazardous Materials Handling)

Below are the hazard controls and safe work practices to follow when working around or using compressed gas cylinders. Ensure the requirements in the referenced SOP are followed.

- Cylinders and pressure-controlling apparatus shall be inspected for defects and leakage prior to use. Damaged or defective items shall not be used. If a cylinder is found to be defective, the gas distributor shall be notified and subsequent instructions followed. If a leak should develop at a fuse plug or other safety device, the cylinder shall be removed from the work area.
- Cylinders shall be labeled with the identity of the contents. Cylinders not labeled shall be sent back to the cylinder distributor. The color of the cylinder shall not be used exclusively to identify cylinder contents.
- Valve caps must be in place when cylinders are transported, moved, or stored.
- Cylinders must be secured in an upright position at all times.
- Cylinder valves must be closed when cylinders are not being used and when cylinders are being moved.
- Cylinders must be secured on a cradle, basket, or pallet when hoisted; they may not be hoisted by choker slings.
- Eye protection (safety glasses or goggles) shall be worn when using cylinders.
- Cylinders must be shielded from welding and cutting operations and positioned to avoid being struck or knocked over; contacting electrical circuits; or exposed to extreme heat sources.
- Cylinders inside buildings shall be stored in dry, well-ventilated locations at least 20 feet (6.1 meters) from highly combustible materials. Cylinders should be stored in definitely assigned places away from elevators, stairs, or gangways. Assigned storage areas shall be located where cylinders will not be knocked over or damaged.
- Oxygen cylinders in storage shall be separated from fuel gas cylinders or combustible materials by a minimum of 20 feet (6.1 meters) or by a noncombustible barrier at least 5 feet (1.5 meters) high, having a fire resistance rating of at least 0.5 hour.
- Signs indicating no smoking shall be provided for storage areas containing flammable gas cylinders.
- Complete the self-assessment checklist for compressed gas cylinders are being used.

4.1.5 Concrete Core Drilling

Below are the hazard controls and safe work practices to follow when working around or performing concrete core drilling.

- Operators must read and understand the Operators Manual(s) for the equipment that will be used.
- Follow all manufacturers' operating instructions and comply with all warning labels on the equipment.
- Inspect equipment to ensure it is in proper operating condition prior to use. Equipment damage or missing parts must be corrected prior to operation.
- Follow all requirements for use of PPE. Minimum PPE includes hearing protection, safety glasses with side shields, safety toed boots. A face shield over safety glasses or liquid splash goggles may be required for wet coring.
- Inspect areas to be cored to ensure there are no obstructions, for example utilities on the opposite side of a wall to be cored through. Follow utility locate procedures for when coring slab on grade.
- Provide dust control (wet coring or local exhaust for dry coring) to avoid potential silica exposure.
- Make sure that all electrical wiring is grounded.
- The power supply line (electric cord, pneumatic or hydraulic line) must be protected from damage and routed to prevent it becoming a tripping hazard.
- When hydraulic coring equipment is uses, all workers must be aware of hydraulic lines running to the coring equipment. Preparations must be made for containment/ clean up in the event of a ruptured hydraulic line.
- All workers must keep their hands and body away from the cutting saw/ cable.
- The power supply must be disconnected when changing bits or conducting other maintenance on the equipment.
- Slippery conditions may exist in wet coring operations. Water needs to be controlled during cutting and proper safety toed footwear used to minimize slip potential.
- Use the Drilling Self-Assessment checklist to evaluate coring operations.

4.1.6 Drilling Safety

(Reference CH2M HILL SOP HSE-204, Drilling)

Below are the hazard controls and safe work practices to follow when working around or performing drilling. Ensure the requirements in the referenced SOP are followed.

- The drill rig is not to be operated in inclement weather.
- The driller is to verify that the rig is properly leveled and stabilized before raising the mast.
- Personnel should be cleared from the sides and rear of the rig before the mast is raised.
- The driller is not to drive the rig with the mast in the raised position.

- The driller must check for overhead power lines before raising the mast. A minimum distance of 10 feet (3 meters) between mast and overhead lines (<50 kV) is recommended. Increased separation may be required for lines greater than 50 kV.
- Personnel should stand clear before rig startup.
- The driller is to verify that the rig is in neutral when the operator is not at the controls.
- Become familiar with the hazards associated with the drilling method used (cable tool, air rotary, hollow-stem auger, etc.).
- Do not wear loose-fitting clothing, watches, etc., that could get caught in moving parts.
- Do not smoke or permit other spark-producing equipment around the drill rig.
- The drill rig must be equipped with a kill wire or switch, and personnel are to be informed of its location.
- Be aware and stand clear of heavy objects that are hoisted overhead.
- The driller is to verify that the rig is properly maintained in accordance with the drilling company's maintenance program.
- The driller is to verify that all machine guards are in place while the rig is in operation.
- The driller is responsible for housekeeping (maintaining a clean work area).
- The drill rig should be equipped with at least one fire extinguisher.
- If the drill rig comes into contact with electrical wires and becomes electrically energized, do not touch any part of the rig or any person in contact with the rig, and stay as far away as possible. Notify emergency personnel immediately.
- Use the drilling self-assessment checklist attached to this HSP to evaluate drilling operations.

4.1.7 Drum Handling

Below are the hazard controls and safe work practices to follow when overseeing the movement of drums or when handling drums.

- Ensure that personnel are trained in proper lifting and moving techniques to prevent back injuries.
- Ensure drum bungs/lids are secured and drums are labeled prior to moving.
- Provide equipment to keep the operator removed from the drums to lessen the likelihood of injury. Such equipment might include: a drum grappler attached to a hydraulic excavator; a small front-end loader, which can be either loaded manually or equipped with a bucket sling; a rough terrain forklift; Roller conveyor equipped with solid rollers; drum carts designed specifically for drum handling.
- Make sure the vehicle selected has sufficient rated load capacity to handle the anticipated loads, and make sure the vehicle can operate smoothly on the available road surface.

- Ensure there are appropriately designed Plexiglas cab shields on loaders, backhoes, etc., when handling drums containing potentially explosive materials.
- Equipment cabs should be supplied with fire extinguishers, and should be air-conditioned to increase operator efficiency.
- Supply operators with appropriate respiratory protective equipment when needed.
- Ensure that drums are secure and are not in the operator's view of the roadway.
- Prior to handling, all personnel should be warned about hazards of handling.
- Before moving anything, determine the most appropriate sequence in which the various drums and other containers should be moved (e.g. small containers may have to be removed first to permit heavy equipment to enter and move the drums.
- Overpack drums and an adequate volume of absorbent should be kept near areas where minor spills may occur.

4.1.8 Drum Sampling Safety

Personnel are permitted to handle and/or sample drums containing certain types of waste (drilling waste, investigation-derived waste, waste from known sources) only. Handling or sampling drums with unknown contents requires a plan revision or amendment approved by the RHSM. The following control measures will be taken when sampling drums:

- Minimize transportation of drums.
- Sample only labeled drums or drums from a known waste stream.
- Do not sample bulging or swollen drums. Contact the RHSM.
- If drums contain, or potentially contain, flammable materials, use non-sparking tools to open.
- Use the proper tools to open and seal drums.
- Reseal bung holes or plugs whenever possible.
- Avoid mixing incompatible drum contents.
- Sample drums without leaning over the drum opening.
- Transfer/sample the content of drums using a method that minimizes contact with material.
- Use the PPE and perform air monitoring as specified in the PPE and Site Monitoring sections of this HSP.
- Have a spill kit accessible during sampling activities.
- If transferring/sampling drums containing flammable or combustible liquids, drums and liquid transfer equipment should be grounded and bonded to reduce the potential of a static discharge.

4.1.9 Forklift Operations

(Reference CH2M HILL, SOP HSE-309, Forklifts)

Below are the hazard controls and safe work practices to follow when working around or operating forklifts. Ensure the requirements in the referenced SOP are followed.

- A rated lifting capacity must be posted in a location readily visible to the operator.
- A forklift truck must not be used to elevate employees unless a platform with guardrails, a back guard, and a kill switch is provided on the vehicle. When guardrails are not possible, fall arrest protection is required.
- The subcontractor operating the forklift must post and enforce a set of operating rules for forklift trucks.
- Only certified forklift operators shall operate forklifts.
- Stunt driving and horseplay are prohibited.
- Employees must not ride on the forks.
- Employees must never be permitted under the forks (unless forks are blocked).
- The driver must inspect the forklift once a shift and document this inspection.
- The operator must look in the direction of travel and must not move the vehicle until all persons are clear of the vehicle.
- Forks must be carried as low as possible.
- The operator must lower the forks, shut off the engine, and set the brakes (or block the wheels) before leaving the forklift operator's position unless maintenance or safety inspections require the forklift to be running.
- Trucks must be blocked and have brakes set when forklifts are driven onto their beds.
- Extreme care must be taken when tilting elevated loads.
- Every forklift must have operable brakes capable of safely stopping it when fully loaded.
- Forklifts must have parking brakes and an operable horn.
- When the operator is exposed to possible falling objects, industrial trucks must be equipped with overhead protection (canopy).
- If using certified CH2M HILL forklift operators—forklifts must be inspected and documented daily using the forklift inspection form.

4.1.10 Groundwater Sampling/Water Level Measurements

Below are the hazard controls and safe work practices to follow when personnel or subcontractors are performing groundwater sampling and/or water level measurements.

Full coolers are heavy. Plan in advance to have two people available at the end of the sampling effort to load full coolers into vehicles. If two people won't be available use several smaller coolers instead of fewer large ones.

- Wear the appropriate PPE when sampling, including safety glasses, nitrile gloves, and steel toe boots (see PPE section of this HSP).
- Monitor headspace of wells prior to sampling to minimize any vapor inhalation (refer to the "Site Monitoring" section of this HSP).
- Use caution when opening well lids. Wells may contain poisonous spiders and hornet or wasp nests.
- Use the appropriate lifting procedures (see CH2M HILL SOP HSE-112) when unloading equipment and sampling at each well.
- Avoid sharp edges on well casings.
- If dermal contact occurs with groundwater or the acid used in sample preservation, immediately wash all affected skin thoroughly with soap and water.
- Avoid eating and drinking on site and during sampling.
- Use ear plugs during sampling if sampling involves a generator.
- Containerize all purge water and transport to the appropriate storage area.
- Use two people to transport full coolers/containers whenever possible. If two people are not available use a dolly to move coolers. If the coolers weigh more than 40 pounds Attachment 1 of the HSE-112, Manual Lifting, shall be completed by the SC. If the coolers weigh more than 50 pounds they should never be lifted by one person.

4.1.11 Hand and Power Tools

(Reference CH2M HILL, SOP HSE-210, Hand and Power Tools)

Below are the hazard controls and safe work practices to follow when personnel or subcontractors are using hand and power tools. Ensure the requirements in the referenced SOP are followed.

- Tools shall be inspected prior to use and damaged tools will be tagged and removed from service.
- Hand tools will be used for their intended use and operated in accordance with manufacturer's instructions and design limitations;
- Maintain all hand and power tools in a safe condition.
- Use PPE (such as gloves, safety glasses, earplugs, and face shields) when exposed to a hazard from a tool.
- Do not carry or lower a power tool by its cord or hose.
- Portable power tools will be plugged into GFCI protected outlets; and

- Portable power tools will be Underwriters Laboratories (UL) listed and have a three-wire grounded plug or be double insulated.
- Disconnect tools from energy sources when they are not in use, before servicing and cleaning them, and when changing accessories (such as blades, bits, and cutters).
- Safety guards on tools must remain installed while the tool is in use and must be promptly replaced after repair or maintenance has been performed.
- Store tools properly in a place where they will not be damaged or come in contact with hazardous materials.
- If a cordless tool is connected to its recharge unit, both pieces of equipment must conform strictly with electrical standards and manufacturer's specifications.
- Tools used in an explosive environment must be rated for work in that environment (that is, intrinsically safe, spark-proof, etc.).
- Working with manual and pistol-grip hand tools may involve highly repetitive movement, extended elevation, constrained postures, and/or awkward positioning of body members (for example, hand, wrist, arm, shoulder, neck, etc.). Consider alternative tool designs, improved posture, the selection of appropriate materials, changing work organization, and sequencing to prevent muscular, skeletal, repetitive motion, and cumulative trauma stressors.

4.1.12 Machine Guarding

- Ensure that all machine guards are in place to prevent contact with drive lines, belts, chains, pinch points or any other sources of mechanical injury.
- Unplugging jammed equipment will only be performed when equipment has been shut down, all sources of energy have been isolated and equipment has been locked/tagged and tested.
- Maintenance and repair of equipment that results in the removal of guards or would otherwise put anyone at risk requires lockout of that equipment prior to work.

4.1.13 Heavy Equipment (earthmoving/excavating machinery)

(Reference CH2M HILL, SOP HSE-306, Earthmoving Equipment)

Below are the hazard controls and safe work practices to follow when working around or operating heavy equipment. Ensure the requirements in the referenced SOP are followed.

CH2M HILL authorizes only those employees qualified by training or previous experience to operate material handling equipment.

- CH2M HILL employees must be evaluated prior to operating earthmoving equipment by a CH2M HILL earthmoving equipment operator evaluation designated person. This evaluation will be documented according to SOP HSE-306, Earthmoving Equipment.
- Equipment must be checked at the beginning of each shift to ensure the equipment is in safe operating condition and free of apparent damage. The check should include: service brakes,

parking brakes, emergency brakes, tires, horn, back-up alarm, steering mechanism, coupling devices, seat belts and operating controls. All defects shall be corrected before the equipment is placed in service. Documentation of this inspection must be maintained onsite at all times (use the Earthmoving Equipment Inspection form if operated by CH2M HILL).

- Equipment must be on a stable foundation such as solid ground or cribbing; outriggers are to be fully extended.
- Equipment must not be used to lift personnel; loads must not be lifted over the heads of personnel.
- Equipment, or parts thereof, which are suspended must be substantially blocked or cribbed to prevent shifting before personnel are permitted to work under or between them. All controls shall be in a neutral position, with the motors stopped and brakes set.
- Equipment which is operating in reverse must have a reverse signal alarm distinguishable from the surrounding noise or a signal person when the operators view is obstructed.
- When equipment is used near energized powerlines, the closest part of the equipment must be at least 10 feet (3 meters) from the powerlines < 50 kV. Provide an additional 4 feet (1.2 meters) for every 10 kV over 50 kV. A person must be designated to observe clearances and give timely warning for all operations where it is difficult for the operator to maintain the desired clearance by visual means. All overhead powerlines must be considered to be an energized until the electrical utility authorities indicate that it is not an energized line and it has been visibly grounded.
- Underground utility lines must be located before excavation begins; refer to the Utilities (underground) section.
- Operators loading/unloading from vehicles are responsible for seeing that vehicle drivers are in the vehicle cab or in a safe area.
- The parking brake shall be set whenever equipment is parked, wheels must be chocked when parked on inclines.
- When not in operation, the blade/bucket must be blocked or grounded; the master clutch must be disengaged when the operator leaves the cab. When equipment is unattended, power must be shut off, brakes set, blades/buckets landed and shift lever in neutral.

4.1.14 Knife Use

Open-bladed knives (e.g., box cutters, utility knives, pocket knives, machetes, and multi-purpose tools with fixed blades such as a Leatherman™) are prohibited at worksites except where the following three conditions are met:

- The open-bladed knife is determined to be the best tool for the job.
- An approved Activity Hazard Analysis (AHA) or written procedure is in place that covers the necessary safety precautions (work practices, PPE, and training).
- Knife users have been trained and follow the AHA.

4.1.15 Lockout/Tagout Activities

(Reference CH2M HILL SOP HSE-310, Lockout and Tagout)

Lockout/tagout (LO/TO) shall be performed whenever service or maintenance is necessary on equipment that could cause injury to personnel from the unexpected equipment energizing or start-up or unexpected release of stored energy. Energy sources requiring lockout/tagout may include electrical, pneumatic, kinetic, and potential.

If work on energized electrical systems is necessary—contact the RHSM. Specific training and procedures are required to be followed before any work on energized electrical systems can be performed and are NOT covered in this section. Energized electrical work is defined as work performed **on or near** energized electrical systems or equipment with exposed components operating at 50 volts or greater. Working near energized live parts is any activity inside a Limited Approach Boundary (anywhere from 3.5 feet to 24 feet [1 meter 7.3 meters] depending on voltage). Examples of energized electrical work include using a voltmeter to troubleshoot electrical systems and changing out controllers.

When lockout/tagout is necessary to perform maintenance/repair of a system, all the requirements of SOP HSE-310, Lockout and Tagout, shall be met including the following bulleted items:

- When CH2M HILL controls the work, CH2M HILL must verify that subcontractors affected by the unexpected operation of equipment develop a written lockout/tagout program, provide training on lockout/tagout procedures and coordinate its program with other affected subcontractors. This may include compliance with the owner or facility lockout/tagout program.
- When CH2M HILL personnel are affected by the unexpected operation of equipment they must complete the electrical safety awareness module on the VO. Authorized personnel shall inform the affected personnel of the LO/TO. Affected personnel shall not tamper with LO/TO devices.
- Standard lockout/tagout procedures include the following six steps: 1) notify all personnel in the affected area of the lockout/tagout, 2) shut down the equipment using normal operating controls, 3) isolate all energy sources, 4) apply individual lock and tag to each energy isolating device, 5) relieve or restrain all potentially hazardous stored or residual energy, and 6) verify that isolation and deenergization of the equipment has been accomplished. Once verified that the equipment is at the zero energy state, work may begin.
- All safe guards must be put back in place, all affected personnel notified that lockout has been removed and controls positioned in the safe mode prior to lockout removal. Only the individual who applied the lock and tag may remove them.
- CH2M HILL authorized employees shall complete the LO/TO training module on the VO and either the electrical safety training module on the VO or 10-hour construction training. The authorized employee must also be trained and qualified on the system they are working on (e.g., qualified electrician for working on electrical components of a system).
- When equipment-specific LO/TO procedures are not available or when existing procedures are determined to be insufficient, CH2M HILL authorized employees shall also complete the

Equipment-Specific LO/TO Procedure Development Form, provided as an attachment to this HSP, to create an equipment-specific lockout/tagout procedure.

4.1.16 Methylene Chloride

(Reference CH2M HILL SOP HSE-509, Methylene Chloride)

Methylene chloride has a faint, sweet odor which is not noticeable at dangerous concentrations. Methylene chloride is shipped as liquefied compressed gas and will cause frostbite on contact.

CH2M HILL is required to control employee workplace exposure to methylene chloride when personal exposures are at or above 12.5 parts per million (ppm) as an 8-hour time-weighted average (TWA) or above 125 ppm short-term exposure limit (STEL) by implementing a program that meets the requirements of the Occupational Safety and Health Administration (OSHA) Methylene Chloride standard, 29 *Code of Federal Regulations* (CFR) 1910.1052. The elements of the CH2M HILL methylene chloride program include the following:

- Exposure monitoring
- Methods of control, including personal protective equipment (PPE) and respirators
- Medical surveillance
- Training on hazards of methylene chloride and control measures (includes project-specific training and the computer-based training on CH2M HILL's Virtual Office, *Methylene Chloride)*
- Recordkeeping requirements

If air monitoring indicates there is potential exposure at the action level concentrations above, notify the RHSM to ensure the above have been adequately addressed. Other exposure control measures include:

- Do not enter regulated work areas unless training, medical monitoring, and PPE requirements established by the competent person have been met.
- Do not eat, drink, smoke, chew tobacco or gum, or apply cosmetics in regulated areas.
- Respiratory protection and other exposure controls selection shall be based on the most recent exposure monitoring results obtained from the competent person.
- Appropriate **air-supplied respirators** must be used when methylene chloride exposures exceed PEL or STEL.
- Air supplied to respirators must meet Grade D breathing air requirements.
- Review the fact sheet included as an attachment to this HSP.

4.1.17 Pressure Washing Operations

Below are the hazard controls and safe work practices to follow when working around or performing pressure washing.

- Only trained, authorized personnel may operate the high-pressure washer.

- Follow manufacturer's safety and operating instructions.
- Inspect pressure washer before use and confirm deadman trigger fully operational
- The wand must always be pointed at the work area.
- The trigger should never be tied down
- Never point the wand at yourself or another worker.
- The wand must be at least 42 inches (1.1 meter) from the trigger to the tip and utilize >10 degree tips.
- The operator must maintain good footing.
- Non-operators must remain a safe distance from the operator.
- No unauthorized attachment may be made to the unit.
- Do not modify the wand.
- All leaks or malfunctioning equipment must be repaired immediately or the unit taken out-of-service.
- Polycoated Tyvek or equivalent, 16-inch-high steel-toed rubber boots, safety glasses, hard hat with face shield, and inner and outer nitrile gloves will be worn, at a minimum.

4.1.18 Traffic Control

(Reference CH2M HILL SOP HSE-216, Traffic Control)

The following precautions must be taken when working around traffic, and in or near an area where traffic controls have been established by a sub contractor. Ensure the requirements in the referenced SOP are followed.

- Exercise caution when exiting traveled way or parking along street – avoid sudden stops, use flashers, etc.
- Park in a manner that will allow for safe exit from vehicle, and where practicable, park vehicle so that it can serve as a barrier.
- All staff working adjacent to traveled way or within work area must wear reflective/high-visibility safety vests.
- Eye protection should be worn to protect from flying debris.
- Remain aware of factors that influence traffic related hazards and required controls – sun glare, rain, wind, flash flooding, limited sight-distance, hills, curves, guardrails, width of shoulder (i.e., breakdown lane), etc.
- Always remain aware of an escape route (e.g., behind an established barrier, parked vehicle, guardrail, etc).
- Always pay attention to moving traffic – never assume drivers are looking out for you.
- Work as far from traveled way as possible to avoid creating confusion for drivers.

- When workers must face away from traffic, a "buddy system" should be used, where one worker is looking towards traffic.
- When working on highway projects, obtain a copy of the contractor's traffic control plan.
- Work area should be protected by a physical barrier – such as a K-rail or Jersey barrier.
- Review traffic control devices to ensure that they are adequate to protect your work area. Traffic control devices should: 1) convey a clear meaning, 2) command respect of road users, and 3) give adequate time for proper traffic response. The adequacy of these devices are dependent on limited sight distance, proximity to ramps or intersections, restrictive width, duration of job, and traffic volume, speed, and proximity.
- Either a barrier or shadow vehicle should be positioned a considerable distance ahead of the work area. The vehicle should be equipped with a flashing arrow sign and truck-mounted crash cushion (TMCC). All vehicles within 40 feet (12.2 meters) of traffic should have an orange flashing hazard light atop the vehicle.
- Except on highways, flaggers should be used when 1) two-way traffic is reduced to using one common lane, 2) driver visibility is impaired or limited, 3) project vehicles enter or exit traffic in an unexpected manner, or 4) the use of a flagger enhances established traffic warning systems.
- Lookouts should be used when physical barriers are not available or practical. The lookout continually watches approaching traffic for signs of erratic driver behavior and warns workers.
- Vehicles should be parked at least 40 feet (12.2 meters) away from the work zone and traffic. Minimize the amount of time that you will have your back to oncoming traffic.
- Traffic control training module on the VO shall be completed when CH2M HILL workers who work in and around roadways and who exposed to public vehicular traffic.

4.1.19 Vinyl Chloride

(Reference CH2M HILL, SOP HSE-512, Vinyl Chloride)

Vinyl Chloride is considered a "Confirmed Human Carcinogen." Vinyl Chloride has a mild, sweet, chloroform-like odor.

CH2M HILL is required to control employee workplace exposure to vinyl chloride when personal exposures are at or above 1.0 ppm as an 8-hour time-weighted average (TWA) or above 5.0 ppm short term exposure limit (STEL), by implementing a program that meets the requirements of the Occupational Safety and Health Administration (OSHA) Vinyl Chloride standard, 29 CFR 1910.1017. The elements of the CH2M HILL vinyl chloride program include the following:

- Exposure monitoring
- Methods of control, including personal protective equipment (PPE) and respirators
- Medical surveillance

- Training on hazards of vinyl chloride and control measures (includes project-specific training and the computer-based training on CH2M HILL's Virtual Office, *Vinyl Chloride)*
- Record keeping requirements

If air monitoring indicates there is potential exposure at the action level concentrations above, notify the RHSM to ensure the above have been adequately addressed. Other exposure control measures include:

- Do not enter regulated work areas unless training, medical monitoring, and PPE requirements established by the competent person have been met.
- Do not eat, drink, smoke, chew tobacco or gum, or apply cosmetics in regulated areas.
- Respiratory protection and other exposure controls selection shall be based on the most recent exposure monitoring results obtained from the competent person.
- Review the fact sheet included as an attachment to this HSP.

4.1.20 Visible Lighting

Lighting shall be evaluated when conducting work inside buildings, confined spaces, or other areas/instances where supplemental light may be needed (e.g., work before sunrise or after sunset). A light meter can be used to evaluate the adequacy of lighting. The following are common requirements for lighting and the conditions/type of work being performed.

- While work is in progress outside construction areas shall have at least 33 lux (lx).
- Construction work conducted inside buildings should be provided with at least 55 lux light.
- The means of egress shall be illuminated with emergency and non-emergency lighting to provide a minimum 11 lx measured at the floor. Egress illumination shall be arranged so that the failure of any single lighting unit, including the burning out of an electric bulb will not leave any area in total darkness.

4.1.21 Working Around Material Handling Equipment

When CH2M HILL personnel are exposed to material handling equipment, the following safe work practices/hazard controls shall be implemented:

- Never approach operating equipment from the rear. Always make positive contact with the operator, and confirm that the operator has stopped the motion of the equipment.
- Never approach the side of operating equipment; remain outside of the swing and turning radius.
- Maintain distance from pinch points of operating equipment.
- Never turn your back on any operating equipment.
- Never climb onto operating equipment or operate contractor/subcontractor equipment.
- Never ride contractor/subcontractor equipment unless it is designed to accommodate passengers and equipped with firmly attached passenger seat.
- Never work or walk under a suspended load.

- Never use equipment as a personnel lift; do not ride excavator buckets or crane hooks.
- Always stay alert and maintain a safe distance from operating equipment, especially equipment on cross slopes and unstable terrain.

4.2 General Hazard Controls

The section provides safe work practices and control measures used to reduce or eliminate potential hazards that are common to all projects. These practices and controls are to be implemented by the party in control of either the work or the particular hazard. Each person onsite is required to abide by the hazard controls. Consult the appropriate CH2M HILL SOP to ensure all requirements are implemented. CH2M HILL employees and subcontractors must remain aware of the hazards affecting them regardless of who is responsible for controlling the hazards. CH2M HILL employees and subcontractors who do not understand any of these provisions should contact the RHSM for clarification.

4.2.1 General Practices and Housekeeping

(Reference CH2M HILL SOP HSE-209, *General Practices*)

The following are general requirements applicable to all portions of the work.

- Site work should be performed during daylight hours whenever possible.
- Good housekeeping must be maintained at all times in all project work areas.
- Common paths of travel should be established and kept free from the accumulation of materials.
- Keep access to aisles, exits, ladders, stairways, scaffolding, and emergency equipment free from obstructions.
- Provide slip-resistant surfaces, ropes, and/or other devices to be used.
- Specific areas should be designated for the proper storage of materials.
- Tools, equipment, materials, and supplies shall be stored in an orderly manner.
- As work progresses, scrap and unessential materials must be neatly stored or removed from the work area.
- Containers should be provided for collecting trash and other debris and shall be removed at regular intervals.
- All spills shall be quickly cleaned up. Oil and grease shall be cleaned from walking and working surfaces.
- Review the safety requirements of each job you are assigned to with your supervisor. You are not expected to perform a job that may result in injury or illness to yourself or to others.
- Familiarize yourself with, understand, and follow jobsite emergency procedures.
- Do not fight or horseplay while conducting the firm's business.
- Do not use or possess firearms or other weapons while conducting the firm's business.

- Report unsafe conditions or unsafe acts to your supervisor immediately.
- Report emergencies, occupational illnesses, injuries, vehicle accidents, and near misses immediately.
- Do not remove or make ineffective safeguards or safety devices attached to any piece of equipment.
- Report unsafe equipment, defective or frayed electrical cords, and unguarded machinery to your supervisor.
- Shut down and lock out machinery and equipment before cleaning, adjustment, or repair. Do not lubricate or repair moving parts of machinery while the parts are in motion.
- Do not run in the workplace.
- When ascending or descending stairways, use the handrail and take one step at a time.
- Do not apply compressed air to any person or clothing.
- Do not wear steel taps or shoes with metal exposed to the sole at any CH2M HILL project location.
- Do not wear finger rings, loose clothing, wristwatches, and other loose accessories when within arm's reach of moving machinery.
- Remove waste and debris from the workplace and dispose of in accordance with federal, state, and local regulations.
- Note the correct way to lift heavy objects (secure footing, firm grip, straight back, lift with legs), and get help if needed. Use mechanical lifting devices whenever possible.
- Check the work area to determine what problems or hazards may exist.

4.2.2 Vehicle Housekeeping

- Ensure equipment and tools are secured (fire extinguishers, coolers, calibration gases, shovels, hand tools.)
- No loose trash, empty water bottles, etc. These can lodge under brake and gas petals causing an accident.
- Vehicle in good working condition – signals, lights, brakes, mirrors all in good working order.
- Equipment is stored securely using boxes, ratchet straps, boards, nets, cages and similar
- Equipment and drums on back of trucks are secured using boxes, ratchet straps, boards, nets, cages and similar
- Field vehicles may be personal vehicles, rental vehicles, fleet vehicles, or project vehicles.
- Maintain a first aid kit, bloodborne pathogen kit, and fire extinguisher in the field vehicle at all times.
- Utilize a rotary beacon on vehicle if working adjacent to active roadway.

- Car rental must meet the following requirements:
    - Dual air bags
    - Antilock brakes
    - Be midsize or larger
- Familiarize yourself with rental vehicle features prior to operating the vehicle:
    - Vision Fields and Blind Spots
    - Vehicle Size
    - Mirror adjustments
    - Seat adjustments
    - Cruise control features, if offered
    - Pre-program radio stations and Global Positioning System (GPS), if equipped
- Always wear seatbelt while operating vehicle.
- Adjust headrest to proper position.
- Tie down loose items if utilizing a van or pick-up truck.
- Close car doors slowly and carefully. Fingers can get pinched in doors.
- Park vehicle in a location where it can be accessed easily in the event of an emergency. If not possible, carry a phone.
- Have a designated place for storing the field vehicle keys when not in use.
- Ensure back-up alarms are functioning, if equipped. Before backing a vehicle, take a walk around the vehicle to identify obstructions/hazards. Use a spotter when necessary to back into or out of an area.

4.2.3 Driving Safety

Follow the guidelines below when operating a vehicle:

- Refrain from using a cellular phone while driving. Pull off the road, put the vehicle in park and turn on flashers before talking on a cellular phone.
- Never operate a device's Personal Digital Assistant (PDA), e-mail, internet, or text messaging function while driving a vehicle.
- Obey speed limits, be aware of blind spots or other hazards associated with low visibility. Practice defensive driving techniques, such as leaving plenty of room between your vehicle and the one ahead of you.
- Do no drive while drowsy. Drowsiness can occur at any time, but is most likely after 18 hours or more without sleep.
- Maintain focus on driving. Eating, drinking, smoking, adjusting controls can divert attention from the road. Take the time to park and perform these tasks when parked rather than while driving.

- Ensure vehicle drivers are familiar with the safe operation of vehicles of the type and size to be operated. Large vehicles such as full size vans and pick-ups have different vision challenges and handling characteristics than smaller vehicles.

4.2.4 Personal Hygiene

Good hygiene is essential for personal health and to reduce the potential of cross-contamination when working on a hazardous waste site. Implement the following:

- Keep hands away from nose, mouth, and eyes during work.
- Keep areas of broken skin (chapped, burned, etc.) covered.
- Wash hands with soap and water prior to eating, smoking, or applying cosmetics.

4.2.5 Slips, Trips, and Falls

(Reference Dow training materials)

- Practice good housekeeping to minimize trip hazards
- Secure grating
- Cover cables, potholes, holes in gratings, etc.
- Identify uneven surfaces with paint, flagging, etc.
- Remove wrinkled carpeting, replace missing tiles, etc.
- Mark changes in walk surfaces with high-visibility paint
- Maintain three points of contact when climbing
- Keep drawers closed to prevent tripping
- Look past immediate area when walking and watch for uneven surfaces, slip hazards, etc. that will be coming up
- Do not carry loads that can't be seen over(obstructed view)
- Report areas with inadequate lighting or burned-out lighting
- Walk, don't run. When walking, limit side conversations, talking on a cell phone, reading, and using a Blackberry™ or similar device
- Keep hands at your sides, not in your pockets, for balance
- Avoid walking on objects (e.g., pallets, pipes, etc.) and do not jump across an obstacle
- Do not walk near edges of curbs, etc

4.2.6 Hazard Communication

(Reference CH2M HILL SOP HSE-107, *Hazard Communication)*

The Hazard Communication Coordinator is to perform the following:

- Complete an inventory of chemicals brought on site by CH2M HILL using the chemical inventory form included as an attachment to this HSP.
- Confirm that an inventory of chemicals brought on site by CH2M HILL subcontractors is available.
- Request or confirm locations of Material Safety Data Sheets (MSDSs) from the client, contractors, and subcontractors for chemicals to which CH2M HILL employees potentially are exposed.
- Before or as the chemicals arrive on site, obtain an MSDS for each hazardous chemical and include on the chemical inventory sheet (attached to this HSP) and add the MSDS to the MSDS attachment section of this HSP.
- Label chemical containers with the identity of the chemical and with hazard warnings, and store properly.
- Give employees required chemical-specific HAZCOM training using the chemical-specific training form included as an attachment to this HSP.
- Store all materials properly, giving consideration to compatibility, quantity limits, secondary containment, fire prevention, and environmental conditions.

The following are general guidelines for storing chemicals and other hazardous materials:

- Keep acids away from bases.
- Keep oxidizers (nitric acid, nitrates, peroxides, chlorates) and organics away from inorganic reducing agents (metals).
- Keep flammables and corrosives in appropriate storage cabinets.
- Do not store paper or other combustibles near flammables.
- Use secondary containment and lipped shelving that is secured.
- Have a fire suppression system available.

4.2.7 Substance Abuse

(Reference CH2M HILL SOP HSE-105, *Drug-Free Workplace*)

Employees who work under the influence of controlled substances, drugs, or alcohol may prove to be dangerous or otherwise harmful to themselves, other employees, clients, the company, the company's assets and interests, or the public. CH2M HILL does not tolerate illegal drug use, or any use of drugs, controlled substances, or alcohol that impairs an employee's work performance or behavior.

Prohibitions onsite include:

- Use or possession of intoxicating beverages while performing CH2M HILL work.
- Abuse of prescription or nonprescription drugs.

- Use or possession of illegal drugs or drugs obtained illegally.
- Sale, purchase, or transfer of legal, illegal or illegally obtained drugs.
- Arrival at work under the influence of legal or illegal drugs or alcohol.

Drug and/or alcohol testing is applicable under CH2M HILL Constructors, Inc. (CCI) and munitions response projects performed in the United States. In addition, employees may be required to submit to drug and/or alcohol testing as required by clients. When required, this testing is performed in accordance with SOP HSE-105, Drug-Free Workplace. Employees who are enrolled in drug or alcohol testing are required to complete annual training located on the CH2M HILL Virtual Office (VO).

4.2.8 Overexertion

(Reference Dow training materials and CH2M HILL SOP HSE-112, *Lifting*)

- Back injuries are the leading cause of disabling work and most back injuries are the result of improper lifting techniques or overexertion. Use the following to mitigate the hazards associated with lifting:
- When possible, the task should be modified to minimize manual lifting hazards.
- Lifting of loads weighing more than 40 pounds (18 kilograms) shall be evaluated by the SC using the Lifting Evaluation Form contained in SOP HSE-112.
- Using mechanical lifting devices is the preferred means of lifting heavy objects such as forklifts; cranes, hoists, and rigging; hand trucks; and trolleys.
- Personnel shall seek assistance when performing manual lifting tasks that appear beyond their physical capabilities.
- In general, the following steps must be practiced when planning and performing manual lifts: Assess the situation before you lift; ensure good lifting and body positioning practices; ensure good carrying and setting down practices.
- All CH2M HILL workers must have training in proper manual lifting training either through the New Employee Orientation or through Manual Lifting module located on the VO.

Pushing/Pulling

- Use a mechanical or powered assist whenever possible for pushing or pulling heavy loads. If not possible, use multiple people.
- Pushing is the preferred movement instead of pulling.
- Use body weight for pushing – and remember, the force required to push/pull is always greatest at the start of the task. Always push with two hands.
- Keep walking surfaces clear of obstacles (i.e., trash or pallets) and slippery substances, and avoid uneven surfaces wherever possible.
- Place hands on transport equipment between waist and shoulder height whenever possible.

- Bending
- Whenever possible, keep the load off the floor. Put it on a surface that is at waist height.
- If bending is necessary to lift an object, bend at the knees, not the back, and keep the load close to the body.

4.2.9 Fire Prevention

(Reference CH2M HILL SOP HSE-208, *Fire Prevention*)

Follow the fire prevention and control procedures listed below.

Fire Extinguishers and General Fire Prevention Practices

Fire extinguishers shall be provided so that the travel distance from any work area to the nearest extinguisher is less than 100 feet (30.5 meters). When 5 gallons (19 liters) or more of a flammable or combustible liquid is being used, an extinguisher must be within 50 feet (15.2 meters). Extinguishers must:

- be maintained in a fully charged and operable condition,
- be visually inspected each month, and
- undergo a maintenance check each year.

The area in front of extinguishers must be kept clear.

Post "Exit" signs over exiting doors, and post "Fire Extinguisher" signs over extinguisher locations.

Combustible materials stored outside should be at least 10 feet (3 meters) from any building.

Solvent waste and oily rags must be kept in a fire resistant, covered container until removed from the site.

Storage of Flammable/Combustible Liquids

- Only approved containers and portable tanks shall be used for storage and handling of flammable and combustible liquids.
- Approved safety cans shall be used for the handling and use of flammable liquids in quantities of 5 gallons (22.7 liters) or less. Do not use plastic gas cans.
- For quantities of 1 gallon (4.5 liters) or less, the original container may be used for storage and use of flammable liquids.
- Flammable or combustible liquids shall not be stored in areas used for stairways or normally used for the passage of people.

Indoor Storage of Flammable/Combustible Liquids

- No more than 25 gallons (113.7 liters) of flammable or combustible liquids shall be stored in a room outside of an approved storage cabinet.
- Quantities of flammable and combustible liquids in excess of 25 gallons (113.7 liters) shall be stored in an acceptable or approved cabinet.

- Cabinets shall be conspicuously lettered: "FLAMMABLE: KEEP FIRE AWAY."
- Not more than 60 gallons (272.8 liters) of flammable or 120 gallons (545.5 liters) of combustible liquids shall be stored in any one storage cabinet. Not more than three such cabinets may be located in a single storage area.

Outside Storage of Flammable/Combustible Liquids

- Storage of containers (not more than 60 gallons [272.8 liters] each) shall not exceed 1,100 gallons (5000 liters) in any one area. No area shall be within 20 feet (6.1 meters) of any building.
- Storage areas shall be graded to divert spills away from buildings and surrounded by an earthen dike.
- Storage areas shall be free from weeds, debris, and other combustible materials.
- Outdoor portable tanks shall be provided with emergency vent devices and shall not be closer than 20 feet (6.1 meters) to any building.
- Signs indicating no smoking shall be posted around the storage area.

Dispensing of Flammable/Combustible Liquids

- Areas in which flammable or combustible liquids are dispensed in quantities greater than 5 gallons (22.7 liters) (shall be separated from other operations by at least 25 feet (7.6 meters).
- Drainage or other means shall be provided to control spills.
- Adequate natural or mechanical ventilation shall be provided to maintain the concentration of flammable vapor at or below 10 percent of the lower flammable limit.
- Dispensing of flammable liquids from one container to another shall be done only when containers are electrically interconnected (bonded).
- Dispensing flammable or combustible liquids by means of air pressure on the container or portable tanks is prohibited.
- Dispensing devices and nozzles for flammable liquids shall be of an approved type.

4.2.10 Electrical

(Reference CH2M HILL SOP HSE-206, *Electrical*)

Below are the hazard controls and safe work practices to follow when using electrical tools, extension cords, and/or other electrical-powered equipment or when exposed to electrical hazards. Ensure the requirements of the referenced SOP are followed.

General Electrical Safety

Only qualified personnel are permitted to work on unprotected energized electrical systems.

Only authorized personnel are permitted to enter high-voltage areas.

CH2M HILL employees who might from time to time work in an environment influenced by the presence of electrical energy must complete Awareness Level Electrical Safety Training located on the CH2M HILL Virtual Office.

Do not tamper with electrical wiring and equipment unless qualified to do so. All electrical wiring and equipment must be considered energized until lockout/tagout procedures are implemented.

Inspect electrical equipment, power tools, and extension cords for damage prior to use. Do not use defective electrical equipment, remove from service.

CH2M HILL has selected Ground Fault Circuit Interrupters (GFCIs) as the standard method for protecting employees from the hazards associated with electric shock.

- GFCIs shall be used on all 120-volt, single phase 15 and 20-amphere receptacle outlets which are not part of the permanent wiring of the building or structure.

An assured equipment grounding conductor program may be required under the following scenarios:

- GFCIs can not be utilized.
- Client requires such a program to be implemented.
- Business group decides to implement program in addition to GFCI protection.

Extension cords must be equipped with third-wire grounding. Cords passing through work areas must be covered, elevated or protected from damage. Cords should not be routed through doorways unless protected from pinching. Cords should not be fastened with staples, hung from nails, or suspended with wire.

Electrical power tools and equipment must be effectively grounded or double-insulated and Underwriters Laboratory (UL) approved.

Operate and maintain electric power tools and equipment according to manufacturers' instructions.

Maintain safe clearance distances between overhead power lines and any electrical conducting material unless the power lines have been de-energized and grounded, or where insulating barriers have been installed to prevent physical contact. Maintain at least 10 feet (3 meters) from overhead power lines for voltages of 50 kV or less, and 10 feet (3 meters) plus ½ inch (1.27 cm) (for every 1 kV over 50 kV.

Temporary lights shall not be suspended by their electric cord unless designed for suspension. Lights shall be protected from accidental contact or breakage.

Protect all electrical equipment, tools, switches, and outlets from environmental elements.

Portable Generator Hazards

Portable generators are useful when temporary or remote electric power is needed, but they also can be hazardous. The primary hazards to avoid when using a generator are carbon monoxide (CO) poisoning from the toxic engine exhaust, electric shock or electrocution, and fire.

NEVER use a generator indoors or in similar enclosed or partially-enclosed spaces. Generators can produce high levels of carbon monoxide (CO) very quickly. When you use a portable generator, remember that you cannot smell or see CO. Even if you can’t smell exhaust fumes, you may still be exposed to CO.

If you start to feel sick, dizzy, or weak while using a generator, get to fresh air RIGHT AWAY. DO NOT DELAY. The CO from generators can rapidly lead to full incapacitation and death.

If you experience serious symptoms, get medical attention immediately. Inform project staff that CO poisoning is suspected. If you experienced symptoms while indoors have someone call the fire department to determine when it is safe to re-enter the building.

Follow the instructions that come with your generator. Locate the unit outdoors and away from doors, windows, and vents that could allow CO to come indoors.

Keep the generator dry and do not use in rain or wet conditions. To protect from moisture, operate it on a dry surface under an open, canopy-like structure. Dry your hands if wet before touching the generator.

Plug appliances directly into the generator. Or, use a heavy duty, outdoor-rated extension cord that is rated (in watts or amps) at least equal to the sum of the connected appliance loads. Check that the entire cord is free of cuts or tears and that the plug has all three prongs, especially a grounding pin.

Most generators come with Ground Fault Circuit Interrupters (GFCI). Test the GFCIs daily to determine whether they are working

If the generator is not equipped with GFCI protected circuits plug a portable GFCI into the generator and plug appliances, tools and lights into the portable GFCI.

Never store fuel near the generator or near any sources of ignition.

Before refueling the generator, turn it off and let it cool down. Gasoline spilled on hot engine parts could ignite.

4.2.11 Spotters During Vehicle Backing Operations and Heavy Equipment Tasks

- Evaluate vehicle operations prior to performing the task to assess the following:
  - Can the distance of reversing the vehicle be eliminated or minimized?
  - Are there any hazards along the route that would interfere with the safe completion of the job including any points along the path of travel where the spotter may be placed in a dangerous position or line of fire?
  - Can the route be modified to make the task safer?
  - Can the route be cleared of workers (pedestrians) within 8 feet / 2.5m of the moving vehicle? If not, do not proceed. Contact HSM and PM.
- In additional to verbal communications, the driver/operator and spotter must agree to communicate via one of the following: hand signals, two-way radio, lights, handheld air horn or other (specify in daily safety briefings, STACs, etc.)
- Only one spotter should be used at a time.
- Spotters responsibilities are:
  - Position to enable the driver to maintain visual contact with me
  - Never cross the path of travel of a **moving** vehicle

  - Maintain a minimum 8 ft (2.5 m) distance from **moving** vehicle
  - Wear a high visibility vest
  - Wear the PPE requirements for the area
  - Communicate to the driver to **STOP** immediately if any unexpected hazards are observed
  - Never ride on the vehicle while it is moving
  - Keep the route free of people that don't need to be there
- Driver responsibilities include:
  - **STOP** immediately if visual contact with the spotter is lost
  - **STOP** immediately if instructed by the spotter
  - **STOP** immediately if anyone comes within 8 ft (2.5 m) of the vehicle
  - Operate the vehicle so speed does not exceed the walking pace of the spotter
  - Communicate the blind spots of the vehicle to the spotter
  - Turn my radio and any other distractions off in the cab of vehicle
  - Make sure window(s) are open to receive spotter communications
  - Make sure windows and mirrors are clear to ensure good visibility

4.2.12 Stairways and Ladders, Elevated Work

(Reference CH2M HILL SOP HSE-214*, Stairways and Ladders*, and Dow training materials)

Stairs:

- A stairway or ladder is generally required when a break in elevation of 19 inches or greater exists.
- Use a handrail when ascending or descending stairs. Avoid having both hands carrying objects while on stairways.
- Personnel must not use pan and skeleton metal stairs until treads (permanent or temporary) are provided the full width and depth of each step and landing.

Ladders:

- Ladders must be inspected by a competent person for visible defects prior to each day's use. Defective ladders must be tagged and removed from service.
- Ladders must be used only for the purpose for which they were designed and shall not be loaded beyond their rated capacity.
- Users are not to stand on the top two steps of a stepladder, nor are users to sit on top of or straddle a stepladder.
- Only one person at a time shall climb on or work from an individual ladder.
- Users must face the ladder when climbing and keep belt buckle between side rails. Do not extend past the side rails.

- Maintain three points of contact (two feet plus one hand). Users must use both hands to climb; rope should be used to raise and lower equipment and materials.
- Straight and extension ladders must be tied off to prevent displacement.
- Ladders shall not be moved, shifted, or extended while in use.
- Fixed ladders > 24 feet in height must be provided with fall protection devices.
- Fall protection should be considered when working from extension, straight, or fixed ladders greater than 6 feet from lower levels and both hands are needed to perform the work, or when reaching or working outside of the plane of ladder side rails.
- Ladders that may be displaced by work activities or traffic must be secured or barricaded.
- Portable ladders must extend at least 3 feet above landing surface.
- Straight and extension ladders must be positioned at such an angle that the ladder base to the wall is one-fourth of the working length of the ladder.
- Stepladders are to be used in the fully opened and locked position.
- Place portable ladders on a secure footing on a firm, level support surface. Use shoes, spurs, spikes, or similar devices as needed to keep the ladder from slipping or sinking into the ground while climbing.
- Secure portable ladders at the top before being using it for elevated work. Have another person hold the ladder in place at the bottom while you are securing the top.
- If you are using a ladder and your feet are 6 feet (1.8 meters) or higher above grade, **or** any ladder within 6 feet (1.8 meters) of a 6 foot (1.8 meters) or more fall, the "Personnel Doing Elevated Work" requirements apply.
- When using a portable ladder where the climbing side is within 6 feet (1.8 meters) of the guardrails:
  - Increase the height of the guardrails, or
  - Use fall prevention/protection.

Elevated Work:

- Elevated work includes any work:
  - Where workers are working within 6 feet of a drop of 6 feet or more as measured from the lowest part of the body.
  - Within 15 feet of the edge of a low-sloped roof.
  - On steep roofs (> 4 in 12 slope)
  - Over dangerous equipment, regardless of height.
  - That creates fall hazards
  - That uses ladders with 4 or more steps

  - That use aerial lifts.
- Any job involving elevated work must be planned to ensure workers doing the job are protected from falls and falling objects.
- No workers are permitted to perform elevated work unless they are trained and protected with fall protection equipment and/or systems.
- People who are potentially exposed to falling objects must be adequately protected with hard hats or by using material nets.
- If work creates a fall hazard, the workers doing the work must protect others by installing temporary guardrails, installing hole covers, or preventing other workers from accesing the area.
- Equipment used for fall prevention or protection or elevated work must meet Dow specifications (active sites) and/or local governmental requirements, whichever is more stringent, and be used in accordance with the manufacturer's instructions.

4.3 Biological Hazards – Animals and Insects

Biological hazards are everywhere and change with the region and season. If you encounter a biological hazard that has not been identified in this plan, contact the RHSM so that a revision to this plan can be made. Whether it is contact with a poisonous plant, a poisonous snake, or a bug bite, do not take bites/stings lightly. If there is a chance of an allergic reaction or infection, or to seek medical advice on how to properly care for the injury, contact the occupational nurse at 1-866-893-2514.

4.3.1 Snakes

- Snakes typically are found in underbrush and tall grassy areas.
- If you encounter a snake, stay calm and look around; there may be other snakes in the area. Turn around and walk away on the same path you used to approach the area.
- If bitten by a snake, wash and immobilize the injured area, keeping it lower than the heart if possible. Seek medical attention immediately. **DO NOT** apply ice, cut the wound, or apply a tourniquet. Try to identify the type of snake: note color, size, patterns and markings.

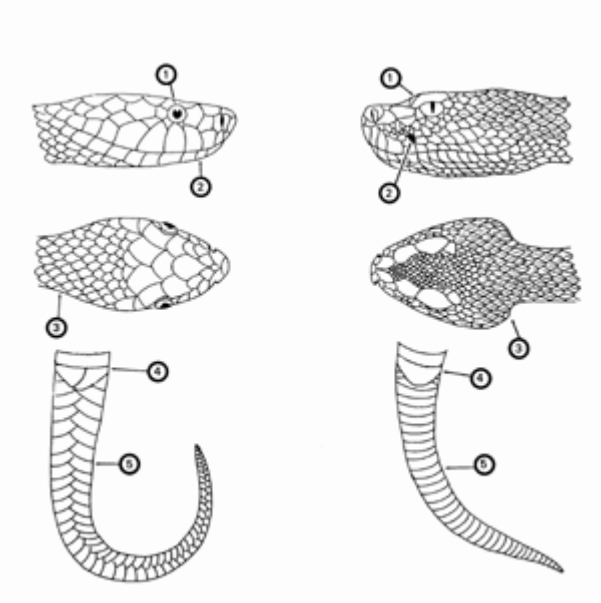
Identification of Poisonous Snakes

(Major Identification Features)
non-venomous snake

1. Round pupils
2. No sensing pit
3. Head slightly wider than neck
4. Divided anal plate
5. Double row of scales on the underside of the tail

venomous snake

1. Elliptical pupils
2. Sensing pit between eye and nostril
3. Head much wider than neck
4. Single anal plate
5. Single scales on the underside of the tail



4.3.2 Ticks

- For sites where ticks are likely to be present, the following or similar products must be onsite and used as necessary:
- BugOut™ Suit
- Tick removal kit
- DEET™

- Staff must be trained on ticks, which are typically found in wooded areas, bushes, tall grass and brush. Ticks are black, black and red, or brown and can be up to one-quarter inch in size.
- Where site conditions warrant (vegetation above knee height, tick endemic area) or when tasks warrant (e.g., having to sit/kneel in vegetation) that diminish the effectiveness of the other controls mentioned above, bug-out suits (obtained from MKE warehouse)/Tyvek shall be used. Bug-out suits are more breathable than Tyvek.
- Wear tightly woven light-colored clothing with long sleeves, and pant legs tucked into boots; spray skin with DEET™ and spray **only the outside** of clothing with permanone, and check yourself frequently.
- If bitten by a tick, grasp it at the point of attachment and carefully remove it. After removing the tick, wash your hands and disinfect and press the bite area. Save the removed tick by placing it in a plastic bag, with the date of the tick bite, and place in your freezer. It may be used at a later date to assist a physician with making an accurate diagnosis (if you become ill). Report the bite to Human Resources. Look for the following symptoms of Lyme disease or Rocky Mountain spotted fever (RMSF): for Lyme disease, a rash that looks like a bullseye with a small welt in the center, and for RMSF, a rash of red spots that develops under the skin 3 to 10 days after the tick bite. In both cases, chills, fever, headache, fatigue, stiff neck, and bone pain may develop. If symptoms appear, seek medical attention.
- Report all incidents to your HS&E Manager.

4.3.3 Bees and Other Stinging Insects

- Bees and other stinging insects may be encountered almost anywhere and may present a serious hazard, particularly to people who are allergic. Watch for and avoid nests. Keep exposed skin to a minimum. Carry a kit if you have had allergic reactions in the past, and inform the SC and fellow workers. If a stinger is present, remove it carefully with tweezers. Wash and disinfect the wound, cover it, and apply ice. Watch for allergic reaction; seek medical attention if a reaction develops. Use BugOut Suits™ or equivalent as necessary.

4.3.4 Mosquito Bites

- Because of the recent detection of West Nile Virus in the Southeastern United States, it is recommended that **preventive measures** be taken whenever possible to reduce the probability of being bitten by mosquitoes. Mosquitoes are believed to be the primary source for exposure to the West Nile Virus, as well as several other types of encephalitis. The following guidelines should be followed to reduce the risk of these concerns for working in areas where mosquitoes are prevalent.
- Stay indoors at dawn, dusk, and in the early evening.
- Wear long-sleeved shirts and long pants whenever you are outdoors. Use BugOut Suits™ or equivalent as necessary.
- Spray clothing with repellents containing permethrin or DEET™ because mosquitoes may bite through thin clothing.

- Apply insect repellent sparingly to exposed skin. An effective repellent will contain 35% DEET™ (N,N-diethyl-meta-toluamide). DEET™ in high concentrations (greater than 35%) provides no additional protection.
- Repellents may irritate the eyes and mouth, so avoid applying repellent to the hands.
- Whenever you use an insecticide or insect repellent, be sure to read and follow the manufacturer's DIRECTIONS FOR USE, as printed on the product.
- Note: Vitamin B and "ultrasonic" devices are NOT effective in preventing mosquito bites.

Symptoms of Exposure to West Nile Virus

- Most infections are mild, and symptoms include fever, headache, and body aches, occasionally with skin rash and swollen lymph glands. More severe infection may be marked by headache, high fever, neck stiffness, stupor, disorientation, coma, tremors, convulsions, muscle weakness, paralysis, and, rarely, death.
- The West Nile Virus incubation period is from 3-15 days.
- If you have any questions or to report any suspicious symptoms, contact the project HS&E Manager.

4.3.5 Poisonous Spiders

- Poisonous spiders, such as the black widow spider or the brown recluse spider, may be encountered during site work. Spiders are usually found in dark, cool, protected areas and such areas should be inspected before placing hands or feet in these areas. Poisonous spiders are commonly found in woodpiles, sheds, basements, garages, and privies.
- The primary species of black widow spider encountered has a glossy black appearance with an orange-red hourglass shape on the underside of the body.
- Black widow spider bite signs and symptoms are: initial pain followed by dull, occasionally numbing pain in the affected extremity; pain and cramps in one or several of the large body muscles; abdominal pain and cramping; sweating, increased salivation, anxiety, weakness, headache, and dizziness; and severe cases can result in uncontrollable muscle spasms, coma, and respiratory failure.
- Black widow spider bite first-aid procedures are: wash wound; apply a cold pack; and get medical care (i.e., muscle relaxants; antivenin).
- The brown recluse spider is also known as the "violin or fiddle back" spider and is light brown in color with a darker brown violin-like marking on the top of the body.
- The brown recluse spider is non aggressive, and most bites occur when the spider is trapped in clothing being put on, stepped on, and when areas where the spider resides are disturbed.
- Brown recluse spider bite signs and symptoms are: localized burning sensation within 2 to 8 hours with itching and redness; small blanched area around immediate bite area appears;

reddened area enlarges and becomes purple during subsequent 1 to 8 hours; and fever, malaise, stomach cramps, nausea, vomiting, and some cases have resulted in death.

- Brown recluse spider bite first-aid procedures are: wash wound; apply a cold pack; and seek immediate medical care.

4.3.6 Rodents

- Rodents include rats, mice, squirrels, and other related mammals and are characterized by gnawing and nibbling traits.
- Rodents can act as a vector for many diseases that may be transmitted directly or through other vectors such as fleas or ticks.
- Diseases that can be transmitted include plague, typhus, Leptospirosis, relapsing fever, and others including Hantavirus pulmonary syndrome.

4.3.7 Bird Droppings

Large amounts of bird droppings may present a disease risk. The best way to prevent exposure to fungus spores in bird droppings is to avoid disturbing it. A brief inhalation exposure to highly contaminated dust may be all that is needed to cause infection and subsequent development of fungal disease.

If disturbing the droppings or if removal is necessary to perform work, follow these controls:

- Use dust control measures (wetting with water or HEPA vacuuming) for all activities that may generate dust from the accumulated droppings.
- Wear Tyvek with hoods, disposable gloves and booties, and air-purifying respirators with a minimum N95 rating.
- Put droppings into plastic/poly bags and preferably into a 55-gallon drum to prevent bag from ripping.

4.3.8 Feral Dogs

Avoid all dogs – both leashed and stray. Do not disturb a dog while it is sleeping, eating, or caring for puppies. If a dog approaches to sniff you, stay still. An aggressive dog has a tight mouth, flattened ears and a direct stare. If you are threatened by a dog, remain calm, do not scream and avoid eye contact. If you say anything, speak calmly and firmly. Do not turn and run, try to stay still until the dog leaves, or back away slowly until the dog is out of sight or you have reached safety (e.g. vehicle). If attacked, retreat to vehicle or attempt to place something between you and the dog. If you fall or are knocked to the ground, curl into a ball with your hands over your head and neck and protect your face. If bitten, contact the occupational nurse at 1-866-893-2514. Report the incident to the local authorities.

4.3.9 Hantavirus

Hantavirus pulmonary syndrome (HPS) is a disease caused by a virus which can be transmitted from certain rodents to humans and is prevalent throughout the southwestern United States. Avoid disturbing rodent nests.

Nesting material/droppings must be removed if work is necessary in a rodent-infested area. PPE for removal shall include:

- Tyvek coveralls;
- Rubber boots or disposable shoe covers;
- Rubber, latex, or vinyl gloves;
- Respiratory protection such as a full face or half-mask air-purifying respirator with a high-efficiency particulate air (HEPA) filter;
- Protective goggles if wearing a half-mask respirator.

Spray any urine, droppings, and nesting materials with either a bleach and water solution (1 parts bleach to 9 parts water) or a household disinfectant prepared according to the label instructions for dilution and disinfection time. Soak well and let stand for 15 minutes. Use a paper towel or rag to pick up the materials and dispose of them.

Mop floors after spraying them using bleach/water solution or a disinfectant. Dirt floors can be sprayed with either bleach and water solution or a disinfectant.

Personal protective gear shall be decontaminated upon removal at the end of the day. All potentially infective waste material (including respirator filters) from clean-up operations shall be double-bagged in plastic bags.

Symptoms of HPS

Symptoms develop between 14 and 31 days after exposure to infected rodents and include fatigue, fever, and muscle aches, especially the large muscle groups--thighs, hips, back and sometimes shoulders. About half of all HPS patients also experience headaches, dizziness, chills and/or abdominal pain. Four to 10 days after the initial phase of the illness, late symptoms of HPS may appear. These include coughing and shortness of breath. If you develop symptoms suggestive of HPS, call the occupational nurse at 1-866-893-2514.

4.3.10 Spiders - Brown Recluse and Widow

The Brown Recluse spider can be found most anywhere in the United States. It varies in size in shape, but the distinguishing mark is the violin shape on its body. They are typically non-aggressive. Keep an eye out for irregular, pattern-less webs that sometimes appear almost tubular built in a protected area such as in a crevice or between two rocks. The spider will retreat to this area of the web when threatened.

The Black Widow, Red Widow and the Brown Widow are all poisonous. Most have globose, shiny abdomens that are predominantly black with red markings (although some may be pale and/or have lateral stripes), with moderately long, slender legs. These spiders are nocturnal and build a three-dimensional tangled web, often with a conical tent of dense silk in a corner where the spider hides during the day.

Hazard Controls

- Inspect or shake out any clothing, shoes, towels, or equipment before use.

- Wear protective clothing such as a long-sleeved shirt and long pants, hat, gloves, and boots when handling stacked or undisturbed piles of materials.
- Minimize the empty spaces between stacked materials.
- Remove and reduce debris and rubble from around the outdoor work areas.
- Trim or eliminate tall grasses from around outdoor work areas.
- Store apparel and outdoor equipment in tightly closed plastic bags.
- Keep your tetanus boosters up-to-date (every 10 years). Spider bites can become infected with tetanus spores.
- If you think you have been bit by a poisonous spider, immediately call the occupational nurse at 1-866-893-2514 and follow the guidance below:
- Remain calm. Too much excitement or movement will increase the flow of venom into the blood.
- Apply a cool, wet cloth to the bite or cover the bite with a cloth and apply an ice bag to the bite.
- Elevate the bitten area, if possible.
- Do not apply a tourniquet. Do not try to remove venom.
- Try to positively identify the spider to confirm its type. If the spider has been killed, collect it in a plastic bag or jar for identification purposes. Do not try to capture a live spider—especially if you think it is a poisonous spider.

Black Widow

Red Widow

Brown Widow

Brown Recluse

4.4 Biological Hazards – Toxic and Noxious Plants

Sites where poison ivy, oak, or sumac are likely to be present must have the following or similar products onsite, to be used as necessary:

- IvyBlock™: used prior to exposure to protect the skin
- Technu™: used to cut oils during clean-up
- Zanfel™: used immediately after exposure to prevent spread of rash

Staff must be trained on plant identification, in all seasons.

- Wear protective clothing that covers exposed skin and clothes. Use IvyBlock™ or similar product on exposed skin. Avoid contact with plants.
- If skin comes in contact with a plant, wash the area with Technu™ or similar product that is designed to break down oils. Do not bathe—bathing can spread oils to other parts of the body. Report incident to your HS&E Manager.
- If a rash appears, immediately apply Zanfel™. If the reaction is severe or worsens, seek medical attention.
- Do not set equipment on ground if poison ivy, oak, or sumac may be present. Decontaminate equipment, vehicles, etc. that may have come into contact with plants.
- Use STAC insert as appropriate.

4.5 Bloodborne Pathogens

(Reference CH2M HILL SOP HSE-202 *Bloodborne Pathogens*)

Exposure to bloodborne pathogens may occur when rendering first aid or cardiopulmonary resuscitation (CPR), or when coming into contact with landfill waste or waste streams containing potentially infectious material (PIM).

Employees trained in first-aid/CPR or those exposed to PIM must complete CH2M HILL's 1-hour bloodborne computer-based training module annually. When performing first-aid/CPR the following shall apply:

- Observe universal precautions to prevent contact with blood or other PIMs. Where differentiation between body fluid types is difficult or impossible, consider all body fluids to be potentially infectious materials.
- Always wash your hands and face with soap and running water after contacting PIMs. If washing facilities are unavailable, use an antiseptic cleanser with clean paper towels or moist towelettes.
- If necessary, decontaminate all potentially contaminated equipment and surfaces with chlorine bleach as soon as possible. Use one part chlorine bleach (5.25 percent sodium hypochlorite solution) diluted with 10 parts water for decontaminating equipment or surfaces after initially removing blood or other PIMs. Remove contaminated PPE as soon as possible before leaving a work area.

CH2M HILL will provide exposed employees with a confidential medical examination should an exposure to PIM occur. This examination includes the following procedures:

- Documenting the exposure
- Testing the exposed employee's and the source individual's blood (with consent)
- Administering post-exposure prophylaxis

4.6 Compressed Gases

- Compressed gas cylinders are hazardous materials and transport must comply with DOT.

- Valve caps must be in place when cylinders are transported, moved, or stored.
- Cylinder valves must be closed when cylinders are not being used and when cylinders are being moved.
- Cylinders must be secured in an upright position at all times.
- Cylinders must be shielded from welding and cutting operations and positioned to avoid being struck or knocked over, contacting electrical circuits, or exposed to extreme heat sources.
- Cylinders must be secured on a cradle, basket, or pallet when hoisted; they may not be hoisted by choker slings.

4.7 Transportation of Hazardous Materials

(Reference CH2M HILL's *Dangerous Goods Transportation Manual* and SOP HSE-403, *Hazardous Materials)*

- Chemicals or petroleum products brought to the site may be defined as hazardous materials by the U.S. Department of Transportation (DOT).
- All staff who ship materials or prepare them for transport by road must successfully complete CH2M HILL Dangerous Goods Shipping training.
- All hazardous materials that are shipped (e.g., via Federal Express) or are transported by road must be properly identified, labeled, packed and documented by trained staff.
- Contact the HS&E Manager, ECC, or the Equipment Coordinator for additional information.

4.8 Heat Stress

- Drink 16 ounces of water before beginning work. Disposable cups and water maintained at 50˚F to 60˚F should be available. Under severe conditions, drink 1 to 2 cups every 20 minutes, for a total of 1 to 2 gallons per day. Do not use alcohol in place of water or other nonalcoholic fluids. Decrease your intake of coffee and caffeinated soft drinks during working hours.
- Acclimate yourself by slowly increasing workloads (e.g., do not begin with extremely demanding activities).
- Use cooling devices, such as cooling vests, to aid natural body ventilation. These devices add weight, so their use should be balanced against efficiency.
- Use mobile showers or hose-down facilities to reduce body temperature, and wear cool, protective clothing.
- Conduct field activities in the early morning or evening and rotate shifts of workers, if possible.

- Avoid direct sun whenever possible because it can decrease physical efficiency and increase the probability of heat stress. Take regular breaks in a cool, shaded area. Use a wide-brim hat or an umbrella when working under direct sun for extended periods.
- Provide adequate shelter/shade to protect personnel against radiant heat (sun, flames, hot metal).
- Maintain good hygiene standards by frequently changing clothing and showering.
- Observe one another for signs of heat stress. Persons who show signs of heat syncope, heat rash, or heat cramps should consult the SC to avoid progression of heat-related illness.

4.8.1 Monitoring Heat Stress

These procedures should be considered when the ambient air temperature exceeds 70˚F, the relative humidity is high (>50 percent), or when workers exhibit symptoms of heat stress.

The heart rate (HR) should be measured by the radial pulse for 30 seconds, as early as possible in the resting period. The HR at the beginning of the rest period should not exceed 100 beats/minute, or 20 beats/minute above resting pulse. If the HR is higher, the next work period should be shortened by 33 percent, while the length of the rest period stays the same. If the pulse rate still exceeds 100 beats/minute at the beginning of the next rest period, the work cycle should be further shortened by 33 percent. The procedure is continued until the rate is maintained below 100 beats/minute, or 20 beats/minute above resting pulse.

Work/rest regimen	Light	Moderate	Heavy
Continuous work	30.0°C (86°F)	26.7°C (80°F)	25.0°C (77°F)
75% Work, 25% rest, each hour	30.6°C (87°F)	28.0°C (82°F)	25.9°C (78°F)
50% Work, 50% rest, each hour	31.4°C (89°F)	29.4°C (85°F)	27.9°C (82°F)
25% Work, 75% rest, each hour	32.2°C (90°F)	31.1°C (88°F)	30.0°C (86°F)
Examples of Work Types: Light: raking; moderate: cleaning floor/beating carpet; Heavy: digging/barking trees/laying railroad tracks			
Modify temperate by the following depending on clothing type: Work cloths: 0; Cotton coveralls: -2C, Winter work clothing: -4C, & water barrier, permeable: -6C, fully encapsulating suits: -10C			

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THRESHOLD LIMIT VALUES WORK/WARM-UP SCHEDULE FOR FOUR-HOUR SHIFT*

Air Temperature Sunny Sky		No Noticeable Wind		5 mph Wind		10 mph Wind		15 mph Wind		20 mph Wind	
° C (approx)	° F (approx)	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks
-26° to -28°	-15° to -19°	(Norm breaks) 1		(Norm breaks) 1		75 min.	2	55 min.	3	40 min.	4
-29° to -31°	-20° to -24°	(Norm breaks) 1		75 min.	2	55 min.	3	40 min.	4	30 min.	5
-32° to -34°	-25° to -29°	75 min.	2	55 min.	3	40 min.	4	30 min.	5	Non-emergency work should cease ↓	
-35° to -37°	-30° to -34°	55 min.	3	40 min.	4	30 min.	5	Non-emergency work should cease ↓			
-38° to -39°	-35° to -39°	40 min.	4	30 min.	5	Non-emergency work should cease ↓					
-40° to -42°	-40° to -44°	30 min.	5	Non-emergency work should cease ↓							
-43° to below	-45° & below	Non-emergency work should cease									

4.9 Cold Emergencies & Ice/Snow

4.9.1 Cold Stress

- Be aware of the symptoms of cold-related disorders, and wear proper, layered clothing for the anticipated fieldwork. Appropriate rain gear is a must in cool weather.
- Consider monitoring the work conditions and adjusting the work schedule using guidelines developed by the U.S. Army and the National Safety Council (NSC).
- The following guidelines can be used with the wind-chill index to estimate work and warm-up schedules for fieldwork. The guidelines are not absolute; workers should be monitored for symptoms of cold-related illnesses. If symptoms are not observed, the work duration can be increased.
- The following can be used to estimate wind speed:
  - 5 mph (8 km/h): light flag moves
  - 10 mph (16 km/h): light flag fully extended
  - 15 mph (24 km/h): raises newspaper sheet
  - 20 mph (32 km/h): causes blowing and drifting snow
- Observe one another for initial signs of cold-related disorders.
- Persons who experience initial signs of immersion foot, frostbite, or hypothermia should consult the SC to avoid progression of cold-related illness.
- Obtain and review weather forecasts before beginning work. Be aware of predicted weather systems along with sudden drops in temperature, increase in winds, and precipitation.

4.9.2 Ice/Snow -- Slips, Trips, and Falls

- Mark potential hazards (e.g., holes, rebar, plastic, etc.) prior to snowfall. Designate walkways that avoid such hazards.
- Give yourself sufficient time and plan your route.
- Walk in designated walkways as much as possible.
- Wear shoes or boots that provide traction on snow and ice or use YakTrax™ or similar product.
- Keep both hands free for balance --NOT in your pockets. Wear gloves to keep hands warm and readily available to hold snow-covered handrails.
- Take short steps or shuffle for stability, bend slightly, and walk flat-footed. Keep your center of gravity directly over your feet as much as possible. Keep you eyes on where you are going.
- Use special care when entering and exiting vehicles: use the vehicle for support, step out planting foot firmly on the ground, and have hands free for support.

4.9.3 Snow and Ice Removal

- Before shoveling, warm up your muscles and avoid caffeine or nicotine.
- Push the shovel to move the snow and avoid lifting whenever possible.
- Protect your back from injury by lifting correctly:
- Stand with your feet about hip width for balance
- Keep the shovel close to your body
- Bend from the knees (not the back)
- Tighten your stomach muscles as you lift the snow
- Avoid twisting movements
- If you need to move the snow to one side, reposition your feet to face the direction the snow will be going.

4.9.4 Symptoms and Treatment Of Cold Stress

Signs and Symptoms

- Feet discolored and painful; infection and swelling present.
- Blanched, white, waxy skin, but tissue resilient; tissue cold and pale.
- Shivering, apathy, sleepiness; rapid drop in body temperature; glassy stare; slow pulse; slow respiration.

Treatment

- Seek medical treatment immediately.
- Remove victim to a warm place. Re-warm area quickly in warm–but not hot–water. Have victim drink warm fluids, but not coffee or alcohol. Do not break blisters. Elevate the injured area, and get medical attention.

- Remove victim to a warm place. Have victim drink warm fluids, but not coffee or alcohol. Get medical attention.

4.10 Lone Work Requirements

- Personnel can only be tasked to work alone by their Project Manager who shall assess potential hazards and appropriate control measures, with assistance from the Responsible Health and Safety Manager (RHSM).
- "Lone workers" with accountability system are permitted, depending on the hazards presented during the execution of the task, such as, isolation, environmental factors, etc. Reference the "Lone worker Protocol."
- The employee shall at all times be equipped with a working voice communication device such as a cellular phone or two way radio to check-in to their project contact (s) at pre-determined times.

  Call in contact name:
  Phone numbers (office and cell):

- Check-in or contact times must be based on the risk associated with the task, or the timeframe expected to complete the task, but at a minimum of at least two times during an 8 hour work shift.
- Call in Contact Form shall be completed by lone worker and given to call in contact prior to going into field.
- Work tasks will cease if communication is lost during work day. Work may resume when communication is re-established.

4.11 Hearing Conservation

(Reference CH2M HILL SOP HSE&Q-108, Hearing Conservation)

- A noise assessment is conducted by the SC or RHSM based on potential to emit noise above 85 dBA..
- Areas or equipment emitting noise at or above 90dBA are evaluated to determine feasible engineering controls. When engineering controls are not feasible, administrative controls can be developed and appropriate hearing protection will be provided..
- Areas or equipment emitting noise levels at or above 85 dBA, hearing protection must be worn.
- Employees exposed to 84 dBA or a noise dose of 50% must participate in the Hearing Conservation program including initial and annual (as required) audiograms.
- The RHSM will evaluate appropriate controls measures and work practices for employees who have experienced a standard threshold shift (STS) in their hearing.
- Hearing protection is selected based upon noise levels and specific tasks to be performed.

- Employees are trained in the hazards of noise and how to properly wear and maintain their hearing protection.
- Hearing protection will be maintained in a clean and reliable condition, inspected prior to use and after any occurrence to identify any deterioration or damage, and damaged or deteriorated hearing protection repaired or discarded.
- In work areas where actual or potential high noise levels are present at any time, hearing protection must be worn by employees working or walking through the area.
- Areas where tasks requiring hearing protection are taking place may become hearing protection required areas as long as that specific task is taking place.
- High noise areas requiring hearing protection should be posted or employees must be informed of the requirements in an equivalent manner.

5 General Requirements

5.1 Roles and Responsibilities

5.1.1 CH2M HILL Project Manager

The Project Manager (PM) is responsible for providing adequate resources (budget and staff) for project-specific implementation of the HSE management process. The PM has overall management responsibility for the tasks listed below. The PM may explicitly delegate specific tasks to other staff, as described in sections that follow, but retains ultimate responsibility for completion of the following in accordance with this document:

Incorporate standard terms and conditions, and contract-specific HSE roles and responsibilities in contract and subcontract agreements (including flow-down requirements to lower-tier subcontractors).

Select safe and competent subcontractors by:

- Choosing potential subcontractors based on technical ability and HSE performance.
- Implementing the subcontractor prequalification process.
- Ensuring that acceptable certificates of insurance, including CH2M HILL as named additional insured, are secured as a condition of subcontract award.
- Ensuring HSE submittals, subcontract agreements, and appropriate site-specific safety procedures are in place and accepted prior field mobilization.

Ensure copies of training and medical monitoring records, and site-specific safety procedures are being maintained in the project file accessible to site personnel.

Provide oversight of subcontractor HSE practices per the site-specific safety plans/procedures.

Manage the site and interfacing with 3rd parties in a manner consistent with the contract and subcontract agreements and the applicable standard of reasonable care.

Ensure that the overall, job-specific, HSE goals are fully and continuously implemented.

Support/implement use of stop-work orders when subcontractor safety performance is not adequate.

5.1.2 CH2M HILL Responsible Health and Safety Manager (RHSM)

The Responsible Health and Safety Manager (RHSM) is responsible for the following:

- Review and evaluate subcontractor HSE performance using the pre-qualification process.
- Approve HSP and its revisions as well as Activity Hazard Analyses (AHA).
- Review and evaluate subcontractor site-specific safety procedures for adequacy prior to start of subcontractor's field operations.
- Support the oversight (or SC's direct oversight) of subcontractor and tiered subcontractor HSE practices.
- Permit upgrades/downgrades in respiratory protection after reviewing analytical data.
- Conduct audits as determined by project schedule and coordination with PM.
- Participate in incident investigations, lessons learned, loss/near loss reporting.

5.1.3 CH2M HILL Safety Coordinator

The Safety Coordinator (SC) is responsible for verifying that the project is conducted in a safe manner including the following specific obligations:

- Verify this HSP is current and amended when project activities or conditions change.
- Verify CH2M HILL site personnel and subcontractor personnel read the HSP and sign the Employee Sign-Off Form, prior to commencing field activities.
- Verify CH2M HILL site personnel have completed any required specialty training (e.g., fall protection, confined space entry) and medical surveillance as identified in this HSP.
- Verify that project files available to site personnel include copies of executed subcontracts and subcontractor certificates of insurance (including CH2M HILL as named additional insured), bond, contractor's license, training and medical monitoring records, and accepted site-specific safety procedures prior to start of subcontractor's field operations.
- Act as the project "Hazard Communication Coordinator" and perform the responsibilities outlined in the HSP.
- Act as the project "Emergency Response Coordinator" and perform the responsibilities outlined in the HSP.
- Post OSHA job-site poster; the poster is required at sites where project field offices, trailers, or equipment-storage boxes are established.
- Hold/verify that safety meetings are conducted and documented in the project file initially and as needed throughout the course of the project (e.g., as tasks or hazards change).
- Verify that project health and safety forms and permits are being used as outlined this HSP.

- Perform oversight and/or assessments of subcontractor HSE practices per the site-specific safety plan and verify that project activity self-assessment checklists are being used as outlined this HSP.
- Coordinate with the RHSM regarding CH2M HILL and subcontractor operational performance, and 3rd party interfaces.
- Verify appropriate PPE use, availability, and training.
- Ensure that the overall, job-specific, HSE goals are fully and continuously implemented.
- Conduct accident investigations including root cause analysis.
- Calibrate and conduct air monitoring in accordance with the HSP. Maintain all air monitoring records in project file.
- Maintain HSE records and documentation.
- Facilitate Occupational Safety and Health Administration (OSHA) or other government agency inspections including accompanying inspector and providing all necessary documentation and follow-up.
- Deliver field HSE training as needed based on project-specific hazards and activities.
- Contact the RHSM and PM in the event of an incident.
- When an apparent imminent danger exists, immediately remove all affected CH2M HILL employees and subcontractors, notify subcontractor safety representative, and stop affected work until adequate corrective measures are implemented. Notify the PM and RHSM as appropriate.
- Document all oral health and safety-related communications in project field logbook, daily reports, or other records.

5.1.4 Subcontractors Responsibilities

Subcontractors must comply with the following activities, and are responsible to:

- Comply with all local, state, and federal safety standards.
- Comply with project and owner safety requirements.
- Actively participate in the project safety program and hold/attend/participate in all required safety meetings.
- Provide a qualified safety representative to interface with CH2M HILL.
- Maintain safety equipment and PPE for their employees.
- Maintain and replace safety protection systems damaged or removed by the subcontractor's operations.
- Notify the SC of any accident, injury, and/or incident immediately and submit reports to CH2M HILL within 24 hours.
- Install contractually required general conditions for safety (example: handrail, fencing, fall protection systems, floor opening covers, etc.).

- Conduct and document weekly safety inspections of project-specific tasks and associated work areas.
- Conduct site-specific and job-specific training for all subcontractor employees, including review of the CH2M HILL HSP, subcontractor HSPs, and subcontractor AHAs and sign appropriate sign-off forms.
- Determine and implement necessary controls and corrective actions to correct unsafe conditions.

The subcontractors listed above may be required to submit their own site-specific HSP and other plans such as Lead or Asbestos Abatement Compliance. Subcontractors are responsible for the health and safety procedures specific to their work, and are required to submit their plans to CH2M HILL for review and acceptance before the start of field work.

Subcontractors are also required to prepare AHAs before beginning each activity posing hazards to their personnel. The AHA shall identify the principle steps of the activity, potential health and safety hazards for each step and recommended control measures for each identified hazard. In addition, a listing of the equipment to be used to perform the activity, inspection requirements and training requirements for the safe operation of the equipment listed must be identified.

5.1.5 Employee Responsibilities

All personnel are assigned responsibility for safe and healthy operations. This concept is the foundation for involving all employees in identifying hazards and providing solutions. For any operation, individuals have full authority to stop work and initiate immediate corrective action or control. In addition, each worker has a right and responsibility to report unsafe conditions/practices. This right represents a significant facet of worker empowerment and program ownership. Through shared values and a belief that all accidents are preventable, our employees accept personal responsibility for working safely.

Each employee is responsible for the following performance objectives:

- Perform work in a safe manner and produce quality results.
- Perform work in accordance with company policies, and report injuries, illnesses, and unsafe conditions.
- Complete work without injury, illness, or property damage.
- Report all incidents immediately to supervisor, and file proper forms with a human resources representative.
- Report all hazardous conditions and/or hazardous activities immediately to supervisor for corrective action.
- Complete an HSE orientation prior to being authorized to enter the project work areas.

Employee Authority

Each employee on the project has the obligation and authority to shut down any perceived unsafe work and during employee orientation, each employee will be informed of their authority to do so.

Standards of Conduct

All individuals associated with this project must work injury-free and drug-free and must comply with the following Standards of Conduct, the HSP, and the safety requirements of CH2M HILL. Commonly accepted standards of conduct help maintain good relationships between people. They promote responsibility and self-development. Misunderstandings, frictions, and disciplinary action can be avoided by refraining from thoughtless or wrongful acts.

Standards of Conduct Violations

All individuals associated with this project are expected to behave in a professional manner. Violations of the standards of conduct would include, but not be limited to:

- Failure to perform work.
- Inefficient performance, incompetence, or neglect of work.
- Willful refusal to perform work as directed (insubordination).
- Negligence in observing safety regulations, poor housekeeping, or failure to report on-the-job injuries or unsafe conditions.
- Unexcused or excessive absence or tardiness.
- Unwillingness or inability to work in harmony with others.
- Discourtesy, irritation, friction, or other conduct that creates disharmony.
- Harassment or discrimination against another individual.
- Failure to be prepared for work by wearing the appropriate construction clothing or bringing the necessary tools.
- Violation of any other commonly accepted reasonable rule of responsible personal conduct.

5.2 Disciplinary Actions

The Environmental Services (ES) business group employees, employees working on ES business group projects, and subcontractor employees are subject to disciplinary action for not following HSE rules and requirements. Potential disciplinary action is equally applicable to all employees including management and supervision. Disciplinary action may include denial of access to the worksite, warnings, reprimands, and other actions up to and including termination depending on the specific circumstances.

5.3 Subcontractor Safety Performance

CH2M HILL should continuously endeavor to observe subcontractors' safety performance and adherence to their plans and AHAs. This endeavor should be reasonable, and include observing for hazards or unsafe practices that are both readily observable and occur in common work areas. CH2M HILL is not responsible for exhaustive observation for hazards and unsafe practices. CH2M HILL oversight does not relieve subcontractors of their responsibility for effective implementation and compliance with the established plan(s).

5.3.1 Observed Hazard Form

When apparent non-compliance or unsafe conditions or practices are observed, notify the subcontractor's supervisor/safety representative verbally, document using the Observed Hazard Form, included as an attachment to this HSP, and require corrective action.

If necessary, stop subcontractor's work using the Stop Work Order Form until corrective actions is implemented for observed serious hazards or conditions. Update the Observed Hazard Form to document corrective actions have been taken. The subcontractor is responsible for determining and implementing necessary controls and corrective actions.

5.3.2 Stop Work Order

CH2M HILL has the authority, as specified in the contract, and the responsibility to stop work in the event any CH2M HILL employee observes unsafe conditions or failure of the subcontractor to adhere to its safe-work practices. This authority and action does not in any way relieve the subcontractor of its responsibilities for the means and methods of the work or, therefore, of any corrective actions. Failure to comply with safe work practices can be the basis for restriction or removal of the subcontractor staff from the job site, termination of the subcontract, restriction from future work, or all three.

When an apparent imminent danger is observed, immediately stop work and alert all affected individuals. Remove all affected CH2M HILL employees and subcontractor staff from the danger, notify the subcontractor's supervisory/safety representative, and do not allow work to resume until adequate corrective measures are implemented. Notify the PM, Contract Administrator (KA) and RHSM.

When repeated non-compliance or unsafe conditions are observed, notify the subcontractor's supervisory/safety representative and stop affected work by completing and delivering the Stop Work Order Form (attached to this HSP) until adequate corrective measures are implemented. Consult the KA to determine what the contract dictates for actions to pursue in event of subcontractor non-compliance i.e., work stoppage, back charges, progress payments, removal of subcontractor manager, monetary penalties, termination of subcontractor for cause.

5.4 Incentive Program

Each project is encouraged to implement a safety incentive program that rewards workers for exhibiting exemplary safety behaviors. Actions that qualify are those that go above and beyond what is expected, like wearing your own safety equipment, seatbelt, etc. Actions that will be rewarded include spotting and correcting a hazard, bringing a hazard to the attention of your foreman, telling your foreman about an incident, coming up with a safer way to get the work done, stopping a crew member from doing something unsafe, etc. The program will operate throughout the project, covering all workers. The incentive program will be communicated to all employees during the project employee orientation and project safety meetings.

5.5 Reporting Unsafe Conditions/Practices

Responsibility for effective health and safety management extends to all levels of the project and requires good communication between employees, supervisors, and management. Accident

prevention requires a pro-active policy on near misses, close calls, unsafe conditions, and unsafe practices. All personnel must report any situation, practice, or condition which might jeopardize the safety of our projects. All unsafe conditions or unsafe practices will be corrected immediately. CH2M HILL has zero tolerance of unsafe conditions or unsafe practices.

No employee or supervisor will be disciplined for reporting unsafe conditions or practices. Individuals involved in reporting the unsafe conditions or practices will remain anonymous.

The following reporting procedures will be followed by all project employees:

- Upon detection of any unsafe condition or practice, the responsible employee will attempt to safely correct the condition.
- The unsafe condition or practice will be brought to the attention of the worker's direct supervisor, unless the unsafe condition or practice involves the employee's direct supervisor. If so, the SC needs to be notified at once by the responsible employee.
- Either the responsible employee or responsible employee's direct supervisor is responsible for immediately reporting the unsafe condition or practice to the SC.
- The SC will act promptly to correct the unsafe condition or practice.
- Details of the incident or situation will be recorded by the SC in the field logbook and/or use the Observed Hazard Form if subcontractor was involved.

5.6 Change Management

The project manager (PM), field team leader (FTL) or safety coordinator (SC) must contact the RHSM whenever the team encounters a change condition (e.g. change in staffing, tasks, hazard change) to determine whether current field planning is still adequate.

Alternately, the following change management form below may be used to evaluate change conditions during field work., If this form is used, project conditions should be reviewed on a **continuous** basis to determine if the current site health and safety plan adequately addresses ongoing project work, and should be completed whenever new tasks are contemplated or changed conditions are encountered.

PROJECT HSE Change Management Form	
Project Task:	Project/Task Manager:
Project Number:	Project Name:

	Evaluation Checklist	Yes	No
1.	Has the CH2M HILL staff listed in the original HSP changed?		
2.	Has a new subcontractor been added to the project?		
3.	Is any chemical or product to be used that is not listed in Attachment 2 of the plan?		
4.	Have additional tasks been added which were not originally addressed in the "Project Information" section of this HSP?		
5.	Have new contaminants or higher than anticipated levels of original contaminants been encountered?		
6.	Has other safety, equipment, activity or environmental hazards been encountered that are not addressed in this HSP?		

If the answer is "YES" to Questions the questions above, HSP revision may be needed. For questions 4-6, contact RHSM prior to continuing work. The following actions can be taken for questions 1-3:

- Confirm that staff's medical and training status is current – check training records at: http://www.int.ch2m.com/hands (or contact your regional safety program assistant (SPA)), and confirm subcontractor qualifications.
- Confirm with the project RHSM that subcontractor safety performance has been reviewed and is acceptable.
- Confirm with the RHSM that subcontractor safety procedures have been reviewed and are acceptable.
- Add the new chemical or product information to the Chemical Inventory Form, inform the RHSM, and ensure that personnel handling the chemical or product have been trained, and that training is documented using the Chemical-Specific Training Form included as an attachment to this HSP. Add the Material Safety Data Sheet(s) (MSDS) for chemicals handled or used at the project to this HSP. AHAs may need to be developed/amended to account for new chemicals.

5.7 Worker Training and Qualification

5.7.1 CH2M HILL Worker Training

(Reference CH2M HILL SOP HSE-110, *Training*)

Hazardous Waste Operations Training

All employees engaging in hazardous waste operations or emergency response shall receive appropriate training as required by 29 CFR 1910.120 and 29 CFR 1926.65. At a minimum, the training shall have consisted of instruction in the topics outlined in 29 CFR 1910.120 and 29 CFR 1926.65. Personnel who have not met these training requirements shall not be allowed to engage in hazardous waste operations or emergency response activities.

Initial Training

General site workers engaged in hazardous waste operations shall, at the time of job assignment, have received a minimum of 40 hours of initial health and safety training for hazardous waste site operations, unless otherwise noted in the above-referenced standards.

Employees who may be exposed to health hazards or hazardous substances at treatment, storage, and disposal (TSD) operations shall receive a minimum of 24 hours of initial training to enable the employee to perform their assigned duties and functions in a safe and healthful manner.

Employees engaged in emergency response operations shall be trained to the level of required competence in accordance with 29 CFR 1910.120.

Three-Day Actual Field Experience

General site workers for hazardous waste operations shall have received three days of actual experience (on-the-job training) under the direct supervision of a trained, qualified supervisor and shall be documented. If the field experience has not already been received and documented at a similar site, this supervised experience shall be accomplished and documented at the beginning of the assignment of the project.

Refresher Training

General site workers and TSD workers shall receive 8-hours of refresher training annually (within the previous 12-month period) to maintain qualifications for fieldwork. Employees engaged in emergency response operations shall receive annual refresher training of sufficient content and duration to maintain their competencies or shall demonstrate competency in those areas at least annually.

Eight-Hour Supervisory Training

On site management or supervisors who will be directly responsible for, or supervise employees engaged in hazardous waste site operations, will have received at least 8 hours of additional specialized training on managing such operations. Employees designated as Safety Coordinator – Hazardous Waste are considered 8-hour HAZWOPER Site Safety Supervisor trained.

First Aid/Cardiopulmonary Resuscitation (CPR)

First aid and CPR training consistent with the requirements of a nationally recognized organization such as the American Red Cross Association or National Safety Council shall be administered by a certified trainer. A minimum of two personnel per active field operation will have first aid and CPR training. Bloodborne pathogen training located on CH2M HILL's Virtual Office is also required for those designated as first aid/CPR trained.

Safety Coordinator (SC) Training

SCs are trained to implement the HSE program on CH2M HILL field projects. A qualified SC is required to be identified in the site-specific Health and Safety Plan/FSIs for CH2M HILL field projects. SCs must also meet the requirements of the worker category appropriate to the type of field project (i.e., construction or hazardous waste). In addition, the SCs shall have completed additional safety training required by the specific work activity on the project that qualifies them to implement the HSE program (i.e., fall protection, excavation, etc.).

5.7.2 Hazardous Waste Operations and Emergency Response

CH2M HILL personnel expected to participate in on site hazardous waste operations or emergency response are required to have a current medical qualification for performing this work. Medical qualification shall consist of a qualified physician's written opinion regarding fitness for duty at a hazardous waste site, including any recommended limitations on the employee's assigned work. The physician's written opinion shall state whether the employee has any detected medical conditions that would place the employee at increased risk of material impairment of the employee's health from work in hazardous waste operations or emergency response, or from respirator use.

Due to the nature of hazards for a particular job or work site, specialized medical surveillance may be necessary. This surveillance could include biological monitoring for specific compounds, or specialized medical examinations.

Site-specific medical surveillance includes:

{e.g., lead}

5.7.3 Respirator User Qualification

Personnel required to wear respirators must have a current medical qualification to wear respirators. Medical qualification shall consist of a qualified physician's written opinion regarding the employee's ability to safely wear a respirator in accordance with 29 CFR 1910.134.

5.7.4 Hearing Conservation

Personnel working in hazardous waste operations or operations that fall under 29 CFR 1910.95 and exposed to noise levels in excess of the 85dBA time-weighted average shall be included in a hearing conservation program that includes annual audiometric testing.

5.8 Emergency Response Plan

(Reference CH2M HILL SOP HSE-106, *Emergency Planning*)

5.8.1 Pre-Emergency Planning

The Emergency Response Coordinator (ERC), typically the SC or designee, performs the applicable pre-emergency planning tasks before starting field activities and coordinates emergency response with CH2M HILL onsite parties, the facility, and local emergency-service providers as appropriate. Pre-Emergency Planning activities performed by the ERC include:

- Review the facility emergency and contingency plans where applicable.
- Determine what onsite communication equipment is available (e.g., two-way radio, air horn).
- Determine what offsite communication equipment is needed (e.g., nearest telephone, cell phone).
- Confirm and post the "Emergency Contacts" page and route to the hospital located in this section in project trailer(s) and keep a copy in field vehicles along with evacuation routes and assembly areas. Communicate the information to onsite personnel and keep it updated.
- Field Trailers: Post "Exit" signs above exit doors, and post "Fire Extinguisher" signs above locations of extinguishers. Keep areas near exits and extinguishers clear.
- Review changed site conditions, onsite operations, and personnel availability in relation to emergency response procedures.
- Where appropriate and acceptable to the client, inform emergency room and ambulance and emergency response teams of anticipated types of site emergencies.
- Designate one vehicle as the emergency vehicle; place hospital directions and map inside; keep keys in ignition during field activities.
- Inventory and check site emergency equipment, supplies, and potable water.
- Communicate emergency procedures for personnel injury, exposures, fires, explosions, and releases.
- Rehearse the emergency response plan before site activities begin, including driving route to hospital. Drills should take place periodically but no less than once a year.
- Brief new workers on the emergency response plan.
- The ERC will evaluate emergency response actions and initiate appropriate follow-up actions.

5.8.2 Incident Response

In fires, explosions, or chemical releases, actions to be taken include the following:

- Notify appropriate response personnel.
- Shut down CH2M HILL operations and evacuate the immediate work area.
- Account for personnel at the designated assembly area(s).

- Assess the need for site evacuation, and evacuate the site as warranted.
- Implement HSE-111, Incident Notification, Reporting and Investigation.
- Notify and submit reports to clients as required in contract.

Small fires or spills posing minimal safety or health hazards may be controlled with onsite spill kits or fire extinguishers without evacuating the site. When in doubt evacuate. Follow the incident reporting procedures in the "Incident Notification, Reporting, and Investigation" section of this HSP.

5.8.3 Emergency Medical Treatment

Emergency medical treatment is needed when there is a life-threatening injury (such as severe bleeding, loss of consciousness, breathing/heart has stopped). When in doubt if an injury is life-threatening or not, treat it as needing emergency medical treatment.

Notify 911 or other appropriate emergency response authorities as listed in the "Emergency Contacts" page located in this section.

The ERC will assume charge during a medical emergency until the ambulance arrives or until the injured person is admitted to the emergency room.

Prevent further injury, perform decontamination (if applicable) where feasible; lifesaving and first aid or medical treatment takes priority.

Initiate first aid and CPR where feasible.

Notify supervisor and if the injured person is a CH2M HILL employee, the supervisor will call the occupational nurse at 1-866-893-2514 and make other notifications as required by HSE SOP-111, *Incident Notification, Reporting and Investigation*.

Make certain that the injured person is accompanied to the emergency room.

Follow the Serious Incident Reporting process in HSE SOP-111, Incident Notification, Reporting and Investigation, and complete incident report using the HITS system on the Virtual Office or if not feasible, use the hard copy forms provided as an attachment to this HSP.

Notify and submit reports to client as required in contract.

5.8.4 Evacuation

Evacuation routes, assembly areas, and severe weather shelters (and alternative routes and assembly areas) are to be specified on the site map.

Evacuation route(s) and assembly area(s) will be designated by the ERC or designee before work begins.

Personnel will assemble at the assembly area(s) upon hearing the emergency signal for evacuation.

The ERC and a "buddy" will remain on the site after the site has been evacuated (if safe) to assist local responders and advise them of the nature and location of the incident.

The ERC will account for all personnel in the onsite assembly area.

A designated person will account for personnel at alternate assembly area(s).

The ERC will follow the incident reporting procedures in the "Incident Notification, Reporting and Investigation" section of this HSP.

Evacuation Signals

Signal	Meaning
Grasping throat with hand	Emergency-help me.
Thumbs up	OK; understood.
Grasping buddy's wrist	Leave area now.
Continuous sounding of horn	Emergency; leave site now.

5.8.5 Inclement Weather

Sudden inclement weather can rapidly encroach upon field personnel. Preparedness and caution are the best defenses. Field crew members performing work outdoors should carry clothing appropriate for inclement weather. Personnel are to take heed of the weather forecast for the day and pay attention for signs of changing weather that indicate an impending storm. Signs include towering thunderheads, darkening skies, or a sudden increase in wind. If stormy weather ensues, field personnel should discontinue work and seek shelter until the storm has passed.

Protective measures during a lightning storm include seeking shelter; avoiding projecting above the surrounding landscape (don't stand on a hilltop--seek low areas); staying away from open water, metal equipment, railroad tracks, wire fences, and metal pipes; and positioning people several yards apart. Some other general precautions include:

Know where to go and how long it will take to get there. If possible, take refuge in a large building or vehicle. Do not go into a shed in an open area.

The inclination to see trees as enormous umbrellas is the most frequent and most deadly mistake. Do not go under a large tree that is standing alone. Likewise, avoid poles, antennae and towers.

If the area is wide open, go to a valley or ravine, but be aware of flash flooding.

If you are caught in a level open area during an electrical storm and you feel your hair stand on end, drop to your knees, bend forward and put your hands on your knees or crouch. The idea is to make yourself less vulnerable by being as low to the ground as possible and taking up as little ground space as possible. Lying down is dangerous, since the wet earth can conduct electricity. Do not touch the ground with your hands.

Do not use telephones during electrical storms, except in the case of emergency

Remember that lightning may strike several miles from the parent cloud, so work should be stopped/restarted accordingly. The lightning safety recommendation is 30-30: Seek refuge when thunder sounds within 30 seconds after a lightning flash; and do not resume activity until 30 minutes after the last thunder clap.

High winds can cause unsafe conditions, and activities should be halted until wind dies down. High winds can also knock over trees, so walking through forested areas during high-wind situations should be avoided. If winds increase, seek shelter or evacuate the area. Proper body

protection should be worn in case the winds hit suddenly, because body temperature can decrease rapidly.

5.8.6 Spill Containment Procedures

CH2M HILL and subcontractor personnel working at the project site shall be knowledgeable of the potential health, safety and environmental concerns associated with petroleum and other hazardous substances that could potentially be released at the project site.

The following is a list of criteria that must be addressed in CH2M HILL's or the subcontractor's plans in the event of a spill or release. In the event of a large quantity spill notify emergency services. Personnel discovering a spill shall (only if safe to do so):

Stop the spill immediately (if possible) or note source. If unsafe conditions exist, then leave the area, call emergency services, inform nearby personnel, notify the site supervisors, and initiate incident reporting process. The SC shall be notified immediately.

Extinguish sources of ignition (e.g., flames, sparks, hot surfaces, cigarettes, etc.)

Clear personnel from the spill location and barricade the area.

Utilize available spill control equipment in an effort to ensure that fires, explosions, and releases do not occur, recur, or spread.

Use sorbent materials to control the spill at the source.

Construct a temporary containment dike of sorbent materials, cinder blocks, bricks or other suitable materials to help contain the spill.

Attempt to identify the character, exact source, amount, and extent of the released materials. Identification of the spilled material should be made as soon as possible so that the appropriate cleanup procedure can be identified.

Assess possible hazards to human health or the environment as a result of the release, fire or explosion.

A Spill Report shall be completed, including a description of the event, root causes, and corrective actions.

5.9 Site-Control Plan

(Reference CH2M HILL SOP HSE-218, *Hazardous Waste Operations)*

The SC will implement site control procedures.

The SC will conduct a site safety briefing (see below) before starting field activities or as tasks and site conditions change.

Topics for briefing on site safety: general discussion of HSP, site-specific hazards, locations of work zones, PPE requirements, equipment, special procedures, emergencies.

The SC records attendance at safety briefings in a logbook and documents the topics discussed.

Post the OSHA job-site poster in a central and conspicuous location in accordance with CH2M HILL Core Standard, *OSHA Postings*.

Establish support, contamination reduction, and exclusion zones. Delineate with flags or cones as appropriate. Support zone should be upwind of the site. Use access control at entry and exit from each work zone.

Establish onsite communication consisting of the following:

- Line-of-sight and hand signals
- Air horn
- Two-way radio or cellular telephone if available

Establish offsite communication.

Establish and maintain the "buddy system."

Initial air monitoring is conducted by the SC in appropriate level of protection.

The SC is to conduct periodic inspections of work practices to determine the effectiveness of this plan. Deficiencies are to be noted, reported to the RHSM, and corrected.

5.10 Hazwoper Compliance Plan

(Reference CH2M HILL SOP HSE-218 *Hazardous Waste Operations*)

Certain parts of the site work are covered by state or federal Hazwoper standards and therefore require training and medical monitoring. Anticipated Hazwoper tasks listed in the "General Project Information" section of this HSP might occur consecutively or concurrently with respect to non-Hazwoper tasks (also specified in the "General Project Information" section).

This section outlines procedures to be followed when approved the approved non-Hazwoper activities do not require 24- or 40-hour training. Non-Hazwoper-trained personnel also must be trained in accordance with all other state and federal OSHA requirements.

In many cases, air sampling, in addition to real-time monitoring, must confirm that there is no exposure to gases or vapors before non-Hazwoper-trained personnel are allowed on the site, or while non-Hazwoper-trained staff is working in proximity to Hazwoper activities. Other data (e.g., soil) also must document that there is no potential for exposure. The RHSM must approve the interpretation of these data.

When non-Hazwoper-trained personnel are at risk of exposure, the SC must post the exclusion zone and inform non-Hazwoper-trained personnel of the:

- Nature of the existing contamination and its locations
- Limitations of their access
- Emergency action plan for the site

Periodic air monitoring with direct-reading instruments conducted during regulated tasks also should be used to ensure that non-Hazwoper-trained personnel (e.g., in an adjacent area) are not exposed to airborne contaminants.

When exposure is possible, non-Hazwoper-trained personnel must be removed from the site until it can be demonstrated that there is no longer a potential for exposure to health and safety hazards.

Remediation treatment system start-ups: Once a treatment system begins to pump and treat contaminated media, the site is, for the purposes of applying the Hazwoper standard, considered a treatment, storage, and disposal facility (TSDF). Therefore, once the system begins operation, only Hazwoper-trained personnel (minimum of 24 hour of training) will be permitted to enter the site. All non-Hazwoper-trained personnel must not enter the TSDF area of the site.

5.11 Incident Notification, Reporting, and Investigation

(Reference CH2M HILL SOP HSE-111, *Incident Notification, Reporting and Investigation*)

5.11.1 General Information

This section applies to the following:

- All injuries involving employees, third parties, or members of the public
- Damage to property or equipment
- Interruptions to work or public service (e.g., hitting a utility)
- Incidents which attract negative media coverage
- Near misses
- Spills, leaks, or regulatory violations
- Motor vehicle accidents

Documentation, including incident reports, investigation, analysis and corrective measure taken, shall be kept by the SC and maintained onsite for the duration of the project.

5.11.2 Section Definitions

Incident: an undesired event which results or could have resulted in loss through injury, damage to assets or environmental harm. This includes all of the definitions below.

Accident: an incident involving actual loss through injury, damage to assets, or environmental harm.

Near Miss: an unsafe act or incident which, in other circumstances, could have resulted in loss through injury, damage to assets, or environmental harm.

Serious Incident:

- All fatalities including contractors, subcontractors, third parties, or members of the public
- Kidnap/Missing Person
- Event that involves a fire, explosion, or property damage that requires a site evacuation or is estimated to result in greater than $ 500,000 in damage.
- Acts or threats of terrorism
- Spill or release of hazardous materials or substances that involves a significant threat of imminent harm to site workers, neighboring facilities, the community or the environment.

5.11.3 Reporting Requirements

All employees and subcontractors' employees shall immediately report any incident (including "near misses," as defined in the section above) in which they are involved or witness to their supervisor.

The CH2M HILL or Subcontractor supervisor, upon receiving an incident report, shall inform his immediate superior and the CH2M HILL SC.

The SC shall immediately report the following information to the RHSM and PM by phone and e-mail:

- Project Name/Site Manager
- Date and time of incident
- Description of incident
- Extent of know injuries/damage
- Level of medical attention
- Preliminary root cause/corrective actions

The SC shall complete an entry into the Hours and Incident Tracking System (HITS) database system located on CH2M HILL's Virtual Office (or if VO not available, use the hard copy Incident Report Form and Root Cause Analysis Form and forward it to the RHSM) within 24 hours and finalize those forms within 3 calendar days.

The CH2M HILL team shall comply with all applicable statutory incident reporting requirements such as those to OSHA and the police.

5.11.4 HITS System and Incident Report Form (IRF)

It is the policy of CH2M HILL to maintain a HITS entry and/or Incident Report Form (IRF) for all work-related injuries and illnesses sustained by its employees in accordance with recordkeeping and insurance requirements. A HITS entry and/or IRF will also be maintained for other incidents (property damage, fire or explosion, spill, release, potential violation, and near misses) as part of our loss prevention and risk reduction initiative.

5.11.5 Injury Management/Return-to-Work (for CH2M HILL Staff Only)

(Reference CH2M HILL, SOP HSSE-124, Injury Management/Return-to-Work)

Background

The Injury Management Program has been established to provide orderly, effective and timely medical treatment and return-to-work transition for an employee who sustains a work-related injury or illness. It also provides guidance and assistance with obtaining appropriate treatment to aid recovery, keep supervisors informed of employee status, and to quickly report and investigate work-related injury/illnesses to prevent recurrence.

To implement the Injury Management/Return-to-Work Program successfully, supervisors and/or SC should:

- Ensure employees are informed of the Injury Management/Return-to-Work Program.
- Become familiar with the Notification Process (detailed below).
- Post the Injury Management/Return-to-Work Notification Poster.

The Injury Management/Return-to-Work Notification Process:

Employee informs their Supervisor.

Employee calls the Injury Management Program toll free number 1-866-893-2514 immediately and speaks with the Occupational Injury Nurse. This number is operable 24 hours per day, 7 days a week.

Supervisor ensures employee immediately calls the Injury Management Program number. Supervisor makes the call with the injured worker or for the injured worker if needed.

Nurse assists employee with obtaining appropriate medical treatment, as necessary schedules clinic visit for employee (calls ahead, and assists with any necessary follow up treatment) with the supervisor or SC accompany the employee if a clinic visit is necessary to ensure that employees receive appropriate and timely care.

Supervisor/SC completes the HITS entry or Incident Report Form immediately (within 24 hours) and forwards it to the Project Manager and RHSM.

Nurse notifies appropriate CH2M HILL staff by e-mail (supervisor, Health & Safety, Human Resources, Workers' Compensation).

Nurse communicates and coordinates with and for employee on treatment through recovery.

Supervisor ensures suitable duties are identified and available for injured/ill workers who are determined to be medically fit to return to work on transitional duty (temporary and progressive).

Supervisor ensures medical limitations prescribed (if any) by physician are followed until the worker is released to full duty.

5.11.6 Serious Incident Reporting Requirements

(Reference CH2M HILL SOP HSE-111, *Incident Reporting, Notification and Investigation*)

The Serious Incident Reporting Requirements ensures timely notification and allows for positive control over flow of information so that the incident is handled effectively, efficiently, and in conjunction with appropriate corporate entities. This standard notification process integrates Health, Safety, Security and Environment (HSSE) and Firm Wide Security Operations (FWSO) requirements for the consistent reporting of and managing of serious events throughout our operations.

Serious Incident Determination

The following are general criteria for determining whether an incident on CH2M HILL owned or managed facilities or program sites is considered serious and must be immediately reported up to Group President level through the reporting/notification process:

- Work related death, or life threatening injury or illness of a CH2M HILL employee, subcontractor, or member of the public
- Kidnap/missing person
- Acts or threats of terrorism

- Event that involves a fire, explosion, or property damage that requires a site evacuation or is estimated to result in greater than $ 500,000 in damage.
- Spill or release of hazardous materials or substances that involves a significant threat of imminent harm to site workers, neighboring facilities, the community or the environment.

Serious Incident Reporting

If an incident meets the "Serious Incident" criteria, the Project Manager is to immediately contact the Crisis Manager at 720-286-4911, then follow the standard incident reporting procedure.

For all serious incidents this standard reporting process is implemented immediately so as to ultimately achieve notification to the Business Group President within 2 hours of incident onset or discovery, and notification to appropriate corporate Crisis Management Support Team.

5.12 Records and Reports

An organized project filing system is essential for good documentation and recordkeeping. There are many benefits to an organized filing system:

- Other CH2M HILL employees can easily and quickly find documents
- Records are readily available for review
- Records may be needed during OSHA investigations, audits, or other legal matters
- Records may be needed on short notice in case of an accident, illness or other emergency
- Systematic recordkeeping aids in overall project organization

The project filing system shall be established at the beginning of the project and maintained throughout all phases of construction and archived in accordance with CH2M HILL's Records Retention Policy. The information contained in the filing system shall be updated regularly and/or as specified in this document. The PM and SC are responsible for collecting documentation, including subcontractor documentation, and maintaining a complete and organized filing system.

Below are examples of records that must be maintained as the project progresses:

- Exposure records includes air monitoring data (including calibration records), MSDSs, exposure modeling results.
- Physical hazard exposure records include noise, ionizing radiation, non-ionizing radiation, vibration, and lasers exposure assessments and measurements.
- Respiratory Fit Test Records
- Training Records
- Injury/illness reports and investigations
- Federal or State Agency Inspection Records
- Other Records
  - Ergonomic evaluations

- HSE audits and assessments
- Project-Specific HSE Plans
- Confined Space Entry Permits
- Equipment inspections
- Equipment maintenance
- SBOs
- Self-Assessment Checklists

5.13 Calibration Specifications

Calibration information for each piece of equipment must be recorded daily in the log book and retained as part of the project files. Information to be documented includes:

- Instrument name
- Serial Number
- Owner of instrument (for example, CH2M HILL, HAZCO)
- Calibration gas (including type and lot number)
- Type of regulator (for example, 1.5 lpm)
- Type of tubing (for example, direct or T-tubing)
- Ambient weather condition (for example, temperature and wind direction)
- Calibration/instrument readings
- Operator's name and signature
- Date and time

Instrument	Gas	Span	Reading	Method
PID: OVM, 10.6 or 11.8 eV bulb	100 ppm isobutylene	RF = 1.0	100 ppm	1.5 lpm reg T-tubing
PID: MiniRAE, 10.6 eV bulb	100 ppm isobutylene	CF = 100	100 ppm	1.5 lpm reg T-tubing
PID: TVA 1000	100 ppm isobutylene	CF = 1.0	100 ppm	1.5 lpm reg T-tubing
FID: OVA	100 ppm methane	3.0 ± 1.5	100 ppm	1.5 lpm reg T-tubing
FID: TVA 1000	100 ppm methane	NA	100 ppm	2.5 lpm reg T-tubing
Dust Monitor: Miniram-PDM3	Dust-free air	Not applicable	0.00 mg/m^3 in "Measure" mode	Dust-free area OR Z-bag with HEPA filter
CGI: MSA 260, 261, 360, or 361	0.75% pentane	N/A	50% LEL ± 5% LEL	1.5 lpm reg direct tubing

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6 Attachments

Attachment 1

Chemical Inventory/Register Form

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CH2MHILL

CHEMICAL INVENTORY/REGISTER FORM

Refer to Standard of Practice HSE-107 Attachment 1 for instructions on completing this form.

Location: Dow Hanging Rock

HCC: Osaguana Ogbebor

☐ Office ☐ Warehouse ☐ Laboratory ☒ Project: Dow Hanging Rock
Project No.: 420671

Regulated Product	Location	Container labeled (✓if yes)	MSDS available (✓if yes)
Alconox	Field Vehicle	X	X
Hydrochloric Acid	Field Vehicle	X	X
Liquinox	Field Vehicle	X	X

MSDS for the listed products will be maintained at: Field Vehicle

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CH2M HILL Health and Safety Plan

Attachment 2

Project Activity Self-Assessment Checklists/Permits/Forms

- **Dow Pressure Washing Checklist**
- **Dow Vehicle/Equipment Spotting PTHA Card**
- **Drilling**
- **Earthmoving Equipment (Skid Steer)**
- **Forklift**
- **Hand and Power Tools**
- **Manual Lifting**
- **Methylene Chloride**
- **Personal Protective Equipment**
- **Respiratory Protection**

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CH2M HILL Health and Safety Plan

Attachment 3

Behavior Based Loss Prevention System Forms

Activity Hazard Analysis

Safety Briefing Form

Safe Work Observations

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CH2M HILL Health and Safety Plan

Attachment 4

Material Safety Data Sheets

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CH2M HILL Health and Safety Plan

Attachment 5

Tick Fact Sheet

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Tick-Borne Pathogens — A Fact Sheet

Most of us have heard of Lyme disease or Rocky Mountain Spotted Fever (RMSF), but there are actually six notifiable tick-borne pathogens that present a significant field hazard. In some areas, these account for more than half of our serious field incidents. The following procedures should be applied during any field activity—even in places that are predominantly paved with bordering vegetation.

Hazard Recognition

An important step in controlling tick related hazards is understanding how to identify ticks, their habitats, their geographical locations, and signs and symptoms of tick-borne illnesses.

Tick Identification

There are five varieties of hard-bodied ticks that have been associated with tick-borne pathogens. These include:

- Deer (Black Legged) Tick (eastern and pacific varieties)
- Lone Star Tick
- Dog Tick
- Rocky Mountain Wood Tick

These varieties and their geographical locations are illustrated on the following page.

Tick Habitat

In eastern states, ticks are associated with deciduous forest and habitat containing leaf litter. Leaf litter provides a moist cover from wind, snow, and other elements. In the north-central states, is generally found in heavily wooded areas often surrounded by broad tracts of land cleared for agriculture.

On the Pacific Coast, the bacteria are transmitted to humans by the western black-legged (deer) tick and habitats are more diverse. For this region, ticks have been found in habitats with forest, north coastal scrub, high brush, and open grasslands. Coastal tick populations thrive in areas of high rainfall, but ticks are also found at inland locations.

Illnesses and Signs & Symptoms

There are six notifiable tick-borne pathogens that cause human illness in the United States. These pathogens may be transmitted during a tick bite—normally hours after attachment. The illnesses, presented in approximate order of most common to least, include:

- Lyme (bacteria)
- RMSF (bacteria)
- Ehrlichiosis (bacteria)
- STARI (Southern Tick-Associated Rash Illness) (bacteria)
- Tularemia (Rabbit Fever) (bacteria)
- Babesia (protozoan parasite)

Symptoms will vary based on the illness, and may develop in infected individuals typically between 3 and 30 days after transmission. Some infected individuals will not become ill or may develop only mild symptoms. These illnesses present with some or all of the following signs & symptoms: fever, headache, muscle aches, stiff neck, joint aches, nausea, vomiting, abdominal pain, diarrhea, malaise, weakness, small solid, ring-like, or spotted rashes. The bite site may be red, swollen, or develop ulceration or lesions. For Lyme disease, the bite area will sometimes resemble a target pattern. A variety of long-term symptoms may result if the illness is left untreated, including debilitating effects and death.

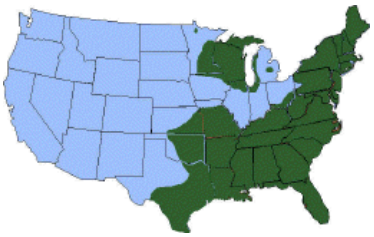
Deer Tick

From Left: adult female, adult male, nymph, and larvae Deer Tick (cm

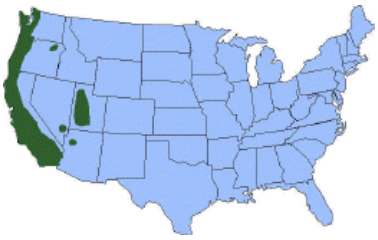
Lone Star Tick

Dog Tick

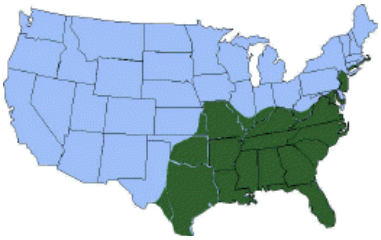
Rocky Mountain Wood Tick



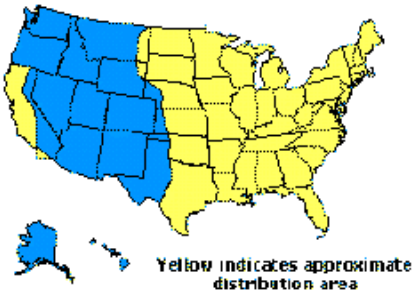
Distribution of Deer Tick (dark green)

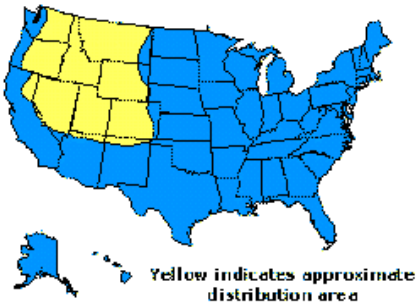


Distribution of Pacific Deer Tick (dark green)



Distribution of Lone Star Tick (Green)





Hazard Control

The methods for controlling exposure to ticks include, in order of most- to least-preferred:

- Avoiding tick habitats and ceasing operations in heavily infested areas
- Reducing tick abundance through habitat disruption or application of acracide
- Personal protection through use of repellants and protective clothing
- Frequent tick inspections and proper hygiene

Vaccinations are not available and preventative antibiotic treatment after a bite is generally not recommended.

Avoidance and Reduction of Ticks

To the extent practical, tick habitats should be avoided. In areas with significant tick infestation, consider stopping work and withdrawing from area until adequate tick population control can be achieved. Stopping and withdrawing should be considered as seriously as entering an area without proper energy control or with elevated airborne contaminants—tick-borne pathogens present risk of serious illness!

In areas where significant population density or infestation exists, tick reduction should be considered. Tick reduction can be achieved by disrupting tick habitats and/or direct population reduction through the use of tick-toxic pesticides (Damminix, Dursban, Sevin, etc.).

Habitat disruption may include only simple vegetative maintenance such as removing leaf litter and trimming grass and brush. Tick populations can be reduced by between 72 and 100 percent when leaf litter alone is removed. In more heavily infested areas, habitat disruption may include grubbing, tree trimming or removal, and pesticide application (Damminix, Dursban, Sevin, etc.). This approach is practical in smaller, localized areas or perimeter areas that require occasional access. Habitat controls are to be implemented with appropriate health and safety controls, in compliance with applicable environmental requirements, and may be best left to the property owner or tenant or to a licensed pesticide vendor. Caution should be exercised when using chemical repellents or pesticides in or around areas where environmental or industrial media samples will be collected for analysis.

Personal Protection

After other prevention and controls are implemented, personal protection is still necessary to control exposure to ticks. Personal protection must include all of the following steps:

- So that ticks may be easily seen, wear light-colored clothing. Full-body New Tyvek (paper-like disposable coveralls) may also be used
- To prevent ticks from getting underneath clothing tuck pant legs into socks or tape to boots
- Wear long-sleeved shirts, a hat, and high boots
- Apply DEET repellent to exposed skin or clothing per product label
- Apply permethrin repellent to the outside of boots and clothing before wearing, per product label
- Frequently check for ticks and remove from clothing
- At the end of the day, search your entire body for ticks (particularly groin, armpits, neck, and head) and shower
- To prevent pathogen transmission through mucous membranes or broken/cut skin, wash or disinfect hands and/or wear surgical-style nitrile gloves any time ticks are handled

Pregnant individuals and individuals using prescription medications should consult with their physician and/or pharmacists before using chemical repellents. Because human health effects may not be fully known, use of chemical repellents should be kept to a minimum frequency and quantity. Always follow manufacturers' use instructions and precautions. Wash hands after handling, applying, or removing protective gear and clothing. Avoid situations such as hand-to-face contact, eating, drinking, and smoking when applying or using repellents.

Remove and wash clothes per repellent product label. Chemical repellents should not be used on infants and children.

Vaccinations are generally not available for tick-borne pathogens. Although production of the LYMErix™ Lyme disease vaccination has been ceased, vaccination may still be considered under specific circumstances and with concurrence from the consulting physician.

Tick Check

A tick check should be performed after field survey before entering the field vehicle (you do not want to infest your field vehicle with ticks). Have your field partner check your back; the backs of your legs, arms, and neck; and your hairline. Shake off clothing as thorough as possible before entering the vehicle. Once the field day is complete, repeat this procedure and perform a thorough self check.

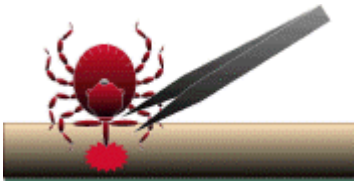
If a tick has embedded itself into the skin, remove the tick as described below.

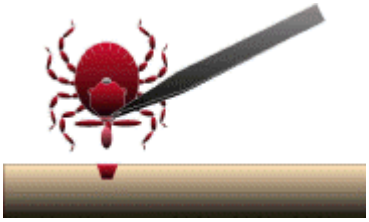
Tick Removal

1. Use the tick removal kit obtained through the CH2M HILL Milwaukee warehouse, or a fine-tipped tweezers or shield your fingers with a tissue, paper towel, or nitrile gloves.

Tick Bites\Tick Remover.pdf

2. Grasp the tick as close to the skin surface as possible and pull upward with steady, even pressure. Do not twist or jerk the tick; this may cause the mouthparts to break off and remain in the skin. If this happens, remove mouthparts with tweezers. Consult your healthcare provider if infection occurs.





3. Avoid squeezing, crushing or puncturing the body of the tick because its fluids (saliva, hemolymph, gut contents) may contain infectious organisms. Releasing these organisms to the outside of the tick's body or into the bite area may increase the chance of infectious organism transmission.

4. Do not handle the tick with bare hands because infectious agents may enter through mucous membranes or breaks in the skin. This precaution is particularly directed to individuals who remove ticks from domestic animals with unprotected fingers. Children, elderly persons, and immunocompromised persons may be at greater risk of infection and should avoid this procedure.

5. After removing the tick, thoroughly disinfect the bite site and wash your hands with soap and water.

6. Should you wish to save the tick for identification, place it in a plastic bag, with the date of the tick bite, and place in your freezer. It may be used at a later date to assist a physician with making an accurate diagnosis (if you become ill).

Note: Folklore remedies such as petroleum jelly or hot matches do little to encourage a tick to detach from skin. In fact, they may make matters worse by irritating the tick and stimulating it to release additional saliva, increasing the chances of transmitting the pathogen. These methods of tick removal should be avoided. In addition, a number of tick removal devices have been marketed, but none are better than a plain set of fine tipped tweezers.

First-Aid and Medical Treatment

Tick bites should always be treated with first-aid. Clean and wash hands and disinfect the bite site after removing embedded tick. Individuals previously infected with Lyme disease does not confer immunity—re-infection from future tick bites can occur even after a person has contracted a tick-borne disease.

The employee should contact the Injury Management/Return To Work provider (IMRTW), WorkCare using the toll-free number 866-893-2514 to report the tick bite. WorkCare will follow-up with each CH2M Hill employee who reports a tick bite and is at risk of developing Lyme disease by monitoring for symptoms up to 45 days, and will refer the employee to a medical provider for evaluation and treatment as necessary.

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CH2M HILL Health and Safety Plan

Attachment 6

Working Alone Standard

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CALL – IN CONTACT FORM

Date of site work:_____ Expected start time:_____

Name of CH2M HILL employee in the field:_____

Name of CH2M HILL employee responsible to receive contact:

Client Emergency Contact (if any):

CH2M HILL employee's contact numbers:

Radio #_____

Cell Phone #_____

Address and Location of work:_____

Directions/Map:

Planned Activity:_____

Specified Frequency and time for call in:_____

Time	Verified	Location

If lone worker fails to call in at specified frequency/time:

1) Call worker's radio and cell to determine if an emergency exists.
2) If no reply, immediately call Client security/emergency service if there is one at the site.
3) If there is no client security call Emergency Services (911). Inform the dispatcher there is a lone worker that cannot be contacted and there may be an emergency

on site. Provide the lone worker's name, their last known location, and your contact information.

4) After Emergency Services have been contacted, call the other emergency contacts, Project Manager, and Health and Safety Manager.

Appendix H
Quality Assurance Project Plan

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Quality Assurance Project Plan
Dow Hanging Rock
Ironton, Ohio

Prepared for

The Dow Chemical Company

November 2011

CH2MHILL®

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Acronyms and Abbreviations

%R	percent recovery
°C	degrees Celsius
AOC	area of concern
CAD	computer-aided drafting
CCB	continuing calibration blank
CLP	Contract Laboratory Program
COC	chain-of-custody
Dow	The Dow Chemical Company
DQO	data quality objective
EDD	electronic data deliverable
facility	The Dow Chemical Company Hanging Rock Facility
FD	field duplicate
FSP	field sampling plan
FTL	field team leader
GIS	geographic information system
HCl	hydrochloric acid
ICB	initial calibration blank
ICP	inductively coupled plasma
ID	identification
L	liter
LCL	lower control limit
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LIMS	laboratory information management system
MB	method blank
MDL	method detection limit
mL	milliliter
MS	matrix spike

MSA	method of standard addition
MSD	matrix spike duplicate
PM	project manager
QA	quality assurance
QAM	quality assurance manual
QAPP	quality assurance project plan
QC	quality control
RFI	Resource Conservation and Recovery Act facility investigation
RL	reporting limit
RPD	relative percent difference
SM	site manager
SOP	standard operating procedure
SVOC	semivolatile organic compound
SWMU	solid waste management units
TB	trip blank
UCL	upper control limit
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound

SECTION 1

Project Management

1.1 Introduction

This quality assurance project plan (QAPP) contains the detailed quality assurance (QA)/quality control (QC) procedures used for the sampling and analysis of soil from The Dow Chemical Company (Dow) Hanging Rock Facility (hereafter referred to as the facility), 925 County Road 1-A, Ironton, Ohio. This QAPP has been tailored for use with the field sampling plan (FSP) included with this work plan.

1.2 Project Task/Organization

A project team composed of CH2M HILL, its subcontractors, and an analytical laboratory will be assembled. CH2M HILL will have overall responsibility for conducting the sampling and monitoring activities specified in the QAPP. Project roles and responsibilities, as determined to date, are listed in Table 1-1.

TABLE 1-1
Project Roles and Responsibilities
Quality Assurance Project Plan, Dow Hanging Rock, Ohio

Name	Title	Responsibilities	Telephone
Timothy A. King	Dow Remedial Applicant, Remediation Leader	Administrative, decision, and approval authority for Dow Hanging Rock, OH facility.	304-747-3763
Mike Ratliff	Dow Site Contact	Onsite contact at the Dow Hanging Rock, OH facility	740-533-4026
Lisa Cundiff	CH2M HILL Project/Site Manager	Supporting Dow in decision making and implementing decisions for the facility.	314-335-3010
David Boehnker	CH2M HILL Senior Technologist	Providing strategic input and technical review to project team.	937-220-2971
Rachel Grand	Assistant Project Manager	Coordinate, direct, and participate in facility activities, coordinate field and laboratory schedules, ensure adherence to the QAPP, communicate issues to Project Manager and field team.	314-335-3018
Osagouna Ogbebor	Field Team Lead	Direct and participate in field activities, ensure health and safety compliance, provide instruction to field staff	937-220-2904
Jason Kearns	CH2M HILL Health and Safety Officer	Oversee and approve facility HS&E Plan, provide programmatic and facility specific health and safety input.	304-747-2511
Shane Lowe	Project Chemist	Oversee analytical activities, track data and oversee data evaluation. Serve as sampling and analytical coordinator to manage samples.	314-335-3024
Dan Moore, Critigen	Data Manager	Oversee analytical data management activities.	314-335-3029

1.2.1 CH2M HILL Project Manager

The CH2M HILL project manager (PM) responsibilities include supporting Dow in producing quality work products within the authorized schedule and budget. The PM is responsible for implementing the project and is authorized to commit resources to meet project objectives and requirements. The PM's primary function is to achieve technical, financial, and scheduling objectives.

The PM will report directly to Dow and will be the major point of contact for matters concerning the project. More specifically, the PM will do the following:

- Define project objectives and develop a detailed work plan and schedule
- Establish project policy and procedures to address the specific needs of the project as a whole, as well as the objectives of each task
- Acquire and apply technical and corporate resources to meet budget and schedule constraints
- Orient field leaders and support staff with regard to the project's special considerations
- Monitor and direct other team members
- Develop and meet ongoing project or task staffing requirements, including mechanisms to review and evaluate each task product
- Review the work performed on each task to ensure quality, responsiveness, and timeliness
- Review and analyze overall task performance with regard to planned schedule and budget
- Review external reports (deliverables) before submission to the U.S. Environmental Protection Agency (USEPA)
- Represent the project team at meetings

1.2.2 CH2M HILL Site Manager

The CH2M HILL site manager (SM) serves as a senior technical resource to the team and becomes a second line of communication with Dow and project stakeholders as necessary to keep them informed of the work progress. For this project, Lisa Cundiff functions as the PM and SM.

1.2.3 CH2M HILL Field Team Leader

The CH2M HILL field team leader (FTL) responsibilities and duties include the following:

- Provide instruction to and coordinate activities with field staff
- Direct and participate in fieldwork activities
- Coordinate field and laboratory schedules
- Ensure all field activities are conducted according to this QAPP
- Inspect and accept all supplies and consumables
- Communicate issues to the project team

- Identify and document nonconformances and corrective actions
- Verify that all field personnel are properly trained to perform field activities according to this QAPP, have proper certification (such as current hazardous waste operations training), and are compliant with medical monitoring requirements

1.2.4 CH2M HILL Project Chemist

The CH2M HILL project chemist will be responsible for tracking data and overseeing data evaluation. Specific responsibilities include the following:

- Schedule and serve as the point of contact for analytical services
- Oversee field custody and documentation procedures
- Oversee the tracking of samples and data from the time of field collection until results have been evaluated for use in project reporting
- Perform or oversee the validation of data provided by the analytical laboratory using the USEPA Functional Guidelines for Data Validation
- Oversee the production of result tables
- Aid in evaluating data usability

1.2.5 Data Manager

The data manager or designee will be responsible for the following:

- Assisting the field team in maintaining the field database's sample tracking program, which initiates the sampling tracking process and is used to collect sample specific information and generate sample labels, field forms, and chains-of-custody (COCs).
- Helps develop and distribute standardized field data collection tools and forms to team members and provides instructions for use.
- Receives field data (after review by the field team) and prepares it for upload into the data warehouse. Reviews the field data for completeness and communicates to the field team any anomalies, inconsistencies, or omissions.
- Oversees upload of all field data after verification and review procedures are complete.
- Oversees upload of all electronic validated chemical data received from the project chemist.
- Maintains project databases.
- Works with the project manager to coordinate the production of figures and maps by appropriate staff (geographic information system [GIS], computer-aided drafting [CAD], hydrology, publications services).
- Prepares draft data entities for review before submittal to the PM (or other technical staff).

- Archives all data entities, any hard copy or electronic client data deliverables, and all correspondence records on project server.

1.2.6 Analytical Laboratory

Overall responsibilities and duties of the analytical laboratory include the following:

- Perform sample analyses and follow associated laboratory QA/QC procedures
- Supply sample containers and shipping cartons
- Maintain laboratory custody of samples
- Adhere to all protocols in the QAPP

The responsibilities and duties of the analytical laboratory project manager include the following:

- Monitor workloads and ensure availability of resources
- Oversee preparation of analytical reports
- Supervise in-house COC
- Coordinate and supervise activities with other laboratories, as necessary
- Serve as primary communication link between the project team, sampling personnel, and laboratory technical staff

The laboratory sample custodian will report to the laboratory operations manager. Responsibilities of the laboratory custodian include the following:

- Receiving and inspecting the incoming sample containers
- Recording the condition of the incoming sample containers
- Signing appropriate documents
- Verifying COC
- Notifying laboratory manager and laboratory supervisor of sample receipt and inspection
- Assigning a unique identification (ID) number and customer number, and entering each into the sample receiving log
- With the help of the laboratory manager, initiating transfer of the samples to appropriate laboratory sections
- Controlling and monitoring access and storage of samples and extracts

1.3 Problem Definition/Background

1.3.1 Project Background

The facility is a manufacturing plant built in 1957. The facility currently manufactures and ships polymeric beads and foams. The investigation will investigate solid waste management units (SWMUs) and areas of concern (AOCs) identified as requiring further investigation by USEPA.

Further details concerning the scope of work and project objectives are contained in the Resource Conservation and Recovery Act facility investigation (RFI) work plan, for which this QAPP is included as an appendix.

1.4 Project/Task Description

This investigation will consist of soil and sediment sampling. Table 1-2 summarizes the sampling to be performed. The purpose of this investigation is to investigate and define the nature and extent of contamination at the site.

TABLE 1-2
Sample Summary
Quality Assurance Project Plan, Dow Hanging Rock, Ohio

Area	Number/Type of Sample Locations	Analytical Parameters	Samples	FD	TB[a]	MS	MSD	Total[b]
Soil/Sediment								
Borings	27	VOCs, SVOCs, RCRA Metals	136	14	14	8	8	173
Sediment	5	VOCs, SVOCs, RCRA Metals	5	1	1	1	1	9

[a] One per cooler containing volatile organic compound analysis
[b] Total number of trip blanks, temperature blanks, field duplicates and MS/MSD may change
FD – field duplicate
MS – matrix spike
MSD – matrix spike duplicate
TB – trip blank
VOC – volatile organic compound
SVOC – semivolatile organic compound

1.5 Quality Objectives and Criteria for Measurement Data

The objective of this QAPP is to develop and implement procedures for sampling, decontamination, COC, laboratory analyses, instrument calibration, data reduction and reporting, internal QC, audits, preventive maintenance, and corrective action such that valid data will be generated.

1.5.1 Data Quality Objectives

Data quality objectives (DQOs) are qualitative and quantitative statements that specify the quality of data required to support decisions made during or after facility-related activities. Table 1-3 summarizes the DQOs for this project.

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TABLE 1-3
Data Quality Objectives Summary
Quality Assurance Project Plan, Dow Hanging Rock, Ohio

DQO	Step 1–State the Problem	Step 2–Goal of the Study	Step 3–Information Inputs	Step 4–Study Boundaries	Step 5–Analytic Approach	Step 6–Performance or Acceptance Criteria	Step 7–Plan for Obtaining Data
1	*Problem.* The following SWMUs and AOCs were identified as requiring further investigation to determine if there has been a release to the environment: • SWMU-01 (Former Flaring Pad) • SWMU-07 (Former Road Side Storage Area) • SWMU-08 (Former Waste Fuel Storage Tanks) • SWMU-11 (Satellite Accumulation Area-ETHAFOAM™ Plant) • SWMU-12 (Former Methylene Chloride Cleaning Tank) • SWMU-15 (Two-Section Septic Tank System) • SWMU-17 (Stormwater Drainage System) • SWMU-18 (Drainage Ditch to Big Thief Creek) • SWMU-19 (Drainage Ditch to North) • SWMU – 24 (Process Sewer Line) • SWMU-25-28 (Former Wastewater Treatment System) • SWMU-29 (Former Used Filter Sand Pile) • SWMU-36 (Former 250-Gallon Pressurized Storage Tanks) • SWMU-37 (Fire Protection Collection Basin) • AOC-A (Styrene Spill Near Pump for Styrene Storage Tanks) • AOC-B (Blowing Agent Release) • AOC-C (Process Filter Area) • AOC-D (Underground Catalyst Storage Tank) • AOC-E (Anecdotal Release Information) • AOC-06 (Barge Demolition Area) • AOC-07 (Former Container Storage Area 2) • AOC-08 (Former Container Storage Area 3) • AOC-09 (Outside Burn Area 2) *CSM of the potential hazard.* Operational information alone is not sufficient to confirm whether there were releases from the SWMUs and AOCs, and if so, are hazardous constituents present at levels exceeding risk based screening criteria in soil at the site. Soil may be contacted by onsite workers and trespassers. *General intended use of collected data.* The data collected in this study will be used to determine if site concentrations exceed background and risk-based concentrations.	*Principal study question.* Do chemicals in soil exist at concentrations greater than background and risk-based screening levels protective of potential exposure pathways at each SWMU and AOC? *Range of possible outcomes:* • Sampling results show that no release has occurred and no further corrective action is necessary. • Chemicals associated with facility operations are detected in soil at concentrations below risk-based screening criteria, indicating no further corrective action is necessary • Chemicals associated with facility operations are detected in soil at levels which exceed risk-based screening criteria. Additional samples should be collected to assess risk to the environment and/or human health. • Delineation to risk-based concentrations has not been achieved at the SWMU or AOC; additional soil samples should be collected until delineation is complete. • Chemicals associated with facility operations are detected in soil at levels which are considered to be an immediate threat to ecological health (select sites) or to human health. Dow, with concurrence from USEPA, will evaluate steps needed to reduce risk to the environment and/or human health.	*Information needed to resolve the decision statement.* Surface and subsurface soil data are needed to determine if releases have occurred and if site-related constituents are present at concentrations that exceed RBSLs. *Source of information.* USEPA RSLs (for human health) and Eco-SSLs for ecological receptors will be used as risk-based concentrations for screening. Site data will be compared to site-specific background soil levels. *How the action level will be determined.* USEPA RSLs and Eco-SSLs for soil will be compared to detected concentrations. RSLs will be adjusted downward by a factor of 10 to account for potential cumulative effects from multiple chemicals. *Variables/characteristics to be measured.* Based on review of waste streams at the facility, analytical parameters for all soil samples will be VOCs, SVOCs, and RCRA metals. *Sampling and analysis methods.* Analyses will be performed according to the following USEPA SW-846 methods: VOCs by SW8260B, SVOCs by SW8270C, and RCRA metals by SW6010B\6020\7471 series methods. Laboratory reporting limits will be less than risk-based concentrations unless standard laboratory methods cannot achieve risk-based concentrations.	*Target population.* Onsite human receptors and ecological receptor populations at select sites. Surface soil (0 to 2 feet) and combined surface and subsurface soil (0 to 10 feet) will be evaluated. For ecological assessment, only the 0 -to 2-foot interval will be evaluated. *Spatial.* For the Phase 1 RFI, the project area is defined by each SWMU and AOC at the site. *Scale of estimates to be made.* The analytical results will facilitate risk-based evaluations at each SWMU and AOC. Concentrations measured in the soil are not expected to change significantly over time and therefore current concentrations will be used to represent future concentrations. *Scale of inference for decision making.* The decision unit is an individual SWMU or AOC at the time of sampling.	*HHRA action levels.* USEPA RSLs for industrial (SWMU 18 will be compared to residential) soil will be compared to detected concentrations; screening levels for noncancer effects will be adjusted downward by a factor of 10 to account for potential cumulative effects from multiple chemicals. *ERA action levels for surface soil.* USEPA Eco-SSLs, if available, will be used as the primary basis for identification of ecological screening values. For constituents without Eco-SSLs, USEPA Region 5 RCRA ESLs (USEPA 2003b) will be used. For chemicals without ESLs and Eco-SSLs, USEPA Region 3 BTAG screening values will be used as a tertiary source (USEPA 1995) *ERA action levels for water*. Potential sources of surface water screening values will include Ohio surface water quality standards, USEPA Region 5 RCRA ESLs (USEPA 2003), USEPA Region 3 BTAG screening values (USEPA 2007), and/or other appropriate values from the literature. *Population of interest and the theoretical decision rule.* The long-term EPC is the appropriate parameter to characterize potential exposures by receptors. If the maximum detected concentration at the SWMU or AOC (represented by the soil samples) exceeds the screening level, the need for collecting additional samples will be evaluated, in consideration of surrounding concentrations, background levels, and the extent of exceedances.	*Baseline condition.* Soil data will be used to make a yes/no decision by comparing the maximum detected concentration to the risk-based screening level. In this situation, a statistical hypothesis test is not being performed and, therefore, it is not necessary to specify limits on making a wrong decision. If concentrations of inorganics in soil at an individual SWMU or AOC are within background levels or below risk-based screening levels, inorganic concentrations are not a concern. If soil concentrations at an individual SWMU or AOC exceed risk-based concentrations, further evaluation of soil may be warranted. If detected soil concentrations at an individual SWMU or AOC exceed 100 times the risk-based screening levels, the need for immediate action will be evaluated.	*Select the sampling design.* Discrete soil samples will be collected from each SWMU and AOC. Because spills or leaks may have occurred on the surface of each SWMU or AOC, and impact may have migrated deeper into the soil column, surficial soil (0 to 2 feet) and subsurface soil (2 to 10 feet) are the exposure intervals of interest. Samples will be sent to an offsite laboratory for analysis.

TABLE 1-3
Data Quality Objectives Summary
Quality Assurance Project Plan, Dow Hanging Rock, Ohio

DQO	Step 1–State the Problem	Step 2–Goal of the Study	Step 3–Information Inputs	Step 4–Study Boundaries	Step 5–Analytic Approach	Step 6–Performance or Acceptance Criteria	Step 7–Plan for Obtaining Data
2	*Problem.* Subsurface stratigraphy and groundwater flow at the site have not been evaluated and therefore potential migration pathways are not understood. *CSM of the potential hazard.* Groundwater . *General intended use of collected data.* Establish flow direction and general site stratigraphy.	*Principal study question.* What is the sitewide groundwater flow direction and shallow (to bedrock) subsurface stratigraphy? *Range of possible outcomes:* • Information is adequate to describe subsurface stratigraphy and groundwater flow direction. • Further information is needed to adequately describe stratigraphy. • Further information is needed to identify groundwater flow direction. • The groundwater CSM will be applied to the Phase 2 RFI addressing potential groundwater contamination.	*Information needed to resolve the decision statement.* • Historical data were reviewed to develop preliminary groundwater flow direction and subsurface stratigraphy. These preliminary data will be used to estimate preliminary locations of monitoring wells and borings. • A sitewide groundwater elevation investigation is needed to determine groundwater flow direction. Data will be used to determine fate and transport of potential contamination. If soil results indicate impact, the groundwater elevation investigation will provide the information needed to determine the appropriate locations for groundwater monitoring. • Boring logs are needed to evaluate site stratigraphy. *Source of information.* Ohio database review, letters of inquiries to environmental agencies. *How the action level will be determined.* Not applicable. *Variables/characteristics to be measured.* Water level. *Sampling and analysis methods.* The groundwater level will be measured using a depth to water meter. The recorded water level will be plotted with the surveyed well elevation to determine the depth to water. The flow direction will be determined by comparing the groundwater levels at the wells to each other. Soil will be logged by a geologist as the wells are installed and the logs will be used to determine the stratigraphy of the site.	*Target population.* Sitewide groundwater (to bedrock) will be evaluated. *Spatial.* The project area is defined by the boundaries of the site. *Temporal.* The groundwater flow direction will be evaluated periodically to determine if there are seasonal variations. *Scale of estimates to be made.* The borings installed and water level readings collected at each SWMU or AOC will be assumed to represent the stratigraphy and water levels at the individual SWMU or AOC. *Scale of inference for decision making.* The stratigraphy and water level readings will be used to develop a sitewide interpretation of flow direction and aquifer characteristics.	*Population of interest and the theoretical decision rule.* If information is adequate to develop a CSM of the subsurface stratigraphy and to determine the groundwater flow, no additional wells will be recommended for determining groundwater flow direction or subsurface stratigraphy. If insufficient information has been collected to describe the groundwater CSM, further studies will be recommended.	*Baseline condition.* Subsurface stratigraphy and groundwater flow direction will be used to prepare the groundwater CSM. The potential for groundwater contamination will be evaluated during the Phase II RFI.	*Select the sampling design.* Soil borings will be installed in each SWMU and AOC to log subsurface stratigraphy across the site. Three of the soil borings are proposed for completion (to bedrock. Water levels will be measured at well to evaluate groundwater flow direction.

TABLE 1-3
Data Quality Objectives Summary
Quality Assurance Project Plan, Dow Hanging Rock, Ohio

DQO	Step 1–State the Problem	Step 2–Goal of the Study	Step 3–Information Inputs	Step 4–Study Boundaries	Step 5–Analytic Approach	Step 6–Performance or Acceptance Criteria	Step 7–Plan for Obtaining Data
3	*Problem.* The relationship between soil impacts at the AOCs and SWMUS and any potential sitewide groundwater contamination is poorly understood. *CSM of the potential hazard.* Historical releases from the SWMUs and AOCs may have impacted groundwater at the site. *General intended use of collected data.* The information collected during Phase 1 will be used to determine where groundwater samples should be collected as part of the Phase 2 RFI.	*Principal study question.* Which AOCs and SWMUs are potentially contributing to groundwater contamination? *Range of possible outcomes:* • Information is adequate to determine that there are no impacts to sitewide groundwater. • Information is adequate to identify potential AOCs or SWMUS that may be contributing to groundwater contamination. • Further information is needed to determine which SWMUS or AOCs are potentially contributing to groundwater contamination. • Soil concentrations are a potential source for groundwater impact. Groundwater will need to be analyzed. • The groundwater CSM described in DQO 2 will be applied to the Phase 2 RFI addressing groundwater contamination, if needed.	*Information needed to resolve the decision statement:* • Historical and soil data collected as part of the Phase 1 investigation. If soil results indicate impact, the groundwater elevation investigation will provide the information needed to determine the appropriate locations for groundwater monitoring. • Groundwater elevations from wells installed as part of the Phase 1 investigation will be reviewed to develop preliminary groundwater flow direction and subsurface stratigraphy. This preliminary data will be used to estimate preliminary locations of monitoring wells and borings. *Source of information.* Previous investigations and results from Phase 1 investigation. *How the action level will be determined.* Action levels will be the risk-based soil screening levels for protection of groundwater, as presented in the USEPA RSL table. *Variables/characteristics to be measured.* Analytical soil data, water levels. *Sampling and analysis methods.* Not applicable.	*Target population.* Groundwater as delineated by AOCs and SWMUs with soil exceedances as determined from the Phase 1 RFI. *Spatial.* The project area is initially defined by the boundaries of the site. *Temporal.* To be determined after the conclusion of the Phase 1 RFI. *Scale of estimates to be made.* Current analytical data will be presumed to be indicative of future conditions. Groundwater elevations measured during Phase 1 will be assumed to be representative of water level. *Scale of inference for decision making.* The analytical soil data, stratigraphy and water level readings will be used to determine areas of the site that require further groundwater investigation.	*Population of interest and the theoretical decision rule.* I f information is adequate to develop a CSM of the site, including subsurface stratigraphy and sources of potential groundwater contamination, then locations for groundwater sampling will be identified based on results of the Phase I RFI. If necessary, groundwater samples will be collected during the Phase 2 RFI. If insufficient information has been collected to describe the groundwater CSM, further studies will be recommended. *HHRA action levels.* If groundwater sampling is performed, USEPA RSLs for tap water will be compared to detected concentrations; RSLs for noncancer effects will be adjusted downward by a factor of 10 to account for potential cumulative effects from multiple chemicals.	*Baseline condition.* Analytical data and physical site information will be evaluated to determine the need for a groundwater analytical investigation. Groundwater impact will be evaluated during the Phase II RFI.	*Select the sampling design.* The data collection program described in DQOs 1 and 2 will be evaluated. Data that exceeds screening levels will be used to determine the need and location of a sitewide groundwater investigation.

AOC - area of concern
CSM – conceptual site model
Eco-SSL - ecological soil screening levels
ERA - ecological risk assessment
HHRA – human health risk assessment
RFI - Resources Conservation Recovery Act facility investigation
SVOC - semivolatile organic compound
USEPA – United States Environmental Protection Agency
BTAG - Biological Technical Assistance Group
Dow – The Dow Chemical Company
EPC - exposure point concentration
ESL - ecological screening level
RCRA - Resources Conservation Recovery Act
RSL - regional screening level
SWMU - solid waste management unit
VOC - volatile organic compound

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1.5.2 Measurement Performance Criteria

The measurement performance criterion is checked on several levels as follows:

- Built-in QC standards
- Senior review
- Management controls

The measurement data are given specific QC standards by which they must abide. If these standards are not met, the data are suitably qualified. The bench chemist, the laboratory's QA manager, and a CH2M HILL data validator will check the analytical data and the QC results.

Data Precision, Accuracy, Comparability, Completeness, and Sensitivity

Field QA/QC samples and laboratory internal QA/QC samples will be collected and analyzed to assess the data's usability. The laboratory's standard operating procedures (SOPs) provide acceptance criteria for precision and accuracy requirements for these QC samples to assess their usability. Completeness is the percentage of usable data obtained during the sampling event and its acceptance criteria is project-specific.

Precision. Precision is a measure of reproducibility of analytical results. It can be defined as the degree of mutual agreement among individual measurements obtained under similar conditions. Total precision is a function of the variability associated with both sampling and analysis.

Precision of laboratory analysis will be assessed by comparing the analytical results between the laboratory control sample (LCS)/laboratory control sample duplicates (LCSDs) and matrix spike (MS)/matrix spike duplicates (MSDs). The precision of the field sampling procedures will be assessed by reviewing field duplicate sample results. The relative percent difference (RPD) will be calculated for the duplicate samples using the following equation:

$$RPD = \{(S - D)/[(S + D)/2]\} \times 100$$

Where: S = First sample value (original value)
D = Second sample value (duplicate value)

The precision criteria for duplicate samples will be ± 50 percent. The limits provided in the laboratory's individual SOPs will be used for LCS/LCSD and MS/MSD precision criteria.

Accuracy. Accuracy is of the degree of agreement between an observed value and a "true" value (correctness) and includes a combination of the random error (precision) and systematic error (bias) components that result from the sampling and analytical procedures. It therefore reflects the total error associated with a measurement. A measurement is considered accurate when the reported value agrees with the true value or known concentration of the spike or standard within acceptable limits. Accuracy of laboratory results will be assessed for compliance with the established QC criteria using the analytical results of method blanks/field blanks, reagent/preparation blanks, LCS/LCSD samples, MS/MSD samples, and surrogate spikes. Laboratory results accuracy will be assessed for compliance with the established QC criteria described in the SOPs. The percent recovery (%R) of laboratory control samples will be calculated using the following equation:

$$\%R = (A/B) \times 100$$

Where: A = The analyte concentration determined experimentally from the laboratory control sample
B = The known amount of concentration in the sample

Laboratory limits will be used to assess the accuracy criteria for the QA/QC samples.

Completeness. The data completeness of laboratory analyses results will be assessed for compliance with the amount of data required for decision making. Complete data are data that are not rejected for projected use. Data qualified with qualifiers such as a "J" or a "UJ" are still deemed acceptable and can still be used to make project decisions. The completeness of the analytical data is calculated using the following equation:

$$\% \text{ Completeness} = [(\text{Valid data obtained}) / (\text{Total data planned})] \times 100$$

The completeness goal for this sampling event is 95 percent.

Representativeness. Representativeness is the degree to which sampling data accurately and precisely represent facility conditions and depends on sampling and analytical variability and the variability of environmental media at the facility. Representativeness is a qualitative "measure" of data quality.

The goal of achieving representative data in the field starts with a properly designed and executed sampling program that carefully considers the overall DQO for the project. Proper location controls and sample handling are critical to obtaining representative samples.

The goal of achieving representative data in the laboratory is measured by assessing accuracy and precision. A laboratory will provide representative data when all of the analytical systems are in control; therefore, representativeness is a redundant DQO for laboratory systems if proper analytical procedures are followed and holding times are met.

In addition, laboratories must demonstrate that its staff is qualified to perform the analyses, is certified, and is proficient with analytical methods being employed.

Comparability. Comparability is the degree of confidence with which one data set can be compared to another. Comparability is a qualitative "measure" of data quality.

The goal of achieving comparable data in the field starts with a properly designed and executed sampling program that carefully considers the overall DQO for the project. Proper location controls and sample handling are critical to obtaining comparable samples.

The goal of achieving comparable data in the laboratory is measured by assessing accuracy and precision. A laboratory will provide comparable data when all of the analytical systems are in control; therefore, comparability is a redundant DQO for laboratory systems if proper analytical procedures are followed and holding times are met.

Sensitivity. Sensitivity is defined as the ability of the method or instrument to detect the constituent of concern and other target compounds at the level of interest. Appropriate sampling and analytical methods have been selected that have method detection and quantification limits that support the achievement of the desired sensitivity and established performance criteria.

Senior Review/Management Controls

All documents that pertain to the quality standards of the project are drafted by and reviewed internally by CH2M HILL personnel with relevant technical experience. While performing field sampling activities, the FTL will supervise activities to assess if SOPs are being followed. Specific QC checks and corrective action measures are described in Section 2.

1.6 Special Training Requirements/Certification

As noted in Section 1.2, project team members were chosen with the necessary experience and technical skills to perform required project tasks. Analytical services will be provided by a laboratory certified by the National Environmental Laboratory Accreditation Program. The laboratories providing analytical services will meet project-specific requirements and certification where applicable.

Project team members, including subcontractors, performing fieldwork will be required to show proof of meeting 29 Code of Federal Regulations 1910.120 regulations.

1.7 Documentation of Records

1.7.1 Field Sampling Documentation

Field sampling activities will be recorded in field logbooks and/or field data sheets. Field logbook entries will be described in as much detail as possible so that persons going to the facility could reconstruct a particular situation without reliance on memory. Modifications to field sampling protocols must be documented in the field logbook. The FTL is responsible for ensuring that atypical observations and conditions, along with their respective responses, are documented in the field logbook. Should modifications be required, the FTL will bring them to the attention of the SM, and the SM will discuss them with the appropriate interested parties.

Field personnel will provide comprehensive documentation covering all aspects of field sampling, field analysis, and sample COC. This documentation constitutes a record that allows reconstruction of all field events to aid in the data review and interpretation process. All documents, records, and information relating to the performance of the fieldwork will be retained in the project file.

1.7.2 Data Reporting

For the investigation, two levels of data reporting have been defined:

- **Field Data and Health and Safety Reporting**—This level of minimal or "results only" reporting is used for the field data recording and health and safety monitoring. This is because such data do not generate or require extensive supporting documentation.
- **Analytical Reporting**—Full "Contract Laboratory Program (CLP)" or "CLP-equivalent" reporting is required for all laboratory analyses.

Field Data Reporting

Information collected in the field through visual observation, manual measurement, and/or field instrumentation will be recorded in field notebooks, data sheets, and/or forms. Data will be reviewed by the FTL for adherence to this QAPP and consistency of data. Any concerns identified as a result of this review will be discussed with the PM, corrected if possible, and incorporated into the data evaluation process.

Field data calculations, transfers, and interpretations will be conducted by the field crew and reviewed for accuracy by the FTL. The appropriate task manager will review field documentation, data reduction, and accuracy of data entries into the data log. The data logs and documents will be checked for the following:

- General completeness
- Readability
- Clear statements about use of appropriate procedures and modifications to sampling procedures
- Appropriate instrument calibration and maintenance records (as appropriate)
- Reasonability of data collected
- Correctness of sample locations
- Correctness of reporting units, calculations, and interpretations

Where appropriate, field data forms and calculations will be processed and included in appendixes to the appropriate report. Original field logs, documents, and data reductions will be kept in the project file.

Laboratory Data Reporting

Data reduction will be done manually or using appropriate application software. Quantitation procedures specified for each method must be followed. Calculations for analyses are based on regression analyses of calibration curves. Regression analysis is used to fit a curve through calibration standard data. Sample concentrations are calculated using the resulting regression equations. If data are reduced manually, the documentation must include the formulas used. Any application software used for data reduction must have been previously verified by the laboratory for accuracy. Documentation of the software's verification must be maintained on file in the laboratory. All documentation of data reduction must allow re-creation of the calculations.

Whenever possible, analytical data will be transferred directly from the instrument to a computerized data system. Raw data will be stored electronically, and a hard copy file will be maintained. Laboratory data entered will be sufficient to document information used to arrive at reported values.

All data will undergo at least two levels of review at the laboratory before release. The analyst performing the tests initially will review 100 percent of the data. After the analyst's review has been completed, 100 percent of the data will be reviewed independently by a senior analyst or by the section supervisor for accuracy, compliance with calibration, and

QC requirements, holding time compliance, and for completeness. Analyte ID and quantitation must be verified. Calibration and QC results will be compared with the applicable control limits. Reporting limits should be reviewed to make sure they meet the project objectives. Results of multiple dilutions should be reviewed for consistency. Any discrepancies must be resolved and corrected. Laboratory qualifiers will be applied when there are nonconformances that could potentially affect data usability. These qualifiers must be properly defined as part of the deliverables. All issues relevant to the quality of the data must be addressed in a case narrative. A copy of the data package will be filed in the project file. Mailed data packages, along with applicable electronic data deliverables (EDDs), will be sealed in an appropriate shipping container with a custody seal and logged on a document mailing log.

Electronic data storage will be used when possible. All electronic data will be maintained in a manner that prevents inadvertent loss, corruption, and inappropriate alteration. Electronic data shall be accessible and retrievable for 10 years after project completion.

Raw data generated by the analytical laboratories will be examined to assess compliance with the QC guidelines stated in the QAPP. CH2M HILL will validate the raw data generated by the laboratory against the appropriate functional guidelines for data validation.

Any deviations from stated guidelines will call for corrective action. Deviations determined to be caused by factors outside the laboratory's control, such as matrix interference, will be noted with an explanation in the report narrative. The hard copy and electronic laboratory reports for samples and analyses will contain the information necessary to perform data evaluation.

Hard copy deliverables, in Level 3 summary format, containing the necessary information to perform data evaluation/data validation are required. Reporting formats similar to those specified in the latest versions of *USEPA Contract Laboratory Program Statements of Work for Organics and Inorganics* are preferred (USEPA 1999/2004). The laboratory data report will be organized in a format that facilitates ID and retrieval of data. Table 1-4 summarizes the requested data format.

1.7.3 Electronic Analytical Record Format

Concurrently with the submittal of the hard copy deliverables, the laboratory will deliver electronic data in the CH2M HILL LabSpec7 format as defined in Attachment 2. There shall be no discrepancies between the hard copy reports and the electronic reports.

1.7.4 Project Record Maintenance and Storage

Project records will be stored and maintained following the guidelines discussed in Section 2.10. Each project team member is responsible for filing all project information or providing it to the administrative assistant familiar with the project filing system. Individual team members may maintain separate files or notebooks for individual tasks but must provide such files to the project file room upon completion of each task. The general project file categories are as follows:

- Correspondence
- Non-laboratory project invoices and approvals by vendor

- Original unbound reports
- Non-laboratory requests for proposal, bids, contracts, and scopes of work
- Field data
- Data evaluation and calculations
- Facility reports from others
- Photographs
- Insurance documentation
- Laboratory analytical data and associated documents and memorandums
- Regulatory submittals, licensing, and permitting applications
- Facility and reference material
- Health, safety, and environment plans
- Figures and drawings

TABLE 1-4
Data Package Deliverables
Quality Assurance Project Plan, Dow Hanging Rock, Ohio

All Analytical Fractions				
Case Narrative – A detailed case narrative per analytical fraction is required and will include explanation of any noncompliance and/or exceptions and corrective action. Exceptions will be noted for receipt, holding times, methods, preparation, calibration, blanks, spikes, surrogates (if applicable), and sample exceptions.				•
Sample ID Cross Reference Sheet (Lab IDs and Client IDs)				•
Completed Chain-of-Custody and any sample receipt information				•
Sample preparation (extraction/digestion) logs				•
Copies of nonconformance memos and corrective actions				•
Form *	**GC/MS Organic Fractions**	**Level II**	**Level III**	**Level IV**
1	Sample results	•	•	• + raw
2	Surrogate Recovery Summary (w/ applicable control limits)	•	•	•
3	MS/MSD Accuracy & Precision Summary **	•	•	• + raw
3	LCS Accuracy Summary	•	•	• + raw
4	Method Blank Summary	•	•	• + raw
5	Instrument Tuning Summary (including tuning summary for applicable initial calibrations)		•	•
6	Initial Calibration Summary (including concentration levels of standards)		•	• + raw
7	Continuing Calibration Summary		•	• + raw
8	Internal Standard Summary (including applicable initial calibrations)		•	•
Form *	**GC/HPLC Organic Fractions**	**Level II**	**Level III**	**Level IV**
1	Sample results	•	• ***	• + raw
2	Surrogate Recovery Summary (w/ applicable control limits)	•	•	•
3	MS/MSD Accuracy & Precision Summary **	•	•	• + raw
3	LCS Accuracy Summary	•	•	• + raw
4	Method Blank Summary	•	•	• + raw
6	Initial Calibration Summary (including concentration levels of standards) ***		•	• + raw
7	Continuing Calibration Summary ***		•	• + raw
7	Degradation Summary (Organochlorine Pesticides only) ***		•	• + raw
8	Analytical Sequence (including internal standard area performance where applicable) ***		•	•
10	Compound Identification Summary (where confirmation required) ***		•	•

TABLE 1-4
Data Package Deliverables
Quality Assurance Project Plan, Dow Hanging Rock, Ohio

Form *	Metals Inorganic Fractions	Level II	Level III	Level IV
1	Sample Results	•	•	• + raw
2A	Initial and Continuing Calibration Summary		•	• + raw
3	Initial and Continuing Calibration Blanks and Method Blanks Summary	•	•	• + raw
4	Interference Check Standard Summary		•	• + raw
5A	Pre-digestion Matrix Spike Recoveries Summary	•	•	• + raw
5B	Post-digestion Spike Recoveries Summary		•	• + raw
6	Native Duplicate or MS/MSD Precision Summary **	•	•	• + raw
7	Laboratory Control Sample Recovery Summary	•	•	• + raw
8	Method of Standard Addition (if necessary)		•	• + raw
9	Serial Dilution		•	• + raw
10	Instrument or Method Detection Limit Summary		•	•
11	ICP Interelement Correction Factors		•	•
12	Linear Range Summary		•	•
13	Preparation Log Summary		•	• + raw
14	Analytical Run Sequence and GFAA Post-spike Recovery Summary		•	• + raw
Form *	**General Chemistry Fractions: (Includes potentiometric, gravimetric, colorimetric, and titrimetric analytical techniques. Examples, TPH (418.1), TOC, etc.)**	**Level II**	**Level III**	**Level IV**
1	Sample Results	•	•	• + raw
2A	Initial and Continuing Calibration Summary		•	• + raw
3	Initial and Continuing Calibration Blanks and Method Blanks Summary	•	•	• + raw
5A	Pre-digestion Matrix Spike Recoveries Summary	•	•	• + raw
6	Native Duplicate or MS/MSD Precision Summary **	•	•	• + raw
7	Laboratory Control Sample Recovery Summary	•	•	• + raw
10	Instrument or Method Detection Limit Summary		•	•

* CLP Form or summary form with equivalent information
** with RPD calculated according to method specifications (CLP using % recovery, SW-846 using concentration)
*** including deliverables for primary and confirmation analysis (where applicable)

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SECTION 2

Data Generation and Acquisition

This section describes the procedures for collecting, handling, measuring, acquiring, and managing data to be performed in support of this sampling activity. It addresses the following aspects of data generation and acquisition:

- Sampling process design
- Sampling method requirements
- Sample handling and custody requirements
- Laboratory analytical methods requirements
- Laboratory QC requirements
- Field and laboratory instrument calibration and frequency
- Inspection and acceptance requirements for supplies and consumables
- Data acquisition requirements
- Data management
- Field and laboratory instrument and equipment testing, inspection, and maintenance requirements

2.1 Sampling Process Design and Rationale

The proposed soil and sediment sampling is described in the work plan, of which this QAPP is an appendix.

2.1.1 Sample Locations

The total number of samples to be collected, inclusive of the QC samples, and the parameters to be analyzed are identified in Table 1-2.

2.2 Sampling Methods Requirements

The SOPs for each field sampling method and decontamination procedures contained in the FSP include the following:

- Groundwater level measurements
- Low-flow groundwater sampling
- Volatile organic compound (VOC) soil sampling
- Decontamination of personnel and equipment

2.3 Sample Handling and Custody Requirements

2.3.1 Sample Handling, Preservation and Storage Procedures

Laboratories will provide the required sample containers for all environmental and associated QC samples. All containers will be certified free of the analytes of concern for this project. No sample containers will be reused. The contract laboratory will add preservatives, if required, before shipping the sample containers to the field. Upon receipt

of the samples, the laboratory will verify the adequacy of the preservation and add additional preservatives if necessary. Adjustments made by the laboratory will be documented on the appropriate sample receipt forms and noted in the case narrative. The containers, minimum sample quantities, required preservatives, and maximum holding times for the parameters are shown in Table 2-1.

Errors associated with the sample bottles will be corrected as soon as a problem is identified. This may include discontinuing the use of a specific bottle lot, contacting the bottle supplier for retesting the representative bottle from a suspect lot, resampling the suspected samples, and validating the data. This would take into account that the constituents could be introduced by the laboratory (i.e., common laboratory solvents, sample handling artifacts, etc.) as a bottle QC problem, and educated evaluation as to whether the bottles and data are still usable must be made.

Sample containers should be received from the laboratory pre-labeled with the preservative. The sample ID, and date and time of sampling will be entered on the label immediately after collection. The labels must be secured using clear tape to maintain the ID of each sample.

2.3.2 Transport

Sample coolers will be transported to the laboratory (an overnight courier may be used) immediately after sample collection. Intermediate stops should be avoided, with the exception of emergencies only, in which case the situation should be noted in the field notebooks. The laboratory should be notified that samples are being shipped.

Sample Packaging

Sample packaging and shipping procedures are designed to ensure that the samples will arrive intact at the laboratory, along with the COC forms. Samples will be batched according to their analytical groups and sample locations in a manner to prevent cross-contamination of other samples.

Shipping Airbills

If samples are shipped, airbills will be retained to provide a record for sample shipment to the laboratory. Completed airbills will accompany shipped samples to the laboratory and will be forwarded along with data packages. The airbill number will be documented on the COC form accompanying the samples to the laboratory for sample tracking purposes. Airbills will be kept as part of the data packages in the project files.

TABLE 2-1
Required Analytical Methods, Sample Containers, Preservation, and Holding Times
Quality Assurance Project Plan, Dow Hanging Rock, Ohio

Analyses	Preparatory / Analytical Method	Sample Matrix[a]	Container[b]	Qty	Preservative[c]	Holding Time [d]
VOC	SW-846 5030B/8260B	W	40-mL, glass	3	HCl, pH<2, cool to 4ºC	14 days
VOC	SW-846 5035A/8260B	S	40 ml glass or 5 gram Encores	3	2-5ml DI water and one 5ml methanol or Encore, cool to 4ºC- freeze	Soil; 14 days (frozen); 48 hours (unpreserved, not frozen)
		SD	4 oz jar	1	Cool 4°C	Sediment: 14 days
SVOC	SW-846 8270C/SW8270SIM	S/SD	4 oz jar	1	Cool to 4°C	7 days to extraction, 40 days to analysis
Metals	SW-846 3050A-SW6010B /SW6020/7000 Series	S/SD	4 oz jar	1	None	180 days (28 days for mercury)

Sample container, and volume requirements will be specified by the analytical laboratory performing the tests. Three times the required volume should be collected for samples designated as MS/MSD samples.
[a]Sample matrix: W = water, S=soil, SD=sediment
[b]All containers will be sealed with Teflon®-lined screw caps.
[c]All samples will be stored promptly at 4°C in an insulated chest.
[d]Holding times are from the time of sample collection.
Source: SW-846, third edition, Updates IVA and IVB (USEPA, 2008).
°C = degrees Celsius
HCl = hydrochloric acid
mL = milliliter
L = liter
VOC= volatile organic compound
SVOC = semivolatile organic compound

2.3.3 Sample Identification System

A sample numbering system devised by CH2M HILL will be used to identify each sample, including duplicates and blanks. Each sample will be assigned a sample ID number. This number, which will be cross-referenced to the sample location on the COC form, will be used to track samples and report analytical results. The sample ID scheme will be established before implementing the work plan.

2.3.4 Sample Chain-of-Custody

Sample and data custody are necessary to provide relevant and defensible data. Custody is addressed during field sample collection, data analyses in the laboratory, and through proper handling of project files. Persons will have custody of samples when samples are in their physical possession, in their view after being in their possession, or in their physical possession and secured to prevent tampering. In addition, when samples are secured in a restricted area accessible only to authorized personnel, they will be deemed to be in the custody of such authorized personnel.

COC forms will provide the record of responsibility for sample collection, transport, and submittal to the laboratory. Field personnel designated as responsible for sample custody will fill out COC forms at each sampling location, at a group of sampling locations, or at the end of each day of sampling. Whenever possible, sample tags and COC forms will be produced by the project database management system. If the designated sampling person relinquishes samples to other sampling or field personnel, COC forms will be signed and dated by the appropriate personnel to document the sample transfer. Original COC forms will accompany samples to the laboratory, and copies will be forwarded to the project files. At a minimum, the COC form must include the following:

- Site name
- Project manager name, telephone number, and fax number
- Unique sample ID
- Date and time of sample collection
- Source of sample (including name, location, sample type, and matrix)
- Number of containers
- Designation of MS/MSD
- Preservative used
- Analyses required
- Name of sampler
- Custody transfer signatures and dates and times of sample transfer from the field to transporters and to the laboratories
- Bill of lading or transporter tracking number (if applicable)
- Turnaround time
- Laboratory name, address, and contact information
- Any special instructions

Erroneous entries on COC records will be corrected by drawing a single line through the error and entering the corrected information. The person performing the correction will date and initial each change made on the COC form.

Field Custody Procedures

COC forms will be required for all samples. The sampling crew in the field will initiate COC forms. COC forms will contain the sample's unique ID number, sample date and time, sample description, sample type, preservation (if any), and analyses required. Original COC forms, signed by the sampling crew, will accompany the samples to the laboratory. A copy of relinquished COC forms will be retained with the field documentation. COC forms will remain with the samples at all times. Samples and signed COC forms will remain in the

possession of the sampling crew until samples are delivered to the express carrier (such as Federal Express), or hand delivered to the laboratory, or placed in secure storage.

Laboratory Custody Procedures

Laboratory custody procedures will be in place to ensure the integrity of sample and laboratory-produced data handling. Laboratory custody procedures are defined in their individual laboratory SOPs regarding sample custody.

Laboratory Sample Receipt

Upon sample receipt, the laboratory sample custodian will verify package seals, open the packages, check temperature blanks (and record temperatures), verify sample integrity, and inspect contents against COC forms. Inspection procedures and corrective actions shall be in compliance with the laboratory's SOPs. The project manager will be contacted to resolve any discrepancies between sample containers and COC forms.

Along with sample receipt documentation, the following information will be documented on sample receipt forms by the sample custodian:

- Date samples received
- CH2M HILL sample ID
- Laboratory sample ID
- Analytical tests requested for the sample batch
- Sample matrix
- Number of samples in the batch
- Container description and location in the laboratory
- Verification of sample preservation

Sample receipt documentation must be submitted to the project chemist within 48 hours of sample receipt.

Laboratory Sample Storage

After the laboratory labels the samples, they will be stored in compliance with their SOP for sample storage. No samples or extracts will be disposed of without prior written approval from an appropriate member of the project team. The sample custodian will note sample disposal date in the sample ledger. The laboratory will dispose of samples in accordance with applicable regulations.

Laboratory Logbooks

Workbooks, bench sheets, instrument logbooks, and instrument printouts will be used to trace the history of samples through the analytical process and document important aspects of the work, including associated QC measures. As such, all logbooks, bench sheets, instrument logs, and instrument printouts will be part of the permanent record of the laboratory. In addition, relevant information will be entered into the laboratory information management system (LIMS) at the time information is generated.

Each page or entry will be dated and initialed by the analyst at the time of entry. Errors in an entry will be crossed out in indelible ink with a single stroke, corrected without obliterating or writing directly over the erroneous entry, and initialed and dated by the

individual making the correction. Lining out unused portions and initialing by the person lining out the page will complete pages of logbooks that are not used.

The analyst will record information regarding the sample, analytical procedures performed, and results on laboratory forms or personal notebook pages and enter this information in LIMS. These notes will be dated and will identify the analyst, instruments used, and instrument conditions.

Sufficient raw data records must be retained to permit reconstruction of initial instrument calibrations (e.g., calibration date, test method, instrument, analysis date, each analyte name, concentrations and responses, calibration curves, response factors, or unique equations or coefficients used to reduce instrument responses into concentrations).

The laboratory group will review laboratory notebooks periodically leaders for accuracy, completeness, and compliance with this QAPP. The laboratory group leader will verify all entries and calculations. If all entries on the pages are correct, the laboratory group leader will initial and date the pages. Corrective action will be taken for incorrect entries before the laboratory group leader signs.

Laboratory Project File

Documentation will be placed in a single, secured project file that will be maintained by the laboratory PM. This file will consist of the following components, all filed chronologically:

- Agreements
- Correspondence
- Memorandums
- Notes and data

Reports (including QA reports) will be filed with correspondence. Analytical laboratory documentation and field data will be filed with notes and data. Filed materials may only be removed by authorized personnel on a temporary basis. The name of the person removing the file will be recorded. Laboratories will retain all project files and data packages for a minimum of 10 years unless otherwise agreed upon.

Computer Tape and Hard Copy Storage

All electronic files will be maintained on CD-ROM (preferred), magnetic tape, or diskette for 10 years; hard copy data packages (including chromatograms) will be maintained in files for 10 years. The computer tape and hard copy storage should include notation of instrument run files and calibration.

2.4 Analytical Method Requirements

Once samples have been properly collected and documented, they will be submitted to the analytical laboratory. Samples will be analyzed in accordance with this QAPP and the specified USEPA method. The target analytes and screening levels are specified in Attachment 1. The laboratory reporting limits and method detection limits will be evaluated pending selection. Required QC checks, minimum frequencies, acceptance criteria, corrective actions and validation flagging criteria are included in Attachment 1. Laboratory QC limits will be used for this project.

Nondetected parameters will be reported at the reporting limit (RL) with a "U" qualifier.

Results between the method detection limit (MDL) and RL will be qualified as estimated and flagged "J".

Deviations from specified methods will be communicated to the contractor's PM before initiation of test procedures. Any deviations also must be addressed in the laboratory case narrative.

All samples must be analyzed undiluted or at the lowest possible dilution. The laboratory will contact the project chemist when dilutions are required because of matrix interference. When a target analyte's concentration exceeds the calibration range, a dilution analysis will be performed to accurately determine the analyte's concentration. The laboratory will report the undiluted/lowest dilution performed and any diluted analyses that are required.

2.4.1 Analytical Standard Operating Procedures

The laboratory uses analytical SOPs to ensure that the samples submitted are accurately and precisely analyzed. The laboratory will follow their analytical SOP or the USEPA method guidance when this QAPP does not specify QC criteria. If not otherwise stated within this QAPP, the QC criteria used during the analyses are those stated within the analytical SOPs.

2.5 Quality Control Requirements

The contracted analytical laboratory has a QC program to assess the reliability and validity of the analyses being performed. The purpose and creation of QC samples is discussed and summarized below. Laboratory QC checks indicate the state of control that prevailed at the time of sample analysis. QC checks that involve field samples, such as matrix, surrogate spikes, and field duplicates, also indicate the presence of matrix effects. Field-originated blanks provide a way to monitor for potential contamination to which field samples are subjected. This QAPP specifies requirements for method blanks, LCSs, surrogate spikes, field duplicates and MS/MSDs that laboratories participating in the data collection effort must follow.

A laboratory QC batch is defined as a method blank, LCS, MS/MSD, or a sample duplicate, depending on the method and 20 or fewer environmental samples of similar matrix that are extracted or analyzed together. For gas chromatography/mass spectrometry volatile analyses, a method blank, LCS, and MS/MSD must be analyzed in each 12-hour period. The number of environmental samples allowed in the laboratory QC batch is defined by the remaining time in the method-prescribed, 12-hour tune period divided by the analytical run time. Each preparation or analytical batch will be identified in such a way as to be able to associate environmental samples with the appropriate laboratory QC samples.

2.5.1 Field Quality Control Samples

Field QC samples will be collected to determine the accuracy and precision of the analytical results. The QC sample frequencies are as stated in this section below. All sampling activities will be conducted in accordance with the health, safety, and environment plan, and all sample handling procedures will be performed in accordance to those specified in this QAPP.

Equipment Blanks

Equipment blanks are collected to monitor the cleanliness of sampling equipment and the effectiveness of decontamination procedures. Contamination from the sampling equipment can bias the analytical results high. Equipment blanks will be prepared by filling sample containers with analyte-free water that has been passed through a decontaminated sampling device. Equipment blanks will be sampled at a frequency of 1 for every 20 samples collected with nondedicated equipment. The results from the equipment blanks will be assessed for bias resulting from contamination. If bias is present, the usability of the associated analytical results will be further assessed and qualified, as appropriate. Equipment blanks will only be analyzed in the event that nondedicated sampling equipment will be used.

Matrix Spike/Matrix Spike Duplicates

MS/MSDs will be used to assess the effects of sample matrix interference on the precision and accuracy of analyte recovery. MS/MSD pairs will be analyzed at a frequency of 1 pair for every 20 samples. The duplicate aliquots for MS/MSD analyses should be collected simultaneously or in immediate succession with the parent sample. They will be treated in the same manner as the parent sample during storage and shipment. The sampling locations for the MS/MSD will be documented in the field logbook.

Laboratory QA/QC limits will be used to evaluate the precision and accuracy of the data.

Field Duplicates

Field duplicates are collected in the field from a single aliquot of sample to assess the precision and accuracy of the sampling procedures of the field team. *Technically, a VOC-in-soil sample is considered a "co-located" sample, not a "duplicate" because of the differences in homogenization; however, the term "duplicate" is applied in this document to simplify discussion.* A field duplicate will be collected and analyzed at a frequency of 1 duplicate for every 10 samples.

Trip Blanks

Trip blanks will be collected and analyzed to assess for possible VOC contamination that could occur during sample shipment. Trip blanks will be provided by the subcontracted laboratory. The trip blanks will consist of laboratory grade deionized water, preserved in hydrochloric acid. Trip blanks are used to assess the potential introduction of constituents from sample containers or during the transportation and storage procedures. One set of trip blanks will accompany each sample cooler containing one or more VOC samples.

2.5.2 Laboratory Quality Control Samples

Method Blank

Blanks are used to monitor each preparation or analytical batch for interference and/or contamination from glassware, reagents, and other potential sources within the laboratory. A method blank is an analyte-free matrix (laboratory reagent water for aqueous samples or Ottawa sand, sodium sulfate, or glass beads [metals] for soil samples) to which all reagents are added in the same amount or proportions as are added to the samples. It is processed through the entire sample preparation and analytical procedures along with the samples in the batch. There will be at least one method blank per preparation or analytical batch. If a target analyte is found at a concentration that exceeds the reporting limit, corrective action

must be performed to identify and eliminate the contamination source. All associated samples must be re-prepared and reanalyzed after the contamination source has been eliminated. No analytical data may be corrected for the concentration found in the blank.

Laboratory Control Sample

The LCS will consist of an analyte-free matrix such as laboratory reagent water for aqueous samples or Ottawa sand, sodium sulfate, or glass beads (metals) for soil samples spiked with known amounts of analytes that come from a source different than that used for calibration standards. All target analytes specified in the QAPP will be spiked into the LCS. The spike levels will be less than or equal to the midpoint of the calibration range. If LCS results are outside the specified control limits, corrective action must be taken, including sample re-preparation and reanalysis, if appropriate. If more than one LCS is analyzed in a preparation or analytical batch, the results of all LCSs must be reported. Any LCS recovery outside QC limits affects the accuracy for the entire batch and requires corrective action.

MS/MSD

An MS is a sample matrix fortified with known quantities of specific compounds. It is subjected to the same preparation and analytical procedures as the native sample. For this project, all target analytes specified in the QAPP will be spiked into the sample. MS recoveries are used to evaluate the effect of the sample matrix on the recovery of the analytes of interest. An MSD is a second fortified sample matrix. The RPD between the results of the duplicate MS measures the precision of sample results. Only project-specific samples designated on the COC form will be spiked. The spike levels will be less than or equal to the midpoint of the calibration range. MS/MSD pairs will be analyzed at a frequency of one pair for every 20 samples.

Surrogates

Surrogates are organic analytes that behave similarly to the analytes of interest, but are not expected to occur naturally in the samples. They are spiked into the standards, and into the samples and QC samples before sample preparation. Recoveries of surrogates are used as an indicator of accuracy, method performance, and extraction efficiency. If surrogate recoveries are outside the specified control limits, corrective action must be taken, including sample re-preparation and/or reanalysis, if appropriate.

Internal Standards

Some methods require using internal standards to compensate for losses during injection or purging, or losses because of viscosity. Internal standards are compounds that have similar properties as the analytes of interest, but are not expected to occur naturally in the samples. A measured amount of the internal standard is added to the standards, and to the samples and QC samples following preparation. When the internal standard results are outside the control limits, corrective action must be taken, including sample reanalysis, if appropriate.

Laboratory Sample Duplicate

A sample duplicate selected by the laboratory is called a laboratory sample duplicate. It is subjected to the same preparation and analytical procedures as the native sample. The RPD between the results of the native sample and laboratory sample duplicate measures the precision of sample results. The data collected may also yield information regarding

whether the sample matrix is homogenous or heterogeneous. The precision criteria for laboratory duplicates will be ± 25 percent.

Interference Check Standards

The interference check samples are used in inductively coupled plasma (ICP) analyses to verify background and inter-element correction factors. They consist of two solutions, A and AB. Solution A contains the interfering analytes, and Solution AB contains both the analytes of interest and the interfering analytes. Both solutions are analyzed at the beginning and at the end of each analytical sequence. When the interference check samples results are outside the control limits, corrective action must be taken, including sample reanalysis, if appropriate.

Retention Time Windows

Retention time windows for gas and liquid chromatographic analyses must be established by replicate injections of the calibration standard over multiple days as described in SW846 8000B, analytical method or appropriate laboratory SOP. The absolute retention time of the calibration verification standard at the start of each analytical sequence will be used as the centerline of the window. In order for an analyte to be reported as positive, its elution time must be within the retention time window.

Holding Time

The holding time requirements specified in this QAPP must be met. For methods requiring both sample preparation and analysis, the preparation holding time will be calculated from the time of sampling to the completion of preparation. The analysis holding time will be calculated from the time of completion of preparation to the time of completion of the analysis, including any required dilutions, confirmation analysis, and reanalysis. For methods requiring analysis only, the holding time is calculated from the time of sampling to completion of the analysis, including any required dilutions, confirmation analysis, and reanalysis.

Sample Dilutions

Dilution of a sample results in elevated RLs and ultimately affects the usability of the data related to potential actions at the sampling site. It is important to minimize dilutions and maintain the lowest possible RLs. When dilutions are necessary because of high concentrations of target analytes, lesser dilutions also should be reported to fully characterize the sample for each analyte. The level of the lesser dilution should be such that it will provide the lowest possible RLs without having a lasting deleterious effect on the analytical instrumentation.

When a sample exhibits characteristics of matrix interference that are identified through analytical measurement or visual observation, appropriate cleanup procedure(s) must be proven ineffective or inappropriate, prior to proceeding with dilution and analysis.

Manual Integration

The laboratory is required to provide all analysts performing methods that rely on interpretation of chromatographic data with training on appropriate software or manual integration practices. The laboratory also will make every effort to minimize the use of manual integration of data. If the need arises to use manual integration to correct a software

auto-integration error, the manual integration will be clearly identified in the instrument data. Before and after enlargements of the region of the chromatogram where the manual integration was performed, will be provided on an appropriate scale that allows an independent reviewer to evaluate the need and quality of the manual integration. The analyst also will document the reason for the manual integration on the chromatogram along with their date and initials. The laboratory manager or designee will approve the manual integration by dating and initialing the chromatogram.

2.6 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

2.6.1 Laboratory Equipment/Instruments

Only qualified personnel will service instruments and equipment. Repairs, adjustments, and calibrations will be documented in the appropriate logbook or data sheet.

Instrument Maintenance

Preventive maintenance of laboratory equipment will follow guidelines established by each laboratory's SOPs for instrument inspection and maintenance. The laboratory will maintain a sufficient supply of spare parts for its instruments to minimize downtime. Whenever possible, backup instrumentation will be on hand.

Whenever practical, analytical equipment should be maintained under a service contract. Such contracts allow for preventative system maintenance and repair on an "as-needed" basis. The laboratory should have sufficient trained staff to allow for the day-to-day maintenance of equipment. All laboratory instruments will be maintained in accordance with manufacturer's specifications and within the requirements of the laboratory quality assurance manual (QAM). All maintenance activities are required to be documented in the logbooks to provide a history of maintenance records.

Equipment Monitoring

On a daily basis, operation of balances, ovens, refrigerators, and water purification systems will be checked and documented. Any discrepancies will be immediately reported to the appropriate laboratory personnel for resolution. Specific laboratory preventative maintenance procedures are found in the laboratory's internal QAM.

2.7 Instrument Calibration and Frequency

2.7.1 Field Instruments

The field instruments to be used will be calibrated at least daily, or more frequently depending on manufacturer's recommendations or field performance questions. All calibrations will be performed by using factory-approved methods, and the calibration methods, times, and responses will be recorded in a field logbook. The serial numbers of the field instruments also will be recorded in the field logbooks at the time of calibration. The instruments include those that measure field conditions (pH, conductance, temperature, etc.) and health and safety conditions (photoionization detector, combustible gas indicator, etc.). Some field instruments have no applicable calibration procedure (such as water level

indicators). These items will be evaluated and removed from service if performance issues arise.

2.7.2 Laboratory Instruments

The instrument calibration procedures are described in the internal laboratory SOPs. Records of calibrations will be filed and maintained by the laboratory. These records will be subject to QA audit. For all instruments, the laboratory will maintain trained repair staff with in-house spare parts or will maintain service contracts with vendors.

All standards used in the calibration of equipment will be traceable, directly or indirectly, to the National Institute of Standards and Technology. All standards received will be logged into standard receipt logs maintained by the individual analytical groups. Each group maintains a standards log that tracks the preparation of standards used for calibration and QC purposes.

2.8 Inspection/Acceptance Requirements for Supplies and Consumables

Subcontractor services must meet the project scope, specified levels of quality, and the submittal schedule. Project contractors or vendors should have contractual arrangements with their suppliers of materials.

All purchased or rented supplies and consumables will be inspected to assure that the quality and function will adhere to the standards necessary to meet all project objectives. Field equipment will be checked and calibrated (if necessary) according to documentation provided. Performance assessment (calibration, trial checks, etc.) will be documented in field logbooks and will become part of the project record. Bottles will be checked to assure that the quality is sufficient to meet the analytical needs as outlined in the certificate of analysis provided with each shipment. All documentation of certified cleanliness will become part of the project files. All chemicals (American Society for Testing and Materials water for blanks, chemical preservatives, etc.) will be inspected to confirm that the required specifications needed to achieve project objectives are met. Inspection and acceptance requirements are the responsibility of the FTL or their designated agent.

2.9 Data Acquisition Requirements (Nondirect Measurements)

This subsection describes the identity of the types of data needed for project implementation and decision making that are not obtained from direct measurements.

The project objectives are first identified, to assess what types of information are needed to implement a project plan to meet these proposed objectives. Project objectives are summarized in Section 1. Typically, the data needed to achieve the project objectives include facility maps, sampling location selection and sample identifiers, laboratory method selection and detection limit verification, analytical parameter lists and critical values, field measurement lists, and a project schedule.

2.10 Data Quality Management

Data management entails storing, handling, accessing, and securing data collected during the project. Data gathered during this project will be consolidated and compiled into a project database that can be used to support project data reporting and exports. The following sections describe the project's data management process.

2.10.1 Archiving

Hard copy and electronic versions will be archived in project files and on electronic archive tapes for the duration of the project, 10 years, or as specified in contractual agreements.

2.10.2 Data Flow and Transfer

The data flow from the laboratory and field to the project staff and data users will be sufficiently documented to ensure that data are properly tracked, reviewed, and validated for use.

2.10.3 Record Keeping

In addition to the data management procedures outlined in Section 2.3 for analytical data, the laboratory will ensure that it maintains electronic and hard copy records sufficient to recreate each analytical event. The minimum records the laboratory will keep contain the following:

- Raw data, including instrument printouts, bench work sheets, and/or chromatograms with compound ID and quantitation reports
- Laboratory-specific written SOPs for each analytical method and QA/QC function in place at the time of analysis of project samples

2.10.4 Final Evidence File

The final evidence file will be the central repository for all documents that constitute evidence relevant to sampling and analysis activities. CH2M HILL is the custodian of the evidence file and maintains the contents of the evidence files for the project, including all relevant records, reports, logs, field notebooks, pictures, contractor reports, and data reviews in a secured, limited access area under the custody of CH2M HILL.

CH2M HILL will keep all records until project completion and project closeout. As necessary, records may be transferred to an off-facility records storage facility. The records storage facility must provide secure, access-controlled storage of records. Records of raw analytical laboratory data, QA data, and reports will be kept by the subcontract laboratory for a minimum of 10 years.

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SECTION 3

Assessment/Oversight

3.1 Assessments and Response Actions

Field and laboratory assessments are performed to assess technical and procedural compliance with this QAPP. Performance and system audits are key to ensuring this compliance. Purposes of the audits are as follows:

- Confirm appropriate documents are properly completed and are kept current and orderly
- Ensure measurement systems are accurate
- Identify nonconformance or deficiencies and to initiate necessary corrective actions
- Verify that field and laboratory QA procedures called for in this QAPP are properly followed and executed

The project chemist and laboratory QAM are responsible for ensuring conformance with the QAPP. The FTL is responsible for ensuring conformance with field QA/QC requirements. Activities selected for audit will be evaluated against specified requirements, which will include an evaluation of the method, procedures, and instructions. Documents and records will be examined as necessary to evaluate whether the QA program is effective and properly implemented. Reports and recommendations must be prepared on all audits and submitted to the QA manager for retention in the project files.

3.1.1 Field Audits

Planning, scheduling, and conducting QA audits and surveillance are required to verify facility activities are being performed efficiently in conformance with approved plans, standards, federal and state regulatory requirements, sound scientific practices, and contractual requirements. Planned and scheduled audits may be performed to verify compliance with aspects of the QA program and to evaluate the effectiveness of the QA program. Audits include an objective examination of work areas, activities, processes, review of documents and records, interviews with project personnel, and review of plans and standards.

Internal review of the sampling program will be conducted after each sampling event by the FTL. The FTL will pay particular attention to the sampling program with respect to representativeness, comparability, and completeness of the specific measurement parameters involved.

Field documentation (e.g., COC forms, field daily sheets, logbooks) will be reviewed as generated by the FTL or designee for accuracy, completeness, and compliance with QAPP requirements. The FTL will audit field sampling procedures periodically for compliance with QAPP procedures. The auditor will check for the following:

- Sampling protocols are being followed.
- Samples are placed in proper containers.
- Samples are stored and transported properly.
- Field documentation is completed.

Field Corrective Action

Any project team member may initiate a field corrective action process. The corrective action process consists of identifying a problem, acting to eliminate the problem, monitoring the effectiveness of the corrective action, verifying that the problem has been eliminated, and documenting the corrective action.

Corrective actions include correcting COC forms; problems associated with sample collection, packaging, shipping, field record keeping; or additional training in sampling and analysis. Additional approaches may include resampling or evaluating and amending sampling procedures. The team member in charge of field operations (FTL) will summarize the problem, establish possible causes, and designate the person responsible for a corrective action. The FTL will verify that the initial action has been taken and whether it appears to be effective. The FTL will additionally follow up to verify that the problem has been resolved.

Technical staff and project personnel will be responsible for reporting suspected technical or QA nonconformances or suspected deficiencies to the FTL. The FTL will be responsible for assessing suspected problems in consultation with the QA manager and the PM as to whether the situation affects data quality. If it is concluded that the situation warrants a reportable nonconformance requiring corrective action, a nonconformance report will be initiated by the FTL.

The FTL will be responsible for ensuring that corrective action for nonconformances are initiated by the following:

- Evaluating all reported nonconformances
- Controlling additional work on nonconforming items
- Selecting disposition or action to be taken
- Maintaining a log of nonconformances
- Reviewing nonconformance reports and corrective actions taken
- Ensuring nonconformance reports are included in the final documentation in the project files

3.1.2 Laboratory Audits

The laboratory QA manager may conduct internal system audits. An internal audit is a qualitative evaluation of all components of the laboratory QC measurement system. The audit serves to determine if all measurement systems are being used appropriately. The system audits are conducted to evaluate the following:

- Sample handling procedures
- Calibration procedures
- Analytical procedures
- QC results
- Safety procedures
- Record keeping procedures
- Timeliness of analysis and reporting

In addition, laboratories are subject to external audits. The focus of these audits is to assess general laboratory practices and conformance to the QAPP. Laboratory audits may be performed prior to the start of analyses for this project and at any time during the course of the project as deemed necessary.

The laboratory QA manager will review internal laboratory performance and will evaluate laboratory precision and accuracy by comparing results of duplicate samples, QC samples, spikes, and blanks. When a beyond-control limit situation is encountered, the laboratory manager or other client services will check analytical results prior to distribution.

Laboratory Corrective Action

Corrective actions may be required for two classes of problems: analytical/equipment problems and noncompliance problems. Analytical/equipment problems may occur during sampling, sample handling, sample preparation, laboratory instrumental analysis, or data review.

For noncompliance problems, a corrective action program will be developed and implemented at the time the problem is identified. The person who identifies the problem will be responsible for notifying the proper project member. If the problem is analytical in nature, information on these problems will be communicated to the laboratory QAM and the QA manager, who will in turn direct information to proper project members. Implementation of corrective action will be confirmed through similar channels.

Implementation of all corrective actions will be documented. No staff member will initiate corrective action without prior communication of action needing correction and proposed corrective action through the proper channels. If corrective actions are insufficient, the PM or the QA manager may issue a stop work order.

Corrective actions are required whenever an out-of-control event or potential out-of-control event is noted. The investigative action taken is somewhat dependent on the analysis and the event. Laboratory personnel are alerted that corrective actions may be necessary if the following occurs:

- QC data are outside the warning or acceptable windows for precision and accuracy
- Blanks contain target analytes above acceptable levels

- Undesirable trends are detected in spike recoveries or RPD between duplicates
- Unusual changes in detection limits occur
- Inquiries concerning data quality are received
- Deficiencies are detected by the laboratory QA manager during internal or external audits or from results of performance evaluation samples

Corrective action procedures are often handled at the bench level by the analyst, who reviews preparation or extraction procedures for possible errors, checks instrument calibrations, spike and calibration mixes, and instrument sensitivity. If problems persist or cannot be identified, matters are referred to the laboratory supervisor, laboratory PM, and/or laboratory QA manager for further investigation. Once resolved, full documentation of the corrective action procedures is filed with the laboratory QA manager after approval by CH2M HILL. Corrective action may include the following:

- Resampling and analyzing
- Evaluating and amending sampling procedures
- Evaluating and amending analytical procedures
- Accepting data and acknowledging the level of uncertainty
- Reanalyzing the samples, if sample or extract volume is adequate and holding time criteria permits

If resampling is deemed necessary due to laboratory problems, the PM must identify the appropriate approach, including cost recovery from the laboratory, for the additional sampling effort.

3.2 Reports to Management

If audits are conducted, audit reports will be submitted to the PM to address any QA issues or proposed corrective actions to maintain QA standards. In addition, after the sample results are received from the laboratory and validated, reduced, and tabulated, a comprehensive data evaluation report will be submitted documenting the field investigation.

SECTION 4

Data Validation and Usability

4.1 Data Review, Verification, and Validation

Data review, verification, and validation are the processes by which data, generated in support of a project, are reviewed against the data QA/QC requirements. The data are evaluated for precision and accuracy against the analytical protocol requirements. Nonconformance or deficiencies that could affect the precision or accuracy of the reported result are identified and noted. The effect on the result is then considered when assessing whether the result is sufficient to achieve DQOs.

All data collected as part of this investigation will be consistent with the QAPP and will be validated by CH2M HILL. Deficiencies discovered as a result of data verification, review, or validation, as well as corrective actions implemented in response, will be documented and submitted in the form of a written report.

4.2 Validation and Verification Methods

Personnel involved in the data validation function will be independent of any data generation effort. The project chemist will be responsible for oversight of the data validation effort. Data validation will be carried out when the data packages are received from the laboratory. It will be performed on an analytical batch basis using the summary results of calibration and laboratory QC, as well as those of the associated field samples. Raw data will be reviewed when deemed necessary by the project chemist. Data validation procedures will include the following:

- Review of the data package for completeness
- Review of COC records for discrepancies that might degrade data quality
- Review for compliance with holding time and QC frequency requirements
- Evaluation of all calibration and QC summary results against the project requirements
- Qualification of the data using appropriate qualifier flags, as necessary, to reflect data usability limitations
- Initiation of corrective actions, as necessary, based on the data review findings

Data validation will be patterned after the *Contract Laboratory National Functional Guidelines for Organic Data Review* (USEPA 1999) and the *Contract Laboratory National Functional Guidelines for Inorganic Data Review* (USEPA 2004) following the criteria in the QAPP. QC requirements specified herein shall take precedence over the functional guidelines requirements. When no specific guidance exists, method requirements will be used.

It is important to note that laboratory qualifying flags are included on the data summary forms (Form I) that are submitted to the project by the laboratory; however, during the data

review and validation process, the laboratory qualifying flags are reviewed along with the project-specific validation flags to determine the final project qualifier applied to the data. Data qualifier flags, if required, are defined in Table 4-1 and will be applied to the electronic sample results. If multiple flags are required for a result, the most severe flag will be applied to the electronic result. The hierarchy of flags from the most severe to the least severe will be as follows: R, J, UJ, and U.

A validation report will be generated and submitted to the PM. Tables 4-2 and 4-3 summarize flagging conventions for organic and inorganic methods, respectively.

TABLE 4-1
Qualifier Flag Definitions
Quality Assurance Project Plan, Dow Hanging Rock, Ohio

Flag	Definition
J	Analyte was present but reported value may not be accurate or precise.
R	This result has been rejected.
U	This analyte was analyzed for but not detected at the specified detection limit.
UJ	The analyte was not detected above the detection limit objective. However, the reported detection limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample

4.3 Reconciliation of Validated Data with Data Quality Objectives

The final data validation activity is assessing whether the data meet the planned DQOs for the unit-specific project. The final results, as adjusted for the findings of any data validation and data evaluation, will be checked against the DQOs, and an assessment will be made as to whether the data are of sufficient quality to support them. The decision as to data sufficiency may be affected by the overall precision, accuracy, and completeness of the data as demonstrated by the data validation process. If the data are sufficient to achieve project objectives, the PM will release the data and work may proceed. If not, corrective action will be required.

TABLE 4-2
Flagging Conventions for Organic Methods
Quality Assurance Project Plan, Dow Hanging Rock, Ohio

Quality Control Check	Evaluation	Flag	Samples Affected
Holding Time	Holding time exceeded for extraction or analysis	J positive results; UJ nondetects	Sample
	Holding time exceeded by a factor of two	J positive results; R nondetects	
Sample Preservation	Sample not preserved	J positive results; UJ nondetects	Sample
Sample Integrity	Bubbles (>pea size) in VOA vial used for analysis	J positive hits; UJ nondetects	Sample
Temperature	> 6°C	J positive results; UJ nondetects	All samples in same cooler
Initial Calibration	RRF <0.050 but >0.01	J positive results, UJ nondetects	All associated samples in analysis batch
	RRF<0.01	J positive results, R nondetects	
	%RSD >30.0% AND calibration curve not used; OR calibration curve used, but with coefficient of correlation or determination < 0.99	J positive results, UJ nondetects	
Calibration Verification (Second-source and continuing calibration verification)	RRF < 0.050 but >0.01	J positive results, UJ nondetects	All associated samples in analysis batch
	RRF<0.01	J positive results, R nondetects	
	%Drift > 25.0% with high recovery	J positive results,	
	%Drift > 25.0% with low recovery	J positive results, UJ nondetects	
Laboratory Control Sample	%R > UCL	J positive results	All samples in preparation batch
	%R < LCL	J positive results, UJ nondetects	
	%R < 10%	J positive results, R nondetects	
Blanks Calibration Blank Method Blank	Convert blank concentration to soil units, if applicable; multiply the highest blank concentration by 5	U positive sample results < 5x highest blank concentration	All samples in preparation batch or analytical batch, whichever one applies, associated with method blank or calibration blank
Equipment Blank Field Blank Ambient Blank			All samples, same site, matrix and date (water) or all samples, same site, matrix (soil) associated with equipment blank
Trip Blank (VOCs only)			All samples shipped in the same cooler as the trip blank

TABLE 4-2
Flagging Conventions for Organic Methods
Quality Assurance Project Plan, Dow Hanging Rock, Ohio

Quality Control Check	Evaluation	Flag	Samples Affected
Matrix spikes			
% Recoveries	%R > UCL	J positive results	MS analytes in parent sample and field duplicate, if any
	%R < LCL>10%	J positive results, UJ nondetects	
	%R <10%	J positive results, R nondetects	
RPDs	RPD > UCL	J positive results	MS analytes in parent sample and field duplicate, if any
Surrogates			
SW8260B	%R > UCL	J positive results	All analytes in sample
	%R < LCL and none < 10%	J positive results; UJ nondetects	
	%R < 10%	J positive results; R nondetects	
SW8270C	2 or more surrogates in same fraction with %R > UCL	J positive results	All analytes in same fraction in sample
	2 or more surrogates in same fraction with %R < LCL but not <10%	J positive results; UJ nondetects	
	Any fraction with 1 or more surrogates %R <10%	J positive results; R nondetects	
Internal Standards	Area >UCL	J positive results	Associated analytes in sample
	Area <LCL but not <10%	J positive results; UJ nondetects	
	Area <10%	J positive results; R nondetects	
Field duplicates	Concentration of reported analytes are > 5 times the reporting limit in either sample and RPD > UCL (30% for water samples; 50% for soil samples)	J positive results	Field duplicate pair
	One or both sample results < 5 times the reporting limit and a difference of ±2 times the reporting limit for water (±4 times for soil).	J positive; UJ nondetect	

TABLE 4-2
Flagging Conventions for Organic Methods
Quality Assurance Project Plan, Dow Hanging Rock, Ohio

Quality Control Check	Evaluation	Flag	Samples Affected
Confirmation (SW8015B; SW8021B,SW8081A; SW8151A	RPD between primary and confirmation results > 25%	J positive results	Sample

All QA/QC criteria are included in Tables A-13 through A-24 and will be used for validation criteria.
Organic methods include SW8015B, SW8015M, SW8081A, SW8082, SW8151A, SW8260B, SW8270C, SW8270C SIM, SW8270-PAHL, and SW8310.
Spike recovery limits do not apply when sample concentration exceeds the spike concentration by a factor of 4 or more.
For methods requiring confirmation, the qualification s applies to primary analysis results (either of the two columns/detectors may be designated as the primary column/detector).
Where one MS recovery meets acceptance criteria and the other MS of the pair does not, professional judgment may be used to determine if the parent sample should be qualified for matrix effects by comparing the MS recoveries to other QC results within the batch or sample site.
Qualifier may not apply in cases where a surrogate coelutes with a non-target analyte.
For SW8015M (DRO) and SW8081A, it is assumed that two surrogates are used. If only one is used, that surrogate must pass the acceptance criteria, otherwise flags will be applied.
Qualifier may not apply in cases where low surrogate recoveries are due to sample dilution.
LCL = lower control limit
MB = method blank
RPD = relative percent difference
UCL = upper control limit
%R = percent recovery

TABLE 4-3
Flagging Conventions for Inorganic Methods
Quality Assurance Project Plan, Dow Hanging Rock, Ohio

Quality Control Check	Evaluation		Flag	Samples Affected
Holding Time	Holding time exceeded for extraction, digestion, or analysis		J positive results; UJ nondetects	Sample
	Holding time for digestion or analysis exceeded by a factor of 2		J positive results; R nondetects	
Sample Preservation	Sample preservation requirements not met (If sample preservation was not done in the field, but was performed at the laboratory upon sample receipt, no flagging is required)		J positive results; R nondetects	Sample
Temperature	> 6°C		J positive results; UJ nondetects	Samples in same cooler
Initial Calibration (Multi-point only)	Correlation coefficient ≤ 0.995		J positive; UJ nondetects	All associated samples in analytical batch
Calibration verification (initial calibration verification, continuing calibration verification) 90-110% accuracy	%R > UCL		J positive results	All associated samples in analytical batch
	%R < LCL		J positive results, UJ nondetects	
Interference check sample (SW6010B/SW6020 only) 80-120% accuracy	%R > UCL		J positive results	All associated samples in analytical batch
	%R < LCL		J positive results; UJ nondetects	
Laboratory Control Sample	%R > UCL		J positive results	Analyte in associated samples
	%R <LCL but ≥30%		J positive results; UJ nondetects	
	%R <LCL but ≤30%		J positive results; R nondetects	
Calibration Blank (ICB,CCB)	**Blank Result**	**Sample Result**		
	≥ MDL but ≤ CRQL	Nondetect	No action	all associated samples in batch
		≥ MDL but ≤ CRQL	Report result at CRQL and "U" flag	
		> CRQL	Use professional judgment	

TABLE 4-3
Flagging Conventions for Inorganic Methods
Quality Assurance Project Plan, Dow Hanging Rock, Ohio

Quality Control Check		Evaluation	Flag	Samples Affected
	> CRQL	≥ MDL but ≤ CRQL	Report result at CRQL and "U" flag	
		>CRQL but < Blank Result	Report result at blank concentration and "U" flag R nondetects	
		> Blank result	Use professional judgment	
	≤ (-MDL) but ≥ (-CRQL)	≥ MDL or nondetect	Use professional judgment	
Method Blank/Equipment Blank (LB/EB)	**Blank Result**	**Sample Result**		
	≥ MDL but ≤ CRQL	Nondetect	No action	
		≥ MDL but ≤ CRQL	Report result at CRQL and "U" flag	
		> CRQL	Use professional judgment	
	> CRQL	≥ MDL but ≤ CRQL	Report result at CRQL and "U" flag	all associated samples in batch
		>CRQL but < 10x the blank result	R Nondetects J positive results	
		≥ 10x the blank result	No action	
	< (-CRQL)	< 10x the CRQL	J- results >CRQL UJ nondetects	
Matrix spikes	%R > UCL		J positive results	MS analytes in parent sample and field duplicate, if any
	%R < LCL		J positive results UJ nondetects	
	RPD > UCL		J positive results	
Dilution Test	If concentration is >25 times the reporting limit and percent difference >UCL		J positive results UJ nondetects	Analyte in parent sample

TABLE 4-3
Flagging Conventions for Inorganic Methods
Quality Assurance Project Plan, Dow Hanging Rock, Ohio

Quality Control Check	Evaluation	Flag	Samples Affected
Post-digestion Spikes/Recovery Test (Metals only)	%R > UCL	J positive	Analytes in parent sample and field duplicate, if any
	%R < LCL	J positive results, UJ nondetects	
MSA (GFAA only) for samples where post-digestion spike (performed as a result of unacceptable serial dilution) fails	r < 0.995	J positive results	Sample
Field Duplicates Laboratory Sample Duplicates	Concentration of reported analytes are > 5 times the reporting limit in either sample and RPD > 50% (25% LR)	J positive results	Field duplicate pair/ parent sample of LR
	One or both sample results < 5 times the reporting limit and a difference of ±2 times the reporting limit	J positive results UJ nondetects	

All QA/QC criteria are included in Tables A-13 through A-24 and will be used for validation criteria.
Spike recovery limits do not apply when sample concentration exceeds the spike concentration by a factor of 4 or more.
CCB = continuing calibration blank.
MDL = method detection limit
ICB = initial calibration blank
MSA = method of standard addition
LCL = lower control limit
RPD = relative percent difference
MB = method blank
%R = percent recovery
UCL = upper control limit
ValAdj = Value reported by laboratory adjusted due to matrix issues
LabA&P = Laboratory accuracy and precision criteria not met

SECTION 5

References

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Attachment 1

Reporting Limit Goals and Corrective Action Requirements

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TABLE A-1
Reporting Limit Objectives for Volatile Organic Compounds in Soil Matrices by SW8260B
Dow Hanging Rock, Ohio

Analyte	USEPA Regional Screening Level (Industrial) (µg/kg)	Ecological Target Detection Limit[a] (µg/kg)	Method Detection Limit[b] (µg/kg)	Reporting Limit[b] (µg/kg)
1,1,1-Trichloroethane	3,800,000	29,800	TBD	TBD
1,1,1,2-Tetrachloroethane	9,300	225,000	TBD	TBD
1,1,2,2-Tetrachloroethane	2,800	127	TBD	TBD
1,1,2-Trichloro-1,2,2-trifluoroethane	18,000,000	--	TBD	TBD
1,1,2-Trichloroethane	5,300	28,600	TBD	TBD
1,1-Dichloroethane	17,000	20,100	TBD	TBD
1,1-Dichloroethene	110,00	8,280	TBD	TBD
1,1-Dichloropropene	110,00	398	TBD	TBD
1,2,3-Trichlorobenzene	49,000	20,000[c]	TBD	TBD
1,2,3-Trichloropropane	95	3,360	TBD	TBD
1,2,4-Trichlorobenzene	27,000	20,000[c]	TBD	TBD
1,2,4-Trimethylbenzene	26,000	--	TBD	TBD
1,2-Dibromo-3-chloropropane	69	35.2	TBD	TBD
1,2-Dibromoethane	170	1,230	TBD	TBD
1,2-Dichlorobenzene	980,000	37,700	TBD	TBD
1,2-Dichloroethane	2,200	21,200	TBD	TBD
1,2-Dichloropropane	4,500	32,700	TBD	TBD
1,3,5-Trimethylbenzene	1,000,000	--	TBD	TBD
1,3-Dichlorobenzene	12,000	20,000[c]	TBD	TBD
1,3-Dichloropropane	2,000,000	32,700	TBD	TBD
1,4-Dichlorobenzene	12,000	546	TBD	TBD
2,2-Dichloropropane	4,500	32,700	TBD	TBD
2-Butanone	20,000,000	89,600	TBD	TBD
2-Chlorotoluene	2,000,000	--	TBD	TBD
2-Hexanone	5,300,000	12,600	TBD	TBD
4-Chlorotoluene	7,200,000	--	TBD	TBD
4-Methyl-2-pentanone	5,300,000	443,000	TBD	TBD
Acetone	63,000,000	2,500	TBD	TBD
Benzene	5,400	255	TBD	TBD
Bromobenzene	180,000	--	TBD	TBD
Bromochloromethane	1,400	--	TBD	TBD
Bromodichloromethane	1,400	540	TBD	TBD
Bromoform	220,000	15,900	TBD	TBD
Bromomethane	3,200	--	TBD	TBD
Carbon Disulfide	370,000	94.1	TBD	TBD
Carbon Tetrachloride	3,000	2,980	TBD	TBD
Chlorobenzene	140,000	13,100	TBD	TBD

TABLE A-1
Reporting Limit Objectives for Volatile Organic Compounds in Soil Matrices by SW8260B
Dow Hanging Rock, Ohio

Analyte	USEPA Regional Screening Level (Industrial) (µg/kg)	Ecological Target Detection Limit[a] (µg/kg)	Method Detection Limit[b] (µg/kg)	Reporting Limit[b] (µg/kg)
Chloroethane	6,100,000	1,190	TBD	TBD
Chloroform	1,500	1,190	TBD	TBD
Chloromethane	50,000	10,400	TBD	TBD
cis-1,2-Dichloroethene	200,000	784	TBD	TBD
cis-1,3-Dichloropropene	8,100	398	TBD	TBD
Cyclohexane	2,900,000	--	TBD	TBD
Dibromochloromethane	3,300	2,050	TBD	TBD
Dibromomethane	11,000	65,000	TBD	TBD
Dichlorodifluoromethane	78,000	39,500	TBD	TBD
Ethylbenzene	27,000	5,160	TBD	TBD
Hexachlorobutadiene	22,000	39.8	TBD	TBD
Isopropylbenzene	1,100,000	--	TBD	TBD
m,p-Xylene	1,700,000	10,000	TBD	TBD
Methyl Acetate	100,000,000	--	TBD	TBD
Methyl tert-Butyl Ether	220,000	--	TBD	TBD
Methylcyclohexane	---	--	TBD	TBD
Methylene Chloride	53,000	4,050	TBD	TBD
Naphthalene	18,000	99.4	TBD	TBD
n-Butylbenzene	1,100,000	--	TBD	TBD
n-Propylbenzene	1,100,000	--	TBD	TBD
o-Xylene	1,900,000	10,000	TBD	TBD
p-Isopropyltoluene	1,100,000	--	TBD	TBD
sec-Butylbenzene	1,100,000	--	TBD	TBD
Styrene	3,600,000	4,690	TBD	TBD
tert-Butylbenzene	1,100,000	--	TBD	TBD
Tetrachloroethene	2,600	9,920	TBD	TBD
Toluene	4,500,000	5,450	TBD	TBD
trans-1,2-Dichloroethene	69,000	784	TBD	TBD
trans-1,3-Dichloropropene	8,100	398	TBD	TBD
Trichloroethene	14,000	12,400	TBD	TBD
Trichlorofluoromethane	340,000	16,400	TBD	TBD
Vinyl acetate	410,000	12,700	TBD	TBD
Vinyl Chloride	1,700	646	TBD	TBD

ug/kg=microgram per kilogram (ppb)
[a] Ecological Target Detection Limits for soil are based on USEPA Region 5 ESLs unless otherwise noted.
[b] The MDLs/RLs will be updated to reflect actual subcontract laboratory's capabilities
[c] The Ecological Target Detection Limit is based on Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process (Efroymson et al. 1997)
-- Screening level not available

TABLE A-1
Reporting Limit Objectives for Volatile Organic Compounds in Soil Matrices by SW8260B
Dow Hanging Rock, Ohio

Analyte	USEPA Regional Screening Level (Industrial) (µg/kg)	Ecological Target Detection Limit[a] (µg/kg)	Method Detection Limit[b] (µg/kg)	Reporting Limit[b] (µg/kg)
USEPA Regional Screening Level (Industrial) Surrogates:				
Bromodichloromethane's RSL was used as a surrogate for Bromochloromethane				
1,3-Dichloropropene's RSL was used as a surrogate for cis-1,3-Dichloropropene				
1,3-Dichloropropene was used as a surrogate for trans-1,3-Dichloropropene				
Methyl isobutyl ketone's (4-methyl-2-pentanone) RSL was used as a surrogate for 2-Hexanone				
1,4-Dichlorobenzene's RSL was used as a surrogate for 1,3-Dichlorobenzene				
1,2,4 trichlorobenzene's RSL was used as a surrogate for 1,2,3-Trichlorobenzene				
1,1-dichloroethene was used as a surrogate for 1,1-Dichloropropene				
1,2-Dichloropropane was used as a surrogate for 2,2-Dichloropropane				
Cumene was used as a surrogate for n-Butylbenzene				
Cumene was used as a surrogate for n-Propylbenzene				
Cumene was used as a surrogate for p-Isopropyltoluene				
Cumene was used as a surrogate for sec-Butylbenzene				
Cumene was used as a surrogate for tert-Butylbenzene				

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TABLE A-2
Reporting Limit Objectives for Volatile Organic Compounds in Sediment Matrices by SW8260B
Dow Hanging Rock, Ohio

Analyte	USEPA Regional Screening Level (Industrial) (µg/kg)	Ecological Target Detection Limit[a] (µg/kg)	Method Detection Limit[b] (µg/kg)	Reporting Limit[b] (µg/kg)
1,1,1-Trichloroethane	3,800,000	213	TBD	TBD
1,1,1,2-Tetrachloroethane	9,300	--	TBD	TBD
1,1,2,2-Tetrachloroethane	2,800	850	TBD	TBD
1,1,2-Trichloro-1,2,2-trifluoroethane	18,000,000	--	TBD	TBD
1,1,2-Trichloroethane	5,300	518	TBD	TBD
1,1-Dichloroethane	17,000	0.575	TBD	TBD
1,1-Dichloroethene	110,00	19.4	TBD	TBD
1,1-Dichloropropene	110,00	--	TBD	TBD
1,2,3-Trichlorobenzene	49,000	--	TBD	TBD
1,2,3-Trichloropropane	95	--	TBD	TBD
1,2,4-Trichlorobenzene	27,000	5,062	TBD	TBD
1,2,4-Trimethylbenzene	26,000	--	TBD	TBD
1,2-Dibromo-3-chloropropane	69	--	TBD	TBD
1,2-Dibromoethane	170	--	TBD	TBD
1,2-Dichlorobenzene	980,000	294	TBD	TBD
1,2-Dichloroethane	2,200	260	TBD	TBD
1,2-Dichloropropane	4,500	333	TBD	TBD
1,3,5-Trimethylbenzene	1,000,000	--	TBD	TBD
1,3-Dichlorobenzene	12,000	1,315	TBD	TBD
1,3-Dichloropropane	2,000,000	--	TBD	TBD
1,4-Dichlorobenzene	12,000	318	TBD	TBD
2,2-Dichloropropane	4,500	--	TBD	TBD
2-Butanone	20,000,000	42.4	TBD	TBD
2-Chlorotoluene	2,000,000	--	TBD	TBD
2-Hexanone	5,300,000	--	TBD	TBD
4-Chlorotoluene	7,200,000	--	TBD	TBD
4-Methyl-2-pentanone	5,300,000	25.1	TBD	TBD
Acetone	63,000,000	9.9	TBD	TBD
Benzene	5,400	142	TBD	TBD
Bromobenzene	180,000	--	TBD	TBD
Bromochloromethane	1,400	--	TBD	TBD
Bromodichloromethane	1,400	--	TBD	TBD
Bromoform	220,000	492	TBD	TBD
Bromomethane	3,200	--	TBD	TBD
Carbon Disulfide	370,000	23.9	TBD	TBD
Carbon Tetrachloride	3,000	1,450	TBD	TBD
Chlorobenzene	140,000	291	TBD	TBD

TABLE A-2
Reporting Limit Objectives for Volatile Organic Compounds in Sediment Matrices by SW8260B
Dow Hanging Rock, Ohio

Analyte	USEPA Regional Screening Level (Industrial) (µg/kg)	Ecological Target Detection Limit[a] (µg/kg)	Method Detection Limit[b] (µg/kg)	Reporting Limit[b] (µg/kg)
Chloroethane	6,100,000	--	TBD	TBD
Chloroform	1,500	121	TBD	TBD
Chloromethane	50,000	--	TBD	TBD
cis-1,2-Dichloroethene	200,000	--	TBD	TBD
cis-1,3-Dichloropropene	8,100	333	TBD	TBD
Cyclohexane	2,900,000	--	TBD	TBD
Dibromochloromethane	3,300	--	TBD	TBD
Dibromomethane	11,000	--	TBD	TBD
Dichlorodifluoromethane	78,000	--	TBD	TBD
Ethylbenzene	27,000	175	TBD	TBD
Hexachlorobutadiene	22,000	26.5	TBD	TBD
Isopropylbenzene	1,100,000	--	TBD	TBD
m,p-Xylene	1,700,000	433	TBD	TBD
Methyl Acetate	100,000,000	--	TBD	TBD
Methyl tert-Butyl Ether	220,000	--	TBD	TBD
Methylcyclohexane	---	--	TBD	TBD
Methylene Chloride	53,000	159	TBD	TBD
Naphthalene	18,000	176	TBD	TBD
n-Butylbenzene	1,100,000	--	TBD	TBD
n-Propylbenzene	1,100,000	--	TBD	TBD
o-Xylene	1,900,000	433	TBD	TBD
p-Isopropyltoluene	1,100,000	--	TBD	TBD
sec-Butylbenzene	1,100,000	--	TBD	TBD
Styrene	3,600,000	254	TBD	TBD
tert-Butylbenzene	1,100,000	--	TBD	TBD
Tetrachloroethene	2,600	990	TBD	TBD
Toluene	4,500,000	1,220	TBD	TBD
trans-1,2-Dichloroethene	69,000	--	TBD	TBD
trans-1,3-Dichloropropene	8,100	333	TBD	TBD
Trichloroethene	14,000	112	TBD	TBD
Trichlorofluoromethane	340,000	--	TBD	TBD
Vinyl acetate	410,000	--	TBD	TBD
Vinyl Chloride	1,700	202	TBD	TBD

ug/kg=microgram per kilogram (ppb)
[a] Ecological Target Detection Limits for soil are based on USEPA Region 5 ESLs unless otherwise noted
[b] The MDL/RL will be updated to reflect actual subcontract laboratory's capabilities
-- Screening level not available
USEPA Regional Screening Level (Industrial) Surrogates:
Bromodichloromethane's RSL was used as a surrogate for Bromochloromethane

TABLE A-2
Reporting Limit Objectives for Volatile Organic Compounds in Sediment Matrices by SW8260B
Dow Hanging Rock, Ohio

Analyte	USEPA Regional Screening Level (Industrial) (µg/kg)	Ecological Target Detection Limit[a] (µg/kg)	Method Detection Limit[b] (µg/kg)	Reporting Limit[b] (µg/kg)
1,3-Dichloropropene's RSL was used as a surrogate for cis-1,3-Dichloropropene				
1,3-Dichloropropene was used as a surrogate for trans-1,3-Dichloropropene				
Methyl isobutyl ketone's (4-methyl-2-pentanone) RSL was used as a surrogate for 2-Hexanone				
1,4-Dichlorobenzene's RSL was used as a surrogate for 1,3-Dichlorobenzene				
1,2,4 trichlorobenzene's RSL was used as a surrogate for 1,2,3-Trichlorobenzene				
1,1-dichloroethene was used as a surrogate for 1,1-Dichloropropene				
1,2-Dichloropropane was used as a surrogate for 2,2-Dichloropropane				
Cumene was used as a surrogate for n-Butylbenzene				
Cumene was used as a surrogate for n-Propylbenzene				
Cumene was used as a surrogate for p-Isopropyltoluene				
Cumene was used as a surrogate for sec-Butylbenzene				
Cumene was used as a surrogate for tert-Butylbenzene				

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TABLE A-3
Reporting Limit Objectives for Semivolatile Organic Compounds in Soil Matrices by SW8270C/SW8270SIM
Dow Hanging Rock, Ohio

Analyte	USEPA Regional Screening Level (Industrial) (µg/kg)	Ecological Target Detection Limit[a] (µg/kg)	Method Detection Limit[b] (µg/kg)	Reporting Limit (µg/kg)
1,4-Dioxane[c]	17,000	2,050	TBD	TBD
1,1'-Biphenyl	5,100,000	600[d]	TBD	TBD
2,4,5-Trichlorophenol	6,200,000	14,100	TBD	TBD
2,4,6-Trichlorophenol	62,000	4000[d]	TBD	TBD
2,4-Dichlorophenol	180,000	9,940	TBD	TBD
2,4-Dimethylphenol	1,200,000	10	TBD	TBD
2,4-Dinitrophenol	120,000	60.9	TBD	TBD
2,4-Dinitrotoluene	5,500	1,280	TBD	TBD
2,6-Dinitrotoluene	62,000	32.8	TBD	TBD
2-Chloronaphthalene	8,200,000	12.2	TBD	TBD
2-Chlorophenol	510,000	243	TBD	TBD
2-Methylnaphthalene	410,000	3,240	TBD	TBD
2-Methylphenol	3,100,000	40,400	TBD	TBD
2-Nitroaniline	600,000	3,160	TBD	TBD
2-Nitrophenol	--	1,600	TBD	TBD
3,3'-Dichlorobenzidine	3,800	646	TBD	TBD
3-Nitroaniline	--	3,160	TBD	TBD
4,6-Dinitro-2-methylphenol	4,900	--	TBD	TBD
4-Bromophenyl-phenylether	--	--	TBD	TBD
4-Chloro-3-methylphenol	6,200,000	--	TBD	TBD
4-Chloroaniline	8,600	20,000[d]	TBD	TBD
4-Chlorophenyl-phenyl ether	--	--	TBD	TBD
3, 4-Methylphenol	310,000	--	TBD	TBD
4-Nitroaniline	86,000	21,900	TBD	TBD
4-Nitrophenol	--	5,120	TBD	TBD
Acenaphthene	3,300,000	682,000	TBD	TBD
Acenaphthylene	--	682,000	TBD	TBD
Anthracene	17,000,000	1,480,000	TBD	TBD
Benzo(a)anthracene	2,100	5,210	TBD	TBD
Benzo(a)pyrene	210	1,520	TBD	TBD
Benzo(b)fluoranthene	2,100	59,800	TBD	TBD
Benzo(g,h,i)perylene	--	119,000	TBD	TBD
Benzo(k)fluoranthene	21,000	148,000	TBD	TBD
Benzyl alcohol	6,200,000	65,800	TBD	TBD
bis(2-Chloroethoxy) methane	180,000	302	TBD	TBD
bis-(2-Chloroethyl) ether	1,000	23,700	TBD	TBD
bis(2-Ethylhexyl) phthalate	120,000	925	TBD	TBD
Butylbenzylphthalate	910,000	239	TBD	TBD

TABLE A-3
Reporting Limit Objectives for Semivolatile Organic Compounds in Soil Matrices by SW8270C/SW8270SIM
Dow Hanging Rock, Ohio

Analyte	USEPA Regional Screening Level (Industrial) (µg/kg)	Ecological Target Detection Limit[a] (µg/kg)	Method Detection Limit[b] (µg/kg)	Reporting Limit (µg/kg)
Carbazole	--	--	TBD	TBD
Chrysene	210,000	4,730	TBD	TBD
Dibenzo(a,h)-anthracene	210	18,400	TBD	TBD
Dibenzofuran	100,000	--	TBD	TBD
Diethylphthalate	49,000,000	24,800	TBD	TBD
Dimethylphthalate	--	734,000	TBD	TBD
Di-n-butylphthalate	6,200,000	150	TBD	TBD
Di-n-octylphthalate	--	709,000	TBD	TBD
Fluoranthene	2,200,000	122,000	TBD	TBD
Fluorene	2,200,000	122,000	TBD	TBD
Hexachlorobenzene	1,100	199	TBD	TBD
Hexachlorocyclopentadiene	370,000	755	TBD	TBD
Hexachloroethane	62,000	596	TBD	TBD
Indeno(1,2,3-cd)-pyrene	2,100	109,000	TBD	TBD
Isophorone	1,800,000	139,000	TBD	TBD
Nitrobenzene	24,000	1,310	TBD	TBD
N-Nitroso diphenylamine	350,000	545	TBD	TBD
N-Nitroso-di-n propylamine	250	544	TBD	TBD
Pentachlorophenol	2,700	119	TBD	TBD
Phenanthrene	--	45,700	TBD	TBD
Phenol	18,000,000	120,000	TBD	TBD
Pyrene	1,700,000	78,500	TBD	TBD

ug/kg=microgram per kilogram (ppb)
-- Screening level not available
[a] Ecological Target Detection Limits for soil are based on USEPA Region 5 ESLs unless otherwise noted.
The MDLs/RLs will be updated to reflect actual subcontract laboratory's capabilities
[c] 1,4-Dioxane will be analyzed by SW8270C SIM
[d] The Ecological Target Detection Limit is based on Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process (Efroymson et al. 1997)

TABLE A-4
Reporting Limit Objectives for Semivolatile Organic Compounds in Sediment Matrices by SW8270C/SW8270SIM
Dow Hanging Rock, Ohio

Analyte	USEPA Regional Screening Level (Industrial) (µg/kg)	Ecological Target Detection Limit[a] (µg/kg)	Method Detection Limit[b] (µg/kg)	Reporting Limit (µg/kg)
1,4-Dioxane[c]	17,000	119	TBD	TBD
1,1'-Biphenyl	5,100,000	--	TBD	TBD
2,4,5-Trichlorophenol	6,200,000	208	TBD	TBD
2,4,6-Trichlorophenol	62,000	208	TBD	TBD
2,4-Dichlorophenol	180,000	81.7	TBD	TBD
2,4-Dimethylphenol	1,200,000	304	TBD	TBD
2,4-Dinitrophenol	120,000	6.21	TBD	TBD
2,4-Dinitrotoluene	5,500	14.4	TBD	TBD
2,6-Dinitrotoluene	62,000	39.8	TBD	TBD
2-Chloronaphthalene	8,200,000	417	TBD	TBD
2-Chlorophenol	510,000	31.9	TBD	TBD
2-Methylnaphthalene	410,000	20.2	TBD	TBD
2-Methylphenol	3,100,000	--	TBD	TBD
2-Nitroaniline	600,000	--	TBD	TBD
2-Nitrophenol	--	13	TBD	TBD
3,3'-Dichlorobenzidine	3,800	127	TBD	TBD
3-Nitroaniline	--	--	TBD	TBD
4,6-Dinitro-2-methylphenol	4,900	--	TBD	TBD
4-Bromophenyl-phenylether	--	--	TBD	TBD
4-Chloro-3-methylphenol	6,200,000	--	TBD	TBD
4-Chloroaniline	8,600	146	TBD	TBD
4-Chlorophenyl-phenyl ether	--	--	TBD	TBD
3, 4-Methylphenol	310,000	--	TBD	TBD
4-Nitroaniline	86,000	--	TBD	TBD
4-Nitrophenol	--	13	TBD	TBD
Acenaphthene	3,300,000	6.1	TBD	TBD
Acenaphthylene	--	5.87	TBD	TBD
Anthracene	17,000,000	57.2	TBD	TBD
Benzo(a)anthracene	2,100	108	TBD	TBD
Benzo(a)pyrene	210	150	TBD	TBD
Benzo(b)fluoranthene	2,100	10,400	TBD	TBD
Benzo(g,h,i)perylene	--	170	TBD	TBD
Benzo(k)fluoranthene	21,000	240	TBD	TBD
Benzyl alcohol	6,200,000	--	TBD	TBD
bis(2-Chloroethoxy) methane	180,000	--	TBD	TBD
bis-(2-Chloroethyl) ether	1,000	3,520	TBD	TBD
Bis(2-chloroisopropyl) ether	--	--	TBD	TBD
bis(2-Ethylhexyl) phthalate	120,000	182	TBD	TBD

TABLE A-4
Reporting Limit Objectives for Semivolatile Organic Compounds in Sediment Matrices by SW8270C/SW8270SIM
Dow Hanging Rock, Ohio

Analyte	USEPA Regional Screening Level (Industrial) (µg/kg)	Ecological Target Detection Limit[a] (µg/kg)	Method Detection Limit[b] (µg/kg)	Reporting Limit (µg/kg)
Butylbenzylphthalate	910,000	1,970	TBD	TBD
Carbazole	--	--	TBD	TBD
Chrysene	210,000	166	TBD	TBD
Dibenzo(a,h)-anthracene	210	33	TBD	TBD
Dibenzofuran	100,000	449	TBD	TBD
Diethylphthalate	49,000,000	295	TBD	TBD
Dimethylphthalate	--	--	TBD	TBD
Di-n-butylphthalate	6,200,000	1,114	TBD	TBD
Di-n-octylphthalate	--	40,600	TBD	TBD
Fluoranthene	2,200,000	423	TBD	TBD
Fluorene	2,200,000	77.4	TBD	TBD
Hexachlorobenzene	1,100	20	TBD	TBD
Hexachlorocyclopentadiene	370,000	901	TBD	TBD
Hexachloroethane	62,000	584	TBD	TBD
Indeno(1,2,3-cd)-pyrene	2,100	200	TBD	TBD
Isophorone	1,800,000	432	TBD	TBD
Nitrobenzene	24,000	145	TBD	TBD
N-Nitroso diphenylamine	350,000	--	TBD	TBD
N-Nitroso-di-n propylamine	250	--	TBD	TBD
Pentachlorophenol	2,700	23,000	TBD	TBD
Phenanthrene	--	689	TBD	TBD
Phenol	18,000,000	49.1	TBD	TBD
Pyrene	1,700,000	195	TBD	TBD

ug/kg=microgram per kilogram (ppb)
-- Screening level not available
[a] Ecological Target Detection Limits for soil are based on USEPA Region 5 ESLs unless otherwise noted.
The MDLs/RLs will be updated to reflect actual subcontract laboratory's capabilities
[c] 1,4-Dioxane will be analyzed by SW8270C SIM

TABLE A-5
Reporting Limit Objectives for Metals in Soil Matrices by SW6010B/SW6020/SW7000 Series
Dow Hanging Rock, Ohio

Parameter	USEPA Regional Screening Level (Industrial) (mg/kg)	Ecological Target Detection Limit[a] (mg/kg)	Method Detection Limit[b] (mg/kg)	Reporting Limit (mg/kg)
Arsenic	1.6	18.0[b]	TBD	TBD
Barium	19000	330[b]	TBD	TBD
Cadmium	80	32.0[b]	TBD	TBD
Chromium	150000	0.40	TBD	TBD
Lead	800	120[b]	TBD	TBD
Mercury	3.4	0.10	TBD	TBD
Selenium	510	0.52[b]	TBD	TBD
Silver	510	560[b]	TBD	TBD

mg/kg=milligram per kilogram (ppm)
-- Screening level not available
[a] Ecological Target Detection Limits for soil are based on USEPA Region 5 ESLs unless otherwise noted.
[b] USEPA Ecological Soil Screening Levels (Eco-SSL)
The MDLs/RLs will be updated to reflect actual subcontract laboratory's capabilities

TABLE A-6
Reporting Limit Objectives for Metals in Sediment Matrices by SW6010B/SW6020/SW7000 Series
Dow Hanging Rock, Ohio

Parameter	USEPA Regional Screening Level (Industrial) (mg/kg)	Ecological Target Detection Limit (mg/kg)	Method Detection Limit[b] (mg/kg)	Reporting Limit (mg/kg)
Arsenic	1.6	9.8	TBD	TBD
Barium	19000	--	TBD	TBD
Cadmium	80	0.9	TBD	TBD
Chromium	150000	43.4	TBD	TBD
Lead	800	35.8000	TBD	TBD
Mercury	3.4	0.174	TBD	TBD
Selenium	510	2	TBD	TBD
Silver	510	0.5	TBD	TBD

mg/kg=milligram per kilogram (ppm)
-- Screening level not available
[a] Ecological Target Detection Limits for soil are based on USEPA Region 5 ESLs unless otherwise noted.
The MDLs/RLs will be updated to reflect actual subcontract laboratory's capabilities

TABLE A-7
Calibration and QC Requirements for Metals by SW6010B/SW6020
Dow Hanging Rock, Ohio

Quality Control Check	Frequency	Criteria	Corrective Action
Initial calibration (a blank and at least one standard)	Before sample analysis, every 24 hours, whenever modifications are made to the system, or when continuing calibration verification fails	If more than one standard is used, correlation coefficient must be > 0.995	N/A
Second-source calibration verification	Immediately following each initial calibration	All analytes within ±10% of expected value for SW6010B and within ±5% of expected value for USEPA 200.7	Correct problem and repeat initial calibration.
Calibration blank	After every Second-source or Continuing calibration verification analysis	No analytes detected at or above the reporting limit	Correct the problem, then reanalyze previous 10 samples
Continuing calibration verification	After every 10 samples and at the end of the analysis sequence	All analytes within ±10% of expected value for SW6010B and within ±10% of expected value for USEPA 200.7	Recalibrate and reanalyze all samples since the last acceptable continuing calibration verification
Method Blank	At least one per analytical batch	No analytes detected at or above the reporting limit	Correct the problem and re-prep and reanalyze all associated samples
Interference check standard	At the start and end of each analytical sequence or twice during an 8-hour period, whichever is more frequent	All analytes within ±20% of expected value	Correct the problem, recalibrate, reanalyze ICS and all affected samples
MS/MSD	One set per 20 project-specific samples. MSD is optional if a laboratory sample duplicate is performed	All analytes within laboratory limits	None
Laboratory sample duplicate	Once per analytical batch if MSD not performed	Concentration of reported analytes are > 5 times the reporting limit in either sample and RPD >20% One sample result < RL and a difference of ±2 times the reporting limit	None
LCS	At least one per analytical batch	All analytes within laboratory limits	Correct the problem, and re-prep and reanalyze the LCS and all samples in the analytical batch.
Dilution test	Each new sample matrix	Result from 1:5 dilution must be within ±10% of the undiluted sample result (applies only if undiluted sample result is at least 25 times the reporting limit)	Perform post-digestion spike addition.

TABLE A-7
Calibration and QC Requirements for Metals by SW6010B/SW6020
Dow Hanging Rock, Ohio

Quality Control Check	Frequency	Criteria	Corrective Action
Linear Range Calibration check standard	Once per quarter	All analytes within ± 10% of expected value	Correct problem then reanalyze or re-set linear range
Post-digestion spike addition	When dilution test fails	Recovery within 75-125% of expected value	None

N/A = not applicable
USEPA = U.S. Environmental Protection Agency
MS/MSD = matrix spike/matrix spike duplicate
ICS = interference check sample
RPD = relative percent difference
LCS = laboratory control sample

TABLE A-8
Calibration and Quality Control Requirements for Metals by SW7000 Series
Dow Hanging Rock, Ohio

Quality Control Check	Frequency	Criteria	Corrective Action
Multi-point initial calibration (a blank and at least five standards)	Before initial sample analysis, every 24 hours, whenever modifications are made to the analytical system, or when continuing calibration verification fails.	Correlation coefficient of linear regression is ≥ 0.995.	Correct the problem and repeat the initial calibration.
Second-source calibration verification	Immediately following each initial calibration.	All analytes within ±20% of expected value.	Correct the problem and repeat initial calibration.
Calibration blank	After every second-source or continuing calibration verification analysis.	No analytes detected at or above the reporting limit.	Correct the problem, then reanalyze previous 10 samples.
Continuing calibration verification	After every 10 samples and at the end of the analysis sequence.	All analytes within ±20% of expected value.	Recalibrate and reanalyze all samples since the last acceptable continuing calibration verification.
Method blank	At least one per analytical batch.	No analytes detected at or above the reporting limit.	Correct the problem and re-prep and reanalyze all associated samples.
MS/MSD	One set per 20 project-specific samples. MSD is optional if a laboratory sample duplicate is performed.	All analytes within laboratory limits	None.
Laboratory sample duplicate	Once per analytical batch if MSD not performed.	Concentration of reported analytes are > 5 times the reporting limit in either sample and RPD >20%. One sample result < the reporting limit and a difference of ±2 times the reporting limit.	None.
LCS	At least one per analytical batch.	All analytes within laboratory limits	Correct the problem, and re-prep and reanalyze the LCS and all samples in the analytical batch.
Dilution test	Each new sample matrix.	Result from 1:5 dilution must be within ±10% of the undiluted sample result (applies only if undiluted sample result is at least 25 times the reporting limit).	Perform recovery test.
Recovery test	When dilution test fails.	Recovery within 85-115% of expected value.	Analyze all samples by MSA.

MS/MSD = matrix spike/matrix spike duplicate
RPD = relative percent difference
LCS = laboratory control sample

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TABLE A-9
Calibration and Quality Control Requirements for Volatile Organic Compounds by SW8260B
Dow Hanging Rock, Ohio

Quality Control Check	Frequency	Criteria	Corrective Action
BFB Tuning	Prior to initial calibration and calibration verification (every 12 hours).	Refer to criteria listed in the method.	Retune instrument and verify.
Multi-point initial calibration (minimum five points for SW8260B and 3 points for EPA 624))	Prior to sample analysis, or when calibration verification fails.	SPCCs average RF ≥ 0.30a and %RSD for RFs for CCCs ≤ 30% and one option below: Option 1: Mean %RSD for all analytes ≤ 15% with no individual analyte RSD > 30%, if using average RRFs Option 2: Least squares regression r ≥ 0.990	Correct the problem and repeat the initial calibration.
Second-source calibration verification	Once for each multi-point initial calibration.	All analytes within ±25% of expected value.	Correct the problem and repeat initial calibration.
Continuing calibration verification	At the start of each analytical sequence and every 12 hours thereafter.	SPCCs [a] average RF ≥ 0.30c and %D for RFs for CCCs ≤ 20% All other analytes within + 20% of expected value, Except for USEPA 624 which will meet the requirements in Table 5 of the method – "D -detected" will be replaced with 10% minimum recovery	Correct the problem, then recalibrate and reanalyze all samples since the last acceptable continuing calibration verification.
Retention time window calculated for each analyte	Each analyte.	Relative retention time of each analyte within + 0.06 relative retention time units of the continuing calibration verification.	Not applicable (used for identification of analyte).
Internal standards	Each sample and quality control sample, method blank, MS/MSD and LCS.	Retention time within ±30 seconds from retention time of the daily continuing calibration verification standard. EICP area within –50% to +100% of the daily continuing calibration verification standard.	Inspect mass spectrometer and gas chromatography for malfunctions; reanalyze all affected samples.
Method blank	At least one per analytical batch.	No analytes detected at or above the reporting limit.	Correct the problem, then re-prep and reanalyze all associated samples.
Surrogate spike	Every standard, sample, method blank, MS/MSD and LCS.	All analytes within laboratory limits	Correct the problem and reanalyze (re-prep if necessary).

TABLE A-9
Calibration and Quality Control Requirements for Volatile Organic Compounds by SW8260B
Dow Hanging Rock, Ohio

Quality Control Check	Frequency	Criteria	Corrective Action
MS/MSD	One set per 20 project-specific samples.	All analytes within laboratory limits	None.
LCS	At least one per analytical batch.	All analytes within laboratory limits	Correct the problem, then re-prep and reanalyze the LCS and all samples in the analytical batch.

[a] SPCC average RRF $\geq$ 0.10 for bromoform, chloromethane, 1,1-dichloroethane
BFB = bromofluorobenzene
CCC = calibration check compounds
EICP = extracted ion current profile
LCS = laboratory control sample
MS/MSD = matrix spike/matrix spike duplicate
RF = response factor
RRF = relative response factor
RSD = relative standard deviation
SPCC = system performance check compounds
USEPA = U.S. Environmental Protection Agency

TABLE A-10
Calibration and Quality Control Requirements for Semivolatile Organic Compounds by SW8270C/SW8270SIM
Dow Hanging Rock, Ohio

Quality Control Check	Frequency	Criteria	Corrective Action
DFTPP Tuning	Prior to initial calibration and calibration verification (every 12 hours).	Refer to criteria listed in the method.	Retune instrument and verify.
Multi-point initial calibration (minimum five points)	Prior to sample analysis, or when calibration verification fails.	SPCCs average RF ≥ 0.050 and %RSD for RFs for CCCs ≤ 30% and one option below: Option 1: Mean %RSD for all analytes ≤ 15% with no individual analyte RSD > 30%, if using average RRFs. Option 2: Least squares regression r ≥ 0.990.	Correct the problem and repeat the initial calibration.
Second-source calibration verification	Once for each multi-point initial calibration.	All analytes within ±25% of expected value.	Correct the problem and repeat initial calibration.
Continuing calibration verification	At the start of each analytical sequence and every 12 hours thereafter.	SPCCs average RF ≥ 0.050 and %D for RFs for CCCs ≤ 20% All other analytes within ± 20% of expected value.	Correct the problem, then recalibrate and reanalyze all samples since the last acceptable continuing calibration verification.
Retention time window calculated for each analyte	Each analyte.	Relative retention time of each analyte within ± 0.06 relative retention time units of the continuing calibration verification.	Not applicable (used for identification of analyte).
Internal Standards	Each sample and quality control sample, method blank, MS/MSD and LCS.	Retention time within ±30 seconds from retention time of the daily continuing calibration verification standard. EICP area within –50% to +100% of the daily continuing calibration verification standard.	Inspect mass spectrometer and gas chromatography for malfunctions; reanalyze all affected samples.
Method Blank	At least one per analytical batch.	No analytes detected at or above the reporting limit.	Correct the problem, then re-prep and reanalyze all associated samples.
Surrogate spike	Every standard, sample, method blank, MS/MSD and LCS.	At least two surrogates per fraction in samples, method blank and LCS within laboratory limits	Correct the problem and reanalyze (re-prep if necessary).
MS/MSD	One set per 20 project-specific samples.	Within laboratory limits	None.
LCS	At least one per analytical batch.	Within laboratory limits	Correct the problem, then re-prep and reanalyze the LCS and all samples in the analytical batch.

TABLE A-10
Calibration and Quality Control Requirements for Semivolatile Organic Compounds by SW8270C/SW8270SIM
Dow Hanging Rock, Ohio

Quality Control Check	Frequency	Criteria	Corrective Action

CCC = calibration check compounds.
EICP = extracted ion current profile.
RF = response factor.
RRF = relative response factor.
SPCC = system performance check compounds.

Attachment 2

Electronic Data Deliverable Specification

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The electronic data deliverable (EDD) file from the laboratory will be a comma-delimited ASCII (CDA) file in the format listed below. There will be one file per hard copy report and the filename of the EDD file will be in the format REPORTID.txt or REPORTID.csv, where REPORTID is the hard copy report identifier of sample delivery group.

The first row of the EDD will contain the 47 field name values as listed in the EDD Specification Table.

The EDD Specification Table lists the attributes of the columns for each row of the CDA file. The fields should be reported in the order indicated.

The **Data Type** column describes the value in the field as either text (alphanumeric), number (numeric only), date (format: mm/dd/yyyy), or time (24-hour format hh:mm). If the field is conditional or optional and there is no value to be reported, report a null (i.e., no) value. For a text field, do not report a zero-length string (i.e., “”).

The **Data Length** column contains the maximum length of a text value for the particular data field.

The **Rqmt** column contains a code indicating whether the value is required (R) for all rows, optional (O) for all rows, or conditional (C) and depends on the type of result reported.

The VVL (Valid Value List) column contains a flag to indicate whether the data field has (Y) or does not have (N) a valid value list provided by CH2M HILL associated with it.

EDD Specification Table						
Field Number	**Field Name**	**Data Type**	**Data Length**	**Rqmt**	**VVL**	**Description and Comments**
1	VersionCode	text	15	R	Y	Code identifying the version of the EDD deliverable.
2	LabName	text	10	R	Y	Identification code for the laboratory performing the work. This value is used to distinguish among different facilities.
3	SDG	text	15	R	N	Sample delivery group designation. Always populated for all samples, including QC.
4	FieldID	text	30	R	N	Client sample ID as appears on COC with optional lab-assigned suffixes and/or prefixes to make it unique. If the sample identifier on the COC and the prefix/suffix is greater than 20 characters, abbreviate the value but make it unique. For laboratory QC samples (i.e., method blanks, lab control samples), use a unique lab sample identifier.
5	NativeID	text	30	R	N	Client sample ID, exactly as on the COC. No prefix or suffix allowed on client sample IDs. Used to identify the native sample from which other samples are derived (e.g., QAQCType = “LR”, “MS”, or “SD”). For laboratory QC samples (i.e., method blanks, lab control samples), use the FieldID value that was assigned. However, for lab blank spike duplicate samples, use the FieldID value that was assigned to the associated lab blank spike sample.
6	QAQCType	text	2	R	Y	This is the code for the sample type. Any field sample that is not used as lab QC and is not otherwise marked on the COC should have the designation of “N” (normal field sample). No suffix allowed (i.e., do not add numbers as suffixes to the QAQCType values as is called for in the ERPIMS guidelines). Note that if all analyses for a given sample are diluted, then the first dilution should be designated as the normal sample. If more dilutions are required, then the next dilution should be designated as the first true dilution with a QAQCType value of “LR” and a LRType value of “DL” (see LRType, below).
7	LRType	text	3	C	Y	This is the code for laboratory replicate sample type. Values are: blank (if QAQCType value is not “LR”), “DL” (dilution), “RE” (re-analysis), “D” (inorganic duplicate), “CF” (confirmation). For multiple dilutions or re-analyses of the same sample, append the replicate number after the LRType value (i.e., “RE”, “RE2”, “RE3”, etc.).
8	Matrix	text	5	R	Y	Sample matrix code. Valid values are as follows: “AIR”, “WATER”, “SOIL”, unless otherwise provided by the project data manager and marked on the COC. The use of “liquid”, “solid”, etc. for lab QC is not allowed.

EDD Specification Table						
Field Number	**Field Name**	**Data Type**	**Data Length**	**Rqmt**	**VVL**	**Description and Comments**
9	LabSampleID	text	12	R	N	Laboratory sample ID that is assigned by the laboratory. Prefix or suffix is allowed. This is where dilutions or re-extractions are noted. Ex: “D97-11111RE” is acceptable.
10	AnalysisMethod	text	20	R	Y	Analysis method code. This is the identifier of the analytical method that was performed on the sample. Example: SW8260A. Generic names such as “EPA” should not be used.
11	ExtractionMethod	text	20	R	Y	Preparation method code. A value in this field is required. If the preparation is described in the method, use “METHOD”. If there is no separate preparation required, use “NONE”. Note that Total and Dissolved metal analyses are differentiated by the value in this column. Note that Total, TCLP, and SPLP analyses are now differentiated by the value in the LeachMethod column (see below).
12	SampleDate	date		C	N	Date of sample collection. Value is required for all samples sent to the laboratory and samples derived from those samples. Format: mm/dd/yyyy
13	SampleTime	time		C	N	Time of sample collection. Value is required for all samples sent to the laboratory and samples derived from those samples. 24-hour format: hh:mm
14	ReceiveDate	date		C	N	Date of sample receipt in the lab. Value is required for all samples sent to the laboratory and samples derived from those samples. Format: mm/dd/yyyy
15	ExtractDate	date		C	N	Date of sample preparation (extraction or digestion). Value is required if the ExtractionMethod field value is other than “NONE”. Format: mm/dd/yyyy
16	ExtractTime	time		C	N	Time of sample preparation. Value is required if the ExtractionMethod field value is other than “NONE”. 24-hour format: hh:mm
17	AnalysisDate	date		R	N	Date of sample analysis. Value is required for all records. Format: mm/dd/yyyy
18	AnalysisTime	time		R	N	Time of sample analysis. Value is required for all records. 24-hour format: hh:mm
19	PercentSolids	number		R	N	Percent solids within the sample. Should be zero for water samples.
20	LabLotCtlNum	text	10	C	N	Identifier of an autonomous group of environmental samples and associated QC samples **prepared** together. For example, its value can be a digestion or extraction batch ID. If there is no separate extraction or preparation performed, leave this field blank.
21	CAS	text	20	C	N	CAS number of analyte, if available.
22	ParamID	text	12	R	Y	Parameter identifier code for the parameter listed in the Analyte field.
23	Analyte	text	60	R	N	Name of analyte, chemical name.

EDD Specification Table						
Field Number	**Field Name**	**Data Type**	**Data Length**	**Rqmt**	**VVL**	**Description and Comments**
24	Result	text	10	R	N	Result of the analysis. Surrogate analytes will be reported in units of percent. All others will be reported in sample concentration units. If undetected, report the adjusted MDL or adjusted RL, depending on the project. (Reported as a text field to preserve significant figures.)
25	ExpectedValue	number		C	N	“100” for surrogates; “0” (zero) for blanks; spike level plus parent result for LCS, and MS/MSD; parent value for lab duplicate; etc.
26	Units	text	10	R	Y	Units of measure used in the analysis. Report “PERCENT” for surrogate analytes and concentration units for all others.
27	Dilution	number		R	N	Total dilution reported in the analysis. Default value should be 1 (one). This value should reflect changes to sample preparation amounts as defined by the method (e.g., less sample used for standard VOC analysis).
28	MDL	number		C	N	Minimum detection limit adjusted for preparation and dilution. Note that this value may be the method detection limit or the instrument detection limit, depending on the method and the project requirements. This value is **not** adjusted for percent moisture.
29	RL	number		C	N	Reporting limit adjusted for preparation and dilution. Value is **not** adjusted for percent moisture. Equivalent to PQL.
30	LabQualifier	text	6	R	N	Lab qualifier for the results, as reported on the hard copy. Use “=” as first (or only) qualifier value for detected results if there are no other qualifiers for the result.
31	Surrogate	text	1	R	Y	Is the chemical a surrogate? Report “Y” for yes or “N” for no.
32	Comments	text	240	O	N	Comment field
33	ParValUncert	text	16	C	N	Radiological parameter value uncertainty.
34	Recovery	number		C	N	Percent recovery for MS, SD, LCS, LCSD, and surrogate compounds.
35	LowerControlLimit	number		C	N	Lower control limit value for spiked compounds, expressed in units of Percent. A value in this field is required if there is a value in the Recovery field (Field No. 34).
36	UpperControlLimit	number		C	N	Upper control limit value for spiked compounds, expressed in units of Percent. A value in this field is required if there is a value in the Recovery field (Field No. 34).
37	Basis	text	1	R	Y	Weight basis for soil (or solid) sample analysis. Use “D” for dry-weight basis, “W” for wet-weight basis, or “X” if not applicable.
38	ConcQual	text	1	R	Y	Concentration qualifier. Use “=” for detects, “J” for estimated value (value between detection limit and reporting limit), “U” for undetected result, or “E” for exceeded result.

EDD Specification Table						
Field Number	**Field Name**	**Data Type**	**Data Length**	**Rqmt**	**VVL**	**Description and Comments**
39	MDLAdjusted	number		C	N	Minimum detection limit adjusted for preparation, dilution **and percent moisture**. See the description of the MDL field (Field No. 28) for an explanation of the contents of this field.
40	RLAdjusted	number		C	N	Reporting limit adjusted for preparation, dilution **and percent moisture**. Equivalent to PQL
41	SampleDescription	text	30	C	N	Full sample identifier value as it appears on the COC. In some cases, this may be the name of the sampling location instead of the sample. Required for all samples that are either collected in the field and specified on the COC, or derived from samples that are collected in the field and specified on the COC.
42	LeachMethod	text	20	R	Y	Analytical method used for leaching the sample. This applies to TCLP, SPLP, or other leaching or pre-extraction leaching procedures. Use “NONE” if the sample was not leached.
43	LeachDate	date		C	N	Date that the leaching method was performed (start date for multi-date leaching procedures). Value is required if the LeachMethod field value is other then “NONE”. Format: mm/dd/yyyy.
44	LeachTime	time		C	N	Time that the leaching procedure started. Value is required if the LeachMethod field value is other then “NONE”. 24-hour format: hh:mm.
45	LeachLot	text	10	C	N	Identifier of an autonomous group of environmental samples and associated QC samples **leached** at the same time. Value is required if the LeachMethod field value is other then “NONE”. If the sample was not leached, leave this field blank.
46	AnalysisLot	text	10	R	N	Identifier of an autonomous group of environmental samples and associated QC samples **analyzed** together. A value in this field is mandatory (i.e., it should not be blank).
47	CalRefID	text	10	C	N	Identifier of a group of environmental and QC samples linked by a common set of calibration records. All results with the same CalRefID value will have had the same initial calibration run.

Each row is uniquely identified by the values in the following fields:

- FieldID
- LabSampleID
- AnalysisMethod
- ExtractionMethod
- LeachMethod
- ParamID

If an analytical sample must be diluted or reanalyzed and reported in addition to the original analytical sample, the diluted or reanalyzed sample should have a FieldID value that is different than that of the original sample. This can be accomplished through the addition of a suffix to the original FieldID that establishes a new and unique FieldID for the associated records.

Example Valid Values

The project data manager will provide the laboratory with a list of valid values that the laboratory will use in constructing the EDD. Listed below are some example valid values.

Field Name	Valid Value	Meaning
VersionCode	4.20AFCEE3	Format 4.20, AFCEE data values. LabQualifier field contains the laboratory qualifier values defined in the AFCEE QAPP, version 3.0.
VersionCode	4.20EPACLP	Format 4.20, EPA data values. LabQualifier field contains the standard EPA CLP lab qualifiers.
QAQCType	N	Normal, environmental sample
QAQCType	LB	Laboratory method blank
QAQCType	MS	Laboratory matrix spike sample
QAQCType	SD	Laboratory matrix spike duplicate
QAQCType	LR	Laboratory replicate (dilution, re-analysis, duplicate)
QAQCType	BS	Laboratory method blank spike
QAQCType	BD	Laboratory method blank spike duplicate
LRType	DL	First dilution sample
LRType	DL2	Second dilution sample
LRType	DL3	Third dilution sample
LRType	RE	First re-analysis/re-extraction sample
LRType	RE2	Second re-analysis/re-extraction sample
LRType	RE3	Third re-analysis/re-extraction sample
LRType	D	Inorganic duplicate sample
LRType	CF	First confirmation analysis sample
LRType	CF2	Second confirmation analysis sample
LRType	CF3	Third confirmation analysis sample
AnalysisMethod	SW8260A	Volatiles by method 8260A in EPA SW846.
AnalysisMethod	SW8270	Semivolatiles by method 8270 in EPA SW846.
AnalysisMethod	SW6010	ICP metals by method 6010 in EPA SW846.
AnalysisMethod	SW7060	GFAA Arsenic by method 7060 in EPA SW846.
ExtractionMethod	FLDFLT	Field filtration for dissolved metals analysis
ExtractionMethod	C3050	CLP-modified SW3050 acid digestion for metals analysis in soil samples.
ExtractionMethod	SW1311	TCLP extraction
ExtractionMethod	DISWAT	Distilled water extraction for analytes in soil samples.
ExtractionMethod	SW3510	Separatory funnel extraction
ExtractionMethod	SW3540	Soxhlet extraction
ExtractionMethod	TOTAL	Digestion of unfiltered waters for total metals analysis
ParamID	ACE	Acetone
ParamID	AS	Arsenic
ParamID	BHCGAMMA	gamma-BHC (Lindane)
ParamID	BZ	Benzene
ParamID	CDS	Carbon disulfide
ParamID	PB	Lead
ParamID	PHENOL	Phenol
ParamID	SE	Selenium
ParamID	TCE	Trichloroethene

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