Treatability Studies Work Plan

In Situ Groundwater Oxidation-Reduction Potential
UV/Ozone/Peroxide Oxidation
Thermal Treatment
Soil Vapor Extraction Pilot Test
Woodlawn Landfill RI/FS
Cecil County, Maryland

Prepared by:
IT Corporation
Monroeville, Pennsylvania

RESPONSIVE TO THE NEEDS OF ENVIRONMENTAL MANAGEMENT

AR305360
March 11, 1992

Ms. Debra Rossi
Remedial Project Manager
U. S. Environmental Protection Agency
Region III
841 Chestnut Building
Philadelphia, PA 19107

Re: Submittal
Treatability Study Work Plan
Woodlawn Landfill RI/FS
Cecil County, Maryland

Dear Ms. Rossi:

Enclosed are four (4) copies of the subject document which is being submitted in accordance with the project Consent Order (U. S. EPA Docket No. III-89-05-DC, December 28, 1988) and in accordance with the U. S. EPA-approved schedule, as revised, for the final submittal date of this document. The subject document is:

Report
Treatability Study Work Plan
Dated March 11, 1992

For records management, the report has the following records management system (RMS) number:

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Please advise us if you have any questions or comments.

Sincerely yours,

George B. Markert
Senior Environmental Consultant
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AR305361
TREATABILITY STUDIES WORK PLANS

- IN SITU GROUNDWATER OXIDATION-REDUCTION POTENTIAL
  - UV/OZONE PEROXIDE OXIDATION
  - THERMAL TREATMENT
  - SOIL VAPOR EXTRACTION PILOT TEST

WOODLAWN LANDFILL RI/FS
CECIL COUNTY, MARYLAND

PREPARED BY:

IT CORPORATION
MONROEVILLE, PENNSYLVANIA

MARCH 11, 1992

PROJECT NO. 303486

Prepared by: ____________________________ Date 3/10/92

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AR305366
1.0 Introduction

On behalf of Bridgestone/Firestone, Inc., IT Corporation (IT) is submitting a treatability study work plan to the U.S. Environmental Protection Agency (U.S. EPA) (with a copy to the state of Maryland) for review and approval. The Treatability Study is performed as part of the remedial investigation/feasibility study (RI/FS) for the Woodlawn Landfill located in Cecil County, Maryland. This submittal is an addition to the RI/FS methodologies plan submitted on September 5, 1989 (Revision 0; revised November 30, 1989).

This work plan satisfies the requirements of the project Consent Order (U.S. EPA Docket No. III-89-05-DC, dated December 28, 1988) and the approved Scope of Work (dated September 30, 1988; Revision 01, November 2, 1988). The Quality Assurance Project Plan (QAPP) (dated December 5, 1988; Revision 05, November 30, 1989) and the Health and Safety (H&S) Plan (dated December 5, 1988; Revision 05, November 30, 1989) have been updated as submitted with the previous treatability study works plan.

1.1 Purpose and Scope

This work plan addresses four required treatability studies necessary to complete the detailed analysis of alternatives for the feasibility study (FS). This work plan also addresses the field sampling plan required to collect samples for the bench-scale tests. A separate work plan which addressed the leaching testing of selected PVC sludge wastes has been previously submitted (January 17, 1992). The studies addressed in this work plan include additional focused field testing and laboratory bench-scale testing. The proposed field testing studies include in situ groundwater oxidation-reduction potential and soil vapor extraction testing. The proposed laboratory bench-scale studies include thermal treatment and UV/ozone/peroxide oxidation treatability.

As discussed in the Preliminary FS, these four treatability studies and Field Sampling Plan are required to complete the evaluation of technologies retained for the detailed analysis of alternatives. The requirements and specific objectives of each test are discussed below.

- The Field Sampling Plan specifies procedures for the collection of Cell B/C material and onsite groundwater. Samples of these materials are required to perform the laboratory bench-scale testing discussed below.
• The In Situ Groundwater Oxidation-Reduction Potential Test will evaluate the potential for a redox reaction to be naturally occurring in the on-site groundwater. This reaction may be a contributing factor to the detected reduction of site contaminants at the property line.

• The Soil Vapor Extraction Pilot Test will assess the effectiveness of in situ SVE for the reduction of VOCs in the Cell A and B/C material. If the test demonstrates that the material has too low of a porosity and SVE is ineffective, this alternative will be eliminated in the detailed analysis.

• The Thermal Treatment Test will evaluate the Cell B/C material handling characteristics under low temperature desorption and incineration treatment conditions. The test will also evaluate the reduction of vinyl chloride under the same conditions. The test is required to evaluate the feasibility of thermal treatment of the cell material.

• The UV/Ozone/Peroxide Oxidation Test will evaluate the destruction of VOCs and other compounds in the on-site groundwater using the process. The test will provide data to evaluate the full scale feasibility of such a system.

The other groundwater treatment options retained for detailed analysis (precipitation, air stripping, steam stripping and carbon adsorption) will not be evaluated with treatability studies. These technologies are widely used for the treatment of site related contaminants and sufficient theoretical and empirical data exists to evaluate them without testing. Specific bench-scale testing will be performed in the design phase if one of them is selected in the record of decision (ROD).

Similarly, aquifer pumping and landfill gas characterization tests will be required in the design phase. Pumping tests on extraction wells will be required to verify the existing modeling results and determine the production rate and zone of influence. Landfill gas tests are required as part of closure and postclosure tasks for municipal landfills. These tests will be performed as required in the ROD.

Generally, the proposed treatability studies will be conducted to achieve the following:

• Provide sufficient data to allow treatment alternatives to be fully developed and evaluated during the detailed analysis and to support the remedial design of a selected alternative

• Reduce cost and performance uncertainties for treatment alternatives to acceptable levels so that a remedy can be selected.
1.2 Site Background
The Woodlawn Landfill occupies approximately 38 acres near Woodlawn, Maryland in northwestern Cecil County. Cecil County is located in the northeastern corner of the state bounded by Pennsylvania on the north, Delaware on the east, Kent County, Maryland along the Sassafras River on the south, and the Chesapeake Bay and Susquehanna River on the west. Cecil County is a rural area influenced by the metropolitan areas of the northern Delaware. The landfill is owned and was operated by Cecil County.

The Woodlawn Landfill was originally a sand and gravel pit. It later received wastes containing hazardous constituents from numerous parties during the period from the 1960s to the early 1980s. These wastes were placed wherever active landfilling operations were taking place at the time as well as elsewhere on the landfill. From 1978 to late 1980, PVC sludge was placed in three cells (A, B, and C). Cell A was formed by the excavation for fill used to cover wastes and the active face of the landfill. Cell C overlies Cell B and comprises waste that was placed over the area of Cell B. This waste (PVC sludge) was also placed in other sections of the site.

Bedrock that underlies the site consists of gneissic granite and metadiorite. It is overlain by a residual soil (saprolite) developed by in situ weathering of the bedrock. Overlying the saprolite and terrace deposits of sand and gravel. These materials were excavated prior to the development of the landfill. The landfill operations included excavation of surface soils and placement of waste fill.

1.3 Work Plan Organization
This work plan addresses the four required studies necessary to complete the detailed analysis of alternatives for the Final Feasibility Study Report. The work plan is organized to provide separate chapters to describe the objectives and unique procedures of each study and single chapters to address those procedures common to all the treatability studies.

Chapter 1.0 provides the general purpose and scope of all treatability studies, the site background, and the organization of the work plan. Chapter 2.0 provides the field sampling plan for collecting the material required for the bench-scale studies. Chapter 3.0 through 6.0 are separate work plans for each of the four required studies. Chapter 7.0, 8.0, and 9.0 described the data management, health and safety and residuals management procedures required for all of the studies. Chapter 10.0 provides the data and results reporting requirements for all of the studies.
2.0 **Field Sampling Plan**

This section describes the field sampling activities required for collecting the PVC sludge and groundwater samples needed for the laboratory bench-scale studies. These studies include the thermal desorption and the UV/ozone/peroxide oxidation treatability studies.

### 2.1 Sampling Objectives

The objectives of the field sampling are the following:

- For the thermal desorption treatability study, collect a total of six PVC sludge samples from three borings in Cell B/C.

- The PVC sludge will be visually identified and samples will be collected of material which is most representative of the existing sludge.

- The samples will not be composited or homogenized to avoid volatilization of the VCM.

- For the UV/ozone/peroxide oxidation treatability study, separate groundwater samples will be collected from five existing monitoring wells on-site.

- The groundwater samples will be collected in a manner to minimize the loss of volatiles.

- The separate groundwater samples will be composited into one sample at the laboratory to perform the study.

### 2.2 Equipment and Materials

The following equipment will be used to perform the PVC sludge and groundwater sampling.

- Truck mount auger drill rig
- Hollow-stem augers
- 2-inch O.D. split spoon or 3-inch O.D. split spoon
- 140-pound hammer (2-inch spoon) or 300-pound hammer (3-inch spoon)
- Stainless steel bailers
2.3 PVC Sludge Sampling

2.3.1 Sample Collection

Three borings to collect samples for the thermal desorption treatability study will be advanced. Two samples per boring will be collected to yield a total of six samples for the test. Approximate locations of the borings are shown in Figure 2-1. The borings (ITW-15, ITW-16, and ITW-17) are located within a 50-foot radius of ITW-7. This boring was drilled and sampled during Phase IV of the RI and found to contain PVC sludge.

The borings will be drilled using a truck-mounted hollow-stem auger rig. The boreholes will be advanced through the fill material until native sapprolite is encountered (approximately 20 feet). The borings will be advanced 10 feet into the native sapprocite to verify the bottom of the fill material has been identified. Split-spoon samples will be continuously collected and logged every 2 feet. The samples that most visibly represent the PVC sludge will be collected for analyses. The boring log for ITW-7 indicated that the PVC sludge is a grayish-white silty powder. If no PVC sludge is encountered, the boring will be relocated approximately ten feet and redrilled as described above.

Each sample visually identified as PVC sludge will be collected into six 60-ml amber glass vials and four 500-ml amber glass jars. Caution will be taken during sample collection to minimize sample disturbance and volatilization of VCM. All cuttings will be stored temporarily on site in the existing staging area in properly labeled 55-gallon drums. Upon completion, all borings will be grouted to ground surface with cement-bentonite grout.
The following specifications will be implemented for split-spoon sampling:

- Clean out the hole to the desired sampling depth ensuring that the material to be sampled is not disturbed by the operation. If saturated soils are encountered, withdraw the drill bit slowly to prevent loosening the soil around the hole and maintain the water level in the hole at or above groundwater level.

- The 2-inch-outside-diameter (O.D.) split-spoon sampler will be driven with blows from a 140-pound hammer falling 30 inches in accordance with ASTM D1586-84, Standard Penetration Test. If a 3-inch O.D. split spoon is used, the sampler must be driven with a 300-pound hammer falling 30 inches in accordance with ASTM D1586-84.

- Repeat this operation at intervals not greater than 2 feet in homogeneous strata.

- Record on the boring log form or field notebook the number of blows required to achieve each 6 inches of penetration or fraction thereof at the completion of the boring. The first 6 inches of penetration is termed the penetration resistance, N. If the sampler is driven less than 18 inches, the penetration resistance is that for the last 1 foot of penetration. (If less than 1 foot is penetrated, the logs shall state the number of blows and the fraction of 1 foot penetrated.) The sample interval shall be terminated when the specified depth is achieved or, alternatively, when any one of the conditions described in ASTM D 1586, Paragraph 7.2 occurs, whichever comes first. These conditions are:
  
  - A total of 50 blows have been applied but less than 6 inches advance obtained
  
  - A total of 100 blows have been applied
  
  - There is no observed advance of the sampler during the application of 10 successful blows of hammer
  
  - The sampler is advanced the complete 18 inches (0.45 m) without the limiting blow counts.

- Bring the sampler to the surface and remove both ends and one half of the split-spoon so that the recovered soil rests in the remaining half of the barrel. Described carefully the approximate recovery (length), the USGS classification, composition, color, moisture, etc., of the recovered soil. Put soil into jars using stainless steel spatulas or spoons. Each sample will be screened using a HNu or OVA.
• All solid samples must be taken as discrete grab samples from continuous split-spoon samplers until samples volume requirements are met. Homogenization of samples will not occur due to the volatile nature of the major contaminant of concern, vinyl chloride. These samples will be collected immediately from the split spoon, and properly packaged.

• Affix labels to the jar and complete Chain-of-Custody (COC) forms, Request for Analysis forms, and other required sample data forms. Protect samples against extreme temperature changes and breakage by placing them in appropriate cartons and stored in a protected area.

2.3.2 Decontamination Procedures

The following decontamination equipment will be used for the sludge sampling.

• H&S items (Section 8.0)

• High pressure steam cleaner

• Existing decontamination pad

• A source of uncontaminated water

• Various scrub brushes and scraping equipment for removing soil from the equipment

• Deionized (DI) water

• Alconox detergent

• Methanol

• 55-gallon drums for decontamination fluid collection.

Consistent uniformity and thoroughness of equipment decontamination are of major importance in this project. This will ensure a greater degree of validity for analytical results obtained from the sample collected.
The decontamination procedure for drilling and soil sampling equipment will consist of the following:

- Wash with high pressure steam cleaner using potable water
- Rinse with DI water
- Rinse with methanol
- Allow equipment to air dry completely before use.

These procedures will be performed prior to each new boring for all downhole tools such as augers, drill rods, and other drilling equipment. All decontaminated water will be temporarily stored on site in 55-gallon drums in the staging area.

2.3.3 Sample Preservation and Handling

The following specifications will be implemented for sample preservation and handling:

- All samples will be collected using the sampling method outlined in Section 2.3.1 of this work plan.

- Preservatives will not be added to samples.

- Samples will be cooled to a temperature of 4 degrees Centigrade to minimize loss of volatile organics and to retard biological activity during transport to the laboratory. Samples will be shipped to the laboratory within 24 hours.

- When the sample is to be analyzed in the laboratory for volatile compounds, care will be taken to minimize the loss of volatiles. Samples will be handled and stored in a manner to prevent the loss of volatile compounds. Sample containers will not be reopened until laboratory analysis is performed.

- Extracts will be prepared for analysis and analyzed as soon as possible following extraction. If they need to be stored, even for a short period of time, storage will be at 4°C, and samples for volatiles analysis will not be allowed to come into contact with the atmosphere.

Samples will be adequately marked for identification at the time of collection. Marking will be on the sample container, on a tag or label attached to the sample container, and in bound
field notebook or sample collection log form. Sample identification will include as a minimum:

- Project name and number
- Unique sample number
- Sampling location (e.g., boring, depth or sampling interval)
- Sampling date
- Name of sampling personnel.

Chain-of-custody (COC) documentation procedures will be followed for each sample. A COC record will be filled out by the sampling person at the time of sample collection. A carbonless copy of the COC record will be kept by the sampling person and the original COC record will accompany samples at all times and will eventually be placed in the project file after final sample disposition. All transfer of custody will be documented on this form.

Samples are considered to be under a person’s custody if:

- The samples are in his possession
- The samples are within view after being in possession
- The samples are sealed and placed in a secure area by the person last having custody.

When a cooler has been filled and is ready to be shipped, a custody seal will be taped onto the cooler in such a way that the cooler cannot be opened without breaking the seal. Similarly, if a cooler containing samples is for any reason out of the immediate custody and observation of the sampler, it will be locked up or sealed whether full or not.

2.4 Groundwater Sampling

2.4.1 Sample Collection

Individual groundwater samples will be collected from five existing monitoring wells on site. These wells are F-2, F-3, F-6, F-7, and F-9 (Figure 2-2). These wells were selected to represent the average quality of groundwater which may be recovered in a full scale pump and treat system. The individual samples will be composited at the laboratory to represent an average groundwater sample.
Before the samples are collected, the wells will be purged with stainless steel bailers of three casing volumes of water or until dry. All purge water will be stored temporarily on site in the existing staging area in 55-gallon drums. Within 24-hours of purging, the wells will be sampled using the stainless steel bailers. The wells will be purged sampled as described in the monitoring well sampling procedure (Appendix A). The samples will be collected into 1-gallon amber glass bottles. The bottles will be sealed with no headspace and will be immediately stored at 4°C.

### 2.4.2 Sample Preservation and Handling

The following specifications will be implemented for sample preservation and handling:

- All samples will be collected using the sampling method outlined in Appendix A of this work plan.

- Preservatives will not be added to samples.

- Samples will be cooled to a temperature of 4 degrees Centigrade to minimize loss of volatile organics and to retard biological activity during transport to the laboratory. Samples will be shipped to the laboratory within 24 hours.

- When the sample is to be analyzed in the laboratory for volatile compounds, care will be taken to minimize the loss of volatiles. Samples will be handled and stored in a manner to prevent the loss of volatile compounds. Sample containers will not be reopened until laboratory analysis is performed.

- Extracts will be prepared for analysis and analyzed as soon as possible following extraction. If they need to be stored, even for a short period of time, storage will be at 4 degrees Centigrade, and samples for volatiles analysis will not be allowed to come into contact with the atmosphere (no headspace).

All appropriate forms (field activity daily logs, sample collection logs, COC/request for analysis forms) will be completed similarly as discussed for the PVC sludge samples in Section 2.3.1. The sample labeling and COC procedures will be the same as outlined in Section 2.3.3.
3.0 In Situ Groundwater Oxidation-Reduction Potential

This work plan describes the proposed field test methods and procedures to evaluate the in situ oxidation-reduction potential of contaminants in the groundwater at the Woodlawn Landfill.

3.1 Test Objectives
The objective of this work plan is to evaluate the potential for an oxidation-reduction (redox) reaction to occur in situ in the on-site groundwater. This reaction may be a contributing factor to the detected reduction in site contaminants at the property line. This objective will be met by sampling and measuring the oxidation-reduction potential (ORP) levels in pairs of existing monitoring wells where the reduction in concentration of site contaminants have been detected.

3.2 Equipment and Materials
The following equipment and materials will be required for the redox potential procedures:

- Stainless steel well bailers
- Portable ORP meter
- pH measurement probe
- Conductivity probe
- Thermometer
- Water level probe
- Disposable beakers
- Coolers
- Sample containers
- Health and safety equipment (Section 8.0)
- Decontamination equipment (Section 2.3.2)
- QA/QC logs (Section 7.0)
- 55-gallon drums

3.3 Sample Collection
The groundwater sample collection task will be performed as described in the monitoring well sampling procedure (Appendix A). The groundwater sampling will be done in existing monitoring wells where the reduction in concentration of site contaminants have been detected. These wells are F-3, F-6, B-3, B-4, B-6, ITB-1, ITB-3, ITS-2, ITZ-1, OW-2, and P-506 (Figure 3-1). The redox potential levels will be measured in the field for the wells.
The samples will be collected into glass bottles, capped with no headspace, and iced immediately after collection. The samples will be transported within 24-hours air in a cooler refrigerated with blue ice to prevent off gas of volatiles.

3.4 Sample Preservation and Handling
The following specifications will be implemented for sample preservation and handling:

- All samples will be collected using the sampling method outlined in Appendix A of this work plan.
- Preservatives will not be added to samples.
- Samples will be cooled to a temperature of 4 degrees Centigrade to minimize loss of volatile organics and to retard biological activity during transport to the laboratory. Samples will be shipped to the laboratory within 24 hours.
- When the sample is to be analyzed in the laboratory for volatile contaminants, care will be taken to minimize the loss of volatiles. Samples will be handled and stored in a manner to prevent the loss of volatile contaminants. Sample containers will not be reopened until laboratory analysis is performed.
- Extracts will be prepared for analysis and analyzed as soon as possible following extraction. If they need to be stored, even for a short period of time, storage will be at 4°C, and samples for volatiles analysis will not be allowed to come into contact with the atmosphere (no headspace).

3.5 Sample Analysis
Preliminary analysis of data from the Phase III Groundwater Evaluation shows the following constituents as possible contaminants of concern:

- Vinyl Chloride
- Benzo(a)pyrene
- Benzo(a)anthracene
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Iron
- Manganese.
The tests will be conducted in accordance with the EPA "Guide for Conducting Treatability Studies Under CERCLA". The tests will be conducted under the classification of remedial screening tests to develop data for application in the RI/FS stage of a project.

### 3.6 Field ORP Measurement
Immediately after each groundwater sample is collected for laboratory analysis, a separate portion of the sample will be measured in the field for ORP level. The portion of sample used for ORP measurement will not be used in the analytical sample.

The field ORP measurement will be made by a laboratory technician experienced in the procedure. The measurement will be made using the procedure in Appendix B. Dedicated disposable beakers will be used to hold the sample. All field data (ORP, pH, temperature) will be recorded in the FADLs.

### 3.7 Data Analysis and Interpretation
After the laboratory analytical work is completed, the percent reduction of each target compound in the on-site and off-site monitoring wells will be calculated, this percent reduction will be compared to the difference in field ORP levels in the same wells. A reduction in target compounds along with a difference in ORP levels may indicate the potential for significant oxidation-reduction to be occurring in situ.
4.0 Soil Vapor Extraction Pilot Test

This field pilot study work plan describes the methods and procedures proposed to evaluate the in situ soil vapor extraction (SVE) of VOCs, including vinyl chloride, in the Cell A and B/C material at the Woodlawn Landfill. Preliminary analysis of data shows vinyl chloride as the major possible contaminant of concern at Cell B/C.

4.1 Technology Description

The application of SVE technology to the remediation of soils contaminated with VOCs is gaining wide acceptance. Not only is this method more effective than other alternatives, but, in many cases, it is also more cost-effective. Case histories are beginning to define the limitations of the technology as well as new applications for its use.

Limitations of SVE include such factors as soil properties, depth to groundwater, and chemical properties of the organic contaminants. All of these factors affect the rate of volatilization of an organic material adsorbed in the soil matrix. The feasibility of SVE can generally be determined by evaluating the geologic and vadose zone characteristics at a site and the contaminants involved. When uncertainty exists concerning the application of SVE, design of a full-scale remediation program is generally based on tests in the field.

SVE technology is based on the principle that VOCs vaporize to a state of equilibrium in the air spaces surrounding soil particles. If the air within the pore spaces is not replaced, these compounds remain trapped until leached by percolating water or until natural diffusion or other transport phenomenon occur. Natural transport processes are relatively slow. The SVE process creates a movement of air through the soil matrix which accelerates the process. The air movement is caused by a vacuum system that is connected to a series of vertical or horizontal wells completed in the vadose zone. Contaminated air is then vented to the atmosphere or discharged to a flare, boiler, catalytic convertor, or activated carbon canister.

4.2 Test Objectives

The objectives of the SVE pilot study on convective air flow are as follows:

- To assess effectiveness of SVE for VOCs/vinyl chloride removal
- To optimize and develop a full-scale design.
4.3 Equipment and Materials

The SVE pilot test setup will consist of the following major components:

- One extraction well (venting well)
- Soil probes (monitoring wells) to determine zone of influence and for soil-gas sampling
- A vacuum pump (blower) system to extract vapors from Cell B/C via the extraction well
- A piping system, set above grade, which would connect the extraction well into the vacuum pump
- A plastic liner to cover Cell B/C surface area to allow indirect VOC removal from landfill area and to prevent short circuiting of air
- Two 155-pound vapor carbon canisters to remove organics from effluent before discharge into atmosphere
- An air/water separator to control the entry of entrained particulates and moisture into the blower.

The soil probes arrangement and equipment for the pilot test are described below. A description of the soil probes and their relation to the extraction well is also provided.

Extraction Well. An extraction well will be installed using the hollow-stem auger drilling technique. The borehole for the well installation will be advanced using 4-inch inside diameter (ID) (approximately 8-inch outside diameter [OD]) augers advanced to a depth of 20 feet below grade. The well will be constructed of 2-inch ID, Schedule 40, polyvinyl chloride (PVC), flush-threaded riser with 0.02-inch slot screen placed from approximately 1 to 20 foot depth. The well will be completed flush with the surface grade.

After the well assembly has been placed into the hollow auger stem, a filter pack of course silica sand will be placed through the stem as the augers are gradually withdrawn from the boring. A bentonite seal will be placed above the filter pack followed by concrete to a depth of approximately 1 foot below the grade.
The upper end of the riser will be equipped with a wellhead connecting the riser to the vacuum blower. The wellhead will be equipped with several features for monitoring and sampling. This includes a 1/4-inch-threaded port to permit the measurement of flow rate using a hot-wire anemometer and hydrocarbon concentration sampling using a photoionization detector (PID).

The sample port will be sealed with a plug when not in use. The entire wellhead will be covered with a rectangular meter box for protection. This meter box will be set flush with grade and concreted in place.

**Soil Probes.** Three deep soil probes (10 feet deep) and seven shallow soil probes (2 feet deep) will be installed at the locations shown in Figure 4-1. The deep soil probes will be used for frequent soil-gas analyses and pressure measurements during the course of SVE pilot test operation.

The shallow soil probes will be installed for determination of the zone of influence. This will be done by measuring the vacuum pressure at these locations. These probes will be 2 inches in diameter with a 3/8-inch teflon tubing connecting the top end to the ground surface. The probes will be installed using the slambar technique. Details on deep soil probes are presented in Figure 4-2.

**Vapor Extraction System.** The piping from extraction well will be connected to a regenerative blower (Rotron® Model DR6R) (Figure 4-3). The pump will be powered by a 3 horsepower motor. The inlet piping will be equipped with a vacuum indicator and a gas sampling port. The blower exhaust will be connected to two activated carbon canisters placed in series before discharge to the atmosphere. The surface area of Cell B/C will be covered with a 6-mil polyethylene liner and sealed by pouring sand along the liner edges (Figure 4-1).

A hot-wire anemometer will be used to measure the linear flow of air from the extraction well. The anemometer probe will be inserted through the sampling port in the suction piping using a rubber stopper to seal the hole. A dual-valve arrangement will be provided in the suction piping to allow ambient air to be bled into the blower suction. This will be done to control the vacuum being pulled on the extraction well.
Field analysis of the exhaust gases will be performed using a field gas chromatograph (GC). An inclined, oil-filled manometer will be used to measure the vacuum induced at each soil probe. The manometer will be connected by rubber tubing to each individual soil probe.

4.4 Sample Collection
The blower will be cycled through a series of vacuum settings, described in Section 4.7, while pressure, temperature, and flow rate are continually monitored. During each cycle, samples and measurements at the blower intake, exhaust, and soil probes will be taken.

The deep soil probes will be used to assess the effectiveness of SVE within Cell B/C. The locations of these probes are given in Figure 4-1. Vapor samples will be collected from the deep soil probes. The vapor samples will be collected by passing 3.0 liters of soil-gas through a carbon sorbent tube attached to the end of the probe via a stainless steel/teflon fitting. The sorbent tubes are activated charcoal with 100 mg in front and 50 mg in a backup section. They are manufactured by SUPELCO ORBO-32. The opposite end of the sorbent tube will be attached to an airtight volumetric 0.5-liter syringe. The sorbent tube is a 2.5-inch-long, glass, double-tapered cylinder. Teflon fittings are attached to both ends. The glass tube has an outside diameter of 1/4 inch and is filled with sorbent (charcoal). VOC vapors present within the soil-gas will be trapped by the sorbent. This effectively concentrates the vapors for subsequent analysis.

4.5 Sample Preservation and Handling
Following sample collection from deep soil probes, the sorbent tubes will be capped, labeled, placed into a secondary sealed container (Ziploc bag), and shipped via overnight carrier to the laboratory for analysis. Sampling information, including sample number, location, date of sampling, and other pertinent information, will be recorded in a field notebook and maintained at the laboratory. The trapped VOCs in the tubes will be stable at ambient temperatures. Because the soil-gas components are adsorbed by the charcoal sorbent, no condensation of the compounds will occur. The samples will be analyzed within one week of collection.
4.6 Sample Analysis

4.6.1 Carbon Sorbent Tubes
The laboratory methodology will consist of carbon disulfide (CS$_2$) desorption of the VOCs trapped in the sorbent tubes. The front section of the sorption tube carbon (100 mg) will be desorbed using 0.5 milliliter (ml) of CS$_2$ and agitated for 30 minutes before analyses. Two microliters (ul) of desorbed sample will be chromatographed via a high-resolution capillary column and subsequently detected utilizing a GC equipped with flame ionization detector (FID). This methodology is an adapted version of the standard National Institute of Occupational Safety and Health (NIOSH) method. The use of a high-resolution capillary column maximizes the separation and resolution of VOCs present in the soil-gas, enhancing the quantification of the "target" compounds. The lower detection limit for VOCs, including vinyl chloride, will be determined in the laboratory. The summed FID response for total VOCs will be estimated.

4.6.2 Field Gas Chromatograph
A Photovac Model 10S5O portable GC equipped with PID and a 4-foot-by-1/8-inch SE-30 (100/120 mesh) column will be used to analyze the total hydrocarbon concentration in the extraction well blower intake. A gas-tight syringe will be used to collect and inject the sample into the GC. A single-point calibration based on the field-generated vinyl chloride standard will be used to quantitate the hydrocarbon peaks detected in the sample.

4.7 Field Testing Protocol
The pilot test will be performed as follows and will be repeated for three consecutive days. This will provide information to relate effects of soil moisture on the zone of influence and SVE efficiency.

- Initial vacuum readings and soil-gas sampling will be taken on the blower intake (extraction well), blower effluent, canister exhaust into the atmosphere, and the deep soil probes to establish a background set of data. The samples from deep soil probes will be taken for field and laboratory GC analysis.

- The vacuum pump will be started with the air bleed valve fully open. A vacuum of 20 inches of water will be established on extraction well.
After running for 10 minutes, the vacuum on the soil probes, temperature, and an air flow rate on blower intake will be measured and recorded.

After running for 10 minutes, the air samples from blower intake and effluent and exhaust will be taken for GC field analysis.

After 30 minutes, the vacuum pump will be shut down and an air sample will be taken from deep soil probes for field and laboratory GC analysis.

After 60 minutes of operation, the well vacuum will be increased to 30 inches of water. The air flow, vacuum pressure, and temperature on the soil probes and the blower will be measured. After the last probe reading is recorded, the first probe is reconnected to the manometer to determine if equilibrium is achieved.

After 95 minutes of operation, the well vacuum will be increased to 35 inches of water. The air flow, vacuum, and temperature on the soil probes and blower intake will be measured. Again, the first reading will be checked to confirm stabilization.

After 135 minutes of operation, the well vacuum is increased to 40 inches of water. The vacuum pump will be momentarily shut down and air samples from deep soil probes will be taken for field and laboratory GC analysis.

After 255 minutes of operation, the air flow, vacuum, and temperature readings at the blower intake and soil probes will be recorded. The first reading will be checked to confirm stabilization. Additionally, soil-gas samples from blower intake, effluent, and exhaust from the canister will be taken for field GC analysis.

After 275 minutes, the well vacuum will be increased to 45 inches of water. The air flow rate, vacuum, and temperature readings will be recorded. The first reading again will be checked.

After 300 minutes of operation, the well vacuum will be increased to 50 inches of water. The air flow rate, vacuum, and temperature readings will be recorded. The first reading will be checked for verification.

After 325 minutes of operation, the well vacuum will be increased to 60 inches of water. The air flow rate, vacuum, temperature readings will be recorded. The first reading will be verified. Additionally, the final air samples from blower intake and effluent and canister exhaust will be taken for field GC analysis.
• After 345 minutes of operation, the vacuum pump will be shut down and final air samples from deep soil probes will be taken for field and laboratory GC analysis.

• The above procedure will be repeated for two more consecutive days.

4.8 Data Analysis and Interpretation
Results and recommendations from this pilot test will be compiled. If this pilot study indicates SVE is a viable technology, it will be considered for further evaluation in the detailed alternative analysis of alternatives. Additionally, the data may be used to optimize and develop a full-scale design.

4.9 Permitting
An air emission permit may be required from the state of Maryland for the discharge from the vacuum blower. Based on experience from other SVE tests, a permit variance may be granted for a short-term pilot test. Any required permit or variance will be acquired before the test is begun.
5.0 **UV/Ozone/Peroxide Oxidation**

This treatability study work plan describes methods and procedures proposed to evaluate the ultraviolet/ozone/peroxide oxidation (UV oxidation) treatment of the groundwater at the Woodlawn Landfill.

5.1 **Technology Description**

UV oxidation is an advanced oxidation process (AOP) utilizing ultraviolet with ozone and/or hydrogen peroxide. Ultraviolet light, when combined with O\(_3\) and/or H\(_2\)O\(_2\) produces a highly oxidative environment significantly more destructive than that created with O\(_3\) or H\(_2\)O\(_2\) by themselves or in combination.

UV light significantly enhances ozone or H\(_2\)O\(_2\) reactivity by:

- Transformation of O\(_3\) or H\(_2\)O\(_2\) to highly reactive (OH) radicals
- Excitation of the target organic solute to a higher energy level
- Cleavage of chemical bonds to destroy the target compound.

Table I (Appendix D) illustrates the relative oxidant strength of hydroxyl radical (OH) versus O\(_3\), H\(_2\)O\(_2\), and Cl\(_2\). Figure I (Appendix D) illustrates the theoretical reaction pathway for the destruction of chlorobenzene that was developed by ULTROX under a research grant from the National Science Foundation.

5.2 **Test Objectives**

The objective of this treatability test is to evaluate the feasibility of using UV oxidation for the destruction of volatile organic compounds (VOC), including vinyl chloride, in the groundwater. As part of this evaluation, the optimum operational parameters for the destruction of the vinyl chloride in the groundwater will be determined.

The specific objectives of the treatability study are as follows:

- To determine if the target contaminants can be significantly reduced economically with UV oxidation
- To identify appropriate dosage of ozone and/or hydrogen peroxide and UV radiation exposure to reach discharge limits
To provide equipment recommendations and capital, operating, and maintenance costs for a UV oxidation system.

The tests will be conducted in accordance with the EPA "Guide for Conducting Treatability Studies Under CERCLA". The tests will be conducted under the classification of remedial screening tests to develop data for application in the RI/FS stage of a project.

5.3 Equipment and Materials

The bench-scale test includes the following equipment and materials:

- A batch reactor
- An ultraviolet radiation lamp
- Hydrogen peroxide
- Ozone and an ozone generator.

The bench-scale oxidation apparatus is made up of a reactor (2.5 L capacity), UV light source, and ozone generator.

**Reactor.** The reactor consists of a cylindrical 500 mm x 80 mm glass vessel with a capacity of 2.4 liters (Appendix D). The reactor is charged with 2 liters of water to be treated. One 40 watt low pressure mercury arc lamp inside a quartz sheath is placed in the center of the vessel so as to permit stirring by a magnetic stirrer. A sparger (gas dispersion tube with a coarse frit) is inserted at the bottom of the reactor and O$_2$-O$_3$ is introduced from the sparger at a predetermined O$_2$-O$_3$ flow rate. For those runs in which H$_2$O$_2$ is also used, the calculated volume of 35% H$_2$O$_2$ is added and mixed for 4-5 minutes before turning on UV light and introducing O$_3$.

**Ozone Generator.** Ozone is being generated by a 2 lb. per day O$_3$ generator Model No. 8341 manufactured by Matheson Gas Products.

**General.** All bench scale testing is done in a laboratory hood equipped with a catalytic ozone decomposer.

**Analytical Equipment.** The ULTROX laboratory is equipped with three gas chromatographs:
• Perkin Elmer Model 8500 equipped with LSC-2 Liquid Sample Concentrator, Model 1000 Hall Detector, and FID detector
• SRI Model 8010 equipped with FID and PID Detector
• Varian Model 1440 equipped with G3Ni Electron Capture Detector.

5.4 Sample Collection
Water will be collected in one gallon glass bottles, capped with no headspace, and iced immediately after collection for shipment to ULTROX. The samples will be transported overnight air in a cooler refrigerated with blue ice to prevent off gas of volatiles. The specific groundwater sample purging, collection, preservation, handling, and shipment procedures are described in Section 2.4.

5.5 Sample Analysis
Prior to the start of the test, ULTROX will analyze the sample feed for the target parameter listed below. These methods will be used in analysis of feed, test interval, and confirmation samples.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>ANALYSIS</th>
<th>METHOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halogenated VOCs</td>
<td>GAC</td>
<td>EPA 601</td>
</tr>
<tr>
<td>Aromatic Hydrocarbons</td>
<td>GAC</td>
<td>EPA 602</td>
</tr>
<tr>
<td>Phthalates</td>
<td>Extraction &amp; Purge and Trap</td>
<td></td>
</tr>
<tr>
<td>Ketones</td>
<td>Extraction &amp; Purge and Trap</td>
<td></td>
</tr>
</tbody>
</table>

5.6 Test Procedure
The reactor is placed on a magnetic stirrer, charged with 2 liters of a water sample to be oxidized, and the calculated volume of 35% \( \text{H}_2\text{O}_2 \) is mixed in through a glass tubing extending 280 mm below the surface of the water. Then the UV light is turned on and \( \text{O}_2\text{-O}_3 \) is introduced through a sparger. The ozone dose being added is monitored by a flow meter with 10 ml to 2000 ml/min capacity. Aliquots of the oxidized water are withdrawn at predetermined intervals through an exit port (glass stopcock) located 150 mm from the bottom of the reactor.
Partially treated 40 ml samples will be drawn from each test after predetermined time intervals of UVR exposure and will be analyzed for the phenolic compounds. In total, ULTROX will conduct approximately 5 batch tests with 3 samples collected and analyzed per test run.

5.7 Treatability Test Plan
Five bench-scale batch tests will be run with three oxidant combinations: 1 test with hydrogen peroxide, 1 test with ozone and 3 tests with hydrogen peroxide and ozone. The ratios and concentrations of the oxidants will be varied in each test (Appendix D). Subsequent tests will vary in oxidant dosing depending on the results of previous tests.

5.8 Data Analyses and Interpretation
The UV oxidation treatability results will aid in determining whether the technology is effective in reducing the concentration of contaminants below discharge levels. The test results will also provide data on the optimum operational design parameters.
6.0 Thermal Treatment

This treatability study work plan describes methods and procedures proposed for the thermal treatment testing of the Cell A and B/C material at the Woodlawn Landfill.

6.1 Test Objectives

The objective of this treatability test is to evaluate the feasibility of using low temperature thermal desorption or incineration to reduce the concentration of vinyl chloride in the Cell B/C material. In order to reach this objective, the following tests will be performed:

- Preliminary test: In this test, one sample is heated at various temperatures at a consistent burn time. The test will provide preliminary information on the waste burning characteristics to assist in selecting the most effective temperatures for desorption and incineration.

- Screening test: Based on the temperatures provided in the preliminary test, the sample will be heated in this test for various retention times. Two other samples will then be tested at the selected time and temperature.

- Confirmatory test: In order to closely approximate the actual desorption and incineration conditions, two rotating thermal apparatus (RTA) tests will be performed at the selected time and temperature.

The tests will provide the following information on the test materials:

- Vinyl chloride reduction for desorption and incineration
- Determination of optimum temperature and time for desorption and incineration
- Physical characteristics (slagging)
- Estimation of residual characteristics for ash disposal.

The tests will be conducted in accordance with the EPA "Guide for Conducting Treatability Studies Under CERCLA". The tests will be conducted under the classification of remedy screening tests to develop data for application in the RI/FS stage of a project.
6.2 Equipment and Materials

The experimental apparatus for the test program consists of a Lindberg Model 51848 muffle furnace with an electronic temperature controller and a 1,600-watt heater. The oven has double-shell construction with interior surfaces made of Moldatherm®, a molded aluminum-silicate insulation material. This oven is capable of operating at temperatures to 1,100°C and has a relatively fast heat-up rate due to its low mass. The interior space is approximately 2.9 in. wide x 4.3 in. high x 8.3 in. deep. A loose block (1/2 in. thick) of Moldatherm is placed on the bottom of the oven to provide additional separation between the tray and the hot interior surface of the oven.

A specially made tray is used to contain the waste sample within the oven. The tray which weighs approximately 430 grams is 3.5 in. wide x 1.3 in. high x 7.6 in. long and is constructed of Incology to resist oxidation during high-temperature tests.

During the test, the oven will be continuously purged with nitrogen which is introduced through a 3/8-inch diameter Incology tube in the back wall of the oven. The purge gas is directed against the back wall to promote even heating and distribution. The purge gas flow rate is measured with a standard rotameter and maintained at approximately 90 cc per minute during the test.

Two thermocouples are used to measure temperature. One is an NBS traceable type K sheathed thermocouple placed approximately 3 centimeters above the test material at the center of the oven. This thermocouple is used to measure the temperature within the test matrix. The thermocouples and the oven temperature indicator are calibrated using a wet test meter. Temperatures are recorded using a multipoint recorder. Experimental test times are measured using a quartz digital chronometer.

6.3 Sample Collection

A total of six (6) PVC sludge samples will be collected from three (3) soil borings. Details on sample collection are presented in a separate work plan for field sampling (Section 2.3).

6.4 Sample Preservation and Handling

Sample preservation and handling will be performed as detailed in Field Sampling Plan (Chapter 2.0).
6.5 Sample Analysis
The samples will be analyzed for vinyl chloride before and after implementation of each tray test and each RTA test. The following quality control procedures will be conducted:

- All data, including quality assurance data, will be maintained and available for reference or inspection.
- Untreated and treated waste samples from the tray testing program will be analyzed for vinyl chloride using Method 8010.
- To ensure the quality of the data, a blank, a matrix spike and a matrix spike duplicate will be analyzed for every set of 20 samples.
- All quality control measures described for the thermal treatment method will be followed.
- In addition to the vinyl chloride analysis, the weight loss of the sample will be calculated and visual observations of the residue for slagging and charring will be made.

Ash residues from all thermal testing will be analyzed for vinyl chloride. Ash residue from the RTA test will be subjected to TCLP testing for full scan of parameters. The TCLP testing will be used to confirm the anticipated nonhazardous characteristics of the ash.

6.6 Preliminary Tests
As discussed in Chapter 2.0, six samples of PVC sludge waste from Cell B/C will be collected for use in the thermal treatment test. All six samples will be initially analyzed for vinyl chloride. Based on this initial analysis, three typical samples will be selected for testing. The selected samples may be those with the highest, average and lowest vinyl chloride concentration. The selection will also be based on those samples which most visually or physically represent the PVC sludge. Any sample with a non-detect concentration of vinyl chloride will not be selected.

One of the selected samples will be subjected to the preliminary thermal tray test. This test will provide preliminary information on the waste burning characteristics to assist in selecting the most effective temperatures for desorption and incineration. Temperatures selected in the preliminary test will provide the basis for the screening test.
The preliminary test will be performed with a small quantity (100 grams) of waste from the selected sample. The waste will be placed in a static tray and heated in the laboratory furnace for five minutes at each of the following temperatures; 100, 250, 400 and 550°C. The test will be performed in accordance with the standard operating procedures outlined in Appendix D. The test will provide screening information on the ash slagging characteristics and percent volatilization of waste as it is heated. Physical characteristics such as mass, volume and appearance, as well as concentration of vinyl chloride, will be measured and recorded before and after the test at each temperature. Observations will also be noted as the material is heated. Based on this preliminary test, the optimum temperatures for desorption and incineration will be selected for the screening test.

6.7 Screening Test
Based on the temperatures selected from the preliminary test, a screening test will be performed to select the optimum burn time for desorption and incineration. The same waste sample used for the preliminary test will be used for the screening test. A small quantity of waste (100 grams) will be placed in a static tray and heated at the selected desorption temperature for each of the following burn times; 5, 10 and 20 minutes. The same procedure will be followed for a portion of sample heated at the selected incineration temperature. The burn times may be modified based on the results of the preliminary test. The tests will be performed in accordance with the standard operating procedures outlined in Appendix D. The same measurements, observations, and analytical work described in the preliminary test will be performed in the screening test.

After the first run of the screening test is performed as described above, the test will be repeated using the other two typical samples selected for testing. These samples will only be run at the selected desorption temperature and burn time and the selected incineration temperature and burn time. The tests will be performed in accordance with the standard operating procedures outlined in Appendix D. The same measurements, observations and analysis described above will be performed. These tests will be used to verify the treatment characteristics of the waste with varying initial waste conditions.

6.8 Rotary Thermal Apparatus Test
Two rotating thermal apparatus tests will be performed on one selected sample using the optimum temperature and burn times for desorption and incineration. These tests will be
performed to more closely approximate the actual desorption and incineration conditions. The tests will be used to confirm the results of the tray tests. The RTA test operates under dynamic conditions in contrast to the tray test which operates under static conditions.

The RTA tests will be performed in accordance with the standard operating procedures outlined in Appendix E. The physical characteristics of the waste will be measured before and after the tests. Other observations of the waste condition will also be noted. The residual ash from both tests will be subjected to full TCLP analysis as well as vinyl chloride content. The TCLP test will be used to characterize the ash for disposal options.

6.9 Data Analysis and Interpretation

The thermal treatment treatability results will aid in determining whether thermal processing of the PVC sludge will reduce the concentration of vinyl chloride to below the potential action levels and to determine the characteristics of the residue for disposal purposes. This treatability study will also investigate any slagging problems that may occur from thermal treatment of PVC sludge.
7.0 Data Management

The ongoing data management process developed for the project and described in detail in the Phase II Report will be continued for the treatability studies. The objectives and procedures to achieve these objectives will remain the same.

The standard IT quality assurance/quality control (QA/QC) data management procedures will be followed for the field sampling tasks of this project. These procedures are described in the updated quality assurance project plan (QAPP).

The standard IT laboratory data management procedures shall be followed for the analytical tasks of this project. These procedures are also outlined in the QAPP which was previously approved by the agency.
8.0 Health and Safety

The approved health and safety (H&S) plan prepared for the RI drilling and sampling tasks has been updated. The plan will follow the requirements for borings in waste with minor modifications.

The standard IT laboratory health and safety procedures will be followed for the analytical tasks of this project. These procedures are also outlined in the QAPP previously submitted to the agency.
9.0 Residuals Management

All residual samples from the laboratory testing program will be disposed of in accordance with the standard IT laboratory procedures. The procedure provides for short-term holding of material at the laboratory and eventual disposal. Drill cuttings generated during drilling and sampling will be placed into labeled drums and stored on site until arrangements are made for U.S. EPA-approved disposal.
10.0 Reporting

A report will be prepared to summarize the results of the studies described in Chapters 3.0 through 6.0 of this work plan. This report will be included as an appendix to the Final Feasibility Study Report for the Woodlawn Landfill. The report will include the following:

- Experimental procedures
- Analytical results data
- Conclusion and recommendations.
Sexton (Parcel 530, 16 acres)

Approximate limits of property

Woodlawn Landfill (Parcel 287, 37.06 acres)

Hinder (Parcel 304, 4.7 acres)

Waibel (Parcel 303, 45.012 acres)

Craft (Parcel 506, 2.91 acres)

MCP Enterprises, Inc. (Parcel 66, 48.83 acres)

Legend:
- Soil monitoring well installed by firestone
- Soil monitoring well installed by Cecil County
- Soil monitoring well installed by the State of Maryland
- Bedrock well (TSTA-1 installed by Cecil County)
- Bedrock well installed by IT Corporation
- Soil well installed by IT Corporation
- Perched water well installed by IT Corporation
- Soil piezometer installed by IT Corporation
- Proposed monitoring well for sampling

Figure 2-2

Proposed monitoring wells for groundwater sampling

Prepared for

Woodlawn Landfill R/FF

Treatability studies

International Technology Corporation
LEGEND:

- **S25**: Shallow soil probe, 25' from extraction well
- **D50**: Deep soil probe, 50' from extraction well
- **EW**: Extraction well

**SCALE**

0 100 200 400

**FIGURE 4-1**
Extraction well and soil probes arrangement
SVE pilot test

Prepared for
Woodlawn Landfill RI/FS
Treatability Studies

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"Do Not Copy This Drawing"
NOTES:

1. END CAPS THREADED INTO PROBE. NO GLUE USED

2. DRAWING NOT TO SCALE

FIGURE 4-2

SOIL PROBE DETAILS
SVE PILOT TEST

PREPARED FOR
WOODLAWN LANDFILL RI/FS
TREATABILITY STUDIES

INTERNATIONAL TECHNOLOGY CORPORATION

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"Do Not Scan This Drawing"
Figure 4-3
Process Flow Diagram
SVE Pilot Test
Prepared for
Woodlawn Landfill RI/FS
Treatability Studies
International Technology Corporation
APPENDIX A

MONITORING WELL SAMPLING PROCEDURE
Monitoring Well Sampling Procedure

Monitoring wells will be sampled using a stainless steel bailer in all cases. Temperature, conductivity, and pH measurements will be taken at regular intervals. Readings will be taken at intervals of approximately 5 gallons of purged water until the temperature, conductivity, and pH are stabilized. For wells that can be purged or bailed to dryness, the well will be evacuated a minimum of two casing volumes and allowed to recover prior to sample withdrawal. Except for those monitoring wells that can be pumped or bailed to dryness, a minimum of three casing volumes will be purged prior to sampling. The wells will be purged according to the procedure established in Section 6.3.1 of the QAPP. Water removed during purging and sampling activities will be held on site pending evaluation of specific management options for removal/disposal.

After purging, monitoring well groundwater samples will be collected according to the procedures identified in Section 6.3 of the QAPP by pouring from the bailer directly to the appropriate sample bottles. Samples designated for inorganic analyses will be poured directly from the bailer into the filtering apparatus and filtered with a 0.45 micron filter prior to preparation for shipment to the laboratory. Each groundwater sample collected will be measured in the field for pH, specific conductance and temperature. These field tests will be completed with properly calibrated equipment as per Section 6.5.1 of the QAPP. Each set of samples will be labeled at the time of collection and stored in a cooler with ice to maintain a temperature of approximately 4 degrees Celsius until final packaging is completed for shipment of samples to the laboratory.

Sampling pumps and bailers will be decontaminated after collection of groundwater samples at each monitoring well location. The decontamination procedure consists of pumping a minimum of five gallons of clean tap water through the pump and discharge line and rinsing the outside of the pump and discharge line with clean tap water. This step will be followed by a final rinse with deionized water of the outside of the pump and discharge hose and pumping a minimum of five gallons of deionized water through the pump. Bailers will be decontaminated by steam cleaning and washing with a nonphosphate detergent and water followed by a tap water rinse, deionized water rinse, methanol, total air drying, and a final deionized water rinse. Field test equipment probes (pH, specific conductance, and temperature) will be decontaminated with deionized water after each use.
Groundwater samples collected will be maintained by IT chain-of-custody protocol as specified in the QAPP from the time of collection to disposal of the samples after laboratory analyses are completed. These procedures required that each sample be recorded on a Chain-of-Custody form. This completed form will accompany the samples after collection to the laboratory. In addition, each sample will be recorded on a Request of Analysis form which identifies the analytical program to be completed for each sample collected. A sample collection log will be completed for each sample collected. These logs will be used to record specific sample collection information (including water level readings). Sample collection logs will be maintained in the project files.
Memorandum

Shahzad Niaki

Craig Lang

Project

Firestone: Oxidation Reduction Potential (Field Measurement)

General:

ORP is proportional to the cumulative oxidation state of a solution. Under controlled conditions, this may be indicative of the presence of oxygen in solution. However, a mildly acidic solution may exhibit a high ORP in the absence of oxygen. It is therefore critical that pH data be collected in conjunction with ORP. In any case, ORP should not be used as a sole indicator of the presence or absence of oxygen in groundwater samples.

Calibration:

Unlike pH electrodes, ORP electrodes undergo no changes of zero-point nor of slope and therefore do not require routine calibration. Manufacturer direction should be followed with respect to storage and cleaning of the electrode. Proper electrode functioning can be checked periodically, however this is a complicated procedure not suitable to being conducted in the field. Manufacturer directions generally describe this procedure in detail.

Sample Measurement:

Because ORP in groundwater samples is often transitory upon atmospheric exposure, agitation during sample collection should be minimized. Immerse the ORP electrode into the sample and swirl gently. Allow the mv reading on the meter to stabilize (this may require 1-2 minutes). Some drift in the mv reading may be encountered as the sample warms or becomes oxidized from atmospheric exposure.

Because ORP is dependent upon pH and temperature these parameters will also require determination.

cc: D. Graves
ULTROX INTERNATIONAL

LABORATORY STUDY PROPOSAL

FOR

I.T. CORPORATION, PENNSYLVANIA

Submitted by:

Bill Himebaugh
January 14, 1992
I. TECHNOLOGY DESCRIPTION

Ultraviolet oxidation is an enhanced or advanced oxidation process (AOP) utilizing ultraviolet with ozone and/or hydrogen peroxide. Ultraviolet light, when combined with O₃ and/or H₂O₂ produces a highly oxidative environment significantly more destructive than that created with O₃ or H₂O₂ by themselves or in combination.

UV light significantly enhances ozone or H₂O₂ reactivity by:

i) Transformation of O₃ or H₂O₂ to highly reactive (OH)⁻ radicals;

ii) Excitation of the target organic solute to a higher energy level; and

iii) Cleavage of chemical bonds to destroy the target compound.

Table I illustrates the relative oxidant strength of hydroxyl radical (OH)⁻, versus O₃, H₂O₂ and Cl₂. Figure I illustrates a theoretical reaction pathway for the destruction of chlorobenzene that was developed by ULTROX under a research grant from the National Science Foundation.
<table>
<thead>
<tr>
<th>Relative Oxidation Potential (Cl2 = 1.0)</th>
<th>Species</th>
<th>Oxidation Potential (Volts)</th>
</tr>
</thead>
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</tr>
<tr>
<td>0.39</td>
<td>iodine</td>
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FIGURE 1: REACTION PATHWAY OF CHLOROBENZENE

OZONE AND HYDROGEN PEROXIDE (H₂O₂) REACT WITH CHLOROBENZENE TO FORM CHLOROPHENOL. CHLOROPHENOL FURTHER REACTS WITH OZONE TO FORM GLYXAL, WHICH CAN ALSO BE FORMED BY THE REDUCTION OF MALIC ACID. MALIC ACID CAN BE FORMED FROM TRIHYDROXY BENZENES. THE OXIDATION OF CHLOROBENZENE RESULTS IN THE FORMATION OF FORMIC ACID AND OXALIC ACID.
II. TEST OBJECTIVES

The objectives of the treatability study are as follows:

1. To determine if the targeted contaminants can be significantly reduced economically with UV/oxidation;

2. To identify appropriate dosages of ozone and/or hydrogen peroxide and UVR exposure to reach POTW discharge limits;

3. To provide equipment recommendations and capital, operating, and maintenance costs for a UV/oxidation system.
III. EQUIPMENT AND MATERIALS

A. The bench scale test includes the following equipment and materials:
   - a batch reactor
   - an ultraviolet radiation lamp
   - hydrogen peroxide
   - ozone and an ozone generator

The bench scale oxidation apparatus is made up of a reactor (2.5 L capacity), UV light source, and ozone generator.

Reactor. The reactor consists of a cylindrical 500 mm x 80 mm glass vessel with a capacity of 2.4 liters. (See the attached drawing.) The reactor is charged with 2 liters of water to be treated. One 40 watt low pressure mercury arc lamp inside a quartz sheath is placed in the center of the vessel so as to permit stirring by a magnetic stirrer. A sparger (gas dispersion tube with a coarse frit) is inserted at the bottom of the reactor and O₃ is introduced from the sparger at a predetermined O₃ flow rate. For those runs in which H₂O₂ is also used, the calculated volume of 35% H₂O₂ is added and mixed for 4-5 minutes before turning on UV light and introducing O₃.

Ozone Generator. Ozone is being generated by a 2 lb. per day O₃ generator Model No. 8341 manufactured by Matheson Gas Products.

General. All bench scale testing is done in a laboratory hood equipped with a catalytic ozone decomposer.
B. **Analytical Equipment**

The ULTROX laboratory is equipped with three gas chromatographs:

1. Perkin Elmer Model 8500 equipped with LSC-2 Liquid Sample Concentrator, Model 1000 Hall Detector, and FID detector.

2. SRI Model 8010 equipped with FID and PID Detectors.

3. Varian Model 1440 equipped with CNi Electron Capture Detector.
Ozone generator emits 2% O₃/O₂ off gas connected to lamp ballast through a silicone rubber stopper. Off gas is directed to hydrogen peroxide traps. Hydrogen peroxide is then connected to a low pressure UV lamp. A water line is connected to the lamp, and a 2-liter glass column is used for the treatment. A glass frit and sample port are also present. A magnetic stirrer is used on the assembly.

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Ultrox International
Bench Scale UV/Oxidation Treatment Assembly

Tolerances

<table>
<thead>
<tr>
<th>DECIMAL</th>
<th>FRACTIONAL</th>
<th>ANGULAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>±</td>
<td>±</td>
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</tr>
</tbody>
</table>

Drawn by: M. Molian
Scale: None
Material: AROF

Date: 10/23/99

Next Assy Used On: 1 of 1

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IV. EXPERIMENTAL PROCEDURES

The treatability test is broken into the following tasks:

A. **Sample Collection and Shipping**

Water should be collected by the client or client’s consultant and, preferably, will be collected in five one gallon glass bottles and capped with no headspace and iced immediately after collection for shipment to ULTROX. Ideally the samples should be transported overnight air in a cooler refrigerated with blue ice to prevent off gas of volatiles.

B. **Sample Analyses**

Prior to the start of the test, ULTROX will analyze the sample feed for the targeted parameters listed below. These methods will be used in analysis of feed, test interval, and confirmation samples.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>ANALYSIS</th>
<th>METHOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halogenated VOCs</td>
<td>GAC</td>
<td>EPA 601</td>
</tr>
<tr>
<td>Aromatic Hydrocarbons</td>
<td>GAC</td>
<td>EPA 602</td>
</tr>
<tr>
<td>Phthalates</td>
<td>Extraction &amp; Purge and Trap</td>
<td></td>
</tr>
<tr>
<td>Ketones</td>
<td>Extraction &amp; Purge and Trap</td>
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</tbody>
</table>

C. **UV/Oxidation Bench Test**

The reactor is placed on a magnetic stirrer, charged with 2 liters of a water sample to be oxidized, and the calculated volume of 35% H₂O₂ is mixed in through a glass tubing extending 280 mm below the surface of the water. Then the UV light is turned on and O₂-O₃ is introduced through the sparger. The ozone dose being added is monitored by a flow meter with 10 ml to 2000 ml/min capacity. Aliquots of the oxidized
water are withdrawn at predetermined intervals through an exit port (glass stopcock) located 150 mm from the bottom of the reactor.

Partially treated 40 ml samples will be drawn from each test after predetermined time intervals of UVR exposure and will be analyzed for the phenolic compounds. In total, ULTROX will conduct approximately 5 batch tests with 3 samples collected and analyzed per test run.

D. Treatability Test Plan

It is expected that five bench scale batch tests will be run with three oxidant combinations: 1 test with hydrogen peroxide, 1 test with ozone and 3 tests with hydrogen peroxide and ozone. The ratios and concentrations of the oxidants will be varied in each test (see Table II).

Subsequent tests will vary in oxidant dosings depending on the results of previous tests.
TABLE II

SAMPLE TEST MATRIX

<table>
<thead>
<tr>
<th>Run</th>
<th>Time</th>
<th>UV</th>
<th>Ozone</th>
<th>Hydrogen Peroxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30 min</td>
<td>On</td>
<td>500</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>45 min</td>
<td>On</td>
<td>750</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>30 min</td>
<td>On</td>
<td>0</td>
<td>750</td>
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<tr>
<td></td>
<td>45 min</td>
<td>On</td>
<td>0</td>
<td>750</td>
</tr>
<tr>
<td>3</td>
<td>30 min</td>
<td>On</td>
<td>500</td>
<td>250</td>
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<td></td>
<td>45 min</td>
<td>On</td>
<td>750</td>
<td>250</td>
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<tr>
<td>4</td>
<td>20 min</td>
<td>On</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>40 min</td>
<td>On</td>
<td>500</td>
<td>250</td>
</tr>
<tr>
<td>5</td>
<td>0.5 best</td>
<td>On</td>
<td>0.5 best</td>
<td>best</td>
</tr>
<tr>
<td></td>
<td>best</td>
<td>On</td>
<td>best</td>
<td>best</td>
</tr>
</tbody>
</table>

Note:

All concentrations above are expressed in milligrams of oxidant per liter of sample. Oxidation ratios and concentrations may be varied depending on the type and concentration of organics actually in the water ULTROX receives for testing and on the treatment results obtained. The term "best" indicates the time or oxidant concentration determined to be most effective based on interpolation or extrapolation of the results of the previous tests. In each test, the H$_2$O$_2$ is added at the beginning of the test. Because H$_2$O$_2$ is soluble in water, the total concentration introduced in the beginning remains constant. Because ozone has a low solubility, it is introduced at a continuous rate and therefore increases over the duration of each test.
APPENDIX D

THERMAL TRAY TEST PROCEDURE
1.0 Purpose and Application

1.1 This SOP describes the operation of the Lindberg muffle furnace for the thermal desorption of samples in trays.

1.2 This procedure applies to all tests performed for projects requiring thermal desorption tray testing.

1.3 Modifications to this procedure are permitted on a project specific basis provided that the changes provide an equivalent method of operation. All such modifications must be approved by the project manager and described as a variance in the project QA plan.

2.0 References

2.1 None

3.0 Associated SOPs and Applicable Methods

3.1 ITAS-TDL SOP No. 100, "Use of Glass S Weights."

3.2 ITAS-TDL SOP No. 102, "Calibration of Thermometers."

3.3 ITAS-TDL SOP No. 103, "Balance Calibration Checks."

3.4 ITAS-TDL SOP No. 200, "Sample Handling and Storage."

3.5 ITAS-TDL SOP No. 201, "Sample Receipt, Coding and Tracking formerly SOP No. DM.1, Sample Tracking)."
4.0 Definitions

4.1 Thermal Desorption - The act of heating a controlled quantity of a contaminated sample to a prescribed temperature for a prescribed period of time for the purpose of reducing the contaminant concentration.

5.0 Procedure

5.1 Define and record planned experiment in the data book (i.e. time, temperature, soil etc.). Set the temperature ranges and points on the multipoint recorder.

5.2 Weigh the empty, clean tray without the film thermocouple.

5.3 Transfer a representative aliquot of prepared soil from the jar to the tray using a stainless steel spatula.

5.4 Weigh the soil and tray and adjust the soil quantity to achieve a uniform layer in the bottom of the tray, usually a 2-3 mm depth for a 30-100 gram aliquot of soil.

5.5 Position the film thermocouple beneath the soil in the center of the tray with a small piece of ceramic fiber paper between the thermocouple and the tray bottom.

5.6 Distribute and level the soil within the tray making sure that the film thermocouple remains covered with soil.

5.7 Turn on the purge gas flow to the proper setting on the rotameter.

5.8 Place the tray with the soil in the oven at ambient temperature and attach the film thermocouple connectors. Make sure that the film thermocouple is not disturbed and continue sliding the tray into the oven and close the oven door.

5.9 Turn on the multipoint recorder and check the continuity of the thermocouple connections.

5.10 Set the oven temperature controller set-point to the target test temperature and start the timer.

5.11 Monitor and record the temperatures and time periodically throughout the test period and record any pertinent observations.

5.12 When the prescribed residence time at the target temperature is reached, shut off the oven heater and open the oven door.
5.0 Procedure (continued)

5.13 Cautiously disconnect the film thermocouple connector and withdraw the hot tray and soil using the special tongs. Disconnect and remove the film thermocouple, place a cover on the tray and place the covered tray in a laboratory hood for cooling. Allow the tray to cool 1/2 hour covered and then remove the cover and allow the tray to cool further.

5.14 Remove the ceramic fiber paper that was under the film thermocouple and weigh the tray (without cover) plus treated soil after 1 hour.

5.15 Transfer an aliquot of the treated soil to a 2-4-oz. jar. Label the sample with the desired sample coding information and hold for analysis.

5.16 Clean the tray, cover, and non-disposable implements using the following procedure:

5.16.1 Rinse with acetone and wipe clean.

5.16.2 Scrub with detergent (Alconox R) solution and rinse with hot tap water followed by distilled water.

5.16.3 Rinse with acetone.

5.16.4 Air dry and store.

6.0 Nonconformance and Corrective Action

6.1 Minor corrections are noted in the laboratory notebook.

6.2 Any necessary recalibrations are also noted in the laboratory notebook.

6.3 Major corrections usually require repair by the manufacturer.

7.0 Records Management

7.1 Data is recorded in the standard laboratory notebook.

7.2 The temperature recorder chart is trimmed and taped into the laboratory notebook.

7.3 Applicable custody sheets and requests for analysis sheets are kept in the project file.
APPENDIX E

ROTATING THERMAL APPARATUS PROCEDURE
1.0 Purpose and Application

1.1 This SOP describes the operation of the rotary thermal apparatus (RTA) and the thermal desorption of samples in the RTA.

1.2 This procedure applies to all tests performed for projects requiring thermal desorption in the RTA.

1.3 Modifications to this procedure are permitted on a project specific basis provided that the changes provide for an equivalent method of operation. All such changes must be approved by the project manager and described as a variance in the project QA plan.

2.0 References

2.1 None

3.0 Associated SOPs and Applicable Methods

3.1 ITAS-TDL SOP No. 100, "Use of Glass S Weights."

3.2 ITAS-TDL SOP No. 102, "Calibration of Thermometers."

3.3 ITAS-TDL SOP No. 103, "Balance Calibration Checks."

3.4 ITAS-TDL SOP No. 200, "Sample Handling and Storage."

3.5 ITAS-TDL SOP No. 201, "Sample Receipt, Coding and Tracking formerly SOP No. DM.1, Sample Tracking)."
4.0 Definitions

4.1 Thermal Desorption - The act of heating a controlled quantity of a contaminated sample to a prescribed temperature for a prescribed length of time for the purpose of reducing the concentration of the contaminants.

4.2 RTA - rotary thermal apparatus.

5.0 Procedure

5.1 Define and record the planned experiment in the laboratory data book (i.e., time, temperature, etc.). Set the temperature ranges and points on the multipoint recorder.

5.2 Set the furnace temperature controller to at least 150 degrees above the desired test temperature and turn on the power.

5.3 Weigh an aliquot of the homogenized test matrix into a large tared stainless steel (or plastic) beaker. Usually a 400-500 g of air-dried and screened soil.

5.4 Transfer the contents of the beaker into the prepared cylinder and reweigh the beaker to calculate the net transfer.

5.5 Place the loaded cylinder into the test apparatus and complete the assembly of the system.

5.6 Insert the thermocouples to measure the gas and the soil temperature in the cylinder.

5.7 Connect the quartz gas outlet tube to the scrubber system and set the purge gas flows to the inlet and outlet distribution boxes.

5.8 Charge the scrubber recirculating system with one liter of 5 percent caustic solution and start the scrubber pump and the system vacuum pump. Adjust the bypass on the vacuum pump to obtain the desired negative pressures at the inlet and outlet distribution boxes. Usually -0.15 to -0.25 " water column.

5.9 Start the cylinder drive and check the bearing alignment. Adjust the alignment if necessary.

5.10 Carefully place the preheated furnace around the rotating cylinder and allow the furnace controller to approach the preheat temperature.
5.0 Procedure (continued)

5.11 Lower the controller set point when the soil temperature is within 125-150 degrees of the desired operating temperature.

5.12 Monitor the temperatures during the test and adjust the furnace as necessary to maintain the desired temperature profile by opening the lid of the oven about 6-8" and reclosing the lid as necessary.

5.13 When the desired residence time at the test temperature has been reached turn off the furnace temperature controller and lower the furnace from the rotating cylinder. Allow the cylinder to continue rotating until the system has cooled to ambient conditions. Additional cooling is provided by an oscillating fan directed at the top of the cylinder.

5.14 Turn off the purge gas, the vacuum pump, the scrubber pump, and the cylinder drive.

5.15 Disassemble the cylinder and transfer the contents to a tared beaker and weigh. Transfer the treated residue to the appropriate containers for analysis and storage.

5.16 If scrubber contents analysis is required, disassemble the scrubber system and measure the volume of the scrubber solution. Transfer to an appropriate container for disposal or analysis.

5.17 Clean the cylinder, the scrubber and other system components according to the prescribed clean-up procedures.

6.0 Nonconformance and Corrective Action

6.1 Minor corrections are made as necessary and recorded in the laboratory notebook.

6.2 Necessary recalibrations are also noted.

6.3 Major corrections usually require repair by the manufacturer.

7.0 Records Management

7.1 Data are recorded in the standard laboratory notebook.

7.2 The temperature recorder chart is trimmed and taped into the laboratory notebook.

7.3 Applicable custody sheets and requests for analysis sheets are kept in the project file.