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915152

Wehran EMCON
Northeast

PCB AND LEAD WORK PLAN

FORMER GM-SAGINAW BUFFALO FACILITY
NYSDEC SITE NO. 915152

Prepared For

GENERAL MOTORS CORPORATION

Detroit, Michigan

and

GENERAL MOTORS CORPORATION

Saginaw, Michigan

June 1994

Revised November 1994

Wehran EMCON Northeast

Grand Island, New York

Environmental Engineers • Scientists • Constructors

PCB AND LEAD WORK PLAN

FORMER GM-SAGINAW BUFFALO FACILITY

NYSDEC SITE NO. 915152

RECEIVED
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N.Y.S. DEPT. OF
ENVIRONMENTAL CONSERVATION
REGION 9

Prepared for

GENERAL MOTORS CORPORATION
485 Milwaukee Avenue
Detroit, Michigan 48202

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GENERAL MOTORS CORPORATION
3900 Holland Road
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WE Project No. 04428.LS

June 1994
Revised November 1994

GENERAL MOTORS - SAGINAW
WORK PLAN
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November 5, 1994

Jaspal Walia, P.E.
New York State Department
of Environmental Conservation
270 Michigan Avenue
Buffalo, New York 14203-2999

Re: Work Plan for the Former GM-Saginaw Facility
Buffalo, New York
NYSDEC Site No. 915152

Dear Mr. Walia:

General Motors Corporation (GM) is pleased to present two copies of the final Work Plan for the above-referenced site.

I will contact you to discuss the schedule of activities. Should you have any questions, please feel free to contact me in this office.

Very truly yours,

Mark Napolitan
Project Manager

/jmv
Enclosures

cc: J. Hazel - NYSDEC
M. Doster - NYSDEC
B. Kogut - Bond, Schoeneck & King
J. Braun - GM Legal
R. Laport - Wehran EMCON

ONE

1.0 INTRODUCTION

General Motors Corporation–Saginaw Division (GM-Saginaw) has prepared this Work Plan as Exhibit B to a Consent Order for its former GM-Saginaw Facility on East Delavan Avenue in Buffalo, New York. This site is listed as a New York State Department of Environmental Conservation (NYSDEC) Class 3 Inactive Hazardous Waste Disposal Site, Site No. 915152. This document along with three appendices will be used for completion of the work related to the two hazardous wastes detected at the site: polychlorinated biphenyls (PCBs) and lead in soil[1]. The three appendices are as follows:

- Appendix A-1 – is the Quality Assurance Project Plan;
- Appendix A-2 – is the Health and Safety Plan; and
- Appendix A-3 – is the PCB and Lead Migration Calculation.

Attachment 1 to the Work Plan immediately follows the text, tables, and figures and contains the standard operating procedures.

1.1 FACILITY DESCRIPTION

The former GM-Saginaw facility is located at 1001 East Delavan Avenue in Buffalo, New York. The property and facility are currently owned and operated by American Axle & Manufacturing, Inc. (AAM) which purchased the property and facility in March, 1994. A location map is presented on Figure 1. The property is divided into two major areas by a Conrail Railroad right-of-way (ROW) (see Figure 2). The property west of the Railroad ROW is comprised of the AAM main manufacturing facility, and consists of approximately 40 acres (+/-). The property east of the tracks, comprising approximately 12 acres, consists of a paved parking area termed Parking Lot No. 4, and the Waste Water Treatment Plant (WWTP). Three (3) tanks are situated adjacent to the WWTP, two for the storage of reclaimed oil, and a third for storage of sulfuric acid used in water treatment. The Site at issue is on a one-acre area located on the east side of the Conrail Railroad ROW in Parking Lot No. 4. Subsurface work completed on the west side of the Railroad indicates lead

1 Soil as used in this document includes native soil (e.g., silty clay and topsoil) and fill matrials (e.g., slag, and "ash-like" fill).

concentrations in the fill materials are less than 500 milligrams per kilogram (mg/kg). Therefore, the Railroad ROW forms the western boundary of the study area. Additional detail on this study is included in Section 1.3.

1.2 PROJECT BACKGROUND

This project was initiated in 1986 with the intent of satisfying the "Conditions for Major Petroleum Facility License." A study was completed in October 1986 to provide a preliminary characterization of the facility soils and groundwater[2]. In the spring of 1987, an investigation was performed to assess the permeability of soils underlying the existing above-ground reclaimed oil storage tank containment area adjacent to the WWTP. The results of the investigation indicated that oil, spilled onto the ground in the tank containment areas, had penetrated the underlying fill material. As a result, the fill layer and groundwater in the vicinity of the tanks became contaminated with oil.

A hydrogeologic investigation was performed by Wehran in August, 1987 to assess the extent of oil contamination. The investigation concluded that an oil plume was present extending southwest from the tank storage area to the Conrail Railroad ROW. Based on the results of this investigation, several recovery and treatment system options were proposed to the New York State Department of Environmental Conservation (NYSDEC). Passive collection and on-site treatment of the oil-contaminated groundwater was selected as the original remediation program for the site. Construction of the collection trench was undertaken in the fall of 1988. The construction involved two arms of the trench along the southern and western sides of the plume and the installation of a manhole which would act as a sump and collection point for the oil/water. The system has yet to be completed due to results of sampling and analysis which indicated the presence of PCBs.

A test pit excavated near the western end of the collection trench exposed a clay tile pipe (six-inch inside diameter) surrounded by gravel approximately four feet below ground surface. Orientation of the pipe appeared to be northeast-southwest, placing it directly within the limits of the previously established oil-contaminated area. The pipe contained a significant amount of oil, and it appeared that the gravel bedding surrounding the pipe

---

2 Groundwater as used in this document refers to water perched in the fill materials. The water is perched on top of a low permeability clay layer which separates the fill materials from the bedrock. The saturated portions of the fill layer are thin typically less than five feet and could not produce sufficient water for household purposes. Therefore, this fill is not an aquifer.

had acted as a preferential pathway for the oil within the subsurface. Oil observed seeping out of the pipe was subsequently sampled and tested for PCBs by both GM and the NYSDEC. Analytical results from both sets of analyses indicated the presence of PCBs between 2,678 and 8,420 ppm.

Following discovery of the pipe and the possibility that residue in the pipe could be a source of PCBs, a series of staged investigations were performed to assess the lateral extent and orientation of the buried pipe. In conjunction with the pipe investigation, further sampling of the oil, fill, and groundwater was conducted. Six borings were advanced and six two-inch inside diameter PVC temporary monitoring wells were installed, three wells within and three wells beyond the oil-contaminated area. These investigations were completed by Wehran in March, 1990.

Results of the investigation indicated the clay tile pipe extended within the oil-contaminated area. Samples from test borings alongside the abandoned pipe and near the aboveground storage tanks were composited. PCBs were detected in these samples.

The issue of lead resulted from an EP Toxicity test made on a sample of oil contaminated "ash-like" fill from test pit TP-2 in 1987. The lead concentration was measured to be 5.8 milligrams per liter (mg/l) in the sample leachate. As a result, additional testing was completed in 1990 from test pit TP-2 (the test pit was re-excavated). The EP Toxicity results did not indicate the presence of lead.

Due to the disparity in results, a third sampling effort was completed in April, 1993 to assess whether lead concentrations were above the EP Toxicity regulatory threshold of 5.0 mg/l. In the third sampling event, samples were collected from the oil contaminated "ash-like" fill from around the test pit TP-2 location and tested for EP Toxicity and Toxicity Characteristic Leaching Procedures (TCLP) lead. The results of this testing are documented in Wehran's report titled "Soil Quality Evaluation of Former Test Pit TP-2", dated May 1993 and Wehran's follow up letter dated June 30, 1993 to Ed Feron of the NYSDEC Region 9 Office. To summarize, lead levels from EP Toxicity testing were an order of magnitude less than the regulatory threshold. However, the TCLP results were very close to the regulatory threshold (5 mg/l).

Further investigations were completed in 1993 to assess the extent of lead in the area of the site. This study concluded with a December 1993 report. Analytical results of the four different material types tested – slag, "ash-like" fill, "ash-like" fill with oil and topsoil indicated lead concentrations to be the highest in "ash-like" fill and "ash-like" fill with oil samples. The maximum total lead concentrations in these two materials were 15,400 and 23,900 mg/kg, respectively. The TCLP lead results indicated lead concentrations in excess of the 5.0 mg/l regulatory threshold in 8 of the 12 samples tested. Review of plan and cross-sectional views of the distribution of lead demonstrated that elevated lead levels were highly variable both vertically and horizontally across the study area. The "ash-like" fill results contained similar lead levels to the "ash-like" fill with oil suggesting the oil and lead issues are unrelated. Furthermore, it was concluded that the lead contamination was not limited to the immediate vicinity of the Oil Containment Area and that the oil did not appear to be the primary contributor to lead. Rather, the results indicated a "random" distribution of lead concentrations associated with the "ash-like" fill. At depth in the original topsoil layer beneath the slag "ash-like" fill layer, the lead concentrations were considerably lower, less than 100 mg/kg. To better define the horizontal extent of lead, a historical review of the placement of the fill needs to be undertaken to see if a pattern exists in order to logically place the borings.

Subsurface Explorations – West of Conrail Railroad ROW

Subsurface explorations and associated analytical testing were completed west of the Conrail Railroad ROW. Figure 3 presents the location of borings and wells completed by GM as part of the property transfer. This work was done in conjunction with the sale of the property to AAM. Preliminary results of this work as they pertain to the lead study are described below. [Note: All available lead test results are presented].

A review of the boring logs indicates the following:

- Typically about one foot of concrete was encountered at the borings; although, at one location, 6.5 feet of concrete was encountered;
- Fill materials were encountered at all boring locations consisting of gravel, sand, clay and silt admixed with brick, glass, and wood fragments. This fill appears to be different than the fill materials (fill thickness (including concrete) averaged approximately six feet and ranged from 1.5 to greater than 11.5 feet.) on the east side of the Railroad ROW (i.e., no coal or plastic);

- Native silty clay was encountered at depths between 1.5 and 9.8 feet. At certain boring locations, silty clay was not encountered.

  A glacial till layer overlying bedrock was reported at three borings/well locations. The glacial till is between 1.5 and 3.1 feet thick.
- Bedrock was reportedly encountered at depths of 6.4 feet at well MW-1 to 17.1 feet at boring SB-109.

Results of lead testing for soil samples are presented below:

BORING NO.	DEPTH (Feet)	LEAD CONCENTRATION (mg/kg)
BCS-101	0-6	28
SB-111	2-4	33.1
SB-111	4-6	27.7
MW-104	4-6	28.8
MW-104	4-6 (duplicate)	25.9
MW-104	6-8	12.2
MW-104	6-8 (duplicate)	12.7
SB-112	0-2	83
SB-112	2-4	74.1
SB-113	0-2	35.2
SB-113	2-4	335
BSS-101	0-2	285
BSS-101	0-2 (duplicate)	259

Based on these data, the lead levels measured west of the Conrail Railroad ROW were substantially less than the lead levels detected on the east side of the Railroad. Also, the fill materials appeared different. Consequently, no work is proposed for the area west of the Railroad.

Summary of Analytical Testing

Selected results for the Site are summarized in Table 1-1. Results indicate that volatile organics (USEPA Method 8240), semi-volatile organics (USEPA Method 8270) and pesticides/herbicides (USEPA Method 8080) have not been detected with the exception of 1,2-dichlorobenzene which was measured at a concentration of 21 micrograms per liter in a water sample from test pit TP-8 (USEPA Method 601).

Metals (inorganics) were detected; however, the eight RCRA metals were detected at concentrations below the EP Toxicity hazardous waste threshold with the exception of lead. Lead exceeded the threshold value for testing completed in 1987, and 1993, but soil testing in 1988 and 1989 did not indicate lead levels above the EP Toxicity threshold value.

1.3 SITE HISTORY

To gain insight into the past use of the Site related to the "ash-like" fill, a preliminary historical record search has been undertaken. Elements of this record search involved the following:

- Aerial photographic analysis and interpretations;
- A title search of the property;
- Review of Sanborn Fire Insurance Maps;
- Interviews with site employees and other personnel such as former residents of the neighborhood;
- Record information provided by the former GM-Saginaw facility;
- NYSDEC – Divions of Solid Waste, Hazardous Waste and Air;
- City of Buffalo Historical Society;
- City of Buffalo Department of Public Works Survey and Plan Department;
- Erie County and Buffalo Public Libraries;
- City of Buffalo Assessor's Office;
- Erie County Clerk's Office;
- Conrail Buffalo Office;
- Conrail Engineering Department in Albany, New York;
- City of Buffalo Sewer Authority;
- City of Buffalo Building Department;

TABLE 1-1
GENERAL MOTORS CORPORATION – SAGINAW DIVISION
SUMMARY OF ANALYTICAL TESTING[1,2]

REPORT	DATE	SAMPLE TYPE	ANALYSES	SAMPLE DESCRIPTION	REMARKS
Soil Sampling and Analytical Testing of the Tank Containment Area	September and December, 1987	Soil/Fill	PCBs, EP TOX Metals, Ignitability, Zinc, TOX	TP-1, TP-2	
Delineation of Groundwater Contamination Associated wit the Reclaimed Oil Tank Containment Area	December, 1987	Soil/Fill	Ignitability, Corr., Reac., EP TOX, TOX, VOCs via 601, 602, 603	TP-3, TP-8. TP-10, TP-13	VOCs not detected except for 1,2 dichlorobenzene
		Groundwater	Gasoline, Kerosene, and Lubricating Oils	TP-8, TP-10, TP-13	Only lubricating oils indicated
Test Pit Grab Sample	October, 1988	Soil/Fill	PCB, VOC by 8010, EP TOX Metals, Free Liquids, pH	TP-19	No VOCs detected
			EP TOX Metals, PCB, pH, THO, VOC, Free Liquids	GM-1	
Additional Sampling of Oily Contaminated Soil as Requested by NYSDEC	March, 1989	Soil/Fill/Oil	PCB	Test Pit Soil/Oil	
		Soil Pile	PCB	Pile No. 1	
		Waste Oil from Pipe	PCB	DEC-15	NYSDEC Split Samples from TP-C
		Soil Pile	PCB	DEC-16	
		Oil Stained Soil	PCB	DEC-17	
Grab Sampling During Excavation	July, 1989	Oil/Water in Exc., Mat. under pipe, Mat. in pipe	PCBs, Cyanide	See sample type	Split Samples form TP-C

Notes:
1. Data from samples collected after 1990 limited to PCBs, EP TOX Lead, TCLP Lead, and Total Lead. Results not depicted by this table.
2. Refer to Wehran report "Response to NYSDEC letter of June 29, 1989" dated October, 1989 for a summary of the above data and Wehran report "Additional Investigations Associated with Delineation of Clay Tile Pipe", dated July, 1990.
3. Abbreviations: TOX-Total Organic Halides; THO-Total Halogenated Organics; SVOC-Semi-Volatile Organic Compound; VOC-Volatile Organic Compound; EP TOX-Extraction Procedure Toxicity Test; Reac-Reactivity; Corr-Corrosivity; PCB-Polychlorinated Biphenyl.

TABLE 1-1 (Continued)
GENERAL MOTORS CORPORATION – SAGINAW DIVISION
SUMMARY OF ANALYTICAL TESTING[1,2]

REPORT	DATE	SAMPLE TYPE	ANALYSES	SAMPLE DESCRIPTION	REMARKS
Response to NYSDEC Letter of June 2, 1989	October, 1989	Fill/Soil	Oil and Grease and PCBs	TB-1 to TB-6	
		Groundwater	Fuel Oil, Kerosene, Gasoline, Lub. Oil, Diesel Fuel, PCBs	TB-1 to TB-6	
			TCL VOC by 8240, TCL SVOC by 8270, Cyanide, 24 Total Metals, Pesticides	TB-2, TB-4	TCL VOCs and SVOCs not detected at quantification limit
Additional Investigations Associated with Delineation of Clay Tile Pipe	July, 1990	Groundwater	23 Metals Total/Dissolved PCB, Cyanide, SVOC by 8270, Pesticides, VOC by 8240	TP-F, TP-E, MW-1, TB-2	SVOCs and VOCs not detected
		Soil/Fill	EP TOX Metals, PCBs	TP-E, TP-F, TP-2 (re-excavated)	TP-2 not analyzed for PCBs

Notes:
1. Data from samples collected after 1990 limited to PCBs, EP TOX Lead, TCLP Lead, and Total Lead. Results not depicted by this table.
2. Refer to Wehran report "Response to NYSDEC letter of June 29, 1989" dated October, 1989 for a summary of the above data and Wehran report "Additional Investigations Associated with Delineation of Clay Tile Pipe", dated July, 1990.
3. Abbreviations: TOX-Total Organic Halides; THO-Total Halogenated Organics; SVOC-Semi-Volatile Organic Compound; VOC-Volatile Organic Compound; EP TOX-Extraction Procedure Toxicity Test; Reac-Reactivity; Corr-Corrosivity; PCB-Polychlorinated Biphenyl.

- Former General Motors-Saginaw Buffalo Facility (i.e., American Axle & Manufacturing, Inc. (AAM);
- Former residents of the neighborhood and former GM-Saginaw employees;
- State University of New York (SUNY) at Buffalo;
- Cornell University; and
- Erie County Soil and Water Conservation Service.

Results of the record search as of May, 1994 are provided below. Additional and more detailed information will be provided following completion of the work task described in Section 2.2, Task 1 of this Work Plan.

1. *Aerial Photographs Review*

The site developmental history was examined by reviewing a series of aerial photographs, which were taken at specific time intervals during the period 1927-1990. Table 1-2 summarizes the aerial photographs available for the site. Several of these photographs have already been reviewed, while others will be analyzed once received. Based on the review completed as of May 1994, the following summary is provided.

During the 1927-1990 period, various activities took place at the Site. For the earliest available photograph, (1927), development on the west side of the tracks included the GM Plant and support structures. Cornwall Avenue appeared to be a dirt road. The parcel of land on the east side of the tracks was undeveloped except for the presence of baseball diamonds. No other significant structures were noted. The former Scajaquada Creek Channel had been filled in. The Creek had been relocated to the south during 1921-1922. Mounds of material appeared evident on the north side of the site adjacent to East Delavan Street.

In the 1942 photograph, the plant area on the west side of the tracks appeared to be relatively unchanged from the 1927 photograph. Cornwall Street had been paved in the interim. East of the tracks, the Site was relatively level and overgrown. Some dirt roads traverse the site. No evidence of mounded material was noted as in the 1927 aerial photograph.

In the 1951 photograph, no significant site changes were observed on the parcel west of the tracks except for the development of some parking areas. In the area east of

TABLE 1-2
FORMER GENERAL MOTORS - SAGINAW BUFFALO FACILITY
SUMMARY OF AERIAL PHOTOGRAPHS AVAILABLE

AERIAL PHOTO DATE	SOURCE	SCALE	AVAILABILITY	PRODUCT
1951 1966 1968	Clears @ Cornell	1:24,000 1:20,000	Internal Review Only	Photocopies
1927 1966 1978	SUNY @ Buffalo	Detailed 1:48,000 1:48,000	Internal Review Only	Photocopies
1958 1978 1989	Buffalo Department of Public Works	1"=100'	Blueprints and/or photostats	Blueprints and/or Photostats
1942 1951 1958 1978 1985 1990	Erie County Soil and Water Conservation Service	Varies	Internal Review Only and/or Copies	Photocopies or Slides Aerial Photos

the tracks, land disturbance was observed. This was apparently related to the presence of a concrete mixing operation by Buffalo Gravel Corporation. A dirt road ran southerly from East Delavan Street to the center portion of the site and the area of greatest site disturbance. A road bordering the southern portion of the site area had also been developed. No signs of the former Creek bed were evident.

The 1958 photograph did not show any substantial changes relative to the 1951 aerial photograph. Buffalo Gravel operations were still evident in the area east of the tracks. Between 1958 and 1966, the area east of the tracks was fully developed and paved.

The 1978 photograph was similar to the 1966 photograph except that the WWTP was clearly evident on the parcel east of the plant. The WWTP was constructed in the late 1960's in the general area of the former gravel operations. Additional plant buildings were evident on the parcel west of the tracks.

No significant changes were evident in the site area west and east of the tracks based on review of the 1985 and 1990 photography.

2. *Title Search*

A search of the Erie County Deed Records was conducted to evaluate several property lots comprising the former General Motors Corporation-Saginaw Division facility located on East Delavan Avenue in the City of Buffalo (see Table 1-3). The Section/Block/Lot (SBL) Parcels pertaining to the former GM-Saginaw property are SBL 101.24-1-1, 101.24-1-3, and 90.80-4-3. Also investigated were the adjacent parcels SBL 101.24-1-2, 101.24-1-4, 90.80-4-1, and 90.80-4-2 (see Figure 4).

The transfer of ownership of the properties was examined by first reviewing the Real Property documents filed at the Erie County Department of Finance Office. These records were rather incomplete, since most of them only showed an ownership back to the mid 1950s.

Once the Real Property information was obtained, a review of the respective deeds was completed at the Erie County Clerk's Office. This provided a reference point from which to start. During the review, many of the deeds indicated the party(s) from whom the property had been conveyed and the deed associated with the conveyance. This provided the next deed to review. This procedure worked well for most of the parcels, except for the ones of interest. In each case for the former GM-Saginaw parcels, the transfer of property could be

TABLE 1-3
GENERAL MOTORS - SAGINAW FACILITY
SUMMARY OF TITLE SEARCH INFORMATION

SECTION BLOCK LOT NO.	CONVEYANCE	DATE OF CONVEYANCE AND ASSOCIATED DEED
SBL 101.24-1-1 (Current Manufacturing Facility Location)	Robert E. Woodruff & John A. Hadden (Trustees) to General Motors Corporation	December 18, 1941; Liber 3194, pg. 539
	General Motors Corporation to Defense Plant Corporation	May 1, 1942; Liber 3380, pg. 374
	Defense Plant Corporation to General Motors Corporation	October 17, 1945; Liber 3782; pg. 548
SBL 101.24-1-2 (Current Consolidated Rail Corporation)	Isaac Taylor & Wife Anne to NY Lake Erie & Western RR Co.	November 15, 1881; Liber 401; pg. 328
	William Taylor & Wife Elizabeth to The Suspension Bridge & Erie Junction RR Co.	September 3, 1870; Liber 250; pg. 564
	NY Lake Erie & Western RR Co./ The Suspension Bridge & Erie Junction RR Co. to General Motors Corporation	
	General Motors Corporation to Erie Lackawanna RR Co.	March 5, 1942; Liber 3217; pg. 195
	Erie Lackawanna RR Co. to Consolidated Rail Corporation	October 11, 1978; Liber 8706; pg. 313
SBL 101.24-1-3 (Currently Southern Section of Parking Lot #4) This Property appears to have been sold in subparcels.	Bardol Company, Inc. to Buffalo Gravel Corporation	April 8, 1953; Liber 5301; pg. 87
	Buffalo Gravel Corporation to General Motors Corporation	May 21, 1965; Liber 7112; pg. 69
	Bardol Company, Inc. to General Motors Corporation	May 21, 1964; Liber 7000; pg. 157

TABLE 1-3
GENERAL MOTORS - SAGINAW FACILITY
SUMMARY OF TITLE SEARCH INFORMATION

SECTION BLOCK LOT NO.	CONVEYANCE	DATE OF CONVEYANCE AND ASSOCIATED DEED
SBL 101.24-1-4 (Currently Niagara Mohawk Right of Way) This Property appears to have been sold in subparcels.	John Taylor, Trustee to Niagara Mohawk Corporation	February 5, 1953; Liber 5268; pg. 379
	Buffalo Gravel Corporation to Niagara Mohawk Corporation	April 8, 1953; Liber 5301; pg. 91
	Bardol Company, Inc. to Niagara Mohawk Corporation	April 8, 1953; Liber 5301; pg. 94
	Lorraine Morrison to Niagara Mohawk Corporation	May 26, 1953; Liber 5331; pg. 97
	Carl Klein to Delaware Lackawanna RR Co.	November 22, 1881; Liber 426; pg. 188
	Delaware Lackawanna RR Co. to Niagara Mohawk Corporation	April 13, 1954; Liber 5528; pg. 242
	Delaware Lackawanna RR Co. to Roman Wiate	August 3, 1954; Liber 5605; pg. 12
	Roman Wiate to Niagara Mohawk Corporation	October 5, 1954; Liber 5620; pg. 506
SBL 90.80-4-1 (Currently Consolidated Rail Corporation)	Henry Weber & Wife Anna to New York Lake Erie RR Co.	November 15, 1881; Liber 401; pg. 327
	John Jackl & Wife Mary to The Suspension Bridge & Erie Junction RR Co.	October 15, 1870; Liber 250; pg. 623
	NY Lake Erie RR Co./ The Suspension Bridge & Erie Junction RR Co. to Erie Lackawanna RR Co.	October 17, 1945; Liber 3782; pg. 548
	Erie Lackawanna RR Co. to Consolidated Rail Corporation	October 11, 1978; Liber 8706; pg. 313

TABLE 1-3
GENERAL MOTORS - SAGINAW FACILITY
SUMMARY OF TITLE SEARCH INFORMATION

SECTION BLOCK LOT NO.	CONVEYANCE	DATE OF CONVEYANCE AND ASSOCIATED DEED
SBL 90.80-4-2 (Currently Italian & French Wine Company)	Erie & Lackawanna Land Association to Henry Weber & Wife Erie & Lackawanna Land Association to Philip Morhres & Wife	
	Henry Weber & Wife/Philip Morhres to Fred C. M. Lautz	February 25, 1889/June 29, 1892 Liber 560/604 Page 164/518
	Fred C. M. Lautz to Bardol Company, Inc.	March 31, 1913; Liber 1245; pg. 96
	Bardol Company, Inc. to Arbee Corporation	April 17, 1951; Liber 4903; pg. 472
SBL 90.80-4-3 (Currently Northern Section of Parking Lot #4)	Bardol Company, Inc. to Buffalo Gravel Corporation	April 8, 1953; Liber 5301; pg. 87
	Buffalo Gravel Corporation to General Motors Corporation	May 21, 1965; Liber 7112; pg. 49

traced to the mid 1940s and 1950s. For SBL 101.24-1-3 and SBL 90.80-4-3, ownership could be traced to a company called The Bardol Corporation. For SBL 101.24-1-1, ownership could not be traced beyond trustee ownership in 1941. The remaining adjacent SBL parcels were traced back to the late 1800s.

Based on a review of the adjacent SBL parcels, it was concluded that a majority of The Bardol Corporation holdings were acquired during the early 1920s. A review of the Grantee Indexes for the years 1906 through 1930 was conducted and each property transaction that involved either The Bardol Corporation or the owner, Frank V.E. Bardol was noted. There were 18 transactions that occurred during the 24-year period. A review of the deeds associated with each transaction was conducted in an effort to cross-reference each transaction with one of the SBL parcels of interest. A majority of the transactions were not associated with SBL parcels of interest.

An additional title search was completed by Monroe Title Insurance Corporation against two parcels of land, A and B, approximately 4.12 acres and 0.285 acres, respectively in the area of the Parking Lot No. 4. In 1922, a Frank and Katherine Bardol conveyed Parcel A to the Bardol Company. The Bardol Company use of the site is unknown. Subsequently, in 1947, the parcel was conveyed to Buffalo Gravel Corporation, Inc. Parcel B was conveyed by the Bardol Company to Buffalo Gravel Corporation in May 1965. During May 1965, Buffalo Gravel Corporation conveyed both Parcels A and B to General Motors Corporation.

Based on the historical record review completed to date, insufficient information is available to determine the origin and depositional history of the fill material. Further insight will be obtained following a receipt and review of the Sanborn Maps, GM-Saginaw Facility records, additional aerial photographs, title search information dating back to periods prior to 1934 and information obtained from interviews.

3. Historical Maps/Figures

A review of historical maps and figures was completed at the GM-Saginaw Facility. A 1965 survey map of the pre-existing conditions showed the structures present on the site prior to GM-Saginaw purchase. (Reference: "Extension to Parking Lot No. 4 Chevrolet Motors Division, General Motors Corporation, Buffalo Plant" prepared by John G. Schwartz, Registered Architect). Features from this figure have been placed onto Figure 5. Of note are the two drainage structures situated east of the conveyor belt, the foundation wall and the clay tile pipeline. [Note: Clay tile pipeline located by Wehran, it is not shown on the above-referenced 1965 survey map]. As can be seen, the orientation of the clay tile pipeline appears to align the foundation wall with the northern most drainage structure. The purpose of the "foundation wall" is unknown.

According to A. Glieco, a former GM-Saginaw employee now an AAM employee, the "foundation wall" was approximately 20 feet x 20 feet, 1.5 feet aboveground and four to five feet deep. Whenever seen by A. Glieco (in the 1955 to 1960 time period), the "foundation wall" was filled with a "clear" blue water. The clay tile pipeline grades toward the foundation wall at a two percent slope. Due to potential inaccuracies in the mapping and transpositioning of features from several maps, it is possible the clay tile pipeline actually drained to the "foundation wall". Whether this in fact occurred, is unknown.

Data suggesting the clay tile pipeline does not exist beyond the area shown is provided by test pits completed on the east side of the WWTP in 1990. Specifically, two test pits were completed along the extrapolated alignment of the clay tile pipeline (TP-F and TP-G, refer to July 1990 Wehran report titled "Additional Investigations Associated with Delineation of Clay Tile Pipe"). This suggests that the clay tile pipeline and drainage sructures were removed. However, the possibility exists that oil could be present in this drainage structure. Subsurface explorations are planned to assess whether this drainage structure exists (see Section 2.1, Subtask 2.2).

1.4 CONCEPTUAL SITE MODEL

Surface Conditions

Parking Lot No. 4 is paved with asphalt throughout. At the WWTP, there is some unpaved areas near the clarifier tanks immediately north of the WWTP. Immediately west of Parking Lot No. 4 is the Conrail Railroad ROW which consists of an unpaved area. The tracks and parking lot are separated by a drainage swale. Certain tracks are at grade and the tracks farthest west are elevated on an embankment. East of the parking lot are unpaved areas sparsely to moderately vegetated except in the southeast corner. Industrial buildings are located southwest of the parking lot. North of the parking lot is paved parking for the Italian and French Wine Company.

Subsurface Conditions

Beneath the pavement is a sequence of various fill materials overlying native silty clay deposits. As observed during test boring explorations, the thickness of the fill materials range between approximately three and nine feet. The fill increases in thickness from the south to north end of the area studied in the vicinity of the WWTP.

The fill materials consist essentially of three different material types. In general, these materials may be described from ground surface to top of native clay as: 1) a sand and gravel pavement subgrade; 2) a discontinuous layer of slag; and 3) a brown sand/silt/gravel mixture with varying amounts of what appear to resemble glass, ash, coal, plaster, and brick. For simplicity, the third layer or sand/silt/gravel/fill mixture, is herein referred to as the "ash-fill" layer. At certain locations, the lower portions of the "ash-fill" layer are saturated with oil and/or are discolored black. Since the lower portions of the "ash-like" fill are saturated with oil, it would appear the oil migrated to these locations on top of the groundwater in the fill materials.

Underlying the "ash-fill" layer, a natural silty clay deposit was encountered at depths between three and nine feet below ground surface. Typically, the deposit consisted of a soft, black organic clay and silt topsoil underlain by a stiff, red-brown silty clay. The topsoil layer most likely represents the original ground surface prior to fill placement.

Groundwater

The flow of groundwater in the fill materials appears to be toward the southwest based on five wells located across the entire AAM facility. The clay overburden within the area studied has been found to be continuous. There is a low potential for vertical migration of groundwater. The clay layer is anticipated to have a horizontal hydraulic conductivity on the order of 10^{-7} cm/sec and vertical hydraulic conductivity on the order of 10^{-8} cm/sec or less. As such, the rate of vertical flow, if any, is expected to be low. Bedrock lies beneath the overburden at expected depths of 10 to 20 feet with some variation.

The transport rate of PCBs in groundwater is expected to be on the order of 1000 times slower than groundwater based on calculation of the retardation coefficient (Appendix A-4). As such, it is unlikely that PCBs will travel any significant distance in the fills or native soils. Furthermore, because of the extremely low travel rates of PCBs, PCBs would not be expected to reach the underlying bedrock. However, as a component of the oil, PCBs will likely travel at the same rate as the oil layer on the groundwater surface. Due to the expected viscosity of oil (i.e., more viscous than water), oils and PCBs will flow through the existing formation more slowly than the water.

During the 1993 investigation, a total of 12 fill samples were analyzed for TCLP lead. TCLP lead concentrations between 0.35 and 316 mg/l were measured.

When viewed within the context of lead behavior in soil systems, and given the presence of 5 to 10 feet of native silty clay soil beneath the fill, no adverse impact to the bedrock groundwater is anticipated. Most researchers have recognized that lead is sparingly soluble and occurs predominantly in a sorbed state or as part of insoluble inorganic or organic compounds. Because of low solubility, movement of lead in soils has generally been considered to be minimal. Lead and other metals are strongly retained in soils by ion exchange and specific adsorption processes (Rai et al., 1986; Clement International Corporation, 1993; Dragun 1988).

Understanding the behavior of lead once it leaches through the fill materials will provide insight into its potential to degrade groundwater. In this regard, the capacity of the underlying native soil materials to retain lead in the immobile state needs to be understood. Chemical attenuation constants provide a mechanism to arrive at reasonable predictions of the potential for lead to migrate in the groundwater system. Specifically, Langmuir adsorption isotherms have been utilized to assess the maximum adsorption capacity of soils with respect to lead and other metal constituents (Rai et al., 1986).

While no site-specific sorption studies have been conducted on the native soil underlying the imported fill areas, reasonable predictions of sorptive capacity can, nevertheless, be obtained from published data.

Appendix A-4 contains a table taken from Rai et al. (1986) summarizing adsorption constants for lead in various media, including a variety of soil types with different clay and organic matter contents, as well as pH and cation exchange capacity (CEC) values. Based on a review of available information on native soils at the site, a Langmuir adsorption maximum of 16.5 uM/g soil was chosen. This adsorption maximum corresponds to a native soil containing approximately 24 percent clay, 0.76 percent organic carbon, a CEC of 12.2 meq/100g and a pH of 7, which appears a reasonable estimation of clayey soil as present on-site. Utilizing the sorption maximum of soil, the retentive capacity of the soils is more than sufficient to accommodate all of the potentially leachable lead from the fill material (Appendix A-4).

While this analysis does not consider competitive effects resulting from the presence of other metal and cationic constituents, the results nevertheless are considered to be a reasonable estimate of lead retention in the soils at the site. Lead is known to have high stability constraints with organic matter (Stevenson and Ardakani, 1972)[3] and has been shown to be preferentially sorbed over other metal constituents such as cadmium and zinc (Petruzzelli et al, 1978; Kuo and Baker, 1980)[4].

As groundwater migrates laterally, it could intercept utility pipelines and/or beddings in the saturated zone. Utility pipelines and/or beddings are commonly preferential pathways for the migration of groundwater. A map has been prepared depicting the known utility locations (see Figure 2). This map consists primarily of sewers. Based on this map, the sewers with potential impact from PCBs/oils are located south and east of the existing collection trench. Therefore, unless significant migration has occurred beyond the limits of the oil/PCB plume, sewers are not expected to be impacted by PCBs/oils. For lead, it is more difficult to assess which sewers may be impacted. However, it appears that the sewer lines shown throughout Parking Lot No. 4 may extend into the "ash-like" fill areas and therefore, could intercept groundwater. While these sewers may intercept groundwater, the potential for lead to migrate in the groundwater of the fill zone is expected to be small.

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3 Stevenson, F.J., and M.S. Ardakani (9172). Organic matter reactions involving micronutrients in soils p. 74-114. In J.J. Mortvedt, P.M. Giordano, and W.L. Lindsay (ed) Micronutrients in agriculture Soil Sci Soc. of Am., Madison, WI.

4 Petruzzelli, G.,G. Guidi and L. Lubrano (9178). Organic matter as an influencing factor on copper and cadmium adsorption by soils (Water Air Soil Pollut 9:263-269.

TWO

TWO

2.0 TECHNICAL APPROACH

GM-Saginaw is prepared to proceed with this project by separating the site into two operable units. The first Operable Unit, OU-1, is for the PCBs. The second Operable Unit, OU-2, is for the lead. These two issues have been separated based on the nature of the sources. For the PCBs, the apparent source is the oil in the clay tile pipeline. The oil is located in a localized area near the WWTP extending to the Conrail Railroad ROW. For the lead, the apparent source is the "ash-like" fill materials found in the area studied inside Parking Lot No. 4. While there is overlap between the two operable units (i.e., oil/PCB area falls within the "ash-like" fill materials), the majority of the lead area falls outside the bounds of the oil/PCB area. Below is a discussion of the work associated with the two operable units.

2.1 OPERABLE UNIT 1 - PCBs

Operable Unit No. 1 consists of eight major tasks as described below. This includes: clay tile pipeline removal; further investigation of PCB extent; development of a remedial alternative for soil and groundwater; design of the remedial alternative; and construction/implementation of the selected remedial alternatives.

Task 1 - Clay Tile Pipeline IRM

Based on the results of earlier investigations, the highest PCB concentrations detected were measured in samples of oil from the clay tile pipeline. This clay tile pipe is a source of PCB contamination at the site. Although the pipe both begins and ends within the contaminated area, it is believed that the backfill around the pipe as well as the pipe itself, may act or did act as a preferential pathway for contaminant migration. Therefore, the pipe and surrounding soils/bedding shown to be visually impacted will be excavated and removed. Additionally, if the drainage structures noted on Figure 5 and discussed in Section 1.3, are found and contain PCBs and oil, then the IRM will be extended to this area to remove the drainage structures and oil using a similar procedure to that described below.

Subtask 1.1 – Preparation of Construction Drawings and Technical Specifications

Construction Drawings and Technical Specifications will be developed to address the excavation and disposal of pipe and bedding materials. These drawings and specifications will be forwarded to qualified PCB and hazardous waste contractors to obtain comprehensive and comparable bids for the work. Drawings will be prepared showing the areal and vertical extent of anticipated pipe, soil and oil removal; stockpile locations; backfill design including pipe and bedding; and associated details such as manholes, clean outs and tie-in to existing system. Among other aspects, the documents will include requirements that the bidder provide sufficient information to demonstrate proven experience in similar projects. Specifications will include descriptions of the work; health and safety requirements; workmanship requirements; material specifications; testing requirements; methods for handling groundwater, oil, and precipitation.; Additionally, consideration will be given to the lead issue as it relates to material handling, treatment, and disposal.

GM-Saginaw intends to commence the clay tile pipeline IRM this year. Consequently, upon completion of the Design Drawings and Specifications, a Contractor will be retained to proceed with this project. It is also GM-Saginaw's intent to extend the existing collection trench based on the results of Task 2. This work may be done concurrently. A copy of the design drawings and performance (or technical) specifications will be submitted to NYSDEC for informational purposes.

Subtask 1.2 – Pipe and Bedding Removal

A trench will be excavated to exhume the pipe and surrounding soils/bedding materials. The trench will begin at the upgradient end of the pipe (i.e., near the WWTP) to help prevent contamination of the "new" backfill with free product from the existing pipe system. The trench will be approximately 100 feet long, three feet wide, and five feet deep as shown on Figure 6. Please note these limits of excavation are approximate. Specifically, the intent is to remove the pipe, bedding, free-product, and oil soaked materials within an approximate 100 foot long by 3 foot wide "footprint". However, if the native silty clay is encountered at a depth less than five feet, the excavation will extend only to the top of the silty clay.

A PCB field screening kit will be used to guide the excavation by developing semi-quantitative PCB concentrations (see the QAPP Appendix A-1). Specifically, PCB measurements will be made at ten foot increments along the trench. Based on results of this testing, areas exhibiting PCB concentrations in excess of 50[1] ppm in the unsaturated zone will be over excavated by approximately one foot. Additional PCB measurements will then be made and used as a guide for GM to decide whether to perform further excavation. In short, the intention is to remove the pipe, bedding and oil soaked materials within the 100 foot by 3 foot "footprint", and residual PCB "hot spots" as determined by field screening. This effort will be coordinated with the NYSDEC on-site representative.

Currently, the ground surface in the area of the pipe is paved. The pavement and subgrade, consisting of the upper 18 inches of material (+/-) is anticipated to be "clean".

Excavated materials will be placed into roll-offs, gondola cars, drums or other similar containers. The containers will be classified as follows:

1. "Clean" pavement and subgrade including slag.
2. "Ash-like" fill without oil.
3. "Ash-like" fill with oil.

From each class of container, two composite samples will be collected for analytical testing by a NYSDOH approved laboratory. The samples will be tested for PCBs, total lead, and TCLP lead (see Table 2-1).

A new trench drain will be installed consisting of a perforated drain pipe with crushed stone bedding and backfill. The backfill will be covered with the stockpiled pavement and subgrade material. This proposed trench drain will provide for collection of PCBs and oil in the vicinity of the original drain through the middle of the suspected source area. The new drain will be graded toward the existing containment trench and be connected to that system.

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1 GM intends to perform the source removal IRM using 50 ppm as a guide to assess the limits of excavation beyond the 3 foot wide by 100 foot long planned excavation. Therefore, if a sample of soil/fill exhibits a concentration greater than 50 ppm, then an additional foot will be removed form the sidewall. However, if the concentration remains greater than 50 ppm, then it will be GM's decision whether or not to proceed with the excavation any further. This will only apply to the unsaturated portion of the soils. The saturated soils will only be excavated as a consequence of pipe removal, as the existing groundwater collection trench will provide collection of the free-product oil and groundwater. The ultimate cleanup goal for PCBs will be determined in accordance with 6 NYCRR §375-1.10 and the cleanup goals which are referenced in the NYSDEC's letter of August 5, 1994 to Mark Napolitan of GM shall be considered as set forth in 6 NYCRR §375-1.10(c)(l)(ii).

TABLE 2-1
GENERAL MOTORS CORPORATION – SAGINAW DIVISION
OPERABLE UNIT NO. 1 – PCBs
ANALYTICAL TESTING PROGRAM

MEDIA	SOURCE	PARAMETERS[1,2]	ESTIMATED NO. OF SAMPLES	METHOD[3,4]	FIELD DUPLICATES	REMARKS
Fill/Soil	Excavation	PCBs	TBD	Field	10%	Grab Samples
Fill/Soil	Excavation	PCBs	TBD	8080	10%	Grab Samples
Fill/Soil	Borings	PCBs	18 (6 borings)	Field	2	Split Spoon
Fill/Soil	Borings	PCBs	6	8080	1	Split Spoon
Fill/Soil	Clean Stockpile	PCBs/TotalLead/ TCLP Lead	2	8080-PCBs 7421-Lead	---	Grab Samples
Fill/Soil	"Ash-like" Fill without Oil Stockpile	PCBs/ Total Lead/ TCLP Lead	2	8080-PCBs 7421-Lead	---	Grab Samples
Fill/Soil	"Ash-like" Fill with Oil Stockpile	PCBs/ Total Lead/ TCLP Lead	2	8080-PCBs 7421-Lead	---	Grab Samples
Groundwater	Wells	PCBs/Lead filtered and Total	5 wells	8080/7421	1	Grab Samples

Notes:
1. Maximum holding time for PCBs is 10 days after verified time of sample receipt (VTSR) until extraction; 40 days for analysis.
2. Maximum holding time for lead is 6 months. Water samples are preserved using HNO_3 to pH<2.
3. Field method is via the use of PCB field screening test kits such as those manufactured by Millipore Corporation.
4. Methods listed are NYSDEC ASP 1991 pursuant to USEPA "Test Methods for Evaluating Solid Waste Physical/Chemical Methods" (SW-846 Third Edition).
5. TCLP – Toxicity Characteristic Leaching Procedure (TCLP) from NYSDEC, 6 NYCRR Part 376 Appendix 35 - Method 1311.
6. TBD – To be determined.

Samples will be obtained from the excavator bucket or trench during excavation. Samples will be collected every 25 feet and on both sides of the pipe at three depths: 1) near the bottom of the unsaturated zone; 2) where oil is first encountered in the middle of the fill layer, and 3) at the bottom depth of the oil layer. We are assuming the natural silty clay is "clean" based on previous testing.

The testing will be completed to verify the assumption that the PCB oils entered the environment as a result of a subterranean leak. The samples will be screened using PCB field testing kits to obtain PCB concentrations (e.g., 50 ppm or greater). Additionally, ten percent field duplicates will be collected and tested. The results of these field tests may affect the placement of test borings to be installed during Task 2. Finally, ten percent of the samples field screened and one quality control duplicate (QC) sample will also be sent to an off-site laboratory for confirmatory PCB analysis. Table 2-1 summarizes the sampling effort. The field screening procedures are described in Appendix A-1.

Detailed field records and measurements will be made of pipe condition, elevation of pipe invert, condition of sidewalls, visual extent of oil and bottom excavation depth. Daily field inspection reports will be prepared documenting the construction activity.

Subtask 1.3 – Determination of Treatment and Disposal Alternatives

This task will address the treatment/disposal of the excavated pipe and associated soils/bedding materials. It is intended that the excavated material will be temporarily placed in secure roll-off boxes on-site or other similar containers. Once the material is characterized via testing discussed under Subtask 2.1, a review of regulatory status will be made and a final disposal option for the material will be selected in accordance with applicable law.

Task 2 – Extent of Residual PCBs

Subtask 2.1 – Obtaining Railroad Right-of-Way (ROW) Access

It is currently understood that the area of oil contamination may extend past the fenceline onto the Conrail Railroad ROW. Investigations are planned for this area; however, appropriate permission to access the property must first be obtained. To accomplish this, the following information will be provided to or sought from the railroad:

- A copy of the approved work plan and schedule will be provided for Conrail review of the scope of intended activities;
- An understanding of the access limitations will be obtained from the railroad (e.g., times of track use, minimum clearance requirements, utilities); and
- An access agreement will be negotiated between Conrail and General Motors Corporation.

Once the access agreement is successfully negotiated, special requirements pertaining to work on the railroad property will be identified. A portion of the fence currently in place will need to be temporarily removed so that work can proceed. At that time, the need for internal access controls or temporary overnight securing of the area will be determined.

Subtask 2.2 – Exploratory Boring/Monitoring Well Installation and Sampling

The intent of the study is to further identify the extent of PCBs. Concurrent with the clay tile pipe line IRM, an extent of contamination study will be conducted for PCBs. The study will involve the advancement of test borings and installation of a groundwater monitoring wells. Soil samples will be collected throughout drilling operations, as well as groundwater samples once the wells are installed and developed.

Additionally, an investigation will be completed at the drainage structure locations to assess whether they are present. To this end, the drainage structure locations will be field located. Two test pits will be excavated perpendicular to the drainage structure locations as shown on Figure 5. If the drainage structure is found to be present, then an examination of the pipe contents will be made by breaking the pipe. If oil is present, samples will be collected for field PCB screening and confirmatory analysis by a NYSDOH laboratory. If PCBs are present, the removal of the drainage structure, pipeline and oil will be undertaken as part of the IRM.

Figure 6 shows the proposed locations of test borings and groundwater monitoring wells to evaluate the PCB extent. At this time, six borings (BL-94-1, BL-94-2, BL-94-3, BL-94-4, MW-200 and MW-104) and two monitoring wells (MW-200 and MW-204) are anticipated. The borings are located to define the north and west extent of the PCBs. The east and south boundaries are sufficiently well defined considering the direction of groundwater flow and the extent of PCBs. The locations and number of borings/wells may change depending on results of PCB field tests conducted for this study. If PCBs are encountered at the proposed boring locations, additional borings may be required to define the extent of PCBs. In this event, the NYSDEC will be advised of the additional boring locations.

Drilling will be accomplished using four and one-quarter inch inside diameter hollow stem augers as described in Attachment 1, SOP 1. The hole will be continuously sampled during drilling using a split-spoon sampler. Three samples will be collected from each boring (i.e., 18 samples) and field screened for PCBs (see Table 2-1). Also, one sample from each boring will be tested for PCBs at a NYSDOH approved laboratory.

Drilling will be halted once the hole has been advanced to the native clay layer. The depth to clay is estimated to be three to nine feet below grade. During drilling, samples retrieved from the hole will be logged with attention paid to the visual presence of oil contamination. For the monitoring wells and borings, drill cuttings will be stockpiled and later commingled with either the "ash-like" fill without oil or "ash-like" fill with oil stockpiles generated during the clay tile pipeline removal and/or recovery trench installation.

Following completion of the drilling and sampling, two two-inch diameter PVC monitoring wells will be installed, one upgradient and the other downgradient in accordance with SOP 2 contained in Attachment 1. The proposed locations are shown on Figure 6. These wells will be used to monitor water quality beyond the limits of the existing containment system. Additionally, in combination with other on-site wells, head measurements of these wells and other wells existing at the site will be obtained for interpreting groundwater flow directions.

Well construction may require some special considerations. Specifically, the shallowest well depth is anticipated to be about five feet. The well screen will be set at least six inches above the water table. The remaining aspect of well installation (sand pack, grout, bentonite, etc.) will be field designed and discussed with the NYSDEC on-site representative. A locking surface mount casing will be used to protect the well head.

After installation is completed, the wells will be developed. Development will proceed in accordance with Attachment 1, SOP 2. In general, well development will be accomplished by repeatedly purging the well with a bailer until the groundwater indicator parameters (specific conductance and pH) have stabilized (i.e., specific conductance is within ten percent and pH is within 0.2 for three consecutive samples).

Upon completion of well development, the installation will be ready for groundwater sampling. Purge water from well development and sampling activities will be drummed for future analysis and disposal.

Four wells (MW-1, MW-5, MW-200, and MW-204) will be sampled as part of this study. Prior to purging the wells for sampling, the depth to groundwater will be measured using an oil/water interface probe capable of measuring the thickness of floating oil. Once this measurement has been made and recorded, the well will be purged of three well volumes or until "dry" and allowed to recover to collect groundwater samples. Purge water will be handled as described above. After purging is complete, an appropriate quantity of groundwater will be obtained for laboratory analysis. Purging and sampling activities will be conducted in accordance with SOP 3 of Attachment 1.

One bedrock well will be installed hydraulically downgradient from the PCB "hotspot". The actual location will be formalized upon completion of the other borings and wells planned for this investigation. The use of a casing grouted into the clay will be installed to limit the potential for downhole contaminant migration. [Note: Soil samples will be collected continuously from the ground surface to the top of rock.] The boring will then be drilled thorough the casing and advanced approximately 10 feet into the rock using "N" or "H" size core barrel. If "N" size rock core is collected, the bedrock hole will then be reamed to a nominal diameter of four inches. A monitoring well will then be screened in the rock. The screen will extend from about three to nine feet in the rock with a sand pack extending from two to ten feet in the rock. A bentonite pellet seal will then be installed at least one foot into the overburden. The borehole will be grouted back to ground surface. A locking casing will be installed to protect the well. It may be necessary to install this well as a surface mount protective casing, since it may be on the Conrail Railroad ROW. Under this scenario, the well will not be vented and a water tight cap installed to protect the well against the potential for surface water infiltration. This consideration for surface mount casing applies to all of the other wells.

Subtask 2.3 – Storm Sewer Sampling

Sampling from storm sewers and sewer bedding materials is planned. Samples of sewer sediment, if present, and water at the outfall to the City of Buffalo's storm sewer along Scajaquada Street will be collected. Also, a sediment sample will be collected from the western lateral that extends into or toward the PCB "hotspot".

A boring will be drilled and sampled in the bedding of the storm sewer lateral that extends into or toward the "hotspot" to assess if PCB oil is migrating into the bedding. Soil samples will be collected continuously as discussed under Task 2.0 above. In the event PCBs or free-product oil is encountered in the bedding of the pipeline, additional borings will be conducted along the pipeline bedding to assess the extent of oil or PCB contamination. The borings and sampling will be conducted in accordance with the Work Plan and will be located at agreed upon locations with the NYSDEC field representative.

Samples of the storm water, sediment, and soil from the boring will be tested for PCBs using the USEPA Method 8080 as specified in the QAPP. The storm water sample will be tested for lead.

Task 3 - Analytical Testing

Analytical testing will be completed at a NYSDOH approved laboratory following the procedures in the QAPP (Appendix A-1). Data developed by this plan will be validated by a qualified person or firm on the NYSDEC list of validators. The number of samples for testing is dependent upon total number of borings and wells. Testing will be primarily for PCBs with some samples also analyzed for lead. Table 2-1 presents the expected number of samples, although this number may change on the basis of PCB field screening.

Task 4 - Risk Assessment Review

The nature and extent of PCB presence at the Site will be evaluated to determine whether further risk analysis is warranted. Available information indicating that risks associated with PCB presence are de minimis and need not be considered further include:

- PCBs detected are limited to the subsurface environment, where they present negligible potential for direct contact to human and environmental receptors; and
- There is little likelihood of future PCB migration once the collection trench is activated.

However, depending upon the results of the residual PCB investigation completed under Task 2, a quantitative Risk Assessment may be necessary. If so, the Risk Assessment will follow the guidelines presented in Task 3.0 of OU-2. GM will notify NYSDEC of its intent to perform a Risk Assessment.

Subtask 4.1 – Identification of SCGs

Standards, Criteria and Guidance (SCGs) will be identified for Operable Unit No. 1 and associated areas. SCGs will be developed for three types of classifications:

1. Ambient or chemical-specific requirements: health- or risk-based numerical values or methodologies;
2. Location-specific requirements: restrictions placed on the concentration of hazardous substances or the conduct of activities because of the locations in which they occur; and
3. Performance-, design- or other action-specific requirements: technology- or activity-based requirements or limitations taken with respect to hazardous wastes.

SCGs will be identified for Items 1 and 2 above under this task. For Item 3, these SCGs will be identified under Task 6.

Task 5 – Reports

Two types of reports will be submitted for this operable unit:

- A monthly status report describing the job progress such as borings installed, samples collected, status of lab data, analytical data, and work to be completed in the following month. Also, any NYSDEC approved modifications to the Work Plan will be listed.
- A Site Investigation Report will be prepared describing the completed field work, geology, groundwater flow directions, analytical testing, screening of technologies, recommendations for additional work, including treatability studies and a Risk Assessment.

Task 6 - Engineering Evaluation of Alternatives

A range of remedial alternatives for soil and groundwater will be evaluated in accordance with the major elements required in NYSDEC TAGM HWR 90-4030. The Report will contain the following sections:

- Existing Conditions and Remedial Action Objectives;

    - Summary of the findings of the extent of PCB and free oil product contamination of the soil and groundwater.
    - Summary of the Risk Assessment.
    - Summary of applicable Standards, Criteria and Guidance ("SCGs")for PCBs in soil and groundwater.
    - Statement of the Remedial Action Objectives.
    - Results of any Treatability Study.
    - Estimate of the volume of soil and areal and vertical extent of groundwater requiring remediation given the extent of contamination, the SCGs, and the Risk Assessment.

- Technology Screening;

    - Containment and treatment (in-situ and ex-situ) will be evaluated for the unsaturated soil. Containment technologies will include caps and vertical barriers. Treatment technologies will include chemical/solvent extraction, dechlorination, and thermal (low-temperature thermal desorption and incineration) processes.
    - Containment, removal, and treatment technologies will be evaluated for groundwater. The suitability of the existing collection drain and pump station will be evaluated. Several processes for on-site pre-treatment before indirect discharge to the Buffalo Sewer Authority (BSA) will be evaluated. Several processes for on-site treatment before direct discharge will also be evaluated.

- Detailed Evaluation of Alternatives;

  - An alternative screening evaluation will not be done because the number of alternatives is expected to be limited. Remedial alternatives utilizing a representative technology for containment, treatment, etc. will be evaluated against the seven detailed evaluation criteria in TAGM HWR 90-4030. The alternatives expected to be evaluated are:

    - Soil
      No Action
      Containment
      In-situ Treatment
      Excavation and On-site Treatment
      Excavation and Off-site Disposal

    - Groundwater
      No Action
      Containment (collection drain), pre-treatment and discharge to BSA
      Containment (collection drain), on-site treatment and direct discharge to a receiving water body

A draft engineering evaluation of alternatives report will be prepared and submitted to NYSDEC for the soil and groundwater. The draft report will contain the sections discussed above under Task 6 and a comparative analysis among alternatives and a recommended alternative. After NYSDEC's review, a final report will be prepared and submitted to NYSDEC.

Task 7 - Remedial Design

This task will include design of the selected remedial alternative for the PCBs in soil, if necessary. In addition, the remedial design for free product on the groundwater surface and PCBs in ground will be completed. The work associated with the groundwater may be completed simultaneously with the clay tile pipeline IRM. It is premature to describe the soil remedial aspect. However, for groundwater, the remedy would include extending the drain to capture the oil/PCB plume and groundwater treatment. This task will also include any additional field work required for the design and initiation of obtaining any required permits and other institutional controls as required.

Task 8 - Implementation

Upon completion of the design, the remedial alternative for soils and groundwater will be initiated. The scope of this effort will likely consist of retaining a hazardous waste contractor to implement the remedy, if needed. Also, obtaining any required permits and other institutional issues will be finalized under this task.

2.2 OPERABLE UNIT 2 - LEAD

Work to be completed for this Operable Unit is described in the following five major tasks. The purpose of this work is to assess the extent of lead and the origin of the lead fill at the Site and select a remedial alternative .

Task 1 - Historical Data Review

In addition to the work completed and described in Section 1.2, the following additional information will be reviewed as part of the history for the site:

- Aerial photographs;
- Interviews of residents living in the neighborhood and former GM-Saginaw employees prior to 1965 with emphasis on the time period pre 1947 (i.e., ownership prior to Buffalo Gravel Corporation); and
- Completion of PRP search.

Delineating the extent of the "ash-like" fill is the goal of this effort in order to define the planned explorations. This will provide a rationale for selecting sample locations.

A technical memorandum will be prepared describing the results of the historical review. Included with the report will be aerial photographs and Sanborn maps, a description of site development and the results of interviews concerning information pertaining to the past uses of the Site. Any identified area of dumping will be detailed on a map. This map would then form the basis for additional testing.

An abbreviated Work Plan for the additional lead sampling will be provided along with the historical report. Included will be a map illustrating revised boring locations relative to the potential locations shown on Figure 7 of the Plan. In the event no additional information delineating the extent of "ash-like" fill is discovered, the sampling and analytical work described in Task 2 will be implemented to define the extent of lead within the property boundaries.

Task 2 - Extent of Contamination

The existing historical and analytical information indicates lead contaminated fill materials exist within and extend from Parking Lot No. 4. The eastern extent is unknown. The western extent appears to be the Conrail Railroad ROW. The eastern edge of the Railroad is considered to be the western boundary on the basis of the title search, which indicated ownership by Railroads back to 1871. Assuming no further information is found regarding the extent of filling at the Site, GM proposes to install 11 borings along the boundaries of Parking Lot No. 4. These tentative boring locations are shown on Figure 7. No borings are anticipated on the west side of the railroad tracks as a result of the sampling program described in Section 1.2. In addition, up to ten borings will be completed in intermediate areas between the WWTP and the property boundary to confirm the continuity of the "ash-like" fill deposit. These borings will be completed at selected locations based on initial perimeter borings and approved by NYSDEC in the field.

The borings will be continuously sampled as described under OU-1. Each sample will be placed in sample containers as described in the QAPP for analytical testing.[2] In the event, a dissimilar fill material is identified from those observed previously, it will be placed in a separate container.[3] Sample selection will be discussed with the NYSDEC field representatives.

Monitoring wells will be installed at three locations, MW-201, MW-202 and MW-203 (MW-200 will be installed as part of the PCB investigation) and existing monitoring wells

2 Sample containers will be provided to the NYSDEC on an as needed basis.

3 If dissimilar waste materials are encountered, the sample may be tested for all of the TCL parameters. This aspect will be discussed with the NYSDEC field representative.

MW-1 and MW-5 will be used. Monitoring wells MW-201 and MW-202 are installed in presumed upgradient locations. Wells MW-5, MW-201, MW-202, and MW-203 are installed in a presumed downgradient location. These wells will be installed to confirm groundwater flow directions in the fill/soil zone (in combination with other on-site wells) and assess groundwater quality for lead both in field filtered and unfiltered samples.

Subtask 2.1 – Analytical Testing

Analysis of "ash-like" samples collected from the borings will be completed for total lead analysis following the QAPP. One "ash-like" sample from each boring will be tested for total lead. One sample from each boring above the "ash-like" fill will also be tested for total lead. Additionally, ten percent of the samples will be archived and then based on the results selected samples will be tested for TCLP lead. If dissimilar fill materials are identified , then additional testing may be warranted. Under this scenario, the testing will be discussed with the NYSDEC.

Task 3 – Baseline Risk Assessment

A Baseline Risk Assessment (RA) will be performed for lead. Both human health and environmental pathways will be addressed. The RA will conform to the guidelines detailed in Risk Assessment Guidance for Superfund Volume I (Part A: Human Health Evaluation Manual) and Volume II: Environmental Evaluation Manual (1989), as well as more recent USEPA guidance on exposure assessment (Fed. Reg. 57:22888; 1992).

Based on the existing data to date, it appears likely that the receptor population of concern regarding lead exposure is on-site workers. The lead has been determined to be primarily associated with subsurface "ash-like" fill material. Since the Site is mostly paved, there is minimal concern for direct contact. The human health RA will focus on establishing the likelihood, if any, of subsurface exposure (e.g., through maintenance or excavation).

The acceptability of any hazard associated with a given degree of lead exposure will be assessed by comparing the exposure likely to be experienced by a worker with the exposure associated with working in an environment containing lead at the OSHA action level for lead (30 ug/m^3, the level at which workers are required to use protective equipment). All exposures will be expressed as mg/kg-day assuming a body weight of 70 kg and standard USEPA assumptions regarding occupational incidental ingestion rates, dermal contact and ventilation rates.

It appears very unlikely that there is potential for off-site lead contamination resulting from migration from the Site. However, the RA will evaluate this potential and, if warranted, assess risks to the local population (e.g., through residential exposure mechanisms such as direct contact with lead-contaminated soils). As the USEPA has determined that it is inappropriate to derive toxicity factors for lead, hazard cannot be quantified in the typical risk assessment manner. Rather, these pathways would be assessed in a similar fashion as the occupational exposures - by comparing estimated intakes with lead intakes that are considered acceptable. In the case of public health exposures, occupational standards would not apply. The lead intakes would be compared with those associated with use of a drinking water supply containing lead at the New York State Department of Health standard (50 ug/l).

Given the low potential for off-site lead migration, it is unlikely that there are ecological impacts of concern. Therefore, this aspect is not included in this Work Plan.

Subtask 3.1 – Identification of SCGs

Standards, Criteria and Guidance (SCGs) will be identified for Operable Unit No. 2 and associated areas. SCGs will be developed for three types of classifications:

1. Ambient or chemical-specific requirements: health- or risk-based numerical values or methodologies;
2. Location-specific requirements: restrictions placed on the concentration of hazardous substances or the conduct of activities because of the locations in which they occur; and
3. Performance-, design- or other action-specific requirements: technology- or activity-based requirements or limitations taken with respect to hazardous wastes.

SCGs will be identified for Items 1 and 2 above under this task. For Item 3, these SCGs will be identified under Task 6.

Task 4 - Treatability Study(s)

As part of the Site Investigation Report, a Treatability Study(s) may be necessary to characterize the applicability of a particular technology. The Treatability Study will provide a basis for determining technical feasibility, implementability, and cost. Currently, it is unknown whether a Treatability Study is required. Recommendations for treatability studies will be completed as part of the Site Investigation Report.

Task 5 - Reports

Two types of reports will be submitted for this Operable Unit No. 2:

- A monthly status report describing the job progress such as borings installed, samples collected, status of lab data, analytical results, and work to be completed in the following month. Also, any NYSDEC approved modification to the Work Plan will be listed. This report will be combined with the monthly status report described for OU-1 when the project work is completed concurrently.
- A Site Investigation Report will be prepared describing field work, geology, groundwater flow directions, analytical testing, screening of technologies, recommendations for additional work, including treatability studies and Baseline Risk Assessment.

Task 6 - Engineering Evaluation of Alternatives

A range of remedial alternatives for soil and groundwater will be evaluated in a focused Feasibility Study (FS) in accordance with the major elements required in NYSDEC TAGM HWR 90-4030. The FS Report will contain the following sections:

- Existing Conditions and Remedial Action Objectives;
    - Summary of the findings of the extent of lead contamination of the soil and groundwater.
    - Summary of SCGs for lead in soil/fill and groundwater.
    - Summary of the Baseline Risk Assessment.

- Results of any Treatability Study.
- Statement of the Remedial Action Objectives.
- Estimate of the volume of soil and areal and vertical extent of groundwater requiring remediation given the extent of contamination, the SCGs, and the Baseline Risk Assessment.

- Technology Screening;

    - Containment and treatment (in-situ and ex-situ) will be evaluated for the unsaturated soil. Containment technologies will include caps and vertical barriers. Treatment technologies will include soil washing and solidification/stabilization processes.
    - Containment, removal, and treatment technologies will be evaluated for groundwater. Collection drains and pumping wells will be evaluated for groundwater collection. Several processes for on-site pre-treatment before indirect discharge to the Buffalo Sewer Authority (BSA) will be evaluated. Several processes for on-site treatment before direct discharge will also be evaluated.

- Detailed Evaluation of Alternatives

    - An alternative screening evaluation will not be done because the number of alternatives is expected to be limited. Remedial alternatives utilizing a representative technology for containment, treatment, etc. will be evaluated against the seven detailed evaluation criteria in TAGM HWR 90-4030.

The alternatives expected to be evaluated are:

- Soil
  No Action
  Containment
  In-situ Treatment

Excavation and On-site Treatment

Excavation and Off-site Disposal

- Groundwater

No Action

Containment (collection drain), pre-treatment and discharge to BSA

Containment (collection drain), on-site treatment and direct discharge to a receiving water body

A draft FS Report will be prepared and submitted to NYSDEC. The draft FS Report will contain the sections discussed above and a comparative analysis among alternatives and a recommended remedial alternative. After NYSDEC's review, a final FS Report will be prepared and submitted to NYSDEC.

THREE

3.0 SCHEDULE

The schedule for implementation of this Work Plan is provided on Figures 8 and 9. This schedule provides approximate timeframes for completion of the work beginning when the Consent Order is signed. As the project progresses, the schedule will be updated based upon the actual scope of work. Certain factors are beyond the control of GM, such as weather conditions, NYSDEC and NYSDOH review schedules, and additional factors as described in the Force Majeure Section of the Consent Order.

ATTACHMENTS

SOP NO. 1

TEST BORINGS

1.0 INSTALLATION

Test borings will be drilled at predetermined locations at the facility. The test borings will be undertaken in order to provide sufficient detail describing subsurface soil and the potential extent of contamination within the subsurface. Following the completion of the test borings, the boreholes will either be backfilled with a cement/bentonite grout or converted to a groundwater monitoring well.

Borehole advancement will be initiated by hollow stem augers into the clay layer below the contaminated soils. The procedures which will be followed during the test boring program are as follows:

1. All drilling equipment and ancillary tools will be decontaminated prior to drilling.
2. Borehole will be advanced with 4-1/4 ID continuous flight hollow stem augers in two-foot intervals to permit the collection of continuous split-spoon samples.
3. Split-spoon samples will be obtained utilizing the Standard Penetration Test Procedures (ASTM-D1586).
4. Soils will be identified in the field utilizing the Unified Classification System (UCS).
5. HNu or equivalent meter readings will be recorded from each split-spoon as the sampler is opened.
6. A portion of the soil sample will be placed in clean, eight-ounce or larger wide-mouthed glass jars. The jars will be sealed and labeled with appropriate information as described below.
7. All drilling cuttings will be containerized for proper disposal. It is likely that the drilling spoil will be disposed of along with any material generated as a result of the clay tile pipe removal activities.

2.0 BORING LOGS AND RECORDKEEPING

During the drilling of each borehole, an accurate log will be kept and include the following:

1. Date and time of drilling, driller's and helper's names, and Wehran geologist.
2. Drilling method utilized.
3. The reference point for all depth measurements (i.e., ground surface and elevation).
4. The depth at which each change of formation is identified.
5. The depth at which the first water bearing zone is defined.
6. The thickness of each stratum.
7. The number of blows required to drive the standard split-spoon sampler every six inches.
8. Amount of sample recovered.
9. The description of the material of which each stratum is composed, including:
   a. Depth, sample number
   b. Grain size, as defined by the Unified Soils Classification System
   c. Color
   d. Degree of weathering, cementation, and density
   e. Other physical characteristics.
10. The depth interval from which each formation sample was taken.
11. The depth at which hole diameters (bit sizes) change.
12. The depth to the static water level (SWL) and changes in SWL with well depth, if possible.
13. Total depth of completed boring.
14. The depth and description of the well casing materials and lengths.
15. The sealing off of water-bearing strata, if any, and the location thereof.
16. Depth or location of any lost drilling materials or tools.
17. The depth of the surface seal, if applicable.
18. The nominal hole diameter of the well bore above and below the casing seal.
19. PID readings.
20. Depth of permeability test, if applicable.

Figure SOP-1-1 is the field borehole log (overburden) to be utilized by Wehran.

Figure SOP-1-1

WEHRAN ENGINEERING
CONSULTING ENGINEERS

Field Borehole Log

CLIENT .... JOB NO. ________ HOLE NO. .... SHEET NO. .... OF ....

PROJECT .... WEATHER .... INSPECTOR ....

SITE .... TEMP. .... °F STARTED .... .M .... 19....

LOCATION .... (LATITUDE) (DEPARTURE) BEARING .... DIP .... ° FINISHED .... .M .... 19....

CONTRACTOR ....

ELEVATIONS: DATUM ....

METHOD OF BORING: SOIL .... CASING DIAM. .... DRILL PLATFORM ....

ROCK .... GROUND SURFACE ....

CORE DIAM. .... WATER LEVELS ....

LOG LEGEND: SILT; SAND; CLAY; GRAVEL

*SAMPLE CONDITION: GOOD; DISTURBED; FAIR; LOST

**SAMPLING METHOD: A - SPLIT TUBE; B - THIN WALL TUBE; C - PISTON SAMPLER; D - CORE BARREL; E - AUGER; F - WASH; K - SLOTTED SAMPLER

**SHIPPING CONTAINER: N - INSERT; O - TUBE; P - WATER CONTENT TIN; Q - GLASS JAR; R - CLOTH BAG; S - PLIOFILM BAG; Y - CORE BOX; Z - DISCARDED

LOG	DESCRIPTION: COLOR; CONSISTENCY DENSITY; TEXTURE; STRUCTURE; SHAPE AND SURFACE CONDITION OF GRAINS; ODOR; ETC.	ELEV. — DEPTH	SAMPLE *	SAMPLE ** TYPE	SAMPLE NO.	SAMPLE SIZE (IN.)	SAMPLE RETD. (IN.)	BLOWS PER 6 INCH	NOTES: BORING; TESTING AND SAMPLING PROCEDURES; WATER LOSS AND GAIN; DRILLING AND TESTING EQUIPMENT; ETC.

SOP NO. 2

GROUNDWATER MONITORING WELLS (Installation, Recordkeeping, and Development)

1.0 INSTALLATION

Three monitoring wells will be installed at the site. Prior to installation, drilling equipment, tools, and well construction materials will be decontaminated. The following is a detailed discussion of the monitoring well installation methodologies which will be used at the site.

OVERBURDEN MONITORING WELLS

Borehole advancement for the wells will be performed by hollow stem augering to a predetermined depth for discrete zone monitoring (see SOP 1 — "Test Borings"). The borehole will be advanced with 4-1/4-inch ID continuous flight hollow stem augers. The procedures which will be followed during the installation are as follows:

1. No drilling fluids will be used unless prior approval is received from the NYSDEC, and if a fluid is recommended, it will be an approved potable water source.
2. The augers will be advanced in two-foot intervals to permit the collection of continuous split-spoon soil samples.
3. Split-spoon soil samples will be obtained according to the procedures described in the Test Boring SOP.
4. The monitoring well will be constructed of two-inch ID PVC screen and riser.
5. A sand pack will be placed within the annular space surrounding the screen to a distance of not more than six inches above the top of the screen.
6. A minimum one-foot bentonite slurry seal will be placed above the sand pack.
7. A concrete seal will be placed to the surface.
8. A six-inch ID protective flush mounted steel casing with a locking cover will be installed to complete the installation.
9. A water tight cap will be placed in the two inch PVC well to limit potential surface water infiltration [Note: Vent holes will not be drilled into the PVC casing].

SAND PACK, BENTONITE PELLET SEAL, AND CONCRETE

Sand Pack

- The sand pack will consist of uniformly-graded, clean inert fine sand with a 100 percent by weight passing the No. 30 Sieve, and less than two percent by weight passing the No. 200 Sieve.

Bentonite Pellet Seal

- Pure Wyoming sodium bentonite pellets (1/4 to 1/2 inch diameter) will be used.

Concrete

- Sakrete (or similar) will be mixed with water to maufacturer's specifications.

2.0 RECORDKEEPING

During the installation of the monitoring well, an accurate accounting of the installation details will be kept and include the following:

1. Total depth of completed well.
2. The depth and description of the well casing materials and lengths.
3. The sealing off of water-bearing strata, if any, and the location thereof.
4. Depth or location of any lost drilling materials or tools.
5. The depth of the surface seal, if applicable.
6. The nominal hole diameter of the well bore above and below the casing seal.
7. The amount of cement and bentonite (number of bags) installed for the seal, if applicable.
8. Screen materials and design.
9. Casing and screen joint type.
10. Screen slot size/length.
11. Pack, seal, and grout material used.
12. Type of protective well cap.
13. PID readings.
14. Depth of permeability test.

3.0 WELL DEVELOPMENT

The purpose of well development is to prepare a monitoring well for future sampling activities. This is achieved by bailing/pumping the well until such time as the water quality obtained from the well is consistent with water quality in the formation from which the water is obtained, usually determined by measurement of pH and specific conductivity. For the purposes of this investigation, well development shall be performed in the following fashion:

1. Inspect locking casing, and surface grouting for integrity.
2. Open the well.
3. Measure static water level, well bottom depth, and calculate standing water volume.
4. Depending upon the response of the well, either a bailer or pump will be utilized to develop the well.
5. If a bailer is used, it will be lowered to the bottom of the well and raised and lowered repeatedly. This surging should be performed in a relatively slow manner to avoid over-development. Following surging, the well should be evacuated to remove any fines which have accumulated in the well.
6. If a pump is utilized, the inlet should be placed approximately two feet above the bottom of the well and activated.
7. During bailing/pumping, record pH and specific conductivity. If the well can be evacuated to dryness, measurements shall be made at least two times per evacuation cycle.
8. The inlet shall be periodically raised and lowered throughout the screened interval to ensure complete development.
9. Development will be considered complete when the following conditions are achieved:

   - pH is within 0.2 pH units for three consecutive measurements.
   - Specific conductance is within ten percent for three consecutive measurements.

10. When the preceding conditions are met, discontinue development, secure and lock the well.

11. Water resulting from well development will be collected and handled per the Work Plan.

Figure SOP-2-1 is the form to be utilized to record well development observations.

WEHRAN ENVIROTECH WELL DEVELOPMENT OBSERVATIONS

JOB NUMBER ________ JOB SITE ________ DATE ________

WELL NUMBER ________

METHOD OF DEVELOPMENT ____________________

OBSERVATION NUMBER	ELAPSED TIME (MINUTES)	AMOUNT DISCHARGED (Q) (GALLONS)	RECOVERY (FEET)	TURBIDITY (NTU)	CONDUCTIVITY	pH	TEMPERATURE (DEGREES C)

TOTAL			

REMARKS: ____________________

Figure SOP-2-1

SOP NO. 3

GROUNDWATER SAMPLING METHODOLOGY

1.0 OBSERVATIONS

Upon arrival at each well, the sampling team will make observations as to the conditions of the well and any outside factors which may affect the well in any way. These observations include well labels, locks, surface seal integrity, and other surrounding conditions which may influence sampling. These observations, as well as date, time, weather, and crew members, are noted in the field log book.

A photoionization detector (PID) will be used to monitor the surrounding air for total concentration of organic gases present. Both "breathing zone" and "head-space" readings will be obtained and recorded in the field log. The breathing zone is the air near the well that comes into contact with sampling team members under ordinary sampling conditions. The head-space is the region just inside the well casing itself. These readings will then be used to determine the level of protection necessary in order for the field crew to proceed with the sampling event.

2.0 PREPARATION

The first step in preparation for sampling is well purging, which requires a determination of the volume of standing water within the well. Depth to the bottom of the well is measured by slowly lowering a weighted, decontaminated, stainless steel surveyor's tape into the well. Once contact with bottom has been made, the tape is placed against the side of the inner casing in line with the notch or other marking to assume consistent measurements and the tape is read to the nearest 0.01 foot. If no inner casing is present, this depth reading will be taken from the top of the protective outer casing. This measurement is then recorded in the field log.

Static water level (depth to water) will then be taken by using a Slope Indicator Co. water level indicator Model 51453 or equivalent. After being decontaminated, the probe is lowered into the well casing until contact with water occurs. This contact will be signalled by a buzzer/light alarm on the take-up reel of the water level indicator. Depth to water will be measured and recorded, taking care to measure from the same reference point on the casing.

Since only one foot divisions are marked on the probe line, an engineer's scale will be used to determine this measurement to the nearest 0.01 foot.

The potential presence of immiscible layers within the wells will be monitored. An ORS 100-foot Teflon quartz interface probe or equivalent will be used to determine the presence of nonaqueous phase liquids or "floaters" within each well. Floaters are relatively insoluble organic liquids which are less dense than water and tend to spread across the potentiometric surface.

The interface probe is capable of measuring oil layers less than 0.01 foot in thickness. This probe is conductivity activated and can differentiate between layers of oil and water. When the probe comes into contact with water, an oscillating tone registers; for hydrocarbon, a solid tone is heard. Measurements are taken and recorded in the same manner as the static water level. When monitoring for immiscible layers, this procedure will take place as soon as the crew arrives.

3.0 PURGING

All wells will be purged using a decontaminated teflon bottom loading bailers. At least three standing well volumes will be purged prior to sampling.

The bailer will be fastened to a new 3/16-inch diameter polypropylene rope and lowered into the well, taking care not to lower the bailer too quickly or to agitate the water excessively. The bailer, once filled, will be raised to the surface and its contents poured into a holding container staged downgradient of the well to make sure that no purge water pools by the base of the well. This process will then be repeated until purging is complete. The rope will then be cut from the bailer and discarded. The bailer will be placed in a storage bag for removal and decontamination. All purge observations and actual purge volume will be noted in the field log.

All purged water will be handled pursuant to the Work Plan.

4.0 SAMPLING

Sampling is usually performed the day after purging within a 24-hour period from the time of purge. This period allows wells to recharge to a level where there is adequate sample volume for each parameter required. In cases where recharge is sufficient on the day of purging, sampling may take place on that day. In general, wells are sampled in the same order as they are purged, allowing similar elapsed time to sample for each well. If a well has not recharged sufficiently to obtain a representative sample within 24 hours, it will be considered a dry well and will be noted as dry on the chain of custody and the field logs.

Teflon, double check valve, bottom filling, bailers will be used to obtain groundwater samples from all wells. The sample bailer will be connected to a 3/16-inch diameter Teflon-coated wire line and will be slowly lowered into the well, taking care not to agitate the water in any manner which would cause loss of volatiles from the sample. The bailer will be lowered into the water column until it has filled completely. The bailer will then be raised to the surface and the appropriate bottles filled.

For all samples, the sample container will be tipped at an angle and the sample water is gently poured down the neck of the container until full. This will minimize both agitation of sample and contact of the sample with surrounding atmosphere. The sample bottles will then be capped, sealed with custody tape and placed in a cooler. When vials with septums are used, a check for air bubbles is made after capping. This is done by inverting the vial and tapping gently. If air bubbles appear, the cap is removed, more water is added, and the process is repeated. The process will be repeated until all aliquots have been filled.

Specific conductivity will then be measured. The meter will be calibrated every two hours using a 1413 umho/cm standard of Kl. Readings will then be recorded in the field logs. If a meter appears to be malfunctioning, it will be replaced by a spare meter and noted. All meters are calibrated according to manufacturer's specifications. Meters will be rinsed with D.I. water before and after each reading to avoid any erroneous measurements.

After field measurements are complete, the field crew will also note the color, clarity, and other observable physical characteristics of the sample. Samples will be stored and transported to the laboratory in coolers which are supplied with ice packs. These ice packs are required to cool the samples to the required four degrees C. Care will be taken not to expose vials directly to the ice packs since they are easily frozen and broken.

All sample containers will be precleaned and labelled in the laboratory. Label information includes client, site, job number, sample I.D. number, test parameters, and preservatives. These containers correspond to a particular well by matching the job number and sample I.D. number of the bottle set used to the well number. These are noted both on the chain of custody and in the field log.

The Chain of Custody forms (see Figure SOP 3-1) are included with each bottle set. The name and signature of the bottle preparer and the laboratory bottle set number is filled out on the chain the day the bottle set is assembled in the lab. These forms are then transported in the sample cooler to the site with the sampling team. Upon completion of

WehranEnviroTech

CHAIN OF CUSTODY RECORD

☐ 666 East Main Street
P.O. Box 2006
Middletown, New York 10940-0858
(914) 343-0660 Fax (914) 343-1946

☐ 6 Riverside Drive
Suite 101
Andover, Massachusetts 01810-1121
(508) 682-1980 Fax (508) 975-2065

☐ 345 Lang Boulevard, Suite 1
Grand Island, New York 14072
(716) 773-1801 Fax (716) 773-1828

☐ 7205 Shadeland Station
First Floor, Suite 120
Indianapolis, Indiana 46256
(317) 841-8845 Fax (317) 841-0614

PROJECT ID: ______________

FOR CLIENT USE				SAMPLE BOTTLE DESCRIPTIONS										
SAMPLE SET	SAMPLE ID	DATE SAMPLED	# LAB SMPL #										TOTAL BOTTLES	COMMENTS
		__/__/__												
		__/__/__												
		__/__/__												
		__/__/__												
		__/__/__												
		__/__/__												
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		__/__/__												
		__/__/__												
		__/__/__												
# NOTE : For Lab Use Only			REF. # :											= TOTAL # OF BOTTLES

COOLER OPENED BY: ______________ DATE: __/__/__ TIME: __:__
COOLER SEALED ? YES NO
SIGNATURE: ______________ SEAL #: ______________

CUSTODY TRANSFERRED TO: ______________ DATE: __/__/__ TIME: __:__
SIGNATURE: ______________

SAMPLES COLLECTED BY: ______________ DATE: __/__/__ TIME: __:__
SEAL INTACT ? YES NO N/A
SIGNATURE: ______________ SEAL #: ______________

COOLER RESEALED BY: ______________ DATE: __/__/__ TIME: __:__
SIGNATURE: ______________ SEAL #: ______________

RELINQUISHED BY: ______________ DATE: __/__/__ TIME: __:__
SIGNATURE: ______________ SAMPLES SEALED? YES NO

RECEIVED IN LAB BY: ______________ DATE: __/__/__ TIME: __:__
SEAL INTACT? YES NO N/A
SIGNATURE: ______________ SEAL #: ______________

WERE SAMPLES SPLIT WITH ANOTHER PARTY? || YES || NO
IF YES IDENTIFY: ______________

COOLER ID: ______________

PAGE ____ OF ____

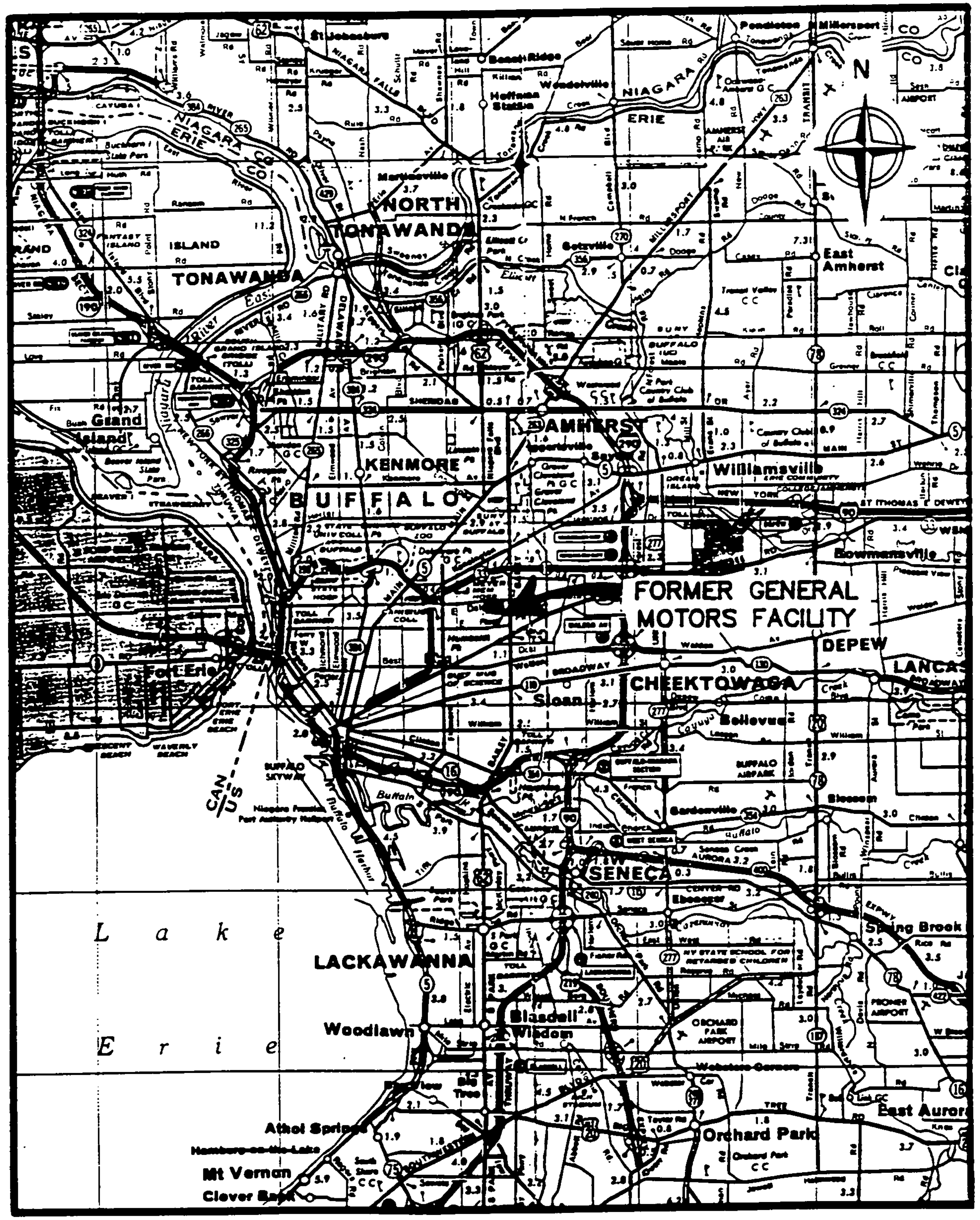
Figure SOP-3-1

sampling, the crew member fills out the chain in order to properly identify the sample for the laboratory. Well locations are assigned a sample I.D. number and are listed. Time and date of sampling, preservative, analysis required, filtering status, and bottle set composition are also filled in at this time. Any dry wells or partial bottle sets are also noted. The technician then fills in the site location and signs his/her name. The chain is then sealed in a plastic bag and replaced in the cooler for transport back to the laboratory.

The sample coolers will always be located within sight of the crew members or secured in a locked vehicle when stored in the field. The sample coolers will be outfitted with custody seals and transported back to the lab in a company vehicle within six to eight hours of sampling or shipped via overnight carrier. Upon arrival at the lab, the custody seals will be checked and samples will be logged into the laboratory sample tracking system.

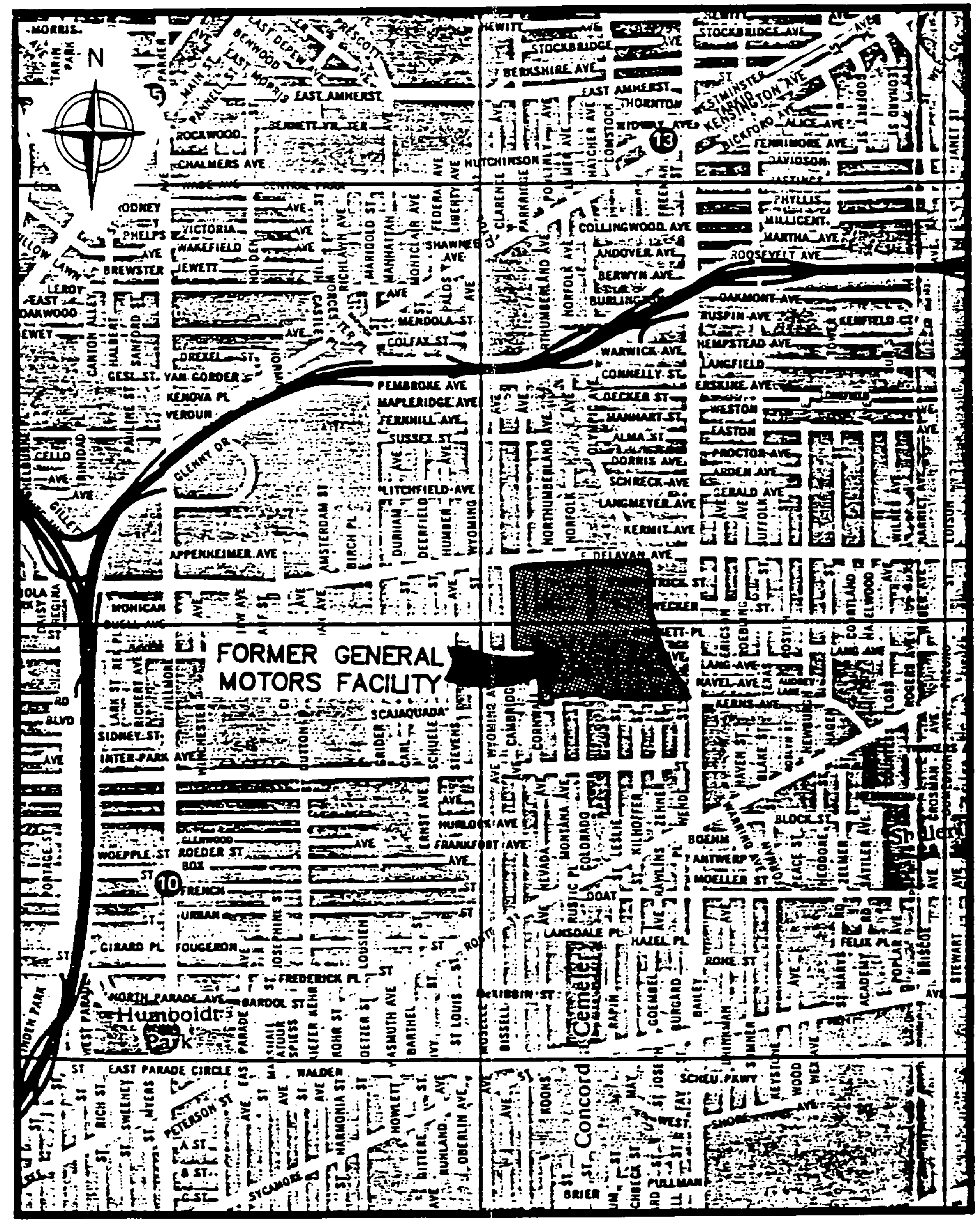
During all procedures involving purging, sampling, and handling of samples, the crew members will wear two pairs of gloves, an inner latex pair and an outer pair of either latex or some other approved substance such as viton or nitril rubber. These gloves will be changed and discarded after every well to avoid cross-contamination.

FIGURES



REGIONAL LOCATION MAP

NOT TO SCALE



SITE LOCATION MAP

NOT TO SCALE

WEHRAN ENGINEERING
CONSULTING ENGINEERS

Drawn by: L. Schwartz

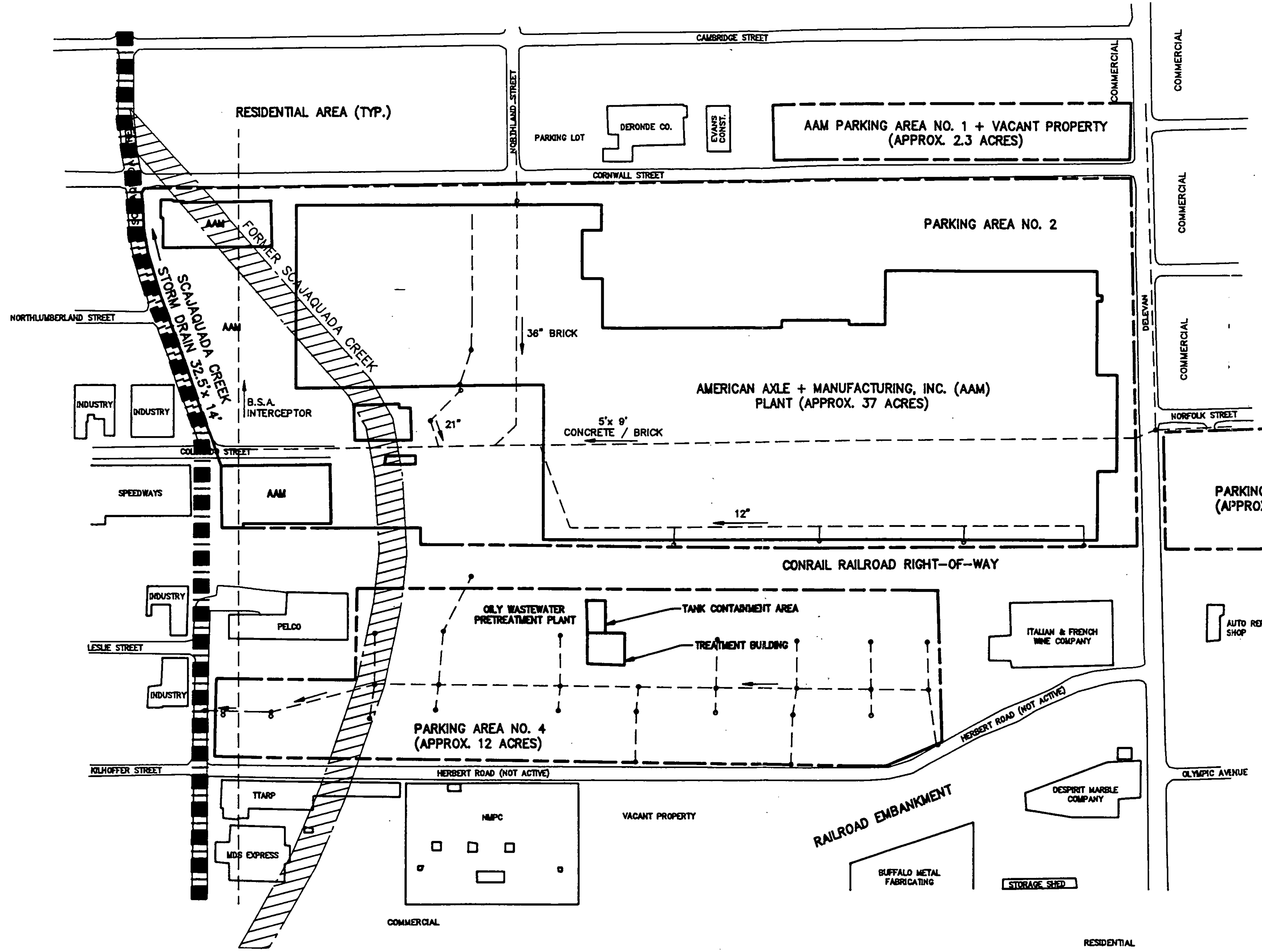
Checked by: R. Henchel

Date:

LOCATION MAPS FOR
GENERAL MOTORS CORPORATION
SAGINAW, BUFFALO PLANT
FIGURE 1

Scale: AS SHOWN

Project No:

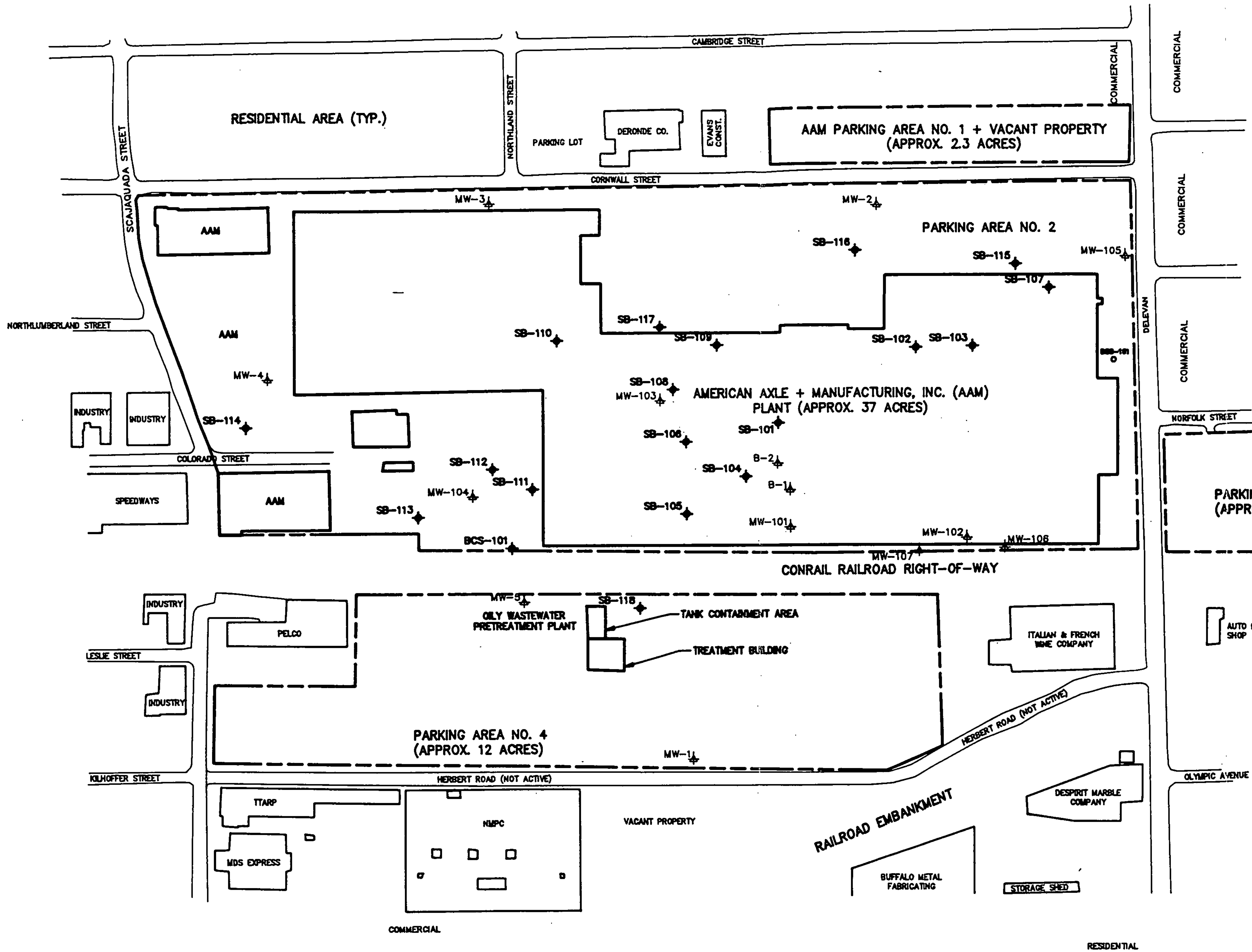


NOTE:

1. THIS MAP WAS DIGITIZED FROM A BASE MAP PROVIDED BY GENERAL MOTORS CORP., SAGINAW BUFFALO PLANT AND IS APPROXIMATE.
2. UNDERGROUND SEWER INFORMATION TAKEN FROM DRAWING NO. PE-D-10 OF THE SPILL PREVENTION CONTROL & COUNTERMEASURE PLAN, DATED MAY 1994.
3. ONLY THE MAJOR SEWER LINES ARE SHOWN WEST OF THE CONRAIL RAILROAD RIGHT-OF WAY FOR CLARITY.
4. FORMER SCAJAQUADA CREEK LOCATION TAKEN FROM 1917 SANBORN MAP FROM ERIE COUNTY AND BUFFALO HISTORICAL SOCIETY.
5. SCAJAQUADA CREEK STORMDRAIN IS LOCATED USING THE SCAJAQUADA STREET LOCATION AND IS ONLY AS ACCURATE AS THE DIGITIZED MAP.
6. SEWER, WATER, ELECTRICAL AND GAS LINES ARE NOT SHOWN.

C:\CADD\04428\GI059429

Wehran EnviroTech Wehran–New York, Inc.	Drawn By : Checked By : Date :	Scale APPROXIMATELY 1"= 238'		GENERAL MOTORS CORP. SAGINAW DIVISION WORK PLAN CITY OF BUFFALO ERIE COUNTY NEW YORK	FACILITY PLAN AND SEWER LOCATION PLAN
					Figure : 2 Project No : 04428



LEGEND:

SB-108 — EXISTING SOIL TEST BORING LOCATION INSTALLED BY HALEY & ALDRICH INC. IN THE SPRING OF 1994

MW-103 — EXISTING MONITORING WELL LOCATION (100 SERIES INSTALLED BY HALEY & ALDRICH INC. IN THE SPRING OF 1994)

SURFACE SAMPLING LOCATION

NOTE:

1. THIS MAP WAS DIGITIZED FROM A BASE MAP PROVIDED BY GENERAL MOTORS CORP., SAGINAW BUFFALO PLANT AND IS APPROXIMATE.
2. THE MONITORING WELLS, TEST BORINGS AND SURFACE SAMPLING LOCATION SHOWN ON THIS PLAN ARE FROM A MAP BY HALEY & ALDRICH INC. TITLED PROPOSED PHASE II EXPLORATION PLAN. THE EXPLORATION WAS PERFORMED IN SPRING OF 1994 AND THE ACTUAL LOCATION MAY VARY.

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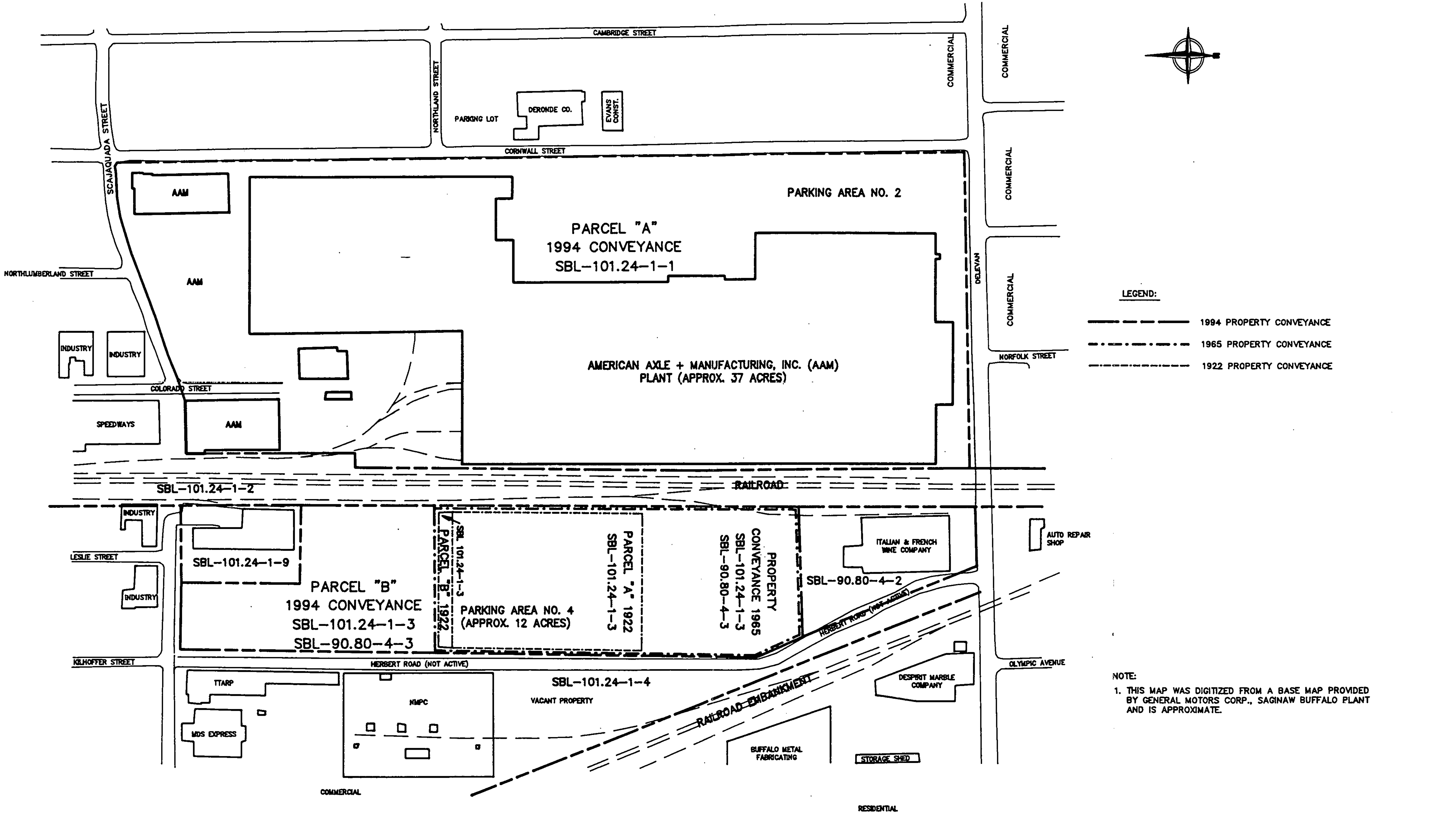
Wehran EnviroTech Wehran–New York, Inc.	Drawn By : Checked By : Date :	Scale APPROXIMATELY 1"= 238'		GENERAL MOTORS CORP. SAGINAW DIVISION WORK PLAN CITY OF BUFFALO ERIE COUNTY NEW YORK	EXISTING SAMPLING LOCATIONS	Figure : 3 Project No : 04428



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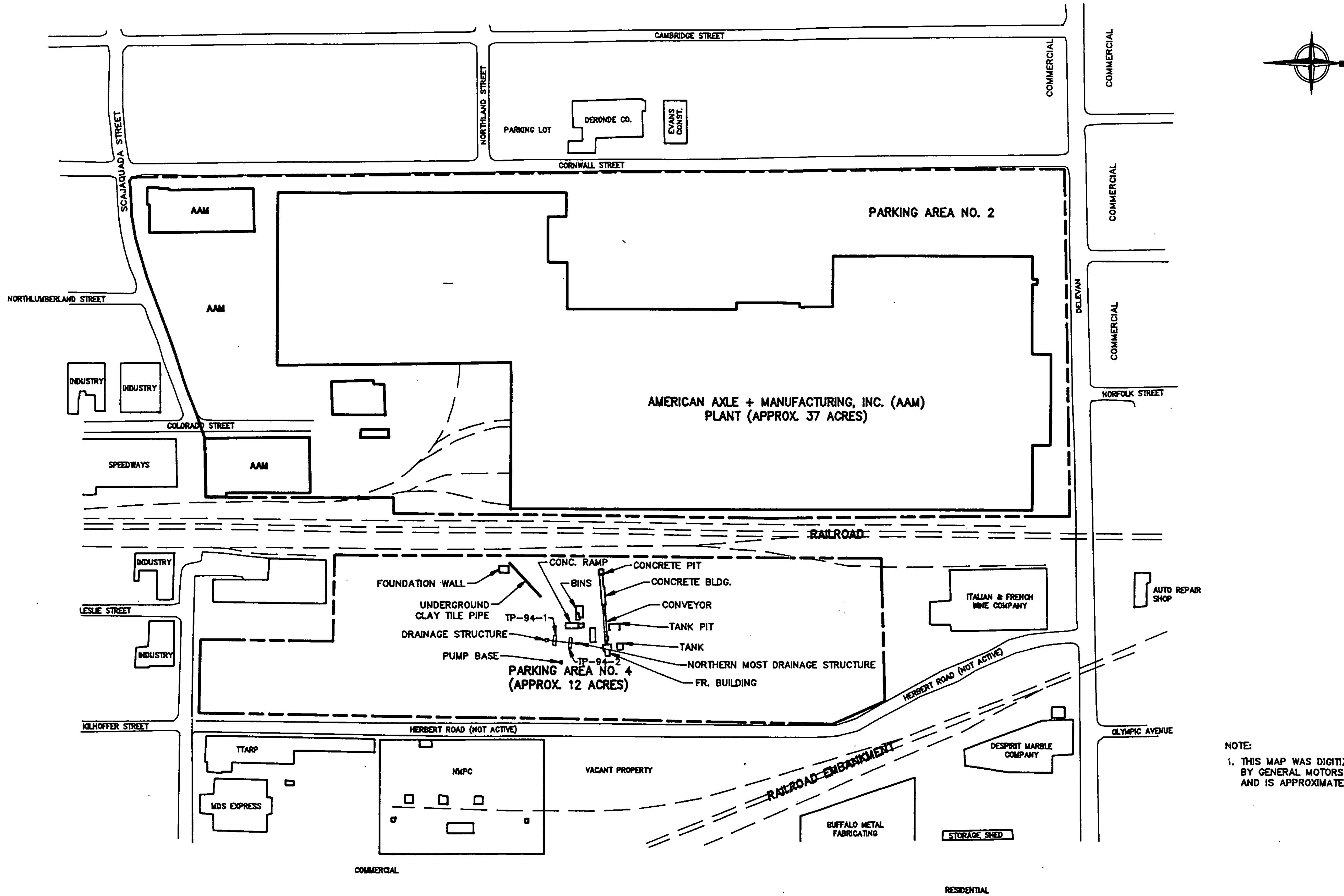
Wehran EnviroTech Wehran–New York, Inc.	Drawn By : Checked By : Date :	Scale APPROXIMATELY 1"= 238'		GENERAL MOTORS CORP. SAGINAW DIVISION WORK PLAN CITY OF BUFFALO ERIE COUNTY NEW YORK	SUMMARY OF PROPERTY PARCELS	Figure : 4 Project No : 04428



NOTE:

1. THIS MAP WAS DIGITIZED FROM A BASE MAP PROVIDED BY GENERAL MOTORS CORP., SAGINAW BUFFALO PLANT AND IS APPROXIMATE.

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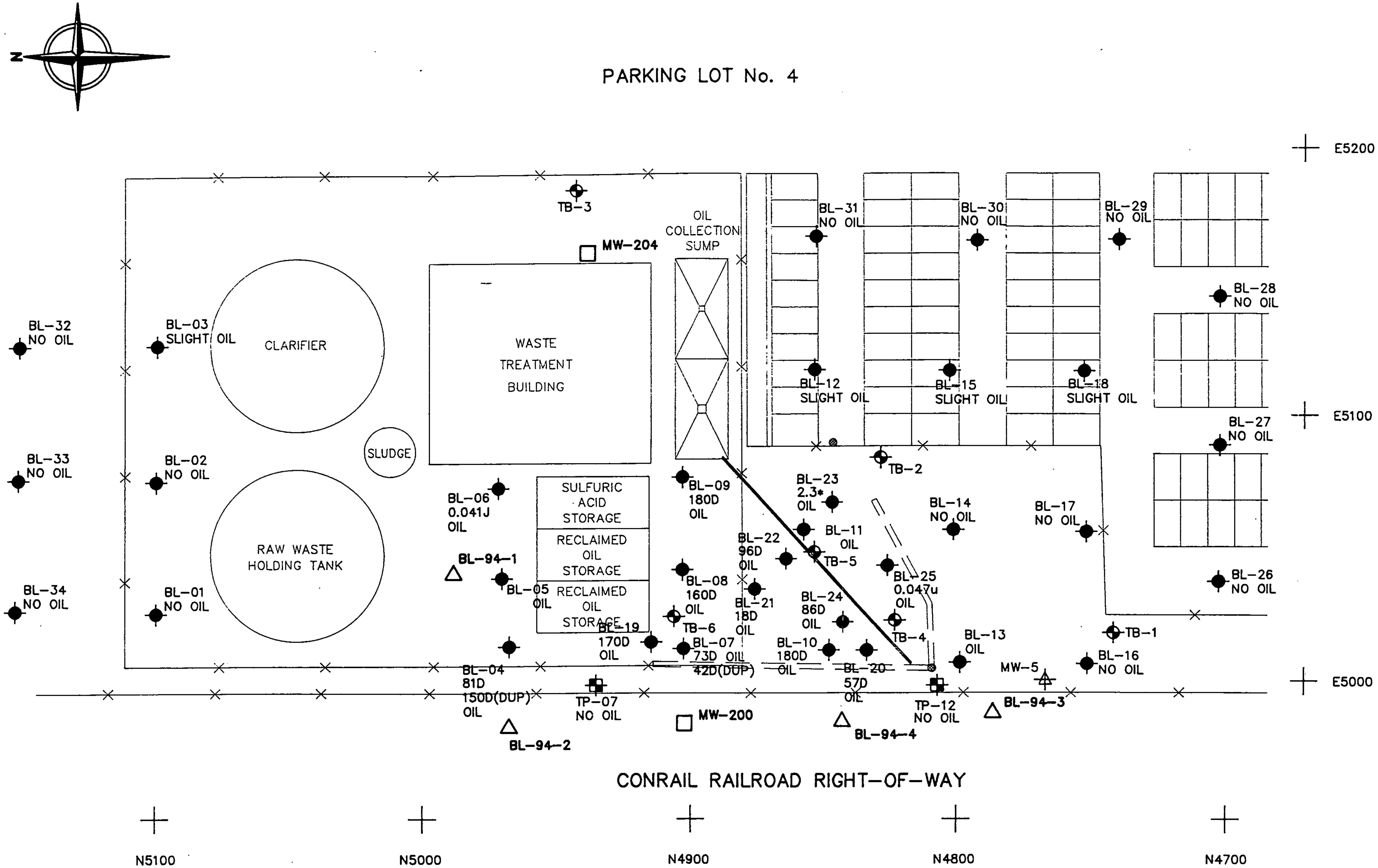
Wehran EnviroTech Wehran-New York, Inc.	Drawn By : ______ Checked By : ______ Date : ______	Scale APPROXIMATELY 1"= 238'		GENERAL MOTORS CORP. SAGINAW DIVISION WORK PLAN CITY OF BUFFALO ERIE COUNTY NEW YORK	FORMER BUFFALO GRAVEL CORPORATION FACILITY	Figure : 5 Project No : 04428



NOTES:

1. REFER TO FIGURE 2 FOR GENERAL LEGEND AND NOTES.
2. AT EACH BORING OR TEST PIT THE VISUAL EXTENT OF OIL IS INDICATED.
3. AT CERTAIN BORING LOCATIONS, TEST RESULTS OF PCBs AS AROCLOR 1248 ARE SHOWN.

   u=NOT DETECTED

   J=ESTIMATED CONCENTRATION

   * = PCB AS AROCLOR 1260.
4. THIS FIGURE IS NOT INTENDED FOR DESIGN OR CONSTRUCTION PURPOSES.

LEGEND:

BL-25 0.047u OIL	NUMBER SHOWN AT THE BOREHOLE LOCATION DEPICTS PCB TEST RESULTS IN UNITS OF MG/KG OR PARTS PER MILLION (SEE NOTE 3). ADDITIONALLY, THE OBSERVED VISUAL EXTENT OF OIL CONTAMINATION IS NOTED.
MW-200	PROPOSED MONITORING WELL LOCATION
BL-94-1	PROPOSED TEST BORING LOCATION
TB-1	PIEZOMETER INSTALLED BY EARTH DIMENSIONS, INC. BETWEEN JUNE 15 AND 16, 1989. DRILLING ACTIVITIES MONITORED BY WEHRAN-NEW YORK, INC.
MW-5	MONITORING WELL INSTALLED BY EARTH DIMENSIONS, INC. IN 1989. DRILLING ACTIVITIES MONITORED BY WEHRAN-NEW YORK, INC.

40 0 40

SCALE IN FEET

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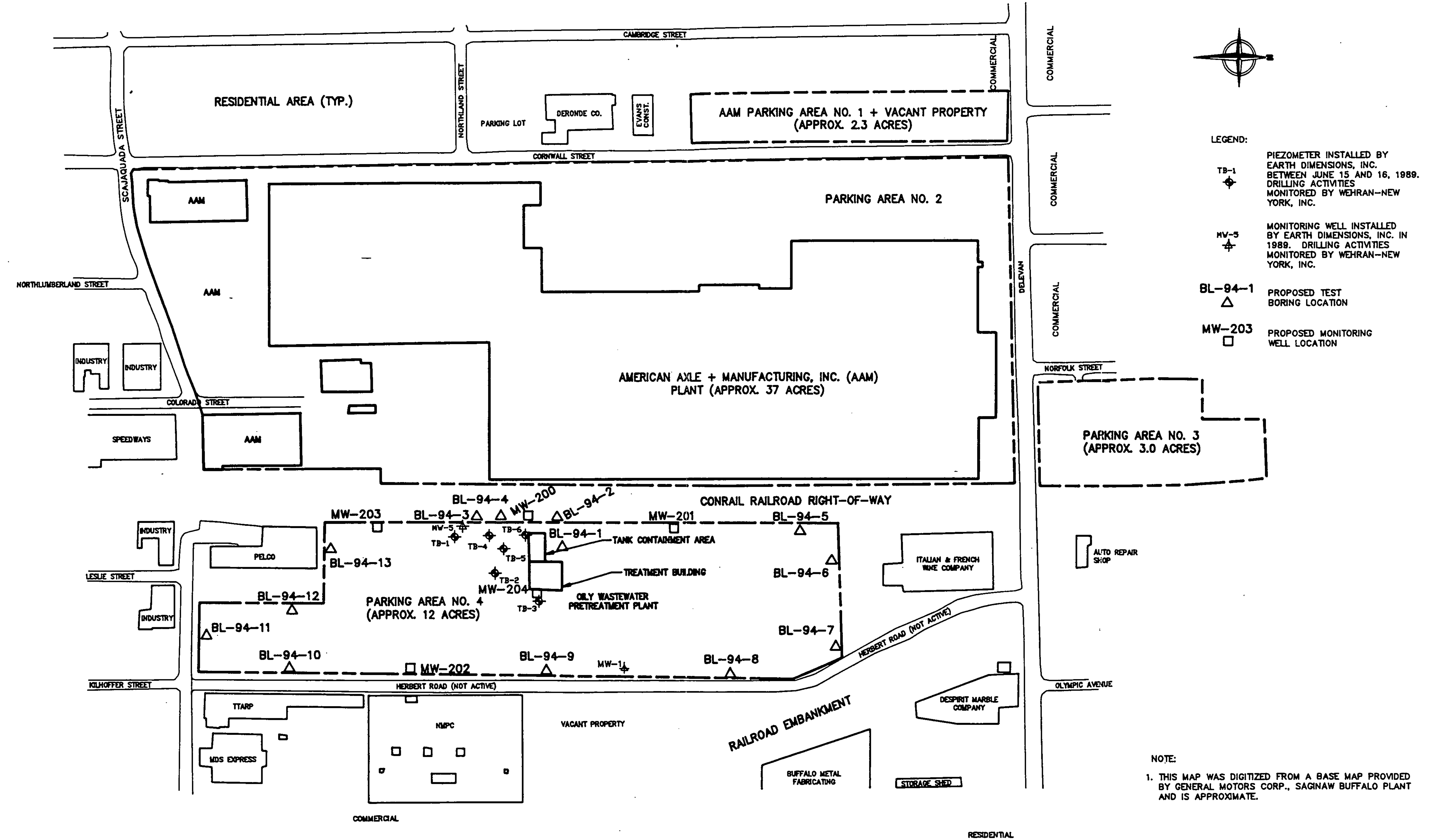
Wehran EnviroTech Wehran-New York, Inc.	Drawn By : ______ Checked By : ______ Date : ______	Scale AS NOTED		GENERAL MOTORS CORP. SAGINAW DIVISION WORK PLAN CITY OF BUFFALO ERIE COUNTY NEW YORK	PROPOSED PCB EXPLORATION PLAN	Figure : 6 Project No : 04428



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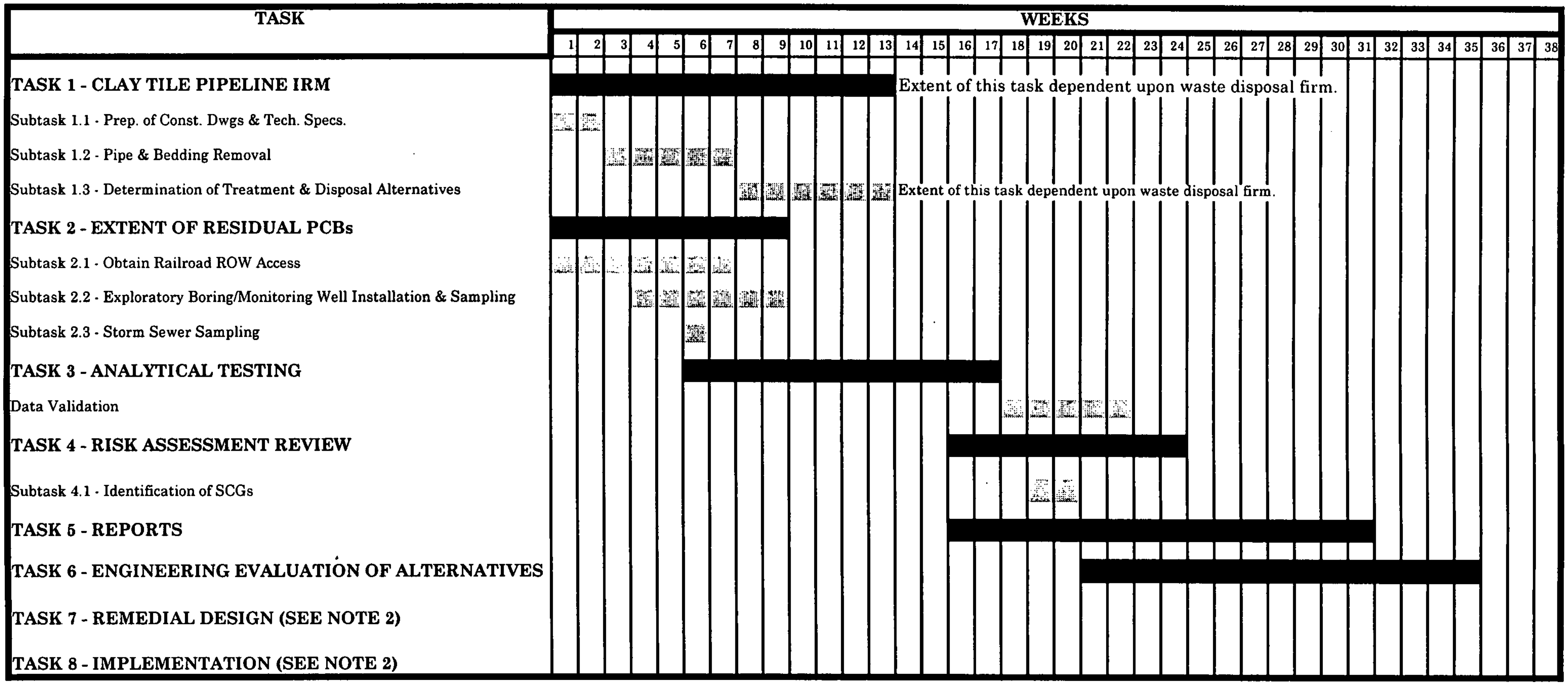
Wehran EnviroTech Wehran-New York, Inc.	Drawn By : ______ Checked By : ______ Date : ______	Scale APPROXIMATELY 1"= 238'		GENERAL MOTORS CORP. SAGINAW DIVISION WORK PLAN CITY OF BUFFALO ERIE COUNTY NEW YORK	POTENTIAL LEAD EXPLORATION PLAN	Figure : 7 Project No : 04428

FIGURE 8
GENERAL MOTORS CORPORATION, SAGINAW DIVISION
WORK PLAN SCHEDULE FOR OPERABLE UNIT NUMBER 1



NOTES:
1) The draft report submittal date is for the draft site investigation and engineering reports.
   Upon receipt of the draft report comments from the NYSDEC, the final report will be submitted within 45 days.
2) Tasks 7 & 8 are not scheduled at this time. A schedule for this work will be submitted along with the Recommendations in the Engineering Evaluation of Alternatives Report.

FIGURE 9
GENERAL MOTORS CORPORATION, SAGINAW DIVISION
WORK PLAN SCHEDULE FOR OPERABLE UNIT NUMBER 2

TASK	WEEKS																																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
TASK 1 - HISTORICAL DATA REVIEW	X	X	X	X	X					X	X																										
NYSDEC Review						X	X	X	X																												
TASK 2 - EXTENT OF CONTAMINATION												X	X	X	X	Estimated duration, actual based on level of effort as defined by Task 1																					
Subtask 2.1 - Analytical Testing																X	X	X	X	X	X	X															
Data Validation																							X	X	X	X											
TASK 3 - BASELINE RISK ASSESSMENT																			X	X	X	X	X	X	X	X	X	X									
Subtask 3.1 - Identification of SCGs																				X	X																
TASK 4 - TREATABILITY STUDY (SEE NOTE 1)																																					
TASK 5 - REPORTS																				X	X	X	X	X	X	X	X	X	X	X	X						
TASK 6 - ENGINEERING EVALUATION OF ALTERNATIVES																												X	X	X	X	X	X	X	X		

NOTES:
1) Treatability schedule is to be determined. This schedule may be affected accordingly.
2) The draft report submittal date is for the draft site investigation and engineering reports.
Upon receipt of the draft report comments from the NYSDEC, the final report will be submitted within 45 days.

APPENDIX

APPENDIX

APPENDIX A-1

QUALITY ASSURANCE PROJECT PLAN

QUALITY ASSURANCE PROJECT PLAN

Prepared for

GENERAL MOTORS CORPORATION
485 Milwaukee Avenue
Detroit, Michigan 48202

and

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3900 Holland Road
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WE Project No. 04428.LS

June 1994

GENERAL MOTORS - SAGINAW
QUALITY ASSURANCE PROJECT PLAN
TABLE OF CONTENTS

1.0 INTRODUCTION

This Quality Assurance Project Plan (QAPP) describes the quality assurance/quality control (QA/QC) measures that will be taken during the collection and analysis of multi-media samples as outlined in the work plan. Procedures for field and laboratory QA/QC and analysis; data reduction, validation, and reporting; and sample control and chain-of-custody are outlined in this plan.

Quality assurance objectives are delineated in Section 2.0 and sampling procedures are discussed in Section 3.0. Activities planned that will acquire information requiring quality controlled generation of analytical data include:

- Subsurface soil sampling and characterization;
- Groundwater sampling and characterization;
- Surface soil sampling and characterization; and
- Data review, validation, and management.

Soil and aqueous samples will be analyzed for polychlorinated biphenyls (PCBs) and total lead. Analytical protocol is outlined in Section 5.0 of this report.

2.0 QUALITY ASSURANCE OBJECTIVES

The primary objective of the QA program for this project is to 1) maintain the evidentiary value of the information produced and 2) insure that field investigations, laboratory analysis, and reports are carried out in accordance with approved protocols. The QA Officer for the project, Kenneth C. Malinowski, Ph.D., is responsible for reviewing data to ensure compliance with protocols and that data is complete, representative, compliant usable and comparable. The quality of data generated by sampling, monitoring or analysis is defined in terms of the following:

Precision and Accuracy

The objectives for precision and accuracy are indicated in Section 10.0. Results of field and laboratory quality control samples are evaluated against approved criteria which measures the precision and accuracy of a given measurement system.

Duplicate analyses are conducted at a minimum rate of ten percent for batch analyses of ten or more samples or at least one sample per every batch if batches are less than ten. Statistics are calculated for determinations of analytical precision as described in Section 10.0.

Accuracy is monitored by the analyses of accepted reference samples (either reference control samples, spiked control samples or surrogate spikes). The use of reference samples is fully described in Section 10.0.

Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared with the amount that was expected to be obtained under correct normal conditions. Naturally, the amount of valid data obtained for this study is expected to be virtually complete, based on the use of published sampling and analytical methods. When comparing the amount of valid data obtained to that of a correct, normal condition, deviations may arise that are a result of the sample matrix. For instance, organic analysis requires an extraction and the proposed method may not fully recover the analyates of interest from the matrix. Dilutions may be necessary to reduce the effect of non-target species which extract with the target ones. These dilutions will raise detection limits above those for correct normal conditions. If this in fact occurs, the QA Officer will review the body of data to provide assurance that the data is adequate for the intended use.

Representativeness

Representativeness expresses the degree to which data accurately and precisely represents a characteristic or environmental condition. By way of the approved work plan, the frequency and location of sampling locations and method of sample acquisition have been designed such that data obtained will be considered representative of site conditions.

Comparability

Comparability expresses the confidence with which one data set can be compared to another. The use of published sampling and analytical methods, standard reporting units, and a program executed in accordance with this QAPP will aid in ensuring this comparability.

3.0 SAMPLE CONTROL PROCEDURES/CHAIN-OF-CUSTODY

Sample control consists of maintaining sample integrity, providing adequate documentation of all sampling procedures, avoiding sample cross-contamination, and ensuring proper sample custody. Sample control and chain-of-custody procedures are described in the following sections.

3.1 MAINTENANCE OF SAMPLE INTEGRITY

All sample containers will be pre-cleaned by the analytical laboratory according to the procedures specified in the USEPA's "Specifications Guidance for Obtaining Contaminant-Free Sample Containers" (April, 1990) or certified clean by the manufacturer providing sample containers. The laboratory will provide manufacturer's certificates attesting to same.

3.2 FIELD DATA AND INFORMATION ACQUISITION

The sampler's field records will contain sufficient information such that someone can reconstruct the sampling situation without reliance on the collector's memory. Entries in the field records will include the following:

- Name and address of project;
- Name of sampler;
- Name of others present;
- Location of sampling and address;
- Date and time of collection;
- Type of sample;
- Description of sampling point;
- Quantity of sample collected;
- Parameters requested for analysis;
- Type of sample container used;
- Preservative(s) used;
- Filtering;
- Sample collection procedure and equipment;

- Well evacuation procedure and equipment;
- Sample layering;
- Well specifics such as static water level, depth, and volume purged;
- Sample identification number(s);
- Field observations;
- Pertinent weather factors such as temperature, wind direction, and precipitation; and
- Any field measurements made such as pH, etc.

3.3 EQUIPMENT DECONTAMINATION/PREPARATION

All sampling equipment that comes in direct contact with samples will be cleaned prior to use and in the field between sample locations to prevent possible sample contamination and cross-contamination. Decontamination and cleaning will be performed using the procedure outlined below:

- Alconox detergent and potable water scrub;
- Potable water rinse;
- Methanol rinse;
- Ten percent nitric acid rinse;
- Deionized water rinse;
- Air dry; and
- Wrap in aluminum foil or store in sealed polyethylene bags.

Large equipment used during field activities will be decontaminated at an on-site decontamination pad with high pressure hot water or steam. All wash water from decontamination activities will be collected and disposed of in accordance with State and Federal regulations.

3.4 SAMPLE CUSTODY

Chain-of-custody records for all samples, beginning with the cleaning and numbering of the sample containers at the laboratory, shall be maintained. A written record of container decontamination procedures shall be kept as well as the source of such containers.

A sample shall be considered to be "in the custody" of an individual if said sample is either in direct view of, or otherwise directly controlled by, the individual in custody. Storage of samples during custody shall be accomplished according to established preservation techniques in appropriately sealed and numbered storage containers. Chain-of-custody shall be accomplished by the exchange of the samples or sealed sample shuttle (e.g., shipping cooler) being directly transferred from one individual to the next with the transferrer witnessing the signature of the recipient upon the chain-of-custody record.

The chain-of-custody records will contain the following information:

- Sample number;
- Signature of collector;
- Date and time of collection;
- Sample type (e.g., groundwater or soil);
- Identification of well or sampling point;
- Number of containers;
- Parameters requested for analysis;
- Signature of person(s) involved in the chain of possession;
- Description of sample bottles and their condition; and
- Problems associated with sample collection (i.e., breakage, no preservatives).

The laboratory chain-of-custody procedures, at a minimum, will include the following:

- Designate a sample custodian/chain-of-custody officer;
- Have set and detailed written procedures for sample tracking through the lab from the time of receipt to final disposition of the sample; and
- Have set procedures to ensure sample holding times are not exceeded.

All sample containers will be labeled with the sample identification number, the preservative (if any), and the parameter(s) requested for analysis. Labels will be affixed to sample containers prior to or at the time of sampling and should be filled out at the time of collection.

Sample seals are used to detect unauthorized tampering of samples following sample collection. The paper seal will include the following information:

- Name of sample;
- Date and time of sampling; and
- Place of collection.

The seal will be attached in such a way that it is necessary to break it in order to open the sample shipping cooler. These seals will be affixed to the sample shipping containers before the samples leave the custody of the sampling personnel.

4.0 CALIBRATION PROCEDURES AND FREQUENCY

There are two areas where calibration procedures and frequency are important: 1) for field equipment; and 2) for laboratory analytical equipment. Each of these areas is discussed below.

Field

Field equipment such as a photoionization detector and pH/conductivity meter will require daily calibration. Equipment log forms are maintained for each piece of equipment used in the field. The forms include the following information:

- Instrument identification/serial number;
- Date and time of calibration;
- Identification of calibrant/standard used;
- Personnel performing calibration;
- Calibration results; and
- Corrective action, if necessary.

In addition, problems encountered and corrective measures taken with a piece of field equipment will be documented on the log forms.

Laboratory

All laboratory instruments will be calibrated according to the specified methodology in the NYSDEC Analytical Services Protocol (ASP) (1991), Methods for Chemical Analysis of Water and Wastes (EPA-600/4-79-020; March 1983), and Test Methods for Evaluating Solid Waste, SW-846, Third Edition (USEPA, Office of Solid Waste and Emergency Response).

5.0 ANALYTICAL PROCEDURES

All laboratory chemical analyses will be performed by a New York State Department of Health (NYSDOH) approved laboratory. Analytical procedures for soil and water matrices will follow the methodologies outlined in the NYSDEC ASP (1991), Methods for Chemical Analysis of Water and Wastes (EPA 60014-79-020; March 1983), and/or Test Methods for Evaluating Solid Waste (SW-846), Third Edition.

Table 2-1 of the work plan details the samples to be collected, the analytical protocol for each sample, and the field QC check samples. QC samples are further described in Section 7.0. Quantitation limits for this project (CRQLs) are listed below:

		CRQLs[1]		Media Target Limit[3]	
PCBs	CAS Number	Water (ug/L)	Soil/Sediment[2] (ug/Kg)	Water (ug/L)	Soil (ug/Kg)
AROCLOR-1016	12674-11-2	1.0	33	10	1000
AROCLOR-1221	11104-28-2	2.0	67	10	1000
AROCLOR-1232	11141-16-5	1.0	33	10	1000
AROCLOR-1242	53469-21-9	1.0	33	10	1000
AROCLOR-1248	12672-29-6	1.0	33	10	1000
AROCLOR-1254	11097-69-1	1.0	33	10	1000
AROCLOR-1260	11096-82-5	1.0	33	10	1000

	CRQL[1]		Media Target Limit[3]	
	Water ug/L	Soil/Sediment ug/Kg	Water (ug/L)	Soil (ug/Kg)
Lead	3.0	300	10.0	100,000.0

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

2 Quantitation Limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculate on dry weight basis, as required by the protocol, will be higher.

3 The media Target Detection Limits were selected based upon analytical results from previous on-site investigations.

6.0 DATA REDUCTION, VALIDATION AND REPORTING

This section addresses the requirements for data reduction, validation and reporting for each major measurement parameter. There are two separate areas where data reduction, validation and reporting apply. These areas are in the field investigation and in the analytical laboratory. Each is discussed separately below.

6.1 FIELD PROCEDURES

6.1.1 Field Recordkeeping

Field measurements (whether analytical or other) will be recorded in the field team member's logbook. This book will have consecutively numbered pages, will be written only in ink, and will be signed at the bottom of each page. The data recorded in the logbook will be spot-checked frequently by the site manager/project manager to ensure that proper procedures for sampling, analysis, and measuring (detailed in other sections of the QAPP) are being followed.

6.1.2 Field Measurements

Field measurements will include measuring pH, specific conductivity, the presence of organic vapors with an HNu, and screening for PCBs using an immunoassay field test kit (Envirogard PCB Test Kit or similar). The field procedures for pH, specific conductivity, HNu use, and PCBs is provided in Appendix A. Specific QA/QC procedures for this method are provided in the respective SOPs.

6.2 LABORATORY PROCEDURES AND REPORTING

The appropriate data and reporting forms outlined below for the sample analyses will be reviewed. Once the entire data package has been reviewed, a narrative report and deliverables summary will be prepared describing data reduction and reporting procedures.

Target Compound – PCBs

- Chain-of-custody (field and laboratory);
- Holding times;
- Instrument performance;

- Calibration - initial and continuing;
- Blanks;
- Surrogate recovery;
- Matrix spike/matrix spike duplicate;
- Full ASP deliverables;
- Field duplicate; and
- Compound identification/quantification.

Target Compound List - Lead

- Chain-of-custody (field and laboratory);
- Holding times;
- Calibration - initial and continuing;
- Blanks;
- Laboratory control sample;
- Laboratory duplicate sample;
- Sample spiking information;
- Furnace atomic absorption standard addition data;
- ICP interference check;
- Field duplicates;
- Full ASP deliverables;
- Quantitation sheets; and
- Blank sample results.

6.3 DATA VALIDATION

Data will be validated for format and content following the guidelines presented in USEPA's Laboratory Data Validation, Functional Guidelines for Evaluating Inorganic (June 13, 1988) and Organic (February 1, 1988) Analyses. The actual validation will be conducted by an independent laboratory under the oversight of the project QA Officer.

Data will be ranked by the independent validator in one of four categories as follows:

- **Acceptable** - Data is within established control limits, or the data which is outside established control limits does not affect the validity of the analytical results.
- **Acceptable with Exceptions** - Data is not completely within established control limits. The deficiencies are identified and specific data is still valid, given certain qualifications.
- **Questionable** - Data is not within established control limits. The deficiencies bring the validity of the entire data set into question. However, the data validity is neither proved nor disproved by the available information.
- **Unacceptable** - Data is not within established control limits. The deficiencies imply the results are not meaningful.

7.0 INTERNAL QUALITY CONTROL CHECKS

There are two segments to internal QC checks; those initiated in the field and those initiated in the laboratory. The internal QC checks performed by the laboratory will follow the NYSDEC ASP for all CLP-related analyses (1991). Field QC checks will consist of the collection of the following samples:

- **Field Blanks** are collected to check the effectiveness of decontamination procedures for sampling equipment. Following a sampling event, sampling equipment will be decontaminated. Deionized water then will be passed through the sampler into the designated container. The field blank should be transported to the laboratory and analyzed for the appropriate parameters with the other samples. At a minimum, one field blank should be collected for each sampling event or for each different type of sampling equipment used.
- **Trip Blanks** are used to check for contaminant introduction due to: (1) interaction between the sample and the container, or (2) a handling procedure which alters the sample analysis results. A trip blank is created by filling a designated sample container with deionized water in the laboratory. The trip blank should be transported to the sampling location and returned to the laboratory in a manner identical to the handling procedures used for all the samples. These blanks should be subjected to the same analyses. At a minimum, one trip blank per day is required.
- **Duplicates** can provide indications of the precision of the analytical system. A duplicate sample is a second sample collected at the exact same location and depth and time as the original sample. A duplicate sample serves to check accuracy and reliability of laboratory instruments and procedures, and field activities. Duplicates should be collected for each matrix at a frequency of ten percent.

8.0 PERFORMANCE AND SYSTEM AUDITS

Field audits from NYSDEC when required will be allowed. A review of field notes and discussions with field team members will verify that field activities were performed according to the work plan and QAPP. The field team leader will provide documentation of all work performed in the form of narrative and checklist tasks.

The laboratory QA/QC director or laboratory project manager will observe work being performed during the time that samples from this project are being processed and analyzed. The laboratory QA/QC director will certify in a short narrative report, and by means of signature approval on any QC reports, that the appropriate work has been performed.

The laboratory chosen for this project will be a NYSDOH approved laboratory for environmental analyses. The laboratory QAPP will be provided once the final laboratory selection is made.

The field sampling team will be required to document all field activities in a bound log book. The QA Officer will review the field book to ensure the following information has been recorded:

Groundwater Well Evacuation/Sampling

- Date and time;
- Type of purging equipment used;
- Type of sampling equipment;
- Total depth of the well;
- Volume of water purged;
- Well or sampling point identification number;
- Water level prior to evacuating and prior to sampling for each well;
- Appearance of water and change, if any;
- Odor of water, if any;
- Amount of water removed;
- Presence of more than one phase;
- Time of sampling; and
- Field measurement results: pH, conductance.

Soil Sample Collection

- Date and time;
- Sampling point identification number/sample number;
- Sample depth and surface area;
- Soil description/characteristics; and
- Collection device.

General

- Duplicate sample locations;
- Location of equipment blanks;
- Number of trip blanks; and
- Equipment decontamination procedures.

The contractor will ensure that the laboratory is informed of any unusual sample characteristics.

9.0 PREVENTIVE MAINTENANCE

Preventive maintenance is primarily a function performed by the laboratory on their analytical equipment to ensure accurate results and to minimize equipment breakdowns/failure. While this is the case, there are a number of items used in field investigations for which preventive maintenance is an important consideration. Specific considerations for laboratory and field equipment are discussed below.

9.1 FIELD EQUIPMENT

Field monitoring equipment (e.g., photoionization detector, pH/conductivity meter) will be checked and maintained according to the standard maintenance schedule. These instruments are normally under contract to be checked/overhauled once annually or whenever problems arise. Batteries for all the equipment should be charged to full capacity prior to use.

A log which documents problems experienced with the instruments, corrective measures taken, battery replacement dates, and when used and by whom for each field instrument will be maintained. Appropriate new batteries will be purchased and kept with the meters to facilitate immediate replacement, when necessary, in the field.

All equipment to be utilized during the field sampling will be examined to certify that it is in operating condition. This includes checking the manufacturer's operating manuals and the instructions with each instrument to ensure that all maintenance items are being observed. Field notes from previous equipment usage and the maintenance log will be reviewed so that any prior equipment problems are not overlooked and all necessary repairs to equipment have been carried out.

In the field, each field instrument will be visually inspected prior to field activities to detect any damages or operational problems. Instrument responses will be checked against known standards prior to beginning field work. The instrument operation manuals will be referred to for trouble-shooting methods should equipment check-out indicate a problem. Instrumentation problems identified in the field should be relayed to the Project Manager.

9.2 LABORATORY

Laboratory equipment is monitored by means of a log book for each instrument recording any maintenance activities and schedule. Daily and weekly tasks serve to maintain instrumentation in proper working order. Validation of optimal instrument performance by acceptable calibration and tuning criteria further support satisfactory data quality. Review of these logs and communication between QA/QC personnel allow for discovery and timely correction of problems. Since most analytical laboratories have sufficient inventory of supplies and equipment, downtime is not anticipated to occur.

10.0 DATA MEASUREMENT ASSESSMENT PROCEDURES

Data assessment procedures are employed to ascertain how reliably the concentration reported by the laboratory reflects the actual concentration of a given analyte in the sampled media. Precision and accuracy are two characteristics of data which can be examined to determine the reliability of results.

Precision is a measure of the mutual agreement among individual measurements of the same property. Reference control samples and analytical replicate control samples are used to determine that the results from an analytical batch of samples are within a known range of precision. The acceptance limits for the reference control samples reflect the precision under conditions with no matrix interferences. The acceptance limits for the analytical replicate control samples reflect the precision that can be obtained. Precision is expressed as either relative percent difference (% RPD) or relative standard deviation (% RSD).

Accuracy is the degree of agreement of a measurement with an accepted reference or true value. Reference control samples, spiked control samples, and surrogate spikes are used to determine that the results from an analytical batch of samples are within a known range of accuracy. The means of the reference control samples reflect the accuracy under conditions with no matrix interferences. The mean recoveries for the spiked control samples and surrogate spikes reflect the accuracy that can be obtained where there may be matrix interferences. Accuracy is expressed as percent recovery.

11.0 CORRECTIVE ACTION

Corrective action is required when field and laboratory generated data are not within the predetermined limits for data acceptability. In most field related instances, data acceptability is determined by, and referenced to, manufacturer specifications during calibration. Once calibrated and operational, data generated by the field instrumentation is assumed to be representative of the field condition measured.

In the event of erratic readings which do not stabilize during the critical usage of the equipment, corrective action will be implemented to identify the problem and its source. Appropriate documentation of this action will be recorded in the field log book and project file.

The laboratory selected to perform the analytical work detailed in the work plan has set protocols for corrective actions. These protocols are the responsibility of the laboratory QA Officer.

Regardless of whether a problem arises in the laboratory or the field, all proposed corrective actions must be approved by the Project Manager prior to their implementation (unless the problem contains the elements of an emergency).

12.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

12.1 LABORATORY

The QA Officer of the laboratory provides periodic assessments of measurement data accuracy and precision to the Laboratory Director, who distributes them to appropriate laboratory staff. Results of the performance audits and system audits are received by the Laboratory Director and also passed on to the lab staff. Other significant QA problems which may be detected throughout the review process of the analytical data are brought to the attention of the Laboratory Director and other appropriate individuals as they arise. The Laboratory Director will immediately notify the Consultant's Project Manager/QA Officer of problems detected, if any, and a mutual solution to the problem will be developed. A written report detailing problems, solutions taken to resolve the problems and impacts on analytical data will be provided to the Consultant with the actual sample analyses data.

12.2 PROJECT REPORTS

As discussed in Section 2 of the Work Plan, periodic project progress reports will be submitted to the NYSDEC project manager. These reports will summarize scheduling progress compared to the approved overall project schedule, significant problems which may have arisen and corrective actions taken or proposed changes (if any) to the QAPP, results of periodic field activity audits completed by the QA Officer, and results of system and performance audits of the lab (at the time the audit results are available).

All applicable raw QA/QC data in support of analyses will be provided as a part of the final report.

In the final project report, a separate QA section will resummarize all data quality information (including audit reports) obtained during the investigation.

The QA section will contain:

- A data quality statement for precision;
- A data quality statement for accuracy;
- A discussion of the QA objectives that were met and not met;

- If QA objectives were not met, a discussion of the impact to the project for not having met them; and
- Changes in the QAPP.

APPENDIX A-1.1

pH is the measure of the acidity or alkalinity of a solution. It is defined as the negative logarithm of the hydrogen ion activity. Hydrogen ion activity is related to the hydrogen ion concentration, which in relatively weak solution is nearly equal. For all practical purposes, pH is the measure of the hydrogen ion concentration.

The operation of a pH meter relies on the same principal as many other ion-specific electrodes. Measurement relies on establishment of a potential difference in the response to hydrogen ion concentrations, which in combination with a reference electrode (which can be combined into a single "combination" electrode), can generate a potential difference proportional to the hydrogen ion concentration.

Variation in temperature will effect the association of hydrogen and hydroxide ions, which without proper compensation will effect the pH. pH meters have several controls to compensate for the variations between electrodes and the different responses to changes in temperature.

Because of the great variety of pH meters available, operators should refer to the manufacturer's instruction manual for specific calibration, operation, and troubleshooting procedures for their instrument. The following general procedure is used for measuring pH in the field with a pH meter:

1. The instrument and batteries should be checked and calibrated prior to the initiation of the field effort. pH electrodes should be kept moist at all times.
2. Buffer solutions used for calibration should be checked. Buffer solutions will degrade upon exposure to the atmosphere.
3. Select either 4.01 and 7.00, or 7.00 and 10.01 buffers, whichever will bracket the expected sample range. Calibration with all three buffers will allow Level II data to be generated.
4. Make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).
5. Immerse the electrode(s) in a pH-7 buffer solution.
6. Adjust the temperature compensator to the proper temperature (on models with automatic temperature adjustments, immerse the temperature probe into

the buffer solution). Alternatively, the buffer solution may be immersed in the sample and allowed to reach temperature equilibrium before equipment calibration. It is best to maintain buffer solution at or near expected sample temperature before calibration.

7. Adjust the pH meter to read 7.0.
8. Remove the electrode(s) from the buffer and rinse well with deionized water. Immerse the electrode(s) in pH-4 or -10 buffer solution (depending on the expected pH of the sample) and adjust the slope control to read the appropriate pH. At least three successive readings during calibration, one minute apart, should be within ± 0.1 pH unit. For best results, the standardization and slope adjustments should be repeated at least once daily before use and every four hours thereafter. All calibration procedures and measurements should be recorded in the logbook.
9. Immerse the electrode(s) in the unknown sample, slowly stirring the probe until the pH stabilizes. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperatures may not be stable, a chemical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. This must be clearly noted in the logbook.
10. Read and record the pH and temperature of the sample, after adjusting the temperature compensator to the sample temperature. pH should be recorded to the nearest 0.1 pH unit.
11. Rinse the electrode(s) with deionized water.

APPENDIX A-1.2

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of ionized substances dissolved in the water and the temperature at which the measurement is made. It is important to obtain a specific conductance measurement soon after taking a sample, since temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect the specific conductance.

Specific conductance can be used to identify the direction and extent of the migration of contaminants in groundwater and surface water. It can also be used to as a measure of subsurface biodegradation of to indicate alternate sources of groundwater contamination.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell may also be used as a measure of conductance. Depending on ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

Because many conductivity meters are available, operators should refer to the manufacturers instruction manual for specific calibration, operation, and troubleshooting procedures. The following procedure is used for obtaining specific conductance measurements:

1. Check batteries and calibrate instrument before going into the field.
2. Calibrate the instrument using a potassium chloride standard solution by completely immersing the electrode into the solution. Check the temperature of the calibration solution and adjust temperature dial on meter (if not self-compensating). Record calibration measurements and time in the field logbook.
3. Check the umho value of the solution in terms of the temperature. Adjust the Cell Constants dial until the display reads the appropriate value.
4. Rinse the electrode with one or more portions of the sample to be tested.

5. Immerse the electrode in the sample, adjust the temperature setting to the sample temperature, and measure the conductivity.
6. Read and record the results in the field logbook. Report the results to the nearest ten units for readings under 1,0000 umhos/cm and the nearest 100 units for readings over 1,000 umhos/cm.
7. Repeat the procedure with fresh sample until reproducible (i.e., ± 5 percent) results are obtained.

If the specific conductance measurements become erratic, or inspection shows that any platinum black has flaked off the electrode, replatinization of the electrode is necessary. See the manufacturer's instructions for details.

APPENDIX A-1.3

SOPs FOR IMMUNOASSAY FIELD SCREENING PROCEDURE

EnviroGard™ PCB Test Kit

ENVR 000 09 (with PCB calibrators)
ENVR 0NC 09 (without PCB calibrators)

Note: The following directions are specifically for use with the EnviroGard PCB Test Kit with PCB calibrators (ENVR 000 09). If you are using the EnviroGard PCB Test Kit (ENVR 0NC 09) with alternative calibrators, the directions should be modified accordingly.

Intended Use

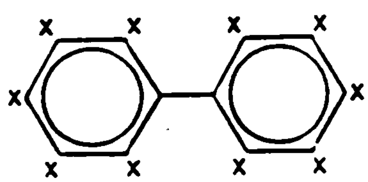
The EnviroGard PCB Test Kit is an enzyme immunoassay for the detection of a range of polychlorinated biphenyls (PCBs) in soil.

Note: This test kit is only recommended for the purpose of screening in soil.

A soil sample that generates a signal (optical density) greater than the signal of the positive assay calibrator has a 99% probability of containing *less* PCB than the concentration of PCB stated on the calibrator label. The EnviroGard PCB Test Kit can be used as a reliable and rapid screening tool to identify soils that contain less PCB than is permissible per applicable regulations.

Test Summary and Explanation

PCBs are a family of compounds with the following general structure.



where x = Hydrogen (H) or Chlorine (Cl)

There are 209 individual forms (or congeners) containing from 1 to 10 chlorine atoms on the biphenyl structure shown. PCBs were originally sold in the U.S.A. under the trade name Aroclor. Each Aroclor is composed of many congeners. Many of the congeners may be found in more than one Aroclor. Aroclors are differentiated on the basis of average chlorine content (percent chlorine by weight). For Aroclor nomenclature, the last two digits of the four digit label are used to indicate this percentage. For example, Aroclor 1248 is approximately 48% chlorine by weight.

The EnviroGard PCB Test Kit employs an antibody against PCB that is coated onto 12 mm x 75 millimeter (mm) polystyrene test tubes. The method is based on the principles of competitive immunoassay, wherein the absorbance signal (optical density) of the final reaction mixture is inversely proportional to the concentration of analyte (PCB) present in the original sample. Refer to the section, "*Specificity,*" for more information about Aroclors.

Test Principles

PCBs that are present in the soil extracts and assay calibrators will be bound during the first incubation by the anti-PCB antibodies, which have been adsorbed onto the test tubes. After the sample is decanted and the test tubes are washed thoroughly, a peroxidase-PCB conjugate is added.

Note: The amount of conjugate that will be bound (by unoccupied anti-PCB antibody binding sites in the test tube) is inversely proportional to the amount of PCB that was originally present in the sample.

After a short incubation, unbound conjugate is decanted and the test tubes are thoroughly washed again. Finally, a chromogenic peroxidase substrate and hydrogen peroxide are added to the test tubes.

Note: Color development is directly proportional to enzyme concentration and inversely proportional to PCB concentration in the original sample in the test tubes.

Visual or spectrophotometric analysis of the test tubes can be used to determine the level of PCBs in unknown samples relative to standard or assay calibrator concentrations of PCB (e.g., 50 ppm).

Precautions

- Treat PCBs, solutions containing PCBs, and potentially contaminated soil samples as hazardous materials.
- Where appropriate, use gloves, proper protective clothing, and means to contain and handle hazardous material.
- Obtain (if appropriate) permits pertaining to the handling, analysis, and transport of PCB-containing materials.
- Store all test kit components at 2°C to 8°C (36°F to 46°F) when not in use.
- Do not freeze test kit components or expose them to temperatures greater than 37°C (99°F).
- Do not use test kit components after the expiration date.
- Do not use reagents or test tubes from one test kit with reagents or test tubes from a different test kit.
- Use approved methodologies to confirm any positive results.
- Distribution of PCB in soils may be highly variable. The use of a composite sampling technique may be appropriate. Adequate sample number and distribution are the responsibility of the analyst.

Materials Provided

EnviroGard PCB Test Kit

contains:

- 20 PCB antibody-coated, 12 mm x 75 mm polystyrene test tubes
- 14 mL Assay Diluent
- 0.5 mL Negative Control (Methanol)
- 4.8 mL PCB-Enzyme Conjugate
- 4.8 mL Substrate
- 4.8 mL Chromogen
- 15 mL Stop Solution
- 20-place test tube rack
- 3 PCB positive assay calibrators:
  0.5 mL 5 ppm calibrator
  0.5 mL 10 ppm calibrator
  0.5 mL 50 ppm calibrator

Note: The PCB positive assay calibrators do not reflect the actual PCB (Aroclor) concentrations provided (see "*Calibrator Concentration*" for the actual PCB concentrations).

Materials Required and Ordered Separately

See "*Ordering Information*" for the appropriate catalogue numbers.

EnviroGard Soil Extraction Kit II

For the extraction of PCB from soil samples. Contains the following items to test 12 samples:

- 12 polypropylene bottles w/screw caps, 30 mL (each bottle should contain five stainless steel mixing beads)
- 12 filtration devices, comprised of 12 upper (filter unit) and lower (sample tube) units
- 12 polyethylene prefilter frits
- 15 wooden spatulas
- 12 screw top glass vials, 4 mL
- 15 weigh boats

Methanol

Methanol (60 mL for 12 samples) is required for soil extraction, but is not included in the EnviroGard Soil Extraction II kit and must be ordered separately (see "*Ordering Information*").

EnviroGard PCB Field Lab
Starter Accessory Kit contains:

- 1 positive displacement precision pipettor, 5 µL
- 1 Eppendorf™ Repeater® pipettor
- 1 electronic timer
- 1 polystyrene test tube, 12 mm x 75 mm, (for blanking the spectrophotometer)
- 1 portable balance with a 50 gram calibrator weight
- 1 wash bottle, 500 mL
- 2 six-position test tube racks
- 1 rack of pipette tips for the positive displacement pipettor
- 8 pipette tips for the Repeater pipettor, 5.0 mL, for dispensing volumes between 0.1 mL and 0.5 mL
- 4 pipette tips for the Repeater pipettor, 12.5 mL, for dispensing volumes between 0.25 mL and 0.625 mL
- 1 pipette tip for the Repeater pipettor, 50 mL, for dispensing volumes between 1.0 mL and 5.0 mL

Note: Replacement pipettor tips can be ordered separately (see "*Ordering Information*").

Millipore Differential Photometer
Refer to "Ordering Information."

Materials Required but Not Provided

- water for washing assay test tubes

Materials Suggested but Not Required

- protective clothing (i.e., latex gloves)
- absorbent paper for blotting test tubes
- waste and liquid containers

ASSAY PROCEDURE

Collect/Store the Sample

- Collect soil in appropriately-sized and labeled containers.
- Take care to remove excess twigs, organic matter, and rocks or pebbles from the sample (especially from the soil to be extracted).
- Soils obtained from areas adjacent to standing water, surface soils collected during or immediately after rain or snow, or any soils with relatively high amounts of water (≥ 30% by weight) should be dried overnight before testing.
- Store soil samples at 4°C (39°F) or room temperature for up to 1 month. Recommended soil stor-age for EPA method 8080 (gas chrom-atography (GC) analysis of PCBs in soil) is at 4°C (39°F).

Prepare the Sample/Extract the Soil

Refer to the EnviroGard Field Soil Extraction II product insert.

1. Use the portable balance and a weigh boat to measure out 5 grams of soil:
   - Place the balance on a level surface and press ON/MEMORY.
   - Place the weigh boat on the balance and press TARE.
   - Weigh the soil.
2. Transfer the 5 grams of soil into an appropriately labeled, 30 mL polypropylene vial. If you are testing more than one soil sample, cap the vial loosely and repeat steps 1 and 2 until all soil samples have been weighed out. Use a clean weigh boat for each sample.

3. Position the Repeater pipettor at setting 5 and use a 50 mL pipette up to pipette 5 mL of Methanol into each soil sample.

4. Cap all vials tightly and shake vigorously for approximately 2 minutes. Let the contents settle briefly.

5. Pour the liquid contents of each vial into the appropriately labeled, lower (sample tube) piece of the filter base unit. In order to obtain optimal filtering efficiency, do not let more than one or two mixing beads slip into the filter device.

   Note: When extracting clay samples, it is possible that all of the Methanol will be soaked up by the soil, leaving little or no excess liquid to decant. If this should happen, add an additional 5 mL of Methanol to the sample, cover, and shake vigorously for an additional 1 to 2 minutes. Continue on to step 6. Make sure to factor the dilution into the calculations (see "*Interpret the Results*").

6. Insert a polyethylene frit into the outside, capped filter end of each plunger unit.

   Note: It is not necessary to use the frit for a number of soil types; however, doing so improves filtration efficiency.

7. Insert the plunger into the filter base unit.

8. Push down on the plunger. After 30 to 60 seconds, push down on the plunger again.

9. For longer term or spill-safe storage, remove the cap from the plunger and carefully pour the sample extract into an appropriately labeled 4 mL glass vial. Cap the vial. Repeat this step for each of the sample extracts.

Perform the Test

Note: Allow all test kit components to come to ambient temperature before use.

1. Label the 12 mm x 75 mm test tubes (no more than 20 tubes/assay).*

Tube Label	Tube Contents
NC	Negative Control (optional control for quality control purposes)
5 ppm	5 ppm positive assay calibrator**
10 ppm	10 ppm positive assay calibrator
50 ppm	50 ppm positive assay calibrator
S1	sample 1
S2	sample 2

*It is not required to perform the assay in duplicate; however, doing so increases the precision.

**The selection of the appropriate positive assay calibrators will depend on the application and specific screening requirements.

   Place the test tubes in the test tube rack and push down on each tube so that it is held firmly and will not fall out when shaken.

   Caution: Do not "snap" the test tubes into the rack as this may result in a cracked tube.

2. Using the positive displacement pipettor, add 5 µL of Negative Control (Methanol) to the "NC" test tubes. Choose an appropriate calibrator (5 ppm, 10 ppm, or 50 ppm) and add it to the corresponding test tubes as follows:
   - 5 µL of the 5 ppm calibrator to the "5 ppm" test tubes
   - 5 µL of the 10 ppm calibrator to the "10 ppm" test tubes
   - 5 µL of the 50 ppm calibrator to the "50 ppm" test tubes
   - 5 µL of each sample extract to the appropriately labeled sample test tubes.

Caution: Replace the cap(s) on the calibrator vials immediately after use to minimize evaporation.

3. Position the Repeater pipettor at setting 2 and use the **12.5 mL** syringe to add 500 µL of Assay Diluent to all test tubes. Briefly shake the test tube rack to mix, then incubate for 5 minutes.

4. Vigorously shake out the test tube contents into a sink or suitable container. Fill the test tubes to overflowing with cool tap or distilled water, then decant and vigorously shake out the remaining water.

   Repeat this wash step three more times, being certain to shake out as much water as possible on each wash. After the final wash, remove as much water as possible by tapping the inverted tubes on absorbant paper.

5. Position the Repeater pipettor at setting 2 and use the **5 mL** syringe to add 200 µL of the PCB enzyme-conjugate to all test tubes. Briefly shake the test tube rack to mix, then incubate for 5 minutes.

6. Vigorously shake out the test tube contents into a sink or suitable container. Fill the test tubes to overflowing with cool tap or distilled water, then decant and vigorously shake out the remaining water.

   Repeat this wash step three more times, being certain to shake out as much water as possible on each wash. After the final wash, remove as much water as possible by tapping the inverted tubes on absorbant paper.

7. Position the Repeater pipettor at setting 2 and use a clean **5 mL** syringe to add 200 µL of Substrate to all test tubes. Using a clean 5 mL syringe, follow immediately with 200 µL of Chromogen to all test tubes.

   Caution: The Substrate ***must*** be added *before* the Chromogen. Do not reverse this order.

   Briefly shake the test tube rack to mix, then incubate for 5 minutes.

8. Position the Repeater pipettor at setting 2 and use a **12.5 mL** syringe to add 500 µL of Stop Solution to all test tubes.

   Warning: Stop Solution is 1.0 N sulfuric acid. Handle carefully.

9. Add 1.0 mL of Stop Solution to the blank test tube and insert the tube into the left well of the spectrophotometer. Dry the outside of each assay tube and measure the absorbance by placing each tube into the right well of the spectrophotometer. Record the absorbance of each tube.

Interpret the Results

- Samples with OD_{450} values ≥ OD_{450} of the 5 ppm positive assay calibrator contain *less* than 5 ppm PCB.
- Samples with OD_{450} values ≤ OD_{450} of the 5 ppm positive assay calibrator *may* contain *more* than 5 ppm PCB.
- Samples with OD_{450} values ≥ OD_{450} of the 10 ppm positive assay calibrator contain *less* than 10 ppm PCB.
- Samples with OD_{450} values ≤ OD_{450} of the 10 ppm positive assay calibrator *may* contain *more* than 10 ppm PCB.
- Samples with OD_{450} values ≥ OD_{450} of the 50 ppm positive assay calibrator contain *less* than 50 ppm PCB.
- Samples with OD_{450} values ≤ OD_{450} of the 50 ppm positive assay calibrator *may* contain *more* than 50 ppm PCB.

Soil samples that were extracted with more than 1.0 mL of Methanol per gram of soil (e.g., for clay samples), require a correction factor in order to interpret the results. Multiply each of the calibrator concentrations by the ratio of Methanol (mL) to soil (grams).

Example
If 10 mL of Methanol is used to extract 5 grams of soil, then the ratio of Methanol to soil would be "2" (10/5). The calibrator levels to be used for this soil would change to 10 ppm, 20 ppm, and 100 ppm (2 x 5 ppm, 10 ppm, and 50 ppm).

For Aroclors 1242, 1016, 1248, and 1254, the confidence interval for negative samples (i.e., ≤ 5 ppm, ≤ 10 ppm, and ≤ 50 ppm) exceeds 99%. For Aroclor 1260, and for PCBs that have a lower chlorine content than Aroclor 1242, the confi-dence interval is smaller.

In order to maximize the accuracy of the EnviroGard PCB Test when measuring Aroclor 1221, 1232, or 1260, it is recom-mended that Aroclor-specific calibrators (corresponding to the Aroclor present in the soil samples) should be substituted for the Aroclor 1248 calibrators that are normally used (for more information, refer to the section, *"Technical Assis-tance"* for the number of the Millipore office nearest you).

Performance Characteristics

Sensitivity

The primary purpose of the EnviroGard PCB Test is to screen out soil samples that have PCB concentrations below certain mandated action levels (i.e., 5 ppm, 10 ppm, or 50 ppm). Sensitivity is sufficient to perform the test at the three calibrator levels with 99% confidence.

The minimum reliable detection limit for the EnviroGard PCB Test Kit is 3.3 ppm. This is the lowest concentration of PCB in soil that can be differentiated 99% of the time from zero.

The sensitivity of the assay also depends on the specific Aroclor being measured (see *"Specificity"*).

Specificity
The PCB antibody in this kit will bind to different Aroclors with different affinities. The test specificity is restricted to PCBs. The test response to Aroclors 1016, 1242, 1254, and 1260 is within twofold of the response for Aroclor 1248.

Interfering Substances
The following substances were tested and found to have less than 0.5% (w/w) of the immunoreactivity of Aroclor 1248.

1,2-dichlorobenzene	2,5-dichlorophenol
1,3-dichlorobenzene	2,4,5-trichlorophenol
1,4-dichlorobenzene	2,4,6-trichlorophenol
1,2,4-trichlorobenzene	biphenyl
2,4-dichlorophenol	pentachlorophenol (PCP)

Limitations of the Procedure
The EnviroGard PCB Test Kit is a screening test *only*. Actual quantitation of PCBs by EnviroGard immunoassay is only possible if the contaminating Aroclor is known, and if the assay is standardized using the corresponding PCB mixture.

Soil sampling error may significantly affect testing reliability. The distribution of PCBs in different soils can be extremely heterogeneous. Soils should be dried and then homogenized thoroughly before analysis by any method. Split samples (i.e., for GC and immunoassay) should always come from the same homogenate.

Every effort should be made to perform the EnviroGard PCB Test at temperatures between 15°C (59°F) and 30°C (86°F).

Expected Values for PCB-Contaminated Soils

Contaminated soils will have PCB levels that correlate well (correlation coefficient (r) ~ 0.9) with GC values. The slope of the correlation will depend on the contaminating Aroclor. Aroclor 1248-contaminated samples have a slope close to "1" because the EnviroGard PCB Test Kit is standardized using Aroclor 1248.

Calibrator Concentrations

Positive Assay Calibrator	Actual Aroclor Conc. (ppm)
0.5 mL 5 ppm calibrator	3.0 ppm Aroclor 1248
0.5 mL 10 ppm calibrator	5.0 ppm Aroclor 1248
0.5 mL 50 ppm calibrator	22.0 ppm Aroclor 1248

Storage

- Store all test kit components at 2°C to 8°C (36°F to 46°F) when not in use.
- Do not expose test kit components to temperatures greater than 37°C (99°F). Prolonged exposure (many days) or repeated exposure to ambient temperatures may result in a loss of reagent (especially the conjugate) activity.
- Do not freeze test kit components. This will likely result in a significant decrease in enzyme conjugate activity.
- Do not use test kit components after the expiration date. The expiration date is located on the product label.

Quality Control

If a blue color does not develop in the negative control test tube within 5 minutes after adding the Substrate and Chromogen, the test is invalid and must be repeated.

References

All data related to the EnviroGard PCB Test Kit is on file at Millipore Corporation. Refer to the section, *"Technical Assistance,"* for the phone number of the nearest Millipore office.

TECHNICAL INFORMATION

Ordering Information

Description	Catalogue No.
EnviroGard PCB Test Kit includes:	ENVR 000 09

- 20 PCB antibody-coated, 12 mm x 75 mm polystyrene test tubes
- 14 mL Assay Diluent
- 0.5 mL Negative Control (Methanol)
- 0.5 mL 5 ppm calibrator
- 0.5 mL 10 ppm calibrator
- 0.5 mL 50 ppm calibrator
- 4.8 mL PCB-Peroxidase conjugate
- 4.8 mL peroxide solution (Substrate)
- 4.8 mL TMB solution (Chromogen)
- 15 mL Stop Solution (1.0 N sulfuric acid)
- 20-place test tube rack

Description	Catalogue No.
EnviroGard Field Soil Extraction Kit II includes the following items to test 12 samples:	ENSP 000 20

- 12 polypropylene bottles w/screw caps, 30 mL, each containing 5 stainless steel mixing beads
- 12 filtration devices, comprised of 12 upper (filter unit) and lower (sample tube) units
- 12 polyethylene prefilter frits
- 15 wooden spatulas
- 12 screw top glass vials, 4 mL
- 15 weigh boats

EnviroGard PCB in Soil Test Kit — ENVR 000 10
shipping kit, which includes:

- EnviroGard PCB Test Kit (ENVR 000 09)
- EnviroGard Field Soil Extraction Kit II (ENSP 000 20)
- Methanol, 100 mL (ELCR 000 07)

Methanol for soil extraction, 100 mL bottle — ELCR 000 07

EnviroGard PCB Field Lab — ENVR L00 09
Starter Accessory Kit, for use with the EnviroGard PCB in Soil Test Kit, which includes:

- 1 positive displacement precision pipettor, 5 µL
- 1 Repeater pipettor
- 1 electronic timer
- 1 polystyrene test tube, 12 mm x 75 mm (for blanking the spectrophotometer)
- 1 portable balance with a 50 gram calibrator weight
- 1 wash bottle, 500 mL
- 2 test tube racks, six-position
- 1 rack of pipette tips for the positive displacement pipettor
- 8 pipette tips for the repeat pipettor, 5.0 mL, for dispensing volumes between 0.1 mL and 0.5 mL
- 4 pipette tips for the repeat pipettor, 12.5 mL, for dispensing volumes between 0.25 mL and 0.625 mL
- 1 pipette tip for the repeat pipettor, 50 mL, for dispensing volumes between 1.0 mL and 5.0 mL

Millipore Differential Photometer

115 V	ENVR 000 00
230 V	ENVR 002 30

Description	Catalogue No.
EnviroGard Replacement Pipettor Tips (available separately):	
• Positive displacement pipettor tips, 1 rack of 96	ENVR L04 09
• Repeater pipettor tips, 5.0 mL, 100/pk	ENVR L01 09
• Repeater pipettor tips, 12.5 mL, 100/pk	ENVR L02 09
• Repeater pipettor tips, 50 mL, 10/pk	ENVR L03 09
EnviroGard PCB Test Kit (without PCB calibrators)	ENVR 0NC 09

Technical Assistance

For additional information about Millipore products, telephone toll-free (including Massachusetts): 800-225-1380.
In Western States, Alaska
& Hawaii: 800-632-2708
In Canada: 800-268-4881
In Toronto: 416-678-2161
In Puerto Rico: 809-747-8444

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Tel. (03) 3474-9111

Korea
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Mexico
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The Netherlands
Tel. (01608) 22000

Norway
Tel. (02) 67-82-53

Puerto Rico
Tel. (809) 747-8444

Singapore
Tel. (65) 253-2733

Spain
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Barcelona: 93-325-96-16
Sevilla: 95-425-68-77

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General Limited Warranty

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P31807, Rev. A, 6/92

EnviroGard™ Field Soil Extraction Kit II

ENSP 000 20

For use with the EnviroGard PCB Test Kit. For laboratory and on-site analysis of soil.

Intended Use

The EnviroGard PCB Field Soil Extraction Kit II is used for extracting polychlorinated bi-phenyls (PCBs) and/or pesticides from soil samples, prior to analysis. The EnviroGard Field Soil Extraction Kit II devices have been qualified for use with methanol solvent, which is used in the EnviroGard PCB Test Kit Soil Extraction procedure.

Before You Start

The EnviroGard Field Soil Extraction Kit II contains the following components:

12 soil extraction bottles with mixing beads
12 two-piece filter/plunger units
12 prefilter frits
15 weigh boats
15 wood spatulas
12 glass vials (5 mL)

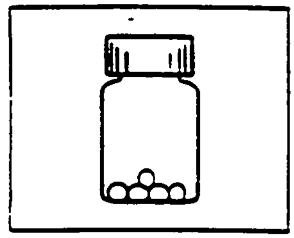
Other Items Needed

- 5 mL of methanol per sample extracted
- pipettes and glass test tubes for diluting high concentration extract (>50 ppm), if a more accurate estimate of these concentrations is desired
- a balance to weigh 5 gram soil samples
- 10 mL glass vials to hold soil extracts

PERFORM SOIL EXTRACTION

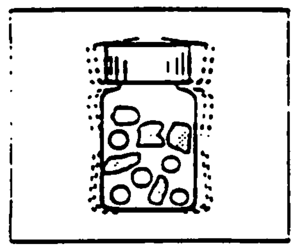
1. Weigh out 5 grams of soil (refer to the application sheet, "*Gravimetric Soil Analysis with the EnviroGard PCB Test Kit*").

2. Add a 5 gram soil sample to the solvent extraction bottle with mixing beads.

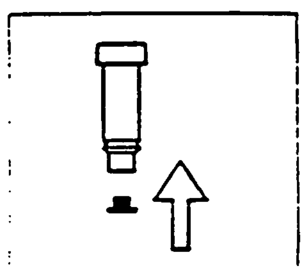


3. Add 5 mL of methanol to the sample in the solvent extraction bottle.

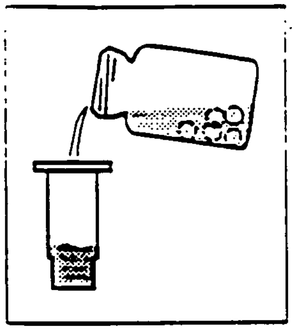
4. Cap and vigorously agitate the bottle for 2 minutes to break up the soil matrix.



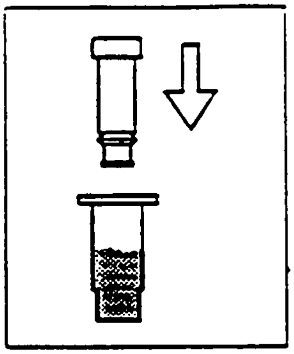
5. Insert a prefilter frit into the filter end of the plunger unit.



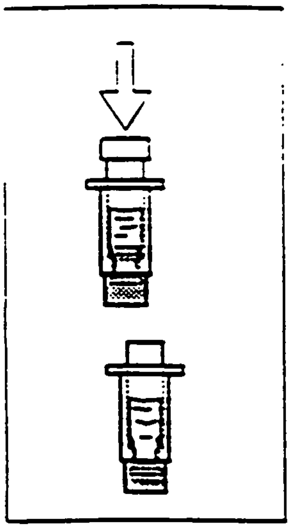
To transfer the soil methanol mixture, simply pour off the mixture into the filter base unit.



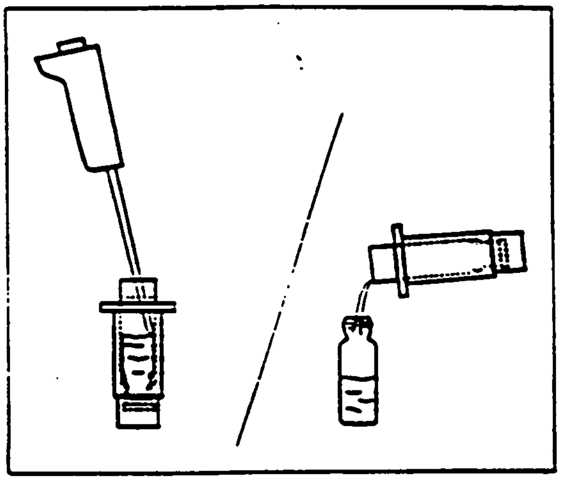
7. Insert the plunger unit into the filter base unit.



8. Press down firmly on the plunger.



9. Uncap the plunger. Using a pipettor, remove the extract for analysis (refer to *"Perform the Test"* in the EnviroGard PCB Test Kit insert).



EnviroGard PCB in Soil Test Protocol

Label the antibody-coated test tubes (≤ 20 tubes/assay) and place them into the test tube holder.

- Using the positive displacement pipettor, add:
  - 5 µL of MeOH into the "0.0 ppm" test tubes.
  - 5 µL of the 5 ppm calibrator to the "5 ppm" test tubes
  - 5 µL of the 10 ppm calibrator into the "10 ppm" test tubes.
  - 5 µL of the 50 ppm calibrator into the "50 ppm" test tubes.
  - 5 µL of each MeOH soil extract into appropriately labeled sample test tubes.

Note: Only use the positive calibrators that are required for your analysis.

3. Position the Repeater® pipettor at setting 2 and use the 12.5 mL syringe to add 500 µL of Assay Diluent to all test tubes. Gently shake the test tubes and incubate for 5 minutes.

4. Vigorously shake the test tube contents into an appropriate waste receptacle. Thoroughly wash the test tubes with water, then shake to empty. Repeat this wash step four times. Invert the test tubes and tap out as much water as possible.

5. Position the Repeater pipettor at setting 2 and use the 5 mL syringe to add 200 µL of PCB enzyme-conjugate into all test tubes. Gently shake the test tubes and incubate for 5 minutes.

6. Vigorously shake the test tube contents into an appropriate waste receptacle. Thoroughly wash the test tubes with water, then shake to empty. Repeat this wash step four times. Invert the test tubes and tap out as much water as possible.

7. Position the Repeater pipettor at setting 2 and use the 5 mL syringe to add 200 µL of Substrate into all test tubes. Follow immediately with 200 µL of Chromogen into all test tubes. Gently shake the test tubes and incubate for 5 minutes.

8. Position the Repeater pipettor at setting 2 and use a 12.5 mL syringe to add 500 µL of Stop Solution into all test tubes. Gently shake the test tubes.

9. Measure the OD of each test tube at 450 nm.

Interpret the Results

- Samples with OD_{450} values ≥ OD_{450} of the 5 ppm positive assay calibrator contain *less than* 5 ppm PCB.
- Samples with OD_{450} values ≤ OD_{450} of the 5 ppm positive calibrator *may* contain *more than* 5 ppm PCB.
- Samples with OD_{450} values ≥ OD_{450} of the 10 ppm positive assay calibrator contain *less than* 10 ppm PCB.
- Samples with OD_{450} values ≤ OD_{450} of the 10 ppm positive calibrator *may* contain *more than* 10 ppm PCB.
- Samples with OD_{450} values ≥ OD_{450} of the 50 ppm positive assay calibrator contain *less than* 50 ppm PCB.
- Samples with OD_{450} values ≤ OD_{450} of the 50 ppm positive assay calibrator *may* contain *more than* 50 ppm PCB.

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Reference Card for EnviroGard™ PCB Field Lab

ENVR L00 09

EnviroGard Soil Extraction II Protocol

Components

12 soil extraction bottles with mixing beads
12 two-piece filter/plunger units
12 prefilter frits
15 weigh boats
15 wood spatulas
12 glass vials (5 mL)

Other Items Needed

- 5 mL of methanol per sample extracted
- pipettes and glass test tubes for diluting high concentration extract (>50 ppm), if a more accurate estimate of these concentrations is desired
- a balance to weigh 5 gram soil samples
- 10 mL glass vials to hold soil extracts (for sample storage, if required)

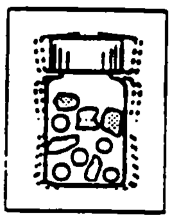
Perform Soil Extraction

1. Weigh out 5 grams of soil.

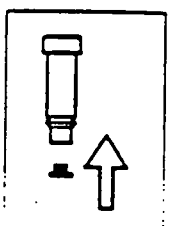
2. Add the 5 gram soil sample to a solvent extraction bottle with mixing beads.

3. Add 5 mL of methanol to the sample in the solvent extraction bottle.

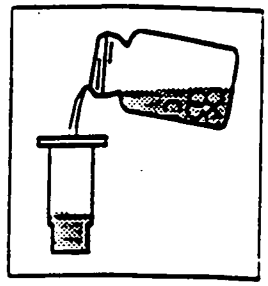
4. Cap and vigorously agitate the bottle for 2 minutes to break up the soil matrix.



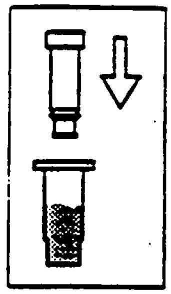
5. Insert the prefilter frit into the filter end of the plunger unit.



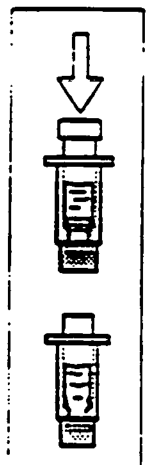
6. Transfer the soil/methanol mixture by pouring it into the filter base unit.



7. Insert the plunger unit into the filter base unit.



8. Press down firmly on the plunger.



9. Uncap the plunger. Using a pipettor, remove the extract for analysis. For long term storage, pour the extract into the glass vials.

EnviroGard PCB Field Lab

ENVR L00 09

This starter accessory kit contains the following items:

- 1 positive displacement precision pipettor, 5 µL
- 1 Eppendorf™ Repeater® pipettor
- 1 electronic timer
- 1 polystyrene test tube, 12 mm x 75 mm, (for blanking the spectrophotometer)
- 1 portable balance with a 50 gram calibrator weight
- 1 wash bottle, 500 mL
- 2 six-position test tube racks
- 1 rack of pipette tips for the positive displacement pipettor
- 8 pipette tips for the Repeater pipettor, 5.0 mL, for dispensing volumes between 0.1 mL and 0.5 mL
- 4 pipette tips for the Repeater pipettor, 12.5 mL, for dispensing volumes between 0.25 mL and 0.625 mL
- 1 pipette tip for the Repeater pipettor, 50 mL, for dispensing volumes between 1.0 mL and 5.0 mL
- 1 reference card

Refer to the *Reference Card for EnviroGard PCB Field Lab* for soil extraction and PCB test instructions.

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TECHNICAL INFORMATION

Ordering Information

Description	Catalogue No.
EnviroGard PCB Test Kit	ENVR 000 09
EnviroGard Field Soil Extraction Kit II, for gravimetric sample handling	ENSP 000 20
Methanol for soil extraction, 100 mL bottle	ELCR 000 07
EnviroGard PCB in Soil Test Kit shipping kit, which includes: • EnviroGard PCB Test Kit (ENVR 000 09) • EnviroGard Field Soil Extraction Kit II (ENSP 000 20) • Methanol, 100 mL (ELCR 000 07)	ENVR 000 10

Technical Assistance

For additional information about Millipore products, telephone toll-free (including Massachusetts): 800-225-1380.
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Västra Frölunda:
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Ursviksvägen:
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Tel. (617) 275-9200

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APPENDIX A-1.4

VOC MEASUREMENT

HNU

An HNU photoionization detector can be used to detect a variety of trace gasses, particularly volatile organic compounds (VOCs). The HNU uses the principle of photoionization to detect and measure the concentrations VOCs in the atmosphere or being emitted from a sample.

The HNU operates using an ultraviolet light source in the sensor. The ultraviolet light emits photons which are absorbed by gas molecules in the chamber with an ionization potential less than that of the lamp. This causes the release of an electron and resulting in a positive ion. The sensor also contains a pair of electrodes, one a bias electrode and the other a collector electrode. When a positive potential is applied to the bias electrode, the positive ions travel toward the collector electrode. An electric current which is created is then measured and the concentration is displayed on the meter in parts per million.

The following procedure is used for calibrating and operating the HNU:

1. Turn the function switch to BATT. The needle should be in the green; if not, the battery should be recharged.
2. Turn function switch to STANDBY and adjust meter needle to read zero using the ZERO set control.
3. Turn the function switch to the 0-200 range with the probe connected to the calibration gas (isobutylene) and note the meter reading. Adjust the SPAN control as needed to obtain the proper concentration reading.
4. Recheck zero setting; if readjustment is needed, repeat step 3.
5. At this point, a two-point calibration has been made (against zero and the gas standard) and is ready to use.
6. Turn function switch to the 0-20 range. The instrument will measure the concentration of any gasses with ionization potential less than the lamp.
7. Use HNU to monitor breathing zone for health and safety precautions or use to screen samples by placing probe near suspected sources of contaminants.
8. Adjust function switch as needed depending on concentrations detected.

APPENDIX A-2

HEALTH & SAFETY PLAN

SITE-SPECIFIC HEALTH AND SAFETY PLAN

Prepared for

GENERAL MOTORS CORPORATION
485 Milwaukee Avenue
Detroit, Michigan 48202

and

GENERAL MOTORS CORPORATION
3900 Holland Road
Saginaw, Michigan 48601

Prepared by

Wehran EMCOM Northeast
345 Lang Boulevard, Suite 1
Grand Island, New York 14072

WE Project No. 04428.LS

June 1994

GENERAL MOTORS - SAGINAW
HEALTH & SAFETY PLAN
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APPENDICES

1.0 PURPOSE

The purpose of this site-specific Health and Safety Plan (HASP) for General Motors Corporation - Saginaw Division (GM) is to provide specific guidelines and establish procedures for the protection of personnel performing the scope of activities, as described in Section 3.0 - Scope of Work of this HASP. The information in this HASP has been developed in accordance with applicable standards and is, to the extent possible, based on previous studies and information available to date. This HASP is a living document and, as such, must be continually updated to reflect the most recent changes in the scope of work, activities, and site conditions.

1.1 PERSONNEL REQUIREMENTS

All personnel conducting activities on site for which potential exposure exists must be in compliance with all applicable Federal/State rules and regulations, including OSHA 29 CFR 1910.120, and OSHA 29 CFR 1926. On-site personnel must also be familiar with the procedures and requirements of this HASP. In the event of conflicting safety procedures/requirements, personnel must implement those safety practices which afford the highest level of protection.

The Health and Safety Officer (HSO) and the Project Manager (PM) shall sign the title page of this HASP to verify that the content is factual, acceptable to both parties, and shall be implemented for all on-site activities covered under the HASP.

A pre-entry briefing, given by the HSO or the PM will serve to familiarize on-site personnel with the procedures, requirements, and provisions of this HASP. In addition, all on-site personnel shall sign a Plan Acceptance Form to document that they have: 1) attended a pre-entry briefing; 2) received and read a copy of the HASP; and 3) agreed to comply with the HASP.

1.2 DESIGNATION OF RESPONSIBILITIES

Corporate Health and Safety Manager (CHSM)

The CHSM shall have overall QA/QC responsibility for the development and implementation of the HASP. In cases where the HSO and the project management/

personnel do not agree with the contents and/or implementation of the HASP, the CHSM shall be contacted to make the necessary evaluation.

Health and Safety Officer (HSO)

The HSO is a Health and Safety Professional and is responsible for the development of the HASP and for providing any health and safety technical assistance and guidance to the PM and on-site personnel. Any significant changes in site operations, conditions, or other issues that may require alterations to the HASP, shall be discussed and approved by the HSO. When project personnel and the HSO cannot reach a solution agreeable to all parties, the CHSM will be contacted to resolve the conflict.

The HSO is also responsible for conducting periodic field audits to ensure compliance with OSHA regulations and Wehran EMCON (Wehran) Health and Safety Programs and Policies.

Project Manager/Task Manager (PM/TM)

The Project Manager (PM) or Task Manager (TM) shall be responsible for the overall implementation of the HASP and for ensuring that all health and safety procedures and policies are carried out in conjunction with this project. This shall include, but is not limited to:

- Review and approval of the HASP.
- Communication of site requirements to Wehran on-site personnel and Wehran subcontractors by means of a pre-entry briefing.
- Consultation with the HSO regarding appropriate changes to the HASP.
- Relating any changes to the site personnel.

Site Safety Officer (SSO)

The SSO shall be appointed by the PM and approved by the Health and Safety Department prior to the commencement of field activities. The SSO need not be a Health and Safety Professional.

The SSO is the person who, under the supervision of the PM/TM, is responsible for ensuring that: 1) all on-site personnel receive a copy of the HASP, understands its contents, and comply with the contents; 2) all necessary maintenance and decontamination of safety equipment is conducted by on-site personnel; 3) local emergency services are contacted in the event of an on-site emergency; 4) all the forms attached to the HASP are completed and submitted to the HSO upon completion of field activities, including the Plan Acceptance Form, Instrument Calibration Form, and the Medical Data Sheet; and, 5) the Medical Data Sheet is completed and kept on site (this form need not be submitted to the HSO at the end of the project).

During on-site activities the SSO has the authority to: 1) suspend field activities or otherwise limit exposures if the health or safety of any person appears to be endangered; 2) direct company or subcontractor personnel to alter work practices that endanger human health or the environment; and 3) suspend an individual from field activities for significant infraction of the requirements of the Health and Safety Plan.

Occupational Physician

Wehran's Occupational Physician, who has been certified by the American Board of Preventive Medicine, is responsible for developing the Health and Safety Medical Surveillance Program protocol in accordance with OSHA 29 CFR 1910.120(f) and good health and safety practices.

1.3 TRAINING REQUIREMENTS

1.3.1 General Training

All personnel conducting the site work at General Motors Saginaw shall have completed at least 40 hours of classroom-style health and safety training and 3 days of on-site training, as required by OSHA 29 CFR 1910.120.

In addition, the SSO and the PM shall receive an additional eight hours of supervisory training. All site employees shall receive a minimum of eight hours of refresher training annually.

1.3.2 Site-Specific Training

1.3.2.1 Initial Training

An initial site-specific training session or briefing shall be conducted by the HSO or PM prior to commencement of work and/or entering the site. During this initial training session, employees shall be instructed on the following topics:

- Personnel responsibilities.
- Content and implementation of the HASP.
- Site hazards and controls.
- Site-specific hazardous procedures (i.e., confined space entry, drum removal, etc.).
- Medical and training requirements.
- Use of direct reading monitoring equipment.
- Levels of protection.
- Action levels for upgrading/downgrading levels of PPE.
- Emergency information, including local emergency response team phone numbers, route to nearest hospital, and emergency response procedures.
- Instruction in the completion of required forms.

1.4 MEDICAL SURVEILLANCE REQUIREMENTS

A medical surveillance program is required for all personnel conducting activities at the General Motors Saginaw site. The medical surveillance program must be in compliance with the provisions set forth in OSHA 29 CFR 910.120, and other applicable Federal and State regulations. Medical surveillance requirements have been reviewed and approved by Wehran's Occupational Physician, Dr. Gary R. Krieger.

1.4.1 Frequency of Medical Exams

All on-site personnel conducting activities at the General Motors Saginaw site shall participate in the medical surveillance program and have a baseline examination. Under the medical surveillance program employees shall have a periodic exam (usually annually, but may be more often or less often according to exposure history), and upon termination of employment. The complete exit exam may be deferred if the employee has successfully completed an exam within six months of termination. Exposure-related exams shall be done regardless of the date of the last exam. Medical exams shall also be given when an employee has developed a lost-time injury or illness, or has been accidently exposed to a chemical contaminant in concentrations which exceed the exposure limit.

1.4.2 Content of Examinations

The content of the baseline exam should include:

- A medical and occupational history questionnaire with emphasis on the following systems: nervous, skin, lung, blood forming, cardiovascular, gastrointestinal, reproductive, as well as ears, nose, and throat.

- A complete physical exam, including at least the following:

  - Height, weight, temperature, pulse, respiration, and blood pressure.
  - Head, nose, and throat.
  - Eyes.
  - Ears (audiometric testing at 500, 1,000, 2,000, 3,000, 4,000, 6,000, and 8,000 Hz, including an otoscopic examination of the ear for wax and a questionnaire).
  - Chest (heart and lungs).
  - Peripheral vascular system.
  - Abdomen (liver, spleen, and kidney).
  - Musculoskeletal system.
  - Genitourinary system.
  - Skin.
  - Nervous system.
  - Pelvic, breast, and rectal (Guaiac) examination for women.
  - Testicular and rectal (Guaiac) examination for men.

- Laboratory tests should include:

  - Chemistry Panel - 24 items, including the following: Calcium, Phosphorus, Sodium, Potassium, Chloride, LDH, AST (SGOT), ALT (SGPT), T. Bili, GGTP, ALK, Phos, HDL, Cholesterol, Triglycerides, T. Protein, Globulin, Albumin, A/G Ratio, BUN, Creatinine, Uric Acid, Glucose, Iron, T4.
  - Complete blood count with differential.
  - Microscopic urinalysis.

- Other tests include:

  - Chest x-ray, PA.
  - Standard 12-lead resting electrocardiogram (EKG).
  - Pulmonary function test to include, at a minimum: forced vital capacity (FVC); forced expiratory volume, one second (FEV1); and the FEV1:FVC ratio.

The annual medical exam is similar to the baseline, with the following exceptions:

- An Annual Medical History Questionnaire is administered in place of the Baseline Medical History Questionnaire.
- Chest x-rays are not performed annually, but less frequently, depending upon age and regulatory requirements (every 3 years for age 40 and under, every 2 years for ages 41 through 50, annually for age. 50 and over, annually for smokers).

The EKG is performed on the same timetable as the chest x-ray.

1.4.3 Certification of Employee Fitness

The CHSM shall obtain a copy of the physician's written opinion about the employees' ability to perform hazardous waste site work and wear respiratory protection.

The opinion shall contain:

- Recommended limits upon the employee's assigned work (e.g., no heavy lifting).
- Any possible increase of risk to employee's health resulting from work.
- A statement that employee has been informed and advised about the results of the examination.

2.0 SITE INFORMATION

2.1 SITE LOCATION AND DESCRIPTION

The former General Motors Corporation, Saginaw Division, Buffalo Plant is located in the east central portion of Buffalo, approximately one-half mile south and one mile east of the Kensington Expressway. The site is bounded on the north by East Delavan Avenue and the Italian and French Wine Company, on the west by Cornwall Avenue, on the south by Scajaquada Street, and to the east by Niagara Mohawk Power Corporation property and other industrial property.

2.2 SITE HISTORY

GM–Saginaw has determined that an area adjacent to the oily wastewater treatment building at the facility is partially contaminated with PCB-bearing oil. A number of investigatory efforts have been undertaken in the area to first verify the presence and nature of the oil contamination, and subsequently to assess the extent of the contamination.

This project was initiated in 1986 with the intent of satisfying the "Conditions for Major Petroleum Facility License." A study was completed in October 1986 that provided a preliminary characterization of the facility soils and groundwater. In the spring of 1987, an investigation was performed to assess the permeability of soils underlying the existing above-ground reclaimed oil storage tank containment area adjacent to the oily wastewater treatment building. The results of the investigation indicated that oil, discharged onto the ground in the tank containment areas, had penetrated the underlying fill material and migrated beyond the limits of the containment walls. As a result, the fill layer and groundwater in the vicinity of the tanks became contaminated with oil.

A hydrogeologic investigation was performed by Wehran in August, 1987 to assess the extent of oil contamination. The investigation concluded that an oil plume was present extending southwest from the tank storage area.

A test pit excavated near the western end of the collection trench exposed a clay tile pipe (six-inch inside diameter) surrounded by gravel approximately four feet below ground surface. Orientation of the pipe appeared to be northeast-southwest, placing it directly within the limits of the previously established oil-contaminated area. The pipe contained a significant amount of oil and it appeared that the gravel bedding surrounding the pipe had acted as a preferential pathway for the oil within the ground. Oil observed seeping out of the pipe was subsequently sampled and tested for PCBs by both GM and the NYSDEC. Analytical results from both sets of analyses indicated the presence of PCBs (8,420 ppm and 2,678 ppm, respectively).

Following discovery of the pipe and the possibility that residue in the pipe could be a source of PCBs, a series of staged investigations were performed to assess the lateral extent and orientation of the buried pipe. In conjunction with the pipe investigation, further sampling of the oil, fill, and groundwater was conducted. These investigations were completed by Wehran in March, 1990.

Results of the investigation indicated the clay tile pipe did not extend further than originally thought (i.e., total length of the pipe was within the oil-contaminated area). The additional sampling confirmed the PCB contamination in all media tested.

Facility Description

The facility is a manufacturing plant for production of axles and steering gear assemblies for automobiles. Included as part of the facility in Parking Lot No. 4 is the WWTP, and two aboveground reclaimed oil storage tanks and one aboveground sulfuric acid storage tank. Parking Lot No. 4, situated on the east side of the Conrail ROW, is the area of interest for this Work Plan.

Relief is very moderate, with elevations varying only about 12 feet across the facility. The majority of the facility is generally flat, having been filled over the years to provide level foundations for the numerous buildings, paved parking lots, and concrete pads.

Significant features include an elevated section of railroad which runs north-south through the central portion of the facility, Scajaquada Creek Conduit (14.5' x 33') which runs under Scajaquada Street along the southern side of the facility, a brick storm sewer (5'x 9') running north-south below the plant from East Delavan Avenue to Colorado Avenue, and a 36-inch storm sewer running east-west from Cornwall to the north-south line. Additionally, there is a deep storm sewer which has been bored through bedrock under the extreme southern portion of the facility. This concrete lined tunnel is approximately 36 to 60 feet below grade, has an outside diameter of about 12 feet, and a finished diameter of about nine feet.

3.0 SCOPE OF WORK

The following is a summary of site activities to be conducted by Wehran personnel and Wehran subcontractors at GM-Saginaw. The field operations to be conducted at GM-Saginaw will take place in Operable Unit Numbers 1 and 2 (OU-1 and OU-2). OU-1 is the area where PCBs/oil and lead exist. The apparent source of PCBs in OU-1 is oil from the clay tile pipeline. The oil is located in a generally localized area extending from the wastewater treatment plant to the Conrail Railroad ROW.

The source of contamination in Operable Unit Two (OU-2) is lead. The source of the lead appears to be an "ash-like" fill material. At this time, field work potentially planned to be conducted in OU-2 consists of borings and monitoring well installations and associated sampling.

Field activities to be conducted in OU-1 include:

- Clay Tile Pipeline Removal

  - The underground clay pipeline will be removed. The pipe is approximately three to four feet below the paved ground surface. A trench will be excavated which will be approximately three feet wide by about five feet deep by 110 feet long.
  - Since the excavation exceeds four feet in depth, it is considered to be a confined space. Confined space entry is not included in this HASP. Thus, no personnel shall be allowed to enter the excavation for any reason.

- Exploratory Boring/Monitoring Well Installation and Sampling

  - This activity will include the advancement of test borings and the installation of monitoring wells. Soil samples will be collected throughout drilling operations. Groundwater samples will be collected once the wells are installed.

If the scope of work is altered or if additional tasks are assigned, an addendum to this HASP shall be developed to address the specific hazards associated with these changes.

4.0 HAZARD EVALUATION

This section identifies and evaluates the potential chemical, physical, and/or biological hazards which may be encountered during all intrusive activities. Specific hazards and associated protective measures for each of these activities are outlined in Table 4-1.

4.1 CHEMICAL HAZARDS

The key contaminants found on this site include PCBs and lead. Exposure to PCBs occurs primarily by direct contact with contaminated media and secondarily through inhalation of airborne sediments containing PCB particles. Exposure to lead occurs primarily through inhalation of airborne dusts and water droplets containing lead.

In previous sampling programs, PCB concentrations have ranged up to 8,420 ppm with most detected concentrations less than 200 ppm.

Total lead concentrations from samples collected in 1993 range up to about 24,000 ppm with most concentrations typically less than 5,000 ppm. Table 4-2 lists the properties of the site contaminants.

4.1.1 Organic/Inorganic Vapor Inhalation

Exposure to organic/inorganic vapors shall be controlled by:

- Monitoring air concentrations for organic vapors shall be conducted in the breathing zone with an HNu or OVM photoionization detector (PID). Monitoring can reduce risks by indicating when action levels have been exceeded, and personal protective equipment must be upgraded.
- Using respiratory protection in areas known to have concentrations above the action level.

4.1.2 Respirable Dust Inhalation

Inhalation of respirable dust-containing particles (metals and PCBs) is possible when using heavy equipment or conducting intrusive activities. Contaminated particulate (e.g., soil, pavement) may become suspended in air due to a combination of factors, including lack of vegetative cover and windy conditions.

TABLE 4-1
GENERAL MOTORS CORPORATION
SAGINAW SITE
TASK-SPECIFIC HAZARD ASSESSMENT

Task	Hazards	Controls
Clay Pipe Removal	Utility Clearances	Call utilities (Section 4.2.3)
	Heavy Equipment	Distancing, safe work practices, inspections (Section 4.2.1)
	Excavation Development Cave-ins	Sloping/shoring practices distancing personnel from excavation (Section 4.2.4)
	Exposure to Chemical Hazards	Monitoring/respiratory protection/PPE (Sections 6.3, 6.4, 7.0)
	Temperature Stress	Sections 4.2.5 and 4.2.6
	Slip/Trip/Hit/Fall	Section 4.2.8
Drilling (Test Borings and Wells)	Heavy Equipment	Distancing, safe work practices, inspections (Section 4.2.1)
	Drill Rig Safety	Section 4.2.2
	Utility Clearances	Call utilities (Section 4.2.4)
	Exposure to Chemical Hazards	Monitoring/respiratory protection/PPE (Sections 6.3, 6.4, 7.0)
	Temperature Stress	Sections 4.2.5 and 4.2.6
	Slip/Trip/Hit/Fall	Section 4.2.8

TABLE 4-1
GENERAL MOTORS CORPORATION
SAGINAW SITE
TASK-SPECIFIC HAZARD ASSESSMENT

Task	Hazards	Controls
Sampling (Soil and Wells)	Exposure To Chemical Hazards	Monitoring/respiratory protection/PPE (Sections 6.3, 6.4, 7.0)
	Temperature Stress	Sections 4.2.5 and 4.2.6
	Slip/Trip/Hit/Fall	Section 4.2.8
	Splash Hazards	Wear safety glasses and gloves. Emergency eyewash available (Section 6.0 and 7.0)

Table 4-2

GENERAL MOTORS CORPORATION

SAGINAW DIVISION

PROPERTIES OF SITE CONTAMINANTS

CHEMICAL NAME	EXPOSURE LIMITS	ROUTE OF ENTRY	SYMPTOMS / HEALTH EFFECTS	CHEMICAL PROPERTIES
POLYCHLORINATED BIPHENYLS (54%) (PCB'S)	TLV: 0.5 mg/m PEL: 0.5 mg/m STEL: NA IDLH: 5 mg/m	INHALATION ABSORPTION INGESTION CONTACT	Irritated eyes, skin; chloracne, dermatitis, liver damage; liver carcinogen.	(FP) NA (VP) NA (IP) NA
POLYCHLORINATED BIPHENYLS (42%) (PCB'S)	TLV: 1.0 mg/m PEL: 1.0 mg/m STEL: NA IDLH: 10 mg/m	INHALATION ABSORPTION INGESTION CONTACT	Irritated eyes, skin; chloracne, dermatitis, liver damage; liver carcinogen.	(FP) NA (VP) NA (IP) NA
POLYAROMATIC HYDROCARBONS	TLV: 0.2 mg/m PEL: 0.2 mg/m STEL: NA IDLH: -	INHALATION CONTACT	Dermatitis, bronchitis, cancer of lungs, skin, bladder, and kidneys skin carcinogen.	(FP) NA (VP) <1 mm (IP) NA
LEAD	TLV: 0.15 mg/m PEL: 0.05 mg/m STEL: 0.1 mg/m IDLH: NA	INHALATION INGESTION CONTACT	Insomnia, lassitude, anxiety tremor, pallor, nausea, anorexia, low weight, convulsions, coma; "lead line" on the gum, decreased hand-grip strength, intense periodic cramping.	(FP) 200° F (VP) 0.2 mm (IP)

NA – Information Not Available
FP – Flash Point
VP – Vapor Pressure
IP – Ionization Potential

TLV – ACGIH Threshold Limit Value
PEL – OSHA Permissable Exposure Limit
STEL – Short Term Exposure Limit
IDLH – Immediately Dangerous to Life and Death

Control of exposure to dust shall be obtained as follows:

- When possible, dust control measures may be utilized to suppress the dust. These include wetting the area and providing artificial ground cover.
- When dust suppression control is not possible, respirators with a HEPA filter must be used to prevent against inhalation of dust.

4.1.3 Skin Contact and Absorption

Skin contact by contaminants may be controlled by use of the proper personnel protective equipment (PPE) and good housekeeping procedures. The proper PPE (e.g., tyvek, gloves) as described in Section 6.6, shall be worn for all activities where contact with potentially contaminated media or materials are expected.

4.2 PHYSICAL HAZARDS

Physical hazards that may be present during these site activities include potential for proximity to heavy equipment; trenching/excavation cave-ins; underground utilities; slip/trip/fall hazard; temperature stress and other adverse weather conditions; and splash hazards. In addition, personnel must be aware that the protective equipment worn during certain activities may limit dexterity and visibility and may increase the difficulty of performing some tasks.

4.2.1 Heavy Equipment

Heavy equipment to be utilized at the site shall include a variety of backhoes, dozers, track loaders, and off-road trucks.

The following practices shall be followed when using heavy equipment:

- Equipment should be inspected daily to ensure that there are no exposed moving belts, fans, etc.
- When not in use, hydraulic and pneumatic components should be left in down or "dead" position.
- Roll-over protection shall be provided on hilly sites.
- No riding on vehicles or equipment except in fixed seats.

Steel-toed shoes and hard hat shall be worn for all work conducted near heavy equipment. Foot traffic shall be restricted while heavy equipment is in operation. Workers remaining around any heavy equipment shall be kept to a minimum. Heavy equipment can produce high noise levels. Personnel shall protect themselves from such noise levels in one of two ways – distancing from the source or the use of hearing protection. If using distance as a means of noise abatement, remain at least 12 feet from the equipment during all high noise operations. If using hearing protection, plugs/muffs should be used during all operations utilizing heavy equipment.

4.2.2 Drill Rig Safety

The following practices shall be used by drilling personnel:

- Equipment should be inspected daily to ensure that there are no exposed moving belts, fans, etc.
- Before leaving the controls, shift the transmission controlling the rotary drive into neutral and place the feed level in neutral. Before leaving the vicinity of the drill, shut down the drill engine.
- Do not drive the drill rig from hole-to-hole with the mast in the raised position.
- Before raising the mast, look up to check for overhead obstructions.
- Before the mast of a drill rig is raised and drilling is begun, the drill rig must first be leveled and stabilized with leveling jacks and/or cribbing. Re-level the drill rig if it settles after initial set up. Lower the mast only when the leveling jacks are down, and do not raise the leveling jack pads until the mast is lowered completely.
- Employees involved in the operation shall not wear any loose-fitting clothing which could get caught in any exposed moving machinery.
- Throwing or dropping tools is not permitted. Carefully pass tools by hand between personnel or use a hoist line.
- During freezing weather, do not touch any metal parts of the drill rig with exposed flesh. Freezing of moist skin to metal can occur almost instantaneously.

- Adequately cover or protect all unattended boreholes to prevent drill rig personnel, site visitors, or animals from stepping or falling into the hole. Cover, protect, or backfill all open boreholes according to local or State regulations on completion of the drilling project.
- Never allow "horsing around" within the vicinity of the drill rig and tool and supply storage areas – even when the drill rig is shut down.
- Due to splash potential, safety glasses shall also be worn during drilling and well installation.

While drilling, all non-essential personnel shall remain at a distance which is past the radius of the boom, whenever possible. Workers (drillers, hydrogeologists, etc.) remaining around the drill rig shall be kept to a minimum.

Personnel working in proximity to the drill rig shall wear steel-toed shoes and hard hats.

The area shall be roped off, marked or posted, to keep the area clear of pedestrian traffic or spectators. All personnel should be instructed in the use of the emergency kill switch on the drill rig.

Drill rigs can produce high noise levels during drilling operations. Heavy equipment can produce high noise levels. Personnel shall protect themselves from such noise levels in one of two ways – distancing from the source or the use of hearing protection. If using distance as a means of noise abatement, remain at least 12 feet from the equipment during all high noise operations. If using hearing protection, plugs/muffs should be used during all operations utilizing heavy equipment.

4.2.3 Utility Clearances

- Elevated superstructures (e.g., drill rig, backhoe) shall remain a distance of 20 feet away from utility lines and 50 feet away from power lines. Distance from utility lines may be adjusted by the SSO depending on actual voltage of the lines.
- During all intrusive activities (e.g., drilling, excavating, probing), Dig-Safe or General Motors should be contacted to mark underground lines before any work is started.

- Personnel involved in intrusive work shall determine the minimum distance from marked utilities which work can be conducted with the assistance of Dig-Safe or General Motors.

4.2.4 Excavation and Trenching

All excavation and trenching operations shall be in compliance with OSHA 29 CFR 1926.650 through 653 (see Appendix A-2.2). Excavations will not be entered under any circumstances under this HASP.

4.2.4.1 Excavation Development

Prior to opening an excavation, effort shall be made to determine whether underground installation; i.e., sewer, telephone, water, fuel electric lines, etc., will be encountered and the estimated location. When the excavation approaches the estimated location of such installation, the exact location shall be determined and when it is uncovered, proper supports shall be provided for the existing installation. Utility companies shall be contacted and advised of proposed work prior to the start of actual excavation.

Barriers shall be erected around excavations in remote work locations. Cover all wells, pits, shafts, and caissons. Backfill temporary wells, pits, and shafts when work is completed.

Vehicular traffic and heavy equipment shall remain at least four feet from the face of the excavation. All excavated or other materials shall be stored and retained at least two feet from excavation.

The work area shall be monitored for the presence of any hazardous conditions and/or atmospheres during excavation activities.

A copy of OSHA 29 CFR 1926.653 Excavation and Trenching Standards is located in Appendix A-2.2.

4.2.5 Heat Stress

4.2.5.1 Recognition and Symptoms

Temperature stress is one of the most common illnesses at hazardous waste sites. Acclimatization and frequent rest periods must be established for conducting activities where temperature stress may occur. Below are listed signs and symptoms of heat stress. Personnel should follow appropriate guidelines if any personnel exhibit these symptoms:

Heat Rash - Redness of skin. Frequent rest and change of clothing.

Heat Cramps - Painful muscle spasms in hands, feet, and/or abdomen. Administer lightly-salted water by mouth, unless there are medical restrictions.

Heat Exhaustion - Clammy, moist, pale skin, along with dizziness, nausea, rapid pulse, fainting. Remove to cooler area and administer fluids.

Heat Stroke - Hot dry skin; red, spotted or bluish; high body temperature of 104°F, mental confusion, loss of consciousness, convulsions or coma. Immediately cool victim by immersion in cool water. Wrap with wet sheet while fanning, sponge with cool liquid while fanning; treat for shock. **DO NOT DELAY TREATMENT. COOL BODY WHILE AWAITING AMBULANCE.**

4.2.5.2 Work Practices

The following procedures will be carried out to reduce heat stress:

- Heat stress monitoring
- Acclimatization
- Work/rest regimes
- Use of ice packet vests
- Shower sprinklers on site
- Liquids that replace electrolytes/salty foods available during rest regimes
- Air conditioned trailer, if possible
- Use of buddy system

4.2.5.3 Acclimatization

The level of heat stress at which excessive heat strain will result depends on the heat tolerance capabilities of the worker. Each worker has an upper limit for heat stress beyond which the resulting heat strain can cause the worker to become a heat casualty. In most workers, appropriate repeated exposure to elevated heat stress causes a series of physiologic adaptations called acclimatization, whereby the body becomes more efficient in coping with the heat stress. Work/rest regimes will be partially determined by the degree of acclimatization provided.

4.2.5.4 Work/Rest Regimes

The work/rest regime for heat stress is shown in Table 4-3.

4.2.5.5 Worker Information and Training

All new and current employees who work in areas where there is a reasonable likelihood of heat injury or illness should be kept informed, through continuing education programs of:

- Heat stress hazards.
- Predisposing factors and relevant signs and symptoms of heat injury and illness.
- Potential health effects of excessive heat stress and first aid procedures.
- Proper precautions for work in heat stress areas.
- Worker responsibilities for following proper work practices and control procedures to help protect the health and safety of themselves and their fellow workers, including instruction to immediately report to the employer the development of signs or symptoms of heat stress overexposure.
- The effects of therapeutic drugs, over-the-counter medications, or social drugs, may increase the risk of heat injury or illness by reducing heat tolerance.

4.2.6 Cold Stress

4.2.6.1 Recognition and Symptoms

Ambient air temperatures during site activities may create cold stress for on-site workers. Procedures for recognizing and avoiding cold stress must be followed. Cold stress can range from frostbite to hypothermia. Below are listed the signs and symptoms of cold stress. Personnel should follow the appropriate guidelines if any personnel exhibit these symptoms:

TABLE 4-3
GENERAL MOTORS CORPORATION
SAGINAW SITE
WORK/REST REGIME FOR
HEAT STRESS

WGBT	Acclimatization (days)	Work/Rest Regime/hour (percent) Level D	Work/Rest Regime/hour (percent) Level C*	Work/Rest Regime/hour (percent) Level B**
77°F	0 to 3 >3	Continuous	Continuous	75/25 Continuous
84°F	0 to 3 >3	Continuous	75/25 Continuous	50/50 75/25
88°F	0 to 3 >3	75/25 Continuous	50/50 75/25	25/75 50/50
90°F***	0 to 3 >3	50/50 75/25	25/75 50/50	No work 25/75
94°F****	0 to 3 >3	25/75 50/50	No Work 25/75	No Work
98°F*****	0 to 3 >3	No Work 25/75	No Work	No Work

WBGT Wet Bulb Global Temperature
* Used also for all Level B work using Saranex/Tyvek suits and ice vests.
** Used also for all Level B work using Saranex/Tyvek suits, no ice vests.
*** No Level B work conducted in temperatures above 90°F.
**** No Level C work conducted in temperatures above 94°F.
***** No Level D work conducted in temperatures above 98°F.

Frostbite - Pain in the extremities and loss of manual dexterity. "Frostnip" or reddening of the tissue, accompanied by a tingling or loss of sensation in the extremities. Continuous shivering.

Hypothermia - Pain in the extremities and loss of manual dexterity. Severe, uncontrollable shivering. Inability to maintain level of activity. Excessive fatigue, drowsiness, irritability, or euphoria. **Severe hypothermia:** clouded consciousness, low blood pressure, pupil dilation, cease of shivering, unconsciousness, and possible death.

Remove the patient to a warm, dry place. If clothing is wet, remove and replace with dry clothing. Keep patient warm. Rewarming of patient should be gradual to avoid stroke symptoms. Dehydration of the loss of body fluids may result in cold injury due to a significant change in blood flow to the extremities. If patient is conscious and alert, warm sweet liquids should be provided. Coffee and other caffeinated liquids should be avoided because of diuretic and circulatory effects. Extremities affected by frostbite should be gradually warmed up and returned to normal temperature. Moist compresses should be applied; begin with lukewarm compresses and slowly increase the temperature as changes in skin temperature are detected. Keep patient warm and calm, remove to a medical facility as soon as possible.

4.2.6.2 Work Practices

The reduction of adverse heath effects from cold exposure is achieved by adopting the following work practices:

- Providing adequate insulating dry clothing to maintain core temperature above 98.6°F to workers if work is performed in air temperature below 40°F. Wind chill cooling rates and the cooling power of air are critical factors. The higher the wind speed and the lower the temperature in the work area, the greater the insulation value of the protective clothing required (see Table 4-4 for Wind Chill Factor Chart).
- If the air temperature is of 32°F or less, hands should be protected by mittens.

Figure 4–4

COOLING POWER OF WIND ON EXPOSED FLESH EXPRESSED AS AN EQUIVALENT TEMPERATURE (under calm conditions)*

Estimated Wind Speed (in mph)	Actual Temperature Reading (°F)											
	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
	Equivalent Chill Temperature (°F)											
Calm	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
5	48	37	27	16	6	-5	-15	-26	-36	-47	-57	-68
10	40	28	16	4	-9	-24	-33	-46	-58	-70	-83	-95
15	36	22	9	-5	-18	-32	-45	-58	-72	-85	-99	-112
20	32	18	4	-10	-25	-39	-53	-67	-82	-96	-110	-121
25	30	16	0	-15	-29	-44	-59	-74	-82	-104	-118	-133
30	28	13	-2	-18	-33	-48	-63	-79	-94	-109	-129	-140
35	27	11	-4	-20	-35	-51	-67	-82	-98	-113	-129	-145
40	26	10	-6	-21	-37	-53	-69	-85	-100	-116	-132	-148

(Wind speeds greater than 40 mph have little additional effect.	LITTLE DANGER In less than an hour with dry skin. Maximum danger of false sense of security.	INCREASING DANGER Danger from freezing of exposed flesh within one minute.	GREAT DANGER Flesh may freeze within 30 seconds.

Trench foot and immersion foot may occur at any point on this chart.

- If only light work is involved and if the clothing on the worker may become wet on the job site, the outer layer of the clothing in use should be impermeable to water. With more severe work under such conditions, the outer layer should be water repellent, and the outer wear should be changed as it becomes wet. The outer garments should include provisions for easy ventilation in order to prevent wetting of inner layer by sweat.
- If available clothing does not give adequate protection to prevent cold injury, work should be modified or suspended until adequate clothing is made available, or until weather conditions improve.
- Observe work/warming regimen as shown in Table 4-5.
- Heated warming shelters should be available nearby (e.g., use of on-site trailer). The workers should be encouraged to use these at regular intervals, the frequency depending on the severity of the environmental exposure. When entering the heated shelter, the outer layer of clothing should be removed and the remainder of the clothing loosened to permit heat evaporation or a change of dry work clothing provided.
- Warm sweet drinks (hot chocolate) and soups should be provided at the work site to provide caloric intake and fluid volume. The intake of coffee should be limited because of the diuretic and circulatory effect.
- The weight and bulk of clothing should be included in estimating the required work performance and weights to be lifted by the worker.

As with heat stress:

- Implementing a buddy system in which workers are responsible for observing fellow workers for early signs and symptoms of cold stress.
- Unacclimatized employees should not be required to work full-time in cold until they become accustomed to the working conditions and required protective clothing.

Figure 4-5

Work/Warming Regimen

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		Non-emergency – work should cease	
-38° to -39°	-35° to -39°	40 min	4	30 min	5	Non-emergency – work should cease		Non-emergency – work should cease		Non-emergency – work should cease	
-40° to -42°	-40° to -44°	30 min	5	Non-emergency – work should cease		Non-emergency – work should cease		Non-emergency – work should cease		Non-emergency – work should cease	
-43° and below	-45° and below	Non-emergency – work should cease		Non-emergency – work should cease		Non-emergency – work should cease		Non-emergency – work should cease		Non-emergency – work should cease	

4.2.6.3 Worker Information and Training

The workers should be instructed in safety and health procedures regarding cold work environments. The training program should include, as a minimum, instruction in:

- Proper rewarming procedures and appropriate first aid treatment.
- Proper clothing practices.
- Proper eating and drinking habits.
- Recognition of impending frostbite.
- Recognition of signs and symptoms of impending hypothermia or excessive cooling of the body even when shivering does not occur.
- Safe work practices.

4.2.7 Adverse Weather Conditions

The SSO shall decide on the continuation or discontinuation of work based on current and pending weather conditions. Electrical storms, tornado warnings, and strong winds are examples of conditions that would call for the discontinuation of work and evacuation of site.

4.2.8 Slip/Trip/Hit/Fall

Slip/trip/hit/fall (S/T/H/F) injuries are the most frequent of all injuries to workers. They occur for a wide variety of reasons, but can be minimized by the following prudent practices:

- Spot check the work area to identify hazards.
- Establish and utilize a pathway which is most free of slip and trip hazards.
- Beware of trip hazards such as wet floors, slippery floors, and uneven surfaces or terrain.
- Carry only loads which you can see over.
- Keep work areas clean and free of clutter, especially in storage rooms and walkways.
- Communicate hazards to on-site personnel.
- Secure all loose clothing, ties, and remove jewelry while around machinery.

- Report and/or remove hazards.
- Keep a safe buffer zone between workers using equipment and tools.

4.2.9 Heavy Lifting

When lifting objects, use the following proper lifting techniques:

- Keep your feet shoulder width apart to get the best footing possible.
- Bend at the knees, not at the waist.
- Tighten stomach muscles to offset the force of the load.
- Grasp the object at opposite corners.
- Lift with the legs instead of the back muscles.
- Keep the back upright and avoid twisting.
- Most importantly, think before lifting.

4.2.10 Motor Vehicle Hazards

4.2.10.1 Driver Safety

The following motor vehicle operator regulations shall be employed when operating a vehicle.

The driver shall:

- Review all pertinent information such as manufacturer's operating instructions, company procedures, and maintenance records.
- Review safe operating techniques and signals.
- Wear seat belts at all times.
- Confirm that the mobile equipment safety devices are functional.
- Operate only his or her own vehicle or a company vehicle.
- Operate only properly maintained vehicles.

Personnel may not operate any vehicle after having consumed alcohol and/or drugs, including legal drugs, which may impair their ability to operate that motor vehicle.

4.2.10.2 Use of a Spotter

Personnel shall act as a spotter for trucks and large vehicles as they back and navigate through tight spaces. Spotting shall be conducted as follows:

- Personnel (driver and spotter) shall know and use standard hand signals when directing the traffic (see attached figure).
- The spotter is to be in position to see both the immediate hazard area and be seen by the driver.
- The area shall be cleared to the rear of the truck before backing.
- The spotter will review with the driver the areas that the spotter is watching.
- If any person, vehicle or object enters the hazard area, immediately give the stop signal to the driver and warn persons away or move objects.
- Be certain the hazard area is clear before signaling the driver to resume the maneuver.
- Spotters should avoid walking backward, and remain clear of the line of movement of the vehicle.
- Be aware of and avoid hazards, such as other vehicles, that may approach from the spotter's back.
- If the spotter must change position during the maneuver, signal to the driver to stop, and move to the new position before the maneuver is to continue.
- The spotter should be positioned so as to keep the hazard area in clear view and maintain visual contact with the driver.

4.2.10.3 Worker Safety While Working in Proximity to Motor Vehicles

- Continuously check the activities of the vehicles operating nearby which may present a hazard.
- Refrain from activities that might distract vehicle operator.
- Use high visibility clothing. Reflective or high visibility clothing should be worn by personnel exposed to moving traffic or equipment hazards such as work collection in heavy traffic areas, in times of darkness or reduced lighting, under rainy or foggy conditions, when spotting in transfer stations, landfills, etc.

4.3 BIOLOGICAL HAZARDS

4.3.1 Blood Poisoning

Blood poisoning is a term used to indicate a large number of bacteria present in the circulating blood. The most common symptom of blood poisoning is the reddening of skin which advances towards the heart. For example, if the point of contact is the hand than a red line will appear at the hand and extended up the arm.

Personnel protective equipment shall be worn to prevent direct contact with media which may be contaminated with bacteria or viral agents.

Signs and symptoms include swelling, stiffness and tenderness in the affected area, fatigue, chills and fever, pustules, and abscesses. If allowed to progress, the organisms may multiply and cause an overwhelming infection and death.

5.0 ACCIDENT PREVENTION

A vital element of the Site and Health and Safety program is the implementation of an accident prevention program. An accident prevention program, as applicable to this site, includes the following measures:

- Communicate the contents of this HASP to all personnel who work on the site.
- Educate personnel as to the requirements of the HASP.
- Eliminate unsafe conditions. Efforts must be initiated to identify conditions that can contribute to an accident and to remove exposure to these conditions.
- Reduce unsafe acts. Personnel shall make a conscious efforts to work safely. A high degree of safety awareness must be maintained so that safety factors involved in a task become an integral part of the task.
- Inspect frequently. Regular safety inspections of the work site, materials, and equipment by qualified persons ensures early detection of unsafe conditions. Safety and health deficiencies shall be correct as soon as possible, or site activities shall be suspended.

The following guidelines describes those specific measures personnel shall take to minimize the occurrence of accidents on site:

- The discovery of any condition that would suggest the existence of a situation more hazardous than anticipated shall result in the evacuation of site personnel and re-evaluation of the hazard and the level of protection.
- Eating, drinking, chewing gum or tobacco, and smoking are prohibited while working in area where the potential for chemical and/or explosive hazards may be present. Personnel must wash thoroughly before initiating any of the aforementioned activities.
- All field investigation activities must be coordinated through the HSO, SSO and the PM.
- Contact lenses will not be worn with any type of respirators.

- Facial hair must not interfere with the fit of the respirator.
- Site activities will not be conducted without adequate lighting.

6.0 PERSONAL PROTECTIVE EQUIPMENT

6.1 GENERAL

The purpose of personal protective equipment (PPE) is to shield or isolate individuals from the chemical and physical hazards that may be encountered during work activities. Full-faced respirators protect lungs, gastrointestinal tract, and eyes against airborne contaminants. Chemical resistant clothing protects the skin from contact with skin destructive and absorbable materials.

The level of protection must correspond to the level of hazard known, or suspected, in the specific work area. PPE has been selected with specific considerations to the hazards associated with the removal of contaminated soil. The specific PPE to be used for each level of protection is located in Table 6-1.

6.2 PPE FOR VISITORS

Appropriate safety equipment and sets of PPE ensembles per day shall be kept in the support zone in order to provide the proper protection for personnel who require access to the exclusion zone.

6.3 AIR-PURIFYING RESPIRATORS

The air-purifying respirator cartridges selected for use during all Level C work at this site are MSA GMC-H, which have the ability to protect against total organic vapor concentration up to 1,000 ppm, 10 ppm chlorine, 30 ppm formaldehyde, 50 ppm hydrogen chloride, and 50 ppm sulfur dioxide. The cartridges contain an attached HEPA filter which will protect against dust mist and fumes having a TWA greater than 0.05 mg/m^3, asbestos-containing dusts and mists, and radionuclides.

6.3.1 On-Site Respirator Fit Test

All personnel who may be required to wear a negative-pressure, air-purifying respirator shall be fitted properly and tested for a face seal at least annually. Employees shall have the opportunity to handle the respirators, and wear them in normal air for a long familiarity period. Following the familiarity period, employees shall test the piece-to-face seal by use of the positive and negative pressure tests:

TABLE 6-1
GENERAL MOTORS CORPORATION
SAGINAW SITE
LEVELS OF PROTECTION

Level D will consist of the following:

Tyvek, steel-toed boots, safety glasses, hard hat (if overhead hazards exists), latex gloves (if contacting any soil or water) hearing protection.

Modified Level D will consist of all the element of Level D above, plus the following:

Saranex coveralls, neoprene outer gloves, inner Nitrile gloves, chemical-resistant boot covers.

Level C will consist of the following:

Saranex coveralls, steel-toed boots, safety glasses, MSA full-faced air-purifying respirator equipped with organic vapor/acid gas combination cartridge with attached HEPA filter, Nitrile outer gloves, surgical inner gloves, chemical-resistant boot covers, hard hat (if overhead hazards exists), hearing protection.

- ***Positive Pressure Test*** – with the exhaust port(s) blocked, the positive pressure of slight exhalation should remain consistent for several seconds.
- ***Negative Pressure Test*** – with the intake ports blocked, the negative pressure of slight inhalation should remain constant for several seconds.

Air-purifying respirators shall not be worn when conditions prevent a seal of the respirator to the wearer. Such conditions may be the growth of a beard, sideburns, a skull cap that projects under the face-piece, or temple pieces on glasses. No employee may wear a beard if it interferes with the fit of the respirator. Also, the absence of one or both dentures can seriously affect the fit of a face-piece, and should be worn at all times that respirators are being used. The worker's diligence in observing these factors shall be evaluated by periodic checks.

6.3.2 Cartridge Changes

All cartridges will be changed a minimum of once daily. Changes will also be made when personnel begin to experience increased inhalation resistance or breakthrough of a chemical warning property.

6.3.3 Respirator Cleaning, Maintenance, and Inspection

All respirators used on site shall be cleaned and maintained in the following manner:

- Remove filters and cartridges.
- Visually inspect face piece and parts, discard faulty items.
- Remove all elastic headbands.
- Remove exhalation cover and inhalation valves.
- Wash, sanitize, and rinse face piece. Wash any parts that were removed separately.
- Dry the mask. Wipe face pieces and valves.
- Disassemble and clean the exhalation valve.
- Visually inspect face piece and all parts for deterioration, distortion, or other faults that might affect the performance of the respirator.
- Replace any questionable or faulty parts.

- Reassemble mask and visually inspect completed assembly.
- Seal mask in plastic bag.

6.4 LEVELS OF PROTECTION

Each activity conducted on-site presents different hazards and therefore required different levels of protection. There are four basic levels of protection, established by EPA field operating procedures. They are A, B, C and D, with Level A being the highest level of protection and Level D being the lowest.

The initial level of protection for each activity is Modified Level D as described in Table 6-1. Actions levels for upgrading or downgrading of PPE from initial level is discussed in Table 7-2.

7.0 EXPOSURE MONITORING

Inhalation hazards are caused from the exposure to vapors and contaminated dust. Air monitoring shall be performed within all work areas to detect the presence and relative concentration of those air contaminants which are inhalation hazards.

The data collected throughout the monitoring effort shall be used to determine the appropriate levels of protection.

7.1 EXPOSURE MONITORING

Air monitoring equipment to be used during site activities described in Section 3.1, shall consist of a photoionization detector (PID) with a 10.2 electron Volts (eV) lamp, and a respirable dust meter.

7.1.1 Photoionization Detector

Exposure to volatile organic compounds (VOCs) shall be monitored with a photoionization detector (PID) with a 10.2 eV lamp, such as a HNU or OVM. The HNU/OVM has the ability to detect organic vapor concentrations from 1 part per million (ppm) to 2,000 ppm. All PID monitoring shall be conducted in the breathing zone.

7.1.2 Respirable Dust Meter

The Respirable Dust Meter measures the concentrations of small-sized, airborne particulates. It has the ability to detect particles in the size range from 0.1 to 10 micrometers in diameter momentarily, as a time-weighted average or 8-hour equivalent shift averages. Concentrations are evaluated by two scales which reads from 0.01 to 10 mg/m^3, and 0.1 to 100 mg/m^3, respectively. All respirable dust monitoring shall be conducted in the breathing zone. Due to the potential of PCB contaminated soil and possible exposure to dust containing PCBs, a respirable dust meter will be used to determine the proper action level and personal protective equipment.

7.1.3 Monitoring Frequency

Monitoring with the PID and Respirable Dust Monitor, shall be conducted initially, during any change in conditions, and every 30 minutes, from every split spoon sample and/or continuously during Level C activities.

Dust monitoring shall also be conducted continuously any time where windy or dusty conditions exist. Upgrades and downgrades shall be dependent on readings obtained with the direct reading instruments. All readings on the PID shall be recorded on Direct Reading Monitoring Forms, shown in the Attachment section, and submitted to the HSO.

Table 7-1 summarizes direct monitoring equipment capabilities for instruments to be used at the Saginaw site.

7.1.4 Health and Safety Action Levels

An action level is a point at which increased protection or cessation of activities is required due to the concentration of contaminants in the work area. All activities shall be initiated in modified Level D. The appropriate actions to be taken at designated action levels, is described in Table 7-2.

In addition to Table 7-2, an upgrade to Level C is required if:

- Any symptoms occur, as described in Table 4-1.
- Requested by an individual performing the task.
- Any irritation to eye, nose, throat, or skin occurs.

A work stoppage and evacuation (cease and desist) at the specific work area is required if concentrations of organic vapors recorded in the work area are greater than 25 ppm.

TABLE 7-1
GENERAL MOTORS CORPORATION
SAGINAW SITE
AIR MONITORING REQUIREMENTS

Monitoring Instrument	Monitoring Frequency	Working Range
HNU/OVM with 10.2 eV lamp	Initially, during change in conditions, half-hourly, and continuously during dusty or windy conditions or during Level C activities.	1 to 2,000 units
Respirable Dust Monitor	Initially, during change in conditions, half-hourly, and continuously during dusty or windy conditions or during Level C activities.	.01 to 10 mg/m^3 0.1 to 100 mg/m^3

TABLE 7-2
GENERAL MOTORS CORPORATION
SAGINAW SITE
ACTION LEVELS FOR FIELD ACTIVITIES

Monitoring Instrument	Hazard	Instrument Reading	Level of PPE
PID	Organic Vapor*	<5 ppm If not contacting environmental media (e.g., soil, water)	Level D
		<5 ppm If contacting environmental media	Modified Level D
		5 - 25 ppm	Level C
		>25 ppm	Cease and Desist all Activities
Respirable Dust Monitor	Respirable Dust	0 - .025 mg/m^3 If not contacting environmental media	Level D
		0 - 0.025 mg/m^3 If contacting environmental media	Modified Level D
		0.025 - 10 mg/m^3	Level C
		>50 mg/m^3	Cease and Desist all Activities

* Above background, measured in breathing zone.

8.0 SITE CONTROL AND WORK ZONES

The purpose of site control is to minimize potential contamination of workers and protect the public from hazards found on site. Site control is especially important in emergency situations.

8.1 WORK ZONES

A three-zone approach shall be used during site operations in order to contain the potential spread of contamination. The three zones include the Exclusion Zone, the Contamination Reduction Zone, and the Support Zone. Delineation of these three zones should be based on sampling and monitoring results, evaluation of potential routes, and the amount of contaminant dispersion in the event of a release. Movement of personnel and equipment among these zones should be minimized and restricted to necessary personnel and equipment.

8.1.1 The Exclusion Zone

The Exclusion Zone is the area where the primary activity occurs such as backhoeing, sampling, etc. This area must be clearly marked with hazard tape or by other means. Only personnel involved in the work activities will be allowed in the Exclusion Zone.

Prior to entering the Exclusion Zone, the following conditions must be met: personnel shall be suited in the designated level of protection, a decontamination station shall be established at the entrance to the exclusion zone, and all personnel leaving the area shall decontaminate and dispose of all disposable garments.

The Exclusion Zone shall be marked off during mobilization activities, and prior to the commencement of intrusive activities. The size of the Exclusion Zone shall be a 30-foot circumference around the particular intrusive activity (e.g., borings, excavation, and trenches). If necessary, the size of the exclusion zone may be increased to allow more working area or to incorporate greater area for higher levels of protection due to volatile organic emissions.

8.1.2 The Contamination Reduction Zone

The Contamination Reduction Zone is the transition area between the contaminated area and the clean area. Decontamination is the main focus in the area. This area must also be clearly marked with hazard tape or by other means, and personnel involved in the work activities or decontamination. A will be established surrounding all of the work areas involving field investigation activities. A contamination reduction corridor containing a decontamination pad will be located in this zone. A contamination reduction corridor is a pathway in which decontamination occurs. One pathway will be established for heavy equipment and one for personnel decontamination. This area will also serve as an access control point for personnel entering the Exclusion Zone.

8.1.3 The Support Zone

The Support Zone is an uncontaminated zone which is the location of administrative and other support functions such as first aid, telephones, equipment supply, and emergency information. The support zone would have negligible potential for exposure to contaminants and is equivalent to that of background.

The majority of site operations will be controlled from the field office trailer as well as access to the site. The support trailers will provide for team communications and emergency response, and sanitary facilities (i.e., Porta-John). Appropriate safety and support equipment also will be located in this zone.

The support trailer will be located upwind of site operations, if possible, and would be used as a potential evacuation point, if appropriate. No potentially contaminated personnel or materials are allowed in this zone except appropriately packaged/ decontaminated and labelled samples. Meteorological conditions shall be observed and noted from this zone as well as those factors pertinent to heat and cold stress.

8.2 COMMUNICATION

Each member of the site entry team will be able to communicate with another entry team member at all times. Communications may be by way of the following methods:

- Air horn
- Walkie-talkies

- Telephones
- Hand signals

The primary means for external communication are telephones and radio. If telephone lines are not installed at a site, all team members should:

- Know the location of the nearest telephone.
- Have correct change.
- Have the necessary telephone numbers readily available in the Support Zone.

The following standard hand signals will be mandatory for all employees to understand regardless of other means of communication:

- Hand gripping throat - Out of air, cannot breath.
- Hands on top of head - Need assistance.
- Thumbs up - OK, I'm alright, I understand.
- Thumbs down - No, negative.
- Gripping partner's wrist, or gripping both of your own hands on wrist (if partner is out of reach) - Leave area immediately.

8.3 BUDDY SYSTEM

8.3.1 Responsibilities

(A buddy system shall be implemented when conducting Level C with an Air Purifying Respirator activities on this site. This buddy shall be able to:

- Provide his or her partner with assistance.
- Observe his or her partner for signs of chemical exposure or temperature stress.
- Periodically the integrity of his or her partner's protective clothing.
- Notify emergency personnel if emergency help is needed.

8.4 SITE SECURITY

Site security is necessary to prevent the exposure of unauthorized, unprotected people to site hazards and to avoid interference with safe working procedures. Security shall be maintained in the Support Zone. Barriers and warning signs should be placed surrounding the work zones.

9.0 DECONTAMINATION

It is the responsibility of the SSO to ensure that all personnel and pieces of equipment coming off site are properly decontaminated according to the procedures outlined below. Documentation of decontamination must be made in the field log notebook that will become part of the permanent project file.

9.1 CONTAMINATION PREVENTION

One of the most important aspects of decontamination is the prevention of the spread of contamination. Good contamination prevention will minimize employee and public exposure, and help ensure valid sample results by eliminating cross-contamination. Proper decontamination procedures and the following procedures of contamination avoidance shall reduce the potential spread of contamination include:

- Do not walk through areas of obvious or known contamination.
- Do not handle or touch contaminated materials directly.
- Fasten all closures on suits, covering with tape if necessary.
- Take particular care to protect any skin injuries.
- Stay upwind of airborne contaminants, when possible.

9.2 PERSONAL DECONTAMINATION

A personnel decontamination area will be established in the Contamination Reduction Zone for all field activities. Decontamination procedures will be followed by all personnel exiting the Exclusion Zone directly into the Contamination Reduction Zone. Under no circumstances (except emergency evacuation or other medical emergencies) will personnel be allowed to leave the site prior to decontamination.

All PPE will be disposed of and/or decontaminated at the conclusion of each work day as described below. Decontamination procedures will follow the concept of deconning the most contaminated PPE first.

All disposable equipment shall be doffed before meal breaks and at the conclusion of the work day and replaced with new equipment prior to commencing work. In addition, respirator cartridges will be changed as breakthrough is obtained, as directed by the SSO.

Designated containers for Tyvek suits an other disposables will be located in the Contamination Reduction Zone.

Respiratory equipment and other non-disposables will be fully decontaminated and then placed in a clean storage area. Respirator decontamination will be conducted daily. Taken from the drop area, the facepieces will be disassembled, the cartridges set aside, and all other parts placed in a cleansing solution. After an appropriate time in the solution, the parts will be removed and reseat with tap water. Facepieces will be allowed to air dry before placing in sanitized bags. Personnel will inspect their respirator on a daily basis to ensure its proper operation.

9.2.1 Level D Decontamination

Level D decontamination procedures to be utilized when leaving the Exclusion Zone are as follows:

- ***Step 1:*** Remove all visible contamination and loose debris by washing with clean de-ionized water.
- ***Step 2:*** Remove all outer clothing that came in contact with the contamination (i.e., boot covers and outer gloves) and either dispose of in disposable container or wash in detergent solution and rinse.
- ***Step 3:*** Remove protective clothing; dispose of in disposable container.
- ***Step 4:*** Wash and rinse hands.

9.2.2 Level C Decontamination

Level C decontamination procedures to be utilized when leaving the Exclusion Zone are as follows:

- ***Step 1:*** Remove all visible contamination and loose debris by washing with clean de-ionized water.
- ***Step 2:*** Remove all outer clothing that came in contact with the contamination (i.e., boot covers and outer gloves) and either

dispose of in disposable container or wash in detergent solution and rinse.

- ***Step 3:*** Remove protective clothing; dispose of in disposable container.
- ***Step 4:*** Remove respirator, sanitize prior to reuse.
- ***Step 5:*** Remove inner gloves; dispose of in disposable container.
- ***Step 6:*** Wash and rinse hands.

The decontamination layout for Levels D and C are shown in Figures 9-1 and 9-2, respectively.

9.3 PERSONAL HYGIENE FACILITIES

The following equipment shall be provided by the for all on-site personnel.

9.3.1 Toilets

One toilet seat, one urinal, and a washbasin shall be provided per every 40 employees conducting field activities on site.

Sites not provided with a sanitary sewer shall be provided with the following toilet facilities, unless prohibited by local codes:

a. Chemical toilets
b. Recirculating toilets
c. Combustion toilets
d. Flush toilets

Doors entering toilet facilities shall be provided with entrance locks controlled from inside the facility.

9.4 EQUIPMENT DECONTAMINATION

9.4.1 Sampling Equipment

Small equipment will be protected as much as possible from contamination by draping, masking, or otherwise covering as much of the instruments as possible with plastic without hindering the operation of the unit. As necessary, air monitoring equipment will

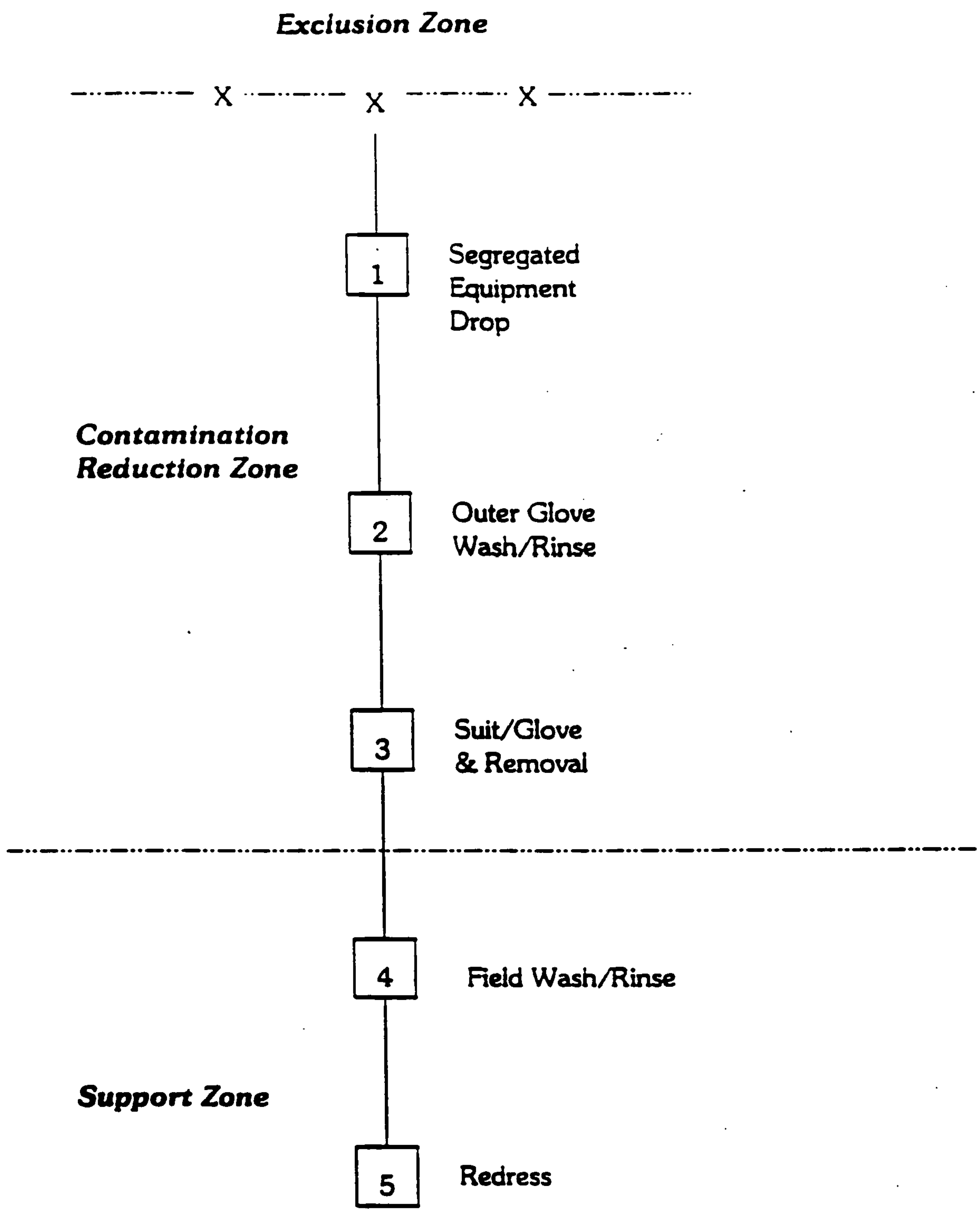

Figure 9–1

LEVEL "D" DECONTAMINATION PROCEDURES

1. Discard monitoring and sampling equipment to be decontaminated.
2. Wash and rinse outer gloves, then remove outer gloves.
3. Remove Tyvek suit.
4. Wash hands and arms.

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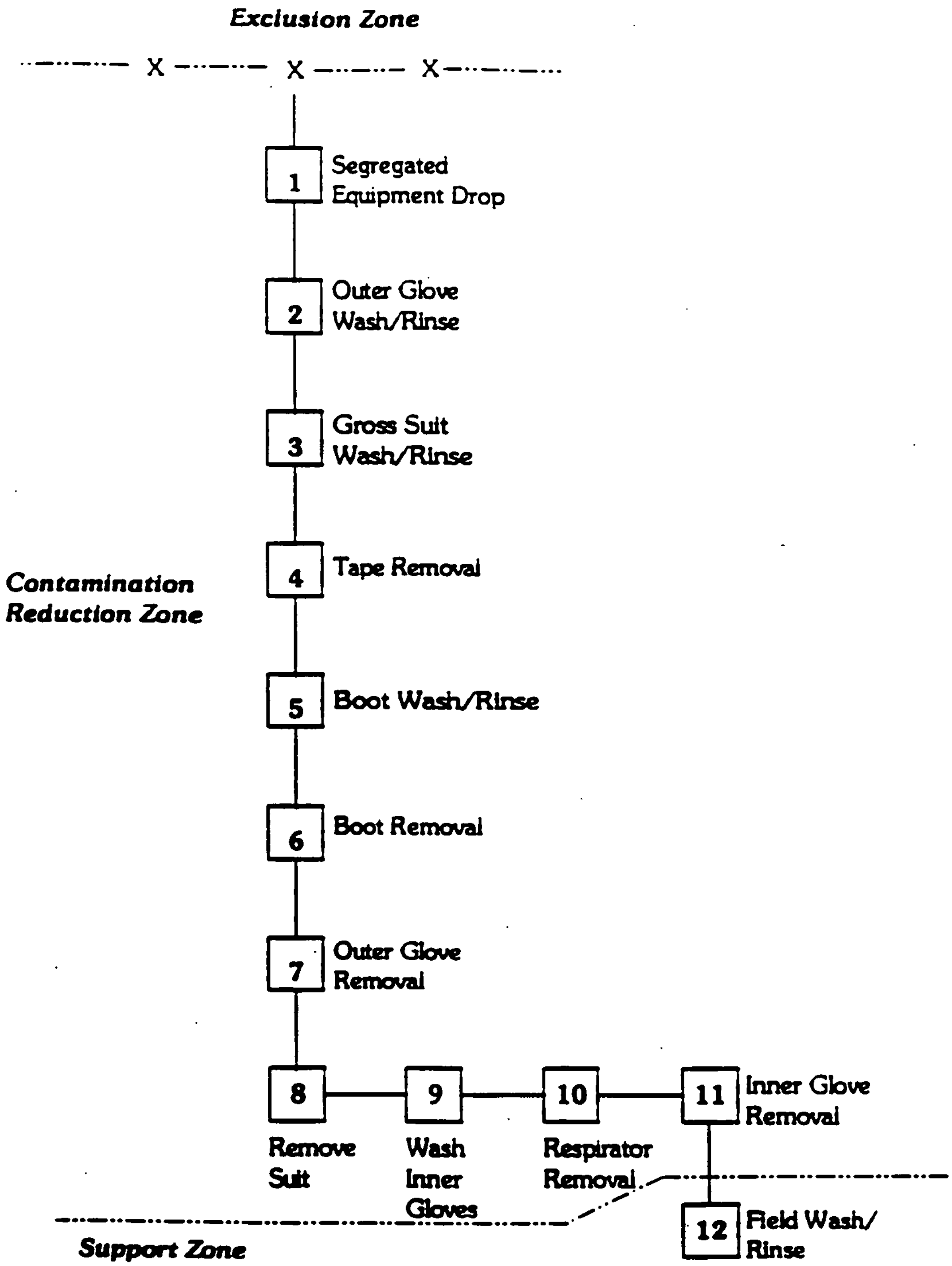


Figure 9-2

LEVEL "C" DECONTAMINATION PROCEDURES

1. Discard monitoring and sampling equipment to be decontaminated.
2. Wash and rinse outer gloves.
3. Rinse down Tyvek suit.
4. Remove tape from gloves and boot covers.
5. Wash and rinse boots.
6. Remove boots.
7. Remove outer gloves.
8. Remove suit.
9. Wash inner gloves.
10. Remove respirator.
11. Remove inner gloves.
12. Wash hands, face and arms.

WehranEnviroTech

be placed in clear plastic bags that allow reading of the scale and operation of the knobs.

Contaminated equipment will be taken from the drop area and shall be decontaminated as follows:

- The protective coverings shall be removed and disposed in the appropriate containers.
- Monitoring equipment will be wiped down with a disposal paper wipe.

9.4.2 Heavy Equipment

Heavy equipment (e.g., drill rig, backhoe, bulldozer) will be decontaminated after each boring using, at a minimum, high-pressure steam cleaning:

- When possible, vehicles should be parked off site or in a non-contaminated area of the site to minimize contamination and thus, avoid the need to decontaminate.
- If the vehicle is potentially contaminated, appropriate deconning procedures must be used before leaving the site. Deconning includes flushing visible dirt from the tires and high-pressure steam cleaning all heavy equipment.
- All vehicles will be decontaminated on a vehicle decontamination unit.
- Upon completion of the equipment decontamination, the equipment decontamination pad shall be thoroughly washed down and sediments and liquids removed from the collection trough and slump.

9.5 ON-SITE CONTAMINATED EQUIPMENT AREA

The Contractor shall provide an on-site contaminated equipment storage area at the entrance point to the Contamination Reduction Zone from the Exclusion Zone. The on-site contaminated equipment storage area shall be lined with polyethylene. The contaminated equipment storage area shall include the following:

- Boot racks for washing and storage.
- Drums or sealed containers for the disposal of protective clothing.

- A 10-foot by 10-foot temporary structure for the storage of contaminated materials and equipment used daily.

10.0 EMERGENCY RESPONSE/CONTINGENCY PROCEDURES

10.1 EMERGENCY EQUIPMENT/FIRST AID

Basic first aid supplies (bandages, gauze, tape) will be located in the first aid box. The first aid box, along with first aid manuals and Medical Data Sheets, will be located in the Support Zone. Other on-site emergency equipment includes emergency alarm, portable emergency eyewash, and a fire extinguisher.

10.2 EMERGENCY PROCEDURES FOR CONTAMINATED PERSONNEL

Whenever possible, personnel should be decontaminated before administering first aid. In the contamination reduction zone there will be a separate decontamination line for emergency use only in order to reduced the risk of exposure.

Skin Contact - Remove contaminated clothing, wash immediately with water, use soap if available.

Inhalation - Remove victim from contaminated atmosphere. Remove any respiratory protection equipment. Initiate artificial respiration if necessary. Transport to the hospital, if necessary.

Ingestion - Remove from contaminated atmosphere. Do not induce vomiting if victim is unconscious. Also never induce vomiting when acids, alkalies, or petroleum products are suspected. Transport to the hospital, if necessary.

If site personnel have unexplainably collapsed, all personnel must evacuate work area. Rescue personnel must don supplied air respiratory protection before evacuating victim from work area.

In case of fire, all personnel must evacuate work area and contact local fire department.

10.3 SITE EVACUATION

If site evacuation is necessary, an alarm shall be sounded and site personnel shall be notified. Upon the sounding of the alarm, all employees shall leave the site through the main entrance to the site via Cornwall Avenue.

10.4 EMERGENCY TELEPHONE NUMBERS

EMERGENCY INFORMATION		
Contact	**Phone Number**	**Hospital Directions**
Local Police	911	**Erie County Medical Center:** Exit the facility on Cornwall Avenue, turn right onto Cornwall and proceed to East Delavan Street. At East Delavan turn left and proceed approximately 1/2-mile to Grider Street, take a right, go about 1/4-mile and the Medical Center is on the left.
Fire Department	911	
Ambulance	911	
Local Hospital	(716) 898-3161	
Safety Officer - C. Andrews Work Home	 (914) 343-0660 (914) 565-1035	
Corporate Health & Safety Manager - L. Birnbaum Work Home	 (914) 343-0660 (914) 783-0026	
Project Manager - R. Laport Work Home	 (716) 773-1801 (716) 625-6984	

APPENDIX A-2.1

ATTACHMENTS

MEDICAL DATA SHEET

This brief Medical Data Sheet will be completed by all Wehran Personnel potentially working on-site and will be kept in the Support Zone during the conductance of site operations. This data sheet will accompany any personnel when medical assistance is needed or if transport to the hospital facilities is required:

Site: ______________________________

Name: ______________________________ Home Telephone: (___) __________

Address: ____

Age: __________ Height: __________ Weight: __________

Person to Contact in Case
of Emergency: ______________________ Phone No. (___) __________

Drug or other Allergies: ______________________________

Particular Sensitivities: ______________________________

Do You Wear Contacts? ______________________________

Provide a Checklist or Previous Illnesses or Exposures to Hazardous Chemicals:

____

____

____

What Medications are you Presently using? ______________________________

____

Do you have any Medical Restrictions? ______________________________

____

____

Name, Address, and Phone Number of Personal Physician: ______________

____

____

FIELD TEAM REVIEW

Each employee conducting field work shall sign this form after the pre-entry briefing is completed and before being permitted to work on site. A copy of this signed form shall be kept at the site, and the original sent to the HSO.

EMPLOYEE SIGN-OFF

I have attended a pre-entry briefing outlining the specific health and safety provisions on this site.

I have received a copy of the Site-Specific Health and Safety Plan for ________________.
I have read the plan, and will comply with the provisions contained therein.

EMPLOYEE

____________________	____________________	____________________
Name Printed	Signature	Date

WITNESS

____________________	____________________	____________________
Name Printed	Signature	Date

DIRECT READING AIR MONITORING FORM

GENERAL INFORMATION

Date: ____________________ Name: ____________________
Project Number: ____________________ Project Name: ____________________
Background Level: ____________________ Background Location: ____________________
Weather Conditions: ____________________
Estimated Wind Direction and Speed: ____________________
(i.e. calm, moderate, strong, etc.)

FIELD ACTIVITIES

Field Activity	Start Time	Stop Time	Comments
1.			
2.			
3.			
4.			

EQUIPMENT USED

HNu
Range: ______ Span: ______
Instrument #: ______

O_2/LEL
Alarm–LEL: ______ O_2: ______
Instrument #: ______

Chemical Specific Monitor
Chemical: ______
Instrument #: ______

Colormetric Detector Tubes
Chemical: ______
Pump Strokes: ______

Time	Reading	Time	Reading	Time	Reading	Time	Reading

COMMENTS

____
____
____

APPENDIX A-2.2

EXCAVATION AND TRENCHING STANDARDS

PART 1926—[AMENDED]

Subpart M—[Amended]

1. By revising the authority citation for subpart M of part 1926 to read as follows:

Authority: Sec. 107. Contract Work Hours and Safety Standards Act (Construction Safety Act) (40 U.S.C. 333); Secs. 4. 6. 8. Occupational Safety and Health Act of 1970 (29 U.S.C. 653. 655. 657); Secretary of Labor's Order No. 12-71 (36 FR 8754), 8-76 (41 FR 25059), or 9-83 (48 FR 35736), as applicable, and 29 CFR part 1911.

2. By revising subpart P of part 1926 to read as follows:

Subpart P—Excavations

Subpart P—Excavations

Authority: Sec. 107, Contract Worker Hours and Safety Standards Act (Construction Safety Act) (40 U.S.C. 333); Secs. 4. 6. 8. Occupational Safety and Health Act of 1970 (29 U.S.C. 653. 655. 657); Secretary of Labor's Order No. 12-71 (36 FR 8754), 8-76 (41 FR 25059), or 9-83 (48 FR 35736), as applicable, and 29 CFR part 1911.

§ 1926.650 Scope, application, and definitions applicable to this subpart.

(a) *Scope and application.* This subpart applies to all open excavations made in the earth's surface. Excavations are defined to include trenches.

(b) *Definitions applicable to this subpart.*

Accepted engineering practices means those requirements which are compatible with standards of practice required by a registered professional engineer.

Aluminum Hydraulic Shoring means a pre-engineered shoring system comprised of aluminum hydraulic cylinders (crossbraces) used in conjunction with vertical rails (uprights) or horizontal rails (walers). Such system is designed, specifically to support the sidewalls of an excavation and prevent cave-ins.

Bell-bottom pier hole means a type of shaft or footing excavation, the bottom of which is made larger than the cross section above to form a belled shape.

Benching (Benching system) means a method of protecting employees from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels.

Cave-in means the separation of a mass of soil or rock material from the side of an excavation, or the loss of soil from under a trench shield or support system, and its sudden movement into the excavation, either by falling or sliding, in sufficient quantity so that it could entrap, bury, or otherwise injure and immobilize a person.

Competent person means one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

Cross braces mean the horizontal members of a shoring system installed perpendicular to the sides of the excavation, the ends of which bear against either uprights or wales.

Excavation means any man-made cut, cavity, trench, or depression in an earth surface, formed by earth removal.

Faces or *sides* means the vertical or inclined earth surfaces formed as a result of excavation work.

Failure means the breakage, displacement, or permanent deformation of a structural member or connection so as to reduce its structural integrity and its supportive capabilities.

Hazardous atmosphere means an atmosphere which by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen deficient, toxic, or otherwise harmful, may cause death, illness, or injury.

Kickout means the accidental release or failure of a cross brace.

Protective system means a method of protecting employees from cave-ins, from material that could fall or roll from an excavation face or into an excavation, or from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection.

Ramp means an inclined walking or working surface that is used to gain access to one point from another, and is constructed from earth or from structural materials such as steel or wood.

Registered Professional Engineer means a person who is registered as professional engineer in the state wh the work is to be performed. Howeve professional engineer, registered in a state is deemed to be a "registered professional engineer" within the meaning of this standard when approving designs for "manufacturec protective systems" or "tabulated da to be used in interstate commerce.

Sheeting means the members of a shoring system that retain the earth position and in turn are supported b other members of the shoring syster

Shield (Shield system) means a structure that is able to withstand th forces imposed on it by a cave-in an thereby protect employees within th structure. Shields can be permanent structures or can be designed to be portable and moved along as work progresses. Additionally, shields ca either premanufactured or job-built accordance with § 1926.652 (c)(3) or (c)(4). Shields used in trenches are usually referred to as "trench boxes "trench shields."

Shoring (Shoring system) means a structure such as a metal hydraulic, mechanical or timber shoring syste that supports the sides of an excava and which is designed to prevent ca ins.

Sides. See "Faces."

Sloping (Sloping system) means a method of protecting employees fro cave-ins by excavating to form side an excavation that are inclined awa from the excavation so as to preven cave-ins. The angle of incline requir prevent a cave-in varies with differences in such factors as the so type, environmental conditions of exposure, and application of surcha loads.

Stable rock means natural solid mineral material that can be excava with vertical sides and will remain intact while exposed. Unstable rock considered to be stable when the ro material on the side or sides of the excavation is secured against cavin or movement by rock bolts or by an protective system that has been designed by a registered profession engineer.

Structural ramp means a ramp bu steel or wood, usually used for vehi access. Ramps made of soil or rock not considered structural ramps.

Support system means a structur such as underpinning, bracing, or shoring, which provides support to adjacent structure, underground installation, or the sides of an excavation.

Tabulated data means tables and charts approved by a registered professional engineer and used to design and construct a protective system.

Trench (Trench excavation) means a narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet (4.6 m). If forms or other structures are installed or constructed in an excavation so as to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet (4.6 m) or less (measured at the bottom of the excavation), the excavation is also considered to be a trench.

Trench box. See "Shield."

Trench shield. See "Shield."

Uprights means the vertical members of a trench shoring system placed in contact with the earth and usually positioned so that individual members do not contact each other. Uprights placed so that individual members are closely spaced, in contact with or interconnected to each other, are often called "sheeting."

Wales means horizontal members of a shoring system placed parallel to the excavation face whose sides bear against the vertical members of the shoring system or earth.

§ 1926.651 General requirements.

(a) *Surface encumbrances.* All surface encumbrances that are located so as to create a hazard to employees shall be removed or supported, as necessary, to safeguard employees.

(b) *Underground installations.* (1) The estimated location of utility installations, such as sewer, telephone, fuel, electric, water lines, or any other underground installations that reasonably may be expected to be encountered during excavation work, shall be determined prior to opening an excavation.

(2) Utility companies or owners shall be contacted within established or customary local response times, advised of the proposed work, and asked to establish the location of the utility underground installations prior to the start of actual excavation. When utility companies or owners cannot respond to a request to locate underground utility installations within 24 hours (unless a longer period is required by state or local law), or cannot establish the exact location of these installations, the employer may proceed, provided the employer does so with caution, and provided detection equipment or other acceptable means to locate utility installations are used.

(3) When excavation operations approach the estimated location of underground installations, the exact location of the installations shall be determined by safe and acceptable means.

(4) While the excavation is open, underground installations shall be protected, supported or removed as necessary to safeguard employees.

(c) *Access and egress*—(1) *Structural ramps.* (i) Structural ramps that are used solely by employees as a means of access or egress from excavations shall be designed by a competent person. Structural ramps used for access or egress of equipment shall be designed by a competent person qualified in structural design, and shall be constructed in accordance with the design.

(ii) Ramps and runways constructed of two or more structural members shall have the structural members connected together to prevent displacement.

(iii) Structural members used for ramps and runways shall be of uniform thickness.

(iv) Cleats or other appropriate means used to connect runway structural members shall be attached to the bottom of the runway or shall be attached in a manner to prevent tripping.

(v) Structural ramps used in lieu of steps shall be provided with cleats or other surface treatments on the top surface to prevent slipping.

(2) *Means of egress from trench excavations.* A stairway, ladder, ramp or other safe means of egress shall be located in trench excavations that are 4 feet (1.22 m) or more in depth so as to require no more than 25 feet (7.62 m) of lateral travel for employees.

(d) *Exposure to vehicular traffic.* Employees exposed to public vehicular traffic shall be provided with, and shall wear, warning vests or other suitable garments marked with or made of reflectorized or high-visibility material.

(e) *Exposure to falling loads.* No employee shall be permitted underneath loads handled by lifting or digging equipment. Employees shall be required to stand away from any vehicle being loaded or unloaded to avoid being struck by any spillage or falling materials. Operators may remain in the cabs of vehicles being loaded or unloaded when the vehicles are equipped, in accordance with § 1926.601(b)(6), to provide adequate protection for the operator during loading and unloading operations.

(f) *Warning system for mobile equipment.* When mobile equipment is operated adjacent to an excavation, or when such equipment is required to approach the edge of an excavation, and the operator does not have a clear and direct view of the edge of the excavation, a warning system shall be utilized such as barricades, hand or mechanical signals, or stop logs. If possible, the grade should be away from the excavation.

(g) *Hazardous atmospheres*—(1) *Testing and controls.* In addition to the requirements set forth in subparts D and E of this part (29 CFR 1926.50–1926.107) to prevent exposure to harmful levels of atmospheric contaminants and to assure acceptable atmospheric conditions, the following requirements shall apply:

(i) Where oxygen deficiency (atmospheres containing less than 19.5 percent oxygen) or a hazardous atmosphere exists or could reasonably be expected to exist, such as in excavations in landfill areas or excavations in areas where hazardous substances are stored nearby, the atmospheres in the excavation shall be tested before employees enter excavations greater than 4 feet (1.22 m) in depth.

(ii) Adequate precautions shall be taken to prevent employee exposure to atmospheres containing less than 19.5 percent oxygen and other hazardous atmospheres. These precautions include providing proper respiratory protection or ventilation in accordance with subparts D and E of this part respectively.

(iii) Adequate precaution shall be taken such as providing ventilation, to prevent employee exposure to an atmosphere containing a concentration of a flammable gas in excess of 20 percent of the lower flammable limit of the gas.

(iv) When controls are used that are intended to reduce the level of atmospheric contaminants to acceptable levels, testing shall be conducted as often as necessary to ensure that the atmosphere remains safe.

(2) *Emergency rescue equipment.* (i) Emergency rescue equipment, such as breathing apparatus, a safety harness and line, or a basket stretcher, shall be readily available where hazardous atmospheric conditions exist or may reasonably be expected to develop during work in an excavation. This equipment shall be attended when in use.

(ii) Employees entering bell-bottom pier holes, or other similar deep and confined footing excavations, shall wear a harness with a life-line securely attached to it. The lifeline shall be separate from any line used to handle materials, and shall be individually attended at all times while the employee wearing the lifeline is in the excavation.

(h) *Protection from hazards associated with water accumulation.* (1) Employees shall not work in excavations in which there is accumulated water, or in excavations in which water is accumulating, unless adequate precautions have been taken to protect employees against the hazards posed by water accumulation. The precautions necessary to protect employees adequately vary with each situation, but could include special support or shield systems to protect from cave-ins, water removal to control the level of accumulating water, or use of a safety harness and lifeline.

(2) If water is controlled or prevented from accumulating by the use of water removal equipment, the water removal equipment and operations shall be monitored by a competent person to ensure proper operation.

(3) If excavation work interrupts the natural drainage of surface water (such as streams), diversion ditches, dikes, or other suitable means shall be used to prevent surface water from entering the excavation and to provide adequate drainage of the area adjacent to the excavation. Excavations subject to runoff from heavy rains will require an inspection by a competent person and compliance with paragraphs (h)(1) and (h)(2) of this section.

(i) *Stability of adjacent structures.* (1) Where the stability of adjoining buildings, walls, or other structures is endangered by excavation operations, support systems such as shoring, bracing, or underpinning shall be provided to ensure the stability of such structures for the protection of employees.

(2) Excavation below the level of the base or footing of any foundation or retaining wall that could be reasonably expected to pose a hazard to employees shall not be permitted except when:

(i) A support system, such as underpinning, is provided to ensure the safety of employees and the stability of the structure; or

(ii) The excavation is in stable rock; or

(iii) A registered professional engineer has approved the determination that the structure is sufficently removed from the excavation so as to be unaffected by the excavation activity; or

(iv) A registered professional engineer has approved the determination that such excavation work will not pose a hazard to employees.

(3) Sidewalks, pavements, and appurtenant structure shall not be undermined unless a support system or another method of protection is provided to protect employees from the possible collapse of such structures.

(j) *Protection of employees from loose rock or soil.* (1) Adequate protection shall be provided to protect employees from loose rock or soil that could pose a hazard by falling or rolling from an excavation face. Such protection shall consist of scaling to remove loose material; installation of protective barricades at intervals as necessary on the face to stop and contain falling material; or other means that provide equivalent protection.

(2) Employees shall be protected from excavated or other materials or equipment that could pose a hazard by falling or rolling into excavations. Protection shall be provided by placing and keeping such materials or equipment at least 2 feet (.61 m) from the edge of excavations, or by the use of retaining devices that are sufficient to prevent materials or equipment from falling or rolling into excavations, or by a combination of both if necessary.

(k) *Inspections.* (1) Daily inspections of excavations, the adjacent areas, and protective systems shall be made by a competent person for evidence of a situation that could result in possible cave-ins, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions. An inspection shall be conducted by the competent person prior to the start of work and as needed throughout the shift. Inspections shall also be made after every rainstorm or other hazard increasing occurrence. These inspections are only required when employee exposure can be reasonably anticipated.

(2) Where the competent person finds evidence of a situation that could result in a possible cave-in, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions, exposed employees shall be removed from the hazardous area until the necessary precautions have been taken to ensure their safety.

(l) *Fall protection.* (1) Where employees or equipment are required or permitted to cross over excavations, walkways or bridges with standard guardrails shall be provided.

(2) Adequate barrier physical protection shall be provided at all remotely located excavations. All wells, pits, shafts, etc., shall be barricaded or covered. Upon completion of exploration and similar operations, temporary wells, pits, shafts, etc., shall be backfilled.

§ 1926.652 Requirements for protective systems.

(a) *Protection of employees in excavations.* (1) Each employee in an excavation shall be protected from cave-ins by an adequate protective system designed in accordance with paragraph (b) or (c) of this section except when:

(i) Excavations are made entirely in stable rock; or

(ii) Excavations are less than 5 feet (1.52m) in depth and examination of the ground by a competent person provides no indication of a potential cave-in.

(2) Protective systems shall have the capacity to resist without failure all loads that are intended or could reasonably be expected to be applied or transmitted to the system.

(b) *Design of sloping and benching systems.* The slopes and configurations of sloping and benching systems shall be selected and constructed by the employer or his designee and shall be in accordance with the requirements of paragraph (b)(1); or, in the alternative, paragraph (b)(2); or, in the alternative, paragraph (b)(3), or, in the alternative, paragraph (b)(4), as follows:

(1) *Option (1)—Allowable configurations and slopes.* (i) Excavations shall be sloped at an angle not steeper than one and one-half horizontal to one vertical (34 degrees measured from the horizontal), unless the employer uses one of the other options listed below.

(ii) Slopes specified in paragraph (b)(1)(i) of this section, shall be excavated to form configurations that are in accordance with the slopes shown for Type C soil in Appendix B to this subpart.

(2) *Option (2)—Determination of slopes and configurations using Appendices A and B.* Maximum allowable slopes, and allowable configurations for sloping and benching systems, shall be determined in accordance with the conditions and requirements set forth in appendices A and B to this subpart.

(3) *Option (3)—Designs using other tabulated data.* (i) Designs of sloping or benching systems shall be selected from and be in accordance with tabulated data, such as tables and charts.

(ii) The tabulated data shall be in written form and shall include all of the following:

(A) Identification of the parameters that affect the selection of a sloping or benching system drawn from such data;

(B) Identification of the limits of use of the data, to include the magnitude and configuration of slopes determined to be safe;

(C) Explanatory information as may be necessary to aid the user in making a correct selection of a protective system from the data.

(iii) At least one copy of the tabulated data which identifies the registered professional engineer who approved the data, shall be maintained at the jobsite during construction of the protective system. After that time the data may be stored off the jobsite, but a copy of the data shall be made available to the Secretary upon request.

(4) *Option (4)—Design by a registered professional engineer.* (i) Sloping and benching systems not utilizing Option (1) or Option (2) or Option (3) under paragraph (b) of this section shall be approved by a registered professional engineer.

(ii) Designs shall be in written form and shall include at least the following:

(A) The magnitude of the slopes that were determined to be safe for the particular project;

(B) The configurations that were determined to be safe for the particular project; and

(C) The identity of the registered professional engineer approving the design.

(iii) At least one copy of the design shall be maintained at the jobsite while the slope is being constructed. After that time the design need not be at the jobsite, but a copy shall be made available to the Secretary upon request.

(c) *Design of support systems, shield systems, and other protective systems.* Designs of support systems shield systems, and other protective systems shall be selected and constructed by the employer or his designee and shall be in accordance with the requirements of paragraph (c)(1); or, in the alternative, paragraph (c)(2); or, in the alternative, paragraph (c)(3); or, in the alternative, paragraph (c)(4) as follows:

(1) *Option (1)—Designs using appendices A, C and D.* Designs for timber shoring in trenches shall be determined in accordance with the conditions and requirements set forth in appendices A and C to this subpart. Designs for aluminum hydraulic shoring shall be in accordance with paragraph (c)(2) of this section, but if manufacturer's tabulated data cannot be utilized, designs shall be in accordance with appendix D.

(2) *Option (2)—Designs Using Manufacturer's Tabulated Data.* (i) Design of support systems, shield systems, or other protective systems that are drawn from manufacturer's tabulated data shall be in accordance with all specifications, recommendations, and limitations issued or made by the manufacturer.

(ii) Deviation from the specifications, recommendations, and limitations issued or made by the manufacturer shall only be allowed after the manufacturer issues specific written approval.

(iii) Manufacturer's specifications, recommendations, and limitations, and manufacturer's approval to deviate from the specifications, recommendations, and limitations shall be in written form at the jobsite during construction of the protective system. After that time this data may be stored off the jobsite, but a copy shall be made available to the Secretary upon request.

(3) *Option (3)—Designs using other tabulated data.* (i) Designs of support systems, shield systems, or other protective systems shall be selected from and be in accordance with tabulated data, such as tables and charts.

(ii) The tabulated data shall be in written form and include all of the following:

(A) Identification of the parameters that affect the selection of a protective system drawn from such data;

(B) Identification of the limits of use of the data;

(C) Explanatory information as may be necessary to aid the user in making a correct selection of a protective system from the data.

(iii) At least one copy of the tabulated data, which identifies the registered professional engineer who approved the data, shall be maintained at the jobsite during construction of the protective system. After that time the data may be stored off the jobsite, but a copy of the data shall be made available to the Secretary upon request.

(4) *Option (4)—Design by a registered professional engineer.* (i) Support systems, shield systems, and other protective systems not utilizing Option 1, Option 2 or Option 3, above, shall be approved by a registered professional engineer.

(ii) Designs shall be in written form and shall include the following:

(A) A plan indicating the sizes, types, and configurations of the materials to be used in the protective system; and

(B) The identity of the registered professional engineer approving the design.

(iii) At least one copy of the design shall be maintained at the jobsite during construction of the protective system. After that time, the design may be stored off the jobsite, but a copy of the design shall be made available to the Secretary upon request.

(d) *Materials and equipment.* (1) Materials and equipment used for protective systems shall be free from damage or defects that might impair their proper function.

(2) Manufactured materials and equipment used for protective systems shall be used and maintained in a manner that is consistent with the recommendations of the manufacturer, and in a manner that will prevent employee exposure to hazards.

(3) When material or equipment that is used for protective systems is damaged, a competent person shall examine the material or equipment and evaluate its suitability for continued use. If the competent person cannot assure the material or equipment is able to support the intended loads or is otherwise suitable for safe use, then such material or equipment shall be removed from service, and shall be evaluated and approved by a registered professional engineer before being returned to service.

(e) *Installation and removal of support*—(1) *General.* (i) Members of support systems shall be securely connected together to prevent sliding, falling, kickouts, or other predictable failure.

(ii) Support systems shall be installed and removed in a manner that protects employees from cave-ins, structural collapses, or from being struck by members of the support system.

(iii) Individual members of support systems shall not be subjected to loads exceeding those which those members were designed to withstand.

(iv) Before temporary removal of individual members begins, additional precautions shall be taken to ensure the safety of employees, such as installing other structural members to carry the loads imposed on the support system.

(v) Removal shall begin at, and progress from, the bottom of the excavation. Members shall be released slowly so as to note any indication of possible failure of the remaining members of the structure or possible cave-in of the sides of the excavation.

(vi) Backfilling shall progress together with the removal of support systems from excavations.

(2) *Additional requirements for support systems for trench excavations.* (i) Excavation of material to a level no greater than 2 feet (.61 m) below the bottom of the members of a support system shall be permitted, but only if the system is designed to resist the forces calculated for the full depth of the trench, and there are no indications while the trench is open of a possible loss of soil from behind or below the bottom of the support system.

(ii) Installation of a support system shall be closely coordinated with the excavation of trenches.

(f) *Sloping and benching systems.* Employees shall not be permitted to work on the faces of sloped or benched excavations at levels above other employees except when employees at the lower levels are adequately protected from the hazard of falling, rolling, or sliding material or equipment.

(g) *Shield systems*—(1) *General.* (i) Shield systems shall not be subjected to loads exceeding those which the system was designed to withstand.

(ii) Shields shall be installed in a manner to restrict lateral or other hazardous movement of the shield in the event of the application of sudden lateral loads.

(iii) Employees shall be protected from the hazard of cave-ins when entering or exiting the areas protected by shields.

(iv) Employees shall not be allowed in shields when shields are being installed, removed, or moved vertically.

(2) *Additional requirement for shield systems used in trench excavations.* Excavations of earth material to a level not greater than 2 feet (.61 m) below the bottom of a shield shall be permitted, but only if the shield is designed to resist the forces calculated for the full depth of the trench, and there are no indications while the trench is open of a possible loss of soil from behind or below the bottom of the shield.

Appendix A to Subpart P

Soil Classification

(a) *Scope and application*—(1) *Scope.* This appendix describes a method of classifying soil and rock deposits based on site and environmental conditions, and on the structure and composition of the earth deposits. The appendix contains definitions, sets forth requirements, and describes acceptable visual and manual tests for use in classifying soils.

(2) *Application.* This appendix applies when a sloping or benching system is designed in accordance with the requirements set forth in § 1926.652(b)(2) as a method of protection for employees from cave-ins. This appendix also applies when timber shoring for excavations is designed as a method of protection from cave-ins in accordance with appendix C to subpart P of part 1926, and when aluminum hydraulic shoring is designed in accordance with appendix D. This Appendix also applies if other protective systems are designed and selected for use from data prepared in accordance with the requirements set forth in § 1926.652(c), and the use of the data is predicated on the use of the soil classification system set forth in this appendix.

(b) *Definitions.* The definitions and examples given below are based on, in whole or in part, the following: American Society for Testing Materials (ASTM) Standards D653–85 and D2488; The Unified Soils Classification System, The U.S. Department of Agriculture (USDA) Textural Classification Scheme; and The National Bureau of Standards Report BSS–121.

Cemented soil means a soil in which the particles are held together by a chemical agent, such as calcium carbonate, such that a hand-size sample cannot be crushed into powder or individual soil particles by finger pressure.

Cohesive soil means clay (fine grained soil), or soil with a high clay content, which has cohesive strength. Cohesive soil does not crumble, can be excavated with vertical sideslopes, and is plastic when moist. Cohesive soil is hard to break up when dry, and exhibits significant cohesion when submerged. Cohesive soils include clayey silt, sandy clay, silty clay, clay and organic clay.

Dry soil means soil that does not exhibit visible signs of moisture content.

Fissured means a soil material that has a tendency to break along definite planes of fracture with little resistance, or a material that exhibits open cracks, such as tension cracks, in an exposed surface.

Granular soil means gravel, sand, or silt, (coarse grained soil) with little or no clay content. Granular soil has no cohesive strength. Some moist granular soils exhibit apparent cohesion. Granular soil cannot be molded when moist and crumbles easily when dry.

Layered system means two or more distinctly different soil or rock types arranged in layers. Micaceous seams or weakened planes in rock or shale are considered layered.

Moist soil means a condition in which a soil looks and feels damp. Moist cohesive soil can easily be shaped into a ball and rolled into small diameter threads before crumbling. Moist granular soil that contains some cohesive material will exhibit signs of cohesion between particles.

Plastic means a property of a soil which allows the soil to be deformed or molded without cracking, or appreciable volume change.

Saturated soil means a soil in which the voids are filled with water. Saturation does not require flow. Saturation, or near saturation, is necessary for the proper use of instruments such as a pocket penetrometer or sheer vane.

Soil classification system means, for the purpose of this subpart, a method of categorizing soil and rock deposits in a hierarchy of Stable Rock, Type A, Type B, and Type C, in decreasing order of stability. The categories are determined based on an analysis of the properties and performance characteristics of the deposits and the environmental conditions of exposure.

Stable rock means natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.

Submerged soil means soil which is underwater or is free seeping.

Type A means cohesive soils with an unconfined compressive strength of 1.5 ton per square foot (tsf) (144 kPa) or greater. Examples of cohesive soils are: clay, silty clay, sandy clay, clay loam and, in some cases, silty clay loam and sandy clay loam. Cemented soils such as caliche and hardpan are also considered Type A. However, no soil is Type A if:

(i) The soil is fissured; or

(ii) The soil is subject to vibration from heavy traffic, pile driving, or similar effects; or

(iii) The soil has been previously disturbed; or

(iv) The soil is part of a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical (4H:1V) or greater; or

(v) The material is subject to other factors that would require it to be classified as a less stable material.

Type B means:

(i) Cohesive soil with an unconfined compressive strength greater than 0.5 tsf (48 kPa) but less than 1.5 tsf (144 kPa); or

(ii) Granular cohesionless soils including: angular gravel (similar to crushed rock), silt, silt loam, sandy loam and, in some cases, silty clay loam and sandy clay loam.

(iii) Previously disturbed soils except those which would otherwise be classed as Type C soil.

(iv) Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration; or

(v) Dry rock that is not stable; or

(vi) Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than four horizontal to one vertical (4H:1V), but only if the material would otherwise be classified as Type B.

Type C means:

(i) Cohesive soil with an unconfined compressive strength of 0.5 tsf (48 kPa) or less; or

(ii) Granular soils including gravel, sand, and loamy sand; or

(iii) Submerged soil or soil from which water is freely seeping; or

(iv) Submerged rock that is not stable, or

(v) Material in a sloped, layered system where the layers dip into the excavation or a slope of four horizontal to one vertical (4H:1V) or steeper.

Unconfined compressive strength means the load per unit area at which a soil will fail in compression. It can be determined by laboratory testing, or estimated in the field using a pocket penetrometer, by thumb penetration tests, and other methods.

Wet soil means soil that contains significantly more moisture than moist soil, but in such a range of values that cohesive material will slump or begin to flow when vibrated. Granular material that would exhibit cohesive properties when moist will lose those cohesive properties when wet.

(c) *Requirements*—(1) *Classification of soil and rock deposits.* Each soil and rock deposit shall be classified by a competent person as Stable Rock, Type A, Type B, or Type C in accordance with the definitions set forth in paragraph (b) of this appendix.

(2) *Basis of classification.* The classification of the deposits shall be made based on the results of at least one visual and at least one manual analysis. Such analyses

shall be conducted by a competent person using tests described in paragraph (d) below, or in other recognized methods of soil classification and testing such as those adopted by the America Society for Testing Materials, or the U.S. Department of Agriculture textural classification system.

(3) *Visual and manual analyses.* The visual and manual analyses, such as those noted as being acceptable in paragraph (d) of this appendix, shall be designed and conducted to provide sufficient quantitative and qualitative information as may be necessary to identify properly the properties, factors, and conditions affecting the classification of the deposits.

(4) *Layered systems.* In a layered system, the system shall be classified in accordance with its weakest layer. However, each layer may be classified individually where a more stable layer lies under a less stable layer.

(5) *Reclassification.* If, after classifying a deposit, the properties, factors, or conditions affecting its classification change in any way, the changes shall be evaluated by a competent person. The deposit shall be reclassified as necessary to reflect the changed circumstances.

(d) *Acceptable visual and manual tests.*—(1) *Visual tests.* Visual analysis is conducted to determine qualitative information regarding the excavation site in general, the soil adjacent to the excavation, the soil forming the sides of the open excavation, and the soil taken as samples from excavated material.

(i) Observe samples of soil that are excavated and soil in the sides of the excavation. Estimate the range of particle sizes and the relative amounts of the particle sizes. Soil that is primarily composed of fine-grained material is cohesive material. Soil composed primarily of coarse-grained sand or gravel is granular material.

(ii) Observe soil as it is excavated. Soil that remains in clumps when excavated is cohesive. Soil that breaks up easily and does not stay in clumps is granular.

(iii) Observe the side of the opened excavation and the surface area adjacent to the excavation. Crack-like openings such as tension cracks could indicate fissured material. If chunks of soil spall off a vertical side, the soil could be fissured. Small spalls are evidence of moving ground and are indications of potentially hazardous situations.

(iv) Observe the area adjacent to the excavation and the excavation itself for evidence of existing utility and other underground structures, and to identify previously disturbed soil.

(v) Observe the opened side of the excavation to identify layered systems. Examine layered systems to identify if the layers slope toward the excavation. Estimate the degree of slope of the layers.

(vi) Observe the area adjacent to the excavation and the sides of the opened excavation for evidence of surface water, water seeping from the sides of the excavation, or the location of the level of the water table.

(vii) Observe the area adjacent to the excavation and the area within the excavation for sources of vibration that may affect the stability of the excavation face.

(2) *Manual tests.* Manual analysis of soil samples is conducted to determine quantitative as well as qualitative properties of soil and to provide more information in order to classify soil properly.

(i) *Plasticity.* Mold a moist or wet sample of soil into a ball and attempt to roll it into threads as thin as ⅛-inch in diameter. Cohesive material can be successfully rolled into threads without crumbling. For example, if at least a two inch (50 mm) length of ⅛-inch thread can be held on one end without tearing, the soil is cohesive.

(ii) *Dry strength.* If the soil is dry and crumbles on its own or with moderate pressure into individual grains or fine powder, it is granular (any combination of gravel, sand, or silt). If the soil is dry and falls into clumps which break up into smaller clumps, but the smaller clumps can only be broken up with difficulty, it may be clay in any combination with gravel, sand or silt. If the dry soil breaks into clumps which do not break up into small clumps and which can only be broken with difficulty, and there is no visual indication the soil is fissured, the soil may be considered unfissured.

(iii) *Thumb penetration.* The thumb penetration test can be used to estimate the unconfined compressive strength of cohesive soils. (This test is based on the thumb penetration test described in American Society for Testing and Materials (ASTM) Standard designation D2488—"Standard Recommended Practice for Description of Soils (Visual—Manual Procedure).") Type A soils with an unconfined compressive strength of 1.5 tsf can be readily indented by the thumb; however, they can be penetrated by the thumb only with very great effort. Type C soils with an unconfined compressive strength of 0.5 tsf can be easily penetrated several inches by the thumb, and can be molded by light finger pressure. This test should be conducted on an undisturbed soil sample, such as a large clump of spoil, as soon as practicable after excavation to keep to a minimum the effects of exposure to drying influences. If the excavation is later exposed to wetting influences (rain, flooding), the classification of the soil must be changed accordingly.

(iv) *Other strength tests.* Estimates of unconfined compressive strength of soils can also be obtained by use of a pocket penetrometer or by using a hand-operated shearvane.

(v) *Drying test.* The basic purpose of the drying test is to differentiate between cohesive material with fissures, unfissured cohesive material, and granular material. The procedure for the drying test involves drying a sample of soil that is approximately one inch thick (2.54 cm) and six inches (15.24 cm) in diameter until it is thoroughly dry:

(A) If the sample develops cracks as it dries, significant fissures are indicated.

(B) Samples that dry without cracking are to be broken by hand. If considerable force is necessary to break a sample, the soil has significant cohesive material content. The soil can be classified as a unfissured cohesive material and the unconfined compressive strength should be determined.

(C) If a sample breaks easily by hand, it is either a fissured cohesive material or a granular material. To distinguish between the two, pulverize the dried clumps of the sample by hand or by stepping on them. If the clumps do not pulverize easily, the material is cohesive with fissures. If they pulverize easily into very small fragments, the material is granular.

Appendix B to Subpart P

Sloping and Benching

(a) *Scope and application.* This appendix contains specifications for sloping and benching when used as methods of protecting employees working in excavations from cave-ins. The requirements of this appendix apply when the design of sloping and benching protective systems is to be performed in accordance with the requirements set forth in § 1926.652(b)(2).

(b) *Definitions.*

Actual slope means the slope to which an excavation face is excavated.

Distress means that the soil is in a condition where a cave-in is imminent or is likely to occur. Distress is evidenced by such phenomena as the development of fissures in the face of or adjacent to an open excavation; the subsidence of the edge of an excavation; the slumping of material from the face or the bulging or heaving of material from the bottom of an excavation; the spalling of material from the face of an excavation; and ravelling, i.e., small amounts of material such as pebbles or little clumps of material suddenly separating from the face of an excavation and trickling or rolling down into the excavation.

Maximum allowable slope means the steepest incline of an excavation face that is acceptable for the most favorable site conditions as protection against cave-ins, and is expressed as the ratio of horizontal distance to vertical rise (H:V).

Short term exposure means a period of time less than or equal to 24 hours that an excavation is open.

(c) *Requirements*—(1) *Soil classification.* Soil and rock deposits shall be classified in accordance with appendix A to subpart P of part 1926.

(2) *Maximum allowable slope.* The maximum allowable slope for a soil or rock deposit shall be determined from Table B-1 of this appendix.

(3) *Actual slope.* (i) The actual slope shall not be steeper than the maximum allowable slope.

(ii) The actual slope shall be less steep than the maximum allowable slope, when there are signs of distress. If that situation occurs, the slope shall be cut back to an actual slope which is at least ½ horizontal to one vertical (½H:1V) less steep than the maximum allowable slope.

(iii) When surcharge loads from stored material or equipment, operating equipment, or traffic are present, a competent person shall determine the degree to which the actual slope must be reduced below the maximum allowable slope, and shall assure that such reduction is achieved. Surcharge loads from adjacent structures shall be evaluated in accordance with § 1926.651(i).

(4) *Configurations.* Configurations of sloping and benching systems shall be in accordance with Figure B-1.

TABLE B-1

MAXIMUM ALLOWABLE SLOPES

SOIL OR ROCK TYPE	MAXIMUM ALLOWABLE SLOPES (H:V) [1] FOR EXCAVATIONS LESS THAN 20 FEET DEEP [3]
STABLE ROCK	VERTICAL (90°)
TYPE A [2]	3/4 : 1 (53°)
TYPE B	1:1 (45°)
TYPE C	1½: 1 (34°)

NOTES:

1. Numbers shown in parentheses next to maximum allowable slopes are angles expressed in degrees from the horizontal. Angles have been rounded off.
2. A short-term maximum allowable slope of 1/2H:1V (63°) is allowed in excavations in Type A soil that are 12 feet (3.67 m) or less in depth. Short-term maximum allowable slopes for excavations greater than 12 feet (3.67 m) in depth shall be 3/4H:1V (53°).
3. Sloping or benching for excavations greater than 20 feet deep shall be designed by a registered professional engineer.

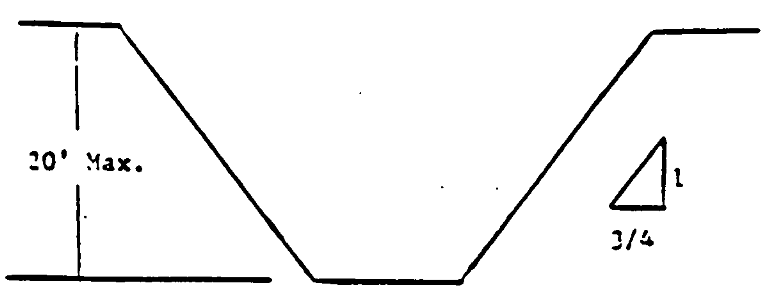
Figure B-1

Slope Configurations

(All slopes stated below are in the horizontal to vertical ratio)

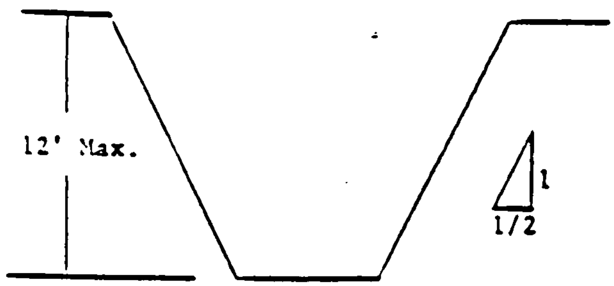
B-1.1 Excavations made in Type A soil.

1. All simple slope excavation 20 feet or less in depth shall have a maximum allowable slope of ¾:1.



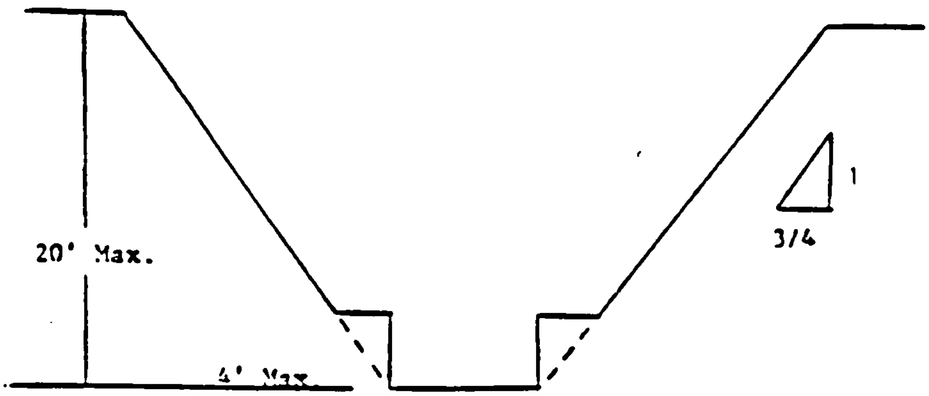
Simple Slope—General

Exception: Simple slope excavations which are open 24 hours or less (short term) and which are 12 feet or less in depth shall have a maximum allowable slope of ½:1.

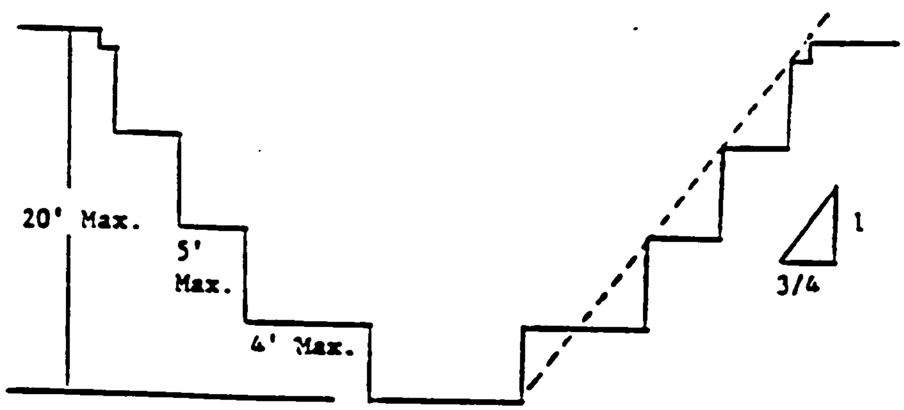


Simple Slope—Short Term

2. All benched excavations 20 feet or less in depth shall have a maximum allowable slope of ¾ to 1 and maximum bench dimensions as follows:

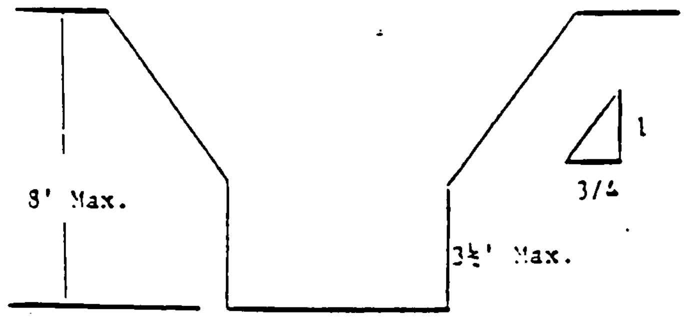


Simple Bench



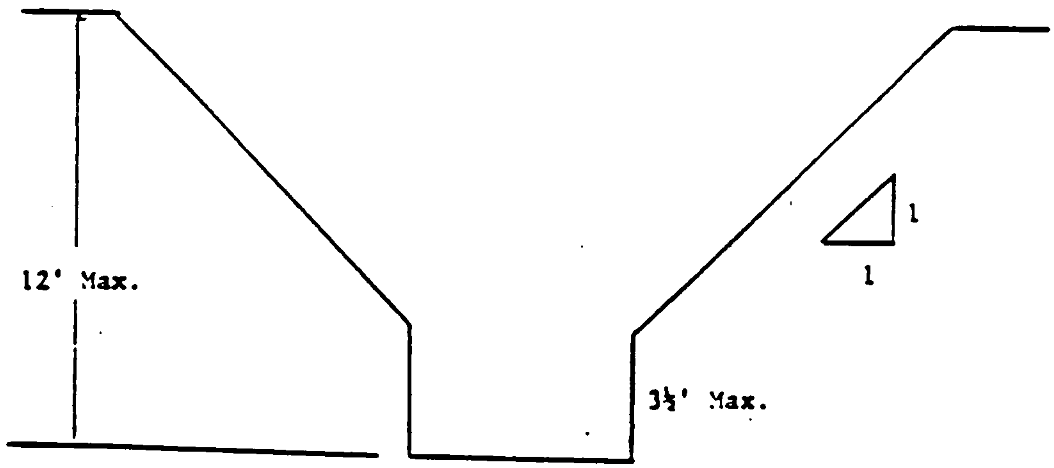
Multiple Bench

3. All excavations 8 feet or less in depth which have unsupported vertically sided lower portions shall have a maximum vertical side of 3½ feet.



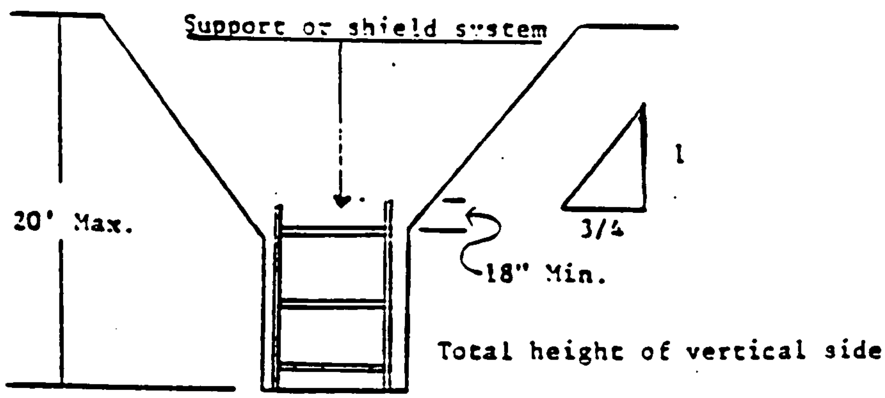
Unsupported Vertically Sided Lower Portion—Maximum 8 Feet in Depth

All excavations more than 8 feet but not more than 12 feet in depth which unsupported vertically sided lower portions shall have a maximum allowable slope of 1:1 and a maximum vertical side of 3½ feet.



Unsupported Vertically Sided Lower Portion—Maximum 12 Feet in Depth

All excavations 20 feet or less in depth which have vertically sided lower portions that are supported or shielded shall have a maximum allowable slope of ¾:1. The support or shield system must extend at least 18 inches above the top of the vertical side.

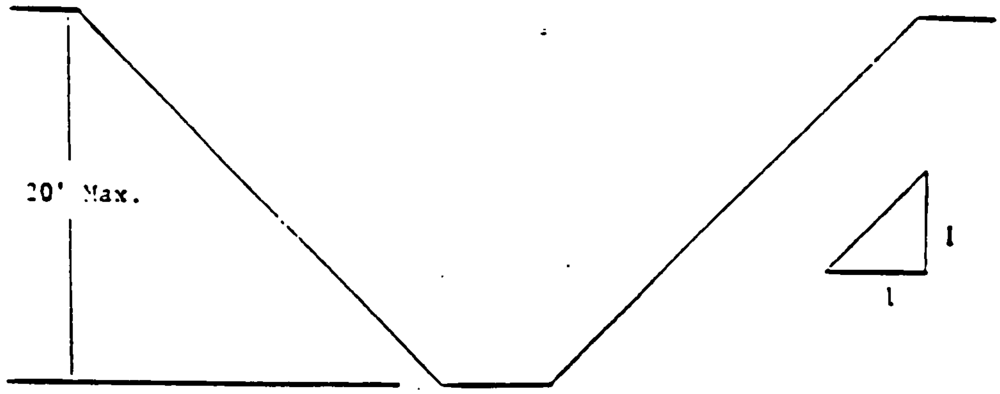


Suported or Shielded Vertically Sided Lower Portion

4. All other simple slope, compound slope, and vertically sided lower portion excavations shall be in accordance with the other options permitted under § 1926.652(b).

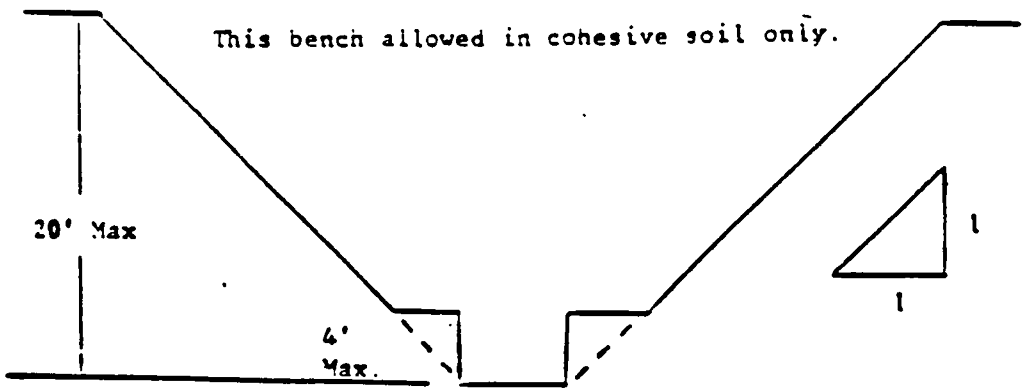
B-1.2 Excavations Made in Type B Soil

1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1.

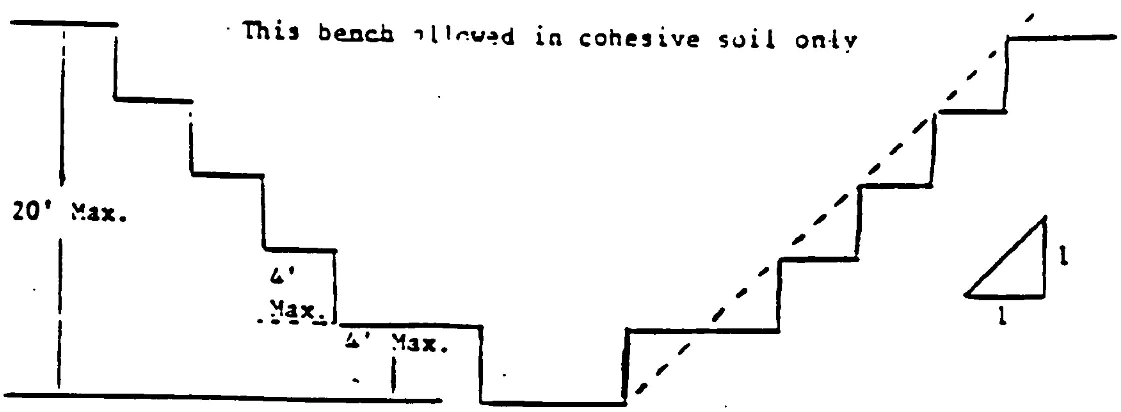


Simple Slope

2. All benched excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1 and maximum bench dimensions as follows:

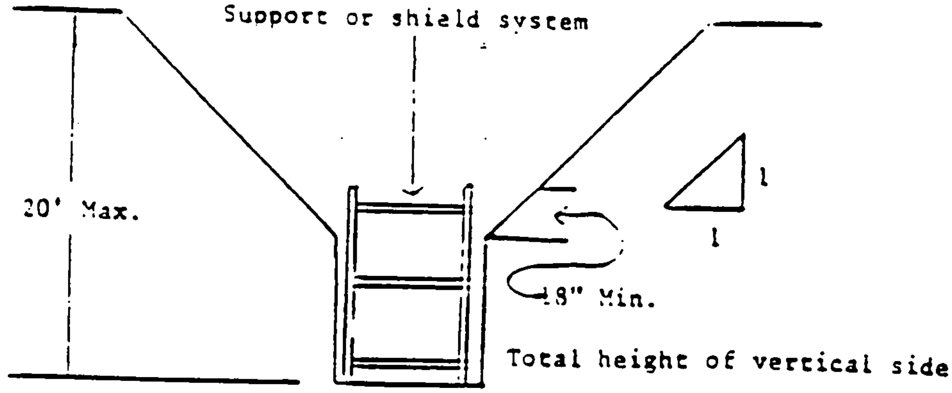


Single Bench



Multiple Bench

3. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1:1.

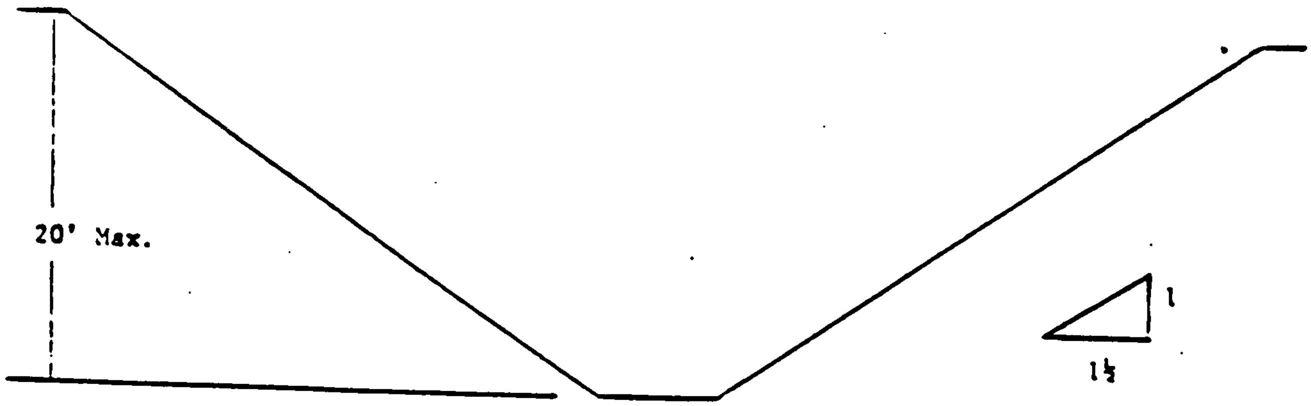


Vertically Sided Lower Portion

4. All other sloped excavations shall be in accordance with the other options permitted in § 1926.652(b).

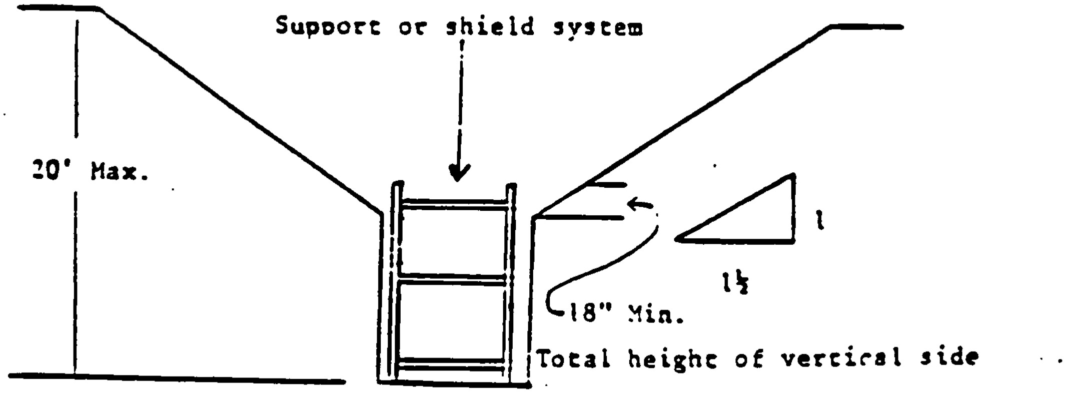
B-1.3 Excavations Made in Type C Soil

1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 1½:1.



Simple Slope

2. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1½:1.

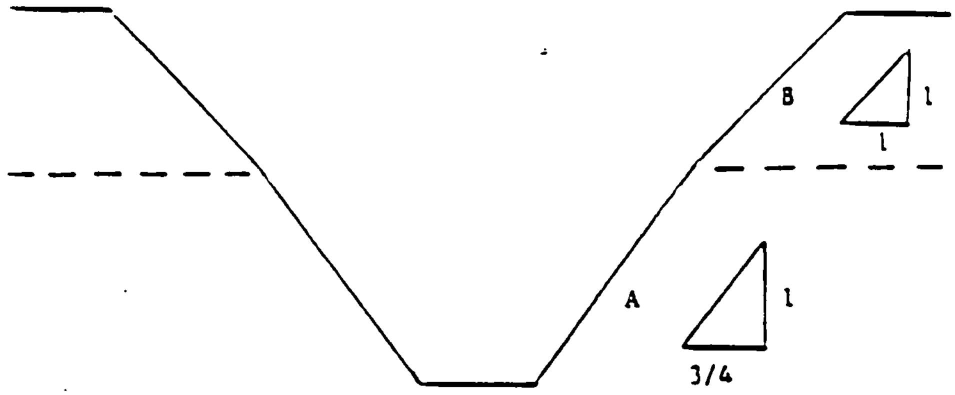


Vertical Sided Lower Portion

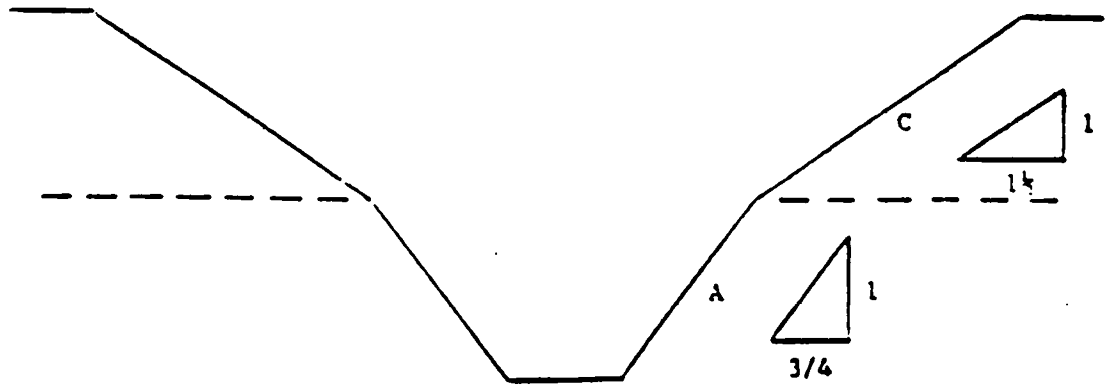
3. All other sloped excavations shall be in accordance with the other options permitted in § 1926.652(b).

B-1.4 Excavations Made in Layered Soils

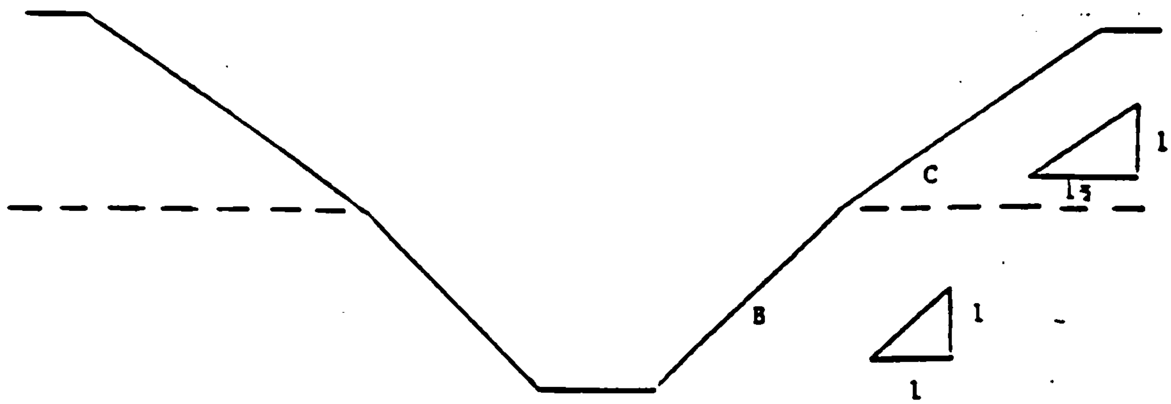
1. All excavations 20 feet or less in depth made in layered soils shall have a maximum allowable slope for each layer as set forth below.



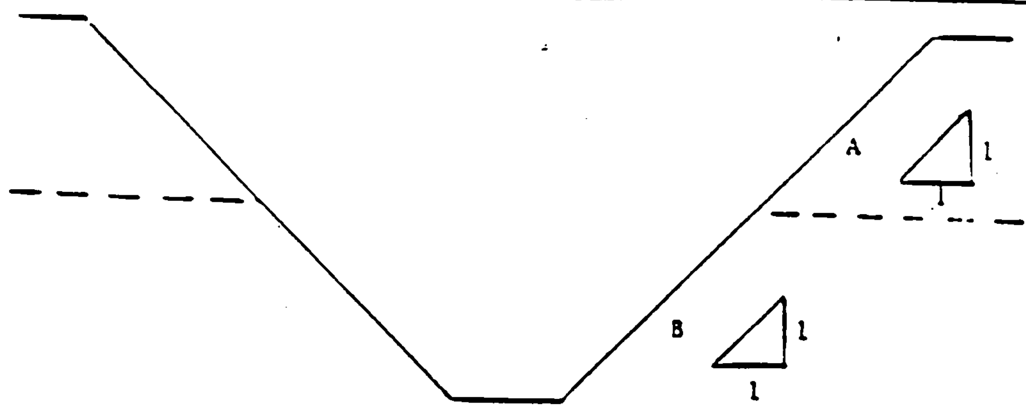
B OVER A



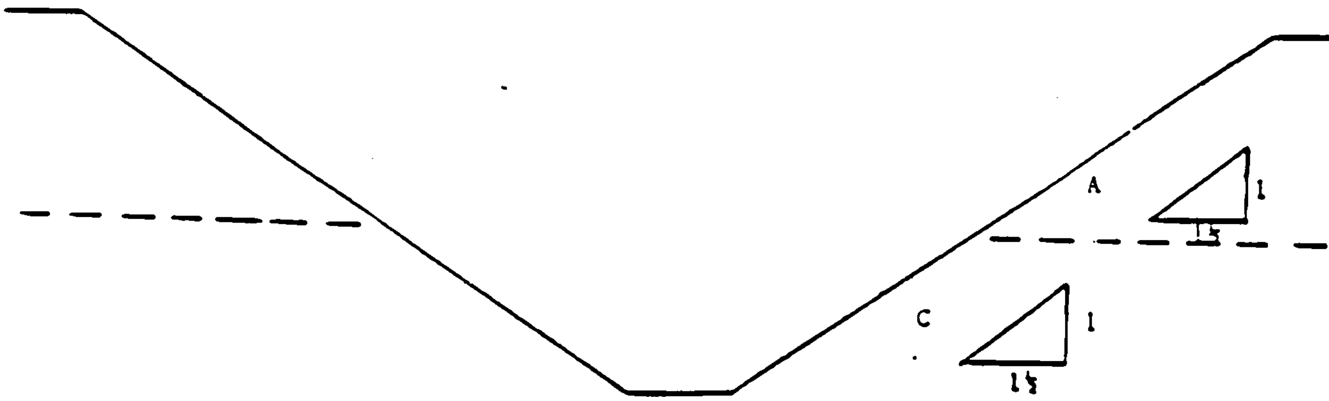
C OVER A



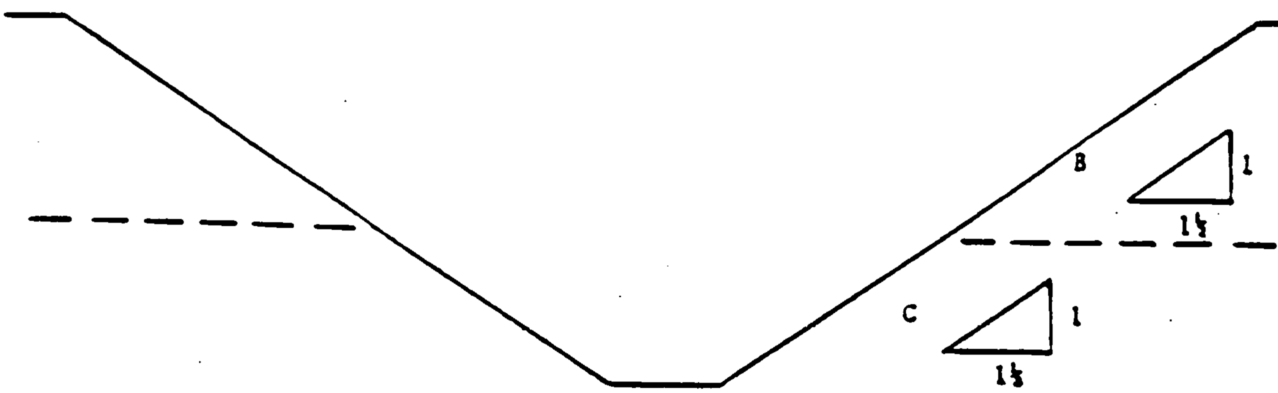
C OVER B



A OVER B



A OVER C



B OVER C

2. All other sloped excavations shall be in accordance with the other options permitted in § 1926.652(b).

Appendix C to Subpart P

Timber Shoring for Trenches

(a) *Scope.* This appendix contains information that can be used timber shoring is provided as a method of protection from cave-ins in trenches that do not exceed 20 feet (6.1 m) in depth. This appendix must be used when design of timber shoring protective systems is to be performed in accordance with § 1926.652(c)(1). Other timber shoring configurations; other systems of support such as hydraulic and pneumatic systems; and other protective systems such as sloping, benching, shielding, and freezing systems must be designed in accordance with the requirements set forth in § 1926.652(b) and § 1926.652(c).

(b) *Soil Classification.* In order to use the data presented in this appendix, the soil type or types in which the excavation is made must first be determined using the soil classification method set forth in appendix A of subpart P of this part.

(c) *Presentation of Information.* Information is presented in several forms as follows:

(1) Information is presented in tabular form in Tables C–1.1, C–1.2, and C–1.3, and Tables C–2.1, C–2.2 and C–2.3 following paragraph (g) of the appendix. Each table presents the minimum sizes of timber members to use in a shoring system, and each table contains data only for the particular soil type in which the excavation or portion of the excavation is made. The data are arranged to allow the user the flexibility to select from among several acceptable configurations of members based on varying the horizontal spacing of the crossbraces. Stable rock is exempt from shoring requirements and therefore, no data are presented for this condition.

(2) Information concerning the basis of the tabular data and the limitations of the data is presented in paragraph (d) of this appendix, and on the tables themselves.

(3) Information explaining the use of the tabular data is presented in paragraph (e) of this appendix.

(4) Information illustrating the use of the tabular data is presented in paragraph (f) of this appendix.

(5) Miscellaneous notations regarding Tables C–1.1 through C–1.3 and Tables C–2.1 through C–2.3 are presented in paragraph (g) of this Appendix.

(d) *Basis and limitations of the data.*—(1) *Dimensions of timber members.* (i) The sizes of the timber members listed in Tables C–1.1 through C–1.3 are taken from the National Bureau of Standards (NBS) report, "Recommended Technical Provisions for Construction Practice in Shoring and Sloping of Trenches and Excavations." In addition, where NBS did not recommend specific sizes of members, member sizes are based on an analysis of the sizes required for use by existing codes and on empirical practice.

(ii) The required dimensions of the members listed in Tables C–1.1 through C–1.3 refer to actual dimensions and not nominal dimensions of the timber. Employers wanting to use nominal size shoring are directed to Tables C–2.1 through C–2.3, or have this choice under § 1926.652(c)(3), and are referred to The Corps of Engineers, The Bureau of Reclamation or data from other acceptable sources.

(2) *Limitation of application.* (i) It is not intended that the timber shoring specification apply to every situation that may be experienced in the field. These data were developed to apply to the situations that are most commonly experienced in current trenching practice. Shoring systems for use in situations that are not covered by the data in this appendix must be designed as specified in § 1926.652(c).

(ii) When any of the following conditions are present, the members specified in the tables are not considered adequate. Either an alternate timber shoring system must be designed or another type of protective system designed in accordance with § 1926.652.

(A) When loads imposed by structures or by stored material adjacent to the trench weigh in excess of the load imposed by a two-foot soil surcharge. The term "adjacent" as used here means the area within a horizontal distance from the edge of the trench equal to the depth of the trench.

(B) When vertical loads imposed on cross braces exceed a 240-pound gravity load distributed on a one-foot section of the center of the crossbrace.

(C) When surcharge loads are present from equipment weighing in excess of 20,000 pounds.

(D) When only the lower portion of a trench is shored and the remaining portion of the trench is sloped or benched unless: The sloped portion is sloped at an angle less steep than three horizontal to one vertical; or the members are selected from the tables for use at a depth which is determined from the top of the overall trench, and not from the toe of the sloped portion.

(e) *Use of Tables.* The members of the shoring system that are to be selected using this information are the cross braces, the uprights, and the wales, where wales are required. Minimum sizes of members are specified for use in different types of soil. There are six tables of information, two for each soil type. The soil type must first be determined in accordance with the soil classification system described in appendix A to subpart P of part 1926. Using the appropriate table, the selection of the size and spacing of the members is then made. The selection is based on the depth and width of the trench where the members are to be installed and, in most instances, the selection is also based on the horizontal spacing of the crossbraces. Instances where a choice of horizontal spacing of crossbracing is available, the horizontal spacing of the crossbraces must be chosen by the user before the size of any member can be determined. When the soil type, the width and depth of the trench, and the horizontal spacing of the crossbraces are known, the size and vertical spacing of the crossbraces, the size and vertical spacing of the wales, and the size and horizontal spacing of the uprights can be read from the appropriate table.

(f) *Examples to Illustrate the Use of Tables C–1.1 through C–1.3.*

(1) *Example 1.*

A trench dug in Type A soil is 13 feet deep and five feet wide.

From *Table C–1.1*, for acceptable arrangements of timber can be used.

Arrangement #1

Space 4×4 crossbraces at six feet horizontally and four feet vertically.

Wales are not required.

Space 3×8 uprights at six feet horizontally. This arrangement is commonly called "skip shoring."

Arrangement #2

Space 4×6 crossbraces at eight feet horizontally and four feet vertically.

Space 8×8 wales at four feet vertically.

Space 2×6 uprights at four feet horizontally.

Arrangement #3

Space 6×6 crossbraces at 10 feet horizontally and four feet vertically.

Space 8×10 wales at four feet vertically.

Space 2×6 uprights at five feet horizontally.

Arrangement #4

Space 6×6 crossbraces at 12 feet horizontally and four feet vertically.

Space 10×10 wales at four feet vertically.

Spaces 3×8 uprights at six feet horizontally.

(2) *Example 2.*

A trench dug in Type B soil in 13 feet deep and five feet wide. From Table C–1.2 three acceptable arrangements of members are listed.

Arrangement #1

Space 6×6 crossbraces at six feet horizontally and five feet vertically.

Space 8×8 wales at five feet vertically.

Space 2×6 uprights at two feet horizontally.

Arrangement #2

Space 6×8 crossbraces at eight feet horizontally and five feet vertically.

Space 10×10 wales at five feet vertically.

Space 2×6 uprights at two feet horizontally.

Arrangement #3

Space 8×8 crossbraces at 10 feet horizontally and five feet vertically.

Space 10×12 wales at five feet vertically.

Space 2×6 uprights at two feet vertically.

(3) *Example 3.*

A trench dug in Type C soil is 13 feet deep and five feet wide.

From Table C–1.3 two acceptable arrangements of members can be used.

Arrangement #1

Space 8×8 crossbraces at six feet horizontally and five feet vertically.

Space 10×12 wales at five feet vertically.

Position 2×6 uprights as closely together as possible.

If water must be retained use special tongue and groove uprights to form tight sheeting.

Arrangement #2

Space 8×10 crossbraces at eight feet horizontally and five feet vertically.

Space 12×12 wales at five feet vertically.

Position 2×6 uprights in a close sheeting configuration unless water pressure must be resisted. Tight sheeting must be used where water must be retained.

(4) *Example 4.*

A trench dug in Type C soil is 20 feet deep and 11 feet wide. The size and spacing of members for the section of trench that is over 15 feet in depth is determined using Table C–1.3. Only one arrangement of members is provided.

Space 8×10 crossbraces at six feet horizontally and five feet vertically.

Space 12×12 wales at five feet vertically.

Use 3×6 tight sheeting.

Use of Tables C–2.1 through C–2.3 would follow the same procedures.

(g) *Notes for all Tables.*

1. Member sizes at spacings other than indicated are to be determined as specified in § 1926.652(c), "Design of Protective Systems."

2. When conditions are saturated or submerged use Tight Sheeting. Tight Sheeting refers to the use of specially-edged timber planks (e.g., tongue and groove) at least three inches thick, steel sheet piling, or similar construction that when driven or placed in position provide a tight wall to resist the lateral pressure of water and to prevent the loss of backfill material. Close Sheeting refers to the placement of planks side-by-side allowing as little space as possible between them.

3. All spacing indicated is measured center to center.

4. Wales to be installed with greater dimension horizontal.

5. If the vertical distance from the center of the lowest crossbrace to the bottom of the trench exceeds two and one-half feet, uprights shall be firmly embedded or a mudsill shall be used. Where uprights are embedded, the vertical distance from the center of the lowest crossbrace to the bottom of the trench shall not exceed 36 inches. When mudsills are used, the vertical distance shall not exceed 42 inches. Mudsills are wales that are installed at the toe of the trench side.

6. Trench jacks may be used in lieu of or in combination with timber crossbraces.

7. Placement of crossbraces. When the vertical spacing of crossbraces is four feet, place the top crossbrace no more than two feet below the top of the trench. When the vertical spacing of crossbraces is five feet, place the top crossbrace no more than 2.5 feet below the top of the trench.

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TABLE C-1.1

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE A P_a = 25 X H + 72 psf (2 ft Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS **													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	4	5	6	8
5 TO 10	UP TO 6	4X4	4X4	4X6	6X6	6X6	4	Not Req'd	---				2X6	
	UP TO 8	4X4	4X4	4X6	6X6	6X6	4	Not Req'd	---					2X8
	UP TO 10	4X6	4X6	4X6	6X6	6X6	4	8X8	4			2X6		
	UP TO 12	4X6	4X6	6X6	6X6	6X6	4	8X8	4				2X6	
10 TO 15	UP TO 6	4X4	4X4	4X6	6X6	6X6	4	Not Req'd	---				3X8	
	UP TO 8	4X6	4X6	6X6	6X6	6X6	4	8X8	4		2X6			
	UP TO 10	6X6	6X6	6X6	6X8	6X8	4	8X10	4			2X6		
	UP TO 12	6X6	6X6	6X6	6X8	6X8	4	10X10	4				3X8	
15 TO 20	UP TO 6	6X6	6X6	6X6	6X8	6X8	4	6X8	4	3X6				
	UP TO 8	6X6	6X6	6X6	6X8	6X8	4	8X8	4	3X6				
	UP TO 10	8X8	8X8	8X8	8X8	8X10	4	8X10	4	3X6				
	UP TO 12	8X8	8X8	8X8	8X8	8X10	4	10X10	4	3X6				
OVER 20	SEE NOTE 1													

* Mixed oak or equivalent with a bending strength not less than 850 psi.

** Manufactured members of equivalent strength may by substituted for wood.

TABLE C-1.2

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE B $P_a = 45 \times H + 72$ psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS**													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	2	3		
5 TO 10	UP TO 6	4X6	4X6	6X6	6X6	6X6	5	6X8	5			2X6		
	UP TO 8	6X6	6X6	6X6	6X8	6X8	5	8X10	5			2X6		
	UP TO 10	6X6	6X6	6X6	6X8	6X8	5	10X10	5			2X6		
	See Note 1													
10 TO 15	UP TO 6	6X6	6X6	6X6	6X8	6X8	5	8X8	5		2X6			
	UP TO 8	6X8	6X8	6X8	8X8	8X8	5	10X10	5		2X6			
	UP TO 10	8X8	8X8	8X8	8X8	8X10	5	10X12	5		2X6			
	See Note 1													
15 TO 20	UP TO 6	6X8	6X8	6X8	8X8	8X8	5	8X10	5	3X6				
	UP TO 8	8X8	8X8	8X8	8X8	8X10	5	10X12	5	3X6				
	UP TO 10	8X10	8X10	8X10	8X10	10X10	5	12X12	5	3X6				
	See Note 1													
OVER 20	SEE NOTE 1													

* Mixed oak or equivalent with a bending strength not less than 850 psi.
** Manufactured members of equivalent strength may by substituted for wood.

TABLE C-1.3

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE C P_a = 80 X H + 72 psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS**														
	CROSS BRACES									UPRIGHTS					
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)			MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET) (See Note 2)					
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15		SIZE (IN)	VERT. SPACING (FEET)	CLOSE					
5 TO 10	UP TO 6	6X8	6X8	6X8	8X8	8X8	5	8X10	5	2X6					
	UP TO 8	8X8	8X8	8X8	8X8	8X10	5	10X12	5	2X6					
	UP TO 10	8X10	8X10	8X10	8X10	10X10	5	12X12	5	2X6					
	See Note 1														
10 TO 15	UP TO 6	8X8	8X8	8X8	8X8	8X10	5	10X12	5	2X6					
	UP TO 8	8X10	8X10	8X10	8X10	10X10	5	12X12	5	2X6					
	See Note 1														
	See Note 1														
15 TO 20	UP TO 6	8X10	8X10	8X10	8X10	10X10	5	12X12	5	3X6					
	See Note 1														
	See Note 1														
	See Note 1														
OVER 20	SEE NOTE 1														

* Mixed Oak or equivalent with a bending strength not less than 850 psi.
** Manufactured members of equivalent strength may be substituted for wood.

TABLE C-2.1

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE A P_a = 25 X H + 72 psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (S4S) AND SPACING OF MEMBERS **													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	4	5	6	8
5 TO 10	UP TO 6	4X4	4X4	4X4	4X4	4X6	4	Not Req'd	Not Req'd				4X6	
	UP TO 8	4X4	4X4	4X4	4X6	4X6	4	Not Req'd	Not Req'd					4X8
	UP TO 10	4X6	4X6	4X6	6X6	6X6	4	8X8	4			4X6		
	UP TO 12	4X6	4X6	4X6	6X6	6X6	4	8X8	4				4X6	
10 TO 15	UP TO 6	4X4	4X4	4X4	6X6	6X6	4	Not Req'd	Not Req'd				4X10	
	UP TO 8	4X6	4X6	4X6	6X6	6X6	4	6X8	4		4X6			
	UP TO 10	6X6	6X6	6X6	6X6	6X6	4	8X8	4			4X8		
	UP TO 12	6X6	6X6	6X6	6X6	6X6	4	8X10	4		4X6		4X10	
15 TO 20	UP TO 6	6X6	6X6	6X6	6X6	6X6	4	6X8	4	3X6				
	UP TO 8	6X6	6X6	6X6	6X6	6X6	4	8X8	4	3X6	4X12			
	UP TO 10	6X6	6X6	6X6	6X6	6X8	4	8X10	4	3X6				
	UP TO 12	6X6	6X6	6X6	6X8	6X8	4	8X12	4	3X6	4X12			
OVER 20	SEE NOTE 1													

* Douglas fir or equivalent with a bending strength not less than 1500 psi.
** Manufactured members of equivalent strength may be substituted for wood.

TABLE C-2.2

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE B P_a = 45 X H + 72 psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (S4S) AND SPACING OF MEMBERS **													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	2	3	4	6
5 TO 10	UP TO 6	4X6	4X6	4X6	6X6	6X6	5	6X8	5			3X12 4X8		4X12
	UP TO 8	4X6	4X6	6X6	6X6	6X6	5	8X8	5		3X8		4X8	
	UP TO 10	4X6	4X6	6X6	6X6	6X8	5	8X10	5			4X8		
	See Note 1													
10 TO 15	UP TO 6	6X6	6X6	6X6	6X8	6X8	5	8X8	5	3X6	4X10			
	UP TO 8	6X8	6X8	6X8	8X8	8X8	5	10X10	5	3X6	4X10			
	UP TO 10	6X8	6X8	8X8	8X8	8X8	5	10X12	5	3X6	4X10			
	See Note 1													
15 TO 20	UP TO 6	6X8	6X8	6X8	6X8	8X8	5	8X10	5	4X6				
	UP TO 8	6X8	6X8	6X8	8X8	8X8	5	10X12	5	4X6				
	UP TO 10	8X8	8X8	8X8	8X8	8X8	5	12X12	5	4X6				
	See Note 1													
OVER 20	SEE NOTE 1													

* Douglas fir or equivalent with a bending strength not less than 1500 psi.

** Manufactured members of equivalent strength may be substituted for wood.

TABLE C-2.3

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE C $P_a = 80 \times H + 72$ psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (S4S) AND SPACING OF MEMBERS **													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE				
5 TO 10	UP TO 6	6X6	6X6	6X6	6X6	8X8	5	8X8	5	3X6				
	UP TO 8	6X6	6X6	6X6	8X8	8X8	5	10X10	5	3X6				
	UP TO 10	6X6	6X6	8X8	8X8	8X8	5	10X12	5	3X6				
	See Note 1													
10 TO 15	UP TO 6	6X8	6X8	6X8	8X8	8X8	5	10X10	5	4X6				
	UP TO 8	8X8	8X8	8X8	8X8	8X8	5	12X12	5	4X6				
	See Note 1													
	See Note 1													
15 TO 20	UP TO 6	8X8	8X8	8X8	8X10	8X10	5	10X12	5	4X6				
	See Note 1													
	See Note 1													
	See Note 1													
OVER 20	SEE NOTE 1													

* Douglas fir or equivalent with a bending strength not less than 1500 psi.

** Manufactured members of equivalent strength may be substituted for wood.

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Appendix D to Subpart P

Aluminum Hydraulic Shoring for Trenches

(a) *Scope.* This appendix contains information that can be used when aluminum hydraulic shoring is provided as a method of protection against cave-ins in trenches that do not exceed 20 feet (6.1m) in depth. This appendix must be used when design of the aluminum hydraulic protective system cannot be performed in accordance with § 1926.652(c)(2).

(b) *Soil Classification.* In order to use data presented in this appendix, the soil type or types in which the excavation is made must first be determined using the soil classification method set forth in appendix A of subpart P of part 1926.

(c) *Presentation of Information.* Information is presented in several forms as follows:

(1) Information is presented in tabular form in Tables D–1.1, D–1.2, D–1.3 and E–1.4. Each table presents the maximum vertical and horizontal spacings that may be used with various aluminum member sizes and various hydraulic cylinder sizes. Each table contains data only for the particular soil type in which the excavation or portion of the excavation is made. Tables D–1.1 and D–1.2 are for vertical shores in Types A and B soil. Tables D–1.3 and D1.4 are for horizontal waler systems in Types B and C soil.

(2) Information concerning the basis of the tabular data and the limitations of the data is presented in paragraph (d) of this appendix.

(3) Information explaining the use of the tabular data is presented in paragraph (e) of this appendix.

(4) Information illustrating the use of the tabular data is presented in paragraph (f) of this appendix.

(5) Miscellaneous notations (footnotes) regarding Table D–1.1 through D–1.4 are presented in paragraph (g) of this appendix.

(6) Figures, illustrating typical installations of hydraulic shoring, are included just prior to the Tables. The illustrations page is entitled "Aluminum Hydraulic Shoring; Typical Installations."

(d) *Basis and limitations of the data.*

(1) Vertical shore rails and horizontal wales are those that meet the Section Modulus requirements in the D–1 Tables. Aluminum material is 6061–T6 or material of equivalent strength and properties.

(2) Hydraulic cylinders specifications. (i) 2-inch cylinders shall be a minimum 2-inch inside diameter with a minimum safe working capacity of no less than 18,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufaturer.

(ii) 3-inch cylinders shall be a minimum 3-inch inside diameter with a safe working capacity of not less than 30,000 pounds axial compressive load at extensions as recommended by product manufacturer.

(3) Limitation of application.

(i) It is not intended that the aluminum hydraulic specification apply to every situation that may be experienced in the field. These data were developed to apply to the situations that are most commonly experienced in current trenching practice. Shoring systems for use in situations that are not covered by the data in this appendix must be otherwise designed as specified in § 1926.652(c).

(ii) When any of the following conditions are present, the members specified in the Tables are not considered adequate. In this case, an alternative aluminum hydraulic shoring system or other type of protective system must be designed in accordance with § 1926.652.

(A) When vertical loads imposed on cross braces exceed a 100 Pound gravity load distributed on a one foot section of the center of the hydraulic cylinder.

(B) When surcharge loads are present from equipment weighing in excess of 20,000 pounds.

(C) When only the lower portion or a trench is shored and the remaining portion of the trench is sloped or benched unless: The sloped portion is sloped at an angle less steep than three horizontal to one vertical; or the members are selected from the tables for use at a depth which is determined from the top of the overall trench, and not from the toe of the sloped portion.

(e) *Use of Tables D–1.1, D–1.2, D–1.3 and D–1.4.* The members of the shoring system that are to be selected using this information are the hydraulic cylinders, and either the vertical shores or the horizontal wales. When a waler system is used the vertical timber sheeting to be used is also selected from these tables. The Tables D–1.1 and D–1.2 for vertical shores are used in Type A and B soils that do not require sheeting. Type B soils that may require sheeting, and Type C soils that always require sheeting are found in the horizontal wale Tables D–1.3 and D–1.4. The soil type must first be determined in accordance with the soil classification system described in appendix A to subpart P of part 1926. Using the appropriate table, the selection of the size and spacing of the members is made. The selection is based on the depth and width of the trench where the members are to be installed. In these tables the vertical spacing is held constant at four feet on center. The tables show the maximum horizontal spacing of cylinders allowed for each size of wale in the waler system tables, and in the vertical shore tables, the hydraulic cylinder horizontal spacing is the same as the vertical shore spacing.

(f) *Example to Illustrate the Use of the Tables:*

(1) Example 1:

A trench dug in Type A soil is 6 feet deep and 3 feet wide. From Table D–1.1: Find vertical shores and 2 inch diameter cylinders spaced 8 feet on center (o.c.) horizontally and 4 feet on center (o.c.) vertically. (See Figures 1 & 3 for typical installations.)

(2) Example 2:

A trench is dug in Type B soil that does not require sheeting, 13 feet deep and 5 feet wide. From Table D–1.2: Find vertical shores and 2 inch diameter cylinders spaced 6.5 feet o.c. horizontally and 4 feet o.c. vertically. (See Figures 1 & 3 for typical installations.)

(3) A trench is dug in Type B soil that does not require sheeting, but does experience some minor raveling of the trench face. The trench is 16 feet deep and 9 feet wide. From Table D–1.2: Find vertical shores and 2 inch diameter cylinder (with special oversleeves as designated by footnote #2) spaced 5.5 feet o.c. horizontally and 4 feet o.c. vertically. plywood (per footnote (g)(7) to the D–1 Table) should be used behind the shores. (See Figures 2 & 3 for typical installations.)

(4) Example 4: A trench is dug in previously disturbed Type B soil, with characteristics of a Type C soil, and will require sheeting. The trench is 18 feet deep and 12 feet wide. 8 foot horizontal spacing between cylinders is desired for working space. From Table D–1.3: Find horizontal wale with a section modulus of 14.0 spaced at 4 feet o.c. vertically and 3 inch diameter cylinder spaced at 9 feet maximum o.c. horizontally. 3×12 timber sheeting is required at close spacing vertically. (See Figure 4 for typical installation.)

(5) Example 5: A trench is dug in Type C soil, 9 feet deep and 4 feet wide. Horizontal cylinder spacing in excess of 6 feet is desired for working space. From Table D–1.4: Find horizontal wale with a section modulus of 7.0 and 2 inch diameter cylinders spaced at 6.5 feet o.c. horizontally. Or, find horizontal wale with a 14.0 section modulus and 3 inch diameter cylinder spaced at 10 feet o.c. horizontally. Both wales are spaced 4 feet o.c. vertically. 3×12 timber sheeting is required at close spacing vertically. (See Figure 4 for typical installation.)

(g) *Footnotes, and general notes, for Tables D–1.1, D–1.2, D–1.3, and D–1.4.*

(1) For applications other than those listed in the tables, refer to § 1926.652(c)(2) for use of manufacturer's tabulated data. For trench depths in excess of 20 feet, refer to § 1926.652(c)(2) and § 1926.652(c)(3).

(2) 2 inch diameter cylinders, at this width, shall have structural steel tube (3.5×3.5×0.1875) oversleeves, or structural oversleeves of manufacturer's specification, extending the full, collapsed length.

(3) Hydraulic cylinders capacities. (i) 2 inch cylinders shall be a minimum 2-inch inside diameter with a safe working capacity of not less than 18,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.

(ii) 3-inch cylinders shall be a minimum 3-inch inside diameter with a safe work capacity of not less than 30,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.

(4) All spacing indicated is measured center to center.

(5) Vertical shoring rails shall have a minimum section modulus of 0.40 inch.

(6) When vertical shores are used, there must be a minimum of three shores spaced equally, horizontally, in a group.

(7) Plywood shall be 1.125 in. thick softwood or 0.75 inch. thick, 14 ply, arctic white birch (Finland form). Please note that plywood is not intended as a structural member, but only for prevention of local raveling (sloughing of the trench face) between shores.

(8) See appendix C for timber specifications.

(9) Wales are calculated for simple span conditions.

(10) See appendix D, item (d), for basis and limitations of the data.

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ALUMINUM HYDRAULIC SHORING
TYPICAL INSTALLATIONS

FIGURE NO. 1
VERTICAL ALUMINUM HYDRAULIC SHORING (SPOT BRACING)

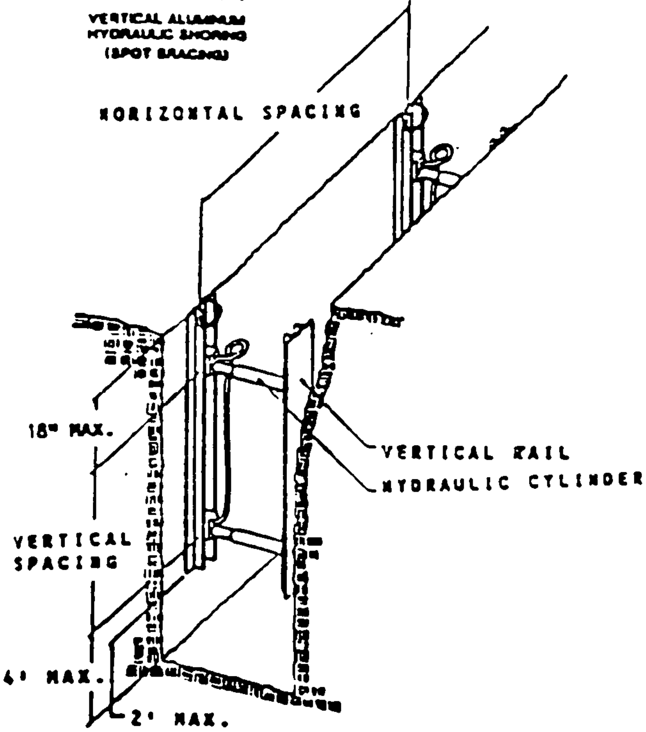

FIGURE NO. 2
VERTICAL ALUMINUM HYDRAULIC SHORING (WITH PLYWOOD)

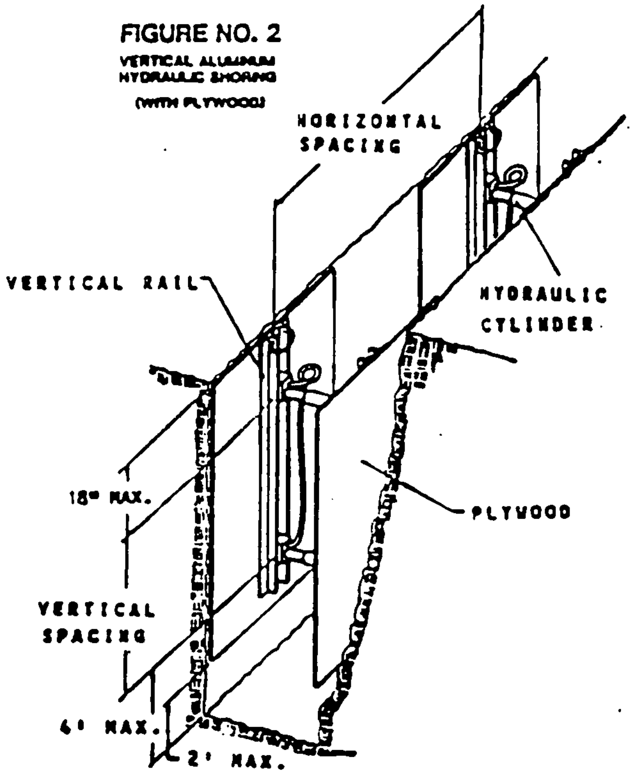

FIGURE NO. 3
VERTICAL ALUMINUM HYDRAULIC SHORING (STACKED)

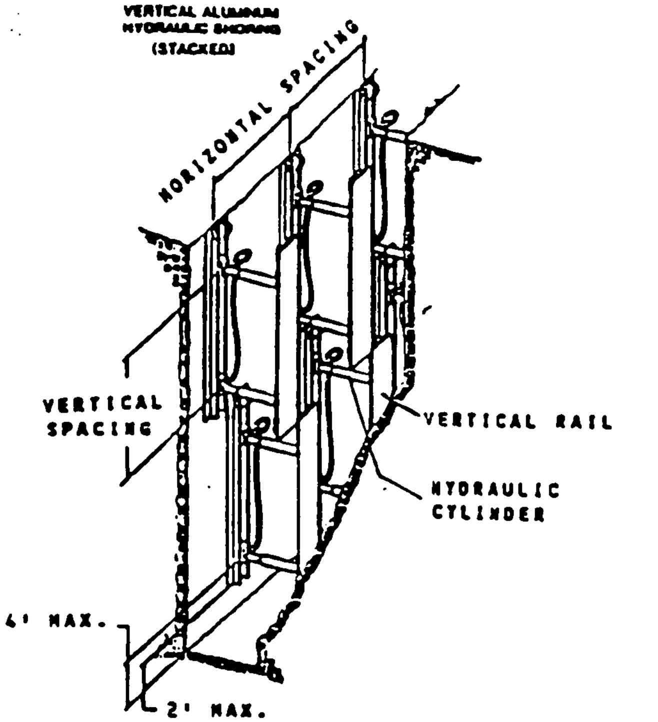

FIGURE NO. 4
ALUMINUM HYDRAULIC SHORING WALER SYSTEM (TYPICAL)

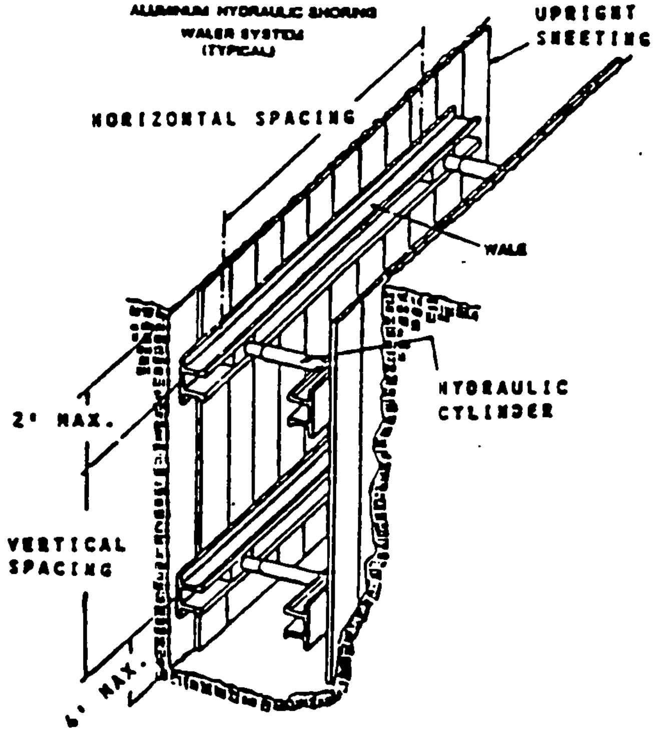

TABLE D - 1.1
ALUMINUM HYDRAULIC SHORING
VERTICAL SHORES
FOR SOIL TYPE A

DEPTH OF TRENCH (FEET)	HYDRAULIC CYLINDERS				
	MAXIMUM HORIZONTAL SPACING (FEET)	MAXIMUM VERTICAL SPACING (FEET)	WIDTH OF TRENCH (FEET)		
			UP TO 8	OVER 8 UP TO 12	OVER 12 UP TO 15
OVER 5 UP TO 10	8	4	2 INCH DIAMETER	2 INCH DIAMETER NOTE (2)	3 INCH DIAMETER
OVER 10 UP TO 15	8				
OVER 15 UP TO 20	7				
OVER 20	NOTE (1)				

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Note (1): See Appendix D, Item (g) (1)
Note (2): See Appendix D, Item (g) (2)

TABLE D - 1.2
ALUMINUM HYDRAULIC SHORING
VERTICAL SHORES
FOR SOIL TYPE B

DEPTH OF TRENCH (FEET)	HYDRAULIC CYLINDERS				
	MAXIMUM HORIZONTAL SPACING (FEET)	MAXIMUM VERTICAL SPACING (FEET)	WIDTH OF TRENCH (FEET)		
			UP TO 8	OVER 8 UP TO 12	OVER 12 UP TO 15
OVER 5 UP TO 10	8	4	2 INCH DIAMETER	2 INCH DIAMETER NOTE (2)	3 INCH DIAMETER
OVER 10 UP TO 15	6.5				
OVER 15 UP TO 20	5.5				
OVER 20	NOTE (1)				

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Note (1): See Appendix D, Item (g) (1)
Note (2): See Appendix D, Item (g) (2)

TABLE D - 1.3
ALUMINUM HYDRAULIC SHORING
WALER SYSTEMS
FOR SOIL TYPE B

DEPTH OF TRENCH (FEET)	WALES		HYDRAULIC CYLINDERS						TIMBER UPRIGHTS		
			WIDTH OF TRENCH (FEET)						MAX.HORIZ.SPACING (ON CENTER)		
	VERTICAL SPACING (FEET)	SECTION MODULUS (IN³) *	UP TO 8		OVER 8 UP TO 12		OVER 12 UP TO 15		SOLID SHEET	2 FT.	3 FT.
			HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER			
OVER 5 UP TO 10	4	3.5	8.0	2 IN	8.0	2 IN NOTE(2)	8.0	3 IN	——	——	3x12
		7.0	9.0	2 IN	9.0	2 IN NOTE(2)	9.0	3 IN			
		14.0	12.0	3 IN	12.0	3 IN	12.0	3 IN			
OVER 10 UP TO 15	4	3.5	6.0	2 IN	6.0	2 IN NOTE(2)	6.0	3 IN	——	3x12	——
		7.0	8.0	3 IN	8.0	3 IN	8.0	3 IN			
		14.0	10.0	3 IN	10.0	3 IN	10.0	3 IN			
OVER 15 UP TO 20	4	3.5	5.5	2 IN	5.5	2 IN NOTE(2)	5.5	3 IN	3x12	——	——
		7.0	6.0	3 IN	6.0	3 IN	6.0	3 IN			
		14.0	9.0	3 IN	9.0	3 IN	9.0	3 IN			
OVER 20	NOTE (1)										

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)

Notes (1): See Appendix D, item (g) (1)

Notes (2): See Appendix D, Item (g) (2)

* Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.

TABLE D - 1.4
ALUMINUM HYDRAULIC SHORING WALER SYSTEMS FOR SOIL TYPE C

DEPTH OF TRENCH (FEET)	WALES		HYDRAULIC CYLINDERS						TIMBER UPRIGHTS		
			WIDTH OF TRENCH (FEET)						MAX.HORIZ SPACING (ON CENTER)		
	VERTICAL SPACING (FEET)	SECTION MODULUS* (IN³)	UP TO 8		OVER 8 UP TO 12		OVER 12 UP TO 15		SOLID SHEET	2 FT.	3 FT.
			HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER			
OVER 5 UP TO 10	4	3.5	6.0	2 IN	6.0	2 IN NOTE(2)	6.0	3 IN	3x12	—	—
		7.0	6.5	2 IN	6.5	2 IN NOTE(2)	6.5	3 IN			
		14.0	10.0	3 IN	10.0	3 IN	10.0	3 IN			
OVER 10 UP TO 15	4	3.5	4.0	2 IN	4.0	2 IN NOTE(2)	4.0	3 IN	3x12	—	—
		7.0	5.5	3 IN	5.5	3 IN	5.5	3 IN			
		14.0	8.0	3 IN	8.0	3 IN	8.0	3 IN			
OVER 15 UP TO 20	4	3.5	3.5	2 IN	3.5	2 IN NOTE(2)	3.5	3 IN	3x12	—	—
		7.0	5.0	3 IN	5.0	3 IN	5.0	3 IN			
		14.0	6.0	3 IN	6.0	3 IN	6.0	3 IN			
OVER 20	NOTE (1)										

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)

Notes (1): See Appendix D, item (g) (1)

Notes (2): See Appendix D, Item (g) (2)

* Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.

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Appendix E to Subpart P—Alternatives to Timber Shoring

Figure 1. Aluminum Hydraulic Shoring

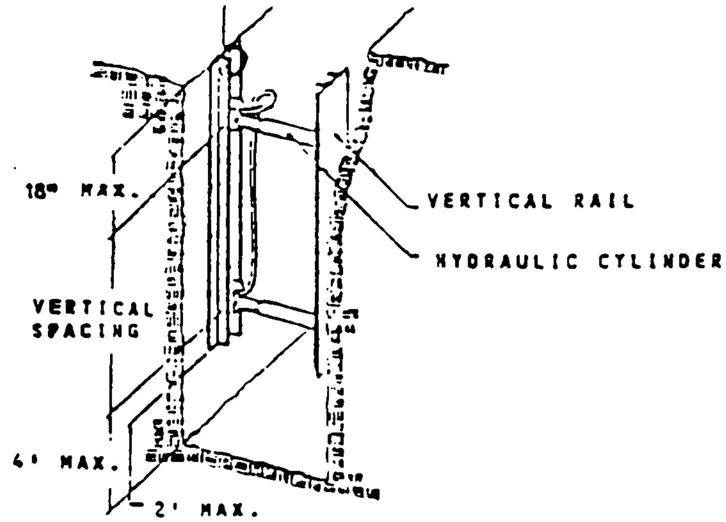
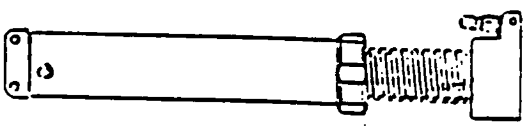


Figure 2. Pneumatic/hydraulic Shoring



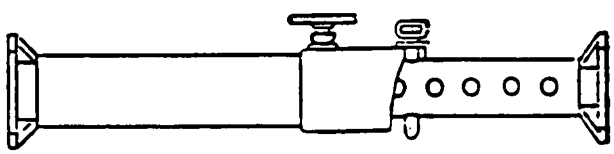


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Figure 3. Trench Jacks (Screw Jacks)

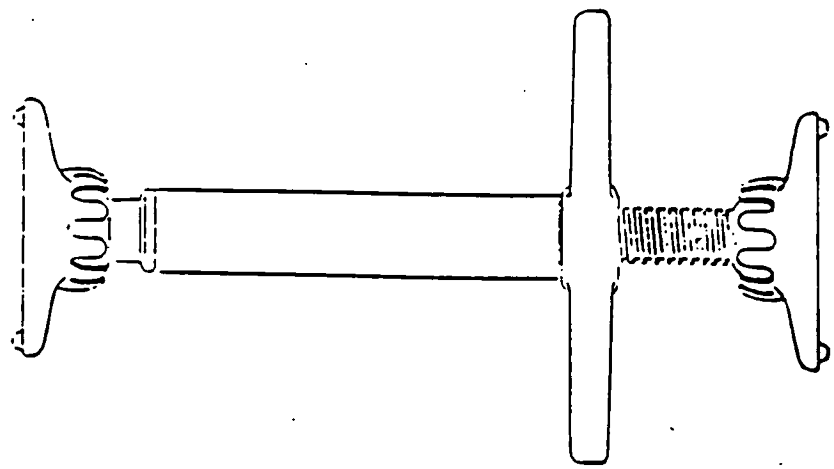
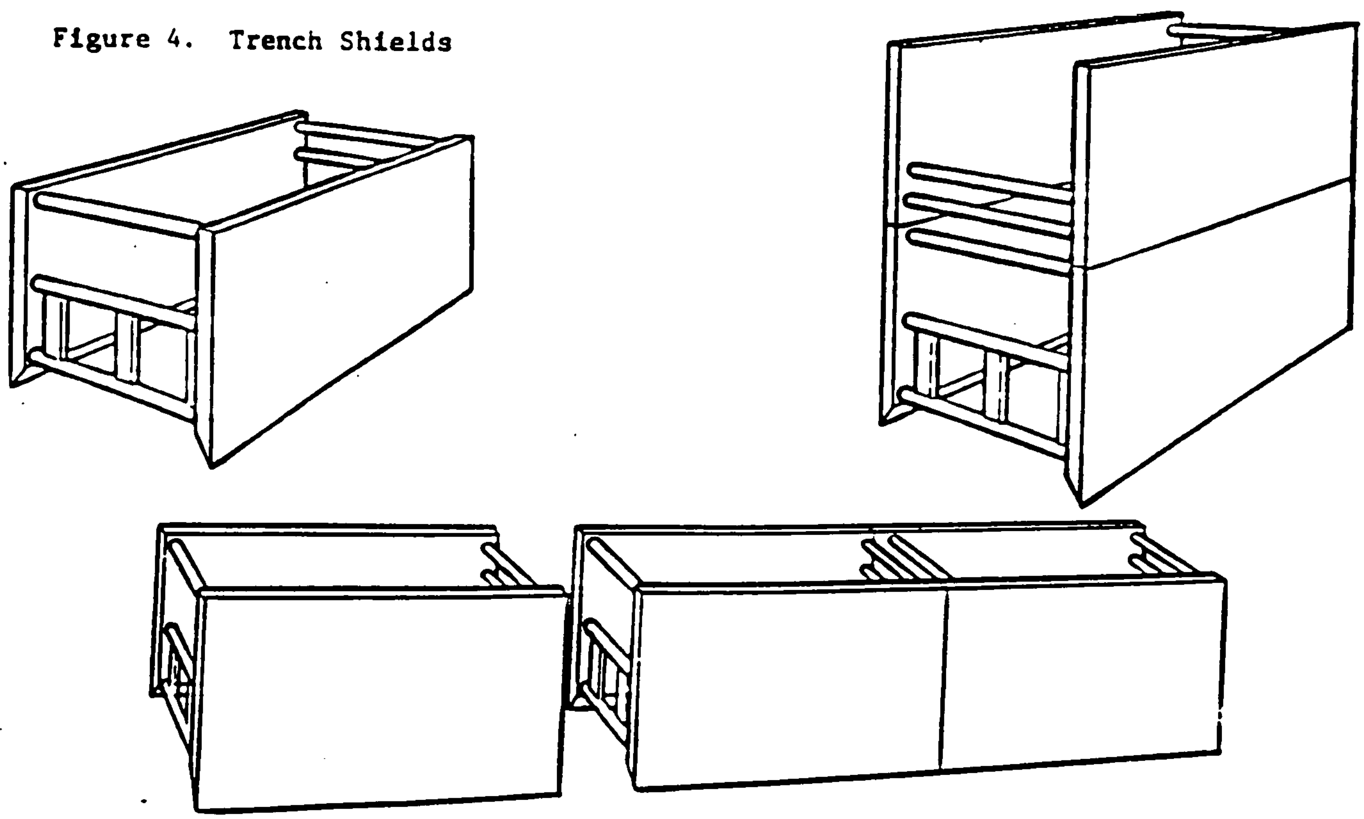


Figure 4. Trench Shields



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Appendix F to Subpart P—Selection of Protective Systems

The following figures are a graphic summary of the requirements contained in subpart P for excavations 20 feet or less in depth. Protective systems for use in excavations more than 20 feet in depth must be designed by a registered professional engineer in accordance with § 1926.652 (b) and (c).

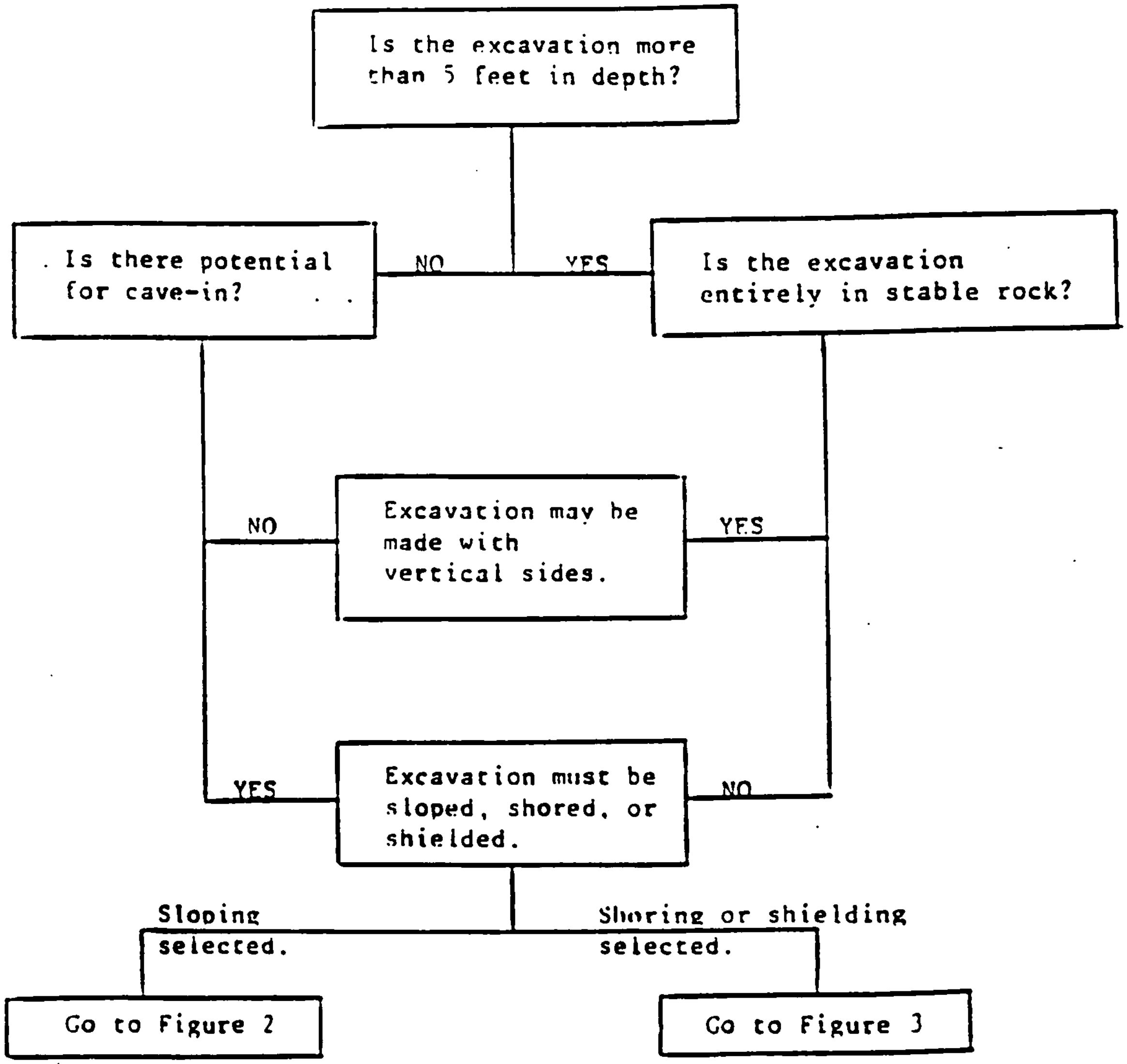

FIGURE 1 - PRELIMINARY DECISIONS

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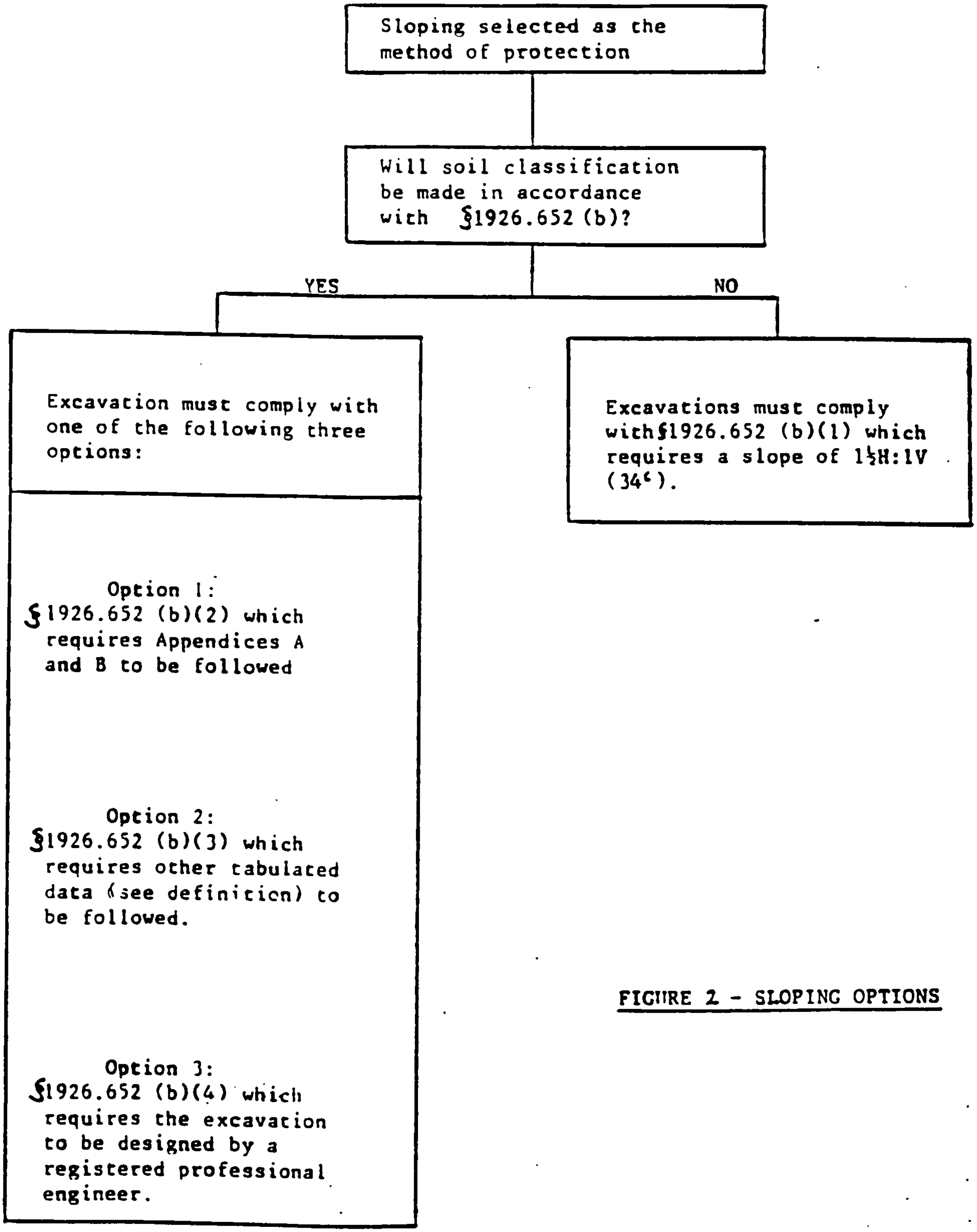

FIGURE 2 - SLOPING OPTIONS

Shoring or shielding selected as the method of protection.

Soil classification is required when shoring or shielding is used. The excavation must comply with one of the following four options:

Option 1
§1926.652 (c)(1) which requires Appendices A and C to be followed (e.g. timber shoring).

Option 2
§1926.652 (c)(2) which requires manufacturers data to be followed (e.g. hydraulic shoring, trench jacks, air shores, shields).

Option 3
§1926.652 (c)(3) which requires tabulated data (see definition) to be followed (e.g. any system as per the tabulated data).

Option 4
§1926.652 (c)(4) which requires the excavation to be designed by a registered professional engineer (e.g. any designed system).

FIGURE 3 - SHORING AND SHIELDING OPTIONS

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BILLING CODE 4510-26-C

APPENDIX A-3

PCB AND LEAD MIGRATION CALCULATIONS

By SPG Date 5/20/94 **WehranEnviroTech** Job No. 04428.LS
Chkd. by [initials] Date 6/1/94 Sheet No. 1 of 2
Subject

RETARDATION OF PCB IN GROUNDWATER

A retardation factor (R_f) can be calculated as follows:

$$R_f = \frac{1}{1+(\rho/n)K_d}$$

where

ρ = bulk density of native soil material
n = porosity of native soil material
K_d = soil/water distribution coefficient

The value K_d is determined by the strength of the solute-soil interactions. The greater the affinity of the solute for the soil phase, relative to its affinity for water the more strongly the solute will adsorb, and the greater the value for K_d. The K_d can be estimated as follows

$$K_d = K_{oc} \times f_{oc}$$

where:
K_{oc} = sorption coefficient normalized for organic carbon
f_{oc} = weight fraction of organic carbon

PCBs are very strongly adsorbed by soil constituents (organic matter) and as such will be readily retarded in the groundwater system

At GM-SAGINAW SITE PCB-AROCLOR 1248, 1254 and 1260 HAVE BEEN DETECTION

UNDERLYING NATIVE MATERIALS ARE SILTY CLAYS

ASSUME THE FOLLOWING
- BULK DENSITY OF NATIVE SOIL (SILTY CLAY) - 2 gm/cc
- POROSITY (EFFECTIVE) - 0.2
- PERCENT ORGANIC MATTER - 0.1
- K_{oc} AROCLOR 1248 = 436,516 (= LOG K_{oc} - 5.64)
  [MONTGOMERY AND WELKOM, 1990]

$$R_f = \frac{1}{1 + (2/2)(436516 \times 0.001)} = \frac{1}{4366} = 0.0002$$

THEREFORE, IF THE ADVECTIVE VELOCITY OF GROUNDWATER WAS 10 FT\YEAR AROCLOR 1248 WOULD MIGRATE

10 X 0.0002 = 0.002 FT IN THE SAME PERIOD.

WHILE THE ABOVE ANALYSIS IGNORES THE POTENTIAL EFFECTS OF DIFFUSION, IT NEVERTHELESS DEMONSTRATES THE VERY LOW MIGRATION RATES OF PCBS

NOTE K_{OC}s ARE SIMILAR FOR AROCLOR 1254 AND 1260 THEREFORE RETARDATION FACTORS WILL BE SIMILAR

By SPG Date 5/31/94 **WehranEnviroTech** Job No. 04428.LS
Chkd. by [initials] Date 6/2/94 Sheet No. 1 of 2
Subject

TCLP LEAD VERSUS NATIVE SOIL ADSORPTION CAPACITY

- Parking Area No. 4 is approximately 12 acres
- The volume of fill is estimated to be 110,000 cy exclusive of the area beneath the storage tank, clarifiers, and wastewater treatment plant. This area is estimated to be about 1 acre
- The top 2 feet of fill is assumed to be clean.

Therefore, the volume of contaminated fill can be estimated as follows:

$$110,000\ cy + \left(\frac{1}{12} \times 110,000\right) - \left(\frac{2\ ft \times 43560\ ft^2/A \times 12\ A}{27\ cf/cy}\right)$$

= 80,447 cy of contaminated fill

1 cy of fill ≅ 1.2 Tons

1.2 T × 2000 pounds/ton × 454 g/pound = 1,089,600 g/cy

1,089,600 g/cy × 80447 cy = 8.77×10^{10} g

The TCLP procedure calls for a 20:1 solution-soil ratio for the extraction, ie 5g of fill extracted in 100 ml of leaching solution or 50 g of fill extracted in 1000 ml of leaching solution.
If the fill is assumed to be 65% on a dry weight basis, then 50 × 0.65 = 32.5 g of dry fill used in extraction process.

The average TCLP-Pb based on 12 Samples analyzed coincident with Wehrans December 1993 Lead Sampling Project = 32 mg/L

Therefore, the amount of Pb extracted = $\frac{32\ mg}{32.5\ g}$ = 0.98 mg/g fill

Therefore, the total quantity of potentially leachable Pb from the fill can be estimated as follows

$$\frac{0.98\ mg\ Pb}{g\ fill} \times 8.77 \times 10^{10}\ g = 8.59 \times 10^{10}\ mg\ Pb$$

- Investigation Area = 12 acres
- Assume porosity of underlying silty clay soil = 0.5
- Assume percent dry weight of silty clay = 70
- The thickness of native silty clay overlying bedrock is 5-10 feet. Use 5 feet

To calculate the quantity of native soil on a dry weight basis:

12 A x 43560 ft^2/A x 5ft x 0.03704 cy/cf x 0.5 x 0.7

= 33883 cy

Say 1 cy of silty clay soil ≅ 2700 pounds (dry wt basis)

Therefore

33883 cy x 2700 pounds/cy x 454 g/pound =

= 4.2×10^{10} g native soil

To determine sorption potential of native soil use Langmuir adsorption maximum taken from Rai et al (1986)

-Say 16.5 μM/g soil

16.5 μM/g x 207.2 μg Pb/μM = 3419 μg Pb/g soil

Therefore, the amount of Pb potentially retained by 5 feet of native soil

4.2×10^{10} g native soil x 3419 μg Pb/g soil =

1.4×10^{14} μg = 1.4×10^{11} mg of Pb that can potentially be adsorbed by 5 feet of native soil

→* 1.4×10^{11} mg > 8.6×10^{10} mg of potentially leachable lead. Therefore no anticipated impact to bedrock groundwater quality because of sufficient adsorption potential in native silty clays

FROM: Rai D., et al (1986) Chemical Attenuation Rates, Coefficients and Constants in Leachate Migration. Volume I: A Critical Review Electric Power Research Institute (EPRI). Prepared by Battelle, Pacific Northwest Laboratories

Table 14-1. ADSORPTION CONSTANTS FOR LEAD

Adsorbent			Adsorbate	Electrolyte			Adsorption Measurements		Reference
Identity[a]	CEC meq/100g	S.A. m^2/g	Conc., M	Identity	Conc., M	pH	Constants[b]	Value[c]	
Clay Minerals									
Montmorillonite	100.8	-	-	Cl^-	10^{-3}	-	K^{Pb}_{Ca}	0.60	Bittell and Miller 1974
Montmorillonite	-	-	0-0.0125	$Ca(ClO_4)_2$	0.1	5.0	A_m, K_L	(440, 3.1-3.4)	Griffin and Au 1977
Montmorillonite	-	-	$10^{-4.3}$ - $10^{-2.7}$	Landfill leachate	~0.1	5.0	A^I_m, K^I_L	8.8, (4.3)	Griffin and Shimp 1976
							A^{II}_m, K^{II}_L	5.30, (2.1)	
	-	-	$10^{-4.3}$ - $10^{-2.7}$	-	-	5.0	A_m	398	
Kaolinite	2.2	-	-	Cl^-	$10^{-3.6}$	-	K^{Pb}_{Ca}	0.34	Bittell and Miller 1974
Kaolinite	-	-	$10^{-4.3}$ - $10^{-2.7}$	-	-	5.0	A_m	76.8	Griffin and Shimp 1976
	-	-	$10^{-4.3}$ - $10^{-2.7}$	NaCl	0.1	5.0	A_m	49.4	
	-	-	$10^{-4.3}$ - $10^{-2.7}$	Landfill leachate	~0.1	5.0	A^I_m, K^I_L A^{II}_m, K^{II}_L	8.1, (4.1) 41.2, (3.0)	
	-	-	$10^{-4.3}$ - $10^{-2.7}$	Landfill leachate	~0.4	5.0	A^I_m, K^I_L A^{II}_m, K^{II}_L	4.8, (4.1) 11.6, (3.5)	
Illite	19.4	-	-	Cl^-	10^{-3}	-	K^{Pb}_{Ca}	0.44	Bittell and Miller 1974
Silica									
SiO_2	-	160	-	-	-	4-7	$^{*}K^{0}_{1}SiOPb$ $^{*}\beta^{0}_{2}(SiO)_2Pb$	-5.09 -10.68	Schindler et al. 1976
SiO_2	-	-	-	-	-	-	K^{int}_{Pb}, K^{int}_{PbOH}	(2.1, 4.2)	Stumm et al. 1976.

Table 14-1 (Contd). ADSORPTION CONSTANTS FOR LEAD

Adsorbent			Adsorbate	Electrolyte			Adsorption Measurements		Reference
Identity[a]	CEC meq/100g	S.A. m^2/g	Conc., M	Identity	Conc., M	pH	Constants[b]	Value[c]	
Silica									
α-SiO_2	-	-	$10^{-6.3}$	-	-	-	K^{int}_{Pb} K^{int}_{PbOH}	4.6, 7.8	Davis and Leckie 1978
Alumina									
γ-Al_2O_3	-	117	10^{-4} - $10^{-3.5}$	$NaClO_4$	0.1	4-7	$*K^{s}_{1}$AlOPb	-2.2	Hohl and Stumm 1976
							$*\beta^{s}_{2}(AlO)_2Pb$	-8.1	
							K^{int}_{Pb}, K^{int}_{PbOH}	(7.3, 9.1)	
γ-Al_2O_3	-	-	$10^{-3.5}$	-	-	-	"	6.4, 8.9	Davis and Leckie 1978
			$10^{-4.3}$	-	-	-	"	- , 8.7	
			$10^{-6.3}$	-	-	-	"	6.4, 10.2	
Fe Oxides									
Goethite (α-FeOOH)	-	51.8	$10^{-7.1}$ - $10^{-4.6}$	Seawater	~0.7	3-7	$*K^{int}_{Pb}$, $*K^{int}_{PbOH}$	-1.8, -3.0	Balistrieri and Murray 1982
							K^{int}_{Pb}, K^{int}_{PbOH}	(8.6, 11.7)	
Goethite	-	89	$10^{-4.5}$	$NaNO_3$	0.08	4-6	K'_c	-2.0	Forbes et al. 1976
Goethite	-	75	10^{-3} - $10^{-2.2}$	KNO_3	0.1	5.0	A_m, K_L	(85, 2.9)	McKenzie 1980
Hematite (α-Fe_2O_3)	-	20	10^{-3} - $10^{-2.2}$	KNO_3	0.1	5.0	A_m, K_L	(56, 3.2)	McKenzie 1980

Table 14-1 (Contd). ADSORPTION CONSTANTS FOR LEAD

Adsorbent			Adsorbate	Electrolyte			Adsorption Measurements		Reference
Identity[a]	CEC meq/100g	S.A. m^2/g	Conc., M	Identity	Conc., M	pH	Constants[b]	Value[c]	
Fe Oxides (contd)									
Amorphous $Fe_2O_3 \cdot H_2O$	-	-	$10^{-3.3}$ - $10^{-2.8}$	-	-				
aged 24 hr						5	A_m, K_L	(2000, 28)	Gadde and Laitinen 1973
fresh						6	A_m, K_L	(2400, 4.9)	
coprecipitation						6	A_m, K_L	(3700, 4.5)	
aged 24 hr						6	A_m, K_L	(2400, 4.10)	
aged 24 hr						6	A_m, K_L	(2700, 3.9)	
Amorphous $Fe_2O_3 \cdot H_2O$	-	-	$10^{-6.3}$	-	-	-	K_{Pb}^{int} K_{PbOH}^{int}	6.9, 11.1	Davis and Leckie 1978
Mn Oxides									
Hydrous Mn oxide	-	-	$10^{-3.3}$ - $10^{-2.8}$	-	-	6	A_m, K_L	(7000, 3.7)	Gadde and Laitinen 1974
δ-MnO_2	-	90	10^{-3} - $10^{-2.2}$	KNO_3	0.1	5	A_m, K_L	(2600, 4.0)	McKenzie 1980
α-$MnO_2(K_2Mn_8O_{16})$		206	10^{-3} - $10^{-2.2}$	KNO_3	0.1	5	A_m, K_L	(2700, 3.8)	McKenzie 1980
Ti Oxide	-	-	-	$NaClO_4$	1.0		${}^*K_1^s$, SiOPb, ${}^*\beta_2^s(SiO)_2Pb$	-5.1, -10.7	Stumm et al, 1976
							K_{Pb}^{int}, K_{PbOH}^{int}	(8.0, 13.5)	
Organic Matter									
Peat	-	-	$10^{-4.6}$ - $10^{-3.6}$	-	-	~4	A_m, K_L	(300-500, 3.7-5.3)	Bunzl 1974a, 1974b
Humic Acid	-	-	$10^{-4.6}$ - $10^{-3.6}$	-	-	~4	A_m, K_L	(560, 3.6)	Bunzl et al, 1976
Humic acid		-	$10^{-4.3}$ - $10^{-3.3}$	-	-	2.4	A_m, K_L	(32, 4.2)	Kerndorff and Schnitzer 1980

Table 14-1 (Contd). ADSORPTION CONSTANTS FOR LEAD

Adsorbent					Adsorbate	Electrolyte			Adsorption Measurements		Reference
Identity[a]			CEC meq/100g	S.A. m^2/g	Conc., M	Identity	Conc., M	pH	Constants[b]	Value[c]	
Soil	% Clay	% O.C.									
	10.1	0.61	6.96	-	$10^{-4.6} - 10^{-3.3}$	KCl	0.1	7	A_m, K_L	7.0, 3.9	Singh and Sekhon 1977
	31.2	1.26	18.2	-	$10^{-4.6} - 10^{-3.3}$	KCl	0.1	7	A_m, K_L	23, 4.9	
	10.4	0.69	6.09	-	$10^{-4.6} - 10^{-3.3}$	KCl	0.1	7	A_m, K_L	11.5, 3.8	
GM SAGINAW →	24.6	0.75	12.18	-	$10^{-4.6} - 10^{-3.3}$	KCl	0.1	7	A_m, K_L	16.5, 4.5	
	20.2	0.76	10.44	-	$10^{-4.6} - 10^{-3.3}$	KCl	0.1	7	A_m, K_L	11.5, 4.3	
	5.5	0.33	3.03	-	$10^{-4.6} - 10^{-3.3}$	KCl	0.1	7	A_m, K_L	8.5, 3.7	
	8.9	0.34	4.35	-	$10^{-4.6} - 10^{-3.3}$	KCl	0.1	7	A_m, K_L	10.5, 3.7	
Soil	% Clay	% O.M.						Soil			
	6.0	7.8	32.5	-	$10^{-6} - 10^{-4.4}$	-	-	7.7	A_m, K_L,	180, 4.2,	Soldatini et al. 1976
									K_F, 1/N	57.4, 0.15	Riffaldi et al. 1976
						$CaCl_2$	0.05	7.7	A_m, K_L	112, 4.7,	
									K_F, 1/N	12.6, 0.33	
	4.0	0.9	8.8	-	$10^{-6} - 10^{-4.4}$	-	-	8.2	A_m, K_L,	42, 4.2,	
									K_F, 1/N	14.4, 0.14	
						$CaCl_2$	0.05	8.2	A_m, K_L	16.5 4.7	
									K_F, 1/N	4.3, 0.22	
	6.6	4.2	20.0	-	$10^{-6} - 10^{-4.4}$	-	-	7.9	A_m, K_L,	122, 4.4,	
									K_F, 1/N	43.6, 0.14	
						$CaCl_2$	0.05	7.9	A_m, K_L,	70, 4.6,	
									K_F, 1/N	16.6, 0.21	

Table 14-1 (Contd). ADSORPTION CONSTANTS FOR LEAD

Adsorbent: Identity[a] Soil	Adsorbent: Identity[a] % Clay	Adsorbent: Identity[a] % O.M.	Adsorbent: CEC meq/100g	Adsorbent: S.A. m^2/g	Adsorbate: Conc., M	Electrolyte: Identity	Electrolyte: Conc., M	Adsorption Measurements: pH Soil	Adsorption Measurements: Constants[b]	Adsorption Measurements: Value[c]	Reference
	7.6	2.1	16.2	-	10^{-6} - $10^{-4.4}$	-	-	8.3	A_m, K_L, K_F, 1/N	78, 4.5, 30.1, 0.13	Soldatini et al. 1976 Riffaldi et al. 1976
						$CaCl_2$	0.05	8.3	A_m, K_L K_F, 1/N	43, 4.3, 9.6, 0.27	
	23.1	4.4	31.2	-	10^{-6} - $10^{-4.4}$	-	-	8.1	A_m, K_L, K_F, 1/N	242,4.8, 82.5, 0.19	
						$CaCl_2$	0.05	8.1	A_m, K_L K_F, 1/N	119, 5.0 25.8, 0.24	
	14.3	4.2	30.0	-	10^{-6} - $10^{-4.4}$	-	-	7.7	A_m, K_L, K_F, 1/N	158, 4.5, 94.6, 0.15	
						$CaCl_2$	0.05	7.7	A_m, K_L K_F, 1/N	79.5, 4.7, 18.0, 0.22	
	10.7	2.0	16.5	-	10^{-6} - $10^{-4.4}$	-	-	8.6	A_m, K_L, K_F, 1/N	84, 4.8, 31.0, 0.14	
						$CaCl_2$	0.05	8.6	A_m, K_L K_F, 1/N	27, 5.1, 8.9, 0.18	
	5.4	1.0	8.7	-	10^{-6} - $10^{-4.4}$	-	-	5.7	A_m, K_L, K_F, 1/N	22, 4.4, 9.9, 0.11	
						$CaCl_2$	0.05	5.7	A_m, K_L, K_F, 1/N	7.5, 4.4, 0.70, 0.37	

Table 14-1 (Contd). ADSORPTION CONSTANTS FOR LEAD

Adsorbent					Adsorbate	Electrolyte			Adsorption Measurements		Reference
Identity[a]			CEC meq/100g	S.A. m^2/g	Conc., M	Identity	Conc., M	pH	Constants[b]	Value[c]	
Soil	% Clay	% O.M.						Soil			
	12.0	3.1	16.2	-	$10^{-6} - 10^{-4.4}$	-	-	8.1	A_m, K_L,	108, 4.8,	Soldatini et al. 1976
									K_F, 1/N	56.3, 0.09	Alffaldi et al. 1976
						$CaCl_2$	0.05	8.1	A_m, K_L,	57.5, 4.5,	
									K_F, 1/N	7.9, 0.29	
	3.8	1.2	14.0	-	$10^{-6} - 10^{-4.4}$	-	-	5.8	A_m, K_L,	50, 4.3,	
									K_F, 1/N	11.8, 0.20	
						$CaCl_2$	0.05	5.8	A_m, K_L,	21, 4.3,	
									K_F, 1/N	1.7, 0.38	
	7.0	1.8	23.7	-	$10^{-6} - 10^{-4.4}$	-	-	7.6	A_m, K_L,	170, 4.4,	
									K_F, 1/N	77.8, 0.11	
						$CaCl_2$	0.05	7.6	A_m, K_L,	56, 4.6,	
									K_F, 1/N	7.0, 0.31	
	1.7	1.4	8.7	-	$10^{-6} - 10^{-4.4}$	-	-	8.1	A_m, K_L,	94, 4.1,	
									K_F, 1/N	33.0, 0.13	
						$CaCl_2$	0.05	8.1	A_m, K_L,	31,4.8,	
									K_F, 1/N	8.7, 0.23	
Sandy loam		-	59	-	$10^{-3.9} - 10^{-3.0}$	$AlCl_3$	$10^{-2.9}$ - $10^{-1.7}$	3.1- 3.8	A_m, K_L	(3.1-3.6, 3.5-3.8)	Lagerwerff and Brower 1973
						$CaCl_2$	$10^{-2.5}$ - $10^{-1.8}$	4.9- 6.3	A_m, K_L	(6.7-7.0, 4.8-5.6)	

Table 14-1 (Contd). ADSORPTION CONSTANTS FOR LEAD

Adsorbent Identity[a]	Adsorbent CEC meq/100g	Adsorbent S.A. m^2/g	Adsorbate Conc., M	Electrolyte Identity	Electrolyte Conc., M	Electrolyte pH	Adsorption Measurements Constants[b]	Adsorption Measurements Value[c]	Reference
Soil									
Silt loam	205	-	$10^{-3.9}$ - $10^{-3.0}$	$AlCl_3$	$10^{-2.7}$ - $10^{-1.7}$	3.1-3.8	A_m, K_L	(4.3-10.7, 3.6)	Lagerwerff and Brower 1973
				$CaCl_2$	$10^{-2.5}$ - $10^{-1.6}$	4.9-6.3	A_m, K_L	(13.3-18.9, 5.3-6.0)	
Clay loam	184	-		$AlCl_3$	$10^{-2.5}$ - $10^{-1.7}$	3.1-3.8	A_m, K_L	(4.0-12.2, 3.4-4.1)	
				$CaCl_2$	$10^{-2.3}$ - $10^{-1.6}$	4.9-6.3	A_m, K_L	(17.9-19.6, 5.4-6.5)	
Sandy loam	59	-	$10^{-3.9}$ - $10^{-3.0}$	See above			K^{Pb}_{Al}, K^{Pb}_{Ca}	0.31, 4.13	Lagerwerff and Brower 1973
Silt loam	205	-	$10^{-3.9}$ - $10^{-3.0}$	See above			K^{Pb}_{Al}, K^{Pb}_{Ca}	0.11, 4.97	
Clay loam	184	-	$10^{-3.9}$ - $10^{-3.0}$	See above			K^{Pb}_{Al}, K^{Pb}_{Ca}	0.24, 11.1	
Sediment % O.M. Time						**Sediment**			
29.7	-	-	10^{-7} - 10^{-6}	-	-	7.4	K_F, 1/N		
1 hr								(0.42, 1.07)	Salim and Cooksey 1980
3 hr								(1.08, 1.08)	
7 hr								(2.21, 1.08)	
15 hr								(5.99, 1.07)	
∞								(6.15, 1.08)	
33.7	-	-	$10^{-5.9}$ - $10^{-4.0}$	-	-	-	Am, K_L	149, 5.4	Ramamoorthy and Rust 1978

Table 14-1 (Contd). ADSORPTION CONSTANTS FOR LEAD

Adsorbent				Adsorbate	Electrolyte			Adsorption Measurements		Reference
Identity[a]		CEC meq/100g	S.A. m^2/g	Conc., M	Identity	Conc., M	pH	Constants[b]	Value[c]	
Sediment										
% Clay	% O.C.						Sediment			
12.6	3.34	-	-	$10^{-4.3} - 10^{-3.3}$	-	-	7.0	A_m, K_L	(21, 5.7)	Dudderidge and Wainwright 1981
13.2	3.7	-	-	$10^{-4.3} - 10^{-3.3}$	-	-	7.4	A_m, K_L	(20, 4.9)	
3.6	0.61	-	-	$10^{-4.3} - 10^{-3.3}$			6.8	A_m, K_L	(20, 4.7)	
4.9	1.06	-	-	$10^{-4.3} - 10^{-3.3}$			7.1	A_m, K_L	(17, 4.9)	

(a) O.C. = organic carbon
O.M. = organic matter

(b) K_{Ca}^{Pb}, K_{Al}^{Pb} = selectivity coefficients

A_m = Langmuir adsorption maximum, μmol g^{-1}

K_L = Langmuir Constant, log M^{-1}

A_m^I, K_L^I, A_m^{II}, K_L^{II} = two adsorption sites

$^{*}K_1^s$, $^{*}\beta_2^s$ = surface complexation constants for ionic species, log

K^{int} = intrinsic adsorption constant for ionic species, log

K_C' = affinity constant, log

K_F, 1/N = Freundlich constants for $A = K_F C^{1/N}$; A = μmol g^{-1}; C = μM

(c) ( ) = estimated values