RETEC

WORK PLAN FOR A LIMITED SUBSURFACE INVESTIGATION TO SUPPORT COMMERCIAL/INDUSTRIAL REDEVELOPMENT OF THE FORMER GENERAL CABLE MANUFACTURING SITE, ROME, NEW YORK

Prepared For:

DEPARTMENT OF PLANNING AND COMMUNITY DEVELOPMENT
City Hall
Rome, NY 13340

Prepared By:

REMEDIATION TECHNOLOGIES, INC.
1001 West Seneca Street, Suite 204
Ithaca, NY 14850

RETEC Project No.: 3-2294-200

Subcontractor To:

THE SARATOGA ASSOCIATES
443 Broadway
Saratoga Springs, NY 12866

SEPTEMBER 1996

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1.0 INTRODUCTION

1.1 Statement of Purpose

This document presents the work plan for the investigation of soil conditions and associated risk to human and ecological receptors at a 17 acre manufacturing site in the City of Rome, Oneida County, New York, formerly owned by General Cable. The site is located between East Dominick Street and the New York State (NYS) Barge Canal in the City of Rome, Oneida County, New York. The property is currently owned by Mr. Charles Gaetano, and is listed by the City of Rome as tax map parcel 242.020-0001-018 (see Figure 1-1, Gaetano Property). The area to be investigated and its wider setting were described to NYSDEC staff in a meeting at their offices in Albany on July 20, 1995, and in a report entitled "Phase I Environmental Site Assessment, City of Rome Industrial Redevelopment Area, Rome, New York" [RETEC, 1995] which was submitted to NYSDEC. The area to be investigated is described in that report at Section 2.3.2.

The purpose of this work plan for the Gaetano Property (as defined in the Consent Order to which this is attached) is to determine the need for (and where applicable, the scope of) remediation on various parcels within the site in the context of development for commercial/industrial use. The elements of the work plan are:

- an analysis of existing data; the identification of the area, media, and substances to be investigated; and a description of additional data to be acquired;
- identification of potential current and future receptors and exposure pathways;
- the identification of appropriate remedial alternatives to address any exposure issues identified in the evaluation of site concentrations.

This work plan is consistent with the New York State Department of Environmental Conservations's (NYSDEC) Preliminary Site Assessment Guidelines and is consistent with the National Contingency Plan (NCP) provisions for removal site evaluation and removal action (Subpart E, Section 300.410 and 300.415).

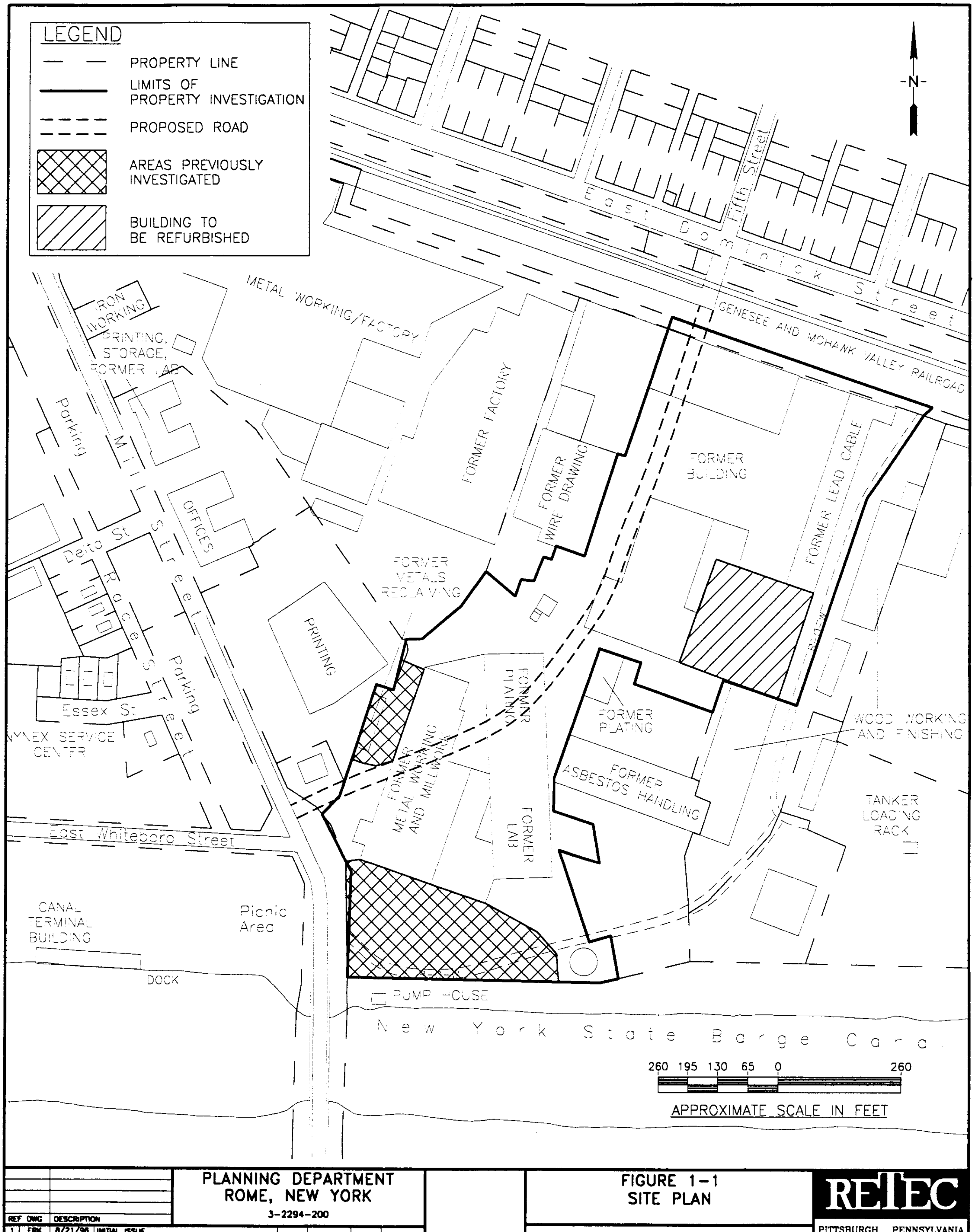

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FIGURE 1-1
SITE PLAN

ROME, NEW YORK

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1.2 Potential Receptors

The focus of this work plan is to collect the information needed to assess potential exposures to individuals during redevelopment of the Gaetano Property and after this property is occupied by commercial or industrial enterprises. This assessment will be used in the evaluation of the need for remedial action. Redevelopment activities are expected to involve the demolition or rehabilitation of roads, parking areas and buildings. This activity could lead to the disturbance of soil at the site. For the purpose of this effort, it is assumed that excavation and rework of soil will be limited to the top six feet and that new buildings will be constructed ongrade and without basements. The following groups of people could theoretically be exposed directly to soil in the top six feet or, indirectly, to vapors or dust emitted from the soil:

- construction workers;
- utility workers;
- nearby residents; and
- future commercial/occupants and visitors.

Based on a review of past site activities and data collected in previous investigations, the following list of potential chemicals-of-interest has been developed:

- petroleum compounds (benzene, toluene, ethylbenzene and xylenes or BTEX and polycyclic aromatic hydrocarbons or PAHs);
- chlorinated solvents (trichloroethene and trans-1,2-dichloroethylene);
- polychlorinated biphenyls (PCBs); and
- metals (arsenic, chromium, copper, lead, nickel, zinc).

For these receptor groups and chemicals-of-interest, a methodology has been developed for developing site-specific health-based screening levels. An initial set of receptor-specific and site-specific health-based screening levels have been calculated for use in evaluating concentration data obtained from the site investigation to determine whether potentially unacceptable exposures exist for specific receptors. The development of this methodology and the proposed HBSLs will be presented and negotiated separately from this work plan. Once completed, this analysis will form the basis of determining whether remedial activity or environmental site management is required. A model for remediation and management of the site is presented in Section 4 of this work plan.

1.3 Surface and Near Surface Investigation

The investigation of the site will focus primarily on characterization of conditions at the ground surface and down to a depth of six feet below the ground surface. Although the water table at the site is below the six-foot level, the investigation will include an evaluation of the water table elevation and determination of the direction of groundwater flow. Elements of the investigation which are described in this work plan include:

Soil Investigation:

- shallow soil (zero to 6-feet below the current ground surface);
- background soil conditions;
- soil gas at 6 to 7 feet below grade; and
- utility trenches.

Groundwater Investigation:

- water table elevation and direction of groundwater flow;
- perched water (if present) within 6 feet of the ground surface; and
- groundwater quality at the areas proposed for immediate redevelopment.

Facility Investigation:

- utility tunnels
- process area pits, sumps, and trenches; and
- storm sewer system.

Regarding deep soils (those below the six-foot depth) and groundwater: if the results of the investigation described in this work plan indicate that exposure conditions to soil and soil gas are acceptable, and that institutional controls will be imposed to prevent access to deep soils or groundwater, then no further action with respect to deep soils or groundwater will be conducted as part of the investigation. Groundwater quality will be assessed at two locations where specific sale and redevelopment plans have been proposed; however, the balance of the groundwater investigation at the site will be performed under a separate, more extensive, groundwater investigation which has been proposed by Rome pursuant to the U.S. EPA Brownfields Economic Development initiative under which Rome has been awarded a Demonstration Pilot Grant. That investigation is not part of this work plan.

1.4 Site Background

The Gaetano property has been the subject of NYSDEC review based on the findings of an investigation at its southern end near the NYS Barge Canal right-of-way. Phase I, Phase II, and Focused Phase II environmental investigations, and a geotechnical investigation and design were performed between 1991 and 1993 by Empire Soils Investigations [Empire, 1990; Empire, 1991; Empire, 1992] in support of a proposed independent power generating facility. The subsurface investigation found that chlorinated volatile organic compounds were present in the groundwater at concentrations exceeding New York groundwater standards. In addition, one soil sample from a set of eight samples obtained from borings at this area of the site exceeded the TCLP limit for lead (100 mg/L as compared to the limit of 5 mg/L). Although permits to construct the facility were granted by NYSDEC Region 6, the facility was not built due to financial and contractual considerations. Since the conclusion of the power plant project, additional investigations of the site have been performed by the City of Rome for asbestos-containing building materials and for demolition of surface structures. A portion of the site was also investigated by a set of test pits as part of a potential real estate transfer [RETEC, 1996]. A preliminary site assessment was to have begun in 1995 by the NYSDEC. This work was deferred by NYSDEC when the City of Rome volunteered to take the lead at the site.

1.5 Overview of The Work Plan

The remainder of this work plan is divided into three additional sections. Section 2 outlines the approach used to characterize potential media and chemicals-of-interest, and identify potential receptors which may be exposed to these media and chemicals.

Section 3 presents the specifics of the site investigation itself. This section presents the locations of soil and water samples at the site, background soil samples, the sampling methods and protocols, and the analytical tests to be performed.

Section 4 is a summary of how the results of the site investigation will be presented in the final report. The final report will include the results of the investigation, an evaluation of the results of the investigation, and recommendations for remedial actions (if necessary) to allow the safe redevelopment and reoccupation of the site for commercial/industrial activities.

2.0 POTENTIAL EXPOSURE PATHWAYS AND RECEPTORS

2.1 Purpose and Overview

The first step in establishing a risk-based framework for safe redevelopment of the site involves the development of a conceptual site model that identifies the potential media of interest, receptors, and exposure pathways. The results of the field investigation will then be used to help delineate the portions of the site that may require remediation or mitigation measures. The general framework and associated methodology presented in this work plan are intended to be applicable and relevant for evaluations of other parcels of property within the redevelopment area for the City of Rome's East Rome Industrial Park, although such evaluations are beyond the scope of the current investigation.

2.2 Conceptual Site Model

2.2.1 Potential Media of Interest

Section 1 of this work plan provided an overview of the site setting and historical site uses. As previously discussed, this investigation and subsequent analysis will be limited to the onsite soils (surface and subsurface). The focus of this evaluation is on potential exposures to surface and unsaturated subsurface soil during redevelopment and after the redeveloped property is occupied by new industrial or commercial ventures. As such, this evaluation considers direct exposure to soil and indirect exposure via releases to the atmosphere or soil gas. No exposures to groundwater are anticipated during redevelopment or after the site has been occupied by new industrial or commercial ventures. Potential exposures associated with chemicals or nonaqueous phase liquid (NAPL) in groundwater will be assessed during the area-wide site investigation and EPA Brownfields pilot.

The chemicals-of-interest (COIs) for this investigation are listed in Table 2-1. These compounds and elements were selected based on our knowledge of past activities at the site and on the results of previous site investigations.

TABLE 2-1
CHEMICALS-OF-INTEREST

Volatile Organic Compounds

- Benzene
- Toluene
- Ethylbenzene
- Xylenes
- Trichloroethene
- Trans-1,2-Dichloroethylene

Semi-volatile Organic Compounds (Polynuclear Aromatic Hydrocarbons)

- Naphthalene
- Acenaphthene
- Acenaphthylene
- Fluorene
- Phenanthrene
- Anthracene
- Fluoranthene
- Pyrene
- Benzo(a)anthracene
- Chrysene
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Benzo(a)pyrene
- Indeno(1,2,3-cd)pyrene
- Dibenzo(a,h)anthracene
- Benzo(g,h,i)perylene

PCBs

- Aroclor 1016
- Aroclor 1221
- Aroclor 1232
- Aroclor 1242
- Aroclor 1248
- Aroclor 1254
- Aroclor 1260

Metals

- Arsenic
- Beryllium
- Chromium (III)
- Chromium (VI)
- Copper
- Lead
- Nickel
- Zinc

2.2.2 Potential Human Receptors and Associated Exposure Pathways

The human receptors considered potentially relevant at the site include: construction workers, utility workers, nearby residents, and future commercial/industrial occupants and visitors to the site. This section contains a discussion of the rationale used for selecting each of these potential receptor groups and their associated exposure pathways. This assessment assumes that institutional controls will be in place to limit access to deep soil and groundwater, if they are found in subsequent investigations to have a potential for impact to human health.

Construction workers are the individuals that will be involved in the construction of new buildings on the property. It is expected that they will come into contact with surface soils and have little contact with subsurface soils. The exposure pathways considered most applicable and plausible for construction workers are: incidental soil ingestion and inhalation of volatiles and particulates that may be released or generated during construction activities.

Utility workers are those individuals that will be involved in the installation and/or maintenance of the utility lines that service the new or renovated buildings on the site. It is anticipated that their exposure will be primarily to subsurface soils or fill and bedding materials in utility trenches. The exposure pathways considered most applicable and plausible for this receptor group include: incidental ingestion of subsurface soils and inhalation of volatiles and particulates released or generated during their work activities.

Nearby residents (i.e., those living along East Dominick Street and near Mill Street) were selected as potential receptors since they may be exposed to either volatile or dust emissions during the construction activities. The exposure pathways considered most applicable for nearby residents include: inhalation of volatilized constituents and particulates released or generated during construction activities. It should be noted that visitors to nearby recreational facilities (i.e., parks) could also be exposed to volatilized constituents or fugitive dust released during construction activities. However, their exposures would be occasional (when they visit the park) and for relatively short periods of time (e.g., two to four hours) so that their overall exposures would be less than the exposures to nearby residents. Consequently, nearby residents are considered have the greatest potential exposure in this receptor group.

Lastly, future commercial/industrial occupants and visitors were selected as potential receptor groups. In evaluating potential exposures to these receptor groups, it is assumed that the redeveloped site is covered by buildings, roads, parking lots, sidewalks or clean soil that is landscaped. Thus, direct exposure to constituents in existing surface soil will not occur. The only relevant exposure pathway for these receptors is inhalation of volatiles that may intrude into onsite buildings from the subsurface. While both future commercial/industrial occupants and visitors can be exposed to constituents volatilized to indoor air, the future commercial/industrial occupants presumably have higher exposures since they are in the building for extended periods of time. Thus, HBSLs are developed for future commercial/industrial occupants.

2.2.3 Potential Ecological Receptors and Associated Exposure Pathways

As the 17-acre site is fully developed, there are no on-site ecological receptors (i.e., terrestrial flora and fauna) to be evaluated. Likewise, all of the neighboring properties except the Barge Canal to the south are developed and have no ecological receptors. Potential risks to ecological receptors in the Barge Canal to the south would be from groundwater discharging to the Canal or surface water runoff. The potential impact of groundwater on the Canal will be investigated during the EPA-funded groundwater investigation. There is no direct surface water runoff from the site to the Canal; storm water is collected by an existing storm sewer system which drains to the Canal. This system, combined with the coverage of the site by buildings and pavement, generally prevents storm water from contacting soil at the site. This system is to be modified and upgraded during site reconstruction so that the present isolation of storm water from the soil and therefore from potential constituents in soil is maintained, thus preventing impacts to storm water and subsequent impact on ecological receptors.

3.0 SITE INVESTIGATION PROCEDURES

This section describes the procedures that will be followed during the field sampling program. The program includes the following operations:

- underground utility clearance;
- soil borings and monitoring well installations;
- surface and subsurface soil collection;
- groundwater measurement and collection;
- soil gas sampling;
- interior (basement) air sampling.; and
- mapping and sampling of subsurface structures.

The soil boring program and soil gas survey are closely integrated in that soil gas samples will be collected after the soil sampling equipment has been advanced to the final depth within each borehole. For the purposes of this work plan, the two programs are discussed in separate sections. The following sections provide descriptions of the procedures which will be used to complete each operation.

3.1 Underground Utility Clearance

Prior to the start of any field work, the proposed sample locations will be established by directly measuring off of existing physical features such as buildings or other landmarks with a measuring tape. A wooden stake or painted markings will then be placed at the location of each sampling point. The Underground Facilities Protective Organization (UFPO, 1-800-962-7962) will be contacted to arrange for the location and marking of all underground utilities in the vicinity of the proposed borings. UFPO will be notified at least two full business days prior to the commencement of any subsurface work to ensure compliance with excavation regulations. If necessary, a private utility locating service will be used to locate private underground utilities which will not be located by the UFPO subscribing utilities.

Borings will be relocated if there is risk of drilling activities damaging any underground or overhead utilities. The field geologist will coordinate and record the results of each utility location.

3.2 Soil Sample Locations

Surface and subsurface soil samples will be collected from 18 locations on-site as shown on Figure 3-1 (16 locations shown, two to be determined later). Six additional surface soil samples will be collected as background samples for metals analysis from off-site locations along East Dominick Street and the Barge Canal. Two surface samples will be collected on-site for PCB analysis at former transformer locations. Table 3-1 provides a summary of the soil sampling program.

In general, the samples represent grab or composite samples, taken from biased locations. The background sample locations were selected to show the conditions of the area surrounding the site, but not directly impacted by activities at the site. Sample locations on-site were chosen by taking into account the following information:

- previous investigation results;
- surface inspection and historical investigations to identify former process areas and materials; and
- proposed redevelopment locations and activities.

The sampling locations shown on Figure 3-1 may be adjusted based on the final layout for site redevelopment. Some boring and sampling locations may be combined if, for example, borings for a utility line are adjacent to those for the roadway or building rehabilitation. The boring locations for subsurface utility lines will be selected later based on the survey of existing utility lines and the construction plans for new utilities. The investigation of subsurface utility lines may be augmented by additional borings or test pits to assess whether subsurface contamination exits which may be migrating in the trench bedding and fill materials.

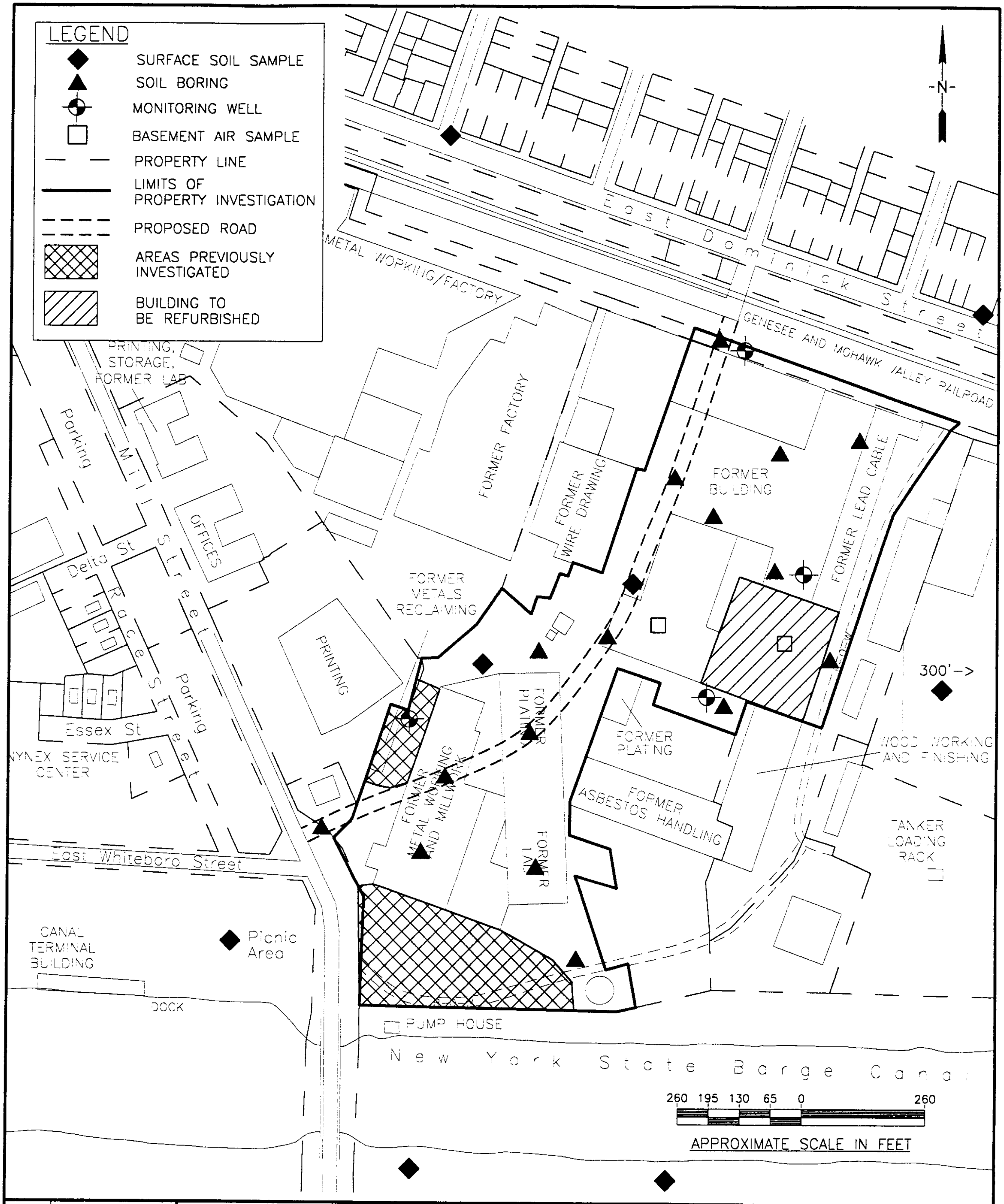

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FIGURE 3-1
PROPOSED SAMPLING LOCATIONS

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TABLE 3-1
SOIL SAMPLING SUMMARY

Soil Boring (Geoprobe), 19 Locations	
0-0.5 feet	volatiles, PAH, priority pollutant metals, TOC, moisture
0.5-6 feet	composite for same analyses
6-7 feet	soil gas sample (volatiles)
Surface Soil Samples - Background Metals, 6 Locations	
0-0.5 feet	priority pollutant metals
Surface Soil Samples - PCBs, 2 Locations	
0-0.5 feet	PCBs

3.3 Water Table Survey Locations

The elevation of the water table will be measured at all existing wells (located at the south side of the site) and at four new monitoring wells which will be installed under this work plan (Figure 3-1). The new wells will be installed near the northern property line (upgradient of the entire site), adjacent to the building to be refurbished in Redevelopment Area A (upgradient and downgradient), and within the footprint of the proposed building expansion on the west side of the site (Redevelopment Area B) in the vicinity of the former metals reclaiming building (Figure 3-2). The proposed well locations were selected to define the water table gradient across the site and to assess water quality in the areas to be redeveloped immediately. As part of the EPA funded groundwater study, additional wells will be installed and sampled under a later work plan to assess water quality at the upgradient side of the site, at the boiler house, and at the building to be rehabilitated. (The soil gas survey will provide a measure of any water-quality issues as they pertain to surface redevelopment).

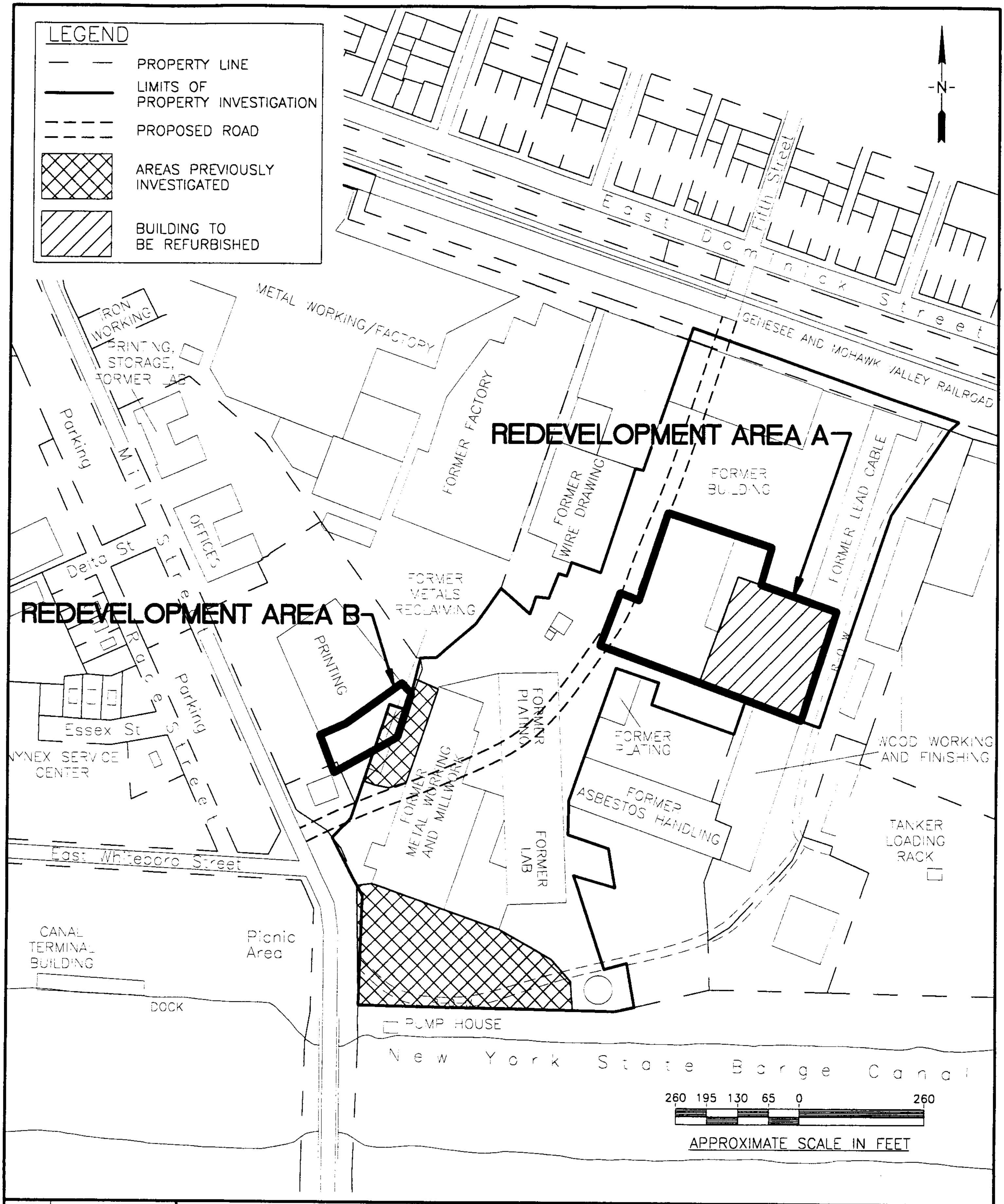

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FIGURE 3-2
PROPOSED REDEVELOPMENT AREAS

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The monitoring wells will be constructed of 2-inch diameter PVC well materials in a soil boring advanced by 4 1/4-inch I.D. hollow stem augers. The well screens will be ten feet long, and extend from approximately three feet above to seven feet below the water table at the time of installation. The screens will have a 0.01-inch slot size and will be installed with a Morie #3Q sandpack, or equivalent. A two-foot thick bentonite pellet seal will be installed above the sandpack, and the remainder of the borehole annulus filled with bentonite cement. The well casing will extend above the ground surface and be secured by a locking steel guard pipe. Each well will be developed following installation by surging and pumping. The locations and reference elevations of the monitoring wells will be surveyed so that a water table map of the site can be created.

3.4 Sample Designation

This section describes the sample designations that will be used in this investigation:

- Surface Soil Samples. These samples will be designated by SS- and the sequential number of the sample location. For example, SS-6 would be collected from boring location number six. Background surface soil samples will be designated SSB-8 for background surface soil sample from location number eight.

- Groundwater Samples. Groundwater samples will be designated by the well number (e.g. MW-2S).

- Subsurface Soil Samples. These samples will be designated by SB- and the sequential number of the sample location. For example SB-7 would be a sample collected from soil boring number seven.

- Soil Gas Survey Samples. Soil gas samples will be numbered by the location of the boring and the depth interval from which it was collected. For example SG-18 (6-7) would be a sample collected from the location of soil boring 18 from a depth interval of six to seven feet below ground surface.

- Surface Soil Samples for PCBs. These samples will be designated by PCB- and the sequential number of the sample location.

- Surface Water Samples. Surface water samples will be designated by SW- followed by the location and depth interval from which it was taken. For example, SW-1 (5-6) would represent a sample collected from soil boring No.1 from a depth interval of 5 to 6 feet below ground surface.

- Basement Air Samples. Air samples will be designated by A- followed by the building number from which it was taken. For example, A-41 will represent the air sample from the basement of Building 41.

- Subsurface Utility Samples. Soil, water or sludge samples obtained from tunnels, pits, or other subsurface structures will be designated by U- followed by the sample number.

3.5 Sample Collection Procedures

This section describes the methods used to collect soil and groundwater samples and the sample handling and documentation procedures required to ensure the integrity of the samples before shipment to the analytical laboratory. All field sampling operations will be directed by the project field geologist. The geologist will be responsible for work certification, preparation of the daily field logs, sampling logs, decontamination of equipment and adherence to the site-specific health and safety plan (HASP).

3.5.1 Surface Soil Sampling Procedures

The soil sample locations, shown in Figure 3-1, will be cleared of brush, rocks, leaves, concrete, bricks and other debris. A stainless steel trowel or soil hand-auger will be used to loosen the top 0.5 feet of soil. A representative portion of this soil will be placed immediately into glass jars with Teflon lined plastic caps for volatiles analysis. The remaining soil will be throughly composited (mixed) in a stainless steel bowl. This composited soil will then be placed in laboratory provided containers for PAH and inorganic constituents analysis. Further details are provided in RETEC Standard Operating Procedure (SOP) 210 (Appendix A).

3.5.2 Subsurface Soil Sampling Procedures

Prior to starting the subsurface soil boring program, groundwater elevation measurements will be collected from the site monitoring wells. This data set will be used to determine the approximate elevation of groundwater in the study area. If water is encountered while advancing the soil borings, the information will be used to distinguish between groundwater and the occurrence of any perched water conditions. Water level measurements will be obtained in accordance with RETEC SOP-231 (Appendix A).

Subsurface borings will be completed using the direct-push (Geoprobe) sample collection technique. A 2-inch outside diameter, 4-foot long sampling tube (Macro-Core) will be advanced from 0.5 to 6 bgs (below ground surface) in each borehole. Each sampling tube will be equipped with a 4-foot long clear plastic (PETG) liner. The sample tube will be driven to the correct depth within the borehole, extracted and sampled according to the following procedures:

- the soil sampling tube liners will be cut open in a manner that minimizes disturbance to the sample;
- a representative sample of soil from the 0.5 to 6 foot depth interval will be immediately placed into laboratory provided containers, specific for VOC analysis;
- the sample will then be described by the field geologist using the American Society for Testing and Materials (ASTM) Standards and the Unified Soil Classification System (USCS);
- the soil sampling tubes will then be subdivided into 1-foot intervals;
- one half of the soil from each 1-foot interval will be placed into jars and screened for organic vapors using a photoionization detector equipped with a 10.2 eV bulb (SOP-310, Appendix A);
- the remaining half of the soil from each 1-foot interval will be placed into a stainless steel bowl and throughly mixed; and
- the composited soil will then be placed into laboratory provided containers for analysis of PAHs, TOC, priority metals and moisture content analysis.

If refusal of the direct-push probing tool is encountered, the borehole will be relocated in the immediate vicinity of the proposed location. If repeated refusal occurs, the soil boring will be completed by drilling using hollow stem augers. Subsurface soil samples will then be collected using a 2-inch diameter split-spoon sampler.

3.5.3 Water Sampling Procedures

Except at the three wells located with the areas to be immediately redeveloped and at the upgradient well, water samples will be collected only if perched water conditions are encountered. The presence from the soil borings of surface water will be established by use of a depth-to-water meter measurement following each Macro-Core tube sample. If surface water is encountered, a water sample will be collected using a Geoprobe screen point groundwater sampler. The sampler will be advanced to the desired sampling depth and allowed to accumulate the water sample. The sample will then be pumped directly into the laboratory provided containers with a peristaltic pump. The samples will be sent to the laboratory for analysis of volatiles, PAH, and priority metals. The method for surface water sampling is described in SOP-250 in Appendix A.

Prior to purging and sampling of the monitoring wells, a static water level measurement will be taken from the top of the PVC well casing. (Note: water levels will be measured in all site wells.) The measurement will be made using an electronic water level indicator to a precision of 0.01 ft. The water level meter will be decontaminated prior to, and following each use in accordance with NYSDEC protocols. Water level measurements in all wells will be collected within a few hours of each other to accurately determine the overall groundwater flow direction. The results of the water level measurements will be summarized into a water table map. Water levels obtained from wells screened below the water table will be used to prepare a map of the piezometric surface below the water table.

A total of three well volumes of water will be purged from each well to ensure that a fresh sample of groundwater is obtained during sample collection. Purging will be completed using a peristaltic pump, equipped with dedicated Tygon tubing for each well, to eliminate any potential cross-contamination. The intake for the tubing will be located as close as possible to the top of the water column during purging and lowered as necessary to purge the entire contents of the well. During purging, the field measurements for pH, specific conductance, temperature and turbidity will be monitored for stabilization to ensure that fresh formation water is sampled.

Following completion of the purging, a final measurement of the field parameters will be recorded and samples of groundwater will be collected immediately by pumping into laboratory supplied bottles. If the well is purged dry, samples will be collected as soon as the well recovers sufficiently and no longer than 24 hours following purging. The samples for laboratory analysis will be collected in the order of decreasing volatility of the parameters. Both whole and filtered water samples will be obtained for metals analysis. Filtration will be through disposable 0.45 micron filters. All relevant sampling information and any observations about the sampling procedures will be recorded in the field log book. The sample bottles will be field preserved as necessary, placed in a cooler with icepacks, and delivered to the laboratory daily following standard chain-of-custody procedures. Supporting information is also presented in RETEC SOP 230 (Appendix A).

3.5.4 Soil Gas Survey Procedures

Following the completion of the subsurface soil sampling, a soil gas sample will be collected in each borehole. The probe rods and an expendable drive point head will be advanced from six to seven feet below the ground surface. The drive point head will be coupled to an adapter to allow soil gas vapors to flow up the polyethylene tubing in response to an applied vacuum. This system will ensure that the vapor sample will originate at the target sample depth. The sampling train will be purged, and the soil vapor sample collected in a Tedlar bag. Each bag sample will be placed in a cooler with icepacks and sent under chain of custody procedures to the laboratory for analysis of volatile organic compounds using analytical method AM4.03. Further details on soil gas procedures are provided in SOP-751, Collection and Analysis of Soil Gas Samples (Appendix A).

3.5.5 Indoor (Basement) Air Sampling Procedures

Indoor ambient air samples will be obtained from the basements of Buildings 33 and 41 (Figure 3-1). Both buildings have full basements, and both buildings are scheduled for rehabilitation. Each sample will be obtained by NIOSH Method 1501/1003 for BTEX and halogenated hydrocarbons. The samples will be obtained over an eight-hour period by passing ambient air through packed tubes at a rate of up to one liter of air per minute. Following sampling, the ends of the tubes will be sealed, packed in a cooler with ice packs, and shipped to the laboratory for analysis by EPA method 8240.

3.5.6 Subsurface Structures

Subsurface structures are present at many locations within the study area. These structures range from sumps and pits associated with specific manufacturing equipment to tunnels large enough for people to walk through which served as major conduits for utility lines. The locations of the major structures are identified on historical site plans. The locations of minor and process-related structures are not mapped. During this investigation the locations of these subsurface structures will be mapped, and the environmental conditions determined by a combination of field and laboratory measurements.

The following field observations will be made for each subsurface structure:

- total interior depth

- depth of water, sediment, or sludge
- direction and estimated flow rate of water (if applicable)
- odors and PID measurements in the headspace of the structure
- sheens, odors, and headspace PID measurements associated with the water and sediment

The presence of potential asbestos containing materials will be noted; however, this material will be sampled as part of a separate pre-demolition asbestos survey.

In locations where analytical samples are called for, sediment, water, and sludge will be analyzed for volatiles, semi-volatiles, and metals by the previously cited EPA methods. At present the number of structures and access points are unknown; therefore, for budgeting purposes, we have assumed that 20 analytical samples will be obtained form the site during this portion of the investigation.

Utility Tunnels

Utility tunnels which are located within the study area will be investigated for the presence of contaminated water, sediment, and sludge. These tunnels are mapped to extend from the south side of the boiler house. One tunnel is shown to pass under Building 13 and to connect with former General Cable Building 34 (the present Mosca warehouse). A second tunnel is mapped as extending from the boiler house to the west, across the northern end of Building 11, and to connect with Building 38 (the former acid reclaiming building) and Building 32 (the current Canterbury Printing building). A third tunnel is mapped as extending from the south end of Building 50 to the Mosca warehouse. This tunnel is wholly outside the study area and appears to have been primarily for moving materials and not part of the utility system for the site, therefore it will not be investigated at this time.

To date the only portion of this system which has been surveyed is that between Buildings 11 and 38, at the west side of the site [RETEC, 1996]. It was found that the floor of the tunnel was covered by approximately 8 inches of sediment, and that a small amount of water was flowing through the sediment to the northeast, back towards the boiler house. Several manways were inspected between this survey location and the boiler house, and it was found that the depth of water increases. The lower portion of the boiler house is flooded, and it is likely that at least one of the utility tunnels, such as that inspected at the west side of the site, is conveying stormwater to the boiler house to maintain its flooded condition (the elevation of the water in the boiler house is well above that of the water table).

The tunnels are considered under OSHA standards to be "confined spaces", therefore all sampling of these structures will be performed from the surface through manways and other access points. The samples will be analyzed for volatile and semi-volatile compounds and for metals.

Pipeways and Process Pits

Shallow pipeways and pits associated with manufacturing processes will be inspected during this investigation for the presence of water, sediment, or sludge. From previous site inspections it appears that the largest concentration of pits is in Buildings 11 and 13. Accumulations of soil or sludge will be sampled for volatile and semi-volatile compounds and for metals. As with the tunnels, no personnel will be permitted to enter any pit, trench, or other structure if it is considered to be a confined space under OSHA regulations.

Stormwater System

Manways associated with the storm sewer system will be identified in the field, their covers removed, and observations made of the field conditions listed above. In locations where the manways and storm sewer lines are to be replaced or abandoned, and in locations which are proposed to be conveyed to new owners, the sediments will be analyzed for volatiles, semi-volatiles, and metals.

3.5.7 Borehole Abandonment

Following collection of the soil gas sample, all down hole equipment will be retracted to the surface. The borehole (approximately 1 to 1½- inch diameter) will be allowed to collapse naturally. If any visible portion of the hole fails to collapse, a Portland cement and bentonite slurry will be used to backfill the open borehole. The slurry mix ratio will consist of, at a minimum, 94 pounds of Portland cement to three to five pounds of bentonite powder to 6.5 gallons of potable water. A Portland cement concrete surface seal will be installed above any slurry.

3.5.8 Decontamination

All down hole or sampling equipment will be decontaminated between borings to minimize the potential for cross-contamination. Decontamination will be accomplished by steam cleaning or by use of the following sequence:

- brushing gross contamination from the equipment;
- tap water rinse;
- an Alconox (detergent) wash;
- rinse with tap water;
- rinse with a laboratory grade methanol followed by a rinse of laboratory grade hexane; and
- final rinse with de-ionized, demonstrated analyte free water.

Protocol for decontamination are further described in SOP-120 (Appendix A).

3.5.9 Waste Management

Several types of waste requiring proper management will be generated during the field work. The wastes, and their management are summarized as follows:

- Any drill cuttings and soil samples not sent to the laboratory will be returned to the borehole prior to borehole abandonment;
- Development water from the new monitoring wells will be discharged to the ground surface as close as is practical to the well sites. The discharge locations will be such that the water infiltrates the soil and does not run off or enter the storm sewer system;
- Personal protective equipment (PPE) will be double-bagged and disposed of by landfilling;
- Plastic sheeting used during decontamination procedures will be double-bagged and disposed of by landfilling; and

- Water generated during decontamination procedures (i.e. steam cleaning downhole drilling and sampling equipment) will be discharged to the ground such that it infiltrates the soil and does not run off. If water appears contaminated, it will be contained and properly labeled and tested for future disposal.

3.6 Analytical Program

3.6.1 Sample Handling and Analysis

Following sample collection, each sample jar will be labeled with the following information: designation, collection depth, time and date of collection, and a list of laboratory analyses to be performed. The sample will be then prepared for sample shipment by wrapping in bubble wrap, placement in plastic zip-lock bags, and placed into coolers with ice packs. The samples will be in the possession of the sampler or in a secured area until shipment to the laboratory. Shipment will be by overnight delivery service such as Federal Express.

3.6.2 Laboratory Analysis

The chemical analysis will be performed by a New York ELAP certified laboratory. A summary of the laboratory analyses for each sample is presented in Table 3-2, along with a summary of the samples which will be collected for quality control purposes. Analytical methods for the analytes are given in Table 3-3.

3.6.3 Quality Assurance Objectives

The overall quality assurance objective is to develop and implement procedures for field sampling, chain-of-custody and laboratory analysis that will provide results which are legally defensible. To meet these goals Data Quality Objectives (DQOs) have been established for the investigation. DQOs are qualitative and quantitative statements which specify the quality of data required to support specific remedial response decisions on regulatory actions. The DQO's focus on the identification of the end use of the data to be collected and to the degree of certainty with respect to the precision, accuracy, reproducibility, completeness and comparability necessary to satisfy the intended end use. The DQOs for field and laboratory work for this effort are summarized as follows:

TABLE 3-2
ANALYTICAL PROGRAM SUMMARY

Sample Type	Sample Type	Sample Number Designation	Sample Depth (bgs)	Volatiles	PAH	Total Organic Carbon (TOC)	Priority Pollutant Metals	Moisture Content	PCBs
Soil Borings	grab	SS-	0-0.5 feet	x	x	x	x	x	
	composite	SB-	0.5 to 6 feet	x	x	x	x	x	
	soil gas	SG-	6 to 7 feet	x					
PCB Soil Samples	grab	PCB-	0-0.5 feet						x
Background Soil Samples	grab	SSB-	0-0.5 feet				x		
Surface Water	grab	SW-	perched above water table	x					
Air	grab	A-	building basement	x					
Water, Sludge or Sediment	grab	U-	subsurface structures	x	x		x		
Groundwater	grab	MW-	screened interval	x	x		x (total and filtered)		

TABLE 3-3
ANALYTICAL METHOD SUMMARY

Analyte	Analytical Method	Units	Quantitation Limits	
Volatiles (soil)	EPA Method 8240	mg/Kg	<0.01 (Note 1)	
Volatiles (soil gas)	EPA 18 - Modified	mg/m^3	<0.02	
Volatiles (water)	EPA Method 604	mg/L	<0.01 (Note 1)	
Volatiles (indoor air)	NIOSH 1501/1003, EPA Method 8240	mg/m^3	<0.01	
PAHs (soil)	EPA Method 8270	mg/Kg	<0.66	
PAHs (water)	EPA Method	ug/L	< (Note 1)	
Total Organic Carbon (soil)	Walkley Black	mg/Kg	100	
PCBs (soil)	EPA Method 8080	mg/Kg	<0.016-0.033	
Priority Metals			soil	water
Antimony	EPA Method 6010	mg/Kg or ug/L	<6	<60
Arsenic	EPA Method 6010	mg/Kg or ug/L	<1	<10
Beryllium	EPA Method 6010	mg/Kg or ug/L	<0.5	<5
Cadmium	EPA Method 6010	mg/Kg or ug/L	<0.5	<5
Chromium	EPA Method 6010	mg/Kg or ug/L	<1	<10
Copper	EPA Method 6010	mg/Kg or ug/L	<2.5	<25
Lead	EPA Method 6010	mg/Kg or ug/L	<0.3	<3
Mercury	EPA Method 7471	mg/Kg or ug/L	<0.1	<0.2
Nickel	EPA Method 6010	mg/Kg or ug/L	<4	<40
Selenium	EPA Method 6010	mg/Kg or ug/L	<0.5	<5
Silver	EPA Method 6010	mg/Kg or ug/L	<1	<10
Thallium	EPA Method 6010	mg/Kg or ug/L	<1	<10
Zinc	EPA Method 6010	mg/Kg or ug/L	<2	<20

Note (1) Practical quantitation limits for individual compounds vary.

- DQO Level 1. This level of effort will be used for field screening for health and safety monitoring and for field screening subsurface soil samples for organic vapors.
- DQO Level 2. This level of effort will be used for the soil gas survey and the collection and chemical analysis of soil and water samples.

3.6.4 Quality Control Samples

Equipment blanks, field duplicates, trip blanks and matrix spike samples will be analyzed to assess the quality of the data resulting from the field sampling program. The frequency and type of quality assurance (QA) samples will be dictated by NYSDOH ASP rules. The exact number of QA samples will be determined based on the actual number of field samples obtained.

- Equipment Blank: The purpose of the equipment blank is to detect any contamination from sampling equipment, cross contamination from previously sampled locations, and contamination caused by conditions at sampling locations (i.e. airborne contaminants). One blank will be collected for every twenty samples collected. The blanks will be collected by pouring distilled, deionized water, prepared in the laboratory, over decontaminated sampling equipment and collecting the rinsate in sample jars. The blanks will be analyzed for volatiles, PAHs, and priority metals.

- Field Duplicate: Field duplicates are collected to determine the precision of the soil samples collected. This is achieved by composting soil and splitting it evenly between the sample jars. One duplicate sample will be collected and analyzed for volatiles, PAHs, TOC and priority metals for every twenty field samples.

- Trip Blank: One trip blank will accompany each sample shipment sent to the laboratory. The trip blank will be analyzed to test for any contaminants introduced while samples are being stored or transported to the laboratory. The trip blanks will be analyzed for volatiles only.

- Matrix Spikes, and Matrix Spike Duplicates: These samples are laboratory quality control samples for organic analysis only. They provide information about the effect of the sample matrix on the digestion and measurement methodology. One MS/MSD sample will be analyzed for volatiles and PAHs for every twenty field samples.

3.6.5 Chain-of-Custody Procedures

To establish the documentation necessary to trace the sample possession from the time of sample collection, a chain-of-custody record will be filled out for each sample. The record will contain the following information:

- sampling site identification;

- sampling date and time;

- identification of sample collector;

- sample identification;

- sample description (type and quantity);
- analysis to be performed;
- signatures of persons involved in the chain of possession; and
- date and times of possession.

3.7 Field Logbooks and Documentation

Field logbooks will provide an accurate history of all aspects of sample collection and handling. Field logbooks will be bound field survey books that will contain a daily log of project specific information including:

- a description of field analytical equipment,
- calibration data for field sampling equipment,
- results of field physical measurements,
- calculations for field sampling; and
- sample description including field duplicate locations.

4.0 APPLICATION OF RESULTS TO SITE DEVELOPMENT

4.1 Reporting of Results

The final report for this investigation will include:

- descriptions of field and analytical investigation methods used;
- field measurements and observations (including boring logs);
- boring and well construction logs;
- water table maps and geologic interpretations;
- analytical results;
- a comparison of soil conditions to the site-specific HBSLs; and
- recommendations (if warranted) for additional investigation or remediation.

The evaluation of chemical concentrations will form the basis for the analysis of remedial measures and recommendations for future actions.

The final report will be provided to NYSDEC for review prior to removal of any at or below grade structures (i.e., floor slabs or basements), and prior to construction (but not demolition) of any buildings or utilities on the site. The final report will be reviewed and signed by a professional engineer licensed by the State of New York.

The City of Rome may wish to move ahead with the rapid redevelopment of a portion of this site. In order to do this, the City may proceed initially with the investigation and reporting of a portion of the 17-acre site. This rapid response would be made necessary by the timetable needed to meet development plans.

4.2 Mitigation of Risk (Presumptive Remedies for Site Redevelopment)

The preliminary site assessment of the property and surrounding area identified the past uses of the site and likely chemicals-of-interest [RETEC, 1995]. Soil and groundwater are known to have been impacted at the southern portion of the site; however, the lack of groundwater use at the site and its depth below the ground surface indicate that exposure, and therefore risk, is minimal. Likewise, soil at the site is covered by pavement and buildings except in small areas, thus limiting contact with potential receptors. Based on this information, it is believed that exposures and risks which may be associated with metals or organic compounds in soils at the site can be mitigated by one or more of the following methods:

- hot spot removal;
- capping and barriers;
- building design and construction methods; and
- institutional controls.

These remedial measures are suggested because they take advantage of the existing site conditions and the proposed approach for redevelopment of the site as commercial property with the city's East Rome Industrial Park. The final report will present an evaluation of these remedial measures and their suitability for managing the exposures and risks identified by the field investigation of the site. As redevelopment of the site occurs, each of the target receptor groups previously discussed will potentially be exposed to media at the site. In that light, the remedial alternatives proposed below should be viewed as a model for site redevelopment which will be tested and refined. The remediation approach is the same as that outlined to NYSDEC in the July 20, 1995, meeting in Albany. A summary of the anticipated environmental issues and solutions is shown in Table 4-1 below.

TABLE 4-1
PRESUMPTIVE REMEDIAL ACTIONS

Environmental Issues	Solutions
Soil gas vapors	Building foundation barriers and vents
Dust	Hot spot removal Capping
Petroleum impacted soil	Hot spot removal In-situ treatment (soil vapor extraction, biological remediation)
Solvent impacted soil	Hot spot removal
Metal impacted soil	Hot spot removal Capping

4.3 Application of HBSLs to Site Management

Where remediation is determined to be necessary, there will be an analysis to determine what the most appropriate site management or remedial strategy should be. Since the goal is to control risk, the response strategy for HBSL exceedances must be tailored to the exposed population and exposure pathways. A proposed response strategy for each receptor group is outlined below.

4.3.1 Construction and Utility Workers

For construction workers and utility workers, potential exposure to soils can occur through the following exposure pathways:

- ingestion;
- inhalation of volatiles; and
- inhalation of dust.

For the construction workers, the greatest exposure to soil will occur during construction of roadways and buildings at the site. Soils which are presently covered by pavement or old buildings will be exposed and contact with soil will be possible. For utility workers, the greatest potential for exposure to soil will occur during excavation to install or maintain utility lines.

If soil concentrations are evaluated to require remediation one or more of the following management alternatives may be carried out.

- If possible, construction and utility excavation activity can be restricted in certain areas.
- If potential exposures of concern are for ingestion only, then additional health and safety requirements can be imposed in certain areas to minimize ingestion exposure.
- If potential exposures of concern are only for inhalation of dust, then dust monitoring can be imposed and measures to suppress dust generation can be imposed based on the procedures outlined in NYSDEC's TAGM-4031, titled "Fugitive Dust Suppression and Particulate Monitoring Program at Inactive Hazardous Waste Sites."
- Soils can be removed or stabilized in place.

The type of construction anticipated for most of the industrial park is slab-on-grade for light industrial/commercial firms. Therefore, groundwater and deep soils will therefore not be encountered in most locations. Where deep foundations are required for heavily loaded buildings it will be possible to use piling-supported structures to minimize contact with groundwater, such as that which was proposed previously for a small power generation facility at the south side of the former General Cable site (Empire Soils, personal communication).

4.3.2 Local Residents

For local residents, potential exposure to soils can occur via inhalation exposures following volatile or dust emissions on site during construction and dispersion to the off-site residential locations. If soil concentrations raise potential exposures of concern for the nearby residents, the following management alternatives can be considered.

- A more refined analysis can be undertaken to develop a more realistic site-specific evaluation of potential exposures.

- Since exposures to these receptors occur as a result of volatile and dust emissions during construction activities, air monitoring can be conducted during construction and measures to suppress either volatile or dust emissions can be implemented based on the monitoring data.
- The affected soil can be removed, stabilized in-place (for metals) or treated in-place for volatiles through a soil venting system.

4.3.3 Future Commercial/Industrial Occupants

Once the site is fully developed it is anticipated that the entire property will be either covered with asphalt/concrete, structures, or new soil. As a result, incidental contact with residuals in the soil by future commercial/industrial occupants is not anticipated. If soils are inaccessible to people at the site, then the only potential exposure to chemicals would be by migration of soil gas vapors to the work space of the buildings and subsequent inhalation by future commercial/industrial occupants.

If soil gas concentrations raise potential exposures of concern then one or more of the following management alternatives can be taken.

- For existing structures, a foundation vent system can be installed.
- For new structures, buildings can be located in areas where soil vapors do not raise exposures of concern. Alternatively, the building can be constructed with a vapor barrier or foundation vent system.
- The affected soil can be removed or treated in-place with a soil venting system.
- If the ultimate source of the soil vapors is impacted groundwater, the buildings will be designed to allow further investigation of groundwater and to enable groundwater to be remediated, if necessary.

4.4 Removal Actions

During the course of the field investigation impacted media may be discovered which can be remediated quickly and simply by removing them for off-site treatment and disposal. It is proposed that such removal actions be allowed, subject to NYSDEC review and approval on a case-by-case basis. Examples of candidates for removal actions would include underground storage tanks, sumps or other process equipment, visually impacted soils, building or equipment debris, and buried wastes. Approval in principle to perform removal actions will not mean that they must be performed; the City of Rome will make the decision on a case-by-case and voluntary basis whether or not to go forward with immediate removal of candidate materials.

4.5 Application of the Work Plan Template to Other Properties

This investigation of the core of the former General Cable site will be carried-out as a pilot project for investigation and redevelopment of the entire East Rome Industrial Park in conjunction with the EPA Brownfields pilot program. Lessons learned from this study will be used to revise the basic elements of the work plan so that it may be applied with minor customization to other properties. This will assure that a standard approach is taken to all investigation and remediation activities across the redevelopment area, and will greatly reduce the time needed for preparation and review of work plans.

5.0 REFERENCES

Empire Soils Investigations, 1990, *Environmental Site Assessment, Mill Street, Rome, New York,* August 1990, Atlantic Energy Systems, Inc.

Empire Soils Investigations, 1991, *Phase II Environmental Site Assessment for Independent Power Plant, Rome, New York,* September, 1991, Atlantic Energy Systems, Inc.

Empire Soils Investigations, 1992, *Phase II Investigation Work Plan, Proposed Power Generation Plant,* September, 1992, Atlantic Energy Systems, Inc.

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RETEC, 1995, *Phase I Environmental Site Assessment, City of Rome Industrial Redevelopment* Area, Rome, New York, Department of Planning and Community Development, City of Rome New York, October, 1995.

RETEC, 1996, *Limited Phase II Environmental Investigation of the Former General Cable Property, Rome, New York*, The Saratoga Associates, Saratoga Springs, New York, February, 1996.

APPENDIX A

RETEC STANDARD OPERATING PROCEDURES

SOP 120: DECONTAMINATION

1.0 Purpose and Applicability

This SOP describes the methods to be used for the decontamination of all field equipment which becomes potentially contaminated during a sample collection task. The equipment may include split spoons, bailers, trowels, shovels, hand augers or any other type of equipment used during field activities.

Decontamination is performed as a quality assurance measure and a safety precaution. It prevents cross contamination between samples and also helps to maintain a clean working environment.

Decontamination is achieved mainly by rinsing with liquids which include: soap and or detergent solutions, tap water, distilled water/carbon free, acetone and methanol. Equipment may be allowed to air dry after being cleaned or may be wiped dry with chemical free cloths or paper towels if immediate re-use is needed.

At most project sites, decontamination will be accomplished between each sample collection point. Waste products produced by the decontamination procedures such as waste liquids, solids, rags, gloves, etc. will be collected and disposed of properly based on the nature of contamination. Specific details for the handling of the decontamination wastes will be addressed in the project plans.

2.0 Responsibilities

It is the responsibility of the field sampling coordinator to assure that the proper decontamination procedures are followed and that all waste materials produced by decontamination are properly managed. It is the responsibility of the project safety officer to draft and enforce safety measures which provide the best protection for all persons involved directly with sampling and or decontamination.

It is the responsibility of any subcontractors (i.e., drilling contractors) to follow the proper, designated decontamination procedures that are stated in their contracts and outlined in the Project Health and Safety Plan. It is the responsibility of all personnel involved with sample collection or decontamination to maintain a clean working environment and to ensure that any contaminants are not negligently introduced to the environment.

3.0 Supporting Materials

- Cleaning liquids and dispensers: soap and or detergent solutions, tap water, distilled/deionized water, and acetone.
- Personal safety gear as defined in the Project Health and Safety Plan,
- Chemical free paper towels,
- Disposable gloves,
- Waste storage containers: drums, boxes, plastic bags,
- Cleaning containers: plastic and/or galvanized steel pans and buckets,
- Cleaning brushes, and
- Aluminum foil

4.0 Methods/Procedures

The extent of known contamination will determine the degree of decontamination required. If the extent of contamination cannot be readily determined, cleaning should be done according to the assumption that the equipment is highly contaminated.

The standard procedures listed below can be considered the procedure for full field decontamination. If different or more elaborate procedures are required for a specific project, they will be spelled out in the project plans. Such variations in decontamination may include following all, just part, or an expanded scope of the decontamination procedure stated herein.

- Remove gross contamination from the equipment by brushing and then rinsing with tap water.
- Wash with soap or detergent solution.
- Rinse with tap water.
- Rinse with acetone.
- Rinse with distilled/deionized water.
- Repeat entire procedure or any parts of the procedure as necessary.

5.0 Quality Assurance/Quality Control

To assess the adequacy of decontamination procedures, field blanks are collected for aqueous samples and replicates are collected for soil samples. The specific number of blanks and replicates will be defined in the project sampling plan. In general, for water samples, one field blank will be collected per sampling event and per sampling equipment.

6.0 Documentation

Field notes will be kept describing the procedure used to collect the field blanks. The field notes will be kept in the project files.

SOP 210: SOIL SAMPLING AND SUBSURFACE EXPLORATION

1.0 Purpose and Applicability

This SOP describes the methods used in obtaining soil samples for physical testing, stratigraphic correlations, and chemical analysis. Soil samples are obtained in conjunction with test pit excavations, soil borings, and monitoring well installation programs. These procedures provide direct information as to the physical makeup of the surface and subsurface environment. This SOP will discuss sampling of the surface material with hand tools and sampling of the subsurface material by augers and split spoons, and within test pits.

2.0 Responsibilities

The project geologist/engineer will be responsible for the proper use and maintenance of all types of equipment used for obtaining surface and test pit samples. The geologist/engineer will determine the location, total depth and overall size of each surface sample collection point and test pit, and the location and depth of all subsurface borings.

It is the responsibility of contractors to provide the necessary materials for obtaining subsurface samples in borings and for the decontamination of these materials. Construction of test pits, split spoon sampling, and subsurface augering will be conducted by the contractor.

It shall be the responsibility of the project geologist/ engineer to observe all activities pertaining to soil sampling and subsurface investigations to ensure that all the standard procedures are followed properly, and to record all pertinent data, including unified soil system classification, on a field log or field book. The collection, handling, and storage of all samples will be the responsibility of the geologist/engineer.

3.0 Supporting Materials

In addition to materials provided by a contractor, the geologist/engineer will provide:

- Sample bottles/containers and labels,
- Boring and test pit logs,
- Field notebook,
- Chain of custody forms,
- Depth measurement device,
- Stakes and fluorescent flagging tape,
- Decontamination solutions,
- Camera for photographing sections, and
- Sample cutting/extracting equipment: knives, trowels, shovels, hand auger.

4.0 Methods

Specific sampling equipment and methodology will be dictated by the characteristics of the soil to be sampled, the type of soil samples required and by the analytical procedures to be employed. Soil samples obtained at the surface may be collected using a shovel, trowel or hand auger. A hand auger can be used to extract shallow soil samples up to 10 feet below the surface. Sampling to obtain uniform coverage within a specified area will often require the use of an area grid. These considerations will be followed based upon specific project requirements.

The sampling depth interval in borings is typically one sample per every five feet with additional samples taken at the discretion of the project geologist/engineer when significant textural or odor changes are encountered. Deviations in the standard operating procedure will be covered in the project specific operating procedures.

Most subsurface explorations by ReTeC will be on privately owned land and often an industrial facility. Prior to commencing subsurface exploration ReTeC will work with the facility manager to locate any subsurface utilities or structures. If no data are available, utilities (electric, water, sewer, etc.) who may have equipment or transmission lines buried in the vicinity will be notified. Many regions have organizations which represent all utilities for these notification purposes. Allow enough time after notification (typically three working days) for the utilities to respond and provide locations of any equipment which may be buried on site.

4.1 General Applications

General locations for test pits and sampling locations may be documented by survey or by using topographic maps and/or plans. A preliminary log of the test pit, or boring shall be prepared in the field by the geologist or engineer. A sketch of the test pit may be necessary to depict the strata encountered.

Sampling locations shall be mapped by the geologist or engineer. Before measuring the depth to the groundwater, if encountered, the geologist or engineer will allow sufficient time for stabilization of the groundwater table. All information shall be recorded in a log book. The data shall be transferred at a later date to profiles or logs at a scale to be determined by the geologist or engineer.

4.2 Surface Sampling

Prior to surface sampling, remove all surface materials that are not to be included such as rocks, twigs, leaves. For sample collection within the upper two to three feet use a shovel or trowel. A hang auger may be used to depths of up to 10 feet. When using the hand auger, auger the hole to the required depth, then slowly remove the auger and collect the soil sample from the auger flight at the point corresponding to the required depth. A tube sampler can be attached to the auger rods after augering to the desired depth, inserted into the open borehole, and then advanced into the deposits at the base of the boring. If sampling is in sandy or non-cohesive soil, a shovel may be necessary to collect samples.

4.3 Test Pit Excavation and Sampling

The test pits shall be excavated in compliance with applicable safety regulations. Walls should be cut as near vertical as possible to facilitate stratigraphic logging. The size and depth of test pit shall be recorded in the Test Pit Log shown in Figure 1.

Photographs of specific geologic features may be required for documentation purposes. A scale or an item providing a size perspective should be placed in each photograph. The frame number and picture location shall also be documented in the field log book.

The test pit shall be inspected to ensure that all the appropriate and/or required data and samples have been collected. All test pits will be backfilled to original grade and compacted.

4.4 Subsurface Sampling

Borings are typically advanced by two methods, rotary drilling and augering. The casing shall be of the flush joint or flush couple type and of sufficient size to allow for soil sampling, coring, and/or well installation. All casing sections shall be straight and free of any obstructions. Hollow stem augers or solid flight augers with casing may be used according to specific project requirements. Rotary drilling may be used in dense formations to advance to the required sample depth where a split spoon sampler or a coring device will be used to obtain the sample. Recirculated water shall not be used when casing is being driven unless specified in project specific plans and/or directed and properly documented by the geologist/ engineer. If recirculated water is used all loose material within the casing shall be removed by washing to the required sampling depth using a minimum amount of water. Care should be taken to limit recirculation of the wash water to those times when the water supply is extremely limited or unavailable.

Subsurface soil samples shall be obtained using a split-tube type sampler (split spoon). Split spoons come in a variety of sizes with the most standard having a 2-inch OD, a 1 3/8-inch ID and a 24-inch long barrel with an 18-inch sample capacity. Split spoons shall be equipped with a check valve at the top and a flap valve or basket type retainer at the bottom. Samples shall be obtained using the standard penetration test (SPT), which allows for determination of resistance within the deposits. The number of hammer blows shall be recorded on the boring log.

The split spoon sampler shall be immediately opened upon removal from the casing. If the recovery is inadequate, further attempts shall be made until the amount of material is of a sufficient quantity as necessary for the required sample size. The sampler shall be decontaminated between attempts, in accordance with SOP 120 to prevent cross contamination.

In the event that gravels or other material prevents penetration by the split spoon, samples will be collected from the auger flights. Slowly remove the auger and collect the sample at the point corresponding to the required depth.

4.5 Sample Handling

Specific procedures pertaining to the handling and shipment of samples shall be followed according to SOP 110. Sample containers (jars or bags) shall be labelled with the following information:

- Client/project name,
- Test pit,boring, or sampling point number,
- Sample number/identification,
- Horizontal/vertical location, and

- Date of collection.

These data shall be similarly recorded on to the sample log sheets and field log book. Larger, bulk samples shall be placed in cloth bags with plastic liners. Sample bags shall be marked with the information listed above.

5.0 Documentation

- Test pit or boring log,
- Sample log sheets,
- Field log book,
- Chain of custody forms, and
- Shipping receipts

All documentation shall be placed in the project files and retained following completion of the project.

BORING LOG

REMEDIATION TECHNOLOGIES, INC.

BORING No.	**WELL No.**	**PAGE OF**
PROJECT	LOCATION	CASING TYPE
PROJECT NO.	CONTRACTOR	CASING O.D./I.D.
DATE	DRILLER	AUGER O.D./I.D.
TOTAL DEPTH	RIG TYPE	GROUT
LOGGED BY	METHOD	

SAMPLE ID & TIME	**PID/FID READING**	**BLOW COUNTS**	**RECOVERY (INCHES)**	**DEPTH (FEET)**	**SAMPLE DESCRIPTION**

GROUNDWATER DEPTH (feet) DATE/TIME

REMARKS

No. 0876

CHAIN OF CUSTODY RECORD

PROJ. NO.

PROJECT NAME

SAMPLERS:

RECEIVING LABORATORY:

SAMPLE NO.	DATE	TIME	SAMPLE LOCATION	NO. OF CONTAINERS							REMARKS

Relinquished by: *(Signature)*	Date/Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date/Time	Received by: *(Signature)*
Relinquished by: *(Signature)*	Date/Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date/Time	Received by: *(Signature)*
Relinquished by: *(Signature)*	Date/Time	Received for laboratory by: *(Signature)*	Date/Time		

REMARKS:

REMEDIATION TECHNOLOGIES INC

REMEDIATION TECHNOLOGIES
3040 William Pitt Way
Pittsburgh, PA 15238
(412) 826-3340
Fax# (412) 826-3409

PINK COPY - Sampler

YELLOW COPY - Laboratory

WHITE COPY - RETEC

SOP No: 230
Rev. Date: 9/01/95
Rev. By: LDN/AMC

SOP 230

GROUNDWATER SAMPLING

1.0 PURPOSE AND APPLICABILITY

This SOP describes the collection of valid and representative samples from groundwater monitoring wells. Specific project requirements as described in an approved Work Plan, Sampling Plan, Quality Assurance Project Plan, or Health & Safety Plan will take precedence over the procedures described in this document.

2.0 RESPONSIBILITIES

The field sampling coordinator will have the responsibility to oversee and ensure that all groundwater sampling is performed in accordance with the project specific sampling program and this SOP. In addition, the field sampling coordinator must ensure that all field workers are fully apprised of this SOP.

3.0 SUPPORTING MATERIALS

The list below identifies the types of equipment which may be used for a range of groundwater sampling applications. From this list, project specific equipment will be selected based upon project objectives and site conditions (e.g., the depth to groundwater, purge volumes, analytical parameters, well construction, and physical/chemical properties of the analytes). The types of sampling equipment are as follows:

Purging/Sample Collection

- Bailers and bailer cord;
- Centrifugal pump;

- Bladder pump; or
- Peristaltic pump.

The most widely applicable equipment that will contact the water must be made of inert materials, preferably stainless steel or fluorocarbon resin.

Sample Preparation/Field Measurement

- pH meter;
- Specific conductance meter;
- Thermometer;
- Filtration apparatus; and
- Water-level measurement equipment.

All equipment will be calibrated before use following the manufacturer's specifications.

General

- Distilled water dispenser bottle;
- Methanol or isopropyl dispenser bottle;
- Decontamination equipment;
- Personal protection equipment as specified in the Project Health and Safety Plan;
- Field data sheets and field book;
- Sample containers, labels, and preservation solutions;
- Buckets and drums;

- Coolers and ice; and
- Paper towels or chemical-free cloths.

4.0 METHODS AND PROCEDURES

The following sections describe the methods and procedures required to collect representative groundwater samples.

4.1 Water-Level Measurement

After unlocking and/or opening a monitoring well, the first task will be to obtain a water-level measurement. A static-water level will be measured in the well prior to the purging and collection of any samples. The water level is needed for estimating the purge volume and may also be used for mapping the potentiometric surface of the groundwater. Water-level measurements will be made using an electronic or mechanical device following the methods described in SOP 231.

The measuring point location for the well should be clearly marked on the outermost casing or identified in previous sample collection records. This point is usually established on the well casing itself, but may be marked on the protective steel casing in some cases. In either case, it is important that the marked point coincide with the same point of measurement used by the surveyor. If not marked from previous investigations, the water level measuring point should be marked on the north side of the well casing and noted in the groundwater sampling form (Figure 1). Whatever measuring point is used, the location should be described on the groundwater sampling form.

To obtain a water level measurement lower a decontaminated mechanical or an electronic sounding unit into the monitoring well until the audible sound of the unit is detected or indicates water contact. At this time the precise measurement should be determined by repeatedly raising

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REMEDIATION TECHNOLOGIES, INC.
Groundwater Sampling Form

PROJECT ______________________ **WELL NO.** ______________________
PROJECT NO. ______________________ **SAMPLERS** ______________________

1. WELL CONDITION CHECKLIST

a. Bump posts __________ Pro. casing/lock __________ Surface pad __________
b. Well visibility (paint) ______________________
c. Well label ______________________

2. WATER LEVEL MEASUREMENT

DATE __________ TIME __________
WEATHER CONDITIONS ______________________
a. Location of measuring point ______________________
b. Depth of water table from measuring point ______________________
c. Height of measuring point above ground surface ______________________
d. Total depth of well below measuring point ______________________
e. Length of water column (line 2d-2b) ______________________

3. WELL PURGING

DATE __________ TIME __________
WEATHER CONDITIONS ______________________
a. Purge method ______________________
b. Required purge volume at 3 well volumes ______________________

Pumping Duration/Vol Rmvd	pH	Cond.	T(C)	Appearance

4. SAMPLE COLLECTION

DATE __________ TIME __________
WEATHER CONDITIONS ______________________
a. Collection Method ______________________
b. Meter Calibration:

	Date	Model
pH Meter		
Conductivity Meter		

c. Sample Information pH __________ Cond. __________ T(C) __________

Analysis	Containers	Sample Prep./Preservation

d. Chain of Custody Form __________ COC Tape __________
e. Shipping Container ______________________

5. COMMENTS:

____

____

and lowering the tape or cable to converge on the exact measurement. The water-level measurement should be entered on the groundwater sampling form. The water-level measurement device shall be decontaminated immediately after use following the procedures outlined in SOP 120.

4.2 Purging and Sample Collection Procedures

Well purging is the activity of removing some volume of water from a monitoring well in order to induce "fresh" groundwater to flow into the well prior to sampling. Under most well construction and hydrogeologic conditions, this provides water that is more representative of the groundwater in saturated materials adjoining the well.

The volume of water to be removed, referred to as the purge volume, is a function of the water-yielding capacity of the well, the well diameter and depth, and the depth to water made just prior to purging. The well depth should be sounded with the water-level cable or tape just before or after measuring the static depth to water. A well volume is defined as the product of the length of water column and the volume per unit length of well casing, a function of casing inside diameter. The following data can be used in this field calculation:

Inside Diameter, inches	Gallons/foot
1 1/4	0.077
1 1/2	0.10
2	0.16
3	0.37
4	0.65
6	1.64

According to the TEGD (USEPA, 1986), the purge volume should equal at least three well volumes when the earth materials will yield relatively large quantities of water, and between one and two well volumes when the earth materials will only yield small quantities to the well. From a field operations viewpoint, large quantities (high yield) means that the well can not be pumped or bailed "dry" by removing three well volumes. Small quantities (low yield) are identified when the well can be pumped or bailed "dry".

Based on experience and recent scientific literature, it will be RETEC's policy to minimize the generation of water turbidity when purging. Turbidity is especially of concern when testing the samples for metals or for selected organics that may be sorbed to the sediment. Turbidity will be minimized by :

- using a low-pumping rate submersible pump such as a compressed-gas driven bladder pump; or
- slowly moving the bailer in and out of the water column; avoid dropping the bailer and removing it quickly.

Purging will be performed for all groundwater monitoring wells prior to sample collection.

Three general methods are used for well purging. Well purging may be achieved using bailers, surface pumps, or down-well submersible pumps. In all cases pH and specific conductance will be monitored during purging. Field parameter values will be entered on the groundwater sampling form along with the corresponding purge volume. The following sections explain the procedures to be used to purge and collect samples from monitoring wells.

4.2.1 Bailing

Obtain a clean decontaminated bailer and a spool of polypropylene rope or equivalent bailer cord. Using the rope at the end of the spool, tie a bowline knot, or equivalent, through the bailer loop. Test the knot for adequacy by creating tension between the line and the bailer. Tie again if needed.

Lower the bailer to the bottom of the monitoring well and remove an additional five feet of cord from the spool. Cut the cord at the spool and secure the rope to the well head or the wrist of the person who shall perform the bailing.

Raise the bailer by grasping a section of cord using each hand alternately. This bailer lift method is used so that the bailer cord will not come into contact with the ground or other potentially contaminated surfaces.

Samples collected by bailing will be poured directly into sample containers from bailers which are full of fresh groundwater. Samples will be collected in the following order:

- Volatile organic compounds;
- Semivolatile organic compounds;
- Pesticides/Herbicides/PCBs/Dioxins;
- Organic indicator compounds;
- Metals (total and/or dissolved);
- Miscellaneous inorganic compounds;
- Radiometric compounds; and
- Microbial analyses.

During sample collection, bailers will not be allowed to contact the sample containers.

4.2.2 Pumping

Groundwater withdrawal using pumps is commonly performed with centrifugal, peristaltic, submersible, or bladder pumps. Peristaltic and centrifugal pumps are limited to conditions where groundwater need only be raised through approximately 20 to 25 feet of vertical distance. Submersible or bladder pumps can be used when groundwater is greater than 25 feet below grade. Specific methods for pumps will be discussed in the project specific sampling plan. Pumping for collection of samples to be analyzed for volatile organics will only be with bladder pumps.

Samples collected by pumping will be transferred directly from the pump discharge tubing into the sample containers. Samples will be collected in the following order:

- Volatile organic compounds;
- Semivolatile organic compounds;
- Pesticides/Herbicides/PCBs/Dioxins;
- Organic indicator compounds;
- Metals (total and/or dissolved);
- Miscellaneous inorganic compounds;
- Radiometric compounds; and
- Microbial analyses.

During sample collection, the discharge tubing will not be allowed to contact the sample containers.

4.3 Sample Preparation and Filtration

Specific procedures pertaining to the handling and shipment of samples shall be in accordance with SOP 110. A clean pair of gloves and decontaminated sampling tools will be used when handling the samples during collection to prevent cross contamination.

Prior to transport or shipment, groundwater samples may require preparation and/or preservation. Field preparation may entail filtration, preservation in the form of chemical additives, or temperature control. Specific preservation requirements will be described in the project specific sampling plans.

Groundwater samples collected for dissolved metals analyses will be filtered prior to being placed in sample containers. Groundwater filtration will be performed using a peristaltic pump and a 0.45 micron water filter unless otherwise specified in the project specific sampling plan.

For most dissolved metal analyses, pH adjustment of the sample is also required and shall be performed after filtration.

5.0 QUALITY ASSURANCE/QUALITY CONTROL

QA/QC requirements include, but are not limited to, blind field duplicates, blind rinsate blanks, and blind field blanks. These samples will be collected on a frequency of one QA/QC sample per 10 field samples or a minimum of one QA/QC sample per day unless otherwise specified in the project specific sampling plan.

6.0 DOCUMENTATION

A number of different documents will be completed and maintained as a part of groundwater sample collection. The documents will provide a summary of the sample collection procedures and conditions, shipment method, the analyses requested, and the custody history. The documents may include:

- Field book;
- Groundwater sampling forms;
- Sample labels;
- Chain of custody; and
- Shipping receipts.

All documentation will be stored in the project files.

REFERENCES

Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells, EPA 600/4-89/034, published by National Water Well Association, 1989.

RCRA Ground Water Monitoring Technical Enforcement Guidance Document, published by National Water Well Association, 1986.

A Compendium of Superfund Field Operations, EPA 540/P-87/001, published by the Office of Emergency and Remedial Response, Office of Waste Programs Enforcement, US EPA, 1987.

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SOP 231

WATER-LEVEL MEASUREMENTS

1.0 PURPOSE AND APPLICABILITY

This SOP is concerned with the measurement of water levels in groundwater monitoring wells. Water-level measurements are fundamental to groundwater and solute transport studies. Water-level data are used to indicate the directions of groundwater flow and areas of recharge and discharge, to evaluate the effects of manmade and natural stresses on the groundwater system, to define the hydraulic characteristics of aquifers, and to evaluate stream-aquifer relations. Measurements of the static-water level are also needed to estimate the amount of water to be purged from a well prior to sample collection.

Specific project requirements as described in an approved Work Plan, Sampling Plan, Quality Assurance Project Plan, or Health & Safety Plan will take precedence over the procedures described in this document.

2.0 RESPONSIBILITIES

The field sampling coordinator will have the responsibility to oversee and ensure that all procedures are performed in accordance with the project specific sampling program and this SOP.

3.0 SUPPORTING MATERIALS

This section identifies the types of equipment which may be used for measurement of groundwater levels. Based on project objectives, observed or probable well contamination, and well construction, a project specific equipment list will be determined from the following equipment:

- Water-level and/or product-level measuring device;

- Distilled water dispenser bottle;
- Methanol or isopropyl dispenser bottle;
- Plastic sheeting;
- Personal protection equipment as specified in the Project Health and Safety Plan;
- Fluid-level monitoring logs and field book; and
- Paper towels or chemical-free cloths.

4.0 METHODS AND PROCEDURES

When taking a series of fluid-level measurements at a number of monitoring wells, it is generally good practice to go in order from the least- to most-contaminated well. Additionally, the measurement of all site wells should be done consecutively and before any sampling activities begin. This will ensure the data are representative of aquifer conditions. All pertinent data should be entered in the fluid-level monitoring log sheet (Figure 1) or the project field book.

4.1 Well Evaluation

Upon arrival at a monitoring well, the surface seal and well protective casing should be examined for any evidence of frost heaving, cracking, or vandalism. All observations should be recorded in the fluid-level monitoring log or the project field book. The area around the well should be cleared of weeds and other materials prior to measuring the static-water level. A drop cloth or other material (e.g., plastic garbage bag) should be placed on the ground around the well, especially if the ground is disturbed or potentially contaminated. This will save time and work for cleaning equipment or tubing if it falls on the ground during preparation or operation. The well protective casing should then be unlocked and the cap removed.

4.2 Safety Considerations

If the well is suspected of being contaminated, or has a history of contamination, the static water-level measurements should be made while wearing appropriate protective gear. The air in the well head should be sampled for organic vapors using either a photoionization analyzer or an organic vapor analyzer. The results shall be recorded in the fluid-level monitoring log or the project field book. This is the first indication of the presence of a non-aqueous phase liquid (LNAPL). If the potential for fire or explosion exists, additional personal monitoring shall be conducted.

4.3 Measuring Point Location

The measuring point location for the well should be clearly marked on the outermost casing or identified in previous sample collection records. This point is usually established on the well casing itself, but may be marked on the protective steel casing in some cases. In either case, it is important that the marked point coincide with the same point of measurement used by the surveyor. If not marked from previous investigations, the water-level measuring point should be marked on the north side of the well casing and noted in the fluid-level monitoring log or the project field book. Monitoring well measurements for total depth and water level should be consistently measured from one reference point so that these data can be used for assessing trends in the groundwater.

4.4 Water-Level Measurement

Water-level measurements shall be made using an electronic or mechanical device. Several methods for water-level measurement are described below. The specific method to be used will be defined in the project specific sampling plan.

4.4.1 Graduated Steel Tape

The graduated steel tape method is considered an accurate method for measuring the water level in nonflowing wells. Steel surveying tapes in lengths of 100, 200, 300, 500, and 1,000 feet are commonly used; a black tape is better than a chromium-plated tape. The tapes are mounted on hand-cranked reels up to 500-ft lengths; for greater depth, a motor-driven tape drive is usually required. A slender weight is attached to the ring at the end of the tape to ensure plumbness and to permit some feel for obstructions.

The lower few feet of tape is chalked by pulling the tape across a piece of blue carpenter's chalk. The wet chalk mark identifies the portion of the tape that was submerged. Lower the graduated steel-tape from the measuring point at the top of the well until a short length of the tape is submerged. The weight and tape should be lowered into the water slowly to prevent splashing. Submergence of the weight and tape may temporarily cause the water level to rise in wells or piezometers having very small diameters. This effect can be significant if the well is in materials of very low hydraulic conductivity.

Under dry surface conditions, it may be desirable to pull the tape from the well by hand, being careful not to allow it to become kinked, and reading the water mark before rewinding the tape onto the reel. In this way, the water mark on the chalked part of the tape is rapidly brought to the surface before the wetted part of the tape dries. In cold regions, rapid withdrawal of the tape from the well is necessary before the wet part freezes and becomes difficult to read. Read the tape at the measuring point, and then read the water mark on the tape. The difference between these two readings is the depth to water below the measuring point. Errors resulting from the effects of thermal expansion of tapes and of stretch due to the suspended weight of the tape and plumb weight can become significant at high temperatures and for measured depths in excess of 1,000 feet.

The observer should make two measurements. If two measurements of static-water level made within a few minutes do not agree within 0.01 or 0.02 foot in observation wells having a depth to water of less than a couple hundred feet, continue to measure until the reason for the lack of agreement is determined or until the results are shown to be reliable. Where water is dripping into the well or covering the well casing wall, it may be impossible to get a good water mark on the chalked tape.

4.4.2 Electrical Methods

Many types of electrical instruments are available for water-level measurement; most operate on the principle that a circuit is completed when two electrodes are immersed in water. Electrodes are generally contained in a weighted probe that keeps the tape taut while providing some shielding of the electrodes against false indications as the probe is being lowered into the well. Before lowering the probe in the well, the circuitry can be checked by dipping the probe in water and observing the indicator (a light, sound, and/or meter).

To obtain a water-level measurement, slowly lower the decontaminated probe into the monitoring well until the indicator (light, sound, and/or meter) shows water contact. At this time the precise measurement should be determined by repeatedly raising and lowering the tape or cable to converge on the exact measurement.

In wells having a layer of NAPL floating on the water, the electric tape will not respond to the oil surface and, thus, the fluid level determined will be different than would be determined by a steel tape. The difference depends on how much NAPL is floating on the water. Dual media tapes are recommended in these instance to measure both NAPL and water levels using the same measuring device.

The water-level measurement should be entered in the fluid-level monitoring log or the project field book. The water-level measurement device shall be decontaminated immediately after use following the procedures described in SOP 120.

4.4.3 Air Line

The air line method is especially useful in pumped wells where water turbulence may preclude using more precise methods. A small diameter air-type tube of known length is installed from the surface to a depth below the lowest water level expected. Compressed air is used to purge the water from the tube. The pressure, in pounds per square inch (psi), needed to purge the water from the air line multiplied by 2.31 (feet of water for one psi) equals the length in feet of submerged air line. The depth to water below the center of the pressure gage can be easily calculated by subtracting the length of air line below the water surface from the total length of air line (assuming the air line is essentially straight).

Accuracy depends on the precision to which the pressure can be read. The accuracy of an air line or pressure gage measurement depends primarily on the accuracy and condition of the gage. It is normally within one foot of the true level as determined by means of a steel-tape measurement. The air lines themselves, however, have been known to become clogged with mineral deposits or bacterial growth, or to develop leaks and consequently yield false information. A series of air line measurements should be checked periodically by the use of a steel tape or an electric water-level indicator.

The air line and any connections to it must be airtight throughout the entire length. A long-term increase in air line pressure may indicate gradual clogging of the air line. A relatively sudden decrease in air line pressure may indicate a leak or break in the air line. Air line pressures that never go above a constant low value may indicate that the water level has dropped below the outlet orifice of the air line. To minimize the effect of turbulence, the lower end of the air line should be at least five feet above or below the pump intake. Corrections should be made for fluid temperatures much different from 20°C and for vertical differences in air density in the well column for cases where the depth to water is very large.

4.5 Procedures for Immiscible Fluids

At those facilities where monitoring to determine the presence or extent of immiscible fluids is required, the sampler will need to use special procedures for the measurement of fluid levels. The procedures required will depend on whether light NAPL (LNAPL) that form lenses floating on top of the water table or dense NAPL (DNAPL) that sink through the aquifer and form lenses over lower permeability layers are present.

In the case of LNAPL, measurements of immiscible fluid and water level usually cannot be accomplished by using normal techniques. For example, a chalked steel tape measurement will only indicate the depth to the immiscible fluid (not the depth to water) and a conventional electric water-level probe will not generally respond to nonconducting immiscible fluids. Similar problems are found with other techniques.

To circumvent these problems, the use of special techniques and equipment can be specified. These techniques have been specially developed to measure fluid levels in wells containing LNAPL or DNAPL, particularly petroleum products. One method is similar to the chalked steel tape method. The difference is the use of a special paste or gel rather than ordinary carpenters chalk. Such indicator pastes, when applied to the end of the steel tape and submerged in the well, will show the top of the oil as a wet line and the top of the water as a distinct color change. Another method, similar to the electric tape method, uses a dual purpose probe and indicator system. The probe can detect the presence of any fluid (through the wetting effect) and can also detect fluids that conduct electricity. Thus, if a well is contaminated with low density, nonconducting LNAPL such as gasoline, the probe will first detect the surface of the gasoline, but it will not register electrical conduction. However, when the probe is lowered deeper to contact water, electrical conduction will be detected. The detection of a DNAPL would be similar.

4.6 Measurement of Total Depth

During water-level measurement, the total depth of the well may also be measured. This measurement gives an indication of possible sediment buildup within the well that may significantly reduce the screened depth. The same methods used for measuring water levels (e.g. steel tape or electrical probes) may be used to measure the total well depth. The most convenient time to measure the total well depth is immediately following measurement of the water level and prior to removing the measurement device completely from the well. The measurement device (steel tape or electrical probe) is lowered down the well until the measurement tape becomes slack indicating the weighted end of the tape or probe has reached the bottom of the well. The total depth of shall be recorded in the field book.

5.0 QUALITY ASSURANCE/QUALITY CONTROL

To ensure that accurate data are collected, repeated measurements of the fluid depths should be made. The readings should be within 0.01 to 0.02 feet of each other. A secondary check, if data are available, is to compare previous readings collected under similar conditions (e.g., summer months, wells pumping, etc.).

6.0 DOCUMENTATION

Data will be recorded in the fluid-level monitoring log form, the project field book, or, if groundwater sampling, the groundwater sample collection record. Additional comments, observations, or details will also be noted. These documents will provide a summary of the water-level measurement procedures and conditions, and will be kept the in project files.

SOP 250: SURFACE WATER SAMPLING

1.0 Purpose and Applicability

This SOP defines the basic techniques and general consid- erations to be followed for the collection of water quality samples from rivers, lakes and ponds. The specific details of actual sample collection are highly dependent upon local conditions as well as upon the purpose of the water quality study. Nevertheless, certain aspects of sample collection procedures are independent of project-specific variations.

2.0 Responsibilities

The project manager is responsible for ensuring that a properly designed sampling program is prepared prior to any sample collection. The sampling program will identify the general sampling location(s), frequency, sample type (grab or composite), water quality parameters and analytical procedures. The field team is responsible for familiarizing themselves with the sampling program, and ensuring that the appropriate sample containers and preservatives are available. The field team is also responsible for proper sample handling as specified in SOP 110, Packaging and Shipment of Samples.

3.0 Supporting Materials

- Project specific sampling program,
- Site area maps,
- Sample containers and preservatives,
- Insulated containers for sample storage and an ample supply of ice,
- Field equipment as specified in the sampling program and the corresponding manufacturer's manuals,

- Calibration standards for field equipment,
- Vertical or horizontal type sample collector,
- Boat or raft,
- Weighted tape measurer or rigid gage, and
- Field data sheets and/or log book.

4.0 Procedures

4.1 Sample Location Selection

The selection of the precise sampling location requires professional judgment and an understanding of the purpose of the study. Sampling locations where mixing is incomplete should be avoided if an average composition is required. Often areas of poor lateral or vertical mixing can be visually identified. For example, color or turbidity differences may be apparent immediately below the confluence of a tributary and the main river or at a wastewater discharge point. Use of a field conductivity meter is recommended for determining the uniformity of the water composition across the width and depth of the water body. Once the sampling point has been selected, it must be fixed by detailed description, maps, or with the aid of stakes, buoys, or other landmarks so that others can identify the sampling location.

4.2 Stream Sampling

In shallow streams (those which can be safely traversed on foot) the sample container can be filled directly with the flowing water. Unless otherwise specified in the project sampling program, samples should be collected at mid-depth section or deepest flow channel of the stream.

In deep rivers, use of a boat or raft will usually be required to obtain a representative sample. As with shallow streams, samples should be obtained at mid-depth in the mid-channel unless otherwise specified in the sampling program. Stream depth can be determined using a depth sounder or by physical measurement with a heavily weighted flexible measuring tape or a rigid gage.

A vertical or horizontal type sampler should be used for collecting samples at a specific depth in the water column.

4.3 Lake and Pond Sampling

Water in lakes and ponds is generally poorly mixed and thermal stratification is frequently observed, Single samples can only represent the specific spot from which they were obtained. For many studies, samples take at the inlet(s) and/or outlet of the lake or pond are of the most interest. In other studies, a grid is established over the lake or pond and samples are collected at grid line intersections. As with deep rivers, an Alpha horizontal type sampler should be used for sample collection.

4.4 Sample Handling and Preservation

In general, the shorter the time lapse between sample collection and analysis, the more reliable the results will be. Certain water quality parameters, especially pH, temperature and dissolved oxygen, are so closely related to the environment of the water that meaningful results can only be obtained by in-situ field measurements.

EPA has developed a list of recommended sample containers, preservatives and maximum holding times for water quality measurements (see Federal Register 44:69464) Unless otherwise specified in the sampling program, this list should be followed. Preservatives may be added to the sample containers in the field after filling, or the containers can be pre-spiked with the preservative. All samples should be placed on ice immediately after collection and should remain iced until delivery to the analytical laboratory.

5.0 Documentation

A record must be kept of every sample collected and every bottle must be clearly marked, preferably with a water proof label. The field record must provide positive sample ident- ification as well as the name of the sample collector, the date, time and exact location of the sample collection point, and results of all field water quality measurements. Other information such as weather and stream-flow conditions should also be noted. All documentation will be retained in the appropriate project files.

SOP 310

JAR HEADSPACE SCREENING

1.0 PURPOSE AND APPLICABILITY

This SOP describes the basic techniques for using a jar headspace analysis to screen for volatile organics from contaminated soils using a portable Photoionization Detector (PID) or Flame Ionization Detector (FID). Specific project requirements as described in an approved Work Plan, Sampling Plan, Quality Assurance Project Plan, or Health & Safety Plan will take precedence over the procedures described in this document.

2.0 RESPONSIBILITIES

The project sampling coordinator is responsible for overseeing work activities to ensure that field screening is performed and documented in accordance with the methods described here and in project specific sampling plan.

3.0 SUPPORTING MATERIALS

The following materials must be on hand in sufficient quantity to ensure that proper field analysis procedures may be followed.

- PID/FID instrument;
- 16 oz. soil or "mason"-type glass jars;
- aluminum foil; and
- project field book.

4.0 METHODS AND PROCEDURES

Half-fill one clean glass jar with the sample to be screened. Quickly cover each open top with one to two sheets of clean aluminum foil and apply screw caps to tightly seal the jars. Allow headspace development for at least ten minutes. Vigorously shake jars for 15 seconds, both at the beginning and end of the headspace development period. Where ambient temperatures are below 32°F (0°C), headspace development should be within a heated vehicle or building.

Subsequent to headspace development, remove the jar lid and expose the foil seal. Quickly puncture the foil seal with instrument sampling probe, to a point about one-half of the headspace depth. Exercise care to avoid uptake of water droplets or soil particulates. As an alternative, use a syringe to withdraw a headspace sample then inject the sample into the instrument probe or septum-fitted inlet. This method is acceptable contingent upon verification of methodology accuracy using a test gas standard. Following probe insertion through foil seal and/or sample injection to probe, record highest meter response as the jar headspace concentration. Using foil seal/probe insertion method, maximum response should occur between two and five seconds. Erratic meter response may occur at high organic vapor concentrations or conditions of elevated headspace moisture, in which case headspace data should be discounted.

5.0 QUALITY ASSURANCE/QUALITY CONTROL

QA/QC will include the collection of duplicate samples. Data generated between the duplicates should be consistent to plus or minus twenty percent. Also, the PID/FID instrument shall be calibrated (see SOP 320 for HNu operation/calibration) before beginning screening, and checked or recalibrated no less often than once every ten analyses.

6.0 DOCUMENTATION

All data generated (results and duplicate comparisons) will be recorded in the field book. Any deviation from the outlined procedure will also be noted. Field conditions (ambient temperature, wind, etc.) should also be recorded in the field notebook.

RETEC
REMEDIATION
TECHNOLOGIES INC

STANDARD OPERATING PROCEDURE

SOIL GAS MEASUREMENTS USING THE *PRE*SIT℠ METHOD

Approved By: L. Paul Chavez Date: 2/17/92

Approved By: Jeffrey A. Miller Date: 2-17-92

STANDARD OPERATING PROCEDURES (SOP)
SOIL GAS MEASUREMENTS USING THE *PRE*SIT℠ METHOD

1.0 PURPOSE AND APPLICABILITY

This SOP describes the methods to be used for measurement of volatile chemical concentrations in soil gas samples using the *PRE*SIT℠ Method of Remediation Technologies, Inc. Chemical concentrations are measured *in situ* using gas detector tubes with results read directly in the field. The investigative program can be changed in the field in response to the results. The data quality objective of this method is to delineate source areas of contamination via chemical concentrations in soil gas in a timely and cost-effective manner. Appendix A is a general brochure on the method with a picture of some of the equipment. Appendix B discusses the chemical rationale of this approach for locating source areas. Appendix C provides a general discission on Dräger tubes.

2.0 RESPONSIBILITIES

The project geologist/scientist will be responsible for ensuring the proper use and maintenance of all equipment used in making the measurements. The geologist/scientist will determine the location and depths of measurement points. The field crew will be responsible to provide, operate, and maintain the equipment and to make the soil gas measurements. The geologist/scientist will be responsible to observe all activities pertaining to the measurements and to ensure that all standard procedures are properly followed.

The geologist/scientist will be responsible to record all pertinent field data including, but not limited to, the following:

- client/project name,
- measurement point name/number,
- date of measurement,
- geologist/scientist's name,
- field crew names,
- location of measurement; map, and
- lithologic description.

All data will be recorded on field logs (Figure 2-1). In addition to the above, the following information specific to each measurement will be recorded by the geologist/scientist or field crew leader:

- depth,
- sample location/number,

- soil type,
- color and stain,
- odor,
- other indication of potential contamination, and
- gas detector tube measurements.

3.0 SUPPORTING MATERIALS

In addition to materials and equipment provided by the field crew, the geologist/scientist will provide:

- chain-of-custody documents,
- sample bottles/containers and labels,
- field notebook,
- stakes and fluorescent flagging tape,
- camera for photographing sections, and
- spatulas for obtaining samples.

4.0 METHODS

4.1 Field Methods

Soil gas concentrations indicative of source areas should be expected to be in the ppm range, typically between 10 ppm and several hundred ppm. Substance-specific gas detector tubes are designed to operate in this range. They allow an on time evaluation and delineation of source areas in a cost-effective manner.

*PRE*SIT℠ requires a borehole of 1 to 1.5 inches in diameter. The borehole is formed by driving a slotted rod, approximately one inch in diameter, containing a slot of approximately 0.375 inch width and 0.25 inch depth. As the rod is extracted, a soil sample is retrieved in the slot. This soil sample can be collected at boring locations for characterization and analysis. The soil sample is removed by scrapping the slot with a screwdriver, afterwhich it is placed in a four ounce glass sample jar. Soil samples for laboratory VOC analysis are placed into 20 ml vials with zero headspace.

Between borings, the drilling rod is scrapped of residual soil, washed in soap and water, and rinsed in succession with tap water and deionized water. This procedure is designed to prevent cross-contamination of boreholes with the drilling equipment.

A probe containing a gas detector tube in the tip is inserted into that hole. Using a small, hand-operated bellows pump, a defined volume of gas (typically 200 to 500 ml, depending on the type of tube used and the indicating range desired) from the bottom of the hole is drawn through the detector tube. The tube contains a reagent that changes color in the presence of a specific chemical. The length of the color band in the tube indicates the concentration of the chemical vapor. The immediate display enables the field crew to adapt the measuring and sampling program in terms of locations and depth levels to the actual contamination pattern.

Detector tubes manufactured by Drägerwerk AG Lübeck (Germany) are used. Appendix C contains a general discussion about the principals of these detector tubes along with a list of available tubes. These were taken from the 1989 Dräger Detector Tube Handbook.

It has to be considered that gas detector tubes show different degrees of cross-sensitivity. They do not only indicate the substance they are designed and calibrated for, but also some other compounds of similar chemistry. Accordingly, the results are only semi-quantitative. The manufacturer gives a standard deviation of 10% to 15% if only a single substance is involved.

To allow a more accurate qualitative and quantitative assessment of the compounds and concentrations present at a pre-screened location, soil gas samples are subsequently taken from selected points. Using the same boreholes as for the detector tube measurements, a probe containing a disposable, gas-tight 5 mL-syringe in the tip is lowered down the hole. The annulus is sealed at the surface with a cone, and the hollow probe is purged with a hand pump, extracting 1,000 to 2,000 mL of air depending on the sampling depth and thus the volume contained in the probe tubing. Using a pulling device, which is connected to the piston of the syringe, the latter is filled with soil gas. After collecting the sample, it is transferred into a 2 mL glass pipette through its narrow open end by means of a needle which extends to the bottom of the presealed pipette. The sampling vial is then sealed immediately with a torch. Since no leaking septum is involved, the holding time for such samples is up to several months, provided they are stored in a dark place. All samples are stored in a cooler after collection.

After each measuring or sampling event, the probe tips are purged with pressurized air to ensure the removal of volatile compounds potentially adsorbed to those parts of the equipment enclosing either the detector tube or the syringe. The same procedure applies to the drilling rods. After measuring at a significantly contaminated location, the probe tips are previously cleaned with petroleum ether.

4.2 Soil Gas Monitoring Probes

When it is desired to provide for a more precise analysis of the soil gas or monitor soil gas over time, permanent soil gas monitoring probes can be installed. Figure 4-1 is a schematic diagram of a typical soil gas monitoring probe as specified by Remediation Technologies, Inc. The probe is a length of 0.25 inch diameter, aluminum tubing placed in a borehole of approximately 1.5 inches diameter with the bottom three inches of the tube slotted. The bottom 12 inches of the annulus space is filled with a sand pack. The rest of the annulus from there to the surface is filled with a bentonite-clay mixture. The top of the tube is protected with a two-inch PVC pipe and screw-on cap in a concrete apron. This probe accesses the soil gas at the desired depth. Immediately after installation of the probe, 2.5 liters of soil gas is withdrawn with a bellows hand pump to flush out air trapped during installation. This volume represents approximately three time the volume of the tube and sand pack pore space for a 12 foot length of tube and 12 inch send pack. This volume should be adjusted accordingly for different lengths. The borehole for the probe is formed as described in Section 4.1.

Twenty-four or more hours after installation, the probe can be sampled for subsequent laboratory analysis. Prior to collecting a soil gas sample from the probe, a volume of at least 0.4 liters of soil gas will be withdrawn with either a bellows hand pump or a calibrated, electric gas pump to purge the aluminum tube. This volume represents approximately three tube-volumes for a 12 foot length of tube. This volume should be adjusted accordingly for a different tube lengths.

After purging the probe soil gas samples can be collected by two methods: adsorptive tubes, glass bulbs, or Tedlar bags. Soil gas constituents can be captured on adsorptive media (e.g., charcoal tubes) by connecting the adsorptive tube to the aluminum tube and then withdrawing an appropriate volume of soil gas from the monitoring probe directly through the adsorptive tube. A hand bellows pump or calibrated, electric pump is used for the withdrawal. The volume withdrawn should be determined at the time based on the requirements of the adsorptive tube and the desired analytical detection limits.

Instead of the adsorptive tubes, the soil gas can be withdrawn through a 125 milliter (ml) glass bulb equipped with gas tight teflon valves on both ends and a septum. At least three to five bulb volumes should be withdrawn through the bulb before the valves are closed to collect a sampled in order to purge the initial contents of the bulb. The septum provides access via syringes to the soil gas samples for subsequent instrumental analysis (e.g., gas chromatography or gas chromatography/mass spectrometry).

Finally, the gas sample can be withdrawn into a Tedler bag using suitable apparatus for subsequent instrumental analysis.

Following these sampling methods, the soil gas samples should be preserved, shipped, and analyzed in accordance with the specific requirements (e.g., holding times) for the analysis being performed.

5.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Sampling and analysis are performed using appropriate QA/QC procedures to assure data validity. Sample collection activities are recorded on a field log describing details of sampling (e.g., location, date, time, volume, method, etc.). Chain-of-custody forms are prepared and shipped with the samples. A duplicate sample is collected with every tenth soil gas sample. A trip blank is collected at the beginning and end of each soil gas sampling episode. These blanks are collected by collecting an appropriate volume of ambient air at a suitable background location at or near the site. Where smaller numbers of samples are collected, duplicates, and blanks should be specified appropriate for the number of samples.

RETEC

REMEDIATION
TECHNOLOGIES INC

PreSIT℠
PRELIMINARY SITE INVESTIGATION TECHNIQUE

INTRODUCTION

ReTeC is pleased to offer PreSIT℠ site investigations to characterize volatile organic compounds (VOC) in soil and groundwater. The PreSIT℠ investigation technique was developed and proven in Europe at more than 500 sites. The PreSIT℠ method was developed to improve the reliability and accuracy of soil gas measurements. The fundamental principles are to collect or analyze soil gas samples *in situ*, at atmospheric pressure, and with small gas volumes. Adherence to these principles provides soil gas results most representative of the conditions at the sampling point.

The PreSIT℠ technique is very flexible, allowing for the collection of soil gas, groundwater, and soil samples. Onsite real time soil gas results can be obtained in the field with gas detector tubes or a portable gas chromatograph. Soil gas samples also can be collected in glass vials for subsequent laboratory analysis by GC or GC/MS. Likewise, groundwater and soil samples can be collected for laboratory analysis. In addition, soil samples collected can be used for field classification and grain-size analysis. Finally, permanent soil gas monitoring probes can be installed during the PreSIT℠ investigation for on-going soil gas monitoring.

This combination of reliability, accuracy, and flexibility makes this technique one of the best for soil gas investigations. The ability to collect soil and groundwater samples takes this technique beyond soil gas to make it an excellent preliminary characterization tool.

APPLICATION

ReTeC has performed PreSIT℠ investigations to identify and delineate areas of subsurface VOC contamination at a variety of industrial and commercial sites in the U.S. Data also may be used for remedial design, monitoring, and environmental assessment purposes. Table 1 lists selected sites, sources of contamination, and chemical(s)-of-interest where PreSIT℠ has been used. Since the equipment used to perform the PreSIT℠ investigation is relatively small, it can be used in many limited access locations. PreSIT℠ investigations have been performed by ReTeC between railroad tracks, under elevated storage tanks, around underground storage tanks, and in operating plants. Because of the small diameter of the borehole (1 to 1.5 inches), PreSIT℠ investigations can be performed even in areas of high underground utility congestion. The method is well-suited for locating "hot spots" and tracking subsurface plumes of VOC contaminants. The results of PreSIT℠ surveys have been used to establish locations for monitoring well and soil borings. This is advantageous since the PreSIT℠ method is used to screen the site rather than using a drilling rig so that monitoring wells and soil borings can then be more cost-effectively located.

Site	Source of Potential Contamination	Chemical(s)-of-Interest
Petroleum Refinery	Leaking pipes and tanks, and spills	Benzene
Manufacturing Plant	Metal stripping process	Methylene chloride
Airport Fuel Station	Spill	Jet fuel
Gasoline Service Station	Leaking underground storage tanks	Gasoline
Radiation Storage Facility	Underground storage tanks	Petroleum hydrocarbons
Superfund Site	Upgradient VOC plume	Trichlorethane, trichloroethylene

TABLE 1. SELECTED PreSIT℠ EXPERIENCE

METHODS

A 1 to 1.5 inch sampling borehole is formed by driving a slotted, steel rod into the soil using an electric jackhammer as shown in Figure 1. If needed, a hole is pre-drilled through concrete, asphalt, building floors, or other surface caps. When the rod is retrieved, a small soil sample is held in the slot of the driving rod. The soil sample is used for field examination and can be used for later chemical analysis or particle size analysis.

Soil gas samples are collected by inserting a sampling probe into the borehole. Soil gas samples may be taken at multiple depths by advancing the borehole downward. Borehole depths of 20 to 30 feet have been achieved depending on soil type. Gas sampling may include the use of specific gas detector tubes for onsite, real time field results or gas samples can be collected in glass vials for laboratory GC or GC/MS analysis. In addition, the sampling probe may be used with an organic vapor analyzer (OVA) for screening purposes.

For on-going projects, permanent soil gas monitoring points can be installed in the borehole after the initial soil gas measurements have been completed. Figure 2 is a schematic diagram of a typical permanent soil gas monitoring point. These points provide a sound means of monitoring soil gas VOCs and pressures during remediation, particularly with soil venting and groundwater aeration systems. Groundwater samples can be collected from boreholes where the water table has been penetrated.

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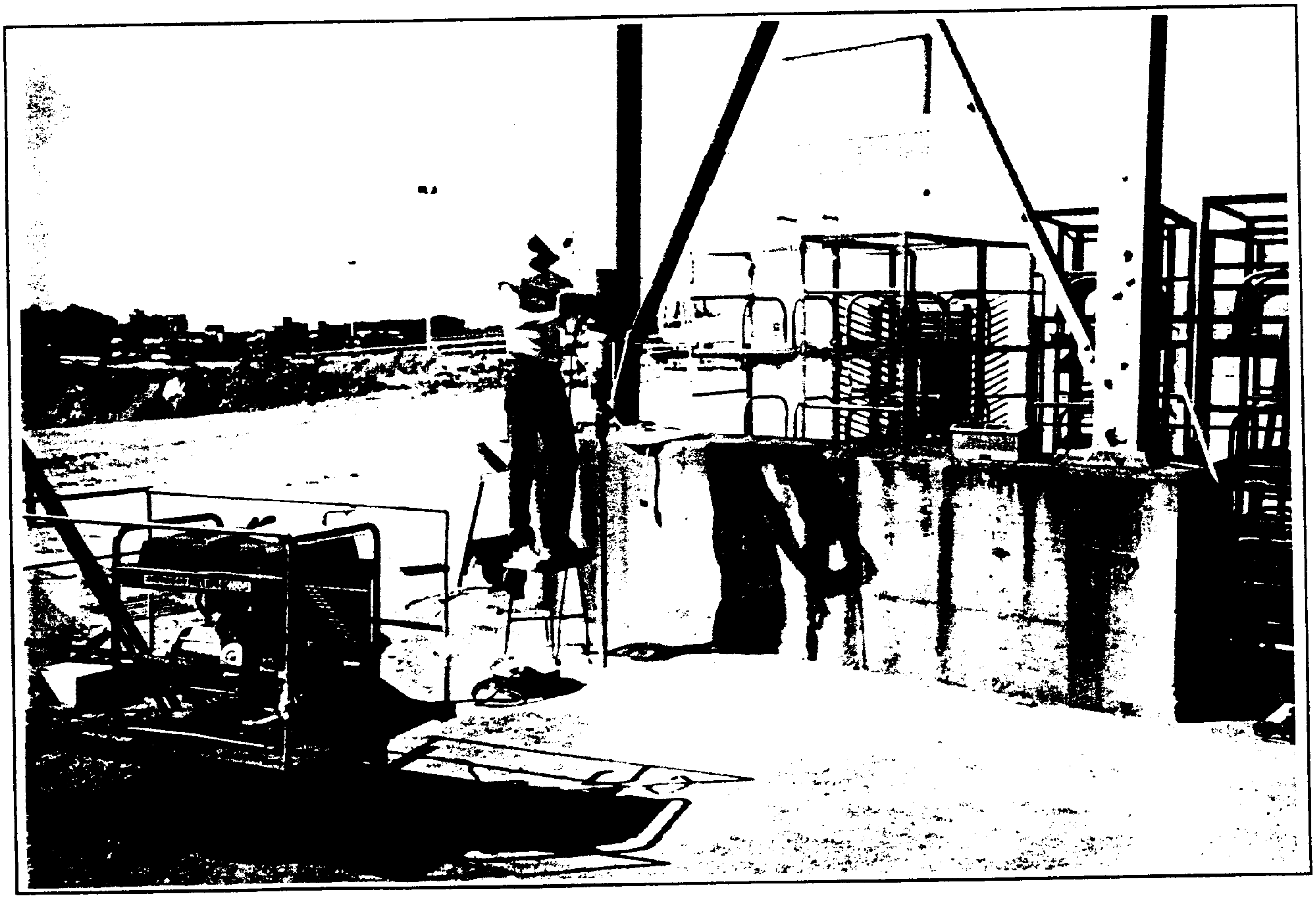

FIGURE 1. BOREHOLE INSTALLATION

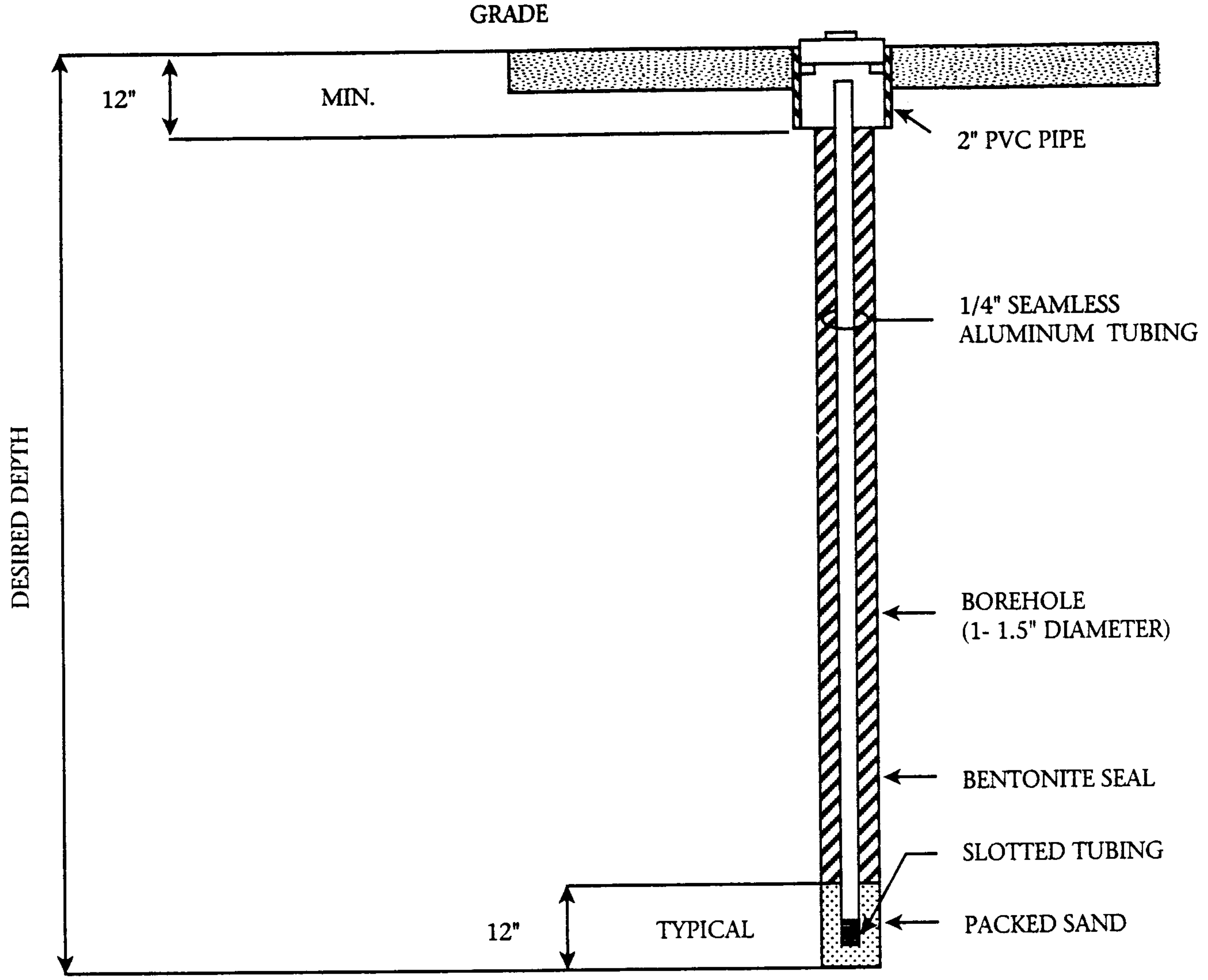

FIGURE 2. TYPICAL SOIL GAS MONITORING POINT

SUMMARY

The *PreSIT*SM site investigation technique provides an inexpensive, reliable method for locating, tracking, monitoring, and evaluating the extent of subsurface VOC contamination in soils and groundwater.

With the 1 to 1.5 inch diameter borehole, there is minimal disruption to the property caused by the investigation.

*PreSIT*SM investigations can be performed in limited access areas where other equipment, such as drill rigs, cannot be used.

Soil gas, soil, and groundwater samples can be collected for characterization and analysis using ReTeC's *PreSIT*SM methods and equipment.

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ReTeC is a full-service environmental company that provides consulting, engineering, and remediation services. For more information regarding soil gas investigations, contact Mr. R. Paul Chavez or Dr. Andrew C. Middleton at (412) 826-3340 or any ReTeC office.

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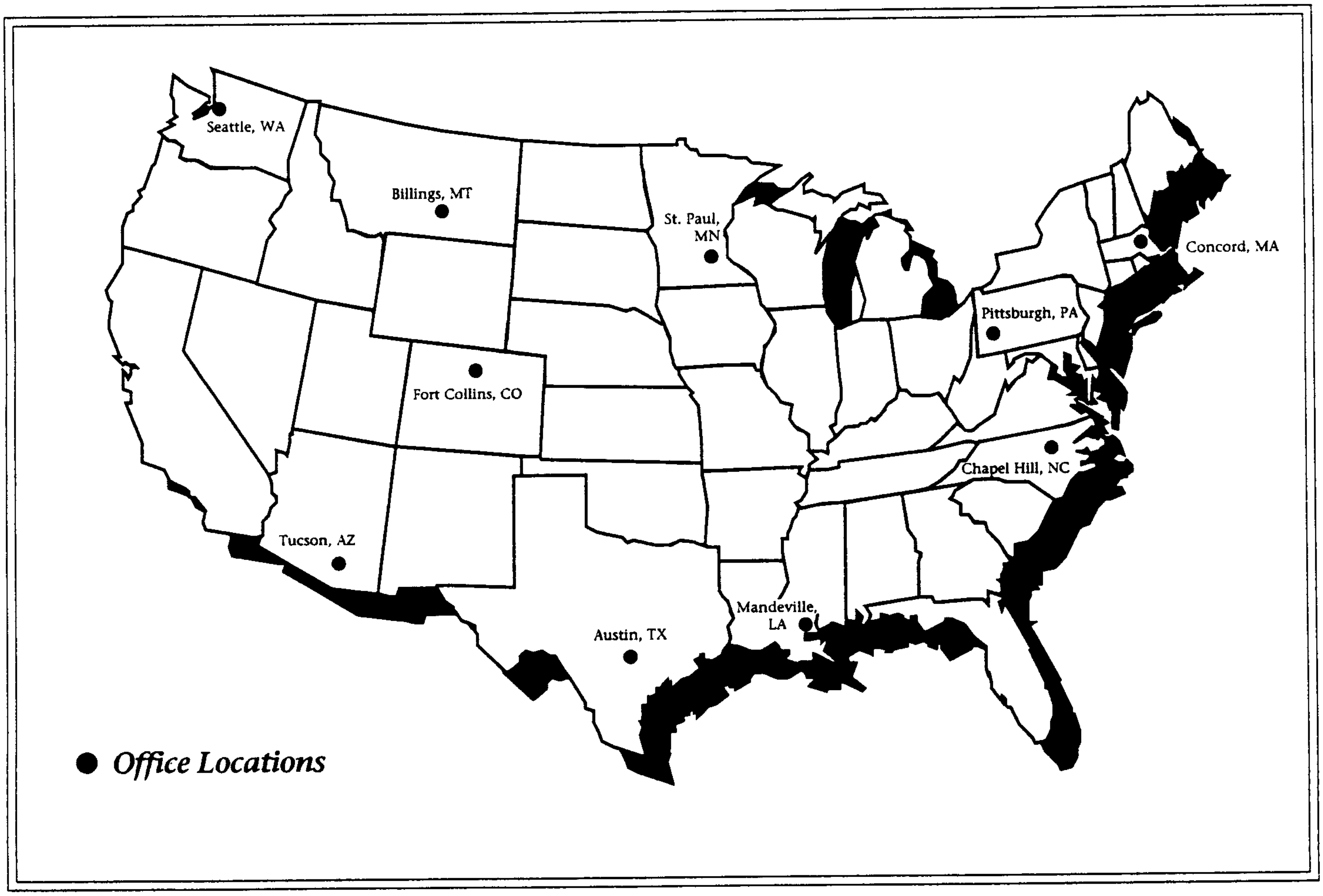

APPENDIX B

Validity of Soil Gas Surveys for Source Definitions
(Halogenated Hydrocarbons Example)

In the absence of significant quantities of separate phase material, the total concentration of volatile organic compounds in a soil sample is a summation of contaminants present as vapors in the soil gas, dissolved in the water making up the soil moisture and adsorbed to the soil matrix. Partition coefficients describe the distribution on contaminant concentrations between the different phases under equilibrium conditions.

Henry's constant (H) can be used to describe equilibrium concentrations between water and vapor phase

$$H = Cg / Cw$$

Cg = concentration in gas (vapor) phase
Cw = concentration in water (aqueous) phase

while the coefficient Kd describes the concentration ratio between contaminants adsorbed to soil solids and dissolved in water

$$Kd = Cs / Cw$$

Cs - concentration on contaminants adsorbed to solid phase.

A third coefficient, Ksg, can be used to describe the relative distribution of volatile contaminants between the solid soil matrix and the vapor phase. If all soil particles are coated with a water film due to the high relative humidity found in most natural soil systems, Ksg can be appraised from Kd and H EINSELE et al., 1988; GRATHWOHL, 1988):

$$Ksg = Kd / H = (Cs / Cw)\ (Cw / Cg) = Cs / Cg$$

EINSELE, G., EISELE, G., and GRATHWOHL, P. (1988): Verteilung und Ausbreitung von leichtflüchtigen chlorierten Kohlenwasserstoffen (LCKW) im System Boden-Wasser-Luft. - Deutsche Gewässerkundliche Mitteilungen, 32, 102-107

GRATHWOHL, P. (1988): Verteilung unpolarer organischer Schadstoffe in der ungesättigten Bodenzone am Beispiel leichtflüchtinger chlorierter Kohlenwasserstoffe. - Zeitschr. d. deutschen geologischen Gesellschaft, 139, 505-513

The sorption of non-polar, volatile contaminants such as volatile halogenated hydrocarbons to soils depends on the amount and type of organic matter in the soil. For sufficiently wet soils, an additional sorption on mineral surfaces can be neglected, since all potential sorption sites are occupied by water. Provided that partition coefficients and sorption constants are known, the contamination of the total soil system can be estimated from soil gas concentrations (GRATHWOHL, 1988).

EINSELE et al. (1988) could show that, for example, a wet sand with a low organic carbon content yields a 1:1 ratio between tetrachloroethane (PCE) concentrations per unit volume in the soil gas and the soil; i.e., a value of 1 ug/l measured in a soil gas sample corresponds roughly to ug/l in the soil. Assuming a density for a loose, partially water saturated sand of approximately 1.5 g/cm3, a soil contamination of 1 ug/kg (or 1 ppb) would thus result in a soil gas concentration of about 1,400 ug/m3 for PCE.

For practical purposes, if different halogenated hydrocarbon compounds and varying soil conditions are considered, it may hence be a valid assumption to expect a soil gas concentration of about 1,000 ug/m3 per micro-gram of halogenated hydrocarbons in 1 kg of soil. Comparing the usual detection limits of volatile halogenated hydrocarbons in soil and soil gas samples, it becomes evident that soil gas sampling is a more sensitive tool in detecting the presence of volatile compounds in soils.

A concentration of 1 ppm in the vapor phase at 20°C (68°F) and 1,013 mbar equals 6,900 ug/m3 for tetrachloroethane (PCE), 5,560 ug/m3 for 1,1,1-trichloroethane (TCA) and 5,480 ug/m3 for tri-chloroethene (TCE), respectively. Accordingly, soil gas concentrations on the low ppm-level would correspond to soil concentrations on the low ppb-level. It is, therefore, conceivable that soil gas concentrations below the ppm-level are unlikely to be indicative of a source area.

As mentioned before, the relation outlined above is only valid for neither completely dry nor water saturated soils, and under the assumption of the absence of separate phase solvents. Different ratios between soil and soil gas concentrations exist for other volatile organics.

APPENDIX C

DETECTOR TUBE HANDBOOK

Air investigations and technical gas analysis with DRÄGER Tubes

Table appendix
Physical and toxicological data
of gases and vapours

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Compiled and published by Kurt Leichnitz
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2 General

The air in working areas is frequently contaminated by gases and vapours. If the concentration of the air contaminant exceeds an admissible level, it can constitute a danger to health. It would be safest to provide completely clean air in working areas, but, for various reasons, this is possible only in very few cases. Hence, one has no choice but to tolerate air contamination in workplaces during the working day, but the concentration must not be at an arbitrarily high level. The contaminant concentration must be reduced to a tolerable level by suitable measures (e.g. ventilation, sealing of reaction vessels, changing the course of operations).

In this respect, an investigation of the ambient air with analysis equipment, a task which is not entirely simple from an analytical point of view, is to be carried out. The aim is to determine very small concentrations with the maximum reliability in a short time. Laboratory methods are not always suitable, since the time expenditure is very high: it often takes hours to obtain the analysis result. In the meantime, however, the health of those working in the area could be damaged by impurities present in the air in high concentrations.

Hence, more than in any other analytical field, in air sampling it is desirable to have an apparatus with which reliable results of measurement can be obtained immediately on the spot.

Many years ago, this desire led to the development in the USA of a simple analysis unit, with which it was attempted to develop a laboratory process to such an extent that it could be used as a complete analysis when required. The stimulus for this came from the mining industry. An instrument was required which would give an early warning of the presence of poisonous carbon monoxide. Laboratory analysis took too long and it was no longer sufficient to use small animals – white mice or canaries – as a means of warning.

In 1919, the Americans A. B. Lamb and C. R. Hoover (1) obtained a patent on a detector tube with which the CO content of the air could be estimated. As indicator, they used a mixture of iodine pentoxide and fuming sulphuric acid on pumice as carrier and called this preparation "Hoolamite". The hoolamite was placed in thin glass tubes. If air containing CO was sucked through these tubes, the preparation changed colour to green. The CO content of the air sample could be estimated from the intensity of the discoloration (e.g. light green or dark green).

This represented a great step forward in the field of occupational safety. However, for a long time – one could say for decades – the method was restricted in practice to the detection of carbon monoxide. In the middle of the nineteen thirties, Littlefield (2) published a paper on a detector tube for the determination of hydrogen sulphide, but the detector tube method was still not of general interest at this time.

A contributory factor to this lack of interest was that difficulties had arisen in the development and preparation of suitable filling agents. It is by no means directly possible to allow an experimentally known wet-chemical process to take place in a "dry medium", i.e. on a solid reagent carrier. It proved to be particularly difficult to obtain preparations with an adequate shelf life: Preparations which change within a few days or weeks to an extent such that their sensitivity of indication is different cannot be used for detector tubes. If one considers the great dilution in which the reagent is present on the reagent carrier, it becomes clear why a long enough shelf life was not always obtained with these preparations.

Let us consider an example here: Hydrogen sulphide is determined with detector tubes filled with a preparation containing lead. Here the following reaction takes place:

$$H_2S + Pb^{++} \rightarrow PbS + 2H^+$$

This equation states that at 0°C and 1013 mbar[1], 207.21 g lead (in ionic form) are necessary to bond 22.4 L hydrogen sulphide (at 20°C, these 22.4 L occupy a volume of 24 L).

In the DRÄGER Tube H_2S 1/c, a lead compound (on a silicagel carrier) is used as reagent. With an air sample volume of 1 litre, the range of measurement extends from 1 to 20 ppm hydrogen sulphide. We will now calculate the amount of reagent (lead in ionic form) which is required for one tube to bond the amount of hydrogen sulphide contained in 1 litre of air. (The following data relate to 20°C and 1013 mbar.)

20 ppm means 20 cm³ H_2S (gaseous) in 1,000 litres of air.

1 litre of air contains 20 µL H_2S.

From the equation given above, we find that 207.21 g Pb^{++} are necessary to bond 24 L H_2S.

$$24\,L\ H_2S \rightarrow 207.21\,g\ Pb^{++}$$

$$20\,\mu L\ H_2S \rightarrow \frac{207.21}{24} \cdot 20 = 173\,\mu g\ Pb^{++}$$

Thus one DRÄGER H_2S 1/c Tube contains 173 µg lead (in ionic form). Now, since one tube is filled with about 1 g preparation (this quantity results from the dimensions of the tube), 173 µg Pb^{++} are contained in 1 g preparation, which is less than 0.02% lead, a minute amount of reagent compared to the amount of reagent carrier.

How small this amount is becomes clear on glancing through a chemical catalogue. Here there will be found many substances which contain more than 0.02% of impurities, even in the highest purity grade. In the DRÄGER H_2S 1/c Tube, however, the lead compound is not an impurity, but the most important constituent. The lead ions must react with the hydrogen sulphide, not only in a freshly prepared preparation, but also after many months.

If part of the lead compound were to react with impurities present in the silicagel, or even with the silicagel itself (formation of lead silicate), the tubes would soon become useless for the purpose of measurement. They would then have a higher sensitivity of indication and would indicate more hydrogen sulphide than was actually present in the air sample.

A brief explanation on this point: As already mentioned, the hydrogen sulphide reacts with a lead compound to give PbS. It has already been calculated that 173 µg Pb^{++} are necessary to bond 20 µL H_2S. This amount of 173 µg Pb^{++} is available for reaction on a given layer length, which means that in the reaction with H_2S, the end of the discoloured zone (PbS formation) lies where, in our example, 20 µL H_2S have reacted with a total of 173 µg Pb^{++}. If the tubes were to show a "storage effect", such that part of the lead compound necessary for the reaction is no longer present, the 173 µg Pb^{++} would no longer be distributed

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[1] 1013 mbar corresponds to 760 mm Hg

over the above layer length. If 20 µL H_2S are again present, the discoloured zone (PbS formation) is naturally longer than in the case of reaction with the original preparation, since the hydrogen sulphide has to flow through a greater layer length to find the total quantity of 173 µg Pb^{++} necessary for the reaction. If not only part, but all of the reagent were to react with the carrier material, the H_2S indication would not take place at all.

This example clearly shows the high requirements which are made of the composition of the reagent system and the quality of the reagent carrier.

However, there are no unconquerable difficulties in the production of the preparation. The filling preparations used for DRÄGER Tubes are so stable that their indicating behaviour in the finished tubes, with correct storage, remains unchanged for at least two years.

The production of suitable filling preparations led, starting in 1950, to the marketing of various new detector tubes. Grosskopf described tubes for the determination of alcohol, benzene and water vapour (3). This was followed, in 1952, by a publication (4) on several newly developed detector tubes, including tubes for the determination of nitrous fumes, chlorine, sulphur dioxide, carbon disulphide and methyl bromide. These detector tubes, developed and manufactured by Drägerwerk (and known briefly as DRÄGER Tubes) soon became indispensible in the investigation of air in workplaces.

There are now more than 200 different DRÄGER Tubes for the DRÄGER Gas Detector, with which a large number of different gases and vapours can be determined. The DRÄGER Gas Detector will be described in somewhat greater detail in the sections which follow.

1 List of all DRÄGER Tubes[1]

1.1 DRÄGER Tubes for short-term measurements

DRÄGER Tube	Order Code	Range of measurement 20°C, 1013 mbar (760 mm Hg)	No. of strokes
Acetaldehyde 100/a	67 26665	100 to 1,000 ppm	20
Acetic acid 5/a	67 22101	5 to 80 ppm	3
Acetone 100/b	CH 22901	100 to 12,000 ppm	10
Acid test	81 01121	Qualitative	1
Acrylonitrile 0.5/a	67 28591	0.5 to 10 ppm	20
		1 to 20 ppm	10
Acrylonitrile 1/a	81 01251	1 to 30 ppm	3
Acrylonitrile 5/b	CH 26901	5 to 30 ppm	3
Alcohol 100/a	CH 29701	10 to 3,000 ppm	10
Amine test	81 01061	Qualitative	1
Ammonia 2/a	67 33231	2 to 30 ppm	5
Ammonia 5/a	CH 20501	5 to 70 ppm	10
		50 to 700 ppm	1
Ammonia 25/a	CH 25501	25 to 700 ppm	10
Ammonia 0.5%/a	CH 31901	0.5 to 10 vol.%	1
		0.05 to 1 vol.%	10
Aniline 0.5/a	67 33171	0.5 to 10 ppm	20
Arsenic trioxide 0.2/a	67 28951	0.2 mg/m³ (calculated as As)	100
Arsine 0.05/a	CH 25001	0.05 to 3 ppm	20
		1 to 60 ppm	1
Benzene 0.5/a	67 28561	0.5 to 10 ppm	40 to 2
Benzene 2/a	81 01231	2 to 60 ppm	20
Benzene 5/a	67 18801	5 to 40 ppm	15 to 2
Benzene 5/b	67 28071	5 to 50 ppm	20
Benzene 0.05	CH 24801	15 to 420 ppm (0.05 to 1.4 mg/L)	20 to 2
Carbon dioxide 0.01%/a	CH 30801	0.01 to 0.3 vol.%	10
Carbon dioxide 0.1%/a	CH 23501	0.1 to 1.2 vol.%	5
		0.5 to 6 vol.%	1
Carbon dioxide 0.5%/a	CH 31401	0.5 to 10 vol.%	1
Carbon dioxide 1%	CH 25101	1 to 20 vol.%	1
Carbon dioxide 5%/A	CH 20301	5 to 60 vol.%	1
Carbon disulphide 5/a	67 28351	5 to 60 ppm	11
Carbon disulphide 0.04	CH 26001	3 to 95 ppm (0.01 to 0.3 mg/L)	15 to 1
Carbon disulphide 30/a	CH 23201	0.1 to 10 mg/l (32 to 3,200 ppm)	6
Carbon monoxide 2/a	67 33051	2 to 60 ppm	10

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[1] The shelf life of DRÄGER Tubes is 2 years, with the exception of Natural Gas Test, with a shelf life of 1 year.

DRÄGER Tube	Order Code	Range of measurement 20°C, 1013 mbar (760 mm Hg)	No. of strokes
Carbon monoxide 5/c	CH 25601	5 to 150 ppm	10
		100 to 700 ppm	2
Carbon monoxide 8/a (only for CO in H_2)	CH 19701	8 to 150 ppm	10
Carbon monoxide 10/a	CH 28900	10 to 300 ppm	10
		100 to 3,000 ppm	1
Carbon monoxide 10/b	CH 20601	10 to 300 ppm	10
		100 to 3,000 ppm	1
Carbon monoxide 0.1%/a	CH 29601	0.1 to 1.2 vol.%	1
Carbon monoxide 0.3%/a	CH 24901	0.3 to 4 vol.%	1
Carbon monoxide 0.3%/b	CH 29901	0.3 to 7 vol.%	1
Carbon tetrachloride 1/a	81 01021	1 to 15 ppm	5
Carbon tetrachloride 5/c	CH 27401	5 to 50 ppm	5
Chlorine 0.2/a	CH 24301	0.2 to 3 ppm	10
		2 to 30 ppm	1
Chlorine 0.3/b	67 28411	0.3 to 5 ppm	20
Chlorine 50/a	CH 20701	50 to 500 ppm	1
Chlorobenzene 5/a	67 28761	5 to 200 ppm	10
Chloroform 2/a	67 28861	2 to 10 ppm	10
Chloroformates 0.2/b	67 18601	0.2 to 10 ppm	20
Chloroprene 5/a	67 18901	5 to 60 ppm	3
		7.5 to 90 ppm	2
Chromic acid 0.1/a	67 28681	0.1 to 0.5 mg CrO_3/m^3	40
Cyanide 2/a	67 28791	2 to 15 mg CN/m^3	10
Cyanogen Chloride 0.25/a	CH 19801	0.25 to 5 ppm	20 to 1
Cyclohexane 100/a	67 25201	100 to 1,500 ppm	10
Cyclohexylamine 2/a	67 28931	2 to 30 ppm	10
Diborane 0.05/a	67 18101	0.05 to 3 ppm	20
p-Dichlorobenzene 2/a	81 01281	2 to 100 ppm	7
Diethyl ether 100/a	67 30501	100 to 4,000 ppm	10
Dimethyl acetamide 10/a	67 28011	10 to 40 ppm	20
Dimethyl formamide 10/b	67 18501	10 to 40 ppm	10
Dimethyl sulphate 0.005/c	67 18701	0.005 to 0.05 ppm	200
Dimethyl sulphide 1/a	67 28451	1 to 15 ppm	20
Epichlorohydrin 5/b	67 28111	5 to 50 ppm	20
Ethyl acetate 200/a	CH 20201	200 to 3,000 ppm	20
Ethyl benzene 30/a	67 28381	30 to 400 ppm	6
		up to 600 ppm	4

DRÄGER Tube	Order Code	Range of measurement 20°C, 1013 mbar (760 mm Hg)	No. of strokes
Ethylene 0.1/a	81 01331	0.2 to 5 ppm	20
Ethylene 0.5/a	67 28481	0.5 to 10 ppm	20
Ethylene 50/a	67 28051	50 to 2,500 ppm	3
Ethylene glycol 10	81 01351	10 to 180 mg/m³	10
Ethylene oxide 1/a	67 28961	1 to 15 ppm	20
Ethylene oxide 25/a	67 28241	25 to 500 ppm	30
Ethyl glycol acetate 50/a	67 26801	50 to 700 ppm	10
Formaldehyde 0.2/a	67 33081	0.2 to 2.5 ppm	20
		0.5 to 5 ppm	10
Formaldehyde 0.5/a	67 26760	0.5 to 10 ppm	16 to 1
Formaldehyde 0.002	CH 26401	2 to 40 ppm (0.002 to 0.05 mg/L)	5
Formic acid 1/a	67 22701	1 to 15 ppm	20
n-Hexane 100/a	67 28391	100 to 3,000 ppm	6
Hydrazine 0.2/a	67 33121	0.2 to 5 ppm	20
		0.5 to 10 ppm	10
Hydrazine 0.25/a	CH 31801	0.25 to 3 ppm	10
Hydrocarbon 0.1%/b	CH 26101	0.1 to 1.3 vol.%	–
Hydrocarbon 2	CH 25401	2 to 23 mg/L	–
Hydrocarbon test	67 28261	500 to 2,500 ppm	–
Hydrochloric acid 1/a	CH 29501	1 to 10 ppm	10
		2 to 20 ppm	5
Hydrochloric acid 50/a	67 28181	50 to 500 ppm	10
		500 to 5,000 ppm	1
Hydrocyanic acid 2/a	CH 25701	2 to 30 ppm	5
		10 to 150 ppm	1
Special tube Hydrogen 0.5%/a	CH 30901	0.5 to 3 vol.%	5
Hydrogen fluoride 1.5/b	CH 30301	1.5 to 15 ppm	20
Hydrogen peroxide 0.1/a	81 01041	0.1 to 3 ppm	20
Hydrogen sulphide 0.5/a	67 28041	0.5 to 15 ppm	10
		2.5 to 75 ppm	2
Hydrogen sulphide 1/c	67 19001	1 to 20 ppm	10
		10 to 200 ppm	1
Hydrogen sulphide 2/a	67 28821	2 to 20 ppm	10
		20 to 200 ppm	1
Hydrogen sulphide 5/b	CH 29801	5 to 60 ppm	10
		50 to 600 ppm	1
Hydrogen sulphide 100/a	CH 29101	100 to 2,000 ppm	1
Hydrogen sulphide 100/b	67 33151	100 to 2,000 ppm	1
Hydrogen sulphide 0.1%/a	81 01181	0.1 to 2 vol.%	1

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Hydrogen sulphide 0.2%/A	CH 28101	0.2 to 7 vol.%	1
Hydrogen sulphide 2%/a	81 01211	2 to 40 vol.%	1
Hydrogen sulphide + sulphur dioxide 0.2%/A	CH 28201	0.2 to 7 vol.%	1
		0.02 to 0.7 vol.%	10
Mercaptan 0.5/a	67 28981	0.5 to 5 ppm (ethyl mercaptan)	20
Mercaptan 2/a	CH 20801	2 to 100 ppm	10
Mercury vapour 0.1/b	CH 23101	0.1 to 2 mg/m³	20 to 1
Methacrylonitrile 1/a	67 30101	1 to 10 ppm	20
Methanol 50/a	67 28941	50 to 3,000 ppm	5
Methyl acrylate 5/a	67 28161	5 to 200 ppm	20
Methyl bromide 3/a	67 28211	3 to 35 ppm	5
		10 to 100 ppm	2
Methyl bromide 5/b	CH 27301	5 to 50 ppm	5
Methylene chloride 100/a	67 24601	100 to 2,000 ppm	10
Methylene chloride 100/b	67 28331	100 to 3,000 ppm	10
Methylisobutyl ketone 50/a	81 01311	50 to 400 ppm	3
Methyl methacrylate 50/a	67 28171	50 to 500 ppm	10
Monostyrene 10/a	67 23301	10 to 200 ppm	15 to 2
Monostyrene 10/b	67 33141	10 to 250 ppm	20
Monostyrene 50/a	CH 27601	50 to 400 ppm	11 to 2
Natural gas test	CH 20001	qualitative	2
Nickel 0.25/A	67 28871	0.25 to 1 mg Ni/m³	100
Nickel tetracarbonyl 0.1/a	CH 19501	0.1 to 1 ppm	20
Nitric acid 1/a	67 28311	1 to 15 ppm	20
		5 to 50 ppm	10
Nitrogen dioxide 0.5/c	CH 30001	0.5 to 10 ppm	5
		5 to 25 ppm	2
Nitrogen dioxide 2/c	67 19101	2 to 50 ppm	10
		5 to 100 ppm	5
Nitroglycol 0.25/a	67 18201	0.25 ppm	20
Nitrous fumes 0.5/a	CH 29401	0.5 to 10 ppm	5
Nitrous fumes 2/a	CH 31001	2 to 50 ppm	10
		5 to 100 ppm	5
Nitrous fumes 20/a	67 24001	20 to 500 ppm	2
Nitrous fumes 100/c	CH 27701	100 to 1,000 ppm	5
		500 to 5,000 ppm	1
Oil 10/a-P	67 28371	2.5 to 10 mg/m³	100
Oil mist 1/a	67 33031	1 to 10 mg/m³	100

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Olefine 0.05%/a	CH 31201	1 to 55 mg/L	20 to 1
Organic arsenic compounds and arsine	CH 26303	qualitative	8
Organic basic nitrogen compounds	CH 25903	qualitative	8
Oxygen 5%/B	67 28081	5 to 23 vol.%	1
Ozone 0.05/b	67 33181	0.05 to 0.7 ppm	10
Ozone 10/a	CH 21001	10 to 300 ppm	1
n-Pentane 100/a	67 24701	100 to 1,500 ppm	5
Perchlorethylene 5/a	67 26699	5 to 50 ppm	10
Perchlorethylene 10/b	CH 30701	10 to 500 ppm	3
Perchlorethylene 0.1%/a	67 28021	0.1 to 1.4 vol.%	5
Petroleum hydrocarbons 100/a	67 30201	100 to 2,500 ppm (n-octane)	2
Phenol 1/a	81 01361	1 to 30 ppm	20
Phenol 5/a	CH 31501	5 ppm	10
Phosgene 0.05/a	CH 19401	0.04 to 1.5 ppm	26 to 1
Phosgene 0.25/b	CH 28301	0.25 to 15 ppm	5
		1.25 to 75 ppm	1
Phosphine 0.1/a	CH 31101	0.1 to 4 ppm	10
		1 to 40 ppm	1
Phosphine 50/a	CH 21201	50 to 1,000 ppm	3
		15 to 300 ppm	10
		150 to 3,000 ppm	1
Phosphoric acid esters 0.05/a	67 28461	0.05 ppm (dimethyldichlorovinylphosphate)	10
Polytest	CH 28401	qualitative	5
Pyridine 5/A	67 28651	5 ppm	20
Simultaneous tube CO 200/a + CO_2 2%/a	67 18301	200 to 2,500 ppm CO	2
		2 to 12 vol.% CO_2	
Sulphur dioxide 0.1/a	67 27101	0.1 to 3 ppm	100
Sulphur dioxide 0.5/a	67 28491	0.5 to 5 ppm	20
		1 to 25 ppm	10
Sulphur dioxide 1/a	CH 31701	1 to 25 ppm	10
Sulphur dioxide 20/a	CH 24201	20 to 200 ppm	10
		200 to 2,000 ppm	1
Sulphur dioxide 50/a	67 26289	50 to 500 ppm	10
Sulphuric acid 1/a	67 28781	1 to 5 mg/m³	100
Tetrahydrothiophene 1/a	67 28251	1 to 10	30
Tetrahydrothiophene 1/b	81 01341	1 to 10	30
Thioether	CH 25803	qualitative	8
Toluene 5/a	CH 23001	5 to 400 ppm	5

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Toluene 25/a	81 01411	0.1 to 7 mg/L (25 to 1,860 ppm)	10
Toluene diisocyanate 0.02/A	67 24501	0.02 to 0.2 ppm	25
o-Toluidine 1/a	67 28991	1 to 30 ppm	20
Trichloroethane 50/d	CH 21101	50 to 600 ppm	2
Trichloroethylene 2/a	67 28541	2 to 50 ppm	5
		20 to 200 ppm	3
Trichloroethylene 10/a	CH 24401	10 to 500 ppm	5
Triethylamine 5/a	67 18401	5 to 60 ppm	5
Vinyl chloride 0.5/a	67 28061	0.5 to 3 ppm	10
		0.25 to 1.5 ppm	20
		1 to 6 ppm	5
Vinyl chloride 1/a	67 28031	1 to 10 ppm	20
		5 to 50 ppm	5
Vinyl chloride 100/a	CH 19601	100 to 3,000 ppm	18 to 1
Water vapour 0.1/a	81 01321	0.05 to 1 mg/L	3
Water vapour 1/a	81 01081	1 to 18 mg/L	2
Water vapour 0.1	CH 23401	0.1 to 40 mg/L	10
o-Xylene 10/a	67 33161	10 to 400 ppm	5