WORK PLAN FOR SOIL VAPOR EXTRACTION SYSTEM PREDESIGN STUDY AT THE WAUSAU WATER SUPPLY NATIONAL PRIORITIES LIST SITE WAUSAU, WISCONSIN

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B.1 PURPOSE

This appendix presents a work plan for performing a predesign investigation for soil vapor extraction (SVE) at the Wausau Superfund Site in Wausau, Wisconsin. The use of soil vapor extraction to remove volatile organic constituents from the source areas at the site is specified in the Consent Decree. The purpose of the predesign investigation is to collect site-specific data needed for the final design of the soil vapor extraction systems for the Wausau Chemical and Marathon Electric/City Landfill sites which were identified as source areas in the Remedial Investigation (RI) report (Warzyn, 1989a).

A detailed description of site background, including site history, environmental setting and source areas for contaminants of concern is provided in Section 2.0 of the RD/RA Work Plan.

B.2 SVE DESIGN CONSIDERATIONS

B.2.1 Target Compounds

The compounds targeted for removal by the SVE system consist of volatile organic compounds (VOCs) detected in subsurface soils at the site as listed in the RI report (Warzyn, 1989a). The VOCs detected during the RI are shown in Table B.1 along with the concentration ranges listed in Table 19 of Volume 1 of the RI report.

Three of these VOCs, tetrachloroethene (PCE), trichloroethene (TCE), and 1,2-dichloroethene (DCE) are specifically listed in the Consent Decree as being the primary contaminants of concern at the Wausau site.

In addition to the compounds listed in Table B.1, the Consent Decree implies that the SVE system may be required to remove additional volatile organic compounds that may be detected in the soils as a result of the performance monitoring. As discussed in Section B.3 of this appendix and Section 5.0 of the RD/RA Work Plan, the predesign investigation will include soil gas sampling and analysis for a wide range of volatile compounds that could be present at the site.

B.2.2 SVE Performance and Design Specifications

In accordance with the Consent Decree the design of the SVE systems will employ the optimum spacing of wells and optimum extraction well vacuum pressure at the extraction well head. This will include at a minimum at least 25% overlap between the cones of influence of adjacent wells, or equivalent capture zones and an extraction well vacuum pressure approved by EPA, in consultation with the WDNR.

The SVE systems will be operated until the SVE cleanup standards specified in the Consent Decree are met.

TABLE B.1
VOLATILE ORGANIC COMPOUNDS DETECTED IN SOILS AT THE WAUSAU SITE

Compound	Minimum Concentration (µg/kg)	Maximum Concentration (µg/kg)
Acetone	71	160
Methylene Chloride	1	2,000
1,2-dichloroethene(total)	21	220
Trichloroethene	6	160,000
Tetrachloroethene	1	3,500
Toluene	1	750
Ethylbenzene	2	2,900
Xylenes	2	21,000

Mass-flux groundwater modeling (see Appendix C of the RD/RA Work Plan) as approved by EPA in consultation with the WDNR will be performed to provide EPA and the WDNR with data on which to base a soil cleanup level. The soil cleanup levels designated by EPA will be achieved in order to eliminate source area contaminant loading to the aquifer, and thereby contribute to the achievement of the cleanup standards.

B.2.3 Preliminary SVE Design Calculations

In general, the degree of success, in terms of mass of contaminants removed, of SVE depends on three factors:

1) The air strippability of the volatile organic contaminants,which is controlled by their vapor pressure, and gas-water and water-solid distribution coefficients;
2) The rate of air circulation that can be achieved with a particular extraction system; and
3) The sweeping efficiency of the extraction system, which is controlled by the air permeability and contaminant distribution in the soil.

These factors are discussed in detail in Section 5.0 of the RD/RA Work Plan.

B.3 SITE-SPECIFIC DATA AND DESIGN ISSUES

With regard to additional site-specific design issues for the SVE systems at the site, the RI report and the discussion presented in Section 5.0 of the RD/RA Work Plan indicate that the soil conditions and contaminant properties in the two source areas, Wausau Chemical Corporation and Marathon Electric/City Landfill, are generally favorable for the use of SVE as a remedial technology. This evaluation is based on the facts that the soils are generally relatively permeable sands and gravels, and that the contaminants of interest (chlorinated ethenes) have physico-chemical properties amenable to vapor extraction. The predesign investigation will, therefore, consist of the following components:

1) Collection and analysis of additional site-specific data on soil properties and contaminant distributions needed to design the SVE systems;
2) Pilot studies needed to anticipate construction and operational constraints on the SVE system and off-gas treatment system; and
3) Collection and analysis of data needed to perform the mass flux calculations that will determine the performance standards for the SVE treatment.

B.3.1 Wausau Chemical Source Area

The key design issues for the SVE system at the Wausau Chemical source area will be:

1) Definition of area of VOC soil contamination;

2) The effect of variable surface conditions and utility corridors on air circulation patterns; and

3) Design of the SVE system to minimize interference with facility operations.

The various investigations that will be performed to address the first two design issues are described in detail below. Accommodation of existing facility operations will be addressed during the design phase of the project.

B.3.1.1 Areas of VOC Soil Contamination

Soil contamination by VOCs at the Wausau Chemical source area may have originated from a number of documented and undocumented releases. The soil gas sampling data in the RI indicate that several isolated areas of soil contamination may exist at the Wausau Chemical source area. A soil gas survey on approximately 50-foot centers will be performed to better define the areas of VOC contamination which require treatment by SVE. The areas to be covered by the soil gas survey are shown in Plan 2.

B.3.1.2 Soil and Surface Conditions

The surface and subsurface conditions at the Wausau Chemical source area are likely to be sufficiently variable to result in complex air circulation patterns around and between the SVE wells. Surface conditions that may contribute to complex air circulation patterns are the varying permeability and nature of surface paving materials and the presence of buildings and above-ground tanks. Subsurface conditions that will affect the design and performance of the SVE systems are the variable thickness and properties of fill materials at the site and the presence of underground utility corridors.

The effect of surface conditions on the design of the SVE systems will be addressed by analyzing the pressure response measured during pilot SVE tests at two locations on the site. Subsurface conditions will be evaluated by:

1) carefully defining the locations of utility corridors and the construction of building foundations;
2) developing structure contour and isopach maps showing the distribution of fill based on existing soil boring logs; and
3) performing drive-point air permeability tests in conjunction with the soil gas measurements to establish the relative distribution of air permeability in both the fill and native soils.

These evaluations are discussed in further detail in Section B.3.3.

B.3.2 Marathon Electric/City Landfill Source Area

The key design issues for the SVE system at the Marathon Electric/City Landfill source area will be:

1) Definition of VOC source areas within the former City Landfill;
2) The effect of heterogeneous soil and fill properties in the landfill on air circulation patterns;

3) The effect of high-organic fill materials on VOC removal by SVE; and

4) The effect of landfill methane and vinyl chloride generation and/or enhanced biological decay on SVE operation and off-gas treatment requirements.

The various investigations that will be performed to address these design issues are described in detail below.

B.3.2.1 VOC Source Areas

The results of the RI investigations on the landfill indicate that VOC contamination is likely to be confined to the eastern one-third of the former landfill (see Plan 3). A soil gas survey on approximately 50-foot centers will be performed to verify the current areas of VOC contamination which require treatment by SVE. The areas to be covered by the soil gas survey are shown in Plan 3.

B.3.2.2 Soil and Surface Conditions

The subsurface conditions at the landfill are likely to be highly variable, resulting in complex air circulation patterns around and between the SVE wells. Surface conditions which may contribute to complex air circulation patterns are the varying permeability and composition of surface paving materials and the existence of both paved and unpaved areas. Subsurface conditions which will affect the design and performance of the SVE systems are the variable thickness and properties of fill materials at the site.

The effect of surface conditions on SVE circulation patterns will be evaluated by analyzing the pressure response measured during the pilot SVE test at the Marathon Electric/City Landfill source area.

Subsurface conditions will be evaluated by:

1) developing structure contour and isopach maps showing the distribution of fill based on existing soil boring logs;
2) performing drive-point air permeability tests in conjunction with the soil gas measurements to establish the relative distribution of air permeability in both the fill and native soils; and
3) analyzing the pressure response measured during the pilot SVE test at the site.

These evaluations are discussed further in Section B.3.3.

B.3.2.3 High Organic Carbon

The fill materials in the former landfill may contain unusually high concentrations of organic carbon that may limit the rate of VOC removal by SVE. Although the heterogeneous nature of the fill materials revealed in the test pits constructed during the RI indicates that collecting meaningful samples of the fill will be impractical, the cuttings exposed during the drilling of the SVE pilot well and permanent piezometers will be carefully inspected and visual estimates made of their organic debris content. Samples of the fine-grained fill matrix will also be collected and analyzed for total organic carbon. These data will be used in conjunction with other data developed during the predesign investigation to determine the air flow rates necessary to meet the cleanup goals specified in the Consent Decree in areas with high organic soils.

B.3.2.4 Degradation Products

Additional investigation at the landfill will be required to evaluate the methane and vinyl chloride concentrations in the gases initially removed by the SVE system. Methane concentrations in the off-gas may create a potential explosive hazard which must be considered in the design of the off-gas treatment system for this source area. Vinyl chloride concentrations may also be high in the gases initially removed from the landfill as a result of anaerobic degradation of the more highly chlorinated compounds. Because vinyl chloride is not effectively removed by activated carbon treatment, the SVE system for the landfill and other areas containing vinyl chloride may need to be designed to operate at low mass emission rates during the initial stage of operation. As aerobic conditions are established in these areas, vinyl chloride production will likely stop and the rate of air circulation can be increased.

An additional concern in the landfill area could be the effect of circulating oxygenated air through residual organic matter. Under the proper conditions, the stimulation of organic decay by the SVE system could result in spontaneous combustion in the landfill. The potential for such an occurrence at the site depends on the organic content of the fill materials in the areas containing chlorinated ethenes. If the chlorinated ethenes are predominantly in areas with low organic content, then the SVE system can be designed to minimize air flow through the high organic areas. Otherwise, the SVE system design may need to include subsurface temperature sensors to monitor the potential for spontaneous combustion.

B.3.3 Scope of Work

All field work performed during the SVE predesign investigation will be conducted in accordance with the Predesign Investigation Health and Safety Plan presented in Attachment B-2 to this appendix. Field, laboratory, and office procedures are described in the Predesign Investigation QAPP which is included as Attachment B-1 to this appendix.

B.3.3.1 Reduction of RI Data

The data presented in the RI on soil types and soil gas measurements will be reduced in the form of detailed maps of the Marathon Electric/City Landfill and Wausau Chemical source areas. These will include structure contour and isopach maps showing the depth and thickness of fill at each source area, and contour maps showing soil gas and soil concentrations reported in the RI.

B.3.3.2 Utility and Building Survey

Prior to any work at either source area, building plans will be inspected to identify documented underground utility corridors and an underground utility survey will be performed by an experienced underground utility locator. The purpose of this work will be to identify potential subsurface hazards to be avoided during the field investigation and to evaluate the effect of utility corridors on the air flow patterns created by the SVE systems. Construction drawings for any existing buildings will also be inspected to evaluate the effects of the foundations on subsurface air flow.

The results of this work will be incorporated into the numerical model used to design the SVE systems for the site. The locations of known or suspected utilities will be marked on the ground with spray paint and recorded onto site maps.

B.3.3.3 Soil Gas Sampling and Drive-point Air Permeability

The spatial distribution of VOC sources at each source area will be defined using soil gas sampling. Drive-point air permeability tests will be performed in conjunction with the soil gas survey. Soil gas sampling will be performed according to the procedures described in Appendix B-1-A of the Predesign QAPP (Attachment B-1 to this appendix).

Target analytes for the soil gas survey are listed in Table B.2. These analytes include all of the VOCs previously detected in soil or soil gas samples at the site as well as additional compounds. The analytes listed in Table B.2 are sufficient to characterize the VOC contamination at the site for the purpose of SVE system design, given the results of the RI (Warzyn, 1989a). In the area of the former City Landfill, soil gas samples will be analyzed for methane in addition to the compounds listed in Table B.2 using the GC procedure described in Section 9 of the QAPP.

The soil gas samples and drive-point air permeability tests will be performed at the approximate locations shown in Plan 2 for the Wausau Chemical source area and in Plan 3 for the Marathon Electric/City Landfill source area. Sampling and air permeability measurements will be performed at each location in both the fill and underlying native soil.

At locations where fill materials overlie native soils, measurement depths will be chosen to collect one sample from the fill material and one sample from the native soil. The depth in feet below land surface (BLS) will be determined on the basis of the structure contour and isopach maps of the fill in each source area. These maps will be prepared prior to the commencement of field work. Sample depths for each location will be determined after these maps are available and prior to the commencement of field work.

TABLE B.2
TARGET VOCs AND REQUIRED DETECTION LIMITS (RDLs) FOR THE WAUSAU SVE PREDESIGN INVESTIGATION

Compound	Soil Gas RDL (µg/L gas)
benzene	0.01
toluene	0.01
ethyl benzene	0.01
m- and p-xylenes	0.01
ortho xylene	0.01
vinyl chloride	0.01
methylene chloride	0.01
1,1-dichloroethene	0.01
1,1,2-trifluoro-1,2,2-trichloroethane	0.01
1,2-dichloroethene	0.01
1,1-dichloroethane	0.01
1,2-dichloroethane	0.01
chloroform	0.01
carbon tetrachloride	0.01
1,1,1-trichloroethane	0.01
trichloroethene	0.01
tetrachloroethene	0.01
*methane	0.01

* analyzed at landfill only

At locations where fill material is absent, where the depth of fill is greater than the depth to groundwater, or where the depth of fill is greater than 15 feet, sample depths will be chosen to provide an indication of the vertical distribution of VOCs in the sediments. In the Wausau Chemical source area, soil gas samples will be collected at depths of 4 and 8 feet BLS. Sampling at depths greater than 8 feet is precluded by the presence of the water table at approximately 10 feet BLS over most of the Wausau Chemical source area. In the Marathon Electric/City Landfill source area, samples will be collected at depths of 5 and 15 feet BLS in areas where no fill is present or where the depth of fill is greater than 15 feet.

After soil gas samples are collected at a particular location, the drive rod will be pulled from the holes and the holes will be backfilled with bentonite chips or pellets. The bentonite will be hydrated with tap water immediately after backfilling. Holes in paved areas will be covered with cold patch after backfilling and hydration.

B.3.3.4 SVE Pilot Tests

B.3.3.4.1 Wausau Chemical Source Area SVE Pilot Test

SVE pilot tests will be performed in the locations of VOC "hot spots" as identified from the soil gas survey. Based on the RI data, two pilot tests are currently planned, one in the area between Wausau Chemical and the Water Treatment Plant and one between Wausau Chemical and the Wisconsin River. The purposes of the pilot tests are:

1) to determine the air permeability of surface materials near the source areas;

2) to determine the effect of surface materials on air circulation rates and patterns; and

3) to measure vapor-phase activated carbon usage.

The SVE wells will be constructed in a manner to permit their inclusion in the final SVE design. Temporary piezometers and soil gas sampling probes will be installed around the SVE wells to monitor the pressure response and soil gas concentrations during the pilot tests. The pilot tests will be performed by evacuating the SVE wells using portable vacuum pumps and carbon treatment systems. Details of the well design and testing procedures are presented below.

B.3.3.4.2 Marathon Electric/City Landfill Source Area SVE Pilot Study

An SVE pilot test will be performed at the location of the highest total chlorinated ethene concentration as identified from the soil gas survey. Based on the RI data, this is expected to be in the eastern third of the former City Landfill. The purposes of the pilot test are:

1) to determine the air permeability of surface materials near the source areas;

2) to determine the effect of subsurface materials on air circulation rates and patterns;

3) to evaluate the effect of SVE on biodegradation in the landfill materials; and

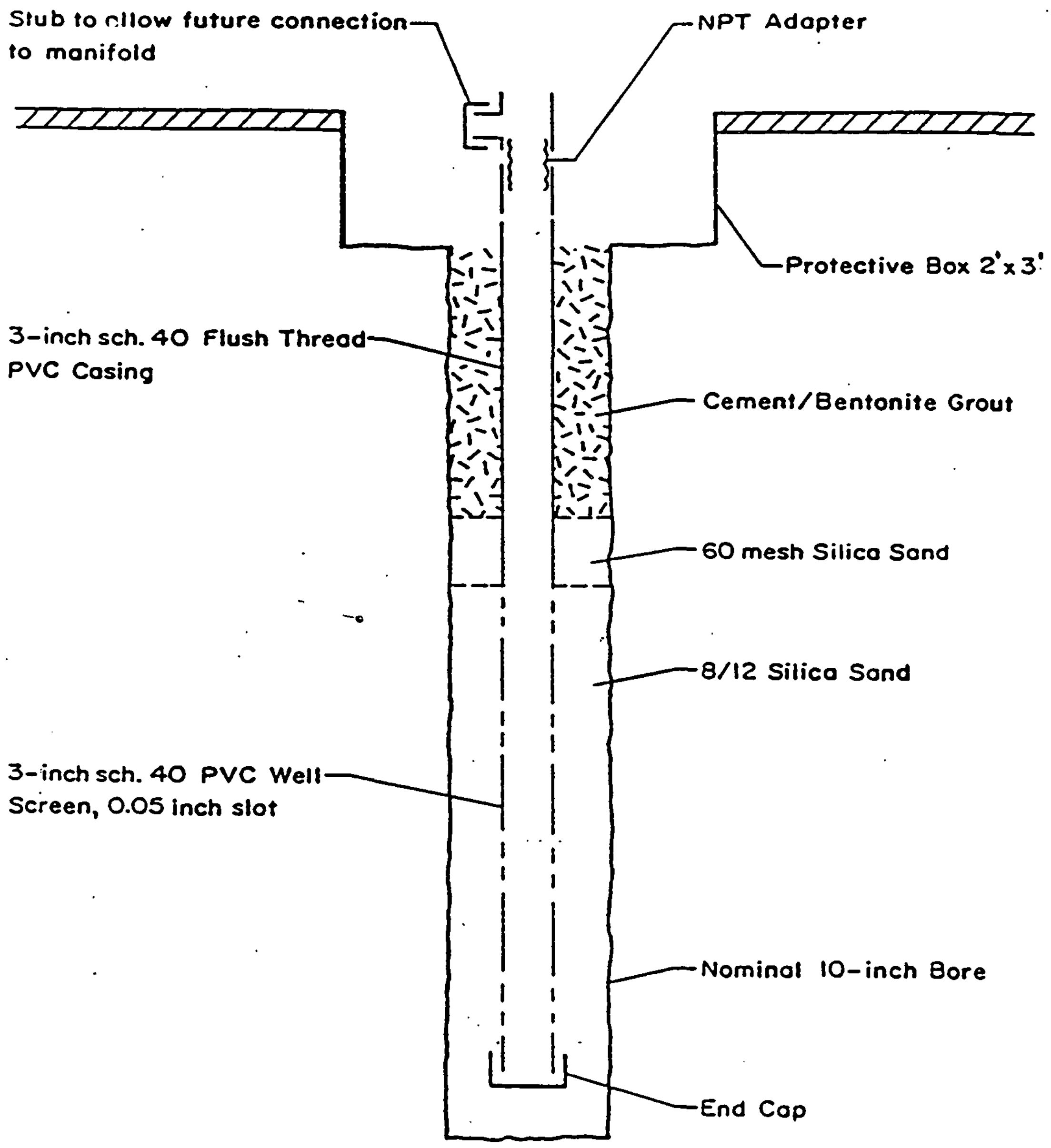
4) to measure vapor-phase activated carbon usage.

The SVE well will be constructed in a manner to permit its inclusion in the final SVE design. Permanent piezometers and soil gas sampling probes will be installed around the SVE well to monitor the pressure response and soil gas concentrations during the pilot test. The pilot test will be performed by evacuating the SVE well using a portable vacuum pump and a carbon treatment system. Details of the well design and testing procedures are presented below.

B.3.3.5 SVE Well Construction

The SVE wells used for the pilot tests will be constructed in a manner and at locations which will permit them to be incorporated into the final SVE system design. Soil samples will also be collected during the drilling of the SVE wells which will be used in the calculation of soil cleanup standards as described in Appendix C to the RD/RA Work Plan. Cuttings generated during drilling which are not preserved for future analyses will be containerized on-site for later disposal in accordance with all applicable State and Federal regulations.

The construction of the SVE wells for the Wausau Chemical pilot study is shown in Figure B.3.1. The construction of the SVE well for the Marathon



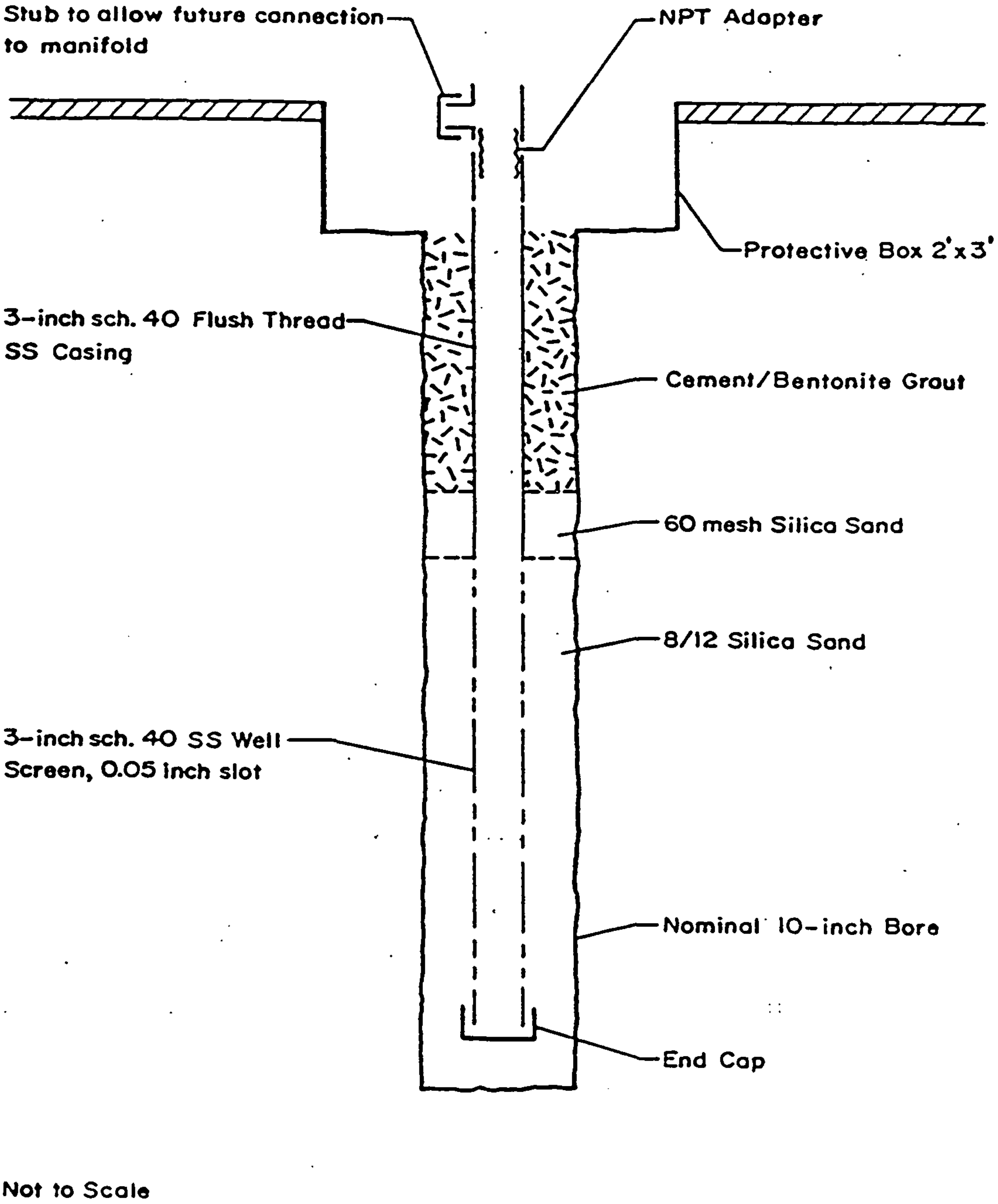
Not to Scale

WAUSAU CHEMICAL
TYPICAL SVE WELL CONSTRUCTION

Figure B.3.1. Wausau Chemical Typical SVE Well Construction

Electric/City Landfill pilot study is shown in Figure B.3.2. The wells will be constructed in boreholes drilled using a nominal 10-inch OD by 6-inch ID hollow-stem auger. At the Wausau Chemical source area, soil samples will be collected continuously during the drilling of the bore using a 3-inch ID by 18-inch long ring-lined split-tube sampler lined with three 6-inch long stainless steel sleeves. The ring-lined split-tube sampler provides better quality samples for physical parameter analyses than a conventional split-tube sample apparatus. The sampler will be advanced by pushing ahead of the auger with the weight of the auger rig as described by ASTM-D3550. At the Marathon Electric/City Landfill source area, soil samples will be collected from the drill cuttings and placed in soil moisture cups for the determination of moisture and organic carbon content.

Each ring of the samples collected at the Wausau Chemical source area will be sealed with plastic end caps immediately after removal from the sampler according to the procedures described in section 6 of the predesign QAPP. The center ring will be preserved and returned to Hydro Geo Chem's laboratory for determination of bulk density and moisture content, and for lithologic description. Aliquots of each of these samples will be processed and analyzed for total organic carbon using the procedures described in Appendix B-1-C of the predesign QAPP (Attachment B-1 of this appendix). Lithologic descriptions will conform to ASTM-D2488 (Appendix B-1-F of the predesign QAPP).



LANDFILL

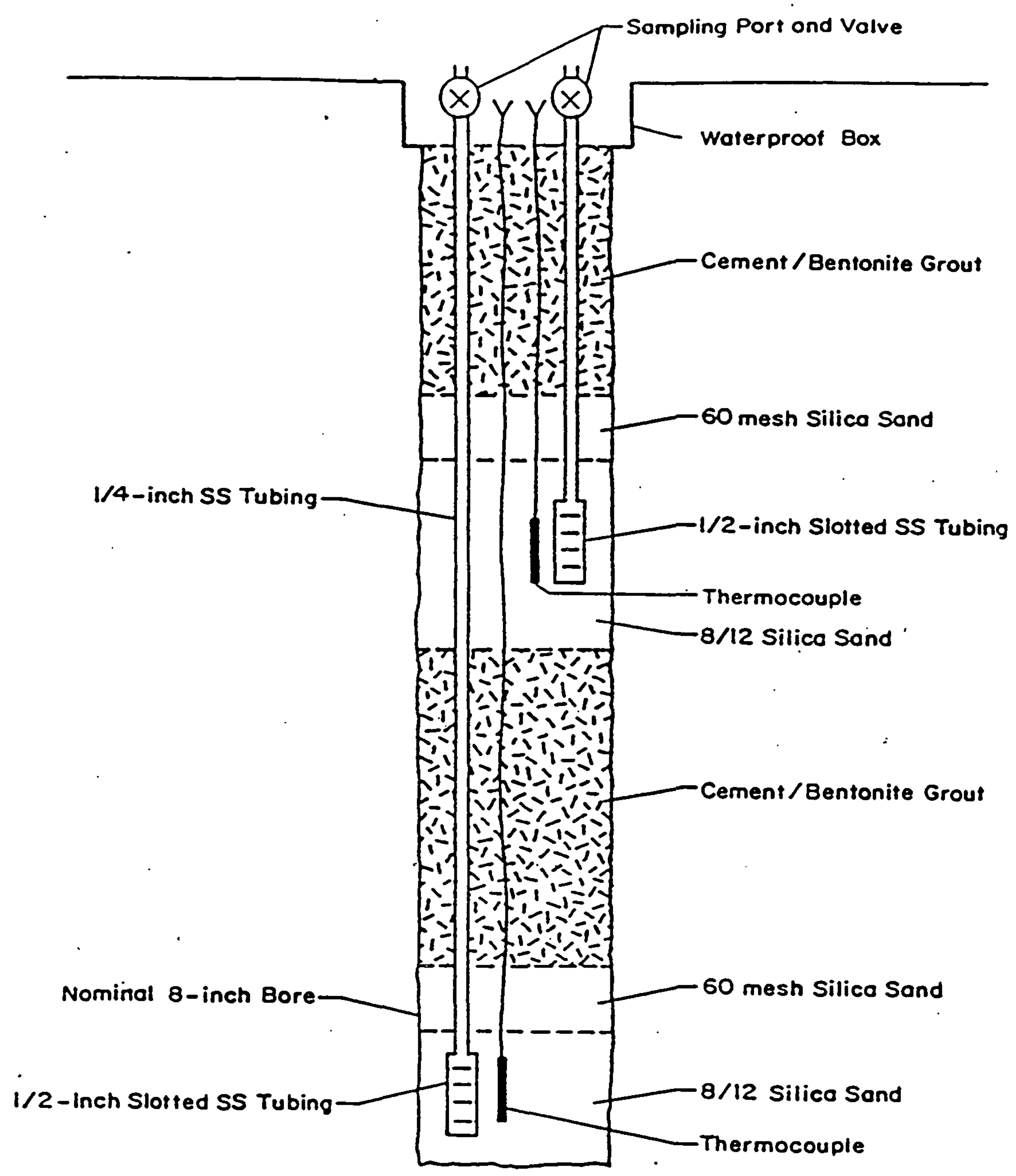
TYPICAL SVE WELL CONSTRUCTION

Figure B.3.2. Municipal Landfill Typical SVE Well Construction

B.3.3.6 Piezometer/Soil Gas Probes Installation and Monitoring

Because the pilot studies at the Wausau Chemical Site may be performed in areas of on-going industrial activities, only temporary piezometers/soil gas probes will be installed during the pilot study. Permanent probes will be installed to monitor the final SVE system. The temporary probes will consist of soil gas sampling drive rods installed using the soil gas sampling drive rig. The probes will be installed at distances of 25, 50 and 100 feet from the pilot SVE wells in directions and at depths determined by the project manager to yield appropriate data on pressure distributions and soil gas concentrations during the tests.

Permanent piezometer/soil gas sampling probes will be installed to monitor the SVE pilot test at the Marathon Electric/City Landfill source area. The probes will be installed at distances of 25, 50, and 100 feet from the pilot SVE wells in directions and at depths determined by the project manager to yield appropriate data on pressure distributions and soil gas concentrations during the tests. The probes will consist of 1/2-inch, machine slotted stainless steel tubing connected to the surface with 1/4-inch stainless steel tubing. The permanent piezometers will be installed in hollow- stem auger bores as shown in Figure B.3.3. The pressure response in the probes will be monitored using the pressure data acquisition system described in Section 9 of the predesign QAPP.



PERMANENT PIEZOMETER INSTALLATION

Figure B.3.3. Permanent Piezometer Installation

Thermocouples will be installed in the sand pack around each sampling probe with leads to the surface. The temperature will be determined by measuring the voltage output from the thermocouple with a microvoltmeter.

Soil gas samples will be collected and analyzed during both pilot studies in the same manner as those collected during the soil gas survey. Supplemental soil gas concentration measurements will be made by attaching the probes to a portable organic vapor meter with photoionization detector and monitoring the organic vapor content until a stable reading is obtained.

B.3.3.7 Pilot Testing

The pilot test at each SVE site will consist of a step-rate flow test at three different extraction rates, each lasting approximately one-half hour, and a three-day constant-rate test. The step-rate test is designed to evaluate the performance of the SVE well at varying rates of air flow. The constant-rate test is designed to evaluate the large-scale pneumatic properties of the soils and surface cover at the site, and to evaluate the efficiency of the activated carbon exhaust treatment system.

B.3.3.7.1 Equipment

The pilot tests will be performed using the portable vacuum extraction system shown in Figure B.3.4. The system will consist of a regenerative blower with an

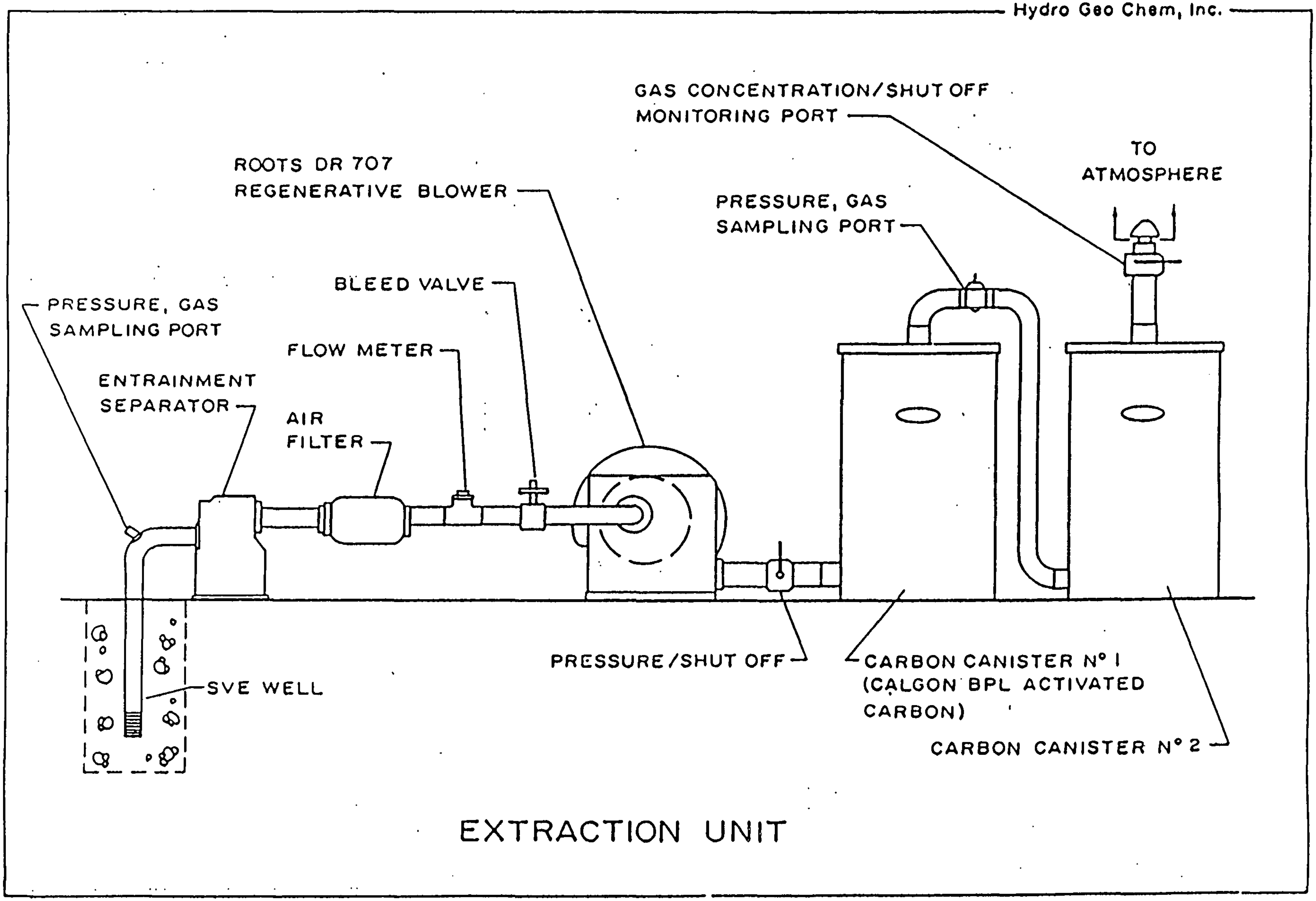


Figure B.3.4. SVE unit to be used for pilot tests operating vacuum range of 0 to 6.5 inches of mercury and air flow rate of 80 to 250 scfm (standard cubic feet per minute). Complete performance specifications for the blower are provided in Attachment B-3 to this appendix. The system will be equipped with a bleed valve to allow testing at flow rates below 80 scfm. Air flow rates out of the SVE well will be monitored with a mass flow meter. Pressure measurements will be made at the SVE well head using a Setra Model 370 pressure sensor with a range of 0 to 20 psi and an accuracy of 0.02% of full scale. The performance specifications for the pressure sensor are presented in Attachment B-5 to this appendix. This pressure measurement device will also be used to measure the pressure response in the piezometers during the constant rate test.

Gas samples from the piezometers and the vacuum extraction system will be collected and analyzed using the soil gas sampling equipment. In addition to the samples collected for analysis by the mobile laboratory, measurements of total volatile organic compounds will be made using an organic vapor meter (photoionization detector) equipped with an 11.7 eV lamp. These measurements will be used to supplement the mobile laboratory analyses, providing more continuous data on soil gas concentrations. At the Marathon Electric/City Landfill source area, measurements of O_2 and CO_2 will be made during the test using a Gas Techtor meter.

The exhaust from the vacuum blower will be passed through two Calgon Ventsorb activated carbon canisters (described in Attachment B-4 to this appendix), each packed with 400 lbs of 4 x 6 mesh Calgon BPL granular carbon. The system will be designed to allow vapor samples to be collected before and after each carbon canister. Samples will be analyzed for the compounds listed in Table B.2.

B.3.3.7.2 Test Procedures

The step-rate test will be performed by evacuating the SVE well at three different rates with each step lasting approximately one-half hour. A gas sample will be collected from the SVE exhaust approximately one minute after the start of the first step. A sample will also be collected immediately before the end of the last step. Pressure at the SVE well will be monitored with a pressure transducer and a PC-based automatic data acquisition system.

The first step will be performed at a nominal rate of 50 scfm. The wellhead pressure will be monitored continuously during each step with the output from the pressure sensor recorded at one-minute intervals. Based on the pressure response observed during the first step, the site manager will determine the rates at which the next two steps will be performed. The exhaust from the final carbon treatment unit will be monitored with the organic vapor meter during the test.

Based on the results of the step-rate test, the site manager will select a sustained flow rate at which to perform the constant-rate test. Prior to the start of the constant-rate test, ambient pressure measurements will be made in each of the piezometers. The organic vapor concentration in each of the piezometers will also be measured by attaching the organic vapor meter to each piezometer and sampling for approximately 5 minutes or until a stable reading is obtained, whichever is shorter.

The constant-rate test will be performed in a manner to allow measurement of the transient pressure response at each of the piezometers. The manner in which this will be accomplished will be determined by the site manager. If practical, the vacuum system will be started and maintained at the design extraction rate while serial pressure measurements are made at the piezometers. If the pressure response is too rapid to allow serial measurements, the vacuum system may be shut down and restarted while pressure measurements are made continuously at individual piezometers. This procedure will be followed until the transient response is recorded at each piezometer. When this is accomplished, the system will be operated at the constant rate for approximately two days. Pressure measurements and vapor concentration monitoring will be performed at six-hour intervals during this period. Flow rates and shut-down times will be accurately recorded during the constant-rate test to permit calculation of extraction volumes and masses.

The gases removed from the vapor extraction well will be monitored at one-hour intervals during the constant-rate test using the organic vapor meter. Measurements will be made at the wellhead, before and after the first carbon unit, and on the exhaust from the final carbon unit. Gas samples will be collected from each location and analyzed in the mobile laboratory at six-hour intervals.

If the exhaust concentration from the final carbon unit exceeds background concentrations at any time, the test will be terminated. Exceedence of background concentrations will be indicated by a stable reading of 2 ppmV or greater on the portable PID. This level is the lowest concentrations which can reliably be detected by the PID. Breakthrough of VOCs from the first carbon unit will be allowed in order to evaluate the carbon efficiency.

B.3.3.7.3 Analysis

The pressure response data generated during the pilot studies will be analyzed using gas well performance solutions implemented in a computer program called ASAP (Airflow Simulation and Analysis Program). The mathematical basis for ASAP is described in Section 9 of the predesign QAPP. The step-rate tests will be interpreted to determine well efficiency parameters and to estimate the air permeability of the soils near the SVE wells. The pressure response data collected during the constant-rate test will be used to estimate the air permeability of various soil horizons away from the SVE wells, the effective air permeability of the surface materials, and the effect of building and utility corridors on air flow patterns. The results of these analyses will be used during the design of the SVE system to determine SVE well spacings and locations, and to optimize the performance of the SVE system to meet the requirements of the Consent Decree.

The data collected on soil gas concentrations will be used to better define the vertical and horizontal distribution of contaminants in the soil. The gas concentration data collected from the SVE unit will be used to select appropriate carbon treatment units and to estimate carbon usage by the full-scale SVE systems.

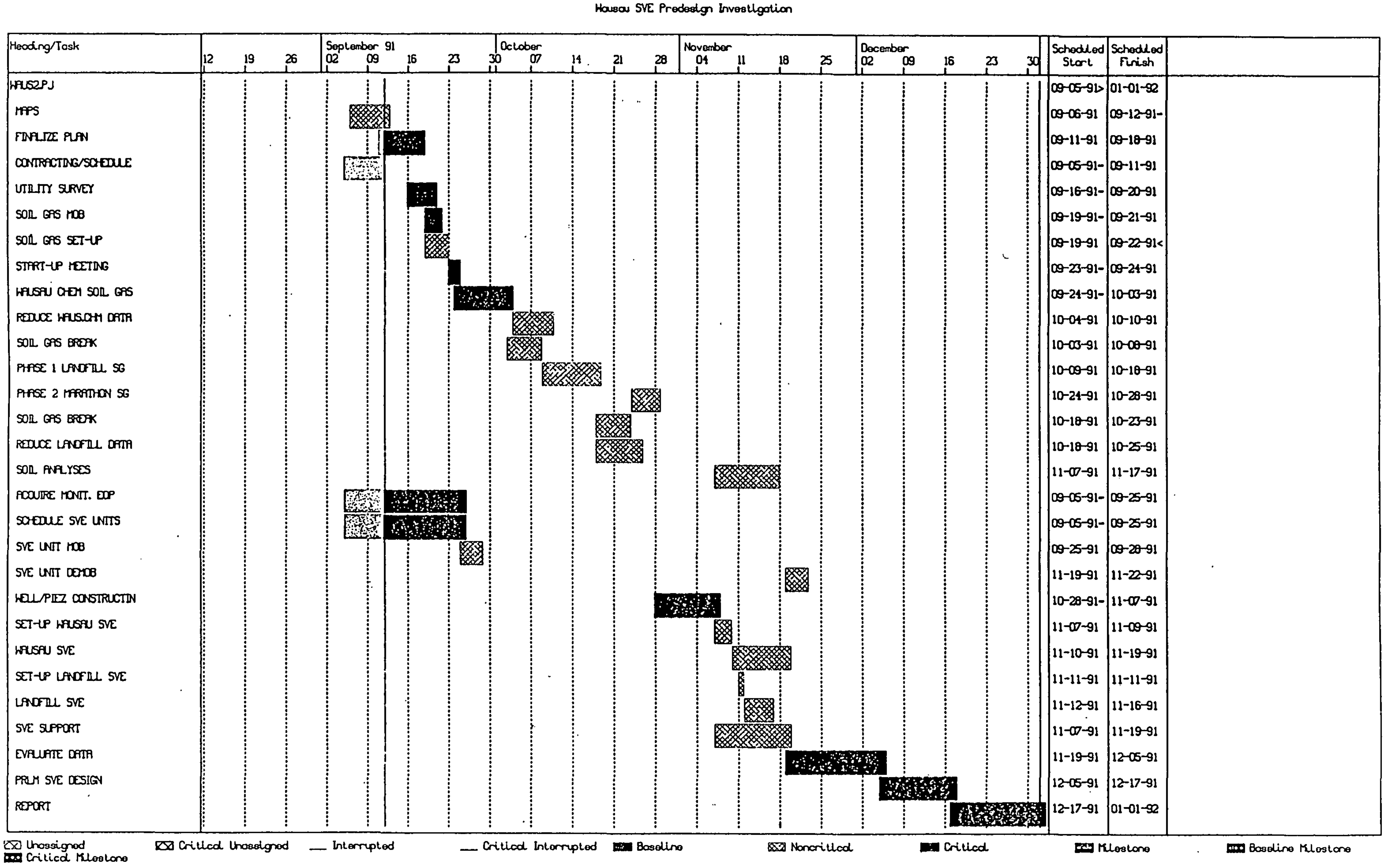
B.3.3.8 Equipment Decontamination

Prior to each use or reuse, sampling equipment such as drive rod, auger flights, soil samplers, stainless steel sleeves, sampling probes and drive points will be steam cleaned. Solid decontamination wastes such as soil scraped off of used auger flights will be containerized for later disposal in accordance with applicable State and Federal regulations. Steam cleaning rinsate will be collected and containerized for disposal to the City sanitary sewer system. Decontamination procedures are presented in more detail in the Predesign QAPP (Attachment B-1) and the Predesign Health and Safety Plan (Attachment B-2).

B.4 SCHEDULE

The SVE predesign investigation is scheduled to begin on September 16, 1991 with the utility survey and field location of sample points. The final report describing the results of the investigation is scheduled for submittal by January 3, 1992. A schedule for the SVE predesign investigation is presented in Figure B.4.1.

Both the U.S. EPA and WDNR will be notified prior to the initiation of field work. Both agencies will be notified of any schedule changes as work progresses.



Wausau SVE Predesign Investigation

Heading/Task	Scheduled Start	Scheduled Finish
WAUS2.PJ	09-05-91>	01-01-92
MAPS	09-06-91	09-12-91-
FINALIZE PLAN	09-11-91	09-18-91
CONTRACTING/SCHEDULE	09-05-91-	09-11-91
UTILITY SURVEY	09-16-91-	09-20-91
SOIL GAS MOB	09-19-91-	09-21-91
SOIL GAS SET-UP	09-19-91	09-22-91<
START-UP MEETING	09-23-91-	09-24-91
WAUSAU CHEM SOIL GAS	09-24-91-	10-03-91
REDUCE WAUS.CHM DATA	10-04-91	10-10-91
SOIL GAS BREAK	10-03-91	10-08-91
PHASE 1 LANDFILL SG	10-09-91	10-18-91
PHASE 2 MARATHON SG	10-24-91	10-28-91
SOIL GAS BREAK	10-18-91	10-23-91
REDUCE LANDFILL DATA	10-18-91	10-25-91
SOIL ANALYSES	11-07-91	11-17-91
ACQUIRE MONIT. EQP	09-05-91-	09-25-91
SCHEDULE SVE UNITS	09-05-91-	09-25-91
SVE UNIT MOB	09-25-91	09-28-91
SVE UNIT DEMOB	11-19-91	11-22-91
WELL/PIEZ CONSTRUCTN	10-28-91-	11-07-91
SET-UP WAUSAU SVE	11-07-91	11-09-91
WAUSAU SVE	11-10-91	11-19-91
SET-UP LANDFILL SVE	11-11-91	11-11-91
LANDFILL SVE	11-12-91	11-16-91
SVE SUPPORT	11-07-91	11-19-91
EVALUATE DATA	11-19-91	12-05-91
PRLM SVE DESIGN	12-05-91	12-17-91
REPORT	12-17-91	01-01-92

Figure B.4.1. Predesign Investigation Schedule

B.5 REFERENCES

Warzyn Engineering, Inc. 1989a. Remedial Investigation, Wausau Water Supply NPL Site a.k.a. Wausau Groundwater Contamination NPL Site, Wausau, Wisconsin, Prepared for U.S. Environmental Protection Agency, Region V, Chicago, Illinois.

ATTACHMENT B-1
QUALITY ASSURANCE PROJECT PLAN WAUSAU WATER SUPPLY NPL SITE SVE PREDESIGN INVESTIGATION

Prepared for:
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651 Colby Drive
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Prepared by:
Hydro Geo Chem, Inc.
1430 N. Sixth Avenue
Tucson, Arizona 85705

September 12, 1991

1. QUALITY ASSURANCE PROJECT PLAN

Project Name: Soil Vapor Extraction Predesign Investigation

Location: Wausau Water Supply NPL Site, Wausau, Wisconsin

Prepared by: Hydro Geo Chem, Inc.
1430 N. Sixth Avenue
Tucson, Arizona 85705

Date: September 12, 1991

Approvals:

______________________________ Date:______________
QA Officer, Hydro Geo Chem

______________________________ Date:______________
Project Manager, Hydro Geo Chem

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3. PROJECT DESCRIPTION

3.1 Introduction

This Quality Assurance Project Plan (QAPP) presents the organization, objectives, functional activities and specific quality assurance and quality control activities associated with the Soil Vapor Extraction (SVE) predesign investigation to be performed at the Wausau Water Supply NPL site located in Wausau, Wisconsin. The QAPP documents the specific data quality goals of the field investigation, the field and laboratory measurements which will be used to achieve those goals, data reduction and analysis methods, and QA/QC procedures to be used during the SVE predesign investigation.

The design phase for the SVE system consists of two tasks. The first task is a predesign field investigation, which is the subject of this QAPP. The objective of the predesign investigation is to gather data on the distribution of volatile contaminants and the physical properties of the soils which are necessary to design the SVE system. Associated with this task is an SVE pilot study. The pilot study will be used to determine air permeability and air circulation patterns on a scale similar to the anticipated SVE well spacing. An additional purpose of the pilot study will be to evaluate carbon trapping efficiencies for estimation of carbon use during SVE system operation.

The second task is the preparation of design plans and specifications for the full-scale SVE system. Associated with this task is the preparation of an SVE monitoring plan, a construction quality assurance plan, a cost estimate and other construction, operation and maintenance documents. Work involved in this second task is described in the RD/RA Work Plan for the Wausau site, and will not be discussed further in this predesign investigation QAPP.

3.2 Site Description

The Wausau Water Supply NPL Site (the Wausau site) is located along both banks of the Wisconsin River within the city of Wausau, which is located in Marathon County in north-central Wisconsin. Figure 3.1 shows the location of the project area. The site consists of two separate locations on the north side of Wausau, separated by the Wisconsin River. The property comprising the former City of Wausau landfill is presently owned by Marathon Electric Company and is located on the west side of the Wisconsin River. The east side location is owned by the Wausau Chemical Corporation. These two locations are considered source areas for contaminants in the aquifer which is the source of drinking water for the City of Wausau.

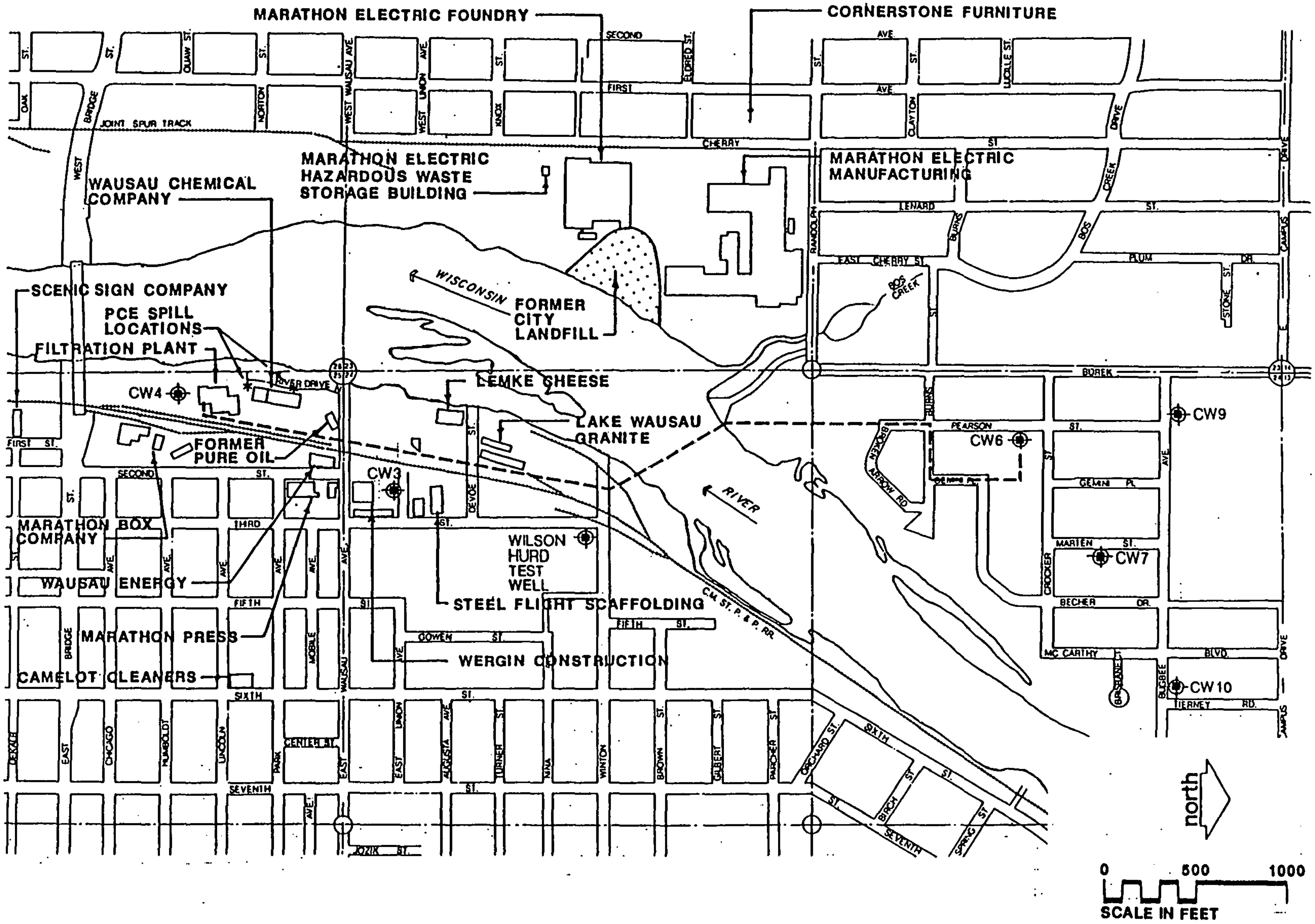


Figure 3.1 Site Location (after Warzyn, 1989a)

3.2.1 Site Geology

Wausau is located near the southern margin of the exposed Precambrian shield. The area is underlain by early Proterozoic metavolcanics which have been intruded by early to middle Proterozoic granitic plutons (Warzyn, 1988). Glacial outwash sediments overlie the Precambrian bedrock. These sediments range from 0 to 170 feet in thickness.

The glacial outwash sediments are described in the RI Phase II report (Warzyn, 1989a) as being heterogeneous gravels, sands and fine sands. These sediments were deposited as Wisconsin Stage glaciers retreated from the area, filling the Wisconsin River valley to an elevation of about 1,230 feet AMSL.

Surface fill materials are reported on both sides of the Wisconsin River in the area of the Wausau site (Warzyn, 1989a). Fill materials in the east well field area primarily consist of granite cuttings from local quarry and stone cutting operations. The former City of Wausau landfill occupies a sand and gravel pit along the west bank of the Wisconsin River beneath portions of what is now Marathon Electric property. The landfill is up to 25 feet thick in the center of the gravel pit. After gravel excavation operations ceased, the pit was filled with unknown quantities and types of residential, commercial and industrial wastes. The landfill was used to dispose of the majority of waste generated in Wausau between about 1948 and 1955.

3.2.2 Site Hydrogeology

Two major hydrostratigraphic units have been identified in the vicinity of the Wausau well field; Precambrian age bedrock and outwash alluvium (Warzyn, 1989a). Only the alluvial aquifer is relevant to the design of the SVE system. The outwash sand and gravel (alluvial) aquifer was deposited by glacial meltwater streams within the bedrock valley formed by the ancestral (pre-Pleistocene) Wisconsin River. Recent alluvial sediments (gravel, sand, silt, and organic materials) have also been deposited since the glacial retreat. The outwash/alluvial aquifer appears wedge-shaped in cross section perpendicular to the Wisconsin River Valley. In the vicinity of the well field, the aquifer width ranges between 0.5 and 1.75 miles. Groundwater occurs at a depth of about 15 feet at the Wausau Chemical source area and at depths of 20 to 30 ft at the Marathon Electric/City Landfill source area.

Groundwater flow in the vicinity of the Wausau well field is influenced by several factors including:

- Bedrock topography;
- Soil heterogeneities;
- Variable production well pumpage;
- The presence and fluctuation of river and stream elevations;
- The hydraulic resistance of the stream and the river beds; and

- The rate and distribution of rainfall percolation recharging the aquifer.

Each of these factors play a role in groundwater flow and contaminant migration routes and velocities. Discussion of the relationships of these factors is beyond the scope of this document. The RI Phase II Report (Warzyn, 1989a) provides a more complete description of the groundwater flow field in the Wausau area.

3.3 Site History

The City of Wausau discovered in early 1982 that its production wells CW-3, CW-4 and CW-6 were contaminated with volatile organic compounds (VOCs). Tetrachloroethene (PCE), trichloroethene (TCE), and 1,2-dichloroethene (DCE) were the predominant contaminants found. TCE was the primary VOC detected at CW-6, with PCE and DCE also reported. Since TCE was first detected, the concentrations at CW-6 have ranged from 26 to over 200 micrograms per liter (ug/l). Sample results from the east well field (CW-4 and CW-3) indicate PCE, TCE and DCE contamination. CW-4 has generally shown a steady decrease in concentrations of these three constituents since 1984. CW-3 has shown decreases in PCE and DCE since they were discovered. TCE concentrations, however, have remained relatively constant at concentrations ranging between 80 to 210 ug/l. Toluene, ethylbenzene and xylene were also detected in well CW-4.

The City instituted a blending program whereby uncontaminated water from CW-9 and CW-7 was blended with water from CW-3, CW-4 and CW-6 in order to decrease VOC levels to acceptable drinking water quality prior to distribution. However, the program was largely ineffective due to continuing increases in VOC concentrations and groundwater quality which exceeded regulatory limits at that time.

In the fall of 1983, the EPA awarded the city a federal grant to help fund the design and installation of research units (GAC and air strippers) to reduce contaminants and provide sufficient water of acceptable quality to City residents. However, during the interim, the Wisconsin Department of Natural Resources requested assistance from the EPA emergency response team to evaluate possible response to the contaminant levels in the City's drinking water supply. Under emergency response, the EPA installed and operated a temporary granular activated carbon (GAC) treatment system at CW-6 starting in July 1984. As part of the research effort, full scale packed tower VOC strippers were operational in August 1984 at the City water treatment plant to treat water from wells CW-3, CW-4 and CW-6. The air stripping towers proved to be very effective for removal of the VOCs from the City's water supply. The temporary GAC system was subsequently removed from service in October 1984.

In December 1985, the Wausau groundwater contamination site was nominated for inclusion on the National Priorities List (NPL). A remedial investigation/

feasibility (RI/FS) study was conducted for the EPA by Warzyn Engineering, Inc. The RI/FS entailed two phases of field sampling. Phase I of the field work was conducted between August 1987 and January 1988. Results of the Phase I study are summarized in a technical memorandum dated April 1988. An Operable Unit Record of Decision (ROD) to address the west side contamination plume was signed in September 1988. Phase II of the RI/FS field work was conducted between June and September 1988. Results of the Phase II study are summarized in the RI/FS report dated August 1989. The remedial alternative selected is outlined in the ROD issued by the EPA in September 1989. A Consent Decree incorporating the ROD in the final remedy was negotiated by the settling defendants and EPA in 1990. The Consent Decree was lodged with the United States District Court for the Western District of Wisconsin on November 9, 1990.

The remedial design and construction of the operable unit groundwater extraction well on the Marathon Electric Corporation property north of the old landfill has been completed. The groundwater extraction well was put into operation on November 14, 1990. A report summarizing the installation and pump testing of the operable unit extraction well was submitted by Conestoga-Rovers and Associates (CRA) in December 1990.

3.3.1 Marathon Electric/Former Landfill

The following background information on the Marathon Electric/City Landfill source area is taken from Warzyn (1989b):

> The former City landfill/Marathon Electric source area (former City landfill) occupies a sand and gravel pit located on the west bank of the Wisconsin River. The landfill covered approximately 4.5 acres, underlying the southeastern portion of Marathon Electric property. The landfill operated from approximately 1948 to 1955 and was reportedly the only landfill operating within the City at the time. During its period of operation, almost all commercial, industrial and residential waste generated within the City was disposed at the site. Generally, the waste was burned prior to landfilling in order to reduce volume. Ash and cinders were reportedly disposed throughout the landfill. Observations made during test pit excavations are consistent with these reports. Former landfill employees indicated that waste burning often could not keep pace with the amount of waste received in a day. In such instances, waste was generally filled directly into the western part of the former sand and gravel pit at the landfill site. Former employees also indicated that bulk liquids contained in 55-gallon drums were frequently emptied directly into the landfill.

The majority of the landfill site is currently covered by bituminous pavement parking lot. The southern portion of the landfill area is vegetated. An electric utility substation is located over the south central portion of the landfill. Marathon Electric reportedly encountered drummed waste materials during foundation excavations beneath the east side of the plant foundry.

The predominant source of TCE contamination at Production Wells CW3 and CW6 appears to be the former City landfill/Marathon Electric area. Elevated concentrations of TCE were detected in groundwater (shallow and deep), soil and soil gas samples obtained within and beyond the limits of the fill area. Soil gas samples were collected during a shallow (2.5 ft) soil gas survey, and while drilling Phase II borings (up to 20 ft). Soil samples were collected from test pits within the landfill and from borings within the landfill and at various locations around the Marathon Electric assembly plant. Soil gas VOC data indicate VOCs are distributed in the northeastern half of the old landfill, beyond the fill to the north, and to the south and east of the Marathon Electric assembly plant (RI Report, Warzyn, 1989a). The highest soil gas concentrations were observed at and near the northeast corner of the fill area. TCE concentrations within the unsaturated zone fill materials in this area ranged up to 160,220 ug/kg (160 ppm).

In addition to VOCs, contaminants identified in landfill soil/waste samples included primarily polycyclic aromatic hydrocarbons (PAH) and metals. PAHs were found throughout the fill, but highest concentrations were observed near the center of the fill area. Heavy metals were distributed throughout the fill. Chromium, zinc and nickel were detected in groundwater samples from beneath the fill. These metals appear to be restricted to the immediate vicinity of the landfill.

3.3.2 Wausau Chemical

The following information is taken from Warzyn (1989b):

Solvents released from the Wausau Chemical Co. source areas are primarily responsible for the shallow groundwater contamination in the East Well Field area. Soil gas data reflecting the distribution of VOCs in unsaturated soils were collected during a shallow (2.5 ft) soil gas survey (Phase I), and while drilling Phase II borings. Shallow soil gas survey data show the highest concentrations of VOCs in unsaturated soils occurred at locations near the southern end of the site, with decreasing concentrations within an elongated contaminant zone trending toward the east-northeast (RI Report, Warzyn, 1989a). Data from soil sample analysis generally confirm this distribution, but elevated VOC concentrations were also found in unsaturated soils near the northeast loading dock and along the east side of the building. It should be noted that approximately 1000 cu yd of soils were removed from the former bulk storage area in 1984. The highest total VOC soil concentrations detected during the RI at the Wausau Chemical facility were 3 mg/kg, for a sample collected near the water table southwest of the former bulk storage area (B24), and 5.3 mg/kg, for a shallow sample (2.5 ft) collected near the northwest loading dock area. Observations reported during the excavation of soils from the former bulk storage area suggest VOC contamination beneath the southern end of the Wausau Chemical building. As indicated previously, VOC contamination beneath the City water treatment plant is also suspected.

3.4 Project Objectives

The objective of the SVE system predesign investigation is to collect the data necessary to prepare a detailed engineering design for the operational SVE system. The predesign investigation represents the first of two tasks necessary to complete the operational SVE system design. The second task is the preparation of all necessary design and construction documents. This second task is described in the Wausau site RD/RA Work Plan.

3.4.1 Data Uses

The data developed during the predesign investigation will be used to support the design of the SVE system. The data will be used to characterize the following parameters necessary for optimal design of the SVE system:

- Lateral and vertical distribution of VOCs in the unsaturated zone at both source locations.
- Physical characteristics of the sediments at the site, including porosity, density, moisture content, total organic carbon content and gas permeability
- Lithology of the upper sediments at the site

The data on soil properties will also be used to support the mass flux calculations to be used to determine soil cleanup concentrations for the SVE system.

The purpose of the SVE predesign investigation is not to attempt to detect and quantify all possible contaminants at the Wausau site. Data from this investigation is only intended for use in support of the SVE system design. Sample collection and analytical methods described later in this QAPP are sufficient to provide the data necessary for these intended uses.

3.4.2 Data Quality Objectives

The overriding data quality objective for this investigation is to provide a data set which is complete and adequate to design the SVE system. Specific sampling and analytical procedures, chain of custody requirements, instrument calibration and maintenance procedures, and corrective action policies are described elsewhere in this QAPP. The QA methods which will be used to achieve the data quality objectives of precision, accuracy, representativeness, comparability and completeness are described in Section 5 of this QAPP.

Analytical levels appropriate to achieve the objectives of the Wausau SVE predesign investigation include Levels I, II and V as described in EPA (1987). Level I methods will be used for field screening and monitoring to meet health and safety requirements. The specific Level I methodologies are described in the Health and Safety Plan for this project. Level II methods will be used for volatile organic analyses of soil gas by the on-site mobile laboratory. Level V methods will include analysis of soil samples for physical characteristics such as water content, bulk density, porosity, total organic carbon content and air permeability. Table 3.1 presents a summary of the analytical levels and methods to be used in this project.

TABLE 3.1
SVE PREDESIGN INVESTIGATION ANALYTICAL LEVELS AND METHODS

Parameters	Matrix	Methods	Analytical Level
Health & Safety screening	----	Described in HASP	I
Lithologic description	soil	ASTM-D2488	I
Water content, bulk density, porosity	soil	ASTM-D2216 ASTM-D3152	V
Total organic carbon (TOC)	soil	Described in Appendix D	V
Table 3.2 VOC	soil, gas	Modified EPA 8021 (mobile lab)	II
Water Content (landfill soil cuttings)	soil	Modified ASTM-D2216	V

3.5 Target Compounds

The purpose of the SVE system is to remove volatile organic compounds (VOCs) from the soils in the Wausau Chemical and Marathon Electric/City Landfill source areas. The target compounds for the SVE predesign investigation, therefore, are those which will impact SVE system design and operation.

Several VOCs have been detected at the Wausau site. The RI report (Warzyn, 1988, 1989a) provides an analysis of the distribution of VOCs in subsurface soils at the site. The primary contaminants at the Wausau site are tetrachloroethene (PCE), trichloroethene (TCE) and 1,2-dichloroethene (DCE). Other VOCs have been detected at the site in low concentrations. Table 3.2 lists the target compounds and required detection limits for the predesign investigation. This suite of target compounds and detection limits is sufficient to characterize the extent of contamination for the purpose of SVE system design.

3.6 Soil Gas Sample Network and Rationale

The sampling pattern has been designed to provide unbiased estimates of the extent of VOC contamination at the Wausau Chemical and Marathon Electric\City Landfill source areas. A total of 97 locations have been selected on a grid with

TABLE 3.2
TARGET VOCs AND REQUIRED DETECTION LIMITS (RDLs)

Compound	Soil Gas RDL (µg/L gas)
benzene	0.01
toluene	0.01
ethyl benzene	0.01
m- and p-xylenes	0.01
ortho xylene	0.01
vinyl chloride	0.01
methylene chloride	0.01
1,1-dichloroethene	0.01
1,1,2-trifluoro-1,2,2-trichloroethane	0.01
1,2-dichloroethene	0.01
1,1-dichloroethane	0.01
1,2-dichloroethane	0.01
chloroform	0.01
carbon tetrachloride	0.01
1,1,1-trichloroethane	0.01
trichloroethene	0.01
tetrachloroethene	0.01
*methane	0.01

* analyzed at landfill only

approximately 50 feet between sample locations along a grid line. Forty-seven of the sample locations are within the Wausau Chemical source area and 50 locations are placed in the Marathon Electric/City landfill area.

Soil gas samples will be collected from two depths at each sample location in the Wausau Chemical source area. Samples will be collected from two depths at the 37 Phase I locations in the Marathon Electric source area. Samples will be collected from a single depth at the 13 Phase II locations in the Marathon Electric source area. A total of 181 soil gas samples will be collected during the course of the investigation.

Approximately 40 ring-lined split-tube samples of soils will be collected during drilling of the SVE pilot study wells and piezometers. The locations of these borings will be determined based on the results of the soil gas surveys. Section 6.1 describes the sample point selection process. The approximate soil gas sampling locations are shown in Figure 3.2 and 3.3.

Table 3.3 summarizes the SVE predesign investigation sampling program. A detailed description of sampling procedures is included in Section 6 of this QAPP.

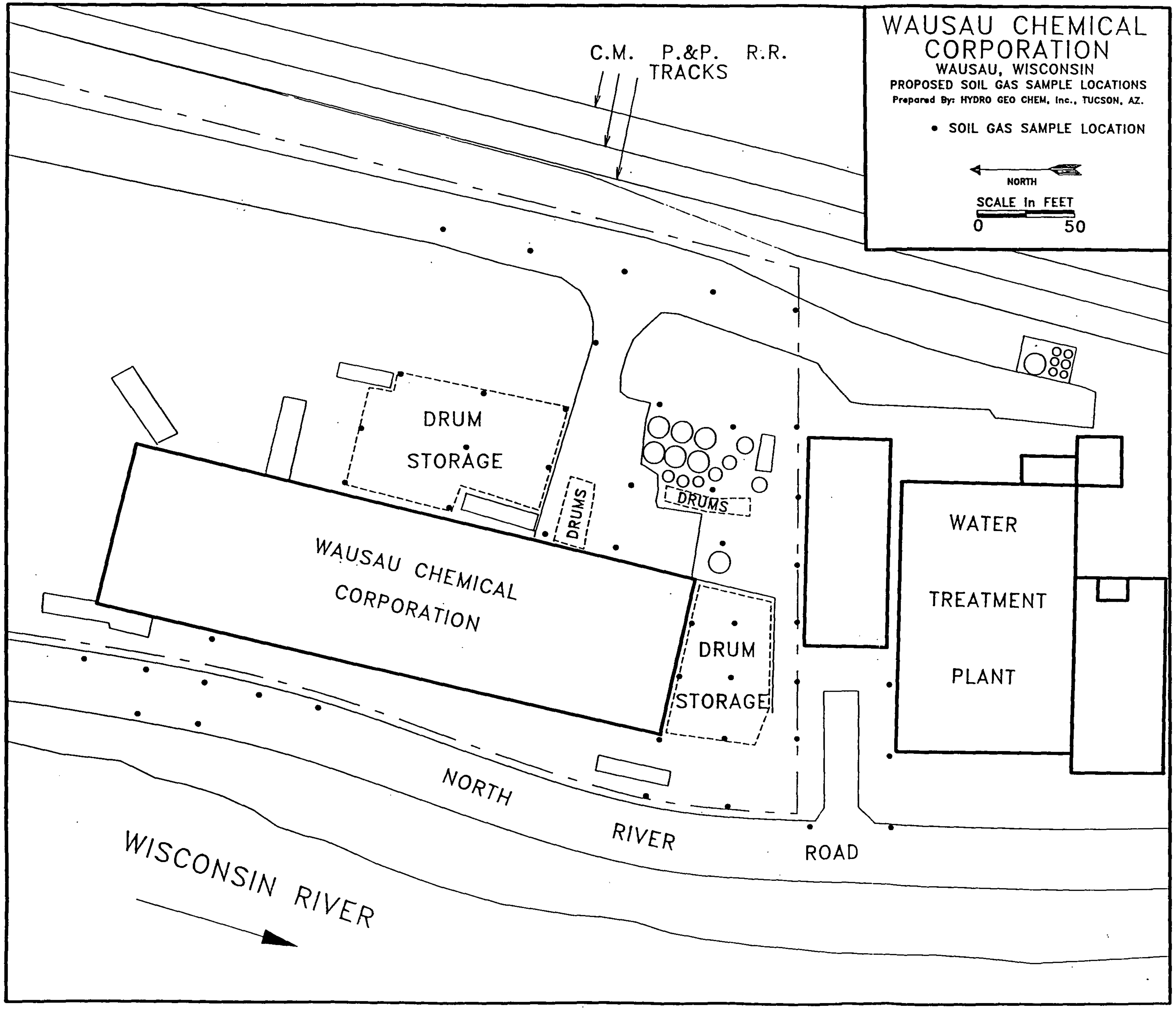


Figure 3.2: Approximate Soil Gas Sampling Locations at Wausau Chemical

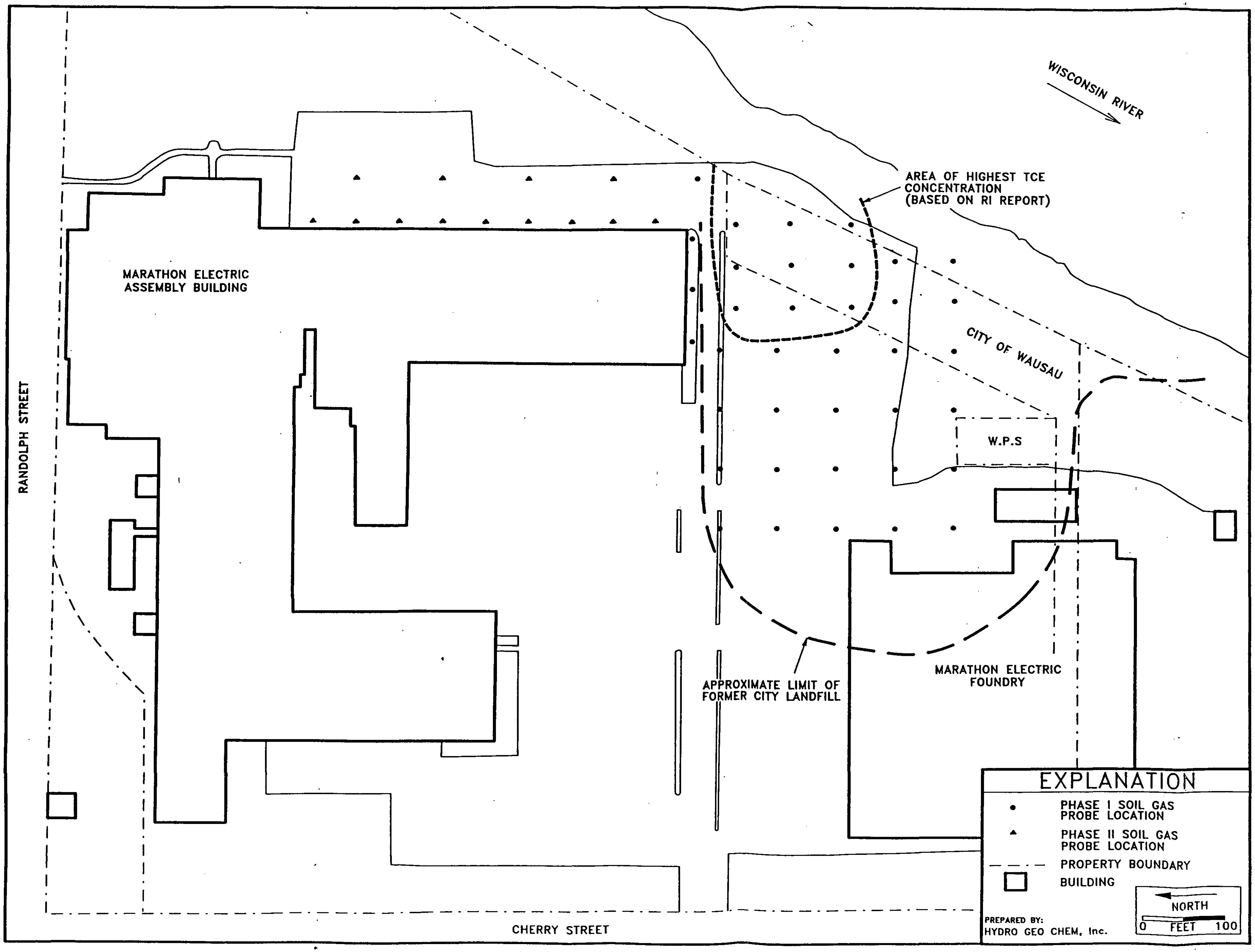


Figure 3.3: Approximate Soil Gas Sampling Locations at Marathon Electric

TABLE 3.3
SVE PREDESIGN INVESTIGATION SAMPLING SUMMARY

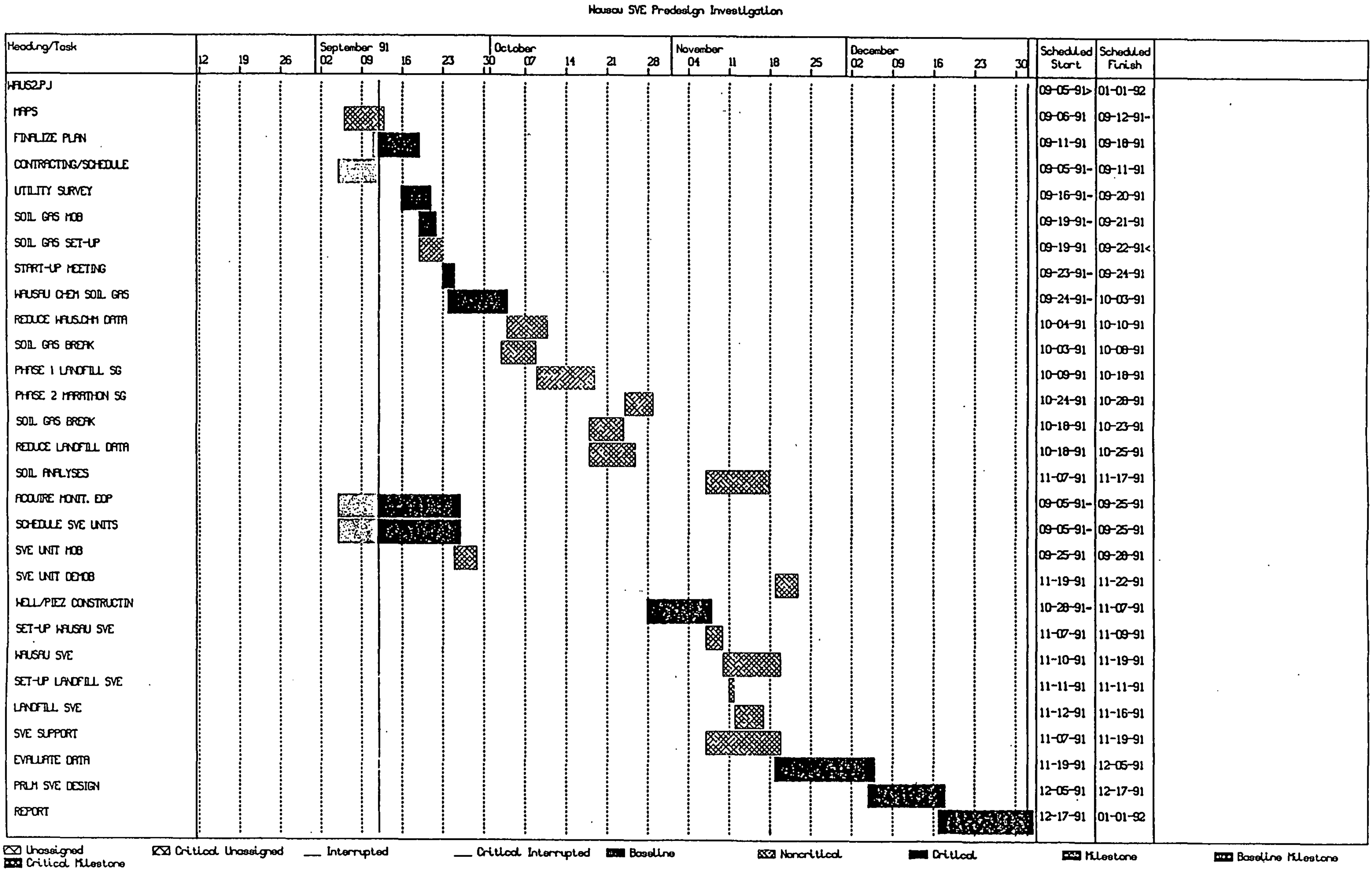
Sample Description	Number of Field Samples	Parameters
1. Ring-lined Split-Tube Samples	40	physical soil parameters, total organic carbon
2. Soil Gas Samples/Air Permeability	181	VOC(1), air permeability(2)

Notes: (1) Specific target VOCs are listed in Table 3.2
(2) Step-drawdown air permeability tests will be performed at each location that a soil gas sample is collected

3.7 Project Schedule

Field sampling for the SVE predesign investigation will begin in accordance with the approved RD/RA Work Plan. The predesign investigation, including sampling, analysis, laboratory permeability measurements and numerical simulations will take approximately 3 months to complete. Figure 3.4 presents a chart of the predesign investigation schedule.

Both the U.S. EPA and WDNR will be notified prior to the commencement of field work. Both agencies will be notified of any changes to the schedule presented in Figure 3.4. No field work will be undertaken without authorization from U.S. EPA and WDNR.



Heading/Task	Scheduled Start	Scheduled Finish
WAUS2.PJ	09-05-91>	01-01-92
MAPS	09-06-91	09-12-91-
FINALIZE PLAN	09-11-91	09-18-91
CONTRACTING/SCHEDULE	09-05-91-	09-11-91
UTILITY SURVEY	09-16-91-	09-20-91
SOIL GAS MOB	09-19-91-	09-21-91
SOIL GAS SET-UP	09-19-91	09-22-91<
START-UP MEETING	09-23-91-	09-24-91
WAUSAU CHEM SOIL GAS	09-24-91-	10-03-91
REDUCE WAUS.CHM DATA	10-04-91	10-10-91
SOIL GAS BREAK	10-03-91	10-08-91
PHASE 1 LANDFILL SG	10-09-91	10-18-91
PHASE 2 MARATHON SG	10-24-91	10-28-91
SOIL GAS BREAK	10-18-91	10-23-91
REDUCE LANDFILL DATA	10-18-91	10-25-91
SOIL ANALYSES	11-07-91	11-17-91
ACQUIRE MONIT. EQP	09-05-91-	09-25-91
SCHEDULE SVE UNITS	09-05-91-	09-25-91
SVE UNIT MOB	09-25-91	09-28-91
SVE UNIT DEMOB	11-19-91	11-22-91
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WAUSAU SVE	11-10-91	11-19-91
SET-UP LANDFILL SVE	11-11-91	11-11-91
LANDFILL SVE	11-12-91	11-16-91
SVE SUPPORT	11-07-91	11-19-91
EVALUATE DATA	11-19-91	12-05-91
PRLM SVE DESIGN	12-05-91	12-17-91
REPORT	12-17-91	01-01-92

Figure 3.4: SVE Predesign Project Schedule

4. PROJECT ORGANIZATION AND RESPONSIBILITY

4.1 Management

Hydro Geo Chem, Inc. will provide sampling supervision and general project management including overall QA/QC review and health and safety review of all activities. Sampling operations and sampling QC will be the responsibility of Mr. Walter Weinig, site manager for Hydro Geo Chem. Overall project management will be provided by Dr. Gary Walter, project manager for Hydro Geo Chem. Oversight of quality assurance procedures will be provided by Ms. Susan Maida, Hydro Geo Chem's Quality Assurance Officer.

4.2 Field Activities

Sample collection, chain-of-custody and sample shipment will be the responsibility of Hydro Geo Chem's field personnel.

4.3 Laboratory Operations

On-site laboratory support will be provided by Hydro Geo Chem's mobile laboratory. Operation of the mobile laboratory will be the responsibility of Hydro Geo Chem's field chemists. Soil physical characteristics determinations will be performed by Hydro Geo Chem personnel at their Tucson, Arizona facility. TOC measurements will be performed by the University of Arizona Soil and Water Laboratory.

4.4 Data Assessment

Data quality review, including data assessment will be the responsibility of Gary Walter, Harold Bentley and Walter Weinig of Hydro Geo Chem. Data processing activities will be the responsibility of Walter Weinig of Hydro Geo Chem.

4.5 Quality Assurance

Overall QA review will be provided by Gary Walter and Susan Maida of Hydro Geo Chem. The requirement for corrective actions will be determined by Gary Walter. Final review and acceptance of this QAPP and the proposed laboratory test procedures will be provided by the U.S. EPA Region V Remedial Project Manager.

4.6 Performance/Systems Audits

Internal performance audit information will be provided by Susan Maida of Hydro Geo Chem, Inc. Field systems audits, consisting of determination that proper sampling procedures and protocols are followed by sampling personnel, will be provided by Walter Weinig of Hydro Geo Chem.

4.7 Hydro Geo Chem Project Organization

The following Hydro Geo Chem personnel will be assigned to this project. A project organization chart is shown in Figure 4.1.

Project Manager:	Dr. Gary Walter
Staff Consultants:	Dr. Harold Bentley Mr. Mark Kuhn
Quality Assurance Officer:	Ms. Susan Maida
Site Manager:	Mr. Walter Weinig
Site Health & Safety Coordinator:	Mr. Walter Weinig
Project Hydrologist:	Mr. Stewart Smith
Field Geologists:	Mr. Mario Pauker
Field Chemist:	Mr. Robert Agnew
Field Technicians:	Mr. Martin Barber Mr. Dick Thompson Mr. Paul Orendain

The project manager and all field personnel have or will have received 40 hours of OSHA health and safety training prior to the field investigation.

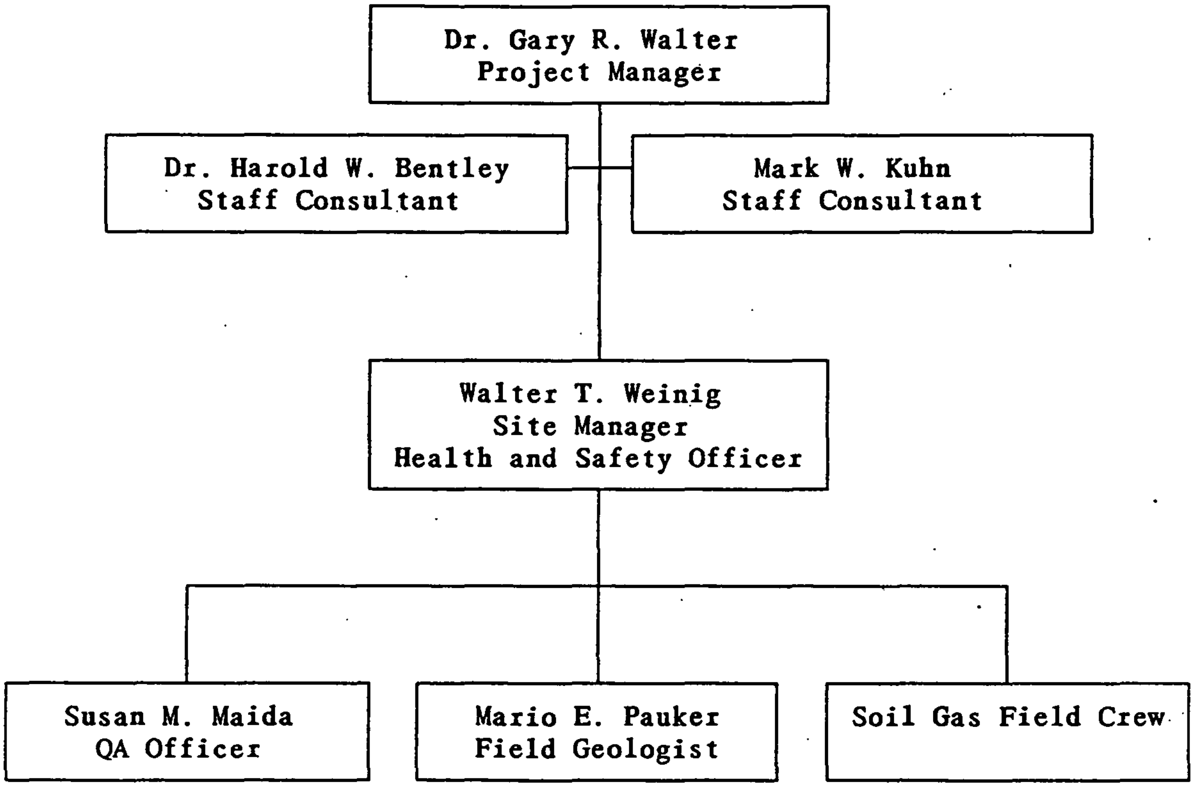


Figure 4.1 Project Organization Chart

5. QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT DATA

5.1 Quality Assurance Effort

The level of QA effort during the remedial investigation will result in additional QA samples comprising 10% of soil gas samples analyzed for chemical parameters. The analyses for physical soil properties result in change or destruction of the sample and therefore cannot be repeated on identical samples. The number of analyses, laboratory, analytical protocols, duplicate analyses, and blanks are listed in Table 5.1.

5.2 Accuracy

Accuracy during sample analysis will be determined from the analysis of surrogate spikes. These will comprise at least an additional 10% of the samples analyzed.

5.3 Precision

Ten percent duplicates will be analyzed for soil gas samples. The acceptable range of precision for mobile laboratory analysis of soil gas will be that specified in the modified 8021 protocols presented in Appendix A.

TABLE 5.1
LEVEL OF QUALITY ASSURANCE EFFORT FOR WAUSAU SVE PREDESIGN INVESTIGATION

Analysis	Parameters to be tested*	Number of Analyses	Laboratory	Protocol	Duplicates(%)	Blanks[(a)]
Soil Gas	1,4	181	HGC	Mod.EPA 8021	19(10)	20 (field) 20 (trip)
Soils	2	40	HGC	ASTM D-2488	0	0
Soils	3	40	HGC	ASTM D-2216 D-3152	0	0
Total Organic Carbon	-	40	Univ.of Arizona	see Appendix D	0	-

* Explanation of parameter notes:
1) See Table 3.2: VOC Analytes
2) Lithologic Description
3) Total porosity, moisture content, bulk density.
4) Point Air Permeability
(a) Estimated number of blanks. Actual numbers may vary due to variations in the number of samples collected or the number of days sampling is performed.

5.4 Detection Limits

Mobile laboratory detection limits are listed in Table 3.2.

5.5 Representativeness

The areal representativeness of the samples will be assured by collecting samples on a regular grid over the site. Samples for analysis of physical soil parameters will be taken from locations representative of conditions at contaminated portions of the site.

5.6 Comparability

Comparability of the data is assured by using standard sampling and analytical procedures for samples sent to outside laboratories and by using mobile laboratory sampling and analytical protocols previously accepted by the EPA (Region 5) and numerous other parties. In addition, the data are reported in consistent and standard units (µg/L; µg/kg, etc.).

6. SAMPLE COLLECTION AND SHIPMENT PROCEDURES

6.1 Sampling Point Selection

A soil gas sampling pattern consisting of the grids shown in Figure 3.2 and 3.3 has been designed to provide measurements of VOC concentrations across the site. A total of 97 soil gas sampling locations have been selected, with sample locations at each of the source areas.

At each of the soil gas locations in the Wausau Chemical source area, Hydro Geo Chem's drive point rig will sample at two depths selected to represent the fill and native soils. If fill materials extend below the water table, or if no fill material is present, samples will be collected from depths of 4 and 8 feet below land surface (BLS). Sample locations at the Wausau chemical source area are shown in Figure 3.2. At each of the Phase I sample location in the Marathon Electric/City Landfill source area, the drive point rig will sample at 2 depths selected to represent landfill materials and the underlying native soils. If no fill materials are present, or if fill materials are greater than 15 feet deep, samples will be collected at depths of 5 and 15 feet BLS.

At each of the Phase II sample locations in the Marathon Electric/City Landfill source area, the drive point rig will sample at a depth of 5 feet BLS. The results of the Phase II soil gas survey will be used to determine the necessity of further work in the area east of the Marathon Electric assembly building. Phase I and Phase

TABLE 6.1
SAMPLE CONTAINERS, PRESERVATIVES, AND HOLDING TIMES

Sample Matrix	Analysis	Required Volume	#Containers	Container Type	Preservatives	Holding Time
Soil	lithologic description	-	-	-	none	-
	TOC	10 grams	1	stainless steel sleeve (3" x 6")	none	-
	water content, bulk density and porosity	-	1	stainless steel sleeve (3" x 6")	none	-
	water content (landfill cuttings)		1	soil moisture cup	none	-

II soil gas sample locations in the Marathon Electric/City Landfill source area are shown in Figure 3.3.

Soil samples for physical description of soils and fill material area will be collected from soil borings performed to install SVE pilot study wells and permanent piezometers. Samples at the Wausau Chemical source area will be used for lithologic description and determination of bulk density, porosity, moisture content, and total organic carbon. Because of the nature of the fill material in the landfill, cuttings will be collected from the Marathon Electric/City Landfill source area for determination of moisture content, and visual determinations of lithology and organic carbon content.

6.2 Sampling Procedures

This section describes the sampling procedures to be used during the SVE predesign investigation.

6.2.1 Soil Gas Sampling Procedures

Soil gas sampling procedures to be followed are described in detail in Appendix A.

6.2.2 Soil Sampling Procedures

Soil samples will be collected for the determination of physical parameters. Sampling procedures are described in this section.

Prior to each use, each sampler, stainless steel liner and auger flight or drill stem will be steam cleaned with a dilute sodium triphosphate solution and stored on racks above ground. Care will be taken with this equipment to eliminate both soil-surface and cross-hole contamination. Vinyl or latex surgical gloves will be worn during handling and assembly of sampling apparatus.

Ring-lined split-tube sampling will be used to collect samples used for determination of bulk density, moisture content, total porosity, and organic carbon content. The sample collection method described in this section conforms to ASTM method D-3550, Standard Practice for Ring-lined Barrel Sampling of soils. A complete description of ASTM D-3550 is included in Appendix B-1-B.

The split-tube sampling device is described in ASTM D-3550. The sampler will have a minimum inside diameter of 3.0 inches and will be 18 inches in length. The sampler will be constructed of 16 gauge stainless steel or other material with sufficient strength for use in clays, silts, sands or gravels.

Prior to obtaining a sample, the boring will be completed to the desired depth using a hollow-stem auger. The sample tube will then be advanced approximately 18 inches beyond the bottom of the auger boring. After the sample tube has been advanced, it will be carefully removed from the boring in a manner which minimizes sample disturbance.

After sample collection, each ring will be removed from the sampler and the ends will be covered with plastic caps. The plastic caps will be sealed to the ring using duct tape.

Each ring will be labeled with the sample location, date and time of sampling, and the ring number. Ring numbering will begin with 1 at the bottom of the sampler (closest to the sampling shoe) and increase by 1 with each ring to the last ring at the top of the sampler (closest to the drive assembly).

6.2.3 Sampling Handling and Shipment

6.2.3.1 *Samples for on-site analysis*

Soil gas samples require no special handling due to the stability of the matrix. Soil gas samples will be delivered to the on-site mobile laboratory in a timely fashion.

6.2.3.2 *Samples for analysis to be performed off-site*

Samples collected for off-site analysis of physical parameters shall be handled as described below.

Samples will be shipped in a timely manner to ensure that excessive holding times do not elapse. Samples will be shipped to outside laboratories no later than one day after collection. Samples will be sent by overnight express (Federal Express Priority One or equivalent) to ensure timely arrival at the laboratory.

Sample packaging and shipping procedures are based on U.S. EPA specifications, as well as U.S. Department of Transportation (DOT) regulations (49 CFR). All samples will be shipped according to low hazard requirements due to the potential for handling contaminated soil samples.

The steps outlined below will be followed by the project team to pack all samples:

1. Arrange decontaminated sample containers in groups by sample number.
2. Arrange containers in front of assigned coolers.
3. Protect sample labels with clear label protection tape.

4. Position container in a sealable plastic bag so that the label may be read. Seal each container inside a separate plastic bag.
5. Line cooler with a large trash bag and place about 2 inches of packing material in bottom of bag.
6. Place samples in cooler and fill remaining volume of cooler with packing material. Arrange containers in coolers so that they do not touch.
7. Sign Chain of Custody form (or obtain signature) and indicate the time and date it was relinquished to Federal Express or other approved carrier.
8. Separate copies of forms. Seal proper copies in a large sealable plastic bag and tape to inside lid of cooler.
9. Tape cooler drain shut.
10. After acceptance by Federal Express (or other approved carrier), close lid and latch and tape cooler shut on both ends, making several complete revolutions with strapping tape. Do not cover any labels. The carrier will not be required to sign the Chain of Custody as long as the shipping container remains sealed.
11. Complete special shipping bill including a Shipper's Certification for Restricted Articles and attach airbills to cooler.
12. Specify delivery as "Priority One/Overnight Shipment"
13. Copy airbill receipt and send to the HGC QA officer along with other documentation.

14. Place mailing label with laboratory address on top of cooler.
15. Put "This Side Up" labels on all four sides, "Fragile" labels on at least two sides, and "Flammable Solid, NOS" labels on at least two sides of each cooler. NOTE: Write "Flammable Solid, NOS" and "UN1325" for solids on wide tape and place on cooler if this is not marked on the margin of your DOT label.
16. Write shipper's address on outside of cooler. If address is stenciled on, just write "shipper" above it.
17. Affix custody seals over lid openings (front right and back left of cooler). Cover seals with wide clear tape.

6.2.4 Equipment Decontamination and Waste Handling

A temporary decontamination area will be established in each of the two source areas, Wausau Chemical and Marathon Electric/City Landfill. Equipment used in one source area will be decontaminated in that source area.

Prior to each use or reuse, sampling equipment such as drive rod, auger flights, soil samplers, stainless steel sleeves, sampling probes and drive points will be steam cleaned. Solid decontamination wastes such as soil scraped off of used auger flights will be containerized for later disposal in accordance with applicable State and Federal regulations. Steam cleaning rinsate will be collected and containerized for disposal to the City sanitary sewer system.

Solid waste generated during the investigation, such as soil cuttings from drilling operations, used latex gloves, Tyvek coveralls, and other disposable items will be placed in sealed containers and held in the source area within which the waste was generated. These wastes will be disposed of at the conclusion of the field investigation in accordance with applicable State and Federal regulations.

6.3 Chain of Custody

6.3.1 Sample Identification Procedures

Prior to collecting either a soil gas or a soil sample from any sampling point, the Site Manager will mark the location and assign a number which will either be written on a stake or painted on the pavement and entered into the field notebook. A map of the site will be prepared showing sample locations and numbers. All samples collected will be assigned a unique site-specific sample number. The sample number will consist of a two letter project identification code, an alpha-code corresponding to the sample matrix and a location number. The project identification code WC identifies the sample as having been collected at the Wausau Chemical source area and the project code ME identifies the sample as having been collected at the Marathon Electric\City Landfill source area.

"SG" will identify the matrix as soil gas. "S" will identify subsurface soil as the matrix. The two digit sample location number refers to the location number identified on the stake and in the field notebook. The last component of the sample identification system will be a number indicating the sampling depth, in feet, at that particular sample location.

Samples collected proximal to a numbered sampling location will receive sequential sample numbers and be documented and identified in detail in the field notebook. Soil gas and soil sample numbers will further be identified in the field notebook by 1) the horizontal distance in feet and compass direction (NW, SE, etc.) from the established, numbered sample location from which the sample was actually collected.

Field blanks will have an identification code of "FB" following the project code but prior to the alpha code for matrix identification. Trip blanks will be labeled in the same manner except "TB" will be used in place of the "FB" designation. Field duplicates will be designated by an identification code of "FD".

6.3.2 Chain of Custody for Hydro Geo Chem's On-Site Laboratories

All samples are labeled with the following information:

1) Sample identification number
2) Date and time of sample collection
3) Name of sampler

A Sample Information and Transfer form (Figure 6.1) will be completed for each sample analyzed on-site. At the time of sample collection, the field sampler signs the Sample Information and Transfer form and records the date, time, and other pertinent information. The sample is then transferred to the laboratory, where the chemist receiving the sample for analysis signs the Sample Information and Transfer form and records the date and time. The Sample Information and Transfer form is then filed in a notebook with the hard copy of the analytical results. Soil gas samples are held for a maximum of 4 hours and are recollected if this holding time is exceeded. Copies of all in-house Sample Information and Transfer forms are maintained in Hydro Geo Chem's QA final evidence file.

6.3.3 Samples to be Analyzed Off-site

6.3.3.1 *Chain of Custody Records*

The chain of custody form for the samples to be sent off-site is shown in Figure 6.2, the "Chain of Custody". After completion of the Chain of Custody, the top, original signature copy and middle copy of the Chain of Custody are enclosed in a plastic bag and secured to the inside of the shipping container (usually a cooler) lid. A copy of the Chain of Custody is retained for the sampler's files.

HYDRO GEO CHEM, INC. SAMPLE INFORMATION AND TRANSFER FORM

Fill out in duplicate

-- Original to Mobile Lab -- Copy Kept in Field Notebook

Location #:____________ Sample #:________ Data Base File:______________

Location Description:____

Sketch ______________________________

Sampler (Signature): ______________________________

Soil? ________ Water? ________ Soil Gas? ________ Atmospheric? _____

Weather:______________________________ Barometric Pressure:___________

Wind Direction/Speed:__________________ Air Temp (°F):________________

Surface Conditions:____________________ Soil Temp (°F):_______________

Time/Date:________________ Cartridge(s)#:_____________________________

Probe Depth:______________ Probe #:_______ Probe Volume:______________

Adapter #:________________ Cylinder #:________ Vacuum Gage Reading:_____

Sample Size:______________ Pump Flow Rate & Duration:__________________

Column Flow Rate & Duration:________________ Additional Comments:______

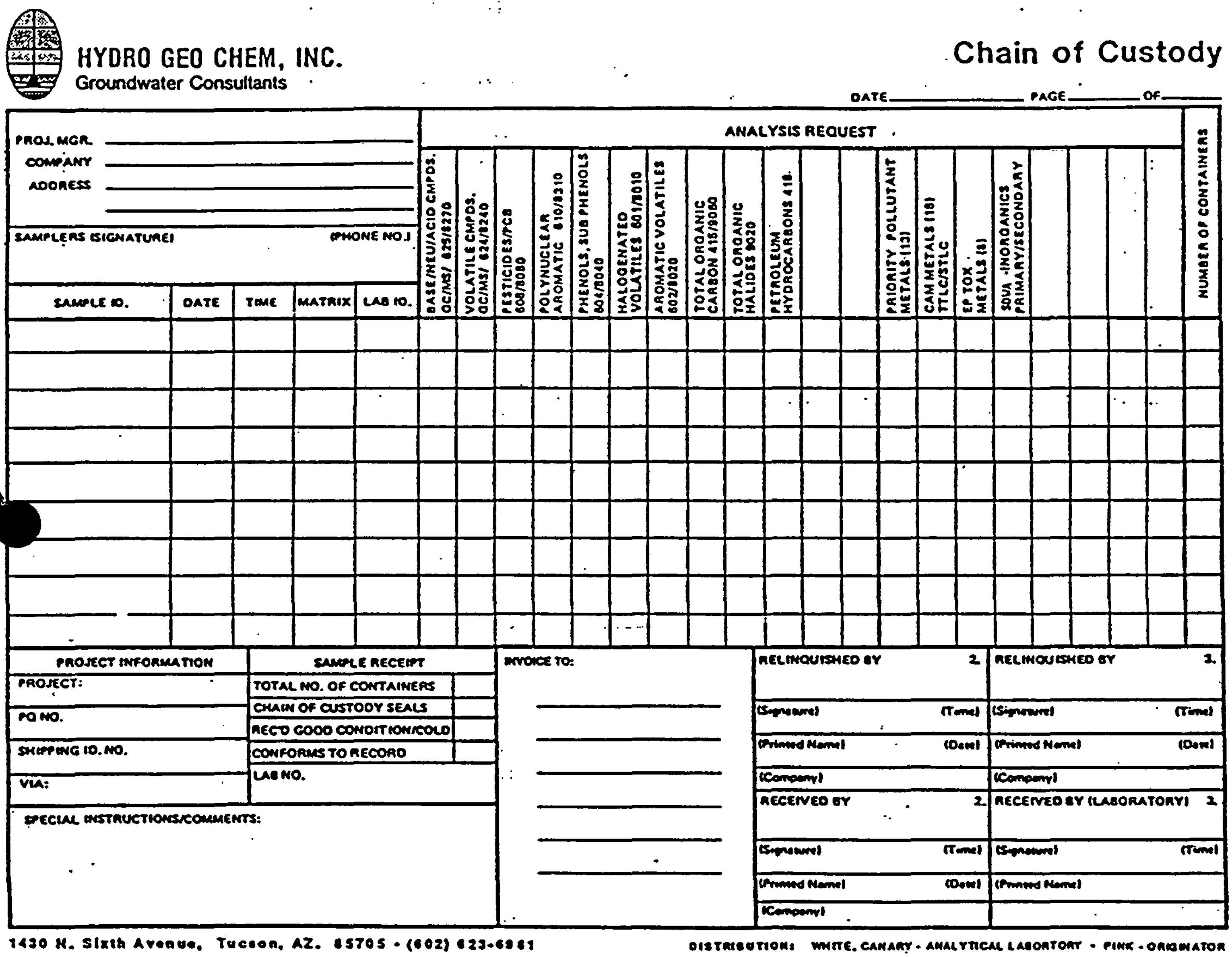
____

Backfill Procedure and Materials:_____________________________________

Lab Receipt:
(Name/Signature):____________________________ Time/Date:____________

Compound Analyzed	Measured Concentration (µg/l)		Chromatogram#
	1st	2nd	

Figure 6.1 Sample Information and Transfer Form



HYDRO GEO CHEM, INC.
Groundwater Consultants

Chain of Custody

DATE________ PAGE_____ OF_____

PROJ. MGR. ________
COMPANY ________
ADDRESS ________

SAMPLERS (SIGNATURE) (PHONE NO.)

					ANALYSIS REQUEST																				
SAMPLE ID.	DATE	TIME	MATRIX	LAB ID.	BASE/NEU/ACID CMPDS. GC/MS/ 625/8270	VOLATILE CMPDS. GC/MS/ 624/8240	PESTICIDES/PCB 608/8080	POLYNUCLEAR AROMATIC 610/8310	PHENOLS, SUB PHENOLS 604/8040	HALOGENATED VOLATILES 601/8010	AROMATIC VOLATILES 602/8020	TOTAL ORGANIC CARBON 415/9060	TOTAL ORGANIC HALIDES 9020	PETROLEUM HYDROCARBONS 418.			PRIORITY POLLUTANT METALS (13)	CAM METALS (18) TTLC/STLC	EP TOX METALS (8)	SDWA -INORGANICS PRIMARY/SECONDARY					NUMBER OF CONTAINERS

PROJECT INFORMATION	SAMPLE RECEIPT	
PROJECT:	TOTAL NO. OF CONTAINERS	
PO NO.	CHAIN OF CUSTODY SEALS	
SHIPPING ID. NO.	REC'D GOOD CONDITION/COLD	
VIA:	CONFORMS TO RECORD	
	LAB NO.	

SPECIAL INSTRUCTIONS/COMMENTS:

INVOICE TO:

RELINQUISHED BY 2.	RELINQUISHED BY 3.
(Signature) (Time)	(Signature) (Time)
(Printed Name) (Date)	(Printed Name) (Date)
(Company)	(Company)
RECEIVED BY 2.	RECEIVED BY (LABORATORY) 2.
(Signature) (Time)	(Signature) (Time)
(Printed Name) (Date)	(Printed Name)
(Company)	

1430 N. Sixth Avenue, Tucson, AZ. 85705 - (602) 623-6981

DISTRIBUTION: WHITE, CANARY - ANALYTICAL LABORTORY - PINK - ORIGINATOR

Figure 6.2 Chain of Custody

6.3.3.2 *Notice of Transmittal*

A notice of transmittal will be sent to the Hydro Geo Chem Tucson office with a copy of all paperwork including a copy of the tracking forms, chain of custody form white and yellow copies, and airbill. The notice of transmittal form is shown in Figure 6.3.

6.4 Quality Control Samples

6.4.1 Field Blanks

6.4.1.1 *Soil Gas*

One field blank of the entire sampling apparatus will be taken and analyzed to check background contamination in the sampling system and cartridges for every 10 soil gas samples collected. Sampling cartridges are attached to both the inlet and outlet end of a sampling probe. The sample collected in the discharge end cartridge is representative of sampling train contamination only, while the intake cartridge provides a measure of the atmospheric concentrations. Additional field blanks are collected prior to any reuse of recleaned sampling equipment.

NOTICE OF TRANSMITTAL

DATE:

TO: Hydro Geo Chem, Inc.
1430 N. 6th Avenue
Tucson, AZ 87505

Attention: HGC QA Officer

FROM: ____________(1)____________/____________(2)____________
Name Firm

Wausau SVE Predesign Investigation

Enclosed are appropriate copies of the sample documentation forms for ______________________ for the ______________________,
19__, shipment of ______________ ______________________samples
Quantity Matrix

from the ______________________________ site located in
______________________, ______________________ to
Laboratory:______________ Address:______________________

Figure 6.3 Notice of Transmittal

6.4.2 Duplicate Samples

6.4.2.1 *Soil Gas*

Two soil gas samples will be analyzed from 10% of the sampling locations.

6.4.3 Trip Blanks

6.4.3.1 *Soil Gas*

A trip blank will consist of a clean sample cartridge which is transported into the field with the sampling equipment. The trip blank cartridge is handled in the same manner as a sample cartridge, but a sample is not actually collected through the cartridge. A trip blank will be analyzed once daily on days when soil gas is being collected.

6.5 Documentation of Sampling Activities

6.5.1 Sample Records

The Site Manager will be responsible for maintaining sample records in site binders. Where applicable, the following procedures will be followed:

6.5.1.1 *Sample Tracking Forms*

Sample tracking forms (Figure 6.4) will be completed in the field to indicate samples collected for off site analysis. The original is to be sent to Hydro Geo Chem's office in Tucson, Arizona to be kept in the QA final evidence file (a copy will also be kept by the Project Manager). A copy is to be kept in the sampling field notebook. A separate sample tracking form will be required for each portion of a sample sent to a different laboratory. The following list itemizes requirements for filling out the sample tracking form:

1. Enter the sample identification number (see Section 6.3.1 for explanation of sample numbering system).
2. Enter Wausau NPL Site SVE Predesign Investigation
3. Enter the laboratory name.
4. Enter a Y if the sample is a blank or background sample and a N if it is not. Circle blank or background if response was Y.
5. Enter sample ID numbers of samples taken at the same geographic location but sent to different laboratories.
6. Enter the sample ID number of duplicate samples taken at the same locations, if sample is part of a duplicate pair of samples.
7. Indicate the specific sampling location including source are.
8. Enter the site name and city and state where site is located.

1) Sample No:____________________

2) Project:____

3) Laboratory Name:_________________

4) Is this a blank or background sample? (Y_____N_____)

5) Matches Sample No(s):____________________________
____

6) Duplicate of Sample No.__________________________

7) Sample Station:_________________________________

8) Site Name:______________________________________
Location:_______________________________________

9) Lead Sampler:________________________Firm:____________________
Other Samplers:_______________________ ____________________
_______________________ ____________________

10) Project Officer____

11) Sample medium:____

12) Contaminant concentration___________________________________

13) Sample protection____

14) Sample container type_______________________________________

15) No. of sample containers____________________________________

16) Sample shipment airbill No._________________________________

17) Date sample collected____/_____/_____

18) Date sample sent to lab____/_____/_____

19) Analysis requested____

20) Comments____
____
____
____
____
____

Figure 6.4 Sample Tracking Form for Off-Site Analyses

9. Enter the last name of the lead sampler and all other samplers. Enter company or agency the sampler works for.

10. Enter the last name of the site project officer.

11. Enter the sample medium (enter SG for soil gas or S for soil).

12. Enter anticipated contaminant concentration (enter low, medium, or high).
13. Enter the packing information relevant to sample preservation (i.e., capped, sealed, stored in blue ice).

14. Enter the sample container type.

15. Enter the number of sample containers (going to the same laboratory).

16. Enter sample shipment airbill number, a nine digit number. Indicate if samples were not shipped by express service, i.e., hand delivered.

17. Enter the date sample is collected.

18. Enter the date sample is sent to laboratory.

19. Enter analysis protocol and analysis requested.

20. Enter any comments you feel are pertinent.

The sample tracking from is to be filled out along with the rest of the paperwork at the time of sampling by the sampler and returned to the HGC office with the other paperwork.

Contact Gary Walter at (602)623-6981 if questions or problems occur.

6.5.1.2 *Sample Information and Transfer Forms*

Samples analyzed on-site will be tracked by sample information and transfer forms (Figure 6.1). This form provides both a record of sample conditions and site chain of custody control. The original will be kept by the mobile laboratory chemist and will be turned over to the QA final evidence file when the field sampling is completed. The duplicate is to be kept in the field sampling notebook.

6.5.1.3 *Chain of Custody Forms for Shipping*

As samples are sent to outside laboratories for analysis, a chain of custody form will be filled out as a packing slip. A copy will be sent to the QA Officer for record.

6.5.1.4 *Record of Laboratory Results*

A copy of lab results is to be given to the QA Officer for record in the QA final evidence file. Review of the sampling process will be done routinely to verify compliance with data quality requirements.

1. Interpretation of data will be the responsibility of the Project Manager.

2. Reviews and written reports of results will be performed at logical intervals throughout the duration of the contract as specified in the contract.

6.5.1.5 *Sample Labels*

Sample labels will be used to label sample containers. Each label will contain the following information as a minimum:

1. Container
2. Wausau SVE/Hydro Geo Chem
3. Date/Time of Sampling
4. Sample Number and Location
5. Preservative
6. Sampler(s) Initials

The field sampling team will be responsible for completing the sample labels and covering each label with clear plastic tape. An indelible felt tip marker will be used for labeling.

The following forms will be sent to the Hydro Geo Chem QA Officer:

- Chain of Custody form, photocopy
- Photocopy of sample tracking sheets

- Carbon (yellow) log book sheets
- Airbills
- Notice of Transmittal

The site manager will retain the following forms for on-site control:

- Chain of Custody form, pink
- Photocopy of sample tracking sheets
- Field log books

6.5.2 Logbook Requirements

6.5.2.1 *Logbook Contents*

Logbook contents shall normally include, but are not limited to:

1. One-Time Entries: The following logbook entries are to be made initially and as test/experiment changes dictate (attach a copy of the test plan to the logbook)

    a. Test/experiment procedure name and number
    b. Name(s) of individual(s) performing test/experiment
    c. Concise statement of overall test/experiment objectives (including case number if appropriate)*
    d. List of equipment and materials used (including serial number, model, etc.)*

e. Sketch or photograph(s) of materials and equipment hookup or installation *

f. Activity location

g. Equipment calibration or field re-calibration statement (including results/values if not entered on data sheets)

h. Table of contents (optional)

* Initial entries can reference the test plan if attached.

2. Daily Entries: The following logbook entries are to be made daily or as appropriate:

a. Date

b. Name of individual making entry

c. Description of test/experiment element attempted, i.e. routine maintenance (referring to procedure paragraphs or literature reference if possible)

d. Conditions (environment, power, etc.) that might adversely affect test/experiment

e. Names of witnesses or peer observers present

f. Samples/specimens received or released (including source or destination)

g. Brief listing of results with notation of those unexpected

h. Data not recorded either on test procedure data sheets or by automated means

i. Interim conclusions reached if appropriate (label as "conclusions" or "summary")

j. Deviations to test/experiment procedure required (ensuring follow-up changes to procedure) *

k. Significant unusual occurrences or nonconformances and their disposition. These should be noted in the logbook margin before and/or after the entry *

l. Corrective action efforts (successful and unsuccessful) keyed to the unusual occurrence or nonconformance *

m. Dates and reasons for test/experiment downtime or delays (covering gaps as appropriate)

* To be highlighted with an asterisk in the left-hand margin

6.5.2.2 *Logbook Control*

1. Test plans shall reference this procedure when invoked and shall specify who shall have custody of the logbook. Only bound notebooks of the type containing carbon copies shall be used and they shall remain at the location of the test/experiment during active periods of conduct of the test or experiment.

2. Logbooks shall be clearly identified on the cover as to test/experiment name. Additionally, a number assignment (coding) should be used if feasible. At the completion of the test or experiment, the logbook(s) shall be forwarded to the project files after a suitable review by the Task Manager and/or Project Manager.

3. To guard against inadvertent loss or damage of logbooks, copies of the logbook pages shall be periodically forwarded as generated to the Project Manager. Once reviewed, the yellow copies will be maintained in the QA final evidence file. Logbooks shall be stored in accordance with the project records requirements. Yellow copies will be sent to the Quality Assurance Officer on a weekly schedule or as requested.

6.5.2.3 *Method of Logbook Entry*

The preferred method of recording logbook entries is by means of waterproof pen or ballpoint pen. Pencil entries should be restricted to emergencies or field situations wherein the logbook could get wet. Corrections to logbook entries should be made by neatly crossing out the erroneous information with a single line so the original entry is still legible, then adding the correct information in a blank portion of the logbook.

6.6 Change Reports

All changes in project requirements or design shall be reported according to control procedures in Section 12. Any changes made by Hydro Geo Chem in processing will be described along with reports of the sample run. Repeatability of the tests shall be made possible by competent record keeping.

6.7 Inspection

1. The QA Officer will be responsible for implementation of a check list for process inspection.
2. Calculations of data will be internally reviewed for errors before reporting.

6.8 Non-Conforming Material

Unexpected phenomena shall be recorded in applicable notebooks. If due to error in analytical procedures, such procedures will be corrected. If unknown causes seem responsible, attempts shall be made to ascertain and amend the cause. Non-conformance procedures are described in Section 15. The Project Manager shall be notified as necessary.

6.9 Quality Records

A file of quality records will be maintained by the Quality Assurance Officer. Reviews, evaluations, tests, audits, telephone and letter communications, and other monitoring of work performance shall be stored in a QA final evidence file.

6.10 Corrective Action

If unusual results are obtained or observed and such are determined to be due to human or equipment error, the conditions adverse to proper experimentation shall be promptly corrected as described in Section 15. Investigation of unexplainable results will be undertaken in cooperation with the Project Manager.

7. SAMPLE CUSTODY PROCEDURES

7.1 Field Specific Custody Procedures

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

7.1.1 Field Procedures

Hydro Geo Chem field personnel will be responsible for the care and custody of the samples from the time of collection until they are properly dispatched to the appropriate laboratory.

7.1.2 Field Logbooks/Documentation

Field logbooks will consist of bound notebooks with carbon paper. Specifics regarding logbook entries are given in section 6.5.2.1.

7.1.3 Transfer of Custody and Shipment Procedures

All samples will be accompanied by a properly completed chain of custody form. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date and note the time on the record. Section 6.5.1 contains detailed information regarding chain of custody documents.

Samples will be properly packaged for shipment and dispatched to the appropriate laboratory for analysis with a signed custody record enclosed with each container. Shipping containers will be secured with tape and custody seals during shipping.

7.1.4 Samples for off-site analysis

The chain of custody form for the samples to be sent off-site is shown in Figure 6.3. Refer to section 6.3.2 and 6.3.3 for detailed chain of custody procedures.

7.2 Final Evidence File

A QA final evidence file will be maintained by Hydro Geo Chem for the Wausau SVE Predesign Study. The custodian of this file will be the QA Officer, Susan Maida, or her qualified delegate. This file will include copies of the following documents:

1) Sample tracking forms (Figure 6.4) and Sample Chain of Custody forms (Figure 6.2) for off-site analyses.

2) Sample Information and Transfer forms (Figure 6.1) for on-site analyses by Hydro Geo Chem.

3) Notices of Transmittal (Figure 6.3) which accompany all documents sent to Hydro Geo Chem's home office for the QA final evidence file.

4) Shipping records, invoices, and airbills.

5) Yellow carbon copies from both field and laboratory log books.

6) All laboratory results, including gas chromatograms, for both outside and in-house laboratory analyses.

7) Analysis Review Sheets (Figure 11.1) for analyses by Hydro Geo Chem's laboratory.

8) Laboratory/Field Test Data Review Sheets (Figure 11.2) for data on flow rates, pump tests, etc.

9) Work plans and changes to work plans for individual tasks and the accompanying Work Plan Review Sheets (Figure 12.1).

10) Documents other than work plans, such as draft contractor reports or basic data reports.

11) Telecon forms documenting all telephone calls relevant to the project.

12) All Nonconformance Reports (Figure 15.1) documenting any deviations from specified work plans.

8. CALIBRATION PROCEDURES

This section describes the calibration procedures that apply to both laboratory analyses and field measurements.

8.1 Soil Gas Calibration Procedures

8.1.1 Mobile Laboratory Analysis

Mobile laboratory calibration procedures are documented for soil gas, soils and soil water analysis in Appendix B-1-A as part of the modified EPA 8021 protocols.

8.1.2 Soil Gas Sampling-Mass Flow Controller

The calibration of the mass flow controller is performed every three months as follows:

Connect flow controller port to the outlet of a 500 or 100 ml buret. Invert the buret and immerse its inlet into water. Turn on the flow controller for a few seconds until water is pulled up into the buret tube until the buret divisions are intercepted. Shut off the controller and record the volume. Enter a flow rate and gas volume into the controller keyboard sufficient to include about 80% of the range of the buret and start the instrument. Record the change in buret volume. Repeat at about 60, 40, and 20% of buret range. Turn down metering valve in the flow train so that a vacuum of about 5" is attained during the flow test. Repeat the test at about 80, 60, 40, and 20% of buret volume. Graph the results. The flow controller should yield entered versus measured volume results better than ±5% for all calibration experiments.

8.1.3 O_2/CO_2 Meter

The field calibration procedure for the Gas Techtor O_2/CO_2 meter is given in Appendix B-1-E.

8.1.4 Organic Vapor Meter

The organic vapor meter will be calibrated according to manufacturer's instructions using a standard gas mixture with a nominal benzene concentration of 10 ppm.

8.2 Hydro Geo Chem's Tucson Laboratory Calibration Procedures

8.2.1 Analytical Balance

The Mettler analytical balance (160 grams ±0.1 mg) is calibrated yearly by a laboratory service using weights traceable to the National Bureau of Standards. A sticker is affixed to the balance indicating the calibration date and calibration performance.

8.2.2 Volumetric Calibration

Volumetric flasks will be Type A and do not require calibration. Pipettes, volumetric flasks, and volumes of water and standards are calibrated by weight using the Mettler balance.

8.3 Reporting

Calibration procedures by Hydro Geo Chem personnel are logged into field or laboratory notebooks as appropriate. Non-conformance and corrective action are reported using standard report forms.

9. ANALYTICAL PROCEDURES

9.1 Mobile Laboratory Analyses for VOCs

Analyses for soil gas are described in Appendix B-1-A.

9.2 Physical Soil Measurements

This section describes the laboratory procedures which will be used to determine the physical properties of soils from the site.

9.2.1 Total Porosity and Relative Moisture Content

The total porosity will be computed from measurements of bulk density, grain density, specific gravity, and moisture content, and samples used in the laboratory. The determinations of bulk density and moisture content will be made by Hydro Geo Chem. The details of these procedures are described in Appendix B-1-C.

9.2.2 Total Organic Carbon

Total organic carbon will be determined by the University of Arizona Soil and Water Laboratory using the procedure described in Appendix B-1-D.

9.3 Point Air Permeability Measurements

This section presents the theory and methodology for estimating the air permeability of soils during the collection of soil gas samples by the drive point method. The soil gas sampling procedure involves driving a 1-inch ID drill rod into the soil with the drive point sealing the lower end of the pipe as shown in Figure 1 of Appendix B-1-A. When the pipe reaches the desired depth, the pipe is raised approximately 6 inches exposing the lower end of the pipe and leaving a cylindrical void in cohesive soils.

In order to collect a soil gas sample or to measure the air permeability, the drive pipe is attached to a vacuum pump through a microprocessor controlled mass flow controller. The pipe is then evacuated at a constant mass volume rate (constant volume flow at standard temperature and pressure). During the evacuation process, the flowing pressure (psia) at the drive pipe head is monitored. The air permeability of the soil can then be determined from analysis of the flowing pressure versus time.

9.3.1 Theory

To a good approximation, the flow of gas to the drive point sampler is similar to that of a partially penetrating well in an infinite media. Assuming that the soil gas behaves as an ideal gas (which is a good approximation at near atmospheric pressures), the flow to the well is governed by the following partial differential equation (Al-Hussaing et al., 1966; Hantush, 1964):

$$k/\mu \cdot 1/r \cdot \partial/\partial r(r\ \partial p^2/\partial r) + k_z/\mu \cdot \partial^2 p^2/\partial z^2 = \phi C_g^{-1}(p) \cdot \partial p/\partial t \qquad (1)$$

where	k	is the intrinsic horizontal air permeability
	μ	is the dynamic viscosity
	r	is radial distance from the drive point
	k_z	is the vertical air permeability
	p	is the pressure
	ϕ	is the air filled porosity of the porous medium
	$C_g(p)$	is the compressibility of the gas
and	t	is time

Letting $p^2 = \Psi$ and assuming an ideal gas and moderate pressure drop so that

$$C_g(p) = p_o^{-1}$$

where p_o is static (non-flowing) pressure, (1) can be written as

$$k/\mu \cdot 1/r \cdot \partial/\partial r(r \cdot \partial \Psi/\partial r) + k/\mu \cdot \partial^2 \Psi/\partial z^2 = \phi p_o \cdot \partial \Psi/\partial t \qquad (2)$$

Equation (2) is identical in form to the partial differential equation used to solve well hydraulics problems in terms of either pressure or hydraulic head. Thus, a variety of previously derived solutions to well hydraulics problems can be applied to analyzing the flow of gas to wells.

In the case of drive point air permeability testing, we are interested in solutions which consider a well partially penetrating a porous medium. Such a solution is given by Hantush (1964), which in the Laplace Domain is

$$\bar{p}_D = 1/q[K_o(rk^{1/2}) + F] \qquad (3)$$

where	q	is the Laplace variable
	K_o	is the zero order Bessel Function of the second kind
	$rk^{1/2}$	is $(r_w^2\, q/\alpha)^{1/2}$
	α	is the pneumatic diffusivity, $kp_o/\phi\mu$
	$\bar{p}_D$	is the dimensionless pressure in the Laplace Domain

$$F = 2/d^2 \Sigma\, 2/n^2[\sin(nd/2)\cos(-nd/2)][K_o(r^2k) + k_z/k(n\pi r_w/b)^2]^{1/2}$$

where	k	is the air permeability
	d	is the length of penetration
	b	is the thickness of the unit tested
and	r_w	is the radius of the borehole.

Equation (3) can be used as a basis for computing and analyzing the pressure response in the drive pipe by letting

$$p_o^2\,(r_w\,,\,t) - p_{wf}^2\,(r_w\,,\,t) = \frac{Q_{sc}\;\rho_{sc}\;T_\mu}{k\;b\;T_{sc}} - \bar{p}_D^{-1}(r_w\,,\,t_D)$$

where	Q	is flow rate [cm^3/s]
	k	is permeability [darcies]
	b	is the formation thickness [cm]
	T_{sc}	is standard temperature [289°K]
	p_o	is the initial pressure [atm]
	p_{wf}	is the flowing pressure at the well [atm]
	μ	is dynamic viscosity [cp]
	p_{sc}	is standard pressure [atm]
	T	is formation temperature [°K]
	r_w	is the radius of the well [cm]
	t_D	is dimensionless time [$ktp_o/\phi\mu r^2_w$]

ϕ is the soil porosity

t is time in seconds

$\bar{p}_D^{-1}$ is the Laplace inverse of the $\bar{p}_D$

Values of p_D can be computed using techniques described by Moench and Ogata (1984). These techniques are implemented in a software program called ASAP (Airflow Simulation and Analysis Program) developed by Hydro Geo Chem. ASAP also provides for automatic parameter estimation. This program will be used for interpretation of the drive point air permeability test results.

9.3.2 Methodology

After driving the drive rod to the desired depth, mark the rod with plumbers chalk at the land surface, pull back approximately 6 inches, measure the actual amount of pullback to the nearest inch and record the pullback on the soil gas sample data sheet.

Next, apply teflon tape to the threads of the rod and attach the vapor extraction assembly to the drive point. Attach the tee-connector with transducer to the vapor extraction assembly and attach the transducer leads to the data acquisition module.

Activate the data acquisition module and record the static soil pressure for at least 1 minute. While monitoring static pressure, program the mass flow controller for three, 1-minute evacuation cycles with mass flow rates of 20, 50, and 100 mL/minute (STP). Activate the mass flow controller and allow the data acquisition module to collect time and pressure data. The data acquisition system can then be shut down and the soil gas sample collected.

9.3.3 Data Processing and Analysis

The data from each drive point air permeability test are stored in RAM in the data acquisition system. At the end of each days work, these data are transferred onto a floppy disk. The data may be analyzed using ASAP software either in the mobile laboratory or later in the office. Floppy disk data records are kept off site with the personal possessions of the field project officer.

10. INTERNAL QUALITY CONTROL CHECKS

10.1 Sampling Activities

10.1.1 Field Blanks

Field blanks will be collected and analyzed prior to any initial sampling and every ten samples thereafter. Additional field blanks will be taken prior to reuse of recleaned equipment. Please refer to section 6.4.1 for details regarding field blank collection.

10.1.2 Trip Blanks

One trip blank will be collected for each sample batch. Refer to section 6.4.3 for specifics regarding collection.

10.2 Laboratory Analyses

10.2.1 On-site Laboratory

Internal quality control protocols for Hydro Geo Chem's mobile laboratories are provided in Appendix B-1-A.

11. DATA REDUCTION, VALIDATION, AND REPORTING

11.1 Data Reduction

Data reduction procedures include entering the raw data on a commercially available data base management program (DBase III, Lotus or equivalent). Each of these programs can prepare files suitable for processing by the other. These raw data are produced as tables suitable for presentation in data, interpretive, and quality assurance reports. Any other processing of data by hand, calculator, or computer program is so identified in the text accompanying tables and graphs produced to present the data.

11.2 Data Validation

Data will be reviewed by the Project Manager or his qualified delegate for precision, accuracy, and completeness as discussed in Section 5.

11.2.1 Analytical Data

11.2.1.1 *Hydro Geo Chem Data*

Data produced by Hydro Geo Chem's mobile or Tucson laboratory will first be reviewed by a chemist who did not perform the analyses. Corrections or alterations to the data reports will be initialed by the reviewer and accompanied by a brief note of explanation. Entries by the analyst found to be incorrect will be neatly crossed out in such a fashion that the original entry remains legible. A data review sign off sheet will be filled out by the reviewer. A second data review and signoff will be made by the Project Manager. His review will include consideration of the reasonableness of the data and the corrections made by the initial reviewer. The analysis review sheet is shown in Figure 11.1. This sheet will be filed with the data sheet in the QA final evidence file.

11.2.1.2 *External Laboratory Data*

Data produced by outside laboratories will have been reviewed as part of their QA procedures. The Project Manager or his qualified delegate will evaluate the validity of the data by examination of the laboratory's data report and its conformance to the QA procedures.

11.2.2 Physical Data

Hydro Geo Chem field or laboratory data on flow rates, pump tests, etc. will be contained in field or laboratory notebooks according to the procedures outlined in Section 6.5.2. These raw data will be entered into computer files as described in Section 11.1. The laboratory notebooks and files and the tabulated raw data will be reviewed by the Project Manager or his qualified delegate for accuracy, precision,

ANALYSIS REVIEW SHEET

Sample Number:____________________Sample/Well Name:____________________
Date of Collection:____/____/____Time:____________________
Laboratory:____
Date of Analysis:____/____/____
Project(s) Involved:____
Type(s) of Analyses:____
____
____

Quality and Reasonability of Analysis:
Precision:____________________
Accuracy:____________________
Comments:____
____
____

Overall Acceptability of Analysis:
Analysis Accepted ( )
Analysis Rejected ( )
Comments (reasons why rejected):______________________________
____
____

Action Taken:
( ) Archive available
( ) Sample (s) sent back for re-analysis
Sample Number____________________Date____/____/____
( ) Nonconformance form completed
( ) Other____

Other Comments:____
____
____
____
____
____

Signature:____
Date:____/____/____

Figure 11.1 Analysis review sheet

completeness, and reasonableness. This procedure will be documented for each by completing the Laboratory/Field Test Data Review Sheet shown in Figure 11.2.

Reports will include tabulations on raw data and any interpreted or statistically processed data (so identified) thought necessary to support the investigation or design report.

LABORATORY FIELD TEST DATA REVIEW SHEET

Name of Test____________________ Type of Test____________________
Sample Number(s):____________________ Sample/Column ID:____________________
Date of Collection: ____/____/____ Time:__________ Site:____________________
Laboratory:____
Date of Analysis: ____/____/____
Project(s) Involved:____
Type(s) of Analyses:____
____
____
____

Quality and Reasonability of Analysis:
Precision:____________________
Accuracy:____________________
Comments:____
____
____

Overall Acceptability of Analysis:
Analysis Accepted ( )
Analysis Rejected ( )
Comments (reasons why rejected):____________________
____
____

Action Taken:
( ) Archive available
( ) Re-analysis required
Sample/Well/Column ID____________________ Date____/____/____
( ) Nonconformance form completed
( ) Other____

Other Comments:____
____
____
____
____
____

Signature:____
Date: ____/____/____

12. PERFORMANCE AND SYSTEM AUDITS

12.1 Sampling and Analysis Plans, Review, and Change Control

12.1.1 Sampling and Analysis Plan

Specific work plans will be prepared for each task which describes the purpose of the task, staffing, budget, equipment, and procedures to be employed when appropriate. Field work will not be initiated without an accepted sampling and analysis plan and without specific permission of the Project Manager. Sampling and analysis plans and their revisions for specific tests will be identified by the date of preparation.

12.1.2 Sampling and Analysis Plan Review

All work plans for individual tasks will be submitted to the Project Manager and the Quality Assurance Officer for review prior to initiation of the work. Attached to each work plan will be a work plan review sheet as shown in Figure 12.1.

WORK PLAN REVIEW SHEET

Work Plan Title:

Date Prepared:

Prepared by:

Review Comments

Adequacy of Experimental Design:

Adequacy of Procedures:

Adequacy of Equipment:

Adequacy of Staffing:

Other Comments:

Reviewers Initials:

Date Reviewed:

Figure 12.1 Work plan review sheet

12.1.3 Change Control

All SAPs and work plans will be identified by their title and date of preparation. For a specific test or procedure, the SAP or work plan with the most recent date will be the operative plan. When a revised SAP or work plan is prepared, the superceded documents will be identified by preparation date.

12.2 Field Audits

12.2.1 Internal Audits

The Hydro Geo Chem QA Officer will perform internal audits to determine adherence to the SAP and the effectiveness of the SAP. Audits of all field and laboratory notebooks will be made on a quarterly basis to assure compliance with the SAP.

12.2.2 Field Audits

The field work manager will review the carbon copies of all field logbooks upon receipt to assure conformance with the SAP.

12.2.3 Equipment

The Hydro Geo Chem QA Officer will review the equipment calibration schedule monthly and insure that the calibrations are performed in a timely manner.

12.2.4 Documentation

The date of all audits, deviations from the SAP, and corrective actions will be documented in the QA final evidence file.

12.3 Laboratory Audits

Laboratory notebooks will be reviewed on a weekly basis to assure compliance with the SAP. Audits will be recorded and documented in the QA final evidence file.

13. PREVENTATIVE MAINTENANCE

13.1 Analytical Equipment and Instruments

Maintenance procedures for field analytical equipment will be carried out in accordance with the owner's manual for each instrument. Maintenance of laboratory analytical instruments will be the responsibility of the laboratory manager or his qualified delegate for each of the laboratories used during the project.

13.2 Field Sampling Equipment

Maintenance of field sampling equipment will be performed as needed to ensure proper operation of each piece of equipment. Sampling equipment will be inspected prior to each use. If an item to be used for sampling does not operate properly, it will be maintained or replaced prior to use.

13.3 Documentation

Maintenance procedures performed on field or laboratory analytical equipment will be noted and described in the logbook at the time the maintenance is performed. Maintenance procedures performed on field sampling equipment will be described in the appropriate field notebook at the time the maintenance is performed.

14. DATA COMPLETENESS, ACCURACY, AND PRECISION

14.1 Outside Laboratory Data

The quality assurance procedures for completeness, accuracy, and precision for laboratory analyses by outside independent laboratories are performed according to protocols documented by their individual quality assurance programs.

14.2 Hydro Geo Chem Data

The procedures for field and laboratory gas chromatographic analyses performed by Hydro Geo Chem are described in the soil gas sampling and analysis section (Appendix B-1-A) and Section 9, Analytical Procedures. Section 5 of this QAPP describes how the specific QA objectives of this investigation will be achieved.

15. CORRECTIVE ACTION

Deviations from specified activities outlined in the Sampling and Analysis Plan or other sections of this document will be noted in logbooks and highlighted with an asterisk. Significant unusual events and anomalies which could affect the validity of data are to be documented on a nonconformance report (Figure 15.1) and reported to the Project Manager. The Project Manager will be responsible for determining the need for corrective actions and initiating appropriate corrective actions.

Corrective actions related to deviations in specified activities will be recorded in the appropriate notebook. Follow up action will be taken by the QA officer to verify implementation of corrective action.

NONCONFORMANCE REPORT
(Services and Activities)

Service or Activity: ____________________ Date: __/__/__

Contractor or Support Organization: ____________________

Date Discovered: __/__/__ Location: ____________ HGC Consultant: ______
Notation in Logbook Vol. No. _____ Page _____ Date __/__/__

Nature of Nonconformance:
( )Procedural Deficiency
( )Data Deficiency
( )Instrumentation Def.
( )Other ____________

Description of Nonconformance and Apparent Cause: ____________________

Recommended Disposition:
( )Accept Deviation
( )Modify Plan/Procedure
( )Repeat Service/Activity
( )Terminate
( )Conditional Acceptance*
*State Conditions ____________

Justification for Recommended Disposition: ____________________

Recommended Corrective Action: ____________________

Originator: ____________ Organization: ____________ Phone: ____________

Corrective Action Verification:
( ) Verified (note any appropriate conditions): ____________________

( ) Cannot verify (note reasons for lack of verification): ____________________

Project QA: ____________________ Date: ____________
(Use space below for comments or extensions to the above topics)

Figure 15.1 Nonconformance Report

16. QUALITY ASSURANCE REPORTS

16.1 Reporting Schedules

The reporting requirements regarding quality assurance include the periodic assessment of data accuracy, precision, and completeness obtained through review of internal and external data generated by laboratory and field efforts. The schedule of these data assessment reports is necessarily tied to the length and time of relevant experiments and to the laboratory schedule. These reports will be made to the Project Manager and sent to the QA final evidence file.

The regular scheduled reporting requirements associated with the Quality Assurance oversight of the project will be prepared by the QA Officer. These include maintenance reports, calibration reports, document audit reports, and internal and external QA audit reports. In addition, where the QA audit program results in discovery of deficiency and need for corrective action, a significant corrective action will result in a report. These reports will be sent to the QA final evidence file.

16.2 Final QA Report

The final report for the project will include a separate QA section which summarizes data quality information contained in the QA final evidence file reports. This final QA report will also document any changes and corrective actions taken during the course of the project.

17. REFERENCES

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EPA, 1987. Data Quality Objectives for Remedial Response Activities, Development Process. EPA/540/6-87/003, OSWER Directive 9355.0-7B. U.S. EPA, Washington, D.C.

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APPENDIX B-1-A
VOLATILE ORGANIC SAMPLING AND ANALYSES IN SOIL GAS BY MODIFIED EPA 8021
HYDRO GEO CHEM, INC.

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Tucson, Arizona 85705
(602)623-6981

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VOLATILE ORGANIC SAMPLING AND ANALYSES IN SOIL GAS BY MODIFIED EPA 8021
HYDRO GEO CHEM, INC.

INTRODUCTION

In summary, the analytical method consists of the recently approved EPA 8021 protocol, modified to allow greater throughput and to minimize the potential for laboratory contamination. These modifications include temperature programming and flow changes to reduce analytical time, the use of gas rather than water-solution standards, and splitting of the sample injection stream to allow simultaneous analysis on a separate column and detector of other compounds not analyzed by the 8021 protocol. Table 1 lists the compounds that can be analyzed using EPA 8021 protocol.

The sampling methods included in the protocol have been designed to allow accurate, contamination-free sampling of soil gas. These methods offer a detection limit of at least 0.01 µg/l in soil gas for any compounds listed in Table 1. Additional, simultaneous analysis is provided for total petroleum hydrocarbons, methane, and total chlorinated hydrocarbons. The following sections document the materials, apparatus, and procedures used.

TABLE 1

COMPOUNDS EPA METHOD 8021 (HALL/PID ANALYSIS)

Benzene
Bromobenzene
Bromochloromethane
Bromodichloromethane
Bromoform
Bromomethane
n-Butylbenzene
sec-Butylbenzene
tert-Butylbenzene
Carbon tetrachloride
Chlorobenzene
Chloroethane
Chloroform
Chloromethane
2-Chlorotoluene
4-Chlorotoluene
Dibromochloromethane
1,2-Dibromo-3-chloropropane
1,2-Dibromoethane
Dibromomethane
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Dichlorodifluoromethane
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethene
cis-1,2-Dichloroethene
trans-1,2-Diochloroethene
1,2-Dichloropropane
1,3-Dichloropropane
2,2-Dichloropropane
1,1-Dichloropropane
Ethylbenzene
Hexachlorobutadiene
Isopropylbenzene
p-Isopropyltoluene
Methylene chloride
Naphthalene
n-Propylbenzene
Styrene
1,1,1,2-Tetrachloroethane
1,1,2,2-Tetrachloroethane
Tetrachloroethene
Toluene
Trichloroethene
1,2,3-Trichlorobenzene
1,2,4-Trichlorobenzene
1,3,5-Trichlorobenzene
1,1,2-Trichloroethane
1,1,1-Trichloroethane
Trichlorofluoromethane
1,2,3-Trichloropropane
1,2,4-Trimethylbenzene
1,3,5-Trimethylbenzene
Vinyl chloride
o-Xylene
m-Xylene
p-Xylene

1. SAMPLING

1.1 Scope and Application

This section covers the materials, equipment and procedures utilized by Hydro Geo Chem, Inc. for collecting soil gas samples in the field.

1.2 Sampling Equipment

1.2.1 Sampling Probes and Drive Point Rigs

Sampling probes consist of 5-foot sections of nickel plated $1^3/_8$" hardened EW drill rod with Acme threads with a detachable high carbon steel point. The steel points are left behind when the pipe is hydraulically pulled back to expose the formation to pumping. Figure 1 shows our probe design.

Nickel has been selected over stainless steel as an inert coating for our sampling probes because of its superior properties; it combines the chemical inertness of glass with the excellent handling characteristics of a malleable metal. Experiments performed by the University of Houston, the Texas Research Institute of Metal Science (Journal of Chromatography, Vol. 140, No.1,9 (1977)), and Alltech Associates, Inc. have shown nickel to be chemically inert, to demonstrate no catalytic activity, and to provide a neutral surface. Nickel has been shown to plate surfaces well; it will not flake or chip easily thereby preventing exposure of the steel surface of the sampling probe.

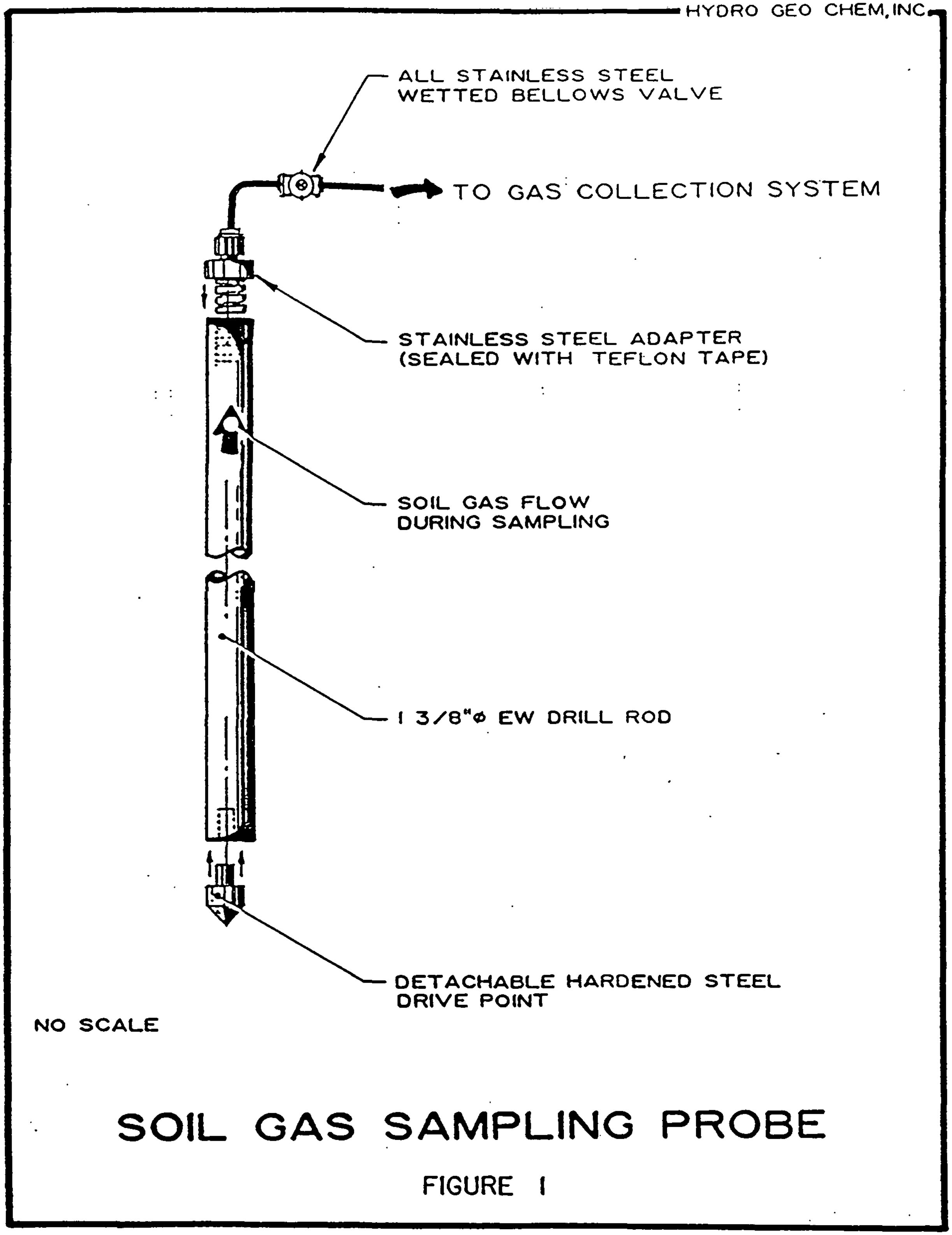


Figure 1. Soil Gas Sampling Probe

The probes are driven to the sampling depth using a heavy duty hydraulic hammer mounted on Ford F-450 trucks. These rigs are capable of driving sampling pipe to a depth in excess of 50 feet under normal driving conditions. The drive point rigs are equipped with hydraulic outriggers, pipe racks and a steam cleaner. The probes are removed by the drive point rig using a hydraulically activated pulling dog. Latex gloves are worn during handling and assembling of the sampling apparatus.

1.2.2 Sampling Adaptors

Soil gas samples are collected from the probes via adaptors constructed of stainless steel pipe caps welded to stainless steel tubing connected to an inline stainless steel bellows valve.

1.2.3 Soil Gas Cartridges

Soil gas samples are collected in stainless steel cartridges housing a glass tube (Supelco) filled with a three layer packing of various types of adsorptive hydrophobic carbon (see Figure 2). The soil gas is passed through these layers, the first, Carbotrap, absorbing "heavy" volatiles such as dichlorobenzene, the second, Carbopack B, the lighter volatiles such as TCE and DCE, and the third, Carbosieve III, the ultralights such methylene chloride or vinyl chloride. The most mobile constituent, vinyl chloride, has a breakthrough volume of 158 liters (vinyl chloride detected at the tube outlet after 158 liters of 25 ppb vinyl chloride are passed through the cartridge). These cartridges are therefore rated to

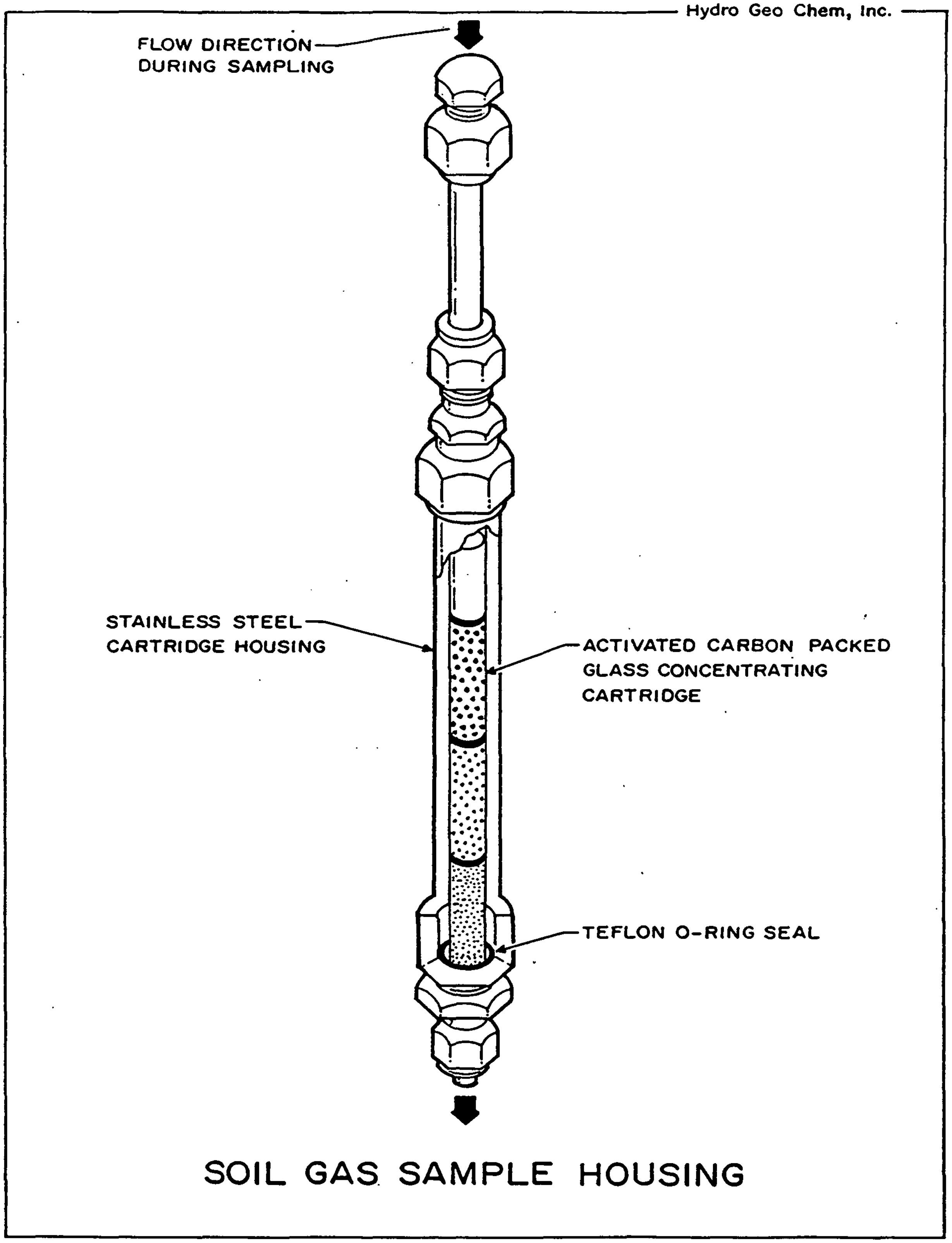


Figure 2. Soil Gas Sample Housing

absorb at least 158 liters of soil gas or atmospheric gas before breakthrough of any of the priority pollutants listed in EPA method 8021. Table 2 shows some breakthrough volumes for the types of carbon sorbents making up the adsorption cartridge. Thus the sampling capacity of this technique far exceeds that of syringe collection. The high capacity is necessary to meet the wide range of specified detection limits encountered in site investigations.

1.3 Sample Collection

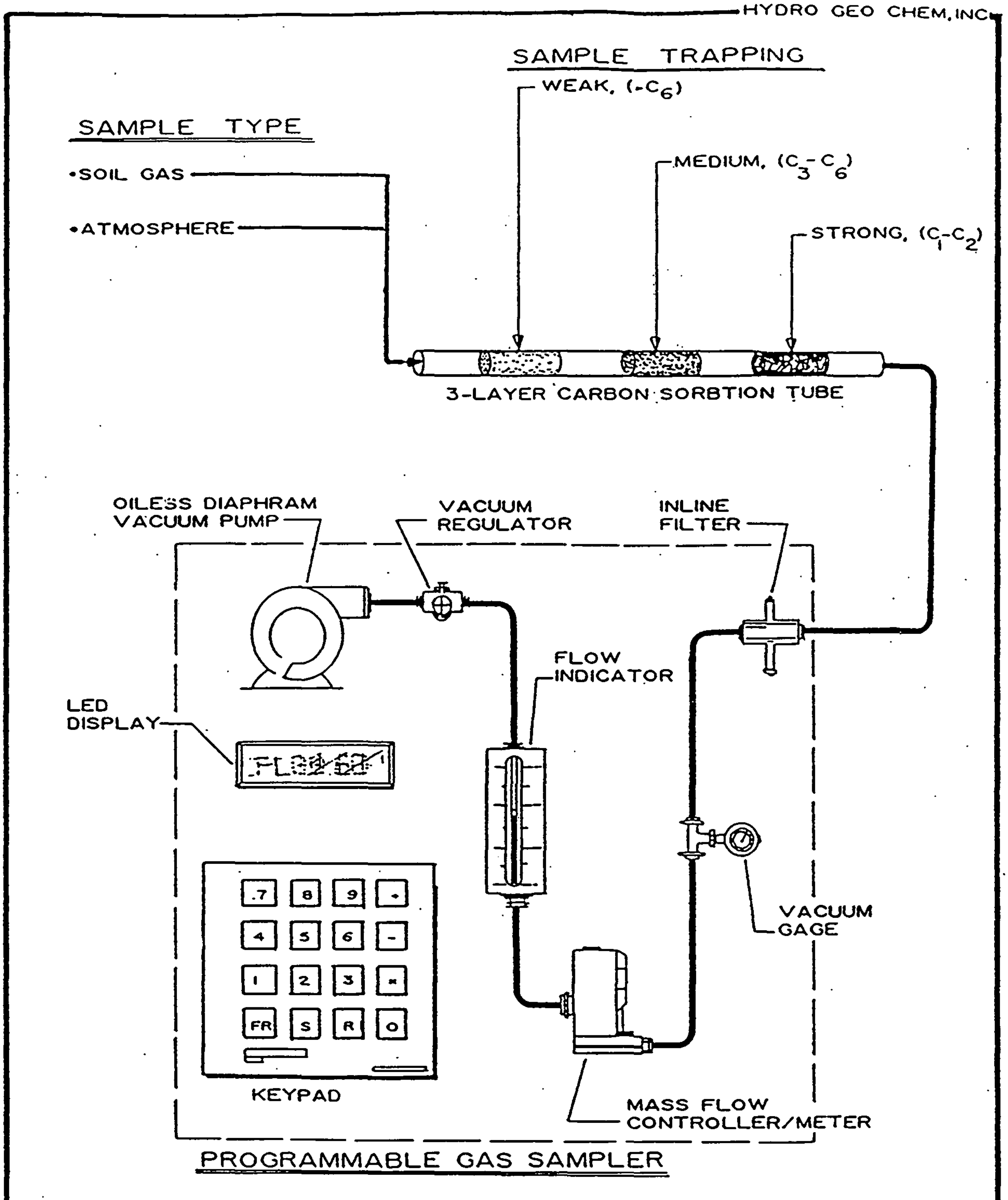
1.3.1 Soil Gas Sampling

After purging 3 probe volumes from the sampling train, the bellows valve on the adaptor is shut off and the stainless steel sample cartridge housing is attached in line using Swagelok compression fittings. The cartridge inlet leads to the adaptor and the outlet to a programmable mass flow controller equipped with a vacuum regulated oilless diaphragm vacuum pump (see Figure 3). The flow controller is

TABLE 2

BREAKTHROUGH VOLUMES (IN LITERS) FOR SELECTED HYDROCARBONS ON THE CARBOSIEVE™ S-III/CARBOPACK B/CARBOTRAP C THERMAL DESORPTION TUBE

Hydrocarbon	Carbosieve S-III (125 mg)	Carbopack B (200 mg)	Carbotrap C (300 mg)
Vinyl Chloride	158		
Chloroform		1.1	
1,2-Dichloroethane		0.4	
1,1,1-Trichloroethane		2.7	
Carbon tetrachloride		4.7	
1,2-Dichloropropane		6.8	
Trichloroethylene		2.5	
Bromoform		1.7	
Tetrachloroethylene		2.2	
Chlorobenzene		316	
n-Heptane		262	
1-Heptene		284	
Benzene		2.3	
Toluene		130	
Ethylbenzene		4060	12.9
p-Xylene			11.2
m-xylene			11.0
o-xylene			11.0
Cumene			27.8



SOIL GAS SAMPLE COLLECTION

Figure 3

Figure 3. Soil Gas Sample Collection

typically programmed to pump 200 ml of soil gas at a flow rate of 100 ml/min. When the specified flow volume has been obtained, a solenoid valve is automatically closed and the sample collection is complete. The mass flow meter delivers sample volumes between 20 and 5000 standard ml with less than 2% error independent of temperature and vacuum conditions.

1.3.2 Methane Sampling

Samples for methane analysis are collected in a 500 ml stainless steel bottle equipped with bellows valves at each end. This bottle is placed in-line during the purging cycle of the soil gas sampling. Three times the volume of the probe and bottle are drawn through the system during the purge cycle. When purging is complete the valves on the sampling container are closed. The valve on the top of the sampling probe is also closed, prior to removing the stainless steel bottle, to keep atmospheric air from entering the sampling probe.

1.4 Decontamination of Equipment

1.4.1 Prior to each use and reuse, each soil sampler, stainless steel sleeve, sampling probe, point and bailer are steam cleaned and stored in clean storage areas on the drive point rigs. Care is taken with this equipment to eliminate both soil-surface and cross-hole contamination. Vinyl or latex surgical gloves are worn during handling and assembly of the sampling apparatus.

1.4.2 Adaptors, stainless steel bottles, and stainless steel cartridge holders are heated to 120°C using a convection oven and held for 1 hour at that temperature. Carbon packed desorption cartridges are purged at 400°C with helium for 8 minutes.

1.4.3 Separate storage areas are provided for used and cleaned equipment. No equipment is reused without cleaning.

2. ANALYSIS

2.1 Scope

This section covers the equipment, materials, and procedures used to determine the concentrations of various volatile organic compounds in the soil gas samples.

2.2 Detection Limits

Method detection limits (MDL's) are matrix dependent. The MDL for soil gas samples is 0.01 µg/l. The applicable concentration range of this method is influenced by sample size and instrument limitations.

2.3 Apparatus and Equipment

2.3.1 Gas Chromatographs

Hydro Geo Chem's mobile laboratories, used to provide on-site analyses, are housed in 18 foot custom built non-motorized trailers. The mobile laboratories are stand-alone vehicles that operate separately from the drive point rig, thereby allowing efficient operation of both. Each mobile lab has a Varian 3400 temperature programmable gas chromatograph (GC) equipped with cryogenics capable of cooling the column to below 0°C using carbon dioxide. The chromatograph is connected to an Envirochem thermal desorber (Model 850) which accepts the glass sorption tubes used to collect the soil gas samples. Figure 4 is a schematic of the analytical apparatus. Helium flow is opposite to the flow direction of sample collection. The thermal desorber rapidly heats the sample sorption tube to 380 ± 4°C in 26 ± 2 seconds releasing the volatile organic compounds from the activated carbon. The released compounds are transferred from the desorber unit to the analytical columns via heated (250°C) nickel lines. The compounds are held in the cooled columns (cryofocused) at the start of the chromatographic run.

The carrier gas is ultra high purity helium at 10-20 ml/minute. The carrier gas flow is augmented with an additional 25 ml/minute helium before entering the photoionization detector (PID) to optimize response of both PID and Hall electrolytic conductivity (Hall) detectors.

2.3.2 GC Columns

Hydro Geo Chem's mobile laboratories employ DB 624 Megabore and DB 1 Megabore columns, 30 m x 0.53 mm (J&W

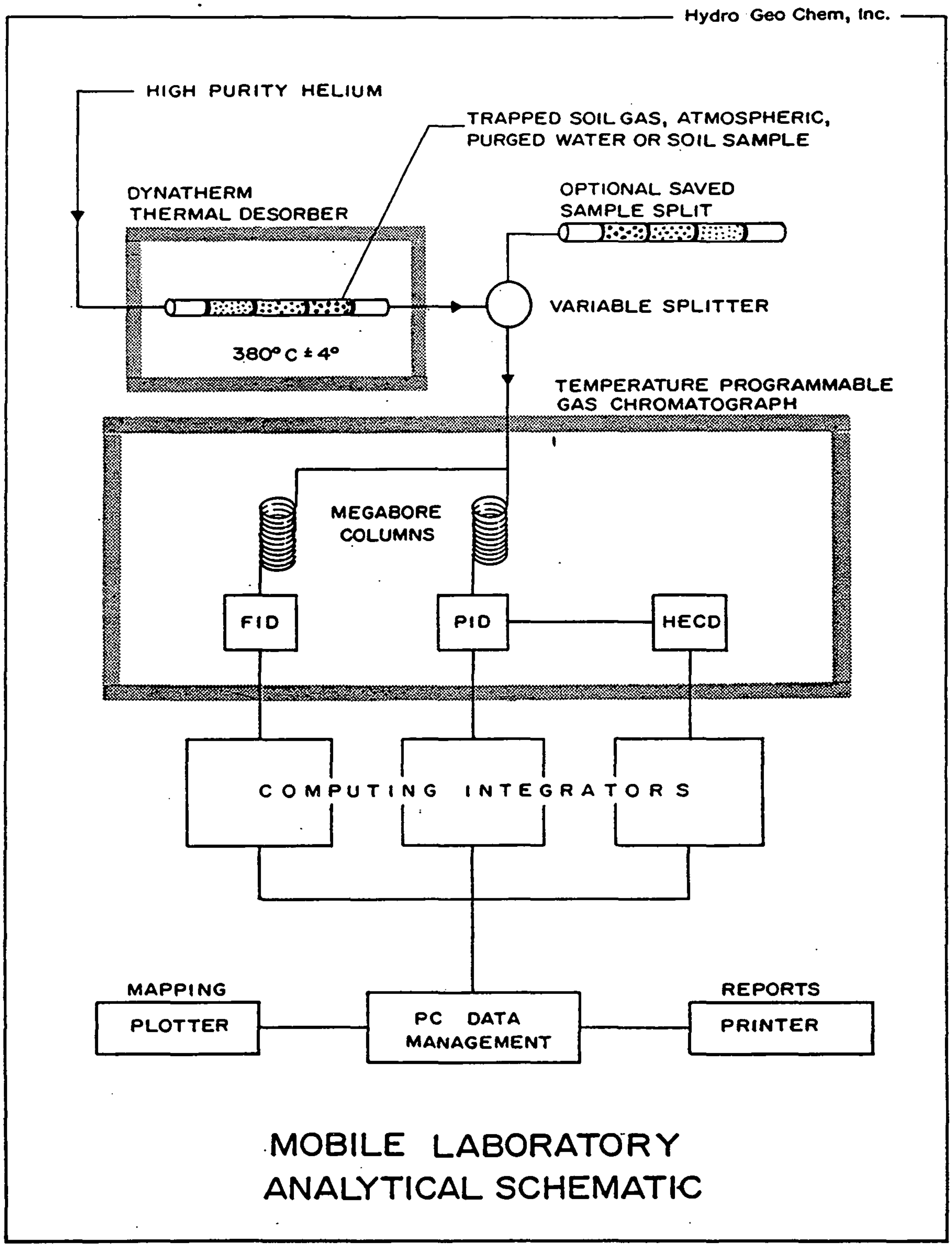


Figure 4. Mobile Laboratory Analytical Schematic

Scientific) is used in the Varian 3400 chromatograph. The helium flow rate is adjusted to approximately 7.0 ml/minute. The temperature program varies with the client needs. A typical temperature program is as follows: the column temperature is held at 2°C for 3 minutes, then programmed to 35°C at 15 C°/minute, no hold time, to 145°C at 8 C°/minute, no hold, to 230°C at 35 C°/minute.

Additional columns are available for the analysis of pesticides and classes of hydrocarbons other than aromatic and halogenated. Columns available include DB-WAX, 30m x 0.53mm, DB-5, 30m x 0.53mm, and DB 608, 15m x .53mm. All columns are obtained from J&W Scientific.

The GC is also equipped with a 1/8" x 18" Carbosphere column, 60/80 mesh, used to analyze for nonsorbable gases, such as methane, by direct injection. This column is operated at ambient temperatures.

2.3.3 Detectors

2.3.3.1 A photoionization detector (PID) equipped with a 10.2ev lamp (Tracor Model 703) is used.

2.3.3.2 A Hall electrolytic conductivity detector (HECD) (Tracor Model 700A) is also used. Operation conditions are as follows:

Reaction tube:	Nickel 1/16" OD
Reactor temperature:	900°C
Reactor base temperature:	250°C
Electrolyte:	n-propyl alcohol
Electrolyte flow rate:	0.7 ml/min
Reaction gas:	hydrogen at 35 ml/min.
Carrier gas plus make up:	helium at 32 ml/min.

2.3.3.3 Hydro Geo Chem also has available an Electron Capture Detector, ECD (Varian).

2.3.3.4 A Flame Ionization Detector, FID (Varian), is also provided for total hydrocarbon analyses.

2.3.4 Integrators

The mobile laboratories are equipped with Spectra Physics dual channel integrators (Model 4400) and Varian integrating printer/plotters.

2.3.5 Standards and Reagents

2.3.5.1 Standards are obtained from certified gas mixtures or prepared from stock mixtures of neat reagent grade compounds. Stock mixtures are prepared by adding a measured aliquot of each compound to be analyzed to a preweighed septum sealed vial. The actual mass of each compound added is determined by weighing the vial. An aliquot volume of the final mixture is then weighed to establish density (weight/volume). Weighing is done on a 0.1 mg Mettler balance calibrated according to manufacturers guidelines with weights traceable to NBS standards. Certified mixtures include vinyl chloride in nitrogen, and methane in nitrogen purchased from Matheson Gas Products, Cucamonga, California.

2.3.5.2 A spiking solution containing two compounds to be used as internal standards are prepared as described in Section 2.3.5.1. The internal standards are selected such that they do not interfere with the compounds of interest. Typical compounds used as internal standards are fluorobenzene, 2-bromo-1-chloropropane, bromochloromethane, 1-chloro-2-bromobutane, and 4-bromo-fluorobenzene. The internal standard is added to the calibration standards or samples and carried through the analytical procedure. The amount of internal standard is selected such that its concentration is 3 to 5 times greater than the expected range of concentrations found in the actual samples.

2.4 Calibration

2.4.1. Calibration

2.4.1.1 For daily soil gas calibration standards, a measured volume of the standard mixture is injected into a nitrogen-filled 1-liter glass, gas bottle through a septum side port. After heating the bottle to achieve volatilization and mixing of the standards, measured volumes are extracted with a gas syringe and injected into a 200 ml/min helium gas stream leading to a carbon packed sorption cartridge. Internal standards, if utilized, will also be injected at this time. After 2 minutes, this cartridge is inserted into the thermal desorber and analyzed exactly as the samples.

2.4.1.2 Spectra Physics calculates response factors when the external standard method is used as follows.

$$RF = A/C$$

where A = area of analyte to be measured

C = concentration of analyte, µg/l

Varian 3400 calculation of RF

$$RF = C/A \times 10000$$

2.4.1.3 The Spectra Physics calculates response factors when internal standards are used as follows.

$$RF_S = \frac{C_S}{A_S} \times \frac{A_{IS}}{C_{IS}}$$

where RF_S = response factor of components

A_S = area of components peak

C_S = amount of component used in the calibration sample, µg

A_{IS} = Area of the internal standard peak

C_{IS} = amount of internal standard used in the calibration sample, µg

2.4.1.4 Acceptable retention time window is ±0.10 minutes from the average retention time derived from the daily calibration analyses.

2.5 Quality Control

2.5.1 System Blank

A randomly selected sampling cartridge is analyzed daily to detail interferences from cartridges or the analytical system. If interference is found at unacceptable levels, an unpacked cartridge is analyzed to determine whether the interference is due to the cartridge or to the analytical system. Appropriate measures are taken to eliminate such interferences.

2.5.2 Field Blanks

2.5.2.1 Soil Gas

Prior to each day's soil gas or atmospheric sampling, field blanks of the entire sampling apparatus are taken and analyzed to check background contamination in the sampling system and cartridges. Sampling cartridges are attached to both the inlet and outlet end of a sampling probe. The sample collected in the discharge end cartridge is representative of sampling train contamination only while the intake cartridge provides a measure of the atmospheric concentrations.

Additional field blanks are collected prior to any reuse of recleaned sampling equipment.

2.5.3 Duplicate Samples

Duplicate soil gas samples are collected from each sampling location. Duplicate analyses are performed on at least 10% of the samples collected. Duplicate analyses must have relative percent differences (RPDs) of less than ± 20%.

2.5.4 Trip Blanks

2.5.4.1 Soil Gas

An unused sample cartridge is transported into the field with the sampling equipment. The trip blank cartridge is handled in the same manner as a sample, but a sample is not collected through this cartridge. The trip blank is returned to the lab with the other samples and analyzed. If VOCs are detected, sample handling and transport procedures are subsequently reviewed.

2.5.5 Matrix Spike/Matrix Spike Duplicate (MS/MSD)

2.5.5.1 Soil Gas

During each standard calibration procedure for soil gas analysis, an activated carbon collection cartridge is directly spiked with standards in the vapor phase and thermally desorbed. This is equivalent to a matrix spike.

2.5.6 Chromatographic Information

2.5.6.1 System Parameters

On the first page of each day's chromatograms, the following system parameters are noted:

A) Gas flows for H_2, He, N_2, and air

B) Tank pressures for H_2, He, N_2, and air

C) Temperatures

1. Injector
2. Columns
3. Detector
4. Thermal desorber oven
5. Thermal desorber transfer lines
6. Thermal desorber desorption temperature and duration

D) Integrator parameters

1. Attenuation
2. Peak markers
3. Baseline offset

E) Column(s)

1. Type
2. Length and diameter
3. Packing material
4. Temperature

F) Operator

G) Date

If any system parameters change, the changes shall be noted.

2.5.7 Internal Quality Control

All chromatograms are reviewed internally by a chemist other than the chemist performing the analysis.

2.5.8 Outside Quality Control Audits

Samples are periodically sent to independent laboratories for analysis as a quality assurance check.

2.5.9 Sample Chain of Custody

All samples are labeled with the following information:

1) Sample identification number
2) Date and time of sample collection

3) Name of sampler

In addition to labeling the samples, a field data/chain of custody form is completed for each sample (Figure 5). At the time of sample collection, the field sampler signs the custody form and records the date, time and sampling conditions. The sample is then transferred to the laboratory, where the individual receiving the sample for analysis signs the original custody form and records the date and time. This Soil Gas Field Data Sheet (Chain of Custody Form) is then filed in a notebook with the hard copy of the analytical results and eventually becomes part of the final report.

2.6 Procedures

2.6.1 Typical chromatographic equations are summarized in Section 2.7.

2.6.2 The system is calibrated daily as described in Section 2.4.1

2.6.3 Gas Samples

The thermal desorption tubes on which the samples are collected are placed in the thermal desorber and heated to 380 ±4°C with a

FIELD DATA SHEET

Sample #____________ Date/Time__________ Data Base File____
Location Description______________________________
Sampler's Signature______________Soil____Water____Soil Gas____
Weather______________Air Temp.(°F)______ Soil Temp.(°F)______
Wind Direction & Speed____________Surface Conditions__________
Cartridge # A= B= __________Sample Size (ml) A= B= ________
Adapter #________Probe Depth________Probe Volume (ml)__________
Purge Rate________Purge Time________Minutes Purge Vacuum__________"Hg
Sample Flow Rate________ml/min Sample Vacuum ("Hg) A= B= ________
Notes______________________________________
Lab Receipt: Signature____________________Date/Time__________

Compound	Concentration (µg/L)		Notes
	A	B	

Figure 5. Field Data Sheet

helium flow of 20 ml/min. at the same time that the GC temperature program is initiated and data acquisition started. The trapped materials are desorbed and carried through the heated transfer lines to the GC columns where separation occurs (Figure 4).

2.6.4 Methane Samples

An aliquot of the methane sample is removed from the stainless steel bottle using a gas tight syringe. The sampling bottle is equipped with a sampling port sealed with a Teflon-backed septum, therefore it is not necessary to open the sample container. The extracted aliquot is immediately injected into the GC. Samples are analyzed for methane using a Carbosphere, 68/80 mesh, packed column at ambient temperatures and a flame ionization detector (FID).

2.7 Calculations

2.7.1 Each analyte in the sample chromatogram is identified by comparing the retention time of the suspect peak to retention times generated by the calibration standards on the appropriate detector. When applicable, the relative response of the alternate detector to the analyte is determined. The relative response should agree to within

20% of the relative response determined from the standards.

2.7.2 Quantitation is usually performed on the detector which exhibits the greater response if all detectors respond to an analyte. In cases where greater specificity or precision would result, the analyst uses his/her professional judgement in determining the alternate detector.

2.7.3 The concentration of the unknowns is determined by using the calibration curve or by comparing the peak height or area of the unknowns to the peak height or area of the standards as follows for external standards:

External Standards:

$$C = (A/RF)(1/SA)$$

or

$$C = (A \times RF/10000)(1/SA)$$

where C = concentration of the analyte in sample in µg/L

SA = sample amount in L or kg

RF = relative response factor

Internal Standards:

$$C_{\mu g/l} = (\frac{IS}{SA})\ (\frac{RF_S A_S}{RF_{IS} A_{IS}})$$

where C µg/L = concentration of the component of interest present in the sample

SA = sample volume or mass (L or kg)

IS = the amount of the internal standard added to the samples

RF_S = response factor of component's determined by calibration

A_S = area count of the components in the sample analysis

RF_{IS} = response factor of the internal standard is 1 by definition

A_{IS} = the area of the internal standard in the sample analysis run

2.7.4 The results for the unknown samples are reported in µg/L. The results are rounded off to the nearest 0.01 µg/L or 2 significant figures.

APPENDIX B-1-B
RING-LINED BARREL SAMPLING OF SOILS ASTM D-3550

Designation: D 3550 – 84

Standard Practice for Ring-Lines Barrel Sampling of Soils[1]

This standard is issued under the fixed designation D 3550; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers a procedure for using a ring-lined barrel sampler to obtain representative samples of soil for identification purposes and other laboratory tests. In cases where it has been established that the quality of the sample is adequate, this practice provides shear and consolidation specimens that can be used directly in the test apparatus without prior trimming. Some types of soils may gain or lose significant shear strength or compressibility, or both, as a result of sampling. In cases like these, suitable comparison tests should be made to evaluate the effect of sample disturbance on shear strength and compressibility.

1.2 This practice is not intended to be used as a penetration test; however, the force required to achieve penetration or a blow count, when driving is necessary, is recommended as supplemental information.

1.3 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 1586 Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Sampling of Soils[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

3. Significance and Use

3.1 This practice is used where soil condition and resistance to advance of the sampler do not permit the use of a thin-wall tube (Practice D 1587) and where the formation does not require diamond coring (Practice D 2113).

4. Apparatus

4.1 *Drilling Equipment*—Any drilling equipment may be used that provides a reasonably clean hole before insertion of the sampler and that does not disturb the soil to be sampled. However, in no case shall a bottom-discharge bit be permitted. Side-discharge bits are permissible.

4.2 *Drive Weight Assembly*—Any drive weight assembly that will provide penetration in the range from 1 to 20 blows per foot (65 blows per metre) may be used. Whenever possible, soils are to be sampled by pushing instead of driving (see Section 5).

4.3 *Ring-Lined Barrel Sampling Assembly*—This shall consist of a shoe, sampler, and waste barrel, as shown in Fig. 1.

4.4 *Ring-Lined Sampler*—Test specimens shall be obtained using a suitable one piece or split sampling barrel lined on the inside with removable rings. These rings shall be thin-walled and shall conform to the size requirements of the particular laboratory test determinations employed. They shall fit snugly inside the sampler with no discernible free play in any direction. The sampler may be sectionalized to allow end-to-end make up of sections as necessary. Each section shall be designed so that addition or removal of sections will not loosen, permit movement, or otherwise adversely affect retention of the rings within the sampler. The sampler and rings shall be free of bumps, dents, scratches, rust, dirt, and corrosion.

NOTE 1—It is recommended that the sampler contain at least six rings in order to provide samples for a variety of tests.

4.5 *Waste Barrel*—A waste barrel that can be removed from the sampler in the field shall be provided to contain space for disturbed soil originally at the bottom of the hole. The length of the waste barrel shall be at least three times its interior diameter, and the inside diameter shall be the same, or slightly larger than, the inside diameter of the rings.

4.5.1 An attachment, check valve, and one or more vents is required. The design of these items is optional.

4.6 *Shoe*—The shoe shall be machined as shown in Fig. 1. The inside of the assembled shoe and ring-lined sampler shall be smooth, straight, and uniform. The thin-walled extension of the shoe shall be 2 to 4 in. (51 to 102 mm) in outside diameter and made of any materials of adequate strength and resistance to corrosion. The length of the thin-walled extension shall be equal to three times the diameter of its opening, but shall not exceed 8 in. (203 mm). The inside clearance ratio shall be between 0.5 and 3.0 %. (See Fig. 1 for inside clearance ratio formula.) The wall thickness of the thin-walled extension shall conform to Table 1.

4.6.1 The thin-walled extension of the shoe shall be perfectly round. Shoes that have become out-of-round for any reason shall not be used. If the thin-walled extension of the shoe deforms during sampling, the sample obtained shall not be used for tests, such as shear strength, where soil disturbance is a factor.

NOTE 2—The thin-walled extension of the shoe is not suitable for stiff or gravelly soils. In cases such as these, a shoe similar to the type specified

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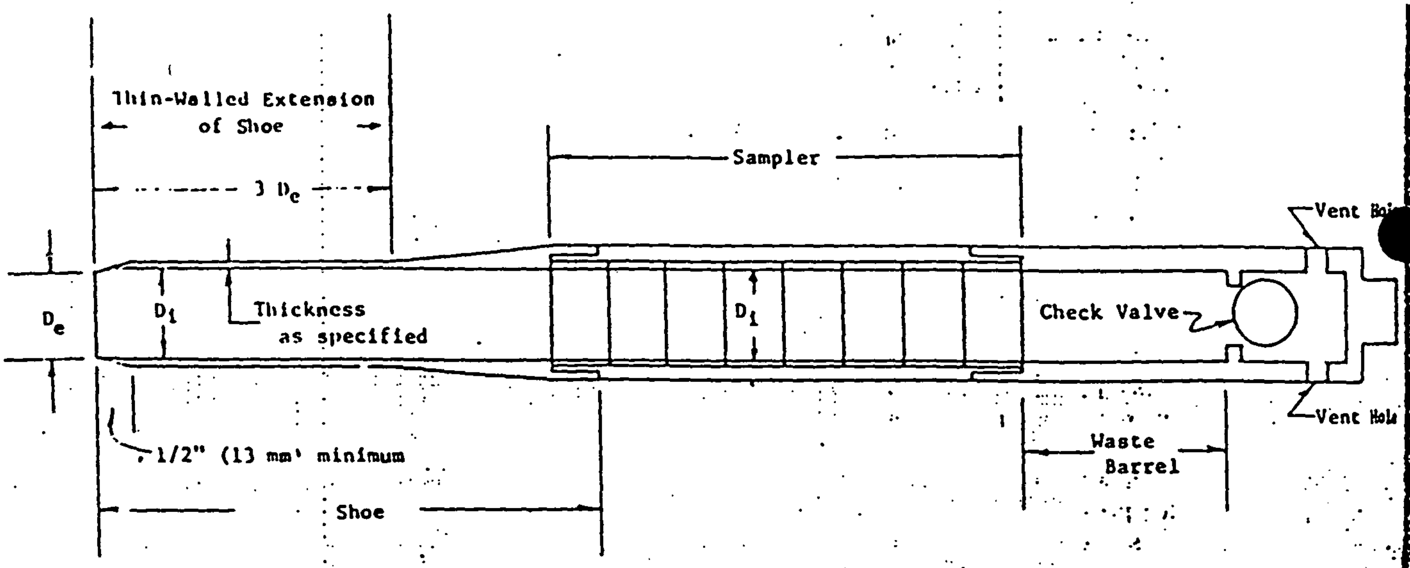
[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

Current edition approved Jan. 27, 1984. Published April 1984. Originally published as D 3550 – 77. Last previous edition D 3550 – 77$^{\epsilon 1}$.

[2] *Annual Book of ASTM Standards*, Vol 04.08.



NOTE 1—Inside clearance ratio = $(D_i - D_e)/D_e$

NOTE 2—Dimensional tolerance of D_i = ±0.003 in. (±0.08 mm)

FIG. 1 Ring-Lined Barrel Sampling Assembly

in Method D 1586 is required for penetration. The use of this type of shoe, however, may result in excessive disturbance of the soil so that it is no longer suitable for shear or consolidation determinations, or both.

4.7 *Sample Extractor*—Specimen-filled rings shall be removed from the sampler by pressing them out or alternatively by the use of a split barrel. The extractor disk shall be at least 0.5 in. (13 mm) thick and shall bear solidly against the sample rings at all points. It shall slide easily inside the sampler barrel without jamming and without free play.

4.8 *Containers for Specimen-Filled Rings*—These shall be snug fitting, tightly sealed (watertight), rigid containers that will not permit movement of the specimen-filled rings inside. They shall be noncorrosive.

4.9 *Miscellaneous Equipment*—This includes a pipe vise, pipe wrenches, spatulas, cleaning brushes, buckets, rags, data sheets, transporting boxes, etc. Water must be available for cleaning the equipment.

5. Procedure

5.1 Clean the hole to sampling elevation using whatever method is preferred that will ensure that the material to be sampled is not disturbed. In saturated sands and silts, withdraw the drill bit slowly to prevent loosening of the soil around the hole. When casing is used, it shall not be driven below sampling elevation. Water or drilling liquid within the boring must be maintained at all times at or above the natural ground water level; it is preferable to keep the hole filled.

5.2 Keep a careful record of drill penetration and sampler depth to ensure that the soil being sampled is the original soil at the bottom of the hole and is not contaminated by soil falling down from the sides of the hole. If there is any significant tendency for soil to fall from the sides of the hole to the bottom, use water, drilling mud, or casing, as necessary, in order to prevent this from happening. The process of jetting through an open-tube sampler and then sampling when the desired depth is reached shall not be permitted. The use of bottom-discharge bits shall not be allowed.

5.3 Assemble the sampling assembly and lower it carefully into the hole. With the cutting edge of the shoe resting on the bottom of the hole and the water level in the boring at the ground water level or above, push the sampling assembly into the soil by a continuous and rapid motion without impact or twisting. Push the assembly in far enough so that all cuttings, sludge, and soil disturbed by drilling are in the waste barrel; however, in no case push the assembly farther than the total length of the shoe, sampler, and waste barrel. Take care that none of the sample is lost due to improper operation of the check valve.

5.4 When the soils are so hard that they cannot be penetrated by pushing, using generally acceptable field proc[illegible] and where recovery by pushing in sands is poor, use a drive hammer to drive the sampling assembly. In such a case, record the hammer weight, height of drop, and number of blows.

5.5 Carefully disassemble the sampling assembly in such a manner as to minimize soil disturbance as much as possible. Trim the soil flush with the ends of the sampling barrel, and remove the specimen (consisting of soil plus rings). Slip the container over the specimen-filled rings and cap both ends. Be certain that there is no movement of the specimen-filled rings inside the container and that the specimen was not disturbed while being removed from the barrel and placed in the container. Label the container in a suitable manner. If the soil in the bottom end ring does not protrude from the ring after removing the shoe, do not use the soil in the bottom ring for tests other than soil classification and moisture content. If the top ring or rings contain voids, depressions, or any material other than the soil which is being sampled, do not use the soil in this ring (or rings) for any purpose whatsoever. The filling of depressions in the end rings with additional soil shall not be permitted. Discard samples that appear to be disturbed or questionable.

5.6 Examine the soil remaining in the shoe for structure, consistency, color, and condition. Record these observations and include them in the report (see 6.1.8).

NOTE 3—The soil remaining in the shoe is relatively und[illegible] therefore may be suitable for a variety of laboratory tests.

Report

1 Data obtained in each boring shall be recorded in the d and shall contain the following:

1.1 Name and location of job,

2 Date of boring and times of start and finish,

3 Boring number and location,

1.4 Surface elevation, if available,

1.5 Sample number and depth,

1.6 Method of advancing sampler, penetration, and re-ry lengths,

1.7 Description and size of sampler,

1.8 Description of soil (see Practice D 2488),

1.9 Thickness of layer,

6.1.10 Depth to water table or depth of overlying water and time of reading,

6.1.11 Size of casing, depth of cased hole,

6.1.12 Type of drilling equipment—description,

6.1.13 Names of personnel: crewman, field engineer, technician, etc.,

6.1.14 Weather conditions, and

6.1.15 General remarks.

7. Precision and Bias

7.1 This practice does not produce numerical or repeatable data and therefore a precision and bias statement is not applicable.

APPENDIX B-1-C
PHYSICAL SOIL MEASUREMENTS

APPENDIX B-1-C: PHYSICAL SOIL MEASUREMENTS

This appendix describes the laboratory procedures which will be used to determine the porosity and moisture content of soils from the site.

Total Porosity

The total porosity of the soil samples used in the air permeability tests will be computed from their bulk density, grain density, and moisture content.

The bulk density will be determined in Hydro Geo Chem's laboratory using the following procedure modified from Head (1980):

(1) Remove the sample tube from the sample holding assembly; clean the outside of the tube, but do not remove the identification label. Record sample identification.

(2) Trim each end of the sample to give flat surface normal to the axis of the tube. Remove all loose material.

(3) Measure the overall length of the sampling tube (L_1) to the nearest millimeter.

(4) Using a steel rule and straight-edge, measure from the ends of the tube to the trimmed surface of the sample to 0.5 mm, taking three or four readings at each end. Calculate the mean of each set to the nearest 0.5 mm (L_2 and L_3).

(5) Using the internal-measuring jaws of the vernier calipers, measure the internal diameter of the tube on two perpendicular diameters at each end, to 0.1 mm. Calculate the average to 0.1 mm (D). Make sure that the calipers are opened to the maximum extent possible, to give a diametrical reading.

(6) Weigh the tube and sample, to an accuracy of 5 g (m_1). The sample is weighed in the tube as a precautionary measure in case the sample cannot be kept on extrusion.

(7) Extrude the sample and collect all material together in a preweighed beaker under the fume hood.

(8) Determine the weight of the extruded material (m_2).

(9) Cover the extruded sample with parafilm in preparation for determining moisture content.

Moisture Content

The moisture content of the samples will be determined using the following procedure:

(1) Homogenize the extruded sample with a spatula under the fume hood.

(2) Transfer approximately 100 grams of homogenized sample into a pre-weighed glass beaker and weigh the beaker immediately.

(3) Place the beaker containing the soil under the fume hood and air dry for at least 24 hours to allow volatile organic compounds to escape.

(4) Place the beaker containing the soil in the drying oven under the fume hood for 24 hours with the oven temperature set at 105 to 110 degrees celsius (°C).

(5) Remove the beaker from the oven and allow to cool in a desiccator tray.

(6) When cooled, weigh the sample to the nearest 0.1 gram.

(7) Compute the moisture content in the following manner.

APPENDIX B-1-D
TOTAL ORGANIC CARBON MEASUREMENTS

APPENDIX B-1-D
PROCEDURE FOR PREPARATION OF SOIL SAMPLES FOR TOTAL ORGANIC CARBON ANALYSIS

INTRODUCTION

This document describes the preparation of soil samples for submission to the University of Arizona Soil and Water Laboratory for analysis of total organic carbon using the NA 1500 N-C-S Analyzer.

PROCEDURE

The entire sample will be transferred from the brass sample tube into a stainless steel pan and air dried under a fume hood. The sample will be homogenized by stirring with a spatula. Loss of volatiles is not considered important because the purpose of the analysis is to evaluate the distribution of volatiles into the non-volatile organic carbon fraction.

After the sample has been homogenized, a 30 gram aliquot will be transferred into a 40 ml VOA vial and sealed. The sample will then be transferred to the Soil and Water Laboratory.

A portion of the sample will be oven-dried and milled in a Spex Ball-Mill until the particulates are approximately 100 µm in size. The rest of the aliquot will be saved in case more sample is required.

Ten grams of the milled sample will be treated with 10 ml of 10% phosphoric acid. The 1:1 sediment to acid ratio is more than adequate to remove all the inorganic carbon in the sample. If the sample still effervesce when the last of the 10 ml is added, more acid will be added until fizzing stops. The acid treated sample will then be dried and crushed using a mortar and pestle.

25 mg of acidified sample will be weighed in a tin cup and placed in the high-temperature furnace. The sample size may be changed if the analyst deems it necessary to obtain more precise results. Duplicates will be performed on each sample and a triplicate will be run if the duplicate results vary by more than 10%. A copy of the University of Arizona Soil and Water Science Laboratory standard operating procedures for the determination of total carbon is attached to this appendix.

All work discussed previously will be performed under a fume hood. Anyone who will be in contact with the sediments will be wearing protective gloves, eye-wear and a lab coat. The sediments remaining after analysis will be returned to Hydro Geo Chem.

OPERATING PROCEDURES FOR THE DETERMINATION OF TOTAL NITROGEN, CARBON AND SULFUR IN SOILS, PLANT TISSUES & WASTES USING THE NA 1500 N-C-S ANALYZER

INTRODUCTION

The procedure makes use of high temperature combustion tube, based on the Dumas principle, to convert/oxidize all forms of N, C and S into N_2, CO_2 and SO_2, respectively. These three species as separated and quantified using gas-solid chromatography. The equipment is designed for solid samples, but may also be used for with liquids with suitable sample containerization. The limit of detection for these three elements in solid samples it tentatively specified (by the manufacturer) at 100 mg/Kg and is very much sample size dependent.

THEORY

A pre-weighed sample (2-50mg) is sealed into a tin cup and introduced into a high temperature (1000°C) quartz furnace, packed with tungstic anhydride (WO_3) granules (25/60 mesh) and ultrapure copper (Cu) granules, via a carrousel. While research grade helium (He) gas is continuously passed through the furnace, a pulse (10 ml) of ultrapure oxygen (O_2) gas is timed to enter to furnace approximately 18 seconds after the sample introduction. In the resulting flash combustion, started by the O_2 introduction and catalyzed by the tin metal and tungsten oxide, N_2, CO_2 and SO_2 are formed. The remaining oxygen reacts with the pure copper granules as the gases are swept though the furnace. The helium carrier gas and the mixture of three gases are subsequently passed through a moisture trap packed with anhydrone to remove any traces of water prior column separation. The mixture of helium and other gases is introduced into a standard Porapak QS (80/100) solid phase packed into a 2 m x 1/4" teflon column. Using a recommended helium carrier flow of 100 ml/min. and an oven temperature of 85°C, the separation of all three gases is achieved in less than 7 minutes. A thermal conductivity detector and a peak integrator are used to quantify the amount of each gas.

Continued...

EQUIPMENT

1. C-N-S analyzer, Carlo Erba Model NA 1500, equipped with autosampler.
2. Micro balance, Khan Model 30 or equivalent.
3. Peak Integrat or, Spectrametrics 4290 or equivalent.
4. Helium, Oxygen and air pressure regulators.
5. Research Grade or Better Helium and Oxygen tanks.
6. Source of pressurized air (400 psi).

REAGENTS

Note: In order to maintain warranty, all chemicals used for the sample preparation and in the furnace packings must be provided by Haake Buchler Instrument company.

1. Tungstic Anhydride (WO_3) granular (25/60 mesh), reagent grade.

2. Copper (Cu) reduced wire granules, ultrapure.

3. Vanadium Pentoxide (V_2O_5) powder, reagent grade.

4. Calibration standards. Certified purity materials, such as NBS orchard leaves, or certified chemical such as 5-chloro-4-hydroxy-3-methoxy-benzylisothiourea phosphate standard. 8.13% N, 31.35% C, and 9.30% S.

5. Phosphoric Acid, 10% solution. Measure 115ml of Reagent Grade phosphoric acid (H_3PO_4) into a 1L volumetric flask. Bring to volume with deionized water and store in a 1L Nalgene bottle.

PROCEDURES

A. Sample Preparation

<u>Plant Tissue:</u> All plant tissue material must be oven dried at 60°C for 4 or more hours and ground through a 40 mesh or smaller screen (using a Wiley Mill) prior to analysis. Since plant tissue samples often have carbon levels exceeding 30%, it is recommended that sample size be kept to a minimum (-5mg) to reduce overlapping of the N and C peaks.

<u>Soil, sludge:</u> Soil material must be prepared according the procedures outlined in OP No. 2. These include oven drying and ball milling of a sub-sample. Total, inorganic or organic carbon

Continued...

can be determined in soil samples as follows:

-Total Carbon determination: No further preparation needed.

-Organic Carbon: This can be determined in soils by pretreating the soil with phosphoric acid prior to analysis as following:

1. Weigh 2.0g of ball milled soil into a weighing dish.
2. Add 3-5 ml of 10% phosphoric acid solution, depending on amount of fizzing. Mix well with a spatula.
3. Dry the soil sample in an oven set at 60°C overnight.
4. Using small mortar and pestle, grind the soil sample, mix thoroughly and seal it into a plastic container.

<u>Liquid wastes:</u> These types of samples may require a special container and sealing device, if volatiles are present, See Carlo Erba manual. Otherwise, a drying agent can be used to absorb the water and improve sample handling. Use the following materials to dry liquids:

1. Anhydrous calcium Sulfate ($CaSO_2$) powder, if S is of no concern.
2. Chromosorb W (80/100 mesh CWR) (diatome earths mixed with sodium carbonate), can be used if C or no concern.
3. Mix equal amounts (1+1g) of either of these materials with the sample. Make sure that the weights recorded are to the nearest mg.
4. Allow a few minutes to for the mixture to absorb all water and grind the sample thourougly with a small mortar and pestle. Seal mixture into a plastic container.

Continued...

B. Instrument Standby Mode

The NA 1500 analyzer is usually left on a "standby" mode as follows:

1. Press in the furnace standby (FURN STBY) and filament (FIL OFF) buttons. This will allow to main furnace to drop down to 795°C and will turn off the current to the detector filaments.
2. Set the carrier (M) and reference (R) gas pressures to about 25 psi (front panel meters).
3. Set the oxygen (O_2) pressure to about 10 psi (from panel meter).
3. Leave the Air pressure as set (330 psi).
4. Shut off the purge valve located below the autosampler.

NOTES: LEAVE ALL GAS TANK REGULATORS AS SET. DO NOT SHUT OFF ANY TANK VALVES.
<u>DO NOT READJUST ANY OTHER MAIN CONTROL PANEL DIALS, BUTTONS OR KNOBS.</u>

C. Instrument Start-up (from Standby mode)

Reverse the standby mode of the instrument as follows:

1. Depress the furnace standby (FURN STBY) and filament (FIL OFF) buttons. This will allow to main furnace to heat up to 1000°C (from 795°C when on stand by) and will turn the current on through the detector filaments.
2. Set the carrier (M) reference (R) gas and oxygen (O_2) flows to about 100 psi (front panel meters). The flows are preset as follows:

GAS		PRESSURE	FLOW
Helium	Main (carrier)	100 psi	80-100 ml/min
Helium	Reference	100 psi	40 ml/min
Helium	Purge	set by knob	50 ml/min
Oxygen		100 psi	>20 ml/min
Air		330 psi	(no flow)

Continued...

3. Leave the Air pressure as set (330 psi).

4. Turn on the purge valve located below the autosampler.

NOTES: LEAVE ALL GAS TANK REGULATORS AS SET. DO NOT SHUT OFF ANY TANK VALVES.
<u>DO NOT READJUST ANY OTHER MAIN CONTROL PANEL DIALS, BUTTONS OR KNOBS.</u>

5. Allow the system to stabilize for about 30 minutes prior to calibration

Other preset instrument control parameters are:

Oxidation Furnace temp.	1000°C
GC oven temp.	85°C
TC detector filament temp.	190°C
Total Run time	490 sec (0:08:10)
Sample Start	18 sec
Sample Stop	60 sec
Oxygen Inject	61 sec (0:01:01)

D. Instrument Calibration (daily)

Definitions:

Bypass:	Material (usually a standard) in a tin cup of unknown weight used initially to condition the system.
Standard:	Material of known weight with a known concentration of C, N, S, placed in a tin cup, and used to determine the response factors of each of these elements. Must have a certified, traceable purity.
Sample:	Material of known weight but unknown C, N, S concentration, placed in a tin cup.

Continued...

Notes: 1. The sample preparation, which includes sample weighing and packing into a tin cup, must be learned from hands-on experience.

2. All refractory materials such as soils, sludges, must have a small scoop (2-4mg) of vanadium pentoxide reagent added into the tin cup before analysis.

1. Prepare two bypass samples using a reference materials (5 mg or less are sufficient) and place them into the carrousel.

2. Press the CYCLE START button on the from panel. Note make sure the integrator is on.

Note: At this point the instrument will cycle through each sample automatically unless:

a) The CYCLE OFF MAN button is pressed <u>at any time</u> during the cycle.
b) No peaks are present (no sample imtroduced) <u>and</u> the MANUAL EXCLUSION NO PK STOP button is in the depressed position.
c) The detector signal is out of range <u>and</u> the MANUAL EXCLUSION O-FLOW STOP button is in the depressed position.

3. Continue to introduce samples into the carrousel in a sequential manner.

4. Record the area counts of each of the peaks of interest and use them to compute the response factor (in the case of the calibration) or the % N, C or S (in the case of the unknown samples.

The response factor is computed as follows:

$$RF_E = \frac{[\text{Sample Wt.(g) X \%E}]}{\text{Area Count}}$$

where %E = %N, %C, or %S in standard

Continued...

5. In the case of unknown samples, the amount of N, C or S is computed using the same relationship, once the RF_E is known.

E. Instrument Shut-down (Standby) Daily

1. Turn off integrator.
2. Proceed with instructions listed in Section A (Standby Mode).

QUALITY CONTROL

Note: The reagents used in the oxidation furnace have a finite life span. The copper wire is usually exhausted (unable to absorb any more oxygen between 200-300 samples. When this occurs, the O_2 peak overlaps the CO_2 peak and is also present in blanks. See the laboratory manager about replacing or repacking the furnace tube.

1. Instrument must be recalibrated each day by running three or more standards (after two bypasses) and determining the RF for each of the elements of interest. These RF values must have a precision of less than 5% RSTD.

2. A standard must be run every 10 samples to verify the condition of the furnace. Its accuracy must be within 5% Rel. Dif. of true value.

3. For plant tissue and sludge samples the optimum sample size is 10 mg. Use of larger samples may produce an unacceptable overlap between the NO_2 and CO_2 peaks.

5. For soil samples low in carbon the optimum sample size is from 10-50mg, depending on the N,C,S content.

Continued...

CARE OF INSTRUMENT

1. To pack furnaces, consult first with instrument supervisor. Follow instructions and Nitrogen Analyzer 1500 Manual.

Note: generally cupper wire must be completely replaced <u>each</u> time the furnace is repacked; whereas, the Tungtic oxide material can be reused several times as long as its color is light lime green.

2. Repack the water (moisture) trap at least every 400 samples (about two furnace packing cycles) with fresh anhydrone [$Mg(ClO_4)_2$].

3. Replace Helium carrier gas <u>only</u> with research grade purity, 99.9999% or better with no hydrocarbons.

4. Replace Oxygen gas only with research grade purity, 99.996% or better with no hydrocarbon impurities.

REFERENCES

Carlo Erba Strumentazione Nitrogen Analyzer Manual.

Approved by:__________ Date 7/9/87
Dr. J.F. Artiola, Laboratory Director

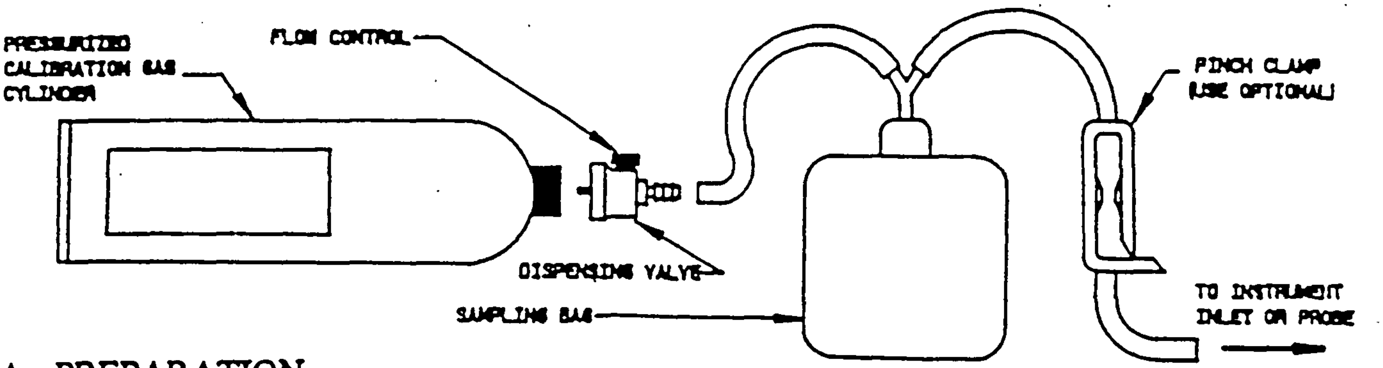
Approved by:__________ Date__________
Dr. I.L. Pepper, QA/QC Officer

APPENDIX B-1-E
CALIBRATION OF GAS TECHTOR O_2/CO_2 METER

CALIBRATION KIT FOR SAMPLE-DRAWING INSTRUMENT

(See other side of this page for diffusion instruments)

GasTech calibration kits for sample-drawing instruments are now furnished with a sampling bag, for more accurate calibration and for conservation of sample gas. Before attempting to use this kit, be certain components are connected as shown in the sketch below, and read the section "CALIBRATION AND ADJUSTMENT" in the Instruction Manual furnished with the instrument to be calibrated. It will save time and calibration gas if the instrument is "warmed up" and calibration controls have been located, prior to turning on the gas valve.



A. PREPARATION

1. Remove protective red plastic cap from cylinder outlet.
2. Check DISPENSING VALVE to see that FLOW CONTROL is shut off (clockwise), but not so tightly as to damage the valve seat.
3. Screw dispensing valve onto cylinder outlet, being careful not to cross-thread. Tighten valve firmly.
4. Push the short piece of flexible plastic tubing from "Y" onto barbed nipple of DISPENSING VALVE.
5. Locate adjustment potentiometer(s) and verify instrument has had adequate "warm-up". (See instruction manual for instrument.)
6. Carefully set instrument to read "0" on known clean gas-free air (for Oxygen instruments, set to 20.9 or " Calib" mark) following instruction manual for specific instrument. (If purity of surrounding air is suspect, use a pressurized cylinder of "Zero Air".)

B. CALIBRATION

1. Connect the longer plastic tube with PINCH CLAMP to the instrument. The PINCH CLAMP should be <u>open</u> (push latch forward to open).
2. Allow the instrument, if internal pump type, to evacuate SAMPLING BAG until flat (or operate aspirator bulb until bag is flat), then close PINCH CLAMP (squeeze parallel faces together until tight and latched).
3. Open FLOW CONTROL slightly so that SAMPLING BAG begins to expand, then quickly open PINCH CLAMP. As instrument takes sample, the bag will either start to expand further or to deflate. If bag is expanding, close down on FLOW CONTROL (clockwise), or if deflating, open FLOW CONTROL slightly until bag stays about half inflated.
4. Observe meter on instrument. Reading will increase, then stabilize. As soon as reading is stable, compare with value on pressurized calibrating gas cylinder and record or change with adjustment potentiometer as appropriate.
5. Quickly close FLOW CONTROL on DISPENSING VALVE (clockwise) and disconnect tube from instrument inlet.
6. Instrument is now calibrated and ready to use.
7. When calibration is complete, remove DISPENSING VALVE from cylinder before storage, to prevent loss of cylinder contents, then re-cap cylinder. SAMPLING BAG, DISPENSING VALVE and PINCH CLAMP may be left connected to the tubing for storage.

GASTECH INC., 8445 CENTRAL AVENUE, NEWARK, CA 94560

APPENDIX B-1-F
LITHOLOGIC DESCRIPTION OF SOILS ASTM D-2488

Designation: D 2488 - $84^{\epsilon 1}$

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

$^{\epsilon 1}$ NOTE—Section 18 was added editorially in January 1989.

1. Scope

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils.

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (See Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

1.5 The values stated in inch-pound units are to be regarded as the standard.

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2487 Test Method for Classification of Soils for Engineering Purposes[2]

3. Definitions

3.1 Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standa sieve, the following definitions are suggested:

Cobbles—particles of rock that will pass a 12-in. (300-mm) squa opening and be retained on a 3-in. (75-mm) sieve, and

Boulders—particles of rock that will not pass a 12-in. (300-mm square opening.

3.1.1 *clay*—soil passing a No. 200 (75-µm) sieve that ca be made to exhibit plasticity (putty-like properties) within range of water contents, and that exhibits considerab strength when air-dry. For classification, a clay is a fin grained soil, or the fine-grained portion of a soil, with plasticity index equal to or greater than 4, and the plot plasticity index versus liquid limit falls on or above the "A line (see Fig. 3 of Test Method D 2487).

3.1.2 *gravel*—particles of rock that will pass a 3-i (75-mm) sieve and be retained on a No. 4 (4.75-mm) sie with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on No. 4 (4.75-mm) sieve.

3.1.3 *organic clay*—a clay with sufficient organic conte to influence the soil properties. For classification, an orga clay is a soil that would be classified as a clay, except that liquid limit value after oven drying is less than 75 % of liquid limit value before oven drying.

3.1.4 *organic silt*—a silt with sufficient organic content influence the soil properties. For classification, an organic is a soil that would be classified as a silt except that its liqu limit value after oven drying is less than 75 % of its liq limit value before oven drying.

3.1.5 *peat*—a soil composed primarily of vegetable tis in various stages of decomposition usually with an orga odor, a dark brown to black color, a spongy consistency, a texture ranging from fibrous to amorphous.

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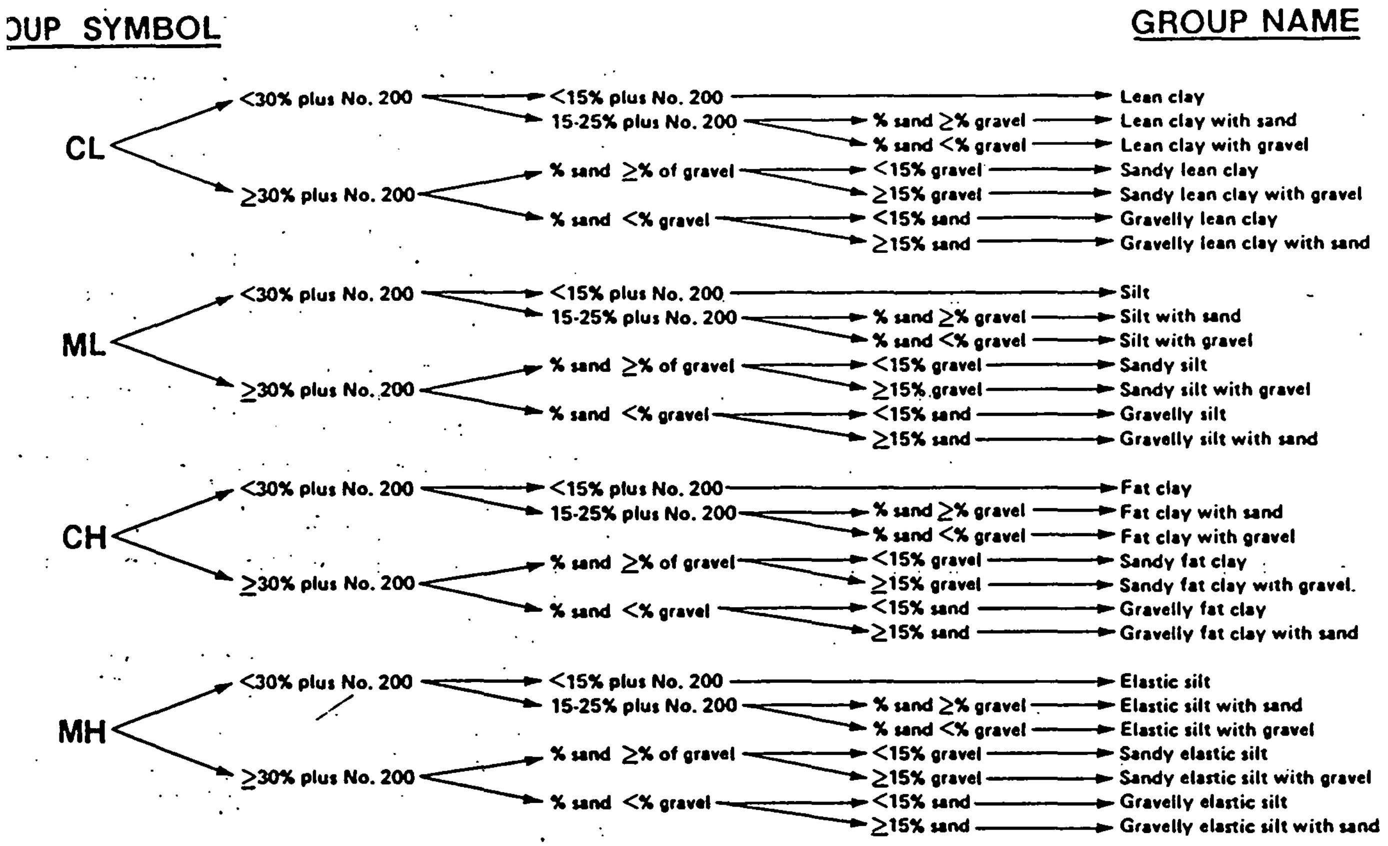
[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

Current edition approved Oct. 3, 1984. Published December 1984. Originally published as D 2488 - 66 T. Last previous edition D 2488 - 69 (1975).

[2] *Annual Book of ASTM Standards*, Vol 04.08.



ote—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)

.1.6 *sand*—particles of rock that will pass a No. 4
75-mm) sieve and be retained on a No. 200 (75-µm) sieve
h the following subdivisions:

oarse—passes a No. 4 (4.75-mm) sieve and is retained on
o. 10 (2.00-mm) sieve.

nedium—passes a No. 10 (2.00-mm) sieve and is retained
a No. 40 (425-µm) sieve.

ine—passes a No. 40 (425-µm) sieve and is retained on a
. 200 (75-µm) sieve.

.1.7 *silt*—soil passing a No. 200 (75-µm) sieve that is
nplastic or very slightly plastic and that exhibits little or no
ength when air dry. For classification, a silt is a fine-
ined soil, or the fine-grained portion of a soil, with a
sticity index less than 4, or the plot of plasticity index
rsus liquid limit falls below the "A" line (see Fig. 3 of Test
ethod D 2487).

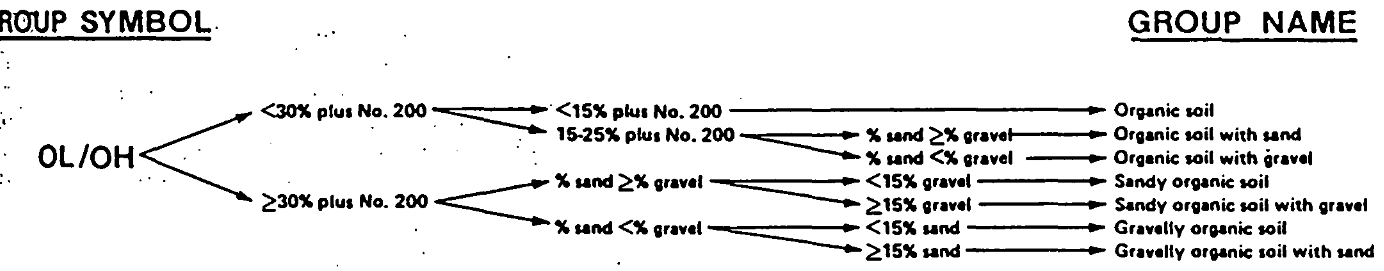
4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Figs. 1a and 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

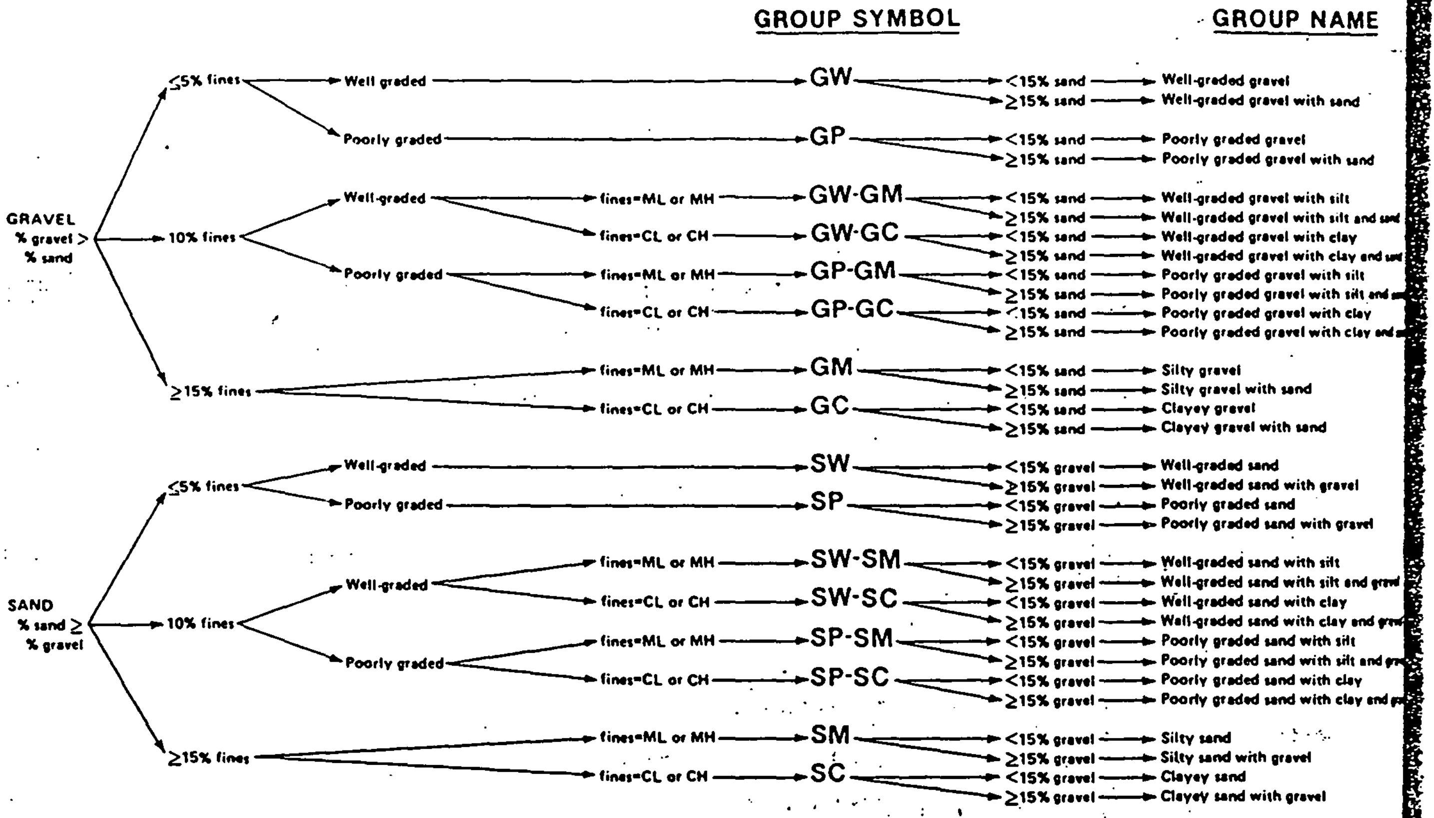
Note 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols.*

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two



Note—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory te results for typical soils of each type with their visual and manu characteristics.

5.6 When describing and identifying soil samples from given boring, test pit, or group of borings or pits, it is no necessary to follow all of the procedures in this practice fo every sample. Soils which appear to be similar can b grouped together; one sample completely described an identified with the others referred to as similar based o performing only a few of the descriptive and identificatio procedures described in this practice.

6. Apparatus

6.1 *Required Apparatus:*

6.1.1 *Pocket Knife or Small Spatula.*

6.2 *Useful Auxiliary Apparatus:*

6.2.1 *Small Test Tube and Stopper* (or jar with a lid).

6.2.2 *Small Hand Lens.*

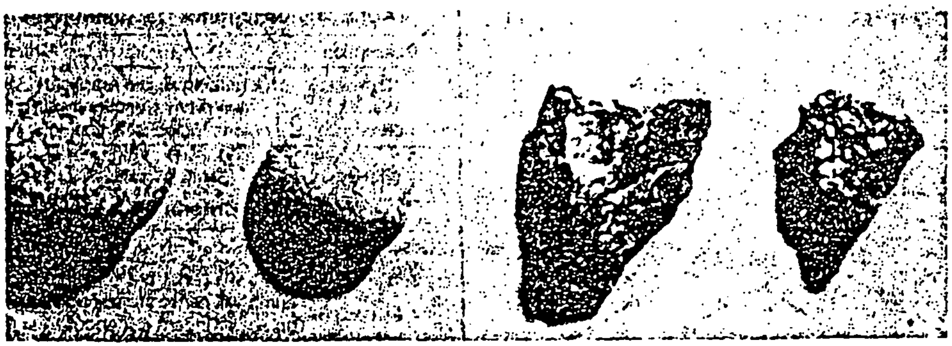
7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, refe ences to water shall be understood to mean water from a ci water supply or natural source, including non-potable wate

7.2 *Hydrochloric Acid*—A small bottle of dilute hydr chloric acid, HCl, one part HCl (10 *N*) to three parts wat (This reagent is optional for use with this practice). S Section 8.

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one p



(a) Rounded (b) Angular

(c) Subrounded (d) Subangular

FIG. 3 Typical Angularity of Bulky Grains

concentrated hydrochloric acid (10 N) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 Caution—Do not add water to acid.

9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 5—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 6—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (⅜ in.)	200 g (0.5 lb)
19.0 mm (¾ in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

NOTE 7—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceeding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

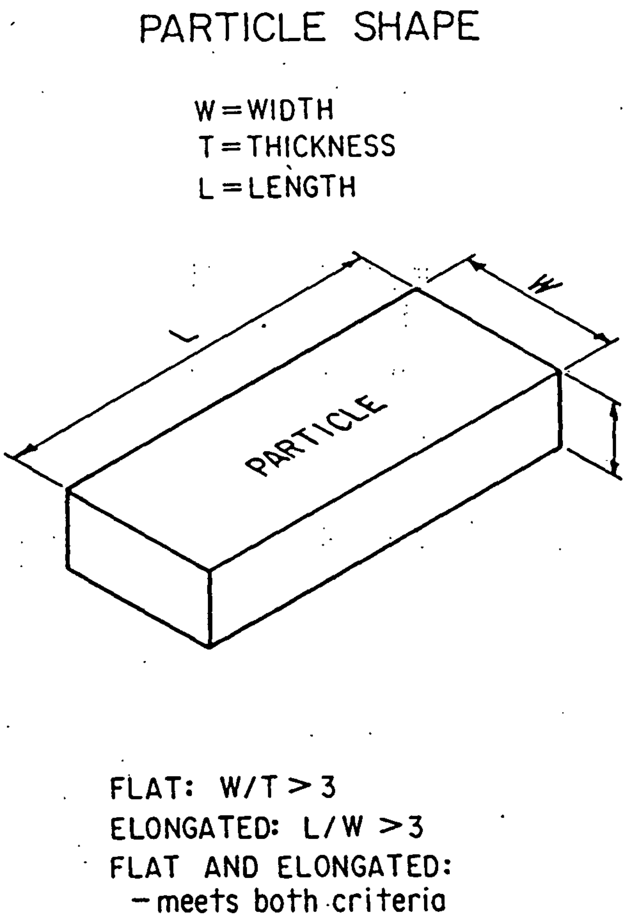


FIG. 4 Criteria for Particle Shape

TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediate

TABLE 5 Criteria for Describing Consistency

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼ in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnai
Very hard	Thumbnail will not indent soil

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, i accordance with the criteria in Table 5. This observation i inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of int coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

10.9 *Structure*—Describe the structure of intact soils i accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand co ponents, describe the range of particle sizes within ea component as defined in 3.1.2 and 3.1.6. For example, abo 20 % fine to coarse gravel, about 40 % fine to coarse sand

10.11 *Maximum Particle Size*—Describe the maxim particle size found in the sample in accordance with t following information:

10.11.1 *Sand Size*—If the maximum particle size is sand size, describe as fine, medium, or coarse as defined i 3.1.7. For example: maximum particle size, medium sand

10.11.2 *Gravel Size*—If the maximum particle size is gravel size, describe the maximum particle size as t smallest sieve opening that the particle will pass. F example, maximum particle size, 1½ in. (will pass a 1½-i square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum parti size is a cobble or boulder size, describe the maxim dimension of the largest particle. For example: maxim dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse s and larger particles as hard, or state what happens when t particles are hit by a hammer, for example, gravel-s particles fracture with considerable hammer blow, so gravel-size particles crumble with hammer blow. "Ha means particles do not crack, fracture, or crumble und hammer blow.

10.13 Additional comments shall be noted, such as t presence of roots or root holes, difficulty in drilling augering hole, caving of trench or hole, or the presenc mica.

TABLE 6 Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger press
Moderate	Crumbles or breaks with considerable finger pressur
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 8—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 9—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength:*

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 10—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accorance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 *Dilatancy:*

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally,

TABLE 8 Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 *Toughness:*

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about ⅛ in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about ⅛ in. The thread will crumble at a diameter of ⅛ in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A ⅛-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

14.7 *Identification of Inorganic Fine-Grained Soils:*

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 11—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silty feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

14.8 *Identification of Organic Fine-Grained Soils:*

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 12—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Figs. 1a and 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Figs. 1a and 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

15. Procedure for Identifying Coarse-Grained Soils (Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
    Gravel—fine, coarse
    Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

NOTE 13—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown
Geologic Interpretation—Alluvial fan

NOTE 14—Other examples of soil descriptions and identification are given in Appendixes X1 and X2.

NOTE 15—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %
Few—5 to 10 %
Little—15 to 25 %
Some—30 to 45 %
Mostly—50 to 100 %

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

18. Index Terms

18.1 Classification, soil classification, visual classification, soil description, clay, silt, sand, gravel, organic soils.

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incororated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—About 60 % gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % fines; "Poorly Graded Gravel with Sand (GP)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard, angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

ATTACHMENT B-2
WAUSAU WATER SUPPLY NPL SITE
PREDESIGN INVESTIGATION
HEALTH AND SAFETY PLAN

Prepared by:
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September 12, 1991

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WAUSAU WATER SUPPLY NPL SITE
PREDESIGN INVESTIGATION
HEALTH AND SAFETY PLAN

1. SITE CHARACTERISTICS AND HAZARDS

1.1. GENERAL PROJECT DESCRIPTION

This health and safety plan pertains to field work to be performed as part of a predesign investigation for soil vapor extraction (SVE) systems to be installed at two source areas in the Wausau Water Supply National Priorities List Site, Wausau, Wisconsin (Figure 1.1). The two source areas under investigation are known as the Wausau Chemical source area and the Marathon Electric/City Landfill source area (see Figure 1.2). Field activities performed as part of this investigation include:

* Soil gas surveys on both sites
* Installation of soil vapor extraction and monitoring wells
* Pilot soil vapor extraction tests

1.2 SITE DESCRIPTION

Both sites are located along the Wisconsin River as shown in Figures 1.2. Site specific maps are provided in Figures 1.3 and 1.4. The sites are also active industrial areas. Portions of the field investigations will be performed in paved parking locations and traffic corridors.

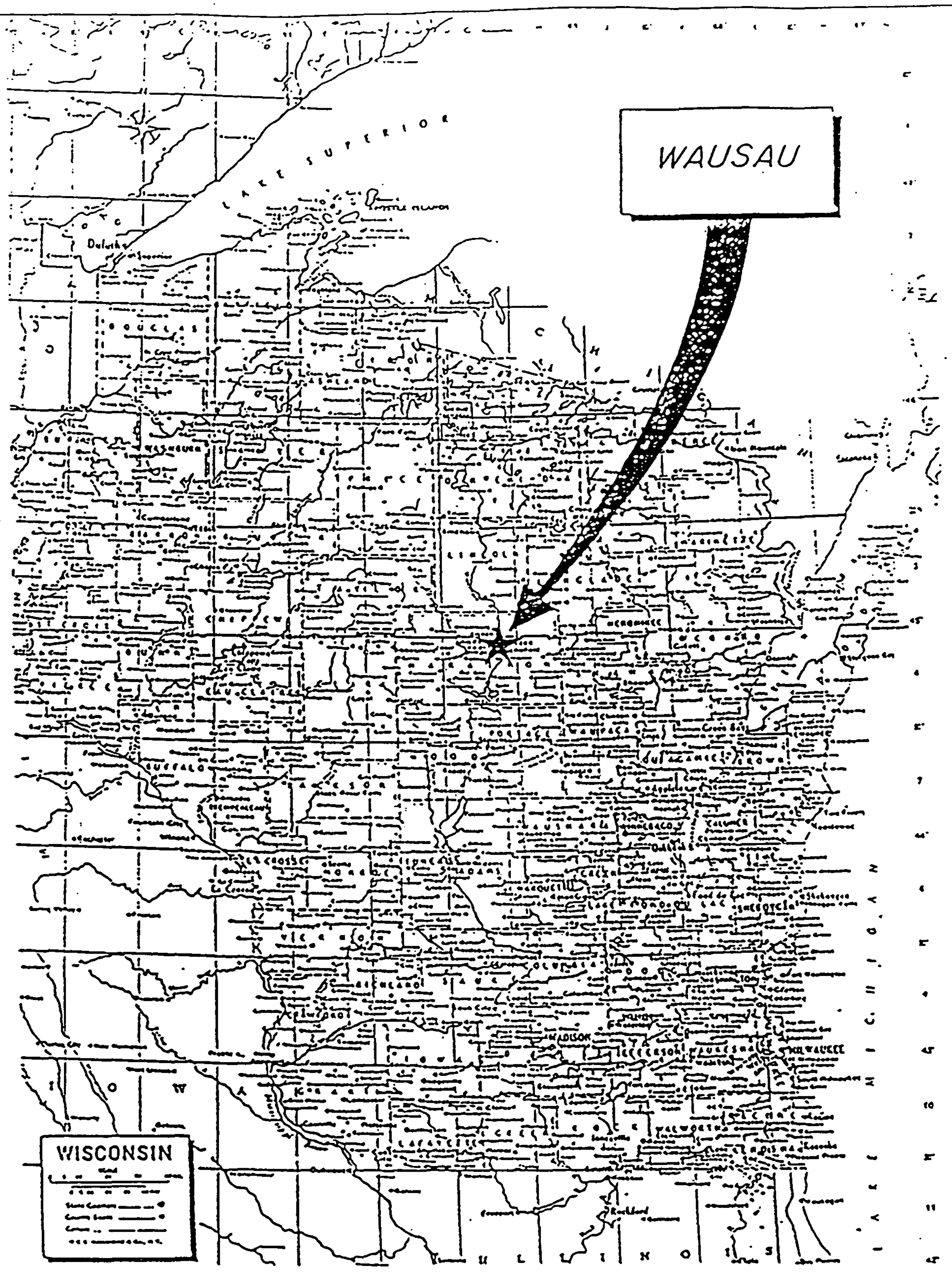

figure 1.1

REGIONAL LOCATION MAP

Marathon Electric Manufacturing Co.

CRA

Figure 1.1 Regional Location Map

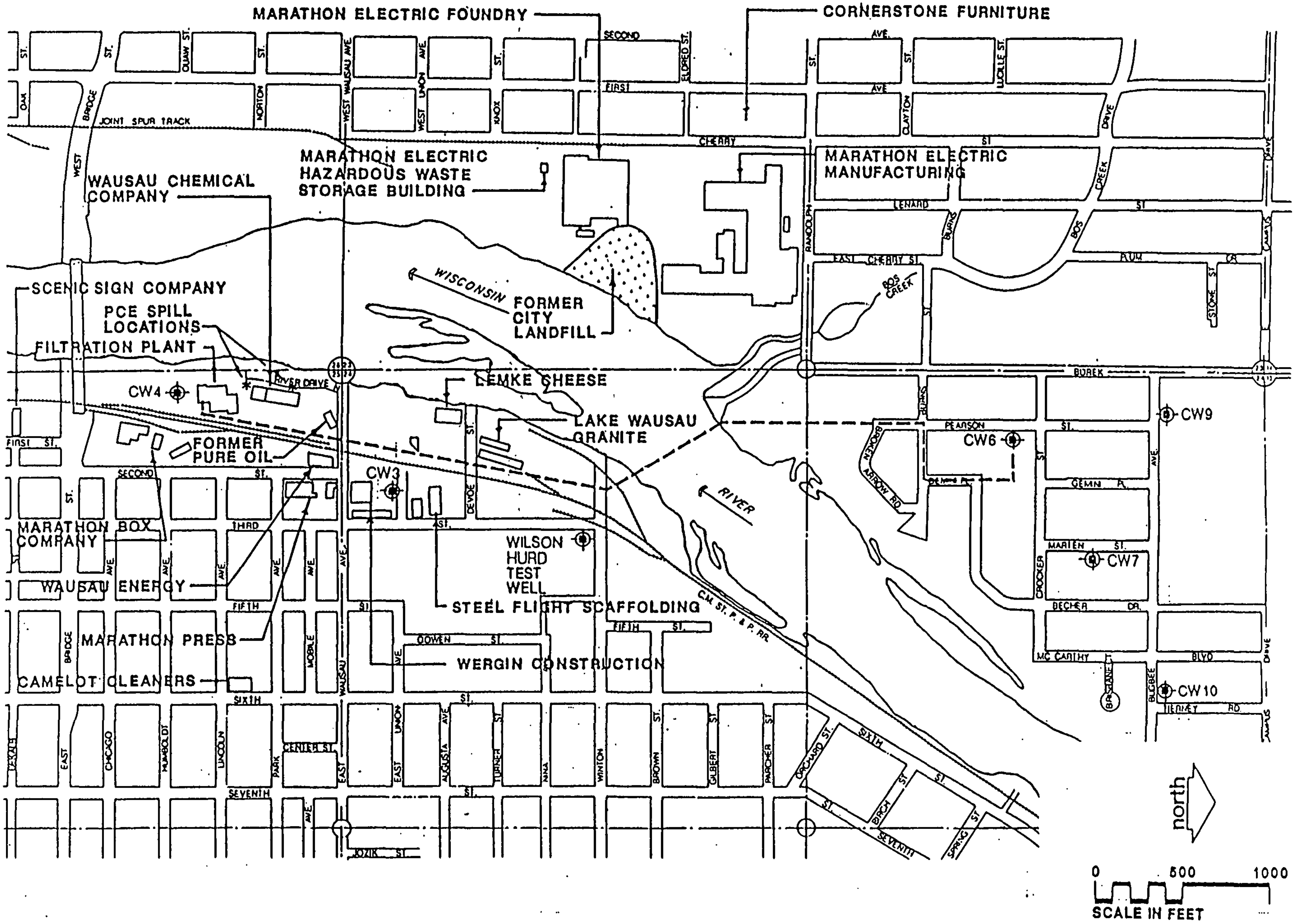

Figure 1.2 Site Location (after Warzyn, 1989a)

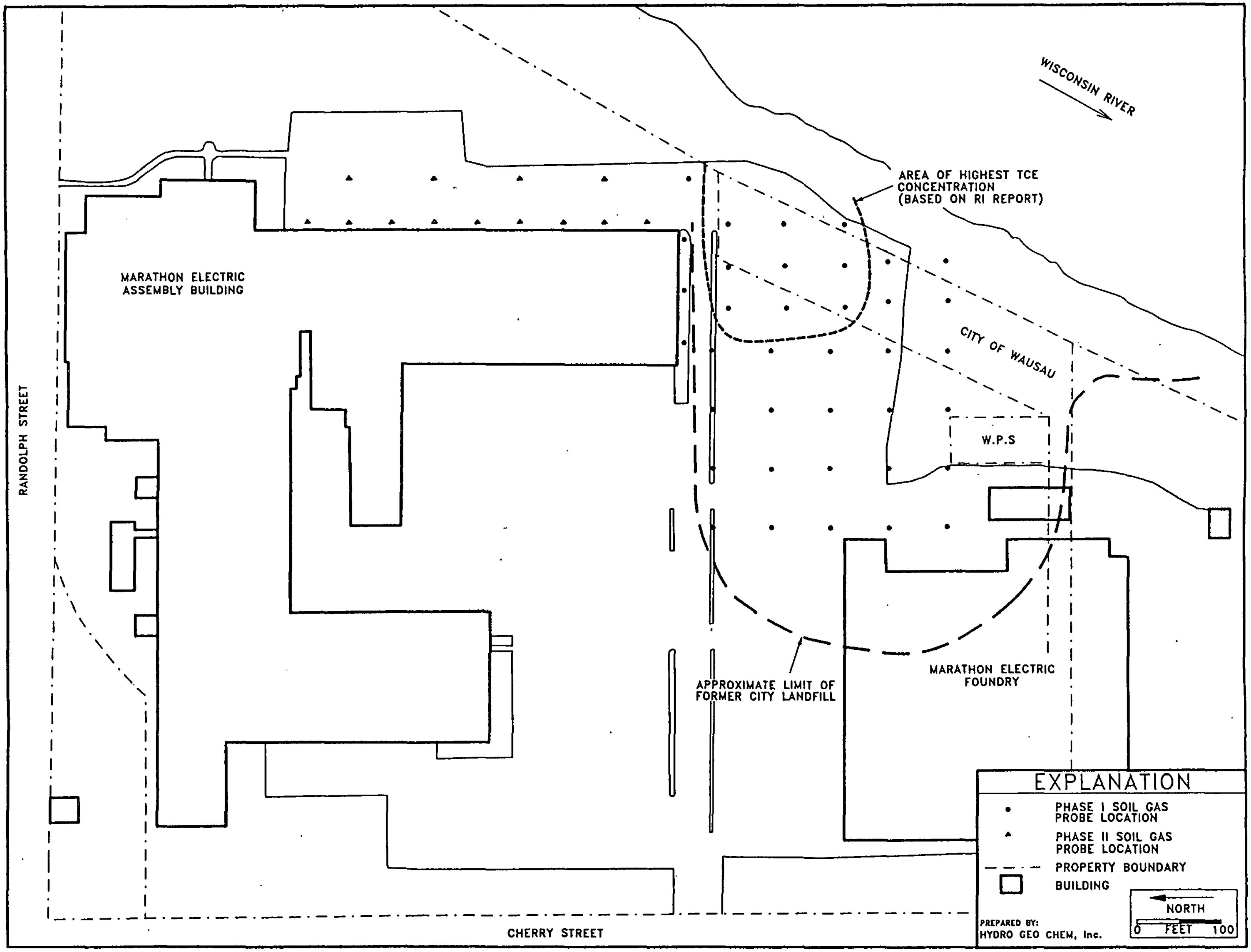

Figure 1.3 Marathon Electric Source Area

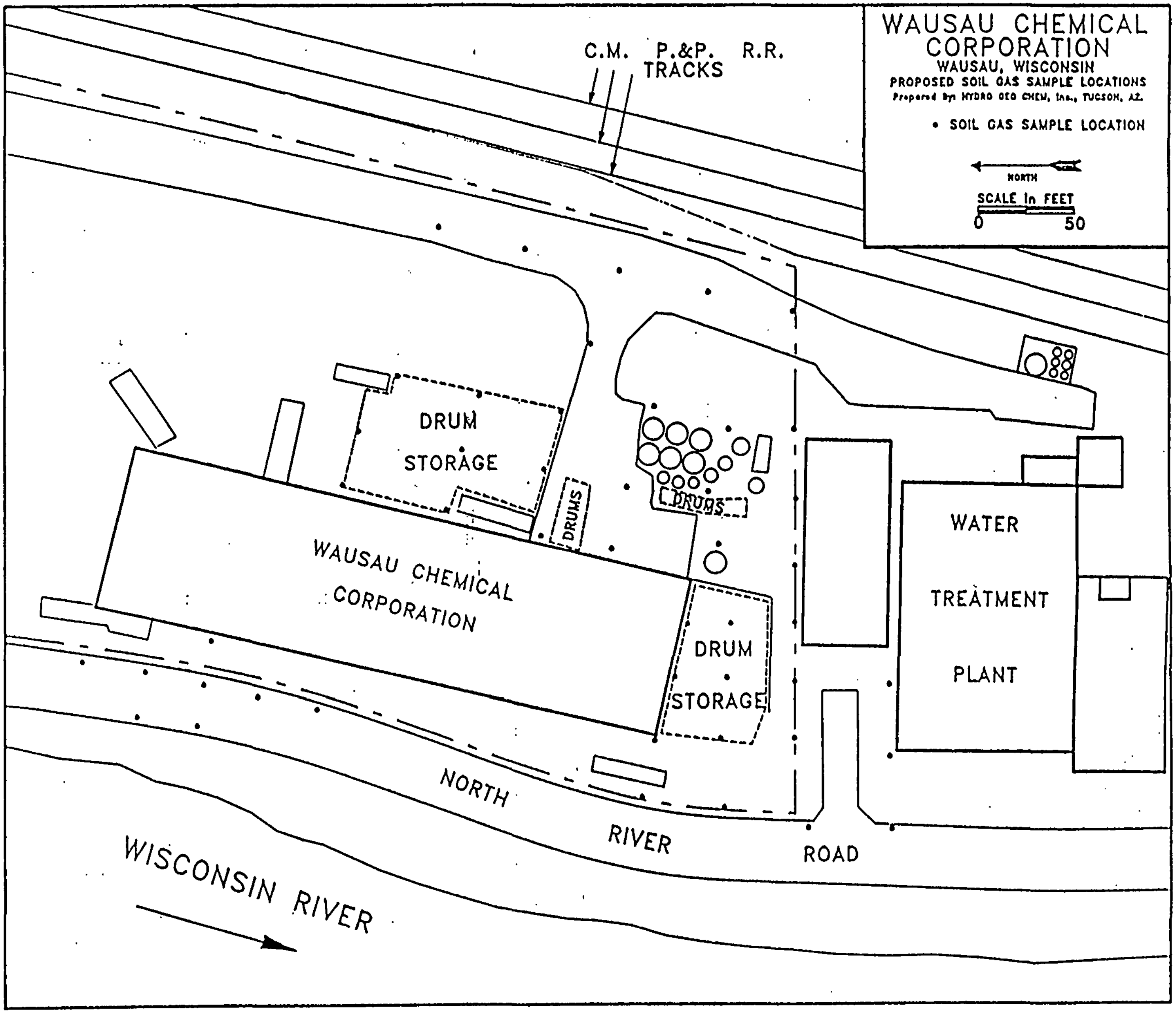

Figure 1.4 Wausau Chemical Source Area

1.3 SITE HISTORY

Descriptions of the two source areas under investigation are provided below.

1.3.1 Marathon Electric/City Landfill

The following background information on the Marathon Electric/Former Landfill site is taken from Warzyn (1989b):

> The Marathon Electric/City Landfill source area (former City Landfill) occupies a sand and gravel pit located on the west bank of the Wisconsin River. The landfill covered approximately 4.5 acres, underlying the southeastern portion of Marathon Electric property. The landfill operated from approximately 1948 to 1955 and was reportedly the only landfill operating within the City at the time. During its period of operation, almost all commercial, industrial and residential waste generated within the City was disposed at the site. Generally, the waste was burned prior to landfilling in order to reduce volume. Ash and cinders were reportedly disposed of throughout the landfill. Observations made during test pit excavations are consistent with these reports. Former landfill employees indicated that waste burning often could not keep pace with the amount of waste received in a day. In such instances, waste was generally filled directly into the western part of the former sand and gravel pit at the landfill site. Former employees also indicated

that bulk liquids contained in 55-gallon drums were frequently emptied directly into the landfill.

The majority of the landfill site is currently covered by bituminous pavement parking lot. The southern portion of the landfill area is vegetated. An electric utility substation is located over the south central portion of the landfill. Marathon Electric reportedly encountered drummed waste materials during foundation excavations beneath the east side of the plant foundry.

Soil samples were collected from test pits within the landfill and from borings within the landfill and at various locations around the Marathon Electric assembly plant. Soil gas samples were collected during a shallow (2.5 ft) soil gas survey, and while drilling Phase II borings (up to 20 ft). Soil gas volatile organic compound (VOC) data indicate VOCs are distributed in the northeastern half of the old landfill, beyond the fill to the north, and to the south and east of the Marathon Electric assembly plant (RI Report, Warzyn, 1989a). The highest soil gas concentrations were observed at and near the northeast corner of the fill area. Elevated concentrations of trichloroethene (TCE) were detected in groundwater (shallow and deep), soil and soil gas samples obtained within and beyond the limits of the fill area. TCE concentrations within the unsaturated zone fill materials in this area ranged up to 160,220 ug/kg (160 ppm).

In addition to VOCs, contaminants identified in landfill soil/waste samples included primarily polycyclic aromatic hydrocarbons (PAH) and metals. PAHs were found throughout the fill, but highest concentrations were observed near the center of the fill area. Heavy metals were distributed throughout the fill. Chromium, zinc and nickel were detected in groundwater samples from beneath the fill. These metals appear to be restricted to the immediate vicinity of the landfill.

1.3.2 Wausau Chemical

The following information is taken from Warzyn (1989b):

Solvents released from the Wausau Chemical Co. source areas are primarily responsible for the shallow groundwater contamination in the East Well Field area. Soil gas data reflecting the distribution of VOCs in unsaturated soils were collected during a shallow (2.5 ft) soil gas survey (Phase I), and while drilling Phase II borings. Shallow soil gas survey data show the highest concentrations of VOCs in unsaturated soils occurred at locations near the southern end of the site, with decreasing concentrations within an elongated contaminant zone trending toward the east-northeast (RI Report, Warzyn, 1989a). Data from soil sample analyses generally confirm this distribution, but elevated VOC concentrations were also found in unsaturated soils near the northeast loading dock and along the east side of the building. It should be noted that approximately 1000 cubic yards of soils were removed from the former bulk storage area in 1984. The highest total VOC soil concentrations detected during the RI at the Wausau Chemical facility were 3 mg/kg, for a sample collected near the water table southwest of the former bulk storage area (B24), and 5.3 mg/kg, for a shallow sample (2.5 ft) collected near the northwest loading dock area. Observations reported during the excavation of soils from the former bulk storage area suggest VOC contamination beneath the southern end of the Wausau Chemical building. VOC contamination beneath the City water treatment plant is also suspected.

1.4 SITE FEATURES

Topography: Both sites are relatively flat except immediately adjacent to the Wisconsin River where the bank has a steep slope. No work is planned on the slope.

Buildings: The locations of buildings and other significant surface structures are shown in Figures 1.3 and 1.4.

Waterways: Wisconsin River

Utilities: Both sites are expected to be crossed by underground utilities. A utility survey will be performed at all locations where subsurface work is to be performed. Overhead power lines cross the former City landfill area.

Population: 45,000

1.5 PRINCIPAL CHEMICAL EXPOSURE HAZARDS

The principal hazardous materials of concern during the predesign investigation will be volatile organic compounds (VOCs) present in the soils at the two source areas. The most abundant VOCs identified during the Remedial Investigation were tetrachloroethene (PCE), trichloroethene (TCE), and 1,2-dichloroethene (DCE). These compounds were detected in soil samples at concentrations ranging from a few μg/Kg to 100,000 μg/Kg. These compounds were also detected in soil gas samples collected at both source areas. PCE and TCE may be present as a free, liquid phase in the more contaminated portions of the site.

In addition to these compounds, vinyl chloride may be present as a result of degradation of the more highly chlorinated compounds. Methane may also be present in the landfill. Phenolic compounds including pentachlorophenol and PCBs may be present in the landfill.

1.6 SAFETY HAZARDS

Safety hazards associated with site operations include the operation of the soil gas drive-point rig, the operation of a drilling rig, and the operation of soil vapor extraction equipment. The hazards associated with specific tasks are discussed under Section 3.0: Task Evaluation.

1.7 HEAT STRESS

The possibility of heat stress will be reviewed by the Site Safety Coordinator during the daily safety briefing. Procedures for preventing, monitoring, and dealing with heat stress are contained in Appendix B-2-A.

1.8 COLD EXPOSURE

The possibility of cold exposure will be reviewed by the Site Safety Coordinator during the daily safety briefing. Procedures for preventing, monitoring, and dealing with cold exposure are contained in Appendix B-2-B.

1.9 ELECTRICAL HAZARDS

Electrical hazards may occur from overhead lines and underground utilities during drilling and soil gas sampling. Electrical hazards may also be present near the soil vapor extraction units. Work areas will be cleared of underground utilities prior to subsurface work. The drilling contractor will be responsible for avoidance of overhead lines. The boom on the soil gas rig will not be raised where it will come within 15 feet of an overhead line.

1.10 SITE CONTROL PROCEDURES

The Wausau NPL Site possesses characteristics that make conditions different from a more typical uncontrolled hazardous waste site. Both sites under investigation are active industrial areas and the contaminants are present below ground. For these reasons, the concepts of restricted access, exclusion zones, and support areas do not readily apply.

Temporary exclusion zones will be established around areas of soil gas sampling, drilling, and soil vapor extraction. An exclusion zone with a radius equal to the height of the boom will be established around the soil gas sampling rig using portable barricades. An exclusion zone with a radius equal to the height of the mast will be established around drilling rigs. An exclusion zone of 50 feet will be established around the areas of soil vapor extraction. The exclusion zones for the drilling rig and SVE unit will be marked with barricades and caution tape.

A hard hat and steel-toed safety shoes or boots will be required within the exclusion zone. Air monitoring will be performed within the exclusion zone as described in Sections 3.1 and 3.2 below. The radii of the exclusion zones may be increased on the basis of air monitoring results. The level of breathing projection required within the exclusion zone will be determined on the basis of air monitoring results. It is anticipated that Level D (no breathing protection) will be adequate during the soil gas surveys.

1.11 ORGANIZATIONAL STRUCTURES

The Hydro Geo Chem site manager will be responsible for coordination of site safety and will also act as Site Safety Coordinator. When appropriate he will designate a subordinate to perform safety monitoring of specific field activities.

1.12 MEDICAL MONITORING REQUIREMENTS

As required by 29 CFR 1910.120 [e] (OSHA) on-site personnel that have a potential for exposure to hazardous material or will be required to wear a respirator must receive a physical examination that will determine their fitness for these tasks. This determination will be made by a qualified physician and its documentation will be received before field work.

1.13 PERSONNEL TRAINING

All personnel who may potentially come into contact with hazardous materials shall have received 40 hours of off-site training pursuant to 29 CFR 1910.120 [e] (OSHA). Subcontractors and regulatory oversight organizations will be responsible for providing personnel with the proper training. Such training will not be required of personnel who come on-site to perform such work as utility surveys and electrical wiring for which no potential for exposure to hazardous materials exists other than those associated with routine facility operations.

2. CHEMICAL HAZARD EVALUATION

Vinyl chloride, 1,2 dichloroethylene, trichloroethene, tetrachloroethene, phenols, and PCBs (Arochlor 1260) have been detected at various times and locations in soil borings and may pose a threat to health and safety. Trichloroethylene, tetrachloroethene, and PCBs are potential human carcinogens. Vinyl chloride is known to be a human carcinogen. The exposure limit for vinyl chloride is defined by NIOSH as the "lowest detectable limit". Other compounds detected at the site have higher exposure limits. Comprehensive chemical data sheets for all compounds discussed above are provided at the conclusion of this document.

The primary pathways for exposure to all compounds at the site are by inhalation and skin contact. To protect personnel from possible exposure, vapor levels at the work sites will be monitored with a portable photoionization detector (PID) equipped with an 11.7 eV lamp and appropriate protective clothing will be worn at all times.

3. TASK EVALUATION

This section discusses the hazards associated with specific tasks at each source area and the levels of protection required for each task.

3.1 SOIL GAS SURVEYS

Soil gas surveys will be performed at both the Wausau Chemical and Marathon Electric/City Landfill source areas. Potential exposures associated with the soil gas survey are inhalation of gases exhausted from the soil gas sampling pump during the purge cycle and contact with contaminants adhering to the drill rod used for soil gas sampling. Soil gas personnel will stand upwind of the pump exhaust whenever feasible. Air in the breathing zone will be monitored with a portable PID equipped with an 11.7 eV lamp during the purge cycle of sample collection. If the PID results exceed 2 ppmV above background levels, the sample pump will be turned off until levels fall below 2 ppmV. The 2 ppmV action level is the lowest concentration which can reliably be detected by the PID and is below the OSHA PEL for PCE, TCE, and 1,2-DCE which are the major volatile contaminants of concern at the site. Contact with hazardous substances will be eliminated by protective clothing. Specific health and safety procedures for the soil gas survey are given below.

Level of Protection:

A___ B___ C___ D_X_

Modifications:

Hard hat, steel-toed, steel shank safety shoes or boots, latex gloves, and neoprene outer gloves will be worn in areas of suspected high contamination when handling drill rods. Leather gloves, if used, are to be left on-site nightly and disposed of after completion of work. Safety glasses and coveralls will be worn. Latex gloves will be worn during all sampling operations, and care will be taken not to expose unprotected skin to potentially contaminated soil and groundwater during sampling operations.

Safety Equipment and Materials:

First aid kit, eye wash kit, 20 lb ABC fire extinguisher.

Monitoring Equipment and Procedures:

Monitoring of the breathing zone will be performed with a portable PID. Calibration and operation procedures are described below.

Work Limitations (Time of day, etc):

- Work will be done during daylight hours only.
- No eating, drinking or smoking on-site.

Special Precautions:

Heat stress in the field is a hazard when protective clothing is worn during warm temperatures. The HSO will implement heat stress prevention techniques when temperatures are above 75°F. Prevention techniques include: a work-rest regime to limit the protective gear wearing time in between rest periods; planning of the work schedule to avoid the warmest time of the day; frequent fluid replenishment; heart rate monitoring; and provisions for shaded rest areas.

3.2 DRILLING

The SVE wells and some soil gas monitoring probes will be installed using a hollow-stem auger rig. Potential exposures associated with the drilling are inhalation of gases emitted from the borehole or cuttings, and contact with contaminants present in the cuttings or adhering to equipment. Other potential hazards are those normally associated with drilling and, in the area of the landfill, an explosive hazard could exist from methane emitted from bore holes. The health and safety procedures to be followed during drilling are described below.

Level of Protection:

A___ B___ C_X_ D___

Modifications:

Full face respirator with organic vapor and dust/mist filters will be worn. Hard hat, steel-toed, steel shank safety shoes or boots (if not neoprene) with disposable neoprene outer boots, latex gloves, neoprene outer gloves in areas of suspected contamination, otherwise 2 pair of latex for samplers and 2 pair of latex with dedicated leather gloves for drillers. Leather gloves are to be left on-site nightly and disposed of after completion of work. Tyvek coveralls will be worn. Latex and neoprene gloves will be worn during all sampling operations, and care will be taken not to expose unprotected skin to potentially contaminated soil and groundwater during sampling operations. If monitoring of the breathing zone with a PID discloses vapor levels in excess of 5 ppm, the worksite will be cleared of personnel and will not be re-occupied until vapor levels diminish and the approval of the Health & Safety Officer (HSO) is given.

Safety Equipment and Materials:

First aid kit, eye wash kit, 20 lb ABC fire extinguisher, stretcher or blanket, clean water, paper cups, wind indicator.

Monitoring Equipment and Procedures:

Carefully inspect each piece of monitoring equipment prior to work startup. Failure of any of the equipment listed below to work properly must be reported to the Project Manager immediately.

PID (Portable Photoionization Detector) with 11.7 eV lamp:

Calibrate prior to each day's activities, according to manufacturer's instructions. Record calibration in log book. Recalibrate after cleaning the lamp or when background levels drift. This instrument is sensitive to humidity and may require periodic lamp cleaning if it is humid. Monitor and record measured levels in the log books (frequency and location).

Combustible Gas Indicator

During drilling in the landfill, a combustible gas indicator (CGI) will be used to monitor the environment of the drilling rig. The CGI will operated continuously near the rear of the rig when the bore hole is open. If the alarm sounds, the rig ignition will be shut off and the area evacuated until the alarm ceases, indicating that the atmosphere has cleared. The exclusion zone may be reoccupied after the alarm ceases.

Action Levels:

If the concentration of organic vapors in the vicinity of the worksite exceeds 5 ppm (as determined with a PID), the worksite will be cleared until vapor levels diminish and the approval of the HSO is given.

Site Entry Procedures:

- Locate nearest available telephone.
- Confirm and post emergency telephone numbers and route to hospital.
- Designate at least one vehicle for emergency use.
- Determine wind direction, establish hotline and set up decontamination facilities.
- If toilet facilities are not located within a 3 minute walk from the decontamination facilities, either provide a chemical toilet and hand

washing facility or have a vehicle available (not the emergency vehicle) for transport to nearby facilities.

Work Limitations (Time of day, etc):

- Work will be done during daylight hours only.
- No eating, drinking or smoking on-site.
- Buddy system at all times in work area.

If Respirators are Required:

- No contact lenses on-site.
- No facial hair that would interfere with respirator fit.

Special Precautions:

Personnel must be observant of not only one's own immediate surroundings, but also those of others. Everyone will be working under constraints; therefore, a team effort is needed to realize and warn of impending dangerous situations. Extra cautions are necessary when working near heavy equipment and while utilizing personal protective gear because vision, hearing, and communication can be restricted.

Heat stress in the field is a hazard when protective clothing is worn during warm temperatures. The HSO will implement heat stress prevention techniques when temperatures are above 75°F. Prevention techniques include: a work-rest regime to limit the protective gear wearing time in between rest periods; planning of the work schedule to avoid the warmest time of the day;

frequent fluid replenishment; heart rate monitoring; and provisions for shaded rest areas.

3.3 DECONTAMINATION PROCEDURES:

Personnel:

Personnel decontamination procedures will be performed at each location prior to leaving the study area. Any subcontractors will provide the protective clothing and equipment necessary for its own personnel to comply with the decontamination procedures as specified in Hydro Geo Chem's Health and Safety Plan.

The following personnel decontamination procedures will be followed:

a) Remove disposable booties (if used) and place in plastic bag for disposal.

b) Wash neoprene boots (if used) with detergent solution and rinse with clean water. Remove boots and retain for subsequent reuse.

c) Wash outer gloves in detergent solution and rinse in clean water. Remove outer gloves and place into plastic bag for disposal or retain for subsequent reuse.

d) Remove tyvek coveralls. Take care to prevent the release and dispersion of dirts which may have accumulated on the coveralls during on-site operations and place overalls into a disposable plastic bag.

e) Remove the respirator (if used) and place spent filters into the plastic bag destined for disposal. Place the respirator onto a reusable table or into a separate plastic bag for later cleaning and disinfection. The respirator must be disinfected nightly using MSA disinfectant.

f) Remove surgeon's gloves.

g) Thoroughly wash hands and face.

h) Place all independent disposable bags that were not on-site into one larger bag. If high concentrations are indicated, disposable items that were on-site will be placed in a container with other solid wastes for eventual disposal.

Level of Protection:

A___ B___ C___ D_X_

Modifications:

Hard hat, steel-toed, steel-shank safety shoes or boots, latex or neoprene gloves, tyvek coveralls, and safety glasses will be worn by personnel performing decontamination procedures. Care will be taken not to expose unprotected skin to rinse water or to cuttings removed from equipment during decontamination.

Decontamination rinsate will be containerized for later disposal in the City sanitary sewer system. A decontamination area will be established at each source area. No equipment which has potentially been contaminated by use in a particular source area will be transported out of that source area without first being decontaminated.

Equipment Decontamination:

All equipment which was on-site or came in contact with potentially contaminated soils will be cleaned prior to and after each use on the project.

Decontamination will consist of combinations of hot water cleaning and/or detergent (trisodium phosphate) wash, water rinse, and distilled water rinse.

Small Equipment Decontamination:

Small equipment will be protected from contamination as much as possible by draping, masking, or otherwise covering the instruments with plastic (to the extent feasible) without hindering operation of the unit. For example, the PID meter can be placed in a clear plastic bag to allow reading the scale and operating the knobs. The PID sensor can be partially wrapped, keeping the sensor tip and discharge port clear.

The contaminated equipment will be taken from the drop area and the protective coverings removed and disposed of in appropriate containers. Any dirt or obvious contamination will be brushed or wiped with a disposable paper wipe. The units can then be taken inside in a clean plastic tub, wiped off with damp disposable wipes, and dried. The units will be checked, standardized, and recharged as necessary for the next day's operation, and then prepared with new protective coverings.

Sampling Equipment:

All tools used for sampling and packaging will be decontaminated prior to the collection of each sample. Probes, adaptors, tubing, etc., are to be delivered to the site in a clean condition. Sampling equipment will be cleaned before reuse or at the end of each day. If high concentrations are indicated on the

PID at the sampling location, decontamination will be conducted at the sample location. Equipment will be decontaminated after use in the following manner.

a) Scrape and remove all earthen materials from the equipment.

b) Hose down equipment with a high-pressure, hot-water washer.

c) Steam-clean bailers and allow to dry before each reuse.

d) Collect rinsate and scrapings and place in containers. Decontamination rinsate will be disposed of in the sanitary sewer. Solid wastes will be stored for disposal at the conclusion of the investigation in accordance with State and Federal regulations.

e) Store containers with those containing any other investigation derived materials. Storage area will be provided by the client.

<u>Samples:</u>

If materials accumulate on sample containers collected for shipment, sample containers will be wiped clean.

<u>Heavy Equipment:</u>

If materials accumulate on vehicles, the vehicles will be cleaned on-site.

Please Note: It is the responsibility of the HSO to make sure that all pieces of equipment coming off-site are properly decontaminated according to the procedures outlined above. Documentation of decontamination must be made in the field log notebook that will then become part of the permanent project file. A suitable tag is to be placed on each piece of decontaminated Hydro

Geo Chem equipment (or group of equipment, such as a bag of hand tools) stating the date of decontamination and initialed by the HSO.

Disposal of Materials Generated On-Site:

Cuttings generated during drilling will be placed in DOT approved metal drums. The drums will be labeled to indicate the boring location and depth interval. Investigative wastes will be disposed of at the conclusion of the investigation in accordance with applicable State and Federal regulations.

Documentation:

The Site Safety Coordinator will document in the field log notebook:

- PID readings (including location and time).
- Level of protection worn by workers.
- Health and Safety equipment calibrations made.
- Weather and site conditions such as estimated temperature, wind direction, precipitation, dust.
- Decontamination of equipment.
- Disposal method of contaminated items.
- Unusual events or conditions.
- Accidents, injuries, or exposures.

3.4 SVE PILOT TESTING

The SVE pilot tests will involve extracting contaminated gases from the soils and exhausting these gases through two vapor phase activated carbon units connected in series. The purpose of the activated carbon is to remove volatile organic compounds from the air stream before it enters the atmosphere. If vinyl chloride is present in the soil, it may pass through the carbon without significant reduction in concentration. The presence of vinyl chloride will be known as a result of soil gas sampling prior to installation of the SVE system and appropriate methods for mitigating the vinyl chloride emissions will be taken. Inhalation exposures will only occur during the SVE pilot tests if leaks occur in the exhaust portion of the air treatment system or if VOCs break through the carbon. Air monitoring with the PID and on-site analysis of gas samples at various locations in the carbon treatment system will reveal such emissions, in which case the system will be shut-down until the emissions are eliminated. For these reasons, respiratory protection will not be required during operation of the SVE system.

If methane is detected in explosive concentrations in the landfill area as a result of soil gas sampling and analysis, the pilot SVE system will be operated in such a manner as to prevent explosive concentrations from occurring in the system or system exhaust.

The health and safety procedures to be followed during SVE pilot testing are described below.

Level of Protection:

A___ B___ C___ D_X_

Modifications:

Hard hat and steel-toed, steel shank safety shoes or boots will be worn. Leather gloves are to be left on-site nightly and disposed of after completion of work. Safety glasses will be worn. Latex gloves will be worn during all sampling operations.

Safety Equipment and Materials:

First aid kit, eye wash kit, 20 lb ABC fire extinguisher.

Monitoring Equipment and Procedures:

PID, CGI. Procedures for both of these instruments are described above.

Work Limitations (Time of day, etc):

* No eating, drinking or smoking on site.

Special Precautions:

Portions of the SVE system may become hot and care will be taken to avoid burns. Leather gloves will be warn to protect hands.

4. SITE EMERGENCY CONTINGENCY PLAN

4.1 CHEMICAL EXPOSURE SYMPTOMS

The symptoms for exposure to specific chemicals at the site are provided in the chemical hazard sheets at the end of the Health and Safety Plan. The greatest risk of exposure is to the vapor of chlorinated hydrocarbons. The vapors of these compounds are irritating to the eyes, nose, and throat. If inhaled in high concentrations, they can cause difficult breathing, nausea, or dizziness.

4.2 FIRST AID TREATMENT

For vapor exposure, remove victim to fresh air. If breathing has stopped, begin artificial respiration.

For other exposures, see chemical data sheets in Appendix B-2-C.

4.3 EMERGENCY RESPONSE

If an injury occurs, take the following steps:

- Prevent further injury and notify HSO.
- Initiate first aid and get medical attention for the injured person immediately.
- Depending upon the type and severity of the injury, call the medical consultant and/or occupational physician.
- Notify the Project Manager.
- Notify the injured person's personnel office. Notification MUST be made within 24 hours of the injury.
- Prepare an incident report. The HSO is responsible for ensuring its preparation and submittal to the Project Manager and Hydro Geo Chem corporate personnel office within 48 yours.
- The HSO will assume charge during a medical emergency.

Under no circumstances will injured persons transport themselves to a medical facility for emergency treatment.

When an injury occurs in a potentially contaminated location, provisions for decontamination of the victim will be made. However, life-threatening injuries may preclude normal decontamination procedures. In such cases, arrangements will be made with the medical facility and transporter to provide for the situation.

Site Evacuation:

When conditions warrant moving away from the work site, the crew will relocate upwind a distance of at least 100 feet as indicated by site monitoring instruments. Should the conditions prompting withdrawal from the work site persist, the Health and Safety Officer will be notified of the site conditions. Because the sites are active industrial facilities which handle toxic compounds, the potential exists for evacuation due to an emergency at the plant. If evacuation from the manufacturing facility is required, the crew will relocate under the direction of appropriate local personnel.

4.4 EMERGENCY RESOURCES

Ambulance: 845-1111

Hospital: Wausau Hospital Center 847-2121
333 Pine Ridge Blvd.

Poison Control Center: Green Bay 414-433-8100

Police/Sheriff: 842-2055

Fire: 845-1111

Gas: Wisconsin Fuel and Light 845-2141

Electric: Wisconsin Public Service 845-7261

Water and Sewer: 843-1430 or 843-1077

4.5 HOSPITAL ROUTE

The following are directions to the Wausau Hospital Center from each of the source areas where work will be performed.

From Marathon Electric:

From main parking lot, turn right (north) onto Cherry. Go 0.15 miles north to Randolph Street, turn left. Go 0.2 miles west on Randolph to Third Avenue, turn left. Go 0.75 miles south on Third Avenue to Bridge Street, turn right. Go 0.9 miles west on bridge, to Westwood Drive. Turn left on Westwood Drive, following blue "hospital" signs. Go 0.15 miles south on Westwood to Pine Ridge Boulevard, turn right. Go 0.4 miles on Pine Ridge Boulevard to Wausau Hospital Center. Follow signs to emergency entrance.

From Wausau Chemical:

Go north on either North River Drive or Filtration Road to Wausau Avenue, turn right. Go 1 block east on Wausau Avenue, turn right on Second Street. Go 0.2 miles south on Second Street to Bridge Street, turn right. Go 1.4 miles west on Bridge Street to Westwood Drive, turn left at "hospital" sign. Go 0.15 miles south on Westwood to Pine Ridge Boulevard, turn right. Go 0.4 miles on Pine Ridge Boulevard to Wausau Hospital Center. Follow signs to emergency entrance.

A map showing the locations of Marathon Electric, Wausau Chemical and the Wausau Hospital Center is shown on Figure 4.1.

5. APPROVALS

This health and safety plan has been written for the use of Hydro Geo Chem, its employees, and subcontractors. HGC claims no responsibility for its use by others. The plan is written for the specific site conditions, purposes, dates, and personnel specified and must be amended if these conditions change.

PLAN PREPARED BY: ________________ DATE: 10/4/91

APPROVED BY: ________________ DATE: 10/4/91

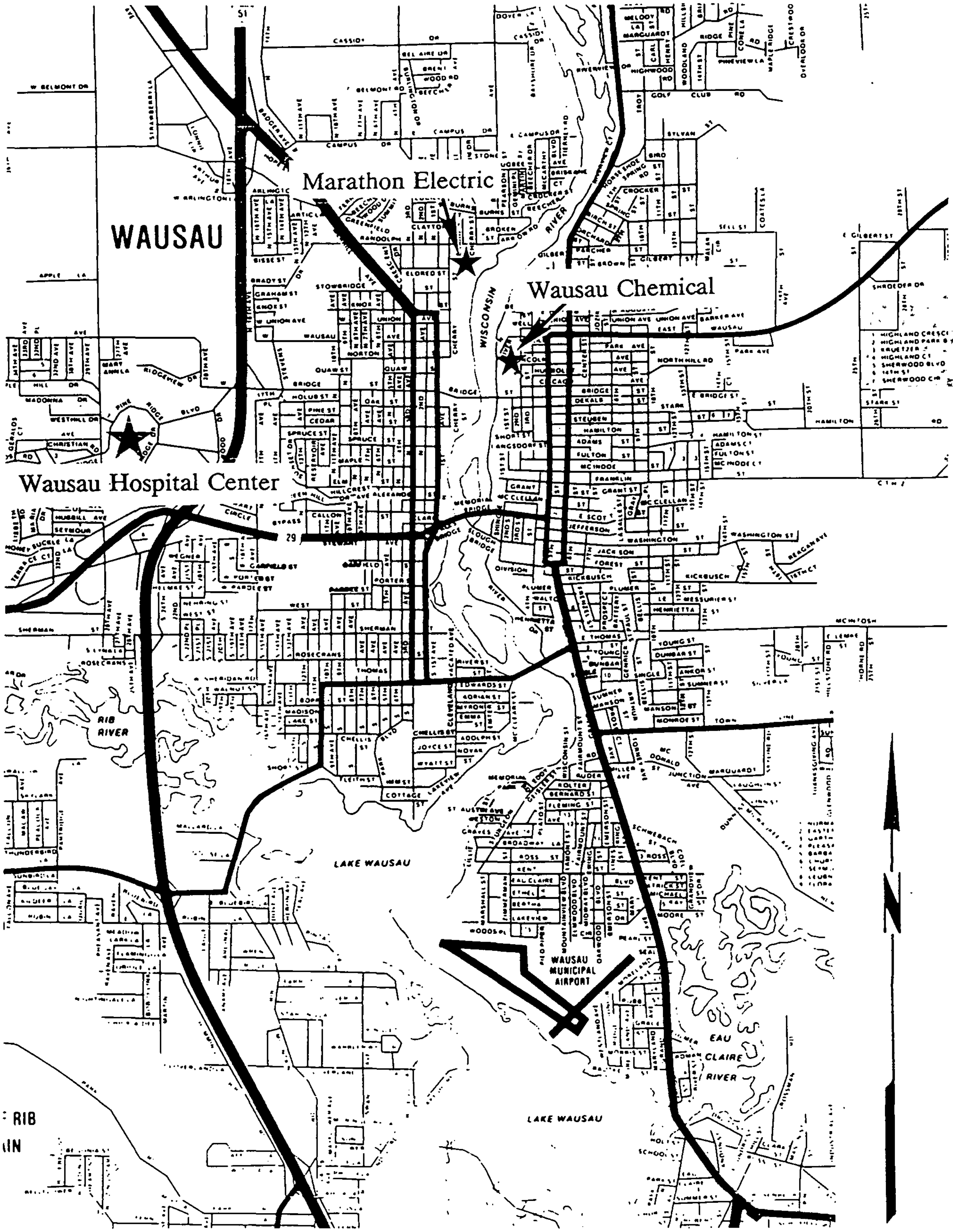

Figure 4.1 Wausau area map

6. ACKNOWLEDGEMENTS

By my signature below, I acknowledge that I have read and understand the provisions of the Health and Safety Plan for the Wausau Water Supply NPL Site SVE Predesign Investigation. I agree to follow the procedures contained therein.

________________________________ DATE: ____________
(signature)

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7. REFERENCES

Warzyn Engineering, Inc., 1989a. Remedial Investigation Wausau Water Supply NPL Site a.k.a. Wausau Groundwater Contamination NPL Site, Wausau, Wisconsin. Prepared for U.S. Environmental Protection Agency, Region V, Chicago, Illinois.

Warzyn Engineering, Inc., 1989b. Draft Feasibility Study. Wausau Water Supply NPL Site a.k.a. Wausau Groundwater Contamination NPL Site, Wausau, Wisconsin. Prepared for U.S. Environmental Protection Agency, Region V, Chicago, Illinois.

Warzyn Engineering, Inc., 1988. Phase I Remedial Investigation, Wausau Water Supply NPL Site, Wausau, Wisconsin. Prepared for U.S. Environmental Protection Agency, Region V, Chicago, Illinois.

RECORD OF HAZARDOUS WASTE FIELD ACTIVITY

SITE NAME: Health and Safety Officer
PROJECT NUMBER:
RECORD OF ACTIVITIES (DATES):

Employee Name	Total Days On-site	Days at site in or days as HSO Level B	Level C	Level D	Activities Performed On-site
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					

Signature of HSO:________________________

APPENDIX B-2-A: HEAT STRESS

STANDARD OPERATING PROCEDURES FOR EMERGENCIES DUE TO HEAT AND HEAT STRESS MONITORING

Field operations during the summer months can create a variety of hazards to the employee. Heat cramps, heat exhaustion, and heat stroke can be experienced and, if not remedied, can threaten life or health. Therefore, it is important that all employees be able to recognize symptoms of these conditions and be capable of arresting the problem as quickly as possible.

THE EFFECTS OF HEAT

As the result of normal oxidation processes within the body, a predictable amount of heat is generated. If the heat is liberated as it is formed, there is no change in body temperature. If the heat is liberated more rapidly, the body cools to a point at which the production of heat is accelerated and the excess is available to bring the body temperature back to normal.

Interference with the elimination of heat leads to its accumulation and thus to the elevation of body temperature. As a result, the person is said to have a fever. When such a condition exists, it produces a vicious cycle in which certain body processes speed up and generate additional heat. Then the body must eliminate not only the normal but also the additional quantities of heat.

Heat produced within the body is brought to the surface largely by the bloodstream and escapes to the cooler surroundings by conduction and radiation. If air movement or a breeze strikes the body, additional heat is lost by convection. However, when the temperature of the surrounding air becomes equal to or rises above that of the body, all of the heat must be lost by vaporization of the moisture or sweat from the skin surface. As the air becomes more humid (contains more moisture), vaporization from the skin slows down. Thus, on a day when the temperature is 95 to 100°F, with high humidity and little or no breeze, conditions are ideal for the retention of heat within the body. It is on such a day or, more commonly, a succession of such days (a heat wave) that medical emergencies due to heat are likely to occur. Such emergencies are classified in three categories: heat cramps, heat exhaustion, and heat stroke.

HEAT CRAMPS

Heat cramps usually affect people who work in hot environments and perspire a great deal. Loss of salt from the body causes very painful cramps of the leg and abdominal muscles. Heat cramps also may result from drinking iced water or other drinks either too quickly or in too large a quantity.

Heat Cramp Symptoms. The symptoms of heat cramp are:

- Muscle cramps in legs and abdomen,
- Pain accompanying the cramps,
- Faintness, and
- Profuse perspiration.

Heat Cramp Emergency Care. Remove the patient to a cool place. Give him sips of liquids such as "Gatorade" or its equivalent. Apply manual pressure to the cramped muscle. Remove the patient to a hospital if there is any indication of a more serious problem.

HEAT EXHAUSTION

Heat exhaustion occurs in individuals working in hot environments, and may be associated with heat cramps. Heat exhaustion is caused by the pooling of blood in the vessels of the skin. The heat is transported from the interior of the body to the surface by the blood. The blood vessels in the skin become dilated and a large amount of blood is pooled in the skin. This condition, plus the blood pooled in the lower extremities when an individual is in an upright position, may lead to an inadequate return of blood to the heart and eventually to physical collapse.

Heat Exhaustion Symptoms. The symptoms of heat exhaustion are:

- Weak pulse;
- Rapid and usually shallow breathing;
- Generalized weakness;
- Pale, clammy skin;
- Profuse perspiration;
- Dizziness;
- Unconsciousness; and
- Appearance of having fainted (the patient responds to the same treatment administered in cases of fainting).

Heat Exhaustion Emergency Care. Remove the patient to a cool place and remove as much clothing as possible. Administer cool water, "Gatorade," or its equivalent. If possible, fan the patient continually to remove heat by convection, but do not allow chilling or overcooling. Treat the patient for shock, and remove him to a medical facility if there is any indication of a more serious problem.

HEAT STROKE

Heat stroke is a profound disturbance of the heat-regulating mechanism, associated with high fever and collapse. Sometimes this condition results in convulsions, unconsciousness, and even death. Direct exposure to sun, poor air circulation, poor physical condition, and advanced age (over 40) bear directly on the tendency to heat stroke. It is a serious threat to life and carries a 20% mortality rate. Alcoholics are extremely susceptible.

Heat Stroke Symptoms. The symptoms of heat stroke are:

- Sudden onset;
- Dry, hot, and flushed skin;
- Dilated pupils;
- Early loss of consciousness;
- Full and fast pulse;
- Breathing deep at first, later shallow and even almost absent;
- Muscle twitching, growing into convulsions; and
- Body temperature reaching 105 to 106°F or higher.

Heat Stroke Emergency Care. Remember that this is a true emergency. Transportation to a medical facility should not be delayed. Remove the patient to a cool environment if possible, and remove as much clothing as possible. Assure an open airway. Reduce body temperature promptly—preferably by wrapping in a wet sheet or else by dousing the body with water. If cold packs are available, place them under the arms, around the neck, at the ankles, or at any place where blood vessels that lie close to the skin can be cooled. Protect the patient from injury during convulsions, especially from tongue biting.

AVOIDANCE OF HEAT-RELATED EMERGENCIES

Please note that, in the case of heat cramps or heat exhaustion, "Gatorade" or its equivalent is suggested as part of the treatment regime. The reason for this type of liquid refreshment is that such beverages will return much-needed electrolytes to the system. Without these electrolytes, body systems cannot function properly, thereby increasing the represented health hazard. Therefore, when personnel are working in situations where the ambient temperatures and humidity are high—and especially in situations where protection Levels A, B, and C are required—the site safety officer must:

- Assure that all employees drink plenty of fluids ("Gatorade" or its equivalent);
- Assure that frequent breaks are scheduled so overheating does not occur; and
- Revise work schedules, when necessary, to take advantage of the cooler parts of the day (i.e., 5:00 a.m. to 1:00 p.m., and 6:00 p.m. to nightfall).

If protective clothing must be worn, especially Levels A and B, the suggested guidelines for ambient temperature and maximum wearing time per excursion are:

Ambient Temperature (°F)	Maximum Wearing Time per Excursion (Minutes)
Above 90	15
85 to 90	30
80 to 85	60
70 to 80	90
60 to 70	120
50 to 60	180

One method of measuring the effectiveness of employees' rest-recovery regime is by monitoring the heart rate. The "Brouha guideline" is one such method:

- During a three-minute period, count the pulse rate for the last 30 seconds of the first minute, the last 30 seconds of the second minute, and the last 30 seconds of the third minute.
- Double the count.

If the recovery pulse rate during the last 30 seconds of the first minute is at 110 beats/minute or less and the deceleration between the first, second, and third minutes is at least 10 beats/minute, the work-recovery regime is acceptable. If the employee's rate is above that specified, a longer rest period is required, accompanied by an increased intake of fluids.

APPENDIX B-2-B: COLD EXPOSURE

ST AID FOR H[illegible]THERMIA VICTIMS

correct treatment of hypothermia victims may e a condition known as "after-drop." This is d by improper rewarming, allowing cold, ant blood from the extremities to return to ore of the body. This may cause the core erature to drop below the level which will in life.

) Move the victim to shelter and warmth. *Do not allow victim to walk.*

) Remove all wet clothing, but handle the victim gently.

Apply heat to the victim's *trunk* by using a warm bath, shower, hot water bottles or *heated* blankets. Do not wrap a hypothermic in a blanket *without* an auxiliary source of heat unless it is to protect him against further heat loss before treatment. An effective field treatment is for one or more of the rescuers to remove their own clothing, using their bodies to warm the victim's naked body. If the victim appears dead, heart massage and mouth-to-mouth resuscitation should be administered.

In cases of mild hypothermia, shelter and dry clothing may be all that is needed. If the victim is conscious and can swallow without difficulty, he may be given a hot sugary drink. Care must be taken to ensure that the victim does not take the liquid into the lungs. Do *not* give the victim alcohol.

ER put an unconscious victim in a bathtub.

hypothermia victims should be seen by a or.

Some of the information i[illegible] brochure has been taken from "Man in Cold W[illegible]" with permission of Dr. Martin Collis, University of Victoria, British Columbia, Canada; and from the U.S. Coast Guard publication, "Hypothermia and Cold Water Survival."

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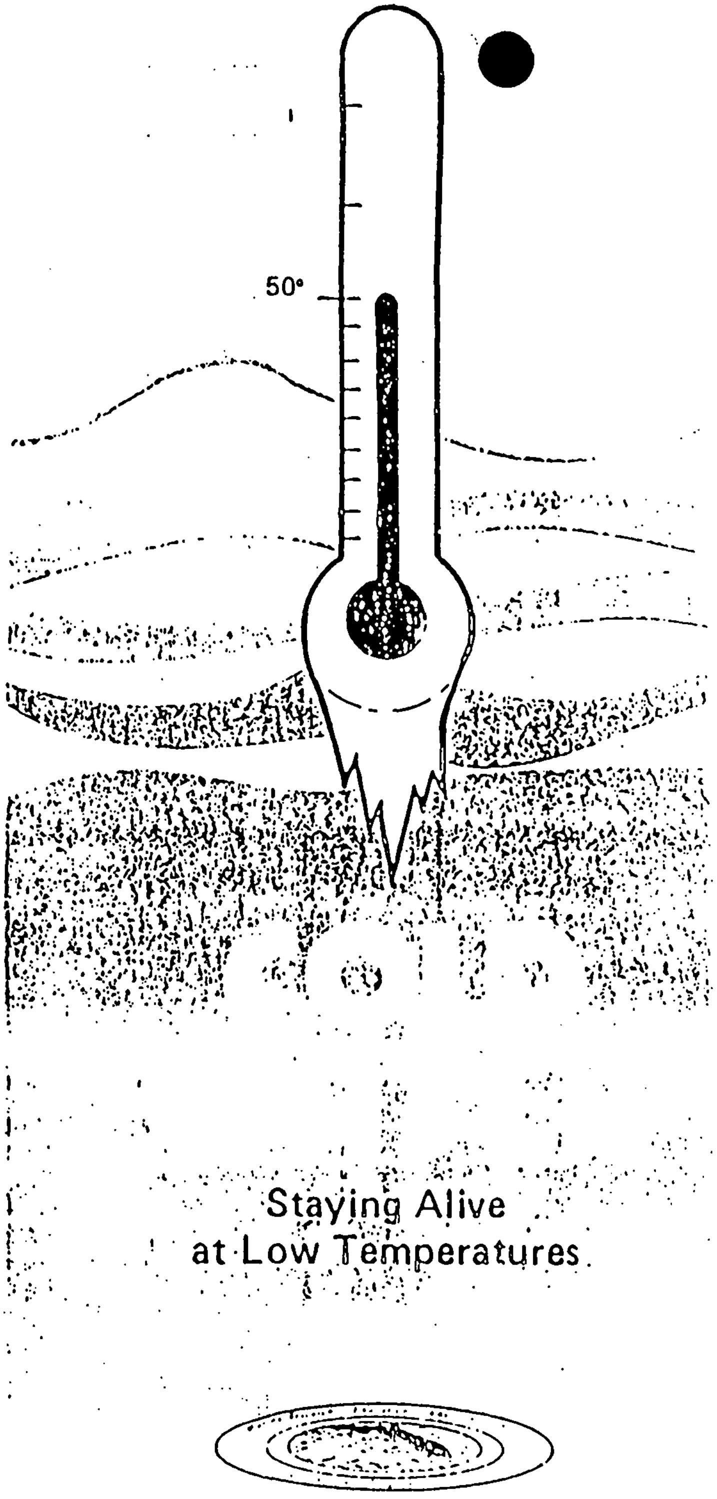
MAPB-5



Staying Alive at Low Temperatures

INTRODUCTION

ven in the Sunshine State, cold water can be a ace.

ll boaters and others in danger of accidental iersion in cold water should be aware of the ors that determine body cooling rate and itual death from hypothermia as well as sur- i techniques.

he following information focuses on the major blems of cold water immersion and provides mmendations for survival.

OTHERMIA · Lowered Deep Body Temperature

cold water, the skin and nearby tissues me cooled very rapidly, but it takes 10-15 ites before the temperature of the heart and begin to cool. Intensive shivering occurs in an npt to counteract large heat loss.

D WATER SHOCK

nmersion in cold water causes immediate r changes in body functions, occasionally lting in heart attacks or ruptured blood vessels. ever, this is unlikely to occur in someone with althy heart and circulatory system. Also, cold r shock causes immediate hyperventilation rbreathing) which could lead to uncontrolled lation of water and drowning.

N ACCIDENT HAPPENS

emember that water conducts heat many times r than air. Most boats will float even when ized or swamped. Therefore, get in or on the to get as far out of the water as possible. ring a personal flotation device (PFD) is a t. It will keep you afloat even if you are un- cious.

IVIVAL FACTORS

emperature of the water is not the only factor e considered in cold water survival. Activity in water, body size and fat have an effect. Small, people cool faster than large, fat people. dren cool faster than adults. The following table vs predicted survival times for the "average" on in 50°F water.

SITUATION	Predicted Survival Time (Hours)
NO FLOTATION	
Drownproofing	1.5
Treading Water	2.0
WITH FLOTATION	
Swimming	2.0
Holding-still	2.7
H.E.L.P.	4.0
Huddle	4.0

Treading water and drownproofing are anti-drowning techniques used when the person is without a PFD. Treading water is the continuous movement of arms and legs in certain patterns which keeps the head out of the water. Body cooling rate is 34% faster when treading water than while holding still in a life jacket.

Drownproofing, which involves restful floating with lungs full of air and raising the head out of the water every 10-15 seconds to breathe causes a person to cool 82% faster than while holding still in a life jacket. This is mostly due to putting the head, a high heat loss area, into the water along with the rest of the body. Drownproofing appears to be the *fastest way to die* from hypothermia.

Swimming is not recommended unless the individual is absolutely certain of reaching safety. Some good swimmers have been able to swim 8/10 of a mile in 50°F water before being overcome by hypothermia. Others have not been able to swim 100 yards.

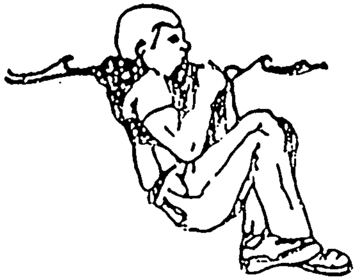
Although the body produces almost three times as much heat when swimming slowly and steadily in cold water compared to holding-still, this extra heat (and more) is lost to the cold water due to more blood circulation to the arms, legs and skin. The average person swimming in a life jacket cools 35% faster than when holding still.

CRITICAL BODY HEAT LOSS AREAS

In addition to the head (which is normally out of the water) certain other body regions have high rates of heat loss while a person is holding-still in cold water. The sides of the chest, where there is little muscle or fat, is a major route for heat loss from the warm chest cavity. Also, the groin region loses much heat due to large blood and lymph vessels near the surface. The following survival techniques focus on these areas.

TECHNIQUES THAT INCREASE SURVIVAL TIME APPROXIMATELY 50%

H.E.L.P. (Heat Escape Lessening Posture) · Hold the inner side of the arms tight against the side of the chest over the warm chest cavity and raise the thighs to close off the groin region · similar to the fetal position.



HUDDLE · If there are several people in the water, form a huddle so that the sides of the chests of different persons are held close together.

APPENDIX B-2-C: CHEMICAL HAZARD DATA SHEETS

CHEMICAL DATA SHEET

CHEMICAL NAME: trichloroethene

CHEMICAL FORMULA: $ClCH=CCl_2$

SYNONYMS: Ethylene trichloride
trichloroethylene

EXPOSURE LIMITS:

IDLH LEVEL: Ca 1000 ppm

OSHA: 50 ppm
NIOSH: Ca 25 ppm

PHYSICAL DESCRIPTION: Colorless liquid with a chloroform-like color

INCOMPATIBILITIES: Strong oxidizers and caustics

CHEMICAL AND PHYSICAL PROPERTIES

Ionization potential, eV: 9.45
Boiling point at 1 atm, F: 189°
Vapor pressure at 68°F, mmHg: 58
Solubility in water at 68°F, % by weight: <0.1%
Upper explosive limit in air, % by volume: 10.5%
Lower explosive limit in air, % by volume: 8%

Flash point, °F: 90°
Molecular weight: 131
Melting point, °F: -99°

ROUTE OF EXPOSURE: Inhalation, skin contact, ingestion

SYMPTOMS: CNS depression, skin irritation, drowsiness, unconsciousness, liver and kidney damage

FIRST AID:

Eye: irrigate immediately. Skin: Soap and flush with water immediately.

Breathe: Artificial respiration. Swallow: Get immediate medical attention.

PERSONAL PROTECTION AND SANITATION

Wear appropriate equipment to prevent: repeated or prolonged skin contact
Wear eye protection to prevent: reasonable probability of eye contact
Employees should wash: immediately upon becoming wet
Work clothing should be changed daily: NA
Remove clothing: immediately upon becoming wet

CHEMICAL DATA SHEET

CHEMICAL NAME: tetrachloroethene CHEMICAL FORMULA: $Cl_2C=CCl_2$

SYNONYMS: perchloroethylene
perc

EXPOSURE LIMITS: IDLH LEVEL: Ca 500 ppm

OSHA: 25 ppm
NIOSH: Ca

PHYSICAL DESCRIPTION: Colorless liquid with a chloroform-like color

INCOMPATIBILITIES: Strong oxidizers and caustics

CHEMICAL AND PHYSICAL PROPERTIES

Ionization potential, eV: 9.32
Boiling point at 1 atm, F: 250°
Vapor pressure at 68°F, mmHg: 14
Solubility in water at 68°F, % by weight: <0.1%
Upper explosive limit in air, % by volume: NA
Lower explosive limit in air, % by volume: NA

Flash point, °F: NA
Molecular weight: 166
Melting point, °F: -2°

ROUTE OF EXPOSURE: Inhalation, skin contact, ingestion

SYMPTOMS: CNS depression, skin irritation, drowsiness, unconsciousness, liver and kidney damage

FIRST AID:

Eye: irrigate immediately. Skin: Soap and flush with water immediately.

Breathe: Artificial respiration. Swallow: Get immediate medical attention.

PERSONAL PROTECTION AND SANITATION

Wear appropriate equipment to prevent: repeated or prolonged skin contact
Wear eye protection to prevent: reasonable probability of eye contact
Employees should wash: immediately upon becoming wet
Work clothing should be changed daily: NA
Remove clothing: immediately upon becoming wet

CHEMICAL DATA SHEET

CHEMICAL NAME: Aroclor 1260   CHEMICAL FORMULA: N/A

SYNONYMS: PCB

EXPOSURE LIMITS: IDLH LEVEL: Ca

NIOSH: Ca

PHYSICAL DESCRIPTION: Clear to yellow thick liquid

INCOMPATIBILITIES: None

CHEMICAL AND PHYSICAL PROPERTIES

Ionization potential, eV: NA   Flash point, °F: NA
Boiling point at 1 atm, C: 385-420°   Molecular weight: NA
Vapor pressure at 68°F, mmHg: UNKNOWN   Melting point, °F: -
Solubility in water at 68°F, % by weight: INSOLUBLE
Upper explosive limit in air, % by volume: NA
Lower explosive limit in air, % by volume: NA

ROUTE OF EXPOSURE: Skin contact, ingestion

SYMPTOMS: Suspected carcinogen

FIRST AID:

Eye: irrigate immediately.   Skin: Soap and flush with water immediately.

Breathe: Artificial respiration. Swallow: Get immediate medical attention.

PERSONAL PROTECTION AND SANITATION

Wear appropriate equipment to prevent: repeated or prolonged skin contact
Wear eye protection to prevent: reasonable probability of eye contact
Employees should wash: immediately upon becoming wet
Work clothing should be changed daily: NA
Remove clothing: immediately upon becoming wet

CHEMICAL DATA SHEET

CHEMICAL NAME: Pentachlorophenol

CHEMICAL FORMULA: C_6Cl_5OH

SYNONYMS: PCP, Penta

EXPOSURE LIMITS:

IDLH LEVEL: 150 mg/m^3

NIOSH/OSHA: 0.5 mg/m^3 skin

PHYSICAL DESCRIPTION: Colorless to white crystalline solid with benzene-like odor

INCOMPATIBILITIES: Strong oxidizers

CHEMICAL AND PHYSICAL PROPERTIES

Ionization potential, eV: NA
Boiling point at 1 atm, F: 588°
Vapor pressure at 68°F, mmHg: 0.001
Solubility in water at 68°F, % by weight: 0.001
Upper explosive limit in air, % by volume: NA
Lower explosive limit in air, % by volume: NA

Flash point, °F: NA
Molecular weight: 266
Melting point, °F: 374

ROUTE OF EXPOSURE: Skin contact, ingestion, inhalation

SYMPTOMS: sweating, headache, dizziness, vomiting, chest pain, irritation eyes, nose, throat

FIRST AID:

Eye: irrigate immediately. Skin: Soap and flush with water immediately.

Breathe: Artificial respiration. Swallow: Get immediate medical attention.

PERSONAL PROTECTION AND SANITATION

Wear appropriate equipment to prevent: repeated or prolonged skin contact
Wear eye protection to prevent: reasonable probability of eye contact
Employees should wash: immediately upon becoming wet
Work clothing should be changed daily: NA
Remove clothing: immediately upon becoming wet

CHEMICAL DATA SHEET

CHEMICAL NAME: 1,2-dichloroethylene CHEMICAL FORMULA: $C_2H_2CL_2$

SYNONYMS: Acetylene dichloride

EXPOSURE LIMITS: IDLH LEVEL: 4000ppm

NIOSH/OSHA: 200 ppm

PHYSICAL DESCRIPTION: Colorless liquid with a slightly acrid, chloroform-like odor

INCOMPATIBILITIES: Strong oxidizers, strong alkalis, potassium hydroxide, copper

CHEMICAL AND PHYSICAL PROPERTIES

Ionization potential, eV: 9.65	Flash point, °F: 36
Boiling point at 1 atm,°F: 118-140	Molecular weight: 97
Vapor pressure at 68°F, mmHg: 180-264	Melting point, °F: NA

Solubility in water at 68°F, % by weight: 0.4
Upper explosive limit in air, % by volume: 12.8
Lower explosive limit in air, % by volume: 5.6

ROUTE OF EXPOSURE: Inhalation, ingestion, skin and/or eye contact

SYMPTOMS: Irritation of eyes or respiratory system, CNS depression

FIRST AID:

Eye: irrigate immediately. Skin: soap wash promptly.

Breathe: artificial respiration. Swallow: immediate medical attention.

PERSONAL PROTECTION AND SANITATION

<u>Wear appropriate equipment to prevent</u>: repeated or prolonged skin contact
<u>Wear eye protection to prevent</u>: reasonable probability of eye contact
<u>Employees should wash</u>: immediately upon becoming wet
<u>Work clothing should be changed daily</u>: NA
<u>Remove clothing</u>: immediately upon becoming wet

CHEMICAL DATA SHEET

CHEMICAL NAME: o,m, or p-xylene CHEMICAL FORMULA: $C_6H_4 \cdot (CH_3)_2$

SYNONYMS: 1,2 dimethyl benzene (ortho xylene)
1,3 dimethyl benzene (meta xylene)
1,4 dimethyl benzene (para xylene)

EXPOSURE LIMITS:

NIOSH: 100 ppm 10-hr TWA
200 ppm 10-min ceil

IDLH LEVEL: 1000 ppm

PHYSICAL DESCRIPTION: Colorless liquid with aromatic odors (pure p-xylene is a solid at <55°F)

INCOMPATIBILITIES: Strong oxidizers

CHEMICAL AND PHYSICAL PROPERTIES

Ionization potential, eV: 8.56/8.56/8.44 eV
Flash point, °F: 90/84/81°
Boiling point at 1 atm, F: 292/282/281°
Molecular weight: 106
Vapor pressure at 68°F, mmHg: 7/9/9 mm
Melting point, °F: -12/-54/55°
Solubility in water at 68°F, % by weight: 3×10^{-5}
Upper explosive limit in air, % by volume: 6/7/7%
Lower explosive limit in air, % by volume: 1/1.1/1.1%

ROUTE OF EXPOSURE: Inhalation, skin absorption, ingestion

SYMPTOMS: Dizziness, excitement, drowsiness, incoherence, staggering gait, irritated eyes, nose, throat; corneal vacuolization, vomiting, abdominal pain, dermatitis.

FIRST AID:
Eye: irrigate immediately
Skin: soap & wash promptly with water
Breathe: artificial respiration
Swallow: get immediate medical attention

PERSONAL PROTECTION AND SANITATION

Wear appropriate equipment to prevent: repeated or prolonged skin contact
Wear eye protection to prevent: reasonable probability of eye contact
Employees should wash: promptly upon contamination
Work clothing should be changed daily: NA
Remove clothing: immediately upon becoming wet
The following equipment should be available:

CHEMICAL DATA SHEET

CHEMICAL NAME: Toluene

CHEMICAL FORMULA: $C_6H_5CH_3$

SYNONYMS: Toluol, Phenylmethane, methylbenzene

EXPOSURE LIMITS:
OSHA PEL: 200 ppm 8-hr TWA
300 ppm ceiling
500 ppm 10-min peak
NIOSH REL: 100 ppm 10-hr TWA
200 ppm 10-min ceiling

IDLH LEVEL: 2000 ppm

PHYSICAL DESCRIPTION: Colorless liquid with an aromatic odor like benzene

INCOMPATIBILITIES: strong oxidizers

CHEMICAL AND PHYSICAL PROPERTIES

Ionization potential, eV: 8.82 eV

Flash point, °F: 40°F

Boiling point at 1 atm, F: 231°F

Molecular weight: 92

Vapor pressure at 68°F, mmHg: 22 mm

Melting point, °F: -139°F

Solubility in water at 68°F, % by weight: 0.05%

Upper explosive limit in air, % by volume: 7.1%

Lower explosive limit in air, % by volume: 1.3%

ROUTE OF EXPOSURE: Inhalation, ingestion, skin contact

SYMPTOMS: Fainting, weakness, confusion, euphoria, dizziness, headache dilated pupils, lacrimation, nervousness, muscle fatigue, insomnia, paresthesia, photophobia

FIRST AID: Eye: wash immediately with large amounts of water, get medical attention. Skin: promptly wash contaminated skin with soap and large amounts of water. Breathe: move immediately to fresh air, give artificial respiration is breathing stops. Swallow: get immediate medical attention. Do not induce vomiting.

PERSONAL PROTECTION AND SANITATION

Wear appropriate equipment to prevent: repeated or prolonged skin contact.
Wear eye protection to prevent: reasonable probability of eye contact.
Employees should wash: promptly wash contaminated skin with soap and water.
Work clothing should be changed daily: NA
Remove clothing: promptly remove non-impervious clothing upon contamination. Immediately remove any wet clothing.
The following equipment should be available: NA

CHEMICAL DATA SHEET

HEMI[illegible]L NAME: Ethylbenzene

CHEMICAL FORMULA: $C_2H_5C_6H_5$

YNONYMS: Phenylethane, Ethylbenzol

XPOSURE LIMITS:
SHA PEL: 100 ppm 8-hr TWA

IDLH LEVEL: 2000 ppm

PHYSICAL DESCRIPTION: Colorless liquid with an aromatic odor

INCOMPATIBILITIES: strong oxidizers

CHEMICAL AND PHYSICAL PROPERTIES

onization potential, eV: 8.76 eV
oiling point at 1 atm, F: 277°F
apor pressure at 68°F, mmHg: 7.1mm
olubility in water at 68°F, % by weight: 0.015%
pper explosive limit in air, % by volume: 6.7%
ower explosive limit in air, % by volume: 1.0%

Flash point, °F: 59°F
Molecular weight: 106
Melting point, °F: -139°F

OUTE OF EXPOSURE: Inhalation, ingestion, skin contact.

YMPT[illegible]S: Irritation to eyes, mucous membranes and upper respiratory tract. ausea, headache, vomiting, dermatitis, CNS, depression, coma.

IRST AID: Eye: wash immediately with large amounts of water, get medical ttention. Skin: wash promptly with large amounts of water. Breathe: move mmediately to fresh air, get medical attention. Swallow: get immediate edical attention.

PERSONAL PROTECTION AND SANITATION

ear appropriate equipment to prevent: repeated or prolonged skin contact.
ear eye protection to prevent: reasonable probability of eye contact.
Employees should wash: promptly with water when skin becomes contaminated.
ork clothing should be changed daily: NA
Remove clothing: remove non-impervious clothing promptly upon contamination. Remove any clothing immediately, if wet.
The following equipment should be available: NA

CHEMICAL DATA SHEET

CHEMICAL NAME: Acetone

CHEMICAL FORMULA: CH_3COCH_3

SYNONYMS: 2-propanone, dimethyl ketone, ketone propane

EXPOSURE LIMITS
OSHA PEL
1000 ppm (2400 mg/m^3) 8-hr TWA
NIOSH REL
250 ppm (590 mg/m^3) 10-hr TWA
ACGIH
750 ppm

IDLH LEVEL 20,000 ppm

PHYSICAL DESCRIPTION
colorless liquid with a fragrant, mint-like odor

INCOMPATIBILITIES
oxidizing materials, acids

CHEMICAL AND PHYSICAL PROPERTIES

Ionization potential, eV: 9.69 eV
Boiling point at 1 atm, F: 133°F
Vapor pressure at 68°F, mmHg: 77°F/266 mm
Solubility in water at 68°F, % by weight: Miscible
Upper explosive limit in air, % by volume: 12.8 %
Lower explosive limit in air, % by volume: 2.6 %

Flash point, °F: 1.4°F
Molecular weight: 58
Melting point, °F: -169 °F

ROUTE OF EXPOSURE: Inhalation, ingestion, contact

SYMPTOMS: Irritation eyes, nose, throat; headache, dizziness; dermatitis

FIRST AID
Eye: Wash eyes immediately, get medical attention immediately, do not wear contact lenses
Skin: Immediately wash skin with soap and water
Breath: Move to fresh air, perform artificial respiration if breathing stops
Swallow: Get medical attention immediately

PERSONAL PROTECTION AND SANITATION

Wear appropriate equipment to prevent: Repeated or prolonged skin contact

Wear eye protection to prevent: any possibility of eye contact

Employees should wash: Promptly when skin becomes wet

Work clothing should be changed daily: NA

Remove clothing: Immediately remove any clothing that becomes wet to avoid flammability hazard
The following equipment should be available: NA

CHEMICAL DATA SHEET

CHEMICAL NAME: Dichloromethane

CHEMICAL FORMULA: CH_2Cl_2

SYNONYMS: Methylene chloride, Methylene dichloride

EXPOSURE LIMITS

OSHA PEL
500 ppm 8-hr TWA
1000 ppm ceiling
2000 ppm 5 min/2-hr peak
NIOSH
NA
ACGIH
100 ppm 8-hr TWA

IDLH LEVEL Potential human carcinogen

PHYSICAL DESCRIPTION
Colorless liquid with a chloroform-like odor

INCOMPATIBILITIES
Strong oxidizers and caustics; chemically active metals, such as aluminum or magnesium powders, sodium, potassium

CHEMICAL AND PHYSICAL PROPERTIES

Ionization potential, eV: 11.35 eV
Boiling point at 1 atm, F: 104°F
Vapor pressure at 68°F, mmHg: 350 mm
Solubility in water at 68°F, % by weight: 1.3%
Upper explosive limit in air, % by volume: 19%
Lower explosive limit in air, % by volume: 12%

Flash point, °F: ?
Molecular weight: 85
Melting point, °F: -142°F

ROUTE OF EXPOSURE: Inhalation, ingestion, skin and/or eye contact

SYMPTOMS: Fatigue, weakness, sleepiness, lightheadedness; limbs numb, tingle; nausea; irritated eyes, skin; vertigo; worsen angina; carcinogenic

FIRST AID
Eye: Immediately wash eyes with water, get medical attention immediately, do not wear contact lenses.
Skin: Promptly wash skin with soap, get medical attention promptly
Breath: Move to fresh air, perform artificial respiration if breathing stops
Swallow: Get medical attention immediately

PERSONAL PROTECTION AND SANITATION

Wear appropriate equipment to prevent: Reasonable probability of skin contact

Wear eye protection to prevent: Reasonable probability of eye contact

Employees should wash: Promptly when skin becomes wet

Work clothing should be changed daily: NA

Remove clothing: Promptly remove non-impervious clothing that becomes contaminated

The following equipment should be available: NA

CHEMICAL DATA SHEET

CHEMICAL NAME: Vinyl Chloride

CHEMICAL FORMULA: C_2H_3Cl

SYNONYMS: VCl, VCm, chloroethylene, chloroethane, monochloroethylene, ethylene mono chloride, monochloroethene, vinyl C monomer trovidur, VC, vinyl chloride monomer

EXPOSURE LIMITS:
OSHA PEL: 1 ppm 8 hr TWA
5 ppm 15 min
NIOSH PEL:
lowest detectable limit in human carcinogen

IDLH LEVEL: Potential human carcinogen

PHYSICAL DESCRIPTION: Colorless gas, liquifies in a freezing mixture

INCOMPATIBILITIES: Copper oxidizing materials

CHEMICAL AND PHYSICAL PROPERTIES

Ionization potential, eV: 9.995
Boiling point at 1 atm, F: 7
Vapor pressure at 68°F, mmHg: 2580
Solubility in water at 68°F, % by weight: slight
Upper explosive limit in air, % by volume: 33
Lower explosive limit in air, % by volume: 3.6

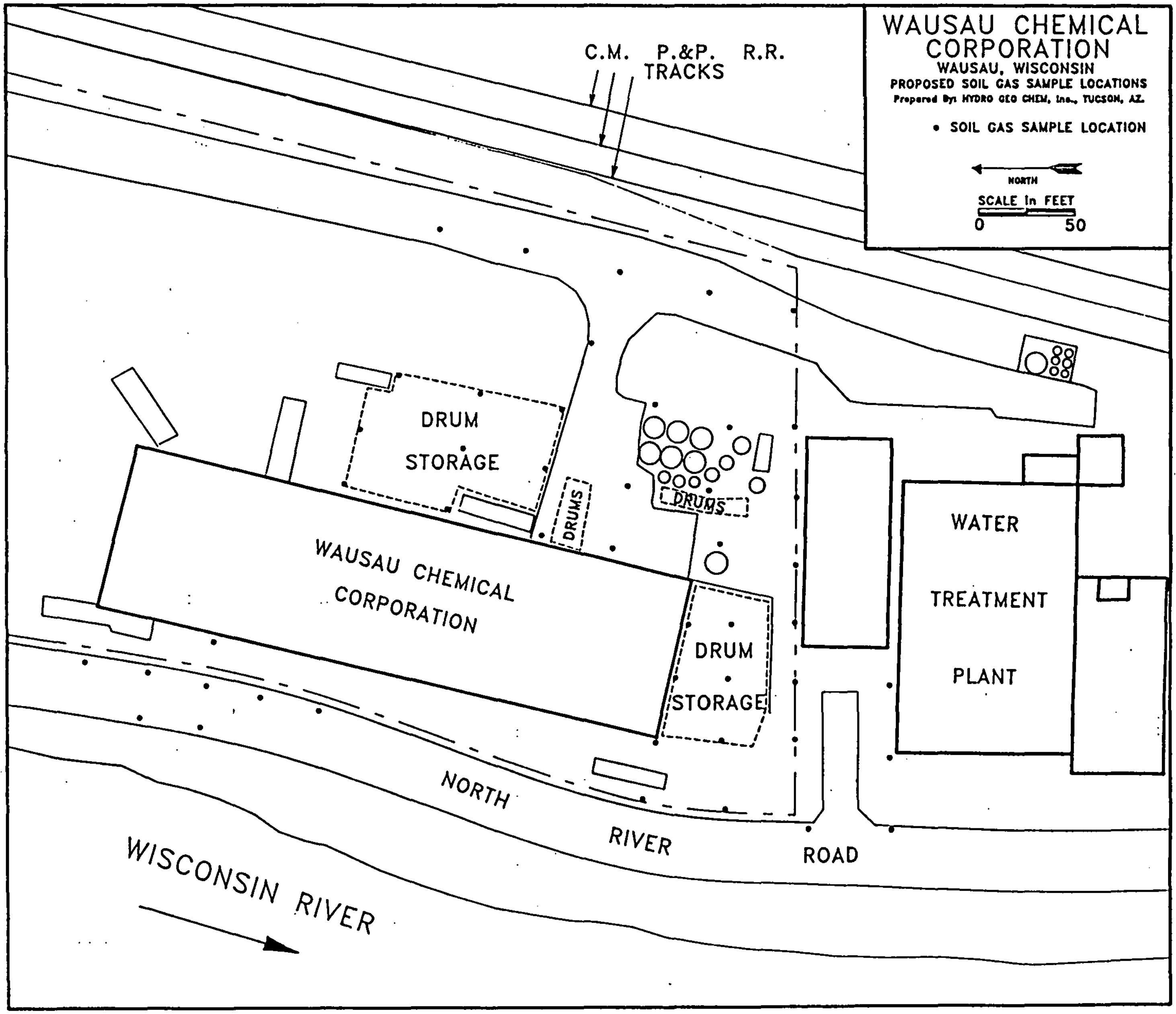
Flash point, °F: -108
Molecular weight: 62.5
Melting point, °F: -245

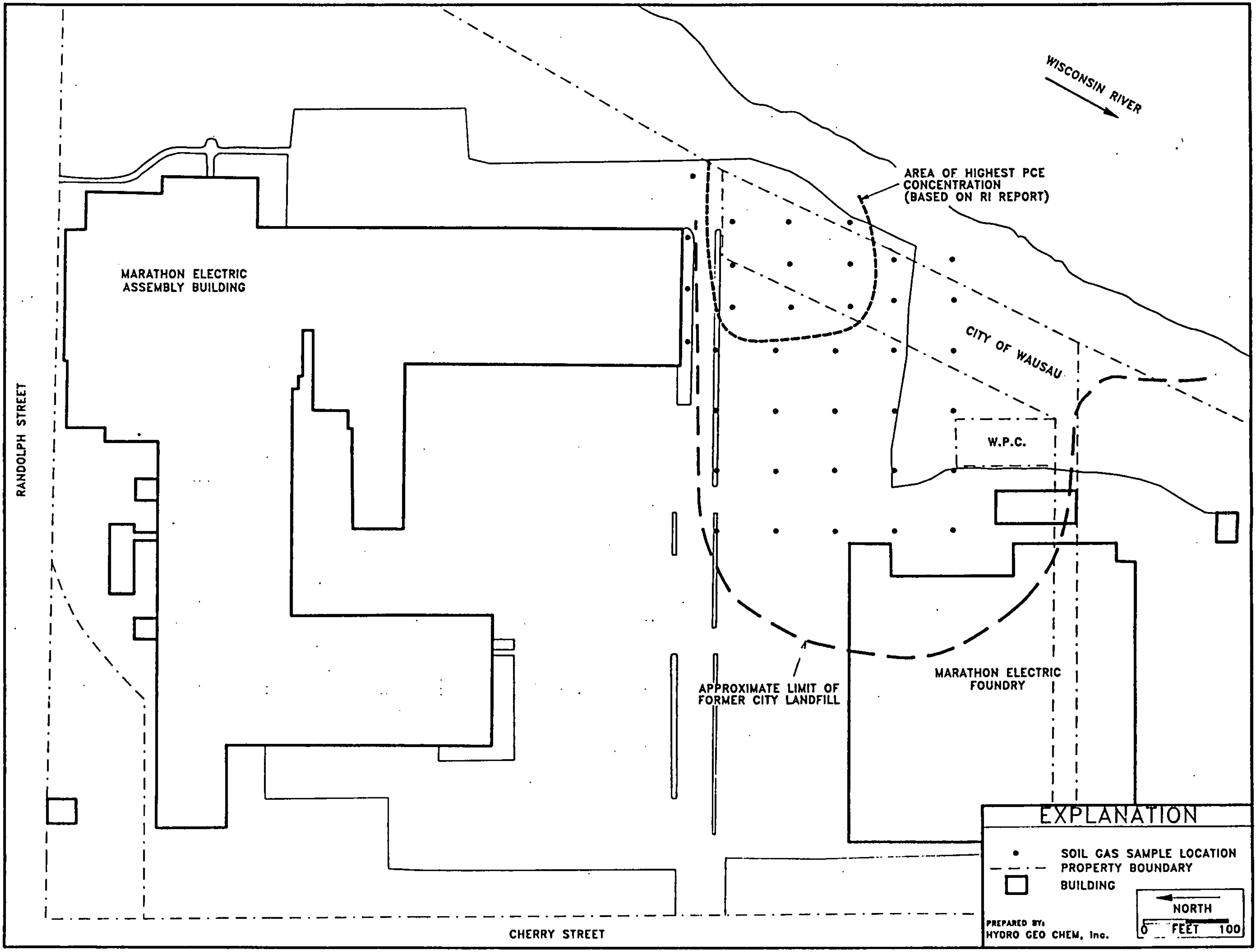
ROUTE OF EXPOSURE: Inhalation

SYMPTOMS: Weakness, abdominal pain, gastrointestinal bleeding, hematomegaly, palor or cyanosis of extremeties, carginogenic

FIRST AID: Breathing: move person to fresh air. Perform artificial respiration if breathing stops. Get medical attention ASAP.

Wear appropriate equipment to prevent: Any possibility of skin contact
Wear eye protection to prevent: Any possibility of contact
Employee should wash: Immediately when skin is contaminated and at end of each day
Work clothing should be changed daily: If there is any possibility that clothing may be contaminated
Remove clothing: Immediately upon becoming contaminated


WAUSAU CHEMICAL CORPORATION
WAUSAU, WISCONSIN
PROPOSED SOIL GAS SAMPLE LOCATIONS
Prepared By: HYDRO GEO CHEM, Inc., TUCSON, AZ.
• SOIL GAS SAMPLE LOCATION
NORTH
SCALE In FEET
0
50
C.M. P.&P. R.R. TRACKS
DRUM STORAGE
DRUMS
DRUMS
WAUSAU CHEMICAL CORPORATION
DRUM STORAGE
WATER TREATMENT PLANT
NORTH RIVER ROAD
WISCONSIN RIVER


WISCONSIN RIVER
AREA OF HIGHEST PCE CONCENTRATION (BASED ON RI REPORT)
MARATHON ELECTRIC ASSEMBLY BUILDING
CITY OF WAUSAU
W.P.C.
RANDOLPH STREET
APPROXIMATE LIMIT OF FORMER CITY LANDFILL
MARATHON ELECTRIC FOUNDRY
CHERRY STREET
EXPLANATION
• SOIL GAS SAMPLE LOCATION
PROPERTY BOUNDARY
BUILDING
NORTH
0 FEET 100
PREPARED BY: HYDRO GEO CHEM, Inc.

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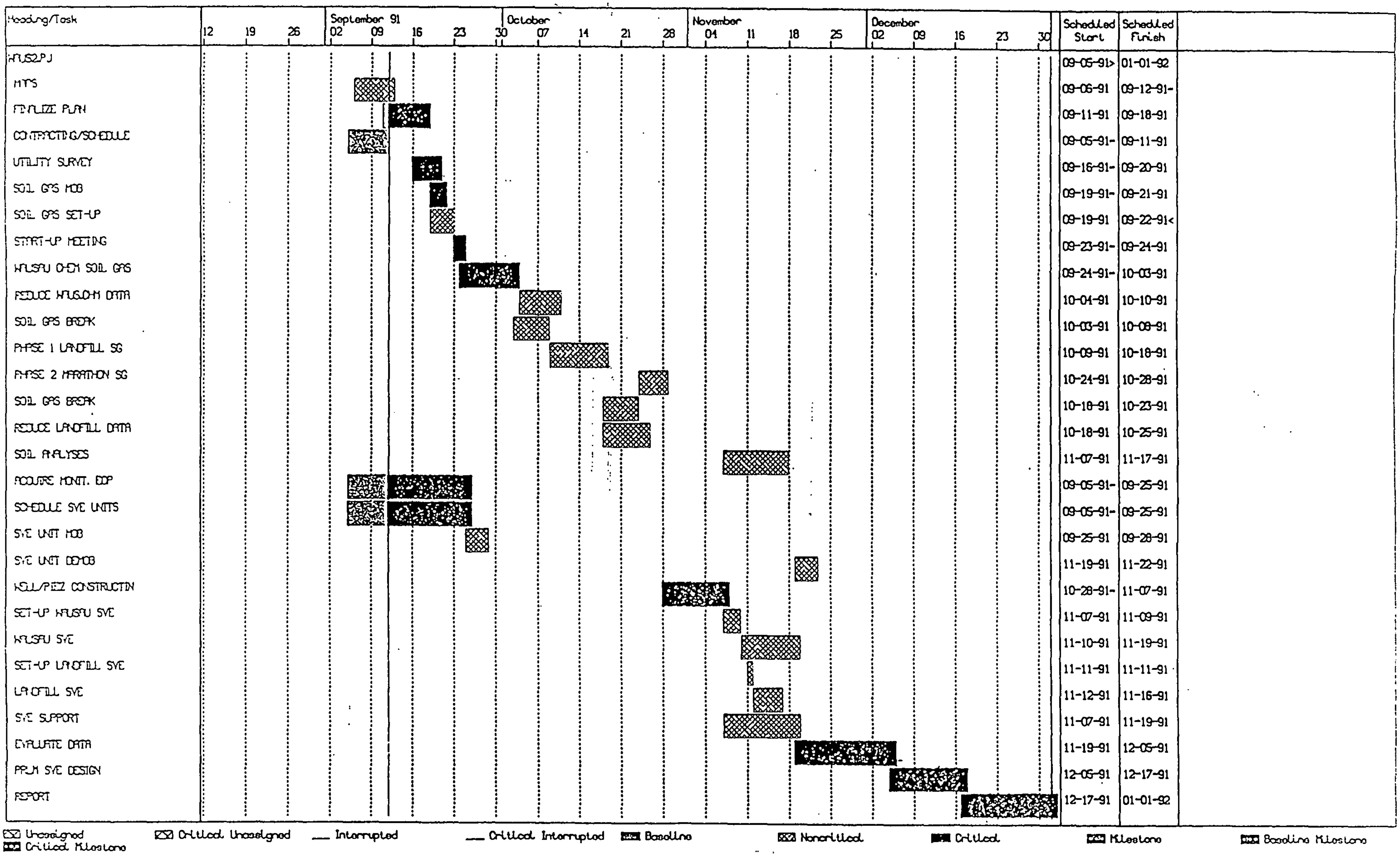
09-12-91 9:34a

Project: WAUS2PJ
Revision: 11

Wausau SVE Predesign Investigation



Heading/Task	Scheduled Start	Scheduled Finish
WAUS2PJ	09-05-91>	01-01-92
HTPS	09-06-91	09-12-91-
FINALIZE PLAN	09-11-91	09-18-91
CONTRACTING/SCHEDULE	09-05-91-	09-11-91
UTILITY SURVEY	09-16-91-	09-20-91
SOIL GAS MOB	09-19-91-	09-21-91
SOIL GAS SET-UP	09-19-91	09-22-91<
START-UP MEETING	09-23-91-	09-24-91
WAUSAU CHEM SOIL GAS	09-24-91-	10-03-91
REDUCE WAUS.CHM DATA	10-04-91	10-10-91
SOIL GAS BREAK	10-03-91	10-08-91
PHASE 1 LANDFILL SG	10-09-91	10-18-91
PHASE 2 MARATHON SG	10-24-91	10-28-91
SOIL GAS BREAK	10-18-91	10-23-91
REDUCE LANDFILL DATA	10-18-91	10-25-91
SOIL ANALYSES	11-07-91	11-17-91
ACQUIRE MONIT. EQP	09-05-91-	09-25-91
SCHEDULE SVE UNITS	09-05-91-	09-25-91
SVE UNIT MOB	09-25-91	09-28-91
SVE UNIT DEMOB	11-19-91	11-22-91
WELL/PIEZ CONSTRUCTN	10-28-91-	11-07-91
SET-UP WAUSAU SVE	11-07-91	11-09-91
WAUSAU SVE	11-10-91	11-19-91
SET-UP LANDFILL SVE	11-11-91	11-11-91
LANDFILL SVE	11-12-91	11-16-91
SVE SUPPORT	11-07-91	11-19-91
EVALUATE DATA	11-19-91	12-05-91
PRLM SVE DESIGN	12-05-91	12-17-91
REPORT	12-17-91	01-01-92

Figure 3.4 SVE Predesign Project Schedule

WAUSAU SVE PREDESIGN INVESTIGATION FIELD SCHEDULE

TASK	Scheduled Start	Scheduled Finish	Scheduled Duration
WAUSAU SVE PREDESIGN	09-05-91	01-01-92	80 days
UTILITY SURVEY	09-16-91	09-20-91	5 days
SOIL GAS MOBILIZATION	09-21-91	09-22-91	2 days
SOIL GAS SET-UP	09-23-91	09-23-91	1 day
START-UP MEETING	09-23-91	09-23-91	1 day
WAUSAU CHEM SOIL GAS	09-24-91	10-03-91	8 days
SOIL GAS BREAK	10-03-91	10-08-91	5 days
PHASE 1 LANDFILL SOIL GAS	10-09-91	10-18-91	8 days
SOIL GAS BREAK	10-18-91	10-23-91	5 days
PHASE 2 MARATHON SOIL GAS	10-24-91	10-28-91	3 days
WELL/PIEZ CONSTRUCTION	10-28-91	11-07-91	10 days
SVE UNIT MOBILIZATION	11-04-91	11-07-91	3 days
SET-UP WAUSAU SVE	11-07-91	11-09-91	2 days
WAUSAU SVE	11-10-91	11-19-91	10 days
SET-UP LANDFILL SVE	11-11-91	11-11-91	1 day
LANDFILL SVE	11-12-91	11-16-91	4 days
SVE UNIT DEMOBILIZATION	11-19-91	11-22-91	3 days

DIRECTIONS TO WAUSAU HOSPITAL CENTER

FROM MARATHON ELECTRIC:

FROM MAIN PARKING LOT, TURN RIGHT (NORTH) ONTO CHERRY

GO 0.15 miles NORTH TO RANDOLPH ST., TURN LEFT (WEST)

GO 0.2 MILES WEST ON RANDOLPH TO THIRD AVE., TURN LEFT

GO 0.75 MILES SOUTH ON THIRD AVE. TO BRIDGE ST., TURN RIGHT

GO 0.9 MILES WEST ON BRIDGE, TO WESTWOOD DRIVE. TURN LEFT ON WESTWOOD DRIVE, FOLLOWING BLUE "HOSPITAL" SIGNS.

GO 0.15 MILES SOUTH ON WESTWOOD TO PINE RIDGE BLVD, TURN RIGHT

GO 0.4 MILES ON PINE RIDGE BLVD. TO WAUSAU HOSPITAL CENTER. FOLLOW SIGNS TO EMERGENCY ENTRANCE

FROM WAUSAU CHEMICAL:

GO NORTH ON EITHER N. RIVER DRIVE OR FILTRATION RD TO WAUSAU AVE, TURN RIGHT

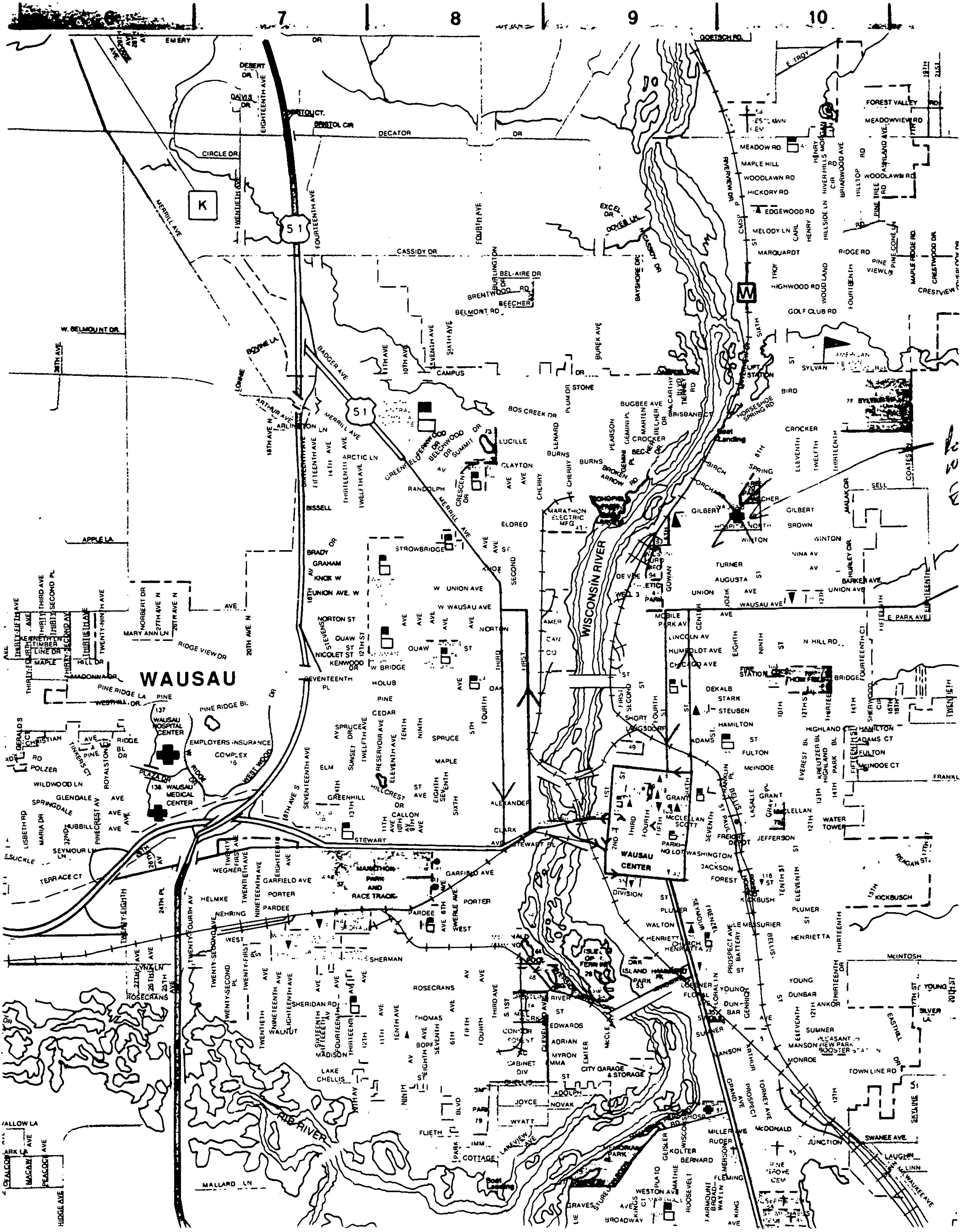
GO 1 BLOCK EAST ON WAUSAU AVE, TURN RIGHT ON SECOND ST.

GO 0.2 MILES SOUTH ON SECOND ST. TO BRIDGE ST., TURN RIGHT

GO 1.4 MILES WEST ON BRIDGE ST. TO WESTWOOD DRIVE, TURN LEFT AT "HOSPITAL" SIGN

GO 0.15 MILES SOUTH ON WESTWOOD TO PINE RIDGE BLVD, TURN RIGHT

GO 0.4 MILES ON PINE RIDGE BLVD. TO WAUSAU HOSPITAL CENTER. FOLLOW SIGNS TO EMERGENCY ENTRANCE


6
7
8
9
10
WAUSAU
WISCONSIN RIVER
RIB RIVER
51
K
W
EMERY DR
GOETSCH RD.
DESERT DR
DAVIS DR
BRISTOL CT.
BRISTOL CIR
DECATOR DR
CIRCLE DR
EIGHTEENTH AVE
TWENTIETH AVE
FOURTEENTH AVE
FOURTH AVE
MERRILL AVE
CASSIDY DR
EXCEL DR
DOYEN LN
BAYSHORE DR
BURLINGTON
BEL-AIRE DR
BRENTWOOD RD
BEECHER
BELMONT RD
W. BELMOUNT DR.
38TH AVE
BOYNE LA
BADGER AVE
LONNIE
ARTHUR AVE
ARLINGTON LN
CAMPUS
STONE
DR
BUREK AVE
PLUM DR
BOS CREEK DR
LUCILLE
CLAYTON
GREENFIELD AV
FERNWOOD DR
BEECHWOOD DR
SUMMIT DR
CRESCENT DR
RANDOLPH
ARCTIC LN
BISSELL
APPLE LA
BRADY
GRAHAM
KNOX W
STROWBRIDGE
ELDRED
MARATHON ELECTRIC MFG
CHERRY
BURNS
LENARD
PEARSON
GEMINI PL
MARTEN
BECHER
CROCKER
BROKEN ARROW RD.
BUGBEE AVE
BRISBANE CT.
TIERNEY RD
McCARTHY BLVD
FOREST VALLEY RD
MEADOWVIEW RD
MEADOW RD
MAPLE HILL
WOODLAWN RD
HICKORY RD
EDGEWOOD RD
MELODY LN
MARQUARDT
RIDGE RD
HIGHWOOD RD
GOLF CLUB RD
PINE VIEW LN
CRESTWOOD DR
MAPLE RIDGE RD
CRESTVIEW
HILLTOP RD
PINE TREE RD
PINE CONE LN
ASHLAND AVE
BRIARWOOD AVE
RIVER HILLS CIR
HENRY
HILLSIDE LN
WOODLAND
RIVERVIEW DR
E. TROY
SYLVAN
BIRD
LIFT STATION
HORSESHOE SPRING RD
Boat Landing
SPRING
BIRCH
ORCHARD
GILBERT
BROWN
WINTON
NINA AV
TURNER
AUGUSTA
HURLEY CIR
BARKER AVE
UNION AVE
WAUSAU AVE
E. PARK AVE
N HILL RD.
FIRE STATION
BRIDGE
SHERWOOD
FOURTEENTH CT
HAMILTON
ADAMS CT
FULTON
McINDOE CT
FRANKL
HIGHLAND CT
EVEREST BL
KREUTZER BL
PARK BL
WATER TOWER
REAGAN ST.
KICKBUSCH
McINTOSH
YOUNG
DUNBAR
ANKOR
SILVER LA
SUMNER
PLEASANT VIEW PARK
BOOSTER STATION
MANSON
MONROE
TOWN LINE RD
EASTHILL
SKYLINE LA
SWANEE AVE.
LAUGHLIN
LINN
MILWAUKEE AVE
JUNCTION
McDONALD
PINE GROVE CEM
W UNION AVE
W WAUSAU AVE
NORTON
NORTON ST
QUAW
NICOLET ST
KENWOOD DR
W BRIDGE
HOLUB
SEVENTEENTH PL
PINE
CEDAR
SPRUCE
MAPLE
ELM
RESERVOIR AVE
HILLCREST
GREENHILL
CALLON DR
STEWART
CLARK
ALEXANDER
SECOND
THIRD
FIRST
FOURTH
STEVENS
MARY ANN LN
NORBERT DR
RIDGE VIEW DR
MAPLE
HILL DR
MADONNA DR
PINE RIDGE LA
WESTHILL DR.
PINE RIDGE BL.
137 WAUSAU HOSPITAL CENTER
EMPLOYERS INSURANCE COMPLEX
138 WAUSAU MEDICAL CENTER
PLAZA DR
WEST WOOD
RIDGE BL DR
CHRISTIAN
POLZER
TINKERS CT
ROYALSTONE
WILDWOOD LN
GLENDALE
SPRINGDALE
HUBBILL
LISBETH RD
MARIA DR
SEYMOUR LN
TERRACE CT
PINECREST AV
WEGNER
GARFIELD AVE
PORTER
PARDEE
NEHRING
HELMKE
MARATHON PARK AND RACE TRACK
WEST
SHERMAN
ROSECRANS
SHERIDAN RD
THOMAS
WALNUT
MADISON
LAKE CHELLIS
BOPF
LYNN LN
TWENTY-EIGHTH
TWENTY-FOURTH AV
TWENTY-SECOND AVE
ISLE OF FERN PK
ISLAND PARK
HAMMOND PK
EDWARDS
ADRIAN
MYRON
EMMA
CABINET DIV
CITY GARAGE & STORAGE
ADOLPH
NOVAK
JOYCE
WYATT
FLIETH
COTTAGE
LAKEVIEW AVE
MALLARD LN
Boat Landing
MEMORIAL PARK
PLATO
GEISLER
KOLTER
BERNARD
FLEMING
WESTON AVE
ROOSEVELT
FAIRMOUNT
BROADWAY
GRAVES
KING
WAUSAU CENTER
PARKING LOT
WASHINGTON
JACKSON
FOREST
DIVISION
PLUMER
WALTON
HENRIETTA
LE MESSURIER
BELLIS
BATTERY
PROSPECT AVE
FREIGHT DEPOT
JEFFERSON
LASALLE
GRANT
McCLELLAN
SCOTT
STARK
DEKALB
STEUBEN
LANGDORF
SHORT
MOBILE
LINCOLN AV
HUMBOLDT AVE
CHICAGO AVE
GOWAN
JOZIK
CENTER
DEWEY
LOEFFLER
FLORAL
DUNBAR
SEYMOUR
FRENZEL
TORNEY AVE
GRAND AVE
ARTHUR
RUDER
MILLER
ALLOW LA
PARK LA
MACAW
PEACOCK AVE
RIDGE AVE
WALCOTT