SUPPLEMENTAL PHASE III EOC WORK PLAN - ADDENDUM NO. 1
COMPANY VEHICLE OPERATIONS PROPERTY
YPSILANTI, MICHIGAN

GENERAL MOTORS
YPSILANTI, MICHIGAN

Prepared For:
ENCORE

APRIL 2004
REF. NO. 17303 (7)

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bgs	below ground surface
CRA	Conestoga-Rovers & Associates
CVO	Company Vehicle Operations
CVOC	Chlorinated Volatile Organic Compound
DNAPL	Dense Non-Aqueous Phase Liquid
ENCORE	Environmental Corporate Remediation
EOC	Extent of Contamination
FMG	Field Method Guidelines
HSA	Hollow Stem Augers
GM	General Motors
GSI	Groundwater/Surface Water Interface
GSIPC	Groundwater Surface Water Protection Criteria
GVIAC	Groundwater Volatilization to Indoor Air Criteria
LEL	Lower Explosive Limit
NAPL	Non-Aqueous Phase Liquid
PAOC	Potential Area of Concern
PCBs	Polychlorinated Biphenyls
PID	Photoionization Detector
SVOC	Semivolatile Organic Compound
TAL	Total Analyte List
TCL	Total Contaminant List
TCLP	Toxicity Characteristic Leaching Procedure
VOC	Volatile Organic Compound
WRBC	Willow Run Business Center

1.0 INTRODUCTION

Conestoga-Rovers & Associates, Inc. (CRA) was retained by Environmental Corporate Remediation (ENCORE), a wholly owned subsidiary of General Motors (GM), to prepare this Supplemental Phase III Extent of Contamination (EOC) Work Plan, Addendum No. 1 (Work Plan Addendum) for the Company Vehicle Operations (CVO) Area (Site) at the former Willow Run Assembly Plant located in Ypsilanti, Michigan. Figure 1.1 presents the Site location. CRA prepared a Supplemental Phase III EOC Work Plan (EOC Work Plan) in October 2003. This Work Plan Addendum was prepared to delineate impacts identified in November and December 2003 during implementation of the EOC Work Plan.

The Site is located on the former Willow Run Assembly Plant property, which currently houses the Willow Run Business Center (WRBC), as well as the GM CVO facility. This Work Plan Addendum addresses issues identified at the CVO area only. The CVO area is bordered on the north and east by Tyler Pond, which influences groundwater flow at the property. The WRBC exists to the west, and Tyler Road abuts the southern Site boundary.

Specifically, this Work Plan Addendum presents additional investigative activities that will be conducted to:

- Further define the groundwater flow pattern to the south;
- Determine if groundwater flow changes seasonally;
- Determine additional locations for groundwater/surface water interface (GSI) monitoring points;
- Further define contaminant flow plume, including semivolatile organic compounds (SVOCs) and inorganics in select wells;
- Evaluate volatilization to indoor air as a pathway near the Haulaway Building;
- Delineate subsurface impacts previously observed in potential area of concern (PAOC) 18 (Kaiser-Frazer Dump Area); and
- Delineate subsurface impacts previously observed at MW19-15.

2.0 BACKGROUND

Supplemental Phase III EOC investigations were conducted at the Site in November and December 2003. The investigations were conducted to further define groundwater flow patterns; characterize the clay confining unit; identify and characterize potential preferential subsurface pathways from the Site to Tyler Pond; gather additional stratigraphy information for the south bank of Tyler Pond; determine appropriate locations for GSI monitoring points; characterize the storm water discharge from the Site to the Pond; delineate subsurface impacts previously observed at two locations (sink hole and pond bank); and identify other potential waste burial sites beneath the CVO parking lot.

The general Site investigation described in the EOC Work Plan identified that a radial groundwater flow pattern exists at the Site. Groundwater flows northeast to Tyler Pond and southeast towards the Fons Landfill and Willow Run Creek. The groundwater volatile organic compound (VOC) analytical results confirm the path of impacted groundwater to the southeast. Due to this information, additional investigative work will be required.

Sixteen monitoring wells were installed in PAOC 19 (CVO Property) to evaluate the VOC impacted groundwater throughout the Site. Groundwater concentrations of vinyl chloride were found to be above the Groundwater Volatilization to Indoor Air Criteria (GVIAC) and the Flammability/Explosivity Screening Criteria near the Haulaway Building. Soil samples collected at PAOC 19 sampling locations (soil borings and wells) were reported to have several constituent concentrations exceeding Groundwater Surface Water Protection Criteria (GSIPC). The EOC Work Plan required groundwater sampling for VOCs, and made provisions that additional constituents detected in the soils (i.e. SVOCs and inorganics) would be sampled following validation of the soil data. Additional groundwater monitoring is described in this Work Plan Addendum to investigate these PAOC 19 issues.

Impacted soils were identified at PAOC 18 along the bank of Tyler Pond and inside the CVO parking lot. During the installation of SB19-13, strong odors were observed and the photoionization detector (PID) reported organic vapors above 2,000 ppm. Sudan Four (a non-aqueous phase liquid (NAPL) detection product) was used to test the soils in this boring and indicated that free product may be present. The soil cuttings from this borehole were drummed separately and classified characteristically hazardous based on the toxicity characteristic leaching procedure (TCLP) results for trichloroethylene. Potential free product was also observed in the soil borings completed to delineate the

seeps along the bank of Tyler Pond in the vicinity of PAOC 18. Additional delineation activities will be conducted in this area and are described in this Work Plan Addendum.

An additional PAOC, PAOC 22 (Paint Sludge Area) was identified at MW19-15. White paint sludge was found at nine feet below ground surface (bgs). Trace amounts of cinders and ash were identified at 7.8 feet bgs. PAOC 22 is located west of the catwalks and north of the CVO fence.

2.1 BASIS FOR INVESTIGATION

Based on the results of the field activities associated with the EOC Work Plan, additional investigative activities are required at the Site. This Work Plan Addendum is designed to collect subsurface information for the following purposes:

- Further define the groundwater flow pattern to the south;
- Determine if groundwater flow changes seasonally;
- Determine additional locations for GSI monitoring points;
- Further define contaminant flow plume, including SVOCs and inorganic analysis in select wells;
- Evaluate volatilization to indoor air as a pathway near the Haulaway Building;
- Delineate subsurface impacts previously observed in PAOC 18; and
- Delineate subsurface impacts previously observed at MW19-15.

3.0 INVESTIGATION PROGRAM

Except as otherwise noted in this Work Plan, all sampling methodologies and analytical procedures will be in accordance with those presented in the EOC Work Plan. Detailed stratigraphy logs will be completed for each borehole and monitoring well installed. Permanent monitoring wells will be installed using 4-¼ inch inside diameter hollow stem augers (HSA). Temporary wells and soil borings will be completed using a GeoProbe direct push rig. Continuous soil samples will be collected from each location to record soil stratigraphy and to screen for organic vapors using a PID.

The investigative program described in this Work Plan Addendum consists of three phases:

- General Site investigation;
- Individual PAOC investigations; and
- GSI investigation.

The following subsections present an overview of these phases. Field related activities (borings, well development, groundwater sampling, etc.) will be conducted following ENCORE Field Method Guidelines (FMG). Applicable ENCORE FMGs (Soil Borings, Well Construction Materials, Well Development and Groundwater Sampling) can be found in Appendix A of the EOC Work Plan. An additional ENCORE FMG for soil gas surveys is included in Appendix A of this Work Plan Addendum. All soil borings and monitoring well locations are approximate and will be located based on actual field conditions.

3.1 GENERAL SITE INVESTIGATION

The Supplemental Phase III EOC investigations included activities to gain a better understanding of the groundwater flow direction, the clay confining layer in the central portion of the Site, and the geology along the south bank of Tyler Pond. An EM Survey was scheduled to identify other potential burial areas in the CVO parking lot, however the survey was postponed until spring 2004 due to snow cover.

Results of the investigations indicate that a radial groundwater flow pattern exists. It was also established that the clay-confining layer has a hydraulic conductivity in the order of $1x10^{-8}$ and is at least 30 feet thick in the central portion of the Site. Additional investigations are required to further define groundwater flow to the southeast, and to identify potential changes in groundwater flow throughout the year. A quarterly

groundwater-monitoring program is also described in this Work Plan Addendum. The general Site investigation is designed to characterize the following:

- Potential changes in groundwater flow seasonally;
- Groundwater flow to the south; and
- Quarterly groundwater monitoring.

3.1.1 POTENTIAL SEASONAL CHANGES IN GROUNDWATER FLOW

Water levels will be collected on a bi-monthly basis to determine if groundwater flow varies throughout the year. Table 3.1 lists the monitoring wells where groundwater levels will be monitored.

3.1.2 GROUNDWATER FLOW TO THE SOUTH

One soil boring (SB19-19) will be completed in the sewer bedding of the deepest utility line that leaves the Site to the south to determine if the groundwater plume is traveling in the sewer bedding corridors. The approximate depth of the sewer bedding is 13-15 feet bgs. A soil sample will be collected from the sewer bedding material and analyzed for total contaminant list (TCL) VOCs. If the bedding surrounding the sewer line is saturated, then a monitoring well will be installed and sampled for TCL VOCs.

Figure 3.1 presents the locations for all monitoring wells (existing and proposed) at the CVO Site and the Fons Landfill site. The Fons Landfill, located south of the CVO property, has two wells south of Tyler Road. CRA will request groundwater level data from these wells.

3.1.3 QUARTERLY GROUNDWATER MONITORING

Regular groundwater sampling was reduced to a semi-annual basis due to additional sampling events following potassium permanganate injections. However further injections have been cancelled, therefore, a quarterly sampling plan has been developed for the Site. Table 3.2 lists the proposed sampling locations and constituents for the quarterly groundwater-monitoring program.

3.2 PAOC INVESTIGATIONS

3.2.1 PAOC 18 – KAISER-FRAZER DUMP AREA

PAOC 18, the Kaiser-Frazer Dump Area, located along the southern bank of Tyler Pond coalesces with PAOC 2, former South Culvert Area, at the northwest corner of the Site. Results of the investigations conducted in November and December 2003 indicate that a possible source area may exist near the injection wells located near PAOC 18. A brown liquid was observed in two locations directly above the confining clay. Also, stained soils have been observed during borehole installation activities throughout PAOC 18. Additional investigations are required to define the extent of the potential source area. The additional activities are summarized below.

Eleven additional boreholes (SB18-65 – SB18-75) will be installed throughout PAOC 18 to delineate impacted soils and potential source areas. Additional borings will be installed to complete the delineation of impacted soils as required. Soil samples will be collected from the surficial soil layer (0-2 feet bgs) and from the 2-foot soil interval above the water table. Four of the eleven soil borings are to be installed near the shore of Tyler Pond. These borings will be installed to a depth of 5 feet into clay if continuous clay is encountered at the surface. All other soil borings will be installed six inches into the confining clay.

Two monitoring wells (MW18-01 and MW18-02) will be installed in PAOC 18 and screened for dense non-aqueous phase liquid (DNAPL). These wells will be installed near soil borings SB18-63 and SB18-64. Sumps will be placed in the wells so DNAPL can accumulate if present. A groundwater sample will be collected for these wells if DNAPL is not present in the wells. If free product is observed in either well, a sample will be collected for chemical (TCL VOCs, TCL SVOCs, total analyte list (TAL) inorganics and polychlorinated biphenyls (PCBs)) and fingerprint analysis. If visually impacted material is observed at any location, a soil sample will be collected from that interval and analyzed for TCL VOCs, TCL SVOCs, TAL inorganics, and PCBs.

Figure 3.2 shows all existing and proposed monitoring wells and soil borings in PAOC 18. Table 3.3 summarizes the groundwater analysis required for each monitoring well. Table 3.4 summarizes the well screen placement and the soil analyses to be conducted on the samples from the soil boring and monitoring wells.

3.2.2 PAOC 19 – CVO PROPERTY

PAOC 19 is the entire CVO Property, where groundwater is impacted with chlorinated VOCs (CVOCs). Results of the investigations conducted in November and December 2003 indicated that several soil and groundwater samples exceeded applicable Part 201 Criteria. Based on these results, it appears that groundwater impacted with CVOCs is flowing to the northeast and southeast. Three monitoring wells exceeded the Flammability/Explosivity Screening Criteria near the Haulaway Building. Also, injection well IW-33 exceeded the Industrial & Commercial II, III & IV GVIAC. This well is close to the Haulaway Building and, therefore, potential volatilization to indoor air will be evaluated. Several SVOCs and inorganic constituents were detected in soil samples above Part 201 Criteria. The scope of work described in the EOC Work Plan required the analysis of groundwater for VOCs. Additional investigations are required to determine if constituents detected in the soil have impacted groundwater, and to investigate the potential for volatilization of vinyl chloride to indoor air. The additional activities are summarized below.

To investigate the potential of vinyl chloride to volatilize to indoor air, groundwater samples will be collected from select wells near the Haulaway Building for vinyl chloride and flashpoint analysis. The headspace of select wells will be tested to determine the percent lower explosive limit (LEL) present. Two soil gas samples will be collected from the 0-2 feet bgs interval beneath the Haulaway Building. One will be collected beneath the maintenance shop floor, and one will be collected from beneath a maintenance pit floor. Figure 3.3 shows the location of the soil gas samples (SB19-17 and SB19-18) which will be analyzed for TCL VOCs. Table 3.5 outlines the soil gas-sampling program.

To determine if constituents in the soil have impacted groundwater at the Site, groundwater samples will be collected from select wells for specific SVOCs and/or inorganics detected at concentrations in soil above GSIPC levels. Samples will be collected from the well or wells downgradient from where the constituent was detected. Figure 3.3 identifies the wells to be sampled.

Table 3.3 summarizes the groundwater analysis required for each monitoring well. Table 3.4 summarizes the environmental analyses to be conducted on samples from each soil boring. In addition to the samples specified in Table 3.4, if odor, staining or high PID readings are observed a sample shall be collected from the impacted interval and submitted for laboratory analysis. Table 3.5 summarizes the soil gas analysis to be conducted from each location.

3.2.3 PAOC 22 – PAINT SLUDGE AREA

During the Supplemental Phase III EOC Investigation, an additional PAOC (PAOC 22) was identified. PAOC 22 is located around MW19-15 on the west of the catwalks and north of the CVO fence. White paint sludge was found at nine feet bgs while installing MW19-15. Trace amounts of cinders and ash were identified at 7.8 feet bgs. Figure 3.4 presents the location of PAOC 22.

Soil samples were collected during the installation of MW19-15; however, the VOC data was rejected during data validation due to poor surrogate recovery. Therefore, one borehole (SB22-01) will be installed adjacent to MW19-15 and soil samples will be collected from the 7-9 ft bgs interval and the 9-9.5 ft bgs interval.

Four additional soil borings (SB22-02 – SB22-05) will be installed to delineate the paint sludge observed at MW19-15. The boreholes will be completed to the top of the confining clay layer. Additional borings will be installed to complete the delineation if required. If visually impacted material is observed, a soil sample will be collected from that interval and analyzed for TCL VOCs, TCL SVOCs, TAL inorganics and PCBs. Table 3.4 summarizes the environmental samples to be collected from each soil boring.

3.3 GSI WELLS

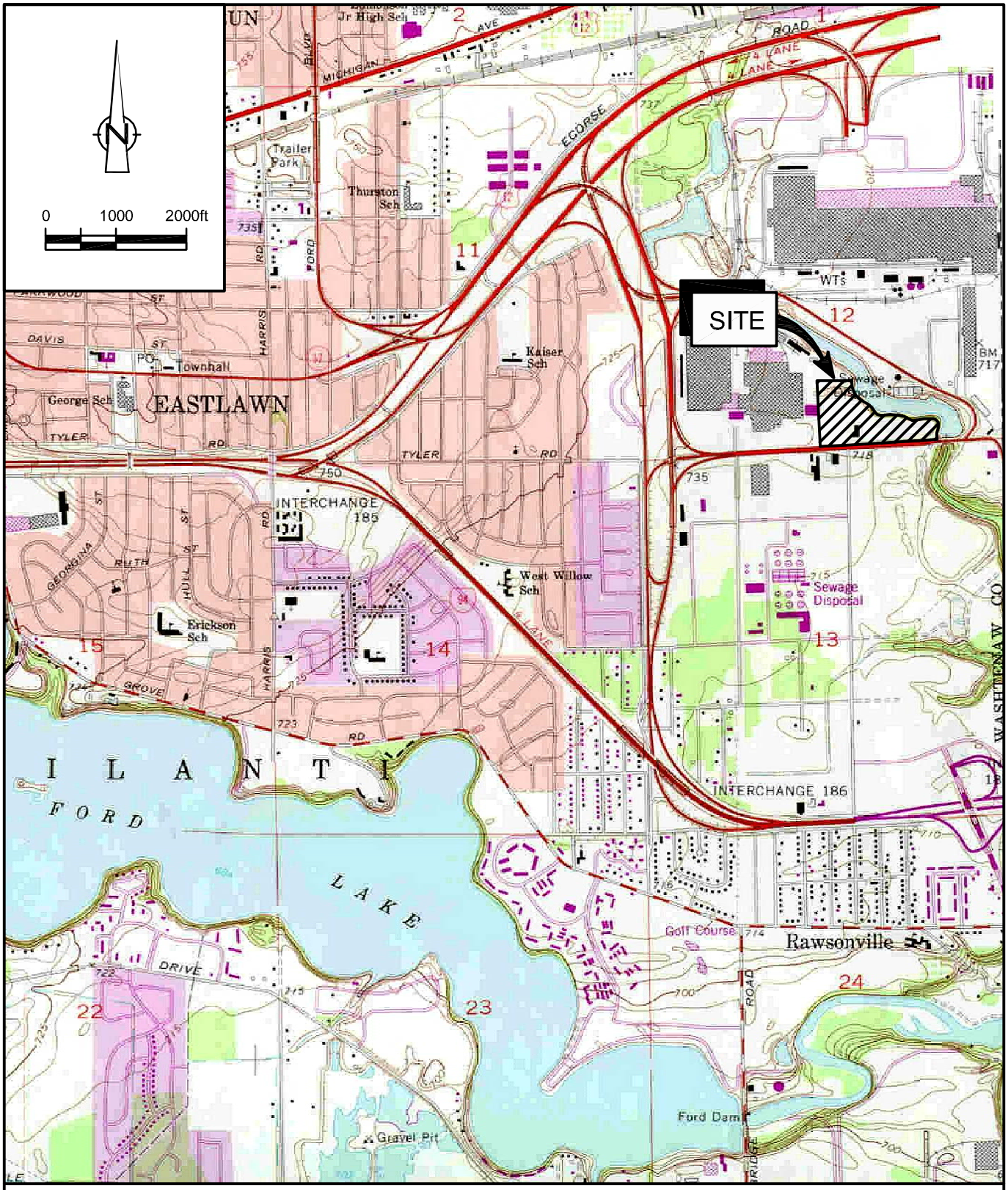
Based on the results of the Supplemental Phase III EOC initial investigation, it is apparent that additional GSI monitoring wells may be required. Locations will be determined following the investigations described in this Work Plan Addendum.

4.0 SCHEDULE

A majority of the work described in this Work Plan Addendum cannot be safely completed until the bank of Tyler Pond is thawed and dry enough to allow work to proceed. Figure 4.1 presents the schedule for completing the fieldwork discussed in this Work Plan.

5.0 REFERENCES

ENCORE. 2003. Supplemental Phase III Extent of Contamination (EOC) Work Plan, Former Willow Run Assembly Plant Property, Ypsilanti, Michigan.



SOURCE: USGS QUADRANGLE MAP;
YPSILANTI EAST, MICHIGAN

figure 1

SITE LOCATION
SUPPLEMENTAL PHASE III EOC WORK PLAN - ADDENDUM NO. 1
COMPANY VEHICLE OPERATIONS AREA
Ypsilanti, Michigan

ENCORE

YPSILANTI

17303-04(007)GN-DE003 SEP 18/2008

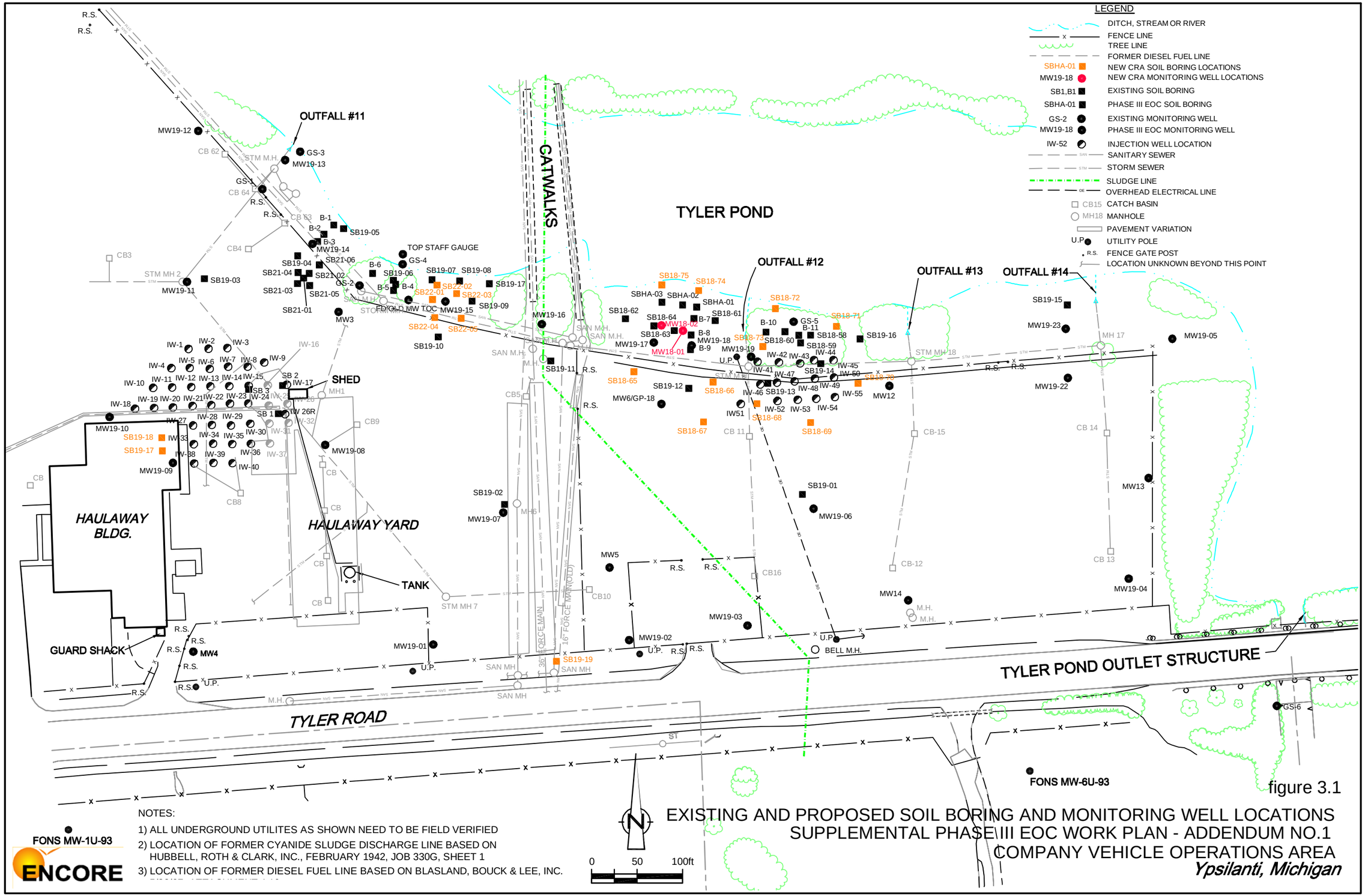
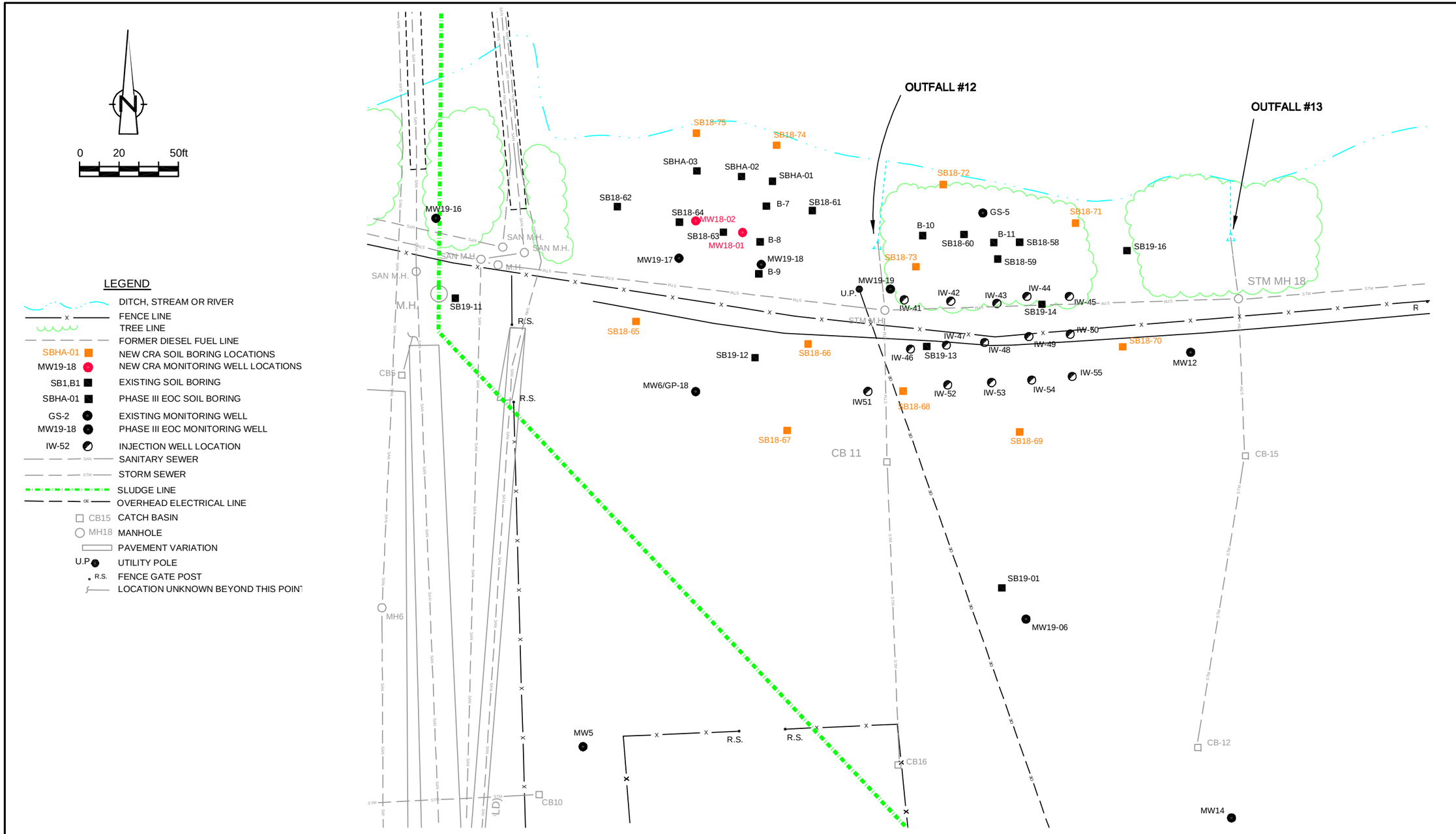


figure 3.1

EXISTING AND PROPOSED SOIL BORING AND MONITORING WELL LOCATIONS
SUPPLEMENTAL PHASE III EOC WORK PLAN - ADDENDUM NO.1
COMPANY VEHICLE OPERATIONS AREA
Ypsilanti, Michigan

17303-04(007)GN-DE005 SEP 18/2008



NOTES:

1) ALL UNDERGROUND UTILITES AS SHOWN NEED TO BE FIELD VERIFIED
2) LOCATION OF FORMER CYANIDE SLUDGE DISCHARGE LINE BASED ON HUBBELL, ROTH & CLARK, INC., FEBRUARY 1942, JOB 330G, SHEET 1
3) LOCATION OF FORMER DIESEL FUEL LINE BASED ON BLASLAND, BOUCK & LEE, INC 5/22/97, ATTACHMENT 4-10

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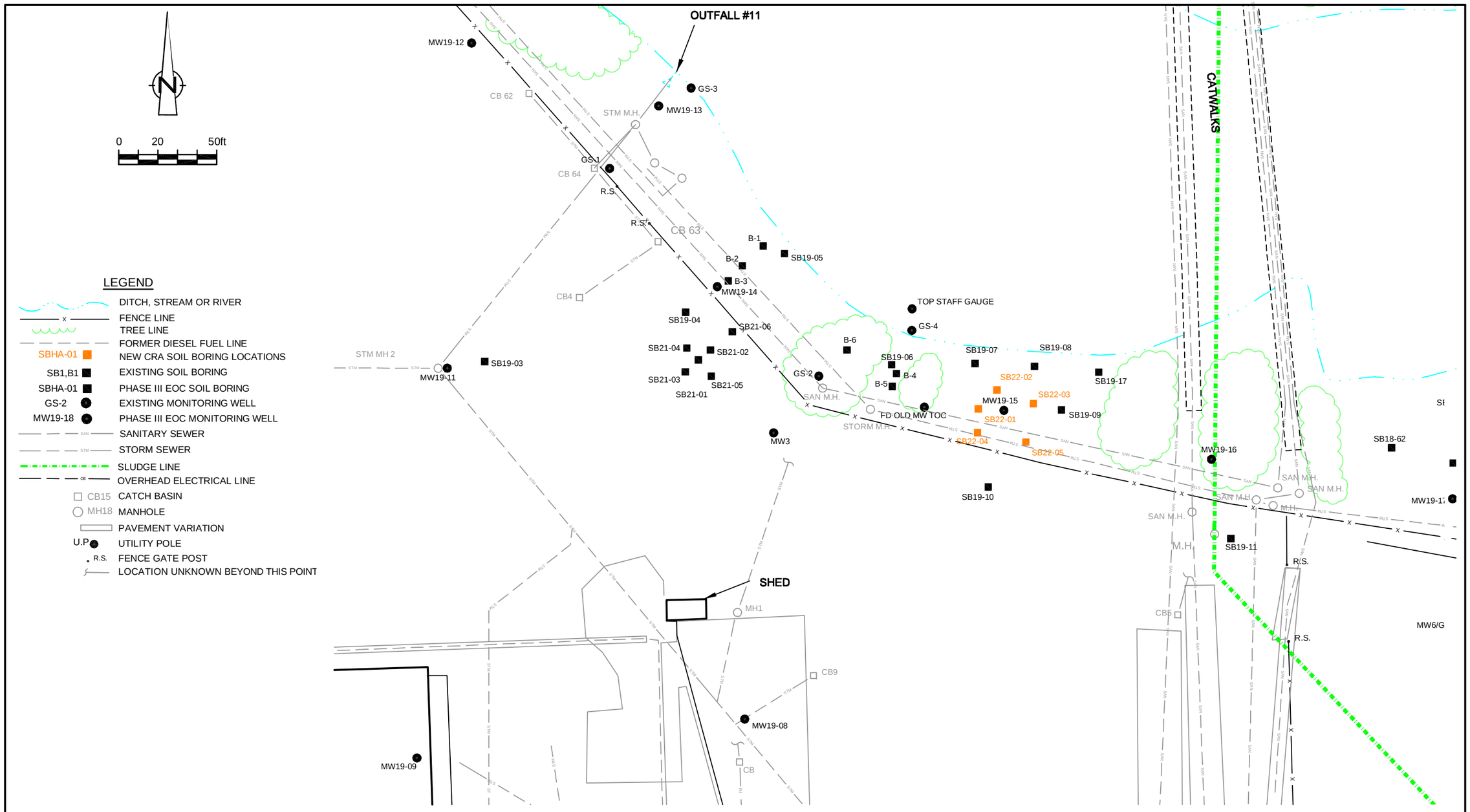
figure 3.2

PAOC 18 - KAISER-FRAZER DUMP AREA
SUPPLEMENTAL PHASE III EOC WORK PLAN - ADDENDUM NO. 1
COMPANY VEHICLE OPERATIONS AREA
Ypsilanti, Michigan



NOTES:

1) ALL UNDERGROUND UTILITES AS SHOWN NEED TO BE FIELD VERIFIED
2) LOCATION OF FORMER CYANIDE SLUDGE DISCHARGE LINE BASED ON HUBBELL, ROTH & CLARK, INC., FEBRUARY 1942, JOB 330G, SHEET 1
3) LOCATION OF FORMER DIESEL FUEL LINE BASED ON BLASLAND, BOUCK & LEE, IN 5/22/97, ATTACHMENT 4-10

figure 3.4

PAOC 22 - PAINT SLUDGE AREA
SUPPLEMENTAL PHASE III EOC WORK PLAN - ADDENDUM NO.1
COMPANY VEHICLE OPERATIONS AREA
Ypsilanti, Michigan

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TABLE 3.1

BI-MONTHLY WATER LEVEL MONITORING PROGRAM
SUPPLEMENTAL PHASE III EOC WORK PLAN - ADDENDUM NO 1
CVO AREA
YPSILANTI, MICHIGAN

GSI Wells	EOC Wells
GS-1	MW19-01
GS-2	MW19-02
GS-3	MW19-03
GS-4	MW19-04
GS-5	MW19-06
	MW19-07
Historical Wells	MW19-08
MW3	MW19-09
MW4	MW19-10
MW5	MW19-11
MW6	MW19-12
MW12	MW19-13
MW13	MW19-14
MW14	MW19-15
	MW19-16
Injection Wells	MW19-17
IW-9	MW19-18
IW-12	MW19-19
IW-33	MW19-22
IW-36	MW19-23
IW-43	
IW-46	
IW-49	
IW-53	

Note:
*Any wells installed as part of the EOC Work Plan Addendum No. 1 will be added to the list.

TABLE 3.2

QUARTERLY GROUNDWATER SAMPLING PLAN
SUPPLEMENTAL PHASE III EOC WORK PLAN - ADDENDUM NO. 1
CVO AREA
YPSILANTI, MICHIGAN

Well Number	Groundwater Analysis[1]
GS-3	TCL VOCs
GS-4	TCL VOCs
GS-5	TCL VOCs
IW-9	TCL VOCs
IW-12	TCL VOCs
IW-33	TCL VOCs
IW-46	TCL VOCs
IW-49	TCL VOCs
MW19-01	TCL VOCs
MW19-02	TCL VOCs
MW19-03	TCL VOCs
MW19-07	TCL VOCs
MW-6	TCL VOCs

Notes:

[1] "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods" SW846, 3rd Edition, updated November 1986

VOCs U.S. EPA Method SW846-8260

TABLE 3.3

GROUNDWATER SAMPLING EVENT
SUPPLEMENTAL PHASE III EOC WORK PLAN - ADDENDUM NO. 1
CVO AREA
YPSILANTI, MICHIGAN

Well Number	Groundwater Analysis[1]
GS-1	TCL VOCs
GS-2	TCL VOCs
IW-14	TCL VOCs, Flashpoint
IW-26R	Flashpoint
IW-29	TCL VOCs, Flashpoint
IW-33	Flashpoint, LEL
IW-42	Antimony, Chromium (Total), Cobalt, Cyanide (Total), Mercury, Selenium, Silver, 4-Methylphenol, Di-n-butylphthalate, Fluoranthene, Naphthalene, Phenanthrene and Phenol
IW-9	Flashpoint, LEL
MW-12	TCL VOCs, TAL
MW-13	TCL VOCs
MW-14	TCL VOCs
MW18-01	TCL VOCs
MW18-02	TCL VOCs
MW19-12	Chromium (Total), Cobalt, Selenium
MW19-14	Antimony, Arsenic, Chromium (Total), Cobalt, Cyanide (Total), Lead, Mercury, Selenium, Silver, Fluoranthene, Naphthalene and Phenanthrene
MW19-15	Chromium (Total), Cobalt, Cyanide (Total), Selenium, Silver, Acenaphthene, Carbazole, Dibenzofuran, Fluoranthene, Naphthalene and Phenanthrene
MW19-17	Chromium (Total), Cobalt
MW19-18	Chromium (Total), Cobalt
MW-4	TCL VOCs

Notes

1 "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods" SW846, 3rd Edition, updated November 1986

VOCs	U.S. EPA Method SW846-8260
SVOCs	U.S. EPA Method SW846-8270
Inorganics	U.S. EPA Method SW846-6000/7000 series

TABLE 3.4

SOIL SAMPLING PROGRAM
SUPPLEMENTAL PHASE III EOC WORK PLAN - ADDENDUM NO. 1
CVO AREA
YPSILANTI, MICHIGAN

Boring/Well Number	Target Depth	Environmental Parameters	
		Sample Intervals[1] (feet bgs)	Chemical Analysis[2]
SB18-65	top of clay	0-2 feet bgs 2 feet above the water table	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs
SB18-66	top of clay	0-2 feet bgs 2 feet above the water table	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs
SB18-67	top of clay	0-2 feet bgs 2 feet above the water table	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs
SB18-68	top of clay	0-2 feet bgs 2 feet above the water table	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs
SB18-69	top of clay	0-2 feet bgs 2 feet above the water table	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs
SB18-70	top of clay	0-2 feet bgs 2 feet above the water table	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs
SB18-71	5' into clay[4]	0-2 feet bgs 2 feet above the water table	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs
SB18-72	5' into clay[4]	0-2 feet bgs 2 feet above the water table	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs
SB18-73	top of clay	0-2 feet bgs 2 feet above the water table	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs
SB18-74	5' into clay[4]	0-2 feet bgs 2 feet above the water table	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs
SB18-75	5' into clay[4]	0-2 feet bgs 2 feet above the water table	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs
SB19-19	sewer bedding	sewer bedding	TCL VOCs
SB22-01	top of clay	7-9 feet bgs 9-9.5 feet bgs	TCL VOCs
SB22-02	top of clay	Field Observations[3]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs
SB22-03	top of clay	Field Observations[3]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs
SB22-04	top of clay	Field Observations[3]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs
SB22-05	top of clay	Field Observations[3]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs
MW18-01	6" into clay	0-2 feet bgs 2 feet above the water table	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs
MW18-02	6" into clay	0-2 feet bgs 2 feet above the water table	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs

Notes

[1] Additional samples may be collected at intervals where field observations indicate impacts (i.e. odors, staining, elevated PID readings).

[2] "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods" SW846, 3rd Edition, updated Novemb

VOCs	U.S. EPA Method SW846-8260
SVOCs	U.S. EPA Method SW846-8270
PCBs	U.S. EPA Method SW846-8082
Inorganics	U.S. EPA Method SW846-6000/7000 series

[3] Sample to be collected if field observations indicated impacts (i.e. staining, odors, elevated PID readings).

TABLE 3.5

SOIL GAS SAMPLING PROGRAM
SUPPLEMENTAL PHASE III EOC WORK PLAN - ADDENDUM NO. 1
CVO AREA
YPSILANTI, MICHIGAN

Boring/Well Number	Target Depth	Environmental Parameters	
		Sample Intervals (feet bgs)	Chemical Analysis[1]
SB19-17	2 feet beneath concrete	0-2 feet bgs	TCL VOCs
SB19-18	2 feet beneath concrete	0-2 feet bgs	TCL VOCs

Notes
1 "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods" SW846, 3rd Edition, updated November 1986

APPENDIX A

ENCORE FIELD METHOD GUIDELINE-SOIL GAS SURVEY

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LIST OF FORMS
(Following Text)

REMEDIATION SECTION	FIELD METHOD GUIDELINE NO.: FMG 1.2
WORLDWIDE FACILITIES GROUP	EFFECTIVE DATE: NOVEMBER 20, 2001
GENERAL MOTORS CORPORATION	
REVISION NO.: 0	REVISION DATE:

SOIL-GAS SURVEY (PASSIVE AND ACTIVE)

INTRODUCTION

This procedure describes protocols for conducting passive and active soil-gas surveys. Soil-gas surveys are used to detect volatile organic compounds (VOCs), such as industrial solvents, BTEX, Stoddard, and associated hydrocarbons and motor fuels, in soil and groundwater. The procedures can be modified to detect mercury or radon gas, if necessary. The typical purpose of conducting a soil-gas survey is to identify soil "hot spots" and to track or map contaminant plumes in the groundwater, thereby limiting the number of exploratory soil borings and monitoring wells.

Conducting a soil-gas survey is appropriate for evaluating the integrity of tanks, pipes, and equipment foundations, for plume mapping, as a screening tool for sites being evaluated for real-estate transactions, and as a means to assess the progress of remediation over time. Soil-gas surveys are generally inappropriate for detecting water-soluble VOCs such as ketones, alcohols, and MTBE, many but not all semi-volatile organic compounds, any mineral-oil-based or water-soluble cutting oils, lubricating oils, greases, pesticides, or PCBs.

An **active** soil-gas survey consists of extracting representative "whole-air" samples of the actual soil gas into airtight sample bags or vessels (e.g., Tedlar® bags) and screening the samples on a gas chromatograph (GC). Active surveys may involve submitting the samples for laboratory analysis or using a portable, on-site GC to screen the samples immediately upon collection. This capacity is useful in situations where real-time data is a high priority.

A **passive** soil-gas survey consists of using passive, adsorptive soil-gas screening modules (e.g., Gore-Sorber™, Emflux®, etc.) which are installed in the ground for a fixed time period and retrieved in accordance with the manufacturer's recommendations. In passive surveys, no actual soil gas is removed from the ground. Instead, the sensor modules are installed in the ground and left for a period of 1 to 2 weeks during which time they adsorb VOCs from the soil gas. The modules are then retrieved and submitted for laboratory analysis. Passive surveys are more sensitive because they integrate the sampling over a period of time. They facilitate detection on sites with low soil permeability and they can "smooth" weather-related fluctuations in soil gas availability.

Soil gas survey methods continue to evolve over the years. There are currently a number of methods on the market; passive methods such as Emflux® and Gore-Sorber™ and active

methods such as Geoprobe® sampling systems. In specific cases, it may be desirable to collect and screen soil-vapor samples in a manner consistent with a previous survey conducted on the site so as to facilitate data comparison. Alternatively, it may be desirable to employ a method that offers greater sensitivity, better detection of a specific target analyte, depth-profiling capability, or lower cost. Therefore, the practitioner is advised to consider which method will most effectively meet the project goals, allowing for developments in methods over time and site-specific conditions.

This FMG, in general terms, provides a generic protocol for performing passive soil-gas screening. Specific methodologies associated with methods such as the Gore-Sorber™ and Emflux® systems have also been incorporated into this FMG, based on their successful usage. These methods are patented, flexible, cost-effective, relatively simple to deploy, sensitive to a wide range of VOCs, give mass-spectral detection of target VOCs and unknowns, and give reproducible results over time.

PROCEDURES REFERENCED

- FMG 1.3 - Utility Clearance.
- FMG 6.10 - Sample Handling and Shipping.
- FMG 8.0 - Field Instruments – Use/Calibration.
- FMG 9.0 - Equipment Decontamination.

PROCEDURAL GUIDELINES

Generic procedures which apply to both passive or active soil vapor surveys are discussed in the following paragraphs, followed by discussion of specific procedures for passive and active screening.

All appropriate project plans should be consulted prior to performing the soil gas survey. Allowances should be made for all site access considerations, safety and personal protection considerations, gathering all necessary equipment, etc.

First, perform an underground utility check of private and/or public utilities for the area to be covered. If exact survey locations are predetermined then there is only the need to locate and mark out the specific locations.

If a generalized survey spanning a wider area is to be performed then a sampling grid must be established and the locations marked out across the survey area. Depending on the size of the coverage area a 25- to 75-foot sample spacing is usually sufficient to provide meaningful contouring of the sample results. Stagger the sample points along adjacent gridlines to provide

optimal coverage with the fewest number of samples. Use transect lines of samples for covering large areas or for surveys where complete grids are unfeasible or unnecessary.

Passive Soil-Vapor Screening Survey

Passive soil vapor systems operate on the premise of adsorption of contaminants by small adsorptive modules composed of proprietary, patented, or highly-specialized materials which are unique to the manufacturer. These materials generally repel water in the subsurface but allow free passage of organic vapors which adsorb onto the modules.

A probe hole is advanced with a small diameter slide-hammer (slam-bar) probe or other rod-type probe to a shallow depth (typically 2 to 4 feet) into the soil. Pilot holes would need to be advanced through concrete, asphalt, or other solid surface seals, if present. The probe hammer or bar is manually driven probe to its full depth into the soils to form a pilot hole and then removed. A total organic vapor reading is then taken from down inside the open probe hole using a PID or FID organic vapor detector, or an equivalent instrument. Record the reading on Form FMG 1.2-01 - Soil Vapor Sampling Log.

The modules are emplaced in the soil borehole in accordance with the manufacturer's recommendations. The holes are then usually sealed off from the atmosphere with a cork, hydrated bentonite granules, or other non-VOC-containing sealant and the modules are allowed to remain in place for a fixed period of time, as specified by the manufacturer's requirements. Volatile organic constituents, if present within the soil-vapor, are passively adsorbed onto the modules.

Records will be kept regarding sample name and location, module serial number, time of installation, installation depth, and organic vapor reading on the forms provided.

After the appropriate length of time the adsorptive portion of the module is then retrieved and sent to the manufacturer. The manufacturer then forwards the modules to an internal, or external, qualified laboratory for contaminant analysis and quantification by thermal desorption/gas chromatography/mass spectrometry (TD/GC/MS), or equivalent methods. These methods also typically provide for quality assurance/quality control (QA/QC) samples in the form of blank samples that are submitted for analysis but, instead of being emplaced in the subsurface as a field sample would, are subjected only to surface atmospheric exposures. This evaluates the effects of environmental cross-contamination during handling, transportation, and pre-deployment.

The manufacturers can typically provide the results of the survey, allowing the Project Manager to interpret and plot the data as desired. Alternatively, the manufacturer may also contour and plot the data using its own evaluative tools. In such cases the manufacturer may require a site plan be sent to them with the sample locations and module serial numbers labeled. The manufacturer will plot the data on the map provided and prepare a concentration results map,

with input from the Project Manager who reviews the data and selects the VOC compounds to be depicted on the final concentration contour map. Either scenario may be implemented.

Active Soil Gas Screening Survey

Apply the same pre-survey procedures to the active soil vapor survey. For conducting an active soil-gas survey, a decontaminated steel probe is advanced using any applicable method to create a probe hole (power hammer, slam-bar, contracted Geoprobe® system, etc.). A length of clean, flexible tubing (typically polyethylene plastic, Teflon, or Tygon) is inserted into the probe hole and sealed around the probe hole at the ground surface using hydrated bentonite clay to prevent short-circuiting of atmospheric air down into the hole. Soil-vapor is drawn up through the probe using a small vacuum pump or an evacuation chamber sampler (e.g., SKC's Vac-U-Chamber, Pelican® case, or equivalent) and directly injected into a sample bag or vessel (e.g., Tedlar® bag) which is connected to the down-probe line using Teflon and Tygon tubing at the surface.

An alternative method for this procedure entails using a steel tube that is perforated near the tip which remains down the probe hole and is similarly sealed at the surface. The vapor sample is then drawn through this tube, as opposed to placing temporary plastic tubing into the hole and drawing the vapor through it. This also requires various related fittings and locking ends to properly join the metal and plastic tubes.

In addition, this procedure can either be performed manually (utilizing manual installation of the appropriate steel sampling tubes, etc.) or can be performed using a Geoprobe® system operated by a contractor who is experienced in this procedure. This method operates on the same basic principals as if performed manually, only it is operated using a single, fully-functional, self-contained unit that performs all aspects of the procedure.

The initial soil-gas sample drawn from the sample probe will also first be screened using a PID or FID organic vapor detector meter (or equivalent) to obtain an initial estimate of VOC vapor concentrations, and the number will be recorded on the field sampling log.

The initial sample serves to purge the small amount of atmospheric air present in the sampling tube when it is installed and to equilibrate the sampling vessel with the soil-vapor (for this reason this initial sample will not be screened for VOCs by GC). The initial sample also serves to reduce the effects of any potential cross-contamination. A second sample is obtained using the same methods as above and submitted for GC screening. Any sample vessels collected shall be labeled with the date, time, and location of the sample. The sample vessel will be placed in a room-temperature cooler or other sturdy container for physical protection and analyzed using a GC within a maximum holding time of 24 hours.

Sampling, collection, and screening procedures are expected to be carried out by personnel with sufficient experience; accordingly, this FMG does not cover the details of their use. Screening of samples using a portable or laboratory GC will only be performed by personnel with extensive

experience in GC operation. Alternatively, the samples may be submitted to a contract laboratory for analysis of volatile organics by an appropriate GC/MS method such as USEPA 8260 or others, as specified in the project Work Plan.

Common target VOCs for field screening during soil-gas surveys include:

- Vinyl Chloride.
- Methylene Chloride.
- Trichloroethene (TCE).
- Tetrachloroethene (PCE).
- 1,1,1-Trichloroethane (1,1,1-TCA).
- 1,1-Dichloroethene (1,1-DCE).
- trans-1,2-Dichloroethene (t-1,2-DCE).
- cis-1,2-Dichloroethene (c-1,2-DCE).
- BTEX compounds.
- Stoddard solvent.
- Site-specific test fuels.

The list of target analytes for field screening may be expanded to include additional or site-specific target compounds, as necessary.

A number of conditions exist with respect to the on-site or in-house GC screening analysis process which require an advanced level of experience to guarantee quality data. As such, only an experienced operator should be responsible for data analysis.

EQUIPMENT/MATERIALS

For All Soil Gas Surveys:

- Site base map to scale.
- Site utility interference maps.
- 100- or 300-foot measuring tape.
- Water-based, non-VOC-containing marker paint.
- Slide hammer probe (slam bar), heavy duty, or equivalent, or
- Powered percussion drill or hammer and bits/tips.
- Electric extension cord.

- Ground-fault interrupter.
- Portable generator (if needed).
- Passive adsorbent modules.
- Corks, strings, insert or retrieval devices, and miscellaneous supplies.
- PID or FID organic vapor detector meter, or equivalent.
- Clipboard and pen.
- Sampling log.
- Insulated cooler (for sample retrieval).
- Personal protective materials.
- Decontamination equipment.
- Scissors.
- Broom and dustpan.
- Portland cement (or fast-setting cement), trowel, and can and stir stick.

Include for Active Soil Vapor Survey:

- Perforated stainless steel sampling tubes, with fittings.
- various length and diameter tubing (e.g., Tygon, Teflon, etc.).
- Sample vessels (e.g., Tedlar® bags).
- Evacuation chamber (allows direct filling of air sample bags using negative pressure).
- Hydrated granular bentonite clay.

REFERENCES

The Gore-Sorber® Screening Survey Guide to Passive Soil Gas Surveys, ©1995 W.L. Gore & Associates, Inc., Elkton, Maryland 21922.

Gore-Sorber® Screening Survey Options; Gore options A2 (BTEX, fuel hydrocarbons, and TPH); A10 (17 chlorinated solvents); A1 (25 Standard Target VOCs/SVOCs); A4 (32 Target VOCs/SVOCs); A6 (Target VOCs/SVOCs and Explosives).

Geoprobe Systems® Equipment and Tools Catalog: Hydraulic Probing Machines, Mobile Laboratories, Small Diameter Sampling Tools, current edition, Corporate Headquarters: Salina, KS 67401, 913-825-1842.