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Cross Sectional drawings in Appendix C; Site topographic map in Appendix F

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Planning Document
Project No. 60721

Volume 1 of 5
Work Plan
Blackwell Landfill NPL Site

Prepared for:
Forest Preserve District
DuPage County, Illinois

Prepared by:
Warzyn Engineering Inc.
Chicago, Illinois

January 1991

WORK PLAN
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
BLACKWELL LANDFILL NPL SITE
DUPAGE COUNTY, ILLINOIS
(January 28, 1991)

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SECTION 1
WORK PLAN PREPARATION

The planning documents for the Remedial Investigation/Feasibility Study at the Blackwell Landfill NPL Site consist of a Work Plan (WP), a Field Sampling Plan (FSP), a Quality Assurance Project Plan (QAPP), and a site specific Health and Safety Plan (HSP). Each of the plans has a specific purpose, and efforts have been made to avoid duplication of focus in the documents.

For example, although monitoring well installation will be discussed in all four of the documents, each document addresses a different aspect of the process. The focus of monitoring well activities in the Work Plan will be to specify the number and locations of wells and describe the rationale for each of the well locations. The focus of the FSP is to describe the details of soil boring and sampling, well construction, groundwater sampling procedure, and aquifer testing. The QAPP contains the specific protocols which will be followed for sampling, sample handling and storage, chain-of-custody, and laboratory (or field) analysis. The Site Specific HSP provides the field personnel with a description of procedures and personal protective equipment to be used for while making soil borings, constructing monitoring wells and collecting samples.

A detailed description of each of the planning documents follows.

1.1 Work Plan (WP)

This RI/FS Work Plan has been developed in conformance with the provisions of the Consent Order and standards set forth in the following statutes, regulations and guidance:

- Section 121 of CERCLA;
- U.S. EPA "Guidance for Remedial Investigations and Feasibility Studies Under CERCLA", Interim Final, EPA/540/G-89/004, OSWER Directive 9355.3-01, dated October 1988;
- National Contingency Plan (NCP), dated February 1990, and
- Additional Guidance Documents provided by U.S. EPA.

The purpose of the Work Plan is to define the scope and objectives of the RI/FS. The scope consists of proposed numbers and locations for each of the field activities and details for completion of non-field activities. Recognizing that some modification of sampling locations and parameters may be appropriate as more is learned about the site, the objectives for each activity are also provided to aid decision making. A Data Management Plan is included as Appendix A of the Work Plan.

The schedule, included as Table 1-1, shows the estimated implementation of tasks and submission of deliverables in weeks subsequent to regulatory approval. It does not include excessive laboratory turnaround times or extended U.S. EPA review periods.

1.2 Field Sampling Plan

A Field Sampling Plan (FSP) addressing data acquisition activities for the RI has been prepared. The plan contains a summary of the site background, a statement of sampling objectives, a listing of sample locations and frequency, sample designation, sampling equipment and procedures, and a summary of sample handling and analysis. The procedures described in the FSP include methods for source characterization and preliminary migration pathway assessment including soil borings, well installations, determination of groundwater levels, hydraulic conductivity tests, and surface water, soil, sediment and groundwater sampling.

1.3 Quality Assurance Project Plan

A Quality Assurance Project Plan (QAPP) has been prepared in accordance with current U.S. EPA guidance. The QAPP specifies the analytical methods and protocols to be used at the various stages of the site investigation. Specific methods are defined for field screening of samples, waste and contaminant characterizations and bench and pilot treatability testing. U.S. EPA Contract Laboratory Program (CLP) protocols will be used for waste and contaminant characterization analyses. The outline for the QAPP includes:

Title Page
Table of Contents
1. Project Description
2. Project Organization and Responsibilities

3. QA Objectives for Measurement
4. Sampling Procedures
5. Sample Custody
6. Calibration Procedures
7. Analytical Procedures
8. Data Reduction, Validation, and Reporting
9. Internal Quality Control
10. Performance and Systems Audits
11. Preventative Maintenance
12. Data Assessment Procedures
13. Corrective Actions
14. Quality Assurance Reports

1.4 Site Specific Health and Safety Plan

The Health and Safety Plan (HSP) has been prepared to address hazards that the investigation activities may present to the investigation team and to the surrounding community. The plan conforms to applicable regulatory requirements and guidance including:

- "Occupational Safety and Health Standards for Hazardous Waste Operations and Emergency Response" [29 CFR 1910.120 (I)(2)], Final Rule, March 6, 1989;
- U.S. EPA Order 1440.3 - "Respiratory Protection";
- U.S. EPA Order 1440.2 - "Health and Safety Requirements for Employees Engaged in Field Activities";
- U.S. EPA Occupational Health and Safety Manual; and
- U.S. EPA Standard Operating Safety Guides (November 1984).

The Health and Safety Plan details personnel responsibilities, protective equipment, procedures and protocols, decontamination, training and medical surveillance. The plan identifies problems or hazards that may be encountered and their anticipated solutions. Procedures for protecting third parties such as visitors or the surrounding community are also provided.

1.5 ATSDR Health Assessment

Copies of the Planning Documents and information collected during the RI/FS will be made available by the U.S. EPA to the Agency for Toxic Substances and Disease Registry (ATSDR) pursuant to SARA.

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SECTION 2
INVESTIGATIVE SUPPORT

2.1 Site Mapping/Description

An accurate topographic map of appropriate working scale and contour interval has been prepared. A base map of the site will be prepared from this topographic map, and will have a scale of one inch to 100 feet (1":100') and two-foot contour intervals. The base map will show the locations of wetlands, floodplains, water features, buildings, utilities, paved areas, and other pertinent features. Larger scale maps may be produced from the base map, as necessary. Maps will be prepared from the base map to show the location of existing monitoring wells, additional wells installed, all sampling locations, and water supply wells.

If necessary, surveying may be conducted to establish horizontal and vertical controls for the site relative to the National Geodetic Vertical Datum of 1929.

A boundary survey has been completed to locate the boundaries so that future activities do not carry over onto adjacent properties without proper permission. Figure 2-1 shows the boundaries of the Blackwell Landfill Study area and also delineates the landfilled area itself.

2.2 Preparation of Support Facilities

A field office and decontamination area will be set-up in Denny's Den, located at the north end of the landfill (Figure 2-1). Denny's is the garage and office area which was used when the landfill was in operation. Access to the area is limited by a locking gate. A concrete decontamination pad will be constructed to collect the water used to decontaminate the drill rig and other sampling equipment. The decontamination and purge water will be contained either in drums or a tanker and analyzed for appropriate disposal. If necessary, a licensed hauler will be used for disposal.

Additional arrangements will be made as necessary to construct the appropriate support facilities and/or procure the equipment necessary to perform a hazardous site investigation. This could include the preparation of decontamination facilities, utility hook-ups, and site access control stations.

SECTION 3
DESCRIPTION OF THE CURRENT SITUATION

3.1 Site Location and History

3.1.1 Site Location and Boundaries

3.1.1.1 Location. The Blackwell Landfill NPL Site (Site) is located in Section 26, Township 39 North, Range 9 East, DuPage County, Illinois. The Site is part of the Roy C. Blackwell Forest Preserve, and is owned by the DuPage County Forest Preserve District (FPD). The landfill itself occupies approximately 40 acres within a forest preserve of more than 1200 acres. The location of the Site is illustrated in Figure 3-1.

3.1.1.2 Site Boundaries. The boundaries that define the extent of the Blackwell Landfill NPL Site are as follows. On the north and east the boundary extends through the center of Silver Lake from Spring Brook on the north to Butterfield Road (Route 56) on the south. The southern boundary extends along Butterfield to the intersection of Butterfield Road and the West Branch of the DuPage River, and then northward from this intersection to the intersection of the West Branch of the DuPage River and Spring Brook. Spring Brook forms the western boundary of the Site. Figure 2-1 and 3-2 illustrates the boundaries of the Site.

3.1.2 Site History

3.1.2.1 History Prior to Landfill Construction. The original 40-acre tract which was developed into the Blackwell Landfill was purchased by the Forest Preserve District of DuPage County in 1960. Over the following five-year period, approximately 1,100 additional acres were acquired by the Forest Preserve District. The property was purchased with the intent that after construction of the landfill the site would be developed as a forest preserve and used for recreational purposes.

The original intent was to use an abandoned gravel pit at the site for solid waste disposal. In 1963, gravel excavation was resumed, and continued until July of 1969. During the course of the gravel mining, the lakes at the site were enlarged and deepened. The mined materials were sold to fund the lake construction, and recreational and flood control projects.

The concept of landfilling within the gravel pit was subsequently abandoned. Instead, it was determined that an environmentally-secure landfill would be constructed on the FPD property. The intent was to construct a landfill that would limit the effects of waste disposal on the surrounding area, create a hill within the preserve which could be used for recreational purposes, and provide an economical means of constructing the lakes at the preserve. The excavation of the lakes would provide clay materials which could be used in landfill construction, and would also provide aggregate which could be sold to help defray the costs of landfilling.

Concern regarding the suitability of the site for landfilling was expressed by several parties, including the Illinois State Geological Survey, the Illinois Sanitary Water Board, and Northeastern Illinois Planning Commission (NIPC) personnel. Concerns regarding the site centered on its geologic and hydrogeologic characteristics, including its position on the edge of the Warrenville cone of depression, extensive sand and gravel deposits in the Site area, and the probable hydraulic connection between the recreational lakes and the buried refuse. The ISGS suggested that careful engineering procedures would be necessary to develop a secure landfill at the site, so the County Board of Commissioners approved the development of an engineering plan for the project.

<u>3.1.2.2 Landfill Design and Construction</u>. Original design recommendations were developed by the NIPC. Preliminary design specifications for the Blackwell Landfill were developed by William Rose and Associates (Rose) for DuPage County and submitted in October, 1966. It was recommended by Rose that the landfill cover a 35-acre area, that a three-to-one clay to refuse ratio be employed, and that the fill area be constructed as a honeycomb of one-acre cells. Each cell would have a one and one-half foot clay base and a perimeter clay berm eight to nine feet in height. Each cell would be filled with two three-foot lifts of refuse, separated by six inches of clay. Each cell would be covered by one and one-half feet of clay, which would form the base of the overlying cell. The cells were to be offset, to maximize stability in the landfill design. The cover design specified a final 12-foot layer of compacted clay, covered by soil and vegetation.

The construction of the landfill was performed as a joint effort between the DuPage County Public Works Department (PWD) and the FPD. Under the agreement between the agencies, the PWD was to build the landfill, under supervision by the FPD. The following construction specifications were included in the contract drawn up between the two agencies:

- Berm Height--Four feet per lift.
- Berm Width--11 to 12 feet at top.
- Refuse Height--Three feet per lift.
- Minimum Daily Cover--Six inches of clay or mixture of clay and gravel.
- Floor Construction--Two feet of blue clay minimum, dove-tailed into existing blue clay.
- Temporary Cap--One to two feet of sand, gravel, clay, or mixture.
- Refuse Compaction--Obtained by maximum use of site tractor crossing deposited refuse.

Construction of the landfill commenced in 1965. By 1967, the shape of the hill and general cell layout had been determined. The original landfill cell configuration consisted of eight cells, and is illustrated in Figure 3-3. Cell 9, also shown on the figure, was not part of the original planned design.

The original layout of the landfill was generally followed. Daily records were not kept to detail how the construction proceeded. However, in general it was the procedure to develop cells several acres in size by building side berms, and then filling the cells with refuse and daily cover. At the completion of each cell, clay covers and side berms would be constructed for the next level of refuse. The clay covers served as the liners for the overlying cells, as the landfill construction proceeded upward.

Significant deviations from the original design are known to have occurred. During the gravel operations which predated landfilling at the site, a drainage ditch had been excavated between the south end of Silver Lake and Spring Brook. This ditch was later partly filled with concrete, logs, and brush and is shown as Cell 9 on Figure 3-3. Cell 8 of the landfill may have been partially constructed over this ditch, but boring logs from landfill vents drilled within Cell 8 indicate that a clay base liner is not present. Additionally, the area northeast of the landfill was designated in the original plans as a non-dumping area. However, refuse was encountered in this area during drilling of vents SV-5 and SV-9.

A series of letters written over the period 1965 to 1968 between the FPD and the PWD also indicate problems in landfill operations. In these letters, the PWD is accused of:

- Instructing public works personnel to disregard FPD instructions and requests;
- Failing to cover refuse at the end of each day;
- Failing to use sufficient fill between individual refuse cells;
- Using sand and gravel for all cover;
- Disregarding design specifications for at least several months in 1968, when the fill was operated as an open dump.

In May of 1968, the FPD refused to be associated further with the landfill project. In May of 1969, the FPD was assigned the responsibility of forming the clay bottoms and side berms prior to filling each cell.

The final load of refuse was accepted at the Blackwell Landfill in October, 1973, and was buried just below an 800 foot, Mean Sea Level (MSL) elevation in the Cell 4 area. Final contouring and landscaping continued until July, 1975. Fifty to sixty feet of clay were added to form the final hilltop at 839 feet, MSL, approximately 150 feet above the surrounding natural topography. The landfill is covered to final grades with two to fifteen feet of cover of varying sand, gravel and clay composition, and a final layer of four to six inches of topsoil, which was vegetated.

The landfill covers approximately 40 acres instead of the initially-designed 35 acres. Indications are that several additional cells were added around the eight original cells to bring the total landfill area to the existing 40 acres. These exterior cells were used for disposing of construction debris and tree trunks and branches. These cells may not have been constructed with clay liners. Cell 9, located along the southern boundary of the landfill and illustrated in Figure 3-3, is an example of one of these exterior cells. The landfill contains approximately 1.5 million cubic yards of refuse and an equal volume of natural fill.

In summary, a conceptual design was developed for the landfill prior to construction, and the design was generally followed. However, it was not standard operating procedure at landfills to produce as-built drawings in the late 1960's when most of the landfill was constructed.

3.1.2.3 Wastes Accepted. Approximately 1.5 million gate yards of refuse were disposed of at the Blackwell Landfill between 1965 and 1973. The waste materials disposed of have been classified as general household refuse and light industrial waste. Historical records indicate that the users of the Blackwell Landfill were generally municipal waste haulers and scavenger companies in the DuPage County area. An estimated three to four tons of refuse per day were disposed of at the landfill.

Specific wastes known to have been disposed of at the Blackwell Landfill include the following. Eight thousand tons of dry sludge from the Metropolitan Sanitary District of Greater Chicago were disposed of in 1968. Owens-Illinois of St. Charles, Illinois, disposed of daily trash from their glass manufacturing facility. Kroehler Manufacturing of Naperville, Illinois, used the landfill for disposal of plant trash of undetermined origin. Yard waste consisting of burnt tree cuttings and grass clippings was also disposed of in the landfill.

3.1.2.4 Post-Construction History. In March, 1986, the Site was evaluated by U.S. EPA using the Hazard Ranking System (HRS). A composite score of 35.57 was assigned, with the following scores assigned to each potential route: Surface Water, 0.0; Air, 0.0; Groundwater, 61.54. The Site was proposed for inclusion on the National Priorities List (NPL) in the Federal Register, Volume 53, Number 122, dated June 24, 1988.

On September 25, 1989, a consent order was signed between the Forest Preserve District of DuPage County and the U.S. EPA. The Blackwell Landfill received final listing on the NPL in the Federal Register, Volume 55, Number 35, dated February 21, 1990.

3.2 Physical Setting

3.2.1 Regional Topography and Physiography

The Blackwell Landfill NPL Site is located in west-central DuPage County in northeastern Illinois. The Site is located on the western edge of the Wheaton Morainal Country in the Great Lakes Section of the Central Lowland Province. The surface topography of this area is generally due to the repeated glaciations which advanced and retreated over the region during the Pleistocene Epoch, and bears little resemblance to the buried bedrock topography. Within DuPage County, the surface topography generally slopes from northwest to southeast across the county, with a total relief of about 245 feet. The most prominent surface features within the area are a series of concentric moraines which parallel the Lake Michigan shoreline. Other glacially-derived geomorphic features within the area include outwash plains, kames, eskers, and filled lake basins.

Surface water drainage within DuPage County is routed mainly to the East and West Branches of the DuPage River in the central portion of the county. On the east, drainage is to the Des Plaines River; on the west, drainage is to the Fox River. Flow within these streams is generally southward, between the morainal ridges.

3.2.1.1 Site Topography. The Site topography is dominated by the landfill itself, which has a maximum elevation of approximately 840 feet, MSL. The landfill slopes steeply to the south towards the closed Swim Lake, at an approximate elevation of 690 feet, MSL, and more gently to the northeast towards Silver Lake, at an approximate elevation of 708 feet, MSL. The topography of the Site is illustrated in Figure 3-4. In addition, a copy of the base map developed for previous investigations has been included in Appendix F.

The Blackwell Landfill NPL Site is almost entirely bounded by surface water bodies, including Silver Lake on the east, Spring Brook on the west, and the Swim Lake, Supply Lake, and West Branch of the DuPage River on the south and southwest. The landfill is located within the Spring Brook watershed of the West Branch of the DuPage River drainage basin. From Spring Brook, surface water drainage is to the West Branch of the DuPage River, located about 1,500 feet southwest of the landfill, and ultimately to the Des Plaines River. Although labeled the "Swim Lake", it has not been open for swimming since 1983.

3.2.1.2 Climate. The Blackwell Landfill NPL Site is located in an area characterized by a humid, continental climate. Winters are generally moderately cold and dry, and summers are warm to hot, and humid. The mean annual temperature is 51°F, and normal monthly mean temperatures range from about 25°F in January to 75°F in July. The mean annual precipitation is approximately 33 to 34 inches, two-thirds of which falls between April and September. Mean annual snowfall is 36 inches. Mean annual evapotranspiration is is approximately 25 inches, with potential evapotranspiration being 28 inches.

3.2.2 Regional Geology

3.2.2.1 Glacial Deposits and History. The surficial deposits of northeastern Illinois are predominantly the result of Wisconsin-age glaciation, with minor modification by Recent alluvial processes. The majority of these deposits are assigned to the Woodfordian Substage of the Wisconsinan Stage.

During Woodfordian time, ice of the Lake Michigan Lobe of the Wisconsinan glacier moved west and south out of the Lake Michigan basin in a series of advances and retreats. As a result of the repeated pulses of the glacier, a series of till units and end moraines were deposited over the area, as well as outwash plains and ice contact deposits. The glacial stratigraphy and history of the Woodfordian Substage have been reconstructed for much of the region near the Blackwell Landfill. However, the complexity of the glacial deposits causes difficulty in establishing the relationships between individual till members in some areas. In general, the moraines represent the areas of highest topography, rising 30 to 50 feet above the surrounding terrain. In the intermorainal areas, stratigraphy may be complex, representing a variety of depositional settings. Deposits which may occur include lodgement tills, ablation tills, lacustrine deposits, valley train, and sand and gravel outwash deposits.

3.2.2.2 Bedrock Geology. The bedrock underlying northeastern Illinois consists of a thick sequence of Paleozoic sedimentary rocks including carbonates, shales, and sandstones. DuPage County is located on the northeastern flank of the Kankakee Arch, a structural feature that separates the Michigan Basin on the east from the Illinois Basin on the south. Regional dip of the bedrock units is generally east and southeast, at about 10 feet per mile.

In the vicinity of the Blackwell Landfill, the uppermost bedrock is dolomite of Silurian age, representing the Niagaran Series. The Niagaran Series is composed of three formations. In order of decreasing age, these are the Joliet Dolomite, Waukesha Dolomite, and Racine Dolomite. The Joliet Dolomite ranges in lithology from a shaley to clean dolomite; the Waukesha is generally silty in character, and the Racine Dolomite is characterized by reef strata. Underlying the Niagaran Series are the dolomites of the Silurian Alexandrian Series. Beneath the Silurian rocks, and separating them from the extensive Ordovician and Cambrian sandstones, limestones, and dolomites, is the Ordovician Maquoketa Group. The Maquoketa consists largely of shaley dolomites and shales with dolomite interbeds.

The bedrock surface in the site area exhibits subdued relief, modified by preglacial stream erosion and subsequent glacial erosion. The resistant Niagaran dolomite forms a wide cuesta, bounded on the west by the softer Maquoketa outcrop. DuPage County is located on the eastern backslope of the Niagaran cuesta.

3.2.3 Site Geology

3.2.3.1 Methods of Investigation. A considerable amount of subsurface information is available regarding the Blackwell Landfill, due to the large number of borings and well installations which have been performed. A total of 51 monitoring wells have been installed at the site, including 13 which extend into bedrock. Nested wells have been installed at 12 locations. A summary of the known construction details for the on-site wells is included in Table 3-1.

Boring logs are available for each of the monitoring wells installed at the Blackwell Landfill, as the wells were logged in the field by a professional geologist or field engineer. Boring logs for the site wells are contained in Appendix B. Grain size analysis was performed on several of the samples to provide information of the physical characteristics of the individual stratigraphic units. Geologic cross-sections have also been developed for the site and several are included in Appendix C.

3.2.3.2 Glacial Stratigraphy. The Wisconsinan glacial deposits present at the Site consist of tills of the Woodfordian Wedron Formation, and sands and gravels of the Henry Formation. The glacial deposits underlying the Site vary considerably in an east to west direction. This is due to the location of the site at the western edge of the West Chicago Moraine, along which the uppermost till unit at the Site, the Yorkville Till Member, was deposited. Meltwater from the glacier which deposited the till appears to have formed a river which flowed north to south along the front of the moraine. Previously deposited glacial sediments were subsequently dissected and eroded, and redeposited as the Henry Formation outwash sand and gravel. The stratigraphic relationships between the different geologic units at the site are illustrated in Figure 3-5. These stratigraphic units are each discussed in detail below, in order of decreasing age.

The Tiskilwa Till Member of the Wedron Formation is generally described as a pinkish tan to reddish brown sandy till. At the Site, the Tiskilwa's composition is generally that of a silt or silty sand, somewhat finer grained in the eastern portions of the Site. Tiskilwa Till mantles the bedrock beneath the majority of the Site, ranging in thickness from about 12 feet in the northern part of the Site to less than three feet in the south. In the eastern portion of the Site, the Tiskilwa is overlain by 40 to 80 feet of till of the Malden and Yorkville Members. In the western portion of the Site, between the landfill and the DuPage River, the Tiskilwa is overlain by up to 40 feet of sand and gravel of the Henry Formation, or may be absent.

The Malden Till Member of the Wedron Formation is generally described as a silty, yellow-gray to gray till that is locally sandy and contains discontinuous beds of sand and gravel. At the Site, the Malden is bounded at its base by sand and gravel, overlain by laminated silt. The Malden thins and disappears in the western portion of the Site.

The Yorkville Till Member of the Wedron Formation is a very clayey gray till. Two units within the Yorkville have been observed at the Site: a lower basal till, separated from an overlying ablation till by a thin layer of finely laminated silt, sand, or gravel. The Yorkville Till Member is the thickest till present at the Site, and is the "blue clay" that was utilized in landfill construction. On-site, the greatest thicknesses are observed near Silver Lake. However, the till appears to thin rapidly with distance to the south and west of the landfill, and is absent at borings G116, G121, G133, and G137.

The Henry Formation generally consists of outwash sands and gravels, with occasional beds of silt. It is not overlain by till, but occasionally is continuous with sandy deposits that intertongue with the tills. The Batavia Member of the Henry Formation covers most of the Blackwell Site, and is as much as 30 to 40 feet thick in the western and southern portions of the Site.

3.2.3.3 Bedrock Stratigraphy. The uppermost bedrock at the Site is the Niagaran dolomite. The dolomite has been described in one core run as being light gray to brown in color and micritic with moderate to high porosity. The presence of stylolites, silt partings, and fractures was also noted.

The topography of the bedrock surface beneath the site is illustrated in Figure 3-6. As this figure indicates, the bedrock surface slopes to the north, with a local bedrock high being present in the southwest portion of the Site. A bedrock valley runs east to west across the north edge of the site, and a minor tributary valley may extend along the western edge. Bedrock surface relief across the site is approximately 38 feet.

3.2.4 Regional Hydrogeology

3.2.4.1 Hydrostratigraphy. In northern Illinois, groundwater resources are found within both the unconsolidated glacial deposits and the underlying bedrock aquifers. Aquifers in this area which are important sources of groundwater include, in ascending order, the Cambro-Ordovician aquifers, the Silurian dolomite aquifer, and unconsolidated glacial aquifers. The Cambro-Ordovician aquifers are essentially isolated from the overlying aquifers by the Ordovician Maquoketa Shale, which acts as an aquitard. The Silurian dolomite and the glacial aquifers are considered a single hydrostratigraphic unit on a regional scale; however, on a local scale they are separate and distinct. The following paragraphs describe the general characteristics of the significant hydrostratigraphic units in the Site vicinity.

The Maquoketa Shale aquitard consists of three shale formations and one interbedded limestone formation. The Maquoketa is considered nonwaterbearing except for occasional small yields from fractures in the dolomite. An average vertical permeability of 2.36×10^{-9} cm/sec has been suggested for the Maquoketa in DuPage County. The Maquoketa is interpreted as forming a partial barrier to downward leakage into the deeper Cambro-Ordovician aquifers from the shallower glacial and dolomite aquifers. The thickness of the Maquoketa in the Site area is thought to be about 100 feet.

The Silurian dolomite is the principal aquifer in the Site area. Flow within this aquifer in DuPage County is generally in a southerly direction toward the West Branch of the DuPage River. The West Branch of the DuPage River is thought to act as a discharge zone for groundwater within the aquifer. This general southerly flow direction is affected by the presence of pumping centers, where municipal wells withdraw large amounts of water from the aquifer. The area northeast of the Site is thought to be a recharge area for the dolomite aquifer, where it is overlain by permeable sand and gravel outwash deposits.

Numerous domestic and municipal wells are completed in this aquifer in the site vicinity. Among these wells are Warrenville municipal wells, located within two miles of the Site. Private wells which have been identified in the immediate site vicinity are illustrated in Figure 3-7. The majority of these wells are thought to be completed in the Niagaran dolomite.

About 68% of the groundwater pumped in DuPage County is obtained from the Silurian dolomite aquifer. The dolomite is generally about 100 to 200 feet thick in the county. While some wells have been developed in the basal layers of the Alexandrian Series, the Niagaran provides the major water-bearing zones within the aquifer. Primary porosity contributes little to the aquifer's water-yielding capabilities; secondary permeability in fractures and joints provides the greater control on well yields. Well yields vary from place to place, and are dependent on the size and interconnection of fractures. Generally high yields, and the relative uniformity of the piezometric surface in this aquifer indicate that these secondary openings are generally well-connected.

Specific capacity values for shallow dolomite wells in northeastern Illinois have been reported in the range of 0.1 to 500 gpm/ft. In DuPage County, a transmissivity of 61,000 gpd/ft, and a storativity of 2.5×10^{-4} have been reported from a pumping test in Wheaton near the Blackwell site. At Argonne National Laboratory in the southeastern part of the county, a transmissivity of 44,000 gpd/ft and a storativity of 9×10^{-5} were reported. Interference was noted in wells more than one-half mile apart, indicating that water-yielding openings extend for large distances. The overall specific yield of the dolomite aquifer in DuPage County has been calculated to be 0.017, with greater yields noted where the dolomite is overlain by sand and gravel deposits. The bedrock topography is also thought to exert considerable control on well yield, as the weathered surface enhances permeability.

Only about 2 percent of the groundwater pumpage in DuPage County is derived from the glacial aquifers. These aquifers generally consist of outwash sands and gravels. The glacial aquifers are considered a major recharge source for the underlying dolomite aquifer, and represent shallow, localized flow systems.

Specific capacity values of wells completed in the sand and gravel aquifers in DuPage County have been reported in the range of 1.0 to 4.7 gpm/ft. Hydraulic conductivities are expected to be in the range of 1 x 10^{-5} to 1 x 10^{-3} cm/sec, or greater.

The till units associated with the glacial drift aquifers act as aquitards, limiting groundwater flow into the underlying dolomite. Clayey tills in Illinois are known to have hydraulic conductivities in the range of 1 x 10^{-9} cm/sec to 1 x 10^{-7} cm/sec, while tills with less clay may have permeabilities a few orders of magnitude greater. It has been demonstrated that the field hydraulic conductivity of tills may be as much as three orders of magnitude greater than laboratory-determined permeabilities.

3.2.4.2 Water Quality. Water quality within the dolomite aquifer in the vicinity of the Site is described as very hard, with a high iron content. The water is considered a calcium-bicarbonate type water. Basic water quality of the dolomite aquifer in DuPage County is summarized in Table 3-2.

Regional water quality within the glacial drift aquifers is similar to that in the shallow dolomite. Table 3-3 summarizes information regarding water quality within the glacial drift aquifers in DuPage County.

3.2.5 Site Hydrogeology

Hydrogeologic properties of the geologic units at the Blackwell site have been evaluated by both laboratory and in-situ methods. Permeability values for the aquifers and till units were estimated by permeameter in the laboratory and by bail tests and pumping tests in the field. The results of both methods are summarized below.

3.2.5.1 Laboratory Methods of Investigation. Split-spoon samples from each unconsolidated unit present at the Site have been analyzed in the laboratory for total porosity and permeability.

Total porosity was calculated for the coarser units by the following method. Samples were first weighed dry, and then saturated. Following saturation, the samples were reweighed, and total porosity was calculated. Porosities of 21 to 23 percent were determined for the sand and gravel samples; a porosity of about 30% was calculated for the silt samples.

Falling head permeability tests were performed on disturbed samples of the non-clay deposits found at the Site. A Soiltest K-605 falling head permeameter was used to determine permeabilities. The permeabilities calculated by this method are considered only rough approximations of true field permeabilities, due to the disturbed nature of the samples, and the inability of small samples to reflect large-scale influences on permeability. However, general comparisons of permeability between units can be made.

Ranges in permeability values determined by permeameter testing for each geologic unit are as follows:

- Yorkville Member: 2.0 x 10^{-6} cm/sec (silty sand)
- Tiskilwa Member: 4.7 x 10^{-5} cm/sec (very fine sandy silt) to 1.5 x 10^{-6} cm/sec (silty sand/silty clay)
- Malden Member: 3.3 x 10^{-2} cm/sec to 1.3 x 10^{-2} cm/sec (coarse sand and gravel)
- Henry Formation: 4.7 x 10^{-2} cm/sec (fine to coarse sand and gravel) to 3.4 x 10^{-4} cm/sec (medium to coarse and and gravel)

Results obtained for the Malden Member are not considered representative of the entire unit, because much of the unit is more clay-rich than the sample tested. Also, it was not possible to perform permeameter testing on the clay-rich portions of the Yorkville. Therefore, the permeability value calculated by the permeameter is not representative of the unit as a whole.

3.2.5.2 Field Methods of Investigation. Fifty-one monitoring wells have been installed at the Blackwell Landfill in order to provide information on hydraulic head distribution, gradients, and groundwater quality. Thirteen of these wells extend into the dolomite bedrock aquifer beneath the Site. Nested well installations have been performed at 12 locations. Table 3-1 summarizes the construction details for the on-site monitoring wells, including the lithology of the screened interval. Not all information is known for all of the wells; these areas have been left blank in the table.

Pumping tests have been conducted at 27 monitoring wells at the Blackwell Landfill. These tests consisted of single well tests and multiple observation well tests. Generally, the single well testing was in the form of bail-down testing on dolomite and till monitoring wells, where hydraulic conductivities were too low to permit continuous pumping. Single well continuous pumping tests were performed on the Henry Formation, Tiskilwa Till, and some dolomite wells. Pumping tests utilizing multiple observations wells yielded results predominantly for the Henry Formation.

Bail-down tests were analyzed by methods designed by Hvorslev and Nguyen and Pinder; the Theis method was utilized to analyze data from the single well tests where continuous pumping was performed. The Jacob straight-line method was employed to analyze data obtained from the tests involving multiple observation wells.

The pumping test results are summarized in Table 3-4. A summary of hydraulic conductivity value ranges obtained for each geologic unit is presented in Table 3-5. The results of permeability testing indicate that the most permeable unit present at the Site is the Henry Formation, an outwash sand and gravel. However, the values obtained for the Henry Formation are quite variable, ranging over several orders of magnitude. The dolomite permeability is also quite heterogeneous, being controlled mainly by the presence or absence of fractures. The Tiskilwa Till has generally low permeability, but it is not as impermeable as the Yorkville Member. The Tiskilwa is considered to form a leaky aquitard in the site area.

3.2.5.3 Hydrostratigraphic Units. Four major hydrostratigraphic units have been identified at the Blackwell Landfill NPL Site. These units are, in ascending order, the Silurian dolomite aquifer, the Tiskilwa Till leaky aquitard, the combined Malden/Yorkville Till aquitard, and the Henry Formation outwash sand and gravel aquifer. The groundwater flow system at the site is controlled by the three-dimensional geometry of these units, and their interaction with the surface water bodies which virtually surround the Site.

Henry Formation outwash deposits at one time covered the majority of the Site. However, the gravel mining operations in the Site area have removed most of these materials from the high-standing area east of the landfill. In this area, sand and gravel extends only a few feet below the water table, at most. The major outwash sand and gravel aquifer, which exists under unconfined conditions at the Site, is located to the south and west of the landfill. The thickness of this aquifer varies from less than ten feet near the edge of the landfill, to greater than 30 feet near Spring Brook. Regional information suggests that the aquifer extends to the West Branch of the DuPage River in the south. The saturated thickness of this aquifer varies several feet, depending on the water table elevation.

While the top and bottom of the outwash aquifer are easily mapped across the site, there is considerable lithologic variability within the unit itself. Lenses and beds within the aquifer are commonly less than three feet thick, and cannot be traced laterally. Thin layers, marked by one to four inch silt beds are common near the landfill itself; individual layers thicken where the outwash is thicker as a whole.

The till units present at the site, the Tiskilwa Till and the combined Malden/Yorkville Tills, act as aquitards in the site area. The Malden and Yorkville Tills form a wedge which is thickest in the east near Silver Lake, and thins and disappears to the south and west of the landfill. As the hydraulic conductivities of these tills are very low, they exclude the outwash aquifer from the east and form a barrier to groundwater flow between Silver Lake and the outwash.

Two zones of higher horizontal permeability have been noted within the till units. One of these is a sand layer one to four inches thick which exists an an approximate elevation of 670 feet, MSL, at the boundary between the Yorkville and Malden Till units. Another thin silty sandy layer is located within the Yorkville Till unit at an elevation of about 680 feet, MSL. Most of the monitoring wells on the north, east, and southeast side of the landfill are screened within one or both of these zones of enhanced permeability. Tests have shown that the hydraulic conductivities of these sandy layers are on the order of 10^{-4} cm/sec.

The lower aquifer at the site consists of the Silurian Niagaran dolomite. This aquifer completely underlies the site. The surface of the aquifer slopes broadly from south to north, and is characterized by a subdued topography which may influence permeability.

While the matrix permeability of the aquifer is low, joints and fractures developed in the upper portion of provide a high degree of secondary permeability.

The Tiskilwa Till forms a leaky aquitard over the dolomite aquifer at the Site. The Tiskilwa is present over most of the site, but may be absent in some areas in the west and southwest. The Tiskilwa is thickest in the north (12 feet at borings G120 and G136) and thinnest in the southwest (less than three feet at borings G116 and G131). In the east, a similar north-south thinning is apparent, between borings G132 and G134. Areas of the site in which the occurrence of the Tiskilwa or other confining units is questionable are illustrated in Figure 3-8.

3.2.5.4 Groundwater Flow System. The Blackwell Landfill NPL Site is almost entirely surrounded by surface water bodies. These surface water bodies are in continuity with the groundwater flow system, and serve as boundaries to it. These surface water bodies include Silver Lake on the east, Spring Brook on the west, and the Swim Lake, Supply Lake, and West Branch of the DuPage River on the south and southwest. This has been shown by the similarity in surface water and groundwater levels measured at monitoring wells and staff gages. Findings are documented in Appendix D.

There are two distinct hydrogeologic flow regimes in the upper zone at the site. East of the landfill, the water table is found in the till units which rise above 700 feet msl. To the west of the landfill, the till is much thinner falling below 690 feet msl. Here, the water table is found in the outwash which overlies the till. Figure 3-9 is a map of the upper surface of the till.

The primary groundwater flow in the outwash is from northwest to southeast, along the West Branch of the DuPage River, in the outwash sand and gravel deposits. The primary flow in the till mound is from Silver Lake in the Northeast, to the southwest toward the outwash aquifer. It is likely that the primary groundwater flow beneath the landfill occurs in the sandy layers within the till. However the total volume of groundwater flowing east to west beneath the landfill is much less than the volume of flow in the outwash along the river valley.

Figure 3-10 illustrates groundwater flow within the upper (outwash) aquifer at the Site. As is shown in this figure, water table elevations range between approximately 706 and 693 feet, MSL. The principal groundwater flow direction in the upper aquifer is in a southwesterly direction, from Silver Lake toward the smaller lakes, Spring Brook, and the West Branch of the DuPage River.

While the principal flow direction is in a southwesterly direction, the existence of the Yorkville Till above the water table forms a hydraulic barrier which limits the groundwater flow between Silver Lake and the outwash aquifer. The steep water table gradient across the till mound, illustrated in Figure 3-10, confirms the presence of the mound as a barrier to flow. However, some flow probably does occur through sandy layers in the till. The trench excavated between Silver Lake and Spring Brook during gravel mining operations may also acts as a higher permeability groundwater pathway.

Water levels in the monitoring wells do not provide evidence of a groundwater mound which could be resulting from leachate leakage. In general, the groundwater levels are lower the further to the southwest one goes from Silver Lake. Monitoring wells located between Silver Lake and the landfill have water levels which are lower than the lake Level so these do not indicate mounding. Contour lines representing water levels on the downgradient side of the landfill are relatively linear and do not curve to follow the outline of the landfill. Consequently these levels do not indicate mounding either. It is possible that mounding does occur directly beneath the landfill, but there are no water level measuring devices beneath the landfill to provide such data.

Prior to urbanization, Spring Brook was probably an effluent or gaining stream, acting as a discharge area for the upper aquifer. However, flow within the stream is currently enhanced by the discharge of sanitary effluent upstream, causing the stream to contribute flow to the groundwater system near the landfill. This flow is thought to be insufficient to create a boundary mound, but does contribute to elevated levels of dissolved solids within the aquifer.

The potentiometric surface within the lower (dolomite) aquifer slopes from east to west across the site, as illustrated in Figure 3-11. The gradient shown by the potentiometric surface in the eastern part of the site is thought to reflect regional, not site, controls. However, in the western portion of the site, the flattening of the gradient is thought to be attributable to site-specific conditions. These conditions include higher permeability within the dolomite and leakage from the outwash aquifer through the Tiskilwa Till. In this area of the site the Tiskilwa Till is thin or may be absent; where it does exist, it consists predominantly of silt.

A downward gradient is ubiquitous at the Site between the upper outwash aquifer and the lower dolomite aquifer. Measurements of vertical head differences indicate that the strongest gradient is across the Yorkville Till confining unit in the eastern portion of the Site. A weaker gradient is present in the western portion of the site where the water table is lower and the Tiskilwa Till is thin, indicating a greater hydraulic connection between the two aquifers.

3.2.5.5 Landfill Leachate Effects. At the present time, there are 24 leachate head wells at the Blackwell Site. These wells were constructed by drilling into the landfill itself. The existing 24 wells have been constructed since landfill closure primarily to allow methane gas to vent from the landfill. They were labeled SV for shallow vent and DV for deep vent. They were constructed of 4-inch ID PVC materials and screened along their entire length. Besides providing an avenue for gas to escape, they have been used to measure leachate levels, collect leachate samples, and extract leachate for disposal. For clarity of discussion, these landfill wells will be referred to as leachate head wells.

Data obtained from the 24 existing leachate head wells indicate that the leachate levels within the landfill form a mound with a peak elevation above 750 feet, MSL. This elevation is significantly higher than the water table elevation beneath the landfill, which has been estimated at 690 to 708 feet, MSL. The degree of connection between the leachate mound and the underlying water table is not known. Based on the known construction of the landfill, e.g., disposal of refuse in cells and lifts bounded by clay, it is possible that some leachate zones are perched or hydraulically isolated. If there were no liner to impede the leakage of leachate, it is unlikely that leachate levels would be found 20 to 40 feet above the underlying groundwater table. Therefore, it is apparent that the liner beneath the site is sufficiently retardative to hold up the leachate mound.

Leachate has been extracted on several occasions from the Blackwell Site. The following table summarizes the leachate removal history. After removal, the leachate was shipped to Waste Management Inc.'s CID facility in Calumet City, Illinois, for treatment and disposal.

DATE	VOLUME	LOCATION
4/5/88	4,500 gallons	MH20
4/19/88	5,000 gallons	MH20
5/31/90	5,000 gallons	MH5
5/31/90	5,000 gallons	MH5
6/1/90	5,000 gallons	MH5
6/1/90	5,000 gallons	MH5
6/7/90	4,500 gallons	MH5
6/7/90	4,500 gallons	MH20
6/18/90	4,500 gallons	MH5
6/18/90	4,500 gallons	MH20
Total	47,500 gallons	

3.3 Nature and Extent of Contamination

3.3.1 Summary of Existing Site Analytical Data

3.3.1.1 Leachate Data. Twenty-four leachate head wells have been installed at the Blackwell Landfill. The locations of these leachate head wells are illustrated in Figure 3-4. These head wells were sampled in 1984 and 1985, and the samples obtained were analyzed for metals, semi-volatile organic compounds, and volatile organic compounds (VOCs). Table 3-6 provides a summary of the available leachate analytical data.

The most commonly detected VOCs in samples obtained from the vents are similar to those that have been detected in the shallow groundwater at the Site. These compounds include 1,1-dichloroethane, 1,2-dichloroethane, tetrachloroethylene, cis-1,2-dichloroethylene, trans-1,2-dichloroethylene, benzene, ethylbenzene, toluene, and xylene.

Analyses for semi-volatile organic compounds were only performed on samples from head wells SV-5 and DV-5. No semi-volatiles were detected in SV-5. In DV-5, however, naphthalene, diethylphthalate, and 1,4-dichlorobenzene were detected. Total dissolved solids concentrations measured in the leachate vents exceed 5000 ppm in some cases.

3.3.1.2 Leachate Level Data. The leachate generation and leakage rate have been calculated for the landfill using water balance methods and level change methods). It has been estimated that on the order of approximately 2,200 cubic feet per day of leachate is leaking from the landfill (See Appendix E).

3.3.1.3 Leachate Vent Air Data. In 1984, leachate vent air quality data was collected at vents DV-1 and DV-6. Vent DV-1 is located at the highest part of the landfill, and DV-6 is located on the eastern slope of the hillside, as illustrated in Figure 3-4. Charcoal tubes were used to collect air samples.

Generally, concentrations of VOCs were higher at DV-1 than at DV-6. Toluene, ethylbenzene, and 1,2-dichloroethane were detected at levels ranging from two to ten parts per million (ppm) on a dry volume basis. Benzene, chlorobenzene, 1,2-dichloroethylene, trichloroethylene, and vinyl chloride were detected at lesser concentrations.

3.3.1.4 Groundwater Data. A total of 21 different VOCs have been detected in groundwater at Blackwell Landfill during its monitoring history. These 21 VOCs are listed in Table 3-7.

Of these 21 compounds, the five which have been most commonly detected are 1,1-dichloroethane, 1,2-dichloroethane, cis-1,2-dichloroethylene, trans-1,2-dichloroethylene, and trichloroethylene. The distribution of these compounds within the aquifers present beneath the site are discussed in detail in the section below titled, "Concentration and Distribution of VOCs".

3.3.1.5 Private Well Data. Several private wells in the vicinity of the Site have been sampled and analyzed for VOCs. These wells are located both on-site and off-site, and in upgradient and downgradient positions with respect to the Site.

VOCs that have been detected in the private wells include chloroform, 1,2-dichloropropane, 1,1,1-trichloroethane, dichlorobromomethane, dibromochloromethane, bromoform, cis-1,2-dichloroethylene, trichloroethylene, vinyl chloride, 1,1-dichloroethane, trans-1,2-dichloroethylene, 1,2-dichloroethane, and xylenes. Existing data is insufficient to identify the source or sources of these results. A purpose of the RI will be to determine if the landfill is a source, and has affected groundwater quality off site.

In November, 1984, chloroform and 1,2-dichloropropane were detected in the Denny's Den well, located off-site in an upgradient position. VOCs have not been detected in the well since that time.

In May, 1985, 1,1,1-trichloroethane was detected just above the detection limit in the campground well. The campground well is located upgradient of the site, on the east side of Silver Lake. A follow-up sample obtained in June of 1987 contained no detectable VOCs.

The picnic well, located west of Silver Lake but upgradient of the landfill, was sampled in June of 1987. Compounds detected included trihalomethanes, chloroform, dichlorobromomethane, dibromochloromethane, and bromoform. The trihalomethanes, generally attributed to recent chlorination and inadequate purging of the well, were not detected during a follow-up sampling event.

A well, located near Swim Lake downgradient of the landfill, has historically contained cis-1,2-dichloroethylene, trichloroethylene, vinyl chloride, and 1,1-dichloroethane. This well has been taken out of service.

Two private wells, one shallow and one deep, are located at the Cenacle southwest of the site across Spring Brook. These wells have exhibited detectable levels of 1,1-dichloroethane, cis-1,2-dichloroethylene, trans-1,2-dichloroethylene, 1,1,1-trichloroethane, and trichloroethylene. In addition to these compounds, the deep well has contained 1,2-dichloroethane and xylenes. Neither of the Cenacle wells is currently used as a source of drinking water.

3.3.1.6 Surface Water Data. Surface water analytical data has been collected at the Blackwell Landfill since 1983. Since 1983, 16 locations have been sampled and analyzed for VOCs, semi-volatile organic compounds, metals, and indicator parameters.

Spring Brook has historically shown the presence of trihalomethanes, which can probably be attributed to chlorination of the Wheaton Wastewater Treatment Plant, located upstream of the Site. At the Cenacle and further downstream, 1,1,1-trichloroethane and tetrachloroethylene have been detected. Spring Brook has exhibited total dissolved solids concentrations in the range of 1,000 to 1,500 ppm, attributed to the sewage treatment effluent released from the upstream treatment plant.

While the Swim Lake has shown sporadic detections of 1,1-dichloroethane, cis-1,2-dichloroethylene, and 1,1,1-trichloroethane, these detections were made under unusual circumstances, e.g., sampling of surface water under the ice cover during the winter.

VOCs have not been detected in Silver Lake, Supply Lake, and the West Branch of the DuPage River.

3.3.1.7 Sediment Data

Decane was tentatively identified in the sediments of Spring Brook both upgradient and downgradient of the Site during a sampling event in 1986. Concentrations in the range of 1 to 1.4 ug/g were tentatively estimated, based on the response of the internal standard 1,4-dichlorobutane. Decane is a constituent of petroleum products, and is common in the environment.

3.3.2 Distribution of Contaminants in Site Aquifers

3.3.2.1 Concentration and Distribution of VOCs. Sampling and analysis for VOCs was first performed at the Blackwell Landfill in 1983, and continued until December of 1989. Sampling was performed for 31 priority and two non-priority organic pollutants. During the course of monitoring for VOCs at the site, a total of 21 different compounds have been detected at different times. These compounds are listed in Table 3-7.

Five compounds have been most commonly detected at the Blackwell Landfill. These compounds are:

- 1,2-Dichloroethane (1,2-DCA)
- 1,1-Dichloroethane (1,1-DCA)
- 1,2-Cis-Dichloroethylene (1,2-C-DCE)
- 1,2-Trans-Dichloroethylene (1,2-T-DCE)
- Trichloroethylene (TCE)

Table 3-8 summarizes the historical occurrence of these compounds in selected monitoring wells located downgradient of the landfill. An additional compound, 1,2-Dichloropropane (1,2-DCP) is also included in this table, because it was the compound detected in monitoring well G-128S which was used by the U.S. EPA to calculate the Hazard Ranking Score for the Site. This compound is not consistently found at high concentrations at the site. Table 3-8 also presents averages and standard deviations for each compound at each well. The monitoring wells chosen to represent the downgradient water quality data are: G-109, G-110, G-111, G-112, G-117, G-118S, G-122, G-127, G-128S, G-128D, G-131DD, and G-133DD.

Groundwater quality at the Site can best be presented by separating these wells into four groups, and discussing VOC occurrence within each group. The four groups are:

1) The well showing greatest impact from the landfill (G-118S).
2) A series of wells located along the southwest (downgradient) toe of the landfill (G-109, G-110, G-111, G-112, G-113, G-127).
3) A series of wells located about 200 feet downgradient of the landfill in the upper outwash aquifer (G-117, G-122, G-128S).
4) Three wells screened in the dolomite aquifer downgradient of the site (G-128D, G-131DD, G-133DD).

<u>Monitoring Well G-118S</u> is located along the western side of the landfill, near the toe of the slope. This well has historically shown the highest concentrations of VOCs at the landfill. There have been significant seasonal trends within the data collected at this well. However, a consistent downward trend in VOC concentrations is apparent.

<u>Monitoring Wells G-109, G-110, G-111, G-112, G-113 and G-127</u> were among the first monitoring wells constructed at the Blackwell Landfill. These wells are located along the southwest border of the landfill. During 1983 and 1984, these wells exhibited highly variable VOC concentrations. However, between 1987 and the present time, VOC concentrations have stabilized and are generally decreasing. Total VOCs concentrations are currently in the range of 20 to 100 ug/l.

Monitoring Wells G-117, G-122 and G-128S represent the second tier of monitoring wells located approximately 200 feet downgradient of the toe of the landfill. VOC concentrations in these wells are significantly lower than those found in the wells in closer proximity to the landfill. Monitoring well G-117 indicates the presence of only two VOCs. Total VOC concentrations are currently in the range of 5 to 20 ug/l. The general trend is toward decreasing VOC concentrations, similar to the behavior noted in other site monitoring wells.

Monitoring Wells G-128D, G-131DD, and G-133DD are screened in the dolomite aquifer. These wells have shown persistent low level VOC concentrations. Of these three wells, G-128D is located closest to the landfill, approximately 200 feet directly west of the landfill toe. At this location, high concentrations of VOCs were initially detected. Since that time, concentrations have varied between the detection limit and approximately 10 ug/l. Monitoring wells G-131DD and G-133DD are located about 700 to 1000 feet from the toe of the landfill. In these wells, VOCs have been consistently below 5 ug/l. Concentrations generally show decreasing trends with time.

3.3.2.2 Summary of VOC Occurrence. There is evidence of VOC contamination within the upper outwash aquifer within 200 feet of the landfill. Although monitoring wells located in close proximity to the landfill have shown elevated concentrations of VOCs, these values have not significantly increased since sensitive analyses were initiated in 1983, and are now generally decreasing. The monitoring wells located further downgradient exhibit lesser concentrations, which also follow a trend toward declining concentrations.

While VOCs have been detected within the dolomite aquifer at the site, it has not been conclusively demonstrated that the landfill is the sole source of these contaminants. In any case, the concentrations are quite low, and have been decreasing with time.

3.4 History of Response Actions

Numerous investigations of the Blackwell Landfill have been performed since construction began in the 1960's, in response to various conditions and concerns. Table 3-9 summarizes these investigations. Details regarding individual investigations and activities are presented below.

Monitoring wells were first installed at the Blackwell Landfill NPL Site in the early 1970's under a grant from the Illinois Institute for Environmental Quality [later the Illinois Environmental Protection Agency (IEPA)]. At that time, ten monitoring wells were installed; two in the landfill and eight around the perimeter of the fill. Laboratory analysis of samples from these wells did not begin until 1980.

In 1980, the consulting firm SMC Martin conducted an unpublished environmental evaluation of the Site for the U.S. EPA. Draft results contained in that report suggested that infiltration into the landfill would produce 180,000 gallons of leachate annually; the resultant groundwater mound would be radially distributed and join the regional gradient to the southwest; flow paths would be short with negligible attenuation; significant dilution of contaminants would occur as they discharged to the West Branch of the Dupage River or the dolomite aquifer.

Eldredge Engineering, retained by the FPD to evaluate the SMC Martin report, made several criticisms. These criticisms included: the monitoring wells were not capable of providing representative samples; infiltration and leachate production had been overestimated; attenuation and chemical interactions within the fill had not been considered; the groundwater mound resulted from capillary attractions and the ability of the more absorbent refuse to retain water around the surrounding soils.

Also in 1980, brown leachate seeps were observed around the landfill. Eldredge Engineering contracted with Testing Service Corporation to construct 12 new monitoring wells for additional monitoring, five of which extended into bedrock. Additionally, landscaping of the landfill surface was performed to control runoff.

In the spring of 1982, 16 leachate headwells/gas vents and three additional perimeter monitoring wells were installed. These were installed due to the continuation of leachate seeps despite the landscaping measures performed previously. The FPD suspected that natural gas accumulation within the fill was expelling liquid and causing fissures which permitted increased infiltration. Additional landscaping was also performed at this time.

In the spring of 1983, the FPD allocated funds for quarterly sampling and analysis of organic and inorganic parameters. During the course of this monitoring in 1983, volatile organic compounds (VOCs) were detected in wells located south and west of the hill. Additional monitoring wells were installed, and the Swim Lake was closed although no contaminants had been detected in surface water samples collected from the Swim Lake prior to that time.

In September of 1984, Dan Raviv and Associates (Raviv) was retained by the FPD to assess the potential impact of the VOCs, and to make recommendations regarding further use of the swimming beach. Conclusions reached by Raviv included the following:

- The landfill was the source of the VOC contamination;
- Summing all detected VOCs into one parameter, Total Volatiles (TVs) allowed the recognition of a generally decreasing pollutant trend between December, 1983, and September, 1984;
- The landfill contained approximately 50 million gallons of leachate;
- While no immediate threat existed regarding contamination of the dolomite aquifer or surface water, the potential did exist.

Raviv recommended continued monitoring for VOCs and the development of a groundwater model.

In 1986, an additional study of the Site was conducted by Booth and Vagt (Appendix D). Conclusions resulting from this study included:

- The landfill leaked leachate as a result of the combination of an unfavorable geologic setting and non-compliance with design, construction, and operational specifications;
- The landfill had adversely affected groundwater quality within the glacial aquifer underlying the site; however, the contamination had not migrated off-site in the glacial aquifer;
- VOC concentrations within the glacial aquifer were not increasing and might be declining;
- Results regarding impacts on the deeper dolomite aquifer were inconclusive.

Quarterly monitoring at site monitoring wells was continued through December 1989.

3.5 Identification of Potential Receptors

The HRS indicated that the potential migration pathway of concern was groundwater. Therefore, the primary receptors of concern are the users of groundwater downgradient of the landfill. Copies of available water supply well records have been obtained from the ISGS and ISWS for all wells in the nine sections which include and surround the landfill. The wells in closest proximity to the site in all directions have been plotted on Figure 3-7.

SECTION 4
SITE INVESTIGATION

4.1 Introduction

The Guidance for Conducting Investigations and Feasibility Studies Under CERCLA, Interim Final, EPA/540/G-89/004, (October 1988) suggests the following sequence for conducting the field investigations at a CERCLA Site.

1. Investigate Site Physical Characteristics
2. Define Sources of Contamination
3. Determine the Nature and Extent of Contamination
4. Assure that Sufficient Information has been gathered to: a) quantify risk to public health and environment (Endangerment Assessment), and b) develop and evaluate viable remedial alternatives (Feasibility Study).

The results of previous investigations and the response actions which have been completed are compiled in Section 3 of this document. In large part, they constitute a Physical Characterization of the Site. The work which has been completed at the site includes: site mapping, geologic characterization, groundwater assessment, evaluation of contaminant sources, and preliminary identification of downgradient water supply wells.

The following tasks have been developed to: (1) complete the investigation of the site physical characteristics, (2) identify and quantify contaminant sources and (3) quantify the nature and extent of contamination:

Task 1	Confining Layer Mapping
Task 2	Soil Sampling
Task 3	Water Level Measurements
Task 4	Surface Water/Sediment Sampling
Task 5	Monitoring Well Construction
Task 6	Groundwater Sampling at Site Monitoring Wells
Task 7	Aquifer Tests
Task 8	Meteorological Data Collection
Task 9	Groundwater Sampling, Water Supply Wells
Task 10	Biological Assessment
Task 11	Leachate Level Measurement
Task 12	Landfill Leachate Sampling
Task 13	Landfill Gas Sampling

Following completion of these tasks, the data which has been compiled and collected will be evaluated to assure that the quality (e.g. QA/QC procedures have been followed) and quantity of data is adequate to quantify the risk to public health and environment (conduct the Endangerment Assessment) and develop and evaluate viable remedial alternatives (complete the Feasibility Study). If these activities do not develop data capable of meeting the objectives of the RI and some additional data gaps remain it may be necessary to develop a scope of work for a Phase II supplemental investigation.

The Field Sampling Plan (FSP) which is submitted with the Work Plan, provides a detailed technical description of how each field task will be conducted.

4.2 Nature and Extent of Contamination

The purpose of the tasks listed below will be to define the nature and extent of contamination, and also to collect additional information to complete the characterization of the physical properties and conditions of the site.

4.2.1 Surface Features

Large scale topographic maps have been developed for the site within the Forest Preserve District for land use planning. These indicate the locations, dimensions, and interrelationships of many of the significant surface features including the landfill, Silver Lake, the Swim Lake, the Supply Lake, Spring Brook, the on-site water supply wells, the monitoring wells and leachate headwells/gas vents, and the engineered structures including roads, fences and buildings. A large scale contour map is included as Appendix F and a smaller scale one is included as Figure 2.4

Aerial photographs are also available for many years in the past. Recent aerial photographs have been obtained and are being used to update the maps which show residences surrounding the site.

4.2.1.1 Investigation Required. Much of the required information for this subtask has already been compiled as a part of developing these planning documents. However, the process will be continued throughout the RI/FS, as additional data is developed, and additional needs are identified. For example, a major effort has been made to identify all potentially affected water supply wells within and surrounding the site; these have been plotted on Figure 3-7. As the investigation continues, more water supply wells may be discovered, or the understanding of the site impacts may result in the plotting of additional wells.

4.2.2 Regional and Local Geology

The regional geology has been extensively documented by both the ISGS and the ISWS. Geologic cross sections and maps have been developed in several of the previous site investigations conducted at the site. From these, the depth to bedrock has been mapped across the entire site and the sequence and thickness of each of the geologic units has been determined. Boring logs are available for each of the more than 50 soil borings made on the site, and grain size analysis has been conducted on several of the samples, to document the physical properties of the various geologic units.

In the eastern half of the site, a deposit of glacial till 30 to 60 feet thick overlies the bedrock aquifer, separating it from the landfill and from potential contamination in the upper aquifer. However, the till thickness decreases from east to west beneath the landfill. Soil borings conducted at the western property boundary indicate that the sand and gravel upper aquifer may be directly overlying the bedrock aquifer. Water level differences in nested monitoring wells indicate that there is a significant downward vertical gradient between the upper aquifer and lower aquifer.

The groundwater monitoring data indicates that groundwater contamination does exist in the upper aquifer, extending several hundred feet downgradient (west and southwest) from the landfill. Apparently the contaminants in the upper aquifer are attenuated, dispersed, or both, before groundwater reaches the property boundary approximately 1000 feet downgradient (see Appendix D for data and evaluation). However, the site soil borings also indicate that the clay confining layer between the upper and lower aquifer thins out and ceases to exist at some distance west of the landfill. If the clay confining layer does not exist in the zone of documented contamination in the upper aquifer (Figure 3-8), there may be a "window" through which contaminated groundwater could be migrating from the upper to the lower aquifers. Auger probes will be used (Task 1) to identify the edge of the till confining layer, and to provide information for well nest locations. Two well nests will be constructed (Task 5) outside of the limit of the clay confining layer to assess potential groundwater contamination. Each well nest will consist of two wells; one will be screened in the upper outwash aquifer, and one will be screened at the top of the dolomite bedrock.

4.2.2.1 Investigation Required. It is important to document the existence or lack of the clay confining layer in the potential "window" area west of the landfill. A series of cased auger probes will be made in the zone indicated on Figure 4-1. Probes will be cased to minimize the potential of cross contamination between aquifers.

4.2.2.2 Task 1 - Confining Layer Mapping. Three steps will be followed to map the existence of the clay confining layer: 1) geophysics will be used to determine the depth to the top of the clay layer, 2) several auger probes will be used to "ground truth" the geophysics results, and 3) monitoring wells will be installed (Task 5).

Recent advances in reflection seismology allow the mapping of thin stratigraphic layers below ground. A reflection seismic profile will be conducted in the zone of known upper aquifer contamination to map the depth and thickness of the clay layer. The survey will extend from G-107 south of the landfill to G-115 west of the landfill, both locations where the clay layer has been identified in boring logs. Figure 4-1 shows the proposed survey area.

On the basis of the geophysics, several auger probes will be performed to confirm the existence and thickness of the confining layer. Either hollow stem augers or a rotary wash with driven casing method will be used to advance the borings. Each boring will be advanced to bedrock. Split-spoon samples will be obtained on 2-1/2 foot centers until a depth of 10 feet above the anticipated bedrock surface. The remainder of each boring will be continuously sampled down to the bedrock surface. Borings will be sealed with a bentonite slurry at completion.

4.2.3 Soils and Vadose Zone

From the site history and previous investigations, it is documented that a landfill was constructed on a known 40 acre site in eight or nine specific areas (Figure 3-3). In each area, lateral barriers were constructed to the fill areas, either through excavation or by berming. Therefore, neither refuse nor wastes were disposed of outside the area documented as the Landfill boundary on Figure 3-2. In general, disposal cells were capped at the end of each day, and finally capped with two feet of clay, when the cell was filled. (The two feet of clay made up the floor to the next overlying refuse cell).

Previous investigations indicate that, (1) some leachate was observed leaking from the landfill at the base of the northern slope in the early 1980s, (2) leachate is leaking from the landfill and mixing with the groundwater in the upper aquifer beneath the landfill, and (3) a groundwater plume extends a distance of up to 600 feet downgradient from the landfill in the upper aquifer (See Appendices D and E for details).

4.2.3.1 Investigation Required. The areas where leachate leaked at the surface were patched by applying additional clay, covered with topsoil and seeded. Contaminant potential of the soils at the base of the north slope will be evaluated by collecting soil samples.

4.2.3.2 Task 2 - Soil Sampling. Soil samples will be collected from two depth intervals at two locations at the base of the north slope and one location in the drainageway to the west of the Swim Lake parking lot. At each location, a sample will be obtained over the depth intervals 0-6 inches and 6-12 inches. Samples will be collected with a hand auger and analyzed for TCL and TAL parameters. The preliminary locations are shown on Figure 4-2; final locations will be marked at the site by Warzyn with concurrence from the U.S. EPA and its representative.

4.2.4 Surface Water Hydrology

Except for the south boundary line, the designated boundaries of the site are surface water boundaries (Figure 3-2). It is evident from previous investigations that these surface water bodies interact with and even control the groundwater flow. Silver Lake on the East represents a source of upgradient surface water recharge and the West Branch of the DuPage River is apparently the regional discharge area for the upper aquifer. Water levels in the closed swim lake and the supply lake are similar to the water levels in adjacent monitoring wells, indicating that the lake levels are expressions of the groundwater elevation, or that these are groundwater "flow-through" lakes.

Spring Brook makes up the northern boundary of the site and curves around, also making the western site boundary until it joins the West Branch of the DuPage River. Indications are, from both water levels and water quality measured in the brook and adjacent monitoring wells, that Spring Brook is a recharge source to the upper aquifer where the aquifer is primarily outwash sand and gravel.

4.2.4.1 Investigation Required. Additional site data will be collected: (1) to better define the interactions between surface water and groundwater, (2) to document the surface water quality surrounding the site, and (3) to evaluate the potential contamination effects of discharging groundwater on bottom sediments in surface water bodies surrounding the site.

4.2.4.2 Task 3 - Water Level Measurements. To document groundwater/surface water interactions, water levels will be measured in the surface water bodies which surround the landfill, in many of the monitoring wells which exist on site and in the new monitoring wells, in leachate head wells in the landfill and in several piezometers which will be installed.

Staff gages will be set in Silver Lake, the closed Swim Lake, the Supply Lake, at four locations along Spring Brook, and at two locations along the West Branch of the DuPage River. Piezometers will be installed at three points along Spring Brook near the staff gage locations, and at one location midway between Silver Lake and the Swim Lake. The staff gage and piezometer locations are shown on Figure 4-3. Water levels will be measured during each quarter of the year-long remedial investigation. Although water level measurement will be made approximately once every three months, the actual dates of measurement will be flexible and selected to document low flow and high flow conditions. Task 11 describes the leachate level measurements which will be collected to evaluate the leachate generation of the landfill. The leachate level collection dates will coincide with the measurements at the wells, piezometers, and staff gages. Water level measurement locations and dates are summarized in Table 4-1.

4.2.4.3 Task 4 - Surface Water/Sediment Sampling. To document the possible effects of the discharge of groundwater to surface water bodies, surface water and sediment samples will be collected in Silver Lake (three locations), the closed Swim Lake (two location), the supply lake (one location) and Spring Brook (two locations). Each sample will be analyzed for full TCL/TAL. Surface water samples will also be analyzed for indicator parameters. Surface water/sediment sampling locations are indicated on Figure 4-4.

Surface water/sediment samples will be collected at three locations in Silver Lake. SW/SD-1 will be collected about 100 feet off-shore in the south east corner of the lake. The purpose will be to provide an indication of background water and sediment quality. The location is beyond the area shown in Figure 4-4. Sample SW/SD-2 will be collected about 25 feet off-shore from monitoring well G-101 and will provide documentation of groundwater leakage and/or surface water run off from the north slope of the landfill. Sample SW/SD-3 will be collected about 25 feet off-shore from monitoring well G-103 and will provide documentation of groundwater leakage and/or surface water run off from the east slope of the landfill. Sampling procedures are outlined in the Field Sampling Plan.

Surface water/sediment samples will be collected at two locations in the closed Swim Lake. SW/SD-4 will be collected about five feet off-shore in the in the center of the original beach area and SW/SD-5 will be collected about 100 feet off-shore in the center of the lake. These samples will provide an indication of potential groundwater leakage into the lake. Sampling procedures are outlined in the FSP.

Surface water and sediment samples will be collected at one location in the Supply Lake (SW/SD-5). The sample will be collected from about five feet off-shore at the north end of the lake. This samples will provide an indication of potential groundwater leakage into the lake. Sampling procedures are outlined in the FSP.

Two locations along Spring Brook are designated as surface water/sediment locations. A weir is located across the Spring Brook where the road crosses the stream at the north end of the site. Water crossing that weir comes directly from the wetland area north of Silver Lake and therefore represents water and sediment quality up stream of the landfill. Sample SW/SD-7 is located at that point to sample background conditions in Spring Brook. Sample SW/SD-8 will be collected just above the confluence of Spring Brook and the West Branch of the DuPage River to test the conditions of Spring Brook down stream from the landfill. Sampling procedures are outlined in the FSP.

The results of Phase I sampling and water level measurement will show whether groundwater is discharging or recharging in Silver Lake, the Swim Lake, the Supply Lake and Spring Brook. A second round of sediment and surface water sampling may be conducted at one or more of the locations in Phase II of the investigation if it has been shown that contamination has resulted from the landfill. The parameter list may be reduced to include only chemical groups detected in the prior round of sampling. (e.g. only VOA if only VOCs were detected at levels above MCLs or metals above background).

4.2.5 Hydrogeology

Two hydrogeologic regimes have been identified at the site. The lower bedrock aquifer extends beneath the whole site and is characterized as a fractured dolomite aquifer, which is highly permeable in its upper 10-50 feet. Groundwater flow in the lower aquifer has been shown to be from east to west (Figure 3-10). The hydraulic gradient is steepest in the east where it may be recharged by Silver Lake; the gradient is flatter to the west where it may be recharged by the upper aquifer.

The upper hydrogeologic regime is unconfined, with a water table existing in the unconsolidated glacial deposits which overlie the bedrock. Previous investigations indicate that nature of the aquifer changes from east to west beneath the landfill. In the east, the saturated glacial deposits are primarily low permeability clay till. To the west of the site, the saturated glacial deposits are high permeability sand and gravel deposits.

Water levels measured at the site indicate that the hydraulic gradient in the upper hydrogeologic regime is from northeast to southwest, beneath the landfill, and that it curves toward the southwest in the sand and gravel deposits west of the landfill (Figure 3-10). However site borings and aquifer tests conducted for previous investigations indicate that permeability of the unconsolidated materials changes from very low permeability near Silver Lake to very high permeability west of the landfill. Since the volume of groundwater flux is controlled by the permeability, the volume of groundwater flowing beneath the landfill from Silver Lake to the west is much lower than the volume of groundwater flowing south and southeast through the outwash deposits west of the landfill.

Previous sampling at the 51 monitoring wells which surround the site indicates that a contaminant plume does extend several hundred feet downgradient from the landfill. The plume is identified by levels of TDS which are above background levels, and the existence of volatile organic compounds. See Appendices D and E for details).

4.2.5.1 Investigation Required. It is known from previous investigations that leakage from the landfill has caused a plume extending several hundred feet downgradient from the landfill in the upper aquifer. It is also known that the clay confining layer between the upper aquifer and the lower, bedrock aquifer thins from east to west. The confining layer exists beneath the landfill, but it does not appear to exist near Spring Brook. It is not known whether the plume from the landfill extends out over a potential "window" through the clay confining layer.

The purpose of Task 1 (above), will be to document the existence of the confining layer in the areas south and west of the landfill. On the basis of that investigation, groundwater sampling will be conducted to evaluate the potential for groundwater contamination in the lower aquifer.

The additional work necessary to document the extent of landfill impact to the upper and lower aquifers includes: (1) installing two additional monitoring well nests, (2) collecting and analyzing samples from 21 existing and the four new monitoring wells, (3) measuring water levels at monitoring wells, piezometers, and staff gages, (4) conducting physical tests on six aquifer and aquitard samples, (5) conducting aquifer tests at 10 monitoring wells, and (6) sampling private wells surrounding the site.

4.2.5.2 Task 5 - Monitoring Well Construction. Monitoring wells will be constructed within the "window" where the clay confining layer may be missing and allowing migration between the upper and lower aquifer. Nests of two monitoring wells will be constructed at two locations (total of four monitoring wells). The locations will be selected by the results of Task 1, which will have identified the potential "window" through the confining layer. At each location, one well will be constructed with a five-foot screen located at the base of the sand and gravel zone, and a second well, with a five-foot screen will be located just below the bedrock surface. Five-foot screens will provide more accurate (less dilute) sampling results, and more precise water level information for calculating vertical gradients. Final locations will be determined by consensus between U.S. EPA and Warzyn Engineering.

During drilling of the deeper well in each nest, the bedrock will be cored. Coring will be performed to determine the characteristics of the dolomite bedrock and to ensure that each well is screened in a fractured, not crystalline, zone.

4.2.5.3 Task 6 - Groundwater Sampling, Monitoring Wells. Sampling and analysis will be conducted at 25 monitoring wells to meet the objectives of the RI/FS. The 25 wells include 21 existing wells surrounding the landfill, and the four new wells which will be constructed. Although 25 wells are less than half of the wells which exist on the site, these have been selected to sufficiently represent the groundwater quality in the upper and lower aquifer, both up and down gradient of the site. Table 4-1 lists the wells to be sampled and Figures 4-5 and 4-6 show the locations of the wells which will be sampled.

Upgradient Lower Aquifer Wells. One monitoring well, G-134, will be sampled to represent upgradient water quality in the dolomite aquifer. The well location is shown on Figure 4-5. The results of this sampling will be supplemented by the upgradient sampling of private wells (Task 9).

Downgradient Lower Aquifer Wells. Six monitoring wells (Table 4-2) will represent the downgradient water quality in the lower aquifer. The well locations are shown on Figure 4-5. The sampling results from the monitoring wells will be supplemented by the sampling of private wells downgradient from the site (Task 9).

Upgradient Upper Aquifer Wells. There is no real "upgradient" in the upper aquifer because the aquifer begins beneath the landfill. Monitoring wells downgradient of the landfill have characteristically shown levels of VOCs. Taken as an indicator, VOC-free groundwater may indicate background groundwater quality, if the groundwater flow regime also indicates that the wells are not downgradient of the landfill. Two monitoring wells, G-121 and G-130, meet this criterion.

In six years of sampling and analysis, VOCs have not been detected at monitoring wells G-130 and G-121. At both locations the groundwater flow, as evidenced by the hydraulic gradient, is parallel to groundwater flow beneath the landfill. Yet both wells are located outside the zone of potential contamination by the landfill. Therefore, wells G-130 and G-121 will represent background water quality in the upper aquifer (Figure 4-6).

Downgradient Upper Aquifer Wells. Eleven wells have been selected to represent downgradient water quality in the upper aquifer (Table 4.2 and Figure 4-6). The other upper aquifer wells surrounding the landfill are either redundant, or do not represent the upper aquifer. The following points provide the rationale for not sampling all the existing wells.

- Monitoring wells G-101 and G-103 are located between Silver Lake and the landfill. Yet they have water levels which are lower than Silver Lake indicating even if there is mounding in the landfill, the lake provides a hydraulic barrier to groundwater movement toward the east. (Surface water/sediment sampling will indicate if contaminants are moving against the gradient).
- Monitoring wells G-106 through G-114 were installed in 1980 along the downgradient toe of the landfill. Most of them have indicated significant levels of VOC contamination during the past six years of monitoring. However, in subsequent investigations, a second tier of monitoring wells have been established to represent water quality 100 to 200 feet downgradient from the landfill. This outer tier of wells is included in the sampling (Table 4-2).

Two rounds of sampling will be conducted at each of the 25 wells. In round 1, each sample will be analyzed for full TCL/TAL and indicator parameters. For round 2, the parameter list may be reduced to include only parameter groups which were detected at above background levels. Refer to the Field Sampling Plan for details regarding well preparation, sample collection and handling, and equipment decontamination.

Water levels will be measured four times during the investigation at the monitoring wells, piezometers, and staff gages identified or constructed for this investigation (Task 3). These will be useful in evaluating potential short term changes in groundwater flow and groundwater/surface water interactions.

4.2.5.4 Task 7 - Aquifer Tests. Aquifer and aquitard materials will be collected for physical testing during the installation of the new monitoring wells. Two samples will be collected at each well nest location and analyzed for grain-size distribution. One sample will be collected at each location approximately five feet above the bedrock surface to represent the upper aquifer material. The second sample at each location will be collect of the material directly overlying the bedrock. Analysis of this sample will be useful in assessing the retardative nature of the material, and to assess whether it has the potential to act as an aquitard.

Bail tests will be conducted at 10 monitoring wells during Phase I of the investigation to provide an indication of the hydraulic properties of the aquifer materials. Four of the test locations will be the new monitoring well locations. Two of these will be in the upper aquifer and two in the lower aquifer and they will be in the zone of greatest concern, within the plume of affected groundwater. The other locations include:

G-134, upgradient of the landfill in the lower aquifer,

G-133 and G-136 in the lower aquifer downgradient of the landfill,

G-130, upgradient of the landfill in the upper aquifer, and

G-133S, and G-126, downgradient of the landfill in the upper aquifer.

These locations are shown on Figure 4-7.

4.2.6 Meteorology

Two aspects of the meteorological conditions will be useful in meeting the objectives of the RI/FS. Wind directions represent the probable air migration routes from the site. Precipitation represents the original source of groundwater, surface water, and leachate.

4.2.6.1 Task 8 - Meteorological Data Collection. During the Phase I investigation, daily temperature and precipitation amounts will be recorded at the FPD nursery located about one mile north of the landfill. These will indicate the approximate amount of precipitation and evapotranspiration at the site during the investigation. Wind directions and velocity records will be obtained from the DuPage Airport for the same time period. These will be used to construct wind rose diagrams.

4.2.7 Human Population and Land Use

The landfill is located in a DuPage County Forest Preserve, in a relatively densely populated part of the metropolitan Chicago area. In preparing this Work Plan, Warzyn obtained well logs for the water supply wells in the nine section blocks which include and surround the landfill (Section 26, Range 9 East, Township 39 N contains the landfill, and sections 22, 23 ,24, 25, 27, 34, 35, and 36 surround section 26). More than 500 well logs were obtained from the Illinois State Water Survey for these nine sections. The time-frame for completion of the planning documents has not permitted the plotting of all 500 wells for which logs were obtained. The wells located closest to the landfill in each direction have been plotted on Figure 3-7. Additional wells will be plotted for the final maps of the Remedial Investigation Report as they are discovered, or if they are found to have the potential for impact.

The majority of these wells are completed in the bedrock aquifer which has been identified as the lower aquifer for this investigation. Previous investigations and the monitoring well results have indicated that the hydraulic gradient in the lower aquifer is to the west-southwest of the landfill, and that there are trace levels of organic compounds in the lower aquifer at the western boundary of the site.

4.2.7.1 Investigation Required. Additional work which will be conducted to complete the requirements of the RI/FS includes: (1) verifying the direction of groundwater flow in the lower aquifer, and (2) collecting and analyzing samples from 26 water supply wells surrounding the landfill site.

4.2.7.2 Task 9 - Groundwater Sampling, Water Supply Wells. Water levels collected at lower aquifer monitoring wells during the second month of the investigation will be used to verify the hydraulic gradient in the lower aquifer. On the basis of previously collected and interpreted data, one upgradient and 25 downgradient water supply wells have been selected for water quality sampling in the vicinity of the Blackwell landfill. The locations are shown on Figure 4-8. The upgradient results will be supplemented with the upgradient monitoring well results. The downgradient locations represent the first tier of water supply wells located west (downgradient) of the site. The samples will be analyzed for low quantitation limits of VOCs. The need to re-sample or add additional downgradient wells will be re-assessed on the basis of Phase I sampling. If additional sampling is necessary, it will be conducted in Phase II.

4.2.8 Ecological Investigation

The Site functions as an undeveloped area in a suburban environment. Biological resources in the Site area include a lake used for fishing and boating, and land areas of woods and fields. The ecological aspects of the Site will be assessed as a part of the Site investigation.

4.2.8.1 Investigation Required. Observation of the ecosystems of the Site will be performed by a field biologist. A qualitative assessment will be performed and results of previous Site and area ecological characterizations will be reviewed. The Site ecosystem will be compared with others in the vicinity.

4.2.8.2 Task 10 - Biological Assessment.

Field observations will be performed in general accordance with the U.S. EPA guidance document, Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference, EPA/600/3-89/013, March 1989. Field assessments will be qualitative and will include aquatic and terrestrial areas.

Aquatic surveys of Silver Lake, the Swim Lake, the Supply Lake, Spring Brook, and the West Branch of the DuPage River will be performed. Species richness and relative abundance will be assessed for phytoplankton/periphyton and macroinvertebrate communities. Park district personnel will be interviewed concerning fish stocks in the Site lakes.

Vegetation of terrestrial areas will be qualitatively assessed by field observation. Approximate areas of woods, fields, and transition zones will be estimated. Terrestrial mammal and bird populations will be assessed by a review of local and/or regional studies and knowledge of academic experts.

With the results of field and reference information, Warzyn will prepare an ecological assessment report. The U.S. EPA guidance document, Risk Assessment Guidance for Superfund, Volume II: Environmental Evaluation Manual, Interim Final, EPA/540/1-89/001, March 1989, will be used in preparation of the ecological assessment report.

Sampling of biota will not be performed as a part of these activities. Present Site information does not indicate the presence of bioaccumulative chemicals. If information collected in this investigation indicates a potential for exposure to the Site fauna or flora, samples of the biota may be collected as a part of a subsequent field investigation.

4.3 Identify and Quantify Sources of Contamination

The source of potential contamination at the Blackwell Landfill is the refuse which was buried in the landfill, and the leachate which is contained within the landfill. A review of the history indicates that the landfill was used for the disposal of household and some light industrial waste. There is no record of the disposal of drums or containerized wastes. Previous investigations indicate the leachate levels have reached an equilibrium condition, varying several inches to several feet during each year, but remaining in the same range (at each well) from year to year.

These observations indicate that the landfill has reached a steady state condition of leachate generation. In a steady state landfill, the leachate generation rate and leakage rate are equal to the the average annual precipitation. With the assumption, previous investigations have estimated that leachate is being generated within the landfill and leaking from the landfill at a rate on the order of 2,200 cubic feet per day (Appendix E).

The previous investigations have used Water Balance methods and a Leachate-Level-Change method to derive the estimates of leachate leakage. The primary water balance method used has been the U.S. EPA's Hydrologic Evaluation of Landfill Performance (HELP) numerical model. The model is an empirical model which provides an estimate of leachate generation for a steady state landfill on the basis of known input (precipitation, evapotranspiration, etc.) and known or assumed landfill construction.

The Leachate-Level-Change method is based on leachate level measurements at wells in the landfill. It is based on the assumption that the landfill is at steady state, and that there is a relationship between the decline in leachate levels and leakage rate out of the landfill during periods of low infiltration. The relationship is shown by the following equation.

$$dV = dH * A * n$$

Where
dV = change in leachate volume
dH = change in leachate level
A = area in over which level change occurs
n = effective porosity (specific yield) of refuse

Phase I of the Remedial Investigation will focus on identifying and quantifying the characteristics of the primary sources of contamination. Water balance and leachate level change methods will be used to evaluate the leachate production rates. Leachate sampling will be conducted to document the contaminants present. Results of other sampling (i.e. groundwater sampling and surface water/sediment sampling which are discussed above), will provide an indication of the levels of contaminants which exist outside the landfill.

Two primary sources of contamination are represented at the landfill (1) the landfill gas and (2) the leachate contained in the landfill. In addition, there are potential secondary sources of contamination including affected groundwater, surface water, sediment, and biota. During the Phase I investigation, samples of leachate and landfill gas will be collected and analyzed for hazardous constituents. Potential secondary sources of contamination include sediment, surface water and groundwater. If the Phase I investigation indicates that these secondary sources contain concentrations high enough to classify them as contaminants, a second phase of investigation and sampling may be conducted to further delineate the potential secondary sources.

4.3.1 Investigation Required. Additional work which will be conducted to complete the requirements of the RI/FS include: (1) evaluating the volume of leachate existing and being generated within the landfill, (2) sampling the leachate within the landfill and (3) identifying the characteristics of the landfill gas.

4.3.1.1 Task 11 - Leachate Volume Evaluation. The leachate production rate will be calculated and an estimate of landfill hydraulics and leachate volume will be generated for the RI report. A water balance method will be used to derive an estimate of the percentage of average annual precipitation which has the potential to become leachate in the landfill. Leachate level changes will be used to develop an estimate of the annual leakage rate using the methodology described above.

The meteorological data collected for Task 8 and the available records of landfill capping will be used in conjunction with the U.S. EPA's Hydrologic Evaluation of Landfill Performance (HELP) numerical model (Schroeder et al., U.S. EPA, 1974) to conduct the water balance.

Leachate levels will be measured in each of the existing 24 headwells in the landfill on six dates during the investigation. Four of the measurements will coincide with the water level measurements at the monitoring wells, staff gages, and piezometers detailed in Task 3.

4.3.1.2 Task 12 - Landfill Leachate Sampling. Leachate samples will be collected from four leachate headwells in the landfill. The sampling locations were selected to represent the largest volume and highest concentration levels of contaminants (Table 3-6). Each sample will be analyzed for full TCL/TAL parameters. The leachate headwells which will be sampled are SB-5, SB-8, SB-9 and DV-5. Figure 4-9 shows the locations of the headwells which will be sampled. Refer to the Field Sampling Plan for details regarding well preparation, sample collection and handling, and equipment decontamination.

4.3.1.2 Task 13 - Landfill Gas Sampling. Reports of site conditions indicate that gas flow rate from the 24 headwell/vents in the landfill is variable with temperature and precipitation. Gas flow volume will be measured from each of the vents on two separate days during the investigation to provide an indication of the relative gas production in various areas of the site. Two high flow vents will be identified and gas samples will be collected and analyzed for VOCs. Vent locations will be selected to represent different parts of the landfill, (i.e. if two adjacent vents have the highest flow rates, only one of those will be sampled, and another vent at least 500 feet away will be selected for sampling).

SECTION 5
SITE INVESTIGATION ANALYSIS

5.1 Baseline Risk Assessment

The overall objective of the RI/FS process is to arrive at site remedies which mitigate threats to human health and the environment posed by site contamination. The Baseline Risk Assessment (BRA) is an essential component of the evaluation of remedial options. By assuming no further remedial activities take place at the site, risks identified in the BRA provide a basis for comparing the efficacy of each alternative in reducing site risks.

Detailed guidance for conducting BRA at Superfund sites is described in U.S. EPA documents entitled Risk Assessment Guidance for Superfund, Volume 1 - Human Health Evaluation Manual and Volume 2 - Environmental Evaluation Manual (1989).

A preliminary Risk Assessment will be prepared as a Technical Memorandum from the results of Phase I sampling. At that time, a meeting will be held among representatives of the U.S. EPA, IEPA, the U.S. Fish and Wildlife Service, the Forest Preserve District, and Warzyn to evaluate and establish the objectives for the Endangerment Assessment.

5.2 General Description

The BRA is performed concurrently with the RI/FS and begins at the project scoping stage with identification of potential exposure pathways and determination of the appropriate types and quantities of data necessary for risk assessment. In subsequent steps, characteristics of potentially exposed populations are determined and estimates of contaminant intake are derived. This exposure information is then integrated with information on the toxicology of contaminants, to arrive at an estimate of risk. Because the depth of scientific information pertaining to the effects of chemicals on human health is much greater than for the effects of chemicals on the natural environment, the BRA generally emphasizes the quantitative evaluation of human health impacts. Evaluation of the environmental impacts of site contaminants is usually less detailed and more qualitative in scope.

The BRA includes evaluation of risks as they presently exist, assuming current land use conditions prevail at the site, as well as evaluation of potential future risks by assuming plausible future land use changes at the site.

The risk assessment process is organized into the following components:

- Human Health Evaluation
  - Contaminants of Potential Concern
  - Exposure Assessment
  - Toxicity Assessment
  - Risk Characterization
- Environmental Evaluation

A brief description of each component is described below.

5.2.1 Contaminants of Potential Concern

In this component of the risk assessment, the results of chemical analysis of environmental samples are evaluated to determine the nature and magnitude of contamination at the site. These data are compared to data from background samples as well as sampling and analysis quality control data to distinguish site contamination from naturally occurring chemicals and those which may be artifacts of sample collection and analysis. Chemicals considered to be site contaminants are further evaluated as "chemicals of potential concern" in the BRA.

5.2.2 Exposure Assessment

The aim of the exposure assessment is to estimate the types and magnitude of exposure to chemicals of potential concern at and migrating from the site. Pathways of potential exposure (e.g. contaminant contact via groundwater ingestion) are characterized, as are populations potentially exposed (e.g., location and activity patterns). For pathways which present realistic exposures, estimates of contaminant intake for exposed populations are calculated.

Contaminant intake estimates incorporate information such as contaminant concentration, frequency of exposure, and exposure duration, and are calculated for applicable routes of contaminant entry into the body (e.g. ingestion, dermal absorption or inhalation). When available, site-specific exposure information is used. When not available, standard exposure assumptions are applied (e.g., 70 kg person consumes 2 L water per day). The contaminant intake estimates are intended to represent "reasonable maximum exposures" which are greater than average exposures, but within the range of possible exposures. Contaminant intake estimates are subsequently evaluated with toxicological information to estimate risk.

5.2.3 Toxicity Assessment

In this section, the toxicological characteristics of the chemicals of potential concern are presented. The potential adverse health effects of chemical exposures are described, as well as information on the relationship between the magnitude of the exposure (dose, frequency and duration) and the toxic response it produces (dose-response relationship). The dose-response relationship for each chemical is addressed in the risk assessment by considering toxicity values, developed by the U.S. EPA. Toxicity values have been derived for noncarcinogenic effects and carcinogenic effects of the chemicals and are *termed reference doses* (RFD) and slope factors (SF), respectively. Specific toxicity values have been developed for varying exposure conditions including chronic versus subchronic duration and oral versus inhalation exposure routes. Appropriate toxicity values are identified for contaminants of potential concern.

5.2.4 Risk Characterization

The risk characterization process integrates findings from the exposure assessment and toxicity assessment. Risks are estimated for potential carcinogenic and noncarcinogenic effects of the chemicals by comparing estimated contaminant intakes with appropriate toxicity values. Calculated risks from multiple chemicals are then summed to obtain a total exposure pathway risk. Essential to the appropriate interpretation of calculated risks is consideration of the numerous assumptions and uncertainties inherent in the risk assessment process. These are described and presented with risks estimates.

5.2.5 Environmental Evaluation

The objective of this component of the BRA is to appraise the actual or potential adverse effects of site contaminants on the ecology of the site or lands influenced by the site. This assessment may only apply to sites were appreciable natural habitats occur; however, evaluation of adverse effects on domesticated animals is also appropriate in this section.

Relative to the human health evaluation described in the previous four components, the concepts for ecological assessments are much less defined. However, the overall approach to environmental assessment is analogous to that of human health assessment and includes identifying contaminants of potential concern, pathways of contamination migration and populations (flora and fauna) potentially affected by site contamination. To the extent possible, actual adverse impacts to natural habitats are determined. Similarly, the potential for future environmental impact is also described. In addition, contaminant concentration data may be compared to available regulatory criteria (e.g., sediment and water quality criteria).

SECTION 6
BENCH/PILOT STUDIES

If findings from the Phase I and II investigation indicate that one or more of the feasible remedial alternatives are likely to include some innovative technologies, it will be necessary to conduct bench-scale and/or pilot-scale testing studies to determine technology applicability to the site conditions.

Therefore, treatability studies may be considered after the second phase of the investigation on the basis of the existing information. The overall purpose of treatability studies will be to assess whether a given innovative or untested technology can be implemented, and/or to judge its effectiveness for use at the site. If treatability studies are found to be necessary, a work plan will be prepared to outline the purpose and procedures of the study or studies and will be submitted to the U.S. EPA for review and comment.

SECTION 7
PROJECT REPORTS

Three categories of reports will be generated during the RI/FS: progress reports, technical memoranda, and Draft and Final RI and FS Reports.

7.1 Monthly Progress Reports

Monthly progress reports will be prepared to describe the technical progress of the RI/FS. The reports will be submitted to the U.S. EPA and IEPA by the fifteenth business day of each month. They will include the following information.

1. A description of the action which has been taken toward achieving compliance with the Consent Order;
2. Summaries of sampling and test results received by Respondent during the previous month relating to the Blackwell Forest Preserve Site;
3. All plans and procedures completed during the past month, as well as such actions, data, and plans which are scheduled for the next month; and
4. Target and actual completion dates for each element of activity, including the project completion, and an explanation of any deviation from the schedule in the RI/FS Work Plan.

7.2 Technical Memoranda

Technical memoranda will be prepared to describe the procedures used to collect specific data and will present the preliminary data. Copies will be sent to the U.S. EPA and IEPA for review. A meeting will be held between the U.S. EPA RPM and Warzyn to discuss the findings and the appropriate level of effort for the next phase of the investigation. Warzyn will also present a written summary of proposed sampling and investigation for the next phase of investigation, if one is necessary. The information included in the technical memoranda will be incorporated into the Draft and Final Remedial Investigation Reports. Four technical memoranda will be produced during the Remedial Investigation.

1. Source Characterization
2. Hydrogeologic Study
3. Ecological Investigation Report
4. Endangerment Assessment

7.3 Remedial Investigation Report

A final report covering the investigations will be prepared following the general outline presented in Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final, EPA/5540/G-89/004, October 1988. The Remedial Investigation Report will be submitted in draft form to the U.S. EPA and IEPA for review. Upon receipt of comments, a draft final report will be prepared and submitted.

SECTION 8
FEASIBILITY STUDY TASKS

The purpose of the Feasibility Study (FS) for the Blackwell Landfill NPL Site is to develop and evaluate alternative remedial actions, and to present the relevant information needed to allow for the selection of a site remedy which will be protective of human health and the environment.

The FS will conform to Section 121 of CERCLA; the NCP, as amended; the FS Guidance, as amended; and U.S. EPA policy. The FS is comprised of the following tasks:

Task 14: Remedial Alternatives Identification and Screening
Task 15: Remedial Alternatives Array Document
Task 16: Remedial Alternatives Evaluation
Task 17: Feasibility Study Report
Task 18: Community Relations Program

8.1 Task 14 - Remedial Alternatives Identification and Screening

The identification and screening of remedial alternatives will be accomplished through implementation of the four interrelated subtasks:

- Preliminary Remedial Technologies
- Development of Remedial Alternatives
- Screening of Alternatives
- Data Requirements

The work to be accomplished under each subtask is discussed below.

8.1.1 Preliminary Remedial Technologies

The purpose of this subtask is to identify and consider a wide range of potentially applicable technologies and, based on site and waste conditions, identify a limited number of specific process options that may be used to address site problems. Conceptually, the screening process may be viewed as consisting of the following:

- Development of general response actions.

- Identification of the general technology types associated with the general response actions.

- Identification of process options associated with each technology type.

- Screening technology types and process options based on an evaluation with respect to technical implementability.

General response actions will be developed for each media of concern at the Blackwell Landfill NPL Site. Response actions may include source control measures, migration control measures or both, depending on the media and/or exposure pathways that may need to be addressed. Response actions will consider the general area(s) of concern and quantity of material to be remediated at the site based upon the initial site evaluation and information from the RI as it becomes available.

Technologies and process options that cannot be effectively implemented at the site will be eliminated from further consideration. This screening will be based on information from the RI and on technology capabilities/limitations. Results of the screening will be summarized in tables.

For each of the technology types considered potentially applicable, one or normally two process options will be selected for further consideration. Process options will be evaluated using effectiveness, implementability and cost criteria. Limiting the number of specific process options is intended to make the development and screening of alternatives more manageable by limiting the potential number of alternatives developed. Selecting specific process options for actual implementation is a Remedial Design (RD) phase activity. Results of the process options evaluation will be presented in tabular form.

8.1.2 Development of Remedial Alternatives

Under this subtask, a range of remedial alternatives will be developed for the site. This subtask is comprised of the four steps described below which may be viewed as involving more specific definitions of potential remedial activities.

8.1.2.1 Establishment of Remedial Action Objectives - Site-specific objectives for the remedial action will be established for the Blackwell Landfill Site; considering the description of the current situation, information gathered during the RI, Section 300.68 of the National Contingency Plan (NCP), the U.S. EPA's interim guidance, and the requirements of other applicable U.S. EPA, Federal, and Illinois environmental standards, guidance and advisories.

These objectives consist of medium-specific or operable unit-specific goals for protecting human health and the environment. They will specify: the contaminant(s) of concern; exposure route(s) and receptor(s); and an acceptable contaminant level or range of levels for each exposure route.

Acceptable exposure levels for human health will be determined on the basis of risk factors and contaminant-specific ARARs. Contaminant levels in each media will be compared with these acceptable levels, which will be determined on the basis of an evaluation of the following factors:

- For carcinogens, whether the chemical-specific ARARs provide protection within the risk range of 10^{-4} to 10^{-6} and whether achievement of each chemical-specific ARAR will sufficiently reduce the total risk from exposure to multiple chemicals.
- For non-carcinogens, whether the chemical-specific ARAR is sufficiently protective if multiple chemicals are present at the site.
- Whether environmental effects (in addition to human health effects) are adequately addressed by the ARARs.
- Whether the ARARs adequately address all significant pathways of human exposure identified in the baseline risk assessment. For example, if exposure from the ingestion of fish and drinking water are both significant pathways of exposure, application of an ARAR that is based only on drinking water ingestion (e.g., MCLs) may not be adequately protective.

If an ARAR is determined to be protective, it will be used to establish the acceptable exposure level. If not (presents a risk greater than 10^{-4}), or does not exist for the specific chemical or pathway of concern, or multiple contaminants may be posing a cumulative risk, acceptable exposure levels will be identified through the risk assessment process. The Superfund Public Health Evaluation Manual will serve as the primary source of guidance for risk assessment. The Risk Assessment Guidelines of 1986 will serve as an additional reference.

Clearly, the determination of acceptable exposure levels will depend on the availability of site investigation results. Where possible, preliminary response objectives will be established based on existing site information and a qualitative assessment of potential risks. Response objectives will be revised as information from the RI becomes available.

8.1.2.2 Alternative Remedial Actions - Alternatives will be assembled by combining general response actions and the process options chosen to represent the various technology types for each media or operable unit. Alternatives will be formulated to provide comprehensive site remedies. Alternatives to be developed will include the following:

a. Treatment alternatives for source control that eliminate or minimize the need for long-term management (including monitoring).

b. Alternatives involving treatment as a principal element to reduce the toxicity, mobility or volume of waste.

At least two additional alternatives will be developed, including the following:

a. An alternative that involves containment of waste with little or no treatment but provides protection of human health and the environment primarily by preventing exposure or reducing the mobility of the waste.

b. A no action alternative.

8.1.3 Initial Screening of Alternatives

The purpose of this subtask is to narrow the list of potential alternatives that will be evaluated in detail. The screening is accomplished using the following steps:

- Alternatives will be further refined as appropriate;
- They will be evaluated on a general basis to determine their effectiveness, implementability, and cost; and
- A decision will be made, based on this evaluation, as to which alternatives should be retained for further analysis.

8.1.3.1 Alternatives Definition - In this step, alternatives will be further defined to form a basis for evaluating and comparing them prior to screening. Sufficient quantitative information to allow differentiation among alternatives with respect to effectiveness, implementability, and cost is required. The following information will be developed, as appropriate, for the various technology processes used in an alternative:

- size and configuration of on-site extraction and treatment systems or containment structures;
- time frame in which treatment, containment, or removal goals can be achieved;
- process flow rates and/or rates of treatment;
- spatial requirements for constructing treatment or containment technologies or for staging construction materials or excavated soil or waste;
- distances to disposal or treatment facilities; and
- required permits and imposed limitations.

8.1.3.2 Initial Screening - In this step, defined alternatives will be evaluated against short- and long-term aspects of three broad criteria: effectiveness, implementability, and cost. These are described as follows:

- Effectiveness: Alternatives will be evaluated to determine whether they adequately protect human health and the environment; attain Federal and Illinois ARARs or other applicable criteria, advisories, or guidance; significantly and permanently reduce the toxicity, mobility, or volume of the hazardous constituents; are technically reliable; and are effective in other respects. The consideration of reliability will include the potential for failure and the need to replace the remedy.
- Implementability: Alternatives will be evaluated as to the technical feasibility and availability of the technologies that each alternative would employ; the technical and institutional ability to monitor, maintain, and replace technologies over time; and the administrative feasibility of implementing the alternative.
- Cost: The cost of construction and long-term costs to operate and maintain the alternative will be evaluated. This evaluation will be based on conceptual costing information and not a detailed cost analysis. At this stage of the FS, cost will be used as a factor when comparing alternatives that provide similar results, but will not be a consideration at the screening stage when comparing treatment and non-treatment alternatives.

8.1.3.3 Preservation of Alternatives - In this step, alternatives with the most favorable composite evaluation of all factors are retained for further consideration during detailed analysis. Alternatives selected will preserve the range of treatment and containment technologies initially developed plus the no action alternative.

8.1.4 Data Requirements

The purpose of this subtask is to provide data not available from the RI to support the detailed analysis of alternatives in Task 16. The need for additional data, if any, will be identified. Additional data gathering may involve site characterization, waste characterization, exposure pathway characterization, other materials testing or treatability studies. Data requirements will be approached in two steps as described below.

8.1.4.1 Determination of Data Requirements - Additional data needs, if any, will be identified by assessing the unknowns associated with the site and/or the application of specific technologies at the site. A literature survey will be conducted to determine whether adequate performance and application data exist for a particular technology, and to determine testing requirements.

8.1.4.2 Treatability Testing or Field Investigation - If needed, the purpose of this step would be to plan, carry out, evaluate and report on the supplemental field or treatability investigation. Investigations or testing may be required to adequately evaluate a specific technology for application at the site. The evaluation may be oriented toward a performance assessment, process sizing, materials identification and testing (e.g., NR512 clay borrow source search and clay testing) or cost estimation. The goal of investigation or testing is to support the remedy-selection process. In general, the following activities would be included in the subtask:

- Work Plan preparation (or revisions to existing Work Plan);
- Field Investigation or sampling, and/or laboratory testing, and/or pilot-scale testing;
- Analysis of data from the investigation or testing program; and
- Report preparation.

Because of the unknowns at this stage of the process, no specific program is proposed or budgeted in this Work Plan.

8.2 Task 15 - Remedial Alternatives Array Document

The purpose of this task is to provide the basis for the determination of possible action specific applicable or relevant and appropriate requirements (ARARs). A description of the screened alternatives which were retained in Task 14 (including extent of remediation, contaminant levels to be addressed, and methods of treatment) will be presented. This document will also include a brief site history and background, a site characterization summary that includes contaminants of concern, migration pathways, receptors, and other pertinent site information. This Alternatives Array Document will be submitted to the U.S. EPA and the IEPA, along with the request for notification of the standards and requirements. If needed, a meeting will be scheduled between the U.S. EPA, IEPA, and Warzyn to discuss the Alternatives Array Document and ARARs.

8.3 Task 16 - Remedial Alternatives Evaluation

Section 121 (b)(1)(A-G) of CERCLA outlines general rules for cleanup actions, and establishes the SARA statutory preference for remedies, in which treatment permanently and significantly reduces volume, toxicity, or mobility of hazardous substances, pollutants and contaminants. Further, it directs that the long-term effectiveness of alternatives be specifically addressed and that at a minimum the following be considered in assessing alternatives:

A. The long-term uncertainties associated with land disposal;

B. The goals, objectives, and requirements of the Solid Waste Disposal Act;

C. The persistence, toxicity, and mobility of hazardous substances and their constituents, and their propensity to bioaccumulate;

D. Short- and long-term potential for adverse health effects from human exposure;

E. Long-term maintenance costs;

F. The potential for future remedial action costs if the alternative was to fail; and

G. The potential threat to human health and the environment associated with excavation, transportation and redisposal, or containment.

The Remedial Alternatives Evaluation task is basically a three-stage process consisting of the following:

- Development of detailed alternatives,
- Analysis of alternatives, and
- Comparison of alternatives.

8.3.1 Development of Detailed Alternatives

Each alternative will be defined in sufficient detail to facilitate subsequent evaluation and comparison. Typically this activity may involve modification of alternatives based on ARARs, refinement of quantity estimates, technology changes, or site areas to be addressed. Prior to detailed definition, the final conceptual alternatives will be agreed on by Warzyn, the Respondents, IEPA and U.S. EPA.

8.3.2 Analysis of Alternatives

Alternatives will be initially evaluated with respect to seven criteria. The seven criteria encompass: technical, cost and institutional considerations and compliance with statutory and regulatory requirements. Each factor is briefly discussed below.

- Overall Protection The assessment against this criterion describes how the alternative as a whole achieves protection and will continue to protect human health and the environment.

- Compliance with ARARs The assessment against this criterion describes how the alternative complies with ARARs, or, if a waiver is required, how it is justified.

- Long-term Effectiveness and Permanence The assessment of alternatives against this criterion evaluates the long-term effectiveness of alternatives in protecting human health and the environment after response objectives have been met.

- Reduction of Toxicity, Mobility and Volume The assessment against this criterion evaluates the anticipated performance of the specific treatment technologies.

- Short-term Effectiveness The assessment against this criterion examines the effectiveness of alternatives in protecting human health and the environment during the construction and implementation period until response objectives have been met.

- Implementability This assessment evaluates the technical and administrative feasibility of alternatives and the availability of required resources.

- Cost This assessment evaluates the capital and O&M costs of each alternative.

The final criteria, state or support agency acceptance and communicated acceptance, will be evaluated following comment on the RI/FS report. The criteria are as follows:

- State Acceptance This assessment reflects the State's (or support agency's) apparent preferences among or concerns about alternatives.
- Community Acceptance This assessment reflects the community's apparent preferences or concerns about alternatives.

8.3.3 Comparison of Alternatives

After each alternative has been analyzed against each of the criteria, a comparative analysis will be conducted. The purpose of this analysis is to compare the relative performance of alternatives with respect to each evaluation criterion. The narrative discussion will describe the strengths and weaknesses of the alternatives relative to one another with respect to each criterion, and how reasonable variations of key uncertainties could change the expectations of their relative performance. If innovative technologies are being considered, their potential advantages in cost or performance and the degree of uncertainty in their expected performance (as compared with more demonstrated technologies) will also be discussed. A table will be prepared summarizing the assessment of each alternative with respect to each of the nine criteria.

8.4 Task 17 - Feasibility Study Report

Feasibility study activities and results will be described and documented in a report. A Feasibility Study report covering the activities and conclusions of Tasks 14, 15 and 16 will be prepared and submitted in draft form to the U.S. EPA and the IEPA for review and comment following approval of the technical memoranda.

A meeting will be scheduled to discuss U.S. EPA and IEPA comments, if any, prior to preparation of the draft final report by Warzyn. The FS report will not be considered "draft final" until a letter of approval is issued by the U.S. EPA RPM.

8.5 Task 18 - Community Relations Program

A program for community relations support will continue throughout the FS, to the selection of a site remedy. The program will be consistent with the Community Relations Plan developed under Task 17 and with the conditions set forth in the Administrative Order by Consent.

Table 1-1

Schedule of Key Events and Deliverables
Blackwell Landfill NPL Site RI/FS
DuPage County, Illinois

Event/Deliverable	Length of Task	Elapsed Time
Field Investigation	7 months	7 months
Draft Endangerment Assessment	3 months	10 months
Draft RI Report	3 months	10 months
EPA Review and Approval	2 months	12 months
Draft Feasibility Study Report	6 months	18 months
EPA Review and Approval	2 months	20 months
Final Feasibility Study Report	2 months	22 months

Notes:

This schedule assumes that the field investigation starts with the initiation of the geophysical investigation, which is dependent upon weather conditions.

30 and 60 day U.S. EPA review periods have been included in this table. It is recognized that changes in review time will result in changes in the overall project time.

TABLE 3-1.

SUMMARY OF WELL CONSTRUCTION DETAILS
Blackwell Landfill
DuPage County, Illinois

	G-100	G-101	G-102	G-103S	G-103D	G-104
Monitoring Well Completion Date	5/20/80	5/20/80	5/5/80	4/5/80	4/5/80	5/8/80
Ground Surface Elevation (ft MSL)						
Total Depth of Boring (ft)	31.0	31.0	31.0	47.0	62.0	31.0
Well Materials	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC
Screen Materials	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC
Slot Size (in)	0.010	0.010	0.010	0.010	0.010	0.010
Screen Length (ft)	10					
Bottom of Screen - Depth (ft)	16.0	11.0	25.0	47.0	62.0	20.0
- Elevation (ft MSL)						
Top of Seal - Depth (ft)	0.0	0.0	0.0	0.0	51.0	0.0
- Elevation (ft MSL)						
Soil Classification at Screen	S&G	S	S&G	S	S	S&G
Presence of Clay above screened zone	No	No	No	Yes	Yes	No
Thickness of clay above Screened zone	None	None	None	28.3	35.1	None
Average Water Elevation	707.5	707.1	708.2	608.3	696.4	
Adjacent Nested Well Number (if any)	G100AB	None	G-132D,DD	G-103D	G-103S	None
Other Location Identifiers	North Well	Sta. 1	Sta. 2	Sta. 3	Sta. 3	Sta. 4

NOTES:

TOIC - Top of Inner Well Casing
ID - Inside Diameter
SS - Stainless Steel
MSL - Mean Sea Level
oh - Open Hole in Bedrock
S - Sand
S&G - Sand and Gravel
Si - Silt
DOL - Dolomite Bedrock

Blank Spaces Indicate Information is not Available

TABLE 3-1.

SUMMARY OF WELL CONSTRUCTION DETAILS
Blackwell Landfill
DuPage County, Illinois

	G-105	G-106	G-107S	G-107D	G-108	G-109
Monitoring Well Completion Date	5/6/80	5/8/80	5/7/80	5/9/80	4/21/80	4/28/80
Ground Surface Elevation (ft MSL)						
Total Depth of Boring (ft)	31.0	31.0	39.0	47.0	31.0	31.0
Well Materials	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC
Screen Materials	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC
Slot Size (in)	0.010	0.010	0.010	0.010	0.010	0.010
Screen Length (ft)						
Bottom of Screen - Depth (ft)	21.5	15.0	39.0	47.0	15.0	20.0
- Elevation (ft MSL)						
Top of Seal - Depth (ft)	0.0	0.0	0.0	0.0	0.0	0.0
- Elevation (ft MSL)						
Soil Classification at Screen	S&G	S&G	S	S&G	S&G	S&G
Presence of Clay above screened zone	No	No	Yes	Yes	No	No
Thickness of clay above Screened zone	None	None	13.5	17.0	None	None
Average Water Elevation	703.4		692.7	691.2	691.9	691.7
Adjacent Nested Well Number (if any)	G-105A	None	G-107D	G-107S	None	None
Other Location Identifiers	Sta. 5	Sta. 6	Sta. 8	Sta. 8	Sta. 9	Sta. 9+140

NOTES:

TOIC - Top of Inner Well Casing
ID - Inside Diameter
SS - Stainless Steel
MSL - Mean Sea Level
oh - Open Hole in Bedrock
S - Sand
S&G - Sand and Gravel
Si - Silt
DOL - Dolomite Bedrock

TABLE 3-1.

SUMMARY OF WELL CONSTRUCTION DETAILS
Blackwell Landfill
DuPage County, Illinois

	G-110	G-111	G-112	G-113	G-114	G-115S
Monitoring Well Completion Date	4/21/80	4/25/80	4/22/80	4/23/80	4/23/80	4/29/80
Ground Surface Elevation (ft MSL)						
Total Depth of Boring (ft)	31.0	31.0	31.0	31.0	31.0	18.0
Well Materials	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC
Screen Materials	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC
Slot Size (in)	0.010	0.010	0.010	0.010	0.010	0.010
Screen Length (ft)						
Bottom of Screen - Depth (ft)	19.0	21.0	20.0	19.0	28.5	18.0
- Elevation (ft MSL)						
Top of Seal - Depth (ft)	0.0	0.0		0.0	0.0	0.0
- Elevation (ft MSL)						
Soil Classification at Screen	S&G	S&G	S&G	S&G	S&G	S&G
Presence of Clay above screened zone	No	Yes	No	No	No	No
Thickness of clay above Screened zone	None	1.2	None	None	None	None
Average Water Elevation	692.6	692.2	692.3	692.6	692.6	692.5
Adjacent Nested Well Number (if any)	None	None	None	None	None	G-115D
Other Location Identifiers	Sta. 10	Sta. 10+178	Sta. 11	Sta. 11+80	Sta. 11+160	Sta. 12 /

NOTES:

TOIC	Top of Inner Well Casing
ID	Inside Diameter
SS	Stainless Steel
MSL	Mean Sea Level
oh	Open Hole in Bedrock
S	Sand
S&G	Sand and Gravel
Si	Silt
DOL	Dolomite Bedrock

SUMMARY OF WELL CONSTRUCTION DETAILS
Blackwell Landfill
DuPage County, Illinois

	G-115D	G-116	G-117	G-118S	G-118D	G-119
Monitoring Well Completion Date	5/9/80	5/14/80	5/19/80	5/13/80	5/13/80	5/15/80
Ground Surface Elevation (ft MSL)						
Total Depth of Boring (ft)	48.5	46.0	31.0	21.0	56.5	31.0
Well Materials	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC
Screen Materials	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC
Slot Size (in)	0.010	0.010	0.010	0.010	0.010	0.010
Screen Length (ft)						
Bottom of Screen - Depth (ft)	48.5	45.5	29.0	21.0	56.5	18.0
- Elevation (ft MSL)						
Top of Seal - Depth (ft)	36.0	0.0	0.0	0.0	0.0	0.0
- Elevation (ft MSL)						
Soil Classification at Screen	S&G	S&G	S&G	S&G	S&G	S&G
Presence of Clay above screened zone	Yes	No	Yes	No	Yes	No
Thickness of clay above Screened zone	4.5	None	1.0	None	14.5	None
Average Water Elevation	690.7	690.7	692.0	693.6	690.7	705.8
Adjacent Nested Well Number (if any)	G-115S	None	None	G-118D	G-118S	G-135
Other Location Identifiers	West Well	Sta. 16	Sta. 17	Sta. 13	Sta. 13	Sta. 14

NOTES:

TOIC - Top of Inner Well Casing
ID - Inside Diameter
SS - Stainless Steel
MSL - Mean Sea Level
oh - Open Hole in Bedrock
S - Sand
S&G - Sand and Gravel
Si - Silt
DOL - Dolomite Bedrock

TABLE 3-1.

SUMMARY OF WELL CONSTRUCTION DETAILS
Blackwell Landfill
DuPage County, Illinois

	G-120S	G-120D	G-121	G-122	G-123	G-124
Monitoring Well Completion Date	5/15/80	5/16/80	5/3/82	4/30/82	5/3/82	6/15/84
Ground Surface Elevation (ft MSL)			702.2	704.8	706.2	712.9
Total Depth of Boring (ft)	58.0	84.0	20.0	26.0	24.0	20.0
Well Materials	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC
Screen Materials	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC
Slot Size (in)	0.010	0.010	0.010	0.010	0.010	0.010
Screen Length (ft)			5.0	5.0	5.0	10.0
Bottom of Screen - Depth (ft)	58.0	84.0	20.0	25.5	21.5	14.5
- Elevation (ft MSL)			682.2	679.3	684.7	698.4
Top of Seal - Depth (ft)	0.0	60.0	4.0		5.0	1.5
- Elevation (ft MSL)						
Soil Classification at Screen	S	S&G	S&G	S&G	S&G	S
Presence of Clay above screened zone	Yes	Yes	Yes	No	No	No
Thickness of clay above Screened zone	40.0	41.5	1.4	None	None	None
Average Water Elevation	697.3	691.4	691.6	691.2	692.1	701.5
Adjacent Nested Well Number (if any)	G-120D	G-120S	None	None	None	None
Other Location Identifiers	Sta. 15	Sta. 15				

NOTES:

TOIC - Top of Inner Well Casing
ID - Inside Diameter
SS - Stainless Steel
MSL - Mean Sea Level
oh - Open Hole in Bedrock
S - Sand
S&G - Sand and Gravel
Si - Silt
DOL - Dolomite Bedrock

TABLE 3-1.

SUMMARY OF WELL CONSTRUCTION DETAILS
Blackwell Landfill
DuPage County, Illinois

	G-125	G-126	G-127	G-128S	G-128I	G-128D
Monitoring Well Completion Date	6/15/84	6/18/84	6/18/84	6/19/84	6/20/84	6/22/84
Ground Surface Elevation (ft MSL)	713.1	703.4	705.0	705.9	705.9	705.9
Total Depth of Boring (ft)	14.0	20.0	20.0	17.0	29.8	56.0
Well Materials	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC
Screen Materials	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC
Slot Size (in)	0.010	0.010	0.010	0.010	0.010	0.010
Screen Length (ft)	5.0	10.0	10.0	10.0	10.0	10.0
Bottom of Screen - Depth (ft)	9.0	17.8	19.0	17.0	29.8	54.5
- Elevation (ft MSL)	704.1	685.6	686.0	688.9	676.1	651.4
Top of Seal - Depth (ft)	0.5	1.0	2.0	2.0	16.0	2.0
- Elevation (ft MSL)						
Soil Classification at Screen	S	S&G	S&G	S&G	S&G	DOL
Presence of Clay above screened zone	No	No	Yes	Yes	Yes	Yes
Thickness of clay above Screened zone	None	None	1.5	2.0	2.0	2.0
Average Water Elevation	705.5	691.5	692.0	692.0	692.3	691.0
Adjacent Nested Well Number (if any)	None	None	None	G-128I,D	G-128S,D	G-128S,I
Other Location Identifiers						

NOTES:

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TOIC	Top of Inner Well Casing
ID	Inside Diameter
SS	Stainless Steel
MSL	Mean Sea Level
oh	Open Hole in Bedrock
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S&G	Sand and Gravel
Si	Silt
DOL	Dolomite Bedrock

SUMMARY OF WELL CONSTRUCTION DETAILS
Blackwell Landfill
DuPage County, Illinois

	G-129	G-130	G-131D	G-131DD	G-132D	G-132DD
Monitoring Well Completion Date	6/25/84	6/25/84	4/8/85	4/8/85	4/9/85	4/9/85
Ground Surface Elevation (ft MSL)	700.9	708.6	704.5	704.5	724.7	724.7
Total Depth of Boring (ft)	18.0	23.4	53.0	63.0	83.0	93.0
Well Materials	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC
Screen Materials	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC
Slot Size (in)	0.010	0.010	0.010	0.010	0.010	0.010
Screen Length (ft)	10.0	10.0	10.0 oh	10.0 oh	10.0 oh	10.0 oh
Bottom of Screen - Depth (ft)	17.5	23.0	53.0	63.0	83.0	93.0
- Elevation (ft MSL)	683.4	685.6	651.5	641.5	641.7	631.7
Top of Seal - Depth (ft)	2.0	2.0	43.0	53.0	73.0	83.0
- Elevation (ft MSL)						
Soil Classification at Screen	S&G	S&G	DOL	DOL	DOL	DOL
Presence of Clay above screened zone	Yes	Yes	Yes	Yes	Yes	Yes
Thickness of clay above Screened zone	7.5	3.8	3.5	3.5	32.8	32.8
Average Water Elevation	693.0	693.6	691.0	690.8	694.9	694.7
Adjacent Nested Well Number (if any)	None	G-136	G-131DD	G-131D	G-132DD	G-132D
Other Location Identifiers						

NOTES:

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MSL - Mean Sea Level
oh - Open Hole in Bedrock
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S&G - Sand and Gravel
Si - Silt
DOL - Dolomite Bedrock

TABLE 3-1.

SUMMARY OF WELL CONSTRUCTION DETAILS
Blackwell Landfill
DuPage County, Illinois

	G-133S	G-133D	G-133DD	G-134D	G-135	G-136
Monitoring Well Completion Date	4/16/85	4/16/85	4/16/85	4/17/85	4/17/85	4/29/85
Ground Surface Elevation (ft MSL)	706.0	706.0	706.0	725.8	719.0	708.6
Total Depth of Boring (ft)	21.0	53.0	73.0	108.5	82.0	101.0
Well Materials	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC
Screen Materials	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC
Slot Size (in)	0.010	0.010	0.010	0.010	0.010	0.010
Screen Length (ft)	10.0	10.0 oh	20.0 oh	30.0 oh	10.0 oh	30.0 oh
Bottom of Screen - Depth (ft)	21.0	53.0	73.0	103.5	82.0	101.0
- Elevation (ft MSL)	685.0	653.0	633.0	622.3	637.0	607.6
Top of Seal - Depth (ft)	3.0	43.0	53.0	73.5	72.0	71.0
- Elevation (ft MSL)						
Soil Classification at Screen	S&G	DOL	DOL	DOL	DOL	DOL
Presence of Clay above screened zone	No	No	No	Yes	Yes	Yes
Thickness of clay above Screened zone	None	None	None	31.5	19.3	41.8
Average Water Elevation	691.9	690.7	690.5	696.8	691.2	688.3
Adjacent Nested Well Number (if any)	G-133D,DD	G-133S,DD	G-133S,D	None	G-119	G-130
Other Location Identifiers						

NOTES:

TOIC - Top of Inner Well Casing
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S&G - Sand and Gravel
Si - Silt
DOL - Dolomite Bedrock

SUMMARY OF WELL CONSTRUCTION DETAILS
Blackwell Landfill
DuPage County, Illinois

	G-137	G-138	G-139
Monitoring Well Completion Date	8/7/86	8/14/86	8/19/86
Ground Surface Elevation (ft MSL)	699.7	706.6	700.1
Total Depth of Boring (ft)	54.5	56.5	56.5
Well Materials	4" PVC	4" PVC	4" PVC
Screen Materials	4" PVC	4" PVC	4" PVC
Slot Size (in)	0.010	0.010	0.010
Screen Length (ft)	10.0	10.0	10.0
Bottom of Screen - Depth (ft)	53.5	54.0	55.5
- Elevation (ft MSL)	646.2	652.6	644.6
Top of Seal - Depth (ft)	40.0	41.0	2.5
- Elevation (ft MSL)			
Soil Classification at Screen	S&G/DOL	Si/DOL	S/DOL
Presence of Clay above screened zone	Yes	No	Yes
Thickness of clay above Screened zone	3.5	None	18.4
Average Water Elevation			
Adjacent Nested Well Number (if any)			
Other Location Identifiers			

NOTES:
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TOIC	Top of Inner Well Casing
ID	Inside Diameter
SS	Stainless Steel
MSL	Mean Sea Level
oh	Open Hole in Bedrock
S	Sand
S&G	Sand and Gravel
Si	Silt
DOL	Dolomite Bedrock

Table 3-2

Regional Bedrock Water Quality
Blackwell Landfill NPL Site
DuPage County, Illinois

Parameter	Range (mg/l)	Average (mg/l)
Hardness	300-500	---
Total Dissolved Solids	383-2157	517
pH	6.2-7.6 (units)	7.1 (units)
Iron	0-29.0	1.9
Chloride	0-38.0	7.2
Sulphate	Less Than 100	---
Temperature	49-59 (°F)	52(°F)

Table 3-3

Regional Glacial Drift Water Quality
Blackwell Landfill NPL Site
DuPage County, Illinois

Parameter	Range (mg/l)	Average (mg/l)
Hardness	387-596	485
pH	---	---
Total Dissolved Solids	413-790	560
Iron	0-10.8	2.7
Chloride	5-38	17.5
Sulphate	80-152	113
Temperature	46-54 (^{o}F)	---

Table 3-4

Pumping Test Results
Single Well Tests
Blackwell Landfill NPL Site
DuPage County, Illinois

Well No.	K (ft/min)	(cm/s)	S	Unit	Method
G-101	1.2×10^{-5}	(6.1×10^{-6})		Henry	Hvorslev
	1.7×10^{-6}	(8.6×10^{-7})	3.1×10^{-4}		Nguyen and Pinder
G-102	2.7×10^{-2}	(1.4×10^{-2})		Henry	Hvorslev
	1.6×10^{-3}	(8.1×10^{-4})	0.15		Nguyen and Pinder
G-103S	6.7×10^{-4}	(3.4×10^{-4})		Yorkville	Hvorslev
	7.4×10^{-5}	(3.8×10^{-5})	3.6×10^{-2}		Nguyen and Pinder
G-103D	2.4×10^{-3}	(1.2×10^{-3})		Tiskilwa	Hvorslev
	2.8×10^{-4}	(1.4×10^{-4})	0.18		Nguyen and Pinder
G-107S	9.4×10^{-4}	(4.8×10^{-4})		Yorkville	Hvorslev
	2.3×10^{-3}	(1.2×10^{-3})			Papadopoulos, Bredehoeft, and Cooper
	1.6×10^{-4}	(8.1×10^{-5})	0.13		Nguyen and Pinder
G-107D	1.1×10^{-3}	(5.6×10^{-4})		Tiskilwa	Hvorslev
	3.2×10^{-3}	(1.6×10^{-3})			Papadopoulos, Bredehoeft, and Cooper
	1.8×10^{-4}	(9.4×10^{-5})	0.16		Nguyen and Pinder
G-108	2.7×10^{-2}	(1.4×10^{-2})		Henry	Recovery
G-115D	6.4×10^{-1}	(3.3×10^{-1})		Tiskilwa	Recovery
G-116	6.5×10^{-1}	(3.3×10^{-1})		Henry	Recovery
G-117	6.4×10^{-1}	(3.3×10^{-1})		Henry	Recovery
G-118D	1.7×10^{-2}	(8.6×10^{-3})		Tiskilwa and Dolomite	Hvorslev
	1.2×10^{-2}	(6.1×10^{-3})			Recovery
G-120S	3.1×10^{-3}	(1.6×10^{-3})		Yorkville	Hvorslev
	4.1×10^{-4}	(2.1×10^{-4})	0.10		Nguyen and Pinder
G-120D	9.6×10^{-3}	(4.9×10^{-3})		Tiskilwa and Dolomite	Hvorslev
	1.7×10^{-3}	(8.6×10^{-4})	0.31		Nguyen and Pinder

Table 3-4
(Continued)

Well No.	K (ft/min)	(cm/s)	S	Unit	Method
G-121	7.1×10^{-1}	(3.6×10^{-1})		Henry	Recovery
G-122	1.6	(8.1×10^{-1})		Henry	Recovery
G-123	3.0×10^{-2} 2.5×10^{-2}	(1.5×10^{-2}) (1.3×10^{-2})		Henry	Hvorslev Recovery
G-126	8.6×10^{-1}	(4.4×10^{-1})		Henry	Recovery
G-128D	3.9×10^{-1}	(2.0×10^{-1})		Dolomite	Hvorslev
G-130	3.1×10^{-2}	(1.6×10^{-2})		Henry	Recovery
G-131DD	1.4×10^{-5}	(7.1×10^{-6})	4.2×10^{-3}	Dolomite	Hvorslev Nguyen and Pinder
G-132D	2.3×10^{-5} 1.3×10^{-6}	(1.2×10^{-5}) (6.6×10^{-7})	5.1×10^{-3}	Dolomite	Hvorslev Nguyen and Pinder
G-132DD	5.1×10^{-7}	(2.6×10^{-7})		Dolomite	Hvorslev
G-133S	6.8×10^{-1}	(3.5×10^{-1})		Henry	Recovery
G-134	1.1×10^{-3} 2.8×10^{-3}	(5.6×10^{-4}) (1.4×10^{-3})		Dolomite	Hvorslev Papadopoulos, Bredehoeft, and Cooper Nguyen and Pinder
	9.8×10^{-5}	(5.0×10^{-5})	0.12		
G-135	9.6×10^{-2}	(4.9×10^{-2})		Dolomite	Recovery
G-136	5.6×10^{-5} 5.8×10^{-6}	(2.8×10^{-5}) (2.9×10^{-6})	0.013	Dolomite	Hvorslev Nguyen and Pinder

Multiple Observation Well Tests

Well No.	Transmissivity ft^2/min	m^2/day	Storativity	Aquifer Unit
G-101	4.4×10^{-5}	5.9×10^{-3}	3.1×10^{-4}	Henry
G-102	3.9×10^{-3}	5.2×10^{-1}	.15	Henry
G-103	5.9×10^{-4}	7.9×10^{-2}	3.6×10^{-2}	Yorkville/Tiskilwa
G-106	7.9×10^{-4}	1.1×10^{-1}		Yorkville/Tiskilwa

Table 3-4
(Continued)

Multiple Observation Well Tests
(continued)

Well No.	Transmissivity ft^2/min	m^2/day	Storativity	Aquifer Unit
G-107	4.4×10^{-4}	5.9×10^{-2}	0.13	Tiskilwa
G-108	1.3×10^{-1}	17.4		Henry
G-114	31.0	4.1×10^{3}	1.14×10^{-4}	Henry
G-116	10.2	1.4×10^{3}		Henry
G-117	2.0	2.7×10^{2}	2.5×10^{-5}	Henry
G-118	3.6×10^{-2}	4.8		Tiskilwa/Dolomite
G-120	9.3×10^{-5}	1.2×10^{-2}	0.1	
G-121	4.9	6.6×10^{2}		Henry
G-122	11.1	1.5×10^{3}		Henry
G-123	13.9	1.8×10^{3}	6.3×10^{-4}	Henry
G-126	6.0	8.0×10^{2}		Henry
G-127	7.3	9.8×10^{2}	4.4×10^{-5}	Henry
G-128	20.0	2.7×10^{2}		Henry
G-130	.31	41.5		Henry
G-131			4.2×10^{-3}	
G-132			5.1×10^{-3}	
G-133S	5.4	7.2×10^{2}		Henry
G-134			1.2×10^{-1}	
G-136			1.3×10^{-2}	

Table 3-5

Summary of Hydraulic Conductivity Values
Blackwell Landfill NPL Site
DuPage County, Illinois

Unit	Range (ft/min)	Measurement
Henry	7×10^{-4} to 0.09 2×10^{-6} to 1.6	permeameter (4 sets) pump tests (12)
Yorkville	too low for measurement	
Malden	0.03 to 0.07 (sandy unit)	permeameter (1 set)
Tiskilwa	3×10^{-6} to 9×10^{-5} 3×10^{-4} to 0.64	permeameter (3 sets) pump tests (6)
Dolomite	5×10^{-7} to 0.39 immeasurably high	pump tests (7) pump test (well G133)

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Table 3-6

Summary of Leachate Sampling Results
Blackwell Landfill NPL Site
DuPage County, Illinois

	SV1			SV2			SV3			SV4		
Compound Detected	+	All	Concentration Range	+	All	Concentration Range	+	All	Concentration Range	+	All	Concentration Range
Acrylonitrile												
Benzene	1	2	<1-3.1	2	2	100-140				1	1	63.9
Bromoform												
Carbon Tetrachloride												
Chlorobenzene												
Chloroethane												
Chloroform	1	2	<1-1.2				1	2	<1-110			
1,2-Dichlorobenzene												
1,3-Dichlorobenzene												
1,4-Dichlorobenzene												
Dichlorobromomethane												
Dibromochloromethane												
1,1-Dichloroethane										1	1	57.7
1,2-Dichloroethane										1	1	14.2
1,1-Dichloroethylene												
Cis-1,2-Dichloroethylene				2	2	180-295				1	1	1,040
Trans-1,2-Dichloroethylene										1	1	32.5
1,2-Dichloropropane				1	2	<1-110						
Ethyl Benzene	1	2	<1-110							1	1	4.6
Methylene Chloride												
1,1,2,2-Tetrachloroethane												
Tetrachloroethylene				1	2	<2-130				1	1	42.6
Toluene				2	2	670-1550				1	1	165
1,1,1-Trichloroethane												
1,1,2-Trichloroethane												
Trichloroethylene				2	2	210-415				1	1	540
Vinyl Chloride										1	1	40.9
Xylenes, Total				2	2	180-500				1	1	63

Legend
+ = Number of sampling events where compound detected.
All = Total number of sampling events.
Concentration Range - Range of detected concentrations.

All Concentrations Reported in ug/l (ppb) Unless Otherwise Noted.

Table 3-6
(Continued)

	SV4			SV5			SV6			SV7		
Compound Detected	±	All	Concentration Range	±	All	Concentration Range	±	All	Concentration Range	±	All	Concentration Range
Acrylonitrile												
Benzene	1	1	63.9	6	7	29.5-126	2	2	72.7-100	1	2	<1-38.3
Bromoform												
Carbon Tetrachloride												
Chlorobenzene										1	2	<1-1.9
Chloroethane							1	2	<20-30.5			
Chloroform				3	7	5.2-137						
1,2-Dichlorobenzene												
1,3-Dichlorobenzene												
1,4-Dichlorobenzene							1	2	<1-82			
Dichlorobromomethane												
Dibromochloromethane												
1,1-Dichloroethane	1	1	57.7	5	7	40.4-124	2	2	16.3-36	1	2	<1-6.3
1,2-Dichloroethane	1	1	14.2	3	7	13.4-25	1	2	<1-14.7	1	2	<1-9.4
1,1-Dichloroethylene												
Cis-1,2-Dichloroethylene	1	1	1040	6	7	29-986	2	2	164-645	2	2	98-130
Trans-1,2-Dichloroethylene	1	1	32.5	4	7	18.3-76.1	1	2	<1-8.2	1	2	<1-19.5
1,2-Dichloropropane							1	2	<1-14.0	1	2	<1-33.4
Ethyl Benzene	1	1	4.6	5	7	14.3-48.3	2	2	130-170	2	2	110-120
Methylene Chloride				2	7	295-808						
1,1,2,2-Tetrachloroethane												
Tetrachloroethylene	1	1	42.6	7	7	46.7-233	2	2	3.8-370			
Toluene	1	1	165	7	7	186-900	2	2	54-520	2	2	800-852
1,1,1-Trichloroethane												
1,1,2-Trichloroethane												
Trichloroethylene	1	1	540	7	7	31-475	1	2	<1-43.3	1	2	<1-2.3
Vinyl Chloride	1	1	40.9	4	7	78-1740	1	2	<20-30.7	1	2	<20-125
Xylenes, Total	1	1	63	6	6	39.9-155	2	2	330-484	2	2	127-330

Legend
+ = Number of sampling events where compound detected.
All = Total number of sampling events.
Concentration Range - Range of detected concentrations.

All Concentrations Reported in ug/l (ppb) unless otherwise Noted

Table 3-6
(Continued)

	SV8			SV9			SV10			SV11		
Compound Detected	+	All	Concentration Range	+	All	Concentration Range	+	All	Concentration Range	+	All	Concentration Range
Acrylonitrile							1	7	<10-24			
Benzene	2	2	170-390	2	2	110-320	5	7	18-75	3	4	24-42
Bromoform												
Carbon Tetrachloride												
Chlorobenzene												
Chloroethane												
Chloroform							3	7	6.3-640	1	4	<1-36.1
1,2-Dichlorobenzene												
1,3-Dichlorobenzene												
1,4-Dichlorobenzene							1	2	<1-220	1	4	<1-55
Dichlorobromomethane												
Dibromochloromethane												
1,1-Dichloroethane	2	2	520-990	2	2	240-710	2	7	8.3-11.3	1	4	<1-13.0
1,2-Dichloroethane	2	2	250-410				1	7	<1-4.4	1	4	<1-6.5
1,1-Dichloroethylene												
Cis-1,2-Dichloroethylene	2	2	330-740	2	2	145-390	6	6	5.3-410	4	4	11-195
Trans-1,2-Dichloroethylene	1	2	<1-135	1	2	<1-130	5	7	18.9-53.3			
1,2-Dichloropropane										1	4	<1-7.7
Ethyl Benzene	1	2	<1-205	2	2	50-200	5	7	61-100	4	4	72-145
Methylene Chloride	1	2	<5-5290	1	2	<5-2060						
1,1,2,2-Tetrachloroethane												
Tetrachloroethylene	2	2	180-1260	1	2	<2-410				4	4	7-90
Toluene	2	2	1350-3760	2	2	1270-4670	7	7	214-1240	4	4	66-168
1,1,1-Trichloroethane												
1,1,2-Trichloroethane												
Trichloroethylene	2	2	520-1750	2	2	395-1240				4	4	15-145
Vinyl Chloride							1	7	<20-211	1	4	<20-407
Xylenes, Total	2	2	230-931	2	2	225-910	6	6	49-404	4	4	235-335

Legend
+ = Number of sampling events where compound detected.
All = Total number of sampling events.
Concentration Range - Range of detected concentrations.

All Concentrations Reported in ug/l (ppb) Unless Otherwise Noted.

Table 3-6
(Continued)

	SV12			DV2			DV3			DV4		
Compound Detected	+	All	Concentration Range	+	All	Concentration Range	+	All	Concentration Range	+	All	Concentration Range
Acrylonitrile				0	2	None Detected						
Benzene	1	2	<1-4.3	0	2	None Detected	2	2	27-30	3	3	15.5-17.7
Bromoform				0	2	None Detected						
Carbon Tetrachloride												
Chlorobenzene				0	2	None Detected	1	2	<1-3.2	3	3	6.6-9.7
Chloroethane				0	2	None Detected				1	3	<20-21.4
Chloroform				0	2	None Detected						
1,2-Dichlorobenzene				0	2	None Detected				1	3	<1-12.5
1,3-Dichlorobenzene				0	2	None Detected						
1,4-Dichlorobenzene				0	2	None Detected	1	2	<1-28	1	3	<1-1.2
Dichlorobromomethane				0	2	None Detected						
Dibromochloromethane				0	2	None Detected						
1,1-Dichloroethane				0	2	None Detected	1	2	<1-2.1	2	3	1.1-2.0
1,2-Dichloroethane				0	2	None Detected						
1,1-Dichloroethylene				0	2	None Detected						
Cis-1,2-Dichloroethylene	2	2	22.4-22.5	0	2	None Detected	1	2	<1-37.8	1	3	<1-3.6
Trans-1,2-Dichloroethylene										2	3	1.2-1.4
1,2-Dichloropropane				0	2	None Detected						
Ethyl Benzene	1	2	<1-16.9	0	2	None Detected	2	2	101-109	2	3	1.4-3.0
Methylene Chloride				0	2	None Detected						
1,1,2,2-Tetrachloroethane				0	2	None Detected						
Tetrachloroethylene				0	2	None Detected	1	2	<2-9.2			
Toluene	2	2	99-101	0	2	None Detected	2	2	72-177	3	3	4.1-11.6
1,1,1-Trichloroethane				0	2	None Detected						
1,1,2-Trichloroethane				0	2	None Detected						
Trichloroethylene				0	2	None Detected	1	2	<1-6.6	1	3	<1-1.1
Vinyl Chloride				0	2	None Detected						
Xylenes, Total	2	2	109-122	0	2	None Detected	2	2	67-165	2	3	3.4-11.3
Napthalene				0	2	None Detected						
Diethylphthlate				0	2	None Detected						
1,4-Dichlorobenzene*				0	2	None Detected						

Legend
+ = Number of sampling events where compound detected.
All = Total number of sampling events.
Concentration Range - Range of detected concentrations.

All Concentrations Reported in ug/l (ppb) Unless Otherwise Noted.

Table 3-6
(Continued)

	DV5			DV6			DV7			DV8		
Compound Detected	+	All	Concentration Range	+	All	Concentration Range	+	All	Concentration Range	+	All	Concentration Range
Acrylonitrile												
Benzene	6	7	52.9-74	1	2	<5-60.5				1	1	100
Bromoform												
Carbon Tetrachloride												
Chlorobenzene				2	2	140-148						
Chloroethane												
Chloroform	2	7	5.1-17				1	1	540			
1,2-Dichlorobenzene												
1,3-Dichlorobenzene	1	7	<1-2250									
1,4-Dichlorobenzene	1	7	<1-2050	1	2	<1-100	1	1	250			
Dichlorobromomethane												
Dibromochloromethane												
1,1-Dichloroethane	4	7	6.1-21.9	1	2	<1-9.0				1	1	140
1,2-Dichloroethane	1	7	<1-7.2									
1,1-Dichloroethylene												
Cis-1,2-Dichloroethylene										1	1	770
Trans-1,2-Dichloroethylene	5	7	10-68				1	1	200			
1,2-Dichloropropane	1	7	<1-8.6									
Ethyl Benzene	6	7	144-204	2	2	120-141	1	1	170			
Methylene Chloride	1	7	<5-34									
1,1,2,2-Tetrachloroethane												
Tetrachloroethylene										1	1	330
Toluene	7	7	156-538	2	2	210-383	1	1	2180	1	1	520
1,1,1-Trichloroethane												
1,1,2-Trichloroethane												
Trichloroethylene										1	1	830
Vinyl Chloride	1	7	<20-276									
Xylenes, Total	7	7	256-729	2	2	160-501	1	1	430	1	1	150
Napthalene	2	2	2.1-696									
Diethylphthlate	1	2	<100-0.07									
1,4-Dichlorobenzene*	2	2	1.1-737									

Legend
+ = Number of sampling events where compound detected.
All = Total number of sampling events.
Concentration Range - Range of detected concentrations.

All Concentrations Reported in ug/l (ppb) unless otherwise Noted

Table 3-6
(Continued)

Compound Detected	DV9			DV10			DV11			DV12		
	±	All	Concentration Range	±	All	Concentration Range	±	All	Concentration Range	±	All	Concentration Range
Acrylonitrile							0	1	None Detected			
Benzene				1	2	<5-51.3	0	1	None Detected	1	1	12.5
Bromoform							0	1	None Detected			
Carbon Tetrachloride							0	1	None Detected			
Chlorobenzene							0	1	None Detected			
Chloroethane							0	1	None Detected			
Chloroform							0	1	None Detected	1	1	1.5
1,2-Dichlorobenzene							0	1	None Detected			
1,3-Dichlorobenzene							0	1	None Detected			
1,4-Dichlorobenzene							0	1	None Detected			
Dichlorobromomethane							0	1	None Detected			
Dibromochloromethane							0	1	None Detected			
1,1-Dichloroethane				2	2	41-110	0	1	None Detected			
1,2-Dichloroethane							0	1	None Detected			
1,1-Dichloroethylene							0	1	None Detected			
Cis-1,2-Dichloroethylene	1	1	630	2	2	170-714	0	1	None Detected	1	1	16
Trans-1,2-Dichloroethylene				1	2	<1-22.5	0	1	None Detected	1	1	1.2
1,2-Dichloropropane							0	1	None Detected			
Ethyl Benzene				1	2	<1-27.9			None Detected	1	1	1.1
Methylene Chloride							0	1	None Detected			
1,1,2,2-Tetrachloroethane							0	1	None Detected			
Tetrachloroethylene	1	1	3)	2	2	186-350	0	1	None Detected			
Toluene	1	1	3)	2	2	528-800	0	1	None Detected			
1,1,1-Trichloroethane							0	1	None Detected			
1,1,2-Trichloroethane							0	1	None Detected			
Trichloroethylene	1	1	560	2	2	348-580	0	1	None Detected			
Vinyl Chloride							0	1	None Detected			
Xylenes, Total				2	2	145-600	0	1	None Detected			

Legend
+ = Number of sampling events where compound detected.
All = Total number of sampling events.
Concentration Range - Range of detected concentrations.

Table 3-6
(Continued)

Compound Detected	DV13			Burner 9 (Near DV1)			Manhole 1			Seep 1 (Near DV4, SV3)		
	+	All	Concentration Range	+	All	Concentration Range	+	All	Concentration Range	+	All	Concentration Range
Acrylonitrile												
Benzene	2	2	140-210	3	3	8.2-16.0	1	1	34			
Bromoform												
Carbon Tetrachloride												
Chlorobenzene							1	1	19.8			
Chloroethane							1	1	24.1			
Chloroform				1	3	<1-5.6						
1,2-Dichlorobenzene												
1,3-Dichlorobenzene												
1,4-Dichlorobenzene												
Dichlorobromomethane												
Dibromochloromethane												
1,1-Dichloroethane	1	2	<1-60.9				1	1	60.6	2	2	1.3-1.7
1,2-Dichloroethane							1	1	10.6			
1,1-Dichloroethylene												
Cis-1,2-Dichloroethylene	2	2	120-235	2	3	23.6-78	1	1	401	2	2	1.1-1.3
Trans-1,2-Dichloroethylene	1	2	<1-31.5	1	3	<1-9.3	1	1	24.0			
1,2-Dichloropropane	2	2	21-220									
Ethyl Benzene	1	2	<1-33	2	3	110-115						
Methylene Chloride				2	3	46-87.8						
1,1,2,2-Tetrachloroethane												
Tetrachloroethylene	1	7	<2-95.9				1	1	113			
Toluene	2	2	770-991	3	3	19-183	1	1	64			
1,1,1-Trichloroethane												
1,1,2-Trichloroethane												
Trichloroethylene	2	2	200-811				1	1	168			
Vinyl Chloride				2	3	115-132	1	1	86.8			
Xylenes, Total	1	2	<1-105	2	3	158-480	1	1	24.1			

Legend
+ = Number of sampling events where compound detected.
All = Total number of sampling events.
Concentration Range - Range of detected concentrations.

Table 3-6
(Continued)

	Seep 2 (Near G113, 114)		
Compound Detected	+	All	Concentration Range
Acrylonitrile	0	1	None Detected
Benzene	0	1	None Detected
Bromoform	0	1	None Detected
Carbon Tetrachloride	0	1	None Detected
Chlorobenzene	0	1	None Detected
Chloroethane	0	1	None Detected
Chloroform	0	1	None Detected
1,2-Dichlorobenzene	0	1	None Detected
1,3-Dichlorobenzene	0	1	None Detected
1,4-Dichlorobenzene	0	1	None Detected
Dichlorobromomethane	0	1	None Detected
Dibromochloromethane	0	1	None Detected
1,1-Dichloroethane	0	1	None Detected
1,2-Dichloroethane	0	1	None Detected
1,1-Dichloroethylene	0	1	None Detected
Cis-1,2-Dichloroethylene	0	1	None Detected
Trans-1,2-Dichloroethylene	0	1	None Detected
1,2-Dichloropropane	0	1	None Detected
Ethyl Benzene	0	1	None Detected
Methylene Chloride	0	1	None Detected
1,1,2,2-Tetrachloroethane	0	1	None Detected
Tetrachloroethylene	0	1	None Detected
Toluene	0	1	None Detected
1,1,1-Trichloroethane	0	1	None Detected
1,1,2-Trichloroethane	0	1	None Detected
Trichloroethylene	0	1	None Detected
Vinyl Chloride	0	1	None Detected
Xylenes, Total	0	1	None Detected

Legend
+ = Number of sampling events where compound detected.
All = Total number of sampling events.
Concentration Range - Range of detected concentrations.

Table 3-7

VOCs Previously Detected in Groundwater
Blackwell Landfill NPL Site
DuPage County, Illinois

1,1-Dichloroethane
1,1-Dichloroethylene
1,2-Dichlorobenzene
1,2-Dichloroethane
1,2-Dichloropropane
1,1,1-Trichloroethane
1,1,2,2-Tetrachloroethane
Benzene
Bromoform
Chlorobenzene
Chloroethane
Chloroform
cis-1,2-Dichloroethylene
Ethylbenzene
Methylene chloride
Tetrachloroethylene
Toluene
trans-1,2-Dichloroethylene
Trichloroethylene
Vinyl chloride
Xylene

Table 3-8. Occurrences of Several VOCs at Downgradient Wells -- Blackwell Landfill NPL Site

Well	VOC (ug/l)	N	AVG	SD	# 13-Dec 1983	13-Apr 1984	12-Jul 1984	05-Sep 1984	21-Dec 1984	14-May 1985	30-Sep 1985	17-Dec 1985	25-Mar 1986	18-Jun 1986	24-Sep 1986	16-Dec 1986	31-Mar 1987	17-Jun 1987	22-Sep 1987	15-Jan 1988	23-Mar 1988	16-Jul 1988	29-Sep 1988	16-Dec 1988 #
G-109	1,2-DCA	0	<1																					
	1,1-DCA	15	21.7	16.7	10.9	66.0	17.0	18.1	13.6	34.5	18.4	46.6	25.0			31.5		15.2		8.5		7.3		10.8
	1,2-C-DCE	14	24.1	17.9		46.1	27.1	9.1	12.4	32.3	21.3	71.0	27.1			37.3		22.8		11.2		8.7		10.6
	1,2-T-DCE	4	4.8	4.1				8.3	9.3							1.5								
	TCE	6	1.5	0.9							1.1					2.4		1.2		1.3		2.8		
	1,2-DCP	9	2.2	1.5						1.6	2.0	5.7	1.9			3.9		1.9		1.5		1.6		
G-110	1,2-DCA	11	4.5	3.2			10.2	11.0	3.4	6.2		3.2	3.4			4.2	2.7	1.9		3.0				
	1,1-DCA	13	18.6	11.1	15.0	15.7	28.8	49.6	20.6	19.7		12.3	11.6			22.7	13.5	18.4		14.0				
	1,2-C-DCE	13	160.4	190.7	154	24.9	551	583	238	264		44.7	36.7			43.3	53.7	30.2		61.4				
	1,2-T-DCE	10	11.6	13.0			18.1	41.6	27.2	13		1.0	1.4			6.0	4.8			2.7				
	TCE	13	39.1	46.8	63.6	14.7	87.1	168	69.5	51.2		5.1	6.4			5.5	26.8	6.5		3.9				
	1,2-DCP	5	10.2	8.7			22.9		10.7	16.2		1.4												
G-111	1,2-DCA	6	2.1	1.8					5.7	1.8		1.8	2.5			1.0								
	1,1-DCA	14	6.8	3.4	10.9	11.5			8.3	8.3	4.5	9.0	12.8			6.5	4.6	4.6		5.4		3.9		4.2
	1,2-C-DCE	16	81.9	94.8	191	84.9	31.7	6.1	50.7	54.0	28.8	155	395			59.2	42.8	40.7		103		32.4		34.7
	1,2-T-DCE	10	4.6	4.4					11.5	2.0		5.4	14.2			3.4	2.9			1.7		2.6		1.9
	TCE	15	34.0	46.3	198	59.2	7.8		23.6	28.8	16.4	39.4	36.3			12.0	16.1	10.0		36.6		18.7		6.8
	1,2-DCP	7	3.0	2.1						3.3	1.1	4.5	6.8			2.0						3.0		
G-112	1,2-DCA	9	5.8	7.3		15.1			3.7	22.5		2.9	4.3			1.2	1.0			1.7				
	1,1-DCA	14	31.3	48.7	43	189			18.7	84.7	10.5	20.8	30.5			5.9	3.7	6.8		12.1		6.1		6.7
	1,2-C-DCE	15	35.3	48.1	71.4	165	6.5		35.3	130	10.2	20.9	44.3			6.0	8.7	5.2		13.4		7.9		4.5
	1,2-T-DCE	13	7.6	5.2	19.2	12.4			7.5	14.6		8.2	9.8			7.2	1.7	2.3		6.0		6.3		4.2
	TCE	13	13.9	12.0	28.3	41.4			23.6	25.5	5.3	7.0	19.3			6.6	9.3	5.0		5.6		3.6		
	1,2-DCP	12	6.4	6.1		22.8			7.6	14.4	2.5	4.1	9.1			3.7	4.0	2.0		3.9		3.0		
G-117	1,2-DCA	2	0.7							1.3														
	1,1-DCA	16	3.6	2.8	10.0			10.3	4.8	4.9	3.0	2.9	3.2	2.5	4.9	2.6	2.2	1.4	2.4	1.0		1.6		
	1,2-C-DCE	20	8.6	5.6	9.2	18.7	9.6	7.8	10.9	24.8	5.8	11.6	6.4	13.4	6.7	5.0	12.4	5.3	5.5	4.0	5.0	8.2		1.0
	1,2-T-DCE	2	3.6						7.2															
	TCE	2	1.0						2.0															
	1,2-DCP																							
G-118S	1,2-DCA	0	<1																					
	1,1-DCA	20	49.4	30.5	91.8	137	36.9	133	110	66.7	39.6	71.2	31.6	24.4	38.9	40.3	33.6	29	27.6	25.0	16.6		11.5	22.6
	1,2-C-DCE	20	116.4	56.0	185	166	162	133	137	132	61.1	237	118	76.8	79	145	71.6	107	193	67.4	113.0		31.5	112.0
	1,2-T-DCE	17	10.9	10.6	43	22.4		21.9	16.1	10.9		15.3	3.1	3.7	2.5	16.8	8.4	3.4	4.5	7.7			2.3	3.7
	TCE	20	47.3	27.7	55.3	55.8	43.7	77.1	57.1	57.2	35.8	132	55.8	52.9	31.1	74.8	48.8	42.0	44.3	37.6	25.4		5.2	14.0
	1,2-DCP	8	3.4	2.2						4.1	2.6	8.0	3.0	2.1	2.7	4.5								
G-122	1,2-DCA	2	3.1	3.1				6.2																
	1,1-DCA	11	3.9	5.1				19.6	4.3	4.6	3.6	2.4	2.0	1.9	1.8		1.3					1.2		
	1,2-C-DCE	17	7.0	9.7	34.3	13.1		30	6.5	7.0	5.7	3.5	2.3	2.7	2.1	1.9	2.5	1.8	1.3	2.3		2.4		
	1,2-T-DCE	3	2.7	3.2				7.2		1.0														
	TCE	15	2.7	2.1		8.3		5.6	4.8	2.7	4.4	2.2	2.2	1.6	1.5	1.7	1.7	1.0	1.0			1.3		
	1,2-DCP	0	<1																					

Table 3-8. Occurrences of Several VOCs at Downgradient Wells -- Blackwell Landfill NPL Site

Well	VOC (ug/l)	N	AVG	SD	# 13-Dec 1983	13-Apr 1984	12-Jul 1984	06-Sep 1984	21-Dec 1984	14-May 1985	30-Sep 1985	17-Dec 1985	25-Mar 1986	10-Jun 1986	24-Sep 1986	16-Dec 1986	31-Mar 1987	17-Jun 1987	22-Sep 1987	15-Jan 1988	23-Mar 1988	16-Jul 1988	29-Sep 1988	16-Dec 1988 #
G-127	1,2-DCA	6	2.0	1.4					3.2	1.9								1.1			4.2	1.4		
	1,1-DCA	17	8.3	4.1			8.6	17.2	15.2	12.4	6.7	10.5	6.3	3.9	6.1	6.4	5.0	7.8	7.8	5.7		8.8		12.8
	1,2-C-DCE	19	82.0	50.8			248	118	106	118	68.4	98.3	68.5	43.4	48	44.2	35.1	65.4	60.9	71.3	60.7	140.0	87.0	77.5
	1,2-T-DCE	18	4.6	3.4			8.7	13.4	10.4	7.1	1.8	4.9	3.3	1.7	1.2	1.6	2.5	2.9	3.3	3.8	3.6	7.1		6.3
	TCE	18	22.8	10.7				46.5	48.2	33.6	19.6	20.1	21.5	22.1	21.6	14.0	19.0	20.2	21.9	18.7	17.4	26.1	24.3	15.4
	1,2-DCP	9	2.5	1.2						4.2	2.8	2.9	2.2	1.9	2.4	1.8						4.0		
G-128S	1,2-DCA	17	9.4	7.1			8.7	17.0	21.8	26.3	9.5	19.1	10.2	4.3	9.3	5.0	5.9	5.7	4.1	5.9	2.7	4.3		
	1,1-DCA	19	16.0	10.6			17.3	38.0	31.5	34.3	17.8	30.9	17.8	11.6	23.0	7.7	13.6	7.1	14.0	13.6	6.6	8.0	6.5	4.5
	1,2-C-DCE	19	28.7	19.0			80.7	58.6	48.1	40.4	23.4	49.8	29.6	20.3	33.3	21.6	22.3	21.0	29.6	18.4	13.2	15.4	11.9	8.5
	1,2-T-DCE	16	7.3	6.4			14.2	24.3	15.1	14.9		9.1	4.9	5.1	8.0		1.8	3.6	4.8	4.2	2.3	2.8		1.7
	TCE	18	4.1	4.1				7.3	7.8	3.4	19.5	3.1	1.7	3.3	4.2	3.0	3.0	2.6	3.9	2.5	1.4	2.8	3.5	1.4
	1,2-DCP	17	6.8	4.1			10.7	14.7	9.3	17.1	5.5		2.5	4.6	7.1	6.2	5.6	6.0	7.0	5.1	3.8	4.8	5.7	
G-128D	1,2-DCA	9	2.8	2.0				7.0	3.0					3.0	5.0	1.1		2.1	1.3			2.6		
	1,1-DCA	16	4.7	4.7				19.9	5.9	1.3	4.6	1.6	3.5	7.5	10.0		1.7	5.0	4.3		1.0	4.6	2.4	1.3
	1,2-C-DCE	17	7.4	7.3				32.2	8.5	2.1	6.6	2.4	5.6	12.0	14.6	5.5	3.3	9.4	8.8	2.4	2.4	8.1		2.3
	1,2-T-DCE	8	2.9	3.7			5.0	11.9	1.2					1.1	1.4				1.6			1.0		
	TCE	6	1.5	0.7					2.0		1.7				2.0			1.2				2.0		
	1,2-DCP	9	2.3	1.5				5.7	1.7		1.5				2.9	1.4		2.4	2.2			2.8		
G-131DD	1,2-DCA	1	<1																					
	1,1-DCA	10	1.6	0.7						2.9	1.8	1.7	1.5	1.5	1.8	1.7		1.3		1.4				
	1,2-C-DCE	13	2.3	1.1						4.4	3.1	3.5	2.7	2.5	2.9	2.3		1.6		3.0		1.1	1.2	1.8
	1,2-T-DCE	1	<1																					
	TCE	1	<1																					
	1,2-DCP	1	<1																					
G-133DD	1,2-DCA	1	<1																					
	1,1-DCA	9	1.5	0.7						2.2	2.5		1.4		1.9	1.1	1.7		1.4	1.0				
	1,2-C-DCE	12	2.6	1.2							5.0	3.6	2.4	1.7	2.9	2.3	3.3	2.7	3.2	2.3				1.4
	1,2-T-DCE	1	<1																					
	TCE	3	1.9	1.3							2.8									2.0				
	1,2-DCP	1	<1																					

NOTES:

Blanks indicate VOC was not detected at location during sampling event
0.5 indicates VOC detected but concentration was below minimum detection limit

Table 3-9

Summary of Previous Investigations Conducted at the Site
Blackwell Landfill NPL Site
DuPage County, Illinois

Year of Activity	Agency or Consultant	Activity or Report
1969	ISGS	The ISGS installed a 4-inch diameter PVC leachate head well in the landfill to monitor leachate levels and quality.
1970s	ISGS and IEPA	During the early 1970's, the ISGS and IEPA worked together to install monitoring wells/piezometers surrounding the landfill. They periodically measured water levels and collected water samples for field analysis of pH and chloride.
1971	ISGS	ISGS included analysis from site data in the Publication Hydrogeology of Solid Waste Disposal Sites in Northeastern Illinois, G.M. Hughes et al.
1980	Eldredge	Eldredge Engineering was retained by the Forest Preserve District (FPD) of DuPage County to evaluate a hydrogeologic study conducted for the U.S. EPA by SMC Martin Consultants. Eldredge recommended a detailed hydrogeologic assessment including construction of monitoring wells at 20 locations.
1980	Eldredge	Monitoring wells G-101 through G-120 were constructed at the Site during April and May 1980. A geologic report was issued.
1982	Eldredge	Monitoring wells G-121, G-122, and G-123 were constructed at the Site during April and May 1982. A geologic report was issued.
1983	Eldredge	The FPD developed a quarterly monitoring program, following recommendations of the IEPA to meet U.S. EPA quality assurance protocols. The system included quarterly and semi-annual analysis of groundwater and surface water samples for water quality and water pollution indicators (including VOC); chain of custody procedures were followed, and field duplicates and blanks were collected for each sampling round.
1984	TSC	Monitoring wells G-124 through G-130 were constructed at the Site during June 1984. A geologic report was issued.

Table 3-9
(Continued)

Year of Activity	Agency or Consultant	Activity or Report
1985	DDRA	DDRA was retained by the FPD to evaluate quarterly monitoring data and to develop a plan for further monitoring and/or remediation at the site.
1985	TSC	Ten new monitoring wells were constructed at six locations (G-131 through G-136) during April 1985. The locations were selected to form well nests at each location to allow sampling and water level measurement from both the upper and lower aquifers. A geologic and water quality report was completed.
1986	U.S. EPA	In March 1986, the Blackwell Site was evaluated using the Hazard Ranking System (HRS). The site received a composite HRS score of 35.57, with the following scores for each potential route: Surface Water = 0.0 Air Route = 0.0 Groundwater = 61.54
1986	TSC	In August, three additional lower aquifer monitoring wells were constructed downgradient of the site (G-137, G-138, and G-139). A geologic and water quality report was completed.
1986	Booth & Vagt	Characterization of a landfill derived contaminant plume in glacial and bedrock aquifers, NE Illinois, Research Report 86-202, was published by Water Resources Centers, University of Illinois Urbana-Champaign, 87 p. The report presented a history and hydrogeologic assessment of the site.
1987	Vagt	Peter Vagt was awarded a Ph.D. degree in Geology by Northern Illinois University. His dissertation included a hydrogeologic and geochemical assessment of the landfill and the surrounding aquifers.
1988	Warzyn	Response to Proposed NPL, DuPage County Landfill, Blackwell Forest Preserve
1989	FPD/U.S. EPA	Consent order signed.
1990	*U.S. EPA*	*Final listing on NPL.*

Table 3-9
(Continued)

Year of Activity	Agency or Consultant	Activity or Report
Quarterly	FPD/TSC	A database containing all groundwater, surface water, leachate and sediment sampling is updated after each quarterly sampling round. It includes results of VOC analysis, inorganic analysis, and water level measurements.

Several abbreviations have been used in the list of investigations. They include:

Abbreviation	Agency/Consultant
DDRA	Dan D. Raviv and Associates, Millburn, NJ
Eldredge	Eldredge Engineers and Architects, Downers Grove, IL
FPD	Forest Preserve District of DuPage County
IEPA	Illinois Environmental Protection Agency, Springfield, IL
ISGS	Illinois State Geological Survey, Champaign, IL
TSC	Testing Services Inc., Carol Stream, Illinois
Warzyn	Warzyn Engineering Inc., Addison, Illinois

Table 4-1
Water Level Measurement Points and Sampling Dates
Blackwell Landfill NPL Site

QUARTERLY WATER LEVEL MEASUREMENTS:

Measurement Dates: April 1991 July 1991
October 1991 January 1992

Lower Aquifer Wells

G-103D
G-107D
G-115D
G-120D
G-128D
G-131D
G-132D
G-133D
G-134D
G-135D
G-136D
G-137D
G-138D
G-139D

Upper Aquifer Wells

G-101S
G-102S
G-103S
G-105S
G-106S
G-107S
G-108S
G-109S
G-111S
G-113S
G-114S
G-115S
G-116S
G-117S
G-118D
G-118S
G-119S
G-121S
G-122S
G-123S
G-124S
G-125S
G-126S
G-127S
G-128S
G-129S
G-130S
G-133S

Staff gages and Piezometers

SG-1
SG-2
P-1
SG-3
SG-4
P-2
SG-5
SG-6
P-3
SG-7
SG-8
P-4

LEACHATE MEASUREMENT DATES:

April 1991 June 1991
July 1991 August 1991
September 1991 January 1992

Leachate Head Wells

SV-1
SV-2
SV-3
SV-4
SV-5
SV-6
SV-7
SV-8
SV-9
SV-10
SV-11
SV-12
DV-2
DV-3
DV-4
DV-5
DV-6
DV-7
DV-8
DV-9
DV-10
DV-11
DV-12
DV-13

Table 4-2
Site Monitoring Wells Designated For Sampling
Blackwell Landfill NPL Site

LOWER AQUIFER MONITORING WELLS

Number	Location	Geologic Unit
G-134D	Upgradient	Dolomite
G-128D	Downgradient	Dolomite
G-133D	Downgradient	Dolomite
G-135	Downgradient	Dolomite
G-136	Downgradient	Dolomite
G-138	Downgradient	Dolomite
G-139	Downgradient	Dolomite

UPPER AQUIFER MONITORING WELLS

Number	Location	Geologic Unit
G-121	Upgradient	Henry Formation
G-130	Upgradient	Henry Formation
G-108	Downgradient	Henry Formation
G-117	Downgradient	Henry Formation
G-118S	Downgradient	Henry Formation
G-118D	Downgradient	Malden/Tiskilwa Till
G-119	Downgradient	Henry Formation
G-122	Downgradient	Henry Formation
G-123	Downgradient	Henry Formation
G-126	Downgradient	Henry Formation
G-127	Downgradient	Henry Formation
G-128S	Downgradient	Henry Formation
G-129	Downgradient	Henry Formation
G-133S	Downgradient	Henry Formation

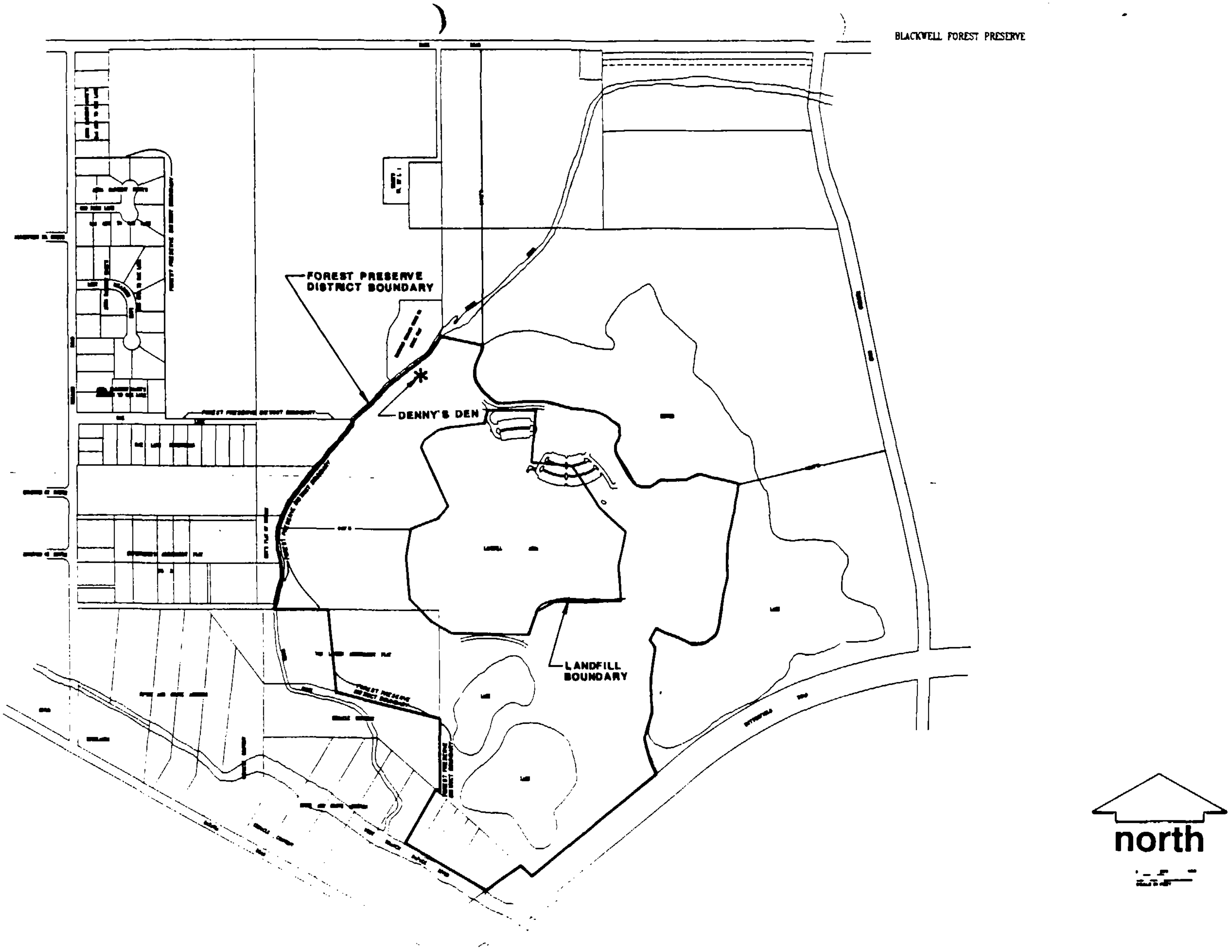


FIGURE 2-1

BOUNDARY SURVEY MAP

WORK PLAN
REMEDIAL INVESTIGATION / FEASIBILTY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

WARZYN

DLL

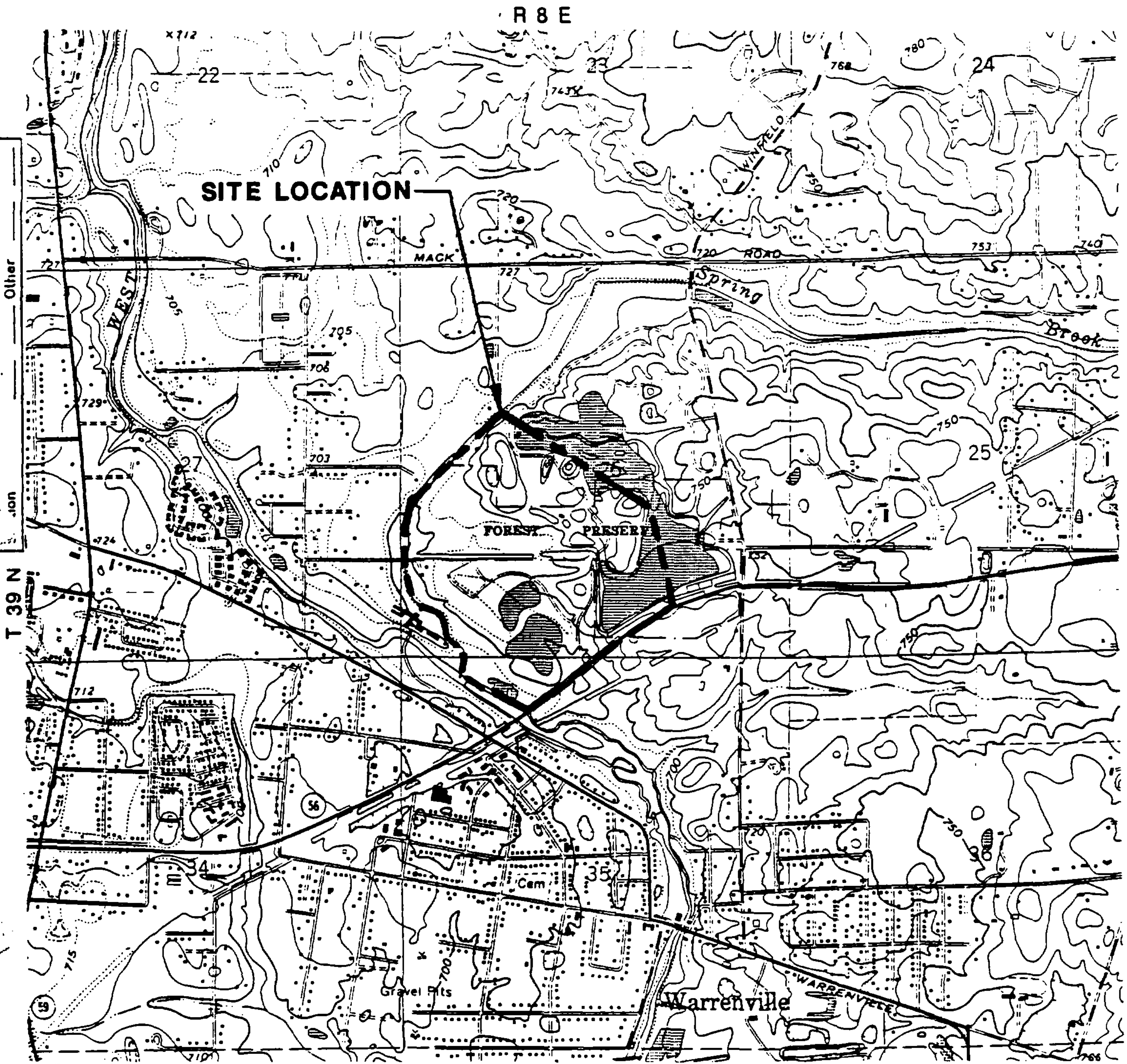
JAW

2/12/90

OF

60721 B1

WARZYN



NOTES

1. BASE MAP DEVELOPED FROM NAPERVILLE, ILLINOIS 7.5 MINUTE USGS TOPOGRAPHIC QUADRANGLE MAP DATED 1962, PHOTOREVISED 1972 AND 1980.

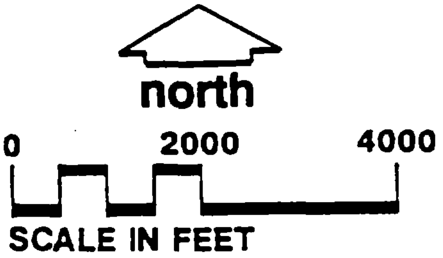


FIGURE 3-1

WARZYN	**SITE LOCATION MAP**	Drawn ELR	Checked JAW
	WORK PLAN REMEDIAL INVESTIGATION / FEASIBILITY STUDY BLACKWELL LANDFILL NPL SITE DU PAGE COUNTY, ILLINOIS	Revisions	App'd Julie B. Widman Date 4/12/90 60721 **A1**

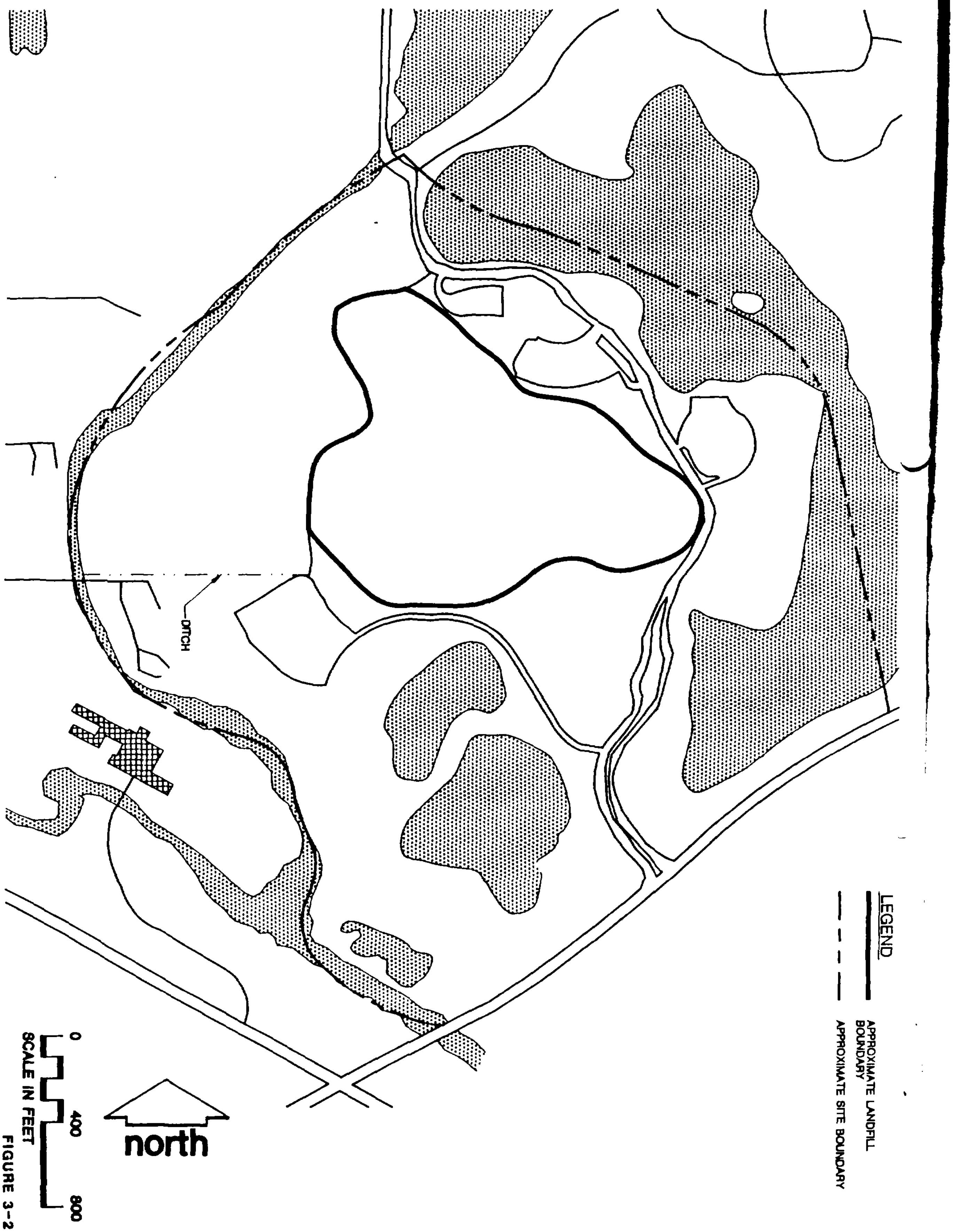


FIGURE 3-2

SITE BOUNDARY MAP

WORK PLAN
REMEDIAL INVESTIGATION / FEASIBILTY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

WARZYN

ELR
JAW
Julie A Widman
4/12/90

60721 B2

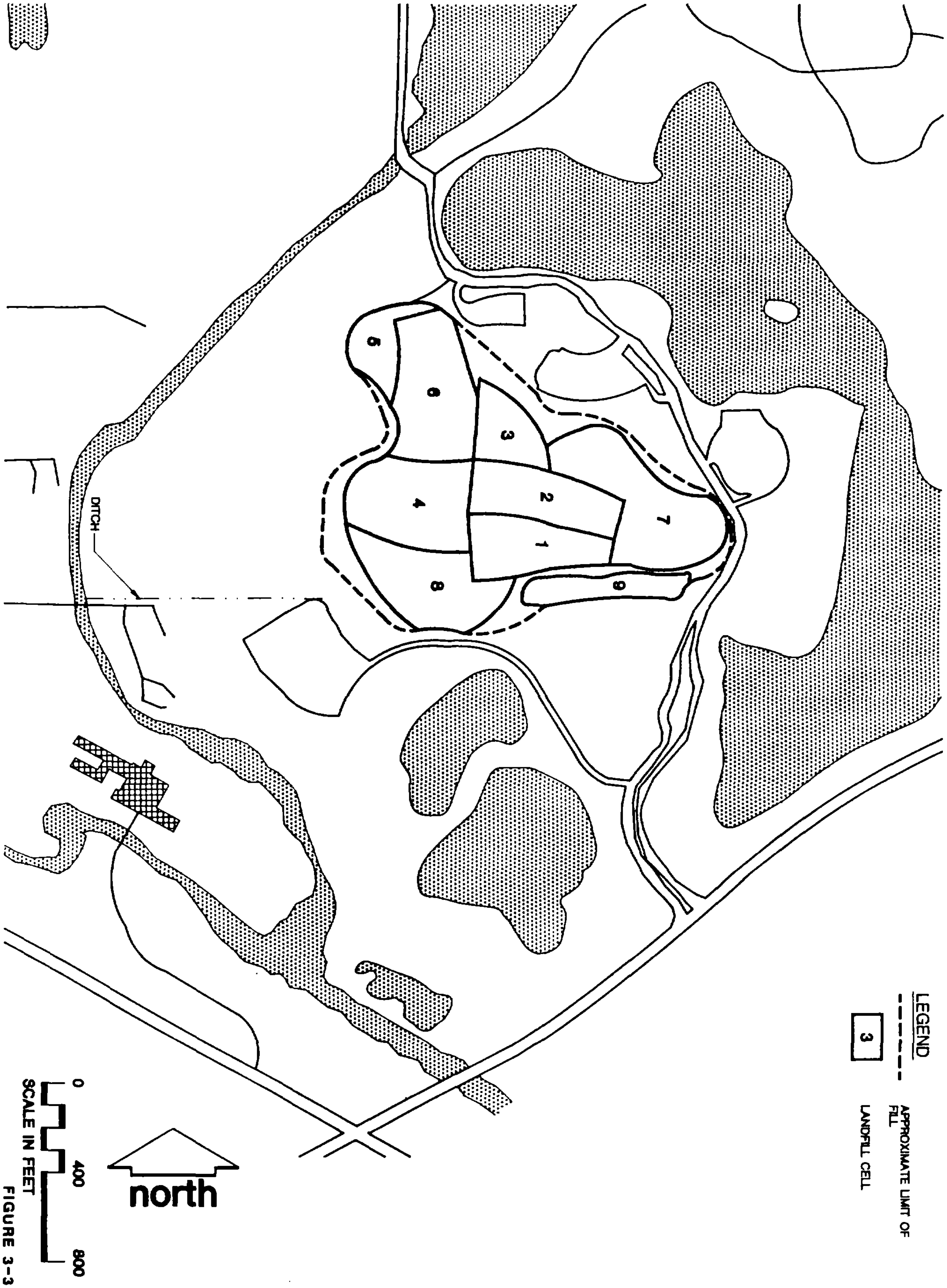


FIGURE 3-3

ORIGINAL LANDFILL CELL CONFIGURATION

WORK PLAN
REMEDIAL INVESTIGATION / FEASIBILTY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

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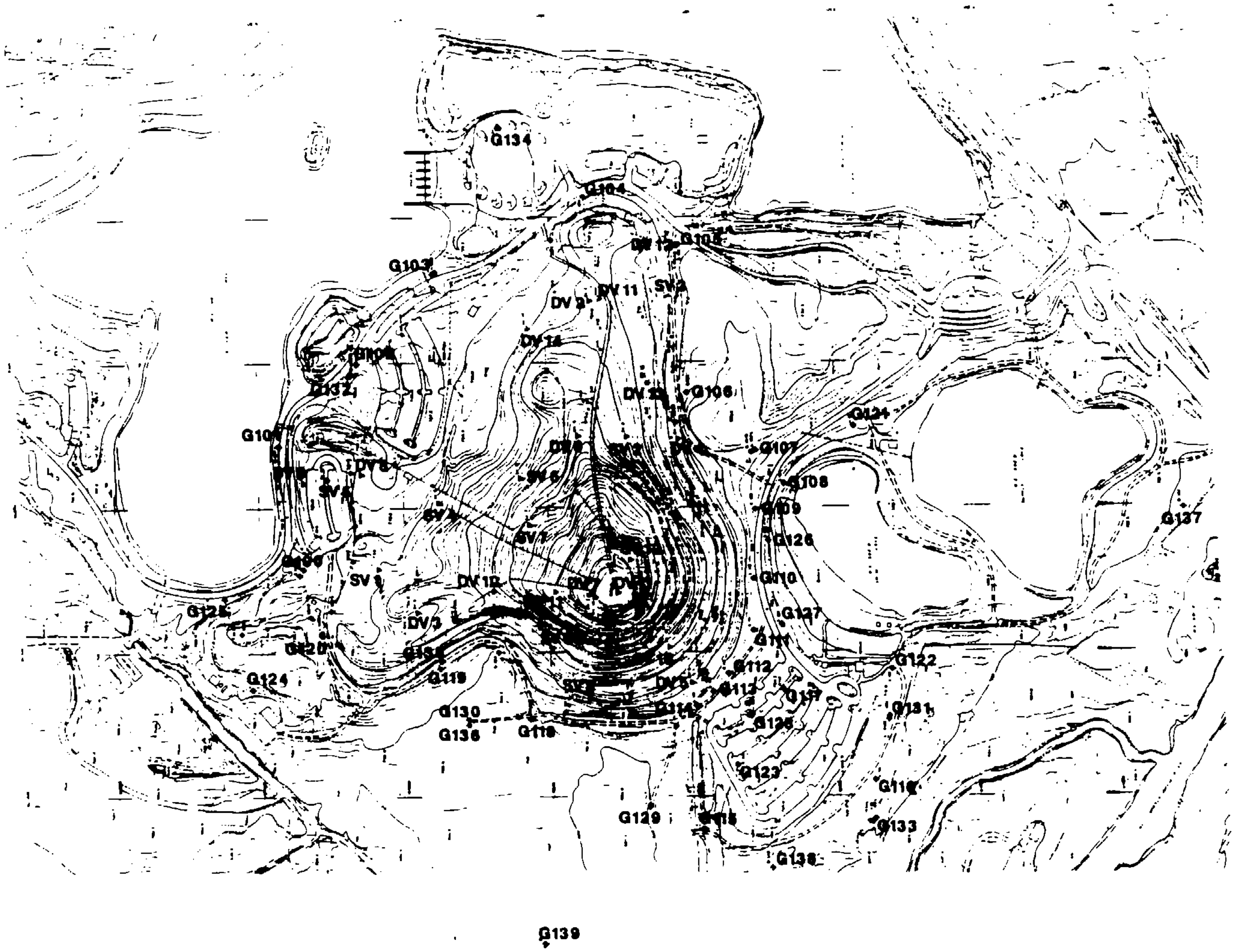
WARZYN ENGINEERING INC.

Drawn By: ELR
Checked By: JAW
Approved By: Julie A Widman
Date: 4/12/90

60721 B3



LEGEND

ᐅDV 6 LEACHATE VENT LOCATION AND NUMBER

⊕G119 MONITORING WELL LOCATION AND NUMBER

NOTES

1. BASE MAP DEVELOPED FROM TOPOGRAPHIC MAP PROVIDED BY CHICAGO AERIAL SURVEY.

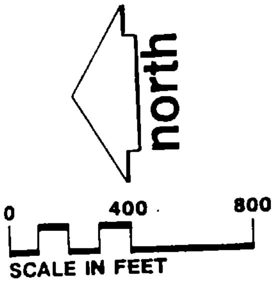


FIGURE 3-4

EXISTING MONITORING WELLS
AND LEACHATE VENTS

WORK PLAN
REMEDIAL INVESTIGATION / FEASIBILTY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

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Checked by JAW
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Date 4/12/90

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Drafting Standards
Professional
PM
Division
Other

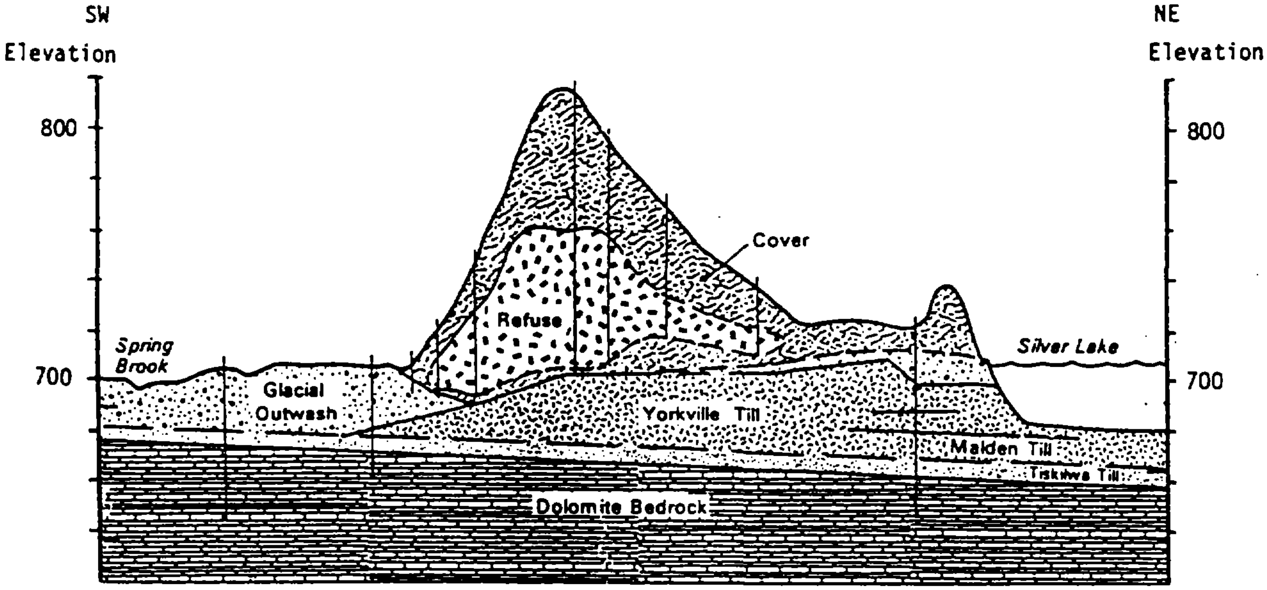

FIGURE 3-5

WARZYN

GENERAL SITE CROSS SECTION
WORK PLAN
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

Drawn ELR
Checked JAW
App'd. Julie A Widman
Revisions
Date 4/12/90
60721 **A2**

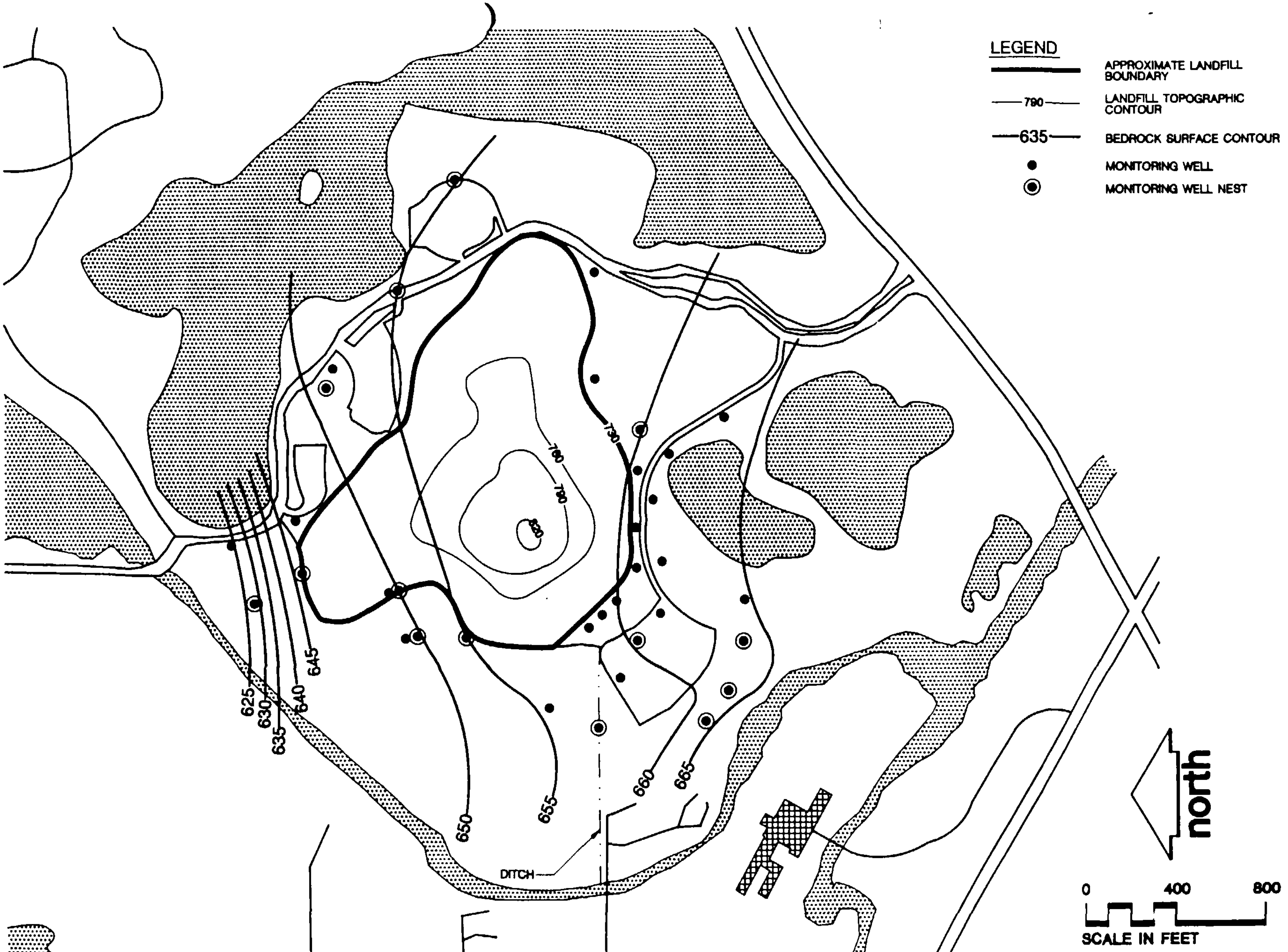

FIGURE 3-6

WARZYN

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Checked By: JAW

Approved By: Julie A. Widman

Date: 4/12/90

BEDROCK SURFACE CONTOUR MAP

WORK PLAN
REMEDIAL INVESTIGATION / FEASIBILTY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

Project Number
60721 B5

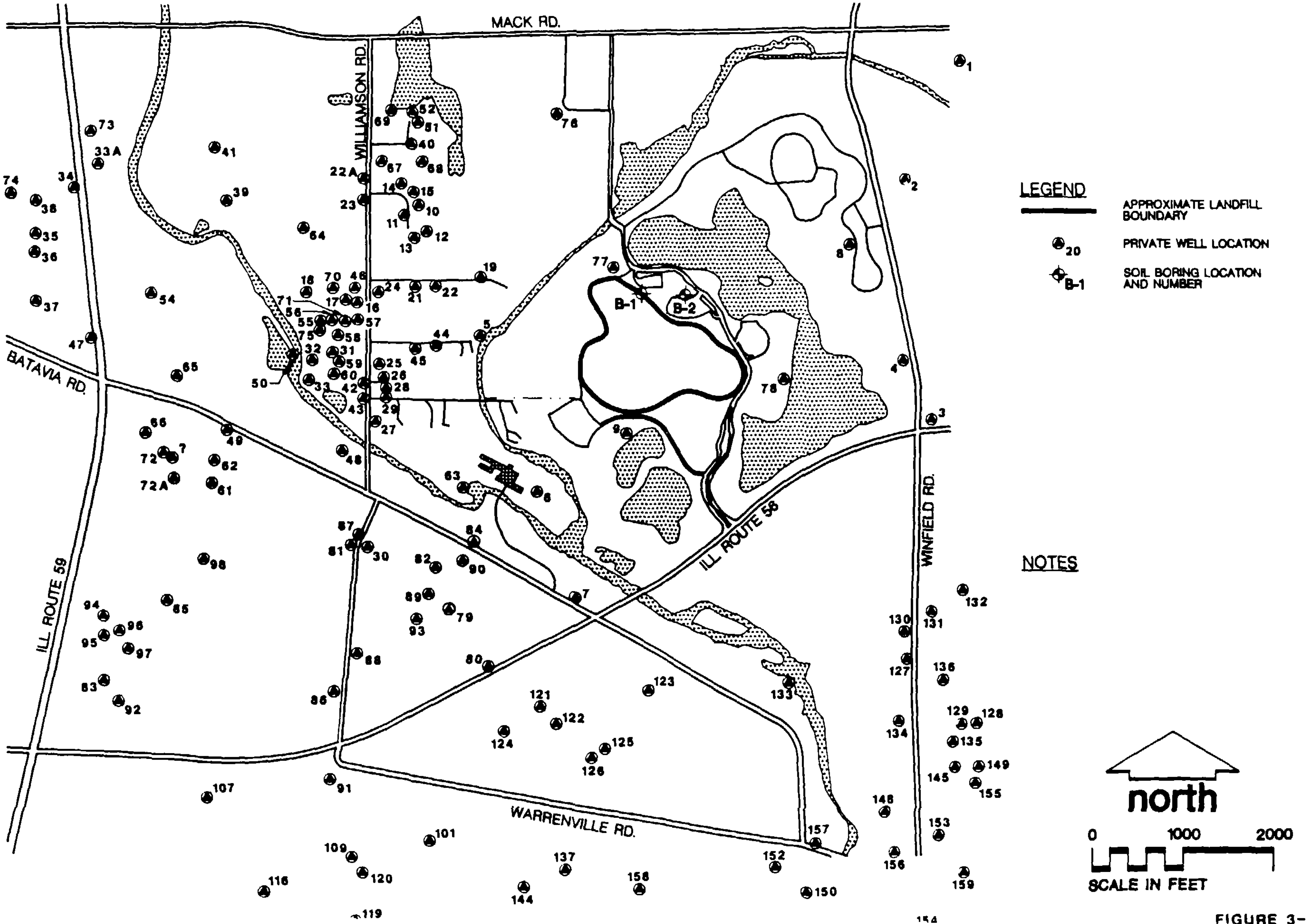

FIGURE 3-7

LOCATIONS OF WATER SUPPLY WELLS IN SITE VICINITY

WORK PLAN
REMEDIAL INVESTIGATION / FEASIBILTY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

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JAW
4/12/90

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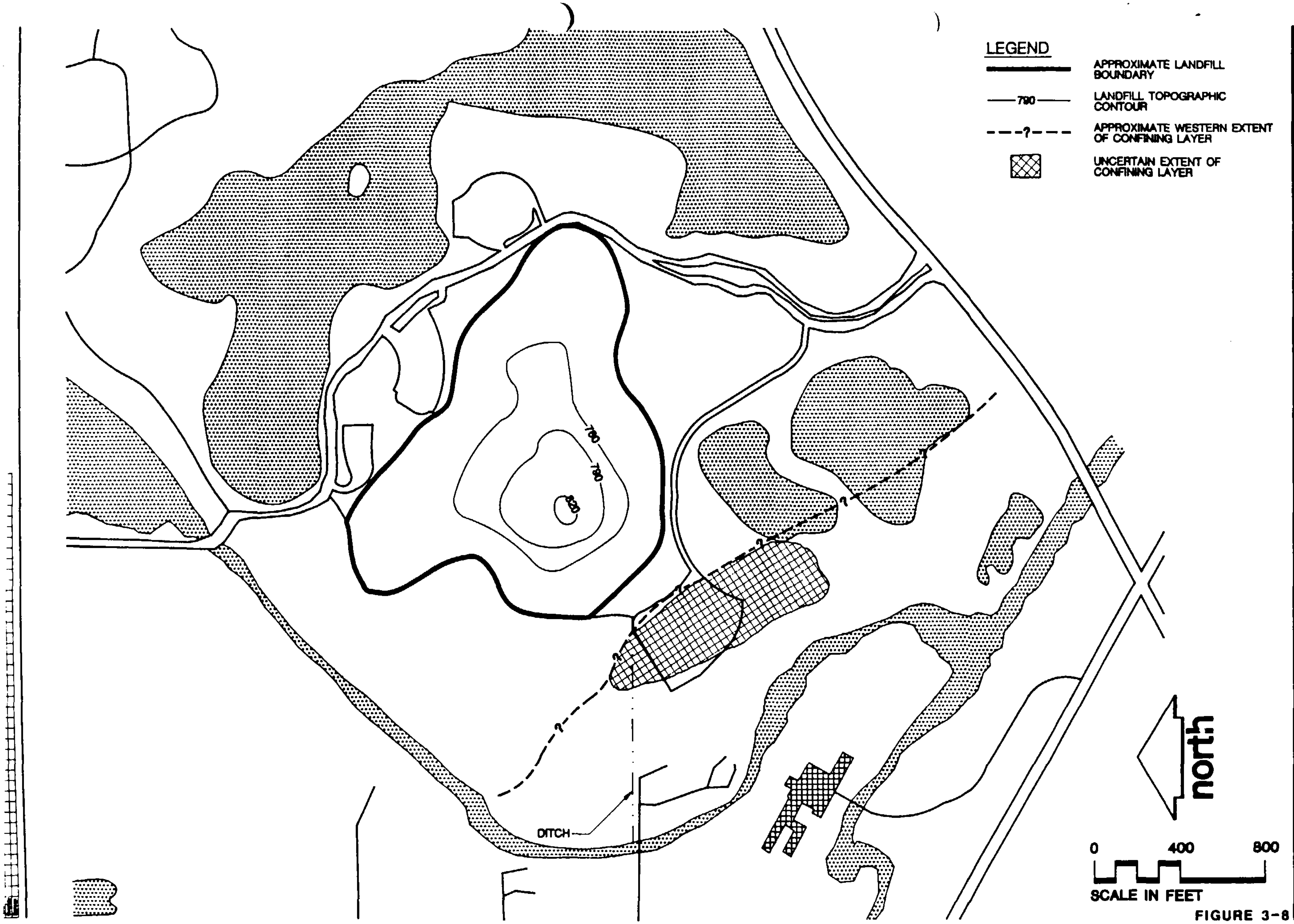

LEGEND

▬	APPROXIMATE LANDFILL BOUNDARY
—790—	LANDFILL TOPOGRAPHIC CONTOUR
- - -?- - -	APPROXIMATE WESTERN EXTENT OF CONFINING LAYER
▩	UNCERTAIN EXTENT OF CONFINING LAYER

FIGURE 3-8

ZONE OF UNCERTAINTY REGARDING CONFINING LAYER EXTENT

WORK PLAN
REMEDIAL INVESTIGATION / FEASIBILTY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

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Date 4/12/90

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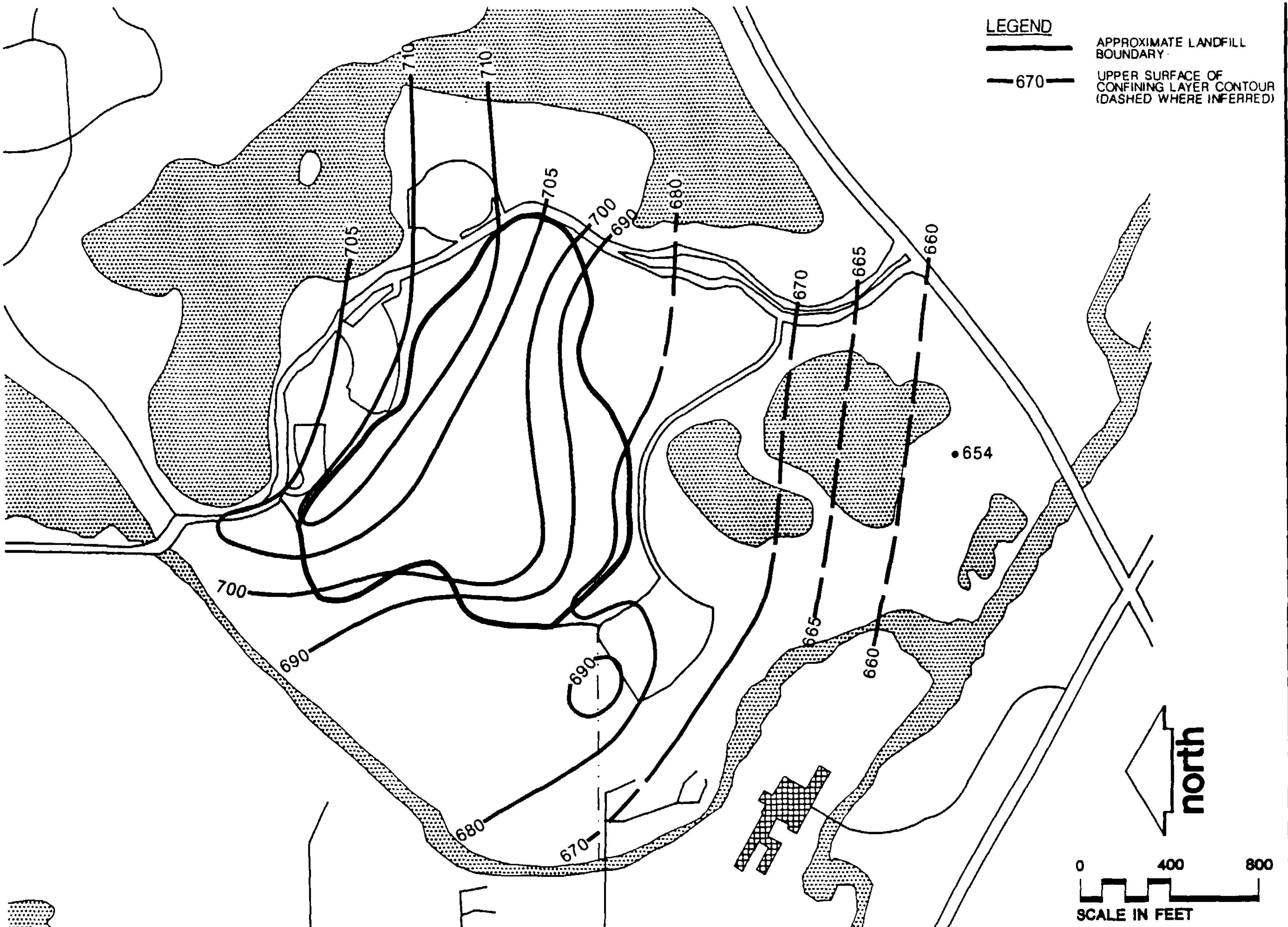

FIGURE 3-9

CONTOUR MAP OF UPPER SURFACE OF CONFINING LAYER
WORK PLAN
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

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Date: 8-9-90

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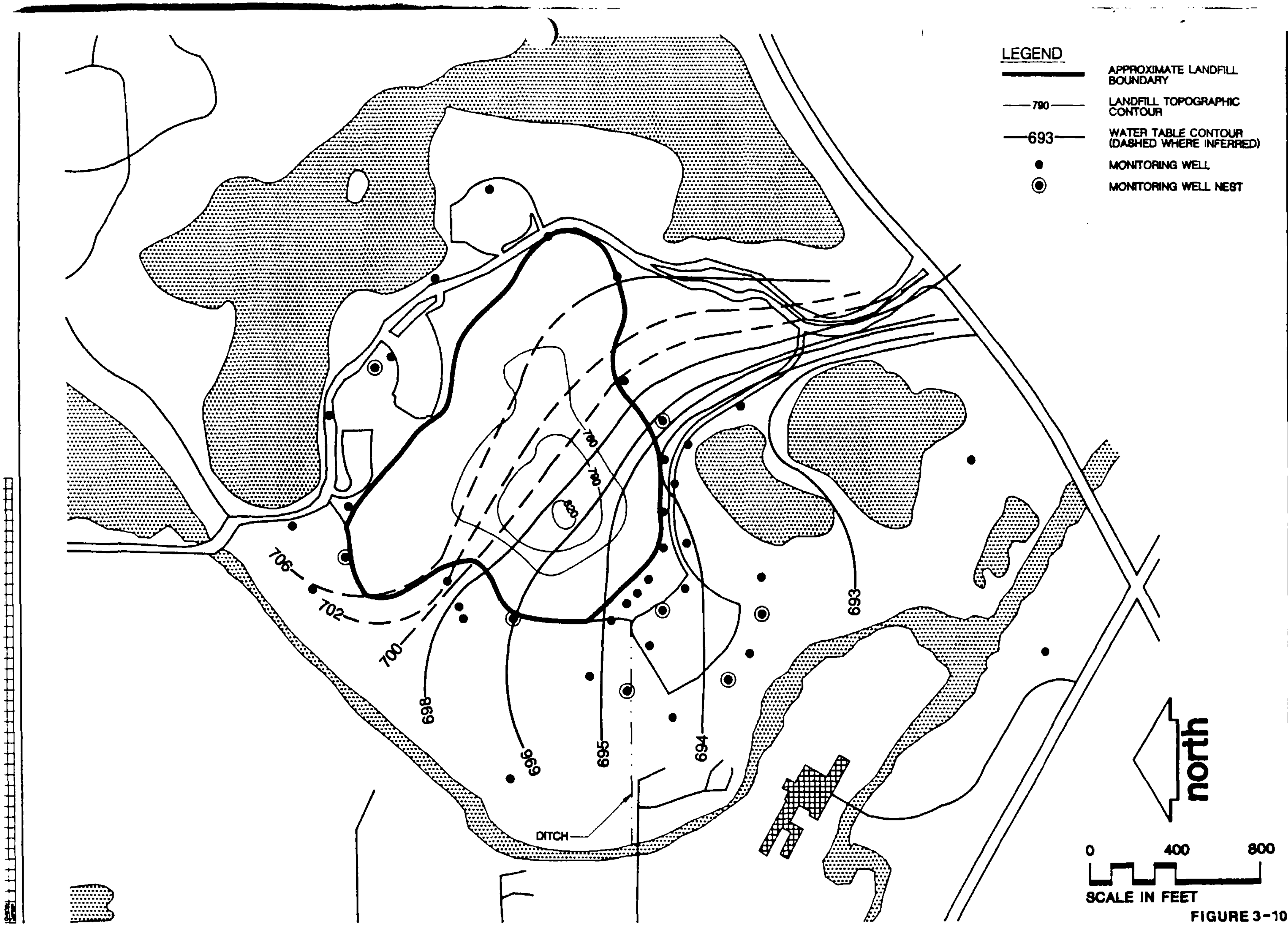

FIGURE 3-10

WATER TABLE MAP - UPPER AQUIFER

WORK PLAN
REMEDIAL INVESTIGATION / FEASIBILTY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

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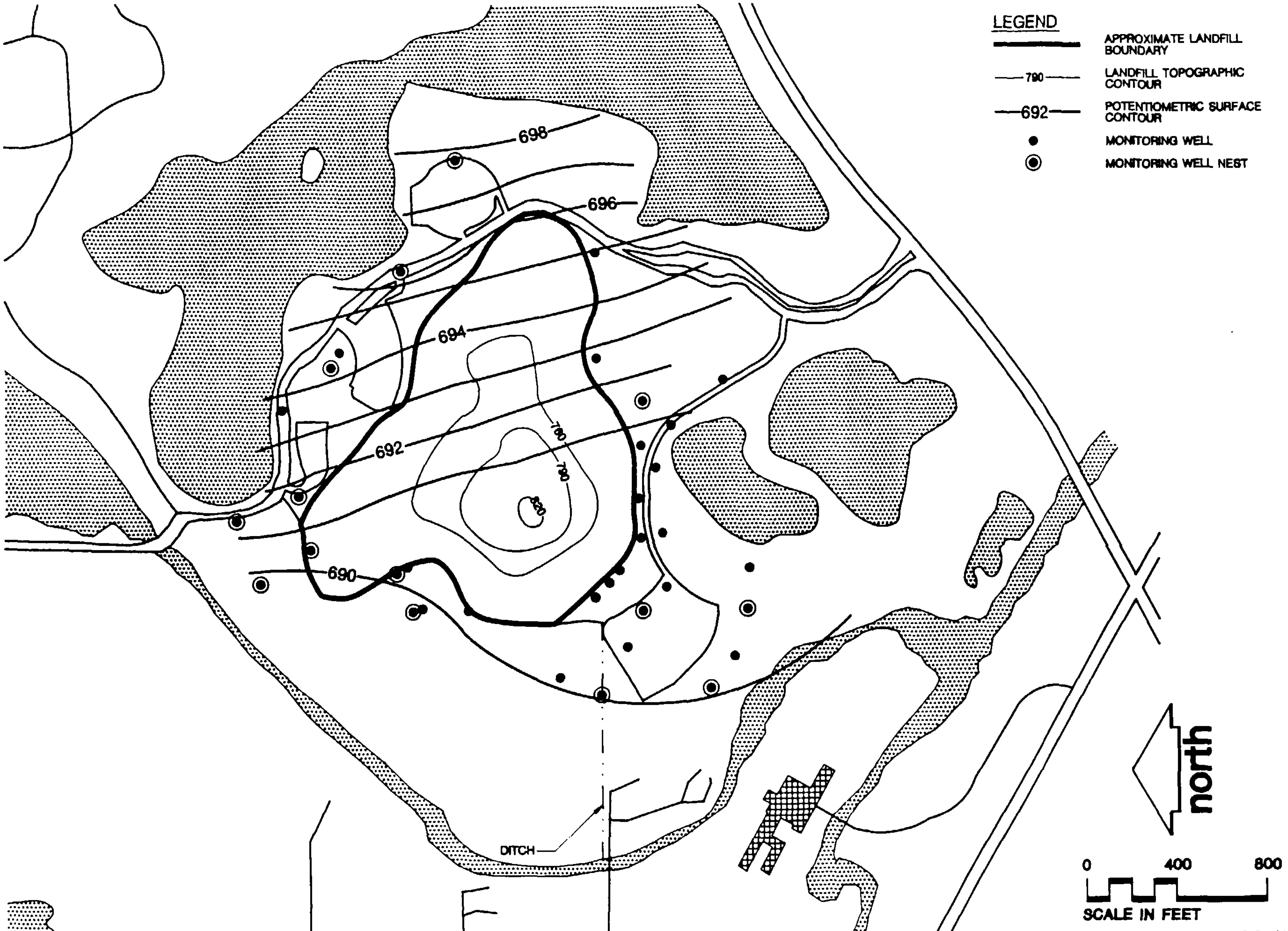

FIGURE 3-11

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Checked By JAW
Date 4/12/90
Approved By Julie A. Wickman

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POTENTIOMETRIC SURFACE MAP-
LOWER AQUIFER

WORK PLAN
REMEDIAL INVESTIGATION / FEASIBILTY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

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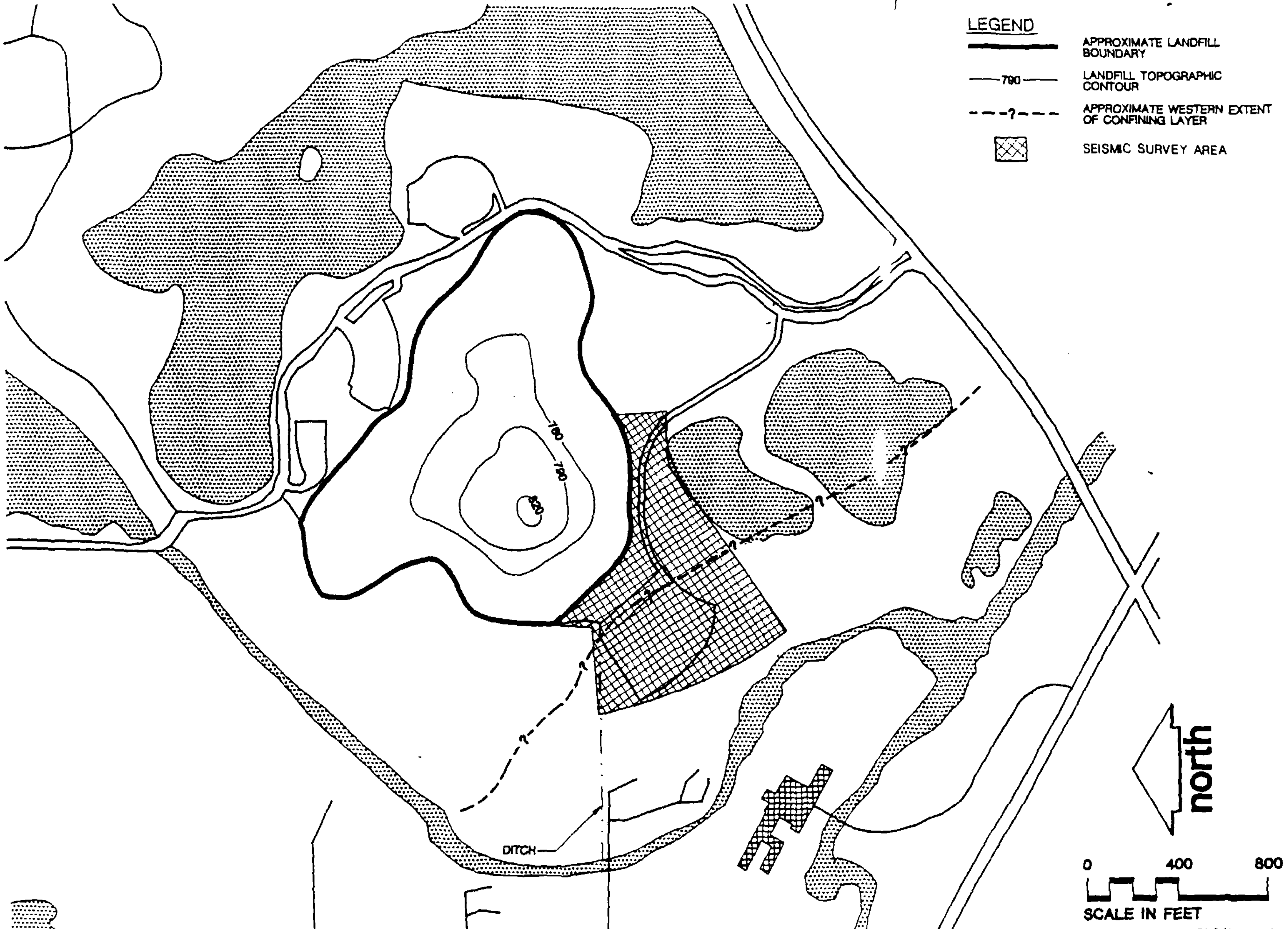

FIGURE 4-1

REFLECTION SEISMIC SURVEY AREA

WORK PLAN
REMEDIAL INVESTIGATION / FEASIBILTY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

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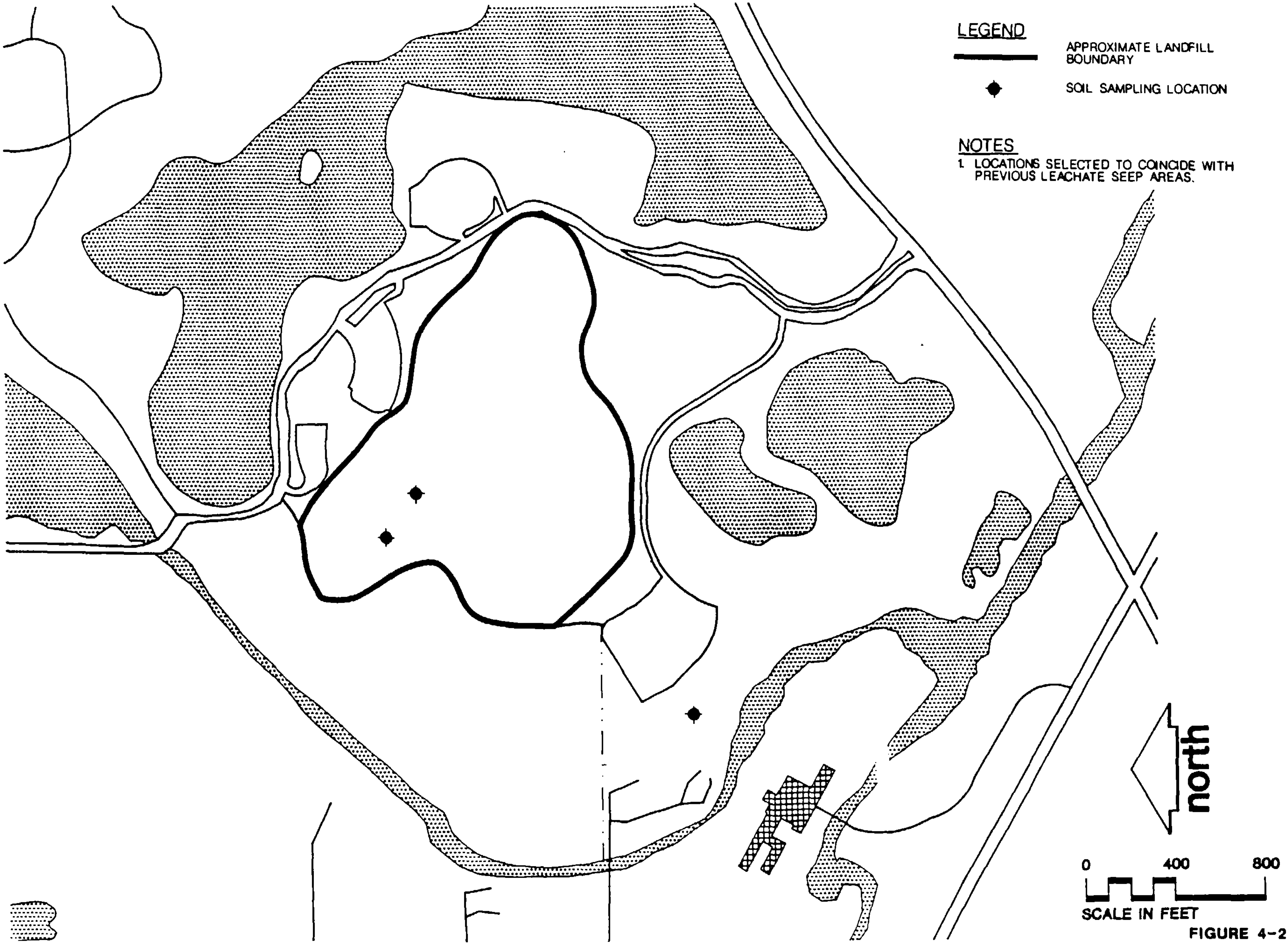

LEGEND

▬ APPROXIMATE LANDFILL BOUNDARY

◆ SOIL SAMPLING LOCATION

NOTES

1. LOCATIONS SELECTED TO COINCIDE WITH PREVIOUS LEACHATE SEEP AREAS.

FIGURE 4-2

WARZYN
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Date 8 9-90
Approved By Julie A Widman

SOIL SAMPLING LOCATIONS
WORK PLAN
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

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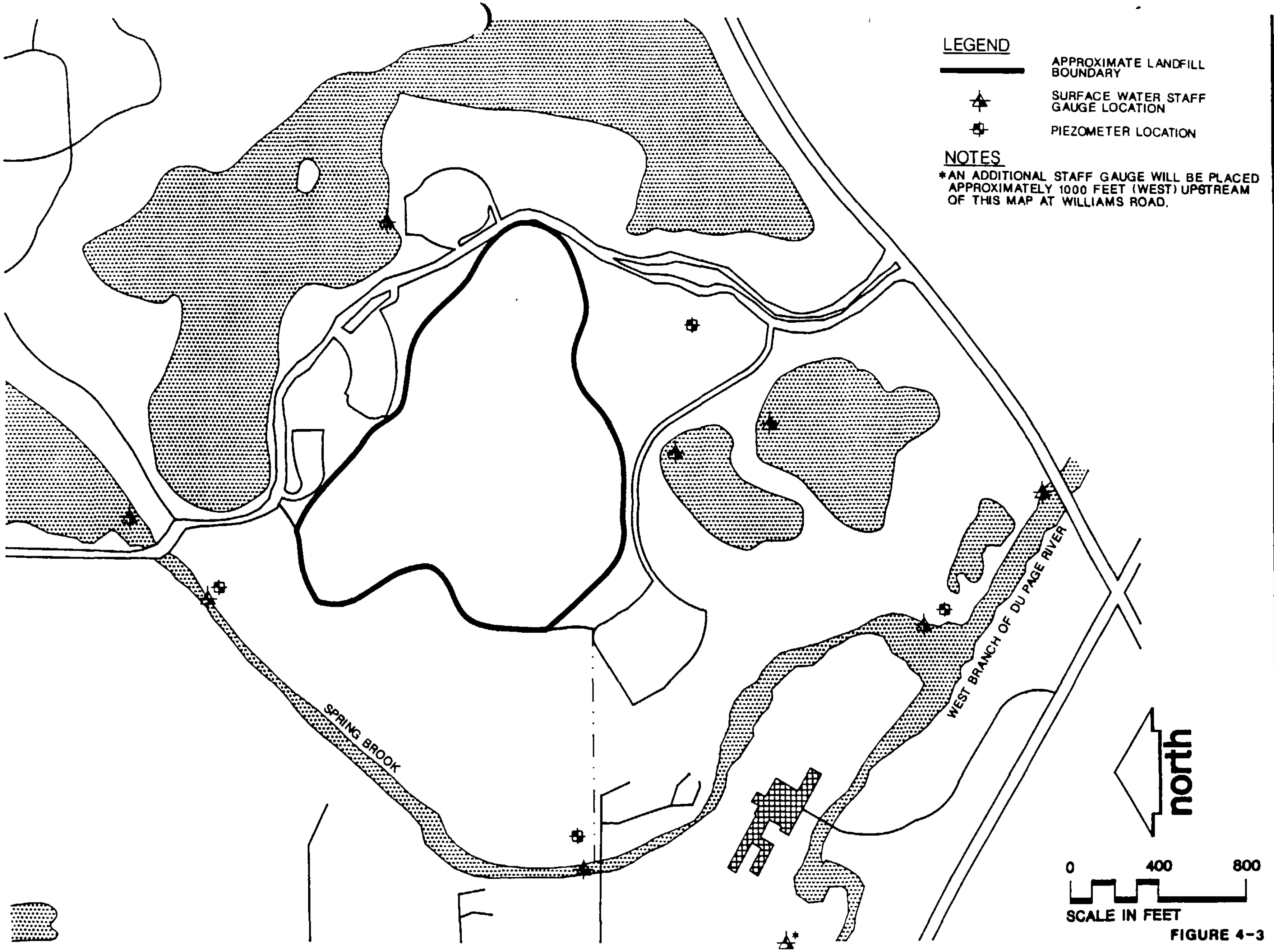

LEGEND

▬	APPROXIMATE LANDFILL BOUNDARY
▲	SURFACE WATER STAFF GAUGE LOCATION
⊕	PIEZOMETER LOCATION

NOTES

*AN ADDITIONAL STAFF GAUGE WILL BE PLACED APPROXIMATELY 1000 FEET (WEST) UPSTREAM OF THIS MAP AT WILLIAMS ROAD.

FIGURE 4-3

SURFACE WATER & PIEZOMETER MEASUREMENT LOCATIONS

WORK PLAN
REMEDIAL INVESTIGATION / FEASIBILTY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

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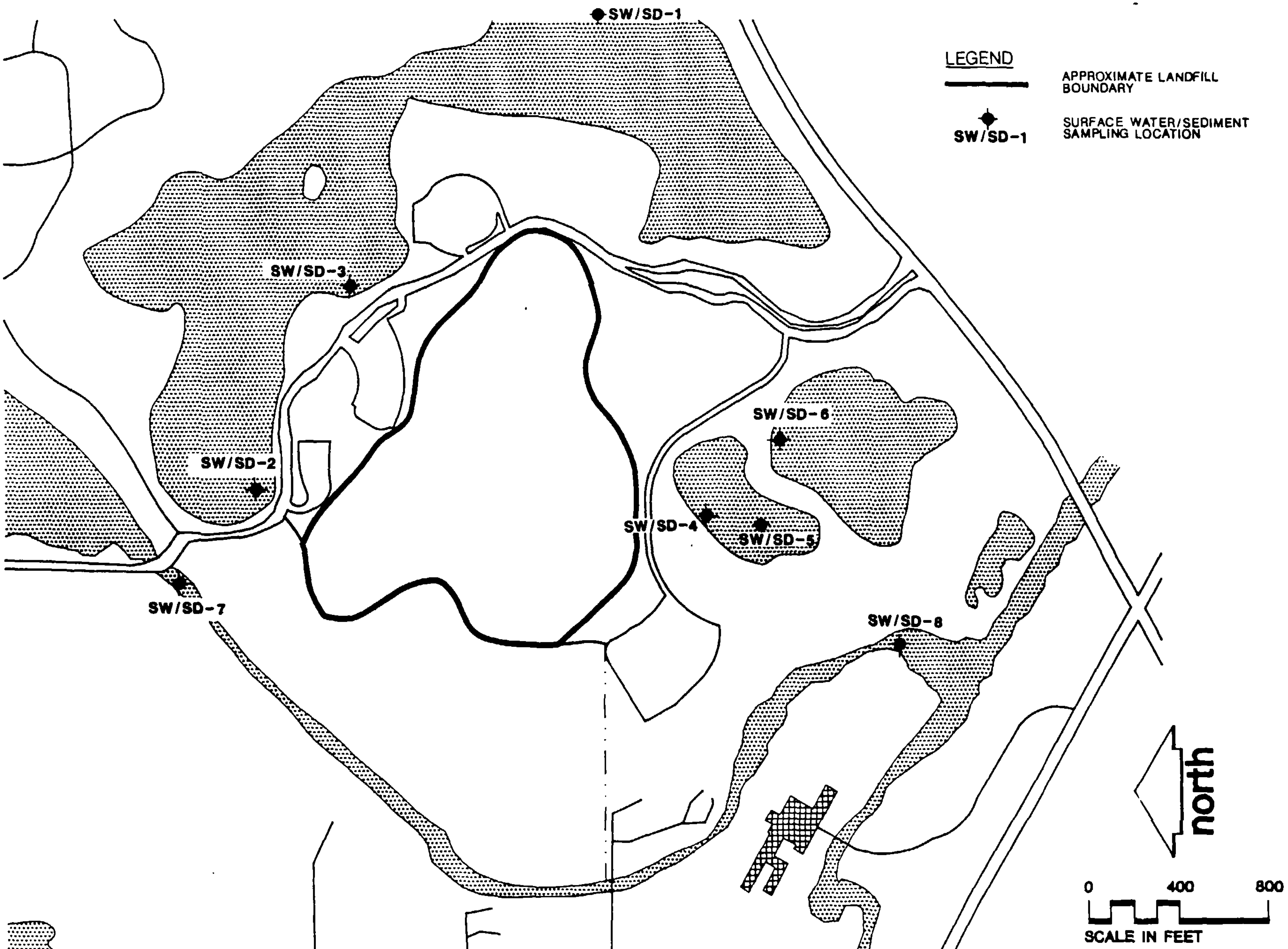

FIGURE 4-4

SURFACE WATER/SEDIMENT SAMPLING LOCATIONS

WORK PLAN
REMEDIAL INVESTIGATION / FEASIBILTY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

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Checked By JAW
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Date 4/12/90

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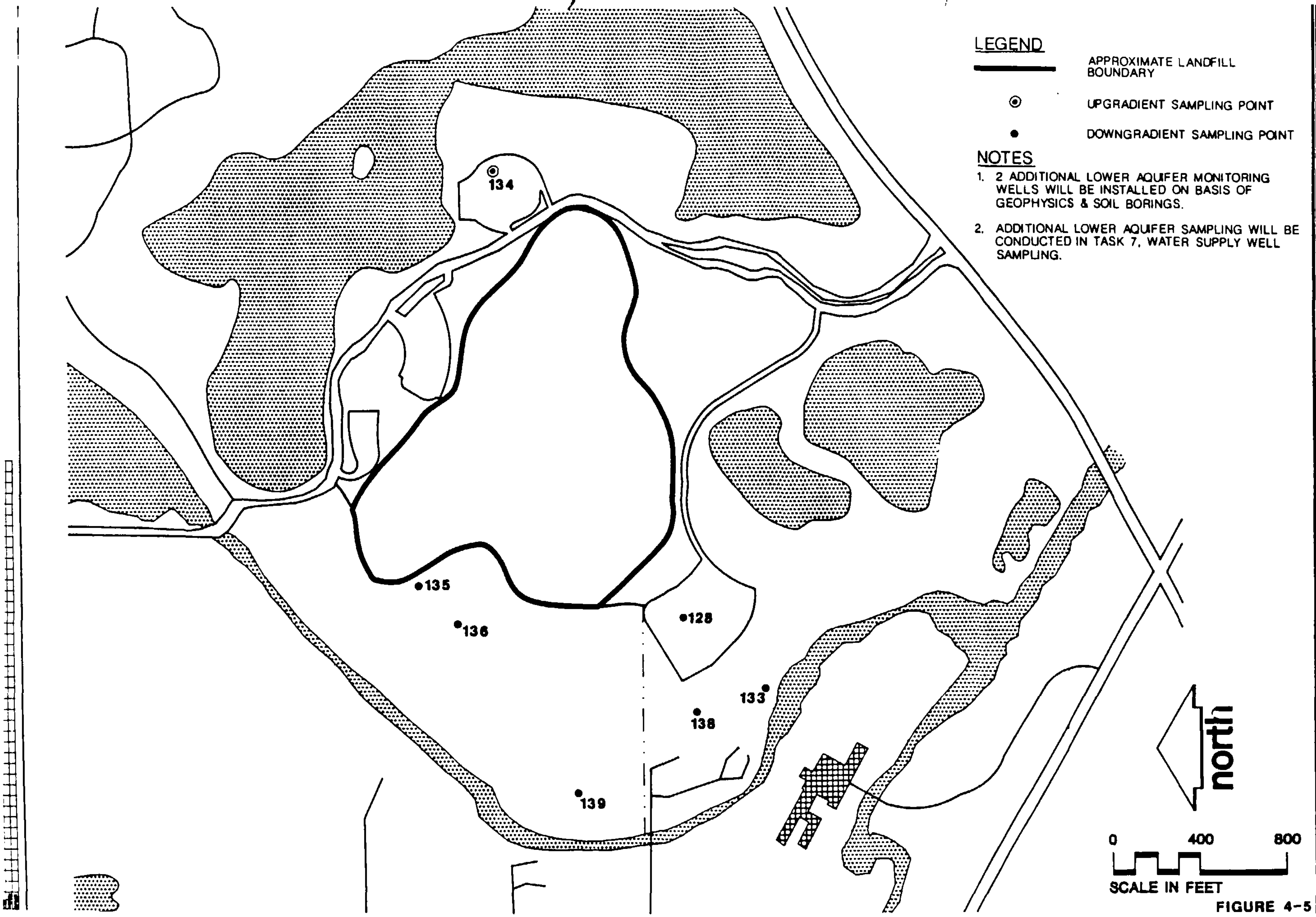

LEGEND

▬ APPROXIMATE LANDFILL BOUNDARY

◉ UPGRADIENT SAMPLING POINT

● DOWNGRADIENT SAMPLING POINT

NOTES

1. 2 ADDITIONAL LOWER AQUIFER MONITORING WELLS WILL BE INSTALLED ON BASIS OF GEOPHYSICS & SOIL BORINGS.
2. ADDITIONAL LOWER AQUIFER SAMPLING WILL BE CONDUCTED IN TASK 7, WATER SUPPLY WELL SAMPLING.

FIGURE 4-5

LOWER AQUIFER GROUNDWATER SAMPLING POINTS
WORK PLAN
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

WARZYN
Designed By:
Drawn By: ELR
Checked By: JAH
Approved By: Julie A. Widman
Date: 8-9-90
Reference:
File Prefix

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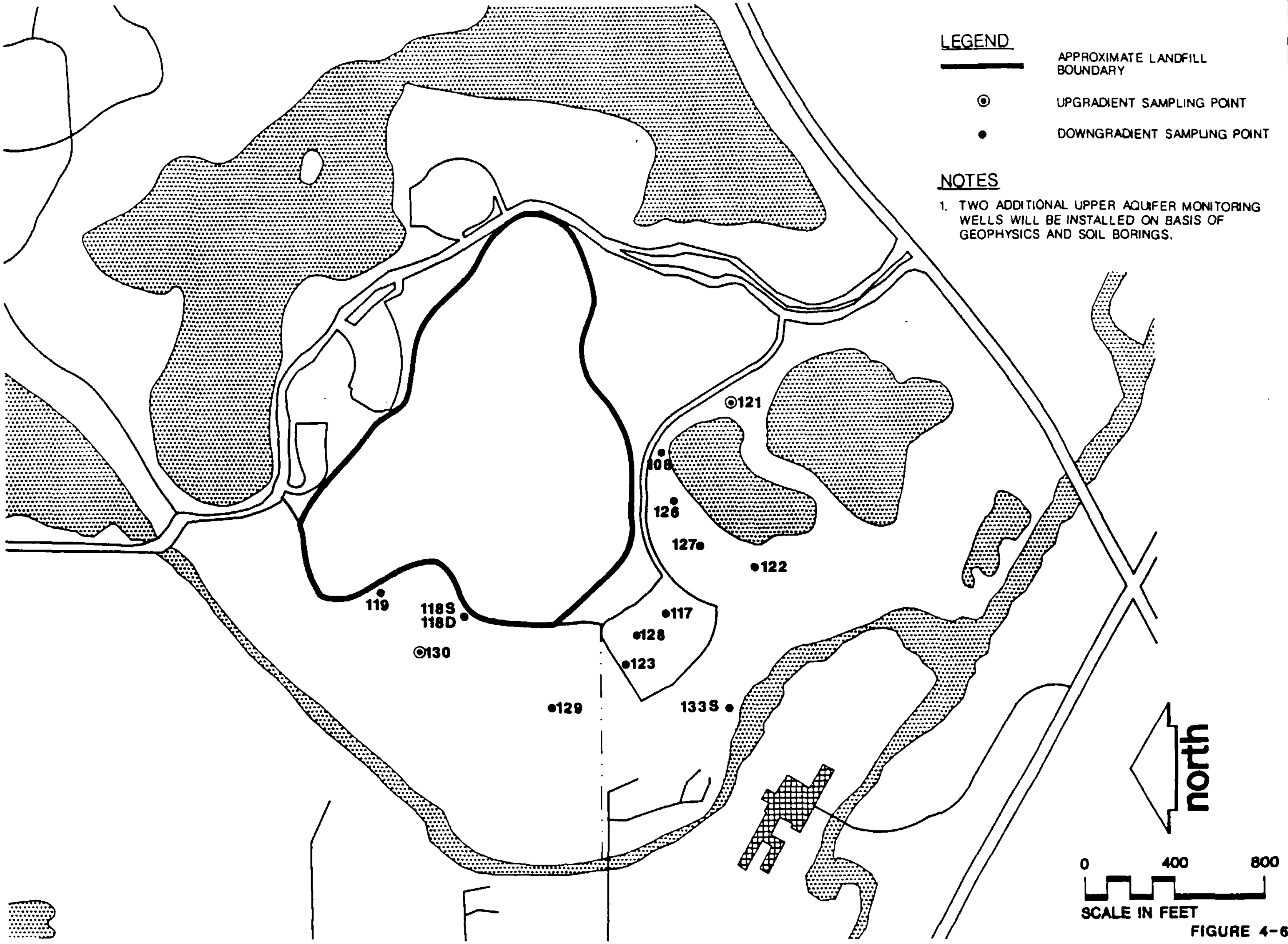

LEGEND

▬	APPROXIMATE LANDFILL BOUNDARY
◉	UPGRADIENT SAMPLING POINT
●	DOWNGRADIENT SAMPLING POINT

NOTES

1. TWO ADDITIONAL UPPER AQUIFER MONITORING WELLS WILL BE INSTALLED ON BASIS OF GEOPHYSICS AND SOIL BORINGS.

FIGURE 4-6

UPPER AQUIFER GROUNDWATER SAMPLING POINTS

WORK PLAN
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

WARZYN

ELR

8-9-90

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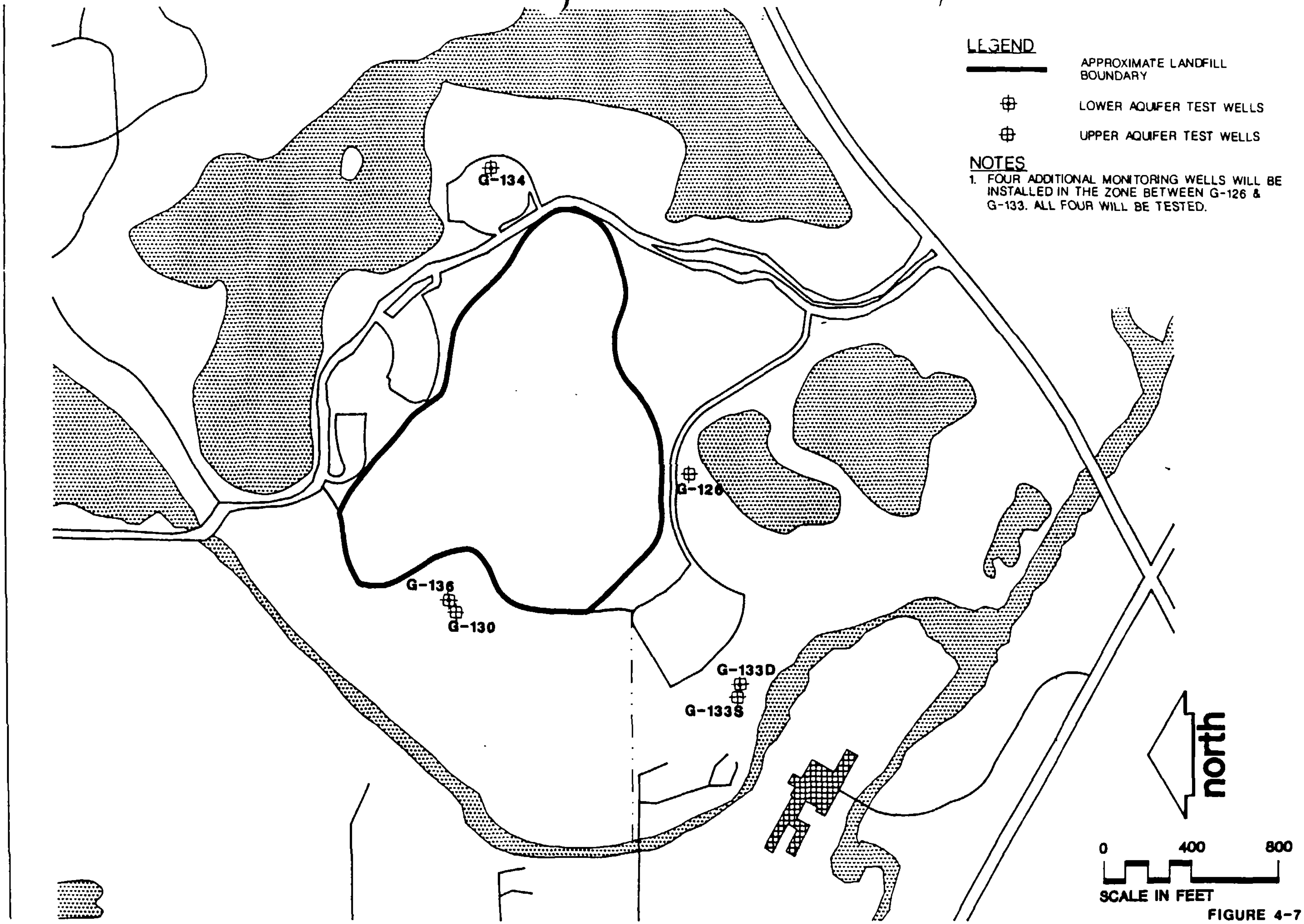

LEGEND

▬	APPROXIMATE LANDFILL BOUNDARY
⌖	LOWER AQUIFER TEST WELLS
⌖	UPPER AQUIFER TEST WELLS

NOTES

1. FOUR ADDITIONAL MONITORING WELLS WILL BE INSTALLED IN THE ZONE BETWEEN G-126 & G-133. ALL FOUR WILL BE TESTED.

FIGURE 4-7

AQUIFER TEST LOCATIONS

WORK PLAN
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

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JAW
8-4-90
Julie A. Widman

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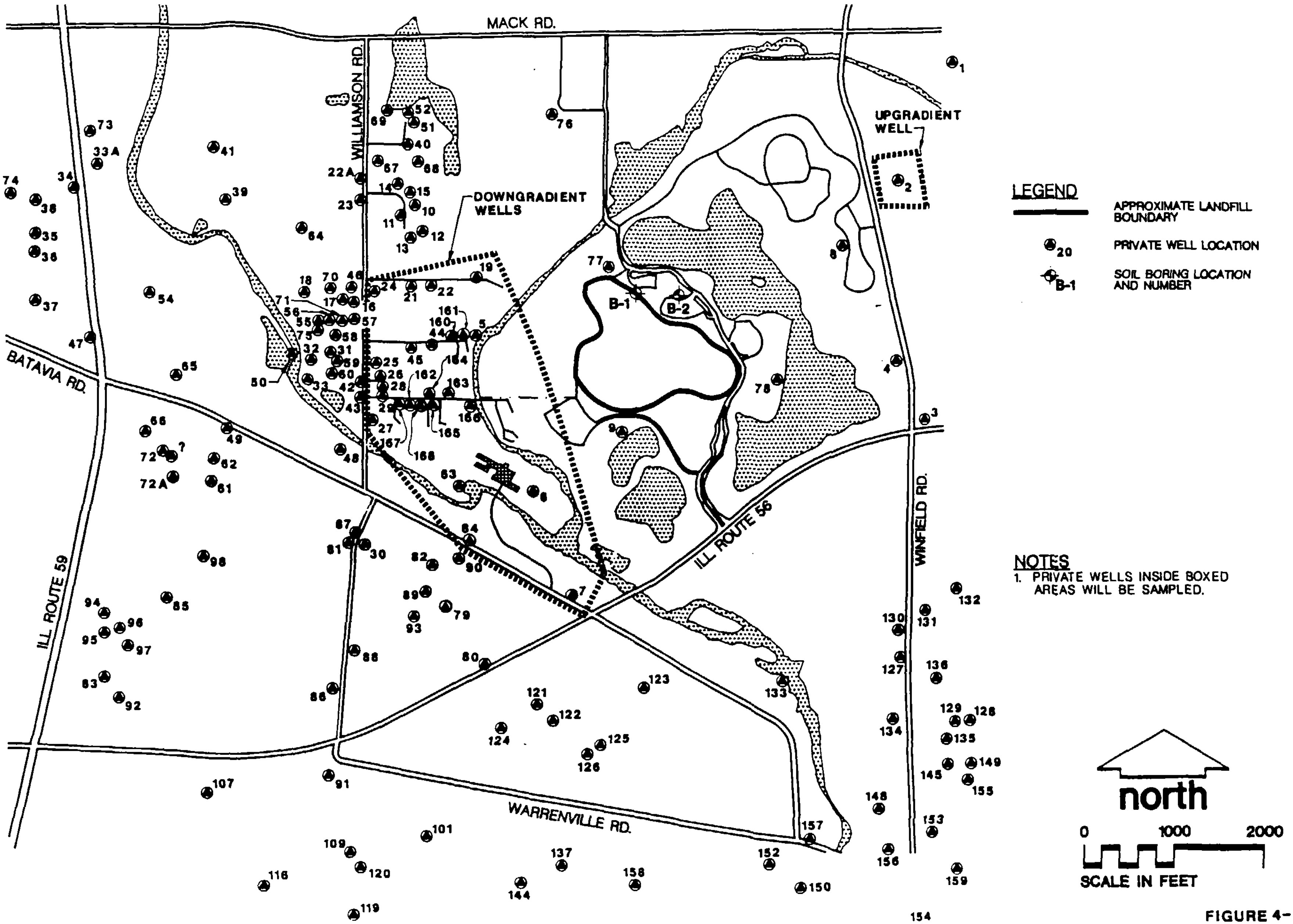

FIGURE 4-8

PRIVATE WELL SAMPLING LOCATIONS
WORK PLAN
REMEDIAL INVESTIGATION / FEASIBILTY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

Revisions

Date · By · Ck'd

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Checked By: JAW
Approved By: Julie A Widman
Date: 4/12/90
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File Path:

Project number
60721B22

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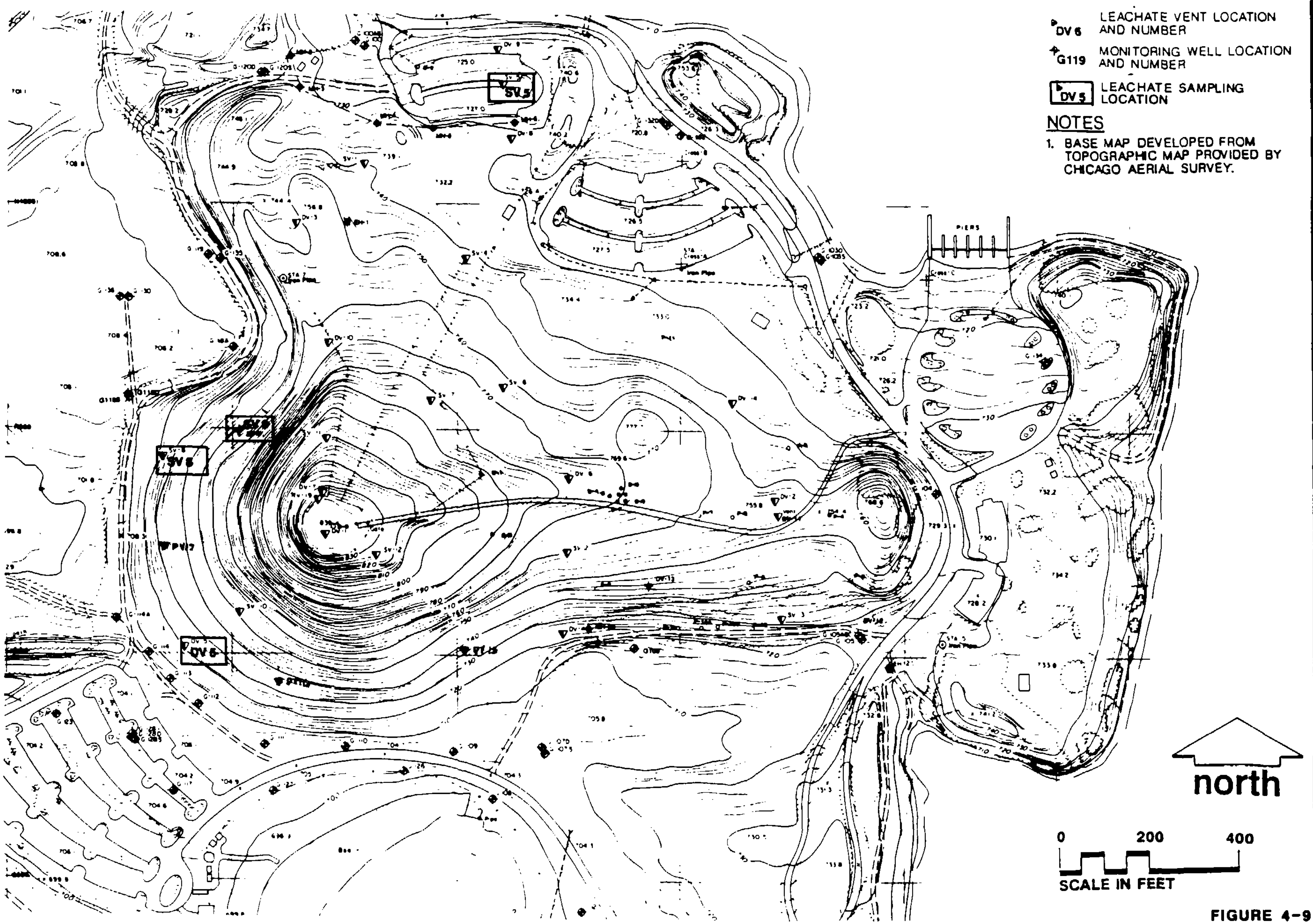

LEGEND

DV 6 LEACHATE VENT LOCATION AND NUMBER

G119 MONITORING WELL LOCATION AND NUMBER

DV 5 LEACHATE SAMPLING LOCATION

NOTES

1. BASE MAP DEVELOPED FROM TOPOGRAPHIC MAP PROVIDED BY CHICAGO AERIAL SURVEY.

FIGURE 4-9

LEACHATE SAMPLING LOCATIONS
WORK PLAN
REMEDIAL INVESTIGATION / FEASIBILTY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

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Date 8 7-90
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OF

60721B23

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APPENDICES

APPENDIX A

DATA MANAGEMENT PLAN

APPENDIX A
WORK PLAN

DATA MANAGEMENT PLAN
REMEDIAL INVESTIGATION AND FEASIBILITY STUDY
BLACKWELL LANDFILL NPL SITE
DUPAGE COUNTY, ILLINOIS
(April 13, 1990)

Prepared by:

WARZYN ENGINEERING INC.
2100 Corporate Drive
Addison, Illinois
(708) 691-5000

Project No. 60721

Peter J. Vagt, Ph.D.
Project Manager

April 1990

TABLE OF CONTENTS

Page

Attachment

SECTION 1
INTRODUCTION

This Data Management Plan describes the program for data management of data and information collected during the remedial investigation and feasibility study phase of the Blackwell Landfill site, DuPage County, Illinois. The plan outlines the procedures that will ensure the quality and integrity of the data that are collected and discusses the disposition of the data collected during the RI/FS tasks and special data handling procedures. Specific data documentation protocols are detailed in the Quality Assurance Project Plan (QAPP).

SECTION 2
DATA TYPES

Two data types are associated with the investigation. The first is technical data that are required for or generated by specific investigative tasks. These data include: field data, data resulting from subsequent laboratory or engineering analysis, background research data and documents, and state of practice technical data and documents.

The second data type includes information associated with monitoring, managing and documenting the actual performance of the RI/FS tasks. Specific data management protocols to be followed for both types of information are discussed in the following sections.

SECTION 3

DATA MANAGEMENT

Specific data management procedures are discussed in the QAPP, Section 9.0, and in the following sections. These sections discuss the fundamental data handling elements and are subject to change based on possible changes in the investigative tasks.

Field Measurements and Observations

Field observations and measurements will be recorded in a project logbook and on field record forms. All information concerning field activities and conditions will be recorded directly and legibly in the field logbooks and on field forms, and all entries will be signed and dated. If an entry must be changed, the change will not obscure the original entry, and the reason for the change will be stated. The changed and the explanation will be signed and dated. The logbook will document the date, weather conditions, site activities, and personnel on site, including visitors. Field data records will be organized into standard form formats and retained in locked permanent files.

Sample Identification and Chain-of-Custody

Field samples will be identified by sample tags and labels. The information on the sample tag will include the data and time the sample was collected, the sampling location, the name of the sample collector, and any pertinent remarks. Copies of the sample tags will be stored in a permanent locked file. Details of the sample labeling are provided in the Sampling Plan.

Chain-of-Custody Procedures

The chain-of-custody procedures for this project are found in detail in the QAPP, Section 5, and discussed briefly here. Prior to delivery of samples to the laboratory, a chain-of-custody form will be prepared identical to the labels and tags secured on the sample jars noting sample identification, date and time of sample collection, number of samples being submitted to the laboratory and the signature of the field personnel collecting the samples. Chain-of-custody forms will be completed in duplicate using carbonless duplicate forms. The original custody form will be taped to the inside lid of the shipping cooler and a duplicate will be maintained for the project files. The shipping cooler will be secured with strapping tape and custody seals will be placed across the cooler opening to ensure sample integrity during shipment.

Laboratory Documentation

Laboratory records will document sample receipt dates, laboratory analysis dates, and report dates. After quality assurance review, the results will be transmitted to Warzyn, who will review the data with the Forest Preserve District.

Document Control, Inventory and Filing Systems

The data storage and information system established for the project will address the receipt of all data, screening and validating of data to identify and reject outliers or errors, and preparation, sorting and entering of data into data storage files. A quality assurance/quality control form will be completed by the internal reviewer that indicates QA/QC activities were used to review the information and describe the precision and accuracy of the analysis. The internal reviewer will then make the data available to the data users. Originals of all data will be secured in locked files. Copies of original data will be maintained only by those personnel who are using the data during the analysis procedures and that which is stored for computer manipulation.

The project manager will be responsible for maintaining the document control system during the investigation. The document inventory and filing system will be based on serially numbered documents. All documents will be given a number and a description of the document and number will be maintained in the file.

Much of the data collected during the remedial investigation will be stored in a computer data base file system. The storage system is based on a VAX mini computer system that has an established backup system to preserve data security and integrity. After keying in the data, a report of all data will be obtained and the internal reviewer will check against the field reports to be sure that the data has been entered correctly. The stored data are then capable of being organized into reports and lists, analyzed statistically, or transferred to design/drafting hardware. There are established file protections so that only designated personnel are allowed access to the data files. At the completion of the database utility, the data files will be closed. The data files can be archived for an undetermined amount of time or completely destroyed. The backup files created during storage will be destroyed in six months.

Other data recording methods during management procedures associated with specific RI/FS sampling activities are discussed in the Sampling Plan, Sections 4, 5 and 6, and also in the QAPP, Section 9.

File Structure

A copy of the filing categories which will be used is attached.

SECTION 4
FINANCIAL AND PROJECT TRACKING

The financial and project tracking function of the data management system includes a detailed Work Plan including cost estimates with level of effort and a schedule for each task, and a detailed project tracking report. The detailed plan of work by task has been discussed in the Field Sampling Plan and in the Work Plan, Section 4.

Monthly project status reports will be submitted to the U.S. EPA and FPD. The reports will include a discussion of the progress made during the current reporting period, discussion of the problems that were resolved, anticipated problem areas and recommended solutions, the deliverables that were submitted during the period, upcoming events and activities that are planned for the next reporting period, and any key personnel changes. Any scheduling changes during the period will also be discussed.

Status reports of the project budget will be reported to the FPD with each monthly invoice. Each status report will include an accounting of all hours worked on the project and all expenses incurred during the previous month.

V721DMP01PJV/dms/GEP

[05/24/89]

PROJECT SINGLE-FILE STORAGE SYSTEM - FILE CHECKLIST SHEET

CATEGORY	FILE	COMMENTS	REQUIRED CATEGORIES[1,2]
File Index		List of all files: copy of this sheet is acceptable	X
Contracts/Proposals/Bids	A	Proposals, contracts, purchase orders, specifications-COPIES ONLY	X
Financial	B	Summary of invoice status: invoices correspondence re: accounts receivable: copy of budget and project task setup; COPIES ONLY	X
Correspondence	C	Various incoming and outgoing letters, memorandums, diary notes.	
		C1-All inhouse correspondence; diary notes and memos	X
		C2-All outgoing letters/memos	X
		C3-All incoming correspondence	X
		C4-Telephone conversation records	X
		C5-Chronological file - all correspondence	
		C6-Miscellaneous	
Planning Documents	D	Documents other than proposals: Health and Safety plans, Sampling plans, QAPPs, permit plans; special instructions/outlines for conducting the project; Work Plans; WEI plans and specifications	X
Quality Assurance	E	A work plan and budget; project history file; etc.	X
Field Data	F	Original field data/notebooks	X
		F1-Field boring logs	
		F2-Well construction details	
		F3-Geotechnical testing	
		F4-Geophysical testing	
		F5-Water Quality testing and water level measurements	
		F6-Daily field logs	
		F7-Baildown testing	
		F8-Structural testing	
		F9-Miscellaneous/Other	
		F10-Surveying/Warzyn Field Reports/Notebooks	

WARZYN

PROJECT SINGLE-FILE STORAGE SYSTEM - FILE CHECKLIST SHEET

(Continued)

CATEGORY	FILE	COMMENTS	REQUIRED CATEGORIES[1,2]
Laboratory Data	G	Laboratory test data: chemical, geotechnical, materials: original data and quality control data G1-Analytical laboratory data G2-Geotechnical laboratory data G3-Materials testing laboratory data G4-Subcontracted laboratory data	X
Calculations	H	Calculations, quantity estimates, computer printouts of tabularized data; sets of data should be bound separately	X
Photographs/Maps	I	Photographs, stereo pairs, site maps (published), zoning, topography, geology, groundwater, bedrock, negatives	X
Originals	J	Warzyn original reports or drafts	X
Warzyn Reports	K	Copies of the project report or previous pertinent WEI reports	X
Warzyn Drawings	L	Reference list of report drawings; copies or reduced copies of original drawings. Note: original or reduced mylars will be stored separately	X
Other Reports/Drawings	M	Non-Warzyn reports and drawings	X
Miscellaneous	N	Other file information which does not fit into other categories; file must be named.	X
Checkprint	O	TEMPORARY FILE of checkprints, draft reports or other work in progress. File must be removed upon job completion.	X

[1] Main file categories indicated with an X are standard on all projects, but will not be set up by Records until category-specific data is generated.

[2] Subcategories may be established by the Project Manager on a project-specific basis (e.g., Superfund projects).

SS/kjw/KEB/DWH
[ckb-400-98]

DOCUMENT AUDIT CHECKLIST*

PROJECT NO. ____________________ DATE OF AUDIT ____________

PROJECT LOCATION ________________ SIGNATURE OF AUDITOR ________

FILE LOCATION ___________________

Yes__ No__ 1. Have individual files been assembled (field investigation, laboratory, other)?

Comments:________________________________

____

____

Yes__ No__ 2. Is each file inventoried?

Comments:________________________________

____

____

Yes__ No__ 3. Is there a list of accountable documents?

Comments:________________________________

____

____

Yes__ No__ 4. Are all accountable documents present or accounted for?

Comments:________________________________

____

____

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* From NEIC Procedure Manual for the Evidence Audit of Enforcement Investigations by Contractor Evidence Audit Teams, EPA-300/9-81-003-R, April, 1984.

Yes__ No__ 5. Is a document numbering system used?

Comments:____

____

____

Yes__ No__ 6. Has each document been assigned a document control number?

Comments:____

____

____

Yes__ No__ 7. Are all documents listed on the inventory accounted for?

Comments:____

____

____

Yes__ No__ 8. Are there any documents in the file which are not on the inventory?

Comments:____

____

____

Yes__ No__ 9. Is the file stored in a secure area?

Comments:____

____

____

Yes__ No__ 10. Are there any project documents which have been declared confidential?

Comments:____

____

____

Yes__ No__ 11. Are confidential documents stored in a secure area separate from other project documents?

Comments:______________________________

____

____

Yes__ No__ 12. Is access to confidential files restricted?

Comments:______________________________

____

____

Yes__ No__ 13. Have confidential documents been marked or stamped "Confidential"?

Comments:______________________________

____

____

Yes__ No__ 14. Is confidential information inventoried?

Comments:______________________________

____

____

Yes__ No__ 15. Is confidential information numbered for document control?

Comments:______________________________

____

____

Yes__ No__ 16. Have any documents been claimed confidential under TSCA?

Comments:______________________________

____

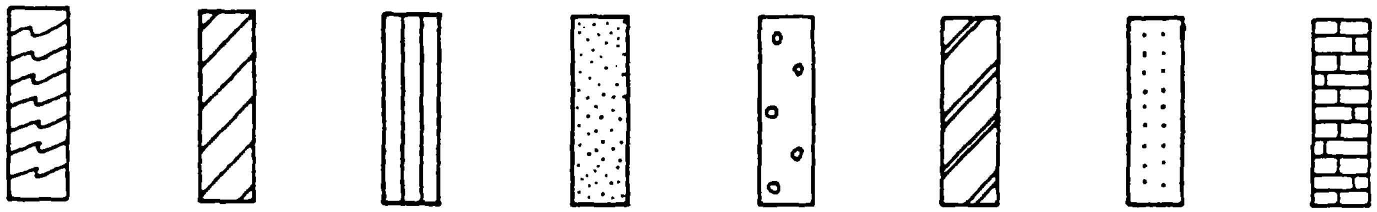
____

APPENDIX B

BORING LOGS FROM PREVIOUS SITE INVESTIGATIONS

TESTING SERVICE CORPORATION

LEGEND FOR BORING LOGS



ST = THIN WALLED TUBE SAMPLE

SS = Split Spoon Sample

γ_D = Dry unit weight in pounds per cubic foot

A = Auger Sample

WC = In situ water content

= Penetration Resistance in Blows per Foot - by driving 2" O.D. Split Spoon Sampler a distance of 12 inches with a 140-pound weight freely falling 30 inches

= water level at end of boring

▼ = water level after elapsed time interval

∇ = water level while Drilling

Qu = Unconfined compression strength in Tons per Square Foot

* = Denotes strength was based on pocket penetrometer measurements . Maximum range = 5.0

MATERIAL	SIZE RANGE
BOULDER	Over 8 inches
COBBLE	8 inches to 2-1/2 inches
Coarse GRAVEL	2-1/2 inches to 1 inch
Medium GRAVEL	1 inch to 3/8 inch
Small GRAVEL	3/8 inch to No. 4 sieve
Coarse SAND	No. 4 sieve to No. 20 sieve
Medium SAND	No. 20 sieve to No. 60 sieve
Fine SAND	NO. 60 sieve to No. 200 sieve
SILT or CLAY	Finer than No. 200 sieve

COHESIVE SOILS

Classification	Qu
Very Soft	0.35
Soft	0.35 to 0.59
Stiff	0.60 to 0.99
Tough	1.00 to 1.99
Very Tough	2.00 to 3.99
Hard	4.00 and over

COHESIONLESS SOILS

Classification	N
Very Loose	0 - 4
Loose	5 - 9
Firm	10 - 29
Dense	30 - 49
Very Dense	50 and over

Modifying Term	Per Cent by Weight
Trace	1 - 10
Little	10 - 20
Some	20 - 35
And	35 - 50

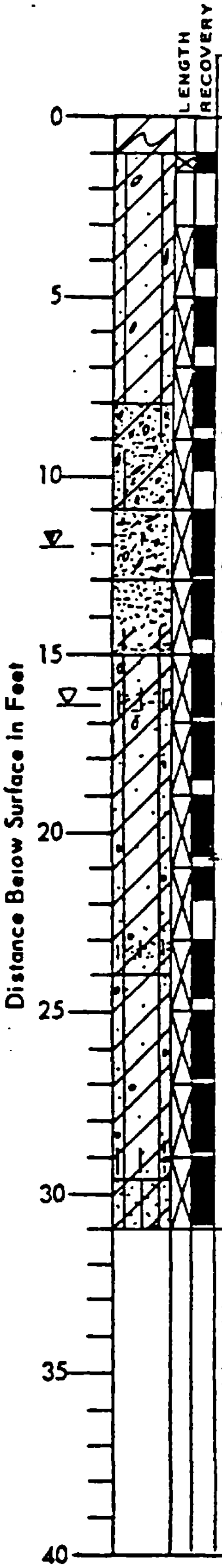
G 100

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBAR

BORING North well DATE STARTED 5-20-80 DATE COMPLETED 5-20-80 JOB 17,45

ELEVATIONS		WATER TABLE	
GROUND SURFACE		AT END OF BORING	-16.5'
END OF BORING		24 HOURS	
		While Drilling	-12.0'



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γ DRY
1	SS	25/6"	7.0		
a 2b	SS	71/10"			
a 3b	SS	71/11"	7.5		
a 4b	SS	46			
a 5b	SS	19			
a 6b	SS	22			
a 7b	SS	16			
a 8b	SS	16	14.4 16.9	4.5+* 3.25*	
a 9b	SS	14	12.3 12.6	4.50* 4.25*	
a 10b	SS	24	12.7 12.8	3.75*	
a 11b	SS	54	12.8 13.4	2.25*	
a 12b	SS	37	16.1 15.4	4.50* 4.5+*	
a 13b	SS	25	12.5 12.5	4.5+* 4.5+*	
a 14b	SS	26	17.1 17.6	4.00* 4.50*	
a 15b	SS	20			

DEPTH	ELEV.	SOIL DESCRIPTIONS
1.0		FILL - Black and dark brown clayey TOPSOIL
8.0		FILL - Brown and black silty CLAY (CL) and small to large GRAVEL (GW); trace sand Note: Slight odor in sample 2B
11.0		Dense to firm light grayish-b[illegible]n fine to coarse SAND, some small t medium gravel, trace silt and cla to 9.0', moist (SW)
13.0		Firm brown fine to coarse SAND an small to medium GRAVEL, very mois to wet at 12.0' (SW/GW)
15.0		Firm dark gray medium to coarse SAND, wet (SP); 2" clayey silt seam at 14.8' – Note: This zone (13.0-15.0') may contain leachate Slight odor noted.
24.0		Hard to very tough gray very silt CLAY, trace sand and gravel, mois (CL); 6" layer of clayey sandy silt at 16.5'; occasional clayey silt layers; occasional silt [illegible] n 8" clayey sandy silt layer at 23.
29.7		Hard gray silty CLAY, trace sand and gravel, moist (CL); silt seam at 29.0'
		Firm gray clayey sandy SILT, very moist (ML)

End of Boring at 31.0'

Bottom of monitoring well was installed at a depth of 16.0' and sealed from 5.0' to ground surface.

*-Approximate unconfined compressio strength based on measurements w a calibrated pocket penetrometer.

TESTING SERVICE CORPORATION

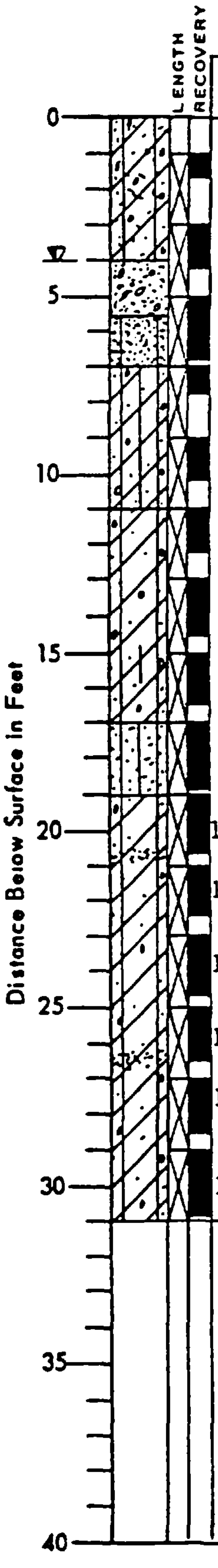
G101

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBARD

BORING Sta. 1 DATE STARTED 5-20-80 DATE COMPLETED 5-20-80 JOB 17.458

ELEVATIONS		WATER TABLE	
GROUND SURFACE		AT END OF BORING	
END OF BORING		24 HOURS	
		While Drilling	- 4.0'



SAMPLE NO.	TYPE	N	WC	Q_u	γ DRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
1_b^a	SS	40	19.8					FILL - Brown silty CLAY (CL) mixed with SAND and GRAVEL (SW/GW)
2_b^a	SS	27				4.0		Firm brown fine to coarse SAND and small to medium GRAVEL, wet (SW/GW)
3_b^a	SS	17				5.5		Firm light brown silty fine SAND, wet (SM) with thin layers of silt
4_b^a	SS	15				7.0		Firm gray clayey SILT, some sand and gravel, very moist (ML)
5_b^a	SS	11	14.2 14.0					
6_b^a	SS	31	13.6 13.2	4.0*		11.0		Hard gray silty CLAY, trace sand and gravel, moist (CL); thin layer of silt below 15.0'
7_b^a	SS	28	14.7	4.5+*				
8_b^a	SS	21	16.7	4.5*				
9_b^a	SS	21				17.0		Firm gray sandy (fine) SILT, wet (ML)
10_b^a	SS	35	13.2			19.0		Hard gray very silty CLAY, little sand and gravel, moist (CL) occasional seams and pockets of silt
11_b^a	SS	37	14.0 10.7	4.5+*				
12_b^a	SS	33	12.5	4.5+*				
13_b^a	SS	28	10.9 11.5	4.5+*				
14_b^a	SS	97	12.6 13.4	4.5+*				
15_b^a	SS	38	13.5	4.5+*				

End of Boring at 31.0 feet

Bottom of monitoring well was installed at a depth of 11.0 feet and sealed from 3.0 feet to ground surface

*-Approximate unconfined compressio strength based on measurements wi a calibrated pocket penetrometer.

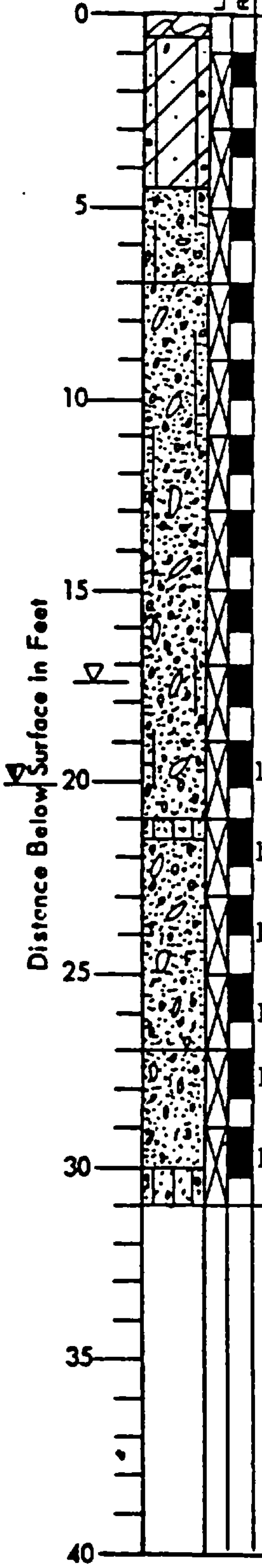
6102

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBARD

BORING Sta. 2 DATE STARTED 5-5-80 DATE COMPLETED 5-5-80 JOB 17,458

ELEVATIONS		WATER TABLE	
GROUND SURFACE		AT END OF BORING	-17.5'
END OF BORING		24 HOURS	
		While Drilling	-20.0'



SAMPLE NO.	TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
						0.6		FILL - Black clayey TOPSOIL
1^{a}_{b}	SS	12	25.4 27.5					FILL - Brown silty CLAY, little sand and gravel (CL)
2^{a}_{b}	SS	10	30.4 30.5			4.5		
3^{a}_{b}	SS	24				7.0		Firm light brown to brown fine to coarse SAND, some gravel, trace silt (SW)
4^{a}_{b}	SS	22						
5^{a}_{b}	SS	11						Firm to dense brown to light brown fine to coarse SAND and small to large GRAVEL, trace silt, very moist to wet at 20.0' (SW/GW)
6^{a}_{b}	SS	20						
7^{a}_{b}	SS	14						
8^{a}_{b}	SS	31						
9^{a}_{b}	SS	29						
10^{a}_{b}	SS	35				21.0		
11^{a}_{b}	SS	22				21.5		Brown SILT, little sand and gravel, wet (ML)
12^{a}_{b}	SS	27						Firm brown to light brown fine to coarse SAND and small to large GRAVEL, wet (SW/GW)
13^{a}_{b}	SS	28				27.0		
14^{a}_{b}	SS	22						Firm to dense fine to coarse SAND and small GRAVEL, wet (SW)
15^{a}_{b}	SS	41				30.0		Dense brown sandy (fine) SILT, trace gravel, very moist (ML)

End of Boring at 31.0 feet

Bottom of monitoring well was installed at a depth of 25.0 feet and sealed from 2.0 feet to ground surface.

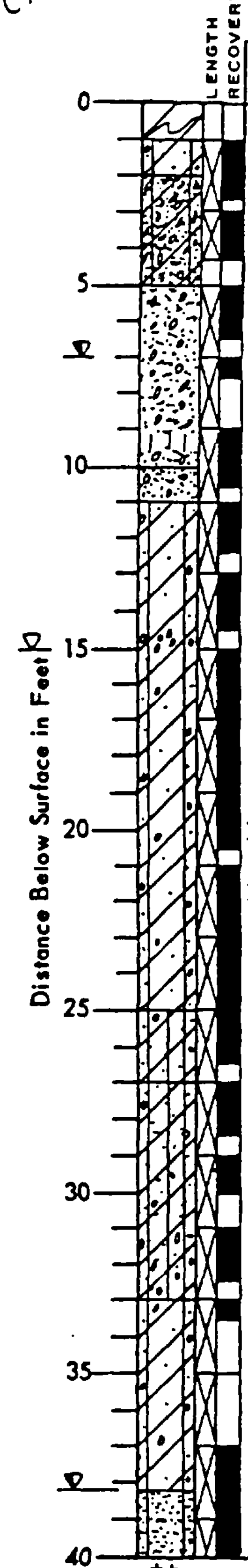
G103S
G103D

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE
CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBARD
BORING Sta. 3 DATE STARTED 4-5-80 DATE COMPLETED 4-5-80 JOB 17,458

ELEVATIONS
GROUND SURFACE
END OF BORING

WATER TABLE
AT END OF BORING -15.0'
24 HOURS
While Drilling - 7.0',-38.3'

SHEET 1 of 2



SAMPLE NO.	TYPE	N	WC	Q_u	γ DRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
						1.0		FILL - Dark brown clayey TOPSOIL
1^a_b	SS	28	12.1			2.0		FILL - Brown and gray silty CLAY, little sand and gravel (CL)
2^a_b	SS	100/10"	7.4 11.2					FILL - Brown silty, sandy, claye small to medium GRAVEL (GC)
3^a_b	SS	49				5.0		Very dense to firm grayish-brown fine to coarse SAND and small to medium GRAVEL, moist to wet at 7.0' (SW/GW) 6" sandy silt layer at 9.5'
4^a_b	SS	70						
5^a_b	SS	20				10.0		Firm brown fine to coarse SAND, little small gravel, wet (SW)
6^a_b	SS	20				11.0		Hard to very tough gray silty CLAY, trace sand and gravel, moist (CL): occasional thin gravel layers to 15.0'
7^a_b	SS	35	16.1 15.6	4.5+* 4.5+*				
8^a_b	SS	17	17.8 15.3	2.75* 4.5+*				
9^a_b	SS	16	16.0 16.3	4.5+* 4.5+*				
10^a_b	SS	16	17.3 17.0	3.75* 3.75*				
11^a_b	SS	16	17.2 17.7	3.0*				
12^a_b	SS	24	18.4 16.1	2.25* 3.5*				
13^a_b	SS	17	18.5 18.9			25.0		Firm brownish-gray clayey SILT, some sand and gravel, moist (ML)
14^a_b	SS	39	9.2 7.9			27.0		Dense to firm gray clayey SILT, some sand and gravel, considerat gravel from 31.0'-33.0', moist (ML)
15^a_b	SS	22						
16^a_b	SS	27	7.2					
17^a_b	SS	15	12.2 13.1	2.5* 2.5*		33.0		Very tough gray silty CLAY, little gravel, trace sand, mois (CL)
18**	SS	14						
19^a_b	SS	10	16.5	2.75*		38.3		Firm gray very silty, very fine SAND, wet (SM)
20a	SS	30						

** - Driving on pc Gravel

TESTING SERVICE CORPORATION

D3 SHD

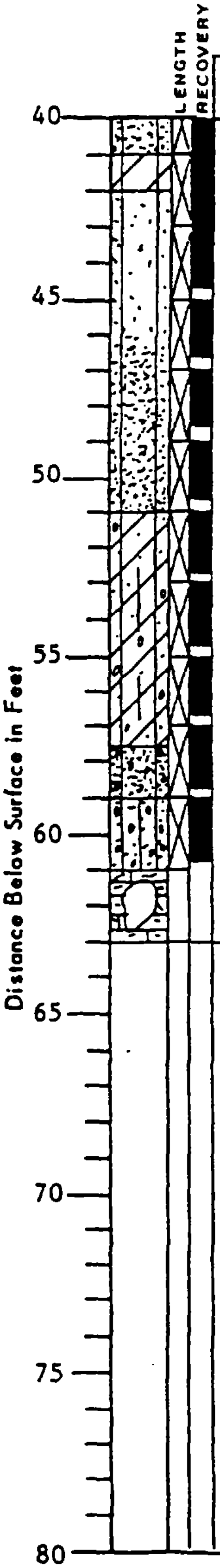
PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBARD

BORING Sta. 3 Con't. DATE STARTED 4-5-80 DATE COMPLETED 4-5-80 JOB 17,458

ELEVATIONS	WATER TABLE
GROUND SURFACE	AT END OF BORING -15.0'
END OF BORING	24 HOURS
	While Drilling - 7.0', -38.3'

SHEET 2 of 2



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γ DRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
20b	SS	30	24.7	1.5*		41.0		Firm gray very silty, very fine SAND, wet (SM)
21^{a}_{b}	SS	3				42.0		Tough gray silty CLAY, laminated, moist (CL)
22^{a}_{b}	SS	12						
23^{a}_{b}	SS	35						Very loose to dense gray very silty, very fine SAND, wet (SM)
24^{a}_{b}	SS	42						
25^{a}_{b}	SS	46				51.0		
26^{a}_{b}	SS	40	8.9					Very tough to hard gray silty CLAY (CL) and dense to very dense gray clayey SILT (ML); little sand and gravel; numerous layers of sand and silt
27^{a}_{b}	SS	50	9.4 12.5	 3.75*				
28^{a}_{b}	SS	44	12.0 10.2	2.25* 4.5+*				
29^{a}_{b}	SS	75				57.8		Very dense brownish-gray silty, gravelly fine to coarse SAND, moist (SM/SW)
$30^{a}_{b\,c}$	SS	120				59.0		Very dense gray sandy, gravelly SILT, very moist (ML)
						61.0		Weathered light gray DOLOMIT or BOULDER

End of Boring at 63.0 feet

Bottom of shallow monitoring well was installed at a depth of 47.0 feet and sealed from 6.0 feet to ground surface.

Bottom of deep monitoring well was installed at a depth of 62.0 feet and sealed from 55.0 feet to 51.0 feet.

*-Approximate unconfined compressi strength based on measurements w a calibrated pocket penetrometer.

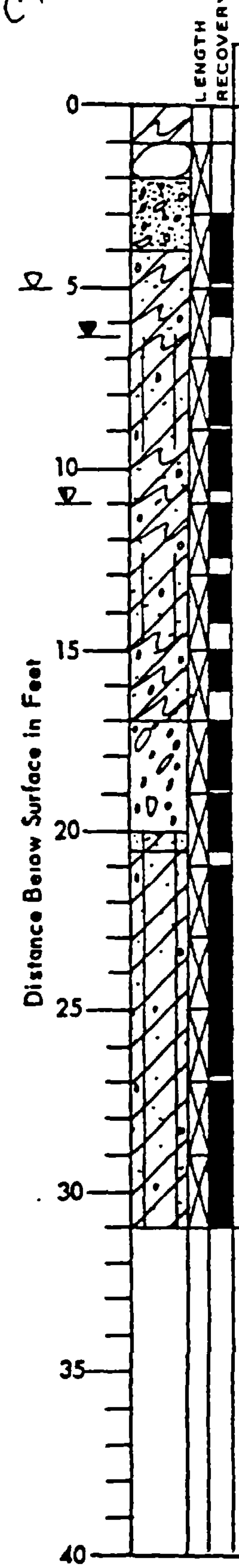
G104

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBA

BORING Sta. 4 DATE STARTED 5-8-80 DATE COMPLETED 5-8-80 JOB 17,4

ELEVATIONS		WATER TABLE	
GROUND SURFACE		AT END OF BORING	-5.0'
END OF BORING		24 HOURS	-6.4'
		While Drilling	-11.0'



SAMPLE NO.	TYPE	N	WC	Qu	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
						1.0		FILL - Black clayey TOPSOIL
								FILL - BOULDER
1**	SS					2.0		FILL - Brown SAND and GRAVEL (SW/GW)
a			26.4			4.0		
2b	SS	7	31.1					FILL - Black clayey TOPSOIL, black to gray slightly organic CLAY and brown silty CLAY, trace sand and gravel (OH/CL)
a			27.1					
3b	SS	7	19.9					
a			23.4					
4b	SS	15	22.7					
a			25.7					
5b	SS	5	26.6					
a			30.2					
6b	SS	5	26.1					
a			24.5					
7b	SS	6	24.4					
a			28.0					
8b	SS	20	24.0			17.0		
a								Very dense brown-gray fine to coarse SAND and small to large GRAVEL, wet (SW/GW)
9b	SS	77						
a						20.0		
10b	SS	21	13.9	2.50*		20.5		Very tough brown very silty CL trace sand, moist (CL)
a			14.5	3.50*				
11b	SS	27	14.4	3.50*				Very tough to hard gray silty CLAY, trace sand and gravel, moist (CL); 4" seam of soft brown and black silty clay at 21.0'
a			13.8	4.50*				
12b	SS	28	13.2	4.50				
a			15.1	2.50*				
13b	SS	20	13.7	4.50*				
a			19.1	3.50*				
14b	SS	19	17.0	3.50*				
a			17.7	4.00*				
15b	SS	16	20.4	2.50*				

**-No sample obtained due to boulder

End of boring at 31.0 feet.

Bottom of monitoring well installed at a depth of 20.0' and sealed from 3.0' to ground surface.

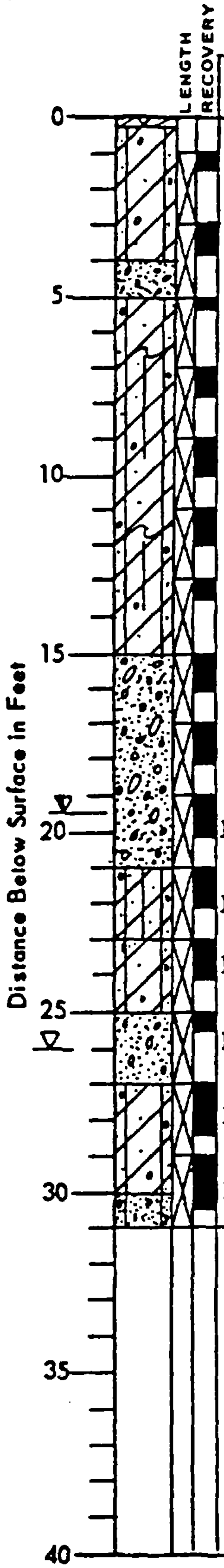
*-Approximate unconfined compre strength based on measurement a calibrated pocket penetromet

TESTING SERVICE CORPORATION

G105

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE
CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBARD
BORING Sta. 5 DATE STARTED 5-6-80 DATE COMPLETED 5-6-80 JOB 17,458

ELEVATIONS		WATER TABLE	
GROUND SURFACE		AT END OF BORING	-26.0'
END OF BORING		24 HOURS	
		While Drilling	-19.5'



SAMPLE NO.	TYPE	N	WC	Q_u	γ DRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
						0.2		FILL - Black sandy, clayey TOPSOI
1^a_b	SS	21	11.0					FILL - Gray silty CLAY, trace sand and gravel (CL)
2^a_b	SS	12	13.6 12.5			4.0 5.0		FILL - Brown SAND and GRAVEL (SW/GW)
3^a_b	SS	61	12.4					FILL - Gray silty CLAY (CL) and clayey SILT (ML), some sand and gravel, trace organic
4^a_b	SS	12	15.4 8.4					
5^a_b	SS	12	12.4 15.0					
6^a_b	SS	12	11.4 14.4					
7^a_b	SS	8	14.8					
8^a_b	SS	34				15.0		Dense to very dense light brown to brownish-gray fine to coarse SAND and small to large GRAVEL, damp to wet at 19.5' (SW/GW)
9^a_b	SS	51						
10^a_b	SS	49						NOTE: Foul odor noted in Sample 10
11^a_b	SS	31	13.3 12.7			21.0		Dense brown clayey SILT, trace sand and gravel, moist ( )
12^a_b	SS	26	15.9 15.0	4.5+* 4.5+*		23.0		Hard gray very silty CLAY, trac sand and gravel, moist (CL)
13^a_b	SS	35				25.0		Dense gray fine to coarse SAND & small to medium GRAVEL, wet (SW/GW)
14^a_b	SS	60	15.6 17.2	4.5+* 4.25*		27.0		Hard gray silty CLAY, trace sand and gravel, moist (CL)
15^a_b	SS	23	18.1	4.5+*		30.0		Firm gray sandy (fine) SILT, trace gravel, moist (ML)

End of Boring at 31.0 feet

NOTE: Gas was being emitted from monitoring well after installation.

Bottom of monitoring well was installed at 21.5' and sealed from 2.0' to ground surface.

*-Approximate unconfined compres strength based on measurements a calibrated pocket penetromete

TESTING SERVICE CORPORATION

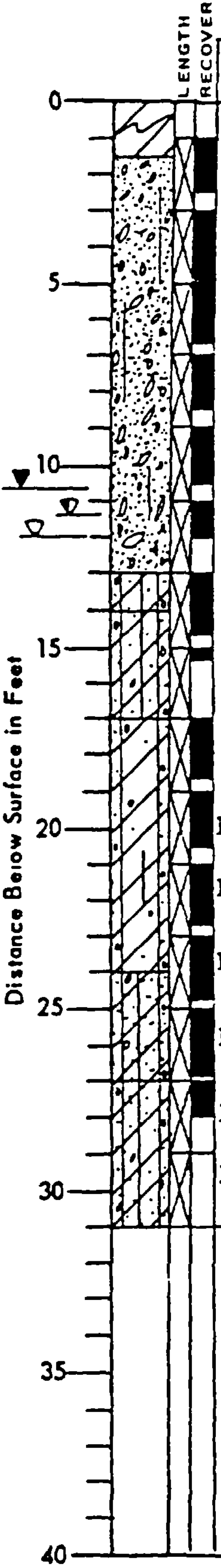
G106

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBARD

BORING Sta. 6 DATE STARTED 5-8-80 DATE COMPLETED 5-8-80 JOB 17,458

ELEVATIONS		WATER TABLE	
GROUND SURFACE		AT END OF BORING	-12.0'
END OF BORING		24 HOURS	-10.8'
		While Drilling	-11.5'



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
1^a_b	SS	17	26.4			1.5		FILL - Dark brown to black clayey TOPSOIL
2^a_b	SS	16						Firm to very dense light grayish-brown fine to coarse SAND and small to large GRAVEL, trace silt, occasional cobbles, damp (SW/GW)
3^a_b	SS	44						
4^a_b	SS	58						
5^a_b	SS	35						
6^a_b	SS	40						
7^a_b	SS	11	11.6 13.4			13.0 14.0		Firm brown clayey SILT, some sand, trace small gravel, very moist (ML)
8**	SS	18	13.6					Firm gray clayey SILT, little sand and gravel, moist (ML)
9^a_b	SS	14	11.6 11.6	3.5* 4.5+*		17.0		Very tough to hard gray silty CLAY, little sand and gravel, moist (CL); occasional clayey gravel zones; layer of silt and clayey silt from 21.0'-22.0'
10^a_b	SS	16	11.5 11.8	4.0* 4.5+*				
11^a_b	SS	23	13.8 17.3	4.5+* 4.25*				
12^a_b	SS	18	20.3	3.5*		24.0		
13^a_b	SS	24	19.8	2.0*				Firm grayish-brown sandy, clayey SILT, trace gravel, very moist (ML): layer of very tough gray silty clay from 25.0'-26.0'
14^a_b	SS	23	9.2			27.0		Firm to dense brownish-gray clayey SILT, some sand, considerable gravel, moist (ML)
15^a_b	SS	35	10.0					

End of Boring at 31.0 feet

Bottom of monitoring well installed at a depth of 15.0 feet and sealed from 2.0 feet to ground surface.

*-Approximate unconfined compressio strength based on measurements w a calibrated pocket penetrometer.

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE

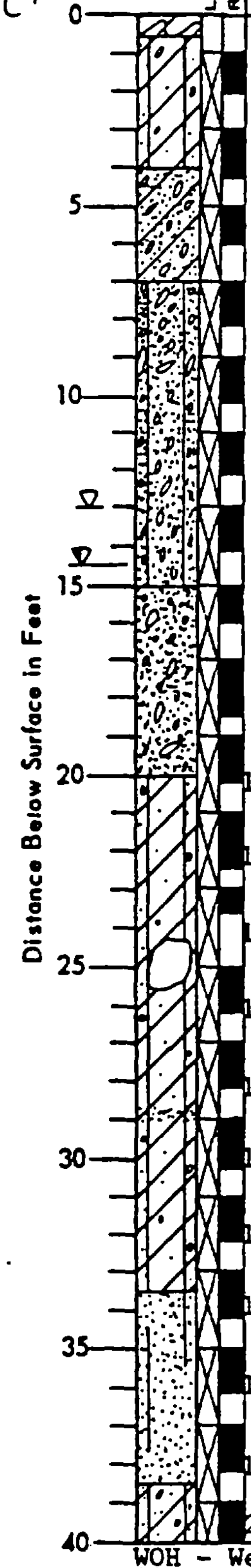
CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBAR

BORING Sta. 8 DATE STARTED 5-7-80 DATE COMPLETED 5-9-80 JOB 17,45

ELEVATIONS		WATER TABLE	
GROUND SURFACE		AT END OF BORING	13.0'
END OF BORING		24 HOURS	
		WHILE DRILLING	14.5'

61075
6107D

SHEET 1 OF



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
1a 1b	SS	12	26.7 29.0			0.5		FILL - Black clayey TOPSOIL FILL - Brown silty CLAY, trace sand & gravel (CL)
2a 2b	SS	7	25.8			4.0		
3a 3b	SS	24				7.0		Firm brown to light brown clayey SAND & GRAVEL, moist (SC)
4a 4b	SS	25						
5a 5b	SS	10						Firm brown to light brown silty fine to coarse SAND & small to large GRAVEL, very moist to wet at 14.5' (SM/GM)
6a 6b	SS	20						
7a 7b	SS	16				15.0		
8a 8b	SS	22						Firm to dense brown to light brown fine to coarse SAND & small to large GRAVEL, wet (SW/G
9a 9b	SS	40				20.0		
10a 10b	SS	16	9.7	4.5*				
11a 11b	SS	38	8.1 9.4	4.5+* 4.5+*				Hard to very tough gray very silty CLAY, little sand & gravel moist (CL); occasional clayey silt layers; boulder at 25'; 2" wet sand seam at 29.0'
12a 12b	SS	65/5"**	9.1 9.2	4.5+* 4.5+*				
13a 13b	SS	38	9.2 8.3	 4.5+*				
14a 14b	SS	35	10.1 10.4	4.5+* 4.5+*				
15a 15b	SS	40	9.3 12.0	4.5+*				
16a 16b	SS	28	13.1 12.6	3.25* 4.25*		33.5		
17a 17b	SS	34						Dense to very loose gray fine SAND, trace silt, wet (SP)
18a 18b	SS	WOH						
19a 19b	SS	8	14.6	1.75*		38.5		
20a	SS	63/6"**	13.9	1.5*				Tough gray very silty CLAY, litt sand & gravel, moist

WOH - Weight of Hammer
** - Driving on Boulder
DRILL RIG NO. 72

TESTING SERVICE

*Approximate unconfined compressi
strength based on measurements w

G107S
G107D

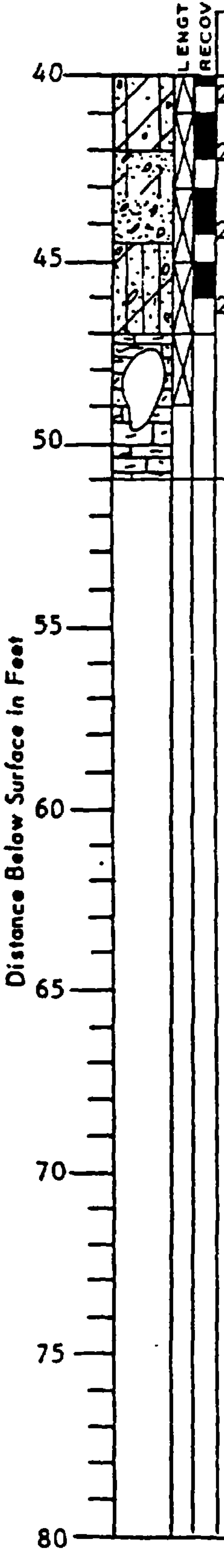
PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBARD

BORING Sta. 8 con't DATE STARTED 5-7-80 DATE COMPLETED 5-9-80 JOB 17,458

ELEVATIONS		WATER TABLE	
GROUND SURFACE		AT END OF BORING	13.0'
END OF BORING		24 HOURS	
		WHILE DRILLING	14.5'

SHEET 2 of 2



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
20b	SS	63/6"	12.7	2.5*				Very tough gray silty CLAY, little sand & gravel, moist (CL); with layers of silt & sand from 41.0' to 43.0'
21^{a}_{b}	SS	26				42.0		Firm to dense gray fine to coarse SAND & small GRAVEL, wet (SW/GW) very tough gray silty clay layer at 43.0'
22^{a}_{b}	SS	43	17.0	2.5*		44.5		Very dense gray sandy SILT, trace clay, some large gravel, wet (ML)
23^{a}_{b}	SS	30/2"				47.0		Weathered light gray DOLOMITE or BOULDER

End of Boring at 51.0'.

Bottom of shallow monitoring well was installed at 39.0' and sealed from 3.0' to ground surface.

Bottom of deep monitoring well was installed at a depth of 47.0' and sealed above 42.0'.

*-Approximate unconfined compression strength based on measurements wit a calibrated pocket penetrometer.

TESTING SERVICE CORPORATION

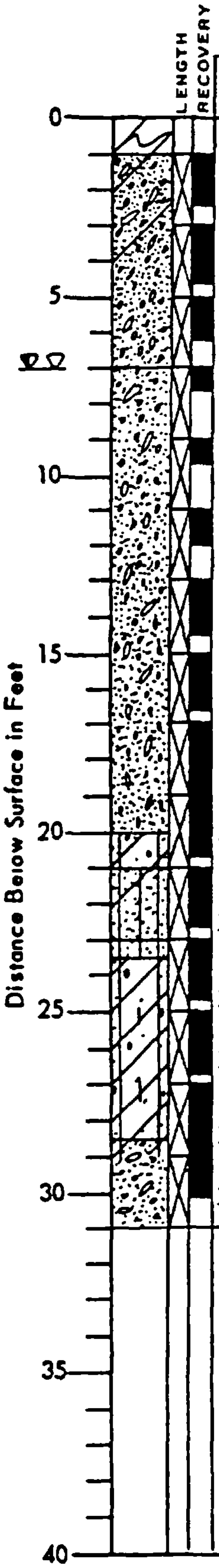
6108

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBA

BORING Sta. 9 DATE STARTED 4-21-80 DATE COMPLETED 4-21-80 JOB 17,45

ELEVATIONS		WATER TABLE	
GROUND SURFACE		AT END OF BORING	-7.0'
END OF BORING		24 HOURS	-5.8'
		While Drilling	-7.0'



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
						1.0		FILL - Black clayey TOPSOIL
1a 1b	SS	60						Very dense to firm light grayish brown to brown fine to coarse SAND and small to large GRAVEL, trace clay to 3.0', damp (SW/GW)
2a 2b	SS	28						
3a 3b	SS	24				7.0		
4a 4b	SS	12						Firm to very dense grayish-b small to large GRAVEL and fine to coarse SAND, occasional cobbles, wet (GW/SW)
5a 5b	SS	38						
6a 6b	SS	37						
7a 7b	SS	51						
8a 8b	SS	37						
9a 9b	SS	74						
10a 10b	SS	24	13.3	4.5+*		20.0		Very tough gray very silty CLAY little sand and gravel, moist (a few seams of silty fine s
						21.0		Firm gray fine SAND, trace clay occasional silty clay laminatio
11a 11b	SS	18				23.0		Firm fine sandy SILT, wet (ML)
						23.5		Hard gray very silty CLAY, litt sand & gravel, moist (CL), occasional clayey sandy silt seams below 26.0'
12a 12b	SS	36	11.7	4.5+*				
13a 13b	SS	22	11.0 11.8	4.5+* 4.5+*				
			12.6	4.5+*				
14a 14b	SS	65				28.5		Very dense to dense gray fine t coarse SAND and small to large GRAVEL, wet (SW/GW); 6" silty clay layer at 29.5'
15a 15b	SS	37						

End of Boring at 31.0 feet

Bottom of monitoring well was installed at depth of 15.0 feet and sealed from 2.0 feet to ground surface.

*-Approximate unconfined compre strength based on measurements a calibrated pocket penetromet

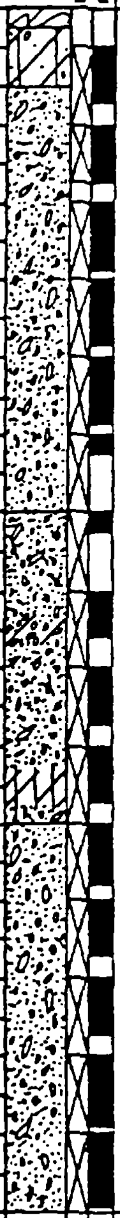
G109

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBARD

BORING Sta 9+140 DATE STARTED 4-25-80 DATE COMPLETED 4-28-80 JOB 17,458

ELEVATIONS		WATER TABLE	
GROUND SURFACE		AT END OF BORING	-10.0'
END OF BORING		24 HOURS	
		While Drilling	-12.5'



Distance Below Surface in Feet	SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
0							0.5		FILL - Black clayey TOPSOIL
	a 1b	SS	22	22.9			2.0		FILL - Brown silty CLAY, little sand and gravel (CL)
	a 2b	SS	43						
5	a 3b	SS	23						Firm to dense light grayish-brown small to large GRAVEL and fine to coarse SAND, occasional cobbles, damp to wet at 12.5' (GW/SW)
	a 4b	SS	34						
∇ 10	a 5b	SS	21						
∇	a 6b	SS	22				13.0		
	a 7b	SS	11						Firm brown small to large GRAVEL little to some sand, a few cobbl wet (GW); 2" clayey gravel seam 16.0'; 5" gray sandy-clayey silt seam at 20.5'
15	a 8b	SS	19						
	a 9b	SS	28						
20	a 10b	SS	26				21.0		
	a 11b	SS	45						Dense to very dense grayish-brow fine to coarse SAND and small to large GRAVEL, a few cobbles, wet (SW/GW)
	a 12b	SS	46						
25	a 13b	SS	35						
	a 14b	SS	34						
30	a 15b	SS	54						

End of Boring at 31.0 feet

Bottom of monitoring well was installed at a depth of 20.0' and sealed from 2.0' to ground surface.

35

40

TESTING SERVICE CORPORATION

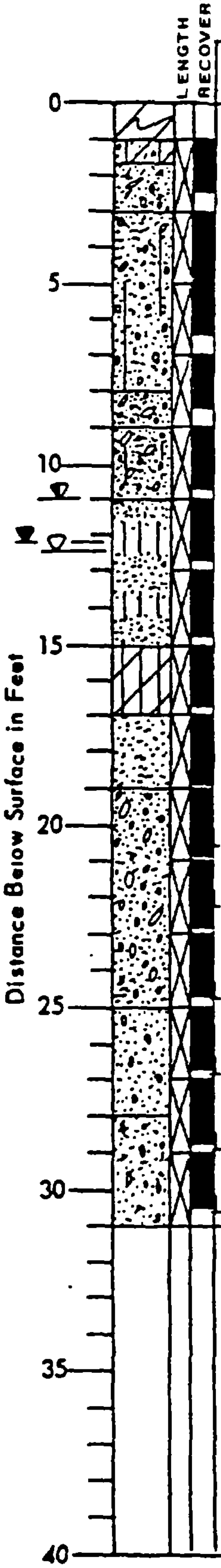
6110

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBARD

BORING Sta. 10 DATE STARTED 4-21-80 DATE COMPLETED 4-22-80 JOB 17,458

ELEVATIONS		WATER TABLE	
GROUND SURFACE		AT END OF BORING	-12.5'
END OF BORING		24 HOURS	-12.3'
		While Drilling	-11.0'



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
						1.0		FILL - Black clayey TOPSOIL
a			22.7			1.7		FILL - Brown silty CLAY, little sa and gravel (CL)
1b	SS	20						
						3.0		Firm grayish-brown small to mediu GRAVEL and fine to coarse SAND, damp (GW/SW)
a								
2b	SS	31						
a								Dense to firm grayish-brown fine to coarse SAND, little small gravel, trace silt, damp (SW)
3b	SS	32						
a								
4b	SS	29				8.0		Dense grayish-brown fine to co SAND and small to large GRAVEL, occasional cobbles, damp (SW/GW)
						9.0		
a								
5b	SS	80				11.0		Very dense grayish-brown small to large GRAVEL, some fine to coarse sand, trace silt and clay, moist (GW)
a								
6b	SS	20						Firm brown fine to medium SAND, w (SP) with layers of gray silt below 13.0'
a								
7b	SS	20				15.0		Firm gray clayey SILT, very moist (ML) with sand seams
a								
8b	SS	10				17.0		Firm gray medium SAND, wet (SP)
a								
9b	SS	19				19.0		Very dense to dense brownish-gray fine to coarse SAND and small to large GRAVEL, wet (SW/GW)
a								
0b	SS	63						
a								
1b	SS	54						
a								
2b	SS	34				25.0		Firm to dense grayish-brown medi to coarse SAND, trace small grav wet (SP)
a								
3b	SS	24				28.0		Dense grayish-brown fine to coar SAND and small to medium GRAVEL, wet (SW/GW)
a								
4b	SS	32						
a								
5b	SS	43						

END OF BORING AT 31.0 FEET

Bottom of monitoring well was installed at a depth of 19.0' and sealed from 2.0 feet to ground surface.

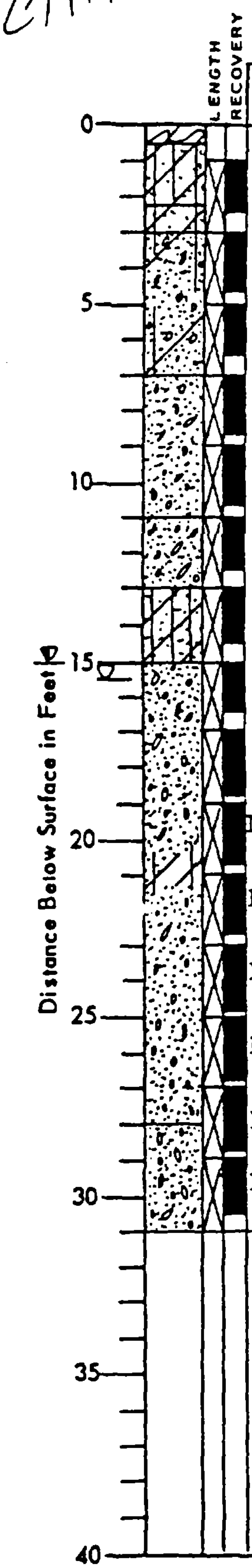
PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBARD

BORING Sta. 10+178 DATE STARTED 4-25-80 DATE COMPLETED 4-25-80 JOB 17,458

G111

ELEVATIONS		WATER TABLE	
GROUND SURFACE		AT END OF BORING	-15.5'
END OF BORING		24 HOURS	
		While Drilling	-15.0'



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
1 a/b	SS	17	16.7 23.9	4.5+*		0.5 2.2		FILL - Black clayey TOPSOIL FILL - Dark gray clayey SILT, trace sand (ML)
2 a/b	SS	14				3.0		Hard brown silty CLAY, little sand, moist (CL)
3 a/b	SS	10						Firm grayish-brown fine to coarse SAND, little to some gravel, little to trace silt and clay, damp (SW)
4 a/b	SS	21				7.0		Firm light grayish-brown fine to coarse SAND and small to medium GRAVEL, damp (SW/GW)
5 a/b	SS	26						
6 a/b	SS	16				11.0		Firm gray fine to coarse SAND and small to large GRAVEL, moist (SW/GW)
7 a/b	SS	14				13.0		Silt seam at 14.7'
8 a/b	SS	35				15.0		Firm brown sandy, clayey SILT, very moist (ML) with wet seams of sand and gravel
9 a/b	SS	43						
10 a/b	SS	64						Dense to very dense brownish-gray to gray sandy (fine to coarse) small to large GRAVEL, wet (GW) Clayey silt seam at 21'. Foul odor noted below 17'.
11 a/b	SS	36						
12 a/b	SS	39						
13 a/b	SS	44						
14 a/b	SS	29				28.0		Firm grayish-brown medium to coarse SAND and small to medium GRAVEL, wet (SW/GW)
15 a/b	SS	26						

End of Boring at 31.0 feet

Bottom of monitoring well installed at a depth of 21.0 feet and sealed from 3.0 feet to ground surface.

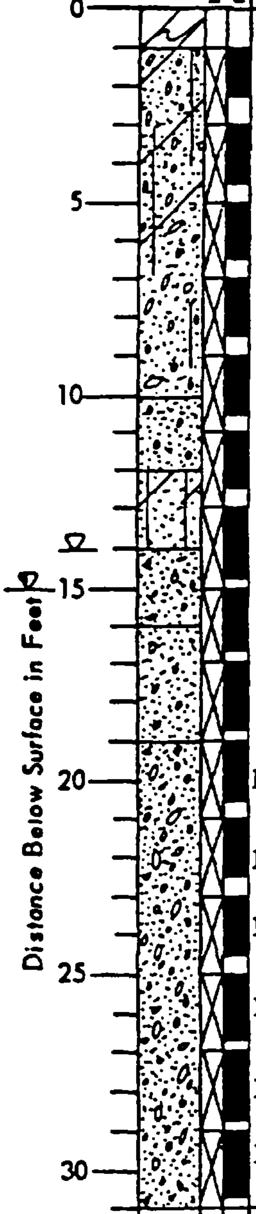
*-Approximate unconfined compressio strength based on measurements w a calibrated pocket penetrometer.

TESTING SERVICE CORPORATION

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE
CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBARD
BORING Sta. 11 DATE STARTED 4-22-80 DATE COMPLETED 4-22-80 JOB 17,458

G112

ELEVATIONS		WATER TABLE	
GROUND SURFACE		AT END OF BORING	-14.0'
END OF BORING		24 HOURS	-13.3'
		While Drilling	-15.0'



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
						1.0		FILL - Black clayey TOPSOIL
1^{a}_{b}	SS	30						Dense to firm light brownish-gray fine to coarse SAND and small to medium GRAVEL, trace silt and clay to 7', damp (SW/GW)
2^{a}_{b}	SS	38						
3^{a}_{b}	SS	26						
4^{a}_{b}	SS	20						
5^{a}_{b}	SS	10				10.0		Firm to loose light grayish-brown fine to coarse SAND, trace to little small gravel, damp (SW)
6^{a}_{b}	SS	8	27.2			12.0		Layers of tough brown silty CLAY, moist (CL); Loose brown and gray silty fine SAND, very moist (SM) and Brown and gray sandy fine SILT, very moist (ML)
7^{a}_{b}	SS	14				14.0		Firm gray medium to coarse SAND, little small to medium gravel, moist to wet at 15' (SP)
8^{a}_{b}	SS	15				16.0		Firm grayish-black fine to coarse SAND and small to medium GRAVEL, wet (SW/GW` NOTE: This zone (16'-19', Sample 8B, 9A, 9B) appeared to contain leachate. Foul odor also noted.
9^{a}_{b}	SS	19						
10^{a}_{b}	SS	20				19.0		Firm to dense gray to brownish-gray fine to coarse SAND and small to large GRAVEL, occasional cobbles, wet (SW/GW)
11^{a}_{b}	SS	37						
12^{a}_{b}	SS	44						
13^{a}_{b}	SS	37						
14^{a}_{b}	SS	31						
15^{a}_{b}	SS	30						

End of Boring at 31.0 feet
NOTE: A small amount of gas was encountered below 15.0 feet.
After completion, gas continued to slowly bubble out of bore hole.
The bottom of this monitoring well actually has an elevation equivalent to a depth of 20', as it was installed at a location having a ground surface elevation 1' below the ground surface elevation of this boring location.

TESTING SERVICE CORPORATION

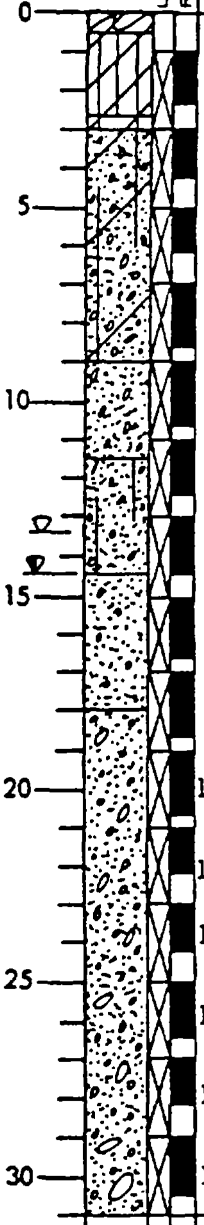
L7113

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBAR

BORING Sta. 11+80 DATE STARTED 4-23-80 DATE COMPLETED 4-23-80 JOB 17,45

ELEVATIONS		WATER TABLE	
GROUND SURFACE		AT END OF BORING	-13.5'
END OF BORING		24 HOURS	
		While Drilling	-14.5'



SAMPLE NO.	TYPE	N	WC	Q_u	γ DRY
1^{a}_{b}	SS	14	21.7		
2^{a}_{b}	SS	28			
3^{a}_{b}	SS	32			
4^{a}_{b}	SS	27			
5^{a}_{b}	SS	32			
6^{a}_{b}	SS	9			
7^{a}_{b}	SS	20			
8^{a}_{b}	SS	17			
9^{a}_{b}	SS	22			
10^{a}_{b}	SS	26			
11^{a}_{b}	SS	30			
12^{a}_{b}	SS	30			
13^{a}_{b}	SS	22			
14^{a}_{b}	SS	22			
15^{a}_{b}	SS	22			

DEPTH	ELEV.	SOIL DESCRIPTIONS
0.5		FILL - Black clayey TOPSOIL
2.7		FILL - Dark gray clayey SILT (ML)
3.0		FILL - Brown silty CLAY (CL)
9.0		Firm to dense light grayish-brown fine to coarse SAND and small to medium GRAVEL, trace silt and clay, moist (SW/GW)
11.5		Dense light grayish-brown fine to coarse SAND, little to small gravel, damp (SW)
14.5		Loose to firm grayish-brown fine to coarse SAND, trace silt and small gravel, very moist (SP)
18.0		Firm blackish-gray medium to coarse SAND, trace to some gravel, wet (SP) NOTE: This zone (14.5'-18.0', Samples 7B, 8A, 8B, 9A) appeared to contain leachate. Foul odor was also noted.
		Firm to dense gray fine to coarse SAND and small to large GRAVEL, wet (SW/GW)

End of Boring at 31.0 feet .

NOTE: Gas was observed coming out of the hollow stem auger after completing the boring.

Bottom of monitoring well was installed at a depth of 19.0 feet and sealed from 3.0 feet to ground surface.

TESTING SERVICE CORPORATION

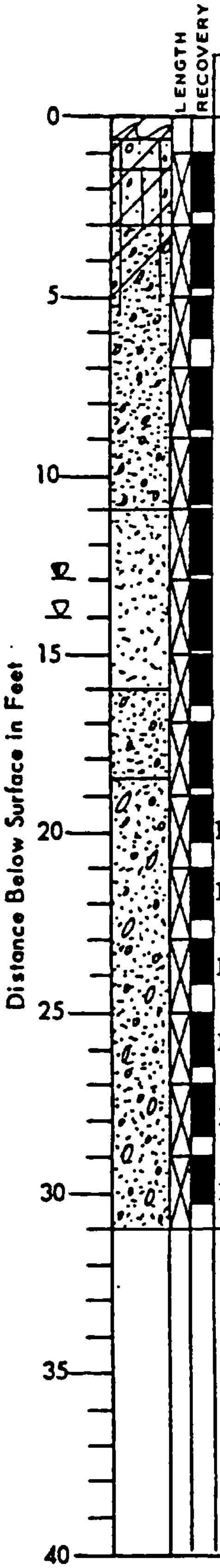
DRILL RIG NO. 53

6114

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE
CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBARD
BORING Sta. 11+160 DATE STARTED 4-23-80 DATE COMPLETED 4-23-80 JOB 17,458

ELEVATIONS
GROUND SURFACE
END OF BORING

WATER TABLE
AT END OF BORING -14.0'
24 HOURS
While Drilling -13.0'



SAMPLE NO.	TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
1^{a}_{b}	SS	18	21.3 22.3			0.7 1.4		FILL - Black clayey TOPSOIL FILL - Brown silty CLAY, little sand and gravel (CL)
2^{a}_{b}	SS	19				3.0		FILL - Dark gray clayey SILT, trace sand and gravel (ML)
3^{a}_{b}	SS	38						Firm to dense light grayish-brown fine to coarse SAND and small to medium GRAVEL, trace silt and clay to 5', damp (SW/GW)
4^{a}_{b}	SS	27						
5^{a}_{b}	SS	22						
6^{a}_{b}	SS	10				11.0		Firm to loose brown fine SAND, moist to wet at 13' (SP)
7^{a}_{b}	SS	7						
8^{a}_{b}	SS	16				16.0		Firm brown fine to coarse SAND, little to some small to medium gravel, wet (SW)
9^{a}_{b}	SS	23				18.5		
10^{a}_{b}	SS	30						
11^{a}_{b}	SS	24						Firm gray small to large GRAVEL and fine to coarse SAND, wet (GW/SW)
12^{a}_{b}	SS	28						
13^{a}_{b}	SS	30						
14^{a}_{b}	SS	31						
15^{a}_{b}	SS	36						

End of Boring at 31.0 feet

NOTE: Gas was encountered below 9.0'

Bottom of Monitoring Well was installed at a depth of 28.5 feet and sealed from 3.0 feet to ground surface.

G115S
G115D

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBARD

BORING Sta.12 West Well

DATE STARTED 4-29-80 EXTENDED 5-9-80

DATE COMPLETED 4-29-80 5-9-80

JOB 17,458

ELEVATIONS

GROUND SURFACE

END OF BORING

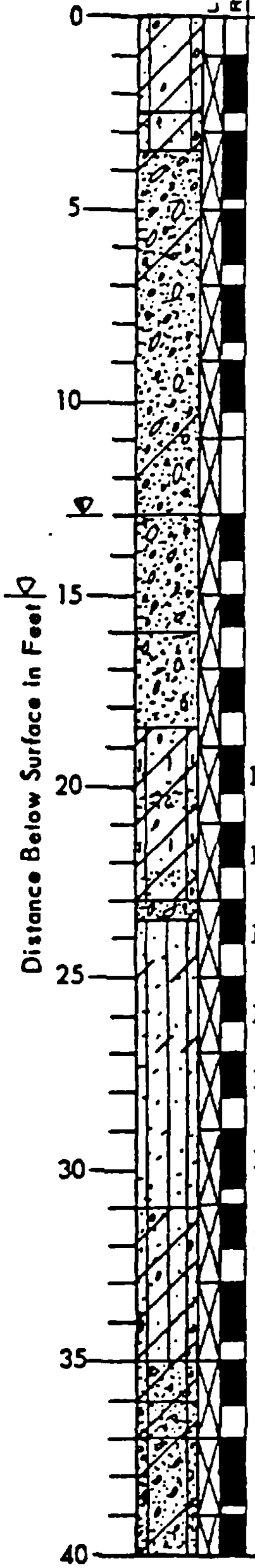
WATER TABLE

AT END OF BORING -15.0'

24 HOURS

While Drilling -13.0'

SHEET 1 of 2



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
1^{a}_{b}	SS	10	25.3 33.0			2.5		FILL - Brown to reddish-brown silty CLAY, trace sand and gravel (CL)
2^{a}_{b}	SS	15				3.5		Tough brown to reddish-brown sandy silty CLAY, little gravel, moist (CL)
3^{a}_{b}	SS	16						
4^{a}_{b}	SS	13						Firm brown fine to coarse SAND and small to large GRAVEL, a few cobbles, trace clay, moist (SW/GW)
5^{a}_{b}	SS	18						
6	SS	28						
7^{a}_{b}	SS	13				13.0		Firm light brown fine to coarse SAND and small to medium GRAVEL, wet (SW/GW)
8^{a}_{b}	SS	16				16.0		Firm gray fine to coarse SAND and small to medium GRAVEL, wet (SW/GW)
9^{a}_{b}	SS	9	22.7	3.75*		18.5		
10^{a}_{b}	SS	18	23.4 21.8	3.5* 1.5*				Very tough to tough gray silty CLAY, trace sand and gravel, moist (CL); occasional thin layers of silt and sand
11^{a}_{b}	SS	10						
12^{a}_{b}	SS	8				23.0 23.5		Loose gray fine to coarse SAND and small to large GRAVEL, wet (SW/GW)
13^{a}_{b}	SS	4	28.6 20.1					Very loose to firm gray sandy (fine) SILT, wet (ML) with thin layers of clayey silt between 23.0' to 27.0'
14^{a}_{b}	SS	7						
15^{a}_{b}	SS	9						
16^{a}_{b}	SS	33				31.0		Dense to firm grayish-brown sand clayey SILT, little gravel, very moist (ML); a few wet layers of sand and gravel
17^{a}_{b}	SS	20						
18^{a}_{b}	SS	17				35.0 36.0		Firm grayish-brown clayey, silty SAND and GRAVEL, very moist (SC)
19^{a}_{b}	SS	93				37.0		Firm grayish-brown fine to coars SAND and small to medium GRAVEL, trace silt & clay, wet (SW/GW)
20a	SS	34						(SEE NEXT PAGE)

Boring Log Continued

TESTING SERVICE

*-Approximate unconfined compressic

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBARD

BORING Sta. 12 con't West Well DATE STARTED 4-29-80 EXTENDED 5-9-80 DATE COMPLETED 4-29-80 5-9-80 JOB 17,458

G115S
G115D

ELEVATIONS

GROUND SURFACE

END OF BORING

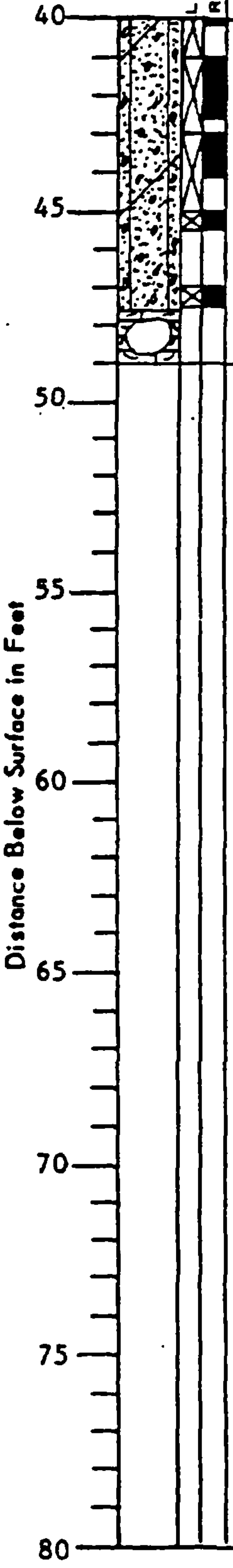
WATER TABLE

AT END OF BORING -15.0'

24 HOURS

While Drilling -13.0'

SHEET 2 of 2



SAMPLE NO.	SAMPLE TYPE	N	WC	Qu	γ DRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
20b	SS	34						Very dense to dense brownish-gray very silty fine to medium SAND, little gravel, trace clay, moist (SM)
21a 21b	SS	78						
22a 22b	SS	183						
23	SS	100/6"						
24	SS	100/5"				47.7		Weathered light gray DOLOMITE or BOULDER

End of Boring at 49.0 feet

Bottom of shallow monitoring well was installed at a depth of 18.0 feet and sealed from 2.0 feet to ground surface.

Bottom of deep monitoring well was installed at a depth of 48.5 feet and sealed from 39.0 feet to 36.0 feet

TESTING SERVICE CORPORATION

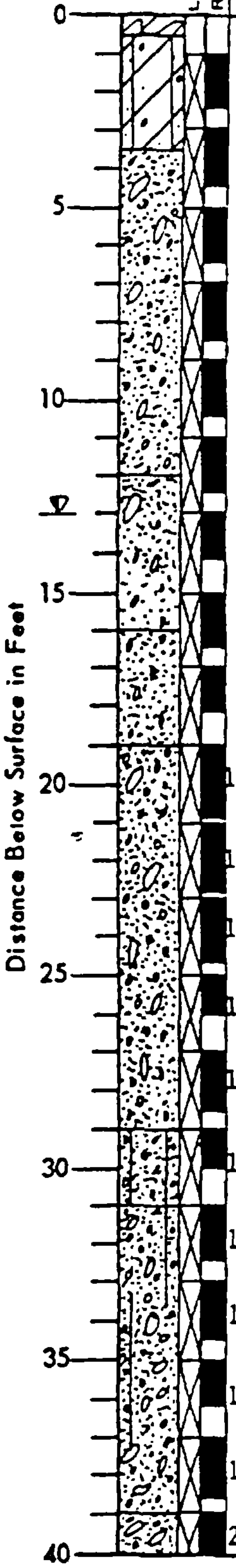
6116

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE
CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD,,LOMBAR
BORING Sta. 16 (SW WELL) DATE STARTED 5-14-80 DATE COMPLETED 5-14-80 JOB 17,45

ELEVATIONS
GROUND SURFACE
END OF BORING

WATER TABLE
AT END OF BORING
24 HOURS
While Drilling -13.0'

Sheet 1 of 2



SAMPLE NO.	TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
						0.5		FILL - Brown clayey TOPSOIL
1^a_b	SS	8	24.0 26.3	1.25*				Tough brown silty CLAY, little sand and gravel, moist (CL)
2^a_b	SS	15				3.5		Firm to very dense grayish-brow fine to coarse SAND and small to large GRAVEL, damp (SW/GW)
3^a_b	SS	43						
4^a_b	SS	19						
5^a_b	SS	22						
6^a_b	SS	26				12.0		
7^a_b	SS	5						Firm to very loose light brown to brown fine to coarse SAND and small to large GRAVEL, mois to wet at -13.0' (SW/GW)
8^a_b	SS	13				16.0		
9^a_b	SS	11						Firm grayish-brown fine to coar SAND, some small gravel, wet (SW)
						19.0		
10^a_b	SS	18						Firm to dense grayish-brown fine to coarse SAND and small to large GRAVEL, wet (SW/GW)
11^a_b	SS	29						
12^a_b	SS	33						
13^a_b	SS	13						
14^a_b	SS	21						
						29.0		
15^a_b	SS	17						Firm gray silty fine to coarse SAND, some small to medium grav wet (SM)
						31.0		
16^a_b	SS	54						Very dense to firm light gray fine to coarse SAND and small t large GRAVEL, trace silt, wet (SW/GW)
17^a_b	SS	48						
18^a_b	SS	28						
19^a_b	SS	56						
						39.0		
20^a	SS	78/9"						(See next page)

Boring Log Continues

TESTING SERVICE *-Approximate unconfined compressio

G116

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBARD

BORING Sta. 16 con't (SW WELL) DATE STARTED 5-14-80 DATE COMPLETED 5-14-80 JOB 17,458

ELEVATIONS

GROUND SURFACE

END OF BORING

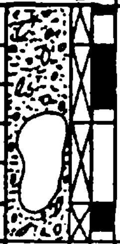
WATER TABLE

AT END OF BORING

24 HOURS

While Drilling -13.0'

SHEET 2 of 2



Distance Below Surface in Feet	LENGTH / RECOVERY	SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γ DRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
40		20b	SS	78/9"						Very dense light grayish-brown sandy (coarse) small to large GRAVEL, occasional cobbles, wet (GW)
		21a b	SS	76/10"						
		22	SS	bounce**						
45		23a b	SS							BOULDER from -43.0 to -45.0'
		**Driving on boulder End of Boring at -46.0 Feet Bottom of monitoring well installed at a depth of -45.5' and sealed from -2.0' to ground surface.								Auger refusal at -46.0' attribut to BEDROCK or BOULDER
50										
55										
60										
65										
70										
75										
80										

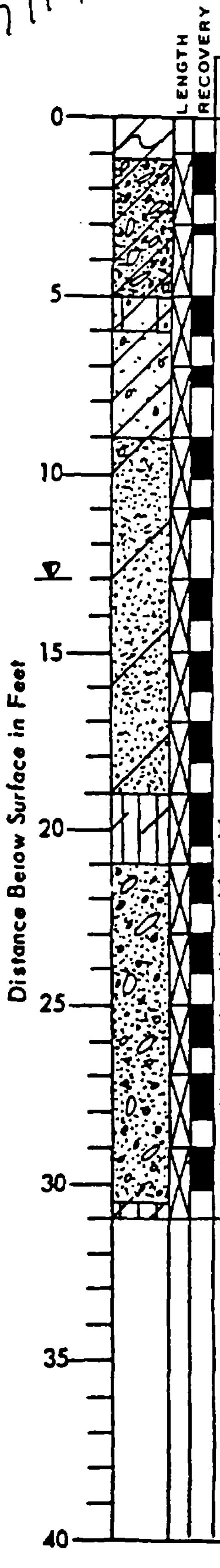
G117

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBARD

BORING Sta. 17 DATE STARTED 5-19-80 DATE COMPLETED 5-19-80 JOB 17,458

ELEVATIONS		WATER TABLE	
GROUND SURFACE		AT END OF BORING	
END OF BORING		24 HOURS	
		While Drilling	-13.0'



SAMPLE NO.	TYPE	N	WC	Q_u	γ DRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
						1.2		FILL - Black clayey TOPSOIL
1_b^a	SS	88/10"						Very dense brown clayey small to large GRAVEL and fine to coarse SAND, occasional cobbles, moist (GC/CL)
2	SS	100/4"				5.0		
3_b^a	SS	16	24.3	3.0*		6.0		Very tough brown silty CLAY, trace sand and gravel, moist (CL)
4_b^a	SS	16	21.5			9.0		Firm brown to reddish-brown clayey medium to coarse SAND & small GRAVEL, moist (CL/GC)
5_b^a	SS	19						Firm to very dense brown fine to coarse SAND, trace clay, moist to wet at 13.0' (SW)
6	SS	21						
7_b^a	SS	14						
8_b^a	SS	66/10"						
9_b^a	SS	43				19.0		
10_b^a	SS	8	19.1 20.2			21.0		Loose gray SILT, very moist (ML) with seams of silty clay
11_b^a	SS	[illegible]						Very dense to firm gray small to large GRAVEL, fine to coarse SAND and COBBLES, wet (GW)
12_b^a	SS	118						
13_b^a	SS	19						
14_b^a	SS	49						
15_b^a	SS	36	19.8			30.5		
								Dense gray clayey SILT, very moist (ML)

End of Boring at 31.0 feet

Bottom of monitoring well was installed at a depth of 29.0 feet and sealed from 2.0 feet to ground surface.

* Approximate unconfined compressi strength based on measurements w a calibrated pocket penetrometer.

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE

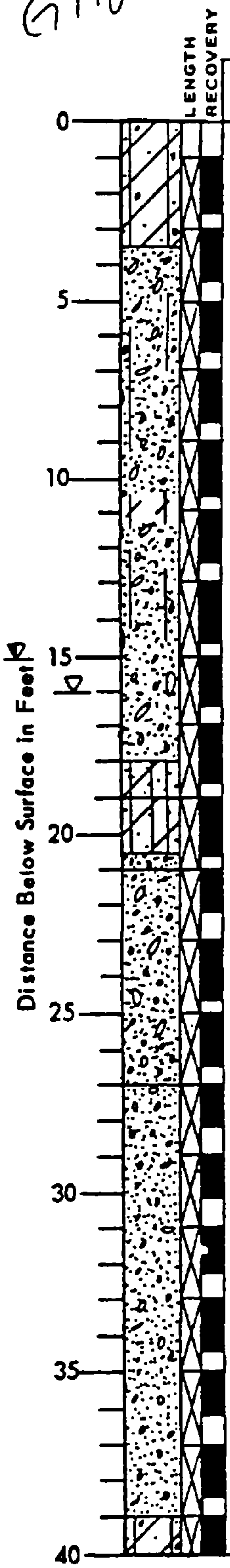
CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBARD

BORING Sta. 13 DATE STARTED 5-13-80 DATE COMPLETED 5-13-80 JOB 17,458

G1185
G1187

ELEVATIONS		WATER TABLE	
GROUND SURFACE		AT END OF BORING	-16.0'
END OF BORING		24 HOURS	
		While Drilling	-15.0'

Sheet 1 of 2



SAMPLE NO.	TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
1a			21.5					FILL - Brown and gray silty CLAY, little sand and gravel (CL)
1b	SS	7	22.1					
2a			30.4			3.5		
2b	SS	22						Firm to dense grayish-brown fine to coarse SAND and small to large GRAVEL, trace silt to 15.0', moist to wet at 15.0' (SW/GW)
3a 3b	SS	32						
4a 4b	SS	28						5" clayey sandy silt seam at 11.0'
5a 5b	SS	12						
6a 6b	SS	16						
7a 7b	SS	23						
8a 8b	SS	31						
9a 9b	SS	17				18.0		Firm gray SILT, little to some fi sand, trace clay, wet (ML)
						19.0		Loose to firm gray clayey SILT, little fine sand, very moist ([illegible])
10a 10b	SS	11				20.5 21.0		Firm reddish-brown fine to coarse SAND, little gravel, wet (SW)
11a 11b	SS	13						
12a 12b	SS	20						Firm brown fine to coarse SAND and small to large GRAVEL, wet (SW/GW)
13a 13b	SS	28				27.0		
14a 14b	SS	22						Firm brown fine to coarse SAND, little to trace small to medium gravel, wet (SW)
15a 15b	SS	23						
16a 16b	SS	23						
17a 17b	SS	34						
18a 18b	SS	27						
19a 19b	SS	51				39.0		Very tough grayish-brown silty CLAY, little sand and gravel, moist (CL)
20a	SS	26	22.5	2.75*				

TESTING SERVICE CORPORATION

G118S
G118D

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBA

BORING Sta. 13 DATE STARTED 5-13-80 DATE COMPLETED 5-13-80 JOB 17,4

ELEVATIONS		WATER TABLE	
GROUND SURFACE		AT END OF BORING	-16.0'
END OF BORING		24 HOURS	
		While Drilling	-15.0'

SHEET 2 of

Distance Below Surface in Feet	SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.
40	20b	SS	16	13.1	4.5+			
	a			13.3	3.50			
	21b	SS	33	13.2	4.25			
	a			10.6	4.5+			
45	22b	SS	32	12.5	4.00			
	a			13.8	1.50			
	23b	SS	35	14.2	1.50			
	a			14.2	3.75			
	24b	SS	36	12.8	4.5+			
	a			14.6	2.00		50.0	
50	25b	SS	43				51.0	
	a							
	26b	SS	22	18.6	2.00			
	a			19.1	2.25		53.5	
	27b	SS	116/10"				54.2	
55								
60								
65								
70								
75								
80								

SOIL DESCRIPTIONS

Hard to tough brownish-gray to gray silty CLAY, little to some sand and small gravel, moist (C 6" sandy silt seam at 39.5'; sa pockets from 45-47'

Dense gray SILT, trace fine san and clay, very moist (ML)

Layers of very tough gray silty moist (CL) and firm gray claye very moist (ML) occasional sanc silt seams

Dense gray medium to coarse SA and small GRAVEL, wet (SW); 3" very dense sandy silt seam at

Weathered light gray DOLOMITE BOULDER

End of boring at 57.0'

Bottom of shallow monitoring well was installed at a depth of 21.0' and sealed from 4.0' to ground surface

Bottom of deep monitoring well was installed at a depth of 56.5' and sealed above 45.0'

*-Approximate unconfined compressi strength based on measurements a calibrated pocket penetrometer.

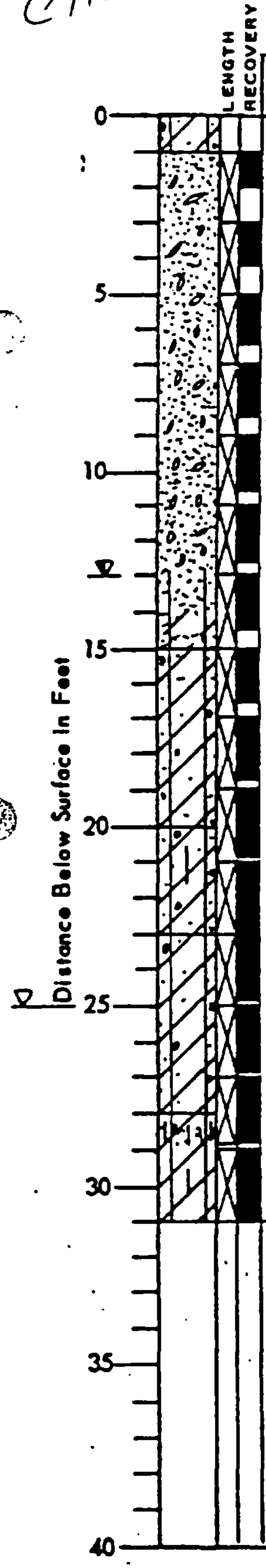
G119

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBARD

BORING Sta. 14 DATE STARTED 5-15-80 DATE COMPLETED 5-15-80 JOB 17,458

ELEVATIONS		WATER TABLE	
GROUND SURFACE		AT END OF BORING	-25.0'
END OF BORING		24 HOURS	
		While Drilling	-13.0' **



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
						1.0		FILL - Dark brown silty CLAY, some sand & gravel (CL)
a 1b	SS	29						Firm grayish-brown fine to coarse SAND and small to medium GRAVEL, moist to wet at 13.0' (SW/GW); sandy silt layers from 13.5' to 14.5'; 3" seam of brown silty clay at 14.7'
a 2b	SS	16						
a 3b	SS	17						
a 4b	SS	17						
a 5b	SS	18						
a 6b	SS	17						
a 7b	SS	17				15.0		
a 8b	SS	13	15.3 15.6	3.00* 3.75*				Very tough to hard gray silty CLAY, trace sand and gravel, moist (CL)
a 9b	SS	22	18.8 18.3	4.5+* 4.5+*				
a 10b	SS	15	17.7 13.4	2.75* 2.25*		20.0		Layers of very tough brownish-gra very silty CLAY (CL); very tou hard gray silty CLAY (CL) and brownish-gray clayey SILT (ML); trace sand and gravel, moist
a 11b	SS	24	11.7 15.6	4.5+*		23.0		
a 12b	SS	29	18.8 18.2	4.5+* 4.5+*				Hard to very tough gray silty CLAY, trace sand and gravel, moist (CL)
a 13b	SS	30	19.1 17.8	4.5+* 4.5+*				
a 14b	SS	77	19.1 13.8	3.00*		28.0		Layers of very dense gray clayey SILT (ML) and hard gray very silt CLAY (CL); trace sand and gravel, moist; 4" seam of sandy silt @ 28
a 15b	SS	63	10.2 13.3	4.5+*				

End of Boring at 31.0 feet

Bottom of monitoring well was installed at a depth of 18.0' and sealed from 2.0' to ground surface.

** Free water did not enter the H.S. auger until several feet below th depth, but the material in the sampler was wet below this depth.

*-Approximate unconfined compressio strength based on measurements wi a calibrated pocket penetrometer.

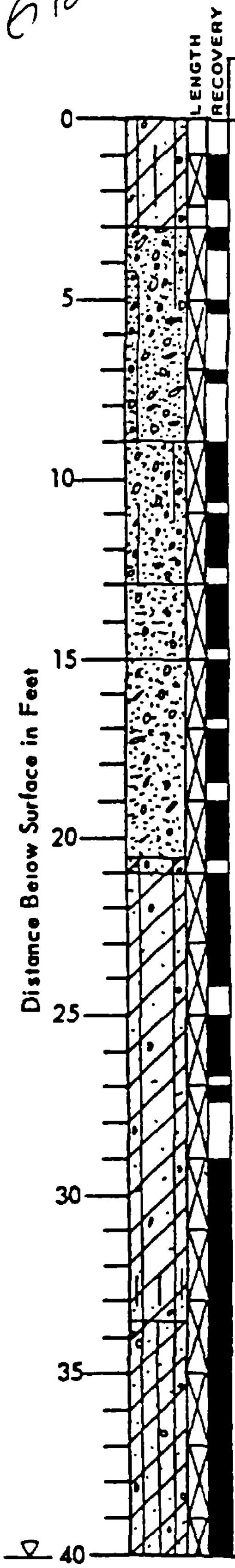
TESTING SERVICE CORPORATION

61205
6120D

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE
CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBARD
BORING Sta. 15 DATE STARTED 5-15-80 DATE COMPLETED 5-16-80 JOB 17,458

ELEVATIONS		WATER TABLE	
GROUND SURFACE		AT END OF BORING	-40.0'
END OF BORING		24 HOURS	
		While Drilling	-51.0'

Sheet 1 of



SAMPLE NO.	TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
1a			9.0					FILL - Brown and gray silty CLAY (CL) and clayey SILT (ML); some sand and gravel; cobble from 2.5' to 3.0'
1b	SS	12				3.0		
2	SS	24						Firm to dense light grayish-brown sandy (fine to coarse) small to large GRAVEL, trace silt, damp (GW)
3	SS	31						
4	SS	13				9.0		
5a								Firm to loose light grayish-brown fine to coarse SAND and small to medium GRAVEL, trace silt, damp (SW/GW)
5b	SS	13						
6a								
6b	SS	9				13.0		
7a								Loose light grayish-brown fine to coarse SAND, little small gravel, moist (SW)
7b	SS	7				15.0		
8a								Firm to loose light grayish-brown fine to coarse SAND and small to medium GRAVEL, damp (SW/GW)
8b	SS	13						
9a								
9b	SS	5						
10a								
10b	SS	11	14.6	4.5+*		20.5 21.0		Hard brown very silty CLAY, little gravel, trace sand, moist (CL)
11a			12.4	3.00*				Very tough to hard gray very silty CLAY, trace sand and gravel, moist (CL); occasional silt seams below 33.0'
11b	SS	17	13.4	3.50*				
12a			11.8	4.50*				
12b	SS	26	12.4					
13a			11.9	4.25*				
13b	SS	25	12.8	4.00*				
14	SS	34	12.5	3.50*				
15a			16.9	4.50*				
15b	SS	22	15.7	4.50*				
16a			16.6	4.5+*				
16b	SS	24	16.4	4.5+*				
17a			16.1	4.5+*				
17b	SS	22	16.9	4.5+*				
18a			16.3	4.5+*		35.5		Very dense to firm gray SILT, trac to little clay, trace sand and gravel, moist (ML); 5" silty clay seam at 37.5'; occasional wet sanc seams below 38.5'
18b	SS	50						
19a								
19b	SS	24	16.4					
20a	SS	32						

TESTING SERVICE CORPORATION

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE

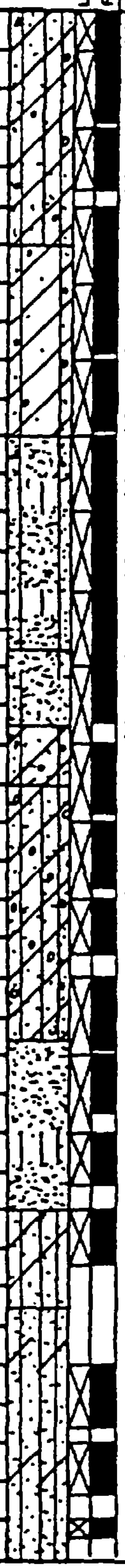
CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBARD

BORING Sta. 15 DATE STARTED 5-15-80 DATE COMPLETED 5-16-80 JOB 17,453

G120S
G120D

ELEVATIONS		WATER TABLE	
GROUND SURFACE		AT END OF BORING	-40.0'
END OF BORING		24 HOURS	
		While Drilling	-51.0'

SHEET 2 of 3



Distance Below Surface in Feet	SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
40	20b	SS	32						Dense to very dense gray very clayey SILT, little to some sand and gravel, moist (ML); occasional wet sand seams; 10" layer of gray silty clay at 43.0'; 10" sandy silt layer at 45.2'
	a			8.4					
	21b	SS	37	8.3					
	a			15.3	4.5+*				
45	22b	SS	55	8.9					
	a						46.0		
	23b	SS	44	12.2	4.5+*				Hard gray silty CLAY, little sand and gravel, moist (CL
	a			11.9	4.5+*				
	24b	SS	34	12.3	4.25*				
50	a			13.7	4.50*				
	25b	SS	28	14.0	4.5+*		51.0		
	a								Firm to dense gray fine SAND, wet (SP); occasional silt and silty sand seams
	26b	SS	18						
	a								
	27b	SS	38						
55	a								
	28b	SS	44				56.5		Dense gray fine to coarse SAND, trace silt, wet (SW)
	a						58.5		
	29b	SS	42	14.1	4.25*				Hard gray silty CLAY, trace sand gravel, moist (CL) with layers o fine to coarse SAND, trace silt, wet (SW)
	a								
60	b			13.0	4.00*		60.0		
	30c	SS	29						Dense to very dense gray cla very sandy SILT, little gravel, moist (ML); occasional seams of silty clay and sand
	a			15.7					
	31b	SS	38	11.9					
	a								
65	32b	SS	174						
	a								
	33b	SS	87				66.8		Firm to very dense fine to coars SAND, wet (SW); 6" sandy silt seam at 69.5'
	a								
	34b	SS	12						
	a								
70	35b	SS	128						
	a						71.0		Very dense gray clayey very san SILT, little gravel, moist (ML) occasional sand seams; boulder from 72.5' to 73.5'
	36b	SS	149/11"						
							73.5		Very dense gray sandy (fine) SI very moist (ML); occasional sea of silty fine sand and clayey s cobble at 79.4'
75									
	a								
	37b	SS	106						
	a								
	38b	SS	162/11"						
	39	SS	100/5"**						
80									

** Driving on Cobble

TESTING SERVICE CORPORATION

G1205
G1200

PROJECT TEST BORINGS & MONITORING STATIONS, BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE COUNTY, 881 W. ST. CHARLES RD., LOMBA

BORING Sta. 15 DATE STARTED 5-15-80 DATE COMPLETED 5-16-80 JOB 17,45

ELEVATIONS		WATER TABLE	
GROUND SURFACE		AT END OF BORING	-40.0'
END OF BORING		24 HOURS	
		While Drilling	-51.0'

SHEET 3 of 3

Distance Below Surface in Feet	SAMPLE NO.	SAMPLE TYPE	N	WC	Qu	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
80							81.0		Very dense gray sandy (fine) SILT, very moist (ML)
	a 40b	SS	85						Very dense gray fine to coarse SAND and small to large GRAVEL, trace silt above 82.0', wet (SW/GW)
	41	SS	100/3"				83.0		Weathered light gray DOLOMITE or BOULDER
85									
90									
95									
100									
105									
110									
115									
120									

Auger Refusal at 84.0'.

End of Boring at 84.0'.

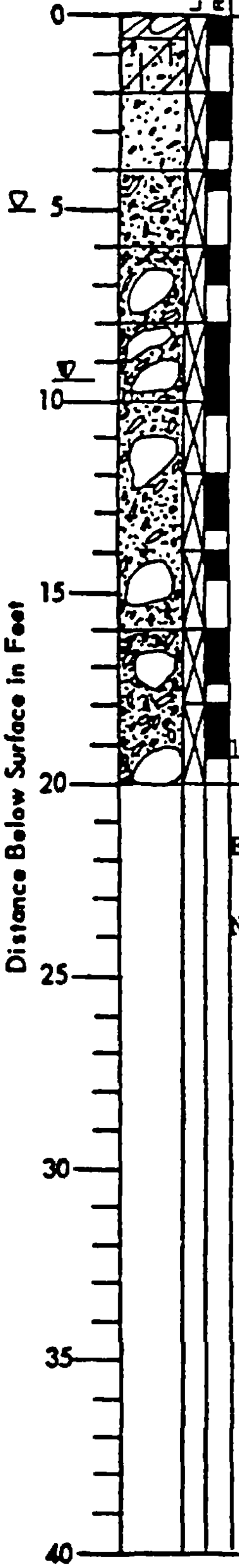
Bottom of shallow monitoring well was installed at a depth of 58.0' and sealed at 40.0'.

Bottom of deep monitoring well was installed at a depth of 84.0' and sealed below 60.0'.

*-Approximate unconfined compression strength based on measurements with a calibrated pocket penetrometer.

PROJECT LEACHATE MONITORING WELLS, BLACKWELL FOREST PRESERVE, DUPAGE COUNTY, ILL.
CLIENT FOREST PRESERVE DIST. OF DUPAGE CO., P.O. BOX 2339, GLEN ELLYN, ILL.
BORING G-121 DATE STARTED 4-29-82 DATE COMPLETED 5-03-82 JOB 18,766

ELEVATIONS		WATER TABLE	
GROUND SURFACE	702.2	AT END OF BORING	CAVE @ - 5.0 FEET
END OF BORING	682.2	24 HOURS	
		WHILE DRILLING	- 9.5 FEET



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
1	SS	16				0.6	701.6	Black clayey TOPSOIL
						2.0	700.2	Stiff brown sandy CLAY, some silt, some gravel, moist (CL)
2	SS	9				4.0	698.2	Loose brown fine SAND, little small gravel, damp (SP)
3	SS	33				6.0	696.2	Dense light brown small to large GRAVEL and medium to coarse SAND, damp (GW-SW)
4	SS	75				8.0	694.2	Very dense brown sandy(medium to coarse) small to large GRAVEL a COBBLES, a few boulders, damp(G
5	SS	48				10.0	692.2	Dense brown medium to coarse SAND and small to large GRAVEL, a few boulders, saturated (SW-GW)
6	SS	33						Dense to firm brown medium to coars SAND and small to large GRAVEL, a few boulders, saturated (SW-GW)
7	SS	11						
8	SS	29						
						16.0	686.2	
9	SS	21						Firm brown sandy coarse small to large GRAVEL and COBBLES, a few boulders, saturated (GW)
10	SS	16						

End of Boring at -20.0 Feet

NOTES: The bore hole for the monitoring well installation was made by the rotary method using revert. The well was backflushed with fastbreak and clear water.

Bottom of plastic screen: 20'
Top of plastic screen: 15'
Gravel backfill from 20' to 6'
Bentonite pellets from 6' to 4'
Backfill above bentonite

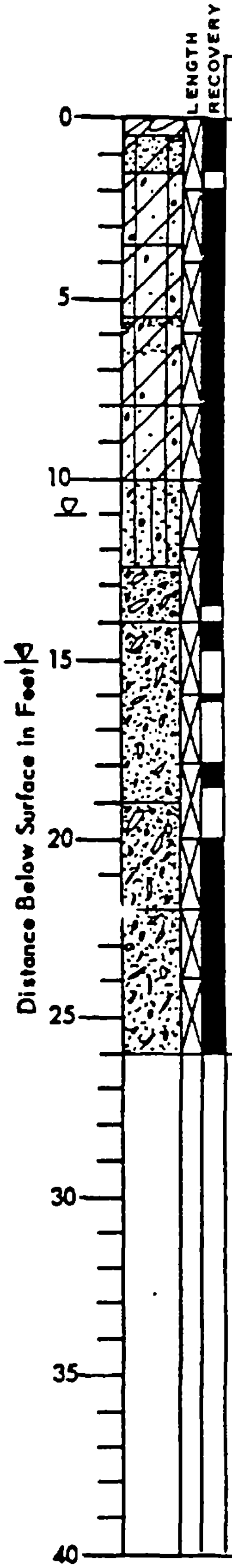
Well purged with submersible pump on May 4, 1982

PROJECT LEACHATE MONITORING WELLS, BLACKWELL FOREST PRESERVE, DUPAGE COUNTY, ILL.

CLIENT FOREST PRESERVE DIST. OF DUPAGE CO., P.O. BOX 2339, GLEN ELLYN, ILL.

BORING G-122 DATE STARTED 4-29-82 DATE COMPLETED 4-30-82 JOB 18,766

ELEVATIONS		WATER TABLE	
GROUND SURFACE	704.8	AT END OF BORING	-11.0 FEET
END OF BORING	678.8	24 HOURS	
		WHILE DRILLING	-15.0 FEET



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY
1a, 1b	SS	8			
2a, 2b	SS	19			
3a, 3b	SS	37			
4	SS	34			
5	SS	19			
6	SS	10			
7	SS	31			
8	SS	31			
9	SS	26			
10	SS	20			
11	SS	23			
12	SS	19			
13	SS	31			

DEPTH	ELEV.	SOIL DESCRIPTIONS
0.5	704.3	FILL - Black clayey TOPSOIL
1.5	703.3	FILL - Brown clayey fine to medium SAND, little silt, moist (SC)
3.5	701.3	FILL - Brown silty CLAY, little sand and gravel, moist (CL)
5.5	699.3	FILL - Brown, black and gray silty CLAY, little sand and gravel moist (CL)
8.0	696.8	FILL - Brownish-gray silty CLAY, trace gravel, occasional sand seams, moist (CL) 3" sand and gravel seam @ -5.5'
10.0	694.8	FILL - Brown sandy CLAY, some silt little small gravel, moist (CL)
12.5	692.3	Firm gray light brown and brown sandy SILT, some small to medium gravel, moist (ML)
14.0	690.8	Dense gray medium to coarse SAND and small to large GRAVEL, very moist (SW-GW)
		Dense to firm gray coarse SAND and small to large GRAVEL, saturated (SW-GW)
19.0	685.8	Firm brown coarse SAND and small to large GRAVEL, saturated (SW-GW)
22.0	682.8	Firm to dense light brown fine to coarse SAND and small to medium GRAVEL, saturated (SW-GW)

End of Boring at -26.0 Feet

NOTES: The bore hole for the monitoring well installation was made by the rotary method using revert. The well was backflushed with fastbreak and clear water.

Bottom of plastic screen: 25.5'
Top of plastic screen: 20.5'
Granular material caved around pipe to 15'

Well purged with submersible pump on May 4, 1982

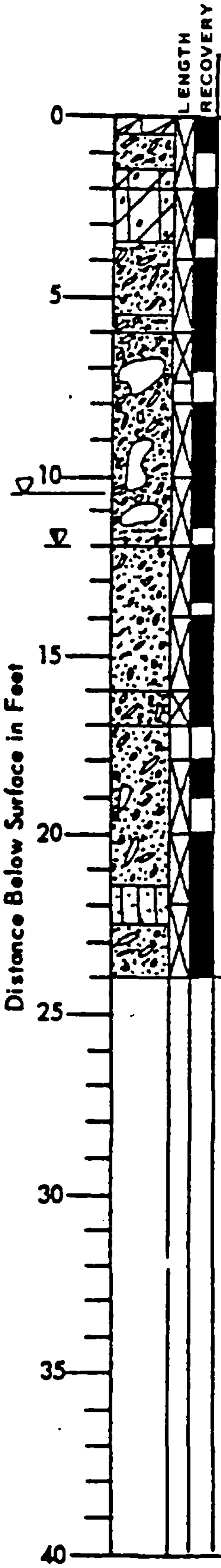
TESTING SERVICE CORPORATION

PROJECT LEACHATE MONITORING WELLS, BLACKWELL FOREST PRESERVE, DUPAGE COUNTY, I

CLIENT FOREST PRESERVE DIST. OF DUPAGE CO., P.O. BOX 2339, GLEN ELLYN, ILL.

BORING G-123 DATE STARTED 4-29-82 DATE COMPLETED 5-03-82 JOB 18,7

ELEVATIONS		WATER TABLE	
GROUND SURFACE	706.2	AT END OF BORING	-10.5 FEET
END OF BORING	682.2	24 HOURS	
		WHILE DRILLING	-12.0 FEET



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
1_b^a	SS	39				0.5	705.7	FILL - Black clayey TOPSOIL
						1.5 2.0	704.7 704.2	FILL - Gray small to large GRAVE some coarse sand, moist(G
2_b^a	SS	27				3.5	702.7	FILL - Gray silty CLAY, trace gr moist (CL)
3	SS	53				5.5 6.0	700.7 700.2	FILL - Brown silty CLAY, little gravel, moist (CL)
4	SS	93						Very dense brown small to large GRAVEL, some coarse sand, dar (
5	SS	49						Very dense light brown large GRA and COBBLES, little sand, damp (
6	SS	64						
						12.0	694.2	Very dense to dense light brown small to large GRAVEL, COBBLES, BOULDERS and fine to coarse SAN damp (GW-SW)
7	SS	39						
8	SS	33						Dense brown fine to coarse SAND and small to medium GRAVEL, satu (SW-GW)
9	SS	50/6"				16.0 17.0	690.2 689.2	
10	SS	50						Very dense brown fine to coarse SAND and small to large GRAVEL, saturated (SW-GW)
11_b^a	SS	22				21.5	684.7	Dense to firm brown and gray me to coarse SAND and small to [illegible] GRAVEL, saturated (SW-GW)
12_b^a	SS	46				22.5	683.7	Firm gray SILT, trace sand, satu (ML)
								Dense gray small to large GRAVE COBBLES, some coarse sand, satu (GW)

End of Boring at -24.0 Feet

NOTES: The bore hole for the monitoring well installation was made by the rotary method using revert. The well was backflushed with fastbreak and clear water.

Bottom of plastic screen: 21.5'
Top of plastic screen: 16.5'
Granular backfill from 21.5' to 7'
Bentonite pellets from 7' to 5'
Backfill above bentonite

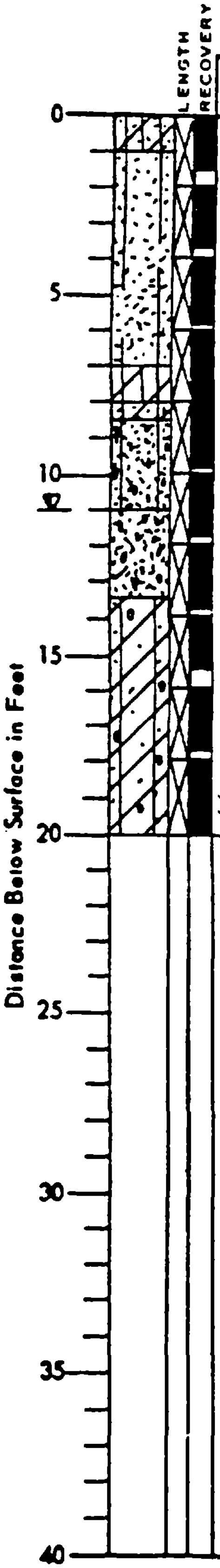
Well purged with submersible pump on May 4, 1982

PROJECT BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE CO., P.O. 2339, GLEN ELLYN, ILLINOIS

BORING G-124 DATE STARTED 6-15-84 DATE COMPLETED 6-15-84 JOB 20,530

ELEVATIONS		WATER TABLE	
GROUND SURFACE	712.9	AT END OF BORING	
END OF BORING	692.9	24 HOURS	
LOCATION:	15 + 32 N 16 + 26 W	WHILE DRILLING	-11.0 Feet



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γ DRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
1A 1B	SS	6				1.0	711.9	FILL: Dark brown sandy (fine) clayey SILT (ML)
2	SS	16						Firm light brown fine SAND, trac to some silt, trace roots, moist (SM)
3A 3B	SS	19						Layers of sandy silt below 5' (Sample 3B)
4A 4B	SS	18				7.0	705.9	Firm grayish-brown clayey SILT, trace roots (ML)
5A 5B	SS	31	27.7 -	3.0* -		8.0 8.7	704.9 704.2	Very tough brownish-gray silty CLAY, trace sand and gravel, moist (CL)
6A 6B	SS	45				11.0	701.9	Dense brown-gray silty gravelly SAND, moist (SM)
7	SS	21				13.7	699.2	Firm brown gravelly (small) fine to coarse SAND, wet (SW)
8	SS	32	14.3	2.25*				
9	SS	29	14.3	3.25*				Very tough grayish-brown silty CLAY, trace sand and gravel, moist (CL)
10	SS	28	19.7	3.0*				

End of Boring at - 20.0 Feet

*-Approximate unconfined compression strength based on measurements with a calibrated pocket penetrometer.

MONITORING WELL NOTES

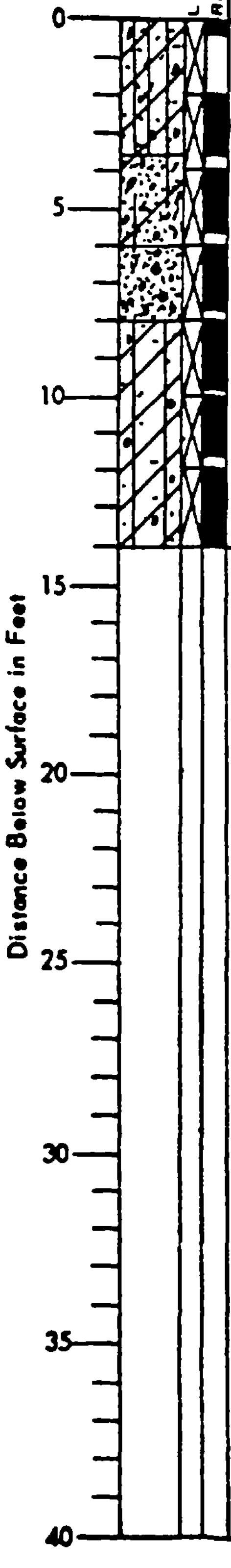
1. Bore hole made by hollowstem auger method.
2. Backfilled to 14.5'.
3. Bottom of 10' PVC screen at 14.5'.
4. Gravel pack from 14.5' to 4.5'.
5. Bentonite pellets from 4.5' to 1.5'.
6. Steel protective pipe concreted into place over well casing.

PROJECT BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE CO., P.O. 2339, GLEN ELLYN, ILLINOIS

BORING G-125 DATE STARTED 6-15-84 DATE COMPLETED 6-15-84 JOB 20,530

ELEVATIONS		WATER TABLE	
GROUND SURFACE	713.1	AT END OF BORING	
END OF BORING	699.1	24 HOURS	
LOCATION:	16 + 24 N 13 + 12 W	WHILE DRILLING	DRY



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
1	SS	44						FILL: Brown clayey very sandy SILT, some gravel (ML-CL)
2	SS	19				3.7	709.4	
3	SS	49				6.0	707.1	Dense brown gravelly (small to medium) fine to coarse SAND, trace silt and clay, occasional thin clayey sand and gravel seams, moist (SW-SM)
4	SS	43				8.0	705.1	Dense brown gravelly (small ~~to~~ medium) fine to coarse SAND, very moist (SW)
5	SS	27	14.0	4.5*				Hard gray silty CLAY, trace sand and gravel, moist (CL)
6	SS	73	16.0	4.5+*				
7	SS	30	17.8	4.5+*				

End of Boring at - 14.0 Feet

*-Approximate unconfined compression strength based on measurements wit a calibrated pocket penetrometer.

MONITORING WELL NOTES

1. Bore hole made by hollowstem auger method.
2. Backfilled to 9'.
3. Bottom of 5' PVC screen at 9'.
4. Gravel pack from 9' to 3.5'.
5. Bentonite pellets from 3.5' to 0.5'.
6. Steel protective pipe concreted into place over well casing.

This bore hole was dry during and at completion of drilling. The well was installed temporarily on 6-15-84 to see if it would produce water. On 6-19, water was observed inside the casing and the well was permanently installed.

TESTING SERVICE CORPORATION

PROJECT BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE CO., P. O. 2339, GLEN ELLYN, ILLINOIS

BORING G-126 DATE STARTED 6-18-84 DATE COMPLETED 6-18-84 JOB 20,530

ELEVATIONS

GROUND SURFACE 703.4

END OF BORING 683.4

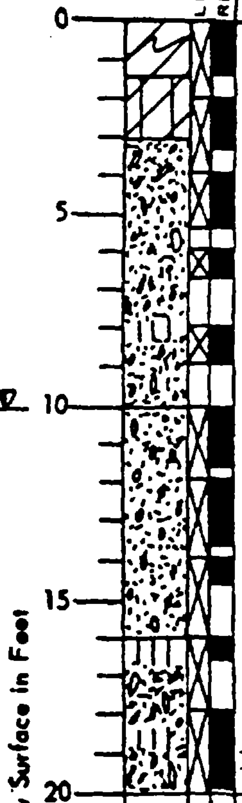
LOCATION: 2 + 56 S
11 + 18 W

WATER TABLE

AT END OF BORING

24 HOURS

WHILE DRILLING -10.0 Feet



SAMPLE NO.	SAMPLE TYPE	N	WC	Qu	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
1A	SS	18	18.1					FILL: Dark brown clayey TOPSOIL (OH)
1B			26.9			1.5	701.9	
2A	SS	45	19.9					FILL: Brown silty CLAY, some sand, trace gravel (CL)
2B			-			3.0	700.4	
3	SS	85						Very dense brown fine to coarse SAND and small to large GRAVEL, occasional cobbles and boulders, moist to wet; 4" silt seam encountered at 8' (SW-GW)
4	SS	50/5"						
5	SS	50/6"				10.0	693.4	
6	SS	24						Firm grayish-brown medium to coarse SAND, little gravel, wet (SP)
7	SS	13						
8	SS	15				16.0	687.4	
9	SS	20						Firm to dense gray and brown fine to coarse SAND and small to large GRAVEL, occasional thin silt seams, wet (SW-GW)
10	SS	42						

End of Boring at - 20.0 Feet

MONITORING WELL NOTES

1. Bore hole made by hollowstem auger method.
2. Bottom of 10' PVC screen at 17 3/4'.
3. Gravel pack from 17 3/4' to 4'.
4. Bentonite pellets from 4' to 1'.
5. Steel protective pipe concreted into place over well casing.

25
30
35
40

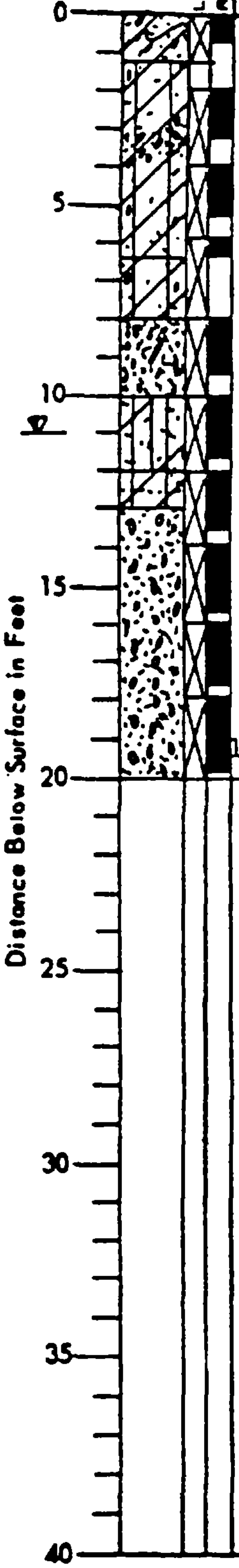
TESTING SERVICE CORPORATION

PROJECT BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE CO., P. O. 2339, GLEN ELLYN, ILLINOIS

BORING G-127 DATE STARTED 6-18-84 DATE COMPLETED 6-18-84 JOB 20,530

ELEVATIONS		WATER TABLE	
GROUND SURFACE	705.0	AT END OF BORING	
END OF BORING	685.0	24 HOURS	
LOCATION:	3 + 05 S 14 + 05 W	WHILE DRILLING	-11.0 Feet



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γ DRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
1	SS	61/9"	17.2			15"	703.8	FILL: Dark brown clayey TOPSOIL, trace sand and gravel (OH)
2A 2B	SS	27	17.7 -					FILL: Brown, gray and black silty CLAY, some sand, little gravel (CL) Clayey sand and gravel layer encountered at 3.5' (Sample 2B)
3	SS	16	22.1					
**4	SS	15	21.1			6.5	698.5	
						8.0	697.0	Brown silty CLAY, trace sand and gravel, moist (CL)
5	SS	34				10.0	695.0	Dense brown fine to coarse SAND and small to large GRAVEL, moist (SW/GW)
6	SS	32	21.2			12.0	693.0	Dense brown and gray SILT, trace clay and fine sand, very moist; occasional wet sandy silt seams (ML)
7A 7B	SS	21	22.3 -	1.75* -		13.0	692.0	Tough gray silty CLAY, moist (CL occasional thin wet sand seams
8	SS	22						Firm to dense brown to brownish-gray fine to coarse SAND and GRAVEL, wet (SW/GW)
9	SS	34						
10	SS	30						

End of Boring at - 20.0 Feet

** Poor sample; driving on piece of gravel.

*-Approximate unconfined compre[illegible]e strength based on measurements wi a calibrated pocket penetrometer.

MONITORING WELL NOTES

1. Bore hole made by solid auger method and reamed by rotary method using 6" bit and Revert.
2. Bottom of 10' PVC screen at 19'.
3. Backflushed with clean water.
4. Gravel pack from 19' to 8'.
5. Bentonite pellets from 8.0' to 2.0'.
6. Steel protective pipe concreted into place over well casing.

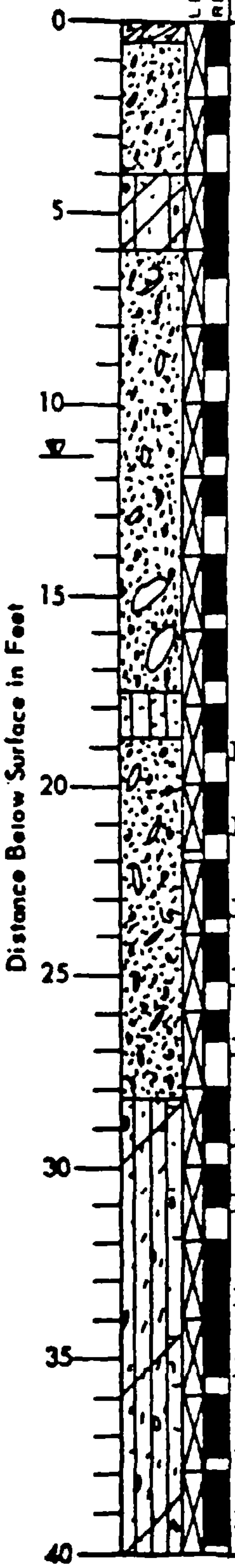
PROJECT BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE CO., P. O. 2339, GLEN ELLYN, ILLINOIS

BORING G-128 DATE STARTED 6-19-84 DATE COMPLETED 6-22-84 JOB 20,530

ELEVATIONS		WATER TABLE	
GROUND SURFACE	705.9	AT END OF BORING	
END OF BORING	649.9	24 HOURS	
LOCATION:	1 + 88 S 17 + 16 W	WHILE DRILLING	-11 1/2 Feet

SHEET 1 OF 3



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γ DRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
1_B^A	SS	20	27.7 -			7"	705.3	Black clayey TOPSOIL, trace sand and gravel (OH)
2	SS	34				4.0	701.9	Firm to dense brown gravelly (small to large) fine to coarse SAND, moist (SW)
3	SS	27	18.6	2.5*		6.0	699.9	Very tough brown silty CLAY, little sand and gravel, moist (
4	SS	51						Dense to very dense brown fine to coarse SAND and small to large GRAVEL, a few cobbles, occasional boulders below 14', moist to wet (SW/GW)
5	SS	48						
6_B^A	SS	40						
7	SS	41						
8	SS	71						
9	SS	63				17.7	688.2	
10_B^A	SS	62				18.8	687.1	Very dense gray SILT, trace cla and sand, very moist (ML)
11	SS	66						Very dense to dense gray fine to coarse SAND, small to large GRAVEL and COBBLES, wet (SW/GW)
12	SS	58						
13	SS	46						
14	SS	50				28.2	677.7	
15	SS	16						Firm to very dense gray sandy SILT, some gravel, trace clay, moist (ML)
16	SS	48						
17	SS	75						
18	SS	60						
19	SS	43						
20	SS	32						

TESTING SERVICE CORPORATION

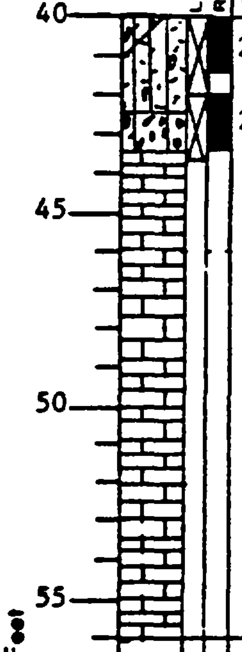
PROJECT BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE CO., P. O. 2339, GLEN ELLYN, ILLINOIS

BORING G-128 cont. DATE STARTED 6-19-84 DATE COMPLETED 6-22-84 JOB 20,530

ELEVATIONS		WATER TABLE	
GROUND SURFACE	705.9	AT END OF BORING	
END OF BORING	649.9	24 HOURS	
		WHILE DRILLING	-11 1/2 Feet

SHEET 2 of 3



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γ DRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
21	SS	21	8.3	3.5*				Firm to very dense gray sandy SILT, some gravel, trace clay, moist (ML)
22 A B	SS	65				42.5	663.4	Very dense gray silty GRAVEL, we (GM)
						43.5	662.9	BEDROCK (Dolomite)

End of Boring at - 56.0 Feet

*-Approximate unconfined compressio strength based on measurements wit a calibrated pocket penetrometer.

MONITORING WELL NOTES

Boring initially advanced by solid auger, but was completed by the rotary method using a 6" bit and Revert.

3 WELLS INSTALLED

G - 128D (Installed in original bore hole)

1. Bottom of 10' PVC screen at 54.5'.
2. Backflushed with clean water.
3. Gravel pack from 54.5' to 40'.
4. Bentonite slurry from 40' to 2'.
5. Steel protective pipe concreted into place over PVC well casing.

PROJECT BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE CO., P. O. 2339, GLEN ELLYN, ILLINOIS

BORING G-128 cont. DATE STARTED 6-19-84 DATE COMPLETED 6-22.84 JOB 20,530

ELEVATIONS		WATER TABLE	
GROUND SURFACE	705.9	AT END OF BORING	
END OF BORING	649.9	24 HOURS	
		WHILE DRILLING	-11 1/2 Feet

SHEET 3 OF 3

LENGTH	RECOVERY	SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γ DRY	DEPTH	ELEV.	SOIL DESCRIPTIONS

Distance Below Surface in Feet

G - 128I

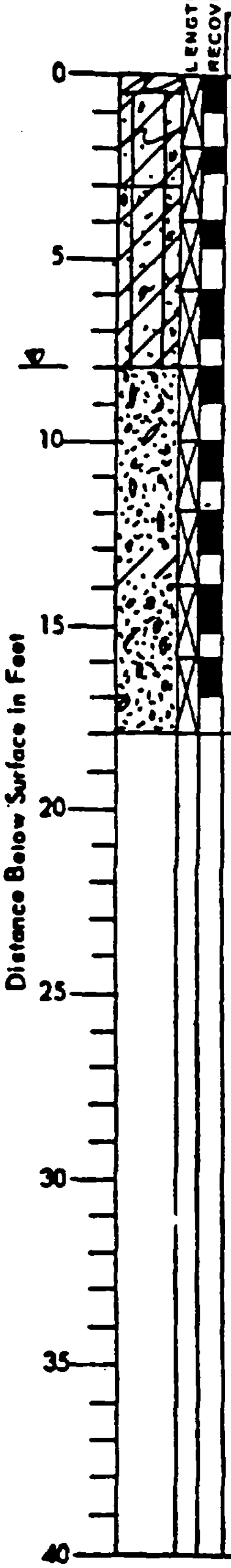
1. New bore hole drilled by rotary method using 6" bit and Revert.
2. Bottom of 10' PVC screen at 29 3/4'.
3. Backflushed with clean water.
4. Gravel pack from 29 3/4' to 19'.
5. Bentonite pellets from 19' to 16'.
6. Bentonite slurry from 16' to 3'.
7. Steel protective pipe concreted into place over well casing.

G - 128S

1. New bore hole drilled by rotary method using 6" bit and Revert.
2. Bottom of 10' PVC screen at 17'.
3. Backflushed with clean water.
4. Gravel pack from 17' to 6'.
5. Bentonite pellets from 6' to 2'.
6. Steel protective pipe concreted into place over well casing.

PROJECT BLACKWELL FOREST PRESERVE
CLIENT FOREST PRESERVE DIST. OF DU PAGE CO., P. O. 2339, GLEN ELLYN, ILLINOIS
BORING G - 129 DATE STARTED 6-25-84 DATE COMPLETED 6-25-84 JOB 20,530

ELEVATIONS		WATER TABLE	
GROUND SURFACE	700.9	AT END OF BORING	
END OF BORING	682.9	24 HOURS	
LOCATION:	1 + 70 N 20 + 35 W	WHILE DRILLING	-8.0 Feet



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
1A	SS	9	29.9	-		0.5	700.4	Black to dark brown clayey TOPSOIL (OH)
1B			22.2	2.0*				
2A	SS	38	30.5	1.25*				Very tough to tough brown silty CLAY, trace sand, gravel and organic, moist (CL)
2B			21.9	-		3.0	697.9	
3	SS	8	21.5	-				Brown sandy silty CLAY, little gravel, moist (CL)
4	SS	9	22.4	-				
						8.0	692.9	
5	SS	75						Very dense to firm gray fine to coarse SAND and small to large GRAVEL, a few cobbles, wet; 3" clay seam at 13 1/2' (SW/GW)
6	SS	77						
7	SS	30						
8	SS	26						
9	SS	60						

End of Boring at - 18.0 Feet

*-Approximate unconfined compression strength based on measurements wit a calibrated pocket penetromet

MONITORING WELL NOTES

1. Bore hole initially advanced by solid auger, but was completed by the rotary method using a 6" bit and Revert.
2. Bottom of 10' PVC screet at 17.5'.
3. Backflushed with clean water.
4. Gravel pack from 17.5' to 6'.
5. Bentonite pellets from 6' to 2'.
6. Steel protective pipe concreted into place over well casing.

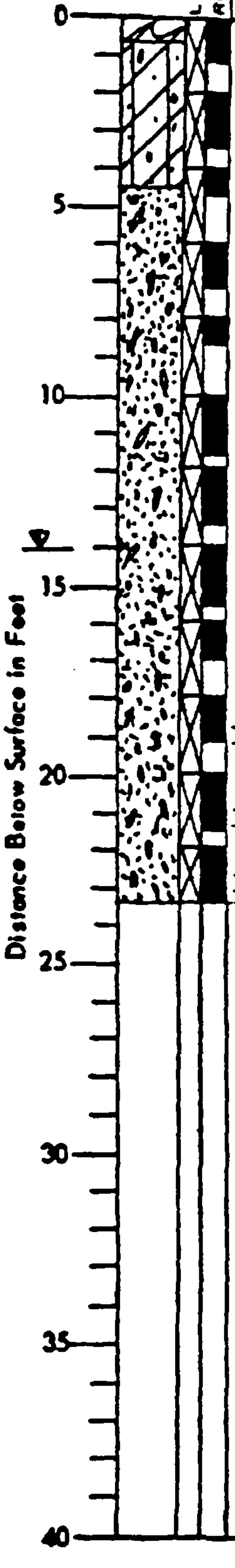
TESTING SERVICE CORPORATION

PROJECT BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST. OF DU PAGE CO., P. O. 2339, GLEN ELLYN, ILLINOIS

BORING G - 130 DATE STARTED 6-25-84 DATE COMPLETED 6-25-84 JOB 20,530

ELEVATIONS		WATER TABLE	
GROUND SURFACE	708.6	AT END OF BORING	
END OF BORING	685.2	24 HOURS	
LOCATION:	7 + 92 N 17 + 31 W	WHILE DRILLING	-14.0 Feet



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
1A 1B	SS	12	56.2 22.9	- 4.25*		0.7	707.9	Black to dark brown clayey TOPSOIL (OH)
2	SS	26	22.4	4.0*				Hard brown silty CLAY, trace sand and gravel, moist (CL)
3	SS	25				4.5	704.1	
4	SS	38						
5	SS	58						
6	SS	48						Firm to very dense brown medium to coarse SAND and small to large GRAVEL, damp to wet (SW/GW)
7	SS	85						
8	SS	88						
9	SS	18						
10	SS	24						
11	SS	34						
12	SS	71/11"						

End of Boring at - 23.4 Feet

*-Approximate unconfined compression strength based on measurements wit a calibrated pocket penetrometer.

MONITORING WELL NOTES

1. Bore hole initially advanced by solid auger, but was completed by the rotary method using a 6" bit and Revert.
2. Bottom of 10' PVC screen at 23'.
3. Backflushed with clean water.
4. Gravel pack from 23' to 5'.
5. Bentonite pellets from 5' to 2'.
6. Steel protective pipe concreted into place over well casing.

TESTING SERVICE CORPORATION

PROJECT BLACKWELL FOREST PRESERVE: DU PAGE COUNTY, ILLINOIS

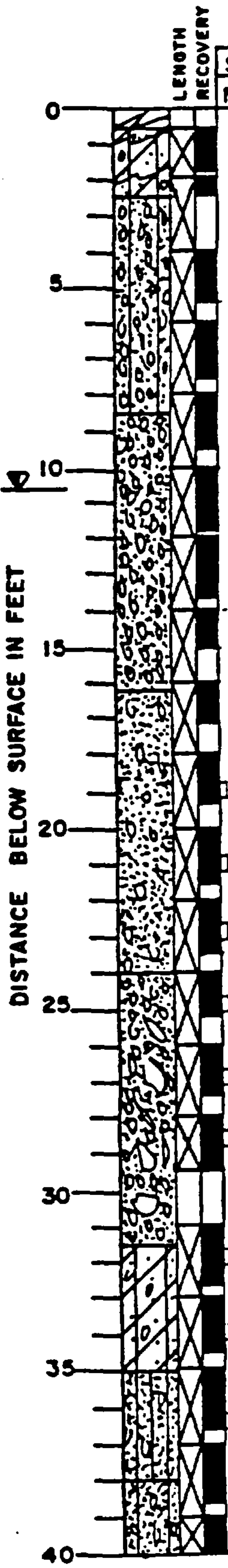
CLIENT FOREST PRESERVE DISTRICT OF DU PAGE CO., P. O. BOX 2339, GLEN ELLYN, IL.

BORING G-131 DATE STARTED 4-1-85 DATE COMPLETED 4-8-85** JOB 21,288

ELEVATIONS		WATER TABLE	
GROUND SURFACE	704.5	AT END OF BORING	
END OF BORING	661.5	24 HOURS	
LOCATION:	685.3 S 1725.2 W	WHILE DRILLING	-10.5 Feet

** Date of well completion

SHEET 1 OF 2



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
						0.5	704.0	FILL: Black clayey TOPSOIL (OL
1	SS	15	31.9					FILL: Brown silty CLAY, some sand and gravel, trace topsoil (CL)
2	SS	50/3"	25.9	(TOP)		2.5	702.0	
3	SS	53						FILL or DISTURBED: Brown silty fine to coarse SAND and small to large GRAVEL (SM/GM)
4	SS	70						
						8.5	696.0	
5	SS	50						Dense to firm brown fine to coarse SAND and small to medium GRAVEL, moist to wet (SW/GW)
6	SS	42						
7	SS	26						
8	SS	11						
						16.3	688.2	
9	SS	21						Firm to dense brown to gray fine to medium SAND, little to trace gravel, wet (SP)
10	SS	28						
11	SS	34						
12	SS	24						
						24.0	680.5	
13	SS	87						Very dense to firm gray medium to coarse SAND and small to large GRAVEL with cobbles and boulders, wet (SW/GW)
14	SS	29						
15	SS	72/8"						
						31.5	673.0	
16A	SS	34						Very tough to hard gray silty CLAY, little sand and gravel, moist (CL)
B			14.2	3.25*				
17	SS	53	16.6	4.25*				
						35.0	669.5	
18	SS	44						Dense to firm layers of gray fine SAND and SILT, trace gravel, moist (SP,ML)
						38.0	666.5	
19A B	SS	26						Firm to dense gray silty SAND, some gravel, moist (SM)
20A	SS	47						

TESTING SERVICE CORPORATION

BORING LOG CONTINUED

PROJECT BLACKWELL FOREST PRESERVE: DU PAGE COUNTY, ILLINOIS

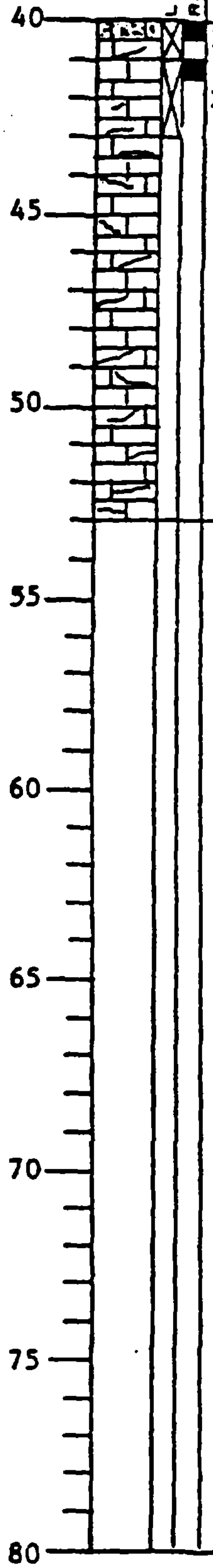
CLIENT FOREST PRESERVE DISTRICT OF DU PAGE CO., P. O. BOX 2339, GLEN ELLYN, IL.

BORING G-131 Cont. DATE STARTED 4-1-85 DATE COMPLETED 4-8-85** JOB 21,288

ELEVATIONS		WATER TABLE	
GROUND SURFACE	704.5	AT END OF BORING	
END OF BORING	661.5	24 HOURS	
LOCATION:	685.3 S 1725.2 W	WHILE DRILLING:	-10.5 Feet

** Date of well completion

SHEET 2 of 2



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u*	γ DRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
20B	SS	47						Firm to dense gray silty SAND, some gravel, moist (SM)
21	SS	50/3"						
								BEDROCK: DOLOMITE, weathered near top

End of Boring at -53.0 Feet

DRILLING AND MONITORING WELL INSTALLATION NOTES

TWO WELLS INSTALLED IN BEDROCK:

Original pilot hole sampled and drilled by rotary method using Revert and 3 3/4" bit. A second hole was drilled by same method. Both holes were reamed with an 8" bit to the desired depth. 4" PVC riser pipe was installed in each hole. Cement grout with bentonite was pumped through drill rod lowered to the bottom of the hole. The entire annular space plus inside of bottom of PVC pipe was filled with grout. After allowing several days for the grout to set, the holes were advanced deeper into rock with a 3 3/4" bit. The open hole (in rock) and casing for each well was flushed with Fastbreak and clean water. A steel protector pipe was concreted into place over each well.

G-131D

1) Bottom of 8" hole and PVC casing: 43'
2) Bottom of uncased open hole: 53'

G-131DD

1) Bottom of 8" hole and PVC casing: 53'
2) Bottom of uncased open hole: 63'

*-Approximate unconfined compressio strength based on measurements wi a calibrated pocket penetrometer.

PROJECT BLACKWELL FOREST PRESERVE: DU PAGE COUNTY, ILLINOIS

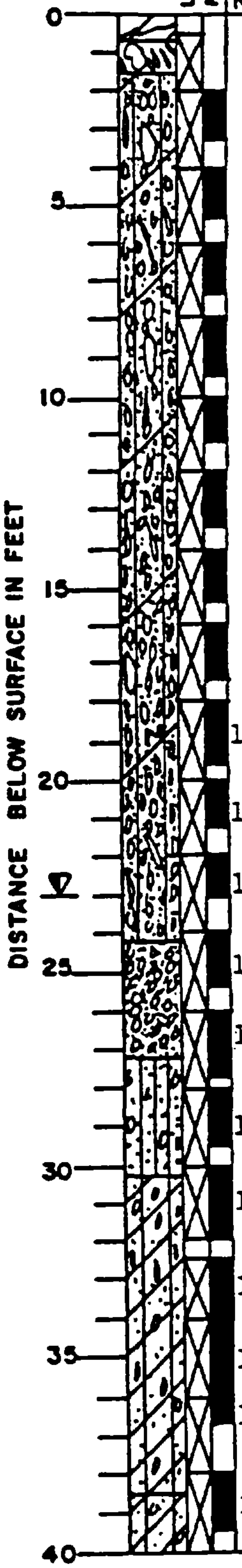
CLIENT FOREST PRESERVE DISTRICT OF DU PAGE CO., P. O. BOX 2339, GLEN ELLYN, IL

BORING G-132 DATE STARTED 4-3-85 DATE COMPLETED 4-9-85** JOB 21,28

ELEVATIONS		WATER TABLE	
GROUND SURFACE	724.7	AT END OF BORING	
END OF BORING	631.7	24 HOURS	
OCATION:	1187.9 N 544.5 W	WHILE DRILLING	-23.0 Feet

** Date of well completion

SHEET 1 OF 3



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γ_{DRY}	DEPTH	ELEV.	SOIL DESCRIPTIONS
1	SS	NO RECOVERY				0.7	724.0	FILL: Black clayey TOPSOIL (O
						1.5	723.2	FILL: BOULDERS and COBBLES
2	SS	55						Very dense to firm brown silt SAND and small to large GF few cobbles and boulders, tt to some clay, moist to wet (SM/GM)
3	SS	53						
4	SS	64						
5	SS	62						
6	SS	51						
7	SS	78						
8	SS	36						
9	SS	43						
10	SS	44						
11	SS	42						
12	SS	27						
						24.5	700.2	
13	SS	27						Firm brown fine to coarse SAN and small GRAVEL, saturated (SP)
14A 14B	SS	50				27.5	697.2	
15	SS	47						Dense brown fine sandy SILT, occasional small gravel, saturated (ML)
						30.2	694.5	
16	SS	24	16.3	2.75*				Tough to hard gray silty CLAY trace to little sand and grav moist (CL)
17	SS	42	19.5	2.5*				
18	SS	32	20.3	2.25*				(6" COBBLE - 32' - 32 1/2')
19	SS	49	24.7	1.0*				
20	SS	18	16.8	2.5*		38.5	686.2	Hard gray very silty CLAY, sc sand and gravel, moist (CL/MI

TESTING SERVICE CORPORATION

PROJECT BLACKWELL FOREST PRESERVE: DU PAGE COUNTY, ILLINOIS

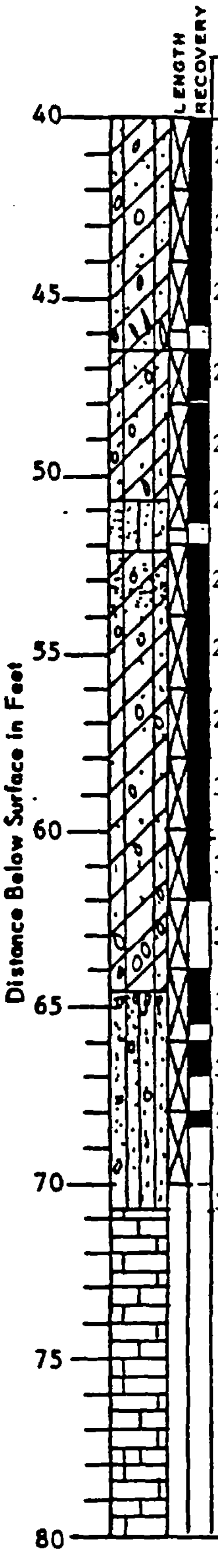
CLIENT FOREST PRESERVE DISTRICT OF DU PAGE CO., P. O. BOX 2339, GLEN ELLYN, IL.

BORING G-132 Cont. DATE STARTED 4-3-85 DATE COMPLETED 4-9-85** JOB 21,28

ELEVATIONS		WATER TABLE	
GROUND SURFACE	724.7	AT END OF BORING	
END OF BORING	631.7	24 HOURS	
LOCATION:	1187.9 N 544.5 W	WHILE DRILLING:	-23.0 Feet

** Date of well completion

SHEET 2 of 3



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
21	SS	39	10.6	4.5+*				
22	SS	59	10.4	4.5+*				Hard gray very silty CLAY, som sand and gravel, moist (CL/ML)
23	SS	41	12.9	4.25*				(COBBLE - 46' - 46 1/2')
						46.5	678.2	
24	SS	46	11.3	3.0*				Hard gray silty CLAY, trace sand and gravel, moist (CL)
25	SS	49	14.9	3.5*				
26A B	SS	86/11	25.2	3.75*		50.8	673.9	Very dense gray SILT, little t some fine sand, saturated (ML)
						52.3	672.4	
27	SS	40	19.6	3.0*				
28	SS	51	12.7	3.25*				
29	SS	34	12.2	2.25*				Very tough to hard gray silty CLAY, trace sand and gravel, moist (CL)
30	SS	32	13.0	2.75*				(Thin sand layer - 53 1/2' to 53 3/4')
31	SS	30	13.2	2.75*				
32	SS	38						
33A B	SS	66	10.7 –	2.25* –		64.5	660.2	
34	SS	86/10						Dense brown gray fine sandy SILT, little gravel, moist
35	SS	65/5						(3" sand and gravel layer between 63 3/4' to 66')
36	SS	100/4				70.8	753.9	
								BEDROCK: Gray DOLOMITE

TESTING SERVICE CORPORATION

PROJECT BLACKWELL FOREST PRESERVE: DU PAGE COUNTY, ILLINOIS

CLIENT FOREST PRESERVE DISTRICT OF DU PAGE CO., P. O. BOX 2339, GLEN ELLYN, IL.

BORING G-132 Cont. DATE STARTED 4-3-85 DATE COMPLETED 4-9-85** JOB 21,288

ELEVATIONS		WATER TABLE	
GROUND SURFACE	724.7	AT END OF BORING	
END OF BORING	631.7	24 HOURS	
LOCATION:	1187.9 N 544.5 W	WHILE DRILLING	-23.0 Feet

** Date of well completion

SHEET 3 OF 3

DISTANCE BELOW SURFACE IN FEET

Depth	LENGTH	RECOVERY	SAMPLE NO.	SAMPLE TYPE	N	WC	Qu	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
80											
85											BEDROCK: Gray DOLOMITE
90											
95											
100											
105											
110											
115											
120											

End of Boring at -93.0 Feet

DRILLING AND MONITORING WELL INSTALLATION NOTES FOR G-132D & G-132DD:

Original pilot hole was drilled and sampled by rotary method using 3 3/4" bit and Revert to a depth of 73'. A second hole was drilled from 0' to the NW by the same method to a depth of 83'. Both holes were reamed with an 8" bit. 4" solid PVC riser pipe was installed in each hole. Cement grout with bentonite was pumped through drill rod lowered to the bottom of the hole. The entire annular space plus inside of bottom of PVC pipe was filled with grout. After allowing several days for grout to set, the holes were advanced deeper into rock with a 3 3/4" bit. The open hole (in rock) and casing for each well was flushed with clean water. A steel protector pipe was concreted into place over each well.

G-132D: Bottom of cased well: 73'
Bottom of open hole: 83'

G-132DD: Bottom of cased well: 83'
Bottom of open hole: 93'

*-Approximate unconfined compressi
strength based on measurements w
a calibrated pocket penetrometer.

TESTING SERVICE CORPORATION

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PROJECT BLACKWELL FOREST PRESERVE: DU PAGE COUNTY, ILLINOIS

CLIENT FOREST PRESERVE DISTRICT OF DU PAGE CO., P. O. BOX 2339, GLEN ELLYN, IL

BORING G-133 DATE STARTED 4-9-85 DATE COMPLETED 4-16-85** JOB 21,28

** Date of well completion

ELEVATIONS

GROUND SURFACE 706.0

END OF BORING 633.0

LOCATION: 614.5 S
2089.7 W

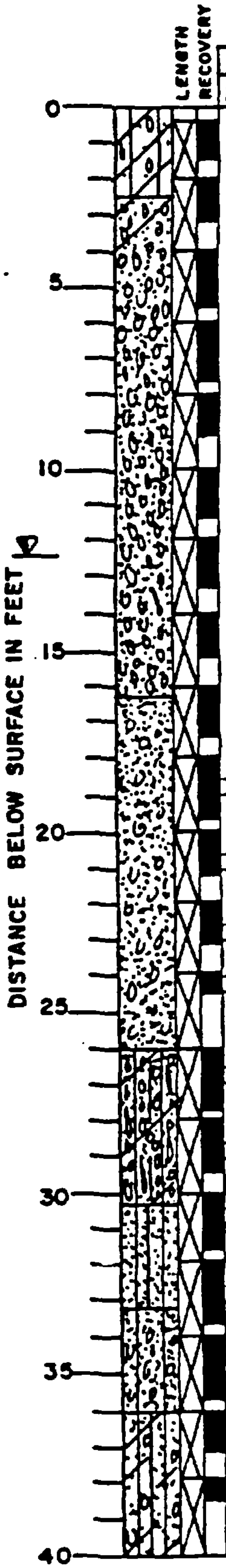
WATER TABLE

AT END OF BORING

24 HOURS

WHILE DRILLING -12.5 Feet

SHEET 1 OF 3



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
1	SS	19	30.7	2.5*				FILL: Brown to dark brown silt CLAY, little sand and gravel, moist (CL)
2A B	SS	28	14.7			2.5	703.5	
3	SS	42						Firm to very dense brown fine to coarse SAND and small to medium GRAVEL mixed with a little brown clay between 2.5' 3.5', moist to saturated at 12.5' (SP)
4	SS	30						
5	SS	43						
6	SS	58						
7	SS	57						
8	SS	35						
						16.2	689.8	
9	SS	35						Firm to very dense brown and gray fine to coarse SAND and small gravel, saturated (SP)
10	SS	26						
11	SS	25						
12	SS	27						
13	SS	50/5						
						26.0	680.2	
14	SS	37						Dense to very dense gray medi to coarse SAND and small to large GRAVEL, occasional cobb little to some silt and clay (SP-GP)
15	SS	52						
16	SS	46				30.2	675.8	Dense brownish gray firm SAND little silt, saturated (SM)
17A B	SS	47				33.2	672.8	
18	SS	48						Dense to very dense gray silt SAND, little gravel, satura (SM)
						36.0	670.0	
19	SS	71						Very dense gray sandy S little gravel, trace c (
20	SS	50/6						

TESTING SERVICE CORPORATION

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BORING LOG CONTINUED

PROJECT BLACKWELL FOREST PRESERVE: DU PAGE COUNTY, ILLINOIS

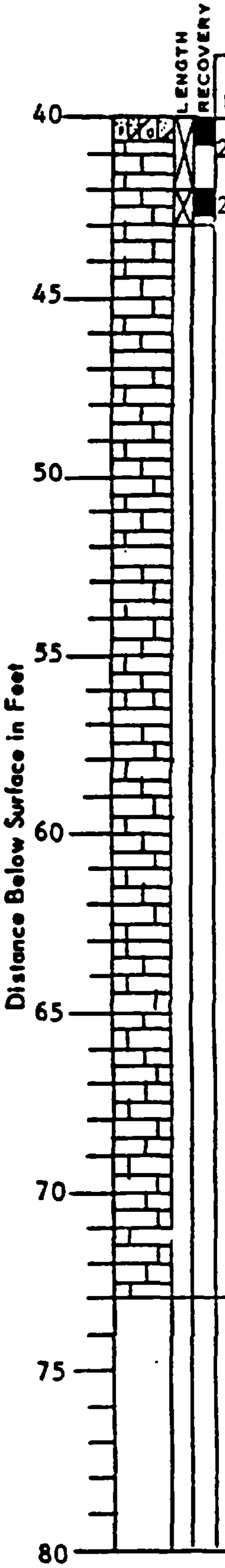
CLIENT FOREST PRESERVE DISTRICT OF DU PAGE CO., P. O. BOX 2339, GLEN ELLYN, IL.

BORING G-133 DATE STARTED 4-9-85 DATE COMPLETED 4-16-85** JOB 21,288

** Date of well completion

ELEVATIONS		WATER TABLE	
GROUND SURFACE	706.0	AT END OF BORING	
END OF BORING	633.0	24 HOURS	
LOCATION:	614.5 S 2089.7 W	WHILE DRILLING:	-12.5 Feet

SHEET 2 of 3



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γ DRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
21 A B	SS	100/10"				40.8	665.2	Very dense gray sandy SILT, little gravel, trace clay, moist (ML)
22	SS	50/5"						
								BEDROCK: Gray DOLOMITE

End of Boring at -73.0 Feet

*-Approximate unconfined compressio strength based on measurements wi a calibrated pocket penetrometer.

TESTING SERVICE CORPORATION

PROJECT BLACKWELL FOREST PRESERVE: DU PAGE COUNTY, ILLINOIS
CLIENT FOREST PRESERVE DISTRICT OF DU PAGE CO., P. O. BOX 2339, GLEN ELLYN, IL.
BORING G-133 DATE STARTED 4-9-85 DATE COMPLETED 4-16-85** JOB 21,288
** Date of well completion

ELEVATIONS		WATER TABLE	
GROUND SURFACE	706.0	AT END OF BORING	
END OF BORING	633.0	24 HOURS	
LOCATION:	614.5 S 2089.7 W	WHILE DRILLING	-12.5 Feet

SHEET 3 OF 3

LENGTH	RECOVERY	SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γ DRY	DEPTH	ELEV.	SOIL DESCRIPTIONS

DISTANCE BELOW SURFACE IN FEET: 80, 85, 90, 95, 100, 105, 110, 115, 120

DRILLING AND MONITORING WELL INSTALLATION NOTES:

One Well-Installed in Outwash Material

G-133S: Borehole was reamed with 8" rotary bit using Revert. The bottom of the 10' PVC screen was installed at 21.0'. Gravel packed from 21.0' to -9.0 feet. The annular space was sealed with bentonite pellets from -9.0 feet to -3.0 feet. A steel protector casing was concreted into place over the PVC well casing.

Two Wells Installed in Bedrock

Original pilot hole sampled and drilled by rotary method using Revert and 3 3/4" bit. A second hole was drilled by the same method. Both holes were reamed with an 8" bit to the desired depth. 4" PVC rise pipe was installed in each hole. Cement grout with bentonite was pumped through the drill rod lowered to the bottom of the bore hole. The entire annular space plus inside the lower portion of the PVC pipe was filled with grout. After allowance of several days for the grout to set, the holes were advanced deeper into rock with a 3 3/4" core barrel. The open hole (in rock) and the casing for each well were flushed with clean water. A steel protector casing was concreted into place over each well.

G-133D:

1). Bottom of 8" hole and PVC Casing: 43'

2). Bottom of uncased open hole: 53'

G-133DD:

1). Bottom of 8" hole and PVC casing: 53'

2). Bottom of uncased open hole: 73'

PROJECT BLACKWELL FOREST PRESERVE: DU PAGE COUNTY, ILLINOIS

CLIENT FOREST PRESERVE DISTRICT OF DU PAGE CO., P. O. BOX 2339, GLEN ELLYN, IL.

BORING G-134 DATE STARTED 4-11-85 DATE COMPLETED 4-17-85 JOB 21,288

ELEVATIONS

GROUND SURFACE 725.8

END OF BORING 654.8

LOCATION: 661.3 N
310.1 E

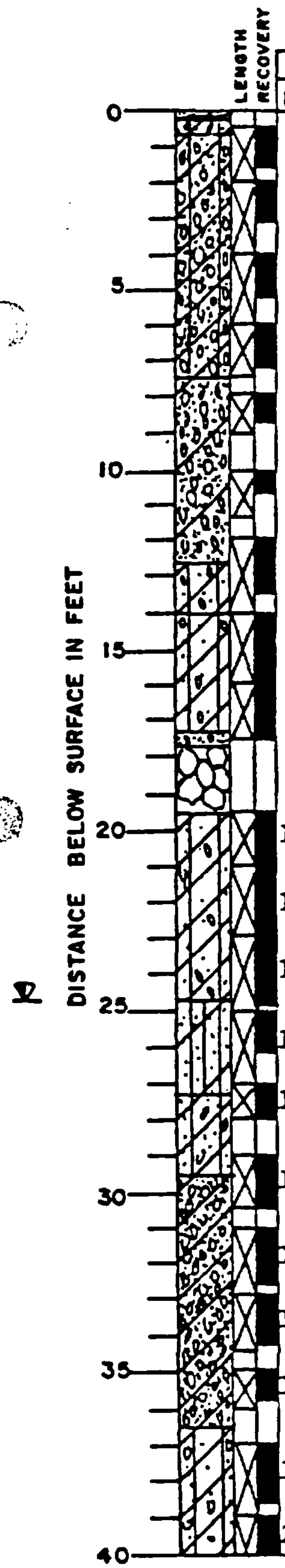
WATER TABLE

AT END OF BORING

24 HOURS

WHILE DRILLING -24.96 Feet

SHEET 1 of 3



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
						0.3	725.5	FILL: Black clayey TOPSOIL, little sand
						0.7	725.1	FILL: Dark brown silty CLAY, little sand and gravel, moist (CL)
1	SS	26						
2	SS	30						
3	SS	100						
4	SS	78						
						7.5	718.3	FILL: Brown fine to coarse SAN and small to large GRAVE mixed with brown silty clay, moist (SC)
5	SS	50/5"						
6	SS	50/4"						
						12.8	713.0	FILL: Brown fine to coarse [illegible]N and small to medium GRAV little clay, moist (SC)
7A	SS	53						
7B			14.3	4.5*				
						14.0	711.8	Very tough to hard brown silty CLAY, little sand and gravel, moist (CL)
8	SS	45	11.6	4.5+*				
9A	SS	43	11.4	4.5+*				
9B			-	-				
						17.5	708.3	Hard gray silty CLAY, trace sand and gravel, moist (CL)
						17.8	708.0	Dense gray fine to coarse SAN and small to large GRAVEL, saturated (SW)
						19.5	706.3	BOULDER
10	SS	31	17.9	4.0*				
11	SS	46	18.6	3.75*				
12	SS	29						
						24.8	701.0	Hard gray silty CLAY, trace sand and gravel, moist (C
13	SS	69						
						27.3	698.5	Very dense brownish-gray SILT little sand, little clay, saturated (ML)
14	SS	55	9.4					
						29.5	696.3	Very tough to hard gray very silty CLAY, little sand and gravel, moist (CL-ML)
15	SS	95	10.4	3.75*				
16	SS	45						
17	SS	90						
18	SS	50	12.6					
						36.5	689.3	Dense to very dense gray clay SAND and GRAVEL, moist to saturated (SC)
19	SS	64	17.3	3.5*				
20	SS	52	16.6	4.5*				Very tough to hard gray silty CLAY, trace sand and gravel, moist (CL)

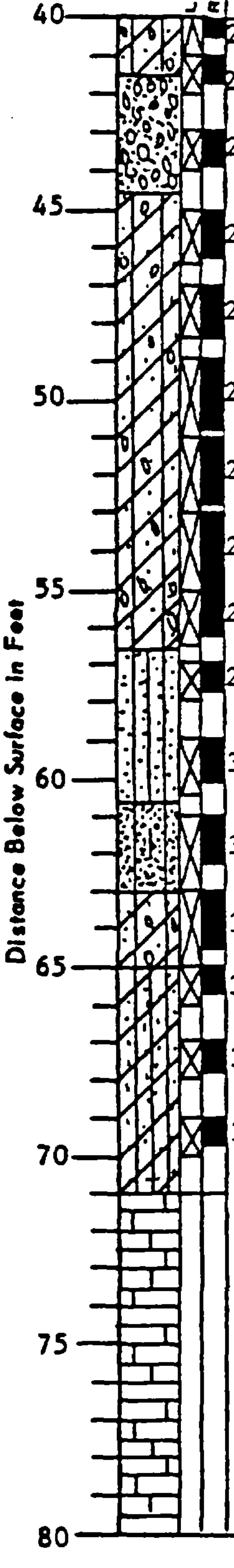
PROJECT BLACKWELL FOREST PRESERVE: DU PAGE COUNTY, ILLINOIS

CLIENT FOREST PRESERVE DISTRIAT OF DU PAGE CO., P. O. BOX 2339, GLEN ELLYN, IL.

BORING G-134 DATE STARTED 4-11-85 DATE COMPLETED 4-17-85 JOB 21,288

ELEVATIONS		WATER TABLE	
GROUND SURFACE	725.8	AT END OF BORING	
END OF BORING	654.8	24 HOURS	
LOCATION:	661.3 N 310.1 E	WHILE DRILLING:	-24.96 Feet

SHEET 2 of 3



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
20	SS	52	16.6	4.5*				Very tough to hard gray silty CLAY, trace sand and gravel, moist (CL)
21A	SS	50	19.5	3.25*		41.5	684.3	
21B			-	-				
22	SS	50						Very dense gray fine to coarse SAND and GRAVEL, saturated (SW-GW)
						44.5	681.3	
23	SS	80	10.1					Very tough to hard gray silty CLAY, little sand and gravel, moist (CL)
24	SS	83	9.8					
25	SS	89	11.7	4.5+*				
26	SS	94	10.6	4.5*				
27	SS	69	12.0	3.75*				
28	SS	78	14.5	2.75*				
						56.8	669.0	
29	SS	53	21.3					Very dense brownish-gray SILT, little sand, saturated (ML)
30	SS	78						
						60.8	665.0	
31	SS	73						Very dense brownish-gray fine t medium SAND, little silt, saturated (SM)
						63.0	662.8	
32	SS	54	12.5	4.5*				Hard gray silty CLAY, trace sand and gravel, moist (CL)
33A	SS	50/4"	-	-		65.0	660.8	Very dense gray clayey SILT, little sand, moist to saturated (ML)
33B			11.2	3.0*				
34	SS	50						
35	SS	56	12.4					
						71.0	654.8	BEDROCK: Gray DOLOMITE

*-Approximate unconfined compressi strength based on measurements · a calibrated pocket penetrometer.

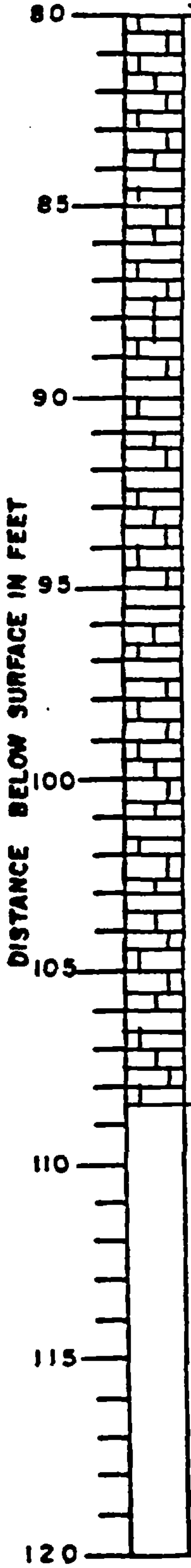
TESTING SERVICE CORPORATION

PROJECT BLACKWELL FOREST PRESERVE: DU PAGE COUNTY, ILLINOIS
CLIENT FOREST PRESERVE DISTRICT OF DU PAGE CO., P. O. BOX 2339, GLEN ELLYN, IL.
BORING G-134 DATE STARTED 4-11-85 DATE COMPLETED 4-17-85 JOB 21,288

ELEVATIONS		WATER TABLE	
GROUND SURFACE	725.8	AT END OF BORING	
END OF BORING	654.8	24 HOURS	
LOCATION:	661.3 N 310.1 E	WHILE DRILLING	-24.96 Feet

SHEET 3 OF 3

LENGTH	RECOVERY	SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
										BEDROCK: Gray DOLOMITE



End of Boring at -108.5 Feet

DRILLING AND MONITORING WELL INSTALLATION NOTES FOR G-134D:

Original pilot hole drilled and sampled by rotary method and reamed with an 8" rotary bit and Revert to a depth of 73.5'. 4" PVC solid riser pipe was installed to 73.5'. Cement grout with bentonite was pumped through drill rod lowered to the bottom of the hole. The entir annular space plus inside of bottom of PVC was filled with grout. Aft allowing several days for the grout to set, the hole was extended usin a 3 3/4" bit and Revert. The open hole was flushed with clean water. A steel protector pipe was installed and concreted over the well at the surface.

1). Bottom of cased hole: 73.5' 2). Bottom of open hole: 103.5'

PROJECT BLACKWELL FOREST PRESERVE: DU PAGE COUNTY, ILLINOIS

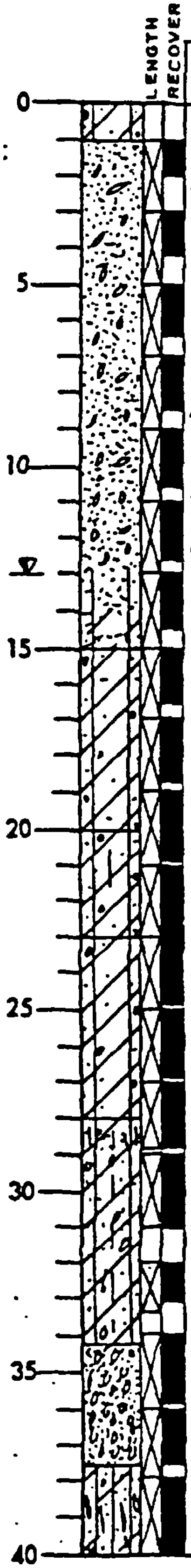
CLIENT FOREST PRESERVE DISTRICT OF DU PAGE CO., P. O. BOX 2339, GLEN ELLYN, IL.

BORING G-135 DATE STARTED 4-11-85 DATE COMPLETED 4-17-85** JOB 21,288

** Date of well completion

ELEVATIONS		WATER TABLE	
GROUND SURFACE	719.0	AT END OF BORING	
END OF BORING	637.0	24 HOURS	
LOCATIONS:	878.6 N 1552.3 W	WHILE DRILLING	-13.0 Feet

SHEET 1 OF 3



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
						1.0	718.0	FILL - Dark brown silty CLAY, some sand & gravel (CL)
a 1b	SS	29						Firm grayish-brown fine to coarse SAND and small to medium GRAVEL, moist to wet at 13.0' (SW/GW); sandy silt layers from 13.5' to 14.5'; 3" seam of brown silty clay at 14.7'
a 2b	SS	16						
a 3b	SS	17						
a 4b	SS	17						
a 5b	SS	18						
a 6b	SS	17						
a 7b	SS	17				15.0	704.0	
a 8b	SS	13	15.3 15.6	3.00* 3.75*				Very tough to hard gray silty CLAY, trace sand and gravel, moist (CL)
a 9b	SS	22	18.8 18.3	4.5+* 4.5+*				
a 10b	SS	15	17.7 13.4	2.75 2.25*		20.0	699.0	
a 11b	SS	24	11.7 15.6	4.5+*		23.0	696.0	Layers of very tough brownish-gray very silty CLAY (CL); very tough t hard gray silty CLAY (CL) and firm brownish-gray clayey SILT (ML); trace sand and gravel, moist
a 12b	SS	29	18.8 18.2	4.5+* 4.5+*				Hard to very tough gray silty CLAY, trace sand and gravel, moist (CL)
a 13b	SS	30	19.1 17.8	4.5+* 4.5+*		28.0	691.0	
a 14b	SS	77	19.1 13.8	3.00*				Layers of very dense gray clayey SILT (ML) and hard gray very silty CLAY (CL); trace sand and gravel, moist; 4" seam of sandy silt @ 28.
a 15b	SS	63	10.2 13.3	4.5+*				
16	SS	100/1	10.9			34.3	684.1	
17	SS	63						Very dense gray fine to coarse SAND and small GRAVEL, little silt, saturated (SP)
18	SS	58				37.3	681.7	
19	SS	92						Very dense gray sandy SILT, some gravel, occasional cobbles or boulders, trace clay, moist (ML)

TESTING SERVICE CORPORATION

PROJECT BLACKWELL FOREST PRESERVE: DU PAGE COUNTY, ILLINOIS

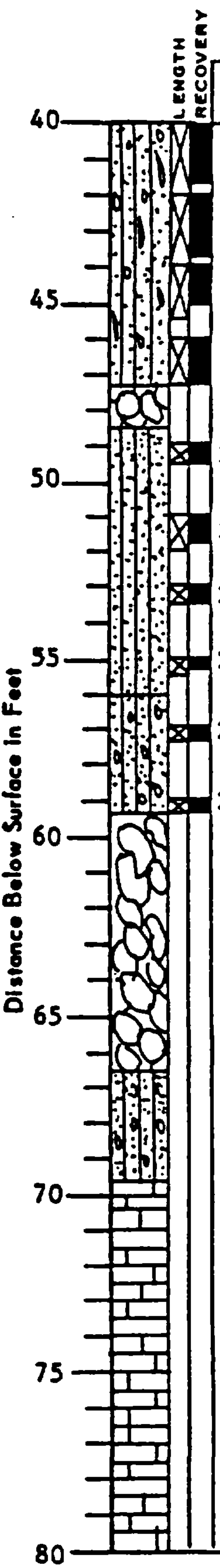
CLIENT FOREST PRESERVE DISTRICT OF DU PAGE CO., P. O. BOX 2339, GLEN ELLYN, IL.

BORING G-135 DATE STARTED 4-11-85 DATE COMPLETED 4-17-85** JOB 21,288

** Date of well completion

ELEVATIONS		WATER TABLE	
GROUND SURFACE	719.0	AT END OF BORING	
END OF BORING	637.0	24 HOURS	
LOCATIONS:	878.6 N 1552.3 W	WHILE DRILLING:	-13.0 Feet

SHEET 2 of 3



SAMPLE NO.	SAMPLE TYPE	N	WC	Qu	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
20	SS	57	8.6					Very dense gray sandy SILT, some gravel, occasional cobbles or boulders, some sand, moist (ML)
21	SS	44	9.6					
22	SS	78/11	10.0					
23	SS	100/ 10"	11.3					
						47.8	671.7	BOULDER
						48.5	670.5	
24	SS	50/5"						Very dense brownish-gray very fine sandy SILT, saturated (ML)
25	SS	100/ 11"						
26	SS	65/6"						
27	SS	100/ 5 1/2"						
						56.0	663.0	
28	SS	100/4"						Very dense gray sandy SILT, some gravel, moist (ML)
29	SS	100/3"				59.5	659.5	
								BOULDER
						66.5	652.5	
								Very dense gray sandy SILT, some gravel, moist (ML)
						69.5	649.5	
								BEDROCK: Gray DOLOMITE

TESTING SERVICE CORPORATION

DRILL RIG NO. 91

BORING LOG CONTINUED

PROJECT BLACKWELL FOREST PRESERVE: DU PAGE COUNTY, ILLINOIS

CLIENT FOREST PRESERVE DISTRICT OF DU PAGE CO., P. O. BOX 2339, GLEN ELLYN, IL.

BORING G-135 **DATE STARTED** 4-11-85 **DATE COMPLETED** 4-17-85** **JOB** 21,288

** Date of well completion

ELEVATIONS		**WATER TABLE**	
GROUND SURFACE	719.0	**AT END OF BORING**	
END OF BORING	637.0	**24 HOURS**	
LOCATIONS:	878.6 N 1552.3 W	**WHILE DRILLING**	-13.0 Feet
		SHEET 3 OF 3	

DISTANCE BELOW SURFACE IN FEET	LENGTH	RECOVERY	SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u*	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
80											BEDROCK: Gray DOLOMITE
85											
90											
95											
100											
105											
110											
115											
120											

End of Boring at -82.0 Feet

DRILLING AND MONITORING WELL INSTALLATION NOTES:

One Well Installed in Bedrock - G-135:

Due to the nearness of G-135 to G-119, the boring log for G-119 was utilized for the first 31.0 feet of this boring log. Sampling at this location resumed at a depth of 32 feet. The boring was made using a 3 3/4" rotary bit and "Revert" drilling mud. The pilot hole was reamed using an 8" rotary bit and "Revert" to a depth of 72.0 feet. 4" PVC riser pipe was installed in the bore hole. Cement grout with bentonite was pumped through the drill rod which was lowered to the bottom of the bore hole. The entire annular space, plus the inside lower portion of the PVC was filled with grout. After allowing the grout to set for several days, the hole was advanced deeper into rock with a d 3/4" rotary bit and Revert to a depth of 82.0 feet. The open hole (in rock) and the PVC well casing were flushed with clean water. A steel protector casing was concreted into place over the well.

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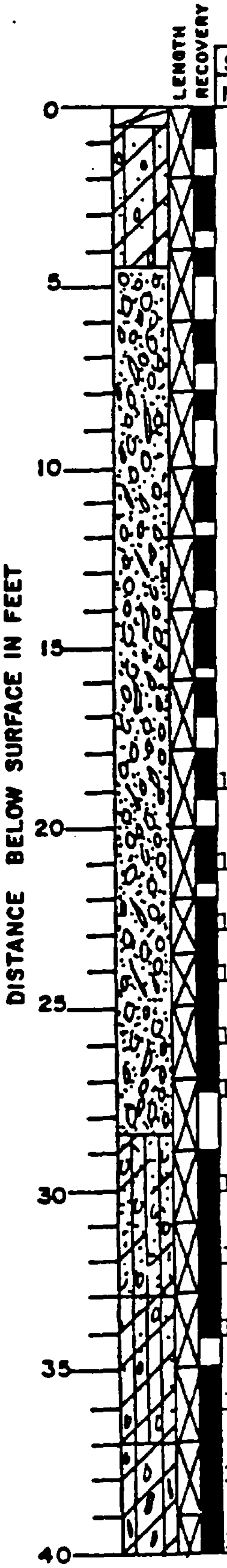
*-Approximate unconfined compressio strength based on measurements wi a calibrated pocket penetrometer.

PROJECT BLACKWELL FOREST PRESERVE: DU PAGE COUNTY, ILLINOIS
CLIENT FOREST PRESERVE DISTRICT OF DU PAGE CO., P. O. BOX 2339, GLEN ELLYN, I
BORING G-136 DATE STARTED 4-27-85 DATE COMPLETED 4-29-85** JOB 21,2
** Date of well completion

ELEVATIONS
GROUND SURFACE 708.6
END OF BORING 607.6
LOCATIONS: 790.1 N
1746.9 W

WATER TABLE
AT END OF BORING
24 HOURS
WHILE DRILLING
SHEET 1 OF 3



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
1A 1B	SS	12	56.2 22.9	– 4.25*		0.7	707.9	Black to dark brown clayey TOPSOIL (OH)
2	SS	26	22.4	4.0*				Hard brown silty CLAY, trace sand and gravel, moist (CL)
3	SS	25				4.5	704.1	Firm to very dense brown medi to coarse SAND and small to large GRAVEL, occasional cobl damp to wet (SW/GW)
4	SS	38						
5	SS	58						
6	SS	48						
7	SS	85						
8	SS	88						
9	SS	18						
10	SS	24						
11	SS	34						
12	SS	71/11"						
13	SS	29						
14	SS	28						
15	SS	66/6"						
						28.5	680.1	Dense to very dense gray san SILT, trace clay, little gra moist (ML)
16	SS	43						
17	SS	55						
						33.0	675.6	Very dense brownish gray cla SILT, little sand and gravel moist (ML)
18	SS	35/11	10.0					
19	SS	77	9.4					
						37.0	671.6	Hard gray silty CLAY, trace small gravel, cobbles, moist (CL)
20	SS	63	11.6	4.5+*				
21	SS	77	11.9	4.5+*				

TESTING SERVICE CORPORATION

DRILL RIG NO. 91

BORING LOG CONTINUED

PROJECT BLACKWELL FOREST PRESERVE: DU PAGE COUNTY, ILLINOIS

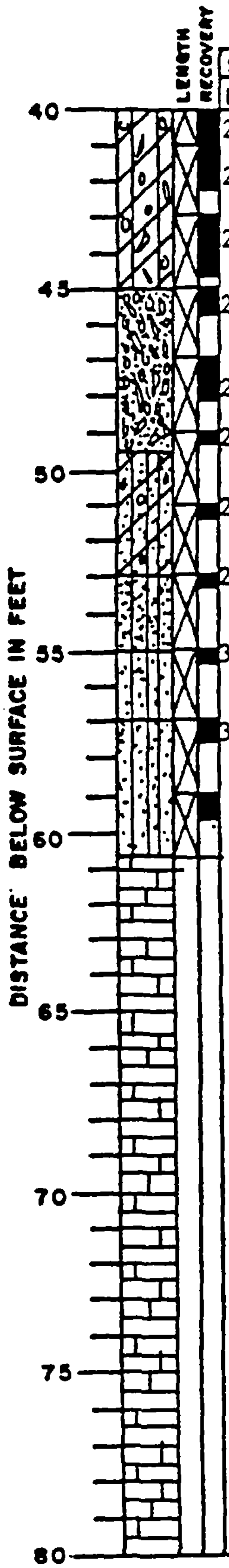
CLIENT FOREST PRESERVE DISTRICT OF DU PAGE CO., P. O. BOX 2339, GLEN ELLYN, IL.

BORING G-136 **DATE STARTED** 4-27-85 **DATE COMPLETED** 4-29-85** **JOB** 21,288

** Date of well completion

ELEVATIONS		WATER TABLE	
GROUND SURFACE	708.6	DATE:	5-13-85
END OF BORING	607.6	WATER LEVEL:	18.87'
LOCATIONS:	790.1 N 1746.9 W	ELEVATION:	691.53

SHEET 2 OF 3



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γ DRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
22	SS	80	19.3	4.5+*				Hard gray silty CLAY, trace small gravel, cobbles, moist (CL)
23	SS	74	19.3	4.5+*				
24	SS	50/5"						
						45.0	663.6	
25	SS	50/5"						Very dense coarse gray SAND and small GRAVEL, COBBLES, saturated (SP)
26	SS	100/4"						
27	SS	36/6"				49.5	659.1	
28	SS	100/5"						Very dense gray sandy SILT, little clay, trace small gravel, moist (ML)
29	SS	90/6"				53.0	655.6	
								Very dense gray fine sandy SILT, saturated (ML)
30	SS	50/4"				55.0	653.6	
								Very dense gray SILT, little sand, saturated (ML)
						57.0	651.6	
31	SS	50/3"						Very dense gray fine sandy SILT, saturated (ML)
						60.8	647.8	
								BEDROCK: Gray DOLOMITE

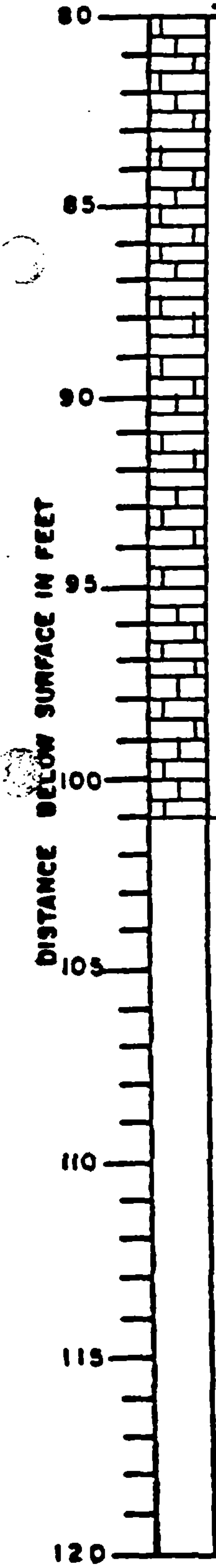
*-Approximate unconfined compress strength based on measurements a calibrated pocket penetrometer

TESTING SERVICE CORPORATION

PROJECT BLACKWELL FOREST PRESERVE: DU PAGE COUNTY, ILLINOIS
CLIENT FOREST PRESERVE DISTRICT OF DU PAGE CO., P. O. BOX 2339, GLEN ELLYN, IL.
BORING G-136 DATE STARTED 4-27-85 DATE COMPLETED 4-29-85** JOB 21,288
** Date of well completion

ELEVATIONS
GROUND SURFACE 708.6
END OF BORING 607.6
LOCATIONS: 790.1 N
1746.9 W

WATER TABLE
AT END OF BORING
24 HOURS
WHILE DRILLING
SHEET 3 OF 3



LENGTH	RECOVERY	SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
										BEDROCK: Gray DOLOMITE

End of Boring at -101.0 Feet

DRILLING AND MONITORING WELL INSTALLATION NOTES:

One Well Installed in Bedrock - G-136:

Due to the nearness of G-136 to G-130, the boring log for G-130 was utilized for the first 23.0 feet of the G-136 boring log. Sampling at this location resumed at a depth of 23'. The boring was made by the rotary method with a 3 3/4" bit and then reamed using an 8" bit and Revert to a depth of 71.0 feet. 4" PVC riser pipe was installed in the bore hole. Cement grout with bentonite was pumped through the drill rod which had been lowered to the bottom of the bore hole. The entire annular space, plus the inside lower portion of the PVC was filled with grout. After allowing the grout to set for several days, the hole was advanced deeper into rock with a 3 3/4" bit to a depth of 101.0 feet. The open hole in rock and the well casing were flushed with clean water. A steel protector pipe was concreted into place over the well.

PROJECT BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DISTRICT OF DU PAGE COUNTY, GLEN ELLYN, ILLINOIS

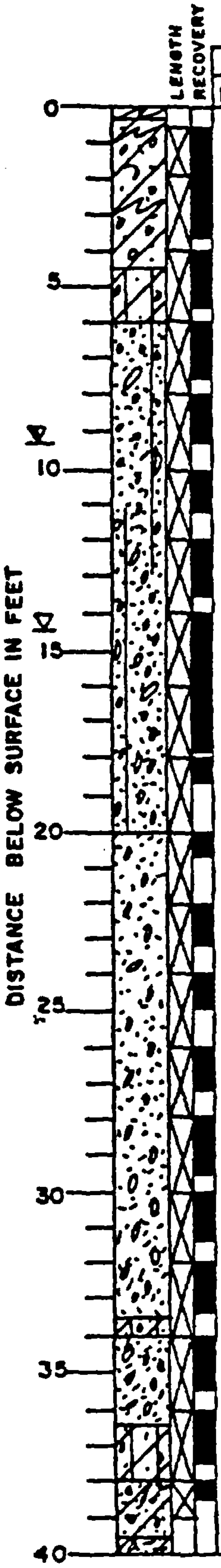
BORING C-137 DATE STARTED 8-7-86 DATE COMPLETED 8-7-86 JOB 23,108

S: 1723.6

W: 1010.2

ELEVATIONS		WATER TABLE	
GROUND SURFACE	699.7	AT END OF BORING	-14.5 Feet
END OF BORING	645.2	24 HOURS	
		WHILE DRILLING	- 9.5 Feet

SHEET 1 OF 2



SAMPLE NO.	SAMPLE TYPE	N	WC	Qu	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
						0.3	699.4	Black clayey TOPSOIL, moist (OL)
1A 1B	SS	29	12.4 13.1					Dark brown very sandy gravelly CLAY, little organics, moist, disturbed (CL)
2	SS	18	17.3	4.5*				
						4.5	695.2	
3A 3B	SS	15	15.5 20.3	-- 3.5*				Very tough dark brown silty CLAY, some sand, trace gravel, moist (CL)
						6.0	693.7	
4	SS	46						Firm to dense brown fine to coarse SAND and small to large GRAVEL, little silt, wet at 9.5' (SW)
5	SS	24						
6	SS	34						
7	SS	36						
8	SS	49						
9	SS	21						
10	SS	34						
						20.0	673.7	
11	SS	55						Dense to very dense gray GRAVEL and SAND, wet (GW)
12	SS	95						
13	SS	61						
14	SS	62						
15	SS	34						
16	SS	33						
17A 17B	SS	11	-- 20.1	-- 2.0*		33.5	666.2	Very tough gray silty CLAY, little sand, trace gravel, moist (CL)
						34.0	665.7	
18	SS	78						Very dense gray GRAVEL and SAND, wet (GW)
						36.5	663.2	
19A 19B	SS	32	13.6 11.1	4.5+* --				Hard gray silty CLAY, little to some sand, trace gravel, moist (CL)
						38.0	661.7	
20	SS	155/9"						Very dense gray clayey SAND and GRAVEL, wet (GC/SC)
						39.5	660.2	

PROJECT BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DISTRICT OF DU PAGE COUNTY, GLEN ELLYN, ILLINOIS

BORING C-137 DATE STARTED 8-7-86 DATE COMPLETED 8-7-86 JOB 23,108

S: 1723.6

W: 1010.2

ELEVATIONS

GROUND SURFACE 699.7

END OF BORING 645.2

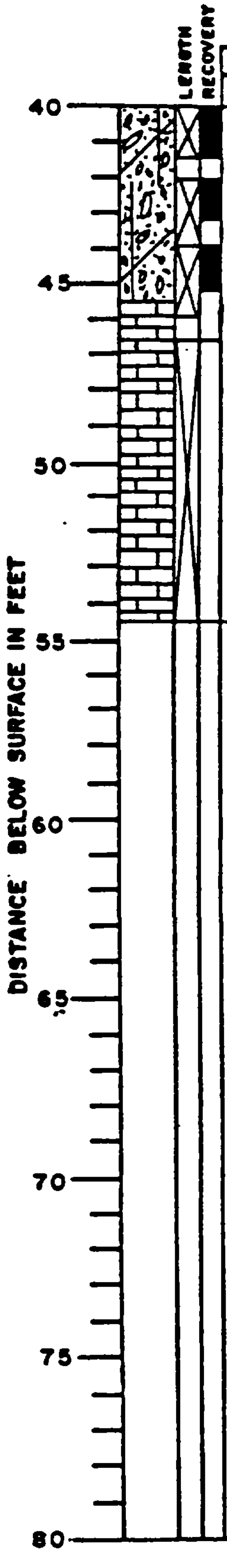
WATER TABLE

AT END OF BORING -14.5 Feet

24 HOURS

WHILE DRILLING - 9.5 Feet

SHEET 2 OF 2



SAMPLE NO.	SAMPLE TYPE	N	WC	Qu	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
21	SS	95						Very dense yellow-gray fine to coarse SAND and small to large GRAVEL, trace silt and clay, wet (GW)
22	SS	55						
23	SS	68/10"						
						45.5	654.2	
24	CORE							BEDROCK: Light gray to brown DOLOMITE, micritic, occasional silt partings, trace stylolit moderate to high porosity, fractured from 47.5'- 48.3' vertical fracture starting at 53.0'

End of Boring at -54.5 Feet

* Approximate unconfined compression strength based on measurements with a calibrated pocket penetrometer.

MONITORING WELL INSTALLATION NOTES

1).	4" Schedule 40 PVC #10 slot screen:	43.5 - 53.5'
2).	4" Schedule 40 PVC riser:	+2.0 - 43.5'
3).	"Best" #490 sand pack:	42.5 - 54.5'
4).	Bentonite Pellets:	40.0 - 42.5'
5).	Volclay Grout:	2.5 - 42.5'
6).	6" Protector casing concreted in place over well	

TESTING SERVICE CORPORATION

PROJECT BLACKWELL FOREST PRESERVE

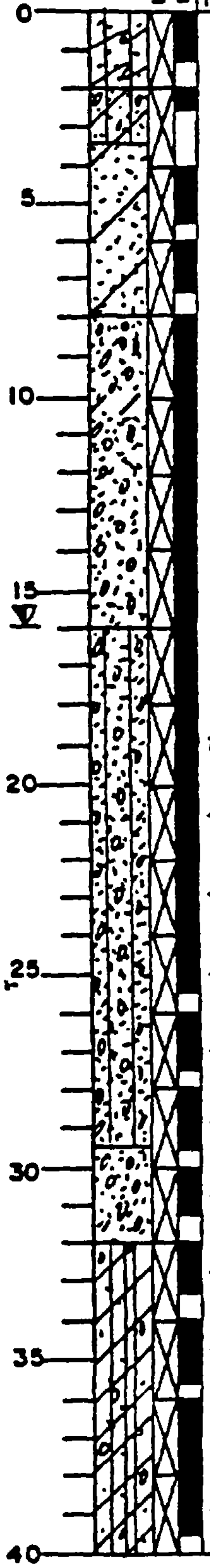
CLIENT FOREST PRESERVE DISTRICT OF DU PAGE COUNTY, GLEN ELLYN, ILLINOIS

BORING G-138 DATE STARTED 8-13-86 DATE COMPLETED 8-14-86 JOB 23,108

S: 254.5
W: 2249.2

ELEVATIONS		WATER TABLE	
GROUND SURFACE	706.6	AT END OF BORING	
END OF BORING	650.1	24 HOURS	
		WHILE DRILLING	-16.0 Feet

SHEET 1 OF 2



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
1	SS	13	19.7					Dark brown silty TOPSOIL, little sand, some roots, damp (OL)
						2.0	704.6	
2	SS	17	21.6					Firm brown silty SAND and GRAVEL, moist clay binder (GC)
						3.3	703.3	
3_B^A	SS	9						Loose to firm brown fine to medium SAND, little clay binder, damp (SP)
4	SS	18						
						8.0	698.6	
5	SS	35						
6	SS	47						Dense brown fine to medium grained SAND with GRAVEL, damp; 0.2' brown sand clay seam at 10.3', damp (SP)
7	SS	35						
8	SS	37						
						16.0	690.6	
9	SS	34						
10	SS	24						Firm to very dense brown silty SAND and GRAVEL, wet (GW/SW)
11	SS	15						
12	SS	13						
13	SS	17						
14	SS	18						
15_B^A	SS	63						
						29.5	677.1	
16	SS	23						Firm gray sandy GRAVEL, wet (GW)
						32.0	674.6	
17	SS	63	8.8					
18	SS	33	8.8					Dense gray clayey SILT, some sand, trace gravel, damp to moist, very moist from 44.0 - 46.0' (ML)
19	SS	37	9.1					
20	SS	41	10.2					

TESTING SERVICE CORPORATION

BORING LOG CONTINUED

PROJECT BLACKWELL FOREST PRESERVE

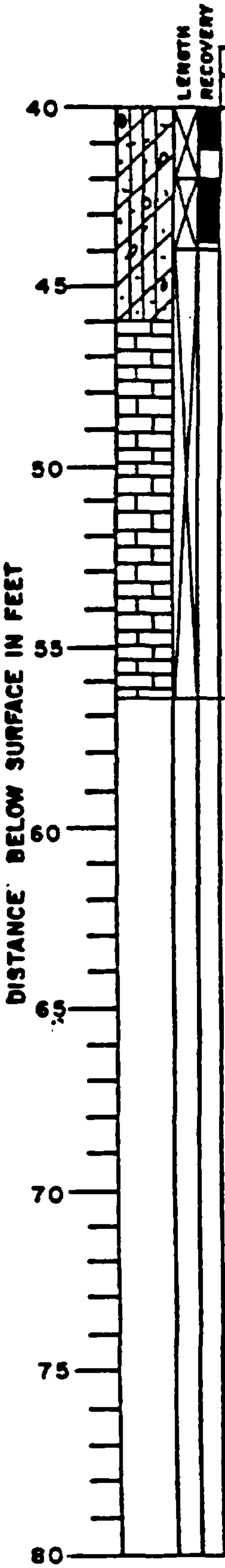
CLIENT FOREST PRESRVE DISTRICT OF DU PAGE COUNTY, GLEN ELLYN, ILLINOIS

BORING C-138 DATE STARTED 8-13-86 DATE COMPLETED 8-14-86 JOB 23,108

S: 254.5
W: 2249.2

ELEVATIONS		WATER TABLE	
GROUND SURFACE	706.6	AT END OF BORING	
END OF BORING	650.1	24 HOURS	
		WHILE DRILLING	-16.0 Feet

SHEET 2 OF 2



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γ DRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
21	SS	33	10.1					Dense gray clayey SILT, some sand, trace gravel, damp to moist, very moist from 44.0 - 46.0' (ML)
22	SS	48	12.0					
23	SS	16	11.5			46.0	660.6	
24	CORE							BEDROCK: Fractured to 48.0' light [illegible]ay to light brown DOLOMITE, micritic, massive, occasional silt partings, high porosity, occasional fractures, trace illite at 56.5'

End of Boring at -56.5 Feet

* Approximate unconfined compression strength based on measurements with a calibrated pocket penetrometer.

MONITORING WELL INSTALLATION NOTES

1). 4" Schedule 40 PVC #10 screen: 44.0 - 54.0'
2). 4" Schedule 40 PVC riser: +2.0 - 44.0'
3). "Best" #490 sand pack: 43.5 - 56.5'
4). Bentonite Pellets: 41.0 - 43.5'
5). Volclay Grout: 2.5 - 41.0'
6). 6" protector casing concreted in place over well

PROJECT BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESRVE DISTRICT OF DU PAGE COUNTY, GLEN ELLYN, ILLINOIS

BORING C-139 DATE STARTED 8-18-86 DATE COMPLETED 8-19-86 JOB 23,108

N: 540.3

W: 2512.8

ELEVATIONS

GROUND SURFACE 700.1

END OF BORING 643.6

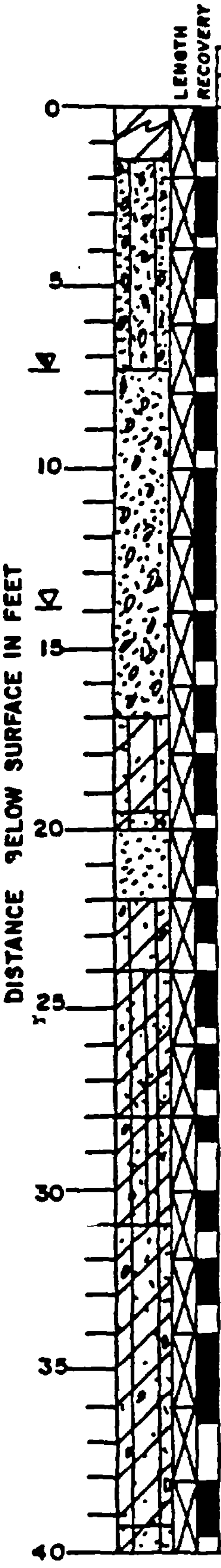
WATER TABLE

AT END OF BORING -14.0 Feet

24 HOURS

WHILE DRILLING - 7.5 Feet

SHEET 1 OF 2



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
1A B	SS	25	14.9 --			1.4	698.7	Black clayey TOPSOIL, moist (OL)
2	SS	54						Firm to very dense light brown CRAVEL and SAND, little silt, damp (GW)
3	SS	28						
4A B	SS	48				7.5	692.6	
5	SS	58						
6	SS	48						Firm to very dense gray SAND and GRAVEL, wet (GW/SW) NOTE: 3" Black sand seam at 9.3', strange odor
7	SS	96						
8	SS	21						
9A B	SS	30	-- 17.8	-- 4.5+*		17.0	683.1	
10A B	SS	30	18.0 --	2.0* --				Very tough to hard gray silty CLAY, little sand, silt partin gs, moist (Cl
						19.5	680.6	Firm brownish gray fine sandy SILT, trace clay, moist (ML)
						20.0	680.1	
11	-	24						Firm gray fine to medium SAND, wet (S
						22.0	678.1	
12	SS	66/10"	10.4	4.5+*				Hard gray silty CLAY, little sand, tr gravel, moist (CL)
						24.0	676.1	
13	SS	74						Very dense (hard) gray very clayey SILTS, very silty CLAY, some sand, occasional silt and sand seams, damp to moist, reddish hue to 26.0' (CL/ML)
14	SS	58	14.9	4.5+*				
						28.0	672.1	
15	SS	45	12.2					Dense brownish gray clayey SILT, trace sand and gravel, moist (ML)
16A B	SS	37	17.3 12.1	-- 4.5+*		31.0	669.1	
17	SS	40	11.9	4.5+*				Tough to hard gray silty CLAY, little sand, some gravel, moist (CL)
18	SS	29	12.8	3.0*				
19	SS	33	18.5	.0*				
20A B	SS	59	16.5 --	2.25* --		39.2	660.9	Very dense brownish gray sandy SILT, trace clay, damp (ML)

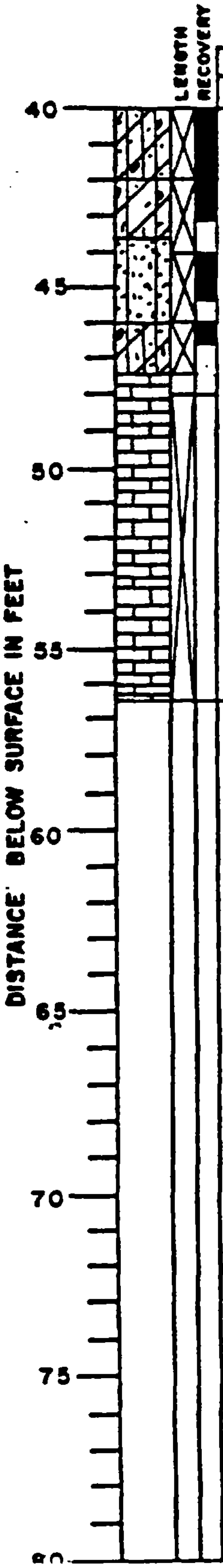
PROJECT	BLACKWELL FOREST PRESERVE
CLIENT	FOREST PRESERVE DISTRICT OF DU PAGE COUNTY, GLEN ELLYN, ILLINOIS

BORING C-139 DATE STARTED 8-18-86 DATE COMPLETED 3-19-86 JOB 23.108

N: 540.3
W: 2512.8

ELEVATIONS		WATER TABLE	
GROUND SURFACE	700. 1	AT END OF BORING	-14.0 Feet
END OF BORING	643.6	24 HOURS	
		WHILE DRILLING	- 7.5 Feet

SHEET 2 OF 2



SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
21	SS	47	11.0			42.0	658.1	Dense gray clayey SILT, trace sand and gravel, moist (ML)
22A B	SS	4	15.9 --	1.0* --		43.7	656.4	Tough gray silty CLAY, little sand, trace gravel, moist (CL)
23	SS	82/10"				46.0	654.1	Very dense gray silty very fine SAND, wet (SM)
24	SS	50/3"	9.6			47.5	652.6	Very dense clayey SILT and SAND, some gravel, damp to moist (ML/SC)
25	CORE							BEDROCK: Light gray DOLOMITE, micritic occasional silt partings, tra stylolites, massive, moderate porosity, fractured from 51.0' - 51.5'; fracture has secondary recrystallization

End of Boring at -56.5 Feet

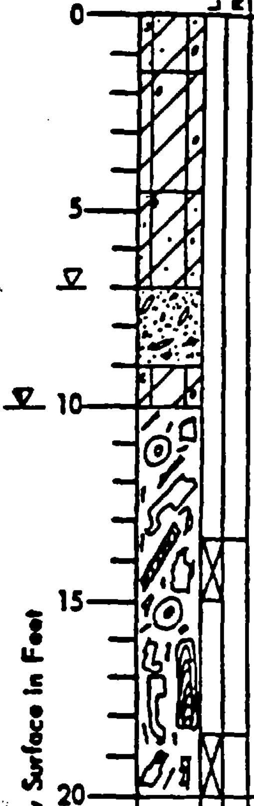
* Approximate unconfined compression strength based on measurements wit a calibrated pocket penetrometer.

MONITORING WELL INSTALLATION NOTES

1). 4" Schedule 40 PVC #10 screen: 45.5 - 55.5'
2). 4" Schedule 40 PVC riser: +2.5 - 45.5'
3). "Best" #490 sand pack: 43.5 - 56.5'
4). Bentone pellets: See Report
5). Volclay Grout: 2.5 - 43.5'
6). 6" Protector casing concreted in place over well

PROJECT LEACHATE MONITORING WELLS, BLACKWELL FOREST PRESERVE, DUPAGE COUNTY, ILL.
CLIENT FOREST PRESERVE DIST. OF DUPAGE CO., P.O. BOX 2339, GLEN ELLYN, ILL.
BORING SV-1 DATE STARTED 5-14-82 DATE COMPLETED 5-17-82 JOB 18,766

ELEVATIONS		WATER TABLE	
GROUND SURFACE	738.9	AT END OF BORING	- 7.0 FEET
END OF BORING	718.9	24 HOURS	
		WHILE DRILLING	-10.0 FEET



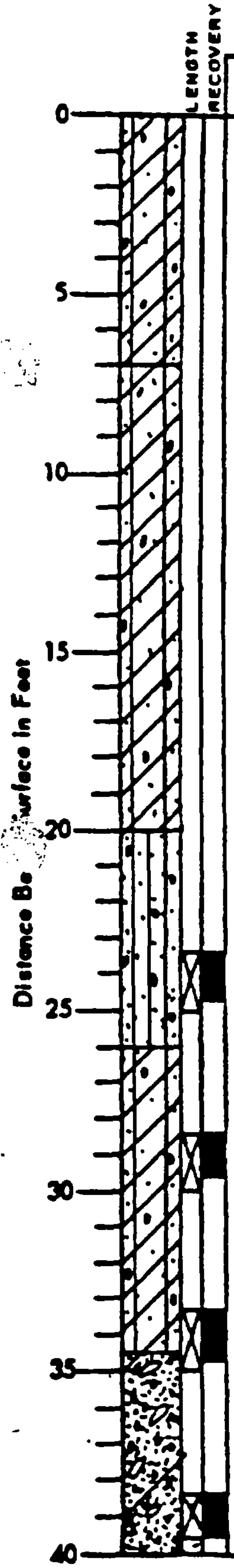
SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γ DRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
						1.5	737.4	FILL - Dark brown silty sandy CLAY, trace small gravel, damp (CL)
						4.5	734.4	FILL - Gray silty CLAY, some gravel moist (CL)
						7.0	731.9	FILL - Brown silty sandy CLAY, trac small gravel, moist (CL)
						9.0	729.9	FILL - Brown coarse SAND and small to large GRAVEL (SW-GW)
						10.0	728.9	FILL - Brown silty CLAY, trace smal gravel, moist (CL)
								REFUSE - METAL, WOOD, PAPER, GLASS, misc. MATERIAL
1								
2								

End of Boring at -20.0 Feet

NOTES:
Bottom of plastic screen: 18.5'
Top of plastic screen: 13.5'
Slotted PVC pipe from 13.5' to 3.5'
Gravel backfill to 6'
Bentonite pellets from 6' to 4'
Backfill above bentonite

PROJECT BLACKWELL FOREST PRESERVE
CLIENT FOREST PRESERVE DIST. OF DU PAGE CO., P. O. 2339, GLEN ELLYN, ILLINOIS
BORING SV-11 DATE STARTED 6-6-84 DATE COMPLETED 6-8-84 JOB 20,530

ELEVATIONS		WATER TABLE	
GROUND SURFACE	808.9	AT END OF BORING	
END OF BORING	713.9	24 HOURS	
LOCATION: 4 + 79 N 12 + 92 W		WHILE DRILLING	-84.0 Feet
		SHEET 1 OF 3	

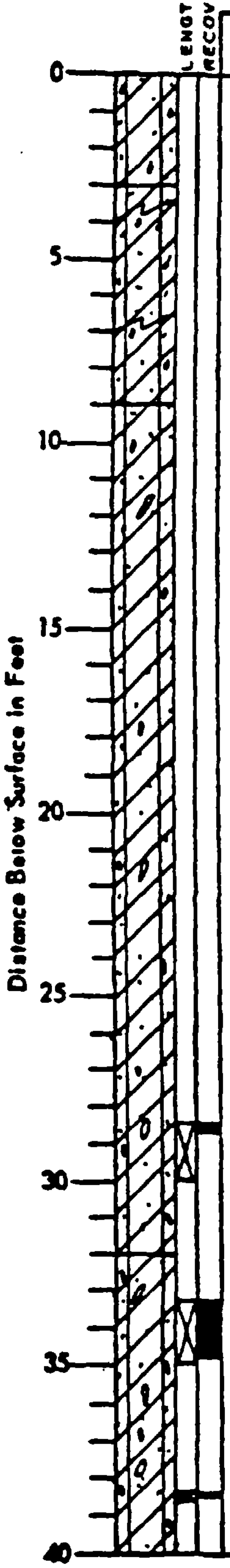


SAMPLE NO.	TYPE	N	WC	Q_u	γ DRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
								FILL: Brown silty CLAY, some gravel, little sand (CL)
						7.0	801.9	
								FILL: Gray silty CLAY, little gravel, trace sand, a few cobbles (CL)
						20.0	788.9	
								FILL: Gray SILT, little sand, trace gravel (ML)
1	SS	12						
						26.0	782.9	
2	SS	31	12.6					FILL: Grayish-brown very silty CLAY, trace sand and gravel (CL-ML)
3A 3B	SS	56	13.3 -					
						34.5	774.4	
								FILL: Brown fine to coarse SAND and small to large GRAVEL, a few cobbles, trace clay above 37' (SW-GW)
4	SS	37/6"						

PROJECT BLACKWELL FOREST PRESERVE
CLIENT FOREST PRESERVE DIST. OF DU PAGE CO., P. O. 2339, GLEN ELLYN, ILLINOIS
BORING SV-12 DATE STARTED 6-11-84 DATE COMPLETED 6-12-84 JOB 20,530

ELEVATIONS
GROUND SURFACE 827.7
END OF BORING 737.7
LOCATION: 2 + 20 N
11 _ 82 W

WATER TABLE
AT END OF BORING
24 HOURS
WHILE DRILLING -78.0 Feet
SHEET 1 OF 3



SAMPLE NO.	TYPE	N	WC	Q_u	γ DRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
								FILL: Brown silty CLAY, some gravel, trace sand (CL)
						3.0	824.7	
								FILL: Black silty CLAY, trace sand, gravel and organic
						9.0	818.7	
								FILL: Gray silty CLAY, trace sand and gravel, occasional cobbles (CL)
1	SS	50						
						32.0	795.7	
								FILL: Gray, brown and dark brown silty to very silty CLAY, trace sand and gravel, occasional cobbles (CL, Cl-ML)
2	SS	63	8.7					
3	SS	75/2"	9.8					

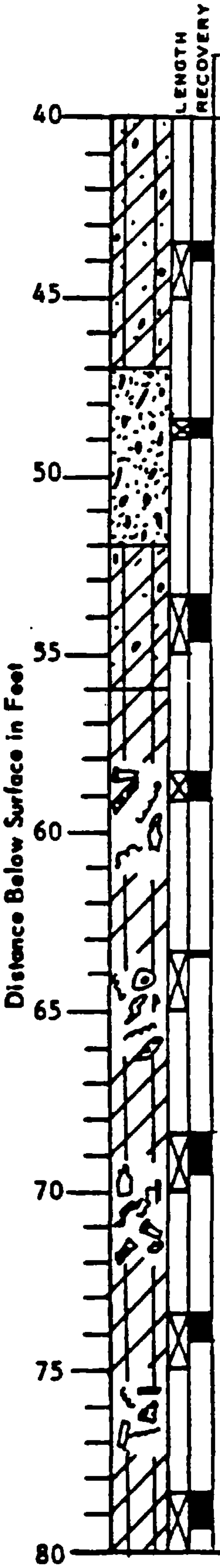
BORING LOG CONTINUED

PROJECT BLACKWELL FOREST PRESERVE
CLIENT FOREST PRESERVE DIST., OF DU PAGE CO., P. O. 2339, GLEN ELLYN, ILLINOIS
BORING SV-12 cont. DATE STARTED 6-11-84 DATE COMPLETED 6-12-84 JOB 20,530

ELEVATIONS
GROUND SURFACE 827.7
END OF BORING 737.7

WATER TABLE
AT END OF BORING
24 HOURS
WHILE DRILLING -78.0 Feet

SHEET 2 of 3



SAMPLE NO.	TYPE	N	WC	Q_u	γ DRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
4	SS	74						FILL: Gray, brown and dark brown silty to very silty CLAY, trace sand and gravel, occasional cobbles (CL, CL-ML)
						47.0	780.7	
5	SS	70/6"						FILL: Brown fine to coarse SAND and small to large GRAV a few cobbles (SW-GW)
						52.0	775.7	
6	SS	23	16.0					FILL: Gray silty CLAY, trace sand and gravel (CL)
						56.0	771.7	
7	SS	67/6"						
8	SS	28						REFUSE with occasional silty clay layers
9	SS	67						
10	SS	79						
11	SS	33						

PROJECT BLACKWELL FOREST PRESERVE

CLIENT FOREST PRESERVE DIST., OF DU PAGE CO., P. O. 2339, GLEN ELLYN, ILLINOIS

BORING SV-12 cont. DATE STARTED 6-11-84 DATE COMPLETED 6-12-84 JOB 20,530

ELEVATIONS

GROUND SURFACE 827.7

END OF BORING 737.7

WATER TABLE

AT END OF BORING

24 HOURS

WHILE DRILLING -78.0 Feet

SHEET 3 OF 3

Distance Below Surface In Feet	SAMPLE NO.	SAMPLE TYPE	N	WC	Q_u	γDRY	DEPTH	ELEV.	SOIL DESCRIPTIONS
80									
85	12	SS	25/6" 50/0"						REFUSE with occasional silty clay layers
90	13	SS	59						

End of Boring at - 90.0 Feet

NOTES:

1. Bore hole made with hollowstem auger.
2. Bottom of 10' PVC screen at 87'.
3. Slotted PVC from 77' to 47'.
4. Gravel pack from bottom of screen to 45'.
5. Bentonite pellets from 45' to 40'.
6. Clay cuttings above 40'.
7. Steel protective casing concreted into place over PVC casing.

95

100

105

110

115

120

TESTING SERVICE CORPORATION

APPENDIX C

CROSS SECTIONAL DRAWINGS FROM PREVIOUS SITE INVESTIGATIONS

APPENDIX D

WATER RESOURCES CENTER REPORT

UIUC-WRC-86-202
Research Report 202

CHARACTERIZATION OF A LANDFILL-DERIVED CONTAMINANT PLUME IN GLACIAL AND BEDROCK AQUIFERS, NE ILLINOIS

By Colin J. Booth
and Peter J. Vagt

University of Illinois
at Urbana-Champaign
Water Resources
Center

Department of Geology
Northern Illinois University
DeKalb, Illinois

July 1986

Project No. 1015-05
Grant Number INT 14 08 0001 1015

Final Project Completion Report
to
U.S. Geological Survey
Department of the Interior
Washington, D.C. 20240

Peter J. Vagt

WRC RESEARCH REPORT NO. 202

CHARACTERIZATION OF A LANDFILL-DERIVED CONTAMINANT PLUME IN GLACIAL AND BEDROCK AQUIFERS, NE ILLINOIS

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Department of Geology
Northern Illinois University
DeKalb, Illinois 60115

Project Completion Report
Project No. G1015-05
Grant Number INT 14 08 0001 1015

July 1986

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University of Illinois
Water Resources Center
Urbana, Illinois 61801
217/333-0536

The conclusions and interpretations presented in this report are solely those of the authors and do not represent, in any way, the views of DuPage County Forest Preserve District, U.S. Department of the Interior, or any other agency, person, or organization.

ABSTRACT

Groundwater contamination by organic and inorganic chemicals is a regional and national problem; landfills are major potential contaminant sources. In this study of the Blackwell landfill, DuPage County, Illinois, the contaminant plume is delineated and related to the site history and hydrogeology. Leachate leakage is attributed partly to landfill construction problems. The landfill is located partly on a sand-and-gravel aquifer and partly on thick, poorly permeable till, all overlying an important dolomite aquifer. A roughly concentric contaminant plume surrounds the landfill in the glacial materials. A leachate leakage rate of between 600 and 3000 ft^3/day was estimated from infiltration and leachate-level calculations. The leakage is rapidly diluted in the aquifer; background TDS levels are reached on site. Volatile organics have concentrations of over 100 ppb in the aquifer close to the landfill, but decrease rapidly away. The contaminant plume appears to have reached equilibrium, and does not extend off site. The bedrock is probably in continuity with the glacial aquifer; however, the traces of organics found therein are not clearly linked to the landfill plume and may originate from other sources. This study has generated considerable field data which should be valuable in future studies.

Booth, Colin J. and Vagt, Peter J.
CHARACTERIZATION OF A LANDFILL-DERIVED CONTAMINANT PLUME IN GLACIAL AND BEDROCK AQUIFERS, NE ILLINOIS
Project Completion Report, USGS Project No. G1015-05, July 1986, 92 pp.

Keywords: Groundwater Hydrology, Sanitary Landfills, Organic Compounds, Glacial Aquifers

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1. INTRODUCTION

Introduction and Objectives

This study delineates the groundwater contaminant plume from a landfill in northeastern Illinois, and examines the hydrogeological setting and site characteristics that control the contaminant pattern. The study is a site-specific investigation, but also, because the site is so well-monitored and well-documented, it serves as a reference example of a landfill in complex glacial materials overlying bedrock aquifers.

The Roy C. Blackwell Forest Preserve, DuPage County, Illinois (Figure 1) was a classic sequential land-use site. Originally a derelict sand-and-gravel quarry, it was used from 1965 to 1972 as a sanitary landfill for solid waste (while further quarrying both prepared the site and defrayed the landfill cost), then was subsequently landscaped as a forest preserve with recreational lakes. Monitoring wells were installed on the landfill and its perimeter, monitored, and sampled - first by the Illinois State Geological Survey (ISGS) and later by the DuPage County Forest Preserve District (FPD). Following the detection of volatile organic compounds (VOC's) in certain wells in 1983, additional wells were drilled, and further hydrogeological investigations (including our own) conducted. As a precaution, the swim lake was closed to the public, although no contaminants had been found in it.

Our objectives in this study were to (1) reconstruct the history of the landfill operation, in order to identify those landfill factors that might have contributed to the contaminant pattern development; (2) collate and evaluate existing chemical and hydrologic data for the site; (3) characterize the site geology and hydrogeology; (4) delineate the size and configuration of the contaminant plume and determine the history of its development; (5) delineate

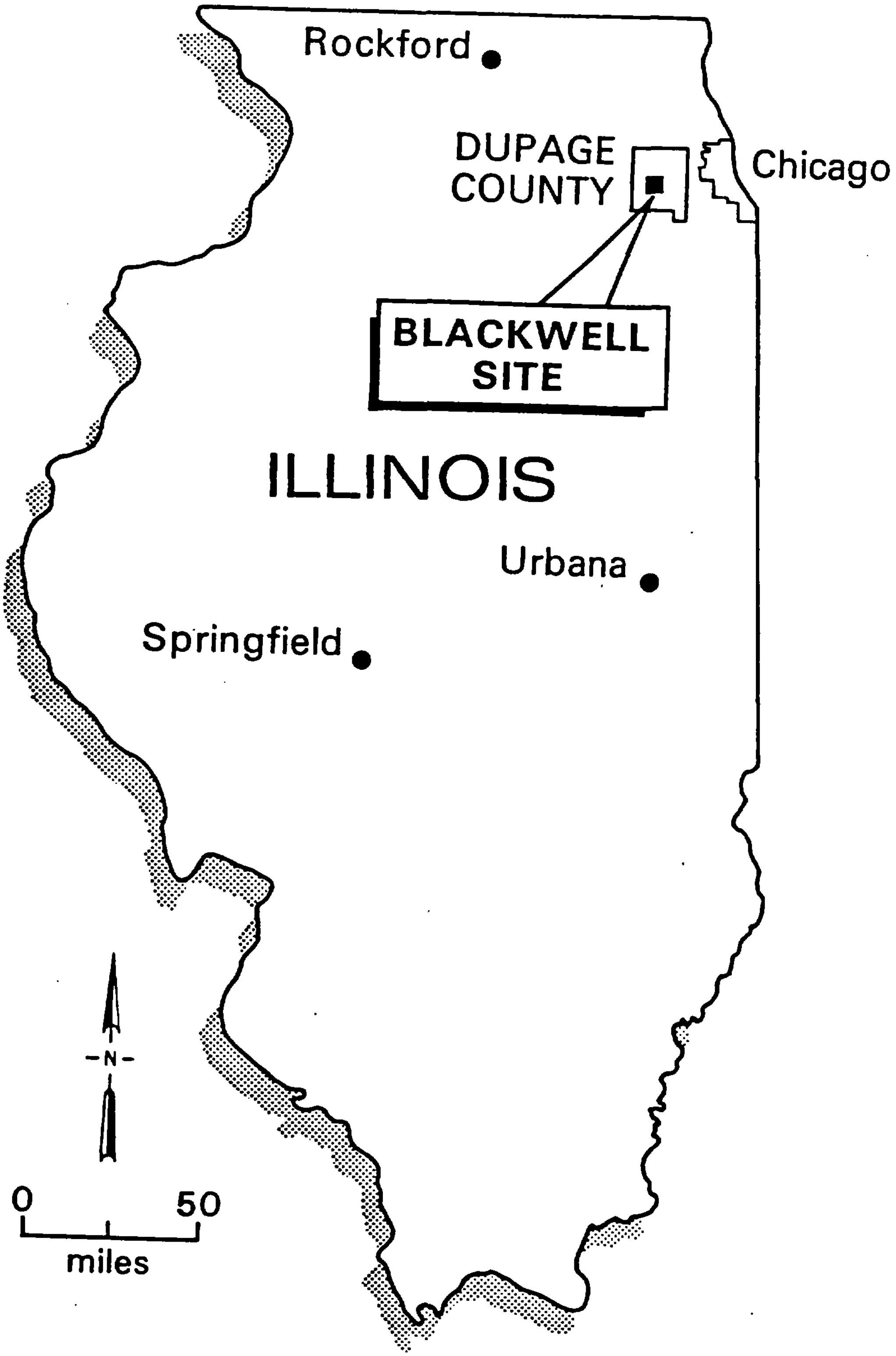


Figure 1. Location of Blackwell Study Area.

the chemical variations within the plume. An ultimate objective, not specifically included in this limited study, is to test existing contaminant-transport numerical models on this site, for which an unusual abundance of data is or will be available.

The principal objectives of the study were achieved and are reported here. A large amount of data on the site geology, aquifer characteristics, groundwater levels and chemistry, leachate levels and site hydrology has been collected or collated in this study; only a summary is presented in this report. The hydrologic budget for the landfill, and therefore also the calculation of leachate production and leakage, remain uncertain estimates. However, we feel that the characterization and interpretation of the site, its hydrogeology, and the contamination of the glacial aquifer presented here is a well-evidenced, substantive contribution to the understanding of landfill-derived contaminant hydrology. Although the contaminant data for the bedrock aquifer is somewhat ambiguous, the study has illustrated the significance of glacial-bedrock linkage in contamination problems.

Justification and Significance of the Work

Groundwater resource protection is recognized as a priority concern at both state and regional levels, as shown in policy documents such as the plan for protecting Illinois groundwater (IEPA, 1986). Volatile organic compounds have been noted as widespread pollutants. Many organics are toxic or carcinogenic. Of the commoner sources of organic contaminants, landfills are potentially serious because they can produce large volumes over long periods.

Although much research has recently been undertaken into the hazards of organic chemicals, of the methods of detecting them in groundwater, and of the mechanisms by which they are transported, the problems are complex and there is a recognized need for more detailed knowledge (Mackay et al., 1985). Much current research is being conducted by laboratory and model studies of the transport and attenuation mechanisms, but because of the expense, time requirements, and lack of control, detailed field studies are less common. Yet field observations of contaminant behavior can provide valuable insights into the processes and controls and the evaluations of concepts and models.

The Blackwell site affords an excellent opportunity to examine the behavior of contaminants in the vicinity of a landfill in unconsolidated materials. Numerous monitoring wells have been installed since the landfill closure in 1972; detailed stratigraphic information is available from boring logs, from later split-spoon samples and from cores of the underlying dolomite bedrock. Sample collection and analysis has been conducted since 1972, and since 1980 sampling for basic inorganic parameters has been carried out two to four times annually. Since the fall of 1983, samples have been analyzed for volatile organics (VOC's). Opportunities for pump testing, monitoring, and other investigations are abundant. Furthermore, the site itself is a representative case of a typical mid-western hydrogeologic environment: unconsolidated glacial materials, both permeable and poorly permeable, overlying a bedrock aquifer.

2. HISTORY OF THE BLACKWELL LANDFILL

The most basic control of groundwater contamination is exercised by the landfill itself: its design, construction, content, and integrity. Therefore, the first study objective was to examine the history of the landfill--information that, while accessible, was not available in a collated form. The records of DuPage County FPD were examined in detail and the results, based on reports, memos, correspondence, etc., are reported here for the development and design, construction, and post-construction phases. Geological and hydrological description and results are presented in later sections.

Development and Design.

The sequential land-use Blackwell Concept was conceived by DuPage County in the 1960's in response to several pressures: Major urban growth was projected in the county; the Northeastern Illinois Planning Commission (NIPC) was urging local governments to maintain open-space "green belts"; and several county waste-disposal sites were nearing capacity and closure. DuPage County's innovative plan was to use derelict FPD land for a solid-waste landfill and subsequently landscape the site for a recreational park; excavation would create lakes, defray landfill costs, and provide fill-and-cover materials.

Both the Illinois State Geologic Survey (ISGS) and the Illinois Sanitary Water Board (ISWB) expressed reservations about the site's suitability as a landfill. K. Piskin (ISGS) listed three unfavorable factors -- the site's position on the edge of the Warrenville cone of depression, the extensive permeable sand and gravel in the area, and the probable connection between the recreational lakes and the buried refuse -- and advised further geological studies of the site's suitability. C.W. Klassen (ISWB) commented that pollution prevention measures should be possible. NIPC engineer J.R. Sheaffer wrote (Oct. 11, 1963) to FPD Director H.C. Johnson that the Blackwell site was particularly unfavorable for refuse disposal because of the geologic environment and valuable groundwater, and suggested that other areas of DuPage County were more favorable.

However, the County Board of Commisioners proceeded, and requested comments from NIPC metropolitan division on the desirability of developing Blackwell Preserve as a nonresidential public area. NIPC Executive Director M.L. Rockwell recommended acquiring additional land around the site to realize recreational, flood-control, and refuse-disposal benefits.

Sheaffer, now in charge of developing an environmentally secure landfill, recommended that:

1. The landfill should be operated for the short time of three years;
2. To meet ISGS and ISWB recommendations, the hill should be based on the higher-level region west of the main gravel pit;
3. Instead of the standard trench-and-fill procedure, clay berms should be built to form above-ground "trenches";
4. Refuse should be enclosed in a series of small cells;
5. The large volume of clay needed to seal the refuse could be excavated from the lake area, where initial test borings had indicated 25 - 40 ft of clay till between gravel and dolomite bedrock;
6. Runoff should be diverted and leachate should be collected in a system constructed 300 ft west (downgradient) of the landfill;
7. The completed hill should rise to fill approximately 180,000 cubic yards of air space.

DuPage County acquired over 1000 surrounding acres. Their consultant, William Rose and Associates (Rose), submitted preliminary design specifications

(October, 1966), which became the Blackwell master plan. They recommended that the hillfill cover a 35-acre area, that a 3:1 clay refuse ratio be used, and that the fill be built as a honeycomb of one-acre cells. Each cell would have a 1½-ft clay base and a perimeter berm 8-9 ft high; it would be filled by two 3-ft lifts separated by 6 inches of clay, and would be covered by 1½ ft of clay which would form the base of the overlying cell, offset to maximize stability. The site would have a final 12-ft layer of compacted clay, covered by soil, and vegetated. The Public Works Department was contracted to build the landfill under FPD supervision and according to the specifications in Table 1.

Table 1. Terms of Original Construction Contract for Blackwell Landfill

To coordinate their joint effort the FPD and Public Works drew up a contract with the following construction specifications:

Berm Height	4 feet per lift
Berm Width	11-12 feet at top
Refuse Height	3 feet per lift
Minimum Daily Cover	6 inches of clay or mixture of clay and gravel
Floor Construction	2 feet of blue clay minimum, dove-tailed into existing blue clay
Temporary Cap	1-2 feet of sand, gravel, clay, or mixture
Refuse Compaction	Obtained by maximum use of site tractor crossing deposited refuse

Construction (1965-1973).

Landfilling and lake excavation were conducted simultaneously. Clay and aggregate excavated to form the north lobe of Silver Lake (the south had been quarried before 1965) were used for landfill cover, while sales of aggregate partly paid the costs of landfilling.

By 1967, the shape of the hill and the general cell layout had been determined. Brief instructions and simple plans show such strategies as building the southern and central cells first to maintain drainage and an easy grade for scavenger trucks, but no records were kept of daily procedure to indicate how construction was continued after the initial levels of the eight planned cells were filled. A site photograph shows a clay base that was the start of the landfill, and is captioned "2-ft of blue clay forming base of cell 1."

Although the original layout was generally followed, significant deviations from design occurred. In the original gravel operation, a drainage ditch had been cut between the south end of Silver Lake and Spring Brook, and later partly filled with concrete, logs and brush. Cell 8 of the landfill was built over the ditch but, from boring logs from landfill vents SV-10 and DV-4, the cell does not seem to have a clay base liner. (Figure 2 shows locations of cells and vents on the landfill.) Additionally, though the plan designates the region northeast of the landfill as a non-dumping area, refuse was found while augering SV-5 and DV-9 in that area: another sign of deviation from the plan. Further problems are indicated by a series of letters (1965-1968) between the FPD and the Public Works Department, through which the FPD accuses the PWD of: (1) instructing public-works personnel to disregard FPD instructions and requests; (2) failure to cover refuse at the end of each day; (3) using insufficient fill between individual refuse cells; (4) using sand and gravel for

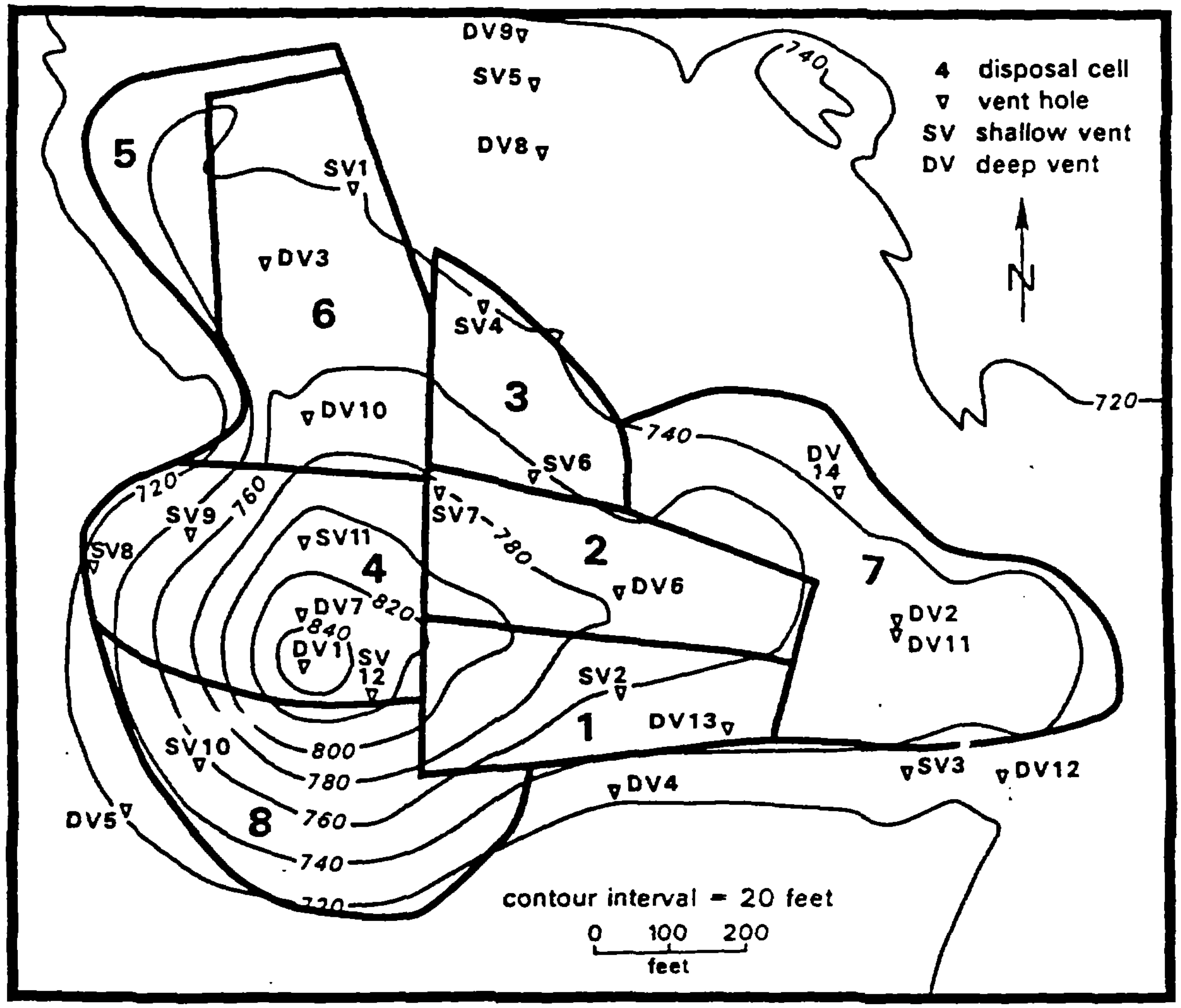


Figure 2. Map of Landfill Showing Location of Vents and Refuse Cells.

all cover; and (5) complete disregard for design specifications for at least several months in 1968 when the fill was operated as an open dump. In May, 1968, FPD personnel refused to be associated further with the project. In May, 1969, the FPD was given responsibility for forming the clay bottoms and side berms.

The landfill was completed in 1973. The last refuse was buried just below the 800-ft elevation level in the western (cell 4) area, and 50 to 60 ft of clay were added to form the final hilltop which, at 846 ft elevation and 150 ft above the surrounding land, is the highest local point (now called Mount Hoy). The hill covers about 40 acres and contains about one million cubic yards of refuse, and an equal volume of natural fill (cf. the original area and refuse/fill ratio specifications, above). The hill is covered to final grade with between two and fifteen feet of cover variably composed of sand, gravel, and (often very little) clay, and was finished with four inches of topsoil, which was vegetated.

In the early 1970's, the Blackwell Concept was nationally hailed as an efficient solution to the dual problem of waste disposal and the need for urban green space. It was written up in several popular publications, including Fortune (Sanford, 1970) and National Geographic (Blair and Young, 1970). Community planners and environmental studies classes visited the site.

Even before completion of the landfill, G. Hughes, ISGS hydrogeologist, had recognized the experimental nature of the Blackwell project and initiated several studies of the site.

Post-Construction Phase

Leachate levels were recorded in a well installed in the landfill in 1968 by ISGS. They rose about 5 ft per year until 1970, then at about 1 ft/year until 1980, when they stabilized in that section at about 760 ft. Because the increases correlated with increased cover material placed on the landfill, it was concluded that the rising level was caused by compaction rather than infiltration of surface water.

In the early 1970's the ISGS, supported by a grant from the Illinois Institute for Environmental Quality (later Illinois Environmental Protection Agency, IEPA), installed ten monitoring wells: two in the landfill, and eight around the perimeter. However, laboratory analyses of monitoring-well samples were not conducted until 1980. In 1980, the consulting firm SMC Martin (King of Prussia, Pennsylvania) conducted an unpublished environmental study of the Blackwell site as part of a U.S. Environmental Protection Agency contract to compare landfill designs. Their draft results, sent to the FPD, suggested that: infiltration would produce 180,000 gallons of leachate annually; that the resultant groundwater mound would be distributed radially and join the regional gradient to the southwest; and that the flow paths would be short and attenuation negligible, although contaminants would be significantly diluted and dispersed as they discharged toward the West Branch of the DuPage River or into the dolomite bedrock aquifer.

Eldredge Engineering was retained by the FPD to evaluate the SMC Martin report. Eldredge's criticisms included the following: the monitoring wells were not capable of giving representative samples; SMC overestimated infiltration and, therefore, leachate; that attenuation and chemical interaction within the fill were not considered. They also stated that the groundwater mound was the result of capillary attraction and the ability of the more absorbent materials to retain water above the surrounding soils.

In early 1980, brown leachate seeps were noted around the landfill. Eldredge called for a more comprehensive monitoring program and contracted with Testing Services Corporation (TSC) to place 12 new wells; 5 to bedrock. They concluded that the leachate seeps were caused by "localized conditions" and could be mitigated by regrading and redirecting runoff with drainage-ways and culverts, and that because the water quality in the up-gradient and down-gradient wells was similar, the landfill had not degraded the groundwater quality.

Leachate seeps continued despite the recommended landscaping. The FPD then suspected that natural gas build-up within the hill was expelling liquid and causing fissures which allowed increased infiltration of surface water. In spring, 1982, 16 gas vents and three more perimeter monitoring wells were installed.

In the spring of 1983, the FPD allocated funds to conduct quarterly sampling for organic and inorganic contaminants. Several of the volatile organic compounds (VOC's) from EPA's priority list (USEPA, 1973) were found at monitoring points south and west of the hill. More monitoring wells were emplaced. Although samples of surface water from the site were uncontaminated, as a precautionary measure the FPD kept the swimming beach -- a prime attraction of the Preserve -- closed in 1985 and 1986.

In September, 1984, Dan Raviv and Associates were retained by the FPD to assess the potential impact of the VOC's and to make recommendations about further use of the swim beach. Raviv identified the landfill as the source of VOC contamination, calculating the total volume of refuse at 43 million cubic feet. Finding no systematic variation in individual organic contaminants with time, he summed all detected VOC's into a single parameter, Total Volatiles (TV's), and noted that there was a generally decreasing pollutant trend in TV's between December 1983 and September 1984 (Table 2). Raviv calculated that the landfill contains about 50 million gallons of leachate and noted that, although there is no immediate threat of contaminating surface water or the dolomite aquifer, that potential remains. He recommended that the swim beach be kept closed, that the VOC monitoring program be continued, and that a groundwater model be developed to aid in assessment of long-term prediction and migration.

Table 2. Contaminant Trends Recorded in Monitoring Wells, Dec. 1983-Sept. 1984 (Dan Raviv and Associates/DuPage County FPD).

Number of Wells	Percentage	Behavior
19	42	Zero Concentration (0.30 ppb TV)
16	36	TV present but no trend
5	11	Increasing concentration
5	11	Decreasing concentration

Summary and Conclusions from Historical Research. The history of the Blackwell site has been elucidated through research of the diverse records of the FPD. From the abbreviated version above, it is clear that Blackwell Concept, an innovative approach to solving environmental problems, had a flaw: The landfill leaks leachate. The problem arises from the combination of two factors. First, the site is unfavorable, because of the extensive glacial sand-and-gravel aquifer, the underlying bedrock aquifer, and the incomplete clay cover. Second, the landfill as constructed did not follow the design criteria. The working design by Rose did not follow Sheaffer's original plan; the area and volume were vastly increased, the ratio of waste to fill was worsened, and the proposal for a leachate collection system was dropped. The construction then failed to follow the working design. Although the layout plan was followed, the refuse disposal procedures were ignored, the construction changed the hydrologic regime, and the landfill basal clay liner and cover layers were, in part, misconstructed using inappropriate materials. The landfill therefore took on water during construction and leaked leachate later. However, the use of gravel for the cover may have, paradoxically, minimized infiltration into the refuse by intercepting it and by reducing cracking of the clay cover where it exists.

3. HYDROGEOLOGY OF THE BLACKWELL SITE

Geology

The Blackwell Forest Preserve is located in west-central DuPage County in northeastern Illinois (Figure 1). The area is within the glaciated Central Lowland Province and is covered with glacially derived unconsolidated sediments. The surface topography, which bears little relation to the buried bedrock topography, slopes broadly from northwest to southeast across the county with a total relief of about 245 ft. The most prominent natural features in the area are a series of concentric moraines roughly parallel to the Lake Michigan shore. The East and West Branches of the DuPage River, the Des Plaines River in the west, and the Fox River in the east provide the main surface drainage, flowing generally southward between the morainal ridges. The highest landscape features in the county are, in fact, the landfills.

In total, 55 wells and boreholes have been drilled across the Blackwell site (Figure 3); of these, 16 penetrate the bedrock. Detailed strata logs are available from most of these holes, and additionally split-spoon samples of the unconsolidated material and some cores of the bedrock were obtained. The site geology has been determined from this information using sections and maps.

The bedrock underlying northern Illinois is a thick sequence of Paleozoic sedimentary rocks following major structural features. DuPage County lies on the northeastern flank of the Kankakee Arch, which separates the Michigan and Illinois Basins to the east and south respectively. The rocks are folded into a series of gentle anticlines and synclines, and broadly dip east and southeast at about 10 ft per mile.

Silurian rocks form the upper bedrock in the immediate area. At the top are the dolomites of the Niagaran Series, comprising three formations: the

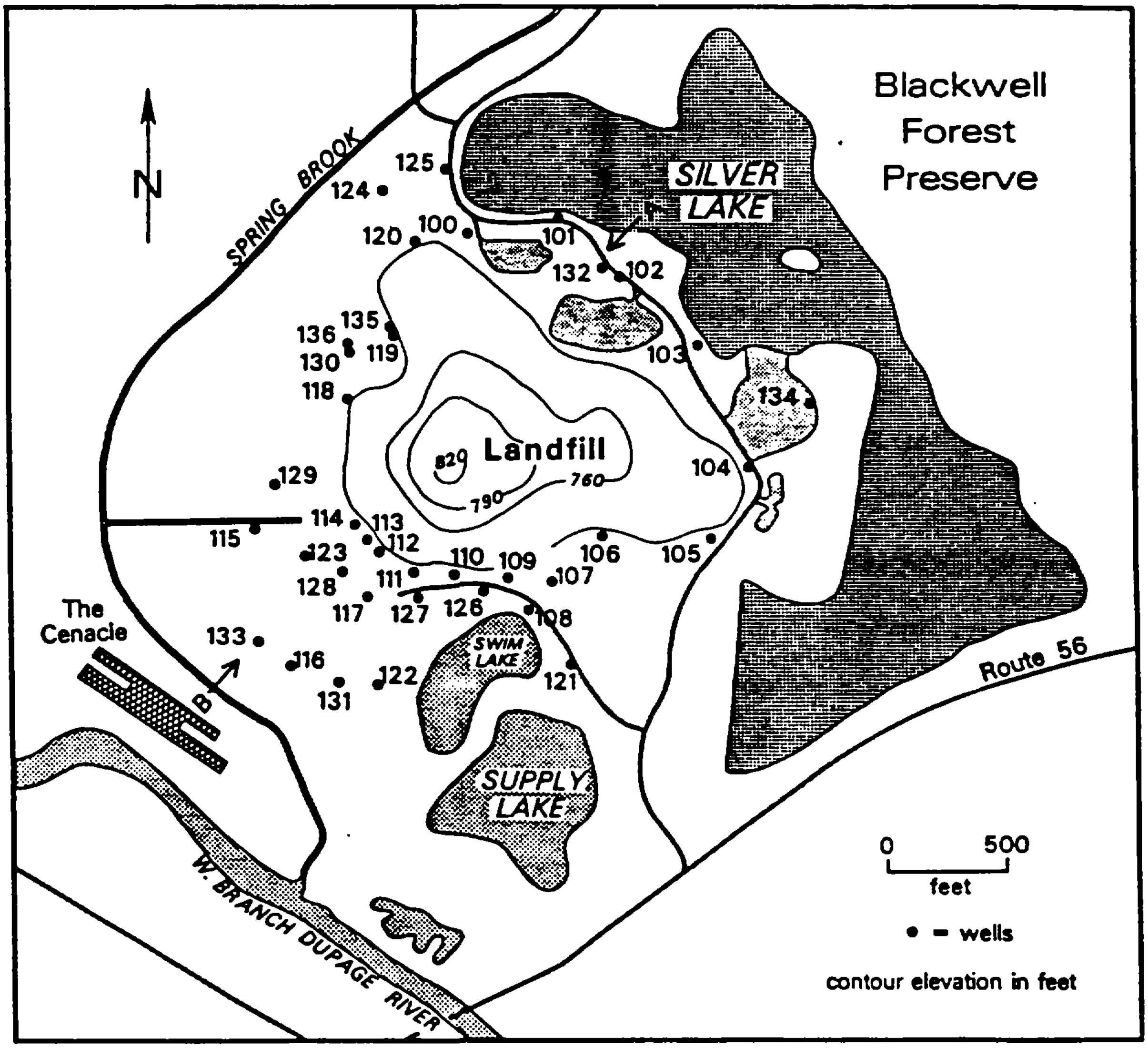


Figure 3. Blackwell Forest Preserve Site Map, Showing Locations of Monitoring Wells and Location of Section Line AB

lowest shaly dolomite, the middle ranging from a clean dolomite to silty, argillaceous, and cherty dolomite, and the upper characterized by reef strata. Beneath the Niagaran are shaly dolomites of the Alexandrian Series, and beneath these, separating the Silurian rocks from the thick sandstone, limestone, and dolomite sequence of the Cambrian and Ordovician, is the Ordovician Maquoketa Formation, consisting mainly of shaly dolomites and shales with dolomite interbeds.

The bedrock surface, subcropping beneath the glacial drift cover, exhibits a subdued relief created by pre-glacial stream erosion and modified by glacial erosion. (Horberg, 1950; Suter et al., 1959; Willman, 1971). The resistant Niagaran dolomite formed a wide cuesta, whose western escarpment was the ancient Mississippi-Michigan drainage divide. In Kane County, to the west, the softer Maquoketa outcrop was a broad vale. The cuesta's eastern backslope carried eastward-flowing streams in valleys, but is relatively flat and not deeply dissected; its total relief is about 100 ft. DuPage County lies on the eastern backslope terrain.

Contours on the bedrock surface of the site, drawn from the borehole information (Figure 4), indicate a northward slope with a local bedrock high in the southwest, a valley running east-west across the north edge of the site, and possibly a minor tributary valley running to it along the western edge. The bedrock surface relief across the site is 38 ft.

Deposits of the Woodfordian Substage (Wisconsinan Stage) of the Pleistocene dominate the surficial materials and surface topography of northern Illinois. In Woodfordian time, glacial ice flowing westward from the Lake Michigan basin overrode the Niagaran cuesta and spread out on a series of lobes to the west and south. Layers of till and a succession of moraines attest to the repeated advances and retreats of the ice. The detailed stratigraphy and glacial history

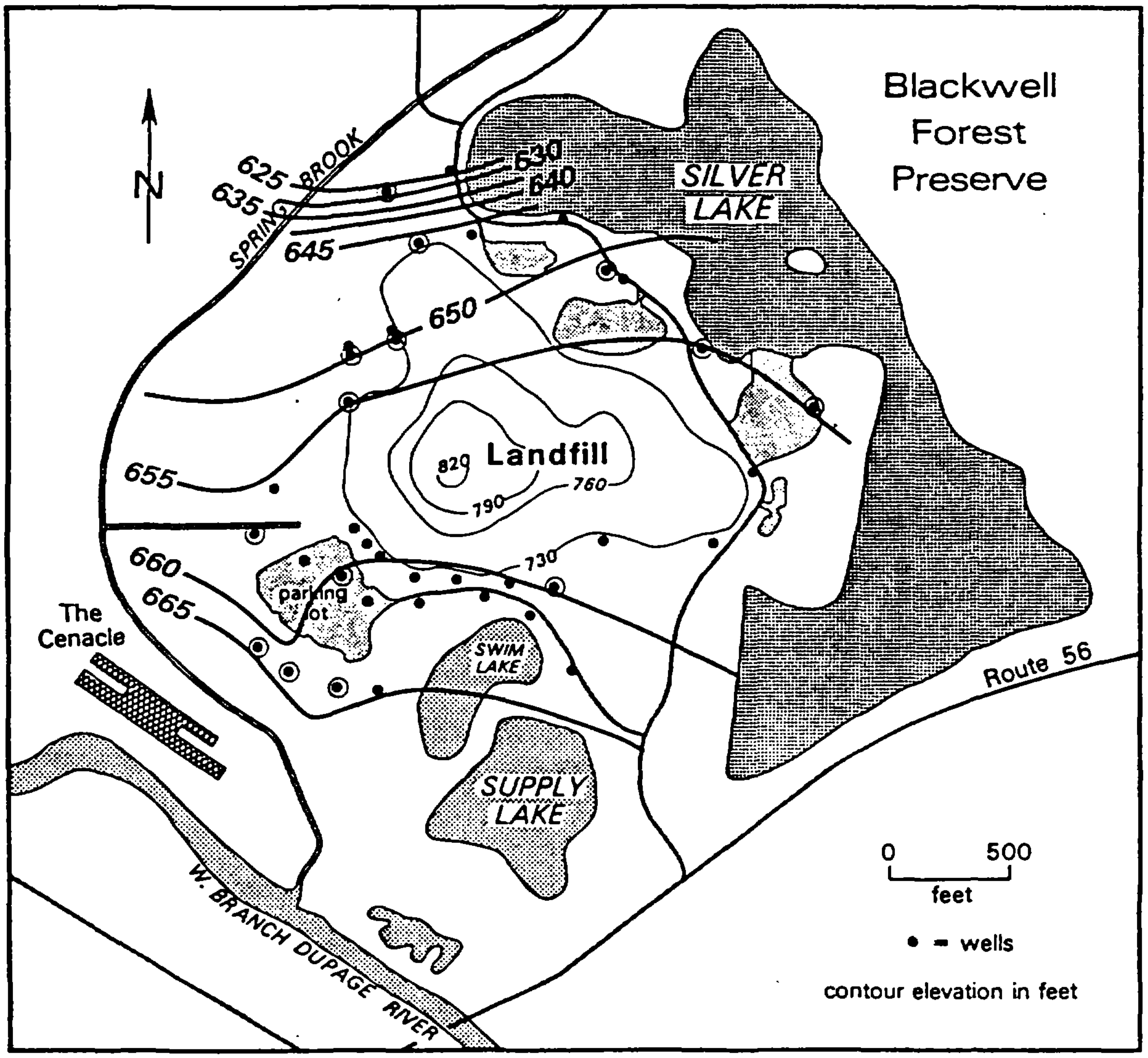


Figure 4. Contours of Elevation of the Bedrock Surface, Blackwell

for much of this Woodfordian area have been reconstructed (Willman et al., 1975), although relationships between till members in several places have yet to be determined (Johnson et al., 1985). Characteristically, the moraines have higher topography, rising 30 to 80 ft above the surrounding terrain. Stratigraphy in the intermorainal areas is complex, consisting of a variety of sediments: lodgement tills, ablation tills, lacustrine deposits, and outwash deposits, primarily sands and gravels which form the principal glacial aquifers.

Three till members of the Woodfordian Wedron Formation have been identified at the Blackwell site: Tiskilwa, Malden, and Yorkville. The Tiskilwa is generally described as a sandy, pink-tan to reddish brown till; the Malden is silty yellow-gray to gray, locally sandy, with discontinuous beds of sand and gravel; and the Yorkville is a very clayey gray till (Willman et al., 1975).

The Tiskilwa mantles the bedrock across the entire site, thinning from approximately 12 ft in the north to less than 3 ft in the south. In the eastern part, the Tiskilwa is overlain by 40 to 80 ft of Malden and Yorkville tills, while to the west, between the landfill and the DuPage River, it is overlain directly by up to 30 ft of sand and gravel of the Henry Formation (Batavia member). This geometry arises because the site is located just beyond the western edge of the West Chicago Moraine, along which the Yorkville till was deposited. Meltwater from the glacier formed a river which flowed north to south along the front of the moraine, dissecting and eroding previously deposited till, and depositing the Henry outwash sand and gravel.

Detailed stratigraphic analysis was conducted for the Fermi National Accelerator Laboratory, two miles west of the Blackwell site, by ISGS (Landon and Kempton, 1971). Clay mineralogy and texture analysis were used to identify five stratigraphic units in the glacial deposits. Split-spoon samples from six borings at the Blackwell site (G131 to G136) were submitted to ISGS for analysis and identification, and have been definitively correlated to the Fermi stratigraphy (B. Curry, ISGS, personal communication to Vagt, 1985).

The borings from Fermi lab show a consistent stratigraphy both vertically and horizontally. While the general stratigraphy is similar, the borings from the Blackwell site are less consistent. On the basis of clay mineralogy and geomorphic position, Curry suggested that most of the materials were deposited in a supraglacial environment or in a subglacial environment in association with a large volume of meltwater.

Cross section A-B (Figure 5), from Silver Lake at boring G132 southwest under the landfill to G133 near Spring Brook, shows that 3 to 12 ft of mixed composition diamicton, correlated to the Tiskilwa, overlies the bedrock. Its composition is generally silt or silty sand, somewhat finer to the east. In the eastern part, the Tiskilwa is overlain by 10 to 15 ft of the Malden till, which is bounded on the bottom by one foot of sand and gravel overlain by one foot of laminated silt; the Malden thins and disappears to the west, and was not found west of the landfill. The Yorkville, the thickest till on the site, is the "blue clay" which was used in the landfill construction. It is thickest near Silver Lake, but appears to thin rapidly to the south and west of the landfill, being absent at borings G116, G121, and G133. Two units of the Yorkville have been described at the Fermi site: a lower basal till, separated from an overlying ablation till by a thin layer of finely laminated silt, sand, or gravel. Many of the boring logs show such a separation at the Blackwell site.

The Henry Formation generally consists of glacial outwash sand and gravel, locally containing silt beds. It is not overlain by till, but sometimes is continuous with sandy deposits that intertongue with tills. Although not found at the Fermi site, the Henry, in the form of the Batavia outwash member, is found extensively at Blackwell, dominating the glacial section in the western

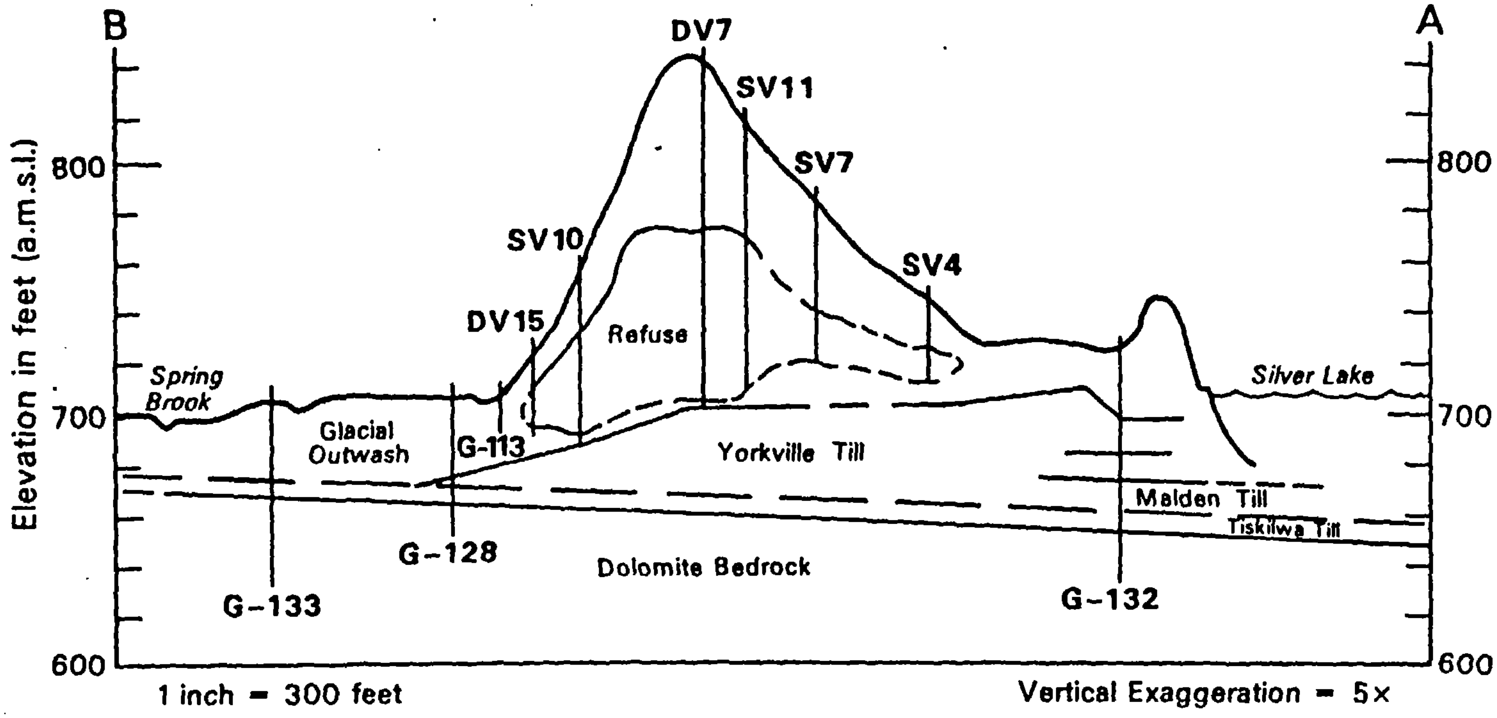


Figure 5. Cross-Section AB, NE-SW Through Blackwell Site.

part and lying over most of the site. Though no borings have been made south of the swim lake, it is thought that the Yorkville thins south and the Henry dominates in that region also.

Hydrostratigraphy

The hydrostratigraphy of northern Illinois has been defined in reports such as Suter et al. (1959) and Hughes et al. (1966). The deeper Cambrian-Ordovician aquifers are effectively isolated from the shallower systems by the Maquoketa Aquifer and are not considered here. The Blackwell site stratigraphy is summarized in the column in Figure 6. Though regionally the Silurian dolomite and glacial aquifers are considered to be a single hydrostatic unit, on a local scale they are separate and distinct. In the following sections, the hydrogeologic units are introduced based on a review of the literature, then examined on the basis of investigations at the Blackwell site.

Maquoketa Aquitard. The Maquoketa consists of two shale members with an interbedded dolomite with shale interbeds. In reports such as Suter et al. (1959) and Csallany and Walton (1963), the Formation is considered nonwaterbearing except for occasional small yields from crevices in the dolomite. Walton (1960) suggested an average vertical permeability of 0.00005 gpd/ft^2 (2.36 x 10^{-9} cm/s) for the Maquoketa in DuPage County. Zeizel et al. (1962) consider that the Maquoketa is a partial barrier to downward leakage of water from the shallower aquifers to the Cambrian-Ordovician Aquifer; they show its thickness in the study area to be about 100 ft. In the context of the study-area hydrogeology, the Maquoketa can be considered an effective lower boundary to the systems of interest.

Dolomite Aquifer. The Silurian dolomite aquifer is the primary water source in the area. Numerous domestic wells and municipal wells, including the

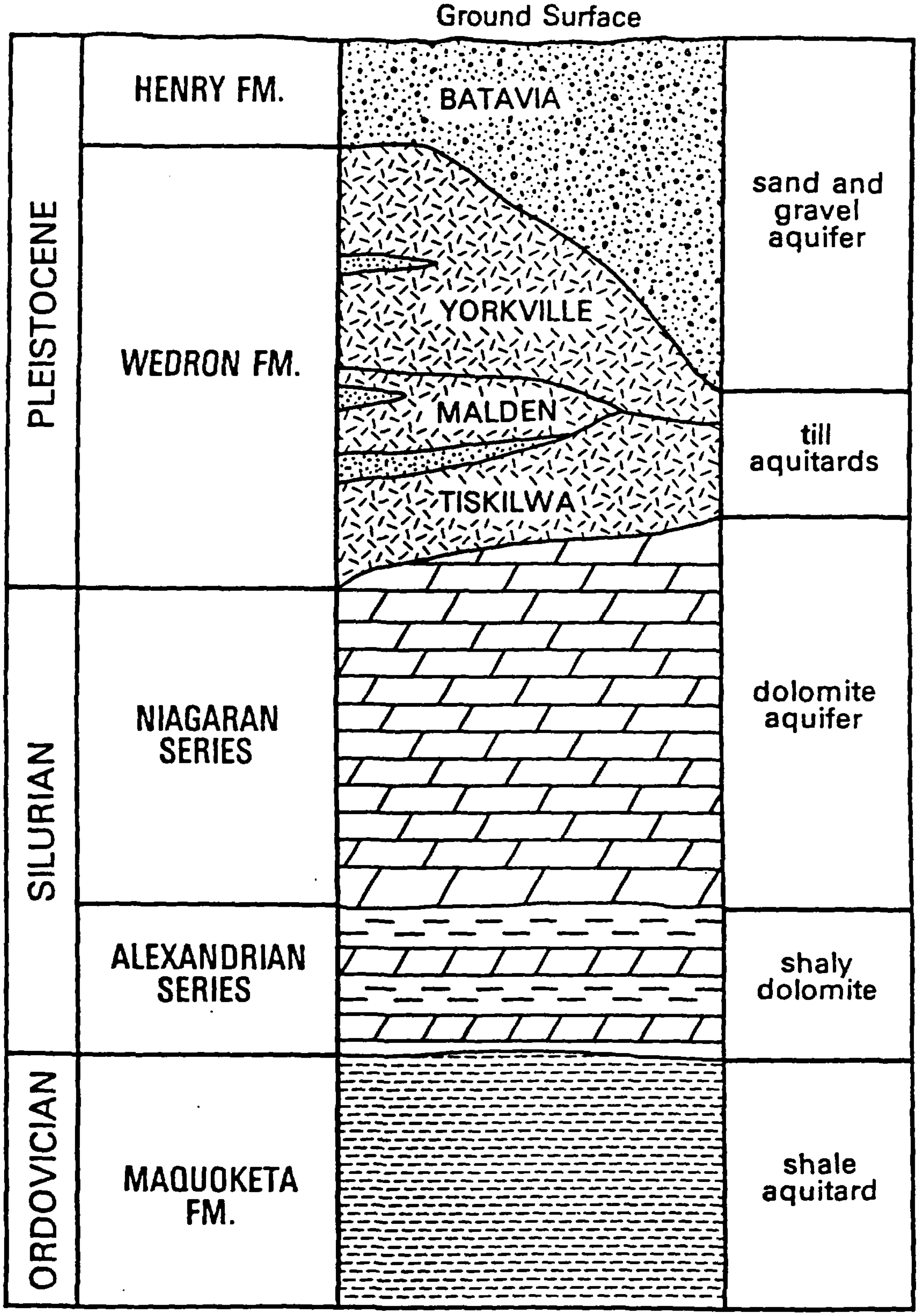


Figure 6. Summary Stratigraphic Column, Blackwell Site

Warrenville wells, are within two miles of the landfill which, according to a piezometric surface map given by Sasman et al. (1981), is within a major recharge area for the aquifer.

The Silurian dolomite in DuPage County is generally 100-200 ft thick. Though some wells have been developed into the basal layers of the Alexandrian, the major water-bearing zones are found in the Niagaran dolomite, especially in the upper fifty feet. Primary porosity contributes little to the water-bearing characteristics; most of the water flows through a network of joints and fissures. Joints observed in quarries, tunnels, and outcrops are seen to be irregularly spaced, often tight but often fairly wide, with widths up to one foot (Zeizel et al., 1962). Although some openings are clay-filled, most are open to flow. Widening is common where joints and fractures intersect shaly layers; smaller horizontal solution openings exist along bedding planes, particularly in dolomites above shaly zones. In general, enlargement of joints by weathering and solution has been greatest in the upper layers.

Well yield varies from place to place and is strongly related to the size and number of interconnected joints. That these openings are well connected is indicated by the reliability of water sources, the generally high yields, and the relative uniformity of the potentiometric surface (Zeizel et al., 1962). According to Suter et al. (1959), shallow dolomite wells in NE Illinois range in specific capacity from 0.1 to 500 gpm/ft. Csallany and Walton (1963) report on two tests in DuPage County: at Wheaton (near the Blackwell site) and at Argonne National Laboratory (in the SE corner of the county). Transmissivities were 61,000 and 44,000 gpd/ft (758 and 546 m^2/day) and storativities were 3.5×10^{-4} and 9×10^{-5} respectively. Interference was noted between wells more than one half-mile apart, indicating that water-yielding openings extend for considerable distances. Sasman et al. (1981) calculate the overall specific yield of the dolomite aquifer in DuPage County at 0.017, and note that yields of wells are generally higher when the dolomite is overlain by basal sand-and-gravel deposits. They also note that withdrawals from the dolomite exceed potential yield in DuPage County, causing excessive withdrawal from storage and dewatering of the aquifer in wide areas.

The bedrock surface may have particular hydrogeological significance. It is well established that the exposed, weathered layers of bedrock in unglaciated regions are zones of extensive permeability development, especially in carbonate rocks where solution opens the joints and fractures. For example, the Cambrian-Ordovician limestones and dolomites exposed in central Pennsylvania host a very active groundwater flow system (Parizek, White, and Langmuir, 1971). Additionally, shallow processes enhancing permeability in consolidated rocks types include stress-relief fracturing along valleys (Wyrick and Borches, 1981). Because the latter are often related to valleys, and because in normal topography groundwater flow and solution are concentrated toward valleys, valleys tend to be the zones of greatest bedrock permeability.

In pre-Pleistocene times, the exposed bedrock surface was subjected to these permeability-enhancing processes. Although the shallowest features may have been destroyed by glacial erosion, it seems probable that at least some of the relict enhanced permeability of the bedrock surface remains, and that furthermore it is related to the buried topography (Suter et al. 1959). The uppermost bedrock forms an extensive aquifer beneath the glacial cover. It can accept water from the overlying glacial aquifers -- which are locally in direct continuity with it -- but may shunt it laterally. Contaminants may be deflected and appear in unexpected positions and, because the localized fracture permeability may be very high, with unexpected rapidity.

Glacial Aquifer. In DuPage County, only about 2% of water is pumped from glacial aquifers, compared to 68% from the dolomite aquifers and 30% from deeper sandstones (Sasman et al., 1981). However, the glacial aquifers are the major recharge sources for the deeper aquifers; a strong correlation has been noted between the yield in dolomite wells and the occurrence of overlying coarse-grained, saturated, unconsolidated deposits (Schicht et al., 1976). The glacial aquifers are also vulnerable to contamination from surface activities and can transmit contaminants to glacial wells, to surface waters, and to the deeper aquifers.

Glacial-outwash sands and gravels are aquifers on a local, shallow scale, and can be highly permeable. Zeizel et al. (1962) report that specific capacities of sands and gravels in DuPage County range from 1.0 to 40.7 gpm/ft (16.6 to 676.1 m^2/day), and that the potential yield is often high enough to support industrial or municipal well development. Berg, Kempton and Cartwright (1984), in a study of the contamination potential for shallow aquifers in Illinois, note that clean sand and gravel can have hydraulic conductivities greater than 1×10^{-3} cm/s (20 gpd/ft^2), while values for silty sand can be as low as 1×10^{-5} cm/s (0.2 gpd/ft^2).

The till units are aquitards, limiting groundwater movement. Clayey tills in Illinois have hydraulic conductivities in the range 1×10^{-9} to 1×10^{-7} cm/s (2×10^{-5} to 2×10^{-3} gpd/ft^2) while tills with less than 25% clay range from 1×10^{-8} to 1×10^{-6} cm/s (2×10^{-4} to 2×10^{-2} gpd/ft^2), and gravelly tills can be more permeable still (Berg, Kempton, and Cartwright, 1984). Grisak et al. (1976) have shown that the field (bulk) hydraulic conductivity of fractured till can be up to three orders of magnitude greater than the laboratory conductivity.

Evaluation of Hydraulic Properties

The purposes of evaluating the hydraulic properties of the geological materials at the site were:

(1) To test and elaborate the qualitative classification of hydrostratigraphy, presented above;

(2) To delineate the variations in hydraulic characteristics across the site, and hence the controls of groundwater flow and contaminant transport;

(3) To obtain quantitative data from which estimates of flow quantities can be made and which can be utilized later in numerical modeling.

Hydraulic properties were determined from laboratory and field (pumping test) methods. Methodology and results are presented below.

Laboratory Analysis. Representative samples of each unconsolidated unit from the Blackwell site were obtained by split-spoon sampling of boreholes and tested in the laboratory for total porosity and permeability.

Several samples of the coarser units were weighed dry, saturated, and reweighed to calculate total porosity. Sand and gravel samples had porosities of 0.21-0.23; silt samples had porosities of about 0.30.

Permeabilities were obtained from disturbed samples of the non-clay deposits, using a SOILTEST K-605 falling-head permeameter following the procedures outlined in Todd (1980). Each sample was 6.5 to 7.0 cm long and 6.35 cm in diameter. The falling-head formula used (K605 operating instructions) was:

$$K = \frac{Q * L}{13.76 * t * (h_1 - h_2)} \log \frac{h_1}{h_2}$$

where K = coefficient of permeability, cm/sec

Q = flow, cm^3/sec

L = length of sample, cm

t = time, sec

h_1 = initial height of water column above chamber outflow port, cm

h_2 = final height of water column above chamber outflow port, cm

The results (Table 3) from the permeameter tests are at best only very rough estimates of the field values of permeability: the samples are disturbed and recompacted in handling, and the laboratory results are only point values which may neglect larger-scale permeability controls such as jointing in the tills. Indeed, it proved impossible with the equipment available to obtain permeability measurements for the tighter tills (the clayey Yorkville, for example). However, in a broad sense the results give a comparison between different geologic units.

Pumping Tests. Pumping tests were conducted at 27 monitoring wells, using a 12-15 gpm submersible pump. Hydraulic conductivities varied from very high (greater than 1 cm/sec) to extremely low (less than 5 x 10^{-7} cm/sec). High values were common in the outwash and the dolomite. Wells in these materials were pumped for times ranging from ½ to 1 hour; though these times are quite short, the proximity of recharge boundaries coupled with high permeabilities and low storativities resulted in rapidly stabilized drawdowns in most wells. In addition, the limited pumping rate possible with a pump which will fit into a four-inch well limited the maximum possible drawdown.

Most tests were conducted as single-well pumping tests. Two wells were, however, pumped using multiple observation wells. The results were consistent with the single-well test results. Low hydraulic conductivities were observed in several limestone and most till wells; the pump was used in these cases to conduct bail tests, quickly removing up to 15 gallons for an effectively

Table 3. Permeameter Results

WELL NO	INTERVAL (ft)	UNIT	K ft/min	(cm/s)	DESCRIPTION
G-103S	41-47	YORKVILLE	3.9×10^{-6}	(2.0×10^{-6})	silty sand
G-118D	47-57	TISKILWA	3.2×10^{-2}	(1.6×10^{-2})	silt, dolomite bedrock
G-130	13-23	HENRY	7.3×10^{-4}	(3.7×10^{-4})	sand, gravel
G-131	16-24	HENRY	1.0×10^{-3} 9.7×10^{-4}	(5.1×10^{-4}) (4.9×10^{-4})	f-m sand
G-131	24-32	HENRY	1.6×10^{-3} 1.1×10^{-3}	(8.1×10^{-4}) (5.6×10^{-4})	m-c sand, gravel, bldrs.
G-133	20-24	HENRY	9.3×10^{-2}	(4.7×10^{-2})	f-c sand, gravel
G-133	34-40	TISKILWA	6.8×10^{-6} 4.9×10^{-6}	(3.5×10^{-6}) (2.5×10^{-6})	sand, sandy silt
G-135	50-55	TISKILWA	9.3×10^{-5} 5.6×10^{-5} 5.6×10^{-5}	(4.7×10^{-5}) (2.8×10^{-5}) (2.8×10^{-5})	v. fine sandy silt
G-136	45-50	MALDEN	6.5×10^{-2} 2.5×10^{-2} 2.6×10^{-2}	(3.3×10^{-2}) (1.3×10^{-2}) (1.3×10^{-2})	coarse sand, gravel, cobbles
G-136	23-26	HENRY	7.9×10^{-4} 6.7×10^{-4}	(4.0×10^{-4}) (3.4×10^{-4})	m-c sand, gravel
G-131/134	38-41/50-55	TISKILWA	8.5×10^{-6} 5.7×10^{-6} 3.0×10^{-6} 3.2×10^{-6}	(4.3×10^{-6}) (2.9×10^{-6}) (1.5×10^{-6}) (1.6×10^{-6})	silty sand/silty clay

instantaneous withdrawal. The recoveries, which took from several minutes to several days, were analyzed for aquifer properties.

Water yields from many wells were too low to permit continuous pumping. In these cases, bail tests were used to provide an estimate of the hydraulic properties of the formation screened. Various limitations of such tests are that (1) the properties represent only a small region immediately adjacent to the well; (2) the analytical solutions available ideally refer to homogeneous, isotropic medium with non-leaky conditions and a specific size and shape of test space at the end of the piezometer. These conditions are not generally satisfied, and determining the exact test dimensions is difficult: The screen length is 5 to 10 ft (1.5 - 3 m) and the diameter the size of the 6 or 8 inch auger used to bore the hole. Two solution methods, Hvorslev (1951) and Nguyen and Pinder (1984) were used to analyze the data.

The Hvorslev method (in Cedergren, 1967) presents several formulas which can be used to estimate formation permeability by bail or slug tests. The "falling head" and "time-lag" methods were used in this study. The hydraulic conductivity determined is the average value for the whole screened length. At the Blackwell site, the permeable layers are commonly sandy and silty horizons within the till. Here the composite thickness of the permeable layers was used as the screen-length parameter for the analysis.

The Nguyen and Pinder method analyzes slug test data (the recharge-test analogy to bail tests). The method is conceptually superior to other slug test methods because the mathematical formulation accounts for the well storage effects and for partial aquifer penetration; it also provides an estimate of formation storativity (S). The formula and methods of graphing the data are given in Nguyen and Pinder (1984).

For aquifer testing of the outwash, the main method used was single-well pumping tests, because of the combination of low pumping rates, high permeabilities, and relatively large distances between wells. The data were analyzed by the Theis recovery method (Kruseman and deRidder, 1979), the assumptions for which are: (1) the piezometric surface is approximately horizontal; (2) the discharge rate is constant; (3) storage in the well can be neglected; (4) the aquifer is apparently infinite in extent; (5) aquifer is homogeneous, isotropic, and of uniform thickness; (6) aquifer is fully penetrated by the well; (7) water removed from storage in the aquifer is discharged instantaneously with decline in head.

Assumptions 1-3 are valid for tests conducted in both the outwash and dolomite aquifers at the Blackwell site. Assumption 4 is probably valid for the dolomite aquifer but not for the outwash, which has a boundary against the till mound under the landfill area; therefore, the permeability is liable to be underestimated. The swimming lake and Spring Brook may act as effectively infinite recharge boundaries for the outwash aquifer; their effects, depending on location of the pumped wells, would be to limit drawdown. Assumption 5 is at least nominally invalid for the dolomite aquifer. Sasman et al. (1981) have noted that the water-bearing capabilities of the dolomite aquifer are largely dependent on fractures in the upper 20 - 50 ft; our own observations indicate that the dolomite is quite heterogeneous. Assumption 6 is generally invalid, because none of the wells tested by continuous pumping fully penetrates the aquifer; the effect is liable to be a slight underestimation of aquifer transmissivity.

Two pumping tests were conducted with multiple observation wells. Data were analyzed by the Jacob straight-line method (Cooper and Jacob, 1946). The assumptions and limitations are the same as those for the single-well tests above.

Test Results. The results of the pumping tests are presented in Tables 4 and 5, and all results are summarized in Table 6. As might be expected, the most permeable material is the outwash sand and gravel, and the least is the clayey Yorkville till. The sole permeameter result for the Malden is not truly representative of this unit, but comes rather from a sand layer contained within it; generally the Malden is much more clayey and less permeable. The result illustrates, however, that the till units are quite heterogeneous. Sandy and silty layers occur within the tills and can provide exceptional permeability in an otherwise poorly permeable unit.

The Tiskilwa Till is poorly permeable, but not as much so as the Yorkville. It forms, in effect, a leaky aquitard. The dolomite bedrock permeability is dominated by fractures and is thus very heterogeneous. The matrix permeability is extremely low, whereas the fracture permeability can be extremely high. For example, in well G133 drawdown was so slight and the recovery was too rapid for any meaningful analysis. It is interesting to note that G133 is located in the minor bedrock valley zone along the western side of the site -- perhaps confirmation that the buried topography might be related to permeability variations. A bedrock core from G133 consisted of generally tight dolomite, with occasional vuggy horizons providing some porous layers. The core intersected a steeply dipping fracture with a weathered surface, evidence for past groundwater flow and for the presence of fracture permeability.

Groundwater System at the Blackwell Site.

Four major hydrostratigraphic units can be defined at the Blackwell site:

Table 4. Pumping Test Results: Single Well Tests

Well No.	K (ft/min)	(cm/s)	S	Unit	Method
G-101	1.2×10^{-5}	(6.1×10^{-6})		Henry	Hvorslev
	1.7×10^{-6}	(8.6×10^{-7})	3.1×10^{-4}		Nguyen and Pinder
G-102	2.7×10^{-2}	(1.4×10^{-2})		Henry	Hvorslev
	1.6×10^{-3}	(8.1×10^{-4})	.15		Nguyen and Pinder
G-103S	6.7×10^{-4}	(3.4×10^{-4})		Yorkville	Hvorslev
	7.4×10^{-5}	(3.8×10^{-5})	3.6×10^{-2}		Nguyen and Pinder
G-103D	2.4×10^{-3}	(1.2×10^{-3})		Tiskilwa	Hvorslev
	2.8×10^{-4}	(1.4×10^{-4})	.18		Nguyen and Pinder
G-107S	9.4×10^{-4}	(4.8×10^{-4})		Yorkville	Hvorslev
	2.3×10^{-3}	(1.2×10^{-3})			Papadopoulos, Bredehoeft, and Cooper
	1.6×10^{-4}	(8.1×10^{-5})	.13		Nguyen and Pinder
G-107D	1.1×10^{-3}	(5.6×10^{-4})		Tiskilwa	Hvorslev
	3.2×10^{-3}	(1.6×10^{-3})			Papadopoulos, Bredehoeft, and Cooper
	1.8×10^{-4}	(9.4×10^{-5})	.16		Nguyen and Pinder
G-108	2.7×10^{-2}	(1.4×10^{-2})		Henry	Recovery
G-115D	6.4×10^{-1}	(3.3×10^{-1})		Tiskilwa	Recovery
G-116	6.5×10^{-1}	(3.3×10^{-1})		Henry	Recovery
G-117	6.4×10^{-1}	(3.3×10^{-1})		Henry	Recovery
G-118D	1.7×10^{-2}	(8.6×10^{-3})		Tiskilwa and Dolomite	Hvorslev
	1.2×10^{-2}	(6.1×10^{-3})			Recovery
G-120S	3.1×10^{-3}	(1.6×10^{-3})		Yorkville	Hvorslev
	4.1×10^{-4}	(2.1×10^{-4})	.10		Nguyen and Pinder
G-120D	9.6×10^{-3}	(4.9×10^{-3})		Tiskilwa and Dolomite	Hvorslev
	1.7×10^{-3}	(8.6×10^{-4})	.31		Nguyen and Pinder
G-121	7.1×10^{-1}	(3.6×10^{-1})		Henry	Recovery
G-122	1.6	(8.1×10^{-1})		Henry	Recovery

Table 4 Continued

Well No.	K (ft/min)	(cm/s)	S	Unit	Method
G-123	3.0×10^{-2}	(1.5×10^{-2})		Henry	Hvorslev
	2.5×10^{-2}	(1.3×10^{-2})			Recovery
G-126	8.6×10^{-1}	(4.4×10^{-1})		Henry	Recovery
G-128D	3.9×10^{-1}	(2.0×10^{-1})		Dolomite	Hvorslev
G-130	3.1×10^{-2}	(1.6×10^{-2})		Henry	Recovery
G-131DD	1.4×10^{-5}	(7.1×10^{-6})		Dolomite	Hvorslev
			4.2×10^{-3}		Nguyen and Pinder
G-132D	2.3×10^{-5}	(1.2×10^{-5})		Dolomite	Hvorslev
	1.3×10^{-6}	(6.6×10^{-7})	5.1×10^{-3}		Nguyen and Pinder
G-132DD	5.1×10^{-7}	(2.6×10^{-7})		Dolomite	Hvorslev
G-133S	6.8×10^{-1}	(3.5×10^{-1})		Henry	Recovery
G-134	1.1×10^{-3}	(5.6×10^{-4})		Dolomite	Hvorslev
	2.8×10^{-3}	(1.4×10^{-3})			Papadopoulos, Bredehoeft, and Cooper
	9.8×10^{-5}	(5.0×10^{-5})	.12		Nguyen and Pinder
G-135	9.6×10^{-2}	(4.9×10^{-2})		Dolomite	Recovery
G-136	5.6×10^{-5}	(2.8×10^{-5})		Dolomite	Hvorslev
	5.8×10^{-6}	(2.9×10^{-6})	.013		Nguyen and Pinder

Table 5. Pumping Test Results: Multiple Observation Wells

TEST WELL NO.	TRANSMISSIVITY ft^2/min	m^2/day	STORATIVITY	AQUIFER UNIT
G-101	4.4×10^{-5}	5.9×10^{-3}	3.1×10^{-4}	Henry
G-102	3.9×10^{-3}	5.2×10^{-1}	.15	Henry
G-103	5.9×10^{-4}	7.9×10^{-2}	3.6×10^{-2}	Yorkville/Tiskilwa
G-106	7.9×10^{-4}	1.1×10^{-1}		Yorkville/Tiskilwa
G-107	4.4×10^{-4}	5.9×10^{-2}	.13	Tiskilwa
G-108	1.3×10^{-1}	17.4		Henry
G-114	31.0	4.1×10^{3}	1.14×10^{-4}	Henry
G-116	10.2	1.4×10^{3}		Henry
G-117	2.0	2.7×10^{2}	2.5×10^{-5}	Henry
G-118	3.6×10^{-2}	4.8		Tiskilwa/Dolomite
G-120	9.3×10^{-5}	1.2×10^{-2}	.1	
G-121	4.9	6.6×10^{2}		Henry
G-122	11.1	1.5×10^{3}		Henry
G-123	13.9	1.8×10^{3}	6.3×10^{-4}	Henry
G-126	6.0	8.0×10^{2}		Henry
G-127	7.3	9.8×10^{2}	4.4×10^{-5}	Henry
G-128	20.0	2.7×10^{3}		Henry
G-130	.31	41.5		Henry
G-131			4.2×10^{-3}	
G-132			5.1×10^{-3}	
G-133S	5.4	7.2×10^{2}		Henry
G-134			1.2×10^{-1}	
G-136			1.3×10^{-2}	

Table 6. Summary of Hydraulic Conductivities Measured at Blackwell Site (Ft/Min.)

Unit	Range	Measurement
HENRY	7×10^{-4} to 0.09	permeameter (4 sets)
	2×10^{-6} to 1.6	pump tests (12)
YORKVILLE	too low for measurement	
MALDEN	0.03 to 0.07 (sandy unit)	permeameter (1 set)
TISKILWA	3×10^{-6} to 9×10^{-5}	permeameter (3 sets)
	3×10^{-4} to 0.64	pump tests (6)
DOLOMITE	[illegible] $\times 10^{-7}$ to 0.39	pump tests (7)
	immeasurably high	pump test (well G133)

the Silurian dolomite aquifer, the Henry outwash aquifer, the Malden and Yorkville aquitard, and the Tiskilwa leaky aquitard. The groundwater system is controlled by the three-dimensional geometry of the aquifer units and by the presence of surface water bodies which almost encircle the site. The broad relationships are shown in the block diagram, Figure 7.

Though outwash deposits originally mantled most of the study area, they have been removed from the high-standing area east of the landfill where they now extend at most only a few feet below the water table. The major outwash aquifer at the Blackwell site is located in the south and west areas, where it forms an unconfined (water-table) aquifer with a saturated thickness varying several feet according to the water-table variation. The aquifer is less than 10 ft thick beneath the edge of the landfill, thickening to greater than 30 ft near Springbrook. A map of surficial deposits prepared for the Northern Illinois Planning Commission indicates that the outwash does extend to the West Branch of the DuPage River in the south.

The top and bottom of the outwash deposits are easily mapped across the site, but there is little vertical or lateral continuity within the unit itself, which consists of numerous beds and lenses which are commonly less than three feet thick and which cannot be traced laterally. Near the landfill, thin beds marked by thin silt layers (1-4") are common; where the outwash as a whole is thicker, so too are the individual layers. Several inches to two feet of soil cover the outwash in the south and west of the preserve, except for areas which have altered by fill or landscaping.

The three till units are lower permeability aquitards. The Malden and Yorkville tills form a wedge, thickest in the east near Silver Lake and under the eastern part of the landfill and thinning and disappearing in the west and south. The vertical and horizontal permeabilities of these units are very low;

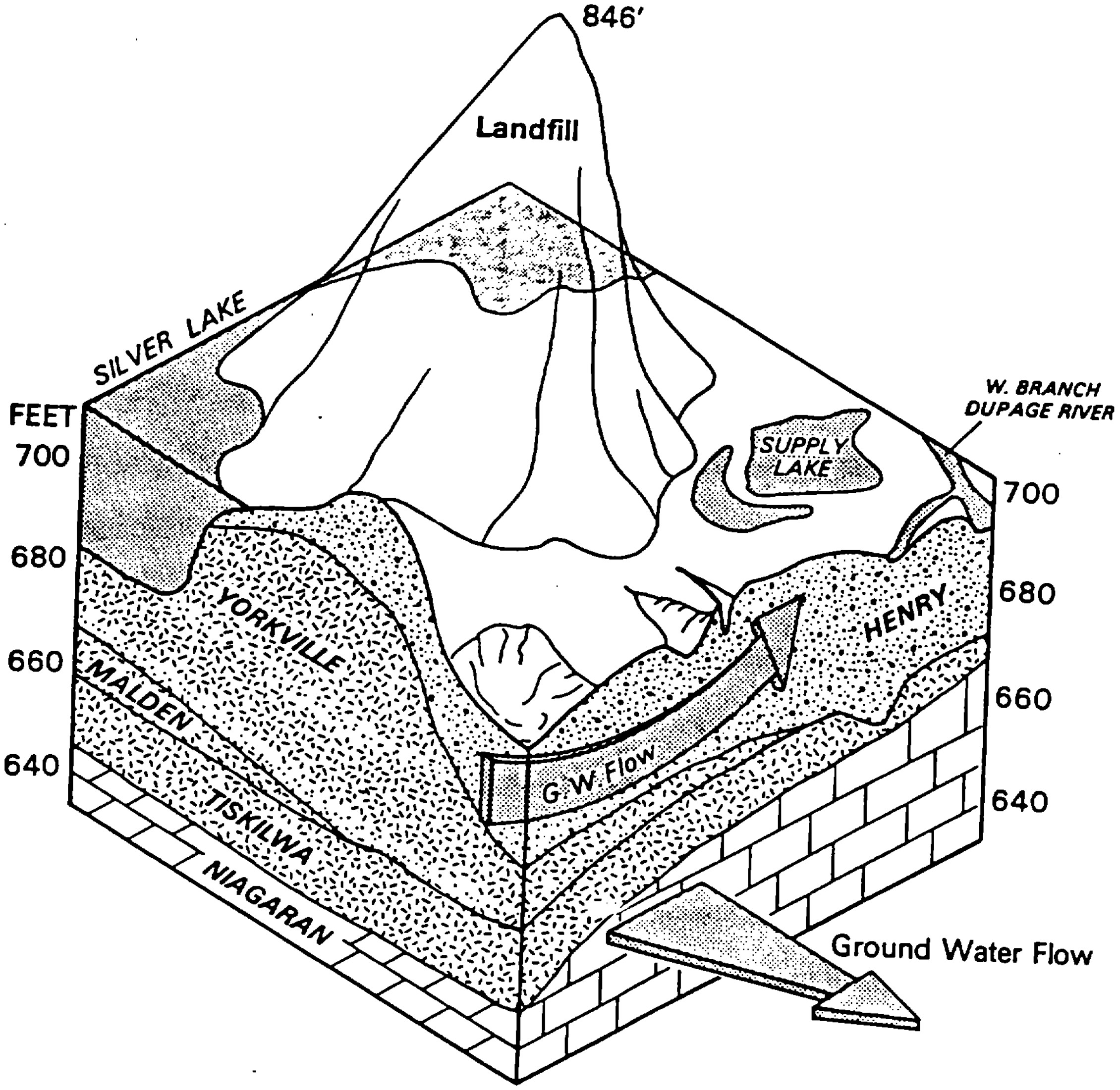


Figure 7. Black Diagram of Aquifer Relationships, Blackwell Site

they exclude the outwash aquifer from the east and form a barrier to groundwater flow between Silver Lake and the outwash. However, at least two intercalated layers provide zones of higher horizontal permeability. One is a sand layer 1 to 4 inches thick at an approximate elevation of 670 ft, marking the boundary between the Malden and Yorkville units. Another thin silty sandy layer bisects the Yorkville at an elevation of about 680 ft. Most of the monitoring wells in the north, east, and southeast side of the landfill are completed into one or both of these horizons, through which virtually all of the lateral flow in the till occurs. Tests show that the permeabilities of these sandy layers are of the order of 10^{-4} cm/s.

The Silurian dolomite completely underlies the site. Its surface slopes broadly from south to north, and exhibits subdued topography which may influence bedrock permeability. The matrix (extra-fracture) permeability of the dolomite is very low, but the network of joints and fractures which is especially developed in the upper sections provides a high degree of secondary permeability.

The bedrock is mantled everywhere (with the possible exception of very localized patches in the southwest) by the Tiskilwa Till. The Tiskilwa is thickest in the north (12 ft at borings G120 and G136) and thinnest in the southwest (less than 3 ft at borings G116, G131). A similar north-south thinning is apparent in the east (G132, G134). It is much less permeable than either the bedrock or the outwash aquifer, and thus forms a confining layer, although probably leaky especially in the southwest where it is thinnest.

The Blackwell site is almost completely surrounded by surface water bodies, which are in continuity with the groundwater system and serve as boundaries to it.

The eastern perimeter is dominated by Silver Lake, which has a maximum depth of about 30 ft. The lake's level is relatively constant, ranging annually between about 706 and 708 ft (Figure 8). During the study, heavy rainfall events (in excess of 2") produced less than a ½-inch response in lake level; however, there is clearly a seasonal variation with a maximum level during the spring recharge period. In the south of the site, the swimming and supply lakes (which have approximately the same water level) have a greater range, standing at nearly 694 ft in spring and dropping to about 689 ft (the elevation of the West Branch of the DuPage River) in late summer and fall (Figure 8).

The elevation of the West Branch DuPage River is held relatively constant, at 689 to 690 ft, by a dam half-a-mile downstream in Warrenville. The elevation is almost constant along the south side of the Blackwell site. Spring Brook borders the site in the north and west, descending at a relatively constant gradient from 701 ft at the access road north of the site to 690 ft at its confluence with the West Branch DuPage River in the south.

The water table in the glacial materials (Figure 9) shows two zones separated by a fairly narrow zone of higher hydraulic gradient. In the east, the groundwater levels are closely linked to the water level in Silver Lake. In the west (i.e. in the sand-and-gravel aquifer) the water table is lower, sloping down from a value of about 705 ft elevation in the north to 690 ft around the swim and supply lakes and the DuPage River. The zone of steep hydraulic gradient follows the western edge of the landfill and crosses between the two small lakes and Silver Lake, roughly following the eastern edge of the sand-and-gravel aquifer.

Based on these contours, the principal groundwater flow directions are southwesterly from Silver Lake toward the lower lake and river system. However, the Yorkville Till mound rises above the water table across the site and forms a barrier, or groundwater dam, between Silver Lake and the outwash aquifer. Water probably leaks from the lake beneath the landfill through the sandy layers discussed above, but the dominant regional flow along the zone of maximum

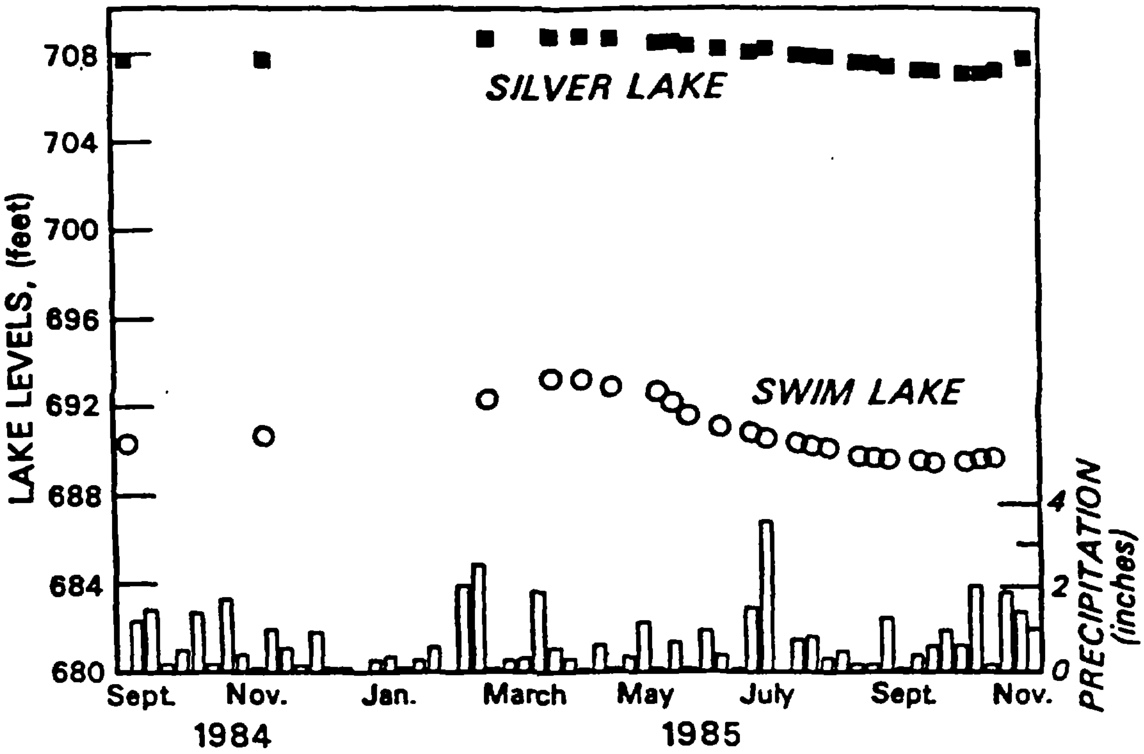


Figure 8. Lake Levels and Weekly Precipitation, Blackwell Site.

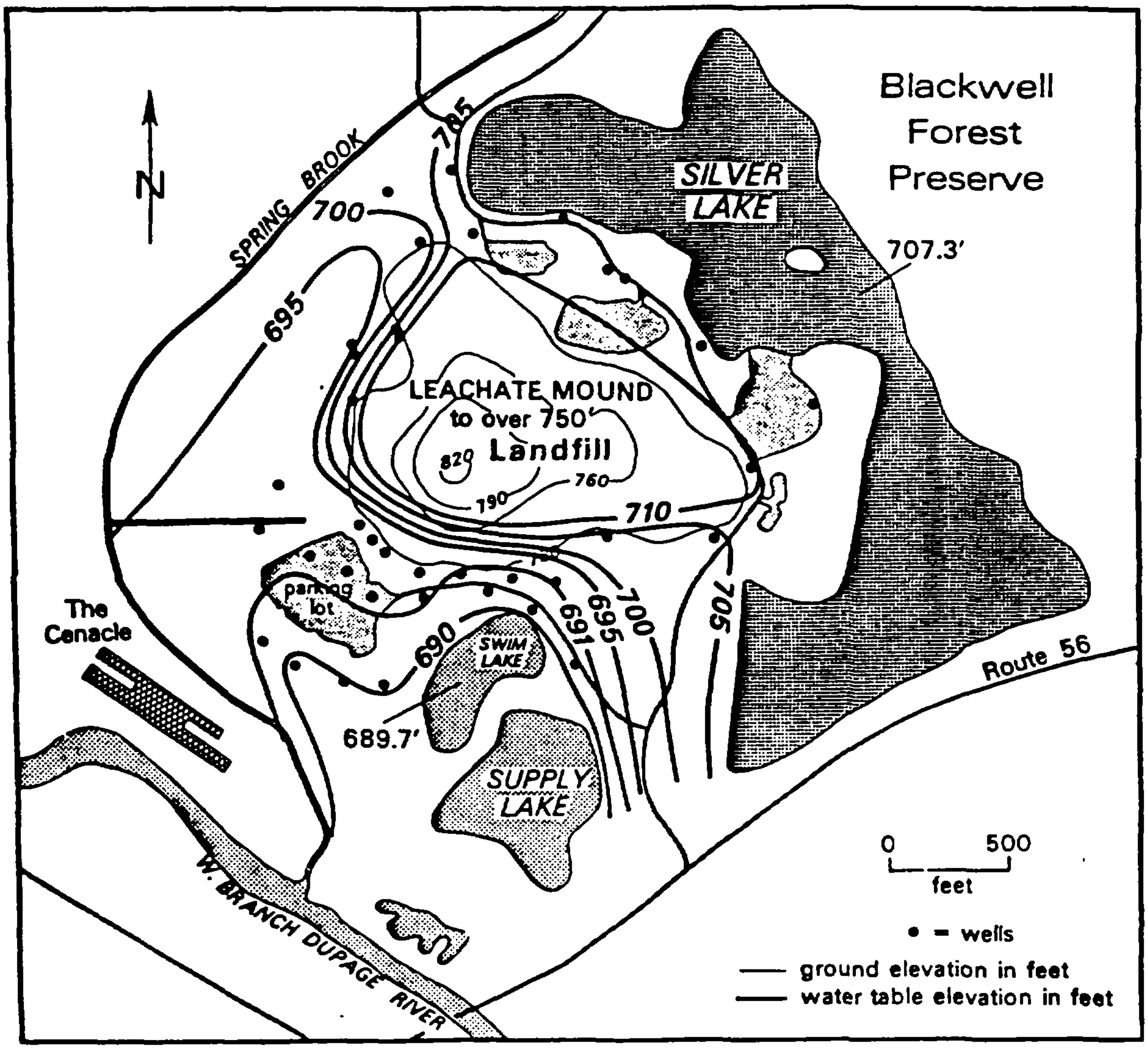


Figure 9. Water Table in the Glacial Aquifer, October 1985

permeability is southward within the outwash aquifer, essentially skirting the landfill. An additional hydraulic link is probably formed by the trench cut during gravel mining that extends from the northern point of the southwest leg of Silver Lake to Spring Brook. The trench was subsequently filled during landfilling but remains a higher permeability pathway.

In its natural state, Spring Brook was probably an effluent or gaining stream, accepting water from the glacial aquifer. However, urbanization has resulted in an anomalously high flow in the stream; for example, Wheaton Sanitary facility, two miles upstream, discharges its treated water into Spring Brook and artificially maintains its higher flow. Thus, the upper part of the stream on site now acts as an influent or losing stream that provides water to the aquifer and creates a local groundwater divide. The lower part remains in a gaining state. As the water table fluctuates throughout the year, the crossover point at which conditions change from influent to effluent migrate back and forth (compare Figure 9, the water table in October 1985, with Figure 10, the water table in April 1985; in the former case almost the whole of Spring Brook loses water, while in the latter the stream is gaining for about half its length around the site.) These stream-aquifer relationships permit the entry of poor quality stream water into the aquifer (see later section on groundwater chemistry).

Figures 11 (a) and (b) show the hydrographs of groundwater levels in several wells in 1984-85. The lower water table and somewhat larger range for the southern glacial wells are evident, as is the head drop between shallow glacial and bedrock wells (the latter with "D" after the number).

The potentiometric surface in the dolomite aquifer (Figure 12) slopes from east to west. It is possible that some leakage is reaching the bedrock from Silver Lake to maintain the eastern high levels, but in view of the thick sequence of poorly permeable tills in that area it seems unlikely that this

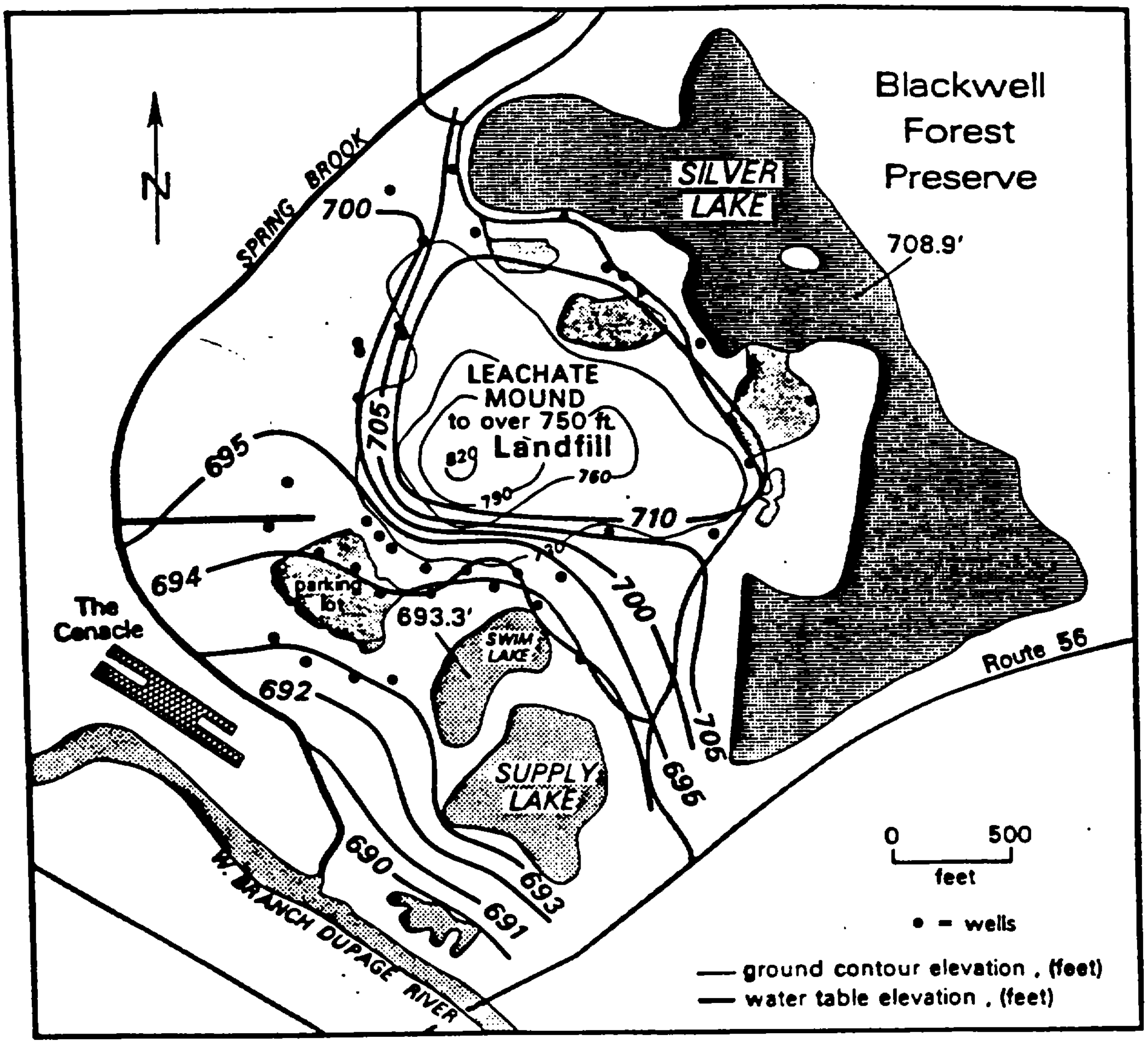
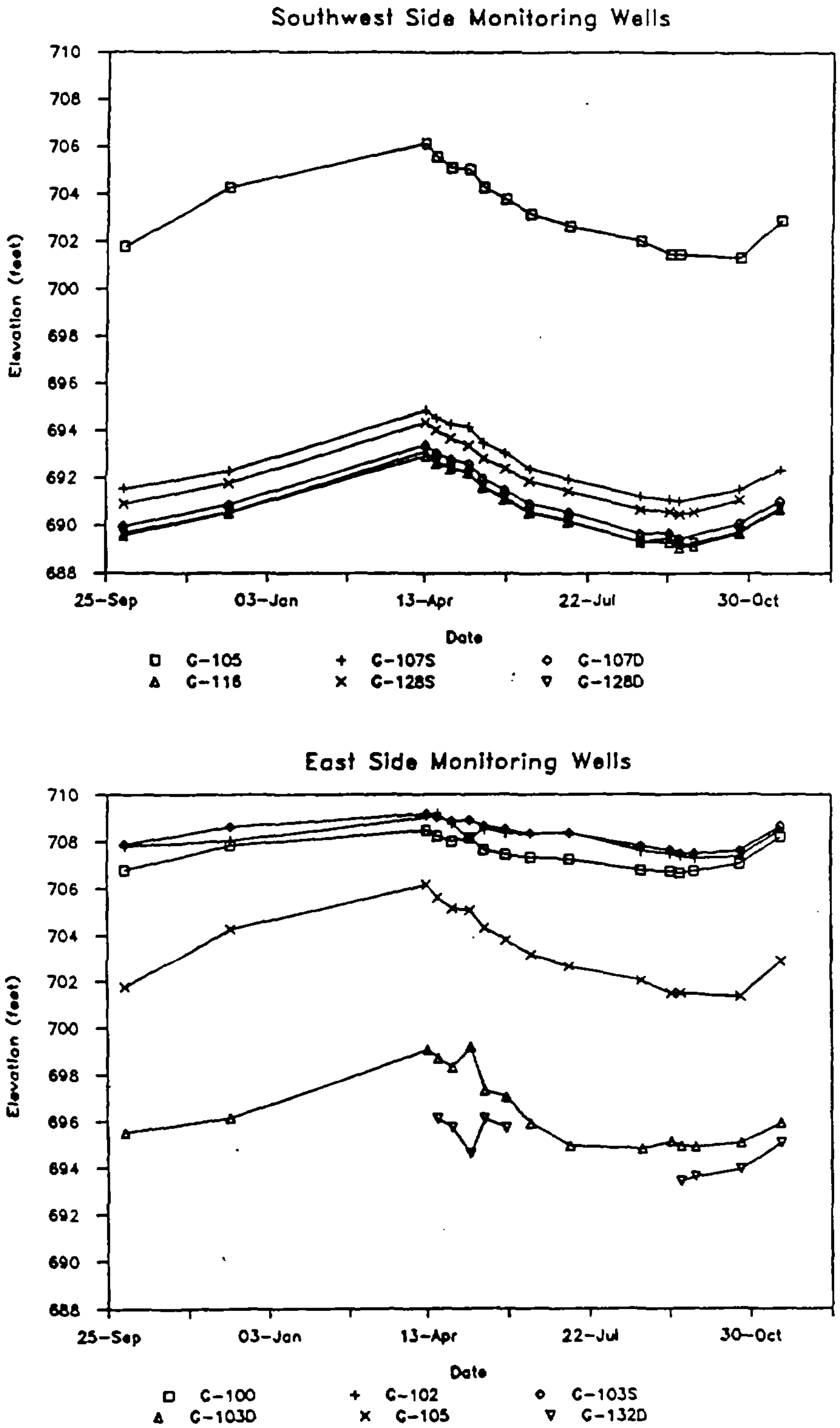


Figure 10. Water Table in the Glacial Aquifer, April 1985



Figures 11 Groundwater Levels in (a) Southwestern and (b) Eastern Wells, 1985-86

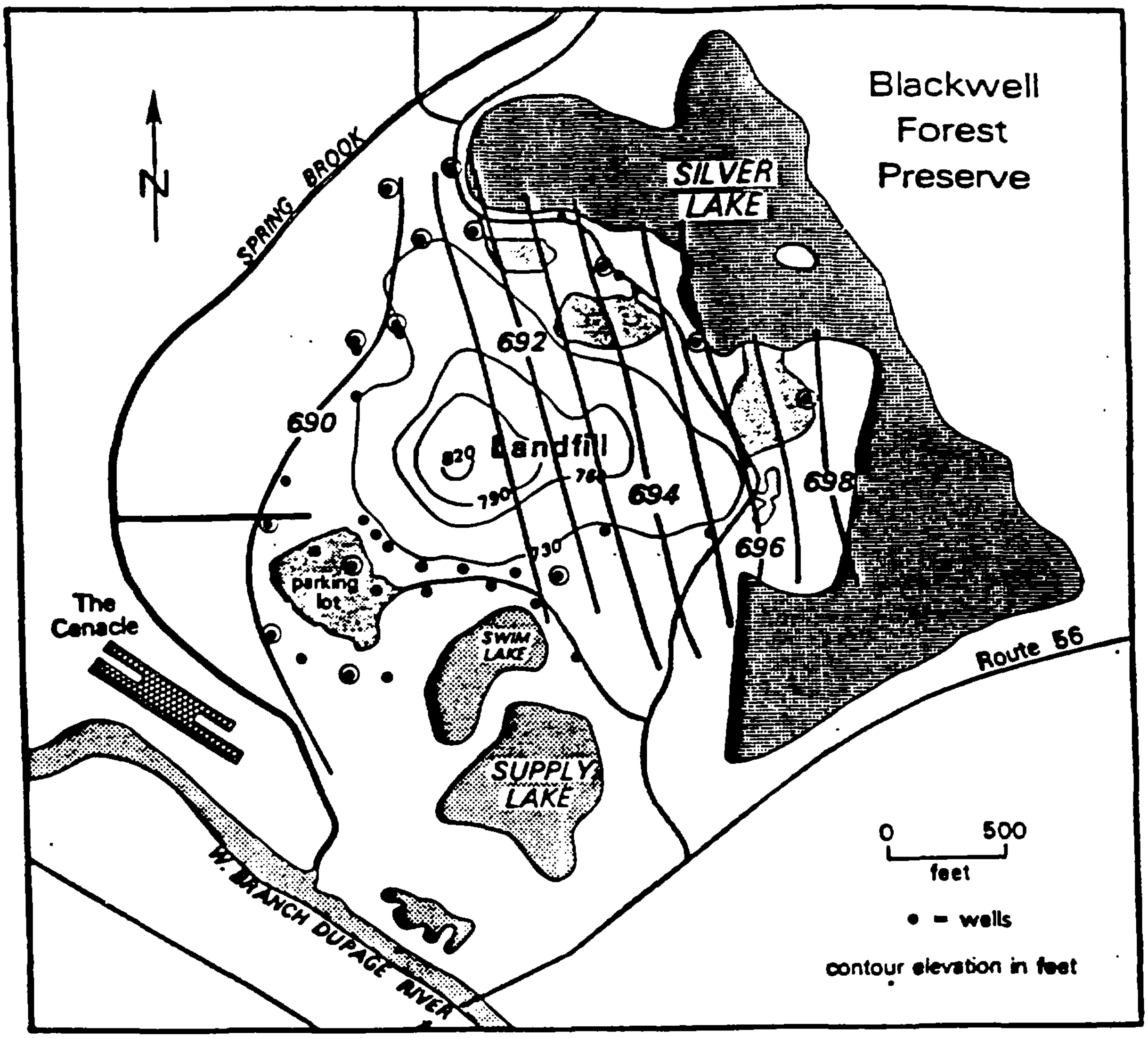


Figure 12. Piezometric Surface in the Dolomite Aquifer, June 1985

leakage is significant on the site. More likely, the gradient reflects regional conditions; according to a potentiometric surface map for the dolomite aquifer given by Sasman et al., (1981) there is a regional high to the northeast and a low related to the Warrenville cone of depression to the south. However, the noticeable slackening of gradient in the western part of the site probably reflects site controls. First, the bedrock permeability in that area, is high (which would permit a gentler head gradient), and second, there is probably some leakage from the outwash aquifer through the thin Tiskilwa Till.

At the Blackwell site, and indeed throughout most of northern Illinois, the heads in the dolomite bedrock aquifer are lower than those in the glacial aquifer. Groundwater therefore leaks downward according to the degree of hydraulic connection of the aquifers. Vertical head drops between the glacial and dolomite aquifers across the site are shown by water levels in sets of adjacent wells screened into the different aquifer units (Figure 13). The head drops across the Yorkville Till confining unit in the eastern half of the site are greater than those in the western part where the water table is lower and the hydraulic connections between the outwash and the dolomite are better. This area has the greatest potential of the site for contamination of the bedrock aquifer from landfill-derived contaminants in the glacial aquifer.

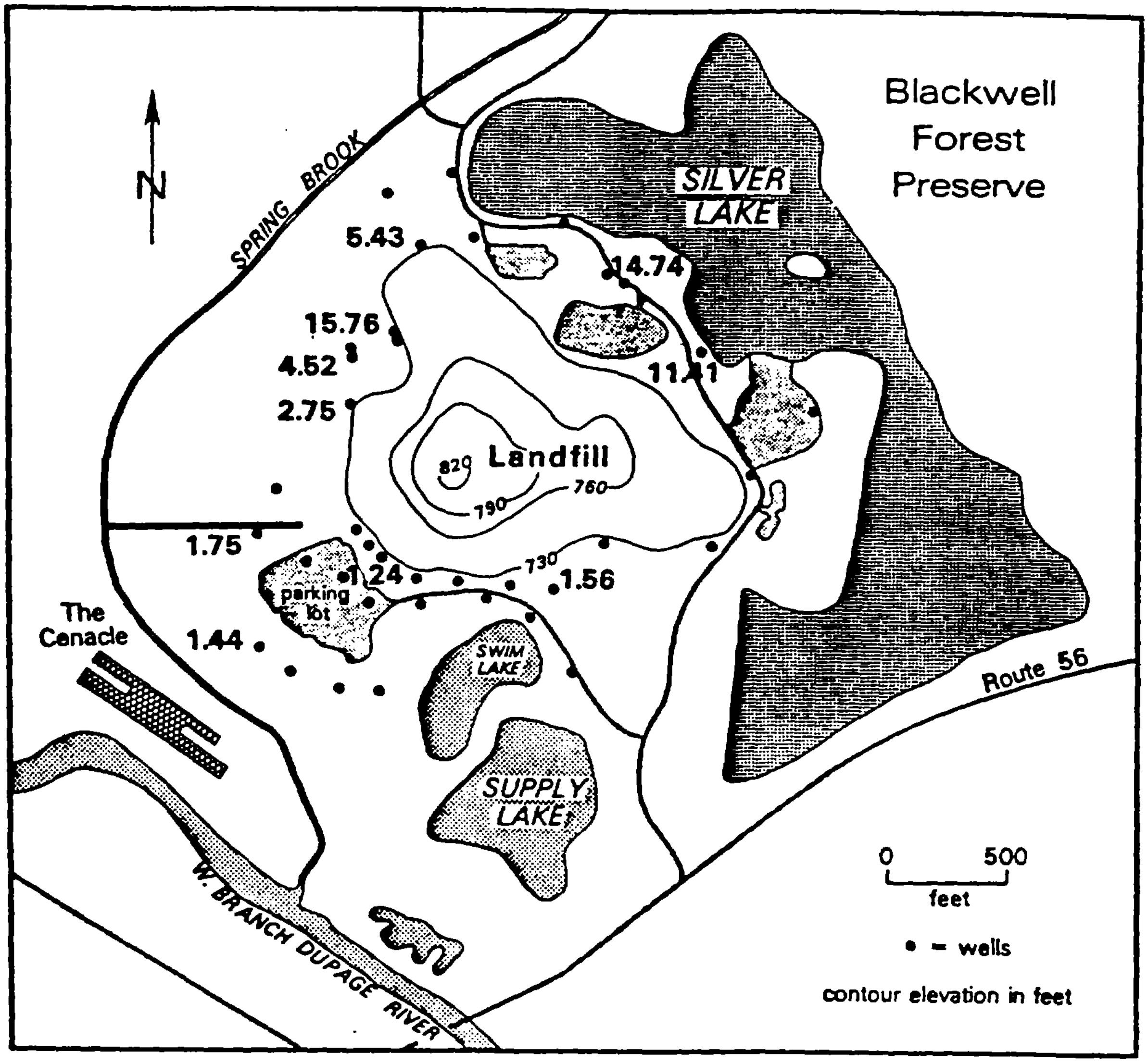


Figure 13. Vertical Head Drops Between Glacial and Dolomite Aquifers: Point Values from Adjacent Wells.

IV. QUANTIFICATION OF LEACHATE SOURCE AND DELINEATION OF THE PLUME

The quantities and concentrations of landfill-derived contaminants in the groundwater system depend on:

-- the volume and rate of leachate production within the landfill

-- the rate of leakage of the leachate from the landfill into the aquifer

-- the concentrations of contaminants within the leachate

-- the volumes of groundwater with which the leachate is mixed and diluted in the aquifer

-- other attenuation and transport processes for the contaminants.

Leachate Production and Leakage.

The production of leachate within the landfill is extremely hard to quantify. It depends first on the moisture originally landfilled with the solid waste, and second on the infiltration of water into the landfill. The original moisture content is unknown; values of original moisture content of solid domestic waste are reported to range between 15 and 50%. However, the original moisture content is not critical to the ultimate leachate production, but rather affects the time after burial for the waste to reach a field capacity for downward percolation of leachate under gravity (Ham, 1986).

Ultimately, the production of leachate depends on the infiltration of water into the landfill (Walsh and Kinman, 1977). Hughes et al. (1971, 1976) estimated infiltration from hydrographs of water levels in piezometers installed in landfills in northeastern Illinois, calculating the amounts by multiplying the cumulative annual rises in water levels by the specific yield of the waste (estimated at a constant value of about 0.25). Data from the Woodstock, Elgin, old DuPage County, and Winnetka landfills indicated that about half the annual precipitation infiltrated into the landfills. They also noted that leachate production was related to freeze-thaw conditions, soil moisture levels, and the duration and intensity of individual rain storms.

Commonly, leachate production is calculated from the landfill water balance (Fenn et al., 1975; Cheremisinoff and Gigliello, 1983; Ham, 1986). A simple formulation is that leachate produced equals the precipitation minus the sum of evapotranspiration and surface runoff. Runoff is calculated from tabulated runoff coefficients for different slopes; evapotranspiration is generally calculated by equations based on temperature and solar radiation. In addition to the uncertainties inherent in these generalized calculations, special problems such as infiltration through cracks are not considered (Ham, 1986) and the leachate production values are very uncertain.

Estimates of potential leachate generation at the Blackwell site were made by calculating infiltration from the water-balance equation:

$$\text{Infiltration (I)} = \text{Precipitation (P)} - \text{Evapotranspiration (ET)} - \text{Runoff (RO)}$$

Daily precipitation and temperature records for 1980 through 1985 were available from the Blackwell Nursery, located one mile northwest of the landfill. The annual average precipitation in the area is 34.2 inches (137 mm), 60% of which falls between April and September mainly during thunderstorms.

The evapotranspiration (as an adjusted potential rate) was calculated using the Thornthwaite Method (Gray, 1970). Runoff was calculated using runoff coefficients given in Chow (1964). The landfill was subjectively divided into 5 areas according to regions of slope steepness, and the average slope of each area estimated, using a detailed (2-ft contour interval) topographic map of the landfill. The runoff for each area is calculated as the precipitation times the runoff coefficient, and infiltration, calculated as above, was converted into volumes as average cubic feet per day for each month.

The results of these calculations are shown in Table 7. The potential generation of leachate from April through September is zero (because infiltration is zero), and ranges from about 2050 day to 18,108 cubic feet per day (58 to 513 m^3/day) for the rest of the year. The figures are specific for 1985 and would differ according to temperature and rainfall in other years. For example, in many years a later snowmelt and wetter April might extend the season of infiltration; also the very high infiltration in November is due to very heavy rainfall.

In addition to the inherent uncertainties of generalized evapotranspiration methods like the Thornthwaite, errors arise in the calculation of runoff. The slopes of the landfill generally exceeded the tabulated values and runoff was probably much greater than that estimated from the maximum runoff coefficient values used. Therefore, infiltration is overestimated. It is also probably overestimated for periods of intense rainfall when the infiltration capacity of the soil is greatly exceeded. Thus, the very high value of 18,108 for November is highly suspect. Some infiltration moves as interflow through the shallow soil and emerges as seepage downhill; in this landfill, some infiltration will also be intercepted by the more permeable layers incorporated into the cover, and will emerge without passing through the refuse. The values of infiltration presented in Table 7 are really maximum possible values of leachate generation from infiltration.

Total annual infiltration (leachate generation) of 1,209,444 ft^3, is indicated (average 3133 ft^3/day). If a more reasonable estimate -say 9000 ft^3/day - for the November infiltration is chosen, an annual average

Table 7. Calculations of Infiltration by Water Balance.

	Precip.	Av. Temp.	PET	INFILTRATION (CUBIC FT./DAY)					
	in.	°F	in.	Area 1	Area 2	Area 3	Area 4	Area 5	Total
Area (ft^2)				364,382	313,962	234,816	34,960	265,596	
Slope %				36	8	18	28	7	
RO Coefft.				0.35	0.30	0.35	0.35	0.30	
Jan	0.94	17.2	0	.580	557	385	57	471	2050
Feb	2.86	23.4	0	.2017	1869	1300	194	1581	6960
Mar	5.18	39.2	0.46	2860	2633	1843	274	2228	9839
April	1.58	55.6	2.40	--	--	--	--	--	--
May	1.55	63.8	3.89	--	--	--	--	--	--
June	2.14	66.8	4.61	--	--	--	--	--	--
July	6.25	75.7	6.10	--	--	--	--	--	--
Aug	1.88	71.0	4.87	--	--	--	--	--	--
Sept	2.32	67.0	3.74	--	--	--	--	--	--
Oct	3.91	55.6	1.97	529	625	341	51	528	2073
Nov	8.58	39.8	0.40	5243	4866	3379	503	4117	18108
Dec	0.58	20.0	0	327	346	240	36	293	1242

infiltration of about 2565 ft^3/day is indicated. If the leachate mound were in equilibrium, this value would also equal leachate leakage from the landfill.

Leachate generation and leakage was also estimated from analysis of the leachate levels, which are monitored in 24 vents in the landfill (Figure 14). The levels recorded between 1982 and 1985 fluctuate around fairly constant levels, suggesting that the initial rising phase is complete and that variations now depend on the balance between infiltration and leakage.

The leachate levels form a mound (Figure 14) with a general elevation of over 720 ft and peaks reaching over 750 ft. The water table across the site has a maximum natural elevation of about 709 ft at Silver Lake, falling to about 700 ft along the western side of the landfill and 690 ft at the south end of the site. Clearly, the leachate mound is well above normal water-table levels. The extent of hydraulic continuity between the leachate mound and the water table is unknown, since (for obvious reasons) no well penetrates both leachate in the waste and groundwater in the aquifer. The refuse is laid in cells which are not necessarily hydraulically connected and which have different basal characteristics. It is possible that some parts of the leachate mound are perched, while others are continuous with the water table.

To use the leachate-level data in a representative way, the landfill was divided into Theissen-type polygonal areas drawn around the vents, and the area around each vent measured. Detailed leachate-level data are available for the dates 7/15, 8/31, 10/20 and 11/17 in 1985; partial data are also available for 6/7 (Table 8). The earlier calculations indicate that for the period 6/7-7/15 and 7/15-8/31, there should be no infiltration and hence no leachate generation. However, in the second of these periods the leachate levels are generally rising. Possible explanations are a lag time from earlier infiltration and

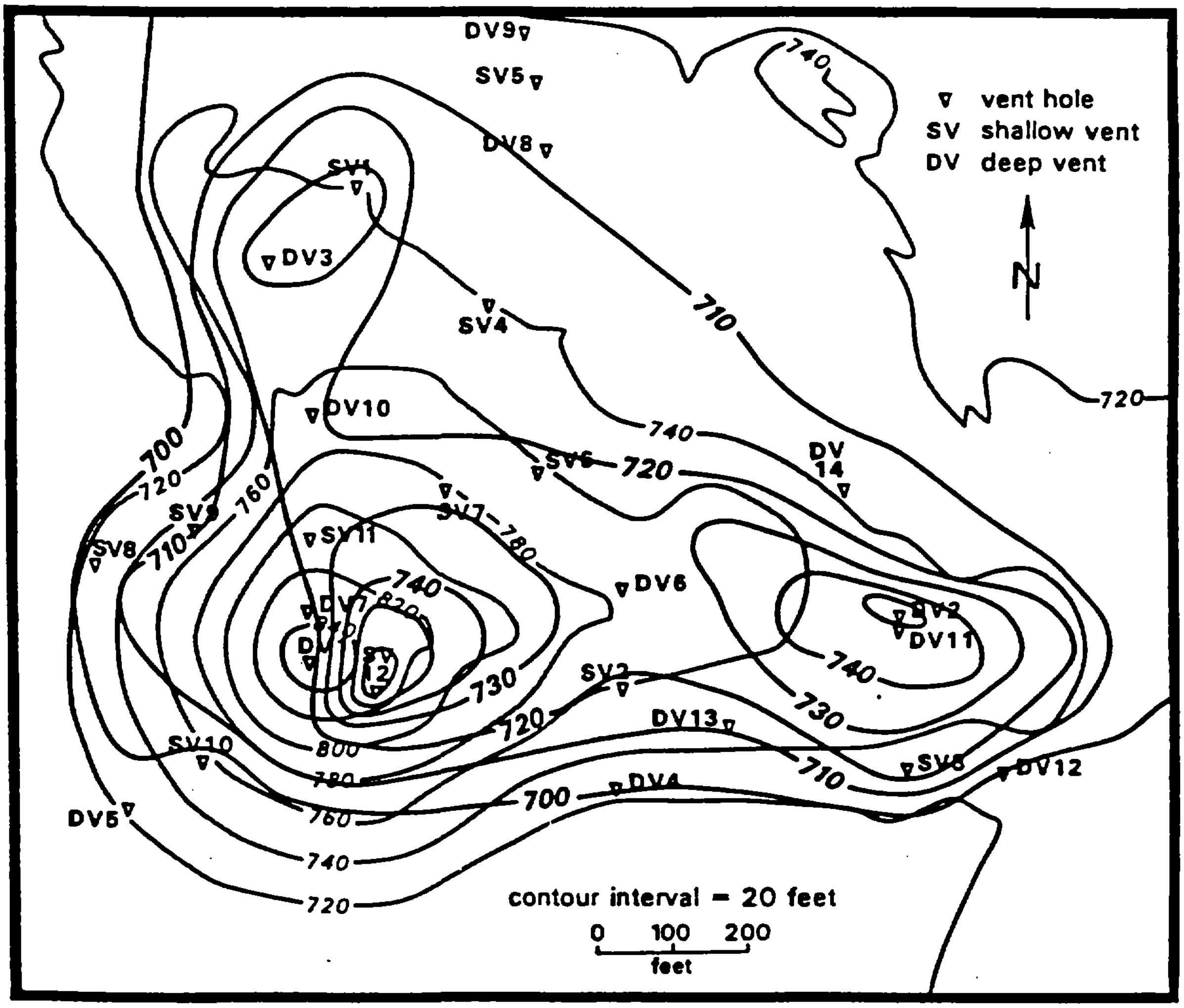


Figure 14. Contour Map of Leachate Levels (Interval 10 ft) in Blackwell Landfill

Table 8. Leachate Levels at Vents in Landfill at Blackwell

Vent Number	Leachate Elevation (ft a.m.s.l.) 7 June 85	15 Jul 85	31 Aug 85	20 Oct 85	17 Nov 85
SV-1	735.71	735.26	735.84	734.51	735.11
SV-2	719.03	718.95	719.01	718.95	718.95
SV-3	723.59	722.63	722.55	721.76	723.84
SV-4	714.63	714.97	715.03	718.05	715.67
SV-5	709.23	708.69	708.17	707.94	708.28
SV-6	724.88	724.84	724.78	724.67	724.30
SV-7	728.04	727.84	727.84	727.25	728.09
SV-8	708.90	708.86	708.95	708.88	708.95
SV-9	709.00	708.96	709.04	709.00	709.00
SV-10	692.38	691.47	690.80	691.17	692.13
SV-11		726.67	726.55	726.50	725.69
SV-12		759.82	760.20	760.17	760.77
DV-2	749.83	748.54	750.71	750.04	749.50
DV-3	737.36	737.07	736.99	736.11	736.82
DV-4	702.54	701.04	699.73	699.17	701.08
DV-5	697.75		697.40	698.29	697.12
DV-6	724.04	723.83	724.17	723.83	724.08
DV-7		714.41	714.22	714.01	714.06
DV-8	710.24	709.42	708.84	708.62	708.72
DV-9	709.20	708.63	708.29	707.99	708.55
DV-10	721.06	720.91	720.96	720.99	721.09
DV-11	739.34	742.94	744.30	744.66	744.50
DV-12	700.15	698.21	697.70	697.21	697.71
DV-13	709.38	709.93	710.20	710.38	710.53
DV-14					

infiltration through cracks in the landfill during the heavy rainstorms in late August.

In the following period, 8/31-10/20, the leachate levels are generally falling. Although 3.94 inches of rain fell in the first 20 days of October, half of that rainfall fell in the last four days of the inventory period. Furthermore, most of the infiltration indicated for October (Table 7) would occur toward the end of the month. Therefore, the leachate levels probably responded little to infiltration during this period, and their declines can be assumed to represent loss of leachate from the landfill.

The change in leachate levels during this later period can be converted to a change in leachate volume according to the relationship

$$V = L \times A \times n$$

where

v = change in leachate volume (i.e. volume of leachate lost from area)

L = change in leachate level in area

A = area

n = effective porosity of compacted refuse

The value of effective porosity (specific yield) for the compacted refuse is unknown. A value of 0.2 was assumed; the volume of leachate lost or gained according to the head changes is proportional to the effective porosity value.

As Table 9 shows, during the inventory period 8/31 through 10/20 approximately 1539 ft^3/day (43.6 m^3/day) of leachate were lost from areas of the landfill in which levels were falling (949,100 of the 1,299,500 ft^2 total landfill area): a leakage rate of 1.62×10^{-3} $ft^3/day/ft^2$ if all was lost through the base. However, there may have been some redistribution within the landfill, perhaps to the gaining areas where an increase of about 922 ft^2/day is indicated; if this quantity is included, a net loss of about 617 ft^3/day would have occurred. In comparison, the leachate loss from areas of falling levels during the period 6/7 through 7/15 (zero infiltration period) was about 3323 ft^3/day, or 3.47 $ft^3/day/ft^2$ of the areas of falling leachate levels.

In the period 10/20 through 11/17, when considerable infiltration occurred, the dominant leachate level changes are positive, indicating production of leachate in excess of loss. The increase (for all vent areas) is 2473 ft^3/day for the period, representing a net excess of leachate production; if leakage at the previous rate of between 617 and 1539 ft^3/day had continued, a total leachate production of 3090-4012 ft^3/day is indicated. These values are much less than the (probably erroneous) 18,108 ft^3/day infiltration for November calculated earlier, but are otherwise consistent with the range of infiltration values.

Table 9. Changes in Leachate Levels and Estimated Changes in Leachate Volumes

		Period 6/7-7/15/85		8/31 - 10/20		10/20-11/17	
Vent #	Area ft^2	Level Change ft	Leachate ft^3/day	Level Change ft	Leachate ft^3/day	Level Change ft	Leachate ft^3/day
SV1	61,600	-0.45	-146	-1.33	-328	+0.60	+264
SV2	54,100	-0.08	-23	-0.06	-13	0.0	0
SV3	34,300	-0.96	-173	-0.79	-108	+2.08	+510
SV4	44,000	+0.34	+130	+3.02	+532	-2.38	-748
SV5	31,200	-0.54	-87	-0.23	-29	+0.34	+76
SV6	53,000	-0.04	-11	-0.11	-23	-0.37	-140
SV7	55,500	-0.02	-6	-0.59	-131	+0.84	+333
SV8	39,900	-0.04	-8	-0.07	-11	+0.07	+20
SV9	38,100	-0.04	-8	-0.04	-6	0.0	0
SV10	79,100	-0.91	-379	+0.37	+117	+0.96	+542
SV11	27,300	N/A	N/A	-0.05	-5	-0.81	-158
SV12	102,800	N/A	N/A	-0.04	-12	+0.60	+441
DV2	68,200	-1.29	-463	-0.67	-183	-0.54	-263
DV3	58,000	-0.29	-89	-0.88	-204	+0.71	+294
DV4	74,900	-1.5	-591	-0.56	-168	+1.91	1022
DV5	33,500	N/A	N/A	+0.89	+119	-1.17	-280
DV6	74,300	-0.21	-82	-0.34	-101	+0.25	+133
DV7	38,100	N/A	N/A	-0.21	-32	+0.05	+14
DV8	46,800	-0.82	-202	-0.22	-41	+0.10	+33
DV9	45,800	-0.59	-137	-0.30	-55	+0.56	+183
DV10	57,700	-0.15	-456	+0.03	+7	+0.10	+41
DV11	68,200	+3.6	+2135	+0.36	+98	-0.16	-78
DV12	45,200	-1.94	-462	-0.46	-89	+0.50	+161
DV13	67,900	+0.55	+324	+ 0.18	49	+0.15	+73

Many uncertainties are involved in the above methods, and different approaches to and interpretations of the leachate-level analysis could certainly be made. Nevertheless, the estimates of leachate production and loss agree within better than order-of-magnitude precision. The leachate production and leakage rates (equal assuming equilibrium) from the infiltration calculations are about 2500 - 3000 ft^3/day, annual average; the leachate loss rates estimated from analysis of the levels for two periods range from 617 to 3323 ft^3/day. Approximately equal quantities appear to be lost from the north, south, and west sides of the landfill.

Attenuation and Dilution of Contaminants.

The chemical composition of the refuse and, therefore, of the leachate is quite variable. Total dissolved solids in the leachate in the Blackwell landfill exceed 5000 ppm in some vents; high values of total volatile organics range between 500 and 5000 ppb. These very high, hazardous concentrations of contaminants will be much diminished by natural attenuation and dilution processes as the leachate leaks to the groundwater system and mixes with fresh water.

Attenuation by ion exchange, adsorption, and other processes will occur as the leachate leaks through the clay liner at the base of the landfill, and again within the underlying glacial materials. These attenuation processes are complex; a full discussion is beyond the scope of this study but a brief summary is given below. The efficiency of such processes is strongly related to the presence of clay materials; thus, the thickness and clay content of the liner and the presence of clays in the glacial materials are critical to attenuation of the leachate contaminants.

To the east, where the landfill is underlain by thick clay-till sequences, groundwater movement is slow and ion exchange and adsorption processes are effective. Leachate entering the glacial material from the northern and eastern sections of the landfill experiences little dilution but undergoes considerable attenuation by other processes, and moves very little. However, a significant discharge of groundwater occurs from Silver Lake beneath the landfill through the sandy layers within the till sequence, eventually joining with the main groundwater flow on the outwash aquifer and adding to the dilution of leachate leaking from the western and southern sections.

As the water-table maps indicate, the leachate leaking from the south and southwest sides of the landfill (according to the earlier estimates) will move south toward the Swim and Supply Lake, mixing with groundwater flowing in the glacial aquifer under the western part of the landfill, in the glacial materials between Silver Lake and the Swim Supply Lakes, and in the sandy layers within the Yorkville sequence under the landfill. If we estimate a leachate leakage of about 500 ft^3/day (3750 gpd) from this area, and from flow-net analysis of the water table maps roughly estimate that about 190,000 gallons of water from the north and a further 200,000 gallons from Silver Lake in the east is flowing through the aquifer per day, we see that the leachate contaminants are diluted by a factor of about 1 in 100.

Not all the landfill leakage is carried toward the Swim and Supply Lakes. From the western and northwestern sides of the landfill, some (perhaps a further 500 ft^3/day) mixes with groundwater flowing through the outwash aquifer from the north and with a quantity of water recharging from Spring Brook, which forms a local divide blocking any further westward movement of groundwater in this section of the aquifer.

An approximate calculation for seepage (average linear) velocity can be made from application of Darcy's Law:

$$V = - K \times I / n$$

where I = hydraulic gradient (L/L)
K = hydraulic conductivity (L/T)
n = porosity
and V = seepage velocity (L/T)

The hydraulic conductivity of the outwash aquifer is quite variable. Considering all the data listed in Tables 3 and 4 above, the median hydraulic conductivity is about 2.6×10^{-2} ft/min and the mean conductivity is about 2.6×10^{-1} ft/min. Choosing as an example the flow path through wells G-113 and G-116, the hydraulic gradient from the water-table maps (Figures 11 and 12) is about 4/720 in October and 2.5/720 in April, an average of about 4.5×10^{-3}. Using a porosity of about 0.23, the seepage velocity is between about 257 ft/year (based on the median K value) and 2570 ft/year (mean K value). This figure represents the predicted advective transport velocity for non-retarded (conservative) contaminants once they have left the landfill and merged with the groundwater flow. Clearly, even with a conservative estimate the contaminants should have travelled several hundred feet from the landfill in the several years that have elapsed since leakage began.

The physical dilution of leachate by groundwater (through mixing and dispersion) is undoubtedly the most important mechanism by which the contaminant concentrations are reduced in the aquifer. However, these processes are largely ineffective in the poorly permeable tills. In the tills, and also as the leachate percolates through the landfill's clay liner, the most effective attenuation will be through sorption processes -- the physical and chemical bonding of pollutants to the solid particles. Overviews of these and other attenuation processes are given by Freeze and Cherry (1979) and Wood et al. (1984). The processes depend on the nature of the porous medium (clay being an effective adsorber), the contaminant species and concentrations, and the ambient chemical conditions. For example, Griffin et al. (1976) passed leachates from the old DuPage landfill through laboratory columns of clay and sand, and found that chloride, sodium, and water-soluble organics were relatively unattenuated by clay whereas heavy metals (Pb, Cd, Zn, and Hg) were strongly attenuated and tended to precipitate out. Calcium increased into the effluent, a finding consistent with the presence of "hardness halos" around landfills.

Attenuation of specific pollutants can also result from hydrolysis, oxidation reactions, precipitation due to changing pH conditions, and various other chemical processes. Organic pollutants absorb readily onto organic material in the porous medium (Griffin and Chian, 1979); even minor variations in the organic content of the aquifer materials (or landfill liner) can cause major directional and spatial variations in the organic component of the contaminant plume. Organic chemicals also undergo chemical and biological degradation, and volatilization (the loss of volatile components into a vapor phase and thence to the atmosphere, where they do not represent a hazard and generally break down quickly). A useful review of transport and attenuation of organic contaminants is given by Mackay et al. (1985). The result of the various attenuation processes is threefold: First, a general reduction in contaminant concentrations away from the contaminant source (landfill); second, a retardation of transport of contaminants, such that the "travel times" of most contaminants are significantly less than the seepage velocities; and third, a differentiation of contaminant species within the contaminant plume, because the attenuation and retardation processes affect different contaminants to different degrees.

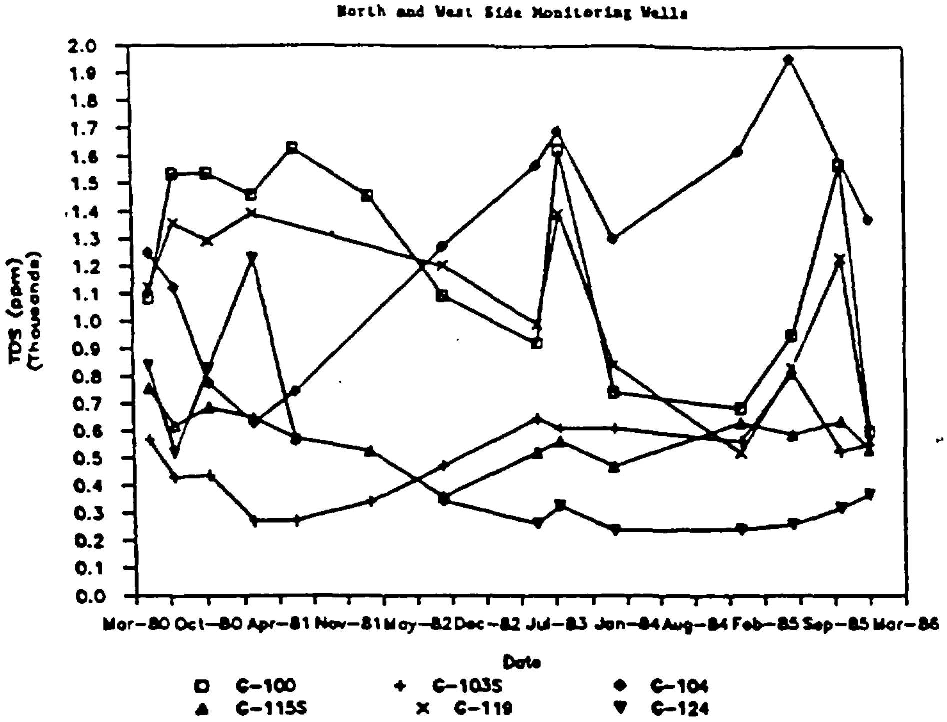
Contaminant Plume in the Glacial Aquifer.

Records suggest that by 1978 inorganic contaminants were already present in the closest wells in the glacial aquifer, in approximate steady-state. The TDS and chloride values show little systematic variation between 1980 and 1986. The TDS values in the southern wells (Figure 15(b)) show a rapid drop in 1980, but then fluctuate between fairly low values (less than 1000 ppm); the northern wells (Figure 15(a)) exhibit both rising (wells 103S, 104) and falling (100, 124) trends.

The TDS values from all glacial monitoring wells form an approximately concentric pattern (Figure 16) around the landfill. The values reach over 5000 ppm within the landfill vents themselves, but decline almost to background levels (500 ppm) just beyond the closest-well zone. Concentrations increase again in the southwest near Spring Brook, where flow is from the stream into the aquifer. Spring Brook, obtaining some of its water as sewage treatment waste upstream of the Blackwell site, has TDS values in the range 1000 - 1500 ppm, with a dominant sodium-chloride assemblage. The distribution of chloride (Figure 17), which is assumed to be a conservative and little-retarded species, resembles that of TDS and also reflects the influence of Spring Brook.

Contrary to expectation, the contaminant plume is not heavily skewed in the downgradient direction. This is perhaps most easily explained as an effect of dilution. The downgradient direction is within the glacial aquifer where attenuation by dilution is very effective and the concentration plume diminishes rapidly. Upgradient, the contaminant plume sits in poorly permeable till; it is not as effectively diluted, but neither does it travel very much.

TDS Concentrations, 1980 - 1986



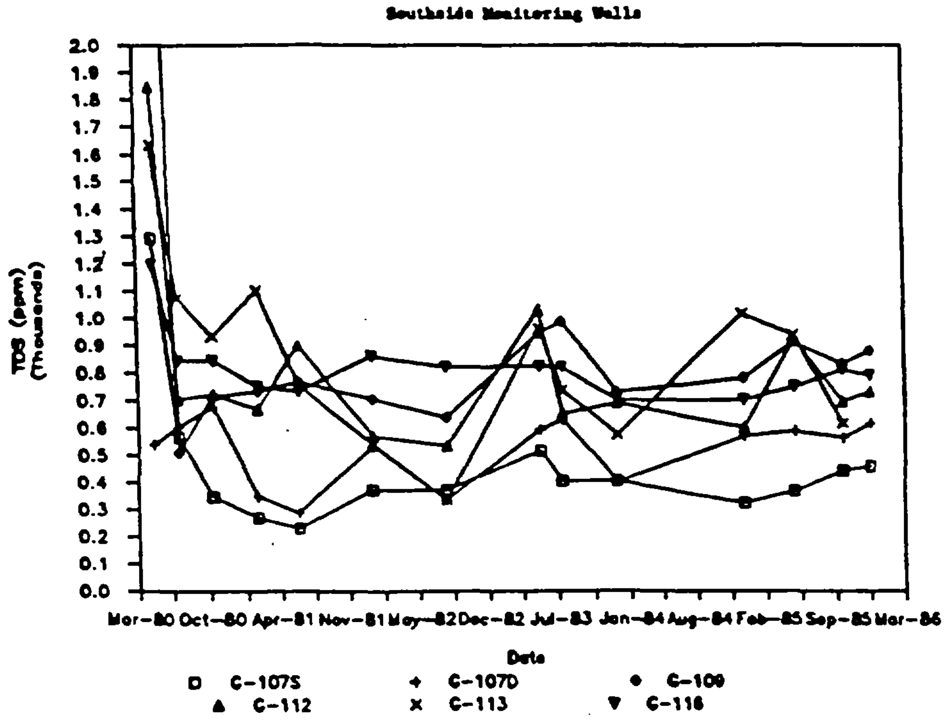


Figure 15. Total Dissolved Solids Concentrations in 1980 - 1986 in (a) North and West Wells and (b) South-Side Wells

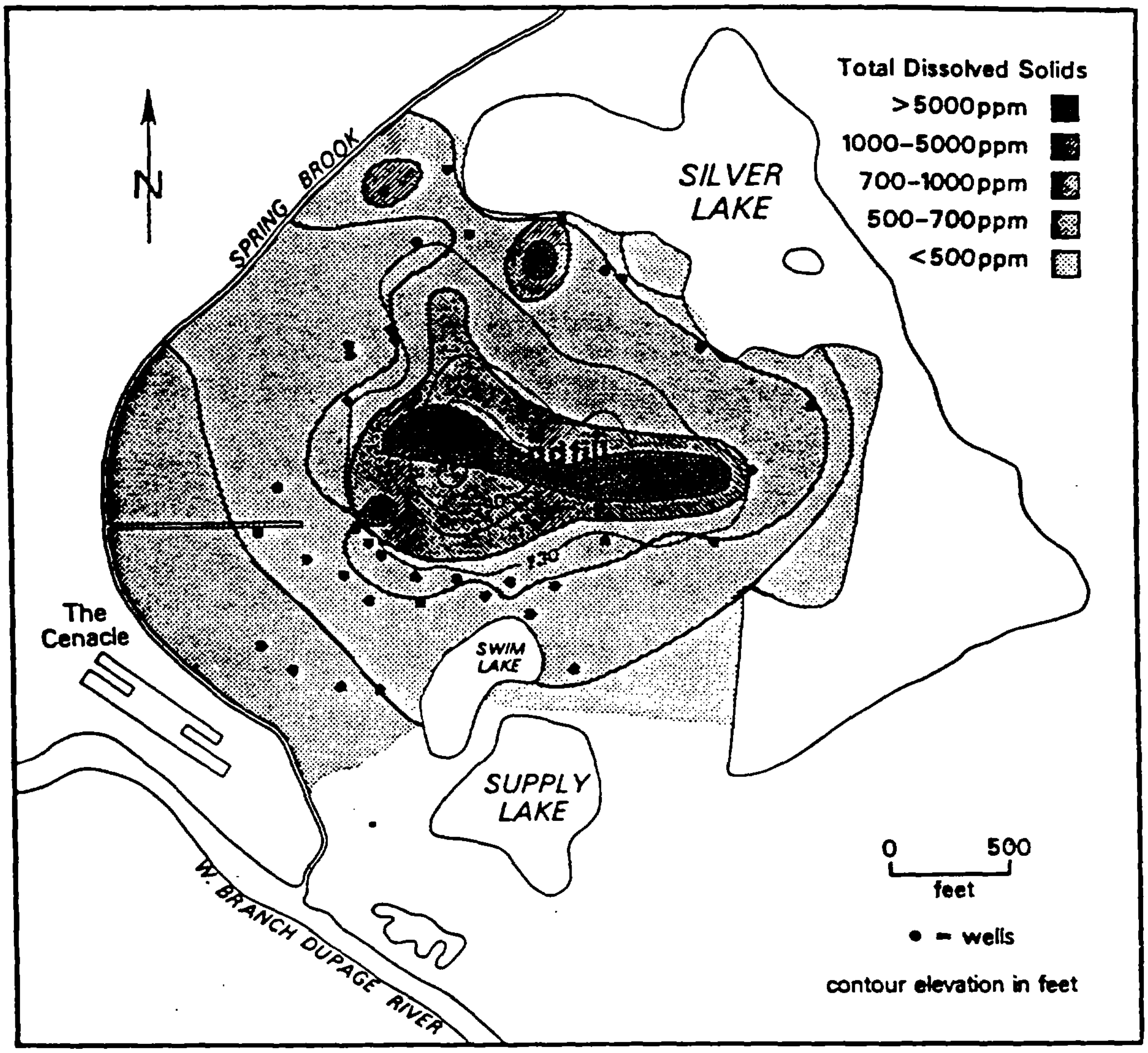


Figure 16. Distribution of Total Dissolved Solids in the Glacial Aquifer

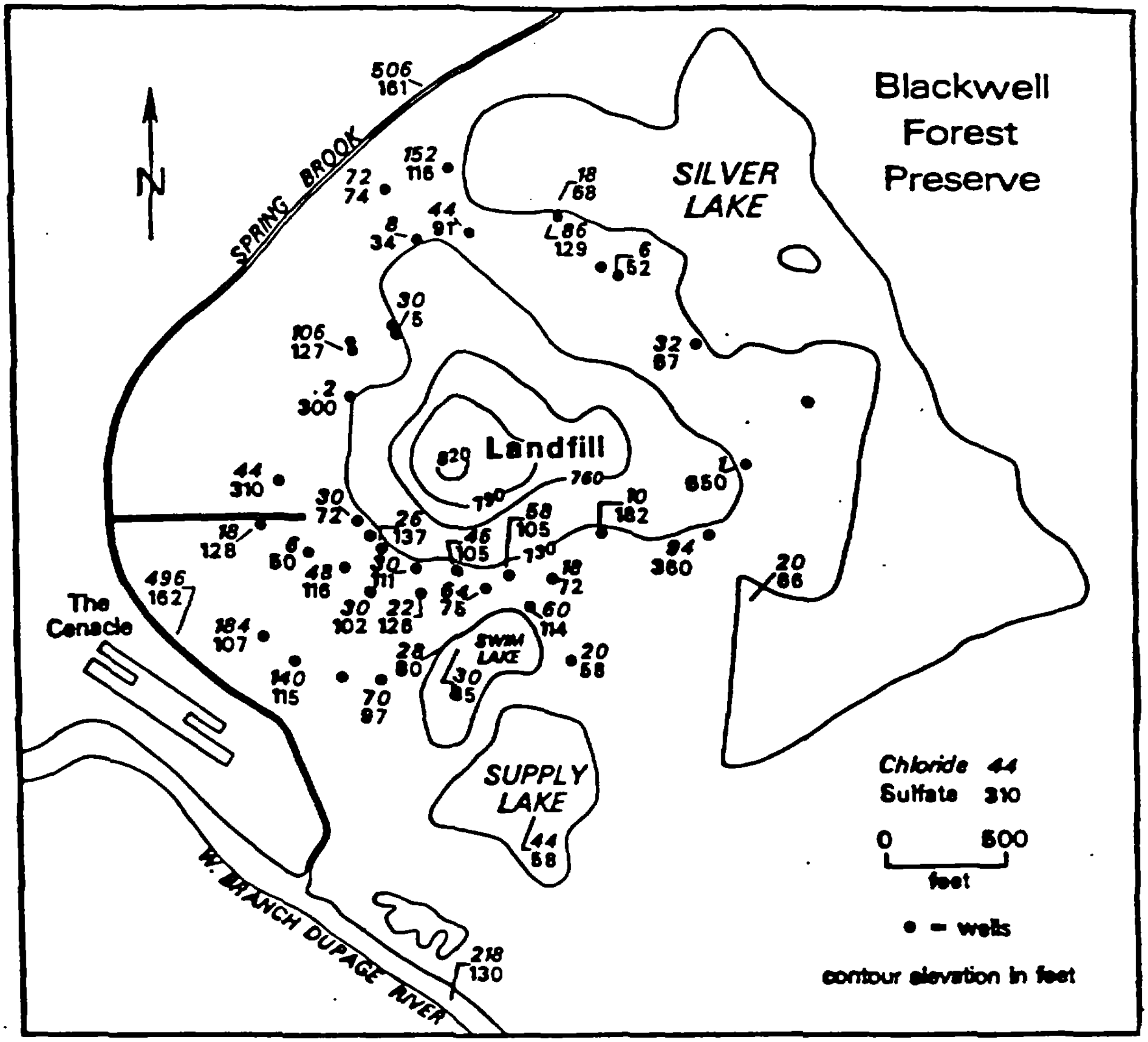


Figure 17. Distribution of Chloride and Sulfate Values in the Glacial Aquifer

By the early 1980's, technology had been developed for the relatively inexpensive analysis of volatile organic compounds (VOC's) at concentrations as low as parts per billion (ppb). Sampling and analysis for VOC's was started at Blackwell by the FPD in Fall, 1983, and continues on a quarterly basis. Samples are analyzed for 31 priority and 2 nonpriority organic pollutants. Table 10 summarizes the analyses for several wells along the southern side of the landfill (110 through 118S close in, 117 through 122 farther off).

The individual pollutants show large spatial and temporal variations with no identifiable pattern. In fact, certain VOC's (1,2-dichlorethane and cis-1,2-dichloroethylene, for example) are breakdown products of other organics and may have formed during transport within the aquifer. The light volatiles (with specific gravities less than 1) are oil- and gasoline-derivatives and are suspected to be derived at least in part from contamination during drilling.

A more meaningful parameter is obtained by summing all volatiles for each well into a single figure, total volatiles (TV). Total volatile concentrations form a roughly concentric pattern around the landfill (Figure 18). The concentrations in the leachate vents can reach over 1000 ppb; however, in the glacial materials they drop off rapidly. Attenuation and retardation processes for the organics appear to be quite effective. An anomalous feature in the TV contaminant plume is the zone of very low concentrations around wells G-114 and G-115; this zone is probably related to the buried ditch mentioned earlier, in which greater contaminant dilution is occurring. Although the total volatile concentrations vary considerably in time (Figure 19), the prevalent trend seems to be a general decrease.

In summary, there is clear evidence of both inorganic and organic contamination of the glacial aquifer in the vicinity of the landfill, but significant concentrations of contaminants are not migrating off site and

Table 10. Selected Analyses of Volatile Organics in Glacial Wells, Dec. 1983-Dec. 1985

Average and (Maximum) concentrations (ppb) in wells:

	110	111	112	113	118S	117	123	128S	127	122
light										--
benzene	1.7 (7.6)	0.1 (1.0)	3.6 (17.2)	1.8 (9.0)	0.5 (3.8)	--	--	--	--	--
CE	--	--	15.3 (76.6)	2.2 (17.7)	2.5 (17.8)	--	--	--	--	--
VC	21.1 (121)	--	--	6.0 (47.7)	--	--	--	--	16.2 (70.6)	--
<u>heavy</u>										
1,2 DCE	5.4 (11.0)	1.2 (5.7)	5.7 (22.5)	4.0 (12.2)	--	0.1 (1.3)	--	17.0 (26.3)	0.6 (3.2)	0.6 (6.2)
1,1 DCE	22.7 (49.6)	6.6 (10.9)	54.8 (189)	27.5 (61.8)	79.5 (137)	4.7 (10.3)	0.2 (1.4)	26.9 (38.0)	12.4 (18.2)	4.0 (19.6)
1,2 TDCE	14.9 (41.6)	2.4 (11.5)	9.2 (22.6)	12.2 (28.3)	18.5 (55.8)	0.7 (7.2)	0.4 (3.3)	11.1 (24.3)	8.2 (13.6)	0.8 (7.2)
TCE	3.9 (18.7)	1.7 (6.9)	0.4 (2.3)	--	9.0 (29.1)	0.1 (1.0)	0.1 (1.0)	0.7 (3.0)	0.7 (3.3)	0.1 (1.2)
Tri	65.7 (168)	46.7 (198)	19.2 (41.4)	0.9 (4.1)	62.4 (132)	0.2 (2.0)	0.4 (1.8)	6.9 (19.5)	28.8 (46.5)	3.4 (8.3)
Cis	266.7 (583)	75.3 (191)	64.6 (165)	10.3 (23.8)	145.4 (241)	13.4 (24.8)	--	46.9 (80.7)	115.7 (248)	12.5 (34.3)

CE = chloroethane; VC = vinyl chloride;
DCE = dichloroethane; TDCE = trans-dichloroethylene;
TCE = tetrachloroethylene; Tri = trichloroethylene;
Cis = cis-1,2-dichloroethylene.

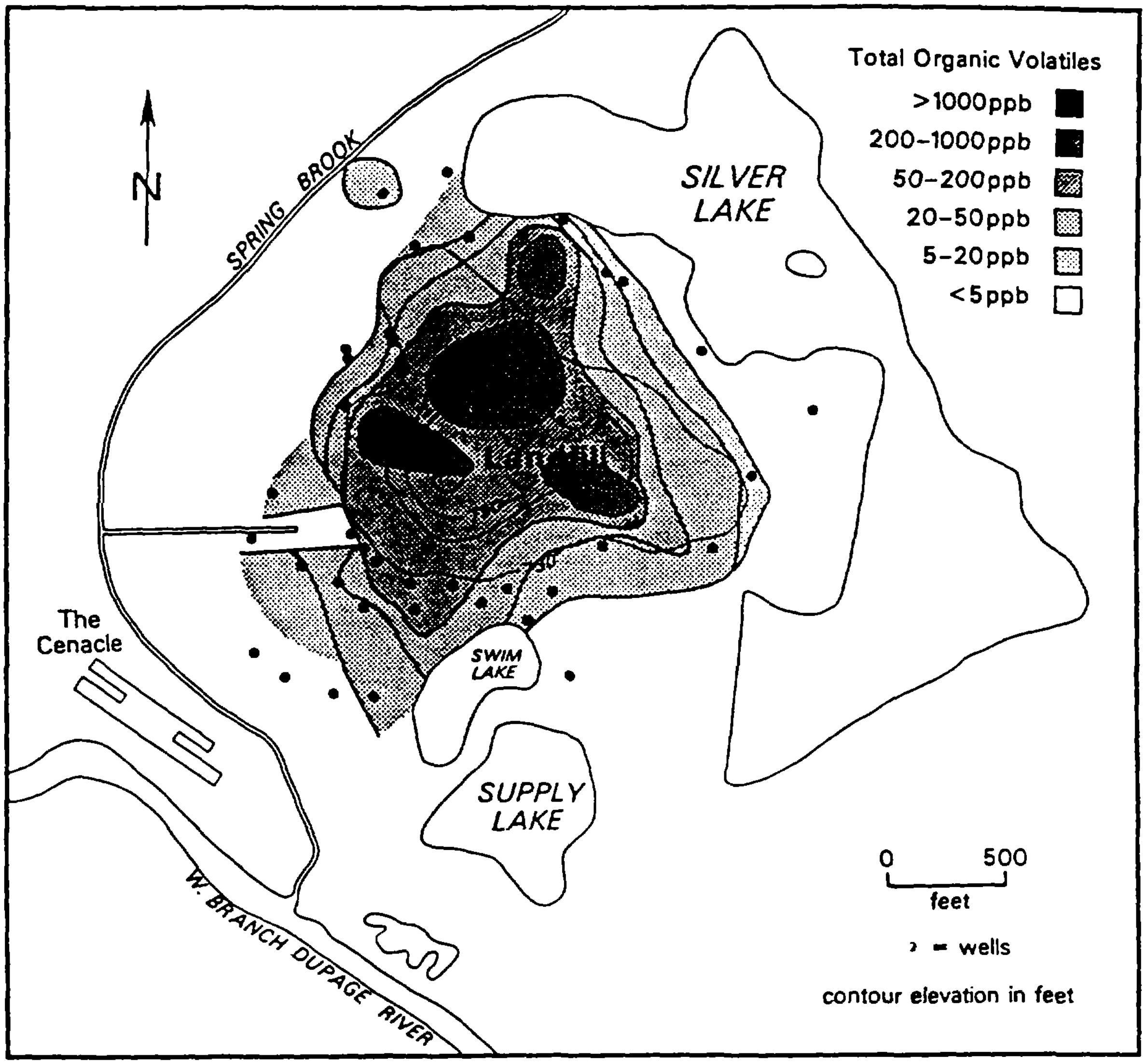


Figure 18. Distribution of Total Volatile Organics in the Glacial Aquifer

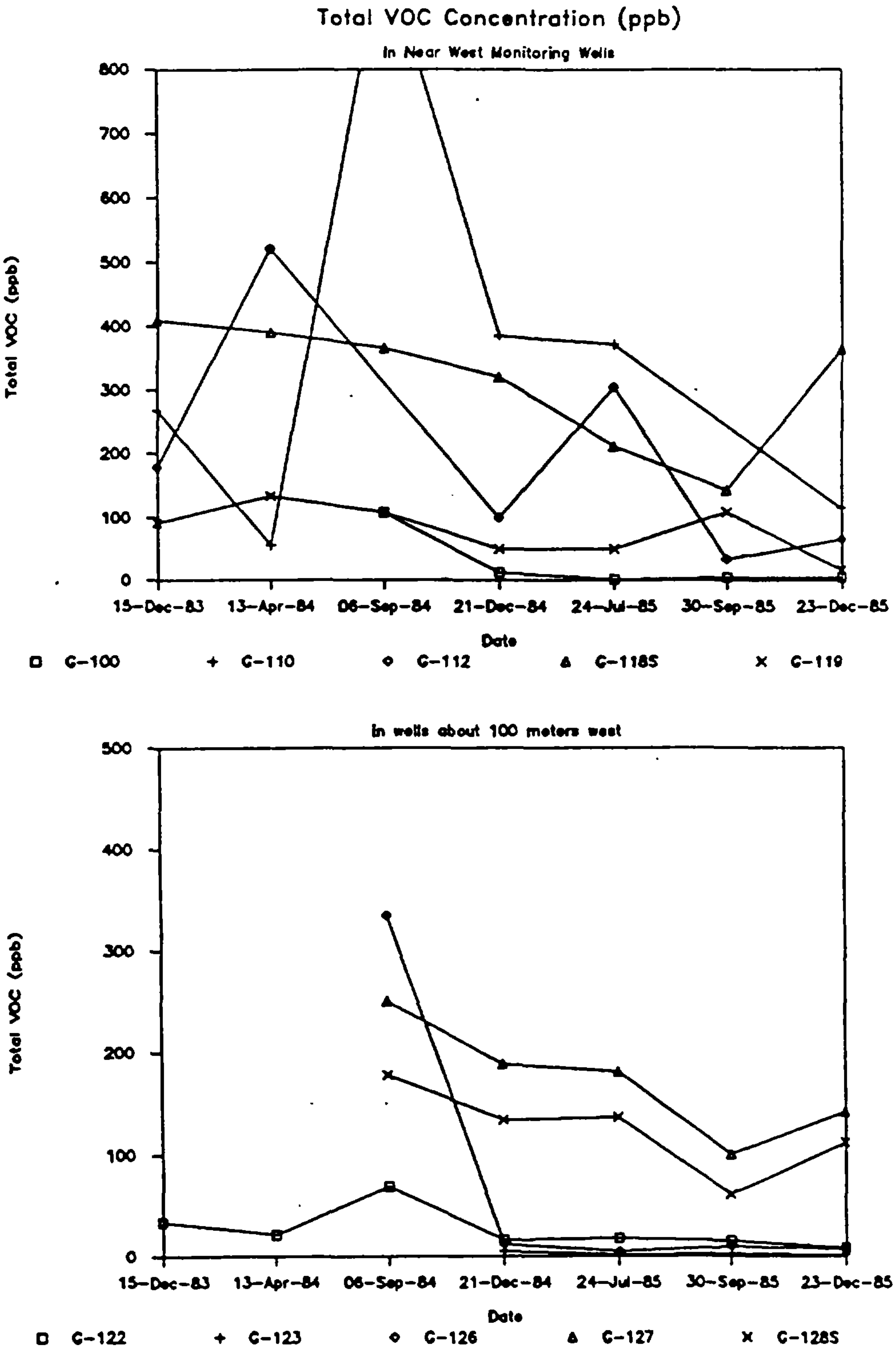


Figure 19. Total Volatiles, 1983-1985, in (a) Closest West Wells and (b) Farther West Wells

probably will not do so. Monitoring wells close to the landfill do show elevated levels of several organic compounds, but those values have shown no significant increase since sensitive analyses were started in 1983, and in fact may now be declining. Monitoring wells at approximately 100 yards distance from the landfill show lower concentrations, while wells into glacial materials at the western perimeter (G-116 and G-133) have no evidence of contamination from the landfill.

The "natural system" of which the landfill is a part appears to have reached a state of equilibrium since its closure 13 years ago. The contaminants in the leachate leaking from the landfill are dispersed, diluted, or otherwise attenuated to background levels before reaching the Swim Lake or the FPD property line. Water table maps of the glacial aquifer indicate that there is a flow of groundwater from the landfill toward the Swim Lake, so there is a possibility that the water and bottom sediments will be contaminated by the landfill leakage. Furthermore, monitoring wells between the landfill and beach consistently exhibit some of the highest contaminant levels on the site. However, in regular quarterly and numerous spot-check analyses, water samples from the Swim Lake have consistently been clean, showing no pollution effects from the landfill. It is apparent that the combined attenuation and dilution processes reduce contaminant levels in the groundwater to near background levels during flow from the landfill to the beach.

Nevertheless, the potential for contamination of the Swim Lake remains; it is because of this potential that the Forest Preserve District closed the Swim Lake for the 1984 season and kept it closed during 1985 and 1986. Closing the Swim Lake has had the further affect of generating a mistaken public opinion that it is in fact contaminated.

Contamination of the Bedrock Aquifer.

Although the original project title refers only to unconsolidated deposits, we feel that the hydrologic data show a close linkage between the glacial and bedrock aquifers in the southwestern area where the Yorkville and Malden Tills are absent: therefore, possible contamination of the bedrock deserves consideration. The dolomite aquifer is an important source of water for municipal and domestic wells in the Blackwell area and any potential for contamination is of major concern.

Contamination of the bedrock aquifer from the landfill would be suggested by the presence of abnormally high TDS, volatile organic, or other contaminants downgradient form the landfill. As noted earlier, the potentiometric gradient in the dolomite is dominantly east to west, with perhaps a slight northerly component in the northwestern part of the site.

Records of TDS concentrations in dolomite wells were collected from surrounding municipalities; these are summarized (Table 11) along with records for two dolomite wells at the Cenacle (a religious retreat just southwest of the site) and for bedrock wells on site. TDS concentrations in the dolomite aquifer in the Blackwell region range from 300 to 800 ppm; higher concentrations are found in Spring Brook and the DuPage River. In the dolomite aquifer, concentrations are highest in several municipal wells, in the Cenacle deep well, and in the FPD residence well located approximately 0.25 miles north of the site. The lower concentrations in the on-site dolomite wells do not suggest the presence of landfill-derived contamination.

The distribution of VOC's down-gradient from the landfill in the dolomite aquifer (Figure 20) does have the appearance of a contaminant plume. Data are too sparse to allow contour plotting but in general the TV concentrations are highest in wells near the landfill and lower concentrations are found at greater

TABLE 11. Total Dissolved Solids (concentrations in ppm) in Rivers and Dolomite Wells in the Blackwell Area

TDS (ppm)			
1500	Springbrook at Cenacle		
	Springbrook at Weir		
1000			
	DuPage River at Rte 56		
900			
800	Winfield #2		
	FPD residence	DuPage River at Mack Road	
		DuPage River at Williams Road	
	Cenacle Deep Well		
700			
	Winfield #4		
	Warrenville #2	Warrenville #4	
	Warrenville #1B	G-128 (FPD)	G-107 (FPD)
600			
	G-133 (FPD)		
	G-115 (FPD)		
	Swim Beach Well (FPD)		
500	Winfield #7		
	Winfield [illegible]	Denny's Den Well	Cenacle Shallow Well
	Warrenville #4b	Warrenville #3	
	Warrenville #5	G-118 (FPD)	Silver & Supply Lake
	Warrenville #8	G-134 (FPD)	Amphitheatre Well (FPD)
400	G-103 (FPD)		
	G-135 (FPD)	Picnic Well (FPD)	
	G-120 (FPD)	Warrenville #6	
	G-136 (FPD)		
300			

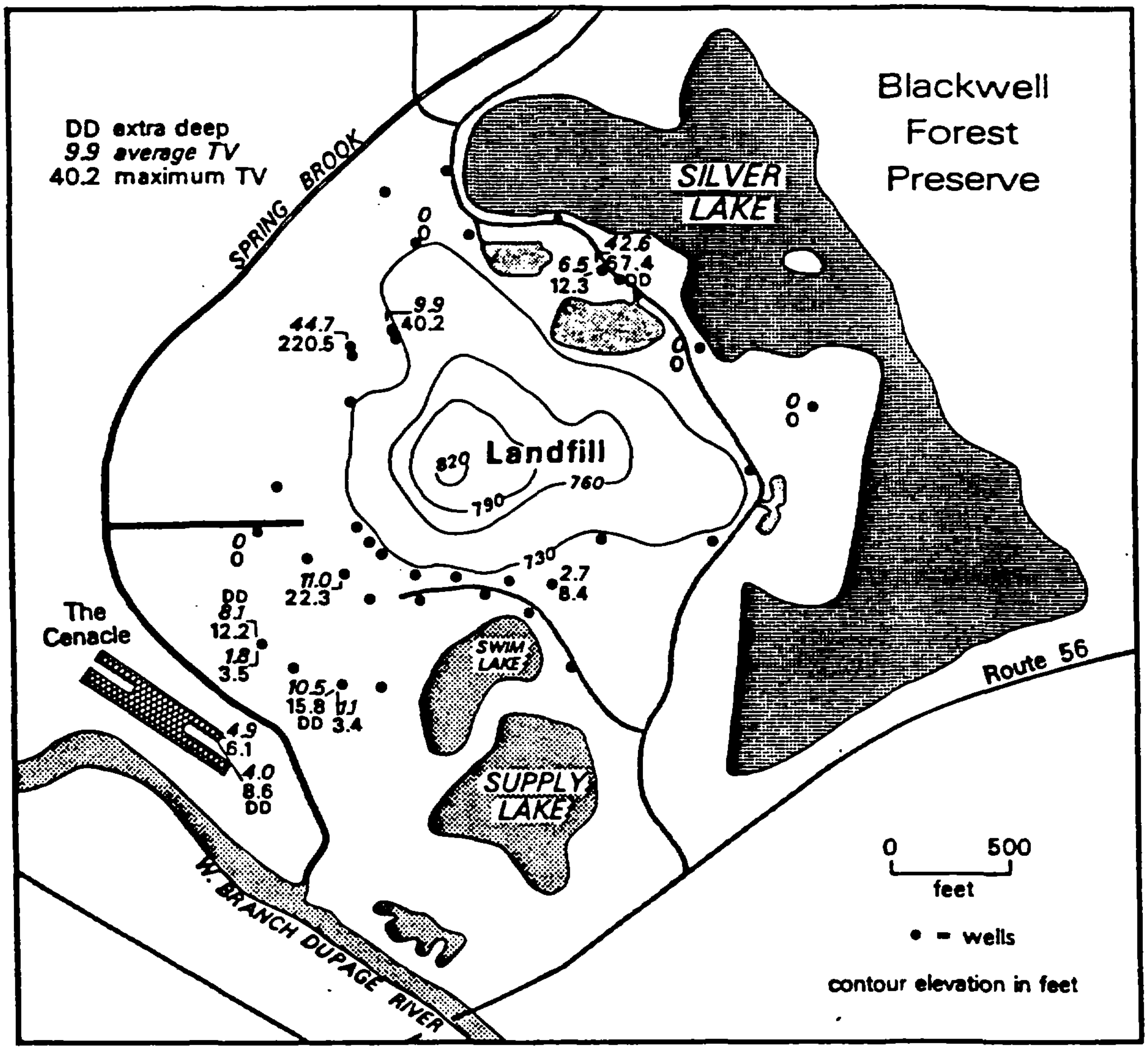


Figure 2C. Map of Total Volatile Organics (Point Values, ppb) in Dolomite Aquifer distances down-gradient from the landfill. The TV parameter consists primarily of two organic compounds; 1,1-dichloroethane and cis-1.2-dichloroethylene. Table 12 shows the concentrations of these compounds and of TV's for each dolomite well between the landfill and the Cenacle for each sampling round in 1985. Figure 21 illustrates the variation in TV's in several bedrock wells; no particular trend is apparent.

The distribution of VOC's in dolomite wells presents the strongest evidence for the existence of a bedrock contaminant plume deriving from the landfill. However, the higher TDS values of water samples from the Cenacle deep well suggest that there is a source (or sources) of high TDS closer than the landfill and that source could also be contributing the volatile organic compounds found in the deep aquifer near the West Branch of th DuPage River. Three possible sources are the DuPage River (780 ppm TDS), Spring Brook (1390 ppm TDS), and the Cenacle's own septic system. All of these possibilities presuppose a hydraulic connection between the dolomite and glacial aquifer, at least in the southwest of the site; such a connection is also a requirement for contamination by the leachate plume.

Septic fields are also common in the housing developments to the west of the Forest Preserve. Septic systems have little ability to degrade or remove VOC's from the water being treated in them so it is possible that VOC's are introduced into the groundwater from septic systems. Trace amounts of 1,1,1-Trichloethane, an ingredient common in septic de-greasing products, have been found on separate occasions in each of the Cenacle dolomite wells.

Finally, the compounds 1,1-dichloroethane and Cis-1,2-dichloroethylene which are the major constituents in the apparent plume, are by-products in breakdown reactions of higher halogenated Volatiles. Therefore any poly-chlorinated organic compound could be the source of the detected

Table 12. Volatile Organic Compounds (concentrations in ppb) in Dolomite Wells in Blackwell Forest Preserve and Vicinity

Well	Distance from Landfill	Sampling Date	Concentration in ppb		
			VOC #1 *	VOC #2 **	TV's ***
G-128	200 feet	14 May 85	1.3	2.1	3.4
		30 Sep 85	4.6	6.6	14.4
		19 Dec 85	1.6	2.4	4.0
Swim Beach Well	300 feet	14 May 85	5.2	9.0	14.2
		30 Sep 85	4.6	10.0	14.6
		19 Dec 85	-	-	-
G-131DD	600 feet	14 May 85	2.9	4.4	7.3
		30 Sep 85	1.8	3.1	4.9
		19 Dec 85	1.7	3.5	5.2
G-133DD	700 feet	14 May 85	2.2	0.0	2.2
		30 Sep 85	2.5	5.0	10.3
		19 Dec 85	0.0	3.6	6.2
Cenacle Deep Well	1200 feet	14 May 85	1.7	3.0	4.7
		30 Sep 85	0.0	2.9	2.9
		19 Dec 85	1.4	2.4	6.1
Cenacle Shallow Well	2000 feet	14 May 85	0.0	2.8	4.9
		30 Sep 85	0.0	0.0	0.0
		19 Dec 85	0.0	2.6	2.6

*	VOC #1:	1,1-Dichloroethane
**	VOC #2:	Cis-1,2-Dichloroethylene, a non-priority pollutant which is a common degradation component of priority contaminants, often found in areas of VOC contamination.
***	TV's:	Total Volatiles, the summed concentration of all VOC's found in a particular sample. It includes VOC #1 and VOC #2.

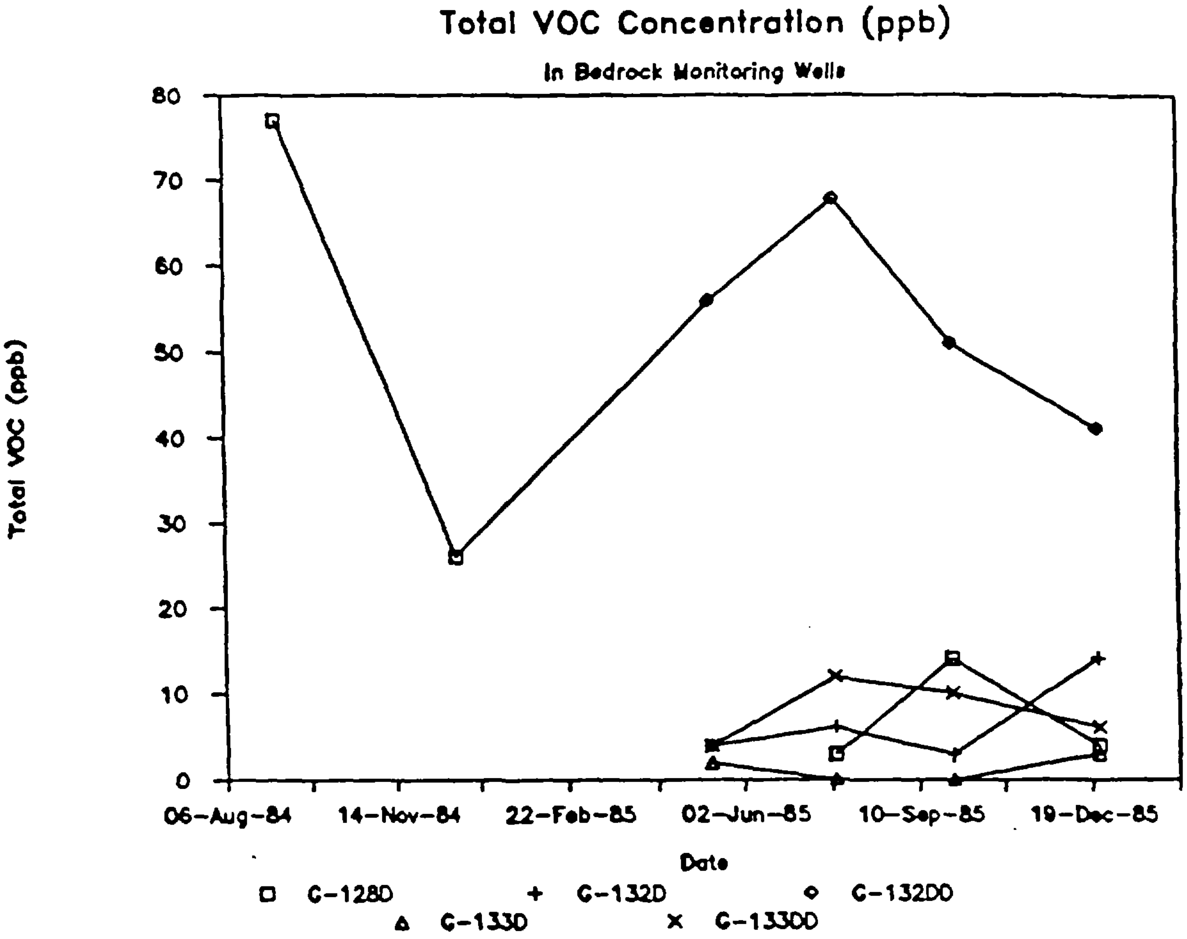


Figure 21. Total Volatile (ppb) in Dolomite Wells, 1983-85

contaminants. Their presence does not definitively prove a common source.

Because of these factors it cannot be conclusively shown that the Blackwell Landfill is the sole source or even a contributing source of the VOC's in the dolomite aquifer near the DuPage River.

5. CONCLUSIONS AND RECOMMENDATIONS

The Blackwell Concept was an innovative land-use plan: to utilize derelict land from solid waste disposal in a safe landfill, the cost to be defrayed from aggregate extracted from the site and the completed site to be landscaped as a recreational Forest Preserve.

Present leakage can be partly attributed to construction errors, including greater-than-recommended landfill area and refuse: fill ratio, neglect of secure disposal procedures, and incomplete or incorrect construction of the clay liner and cover. Several studies have indicated the presence of landfill-derived contaminants in groundwater on the site. Using wells drilled before and during this study, and information collected in it or collated from the FPD records, we have investigated the hydrogeology of the site, delineated the contaminant plume, and attempted to relate the two.

The geological and hydrogeological investigations showed that the site has four major hydrogeological units: (1) the underlying dolomite bedrock aquifer, with a generally high but heterogeneous fracture permeability; (2) three to twelve feet of silty Tiskilwa Till, of low to moderate permeability, forming an almost complete leaky confining layer on the dolomite aquifer; (3) ten to thiry feet of permeable sand and gravel of the Henry Formation, forming the unconfined glacial aquifer that dominates the western part of the site; (4) a thick sequence of poorly permeable Yorkville and Malden Till occupying the glacial sequence across the eastern part of the site and, except for some thin sandy interlayers, blocking groundwater flow in that area. The landfill sits over units (3) and (4). The water table in the east is controlled by Silver Lake, declines steeply between the till and glacial aquifer units, and slopes down toward the West Branch DuPage River; total water-table relief is about twenty feet. Sections of Spring Brook recharge the glacial aquifer. The main groundwater flow is southwards along the glacial aquifer, with some flow between Silver lake and the Swim and Supply Lakes. The potentiometric surface of the dolomite aquifer slopes generally east to west under the site. Bedrock-aquifer heads are lower than heads in the glacial aquifer; the south-western part of the site, where the aquifer separation is slight and the potentiometric surface less steep, is a probable zone of leakage from glacial to bedrock aquifers.

Quantification of leachate production and leakage from the landfill was made both by calculation of infiltration and by analysis of leachate-level changes. A total leakage of between 600 and 3000 ft^3/day was estimated; however, the calculations are uncertain and the figures are probably overestimates. For the purpose of further analysis, leakages of about 500 ft^3/day from each of the northwestern, southern, and northeastern parts of the landfill are assumed. A dilution of about 1 in 100 in the aquifer south of the landfill was indicated.

Contaminant plumes of both total dissolved solids (TDS) and total organic volatiles (TV) are observed from monitoring wells around the landfill. The TDS plume is roughly concentric (the tendency for downgradient skew is countered by the greater dilution in the aquifer there than in the tills upgradient) and background levels are reached quickly; the higher concentrations in the southwest area are attributed to Spring Brook recharge. The TV plume attenuates more rapidly. There is no evidence of increases in contaminant levels; the plumes appear to have reached steady-state or even decline. The landfill is not causing off-site contamination in the glacial aquifer. The only evidence for contamination of the dolomite aquifer is the presence of trace volatile organics in some bedrock wells; however, sources other than the landfill are possible, and the evidence is not conclusive.

On the basis of hydrogeological findings, drastic and immediate remedial actions are not recommended. Regular groundwater monitoring should be continued to confirm that the contaminant plume has indeed reached steady-state, and to ensure that if a serious problem developed it would be detected quickly. If it is determined that the trace quantities of volatile organics in the bedrock aquifer are unacceptable, a more extensive study should be undertaken to identify all sources of contaminants and delineate the bedrock problem more clearly. Remedial actions to clean up the shallow aquifer would also remove the source of landfill-derived contamination of the bedrock aquifer. Various remedial actions might include further landfill engineering to reduce infiltration, removal of the leachate, placement of extraction wells in the shallow aquifer, emplacement of passive cut-off structures to block the movement of contaminants within the shallow aquifer, and recharge of the Swim Lake by piping from Silver Lake, to maintain higher lake levels and block groundwater inflow. Such actions would, of course, require engineering feasibility studies.

ACKNOWLEDGEMENTS

In addition to the support provided by the Water Resources Center, (University of Illinois-Urbana-Champaign) from funds provided by U.S. Department of the Interior, support for the field investigation was also provided by the DuPage County Forest Preserve District, and is gratefully acknowledged. We are indebted to the FPD for providing data, records, and access to the Blackwell site, and especially to Richard Utt, Superintendent, for his advice and support.

Thanks are also due to Brandon Curry, Illinois State Geological Survey, for his correlations of the glacial stratigraphy; to Bethany Price, Steven Terhaar, Marcia Honz, and Joanna Wood, NIU, for their assistance in preparing this report; to Jerry Hartwig, DuPage County FPD, for reviewing the report; and to Dr. Ronald Flemal, NIU, for his help in developing the project.

List of Publications Resulting from the Project

Two papers were presented at the North-Central Regional Meeting of the Geological Society of America held at Kent, Ohio, April 24-25, 1986:

Booth, Colin J. and Vagt, Peter J. Hydraulic Connection Between Glacial and Bedrock Aquifers at a Landfill Site in N.E. Illinois.

Vagt, Peter J. Delineating a Landfill-Derived Contaminant Plume of Diffuse Nature in Glacial Outwash Deposits.

Acknowledgement of the USGS/WRC and FPD support was made during the talks. Mr. Vagt won a "best student paper" award for his presentation. The Abstracts are attached.

HYDRAULIC CONNECTION BETWEEN GLACIAL AND BEDROCK AQUIFERS AT A LANDFILL SITE IN N.E. ILLINOIS

Nº 93288

BOOTH, Colin J. and VAGT, Peter J., Department of Geology, Northern *Illinois University, DeKalb, Illinois 60115*

Local hydraulic connection between glacial and bedrock aquifers is shown in a study of the Blackwell landfill, DuPage County, Illinois, which was constructed in glacial outwash and till overlying Silurian dolomite. Several monitoring wells at the site penetrate through 40 to 80 ft of drift into bedrock, cores of which show a vuggy but tight dolomite with occasional subvertical weathered fractures. Pump tests indicate that bedrock hydraulic conductivities range from 10^{-7} cm/s to incalculably high; groundwater flow in the dolomite is almost certainly in fissures.

Over most of the site the bedrock is immediately overlain by dense silty clay (lodgement till ?) at the base of the drift, and, as shown by adjacent cased wells of different depths, vertical head drops from glacial to bedrock aquifers are 6 to 10 ft. In an area downgradient, however, the immediate cover is sand and gravel, and the glacial-bedrock head drop is only 1 to 2 ft. Similarly, the bedrock piezometric surface has a regular slope (of about 0.006) in the till-covered area, but is distorted and has a flatter (0.001) slope in the sand-covered area. These relationships suggest that the bedrock is being recharged where it is overlain by the sand and gravel.

Further evidence is given by the presence of organic contaminants in samples from bedrock monitoring wells, from total VOC levels of 15 ppb in the sand-covered bedrock near the landfill to 5 ppb downgradient. The contaminants are probably leaking into the bedrock aquifer from the main plume in the overlying glacial aquifers, through the sand and gravel layer in direct contact with the dolomite.

The existence of a local hydraulic connection between glacial and bedrock aquifers is significant not only for this site but also because such connections may be common pathways for contaminant movement into bedrock aquifers in this widespread type of hydrogeological setting.

DELINEATING A LANDFILL-DERIVED CONTAMINANT PLUME OF DIFFUSE NATURE IN GLACIAL OUTWASH DEPOSITS.

Nº 102479

VAGT, Peter J., Geology Department, Northern Illinois University, DeKalb, Illinois 60115.

Between 1965 and 1972 a forty-acre, 150-foot high landfill was constructed in western DuPage County (IL) in glacial outwash deposits. 58 monitoring wells were installed between 1972 and the present. In 13 years of monitoring data, no time-variation of inorganic parameters was evident, however a halo of relatively higher concentrations was found to surround the landfill [illegible] the glacial aqu[illegible]

It could not be conclusively shown that the landfill was contaminating the glacial aquifer until 1983 when monitoring samples were analyzed for volatile organic compounds (VOC's). At that time concentrations of total volatiles were found to range from 140 ppb near the landfill to 3 ppb at distances 300 to 400 meters downgradient from the landfill. The VOC's proved to be the constituents conservative enough to mark the contaminant plume in the high permeability outwash deposits.

To determine pollutant loading and potential aquifer degradation, well logs, pumping and slug tests, and flow modeling were used to develop a detailed hydrogeologic characterization of the site. It was found that the configuration of the man-made lakes, the site geology, and the local flow regime have combined to form a flow system which quickly dilutes the leaking solutes to low concentrations within short travel distances from the landfill.

Because of the thorough site documentation and the availability of relatively long-term monitoring records, this has been an ideal study to test several solute transport models.

Copies of Abstracts: From Geological Soc. America, Abstracts with Programs (20th Annual Meeting, North-Central Section), v.18, no.4, March, 1984

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E

APPENDIX E

ENVIRONMENTAL GEOLOGY WATER SCIENCE PUBLICATION

Hydrogeology and Historical Assessment of a Classic Sequential-Land Use Landfill Site, Illinois, U.S.A.

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ABSTRACT / The Blackwell site in northeastern Illinois was a classic sequential-use project combining land reclamation, a sanitary landfill, and a recreational park. This paper adds a recent assessment of leachate generation and groundwater contamination to the site's unfinished record. Hydrogeological studies show that (1) the landfill sits astride an outwash aquifer and a till mound, which are separated from an underlying dolomite aquifer by a thin, silty till; (2) leachate leaks from the landfill at an estimated average rate between 48 and 78 m^3/d; (3) the resultant contaminant plume is virtually stagnant in the till but rapidly diluted in the outwash aquifer, so that no off-site contamination is detected; (4) trace VOC levels in the dolomite probably indicate that contaminants have migrated there from the landfill-derived plume in the outwash. Deviations from the original landfill concepts included elimination of a leachate collection system, increased landfill size, local absence of a clay liner, and partial use of nonclay cover. The hydrogeological setting was unsuitable for the landfill as constructed, indicating the importance of detailed geological consideration in landfill and land-use planning.

Introduction

Environmental land-use planning is today established enough to be included in classroom texts on environmental geology (Keller 1985; Montgomery 1989). In the 1960s, it was a novel concept. A classic sequential-use site of the time was the Blackwell Forest Preserve in DuPage County, Illinois, a combined land-reclamation project, sanitary landfill, and recreational park. The site now provides an excellent example of the long-term hydrogeological impact of a land-use plan.

DuPage County, just west of Chicago, was in the 1960s facing several environmental pressures. Major urban growth was projected; the county's waste-disposal sites were almost full; local governments were being urged to maintain open-space "green belts." The Forest Preserve District of DuPage County (FPD) responded with the then-new concepts of sequential land-use planning and sanitary landfilling to produce what is now the Roy C. Blackwell Forest Preserve. Derelict land, originally a sand-and-gravel quarry, was used for an engineered, municipal solid-waste landfill from 1965 to 1973, with costs partly offset by quarrying for aggregate and cover, and was subsequently landscaped as a forest park complete with a 28-ha lake for boating and fishing and a 1.6-ha lake for swimming. The landfill itself is both a scenic amenity and a winter sports hill.

The project was hailed as innovative and environmentally sound in publications such as *Fortune* (Rose 1970) and *National Geographic* (Blair and Young 1970). In their 1983 book *Future Water*, Sheaffer and Stevens (the former was the landfill's original designer) report that the site has become a major recreational amenity with continued protection of ground water. Nevertheless, evidence of on-site groundwater contamination has accumulated since the early 1970s through an extensive monitoring program. The swimming lake has been closed as a precaution since 1984. Reports in the local press express public concern about groundwater contamination.

Neither the published record of a trouble-free exemplary site nor the local misapprehension of a contaminant threat accurately portrays Blackwell. The record of this classic site is incomplete, and therefore the first purpose of this paper is to provide an objective later record and hydrogeological assessment.

Except for a preliminary research report on our recent hydrogeological investigation (Booth and Vagt 1986), and Vagt's (1987) dissertation, results of the postconstruction studies at Blackwell are unpublished. Yet, as a model land-use site and the subject of several investigations, Blackwell has a combination of historical and current information not available in most landfill studies: a record of design and construction, leachate data, detailed geological and hydrological data, and recent characterization of the contaminant plume. Blackwell remains a classic example of how the impact of a landfill is controlled by the interaction of the landfill design and construction with the hydrogeological setting. The second purpose of this paper is to summarize the hydrogeological and landfill information to illustrate this interaction.

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Description of the Site

The Blackwell site is an area of over 480 ha located south of Winfield in DuPage County, Illinois (Fig. 1). The natural on-site relief is about 6 m. Characterization of the site geology is based on correlation of split-spoon samples, rock cores, and strata logs from borings for more than 50 monitoring wells.

The geological section (Fig. 2) comprises 9–21 m of Wisconsinan-age glacial drift materials, overlying Silurian-age dolomite bedrock. Drift samples from several wells have been tentatively correlated to known stratigraphy by the Illinois State Geological Survey (ISGS; B. Curry, personal communication to Vagt 1985). The basal drift mantling the bedrock is a silty till, 1–4 m thick, probably the basal Tiskilwa. In the east, this till is overlain by a thick (12–18 m) mound of clayey tills, probably the Malden and Yorkville forming part of the West Chicago Moraine. Sand-and-gravel outwash of the Henry formation outcrops over the entire site, thinly over the till mound in the east but forming a thick (up to 9 m) wedge lying directly on the Tiskilwa in the west.

The Silurian dolomite is the primary local aquifer, tapped by numerous domestic and municipal wells. Its major water-bearing zones are fractures and joints (Zeizel and others 1962), an observation supported in this study by both pumping-test results and core examination. Glacial outwash provides only 2 percent of water supplies in the county (Sasman and others 1981) but can be highly permeable and form potential contaminant pathways to the dolomite.

A summary of measured hydraulic conductivities for the various lithologies is given in Table 1. Laboratory measurements by permeameter were extremely low for the clayey Yorkville, moderately low for the silty Tiskilwa, and moderately high for the outwash. The permeameter tests for the Malden are for a sand layer, indicating that sandy interbeds may provide flow pathways within the otherwise poorly permeable till mound. Pumping and bail tests in the field confirm that the outwash is the most permeable drift unit and the Yorkville the least, but generally show higher and more variable hydraulic conductivities, further reflecting the influence of lithologic heterogeneities. The field permeability of the Yorkville is probably exaggerated by the placement of screened intervals in sandier zones. The dolomite permeability ranges from very tight to very high depending, presumably, on fracture interception.

There are thus four major hydrostratigraphic units at the site: the underlying dolomite aquifer, the Tiskilwa leaky aquitard overlying it, the outwash aquifer in the west, and the Malden–Yorkville aquitard mound in the east. The landfill sits astride the outwash aquifer and till mound.

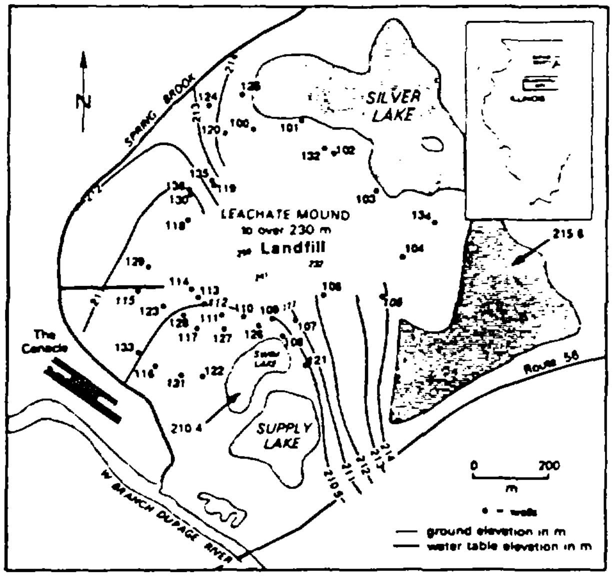

Figure 1. Location and site map of Blackwell Forest Preserve, showing *off*-landfill water-table contours (October 1985) and monitoring-well numbers.

Surface-water bodies virtually surround the site (Fig. 1). The water table slopes west from Silver Lake and south to the West Branch DuPage River, constant-head boundaries with water levels 215.2–215.8 m and 210.3 m, respectively. Spring Brook on the north and west is maintained by sanitary effluent from upstream and loses to groundwater in its lowermost reach. Numerical modeling (Vagt 1987) suggests that this recharge is insufficient to create a boundary mound, but hydrochemical data (see below) indicate its importance as a local contaminant source.

The steep water-table gradient west from Silver Lake across the till mound to the outwash aquifer confirms that the mound is largely a barrier to groundwater flow. The dominant groundwater movement is instead southward through the outwash aquifer. The potentiometric surface in the underlying dolomite aquifer slopes westward. From the water table down to the potentiometric surface, there is a vertical head drop ranging from over 3 m in the northeast to 0.3–0.6 m in the southwest. The area of maximum potential leakage from glacial to bedrock aquifers is in the southwest, where the Tiskilwa mantle beneath the outwash is thinnest and possibly locally absent.

Design and Construction of the Landfill

Sheaffer and Stevens (1983, p. 218) note that to minimize groundwater contamination, the Blackwell

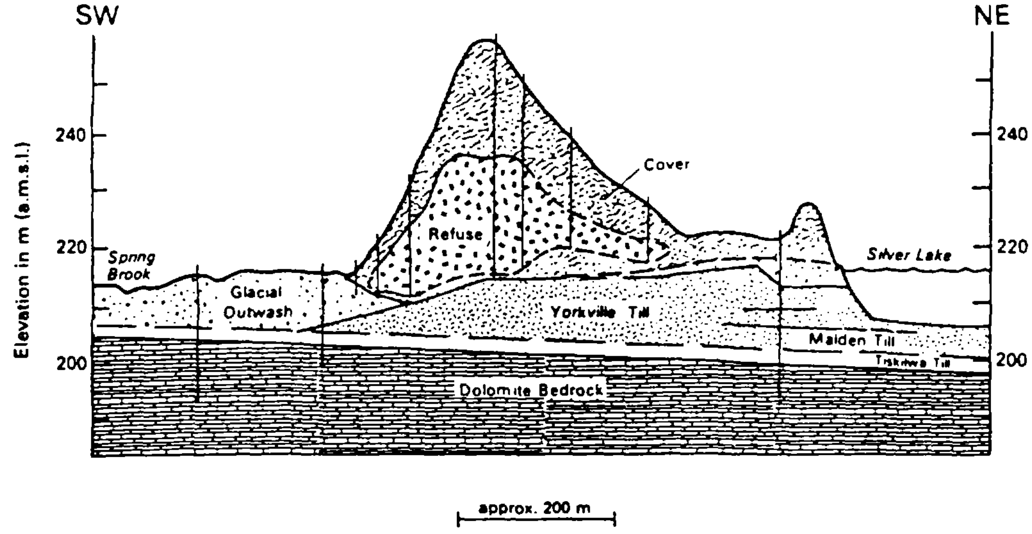

Figure 2. West–east section through Blackwell landfill and site geology.

Table 1. Summary of hydraulic conductivities from Blackwell tests

Geologic unit	Range of values (cm/sec)	Lognormal mean (cm/sec)	Test method
Henry Outwash	3.4E-04–4.7E-02	8.5E-04	Permeameter (8 sets)
	8.1E-04–8.1E-01	5.8E-02	Single-well tests 13 analyses/11 tests
	1.0E-01–1.6E+00	4.2E-01	Cross-well tests (6 observation wells)
Yorkville Till	<1.0E-07		Permeameter tests
	8.6E-07–1.6E-03	7.4E-05	Single-well tests 8 analyses/4 tests
Malden Till (sand unit)	1.3E-02–3.3E-02	1.8E-02	Permeameter (3 sets)
Tiskilwa Till	1.5E-06–4.6E-05	3.5E-06	Permeameter (9 sets)
	9.1E-05–3.3E-01	1.2E-03	Single-well tests 6 analyses/3 tests
Dolomite	2.6E-07–2.0E-01	8.3E-05	Single-well tests 11 analyses/7 tests
	immeasurably high		Single-well test G133

landfill was built above grade (in contrast to the then-usual trench approach) on an impermeable clay floor, above the water table, with the waste packed in small cells sealed by clay. The earliest design recommendations (unpublished material in FPD files) were to build a pilot landfill of about 0.8 ha in area, with the refuse in small cells separated by clay berms, and to collect leachate (water that has been in contact with the refuse) down-gradient. The working design (Table 2) kept the above-grade cellular concept, but in an operational, much larger landfill without a leachate collection system.

DuPage County Department of Public Works (DPW) was contracted to build the landfill under FPD supervision. Lake excavation was conducted simultaneously with landfilling. The clay and aggregate excavated from the north lobe of Silver Lake (the south had already been quarried) was used for landfill cover. Although the design was generally followed, some deviations did occur. For example, a drainage ditch between Silver Lake and Spring Brook, cut during the original quarry operation, was partly filled with concrete, brush, and logs and then covered by a cell on the southern side of the landfill; from boring logs, it appears that this area was not lined with clay. Letters between the FPD and DPW also suggest that fill-to-refuse ratios were lower than designated (1 to 1 to 2 to 1 instead of 3 to 1) and that sand-and-gravel aggregate was mixed with the clay cover material.

The landfill was completed in 1973. The area of the

Table 2. Working design specifications of the Blackwell landfill

Landfill area	35 acres (14.2 ha)
Fill–refuse ratio	3:1
Cell berm	4 ft (1.2 m) per lift
Cell berm width	11–12 ft (3.4–3.7 m) at top
Refuse height	3 ft (0.9 m) per lift
Minimum daily cover	6 inches (0.15 m) clay or clay and gravel
Cell cover	1.5 ft (0.46 m) clay, forming the floor of the overlying cell and offset for stability
Landfill base	2 ft (0.6 m) of blue clay dovetailed into existing blue clay formation
Compaction	By maximum use of site tractor crossing refuse
Landfill cover	12 ft (3.7 m) of compacted clay, covered by soil, and vegetated

initial eight cells is about 12.2 ha, but refuse has been penetrated by vent borings over a wider area, uncertainly estimated at about 3.1 ha (Fig. 3). The final hilltop, formed of 15–18 m of clay, stands 46 m above the surrounding landscape at an elevation of 256 m. Coarse-grained material was used to bring the landfill, which had a terraced shape because of the offset of berms, to a smooth grade. The final cover above the grading cover is 0.6–4.6 m thick; composed of sand, gravel, and clay; with about 10 cm of topsoil, vegetated mainly with grass.

Leachate Generation and Leakage

Behavior of Leachate Levels

Changes in the volumes and levels of leachate reflect the difference between gains and losses of water to and from the landfill. The hydrologic behavior changes through time. According to Ham (1986), the initial moisture content of buried refuse is below field capacity, so that during the early stages drainage and potential leakage is limited to localized channeling. Water from infiltration gradually builds up the moisture content to field capacity, at which stage general gravity drainage can begin. Eventually, a leachate mound builds up, until an approximate hydrologic balance is reached in which average outflow (primarily from basal leakage, and possibly from seepage through the sides) equal the average infiltration, and leachate levels stabilize.

The leachate level recorded in an in-fill well installed by the ISGS in 1968 rose about 1.5 m/yr until 1970, then about 0.3 m/yr until 1980. This increase may reflect refuse compaction as well as increasing water content. Leachate levels recorded at several landfill vents since 1982 have fluctuated around fairly constant levels, suggesting that an approximate equilibrium has been reached.

Based on measurements from the present 24 vents (Appendix A), the leachate within the landfill forms a mound (Fig. 4) with a peak elevation above 229 m, well above the ambient water-table elevation of 213–216 m interpolated beneath the landfill from the surrounding wells. Care has been taken not to penetrate the landfill's liner with vents or wells; therefore, the degree of saturated hydraulic continuity between the mound and the water table is not known, nor is the internal continuity between cells and lifts. Some leachate zones may be perched or isolated. Furthermore, leachate water may be ponded in some monitoring wells, indicating false levels, and conversely the vents may facilitate vertical drainage through retarding layers between zones in the landfill. Thus, Figure 4 is only the most straightforward contour interpretation; other interpretations are possible.

In the absence of a leachate collection system, available methods of estimating leachate generation or leakage rely on a water balance. Three such methods, discussed below, were applied in this study. Additions to the initial moisture buried with the refuse come principally from the percolation of water that has infiltrated from precipitation. Water may leave the landfill by:

1. Leakage through the base, a function of the hydraulic conductivity and integrity of the basal liner and the head drop across the liner. The liner appears to be sufficiently retardative to hold up the leachate mound; as a corollary, significant leakage is more probable in areas where the leachate levels are lower, for example in the northeast and along the buried ditch in the south.
2. Seepage of water through the sides of the landfill. At Blackwell, numerous minor leachate seeps were reported in 1980–1982. They were considered by the FPD and consultants to be the localized results of near-surface interflow rather than discharge of leachate from the refuse pile itself and were corrected by engineering measures such as underdraining the north side of the landfill and surface patching the west side. However, hillside seepage and interflow remain a source of uncertainty in the infiltration budget.

Water may also be generated or consumed by the chemical and biological processes of decomposition (Baedecker and Back 1979; Ham 1986). Water may also be lost by evaporation directly from the leachate within the refuse (additional to the evapotranspiration from the soil moisture in the cover, which is considered as part of the surface infiltration balance). Opportunities for escape of vapor are provided by degassing vents and by gas seepage through the pores

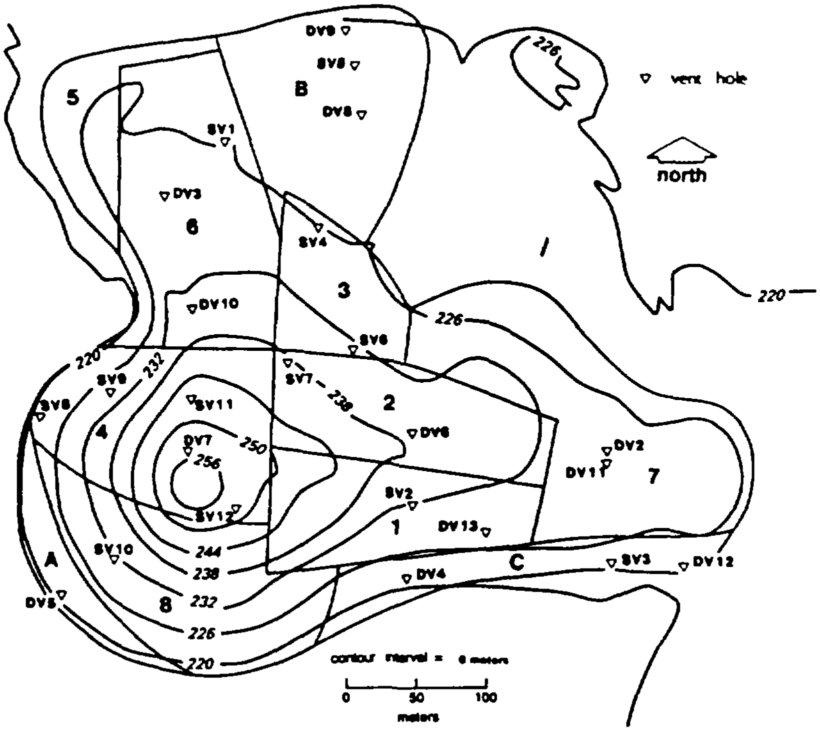

Figure 3. Layout of original cells (1–8) and delineation of extra refuse areas (A–C).

and cracks of the cover. Such losses and gains do not appear to have been quantified and are neglected in the standard budget methods used in this study.

EPA Water-Balance Method

An estimate of leachate generation was made using the U.S. Environmental Protection Agency (EPA) water-balance method (Fenn and others 1975), which is based on the straightforward budget equation:

$$L = P - R - dS - AET$$

where L is percolation to form leachate, P is precipitation, R is surface runoff, dS is change in soil-moisture storage, and AET is actual evapotranspiration. The equation is applied on a mean monthly basis. Surface runoff is treated as the first fractionation of precipitation and estimated by multiplying incident precipitation by tabulated, slope-dependent, empirical, runoff coefficients. In the application of the water-balance method to Blackwell, the landfill was subdivided into nine subareas on the basis of slope and cover thickness. Changes in soil-moisture storage and values of potential and actual evapotranspiration were calculated using the tables of Thornthwaite and Mather (1957), as in the EPA documentation. Site-specific meteorological data (temperature, precipitation) for the year 1985 were used, and a clay loam cover with a 10-cm root zone was assumed. Detailed information on input data and on percolation estimates by subarea and month, for all methods used, is available in Vagt (1987) or from the authors.

Based on the water-balance method, the total annual percolation for the whole landfill is 28,464 m^3, or 23 percent of annual precipitation, an annual average rate of 78 m^3/d but concentrated during the nonsummer months when evapotranspiration is low. For hydrologic equilibrium, this percolation should equal average leachate leakage. The principal weakness of the EPA water-balance method is the arbitrary assignment of parameters—for example, tabulated and possibly unrepresentative runoff coefficients, and the assumption of natural soil conditions—which makes its site-specific application uncertain.

EPA HELP Model

An estimate of leachate generation was also made using the HELP (Hydrologic Evaluation of Landfill Performance) model of the EPA (Schroeder and others 1984). Noted as "state-of-the-art" by Gebhardt and Jankowski (1987), the HELP model calculates percolation using a combination of water-balance and flow-modeling routines and permits detailed specification of landfill design characteristics.

The HELP model was run using the same areal subdivisions as for the water-balance method, a specification of "fair grass" vegetation, and a three-layer cap (15.2-cm root zone, 0.305-m unpenetrated loosely compacted clay, and a dense consolidated clay base), together with default climatological data. The model

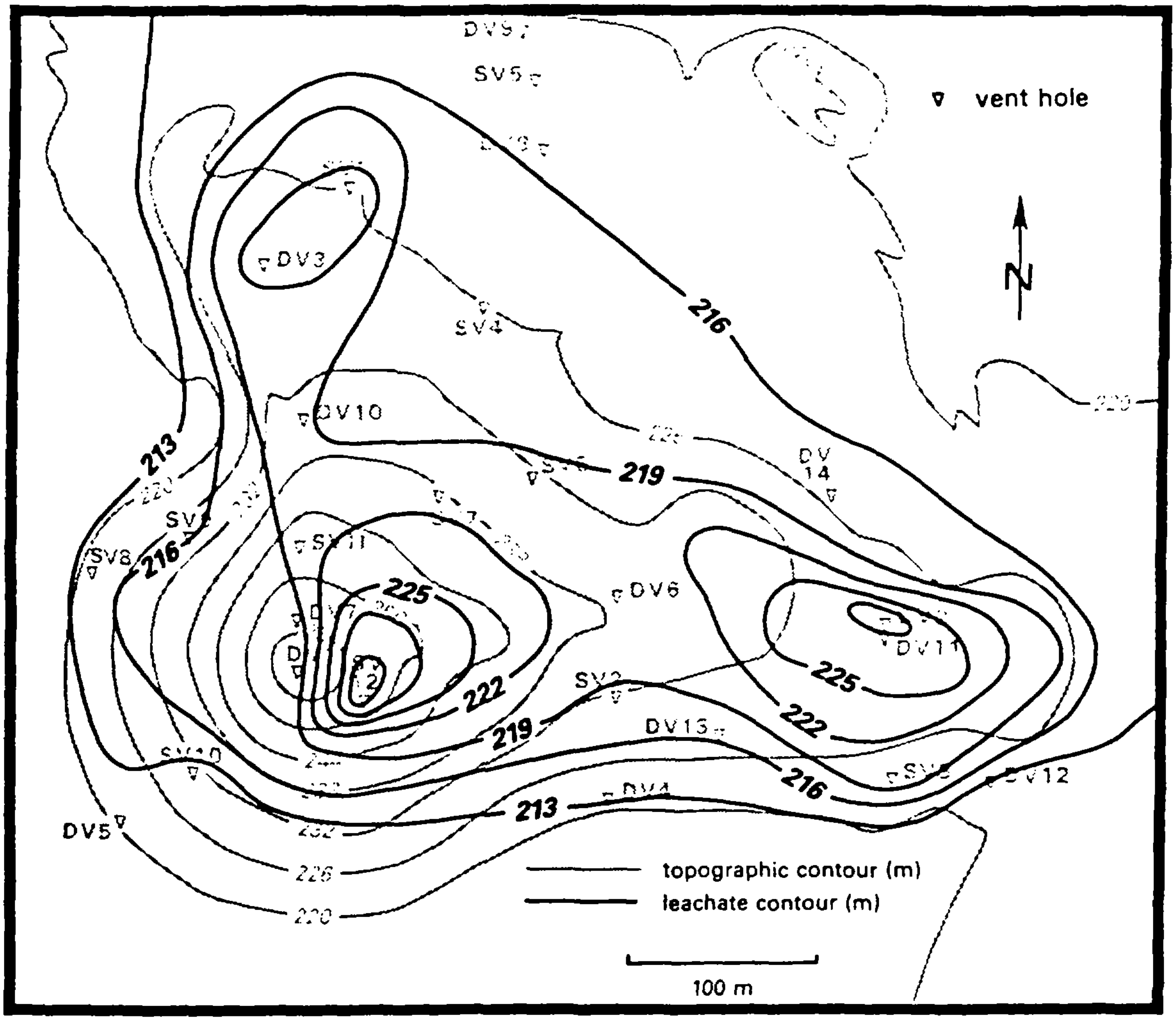

Figure 4. Leachate mound in the Blackwell landfill.

calculated the annual leachate generation as 17,650 m^3, or 16 percent of annual precipitation, an annual average rate of 48 m^3/d.

Additional runs for representative selected areas showed that differences in vegetation quality have little effect (increased evapotranspiration compensated increased root penetration), but the inclusion of a 0.6-m sand-and-gravel layer (present in some logs) in a four-layer cap reduced the infiltration by 25 percent. Since the extent of the coarse layer is poorly known, the simulation represents merely one possibility.

Leachate-Level Change Method

Both the water-balance and HELP methods depend on non-site-specific approaches. In a site-specific method independent of hydrometeorological approximations, Hughes and others (1971, 1976) had used leachate-level hydrographs to estimate leachate generation in several landfills in Illinois, relating leachate level changes (rises) to volume changes by the equation:

$$dV = dH * A * n$$

where dV is the change in leachate volume, dH is the change in leachate level, A is the area over which change is effective, and n is the effective porosity (specific yield) of refuse.

Leachate levels were measured several times at Blackwell at most vents between April and November 1985 (Appendix A); the above equation was applied to the period of dominant decline between June and September. Falling leachate levels may be attributed to absolute loss through leakage or to local drainage within the landfill. The few anomalous rises in level during the recessional period may be due to lagged or summer-storm infiltration or to gains from local internal drainage. Because of these ambiguities, two extreme approaches were used:

1. A minimum leachate leakage rate was calculated from the net change in leachate level for the whole period between June and October. Any rises in levels during the inventory period are incorporated into the net change and therefore are considered as internal redistribution of leachate.
2. A maximum leachate leakage rate was calculated from the cumulative declines for each vent, for the decline periods only; any periods of rising levels at particular vents are disregarded and therefore considered due to delayed or anomalous recharge.

In both cases, the average daily head change for the periods considered was converted to an average daily volume change for each area represented by the particular vent. An effective porosity of 0.3 is used, following the EPA report by Fenn and others (1975). It should be noted that all leachate volumes calculated by this method are directly proportional to the effective porosity, which is not known with any certainty.

The original classification of vents into shallow (SV) and deep (DV) appears to be arbitrary and not consistently related to layers within the landfill. Therefore, no distinction is made between SV and DV vents. The area of leachate mound represented by a particular vent is uncertain. For this exercise, the landfill was subdivided according to the cell plan (Fig. 3), leachate changes for each cell being based on the average change in level in all vents within that cell area (cell 5, with no vents, being grouped with adjacent cell 6). As a comparison, the landfill was also subdivided into Thiessen-type polygons centered on each vent. The estimates produced by the polygon method was virtually identical to those produced by the cell subdivision method and are therefore not further discussed.

Immediately adjacent vents DV2 and DV11, in cell 7, show suspect behavior. DV2 was completed only into the grading cover; DV11 was drilled next to DV2, into the refuse. During the inventory period, the water level in DV2 declined while the leachate level in DV11 rose substantially, suggesting local drainage between the vents. Since the validity of these data is uncertain, a comparison calculation has been made totally excluding the area represented by these vents.

Leachate leakage estimates from all methods are summarized in Table 3, which (since the different methods consider somewhat different landfill areas) also shows leakage rates averaged per area. Including the suspect DV2–DV11 data scarcely affected the maximum leakage estimate but considerably lowers the minimum estimate, which is sensitive to the rising level in DV11. Therefore, the minimum estimate is probably too low. However, given the inherent uncertainty in assuming an effective porosity value, the leachate-level method does suggest an extreme range of leachate leakage quantities, between a minimum of about 0.93 and a maximum of about 8.56 m^3/d/ha (14–129 m^3/d for the whole landfill). Estimates by the EPA water-balance method (5.99 m^3/d/ha; 78 m^3/d annual average for the whole landfill) and HELP model (3.69 m^3/d/ha; 48 m^3/d total, for the three-layer case) are intermediate to this extreme range. Despite the uncertainties and imprecision of the various methods, their results are broadly consistent. A working value for the annual average rate of leachate leakage for the whole landfill is thus about 63 m^3/d (average of HELP and water balance, intermediate between level-change maximum and minimum estimates).

Table 3. Estimates of annual average daily leakage of leachate

Method	Volume (m^3/d)	Area (m^2)	Vol/area (m^3/ha)
Leachate-level changes			
Maximum	129	150,692	8.56
Minimum	14	150,692	0.93
Minimum excl. DV2–DV11 data	59	126,203	4.68
EPA water balance	78	130,154	5.99
EPA HELP model, three-layer cover	48	130,154	3.69
EPA HELP model, four-layer cover	36	130,154	2.77

Leachate Chemistry

Leachate chemistry reflects not only the refuse composition but also different stages and rates of decomposition. A landfill tends to evolve through three major stages (Cartwright 1984; Ham 1986):

1. aerobic, primarily producing CO_2 and hence carbonic acid; the leachate is typically high in total dissolved solids (TDS), but is produced in small volumes, because the moisture content is still low.
2. Facultative (anaerobic nonmethanogenic), producing large quantities of acidic leachate high in TDS.
3. Methanogenic, during which anaerobic bacteria generate methane; the stage produces a more benign leachate (higher pH and lower TDS) but requires very reducing conditions and adequate or abundant water.

The strongest leachates in the greatest volumes are therefore produced in the facultative stage. Cartwright (1984) notes that most landfills should reach the steady phase of the methanogenic stage in 180–500 days. However, different zones of the landfill may be in different decompositional stages at the same time because of their different environments of degradable refuse and availability of oxygen and water.

Chemical analyses of Blackwell leachate, available for a single 1969 sample (Hughes and others 1971) and for several samples taken between December 1984 and May 1985, are summarized in Table 4. Analyses of selected constituents from particular vents are shown in Appendix B. The leachate has a wide range of chemical characteristics (for example, pH ranging from 5.3 to 8.1, TDS from 583 to 49,100 mg/l), suggesting that different decompositional environments are present in the landfill. The environmental differences probably are due in part to variations in throughflow of water. Greater percolation rates favor the earlier exhaustion of readily degraded refuse, and, later, the maintenance of the more benign methanogenic stage. Therefore, in a landfill of Blackwell's age, the recent leachate should be weaker in areas of greater throughflow and stronger in hydraulically isolated areas.

Generally, the strongest leachates are found at vents in the central part of the landfill (SV2, SV9, SV11, SV12, DV7, DV10), where the clay cover is thicker and percolation presumably less, whereas the weakest leachates are found where the clay cover is thinnest (SV4, SV6, SV7) and in the old drainage ditch area (SV3, DV4, DV12). Furthermore, an overall inverse relationship is observed (Fig. 5) between leachate strength (TDS) and leachate-level variation, which, according to Hughes and others, should indicate higher percolation rates. The weaker leachates are generally found at vents with greater variation and presumed greater throughput, while the stronger are found at vents with less variation and presumed less throughput.

The average TDS concentration of leachate samples is 10,038 mg/l (lognormal average 3,893 mg/l). However, weighted contaminant-loading calculations based on concentrations and volumes for individual vents estimate average concentrations of about 2,500 mg/l TDS and 330 mg/l Cl in the leakage itself. These concentrations would be further diminished, before entering the aquifer, by adsorption and other attenuation processes through the landfill liner.

Contaminant Plume

Leachate from the Blackwell landfill is leaking into the glacial aquifer system at an estimated annual average rate of about 63 m^3/d (average of EPA water-balance and HELP calculations). The overall flux of groundwater across the site has been calculated as 1,133–2,266 m^3/d using flow nets and the observed hydraulic gradients and conductivities (Vagt 1987). The on-site dilution of the contaminant loading is therefore probably in the range 18 to 1–36 to 1. However, neither the contaminant loading nor the attenuation and dilution in the aquifer is evenly distributed, as analyses of samples from monitoring wells show.

A drilling and sampling program has revealed the existence of a contaminant plume. A summary of major ion analyses for wells and surface waters at the Blackwell site from the December 1985 sampling is given in Table 5; average values of chloride, TDS, and total volatile organics for identified off-landfill monitoring wells are shown in Appendix C.

Background TDS and chloride concentrations in the sand and gravel aquifer in this area are reported (Schicht and others 1976) as 556 and 36 mg/l. The concentrations of most solutes in the glacial drift monitoring wells are somewhat above background. Monitoring wells immediately adjacent to the landfill show TDS values of 700–1,000 mg/l downgradient and over 1,200 mg/l upgradient (Fig. 6). However, in wells only 60 m from the landfill, values approach background levels. Chloride concentrations behave similarly. No systematic trend in contaminant levels has been observed between 1980 and 1985, suggesting that the plume has achieved an approximate steady state.

The separate area of elevated TDS and chloride concentration in the far west of the site (Fig. 6) reflects the independent contaminant source of Spring Brook. This wastewater-fed losing stream has poor quality water high in TDS, sodium, and chloride levels (Table 5).

Since the FPD began documentation and sampling according to EPA protocols in 1983, 21 volatile organic compounds (VOCs) have been detected in groundwater at the Blackwell site, although only four consistently: 1,1-dichloroethane (DCA), *cis*-1,2-dichloroethylene (*cis*-DCE), *trans*-1,2-dichloroethylene (*trans*-DCE), and trichlorethylene (TCE). *cis*-DCE and *trans*-DCE can be formed as breakdown products of TCE (Parsons and others 1984).

In leachate within the landfill, volatiles locally exceed 10,000 ppb (parts per billion) and average 2,000–3,000 ppb. VOCs do not occur naturally in groundwater and therefore definitively indicate the presence of contaminants, although since they can originate from a wide variety of human activities, they are not uniquely linked to the landfill. Nevertheless, the VOC occurrence in the shallow wells at Blackwell is unmistakably part of the landfill contaminant plume. Summed concentrations of the four major VOCs are of the order of 100–300 ppb adjacent to the landfill, dropping to 20 ppb 30 m downgradient and zero in the glacial aquifer along Spring Brook. Over the two-year sampling period, the VOC concentrations in most

Table 4. Leachate characteristics from Blackwell landfill[a]

Parameter	1969 sample	1984–1985 samples		
		Maximum	Minimum	No. of samples
BOD	39,680	NA	NA	
TDS	19,144	583	49,100	24
pH	NA	5.3	8.1	24
Total alk ($CaCO_3$)	3,255	357	8,780	
Hardness ($CaCO_3$)	7,830	NA	NA	
Cadmium	<limit	<limit	0.56	15
Chloride	1,697	6	4,300	24
Iron	5,500	0.03	2,370	21
Lead	<limit	<limit	1.24	
Magnesium	600	70	695	
Potassium	790	2.5	672	
Sodium	900	8	1,170	
Sulfate	680	<limit	552	
Zinc	40	<limit	2.1	

[a] All concentrations except pH are in mg/l.

wells appear to be either fluctuating around a steady-state value or slowly decreasing.

Whereas landfill-derived contaminant plumes normally tend to be skewed downgradient, at Blackwell the contaminant concentrations have an approximately concentric distribution around the landfill (Fig. 6). This pattern is most logically ascribed to dilution in the highly asymmetrical aquifer system. Downgradient, the plume is in the glacial outwash aquifer where attenuation by dilution is very effective. Upgradient, the plume sits within the till aquitard, where it remains relatively immobile and concentrated because there is little diluting flow.

Groundwater from between the landfill and the Swim Lake has exhibited some of the highest inorganic and VOC contaminant levels. However, with the exception of traces of *cis*-DCE in two samples collected through the ice in December 1985, contaminants have not been detected in the Swim Lake. Nevertheless, as a precaution against the contamination risk the lake has been closed to the public since 1984. The FPD is caught in something of a paradox. Closing the Swim Lake has reinforced the mistaken opinion that it is contaminated. To reopen it in the present climate of environmental liability and public distrust, the FPD would have to take remedial action to eliminate the contamination potential. However, since the lake is not actually contaminated, no quantifiable remedial action is possible.

The underlying dolomite is the principal aquifer in the area. West (down piezometric gradient) of the forest preserve there are several private and municipal dolomite wells, while to the south is a municipal cone of depression. Therefore, any potential for contamination of the dolomite is of major concern.

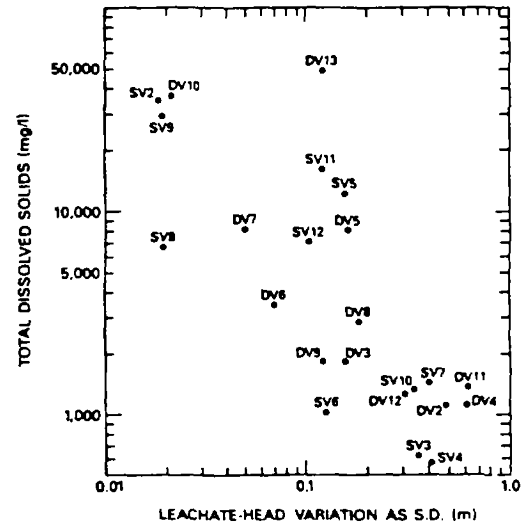

Figure 5. Relationship of leachate TDS concentrations and leachate-level variation (as standard deviation).

Chloride and TDS concentrations in the dolomite aquifer on site have not shown increasing trends during the monitoring period. Further, with the exception of some probably erroneous (high charge-balance error) values from northeastern wells G132, the observed solute and TDS concentrations in the dolomite wells are approximately at the background levels (400–800 mg/l) of nearby municipal and private dolomite wells. The maximum total VOCs in the dolomite monitoring wells are in the range <20 ppb. These results suggest that landfill-derived contaminants may have entered the dolomite aquifer; however, they are not definitive, since other sources are possible, particularly local septic-tank systems.

A landfill source for bedrock contaminants requires

Table 5. *Summary of major ion analyses of monitoring samples, December 1985*

	Concentration (mg/l)							Charge balance *error (%)*
	Mg	Na	Ca	HCO_3	Cl	SO_4	TDS	
Shallow (glacial) wells: N = 32								
Mean	48	31	103	267	50	134	692	11
Std. Dev.	15	27	35	142	44	119	211	12
Maximum	96	109	218	836	184	650	1370	31
Minimum	23	4	34	128	0	0	330	−21
Background					36	NA	556	
Bedrock wells (excluding G132)[b]: N = 14								
Mean	39	38	58	188	43	80	500	16
Std. Dev.	11	23	29	114	48	23	134	10
Maximum	53	94	77	548	170	124	843	29
Minimum	5	17	3	7	0	49	333	−13
Dolomite-well background, Dupage County[c]								
Median	NA	30	NA	NA	22	166	625	
Maximum	NA	317	NA	NA	450	864	1832	
Minimum	NA	4	NA	NA	0	0.1	259	
Surface-water and Cenacle well								
Cenacle	43	47	82	201	69	94	605	15
Spring Brook	49	337	107	270	507	163	1352	4
Silver Lake	28	13	33	88	19	67	402	14
Swim Lake	45	22	59	173	29	81	509	17

[a] Schicht and others (1976).

[b] Note: Wells G132D and G132DD had TDS = 3090, 4110 and CBE = 86, 98%.

[c] Sasman and others (1981).

a hydraulic connection between bedrock and glacial aquifers. The most likely area is in the southwestern part of the Blackwell site where the outwash is virtually in contact with the bedrock. Using an average outwash hydraulic conductivity of 5.8 × 10^{-2} cm/sec (Table 1), a measured outwash effective porosity of 0.23, and annual average observed hydraulic gradients of 3.25/720 along a typical flow path, a seepage velocity of about 1 m/d is indicated. Even allowing for considerable error in the conductivity estimate, there has been adequate time for landfill-leakage solutes (at least if not strongly retarded) to have migrated through the outwash across the entire southwestern part of the site. Similarly, using an observed vertical head difference of 0.46 m across the typical thickness of 1.2 m of Tiskilwa till in the southwest of the site, a Tiskilwa measured porosity of 0.3, and minimum measured laboratory permeability of about 5 × 10^{-7} cm/sec, the maximum travel time across the till for nonretarded contaminants is about 2,000 days. This time is enough for landfill-derived contaminants to have reached the dolomite aquifer.

Conclusions

The Blackwell concept was an innovative environmental land-use plan. Derelict land was reclaimed by municipal solid-waste disposal in an engineered landfill, then landscaped as a recreational forest preserve. Postlandfill groundwater monitoring since the early 1970s has revealed the existence of a landfill-derived contaminant plume in the glacial outwash aquifer on site, with possible evidence of minor contamination of the underlying bedrock aquifer. As a precautionary measure, the on-site Swim Lake has been closed.

The annual average daily leachate leakage rate is estimated between 14 and 129 m^3/d, by analysis of leachate-level changes, and is most likely about 63 m^3/d, the average of the HELP and water-balance methods. That volume of leakage, over a landfill area of approximately 130,000 m^2, translates to about 22,995 m^3/yr, or 15.9 cm/yr: 17 percent of the annual average precipitation. A typical landfill of the period would more likely have had almost half of the precipitation infiltrating to form leachate (Hughes and others 1976), with no underlying barrier to leakage.

Had a leachate collection system been installed as originally suggested, the leachate presumably would not have entered the aquifer. Deviations from the working design that probably increased the quantity and/or strength of the leachate were the increased refuse–fill ratio and the lack of a clay liner in certain areas. However, the fortuitous localized use of gravel cover at Blackwell, which was not originally specified,

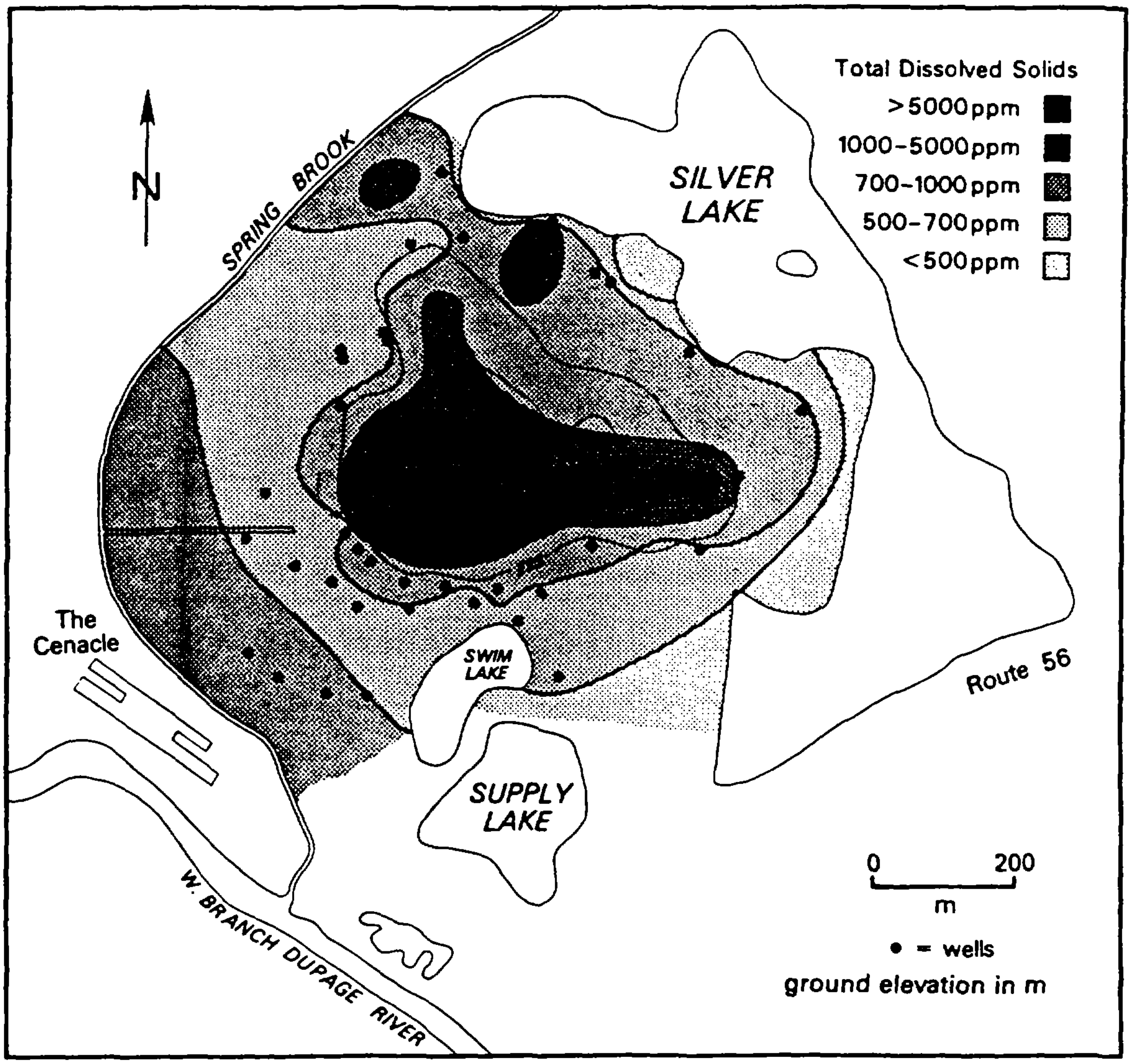

Figure 6. Map of TDS (mg/l) of samples from landfill leachate vents and ground-water monitoring wells, Blackwell site.

more closely follows modern design recommendations and permits interception and lateral discharge of infiltration before percolation to leachate. Furthermore, areas of the landfill with greater throughflow appear by now to have weaker leachate. It is thus by no means certain that more rigid adherence to design criteria would have substantially altered the leachate leakage condition, but the contamination problem would certainly have been worse with a below-grade landfill more typical of the time.

Geologically, the site is somewhat unsuitable for waste disposal. The presence of a permeable glacial outwash aquifer on the western side allows the rapid migration of contaminants from beneath the landfill. An approximately concentric contaminant plume is observed in the glacial materials, since the tendency for downgradient skew is countered by the greater dilution in the outwash downgradient than in the till upgradient. Contamination of groundwater in the outwash is not itself a serious problem, because dilution is sufficient to attenuate the contaminant plume rapidly close to the landfill, so that no off-site contamination has been detected. The greater concern is the route provided by the outwash for contaminant migration to the Swim Lake and the dolomite aquifer.

Although the lake has proved remarkably free of contaminants because of the combination of flow pathways and dilution factors, there remains the possibility of deterioration should the flow system change, for example by a change in water-table gradients. The impact of any proposed remedial action on the flow system should be thoroughly predicted.

Geological investigations have shown that the outwash downgradient from the landfill is separated from the underlying dolomite bedrock aquifer by a thin, leaky layer of silty till. There has been sufficient time for landfill-derived contaminants in the outwash aquifer to have leaked into the dolomite aquifer. Although TDS and inorganic solute levels in the dolomite monitoring wells are scarcely above background, there are trace levels of VOCs, probably although not certainly from the landfill.

Despite the problems, the forest preserve is still a recreational asset. In its combination of land reclamation, sanitary waste disposal, recreational amenity, and economic use of resources, Blackwell remains a model of land-use planning. The major weakness is that the geological (and hence hydrogeological) conditions of the site were unsuitable for the landfill as built, and the major lesson for future landfills and land-use plans is the danger of insufficient geological consideration during engineering design and operations.

Acknowledgments

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Appendix A. Leachate levels measured at Blackwell in 1985

	Leachate level (m above datum)					
Vent	Apr 23	Jun 7	Jul 15	Aug 31	Oct 20	Nov 17
SV1	224.44	224.24	224.11	224.28	223.88	224.06
SV2	219.19	219.16	219.14	219.15	219.14	219.14
SV3	221.12	220.55	220.26	220.23	219.99	220.63
SV4	218.74	217.82	217.92	217.94	218.86	218.14
SV5	216.18	216.17	216.01	215.85	215.78	215.88
SV6	221.18	220.94	220.93	220.91	220.88	220.77
SV7	222.91	221.91	221.85	221.85	221.67	221.92
SV8	216.07	216.07	216.06	216.09	216.07	216.09
SV9	216.12	216.10	216.09	216.12	216.10	216.10
SV10	211.60	211.04	210.76	210.56	210.67	210.96
SV11	NA	NA	221.49	221.45	221.44	221.19
SV12	NA	NA	231.59	231.71	231.70	231.88
DV2	229.70	228.55	228.15	228.82	228.61	228.45
DV3	224.89	224.75	224.66	224.63	224.37	224.58
DV4	214.96	214.13	213.68	213.28	213.11	213.69
DV5	212.91	212.67	NA	212.57	212.84	212.48
DV6	220.83	220.80	220.62	220.73	220.62	220.70
DV7	NA	NA	217.75	217.69	217.63	217.65
DV8	NA	216.48	216.23	216.05	215.99	216.02
DV9	NA	216.16	215.99	215.89	215.80	215.97
DV10	NA	219.78	219.73	219.75	219.76	219.79
DV11	NA	225.35	226.45	226.86	226.97	226.92
DV12	NA	213.41	212.81	212.66	212.51	212.66
DV13	NA	216.22	216.39	216.47	216.52	216.57

Appendix B. Selected chemical characteristics of Blackwell leachate

		Conc (mg/l)		
Vent	pH	TDS	Cl	Fe
SV1	7.0	1,690	14	NA
SV2	5.9	45,600	5,650	0.12
SV3	7.4	643	6	1.2
SV4	6.6	583	10	10.4
SV5	6.9	12,240	1,270	0.2
SV6	7.0	1,023	74	39
SV7	6.9	1,407	115	1,620
SV8	5.5	6,713	345	690
SV9	5.6	29,700	2,400	2,370
SV10	7.1	1,343	262	1.8
SV11	7.1	16,100	2,050	2
SV12	8.1	7,043	16	1,960
DV2	7.5	1,143	26	0.11
DV3	6.3	1,807	130	800
DV4	7.3	1,160	124	0.03
DV5	7.6	8,093	2,580	1.1
DV6	7.2	3,510	510	143
DV7	8.0	8,360	3,830	76
DV8	5.3	2,820	1,160	NA
DV9	5.5	1,860	440	NA
DV10	5.3	36,300	3,100	390
DV11	7.3	1,390	30	6.1
DV12	7.2	1,290	80	280
DV13	5.4	49,100	4,300	4.1
Average	6.7	10,038	1,188	349.8
Std. Dev.	0.9	14,365	1,595	662.09
Avg. of log values		3,893	264	—

Appendix C. Average values of selected chemical constituents in off-landfill monitoring wells, 1980–1986[a]

	TDS (mg/l)			CHLORIDE (mg/l)			
Well	Mean	SD	N	Mean	SD	N	VOC (ppb) mean total
G100	3,343	7,257	14	270	179	14	57.4
G101	946	637	13	75	35	13	312.7
G102	1,275	2,146	12	25	29	12	176.1
G103S	507	144	14	24	12	14	
G103D*	333	66	14	12	8	14	
G104	1,275	390	12	12	7	12	
G105	943	266	14	23	24	14	
G107S	452	249	14	8	5	14	
G107D	521	119	14	34	17	14	2.4
G108	531	146	14	26	11	14	
G109	987	755	14	44	14	14	57.4
G110	734	209	10	52	16	12	312.7
G111	687	159	14	34	19	14	176.1
G112	805	319	14	32	24	14	143.9
G113	864	315	13	41	29	13	41.1
G114	589	91	14	27	14	14	
G115S	578	95	14	30	18	14	
G115D*	722	140	14	68	14	14	
G116	818	117	14	143	37	14	
G117	579	92	14	31	11	14	20.2
G118S	780	97	13	10	8	13	280.8
G118D*	734	165	13	80	36	13	
G119	1,060	297	12	101	78	12	
G120S	339	91	14	9	3	14	

G120D*	388	30	14	5	10	14	0.0
G121	422	63	6	22	3	6	
G122	601	53	6	48	19	6	21.2
G123	536	50	6	8	7	6	
G124	1,055	285	5	126	33	5	
G125	855	124	4	139	77	4	
G126	650	68	5	55	6	5	
G127	737	72	5	20	6	5	143.4
G128S	954	209	5	29	12	5	74.3
G128D*	549	67	5	25	5	5	18.2
G128I	485	19	5	25	8	5	
G129	615	117	5	36	22	5	
G130	752	109	5	84	23	5	
G131D*	780	111	3	100	57	3	1.1
G131DD*	1,568	772	3	47	5	3	5.1
G132D*	3,207	103	3	11	4	3	6.5
G132DD*	4,900	881	3	6	5	3	42.6
G133S	890	72	3	183	30	3	
G133D*	598	180	3	99	27	3	1.8
G133DD*	589	61	3	63	7	3	6.7
G134*	573	250	3	1	0	3	
G135*	463	102	3	21	4	3	9.9
G136*	525	147	3	5	3	2	

* indicates dolomite well; otherwise well is in outwash or till. SD = standard deviation; N = number of samples. First samples for TDS and Cl taken May 1980 (G100–G120), August 1982 (G121–G123), July 1984 (G124–G130), May 1985 (G131–G136). Samples of VOCs taken December 1983 or later; figure cited is sum of average values of 1,1-DCA, 1,2-*cis*-DCE, 1,2-*trans*-DCE, and TCE; thus no single standard deviation can be cited.

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APPENDIX F

SITE TOPOGRAPHIC MAP

WARZYN

Volume 2 of 5

Planning Document
Project No. 60721

Quality Assurance Project Plan
Blackwell Landfill NPL Site

Prepared for:
Forest Preserve District
DuPage County, Illinois

Prepared by:
Warzyn Engineering Inc.
Chicago, Illinois

January 1991

QUALITY ASSURANCE PROJECT PLAN (QAPP)
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
BLACKWELL LANDFILL SITE
DUPAGE COUNTY, ILLINOIS
(January 28, 1991)

Prepared By:

WARZYN ENGINEERING INC.
2100 Corporate Drive
Addison, Illinois 60101

(708)691-5000

APPROVALS:	DATE:
____________________ PRP Steering Committee Representative	____________
____________________ Warzyn Site Project Director	____________
____________________ Warzyn Site Project Manager	____________
____________________ Warzyn Site Quality Assurance Officer	____________
____________________ U.S. EPA Region V, Remedial Project Manager	____________
____________________ U.S. EPA, Region V, Quality Assurance Officer	____________

INTRODUCTION

The United States Environmental Protection Agency requires that PRP-lead investigations under CERCLA have an approved Quality Assurance Project Plan (QAPP) covering environmental measurements. It is the responsibility of the Respondents or their representatives to implement minimum procedures so the accuracy, precision, completeness and representativeness of data collected are known and documented.

This QAPP presents the organization, objectives, functional activities and specific quality assurance (QA) and quality control (QC) activities associated with the Remedial Investigation/Feasibility Study (RI/FS) at the Blackwell Landfill site located in DuPage County, Illinois. The objective of the RI is to determine the nature and extent of the contamination at the site in order to support the activities of the FS. The objective of the FS is to develop and evaluate appropriate remedial action alternatives based on the RI data.

This QAPP has been prepared using the following guidance documents:

- U.S. EPA, December 1980, Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, QAMS-005/80.
- U.S. EPA, Region V, June 1989, Final Standard Quality Assurance Project Plan Content Document (aka Q.DOCC).
- U.S. EPA, Region V, Content Requirements for Quality Assurance Project Plan prepared by Cheng-Wen Tsai, QAS, Revised January, 1989.

The planning documents for the RI/FS at the Blackwell Landfill site consist of a QAPP, a Work Plan (WP), a Field Sampling Plan (FSP), a site specific Health and Safety Plan (HSP), and a Data Management Plan. Each of the plans has a specific purpose, and efforts have been made to avoid duplication of focus in the documents. The purpose of this QAPP is to describe the specific protocols which will be followed for sampling, sample handling and storage, chain-of-custody, and laboratory (or field) analysis. The purposes of the other documents are as follows:

- The Work Plan presents the background of the site, describes the rationale for each aspect of the investigation, and specifies the number and locations of sampling points.

- The Field Sampling Plan describes the details of the field procedures, such as soil boring procedures, monitoring well construction details, sampling techniques, aquifer testing and data analysis methodologies.
- The *Site Specific Health and Safety Plan provides the field personnel* with a description of procedures and personal protective equipment to be used while conducting the field investigation.
- The Data Management Plan, which is an Appendix to the Work Plan, outlines the procedures which will ensure the quality and integrity of the data that are collected and discusses the disposition and handling of the data collected during RI/FS tasks.

Each of the documents has been developed in conformance with the appropriate U.S. EPA guidance documents.

QUALITY ASSURANCE PROJECT PLAN (QAPP)
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
BLACKWELL LANDFILL SITE
DUPAGE COUNTY, ILLINOIS

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SECTION 1
PROJECT DESCRIPTION

1.1 Site Description and Site History

The Blackwell Landfill NPL Site is located within the limits of the Roy. C. Blackwell Forest Preserve near the intersection of Butterfield and Warrenville Roads in Section 26, Township 39 North, Range 9 East, DuPage County, Illinois.

The landfill was developed by the DuPage County Forest Preserve District, and covers approximately 40 acres. Approximately 1.5 million cubic yards of refuse were disposed of in the landfill over the period 1965 to 1973. The landfill accepted mainly household refuse, yard wastes, and light industrial wastes. There is no record of hazardous wastes being disposed of at the Blackwell Site.

The original design of the landfill consisted of a series of overlapping cells, constructed with clay side berms and liners. Some doubt exists as to how strictly the original design criteria were adhered to during construction.

Geologic information for the site has been document by soil boring made for the more than 50 monitoring wells which have been constructed in several previous investigations. Boring logs exist for each of the monitoring wells, and are included as an Appendix to the Work Plan. Geologic cross sections have been developed; a generalized section is included in the Work Plan.

Quarterly groundwater monitoring was initiated [illegible] the site monitoring wells in 1983; the analytical parameters included volatile organic compounds and several inorganic water quality indicators. The sampling procedure was developed in consultation with representatives of the IEPA to assure a sampling procedure matching the U.S. EPA protocols. It included the purging each well prior to sampling, collection and preservation of samples, chain-of-custody procedures, and the collection of field duplicates and blanks.

A total of twenty-one different volatile organic compounds (VOCs) have been detected in groundwater at the Blackwell site at one time or another, but five have been most commonly detected:

1,2-Dichloroethane
1,1-Dichloroethane
1,2-Cis-Dichloroethylene
1,2-Trans-Dichloroethylene
Trichloroethylene

Volatile organic concentrations within the groundwater have exhibited stable or decreasing trends since first sampled in 1983.

The Site was assigned a Hazard Ranking System (HRS) score of 35.57 by the U.S. EPA in March, 1986. Final listing on the National Priorities List (NPL) occurred on February 21, 1990.

A more detailed description of the site history and background are contained in the Work Plan.

1.2 Target Compounds

Groundwater, surface water and leachate samples will be analyzed for TCL/TAL parameters and general water quality parameters consisting of alkalinity, chloride, sulfate, total dissolved solids (TDS), nitrate+nitrite nitrogen, ammonia nitrogen and total kjeldahl nitrogen (TKN). In addition, chemical oxygen demand (COD) will be analyzed on leachate samples. Soil and sediment samples will be analyzed for TCL/TAL parameters. Water supply wells will be analyzed for low-level detection TCL volatiles. Parameter lists and associated detection limit requirements are contained in Appendix A.

1.3 Project Objectives

The purpose of the RI is to gather sufficient information to quantify risk to public health and environment (Endangerment Assessment) and to develop and evaluate viable remedial alternatives (Feasibility Study) at the site. The objectives of the RI are to:

- Investigate site physical characteristics,
- Identify and quantify contaminant sources, and
- Qualify the nature and extent of contamination.

All tasks, subtasks and activities are directed toward the accomplishment of these primary objectives. Refer to the Work Plan for a detailed description of the RI tasks, subtasks and activities.

A summary of data generating activities, the intended data uses and Data Quality Objectives (DQOs) for the site investigation are presented in Table 1.

1.4 Sample Network and Rationale

The activities and subtasks related to the field work are described in detail in the Work Plan. Table 2 (this document) provides a listing of sample types, parameters and estimated number of samples. Table 3 summarizes sample quantities, containers, preservatives and packaging information.

1.5 Project Schedule

A schedule of RI/FS activities for the Blackwell Landfill site is summarized in Figure 2.

SECTION 2
PROJECT ORGANIZATION AND RESPONSIBILITY

2.1 Overall Responsibility

PRP Steering Committee Representative

- Richard Utt
  DuPage County Forest Preserve District
  DuPage County, Illinois

U.S. EPA Remedial Project Manager

- Robert Lance
  U.S. EPA Region V
  Chicago, Illinois

PRP Project Director

- Daniel Hall, CPGS
  Warzyn Engineering Inc.
  Madison, Wisconsin

PRP Project Manager

- Peter Vagt, Ph.D.
  Warzyn Engineering Inc.
  Chicago, Illinois

Quality Assurance Officer (QAO)

- Gary Parker
  Warzyn Engineering Inc.
  Chicago, Illinois

- RI/FS Reports and technical memoranda prepared by Warzyn Engineering Inc., Chicago, Illinois.

2.2 Monitoring and Sampling Operations and QC

- Principal Engineering Firm - Warzyn Engineering Inc., Chicago, IL
- Drilling - To be determined through bidding process.
- Sampling, Monitoring and Survey - Warzyn Engineering Inc., Chicago, IL
- On Site Day-to-day Field Activities - Field Team Leader, Warzyn Engineering, Inc., Chicago, IL
- Quality Control - QAO, Warzyn Engineering Inc., Chicago, IL

2.3 Laboratory Analyses and QC

- Analysis of groundwater, surface water, sediments and leachate samples for Target Compound List (TCL) organics and analysis of water supply wells for low level TCL volatiles using Contract Laboratory Program (CLP) protocols (see Appendix A for the analyte list):

  Compuchem
  3308 Chapel Hill/Nelson Hwy.
  Research Triangle Park, NC 27709

- Analysis of groundwater, surface water, sediment and leachate samples for Target Analyte List (TAL) inorganics using CLP protocols (see Appendix A for analyte list):

  Warzyn Engineering Inc.
  One Science Court
  Madison, Wisconsin 53711

- Analysis of groundwater, surface water and leachate samples for general water quality indicator parameters including alkalinity, chloride, sulfate, TDS, nitrate+nitrite nitrogen, ammonia nitrogen and TKN using procedures specified in Appendix B-1. Leachate samples will also be analyzed for COD using the procedure found in Appendix B-1.

Warzyn Engineering Inc.
One Science Court
Madison, Wisconsin 53711

- Analysis of soil samples for grain size distribution using the procedure specified in Appendix B-3.

EWI Engineering Inc.
505 Science Court
Madison, Wisconsin 53711

- Analysis of landfill gas samples for Volatile Organic Compounds (VOCs) using the procedure specified in Appendix B-4.

Enseco, Inc. - Air Toxics Laboratory
9537 Telstar Ave., Suite 118
El Monte, CA 91731

2.4 Specialized Responsibility for Laboratory Analyses

- Compuchem Laboratory Data
  - Analytical protocol specified - Warzyn Engineering Inc., Madison, WI
  - Review of analytical protocol - Compuchem, Research Triangle Park, NC
  - Review of analytical protocol - U.S. EPA Region V Quality Assurance Section (QAS) and Central Regional Laboratory (CRL), Chicago, IL
  - Internal QA/QC - Compuchem, Research Triangle Park, NC
  - Final data review and validation - Staff chemist, Warzyn Engineering Inc., Madison, WI
  - Review of tentatively identified compounds and assessment of need for confirmation - Staff chemist, Warzyn Engineering Inc., Madison, WI

- Warzyn Laboratory Data
  - Review of analytical specifications - U.S. EPA Region V QAS and CRL, Chicago, IL
  - Internal QA/QC - Warzyn Engineering Inc., Madison, WI
  - Final data review and validation - Staff chemist, Warzyn Engineering Inc., Madison, WI

- EWI Engineering Data
  - Review of analytical specifications - U.S. EPA Region V QAS and CRL, Chicago, IL
  - Internal QA/QC - EWI Engineering Inc., Madison, WI
  - Final data review - Staff chemist, Warzyn Engineering Inc., Madison, WI

- Enseco Laboratory Data
  - Review of analytical specifications - U.S. EPA Region V QAS and CRL, Chicago, IL
  - Internal QA/QC - Enseco, El Monte, CA
  - Final data review and validation - Staff chemist, Warzyn Engineering Inc., Madison, WI

2.5 Quality Assurance

- Overall QA Responsibility - QAO, Warzyn Engineering Inc., Chicago, IL
- QA for Warzyn Subcontracted Activities - Warzyn Engineering Inc., Madison, WI
- Review of QAPP - U.S. EPA Region V QAS and CRL, Chicago, IL
- Field Analyses - Warzyn Engineering Inc., Madison, WI

2.6 Performance and Systems Audits

- Field Operations

  Internal Audits - QAO, Warzyn Engineering Inc., Madison, WI
  External Audits - U.S. EPA Region V CRL and Central District Office (CDO), Chicago, IL

- Analytical Laboratories

  COMPUCHEM
  Internal Audits - Laboratory QAO, Compuchem, Research Triangle Park, NC
  External Audits - U.S. EPA Region V CRL, Chicago, IL

  WARZYN ENGINEERING INC.
  Internal Audits - Laboratory QAO, Madison, WI
  External Audits - U.S. EPA Region V CRL, Chicago, IL

  ENSECO
  Internal Audits - Laboratory QAO, El Monte, CA
  External Audits - U.S. EPA Region V CRL, Chicago, IL

- Final Evidence File Audits - QAO, Warzyn Engineering Inc., Chicago, IL

An organizational chart is provided in Figure 4.

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SECTION 3

QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT DATA IN TERMS OF PRECISION, ACCURACY, COMPLETENESS, REPRESENTATIVENESS AND COMPARABILITY

The purpose of this section is to address the objectives of accuracy, precision, completeness, representativeness and comparability. Precision and accuracy are criteria for which quantitative limits can be developed. Precision describes the degree to which data generated from replicate or repetitive measurements differ. Accuracy is defined as the difference between the value of the reported data and the true value of the parameter being measured, and is assessed through the analysis of blanks, spikes, calibration standards and reference standards. The QA objective with respect to precision and accuracy is to achieve the established limits for the analyses required. Representativeness, completeness and comparability are qualitative criteria used to determine the degree to which sample data accurately represent the site.

The overall quality assurance (QA) objectives are to implement field sampling, chain-of-custody, and quality control reporting procedures that will provide legally defensible data from laboratory analyses in a court of law. Field analyses are being made primarily to aid in site selection for more detailed observations and analyses. Quality control objectives for these data, as well as those collected for health and safety purposes, are to obtain reproducible data consistent with limitations imposed by measurement methods used.

Specific procedures to be used for sampling, chain-of-custody, calibration, laboratory analyses, data reporting, internal quality control, audits, preventative maintenance, and corrective actions are described in other sections of this QAPP. This section (3.0) defines goals for the QC effort (accuracy, precision, and sensitivity of analyses and completeness, representativeness, and comparability) for data from analytical laboratories and presents quality control objectives for field measurements. A summary of data generating activities and associated data quality objectives is provided in Table 1. A summary of QC requirements for the analyses performed is provided in Table 4.

3.1 Level of Quality Control Effort

3.1.1 Field Sampling Program

The quality of data from the field sampling program for laboratory analyses will be evaluated through the collection of field duplicates, field blanks and trip blanks. Bottle blanks will also be analyzed and will serve as a check for bottle contamination.

Duplicates will be used to assess the combined effects of sample collection, handling and analysis on data precision. The general level of effort for all matrices will be one field duplicate per 10 or fewer investigative samples.

Bottle blanks will be collected at a frequency of one per group of 100 or fewer samples in each bottle QC lot and will serve as a check for contamination in the sample containers. The bottle blank, to be prepared in the laboratory, will consist of deionized water poured into the bottle with the appropriate preservative added. The QC lot number will be clearly identified for each bottle blank. Pre-cleaned bottles will be purchased from I-Chem Research and Eagle Picher Environmental Services. The cleaning procedures used will be in accordance with the EPA document: "Specifications and Guidance for the Preparation of Contaminant-Free Sample Containers", U.S. EPA, April 1989.

Pre-cleaned SUMMA passivated canisters (6-liter) will be provided to the sampling personnel by Enseco. The procedure used for cleaning the canisters is found in Appendix B-4. One canister from each batch of 8 canisters is analyzed to check the effectiveness of the cleaning procedure. The batch is considered acceptable if target compounds were not detected above 0.2ppbv.

Where appropriate, field blanks will be collected at a frequency of one per group of 10 or fewer samples per aqueous matrix per day. Field blank samples will serve as a check for procedural contamination or ambient conditions at the site that may result in apparent contamination of samples. Field blanks for samples not requiring filtration, will consist of deionized water passed through decontaminated sampling equipment. Field blanks for samples requiring filtration will consist of deionized water passed through decontaminated sampling equipment and filtering apparatus.

A trip blank (two 40 mL VOA vials filled with deionized water and preservative) will be included with each shipment of samples for volatile analysis. Trip blanks for water supply wells will consist of four 40 mL VOA vials filled with deionized water and preservative. A shipment is to be considered a shipping unit, i.e. a single cooler. The purpose of a trip blank is to assess cross contamination in the shipment cooler of samples targeted for volatile organic analysis. The trip blank will be prepared in the laboratory and will remain sealed during sampling activities. All trip blank samples collected will be analyzed.

For organics analyses, extra sample volume is required for matrix spike/matrix spike duplicate (MS/MSD) analyses at a frequency of one per group of twenty or fewer investigative samples. Extra volume for TCL organics MS/MSD quality control (QC) requirement consists of: triple volume for VOCs and double volume for semi-volatiles and pesticides/PCBs.

3.1.2 Laboratory Analyses

Compuchem. Analysis of groundwater, surface water, leachate and sediment samples for TCL organics (see Appendix A for analyte list) will be performed by Compuchem using CLP protocols. Levels of QC effort for these analyses are described in the CLP Statement of Work SOW 2/88 (or most current). Additional volumes will be collected in the field for the MS/MSD analyses at a frequency of one per twenty investigative samples.

Analysis of water supply wells for low level TCL volatiles (see Appendix A for analyte list) will be performed by Compuchem using CLP protocols. Levels of QC effort for these analyses are described in the procedure specified in Appendix B-2, which provides for low level detection limits. Additional volumes will be collected in the field for the MS/MSD analyses at a frequency of one per twenty investigative samples.

Warzyn. Analysis of samples for TAL inorganics (see Appendix A for analyte list) will be performed by Warzyn using CLP protocols. Levels of QC effort for these analyses are described in the CLP Statement of Work SOW 7/88 (or most current).

Analyses for general water quality indicator parameters (see Appendix A for analyte list) will be performed by Warzyn using methods specified in Appendix B-1. QC requirements include, where applicable, matrix spikes, laboratory duplicates, blanks, calibration check standards, and EPA reference samples. Required frequencies and acceptance limits are also summarized in Appendix B-1.

EWI Engineering. Analysis of soil samples for grain size distribution will be performed by EWI using the procedure specified in Appendix B-3. Level of QC effort will be limited to duplicate analyses.

Enseco. Analysis of landfill gas samples for VOCs using procedure specified in Appendix B-4. QC requirements include blanks and calibration check standards. Field duplicates will be collected and will be used to assess precision.

3.1.3 Field Measurements

pH. Level of QC effort for the field measurement of pH will consist of precalibration using two certified buffer solutions, calibration checks at a frequency of every ten or fewer samples, and duplicate analyses at a frequency of one per ten or fewer samples as outlined in Appendix C-1.

Specific Conductance. Level of QC effort for specific conductance measurements will consist of initial and continuing calibration checks at a frequency of every ten or fewer samples and duplicate analyses at a frequency of one per ten or fewer samples as outlined in Appendix C-2.

Water Elevation. Water elevations will be measured using an electronic water level indicator or a steel tape with a sounding device. Both devices make an audible sound in contact with liquid and will be used as a basis for measuring depth to groundwater. Quality control will be limited to averaging repeated measurements at each location.

3.2 Accuracy, Precision and Sensitivity of Analyses

The QA objectives for laboratory and field analyses with respect to accuracy, precision and sensitivity are to achieve acceptable data based on specified performance criteria. Precision of laboratory and field analyses is judged from results obtained from duplicate analyses. A method specific, minimum relative percent difference (RPD) (see Section 12 for definition) will be used for assessing data quality. Data accuracy will be assessed from results of U.S. EPA reference samples, check standards, blanks and matrix spike analyses. A minimum percent recovery (see Section 12 for definition) will be used for assessing data quality.

3.2.1 Laboratory Analyses

Accuracy and precision requirements for TCL organics are described in the CLP Statement of Work 3/90 (or most current). TAL inorganics accuracy and precision requirements are described in the CLP Statement of Work 7/88 (or most current). The required quantitation limits for the TCL/TAL parameters are summarized in Appendix A.

Accuracy and precision requirements for low level TCL volatiles, indicator parameters and landfill gas VOCs are summarized in Table 4. The required quantitation limits are summarized in Appendix A.

3.2.2 Field Sampling Program

In addition to laboratory QC samples, field QC samples will also be collected. These will include both duplicate and blank samples. Variability in duplicate samples will reflect combined effects of both sampling and analytical error. No project specific maximum RPD has been set for field duplicate samples. Blank samples (field, trip and bottle blanks) will be used to assess cross contamination associated with sampling activities. No project specific maximum for results of blank samples has been established, however, blank data will be evaluated to determine what affect, if any, the data may have on the investigative samples.

3.2.3 Field Measurements

Accuracy of field measured pH will be judged from agreement of instrument readings with certified standard buffer solutions. Agreement with standards will be within 5% of the expected values, or the unit will be replaced. Precision will be measured by making duplicate readings of samples at least every 10 samples.

Accuracy of the conductivity meter will be assured by calibration checks with a standard of known concentration. If readings vary more than 5% from expected values, the unit will be replaced. Precision will be measured by making duplicate readings of samples at least every 10 samples.

Data needs for geophysical measurements require the ability to detect differences on a consistent relative scale. Hence, in most cases, an absolute calibration is not required. However, where applicable, instruments will be calibrated prior to use or be checked using manufacturer's suggested test procedures to monitor proper and consistent operation.

3.3 Completeness, Representativeness and Comparability

Completeness is defined as the proportion of data collected that meet project specific acceptance criteria. It is anticipated that at least 95% of the data collected will meet acceptance criteria. If required performance criteria are not met by performing laboratories, they will reanalyze samples if holding times permit. If holding times are exceeded, the performing laboratory will inform the Warzyn project manager as soon as possible, so that a decision can be made whether to resample or to accept the data with limitations. The method of calculation for completeness is discussed in Section 12.

Sampling, preservation and analysis methods are designed to provide analysis results that are representative of the sample matrix at the point of collection. Warzyn recognizes the potential for considerable spatial heterogeneity in parameters measured at the site. Hence, the degree to which the sampled locations represent the population of all potential sampling points cannot be stated precisely. Consequently, no quantitative expression of representativeness is proposed.

The analytical methods used are expected to provide data of comparable or greater quality with that previously collected and that which may be collected in subsequent project phases. Although data proposed for collection are judged to be of acceptable comparability, no quantitative expression of comparability is proposed.

SECTION 4
SAMPLING PROCEDURES

A Field Sampling Plan (FSP) has been prepared and is included with this submittal. The FSP contains sampling procedures and includes the following:

- Detailed procedures for the collection of samples for the required parameters;
- Detailed procedures for sample packaging, handling and shipment;
- Summary of sample container, reagent, preservative and hold time requirements;
- Chain-of-custody procedures;
- Detailed procedures for preparation/collection of trip blanks and field blanks;
- Documentation requirements of sampling activities (use of field log books, field measurement forms, etc.); and
- Summary of the sampling and analysis program.

Refer to Table 2 for sampling and analysis program and Table 3 for summaries of sample quantities, containers, preservatives, and packaging requirements.

SECTION 5
SAMPLE CUSTODY AND DOCUMENTATION

5.1 Chain-of-Custody Procedure for Field Activities

All samples will be collected under chain-of-custody procedures which will include the use of chain-of-custody forms, sample labels, sample tags, custody seals, sample identification records and field notebooks. Standard forms and field notebooks are to be maintained throughout the RI/FS sampling activities. Field notebooks shall include information pertinent to the sampling episode. Field notebooks shall include, but not be limited to sampling location and time, field measurements, weather conditions and sampling equipment used. Refer to the "Field Custody" and "Transfer of Custody and Shipment" sections of the Warzyn Chain-of-Custody Procedure found in Appendix D.

An example of the chain-of-custody form to be used is shown in Figure 5. Requirements are as follows:

- Complete custody form as described in the above-mentioned procedure for all samples collected.
- Completed forms must be specific to a shipping container.
- The carrier service does not need to sign the form if custody seals remain intact during shipment. (Note carrier and air bill number of the chain-of-custody.)
- Sample designations must be in accordance with the FSP.

Chain-of-custody seals are to be used for sample shipping. An example is shown in Figure 6. Seal requirements are as follows:

- Two (2) chain-of-custody seals are required per shipping container to secure the lid and provide evidence that the samples within have not been tampered with.
- Cover seals with clear tape prior to shipping sample containers.
- Record seal numbers on the chain-of-custody forms as well as the sample identification record forms.

A copy of the sample label to be used is shown in Figure 7. Label requirements are as follows:

- Each sample container must have a completed sample label affixed to it.
- Use for all samples.
- Use waterproof ink, unless prohibited by weather conditions.
- Record bottle tag number on sample label.

An example of a sample tag is shown in Figure 8. Sample tag requirements are as follows:

- Each sample container must have a completed sample tag affixed to it.
- Record sample tag numbers on the chain-of-custody form and sample identification record form.
- Use for all samples.
- Use waterproof ink, unless prohibited by weather conditions.

An example of the Sample Identification Record Form to be used is shown in Figure 3. This form will provide means of recording crucial shipping and tracking information and will include such information as:

- Sample matrix
- Sample number
- Sample location code
- Sample round
- Laboratory code
- Sample tag number(s)
- Chain-of-custody number
- Date sampled
- Date shipped
- Airbill number

The documentation accompanying the samples shipped to the laboratory will be sealed in a plastic bag and taped to the inside of the cooler lid. The lid of the shipping container will be securely taped shut prior to shipment. Once in the laboratory's possession, sample custody will be the responsibility of the laboratory sample custodian.

Original field notes and field documents will be retained by Warzyn in a final evidence file.

5.2 Chain-of-Custody Procedure for Laboratory Analysis

Internal chain-of-custody procedures for Compuchem, Warzyn and Enseco are provided in Appendix D. Chain-of-custody forms, sample tags, data package and pertinent laboratory records shall be forwarded to Warzyn's final evidence file as permanent documentation of the analytical activities.

5.3 Final Evidence File

The format, contents and maintenance of Warzyn's final evidence file are provided in Appendix E. The file custodian will be responsible for the maintenance of the file, while Warzyn's Quality Assurance Officer will be responsible for auditing the file.

SECTION 6
CALIBRATION PROCEDURES AND FREQUENCY

6.1 Field Calibration

Calibration of pH and specific conductance meters are detailed in Appendices C-1 and C-2. The pH meter will be calibrated using certified buffer solutions. The specific conductance meter will be calibrated using a standard of known conductivity.

6.2 Laboratory Calibration

Procedures for the calibration and maintenance of measurement instruments must be established and maintained to ensure that equipment is functioning properly and that data collected are accurate and reliable. Requirements include step-by-step calibration procedures, frequency of re-calibration, equipment maintenance logs, instrument accuracy criteria, corrective action procedures and equipment limitations (e.g. working ranges), and are described, in detail, in the Standard Operating Procedures (SOPs) referenced below.

Procedures and frequency of instrument calibration for the indicator parameters are detailed in the SOPs found in Appendix B-1; for TCL organics, refer to the CLP Statement of Work SOW 2/88 (or most current); for low level TCL volatiles, refer to the procedure detailed in Appendix B-2; and for TAL inorganics, refer to the CLP Statement of Work SOW 7/88 (or most current).

Procedures and frequency of instrument calibration for VOC analysis of gas samples are detailed in the SOP found in Appendix B-4.

SECTION 7
ANALYTICAL PROCEDURES

7.1 Laboratory Analytical Procedures

COMPUCHEM

Groundwater, surface water, leachate and sediment samples analyzed by Compuchem for TCL volatiles, semi-volatiles, and pesticides/PCBs (see Appendix A for analyte list) will follow CLP protocols as outlined in the CLP Statement of Work SOW 2/88 (or most current).

Water supply samples analyzed by Compuchem for low level TCL volatiles (see Appendix A for analyte list) will follow the procedure outlined in Appendix B-2.

WARZYN

Groundwater, surface water, leachate and sediment samples analyzed by Warzyn for TAL inorganic parameters (see Appendix A for analyte list) will follow CLP protocols outlined in the CLP Statement of Work SOW 7/88 (or most current).

Groundwater, surface water, leachate and water supply samples analyzed by Warzyn for general water quality parameters (see Appendix A for analyte list) will follow the procedures outlined in Appendix B-1.

EWI ENGINEERING

Soil samples analyzed by EWI for grain size distribution will follow the procedure outlined in Appendix B-3.

ENSECO

Landfill gas samples will be collected from landfill vents and analyzed for VOCs using the procedure outlined in Appendix B-4.

7.2 Field Analytical Procedures

WARZYN

Groundwater, surface water, leachate and water supply samples analyzed for field pH and specific conductance will follow the procedures as outlined in Appendices C-1 and C-2.

SECTION 8
INTERNAL QUALITY CONTROL CHECK

8.1 Field

Required quality control checks for field measurements (pH and specific conductance) are summarized in Appendices C-1 and C-2. They include continuing calibration checks and duplicates analyses. Field quality control samples and their required frequency are specified in the FSP. Field quality control will include field blanks, trip blanks, bottle blanks and field duplicates.

8.2 Laboratory

Internal quality control procedures are an integral part of the analytical methods, and are discussed in detail within the analytical procedures. The overall objectives of the internal quality control checks are to verify the established precision, accuracy and integrity of the methodology and to support the technical validity of the data. Where appropriate, internal quality control checks for other than CLP protocol analyses will include method blanks, preparation/reagent blanks, calibration check samples, laboratory duplicates, matrix spikes and continuing calibration standards.

The required quality control frequency and performance criteria for TCL organics are summarized in the CLP Statement of Work SOW 2/88 (or most current). Low level TCL volatile QC requirements are summarized in the procedure found in Appendix B-2. QC requirements for TAL inorganics are summarized in the CLP Statement of Work SOW 7/88 (or most current).

QC requirements for the general water quality indicator parameters are summarized in Appendix B-1. The required QC frequency and performance criteria for the VOC analysis of gas samples is summarized in the procedure found in Appendix B-4.

SECTION 9
DATA REDUCTION, VALIDATION AND REPORTING

9.1 Laboratory Analyses

Compuchem - TCL Organics using CLP Protocols

Specific procedures for identification, quantification, data reporting and required data deliverables for the TCL organics are covered in the CLP Statement of Work SOW 2/88 (or most current). Validation of the data will be performed by Warzyn using Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses, February, 1988.

Compuchem - Low Level TCL Volatiles

Requirements for identification, quantification, data reporting and required data deliverables for the low level TCL volatiles will follow those in the CLP Statement of Work SOW 2/88 (or most current). Validation of the data will be performed by Warzyn using Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses, February, 1988 in conjunction with the quality control criteria and detection limit requirements specified within the procedure found in Appendix B-2.

Warzyn - TAL Inorganics using CLP Protocols

Specific procedures for quantification are documented in the methods found in Appendix B. Data reporting and required data deliverables for the TAL Inorganics are covered in the CLP Statement of Work SOW 7/88 (or most current). Data validation will be performed by Warzyn using Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses, July, 1988.

Warzyn - General Water Quality Indicator Parameters

Specific procedures for the quantification of the general water quality indicator parameters are documented in the methods found in Appendix B-1. Deliverables for the indicators will include, where applicable, raw data, strip charts, results of calibration standards, duplicates, blanks, matrix spikes and performance evaluation samples. Data validation will be performed by Warzyn using the Data Validation procedure found in Appendix G in conjunction with the performance criteria tabulated in Table 4.

Enseco - Analysis of Gas Samples for VOCs

The specific procedure for the quantification of VOCs are documented in the method found in Appendix B-4. Deliverables for this analysis will include, where applicable, all raw data, instrument printouts and chromatograms, results of calibration standards, duplicates and blanks. Data will be validated by Warzyn using the performance criteria summarized in Table 4 and the Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses, February, 1988.

9.2 Field Analyses

Field pH and Specific Conductance

Field pH and specific conductance data will be summarized, along with the calibration verification and duplicate data on field sheets (see Figure 9). All specific conductance data will be corrected to 25 degrees centigrade, as described in the procedure found in Appendix C-2. No formal validation process will be performed, as this data is to be used for screening purposes only, however, the data will be reviewed by the field team leader to ensure procedures were being followed and QC requirements were met.

9.3 Field Sampling

Field duplicates will be collected at the appropriate frequencies noted in the FSP. The validation procedures described in section 9.1 of this QAPP address field duplicates and how they will be evaluated. Field blanks, trip blanks and bottle blanks will be collected at the appropriate frequencies noted in the FSP. Data quality will be assessed using the same criteria described in the validation procedures in Section 9.1 for method blanks.

SECTION 10
PERFORMANCE AND SYSTEM AUDITS

External Audits

The U.S. EPA Region V CRL will audit performing laboratories and provide recommendations for approval of the laboratory for the requested analyses to the U.S. EPA RPM. The audit may consist of a review of analytical and chain-of-custody procedures, evaluation of performance samples, and may also include an on-site audit of each participating laboratory.

The responsibility of external audits of field activities will include audits conducted by the EPA Region V CRL and CDO.

Internal Audits

The purpose of the internal laboratory audit is to evaluate and document adherence to analytical procedures described in this QAPP. Internal audits of field and laboratory activities are the responsibility of Warzyn. Internal audits of Warzyn, Compuchem and Enseco will be performed at the frequency specified in the internal audit procedure found in Appendix F. Internal audits of the other participating laboratories will be the responsibility of the individual laboratory. Data validation of the data received, along with the external audit performed by the U.S. EPA Region V CRL will provide sufficient information to document and evaluate adherence to analytical procedures.

Internal field audits will be accomplished through unannounced site visits. The purpose of the field audit will be to evaluate and document adherence to procedures described in the QAPP. The audit will include review of field activities, sample tags, chain-of-custody forms, field notebooks and sampling and decontamination activities. The audit procedure to be performed at a frequency of a minimum of one per project phase is included in Appendix F.

A summary of the audit results will be included in scheduled progress reports.

SECTION 11
PREVENTATIVE MAINTENANCE

Preventative maintenance procedures for field instrumentation including pH, specific conductance are detailed in the instrument manuals found in Appendices C-1 and C-2 Field instruments will be checked and calibrated daily. Batteries will be checked and recharged as necessary. Spare parts (batteries, etc.) will be kept on-site to minimize "down time" of the field instruments.

Maintenance procedures for laboratory instrumentation and equipment for TCL organics (including low level TCL volatiles) are referenced in the CLP Statement of Work SOW 2/88 (or most current). Preventative maintenance procedures for laboratory instrumentation and equipment for TAL inorganics are referenced in the CLP Statement of Work SOW 7/88 (or most current).

Preventative maintenance of laboratory instruments associated with the indicator parameters will be as directed in factory manuals, instrument operating procedures, and analytical methods. Periodic maintenance by factory representatives will be performed. Daily logs documenting use and maintenance activities are kept for each analytical instrument. Refer to Appendix H for Warzyn's preventative maintenance SOP.

Preventative maintenance procedures for laboratory instrumentation and equipment for the VOC analysis fo the gas samples are found in Appendix B-4.

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SECTION 12

SPECIFIC ROUTINE PROCEDURES USED TO ASSESS DATA PRECISION, ACCURACY, AND COMPLETENESS

Assessment of accuracy, precision and completeness for analyses based on CLP protocols will follow specifications stated in the CLP Statement of Work. Accuracy and precision definitions for analysis of general water quality indicator parameters and TOC are specified in the method descriptions found in Appendices B and C.

Assessment of accuracy precision and completeness of analytical data is based on the acceptable results of QC samples. Where appropriate, these include blanks, duplicate samples, laboratory control spikes and matrix spike duplicates.

Method, field, trip blank and bottle blank results are expected to provide a measured value that is less than or equal to the reported detection limit.

Field and laboratory duplicate sample results are assessed based on relative percent difference (RPD) between values, using the following equation:

$$RPD = \frac{[D1 - D2]}{(D1 + D2)/2} \times 100$$

where, D1 = first sample value
D2 = Second sample value (duplicate)

Laboratory control spike results are assessed based on the percent recovery (%R) of fortified analytes. Percent recovery is calculated using the following equation:

$$\%R = \frac{Qd}{Qa} \times 100$$

where, Qd = Quantity determined by analysis
Qa = Quantity added to sample.

Matrix spike/matrix spike duplicate data are assessed based on %R of fortified analytes using the following equation:

$$\%R = \frac{(SSR - SR)}{SA} \times 100$$

where, SSR = Spike Sample Result
SR = Sample Result
SA = Spike Added

Relative percent difference (RPD) between matrix spike and matrix spike duplicate is calculated using the same equation for RPD described above.

Data completeness is the percentage of data meeting acceptance criteria. It is calculated using the following equation:

$$\text{Completeness} = \frac{N_1}{N_2} \times 100$$

where, N_1 = Number of Acceptable Observations
N_2 = Total Number of Observations Required or Expected Under Normal Conditions

SECTION 13
CORRECTIVE ACTION

Corrective action must be initiated whenever a system is out of control. If quality control audits (laboratory or field) result in detection of unacceptable conditions or data, steps of recommending, approving and implementing corrective action must be taken. Corrective action may include instrument recalibration or replacement, reanalysis or resampling. Appropriate personnel must be involved in approving and implementing the corrective action.

Corrective action for the analytical laboratories (Warzyn, Compuchem and Enseco) is addressed in the laboratory audit procedures found in Appendix F. Any problems which cannot be resolved at the laboratory level by the analyst, supervisor or laboratory QAO, will be brought to the attention of the Warzyn Project Manager. The Warzyn Project Manager and U.S. EPA RPM will determine what corrective action, if any, will be taken. Corrective action my include, but is not limited to, recalibration, reanalysis, qualification of data or resampling.

If problems arise in the field which cannot be resolved at the field supervisory level, the situation will be brought to the attention of the Warzyn Project Manager. The Warzyn Project Manager and U.S. EPA RPM will determine what corrective action, if any, will be required.

SECTION 14
QUALITY ASSURANCE REPORTS TO MANAGEMENT

Reports will be submitted to the U.S. EPA as described in Section 7 of the Work Plan. Monthly progress reports submitted to U.S. EPA will include a summary of the qualified sampling and analysis activities for the month and will highlight any QA problems associated with field or laboratory activities, as well as any corrective action proposed or already taken. Technical memoranda will be prepared to describe the procedures used to collect the data, and will present the data. The final RI report will contain separate sections that will summarize the data quality.

TABLE 1
SUMMARY OF DATA GENERATING ACTIVITIES AND ASSOCIATED DATA QUALITY OBJECTIVES
BLACKWELL LANDFILL SITE

TIVITY	TASK	DESCRIPTION	INTENDED DATA USAGES	ANALYSIS PARAMETERS	DATA QUALITY OBJECTIVE (ANALYTICAL LEVEL)	ANTICIPATED NO. OF INVESTIGATIVE SAMPLES
FINE NATURE AND EXTENT OF CONTAMINATION						
nfining Layer pping	1	Conduct shallow seismic investigation; make auger probes to bedrock southwest of landfill.	Determine the depth to the bedrock surface and delineate the existence of the clay confining layer in the area west of the landfill.		Level I Data	0
il Sampling	2	Conduct soil sampling in areas of past leachate seeps.	To characterize any soil contamination resulting from past leachate seeps.	Analysis of soil samples for TCL and TAL parameters.	Level IV Data for TCL, TAL	3
rface Water ydrology	3	Water Level Measurements and Piezometer Installation	To better define the interactions between surface water and groundwater.		Level I Data	0
rface Water/ ediment Sampling	4	Surface water and sediment samples taken at locations on Silver, Swim and Supply Lakes and Springbrook.	To document surface water quality surrounding the site and to evaluate the potential contamination effects of discharging groundwater on bottom sediments in surface water bodies surrounding the site.	Analysis of surface water samples for TCL, TAL, indicators and field pH and conductivity. Analysis of sediments for TCL and TAL parameters.	Level IV Data for TCL, TAL Level III Data for Indicators Level I Data for pH and conductivity.	8 Surface Water 8 Sediments
nitoring Well onstruction	5	Installation of 2 additional monitoring well nests (total of 4 monitoring wells).	To better define the "window" where the clay layer may be missing and allowing migration between the upper and lower aquifers.			0
roundwater Sampling	6	Sampling of 21 existing and the 4 new monitoring wells. Measurement of water levels four times during the investigation.	To evaluate potential groundwater flow paths, assess the groundwater contamination migration pathway, and to characterize the groundwater quality.	Analysis of groundwater samples for TCL, TAL, indicators and field pH and conductivity.	Level IV Data for TCL, TAL Level III Data for Indicators Level I Data for pH and conductivity.	25 Groundwaters
quifer Tests	7	Collection of 2 soil samples at each new monitoring well nest location. Samples will represent the upper aquifer and material directly overlying the bedrock.	The upper aquifer samples will be used to assess the upper aquifer material. The material directly over the bedrock will be used to assess the retardative nature of the material and assess its potential to act as an aquitard.	Analysis of soil samples for grain size distribution.	Level III Data	4 Soil Borings

TABLE 1
(CONTINUED)

CTIVITY	TASK	DESCRIPTION	INTENDED DATA USAGES	ANALYSIS PARAMETERS	DATA QUALITY OBJECTIVE (ANALYTICAL LEVEL)	ANTICIPATED NO. OF INVESTIGATIVE SAMPLES
EFINE NATURE AND EXTENT OF CONTAMINATION (CONTINUED)						
eteorological Data ollection	8	Collection of daily temperature, precipitation, wind direction and wind velocity data.	Precipitation records will represent the original source of groundwater, surface water and leachate. Wind directions and velocity data will be used construct wind rose diagrams and will represent probable air migration routes from the site.			0
dditional Water evel Measurements	9	Water levels collected at lower aquifer monitoring wells.	To verify the hydraulic gradient of the lower aquifer.			0
ater Supply Sampling	9	Sampling of 26 water supply wells.	To characterize the water quality and determine if water supply wells have been affected by the contaminant plume.	Analysis of water supply wells for VOCs with low level detection limit requirements.	Level V Data for VOCs	26 Water Supply Wells
DENTIFY AND QUANTIFY SOURCES OF CONTAMINATION						
eachate Volume valuation	~~10~~ 11	Leachate level measurements at all headwells six times during the investigation.	To estimate leachate volume and generation rate.			0
andfill Leachate ampling	~~11~~ 12	Sampling of 4 leachate headwells.	To identify the characteristics of the leachate within the landfill.	Analysis of leachate samples for TAL, TCL, COD and indicator parameters.	Level IV Data for TAL, TCL Level III Data for COD and Indicators	4 Leachates
andfill Gas ampling	~~12~~ 13	Sampling of 2 high flow vents. Measurement of gas flow volume from 24 headwell/vents.	To provide an indication of gas production in various areas of the site. To characterize the landfill gas and to provide for modeling of probable air migration.	Analysis of leachate gas samples for VOCs.	Level V Data	2 Landfill Gas Samples

TABLE 2
SAMPLE TYPE AND ESTIMATED SAMPLE NUMBERS
BLACKWELL LANDFILL SITE

SAMPLE (1) MATRIX	LAB (2)	NO. OF SAMPLES	FIELD DUPLICATES	FIELD (3) BLANKS	MS/MSD (4)	TOTAL NO. SAMPLES	TEST (5,7) PARAMETERS
DEFINE NATURE AND EXTENT OF CONTAMINATION							
Soil Sampling	Warzyn	3	1	0	-	4	TAL Inorganics
	Compuchem	3	1	0	-	4	TCL Volatiles
	Compuchem	3	1	0	-	4	TCL Semivolatiles
	Compuchem	3	1	0	-	4	TCL Pest/PCBs
Surface Water Sampling	Warzyn	8	1	1	-	10	TAL-Inorganics
	Compuchem	8	1	1	1	10	TCL-Volatiles
	Compuchem	8	1	1	1	10	TCL-Semivolatiles
	Compuchem	8	1	1	1	10	TCL-Pest/PCBs
	Warzyn	8	1	1	-	10	Alk,Cl,SO4,TKN, NH3,NO3+NO2,TDS
Sediment Sampling	Warzyn	8	1	0	-	9	TAL-Inorganics
	Compuchem	8	1	0	-	9	TCL-Volatiles
	Compuchem	8	1	0	-	9	TCL-Semivolatiles
	Compuchem	8	1	0	-	9	TCL-Pest/PCBs
Groundwater Monitoring	Warzyn	25	3	3	-	31	TAL-Inorganics
	Compuchem	25	3	3	2	31	TCL-Volatiles
	Compuchem	25	3	3	2	31	TCL-Semivolatiles
	Compuchem	25	3	3	2	31	TCL-Pest/PCBs
	Warzyn	25	3	3	-	31	Alk,Cl,SO4,TKN, NH3,NO3+NO2,TDS
Soil Borings	EWI Eng.	4	1	0	-	5	Grain Size
Water Supply Sampling	Compuchem	26	3	3	2	32	TCL-Volatiles(6)
IDENTIFY AND QUANTIFY SOURCES OF CONTAMINATION							
Leachate Headwell Sampling	Warzyn	4	1	1	-	6	TAL-Inorganics
	Compuchem	4	1	1	1	6	TCL-Volatiles
	Compuchem	4	1	1	1	6	TCL-Semivolatiles
	Compuchem	4	1	1	1	6	TCL-Pest/PCBs
	Warzyn	4	1	1	-	6	Alk,Cl,SO4,TKN, NH3,NO3+NO2,TDS, COD
Landfill Gas Vent Sampling	Enseco	2	1	1	-	4	Volatile Organics

TABLE 2
(Continued)

Notes

(1) Samples will be considered low or medium concentration.

(2) Compuchem
3308 Chapel Hill/Nelson Hwy
Research Triangle Park, NC 27709

Warzyn Engineering Inc.
One Science Court
Madison, WI 53705

EWI Engineering
505 Science Court
Madison, WI 53705

Enseco, Inc.
9537 Telstar Ave.
Suite 118
El Monte, CA 91731

(3) A trip blank for VOC analysis will be included with each cooler shipped for aqueous (leachate, groundwater, surface water and water supply wells) samples. One trip blank (pre-cleaned SUMMA passivated canister) is required for the sampling of landfill gas vents for volatiles.

(4) EXTRA VOLUME REQUIREMENT: Extra volume is required for the TCL organic MS/MSD quality control requirement (triple volume for VOC, double volume for BNAs and Pesticides/PCBs). TAL inorganics and general water quality indicator parameters require MS/MSD analysis, however, do not require additional sample volume to meet the specified QC.

(5) See Appendix A for EPA TCL and TAL analyte lists.

(6) Low level detection limits required for water supply wells (see Appendix D).

(7) Groundwater samples for metals analysis will be field filtered through a 0.45 micron filter prior to the addition of preservatives.

TABLE 3

SAMPLE QUANTITIES, CONTAINERS, PRESERVATIVES AND PACKAGING FOR SAMPLES FROM THE BLACKWELL LANDFILL SITE RI/FS

Analysis	Bottles and Jars	Preservation	Holding Time(2)	Volume of Samples	Shipping	Normal Packaging (1)
Low Concentration (Organics)						
Groundwater Samples						
Extractable, Base/neutral, and acids	Two 1-Liter amber glass bottles	Iced to 4°C	5 days from VTSR to extraction, analysis within 40 days after extraction	Fill bottle to neck	Shipped daily by overnight carrier	Vermiculite
Pesticides/PCBs	Two 1-Liter amber glass bottles	Iced to 4°C	5 days from VTSR to extraction, analysis within 40 days after extraction	Fill bottle to neck	Shipped daily by overnight carrier	Vermiculite
Volatiles	Two 40-mL volatile organic analysis (VOA) vials.	1:1 HCL (2 drops/vial), iced to 4°C.	10 days from VTSR	Fill completely no headspace	Shipped daily by overnight carrier	Vermiculite
Water Supply Well Samples						
Volatiles	Four 40-mL VOA vials	Iced to 4°C.	7 days	Fill completely no headspace	Shipped daily by overnight carrier	Vermiculite
Surface Water Samples						
Extractable, Base/neutral, and acids	Two 1-Liter amber glass bottles	Iced to 4°C	5 days from VTSR to extraction, analysis within 40 days after extraction	Fill bottle to neck	Shipped daily by overnight carrier	Vermiculite
Pesticides/PCBs	Two 1-Liter amber glass bottles	Iced to 4°C	5 days from VTSR to extraction, analysis within 40 days after extraction	Fill bottle to neck	Shipped daily by overnight carrier	Vermiculite
Volatiles	Two 40-mL VOA vials	1:1 HCL (2 drops/vial), iced to 4°C.	10 days from VTSR	Fill completely no headspace	Shipped daily by overnight carrier	Vermiculite

TABLE 3
(Continued)

Analysis	Bottles and Jars	Preservation	Holding Time(2)	Volume of Samples	Shipping	Normal Packaging (1)
Leachate Samples						
Extractable, Base/neutral, and acids	Two 1-Liter amber glass bottles	Iced to 4°C	5 days from VTSR to extraction, analysis within 40 days after extraction	Fill bottle to neck	Shipped daily by overnight carrier	Vermiculite
Pesticides/PCBs	Two 1-Liter amber glass bottles	Iced to 4°C	5 days from VTSR to extraction, analysis within 40 days after extraction	Fill bottle to neck	Shipped daily by overnight carrier	Vermiculite
Volatiles	Two 40-mL VOA vials	Iced to 4°C.	7 days	Fill completely no headspace	Shipped daily by overnight carrier	Vermiculite
Low Concentration (Inorganics)						
Groundwater Samples						
Metals	One 1-liter high density polyethylene bottle	Field filter through 0.45 um filter. HNO_3 to pH<2. Iced to 4°C.	180 days from VTSR (26 days from VTSR for mercury)	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
Cyanide	One 1-liter high density polyethylene bottle	Add NaOH to pH>12. Iced to 4°C	12 days from VTSR	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
Surface Water Samples						
Metals	One 1-liter high density polyethylene bottle	HNO_3 to pH<2. Iced to 4°C.	180 days from VTSR (26 days from VTSR for mercury)	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
Cyanide	One 1-liter high density polyethylene bottle	Add NaOH to pH>12. Iced to 4°C	12 days from VTSR	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
Leachate Samples						
Metals	One 1-liter high density polyethylene bottle	HNO_3 to pH<2. Iced to 4°C.	180 days from VTSR (26 days from VTSR for mercury)	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite

TABLE 3
(Continued)

Analysis	Bottles and Jars	Preservation	Holding Time(2)	Volume of Samples	Shipping	Normal Packaging (1)
Cyanide	One 1-liter high density polyethylene bottle	Add NaOH to pH>12. Iced to 4°C	12 days from VTSR	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
Water Quality Parameters						
Groundwater Samples						
TKN, Nitrate + Nitrite-N and Ammonia	One 1-liter high density polyethylene bottle	H_2SO_4 to pH<2. Iced to 4°C.	28 days	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
Alkalinity, Chloride, Sulfate	One 500-mL polyethylene bottle	Iced to 4°C.	28 days (14 days alkalinity)	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
TDS	One 500-mL polyethylene bottle	Field filter through 0.45 um filter. Iced to 4°C	7 days	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
Surface Water Samples						
TKN, Nitrate + Nitrite-N and Ammonia	One 1-liter high density polyethylene bottle	H_2SO_4 to pH<2. Iced to 4°C.	28 days	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
Alkalinity, Chloride, Sulfate	One 500-mL polyethylene bottle	Iced to 4°C.	28 days (14 days alkalinity)	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
TDS	One 500-mL polyethylene bottle	Iced to 4°C.	7 days	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
Leachate Samples						
TKN, Nitrate+Nitrite-N, Ammonia and COD	One 1-liter high density polyethylene bottle	H_2SO_4 to pH<2. Iced to 4°C.	28 days	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
Alkalinity, Chloride, Sulfate	One 500-mL polyethylene bottle	Iced to 4°C.	28 days (14 days alkalinity)	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
TDS	One 500-mL polyethylene bottle	Iced to 4°C.	7 days	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite

TABLE 3
(Continued)

Analysis	Bottles and Jars	Preservation	Holding Time(2)	Volume of Samples	Shipping	Normal Packaging (1)
Low or Med Concentration (Organics)						
Soil and Sediment Samples						
Extractable, Base/neutral and acids	One 8-oz wide mouth glass jar	Iced to 4°C	10 days from VTSR to extraction, analysis within 40 days after extraction.	Fill 3/4 full	Shipped daily by overnight carrier	Vermiculite (Med in cans/ vermiculite)
Pesticides/PCBs	One 8-oz wide mouth glass jar	Iced to 4°C	10 days from VTSR extraction, analysis within 40 days after extraction.	Fill 3/4 full	Shipped daily by overnight carrier	Vermiculite (Med in cans/ vermiculite)
Volatiles	Two 4-oz wide mouth glass jars	Iced to 4°C	10 days from VTSR	Fill Completely no headspace	Shipped daily by overnight carrier	Vermiculite (Med in cans/ vermiculite)
Low or Med Concentration (Inorganics)						
Soil and Sediment Samples						
Metals and Cyanide	One 8-oz wide mouth glass jar	Iced to 4°C	180 days from VTSR (26 days from VTSR for mercury and 12 days from VTSR for cyanide)	Fill 3/4 full	Shipped daily by overnight carrier	Vermiculite (Med in cans/ vermiculite)
Physical Analysis						
Soil Samples						
Grain Size Distribution	Two 8-oz wide mouth glass jars	NONE	Not established	Fill 3/4 full	Ship by carrier	Vermiculite

TABLE 3
(Continued)

Analysis	Bottles and Jars	Preservation	Holding Time(2)	Volume of Samples	Shipping	Normal Packaging (1)
Landfill Gas Analysis						
Volatiles	One 6-liter SUMMA passivated canister	Iced to 4°C.	Not established	Fill as described in procedure.	Shipped daily by overnight carrier	Vermiculite

Notes
(1) The packing material should completely cushion the sample bottles - botttom, sides and top.
(2) VTSR - verified time of sampling receipt. Unless otherwise noted the holding time is from the date sampled.

TABLE 4
SUMMARY OF QUALITY CONTROL REQUIREMENTS FOR ANALYSES PERFORMED AT THE BLACKWELL LANDFILL SITE RI/FS

PARAMETER	AUDIT	FREQUENCY[1]	LIMITS[2]
TCL Organics	Requirements per SOW 2/88 (or most current)		
TAL Inorganics	Requirements per SOW 7/88 (or most current)		
TCL Volatiles (Low Level Detection Limits for Water Supply Wells)	The acceptance control limits specified in Sections 8,9 and 11 of the SOP (Appendix B-3) should be met. Method blank sampls shall be analyzed daily and at the beginning of the day before analysis of any samples, and at the beginning of each 12 hour shift. MS/MSD should be analyzed at a frequency of on3 per group of 20 or fewer samples analyzed.		
Alkalinity, Choride, Sulfate, Nitrate+Nitrate Nitrogen			
	Lab Blank	1 per 10 samples	< Detection Limit (DL)
	Check Standard	1 per 10 samples	90 - 110 % Recovery
	EPA QC Reference Standard	1 per set	80 - 120 % Recovery
	Lab Duplicate	1 per 10 samples	10 RPD (± 2xDL if sample concentration is <5 x DL)
	Matrix Spike	1 per 10 samples	85 - 115 % Recovery
	Standard at 2 times detection limit	1 per set after calibration and EPA QC reference standard.	± Instrument DL
Chemical Oxygen Demand			
	Lab Blank	1 per 10 samples	< Detection Limit (DL)
	Check Standard	1 per 10 samples	90 - 110 % Recovery
	EPA QC Reference Standard	1 per set	80 - 120 % Recovery
	Lab Duplicate	1 per 10 samples	10 RPD (± 2xDL if sample concentration is <5 x DL)
	Matrix Spike	1 per 10 samples	85 - 115 % Recovery

TABLE 4
(continued)

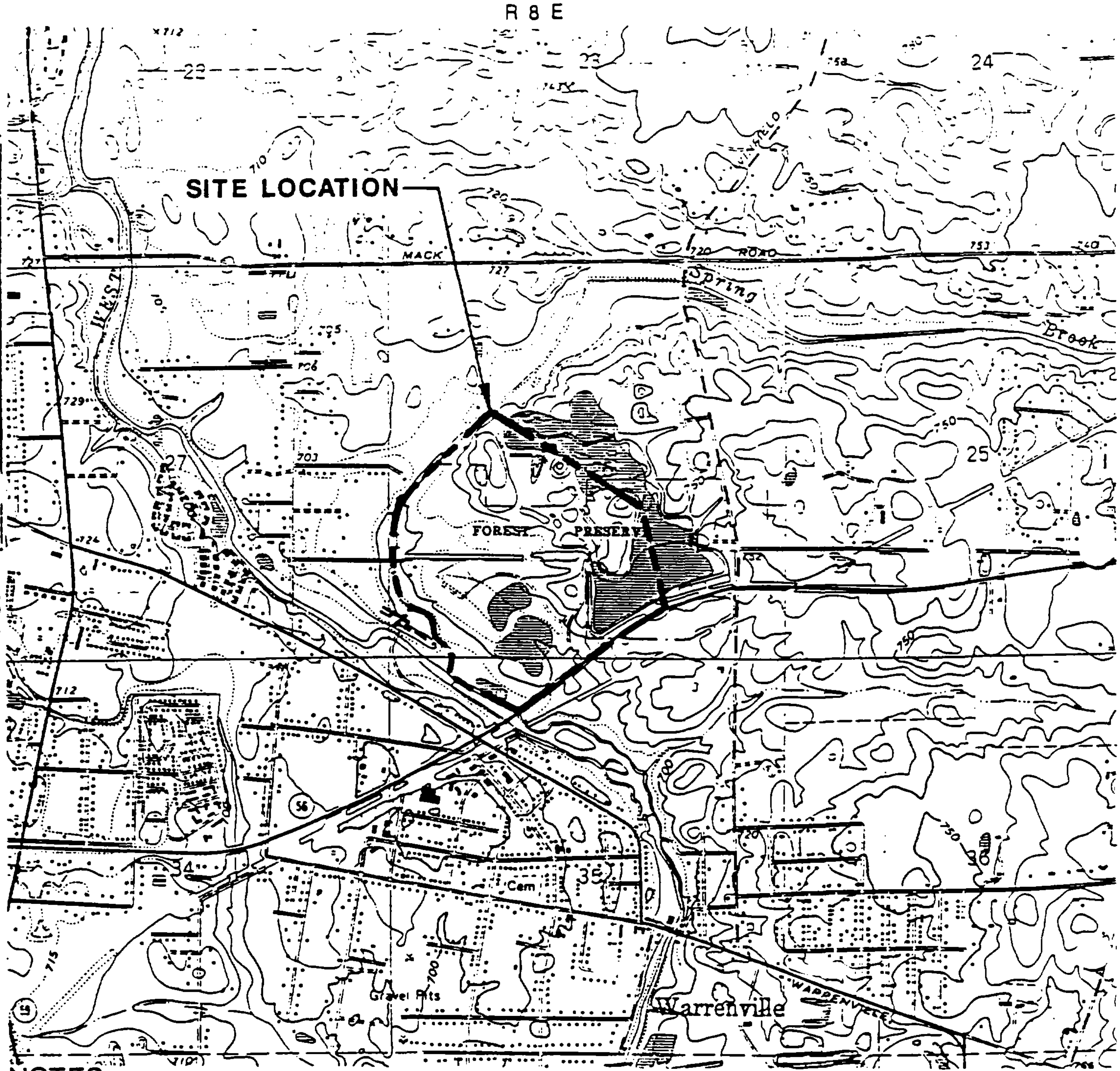
PARAMETER	AUDIT	FREQUENCY[1]	LIMITS[2]
Ammonia Nitrogen			
	Lab Blank	1 per 10 samples	< DL
	Preparation Blank	1 per set	< DL
	Check Standard	1 per 10 samples	90 - 110 % Recovery
	EPA QC Reference Standard	1 per set	80 - 120 % Recovery
	Lab Duplicate	1 per 10 samples	10 RPD (± 2xDL if sample concentration is <5 x DL)
	Matrix Spike	1 per 10 samples	85 - 115 % Recovery
TKN			
	Lab Blank	1 per 10 samples	< DL
	Preparation Blank	1 per set	< DL
	Check Standard	1 per 10 samples	90 - 110 % Recovery
	EPA QC Reference Standard	1 per set	80 - 120 % Recovery
	Lab Duplicate	1 per 10 samples	10 RPD (± 2xDL if sample concentration is <5 x DL)
	Matrix Spike	1 per 10 samples	85 - 115 % Recovery
Total Dissolved Solids			
	Lab Blank	1 per set	< DL
	EPA QC Reference Standard	1 per set	80 - 120 % Recovery
	Lab Duplicate	1 per 10 samples	10 RPD (± 2xDL if sample concentration is <5 x DL)
Grain Size Distribution			
	Lab Duplicate	1 per 10 samples	10 RPD or <2% by weight

TABLE 4
(continued)

PARAMETER	AUDIT	FREQUENCY[1]	LIMITS[2]
Field pH			
	Check Standard	1 per 10 samples	± 0.05 pH unit of buffer selection
	Duplicate	1 per 10 samples	± 0.2 pH unit
Field Specific Conductance			
	Check Standard	1 per 10 samples	± 5% of standard
	Duplicate	1 per 10 samples	15 RPD (± 2xDL if sample concentration is <5 x DL)
Volatile Organic Compounds (for leachate gas samples)			
	Check Standard	One standard containing all target compounds (after initial tuning)	90 % of the target compounds must be within ± 30 % of the 3 point calibration curve.
	Lab Control Sample and Duplicate Control Sample (containing 5 specified compounds)	1 per 20 samples	85 - 115 % and <20 RPD (for all 5 compounds)
	System Blank	1 per 20 samples	All compounds < MDL

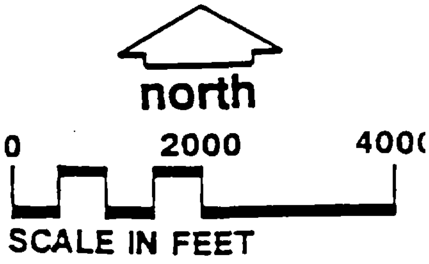
[1] Frequencies apply to each individual matrix.
[2] Refer to Appendix A for required detection limits for each analyte.

FIGURES



NOTES

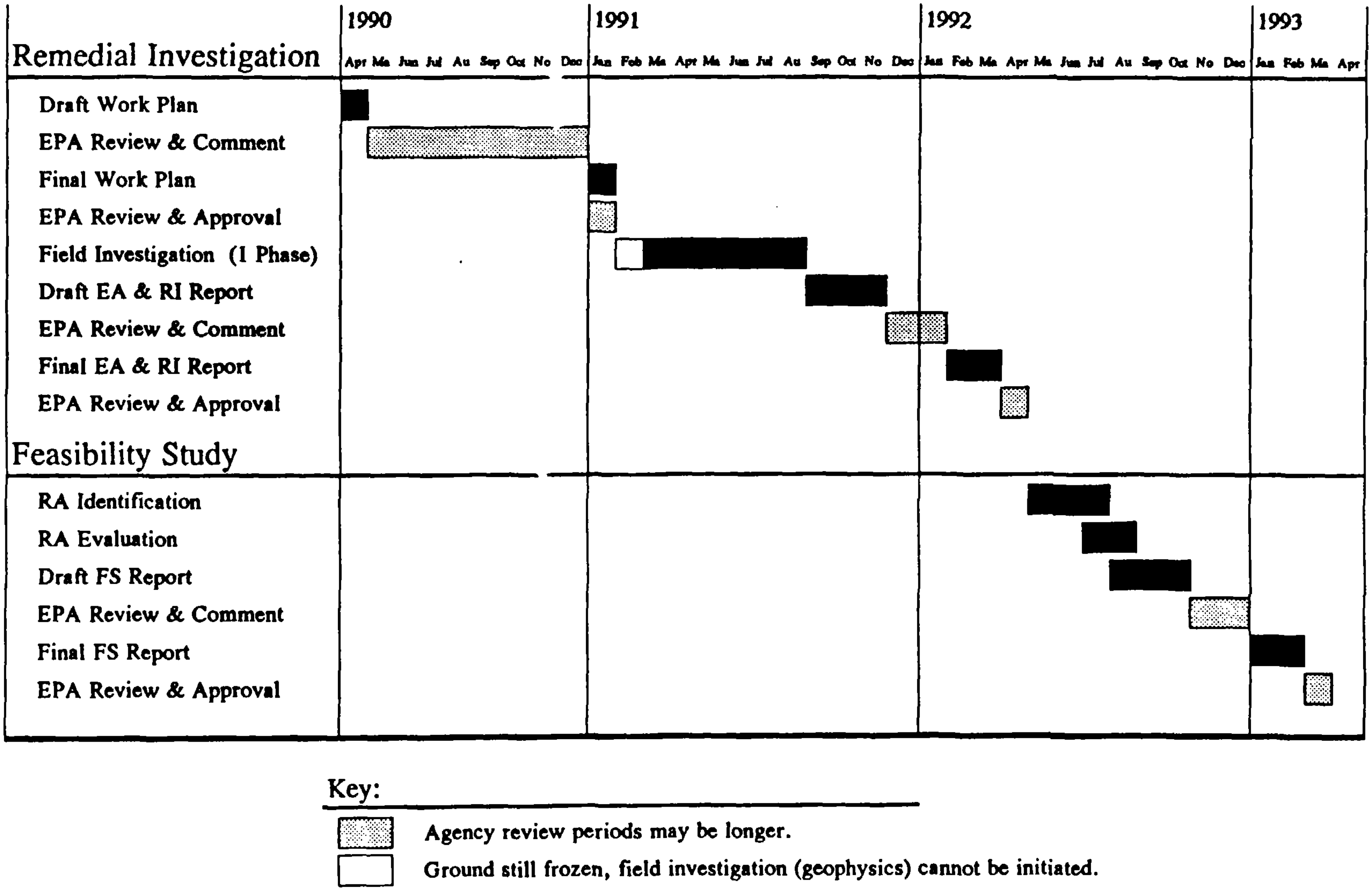
1. BASE MAP DEVELOPED FROM NAPERVILLE, ILLINOIS 7.5 MINUTE USGS TOPOGRAPHIC QUADRANGLE MAP DATED 1962, PHOTOREVISED 1972 AND 1980.



FIGURE

WARZYN	SITE LOCATION MAP	Drawn	Checked JAW	App'd. Julie A. Widman
	FIELD SAMPLING PLAN REMEDIAL INVESTIGATION / FEASIBILITY STUDY BLACKWELL LANDFILL NPL SITE DU PAGE COUNTY, ILLINOIS	Revisions		Date 4/12/90 60721 A

Figure 2. RI/FS Schedule



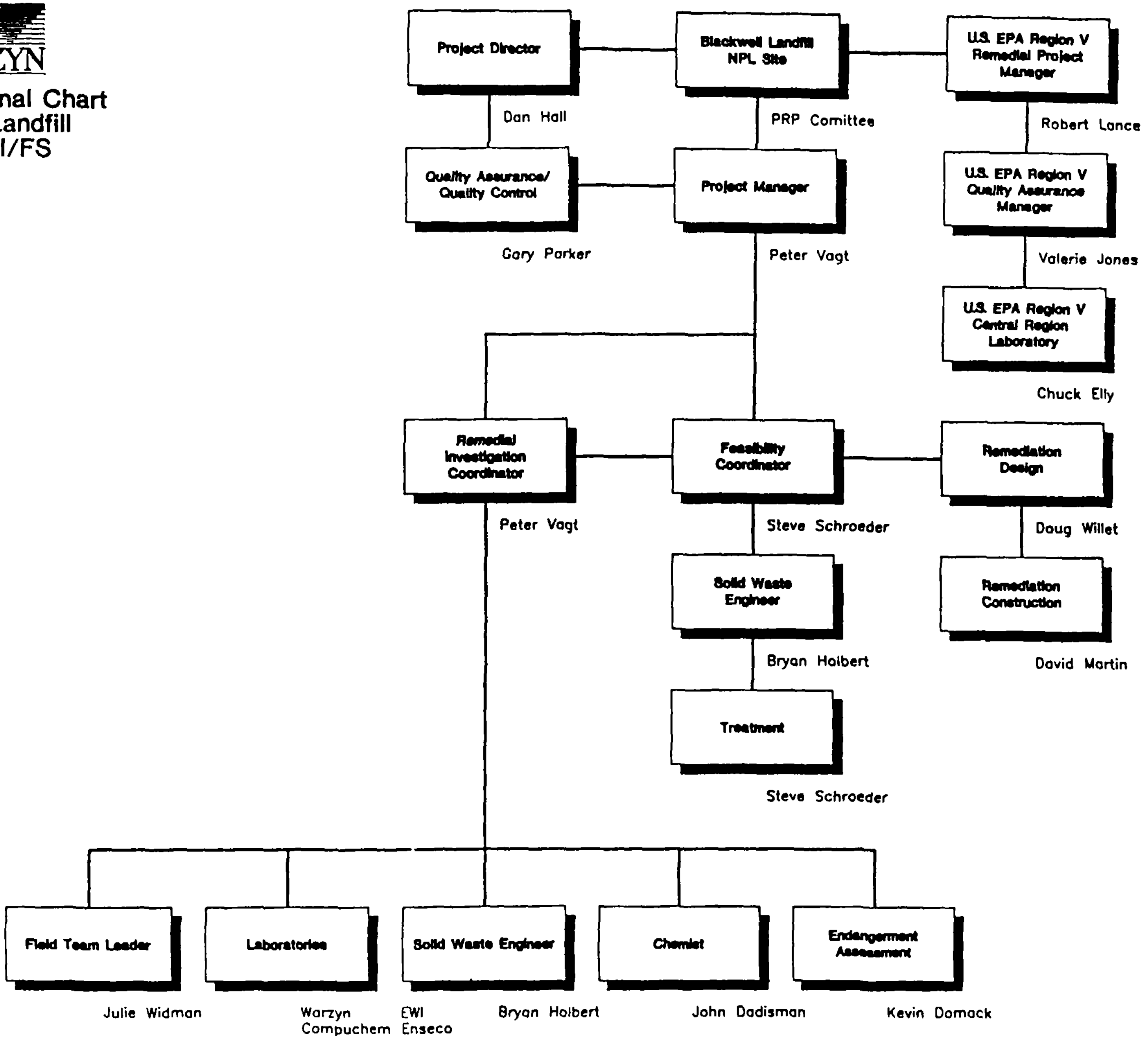
SAMPLE IDENTIFICATION MATRIX

CASE NUMBER	CRL NUMBER	MATRIX	SAMPLE NUMBER	OTR OR HHTR	ITR	CHAIN OF CUSTODY	LAB	DATE SAMPLED	DATE SHIPPED	AIRBILL NUMBER	SAMPLE TAG NUMBERS		QC LOT NUMBERS	

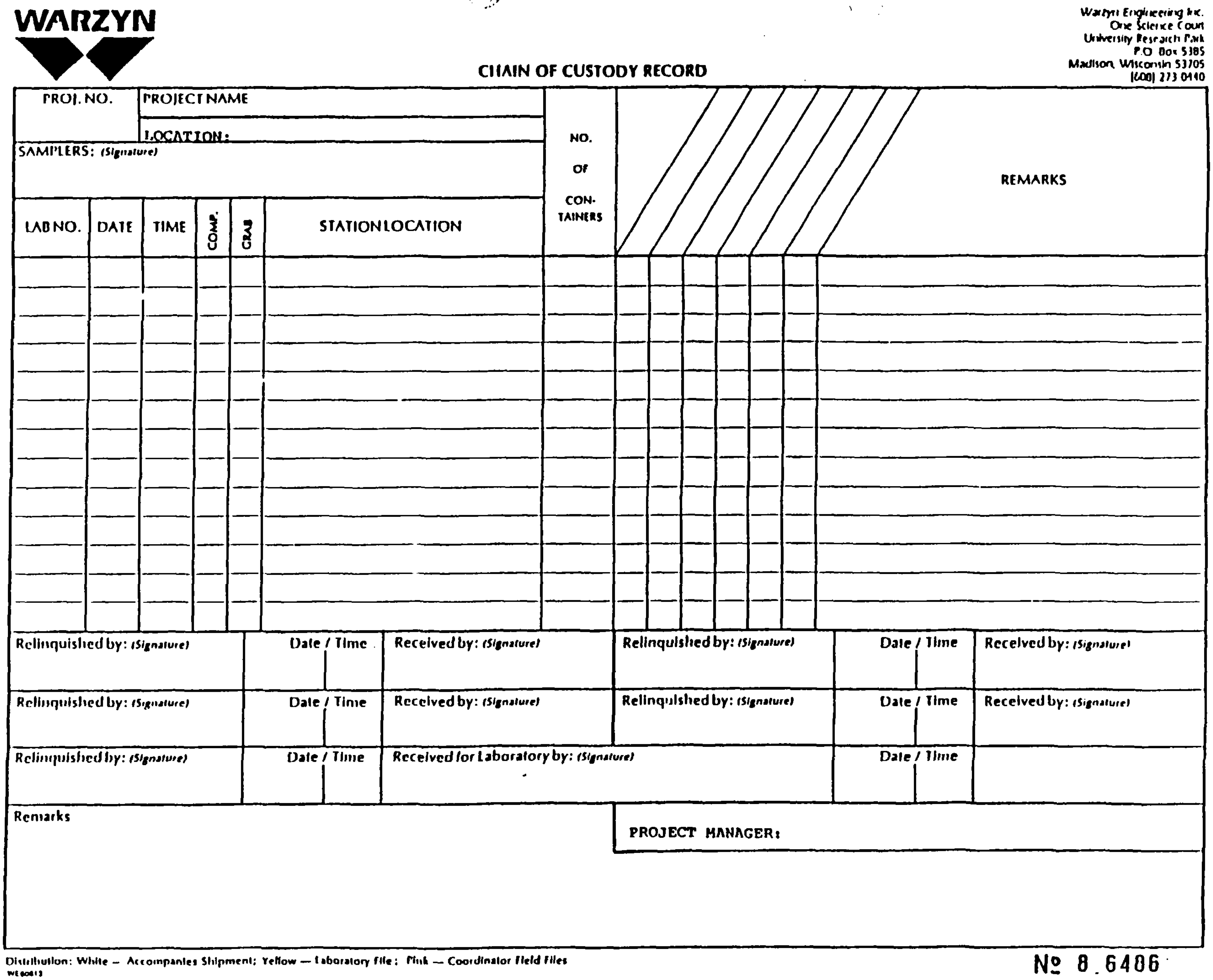
Figure 3. Sample Identification

WARZYN

Organizational Chart
Blackwell Landfill
NPL Site RI/FS
Figure 4



C0721\ORGCHT1



WARZYN

Warzyn Engineering Inc.
One Science Court
University Research Park
P.O. Box 5385
Madison, Wisconsin 53705
(608) 273-0440

CHAIN OF CUSTODY RECORD

PROJ. NO.

PROJECT NAME

LOCATION:

SAMPLERS: *(Signature)*

LAB NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CON-TAINERS							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	

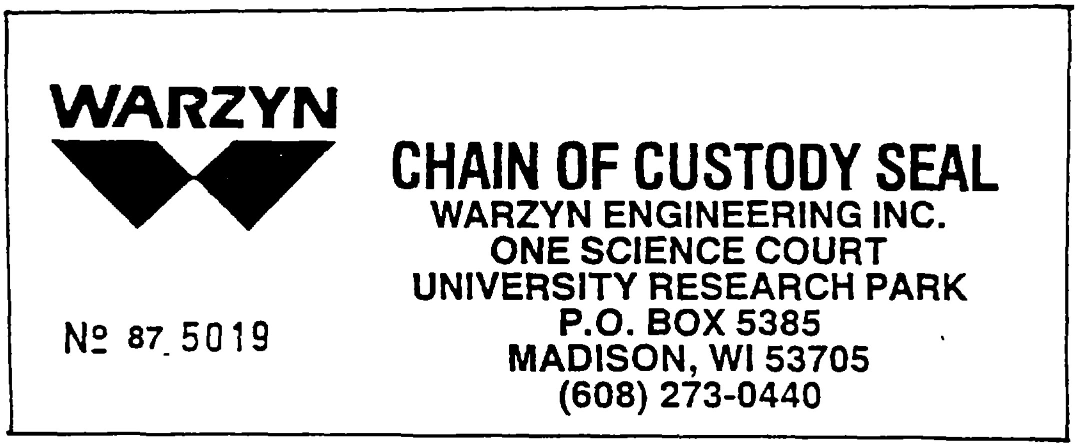
Remarks

PROJECT MANAGER:

Distribution: White — Accompanies Shipment; Yellow — Laboratory File; Pink — Coordinator Field Files

№ 8 6406

Figure 5. Chain-of-Custody Record



WARZYN

CHAIN OF CUSTODY SEAL
WARZYN ENGINEERING INC.
ONE SCIENCE COURT
UNIVERSITY RESEARCH PARK
P.O. BOX 5385
MADISON, WI 53705
(608) 273-0440

№ 87-5019

Figure 6. Chain-of-Custody Seal

Project # ________________ **Lab #** ________

Sample Description ______________________

Date Collected ____________ **By** ____________

Preservative: HNO_3 H_2SO_4 NaOH None Other ____

Filtered Unfiltered

Figure 7. Sample Label

Date ______________________

FIELD TESTING/SAMPLE PREPARATION

Page of

Lab #	Sample #	Time Filtered/ Analyzed	pH	Spec. Cond.	Temp.	Spec. Cond. @ 25°	Analyst	Comments

Filter:

pH Meter: ______________________

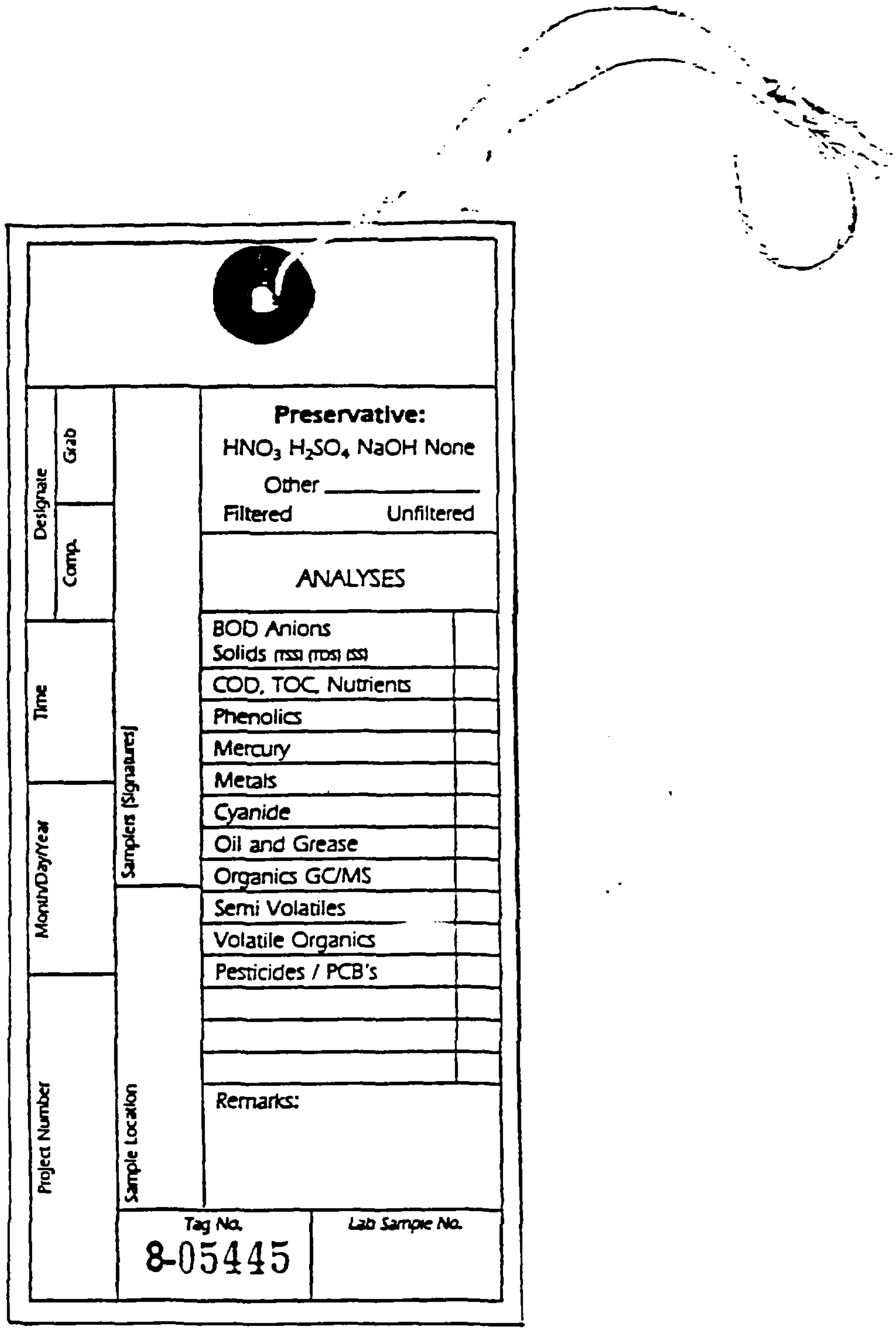
Conductivity Meter: ______________________

Bottle Types/Preservation: ______________________

Conductivity of Standard: ______________________

PVC/cwl/mlf
[mlf-160-31]

Figure 9. Field pH and Specific Conductance Bench Sheet



Designate

Grab

Comp.

Time

Month/Day/Year

Project Number

Samplers (Signatures)

Sample Location

Preservative:

HNO_3 H_2SO_4 NaOH None

Other __________

Filtered Unfiltered

ANALYSES

BOD Anions Solids (TSS) (TDS) (SS)	
COD, TOC, Nutrients	
Phenolics	
Mercury	
Metals	
Cyanide	
Oil and Grease	
Organics GC/MS	
Semi Volatiles	
Volatile Organics	
Pesticides / PCB's	

Remarks:

Tag No. 8-05445	Lab Sample No.

Figure 8. Sample Tag

APPENDICES

APPENDIX A

ANALYTE LISTS AND DETECTION LIMITS

FIELD MEASUREMENTS

Parameter	Required Detection Limit
pH	1.00 (s.u.)
Specific Conductance @25 deg. C	10 (umhos/cm)

WATER QUALITY INDICATOR PARAMETERS

PARAMETER	REQUIRED DETECTION LIMIT (MG/L)
Alkalinity	5.0
Chloride	1.0
Sulfate	5.0
Ammonia Nitrogen	0.10
Nitrate+Nitrite Nitrogen	0.02
Total Kjeldahl Nitrogen	0.10
Total Dissolved Solids	20
Chemical Oxygen Demand (Leachates only)	20

INORGANIC TARGET ANALYTE LIST (TAL)

Analyte	Contract Required Detection Limit (1,2) (ug/L)
Aluminum	200
Antimony	60
Arsenic	10
Barium	200
Beryllium	5
Cadmium	5
Calcium	5000
Chromium	10
Cobalt	50
Copper	25
Iron	100
Lead	3
Magnesium	5000
Manganese	15
Mercury	0.2
Nickel	40
Potassium	5000
Selenium	5
Silver	10
Sodium	5000
Thallium	10
Vanadium	50
Zinc	20
Cyanide	10

(1) Subject to the restrictions specified in the first page of Part G, Section IV of Exhibit D (Alternate Methods - Catastrophic Failure) any analytical method specified in SOW Exhibit D may be utilized as long as the documented instrument or method detection limits meet the Contract Required Detection Limit (CRDL) requirements. Higher detection limits may only be used in the following circumstance:

> If the sample concentration exceeds five times the detection limit of the instrument or method in use, the value may be reported even though the instrument or method detection limit may not equal the Contract Required Detection Limit. This is illustrated in the example below:
>
> For lead:
>
> Method in use - ICP
> Instrument Detection Limit (IDL) - 40
> Sample concentration - 220
> Contract Required Detection Limit (CRDL) - 3

The value of 220 may be reported even though instrument detection limit is greater than CRDL. The instrument or method detection limit must be documented as described in Exhibit E.

(2) The CRDL are the instrument detection limits obtained in pure water that must be met using the procedure in Exhibit E. The detection limits for samples may be considerably higher depending on the sample matrix.

Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL)*

		Quantitation Limits**	
Volatiles	CAS Number	Water ug/L	Low Soil/Sediment^a ug/Kg
1. Chloromethane	74-87-3	10	10
2. Bromomethane	74-83-9	10	10
3. Vinyl Chloride	75-01-4	10	10
4. Chloroethane	75-00-3	10	10
5. Methylene Chloride	75-09-2	5	5
6. Acetone	67-64-1	10	10
7. Carbon Disulfide	75-15-0	5	5
8. 1,1-Dichloroethene	75-35-4	5	5
9. 1,1-Dichloroethane	75-34-3	5	5
10. 1,2-Dichloroethene (total)	540-59-0	5	5
11. Chloroform	67-66-3	5	5
12. 1,2-Dichloroethane	107-06-2	5	5
13. 2-Butanone	78-93-3	10	10
14. 1,1,1-Trichloroethane	71-55-6	5	5
15. Carbon Tetrachloride	56-23-5	5	5
16. Vinyl Acetate	108-05-4	10	10
17. Bromodichloromethane	75-27-4	5	5
18. 1,2-Dichloropropane	78-87-5	5	5
19. cis-1,3-Dichloropropene	10061-01-5	5	5
20. Trichloroethene	79-01-6	5	5
21. Dibromochloromethane	124-48-1	5	5
22. 1,1,2-Trichloroethane	79-00-5	5	5
23. Benzene	71-43-2	5	5
24. trans-1,3-Dichloropropene	10061-02-6	5	5
25. Bromoform	75-25-2	5	5
26. 4-Methyl-2-pentanone	108-10-1	10	10
27. 2-Hexanone	591-78-6	10	10
28. Tetrachloroethene	127-18-4	5	5
29. Toluene	108-88-3	5	5
30. 1,1,2,2-Tetrachloroethane	79-34-5	5	5

(continued)

Volatiles	CAS Number	Quantitation Limits** Water ug/L	Quantitation Limits** Low Soil/Sediment[a] ug/Kg
31. Chlorobenzene	108-90-7	5	5
32. Ethyl Benzene	100-41-4	5	5
33. Styrene	100-42-5	5	5
34. Xylenes (Total)	1330-20-7	5	5

---

[a] Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for Volatile TCL Compounds are 125 times the individual Low Soil/Sediment CRQL.

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

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

Target Compound List (TCL) and
Contract Required Quantitation Limits (CRQL)*

Semivolatiles	CAS Number	Quantitation Limits** Water ug/L	Low Soil/Sediment[b] ug/Kg
35. Phenol	108-95-2	10	330
36. bis(2-Chloroethyl) ether	111-44-4	10	330
37. 2-Chlorophenol	95-57-8	10	330
38. 1,3-Dichlorobenzene	541-73-1	10	330
39. 1,4-Dichlorobenzene	106-46-7	10	330
40. Benzyl alcohol	100-51-6	10	330
41. 1,2-Dichlorobenzene	95-50-1	10	330
42. 2-Methylphenol	95-48-7	10	330
43. bis(2-Chloroisopropyl) ether	108-60-1	10	330
44. 4-Methylphenol	106-44-5	10	330
45. N-Nitroso-di-n-dipropylamine	621-64-7	10	330
46. Hexachloroethane	67-72-1	10	330
47. Nitrobenzene	98-95-3	10	330
48. Isophorone	78-59-1	10	330
49. 2-Nitrophenol	88-75-5	10	330
50. 2,4-Dimethylphenol	105-67-9	10	330
51. Benzoic acid	65-85-0	50	1600
52. bis(2-Chloroethoxy) methane	111-91-1	10	330
53 2,4-Dichlorophenol	120-83-2	10	330
54. 1,2,4-Trichlorobenzene	120-82-1	10	330
55. Naphthalene	91-20-3	10	330
56. 4-Chloroaniline	106-47-8	10	330
57. Hexachlorobutadiene	87-68-3	10	330
58. 4-Chloro-3-methylphenol (para-chloro-meta-cresol)	59-50-7	10	330
59. 2-Methylnaphthalene	91-57-6	10	330
60. Hexachlorocyclopentadiene	77-47-4	10	330
61. 2,4,6-Trichlorophenol	88-06-2	10	330
62. 2,4,5-Trichlorophenol	95-95-4	50	1600
63. 2-Chloronaphthalene	91-58-7	10	330
64. 2-Nitroaniline	88-74-4	50	1600
65. Dimethylphthalate	131-11-3	10	330
66. Acenaphthylene	208-96-8	10	330
67. 2,6-Dinitrotoluene	606-20-2	10	330
68. 3-Nitroaniline	99-09-2	50	1600
69. Acenaphthene	83-32-9	10	330

(continued)

Semivolatiles	CAS Number	Quantitation Limits** Water ug/L	Low Soil/Sediment[b] ug/Kg
70. 2,4-Dinitrophenol	51-28-5	50	1600
71. 4-Nitrophenol	100-02-7	50	1600
72. Dibenzofuran	132-64-9	10	330
73. 2,4-Dinitrotoluene	121-14-2	10	330
74. Diethylphthalate	84-66-2	10	330
75. 4-Chlorophenyl-phenyl ether	7005-72-3	10	330
76. Fluorene	86-73-7	10	330
77. 4-Nitroaniline	100-01-6	50	1600
78. 4,6-Dinitro-2-methylphenol	534-52-1	50	1600
79. N-nitrosodiphenylamine	86-30-6	10	330
80. 4-Bromophenyl-phenylether	101-55-3	10	330
81. Hexachlorobenzene	118-74-1	10	330
82. Pentachlorophenol	87-86-5	50	1600
83. Phenanthrene	85-01-8	10	330
84. Anthracene	120-12-7	10	330
85. Di-n-butylphthalate	84-74-2	10	330
86. Fluoranthene	206-44-0	10	330
87. Pyrene	129-00-0	10	330
88. Butylbenzylphthalate	85-68-7	10	330
89. 3,3'-Dichlorobenzidine	91-94-1	20	660
90. Benzo(a)anthracene	56-55-3	10	330
91. Chrysene	218-01-9	10	330
92. bis(2-Ethylhexyl)phthalate	117-81-7	10	330
93. Di-n-octylphthalate	117-84-0	10	330
94. Benzo(b)fluoranthene	205-99-2	10	330
95. Benzo(k)fluoranthene	207-08-9	10	330
96. Benzo(a)pyrene	50-32-8	10	330
97. Indeno(1,2,3-cd)pyrene	193-39-5	10	330
98. Dibenz(a,h)anthracene	53-70-3	10	330
99. Benzo(g,h,i)perylene	191-24-2	10	330

---

[b] Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for SemiVolatile TCL Compounds are 60 times the individual Low Soil/Sediment CRQL.

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

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

Target Compound List (TCL) and
Contract Required Quantitation Limits (CRQL)*

Pesticides/PCBs	CAS Number	Quantitation Limits** Water ug/L	Low Soil/Sediment[c] ug/Kg
100. alpha-BHC	319-84-6	0.05	8.0
101. beta-BHC	319-85-7	0.05	8.0
102. delta-BHC	319-86-8	0.05	8.0
103. gamma-BHC (Lindane)	58-89-9	0.05	8.0
104. Heptachlor	76-44-8	0.05	8.0
105. Aldrin	309-00-2	0.05	8.0
106. Heptachlor epoxide	1024-57-3	0.05	8.0
107. Endosulfan I	959-98-8	0.05	8.0
108. Dieldrin	60-57-1	0.10	16.0
109. 4,4'-DDE	72-55-9	0.10	16.0
110. Endrin	72-20-8	0.10	16.0
111. Endosulfan II	33213-65-9	0.10	16.0
112. 4,4'-DDD	72-54-8	0.10	16.0
113. Endosulfan sulfate	1031-07-8	0.10	16.0
114. 4,4'-DDT	50-29-3	0.10	16.0
115. Methoxychlor	72-43-5	0.5	80.0
116. Endrin ketone	53494-70-5	0.10	16.0
117. alpha-Chlordane	5103-71-9	0.5	80.0
118. gamma-Chlordane	5103-74-2	0.5	80.0
119. Toxaphene	8001-35-2	1.0	160.0
120. Aroclor-1016	12674-11-2	0.5	80.0
121. Aroclor-1221	11104-28-2	0.5	80.0
122. Aroclor-1232	11141-16-5	0.5	80.0
123. Aroclor-1242	53469-21-9	0.5	80.0
124. Aroclor-1248	12672-29-6	0.5	80.0
125. Aroclor-1254	11097-69-1	1.0	160.0
126. Aroclor-1260	11096-82-5	1.0	160.0

---

[c] Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for Pesticide/PCB TCL compounds are 15 times the individual Low Soil/Sediment CRQL.

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

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

TABLE 1

TARGET COMPOUND LIST (TCL) AND QUANTITATION LIMITS (QLs)

(FOR RESIDENTIAL WELL WATER SAMPLES)

VOLATILE ORGANICS	CAS NUMBER	QUANTITATION LIMITS(ug
Benzene	71-43-2	1.5
Bromdichloromethane	75-27-4	1.5
Bromoform	75-25-2	1.5
Bromomethane	74-83-9	1.5
Carbon Tetrachloride	56-23-5	1.5
Chlorobenzene	108-90-7	1.5
Chloroethane	75-00-3	1.5
Chloroform	67-66-3	1.5
Chloromethane	74-87-3	1.5
Dibromochloromethane	124-48-1	1.5
1,1-Dichloroethane	75-34-3	1.5
1,2-Dichloroethane	107-06-2	1.5
1,1-Dichloroethene	75-35-4	1.5
1,2-Dichloroethene (Total)		1.5
1,2-Dichloropropane	78-87-5	1.5
Cis-1,3-Dichloropropene	10061-01-5	2.0
Trans-1,3-Dichloropropene	10061-02-6	1.0
Ethyl Benzene	100-41-4	1.5
Methylene Chloride (*)	75-09-2	1.0
1,1,2,2-Tetrachloroethane	79-34-5	1.5
Tetrachloroethene	127-18-4	1.5
Toluene (*)	108-88-3	1.5
1,1,1-Trichloroethane	71-55-6	1.5
1,1,2-Trichloroethane	79-00-5	1.5
Trichloroethene	79-01-6	1.5
Vinyl Chloride	75-01-4	1.5
Acrolein	107-02-8	25.0
Acetone (*)	67-64-1	5.0
Acrylonitrile	107-13-1	25.0
Carbon Disulfide	75-15-0	3.0
2-Butanone (*)	78-93-3	5.0
Vinyl Acetate	108-05-4	5.0
4-Methyl-2-Pentanone	108-10-1	1.5
2-Hexanone	519-78-6	5.0
Styrene	100-42-5	1.0
m-Xylene **	108-38-3	1.5

O-Xylene **	95-47-6	1.5
p-Xylene **	106-42-3	1.5

NOTE: * Common laboratory solvent. Control limits for blanks are 5 the method detection limits.

** m-Xylene, o-Xylene and p-Xylene are reported as a total of three.

ANALYTE LIST AND REPORTING LIMITS FOR THE DETERMINATION OF VOCS IN AMBIENT AIR SAMPLES

Volatile Compound	Reporting Limit ppb (vol/vol)
Dichlorodifluoromethane	2
Chloromethane	2.5
1,2-Dichloro-1,1,2,2-Tetrafluoroethane	2
Vinyl Chloride	2.5
Bromomethane	3
Chloroethane	5
Trichlorofluoromethane	1
cis-1,2-Dichloroethene	2
Carbon Disulfide	10
1,1,2-Trichloro-1,2,2-Trifluoroethane	2
Acetone	10
Methylene Chloride	4
trans-1,2-Dichloroethene	4
1,1-Dichloroethane	2.5
Vinyl Acetate	2.5
1,1-Dichloroethene	2
2-Butanone	3
Chloroform	2
1,1,1-Trichloroethane	2
Carbon Tetrachloride	2
Benzene	3
1,2-Dichloroethane	2
Trichloroethene	2.5
1,2-Dichloropropane	8
1,4-Dioxane	7
Bromodichloromethane	2
cis-1,3-Dichloropropene	3
4-Methyl-2-Pentanone	3
Toluene	3
trans-1,3-Dichloropropene	3
1,1,2-Trichloroethane	3
Tetrachloroethene	3
2-Hexanone	5
Dibromochloromethane	3
1,2-Dibromomethane	2
Chlorobenzene	2.5
Ethylbenzene	2.5
Total Xylenes	5
Styrene	7
Bromoform	2
1,1,2,2-Tetrachloroethane	4
Benzyl Chloride	2
4-Ethyl Toluene	4
1,3,5-Trimethylbenzene	2.5
1,2,4-Trimethylbenzene	3

ANALYTE LIST AND REPORTING LIMITS FOR THE DETERMINATION OF VOCS IN AMBIENT AIR SAMPLES
(continued)

Volatile Compound	Reporting Limit ppb (vol/vol)
1,3-Dichlorobenzene	3
1,4-Dichlorobenzene	4
1,2-Dichlorobenzene	5
1,2,4-Trichlorobenzene	7
Hexachlorobutadiene	5

B

APPENDIX B

LABORATORY PROCEDURES

APPENDIX B-1

PROCEDURES FOR WATER QUALITY INDICATOR PARAMETERS

Effective Date: 2-14-90

NITRATE - AUTOANALYZER

Scope and Application: This method is applicable to drinking water, surface water, groundwater and wastewater.

Reference: EPA 1983, Method 353.2
Lachat Instruments, 1986

Detection Limit: 0.02 mg/L

Optimum Range: 0.02 - 2.00 mg/L $NO_3 + NO_2 - N$

Sample Handling: Preserve with sulfuric acid to pH <2 and refrigerate at 4°C. Analyze within 14 days. Alternatively, unpreserved samples, kept at 4°C can be analyzed within 48 hours of sampling.

Instrument Conditions:

1. Pump speed: 35
2. Cycle period: 50 seconds
3. Load period: 20 seconds
4. Inject period: 20 seconds
5. Inject to start of peak period: 22 seconds
6. Inject to end of peak period: 68 seconds
7. Gain: 450
8. Zero: 400
9. Interface filter: 520 nm
10. Sample loop: 17 cm
11. Standards for curve set-up: 0, 0.20, 0.50, 1.00, 2.00 mg/L
12. Column: (see reagents 7-10)

Reagent Preparation: (Prepare fresh every 6 months, unless otherwise stated.)

1. Degassed Milli-Q water (2 options):

   a. Boil Milli-Q water vigorously for 5 minutes. Cool and store in a cubitainer, or

   b. Bubble helium, using the fritted gas dispersion tube, through the Milli-Q water. Store in cubitainer. (15 min/20 L)

2. Stock nitrate standard (100 mg/L NO_3): In a 1 liter volumetric flask, dissolve 0.7218 potassium nitrate (KNO_3) in about 600 mL of Milli-Q water. Add 2 mL of concentrated H_2SO_4 as a preservative. Dilute to the mark. Store in a dark glass bottle. Refrigerate.

3. Working stock nitrate standard (10 mg/L NO_3): Add 50 mLs D.I. water to a 100 mL volumetric flask. Add 0.2 mLs concentrated H_2SO_4 and pipet 10.0 mL of the stock nitrate standard. Dilute to the mark with DI water. Prepare fresh every 2 weeks. Refrigerate.

4. Standards: (Prepare fresh every 2 weeks.) Preserve with 0.2 mL H_2SO_4. Dilute to volume with D.I. water. Refrigerate.

Concentration of Standard	Letter Identifier	Volume of NO_3 Standard	Dilute to
0 mg/L	A	0	100 mLs
0.20 mg/L	B	2.0	100 mLs
0.50 mg/L	C	5.0	100 mLs
1.00 mg/L	D	10.0	100 mLs
2.00 mg/l	E	20.0	100 mLs

Note: Computer refers to standards by letter.

5. Sodium hydroxide (15M): To 250 mL of D.I. water, add 150.0g NaOH. *SLOWLY! This solution will get very HOT! Swirl to dissolve. Store* in a plastic bottle.

6. Ammonium chloride buffer solution: In a 1 liter volumetric flask, dissolve 85.0g of ammonium chloride (NH_4Cl)* and 1.0g of disodium ethylenediamine tetracetate dihydrate (EDTA) in approximately 800 mL D.I. water. Adjust the pH to 8.5 with 15M NaOH. Dilute to the mark and filter through a 0.45 um filter. Refrigerate.

* See Notes #5.

7. Sulfanilamide color reagent: In a 1 liter volumetric flask, add approximately 800 mL of Milli-Q water. Then add 100 mL concentrated phosphoric acid (H_3PO_4). Add 40.0g sulfanilamide and dissolve completely. Dissolve 1.0g N-1-naphthlethylendeiamine dihydrochloride (NED) and dilute to one liter. Store in dark bottle at 4°C. Stable for 2 months when refrigerated.

8. Column Preparation:

   a. Cadmium preparation: Place 10-20g of coarse cadmium powder (granules) in a 250 mL beaker and wash with 50 mL of acetone, then distilled water, then two 50 mL portions of 1 M hydrochloric acid (8 mL concentrated hydrochloric acid plus 92 mL deionized water). Then rinse thoroughly with deionized water. If using cadmium for second time, rinse with 1 M hydrochloric acid before beginning process. CAUTION: Collect and store all waste cadmium. Wear gloves!

   b. Copperization: Prepare a 2% copper sulfate solution (20g of $CuSO_4 \cdot 5H_2O$) per liter of deionized water) and add a 100 mL portion to the cadmium prepared in "a" above. Swirl gently for about 5 minutes, then decant the liquid and repeat with a fresh 100 mL portion of 2% copper sulfate. Continue this process until colloidal copper is visible in the supernatant (a red-brown precipitate) and solution remains blue in color. Rinse with D.I. water until all colloidal copper is removed from the supernatant. Wash once with ammonium chloride buffer. The cadmium should be black or dark gray. The cadmium granules may be stored in a stoppered bottle in ammonium chloride buffer.

c. Packing the column (wear gloves!): Place a small piece of polyurethane foam (or glass wool) loosely in the end of the glass tube. Insert the plugged end of the glass tube into the column end fitting. Cut a length of 0.032" id teflon tubing 3 to 4 inches longer than the column.

Insert the teflon tube in the end fitting and fill the whole tube with water, holding the flexible tube in a U-shape so that the ends are level. Place the second end fitting on the other end of the teflon tubing. (Placing a small funnel onto the end fitting may aid filling.) Taking care that no air bubbles are introduced, place the copperized cadmium granules in the column. Tap the column gently, every 1-2 cm, to pack the granules. When the column is packed to within about 5 mm of the end of the glass column, insert another foam plug, then the column end fitting. Store the column with the ends connected with a length of teflon tubing, as air pockets or having the column dry out will necessitate repacking. If air remains in the column, connect the column to the manifold and turn the pump on maximum. Tap column firmly until all air is removed.

d. Column activation: The column must be activated before use or it will not reduce nitrate. This may be accomplished by pumping the 10 mg/L nitrate standard through the sample line. When the solution is injected, a brilliant pink color will be visible in the coil. The cadmium column efficiency should be above 80%, if less, the column must be repacked.

To check column efficiency, standardize with nitrite standards and then analyze all nitrate standards. The recovery of the nitrate standards should be consistant at all standard concentrations.

Notes:

1. Interferences:

   - Build up of suspended matter in the reduction column will restrict sample flow. Since nitrate-nitrogen is found in a soluble state, the sample must be pre-filtered.
   - Low results might be obtained for samples that contain high concentrations of iron, copper or other metals. EDTA is added to the samples to eliminate these interferences.
   - Samples that contain large concentrations of oil and grease will coat the surface of the column. This interference is eliminated by pre-extracting the sample with an organic solvent.

2. Samples must be diluted to obtain concentrations within the optimum working range.

3. The gain and zero settings are guidelines and must be optimized each day.

4. Color will interfere: dilute the sample and also spike the dilution to confirm the quality of the result. Record on data sheet.

5. ACS grade ammonium chloride has been found occasionally to contain significant nitrate contamination, so an alternative preparation for the ammonium chloride buffer (Reagent #6) is as follows:

   In the hood, add 126 mL concentrated HCl to a 1 liter volumetric flask containing 500 mL degassed Milli-Q water. Mix. Add 95 mL ammonium hydroxide and 1.0 gm disodium EDTA. Dissolve and dilute to the mark. The pH should be 8.5 ± .1, adjust pH if necessary.

System Operation:

1. Refer to Auto Analyzer Operation - Start-up Procedure (IOP# LAA-section A).

2. After pumping reagents through the lines, turn off the pump and insert column, making sure that air bubbles are not introduced into the column.

3. Activate column if necessary. (See #8d. above.)

4. Analyze an initial calibration check standard, a blank, and a reference standard at the beginning of each run. The blank must be below the IDL and standards must be within the control limits.

5. To spike samples, mix equal volumes of sample and 1.00 mg/L standard for a final spike level of 0.50 mg/L.

6. The calibration check standard is 1.00 mg/L NO_3 (D).

7. If only nitrate is requested, nitrites must be analyzed and subtracted from the nitrate + nitrite value.

8. After use, turn off the pump and remove the column from the manifold.

9. Refer to Auto-Analyzer Shut-down Procedure. (IOP# LAA-Section B.)

Quality Control:

1. Establish a standard curve with the standards listed above. The derived concentrations for each calibration standard must be within 10% of the true value. The derived value for the blank must be below the method detection limit.

2. A quality control calibration standard of 1.00 mg/L and a blank are to be analyzed, at a minimum, after every 10 samples. If less than 10 samples are analyzed, a calibration standard and blank are still required. The last samples analyzed in the run are to be the calibration standard and blank. These standards must be within the acceptable ranges or the samples run after the last acceptable check standard are to be reanalyzed.

3. Duplicate and spike a minimum of 1 out of 10 samples. If less than 10 samples are analyzed, a duplicate and spike are still required. Spike recoveries and duplicates are to be within acceptable ranges or data must be flagged appropriately.

Calculation:

1. Calculate with Lachat Quikchem software, in the concentration mode, using the IBM XT computer.

Effective Date: 10-16-90

TOTAL DISSOLVED SOLIDS

Scope and Application: This method is applicable to drinking water, surface water, groundwater, and domestic and industrial wastewaters.

Method: Gravimetric, dried at 180°C.

Reference: EPA 1983, Method 160.1

Detection Limit: 20 mg/L (using a 50 mL sample volume)

Sample Handling: Refrigerate at 4°C and analyze sample within 7 days of sampling.

Reagents and Apparatus:

1. Glass fiber filters, Whatman GF/C
2. Gelman filtration funnel and support
3. Suction flask, 1000 mL
4. Porcelain evaporating dishes
5. Volumetric pipet, 50 mL
6. Drying oven at 180°C ± 2°C
7. Desiccator
8. Analytical balance
9. Deionized water

Notes:

1. **Interferences:** Samples with high concentrations of bicarbonate, Ca, Mg, Cl, and SO_4 will require prolonged drying, desiccation, and rapid weighing.

2. Total residue should be < 200 mg. Excessive residue (>200 mg) is difficult to dry thoroughly. Use a smaller volume if TDS is suspected to be high; likewise use a larger volume if TDS is suspected low.

3. Groundwater samples which have already been filtered through a 0.45 micron membrane filter do not need to be carried through the filtration step of the procedure.

Procedure:

1. All glassware is to be soap and water washed, tap rinsed and deionized rinsed prior to analysis.

2. **Evaporating Dish Preparation:** If volatile dissolved solids are also to be analyzed, prepare the evaporating dishes by washing at 550 ± 50°C for one hour in a muffle furnace.

   Otherwise, heat the dishes at 180 ± 2°C for one hour. Cool in desiccator. Weigh. Record the weight. The dishes must be cool before being weighed (about one hour). Repeat this cycle until a constant weight is obtained (± 0.5 mg).

3. **Filter Preparation:** Place the glass fiber filter on the filtration support, place the funnel on top, and wash the filter with three 20 mL portions of deionized water while vacuum is applied. Discard the washings. The filters may be prepared ahead of time. If this is the case, dry them for 1 hour at 103 - 105°C and store in the desiccator until needed.

4. Assemble the filtering apparatus, place a prepared filter on the support and begin suction. Shake the sample and measure out 100 mL in graduated cylinder.

5. Pour sample into filtering apparatus. Apply vacuum until all the sample has been filtered.

6. Pipet 50 mL of the filtrate (less, if the sample is expected to have a high dissolved solids content) into a prepared evaporating dish.

7. Evaporate the sample to dryness in the oven at 180 ± 2°C. Cool in a desiccator for at least one hour and weigh. Repeat the drying cycle until the weight loss is <0.5 mg.

Quality Control:

1. Duplicate 1 out of 10 samples. If less than 10 samples are analyzed, a duplicate is still required. Duplicates should be within acceptable ranges.

2. A blank must be analyzed with every set of samples. (This is a check on contamination, cleanliness of dishes, oven, pipettes, etc.)

3. An EPA or ERA reference standard must be analyzed at the beginning of each analytical run.

Calculations:

$$\text{TDS, mg/L} = \frac{(A-B) \times 1000000}{C}$$

Where A = weight of dish plus residue (g)
B = weight of dish (g)
C = volume of filtered sample used (mL)

[rff-wetcont-705]

Effective Date 1-29-90

AMMONIA NITROGEN

Scope and Application: This method is applicable to the determination of ammonia-nitrogen in drinking water, surface water, groundwater, sludges, soils, and industrial wastes.

Method: Micro-distillation, Colorimetric

Reference: EPA, 1983, Method 350.2

Detection Limit: 0.10 mg/L for aqueous samples
5.00 mg/kg for soils and sludges

Optimum Range: 0.10 - 2.00 mg/L for aqueous samples
5.00 - 100 mg/kg for soils and sludges

Sample Handling: Acidify aqueous samples with concentrated sulfuric acid to pH <2 and refrigerate at 4°C. Refrigerate soils and sludges at 4°C. Analyze within 28 days of sampling.

Reagents and Apparatus:

1. Kjeldahl flasks, 100 mL
2. Keeney distillation apparatus
3. Spectrophotometer, set at 425nm with sipper cell
4. Erlenmeyer flasks, 50 mL
5. Sulfuric acid, concentrated
6. Milli-Q water
7. pH meter, 0.1 pH unit sensitivity
8. Volumetric glassware, Class A (pipets and flasks)
9. Top loading balance, 0.01g sensitivity
10. Graduated cylinders, 50 mL
11. Mixing cylinders, 50 mL
12. Ammonium chloride (NH_4Cl)
13. Boric acid (H_3BO_3)
14. Mercuric iodide (HgI_2)
15. Potassium iodide (KI)
16. Sodium hydroxide (NaOH)
17. Sodium tetraborate ($Na_2B_4O_7 \cdot 10H_2O$)
18. Sodium thiosulfate ($Na_2S_2O_3 \cdot 5H_2O$)
19. Analytical balance, 0.0001g sensitivity
20. 150 mL beaker
21. Stir bars and stir plate

Reagent Preparation: (Prepare fresh every 6 months, unless otherwise stated).

1. Ammonium chloride stock solution(1000 mg/L): In a 1 liter volumetric flask, dissolve 3.819g NH_4Cl in approximately 300 mL Milli-Q water and bring to volume. Preserve with H_2SO_4 to a pH<2. Refrigerate.

2. Ammonium chloride standard solution (10 mg/L): Dilute 10.0 mL of the ammonium chloride stock solution to 1 liter with Milli-Q water in a volumetric flask. Preserve with H_2SO_4 to a pH<2. Prepare monthly. Refrigerate.

3. Boric acid solution: Dissolve 20.0g H_3BO_3 in Milli-Q water and dilute to 1 liter in a volumetric flask.

4. Nessler reagent: Dissolve 100g of mercuric iodide and 70g of potassium iodide in about 200 mL of Mill-Q water. Add this mixture slowly, while stirring to a COOLED solution of 160g NaOH in 500 mL Milli-Q water. Dilute the mixture to 1 liter. Store in a Pyrex bottle and keep out of direct sunlight. Refrigerate. NOTE: Commercially available.

5. Sodium hydroxide (1N): Dissolve 40g of NaOH in Milli-Q water and dilute to 1 liter.

6. Sodium hydroxide (0.1N): Dilute 100 mL of 1N NaOH to 1 liter with Milli-Q water.

7. Sodium tetraborate solution (0.025M): Dissolve 9.5g of $Na_2B_4O_7 \cdot 10H_2O$ or 5.0g anhydrous $Na_2B_4O_7$ in Milli-Q water and dilute to 1 liter.

8. Borate buffer: Add 88 mL of 0.1N NaOH solution to 500 mL of 0.025M sodium tetraborate solution. Dilute to 1 liter with Milli-Q water.

9. Sodium thiosulfate (1/70N): Dissolve 3.5g $Na_2S_2O_3 \cdot 5H_2O$ in Milli-Q water and dilute to 1 liter. (1 mL of this solution will remove 1 mg/L of residual chlorine in 500 mL of sample).

NOTES:

1. Residual chlorine must be removed prior to distillation by pretreating the sample with sodium thiosulfate solution.

2. Pre-steam the distillation apparatus with 10% NaOH before use.

3. Cyanate and some volatile alkaline compounds may cause an off-color nesslerization. This off-color can be eliminated by boiling the sample at a low pH (pH 2-3) to drive off the compound. This should be done prior to the distillation step.

Procedure: Sample must be homogenized prior to analysis to ensure a representative sample aliquot.

Distillation:

1. All glassware is to be soap and water washed, tap water rinsed, and Milli-Q water rinsed prior to use.

2. The reservoir should be 2/3 full with Milli-Q water. Add a few boiling chips. Add sulfuric acid to reservoir to bring to a pH <2. Turn on the heater. Set heater control to HIGH. Allow the steam reservoir to heat up. This unit will take about 45 minutes to heat-up. Turn the heater control to about a setting of 8 and bring to boiling. Analysis can begin once boiling begins.

3. Prepare the distillation apparatus as follows: Steam out the distillation apparatus with a 10% NaOH solution. Turn on water and continue until 40 mL has been distilled.

4. <u>Aqueous samples</u>:

   Place 50 mL or an aliquot of sample diluted to 50 mL in a 150 mL beaker. Record the volume used. Add 1N NaOH while stirring very slowly until the pH is 9.5 ±0.1 using pH meter.

   <u>To spike</u>: Place 50 mL sample and 5 mL of the 10 mg/L ammonia standard into a beaker, adjust pH to 9.5 ±0.1 and continue with procedure. Final spike level is 1.0 mg/L.

   <u>Non-aqueous samples</u>:

   Place approximately 1.0g in a 150 mL beaker. Record weight used. Add 50 mL Milli-Q water and adjust the pH with 1N NaOH, while stirring slowly, to pH 9.5 ±0.1 using pH meter.

   <u>To spike</u>: Place 1.0g sample, 5 mL of the 10 mg/L ammonia standard in the beaker. Add 50 mL Milli-Q water, adjust pH, and continue with procedure.

5. Transfer the pH-adjusted sample to a 100 mL Kjeldahl flask. Add 2.5 mL of borate buffer.

6. Add 5 mL of boric acid to a 50 mL Erlenmeyer flask and place flask at the condenser outlet with the <u>tip of the condenser immersed in the boric acid</u>.

7. Connect the Kjeldahl flask to the distillation apparatus and secure with springs.

8. Close the stopcock on the condensation chamber. Close the drain stopcock. The steam will now pass through the Kjeldahl flask.

9. Steam distill 30-40 mL at a rate of 4-5 mL/min.

10. Rinse tip of condenser into erlenmeyer flask, remove the erlenmeyer flask.

11. Rinse the tip of the condenser and steam outlet into a waste beaker.

12. Continue distilling remaining samples, blanks and standards. When all samples, blanks and standards are distilled, the colorimetric determination can be performed.

Colorimetric Determination:

1. Prepare the following series of blanks and standards in 50 mL mixing cylinders containing 5 mLs of boric acid solution (These do not need to be taken through the distillation step).

mL of 10 mg/L ammonium chloride solution	Dilute to	Concentration (mg/L)
0	50 mL	BLANK
0.5	50 mL	0.10
1.0	50 mL	0.20
2.0	50 mL	0.40
5.0	50 mL	1.00
10.0	50 mL	2.00

2. Add 2.0 mL of Nessler reagent to the blank and standards. Stopper and mix by inverting several times.

3. After 20 minutes, read the absorbances on the spectrophotometer set at 425nm using the sipper cell. Zero the spectrophotometer to the reagent blank.

4. Transfer distilled samples to 50 mL mixing cylinders and dilute to 50 mL with Milli-Q water. Mix.

5. Determine the ammonia in the distillate as follows:

   - Transfer 25 mL of distillate, or an aliquot diluted to 25 mL, to a mixing cylinder.

   - Add 1 mL of Nessler reagent and mix by inverting several times.

   - After 20 minutes, read the absorbance as described in Step 3.

Calculations:

1. Aqueous Samples:

   a. Calculate using linear regression.

   b. Multiply in any dilution factors performed in the distillation and colorimetric steps to obtain the final result in mg/L.

2. Non-Aqueous Samples:

   a. Calculate using regression to obtain a mg/L value.

   b. Multiply in any dilution factor performed in the colorimetric step (mg/L).

   c. Multiply result obtained from "Step b" by 50 and divide by grams of sample used to obtain the final result in mg/kg.

Quality Control:

1. Establish a standard curve with the standards listed above plus a blank. Record the absorbance check standards (1.00 mg/L) in the absorbance check book. The absorbances should remain consistent from run to run. If not, necessary troubleshooting must be performed before continuing (check wavelength, spectrometer bulb, solutions, etc.).

2. A distilled blank, standard (1.00 mg/L), and known reference standard are to be analyzed at the beginning of the analytical run. The standards must be within acceptable ranges and the blank less then the detection limit, or troubleshooting must be performed.

3. A quality control calibration standard of 1.00 mg/L and a blank are to be analyzed, initially and after every 10 samples. This standard does not need be carried through the distillation procedure. The last samples analyzed in the run are to be the calibration standard and blank. These standards must be within the acceptable ranges (± 10% of the true value) or the samples run after the last acceptable check standard are to be reanalyzed.

4. Duplicate and spike a minimum of 1 out of 10 samples. If less than 10 samples are analyzed, a duplicate and spike are still required. Spike recoveries and duplicate results are to be within acceptable ranges, or data must be flagged appropriately.

Effective Date 1-29-90

TOTAL KJELDAHL NITROGEN

Scope and Application: This method is applicable for the determination of total kjeldahl nitrogen in drinking water, surface water, groundwater, domestic and industrial wastewaters. Soils, sludges and solid waste samples may also be analyzed by this method.

Method: Micro-digestion, micro-distillation, colorimetric

Reference: EPA 1983, Method 351.3.

Detection Limit: 0.10 mg/L or aqueous samples
5.00 mg/kg for non-aqueous samples

Sample Handling: Acidify aqueous samples with concentrated H_2SO_4 to pH <2 and refrigerate at 4°C. (Non-aqueous samples should be refrigerated at 4°C.) Analyze samples within 28 days of collection.

Reagents and Apparatus:

1. Mercuric oxide, red (HgO)
2. Sulfuric acid, concentrated (H_2SO_4)
3. Potassium sulfate (K_2SO_4)
4. Sodium hydroxide (NaOH)
5. Sodium thiosulfate ($Na_2S_2O_3 \cdot 5H_2O$)
6. Micro kjeldahl digestion apparatus
7. Milli-Q water
8. Boiling chips
9. Volumetric glassware (flasks and pipets)
10. 100 mL Kjeldahl flasks
11. Wide-mouth pipets
12. Graduated cylinders, 50 mL
13. Keeney distillation apparatus
14. Spectrophotometer, set at 425nm with sipper cell
15. Erlenmeyer flasks, 50 mL
16. pH meter, 0.1 pH unit sensitivity
17. Top loading balance, 0.01g sensitivity
18. Mixing cylinders, 50 mL
19. Ammonium chloride (NH_4Cl)
20. Boric acid (H_3BO_3)
21. Mercuric iodide (HgI_2)
22. Potassium iodide (KI)
23. Analytical balance, 0.0001g sensitivity

Reagent Preparation: (Prepare fresh every 6 months, unless otherwise stated.)

1. Mercuric sulfate solution: Dissolve 4.0g red HgO in 25 mL of 1:4 sulfuric acid (5 mL conc. H_2SO_4:20 mL Milli-Q water) and dilute to 50 mL with Milli-Q water.

2. Digestion solution: Dissolve 133.5g K_2SO_4 in 650 mL Milli-Q water and 200 mL conc. H_2SO_4. Add 25 mL of mercuric sulfate solution and dilute to 1 liter with Milli-Q water. Store at room temperature in glass to prevent crystallization. If crystals do form, heat slowly, while stirring, to dissolve.

3. Sodium hydroxide-sodium thiosulfate solution: Dissolve 500g NaOH and 25.0g $Na_2S_2O_3 \cdot 5H_2O$ in Milli-Q water and dilute to 1 liter. Caution - solution becomes very hot. Store in a plastic bottle.

4. Ammonium chloride stock solution (1000 mg/L): In a liter volumetric flask, dissolve 3.819g NH_4Cl in approximately 300 mL Milli-Q water and bring to volume. Preserve with H_2SO_4 to a pH <2. Refrigerate.

5. Ammonium chloride standard solution (10 mg/L): In a volumetric flask, dilute 10.0 mL of the ammonium chloride stock solution to 1 liter with Milli-Q water. Preserve with H_2SO_4 to a pH <2. Prepare monthly. Refrigerate.

6. Boric acid solution: In a volumetric flask, dissolve 20.0g H_3BO_3 in Milli-Q water and dilute to 1 liter.

7. Nessler reagent: Dissolve 100g of mercuric iodide and 70g of potassium iodide in about 200 mL of Milli-Q water. Add this mixture slowly, while stirring to a COOLED solution of 160g NaOH in 500 mL Milli-Q water. Dilute the mixture to 1 liter. Store in a Pyrex bottle and keep out of direct sunlight. Refrigerate. Note: Also commercially available.

8. Sodium hydroxide (1N): Dissolve 40g NaOH in Milli-Q water and dilute to 1 liter.

9. Nicotinic acid stock solution (1000 mg-N/L): Dissolve 8.788g in 900 mL Milli-Q water, add 2 mL H_2SO_4 and dilute to 1 liter. Refrigerate.

10. Nicotinic acid standard solution (50 mg-N/L): In a 100 mL volumetric flask, dilute 5.0 mL of the nicotinic acid stock solution to 100 mL with Milli-Q water. Refrigerate.

NOTES:

1. High nitrate concentrations (10 times or greater than of the TKN level) result in low TKN values. Dilute samples and spike if nitrate interferences are expected.

2. The distillation unit can occasionally build up with mercury. Wash the distillation unit with 10% HCL to prevent build-up in the tubes.

3. Contamination can be a problem. Be sure to wash all glassware and apparatus thoroughly and rinse with Milli-Q water prior to use.

Procedure: Sample must be homogenized prior to analysis to ensure a representative sample aliquot.

A. Digestion:

1. All glassware must be soap and water washed, tap water rinsed and Milli-Q water rinsed prior to use.

2. Prepare the following series of blanks and standards. These standards are to be taken through the distillation step.

mL of 10 mg/L ammonium chloride solution	Dilute to	Concentration (mg/L)
0	50 mL	BLANK
2.0	50 mL	0.40
5.0	50 mL	1.00
7.0	50 mL	1.40
10.0	50 mL	2.00

3. Aqueous samples: Measure out 50 mL sample (or an aliquot diluted to 50 mL if elevated TKN levels are expected) into a 100 mL Kjeldahl flask. Record the volume used.

   To spike aqueous samples: Measure 50 mL sample and 1.0 mL of the 50 mg/L nicotinic acid standard and proceed. Final spike level is 1.0 mg/L.

   Non-aqueous samples: Weigh out approximately 1.0g sample into a 100 mL Kjeldahl flask. Record weight used. Add 50 mL Milli-Q water.

   To spike non-aqueous samples: Weigh out approximately 1.0g sample, add 1.0 mL of the 50 mg/L nicotinic acid standard and proceed. Record weight used.

4. Add 10 mL of digestion solution to the kjeldahl flask using a 10 mL wide-mouth pipet. Add 3-5 boiling chips.

5. Place flask on micro Kjeldahl digestion apparatus and digest until dense, white SO_3 fumes are given off and the solution turns colorless or straw yellow. Digestion must be performed in the hood! Digest the samples with the digestion apparatus set at 3-4.

6. Digest for 30 minutes after the appearance of SO_3 fumes.

7. Cool and add 30 mL Milli-Q water. Cap with parafilm if not distilling immediately.

8. *Proceed to the distillation portion of the procedure.*

B. Distillation:

1. All glassware is to be soap and water washed, tap water rinsed, and Milli-Q water rinsed prior to use.

2. The reservoir should be 2/3 full with Milli-Q water. Add a few boiling chips. Add sulfuric acid to reservoir to bring to a ph <2. Turn on the heater. Set heater control to HIGH. Allow the steam reservoir to heat up. This will take about 45 minutes. Turn the heater control to about a setting of 8 and bring to boiling. Analysis can begin once water is boiling.

3. Preparation of the distillation apparatus: Steam out the distillation apparatus with a 10% NaOH solution. Turn on water and continue until 40 mL has been distilled.

4. Add 5 mL of boric acid to a 50 mL Erlenmeyer flask and place at the condenser outlet with the tip of the condenser immersed in the boric acid.

5. Connect the Kjeldahl flask to the distillation apparatus and secure with springs.

6. Fill the NaOH chamber to the 10 mL mark with NaOH/thiosulfate solution. Slowly lift glass stopper to allow solution to run down tube and into sample distillation flask. Stop flow if "neutralizing action" becomes too vigorous or siphoning back of receiving solution occurs. Replace glass stopper in chamber.

7. Close the stopcock on the condensation chamber. Close the drain stopcock. The steam will now pass through the Kjeldahl flask.

8. Steam distill 30-40 mL at a rate of 4-5 mL/min.

9. Rinse tip of condenser with Milli-Q into erlenmeyer flask, remove the erlenmeyer flask.

10. Rinse the top of the condenser and steam outlet into a waste beaker.

11. Continue distilling remaining samples, blanks and standards. When all samples, blanks and standards are distilled, the colorimetric determination can be performed.

C. Colorimetric Determination:

1. Transfer distilled blanks, standards and samples to 50 mL mixing cylinder and dilute to 50 mL with Milli-Q water. Mix.

2. Determine the TKN in the distillate colorimetrically as follows:

   - Pour 25 mL of distillate or an aliquot diluted to 25 mL in a mixing cylinder.

- Add 1 mL of Nessler reagent. Stopper and mix by inverting several times.

- After 20 minutes, using the sipper cell read the absorbances on the spectrophotometer set at 425 nm. Zero the spectrophotometer to the distilled reagent blank.

Calculations:

1. Follow the calculations as stated in the ammonia nitrogen SOP. Make sure to calculate any digestion dilution into the final result to obtain the TKN value.

Quality Control:

1. Establish a standard curve with the standards listed above plus a blank. Distill the standard curve and blank. Record the absorbance check standard (1.00 mg/L) in the absorbance check book. The absorbances should remain consistent from run to run. If not, necessary troubleshooting must be performed before continuing (check wavelength, spectrometer bulb, solutions, etc.).

2. A digested/distilled blank and standard (1.00 mg/L), blank, and known reference standard are to be analyzed at the beginning of the analytical run. The standards must be within acceptable ranges and the blank less than the detection limit or troubleshooting must be performed.

3. A quality control calibration standard (1.00 mg/L) and a blank are to be analyzed, initially and after every 10 samples. The standard and blank need to be carried through the digestion/distillation procedure. The last samples analyzed in the run are to be the calibration standard and blank. These standards must be within the acceptable ranges (± 10% of the true value) or the samples run after the last acceptable standard are to be reanalyzed.

4. Duplicate and spike a minimum of 1 out of 10 samples. If less than 10 samples are analyzed, a duplicate and spike are still required. Spike recoveries and duplicate results are to be within acceptable ranges, or data must be flagged appropriately.

Effective Date KDf 1-29-90

CHEMICAL OXYGEN DEMAND

Scope and Application: This method is applicable to surface water, sewage, wastewater, and groundwater.

Method: Dichromate reflux, Colorimetric

Reference: EPA 1983, Method 410.4

Detection Limit: 20 mg/L

Optimum Range: 20-700 mg/L

Sample Handling: Preserve with sulfuric acid to a pH <2 and refrigerate at 4°C. Analyze within 28 days.

Reagents and Apparatus:

1. Dichromate - mercuric sulfate-sulfuric acid digestion solution
2. Silver sulfate-sulfuric acid catalyst solution
3. COD standard solutions
4. Block digestor, set at 150°C
5. 16 x 100 mm culture tubes with teflon lined screw caps
6. Eppendorf macropipetter, 0-5 mL
7. Spectrophotometer, set at 600 nm wavelength with sipper cell
8. Eppendorf microliter pipetter, 10-100 uL
9. 2 Repipette Dispensers, 1000 mL
10. De-ionized water

Reagent Preparation: (Prepare fresh every 6 months, unless otherwise noted.)

1. Digestion solution: Add 10.2 g of dried potassium dichromate ($K_2Cr_2O_7$), 33.3 g of mercuric sulfate ($HgSO_4$) and 167 mL of concentrated H_2SO_4 to about 500 mL of DI water; dilute to 1000 mL in a volumetric flask and stir until dissolved. Store in a dark place.

2. Silver sulfate-sulfuric acid catalyst solution: Add 22.0 g of silver sulfate (Ag_2SO_4) to a 2.5L bottle of conc. H_2SO_4. Stir to dissolve.

3. COD stock standard, 1000 mg/L: Carefully weigh 0.8500 g of dried potassium acid phthalate (KHP), dissolve in DI water and dilute to 1 liter in a volumetric flask. Preserve the stock solution with H_2SO_4 (2 mL conc. H_2SO_4 / L of solution). Refrigerate.

4. Working COD standards: (Prepare fresh monthly and refrigerate.) All working standards should be preserved with H_2SO_4, (0.2 mL conc. H_2SO_4 in 100 mL).

   A. 700 mg/L standard: To a 100 mL volumetric flask, add 70 mL of 1000 mg/L stock standard and dilute to the mark with DI water.

B. 300 mg/L COD standard: To a 100 mL volumetric flask, add 30 mL of 1000 mg/L stock standard and dilute to the mark with DI water.

C. 100 mg/L COD standard: To a 100 mL volumetric flask, add 10 mL of 1000 mg/L COD stock standard and dilute to the mark with DI water.

D. 50 mg/L COD standard: To a 100 mL volumetric flask, add 5 mL of 1000 mg/L COD stock standard and dilute to the mark with DI water.

E. 20 mg/L COD standard: To a 100 mL volumetric flask, add 2 mL of 1000 mg/L COD intermediate standard and dilute to the mark with DI water.

Notes:

1. If a dark green or turquoise color occurs when sample is added or when the tube is being heated; the sample is over the upper limit of the curve and must be diluted and redigested.
2. Interference: Chlorides represent a positive interference. Mercuric sulfate is added to the digestion tubes to complex the chloride. Mercuric sulfate can complex up to 2,000 mg/L chloride before reacting with dichromate in the sample. If chloride exceeds 2,000 mg/L, dilute the sample.
3. Reagents are corrosive and toxic. Avoid skin contact.
4. Store standards in the refrigerator.
5. Store the dichromate solution and prepared tubes in the dark.

Procedure:

1. All glassware is to be soap and water washed, tap rinsed and DI water rinsed prior to analysis. Rinse digestion tubes and caps with DI water prior to use. Caps deteriorate over time. Discard caps after 3 uses.
2. Into each tube, pipet exactly 1.5 mL of COD digestion solution, using repipetter dispenser.
3. Using the repipettor dispenser, pipet down the side into each tube exactly 3.5 mL of the silver sulfate-sulfuric acid solution. Avoid any mixing with the digestion solution. These tubes may be stored, with caps having teflon liners, indefinitely. Store in the dark!
4. Prepare a standard curve consisting of the following standards: 0, 20, 50, 100, 300, and 700 mg/L COD.

   The standards are carried through the digestion step.
5. Analyze an initial calibration standard, a blank, and a reference standard at the beginning of each run.

6. Using the Oxford 0-5 mL pipet, add 2.5 mL of sample, standard, or blank to the tube. Be careful to avoid air bubbles in the pipet tip and to eject all of the sample. Cap tubes tightly and mix by inverting 10-12 times.

   To Spike: In a disposable cup, place 2.5 mL sample, add 2.5 mL of the 300 mg/L standard. Mix well. Use 2.5 mL of this mixture for the spiked sample analysis.

7. Place tubes in a block heater at 150°C for 2 hours. Block heater should be preheated at least 1 hour prior to use.

8. Remove tubes from block heater. Cool to room temperature. Using the sipper cell, read the absorbance on spectrophotometer, set at 600 nm. Samples can be stored in refrigerator overnight and read the next day. Do not shake tubes. Be very careful not to aspirate any of the precipitate in the bottom of the tube. Initially zero with the blank standard.

Quality Control:

1. Establish a standard curve with the standards listed above plus a blank. Record the absorbance check standard in the absorbance check book. The absorbances should remain consistent from run to run. If not, necessary troubleshooting must be performed before continuing (check wavelength, spectrophotometer bulb, solution, etc.)

2. A quality control calibration standard of 100 mg/L COD and a blank are to be analyzed, initially and after every 10 samples. If less than 10 samples are analyzed, a calibration standard and blank are still required. The last samples analyzed in the run are to be the calibration standard and blank. These standards must be within the acceptable ranges or the samples run after the last acceptable check standard are to be reanalyzed.

3. Duplicate and spike a minimum of 1 out of 10 samples. If less than 10 samples are analyzed, a duplicate and spike are still required. Spike recoveries and duplicate results are to be within acceptable ranges, or data must be flagged appropriately.

Calculation:

1. Calculate using linear regression.

To Calculate Spike:

$$\% \text{ Recovery} = \frac{(2)(\text{spike value}) - (\text{sample value})}{300} \times 100$$

AUTOANALYZER

Scope and Application: Ions can be readily analyzed by a flow-injection autoanalyzer. The flow injection design gives the system excellent washout characteristics, to prevent carry over and cross contamination. The autoanalyzer is generally more sensitive and accurate than the manual wet-chemistry techniques.

Method: Flow injection

References: Lachat Instruments, 1986.

Sample Handling: See separate SOP's for requirements.

Reagents and Apparatus:

1. Lachat 3-channel autoanalyzer
2. Stock and standard ion solutions
3. Class A volumetric flasks
4. Class A volumetric pipets
5. Milli-Q water
6. Required interference filters
7. Disposable 4 mL cups
8. Automatic sampler
9. Proportioning pump
10. Injection module
11. Colorimeters
12. Manifolds
13. Columns - if needed
14. Helium gas
15. Computer
16. Printer

Procedure:

A. Instrument Set-Up

1. Depress red power switch on power strip located behind the computer terminal. This will turn on the computer, the screen, and the printer.

2. Depress red power switch on rear power strip on Lachat system.

3. Select manifold and make appropriate hydraulic connections.

   Hydraulic connections:

a. Use <u>correct</u> sample loop length to connect. Lines 1, 4.

b. Line 2 is carrier line.

c. Line 3 goes to manifold.

d. Line 5 goes to waste container.

e. Line 6 comes from sample probe.

f. Connect manifold to flow through cell.

Tension levers should be up when pump tubing is inserted. Snap pump tubing cartridges into place.

4. Insert correct filter.

5. Pump Milli-Q water through lines for 5 minutes by depressing the pump ON button. Check for leaks.

6. <u>Computer</u> - At the C> type in "quikcalc". This calls up the Lachat software and puts you at the master menu. Press <enter>.

7. Put lines into reagents and/or degassed Milli-Q water.

8. <u>Computer</u> - Select "Load/Stop Background Method" on the master menu. Press <enter>.

9. Select appropriate method. Press <enter>.

10. Printer should be set at FONT 0.

11. Pump reagents until a steady baseline is achieved.

12. When using a method with a column (SO_4 or NO_3), the column may be inserted at this point. See method SOP's for more details.

13. For each analytical channel, adjust zero knob so that the baseline is near the bottom of the screen (between .000 - .030).

14. Adjust gain while injecting top standard.

    a. Place autosampler probe into the highest standard bottle.

    b. After 20-30 seconds, press cycle button on front panel so that LED light is red. This is the load position.

    c. After 25 seconds (or less depending on sample loop size), press cycle button so that LED light is green. This is the inject position.

   d. Adjust gain knob on detector so that peak reading on the colorimetric is 1.700-1.950.

   e. Repeat until gain is properly adjusted.

   f. Wipe probe and replace the autosampler probe into the sampler.

15. Select menu item by going into foreground. (Press and hold Alt key, then press Esc key).

   a. Select "Sample Tray Information and Start Analysis" on master menu. Press <enter>.

   b. Press <enter> or type in sample tray reference number if it is a tray which has already been typed in.

   c. Enter tray ID and operator. Check "Display Standards Position in Tray" to insure the tray is set-up properly.

   d. Select "Enter Sample ID's". Press <enter>.

   e. Type in sample information. Check standards will automatically be placed in the tray information portion.

   f. Press Esc once to return to menu.

16. Put tray with samples in appropriate cup locations on autosampler. Position try to the cup containing standard A (usually #35 or so). Select "Start Analysis." Press <enter>.

17. The second screen will ask if the tray has standards or not. If you standardized the first tray of the run and all the check standards are within QC ranges, recalibration for the next tray is <u>not</u> necessary. Select appropriate option. Press <enter>.

18. Press Alt, Esc keys together, to get back to background to view the calibration peaks.

    After calibration is complete:

    - go into the foreground (Press Alt, Esc keys)
    - select "display calibration graph" (Press <enter>)
    - review the data
    - return to the background (Press Alt, Esc keys)

- press "G" for good calibration. Analysis will continue.
- press "R" for re-calibration. Remember to refill standard cups and reposition sample tray <u>before</u> pressing "R"!

B. <u>Instrument Shut-Down</u>

1. Press Alt/Esc keys to get to the foreground. Select "Load/Stop Background Method". Press <enter>. To question-"Stop background (Y/N)?" Press "Yes". Press Esc key to return to main menu.
2. If column is used, stop the pump and disconnect from manifold.
3. Pull lines from reagents into a wash beaker of D.I..
4. Pump D.I. through lines for 2-5 minutes.
5. Pump air through lines until manifold is dry.
6. Turn off pump.
7. Release tubing cartridges and lower tension levers. Release tubing.
8. Turn off main switch on rear power strip.
9. Empty and rinse waste containers, if necessary.
10. Perform back-up on current data files, once a week. (See Section C)
11. Turn off the computer and printer.

C. <u>Backing-up the Data Files</u>

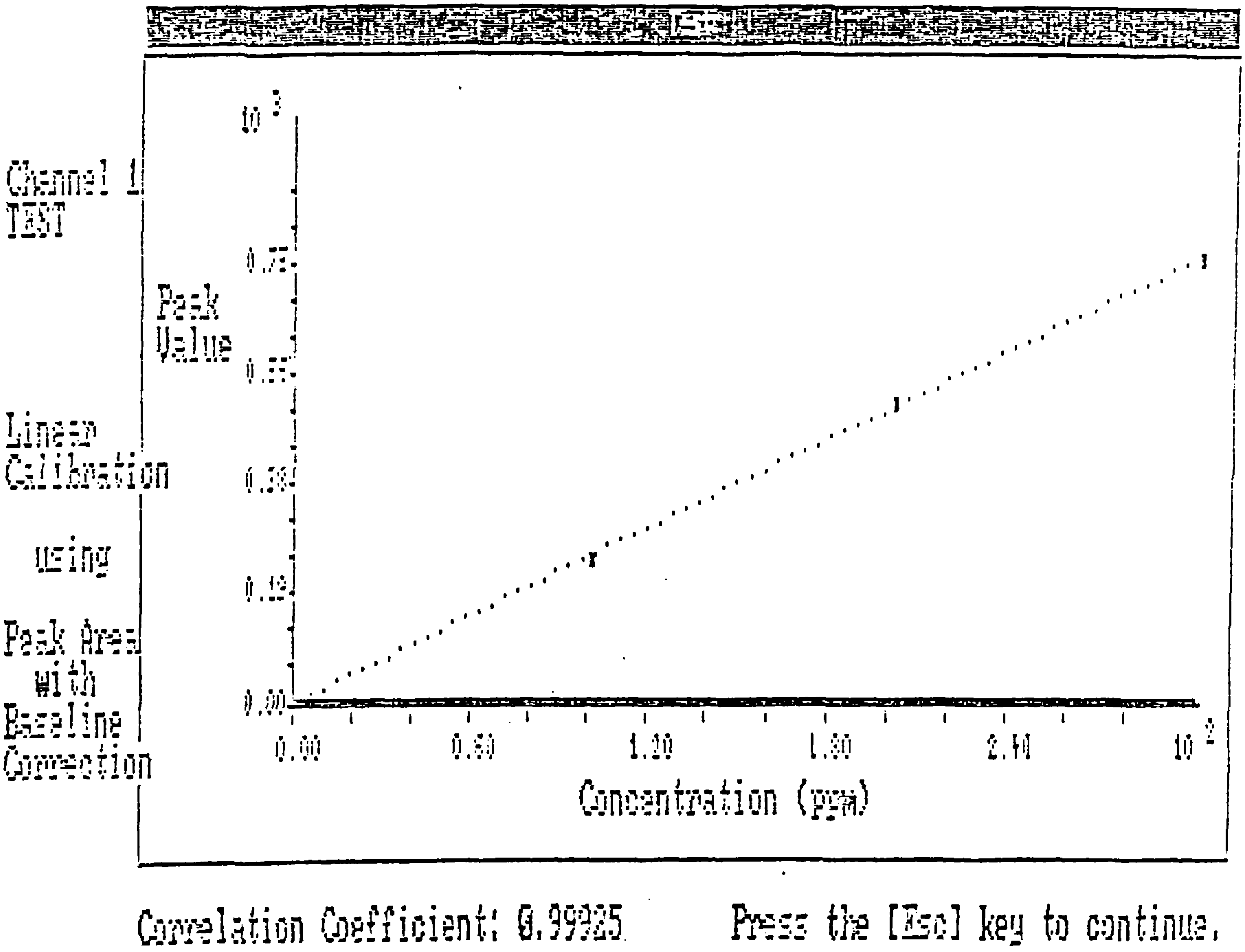
1. Exit to DOS
2. At C> Type: cd\fialab\data Press <enter>
3. At C> Type: copy *.rpt a: Press <enter>
   After everything is copied - remove disc.
4. At C> Type: del *.* Press <enter>
5. Are you sure (Y/N)? Type: Y Press <enter>
6. At C> Type: cd\ Press <enter>
7. Turn off the red switch on the computer power strip to turn off the computer, printer and screen.

D. Quikchem Calibration

QuikCalc II uses a calibration technique called multisegment linear fitting which gives extensive flexibility to the user. It allows the calibration curve to be defined in terms of individual linear segments which can span each of several standards. Following processing of the calibration standards, a correlation coefficient is calculated for each segment with more than two standards or replicates. It provides important statistical information about each segment and gives the user a high degree of confidence in the determined sample values. See Figure 1.

Un[illegible] Calibration

FIGURE 1



Correlation Coefficient: 0.99925   Press the [Esc] key to continue.

Effective Date 1-2-90

ALKALINITY - AUTOANALYZER

Scope and Application: This method is applicable to drinking water, surface water, groundwater and wastewater.

Reference: EPA 1983, Method 310.2
Lachat Instruments 1986, Method 10-303-31-1-C

Sample Handling: Refrigerate at 4°C and analyze within 14 days of collection.

Detection Limit: 5.0 mg/L as $CaCO_3$

Optimum Concentration Range: 5.0 - 500 mg/L

Instrument Conditions:

1. Pump speed: 35
2. Cycle period: 60 seconds
3. Load period: 30 seconds
4. Inject period: 15 seconds
5. Inject to start of peak period: 10 seconds
6. Inject to end of peak period: 56 seconds
7. Gain: 150 x 10
8. Zero: 180
9. Interference filter: 410 nm
10. Sample loop: 90 cm
11. Standards for curve set-up: 0, 20.0, 50.0, 100, 250, 500 mg/L.

Reagent Preparation: (Prepare fresh every 6 months, unless otherwise stated.)

1. Degassed Milli-Q water - 2 options:
   a. Boil Milli-Q water vigorously for 5 minutes. Cool and store in cubitainer.
   b. Bubble helium, using the fritted gas dispersion tube, through the Milli-Q water (15 min/20 L.) Store in cubitainer.
2. Stock alkalinity standard (1000 mg/L as $CaCO_3$): In a 1 liter volumetric flask, dissolve 1.060 g of anhydrous primary standard grade sodium carbonate (Na_2CO_3-dried at 250°C for 4 hours) in approximately 900 mL of helium purged Milli-Q water, and dilute to mark.

3. Standards: (Prepare fresh every 2 months). Dilute to volume using degassed Milli-Q water. Refrigerate.

Concentration of Standard	Letter Identifier	Volume of Alk. Stock	Dilute to
0 mg/L	A	0	200 mL
20.0 mg/L	B	4.0	200 mL
50.0 mg/L	C	10.0	200 mL
100 mg/L	D	50.0	500 mL
250 mg/L	E	125.0	500 mL
500 mg/L	F	100.0	200 mL

NOTE: Final volumes are not the same!
Computer refers to standards by letter.

4. Sodium hydroxide (0.1M): In a 1 liter flask, dissolve 4.0 g sodium hydroxide (NaOH) and dilute to the mark with Milli-Q water.

5. Hydrochloric acid (0.1M): In a 1 liter flask, dilute 8.3 mL of concentrated HCL in Milli-Q water and dilute to the mark.

6. KHP buffer (0.025 M, pH 3.1): In a 1 liter flask, dissolve 5.10 g of potassium acid phthalate (KHP) ($KHC_3H_4O_4$) in approximately 500 mL of helium purged Milli-Q water. Add 87.6 mL of 0.1M HCL and dilute to the mark. Adjust the pH of the buffer to 3.1 with 0.1M HCL or 0.1M NaOH. Vacuum filter through a 0.45 micron membrane filter before each use. STORE IN GLASS AND PREPARE MONTHLY!

7. Methyl orange reagent: In a 1 liter volumetric flask, dissolve 0.125 g of methyl orange indicator in about 700 mL of Milli-Q water and dilute to the mark. Mix well and vacuum filter through a 0.45 micron membrane filter before each use. Store in amber glass! NOTE: Amount of methyl orange may be adjusted to correct for variances in lots of methyl orange.

Notes:

1. Samples must be diluted to obtain concentrations within the optimum working range.

2. The gain and zero settings are guidelines and must be optimized each day.

3. The alkalinity standards can be combined with chloride and sulfate standards for use with the 3 channel method.

4. Turbidity will interfere. Samples must be filtered prior to analysis. (Use Whatman #1 or #4 filter paper.)

5. Color will interfere, dilute the sample and also spike the dilution to confirm the quality of the result.

System Operation:

A. Refer to "Auto Analyzer Operation start-up procedure." (IOP# LAA-Section A).

B. Analyze an initial calibration standard, a blank, and a known reference standard at the beginning of each run. The blank must be below the detection limit and the standards must be within required control limits before any samples are analyzed.

C. Spike samples by mixing sample with an equal volume of 250 mg/L standard (E), for a final spike level of 125 mg/L.

D. The calibration check standard is 100 mg/L (D).

E. Refer to "Auto Analyzer shut-down procedure". (IOP# LAA-Section B).

Quality Control:

1. Establish a standard curve with the standards listed above. The derived concentration of each calibration must be ± 10% of the true value.

2. A quality control calibration standard of 100 mg/L and a calibration blank are to be analyzed, at a minimum, after every 10 samples. If less than 10 samples are analyzed, a calibration standard and blank are still required. The last samples analyzed in the run are to be the calibration standard and blank. These standards must be within the acceptable ranges or the samples run after the last acceptable check standard are to be reanalyzed.

3. Duplicate and spike a minimum of 1 out of 10 samples. If less than 10 samples are analyzed, a duplicate and spike are still required. Spike recoveries and duplicates are to be within acceptable ranges or data must be flagged appropriately.

Calculation:

1. Calculate with Lachat QuikChem software, in the concentration mode, using the IBM XT computer. See LAAC SOP for further detail.

Effective Date 2-1-90

CHLORIDE - AUTOANALYZER

Scope and Application: This method is applicable to drinking water, surface water, groundwater and wastewater.

Reference: EPA 1983, Method 325.2
Lachat Instruments 1986, Method 10-117-07-1-B

Sample Handling: Refrigerate at 4°C and analyze within 28 days of collection.

Detection Limit: 1.0 mg/L.

Optimum Concentration Range: 1.0 - 100 mg/L

Instrument Conditions:

1. Pump speed: 35
2. Cycle speed: 30 seconds
3. Load period: 15 seconds
4. Inject period: 15 seconds
5. Inject to start of peak period: 8 seconds
6. Inject to end of peak period: 31 seconds
7. Gain: 200
8. Zero: 250
9. Interference filter: 480 nm
10. Sample loop: 20 cm
11. Standards for curve set-up: 0, 10.0, 20.0, 50.0, 80.0, and 100 mg/L Cl.

Reagent Preparation: (Prepare fresh every 6 months, unless otherwise stated.)

1. Degassed Milli-Q water - 2 options:

   a. Boil Milli-Q water vigorously for 5 minutes. Cool and store in cubitainer.

   b. Bubble helium, using the fritted gas dispersion tube, through the Milli-Q water (15 min/20 L.) Store in cubitainer.

2. Stock chloride standard (1000 mg/L): In a 1 liter volumetric flask, dissolve 1.648 g of primary grade sodium chloride (NaCl), previously dried at 140°C, in 500 mL D.I. water. Dilute to the mark and invert to mix. Refrigerate.

3. Standards: (Prepare fresh every 2 months). Dilute volume using D.I. water. Refrigerate.

Concentration of Standard	Letter Identifier	Volume of Chloride Stock (ml)	Dilute to
0 mg/L	A	0	200 mL
10.0 mg/L	B	2.0	200 mL
20.0 mg/L	C	4.0	200 mL
50.0 mg/L	D	25.0	500 mL
80.0 mg/L	E	40.0	500 mL
100 mg/L	F	20.0	200 mL

NOTE: Computer refers to standards by letter.
Final volumes are not the same!

4. Sodium mercuric thiocyanate reagent: In a 1 liter volumetric flask, dissolve 4.17 g of mercuric thiocyanate ($Hg(SCN)_2$) in one liter of methanol. Invert to mix. Store in amber glass. Refrigerate.

   CAUTION: Mercury is a very toxic metal. WEAR GLOVES!

5. Stock ferric nitrate reagent (0.5M): In a 1 liter volumetric flask, dissolve 202.0 g of ferric nitrate ($Fe(NO_3)_3 \cdot 9H_2O$) in approximately 800 mL of deionized water. Add 25 mL of concentrated nitric acid and dilute to one liter. Invert to mix. Refrigerate.

6. Combined color reagent: Mix 150 mL of stock mercuric thiocyanate solution with 150 mL of stock ferric nitrate reagent and dilute to 1000 mL with deionized water. Vacuum filter through a 0.45 micron membrane filter. Store at room temperature. Do Not Refrigerate.

Notes:

1. Samples must be diluted to obtain concentrations within the optimum working range.

2. The gain and zero settings are guidelines and must be optimized each day.

3. The chloride standards may be combined with alkalinity and sulfate standards for use with the 3 channel method.

4. Any sample with turbidity must be filtered prior to analysis. (Use Whatman #1 or #4 filter paper.) Record on data sheet.

5. Color is an interference, dilute the sample and also spike this sample to confirm the quality of the result.

System Operation:

A. Refer to "Auto Analyzer Operation start-up procedure." (IOP# LAA-Section A).

B. Analyze an initial calibration check standard, a blank, and a reference standard at the beginning of each run. The blank must be below the IDL and the standards within control limits.

C. To spike samples, mix equal volumes of sample and 80 mg/L Cl standard for a final spike level of 40 mg/L Cl.

D. The calibration check standard is 50 mg/L (D).

E. Refer to "Auto Analyzer shut-down procedure". (IOP# LAA-Section B).

Quality Control:

1. Establish a standard curve with the standards listed above. Note that the calibration curve is calculated in a "piece-wise" fashion and is not linear. Be sure that calibration points describe a smooth curve.

2. A quality control calibration standard of 50.0 mg/L and a blank are to be analyzed, at a minimum, after every 10 samples. If less than 10 samples are analyzed, a calibration standard and blank are still required. The last samples analyzed in the run are to be the calibration standard and blank. These standards must be within the acceptable ranges or the samples run after the last acceptable check standard are to be reanalyzed.

3. Duplicate and spike a minimum of 1 out of 10 samples. If less than 10 samples are analyzed, a duplicate and spike are still required. Spike recoveries and duplicates are to be within acceptable ranges or data must be flagged appropriately.

Calculation:

1. Calculate with Lachat QuikChem software, in the concentration mode, using the IBM XT computer. See LAA SOP for further detail.

Effective Date 1-29-90

SULFATE - AUTOANALYZER

Scope and Application: This method is applicable to drinking water, surface water, groundwater and wastewater.

Reference: EPA 1983, Method 375.2
Lachat Instruments 1986, Method 10-116-10-2-B

Detection Limit: 5.0 mg/L.

Optimum Concentration Range: 5.0 - 200 mg/L

Sample Handling: Refrigerate at 4°C and analyze within 28 days of collection.

Instrument Conditions:

1. Load time: 20 seconds
2. Inject period: 30 seconds
3. Inject to start of peak period: 9 seconds
4. Inject to end of peak period: 54 seconds
5. Cycle time: 50 seconds
6. Gain: 700
7. Zero: 200
8. Interference filter: 460 nm
9. Sample loop: 10 cm
10. Standards for curve set-up: 0, 25.0, 50.0, 100, 150, 200 mg/L.

Reagent Preparation: (Prepare fresh every 6 months, unless otherwise stated.)

1. Degassing with helium - 2 options:
    a. Boil Milli-Q water vigorously for 5 minutes. Cool and store in cubitainer.
    b. Bubble helium, using the fritted gas dispersion tube, through the Milli-Q water (15 min/20 L.) Store in cubitainer.
2. Carrier (0.3 ppm SO_4): In a 1 liter volumetric flask, add 0.3 mL of 1000 ppm stock sulfate solution and dilute to mark with degassed Milli-Q water.
3. Barium chloride solution (6.24M): In a 1 liter volumetric flask, dissolve 1.526 g of barium chloride dihydrate ($BaCl_2 \cdot 2H_2O$) in 500 mL of Milli-Q water and dilute to 1 liter.
4. Hydrochloric acid (1.0N): In a 100 mL volumetric flask, containing approximately 80 mL of Milli-Q water, add 8.3 mL of concentrated hydrochloric acid and dilute to the mark with Milli-Q water.

5. Barium - MTB color reagent: (The purity of the methylthymol blue and the alcohol can be critical. USE THE SOURCES STATED BELOW).

   In a dry 1000 mL volumetric flask, place 0.2364 g of methylthymol blue (3', 3" bis-N, N-bis carboxymethyl)-amino methylthymolsulfon-ephthalein pentasodium salt (Kodak No. 8068). Add 50 mL of barium chloride solution ("3" above). The solution may be used to aid in the transfer of the dye. Swirl to dissolve. Add 8.0 mL of the 1.0N HCL solution ("4" above) and mix - solution may turn orange. Add 142 mL deionized water and dilute to 1000 mL with ethanol (Aldrich 24.511.9) Mix. The pH of this solution should be 2.5. Prepare this solution the day before use and store it refrigerated in an amber bottle. NOTE: amount of methylthymol blue may be adjusted up/down to correct for variance in lots of MTB and resulting changes in method sensitivity.

6. Sodium hydroxide (50% stock solution): Cautiously dissolve 500 g of sodium hydroxide (NaOH) in 600 mL of Milli-Q water. Cool and dilute to 1 liter. Store in plastic bottle. CAUTION: The solution will become very hot!

7. Sodium hydroxide (0.18 N): In a 1 liter volumetric flask, add 14.4 mL of 50% sodium hydroxide ("6" above) to degassed Milli-Q water, and dilute to the mark.

8. Buffered EDTA (for cleaning manifold): In a 1 liter volumetric flask, dissolve 6.75 g ammonium chloride (NH_4Cl) in 500 mL DI water. Add 57 mL concentrated ammonium hydroxide and 40.0 g tetrasodium EDTA dihydrate. Dissolve by swirling; dilute to the mark with DI water.

9. Sulfate stock (1000 mg/L): Dry approximately 2 g of sodium sulfate (Na_2SO_4) at 105°C for 2 hours. Cool in a desiccator. In a 1 liter volumetric flask, dissolve 1.479 g of the dried sodium sulfate in Milli-Q water and dilute to 1 liter. (1.0 mL = 1.0 mg SO_4).

10. Working standard: (Prepare fresh every 2 months). Refrigerate.

Concentration of Standard	Letter Identifier	Volume of Sulfate Standard	Dilute to
0 mg/L	A	0	200 mL
25.0 mg/L	B	5.0	200 mL
50.0 mg/L	C	10.0	200 mL
100 mg/L	D	50.0	500 mL
150 mg/L	E	75.0	500 mL
200 mg/L	F	40.0	200 mL

NOTE: Final volumes are not the same!
Computer refers to standards by letter.

Preparation of Ion Exchange Column:

1. Make a slurry of approximately 0.5 g of BioRex 70, 50-100 mesh ion exchange resin in Milli-Q water.

2. Remove one column end from the glass column. Fill the column with water, then aspirate the slurry or allow it to settle by gravity to pack the column. Take care to avoid trapping air bubbles in the column and its fittings at this point and all subsequent operations.

3. After the resin has settled, replace the end fitting. To ensure a good seal, remove any resin particles from the threads of the glass, the column end and the end fittings. To store the column, the ends of the Teflon tubing may be joined with a union.

4. To test the effectiveness of the column, make up a standard of pure sodium sulfate and compare its peak height to an identical standard with hardness typical of the samples added. If the column is being depleted, the standard with hardness will read lower because the divalent cations are complexing the free MTB. The concentration of the standard should be mid-range. If depletion has occurred, repack the column with fresh resin.

5. Regenerating Resin: Batch regeneration is recommended because the hydrogen form of BioRex 70 can swell considerable more than the sodium form. Collect the used resin in a small beaker or flask. Wash with dilute HCL until the wash tests free of calcium and/or magnesium. This procedure removes the divalent cations by converting the carboxylate exchange group to the protonated form - COOH. Convert the resin back to the sodium form by neutralizing with washes of 0.5M NaOH until the wash has a pH of 9 or greater. Rinse with deionized water for storage or repacking. A column may be used for 3-4 trays (approximately 150 samples) before it needs to be replaced.

Notes:

1. Samples must be diluted to obtain concentrations within the optimum working range.

2. Sulfate standards may be combined with alkalinity and chloride standards for use with the 3-channel method.

3. The gain and zero settings are guidelines and must be optimized each day.

4. All coils (including waste coil) must be changed at least once each quarter to prevent build-up in lines.

4. Interferences:

- The cation exchange column removes multivalent cations. Run a mid-range sulfate standard containing a typical concentration of $CaCO_3$ periodically to check performance. Any decrease in peak height should indicate the need to regenerate or replace the resin. (At 600 ppm $CaCO_3$, the column is good for 80 + injections.)

- Samples with pH <2 should be neutralized. High acid concentrations can displace multivalent cations from the column.

- Color will interfere. Dilute the sample and also spike the dilution to confirm the quality of the result.

- Turbidity - turbid samples may be filtered (use Whatman #1 or #4 filter paper) prior to analysis on Lachat.

- Orthophosphate also forms a precipitate with barium at high pH. Check the response of pure orthophosphate standards, if samples are known to be high in $PO_4^{=}$.

5. Troubleshooting:

   A. Baseline noise with reagents pumping.

      1. Noise with column in line but good baseline without column.

         a. Repack column, air bubbles may be causing pulsing.

         b. Check flow fit connectors and end fittings on column for blockage or leaks.

      2. Noise with and without column in line.

         a. Degas carrier and/or reagents. Fine bubbles cause sharp spikes on baseline.

         b. Place a longer piece of manifold tubing on the outlet of the flow cell leading to the waste container. This method requires the use of the screw type flow cell.

         c. Replace the pump tubes. The silicone tube, used for the color reagent, wears faster than the PVC pump tubes.

         d. With water pumping in the lines, check all hydraulic connections for blockages, leaks, etc.

B. Baseline drift.

1. Clean the manifold with the buffered EDTA.

2. Turn the gain high and use the shortest sample loop possible. This improves the linearity of the calibration curve, prolongs the useful life of the column, and minimizes the build up of $BaSO_4$ on the manifold tubing.

<u>System Operation</u>:

1. Refer to "Auto Analyzer Operation start-up procedure." (SOP# LAA-Section A).

2. Pump reagents through the lines <u>before</u> inserting the column. Use a short piece of manifold tubing in place of the column. When all air has passed and the baseline is steady, turn <u>off</u> the pump and insert the column. The column should be placed in a vertical position with flow in the top and out the bottom. In this configuration, the column will operate effectively even if the resin packs down more to leave a gap at the top. Resume pumping.

3. Analyze an initial check standard, a blank, and a known reference at the beginning of each run. The blank must be less than the detection limit and the standards within acceptable limits.

4. To spike: Mix equal volumes of sample and 150 mg/L SO4 standard (D) for a final spike level of 75 mg/L.

5. The calibration check standard is 100 mg/L (D).

6. To shut down, turn off pump and remove the column.

   To remove the column:

   a. Turn off the pump.
   b. Remove the column.
   c. Join ends of the column with a union.
   d. Replace the column on the manifold with the short teflon tubing piece.
   e. Rinse manifold with Milli-Q water.
   f. Rinse manifold with EDTA cleaning solution.
   g. Continue with "Auto Analyzer Shut-down procedures" (SOP # LAA-Section B).

Quality Control:

1. Establish a standard curve with the standards listed above. Note that the calibration curve is calculated in a "piece-wise" fashion and is not linear. Be sure that calibration points describe smooth curve. If not, necessary troubleshooting must be performed before continuing (check reagents, pump tubing, valves, etc.).

2. A quality control calibration standard of 100 mg/L and a blank are to be analyzed, at a minimum, after every 10 samples. If less than 10 samples are analyzed, a calibration standard and blank are still required. The last samples analyzed in the run are to be the calibration standard and blank. These standards must be within the acceptable ranges or the samples run after the last acceptable check standard are to be reanalyzed.

3. Duplicate and spike a minimum of 1 out of 10 samples. If less than 10 samples are analyzed, a duplicate and spike are still required. Spike recoveries and duplicates are to be within acceptable ranges or data must be flagged appropriately.

Calculation:

1. Calculate with Lachat QuikChem software, in the concentration mode, using the IBM XT computer. See LAAC SOP for further detail.

APPENDIX B-2

PROCEDURES FOR TCL VOLATILES WITH LOW LEVEL DETECTION LIMITS FOR WATER SUPPLY WELLS

STANDARD OPERATING PROCEDURE
FOR
THE ANALYSIS OF VOLATILE ORGANICS WITH LOW DETECTION LIMITS IN RESIDENTIAL WELL WATER SAMPLES USING GAS CHROMATOGRAPHY/MASS SPECTROMETRY

BY COMPUCHEM

Prepared October 1987
Revised January 1989
Revised May, 1989

ANALYSIS OF VOLATILE ORGANICS WITH LOW DETECTION LIMITS

BY

PURGE AND TRAP GAS CHROMATOGRAPHY/MASS SPECTROMETRY METHOD

REVISED JANUARY 1989
Revised May, 1989

1.0 SCOPE AND APPLICATION

1.1 This standard operating procedure describes the method for the analysis of volatile organics in private well, municipal water supply and domestic well samples.

1.2 This is a purge and trap gas chromatography/mass spectrometry (GC/MS) method applicable to the determination of 38 compounds (See Table 1) in municipal water supply, and private well water samples.

1.3 The required method detection limit (MDL) for each compound is listed in Table 1.

1.4 This method is restricted to use by or under the supervision of analysts experienced in the operation of a purge and trap system, and gas chromatography/mass spectrometry, and in the interpretation of mass spectra. Each analyst must demonstrate the ability to generate acceptable results with this method using the procedure described in Section 10.

2.0 SUMMARY OF METHOD

2.1 An inert gas is bubbled through a 20-ml water sample contained in a specially designed purging chamber at ambient temperature. The purgeables are efficiently transferred from the aqueous phase to the vapor phase. The vapor is swept through a sorbent trap where the purgeables are trapped. After purging is completed, the trap is heated and backflushed with the inert gas to

TABLE 1

TARGET COMPOUND LIST (TCL) AND QUANTITATION LIMITS (QLs)

(FOR RESIDENTIAL WELL WATER SAMPLES)

VOLATILE ORGANICS	CAS NUMBER	QUANTITATION LIMITS(ug
Benzene	71-43-2	1.5
Bromdichloromethane	75-27-4	1.5
Bromoform	75-25-2	1.5
Bromomethane	74-83-9	1.5
Carbon Tetrachloride	56-23-5	1.5
Chlorobenzene	108-90-7	1.5
Chloroethane	75-00-3	1.5
Chloroform	67-66-3	1.5
Chloromethane	74-87-3	1.5
Dibromochloromethane	124-48-1	1.5
1,1-Dichloroethane	75-34-3	1.5
1,2-Dichloroethane	107-06-2	1.5
1,1-Dichloroethene	75-35-4	1.5
1,2-Dichloroethene (Total)		1.5
1,2-Dichloropropane	78-87-5	1.5
Cis-1,3-Dichloropropene	10061-01-5	2.0
Trans-1,3-Dichloropropene	10061-02-6	1.0
Ethyl Benzene	100-41-4	1.5
Methylene Chloride (*)	75-09-2	1.0
1,1,2,2-Tetrachloroethane	79 34-5	1.5
Tetrachloroethene	127-18-4	1.5
Toluene (*)	108-88-3	1.5
1,1,1-Trichloroethane	71-55-6	1.5
1,1,2-Trichloroethane	79-00-5	1.5
Trichloroethene	79-01-6	1.5
Vinyl Chloride	75-01-4	1.5
Acrolein	107-02-8	25.0
Acetone (*)	67-64-1	5.0
Acrylonitrile	107-13-1	25.0
Carbon Disulfide	75-15-0	3.0
2-Butanone (*)	78-93-3	5.0
Vinyl Acetate	108-05-4	5.0
4-Methyl-2-Pentanone	108-10-1	1.5
2-Hexanone	519-78-6	5.0
Styrene	100-42-5	1.0
m-Xylene **	108-38-3	1.5

0-Xylene **	95-47-6	1.5
p-Xylene **	106-42-3	1.5

NOTE: * Common laboratory solvent. Control limits for blanks are 5 the method detection limits.

** m-Xylene, o-Xylene and p-Xylene are reported as a total of three.

desorb the purgeables onto a gas chromatographic column. The gas chromatograph is temperature programmed to separate the purgeables which are then detected with mass spectrometer.

3.0 INTERFERENCES

3.1 Impurities in the purge gas, organic compounds outgasing from the plumbing ahead of the trap, and solvent vapors in the laboratory account for the majority of contamination problems. The analytical system must be demonstrated to be free from contamination under the conditions of the analysis by running laboratory reagent blanks. The use of non-telfon plastic tubing, non-telfon thread sealants, or flow controllers with rubber components in the purge and trap system should be avoided.

3.2 Samples can be contaminated by diffusion of volatile organics through the septum seal into the sample during shipment and storage. A trip blank sample prepared from organic-free water and carried through the sampling and handling protocol can serve as a check on such contamination.

3.3 Contamination by carry-over can occur whenever high level and low level samples are sequentially analyzed.To reduce carry-over, the purging device and sample syringe must be rinsed with reagent water between sample analysis. Whenever an unusually concentrated sample is encountered, it should be followed by an analysis of reagent water to check for cross contamination. It may be necessary to wash the purging device with a detergent solution, rinse it with distilled water, and then dry it in a 105^{0}C oven between analysis. The trap and other parts of the system are also subjected to contamination; therefore, frequent bakeout and purging of the entire system may be required.

4.0 SAFETY PRECAUTIONS

4.1 The toxicity or carcinogenicity of chemicals used in this method has not been precisely defined, each chemical should be treated as a potential health hazard, and exposure to these chemicals should be minimized. Each laboratory is responsible for maintaining awareness of OSHA regulations regarding safe handling of chemicals used in this method. A reference file of material data handling sheets should also be made available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available for the information of the analysts.

4.2 The following parameters covered by this method have been tentatively classified as known or suspected human or mammalian carcinogens: benzene, 1,4-dichlorobenzene, hexachlorobutadiene, tetrachloroethene, trichloroethene, carbon tetrachloride, bis-2-chloroisopropyl ether, 1,2-dichloroethane, 1,1,2,2,-tetra-chloroethane, 1,1,2-trichloroethane, chloroform, 1,2-dibromo-methane, and vinyl chloride. Primary standards of these toxic compounds should be prepared in a hood. NIOSH/ MESA approved toxic gas respirator should be worn when the analysts handle high concentrations of these toxic compounds.

5.0 APPARATUS AND MATERIALS

5.1 Sample Containers

Forty milliliter (40-ml) screw cap glass vials with PTFE-faced silicone septum seals should be used. Wash vials and seals with detergent, rinse with tap water, then distilled water, and dry at 105^{0}C, allow to cool in area known to be free of organic vapors.

5.2 purge and Trap System (Tekmar LSC-2 or equivalent)

5.2.1 Purging Device

The all glass purging device must be capable of accepting 20-ml samples withn a water column at least 5-cm deep. A glass frit installed at the base of sample chamber allowing purging gas to pass through the water column as finely divided bubbles with a diameter of 3 cm at the origin.

5.2.2 Volatile Trap

The trap must be at least 25 cm long and have an inside diameter of at least 0.105 inches. The trap must contain the following amounts of adsorbents: 1/3 of 2,6-diphenylene oxide polymer, 1/3 of silica gel, and 1/3 of coconut charcoal. Prior to daily use, the trap is conditioned for 10 minutes at 220^{0}C while backflusing with an inert gas flow of at least 20 ml/min. The trap effluent is vented to the room through a charcoal trap.

5.2.3 Desorber

The desorber must be capable of rapidly preheating the trap to 180°C, then desorbing the trap to the GC column while maintaining the temperature of 180°C.

5.3 GC/MS SYSTEM

5.3.1 Gas Chromatograph (Hewlet Parkard 5993 GC or Equivalent)

Gas chromatograph must be capable of temperature programming and achieving an initial column temperature of 30°C - 45°C. Variable constant differential flow controllers capable of maintaining constant flow rates throughout the desorption and temperature program should be used.

5.3.2 Gas Chromatographic Column

Eight Ft. long x 1/8 O.D. glass column, packaed with 1% SP-1000 on Carbopack B (60/80 mesh) or equivalent.

5.3.3 Mass Spectrometer (Finnigan 5100 MS or equivalent)

Must be capable of scanning from 20 to 260 amu every 7 seconds or less, utilizing 70 V (nominal) electron energy in the electron impact ionization mode, and producing a mass spectrum which meet all the criteria in Table 3 when 50 ng of 4-bromofluorobenzene (BFB) is injected through the GC inlet.

5.3.4 GC/MS Interface

GC to ms interface constructed of all glass or glasslined materials should be used. Glass can be deactivated by silanizing with dichlorodimethylsilane.

5.3.5 Data System

A computer system must be interfaced to the mass spectrometer that allows the continuous acquisition and storage on machine-readable media of all mass spectra obtained through the duration of the chromatographic program. The computer must have the software that allows searching any GC/MS data file for spectra m/z (masses) and plotting such m/z abundance versus time or scan number. Software must also allow integrating the abundance in any Extracted Ion Current Profile (EICP) between specific time or scan number limits.

5.3.6 Syringe and Syringe Valves

5.3.6.1 Syringes - 5-ml and 25-ml glass hypodermic with luerlock tip (two each).

5.3.6.2 Micro Syringes - 25- and 100-ul.

5.3.6.3 Gas Syringes - 1.0 and 5.0 ml gas tight, with shut-off valve.

5.3.7 Miscellaneous

5.3.7.1 Standard Storage Containers - 3.7 ml screw cap amber vilas.

5.3.7.2 Mininert Valves - Screw cap.

6.0 REAGENTS

6.1 Methanol, demonstrated to be free of analytes (spike 100 ul into 25 ml of reagent water and analyze. Result should be less than detection limits.).

6.2 Reagent water, producing less than detection limits of those compounds that are monitored. Prepared by boiling distilled or natural waters for 15 minutes followed by 1 hour purge with inert gas while temperature is held at 90^0C or carbon filtered. Store in clean, narrow mouthed crip top PTFE-lined septa bottles.

6.3 Stock Standards - Commerical mixed stock solutions are available (Supelco Purgeeables A, B, and C) that contain most of the compounds of interest at a concentration of 0.2 mg/ml. Stock solutions must be prepared from neat, as folows for those compounds not included in the commerical mixes(NOTE 1).

6.3.1 Place 24.4 ml of methanol in a 25-ml volumetric flask. Allow flask to stand unstoppered for 10 minutes or until all alcohol-wetted surfaces have dried, and then tare.

6.3.2 Using a 100-ul syringe, add 50 mg of assayed reference material to the flask. Be sure that the drops fall directly into the alcohol without contacting the neck of the flask. Retare the flask and add 50 mg of the next compound. Repeat the process until all compounds have been added.

6.3.3 Dilute to volume, and stopper. Mix by inverting flask several times. The resulting solution will contain each analyte at a concentration of 2.0 mg/ml.

6.3.4 Store stock standard solutions in 3-ml vials equipped with PTFE mininert valve tops at 0^{0}C. All standards must be replaced each month.

NOTE 1: The following compounds must be made from neat: Cis-1,2-dichloroethene, trans-1,2-dichloroethene, O-xylene, m-xylene, p-xylene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, styrene, 1,2-dichlorobenzene.

6.4 Secondary Dilution Standards

Using stock standards to prepare secondary dilution standards in methanol. The secondary dilution standards are prepared at concentrations that can be easily diluted to prepare aqueous calibration standards that will bracket the working range of the method.

6.4.1 To prepare secondary dilution standards, place 9.0 ml of methanol into a 10-ml volumetric flask.

6.4.2 Inject exactly 250 ul of the speclco purgeable A and purgeable B stock solution, and 250 ul of the stock solution prepared from neat (6.3) into the methanol. When the standard solution is prepared as above, the solution will contain each analyte at a concentration of 5 ng/ul.

6.4.3 Separate secondary dilution standard mixture should be prepared weekly for the gases from the Supelco purgeable C mix.

6.4.4 Store secondary dilution standards in 3-ml glass vials equipped with PTFE mininert valve screw tops. Storage conditions and time described for stock standary solutions (6.3.4) also apply to the secondary dilution standard solutions.

6.5 Working Aqueous Calibration Standards

Using the secondary dilution standards to prepare five calibration standards at concentrations of 5, 10, 20, 40 and 60 ug/L for all volatile compounds except the acrolein and acrylonitrile, which should be at concentrations of 25, 50, 75, 100 and 125 ug/L.

6.6 Continuing Calibration Check Standard

Prepare the aqueous continuing calibration check standard solution at concentration of 20 ug/L for all compounds except acrolein and acrylonitrile, which should be at concentration of 50 ug/L.

6.7 Sample matrix Spiking Solution

Prepare a matrix spiking solution containing all compounds of interest in methanol using the procedures described in Section 6.3 and 6.4. It is recommended that the secondardy dilution standard be prepared at a concentration of 50 ug/mL for all compounds except acrolein and acrylonitrile, which shall be at a concentration of 125 ug/mL. The addition of 10 uL of such standard solution to 25 mL of reagent water or samples would be equivalent to 20 ug/L. Store at 0^0C. The sample matrix spiking solution should be discarded after 1 month.

6.8 Internal Standard Solution

Prepare a spiking solution containing Bromochloromethane, 1,4-Difluorobenzene, and chlorobenzene-d5 in methanol using the procedures described in Section 6.3 and 6.4. It is recommended that the secondary dilution standard be prepared at a concentration of 50 ug/mL of each internal standard compound. The addition of 10 uL of such a standard to 25 mL of sample or calibration standard would be equivalent to 20 ug/L.

6.9 Surrogate Spike Standard Solution

Prepare a surrogate spiking solution containing Toluene-d8, Bromofluorobenzene, and 1,2-dichloroethane-d4 in methanol using the procedures described in Section 6.3 and 6.4. It is recommended that the secondary dilution standard be prepared at a concentration of 50 ug/mL of each surrogate spike compound. The addition of 10 uL of such as standard to 25 mL of sample or calibration standard would be equivalent to 20 ug/L.

6.10 4-BORMOFLUOROBENZENE (BFB) Solution

Prepare a 25 ug/mL solution of bromofluorobenzene in methanol. This solution would be used for MS tuning.

7.0 SAMPLE COLLECTION, PRESERVATION, AND STORAGE

7.1 Sample collection

7.1.1 Collect all samples in duplicate(2 40-ml glass vials). Fill sample bottles to overflowing. No air bubbles should pass through the sample as the bottle is filled, or be trapped in the sample when the bottle is sealed.

7.1.2 When sampling from a water tap, open the tap and allow the system to flush until water temperature has stabilized (usually about 10 minutes). Adjust the flow to about 500 ml/min. and collect duplicate samples from the flowing system.

7.1.3 When sampling from an open body of water, fill a 1-quart wide-mouth bottle or 1-liter beaker with sample from a respresentative area, and carefully fill duplicate sample bottles from the container.

7.2 Sample Preservation

7.2.1 Adjust the pH of the duplicate samples to <2 by carefully adding one drop of 1:1 HCl for each 20 ml of sample volume (See Reference No.6). Seal the sample bottles, PFTE-face down, and shake vigorously for one minutes.

7.2.2 The samples must be chilled to 4^{0}C on the day of collection and maintained at that temperature until analysis. Field samples that will not be packaged for shipment with sufficient ice to ensure that they will be at 4^{0}C on arrival at the laboratory.

7.3 Sample storage

7.3.1 Store samples at 4^{0}C until analysis. The sample storagearea must be free of organic solvent vapors.

7.3.2 Analyze all samples within 7 days of collection. Samples not analyzed within this period must be discarded and replaced.

8.0 CALIBRATION AND STANDARDIZATION

8.1 Tuning and GC/MS Calibration

8.1.1 The laboratory must establish that a given GC/MS system meet the standard spectral abundance criteria prior to initiating any on-going data collection. The GC/MS system must be hardware tuned to meet the abundance criteria listed in Table 4 for a maximum of a 50 ng injection of 4-Bromofluorobenzene (BFB). Add 50 ng of BFB solution to 20 ml of reagent water and analyze alone. BFB should NOT be analyzed simultaneously with any calibration standards or blanks. This criteria must be demonstrated dialy or for each twelve-hour (12) time period. If required, background substraction must be straight forward and designed only to eliminate column bleed or instrument background.

8.1.2 BFB criteria MUST be met before any standards, samples or blanks are analyzed.

8.1.3 Any action taken which may results in effecting the tuning criteria for BFB, the tune must be verified irrespective of the twelve-hour tuning requirement.

8.1.4 The laboratory shall document the GC/MS tuning and mass calibration each time the system is tuned.

8.2 Calibration of GC/MS System

8.2.1 Initial Internal Standard Calibration

8.2.1.1 Prior to the analysis of samples and required blanks and after tuning criteria have been met, the GC/MS system must be initially calibrated at a minimum of five concentrations to determine the linearity of response utilizing the initial calibration standard solutions containing all compounds listed in Table 2. Once the system has been calibrated, the calibration must be verified after the initial calibration and each twelve(12) hours time period for each GC/MS system.

TABLE 2

CHARACTERISTIC IONS FOR VOLATILE ORGANIC COMPOUNDS

Parameters	Primary Ion	Secondary Ions
Chloromethane	50	52
Bromomethane	94	96
Vinyl Chloride	62	64
Chloroethane	64	66
Methylene Chloride	84	49, 51, 86
Acetone	43	58
Carbon Disulfide	76	78
1,1-Dichloroethene	96	61, 98
1,1-Dichloroethane	63	65, 83, 85, 98, 100
1,2-Dichloroethene	96	61, 98
Chloroform	83	85
1,2-Dichloroethane	62	64, 100, 98
2-Butanone	72	57
1,1,1-Trichloroethane	97	99, 117, 119
Carbon Tetrachloride	127	119, 121
Vinyl Acetate	43	86
Bromodichloromethane	83	85
1,1,2,2-Tetrachloroethane	83	85, 131, 133, 166
1,2-Dichloropropane	63	65, 114
Trans-1,3-Dichloropropene	75	77
Trichloroethene	130	95, 97, 132
Dibromochloromethane	129	208, 206
1,1,2-Trichloroethane	97	83, 85, 99, 132, 134
Benzene	78	-
Cis-1,3-Dichloropropene	75	77
Bromoform	173	171, 175, 250, 252, 254,
2-Hexanone	43	58, 57, 100
4-Methyl-2-pentanone	43	58, 100
Tetrachloroethene	164	129, 131, 166
Toluene	92	91
Chlorobenzene	112	114
Ethyl Benzene	106	91
Styrene	104	78, 103
Total Xylenes	106	91

The primary ion should be used unless interferences are present, in which case, a secondary ion may be used.

TABLE 3

VOLATILE INTERNAL STANDARDS WITH CORRESPONDING TCL ANALYTES ASSIGNED FOR QUANTITATION

Bromochloromethane	1,4-Difluorobenzene	Chlorobenzene-d_5
Chloromethane	1,1,1-Trichloroethane	2-Hexanone
Bromomethane	Carbon Tetrachloride	4-Methyl-2-Pentanone
Vinyl Chloride	Vinyl Acetate	Tetrachloroethene
Chloroethane	Bromodichloromethane	1,1,2,2-tetrachloroethane
Methylene Chloride	1,2-Dichloropropane	Toluene
Acetone	Trans-1,3-dichloropropene	Chlorobenzene
Carbon Disulfide	Trichloroethene	Ethylbenzene
1,1-dichloroethene	Dibromochloromethane	Styrene
1,1-dichloroethane	1,1,2-Trichloroethane	Xylene (total)
1,2-Dichloroethene(Total)	Benzene	Bromofluorobenzene (Surrogate)
Chloroform	Cis-1,3-dichloropropene	
1,2-Dichloroethane	Boroform	Toluene-d_8(surrogate)
2-Butanone		
1,2-Dichloroethane-d_4 (surrogate)		

TABLE 4

p-BROMOFLUOROBENZENE (BFB) KEY IONS AND ABUNDANCE CRITERIA

Mass	Ion Abundance Criteria
50	15.0 - 40.0 % of the base peak
75	30.0 - 60.0 % of the base peak
95	Base peak, 100 % relative abundance
96	5.0 - 9.0% of the base peak
173	Less than 1.00% of the base peak
174	Greater than 50.0% of the base peak
175	5.0 - 9.0% of mass 174
176	Greater than 95.0%, but less than 101.0% of mass 174.

NOTE: BFB criteria MUST be met before any samples, sample extracts, blanks, or standards are analyzed.

8.2.1.2 Prepare calibration standards by spiking five portions of 20 ml reagent waters with various amount of secondary dilution standard solution (6.4) to yield the following specific concentrations: 5, 10, 20, 40, and 60 ug/L for all compounds except acrolein and acrylonitrile, which have the specific concentrations at 25, 50, 75, 100 and 125 ug/L.

Internal standards and surrogate spike standards will be added to each each calibration standard solutions to yield a concentration of 20 ug/L.

8.2.1.3 Analyze each calibration standard solution and tabulate the area of the primary characteristic ion againt concentration for each compound including all required internal standards and surrogate standard compounds. The relative retention time (RRT) of each compound in each calibration run should agree within 0.06 RRT units.

8.2.1.4 Use Table 4 and Equation 1 to calculate the relative response factor (RRF) for each compound at each concentration level.

$$RRF = \frac{A_x}{A_{is}} \times \frac{C_{is}}{C_x} \qquad \text{Equation 1}$$

Where,

A_x = Area of the characteristic ion for the compound to be measured.

A_{is} = Area of the characteristic ion for the specific internal standards from Table 2.

C_{is} = Concentration of the internal standard (ng/UL).

C_x = Concentration of the compound to be measured (ng/uL).

8.2.1.5 Use equation 2 and the relative response factors (RRF) from the initial calibration to calculate the relative standard deviation (%RSD) for compounds labelled as calibration check compounds in Table 4.

$$\%RSD = \frac{SD}{X} \times 100 \qquad \text{Equation 2}$$

Where,

RSD = Relative Standard Deviation

SD = Standard Deviation of initial relative response factors (per compound).

Where : $$SD = \sqrt{\sum_{i=1}^{N} \frac{(X_i - X)^2}{N-1}} \qquad \text{Eq.}$$

X = Mean of initial relative response factors (per compoun

The %RSD for each individual calibration check compound must be less than or equa to 30.0%. This criteria must be met for the initial calibration to be valid.

8.2.1.6 System Performance Check

A system performance check must be performe to insure that minimum average relative response factors are met before the calibration curve is used. This is done by analyzi five system check compounds (SPCCs): Chloromethane, 1,1-dichloroethane, bromofor 1,1,2,2-tetrachloroethane, and chlorobenzen The minimum acceptable RRF for these compou is 0.300 (0.100 for bromoform, and 0.200 fo 1,1,2,2-tetrachloroethane).

8.2.1.7 The initial calibration is valid only after both the %RSD for calibration check compound and the minimum RRF for SPCC have been met. Only after both of these criteria are met ca sample analysis begin.

8.3 Continuing Calibration Check

8.3.1 A calibration standard(s) containing all volatile organics listed in Table 2, including all required surrogate compounds, must be analyzed each twelve hours during analysis. The concentration of each compound in the continuing calibration check (CCC) is 20 ug/L except acrolein and acrylonitrile (50 ug/L). Compare the relative response factor data from the standards each twelve hours with the average relative response factor from the initial calibration for a specific instrument. A system performance check must be made each twelve hours. If the SPCC criteria are met, a comparison of relative response factors is made for all compounds.

8.3.2 After the system performance check is met, use equation 4 to calculate the percent difference (% difference) for all calibration check compounds in Table 4 in order to check the validity of the initial calibration.

8.3.2.1 Calculate the percent difference using Equation 4.

$$\%\text{Difference} = \frac{RRF_I - RRF_C}{RRF_I} \times 100 \qquad \text{Eq. 4}$$

Where

RRF_I = Average relative response factor from initial calibration.

RRF_C = Relative response factor from current calibration check.

8.3.2.2 If the percent difference for any compound is greater than 20%, the laboratory should consider this a warning limit. If the percent difference for each CCC is less than or equal to 25.0%, the initial calibration is assumed to be valid. If the criteria are not met (>25.0% difference), for any one of the calibration check compound, corrective action MUST be taken. Problems similar to those listed under SPCC could affect this criteria. If no source of the problem can be determined after corrective action have been taken, a new initial five points calibration MUST be generated. These criteria MUST be met before sample analysis begins.

9.0 QUALITY CONTROL

9.1 Each laboratory that uses this method is required to operate formal quality control program. The minimum requirements of this program consists of an intial demonstration of laboratory capability and an ongoing analysis of spiked samples to evaluate and document data quality. The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established perfromance criteria to determine if the results of analysis meet the performance characteriztics of the method. A quality control check standard must be analyzed to confirm that the measurements were performed in an in-control mode of operation.

9.1.1 The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method. This ability is established as are described in Section 9.2 .

9.1.2 In recognition of advances that are occurring in chromatography, the analyst is permitted certain options (detailed in Section 10.2.2) to improve the separation or lower the cost of measurements. Each time such a modification is made to the method, the analyst is required to repeat the procedure in Section 9.2 .

9.1.3 Each day, the analyst must analyze a reagent water blank to demonstrate that interferences from the analytical system are under control.

9.1.4 The laboratory must, on an ongoing basis, demonstrate through the analyses of quality control check standards that the operation of the measurement system is in control. The frequency of the check standard analyses is equivalent ot 10% of all samples analyzed but at least two samples per month. Using the following procedure to analyze a quality control check sample for all analytes of interest at 10 ug/L:

9.1.4.1 Prepare a QC check sample by adding 50 ul of QC check sample concentrate to 20 ml of reagent water in a glass syringe.

9.1.4.2 Analyze the QC check sample according to Section 10, and calculate the recovery for each analyte. The recovery must be between 60% and 140% of the expected values.

9.1.4.3 If the recovery for any analyte falls outside the designated range,the analyte has failed the acceptance criteria. A check standard containing each analyte that failed must be re-analyzed.

9.1.5 On a weekly basis, the laboratory must demonstrate the ability to analyze low level samples. The following procedure should be used:

9.1.5.1 Prepare a low level check sample by spiking 10 ul of QCcheck sample concentrated to 25 ml of reagent water and analyze according to the method in Section 10.0 .

9.1.5.2 For each analyte, the recovery must be between 60% and 140% of the expected value.

9.1.5.3 When one or more analytes fail the test, the analyst must repeat the test only for those analytes which failed to meet the criteria. Repeated failure, however, will confirm a general problem with the measurement system. If this occurs,locate and correct the source of the problem and repeat the test for all compounds of interest beginning with 9.1.5.1.

9.1.6 The laboratory must maintain performance records to document the quality of data that is generated. The following procedure should be performed:

9.1.6.1 It is recommeded that the laboratory adopt additional quality assurance practices for use with this method. The specific practices that are most productive depend upon the needs of the laboratory and the nature of the samples. As a minimum, field duplicate samples must be analyzed to assess the precision of the environmental measurements.

9.2 To establish the ability to generate acceptable accuracy and precision, the analyst must perform the following operations.

9.2.1 A quality control check sample concentrate containing each analyte at a concentration of 500 times the MDL in methanol is required. The QC check sample must be prepared by the laboratorry using stock standards prepared independently from those used for calibratio

9.2.2 Analyze seven 20-ml QC check samples at 2 ug/L according to the method beginning in Section 10.0 Each sample is produced by injecting 10 ul of QC check sample concentrate into 25 ml of reagent water in a glass syringe through the syringe valve.

9.2.3 Calculate the average recovery (X) in ug/L, and the standard deviation of the recovery (S) in ug/L for each analyte using the seven results. Calculate the MDL for each analyte as specified in Reference 2. The calculated MDL must be less than the spike level.

9.2.4 For each analyte, (X) must be between 90% and 110% of the true value. Additionally, s must be <35% of X. If s and X for all analytes meet the criteria, the system performance is acceptable and analysis of actual samples can begin. If any s exceeds the precision limits or any X falls outside the range for accuracy, the system performance is unacceptable for that analyte.

NOTE: The larger number of analytes present a substantial probability that one or more will fail at least one of the acceptance criteria when all analytes are analyzed.

9.2.5 When one or more of the analytes tested fail at least one of the acceptance criteria, the analyst must proceed according to Section 9.2.2 only for the analytes which fialed the test.

10.0 PROCEDURE OF SAMPLE ANALYSIS

10.1 DAILY GC/MS PERFORMANCE TESTS

10.1.1 At the beginning of each day that analyses are to be performed, the GC/MS system must be checked to see if acceptable performance criteria are achieved for 4-Bromofluorobenzene (BFB). The performance test must be passed before any samples, blanks, or standard are analyzed.

10.1.2 At the beginning of each day, inject 2 ul (50 ng) of BFB solution directly onto the column. Alternatively, add 2 ul of BFB solution to 20.0 ml of reagent water or calibration standard and analyze the solution according to Section 8.1 Obtain a background-corrected mass spectrum of BFB and confirm that all the key m/z criteria in Table 4 are achieved. If all the criteria are not achieved, the analyst must re-tune the mass spectrometer and repeat the test until all criteria are achieved.

10.2 INITIAL CONDITIONS

10.2.1 Acquire GC/MS data for perfomance tests, standards and samples using the following instrumental conditions:

Electron Energy : 70 V (Nominal)

Mass Range : 35 to 300 amu

Scan Time : To give at least 5 scans per second, but not to exceed 2 seconds per scan.

10.2.1. The operating conditions for the gas chromatograph are summarized under Section 10.4.2.2 . Table 1 and Table 2 list the retention times and MDL that can be achieved under these conditions. Other columns or chromatographic conditions may be used if the requirements of Section 9.0 are met.

10.3 SAMPLE INTRODUCTION AND PURGING

10.3.1 Adjust the purge gas (nitrogen or helium) flow rate to 40 ml/min. Attach the trap inlet to the purging device and open the syringe valve on the purging device.

10.3.2 Remove the plungers from two 25-ml syringes and attach a closed syringe valve to each. Warm the sample to room temperature, open the sample (or standard) bottle, and carefully pour the sample into one of the syringe barrels to just short of overflowing. Replace the syringe plunger, invert the syringe, and compress the sample. Open the syringe valve and vent any residual air while adjusting the sample volume to 20.0 ml. Add 10 ul of the internal standard spiking solution (Section 6.8) and 10 ul of the surrogate spiking standard solution (Section 6.9) to the sample through the syringe valve. Close the valve. Fill the second syringe in an identical manner from the same sample bottle. Reserve the second syringe for a reanalysis if necessary.

10.3.3 Attach the sample syringe valve to the syringe valve on the purging device. Be sure that the trap is cooler than 25_0C, then open the sample syringe valve and inject the sample into the purging chamber. Purge the sample for 11.0 ±0.1 min at ambient temperature.

10.4 SAMPLE DESORPTION

The mode of sample desorption is determined by the type of capillary column employed for the analysis. When using a wide-bore capillary column, follow thw desorption conditions of Section 10.4.1 . The conditions for using narrow-bore capillary column is described in Section 10.4.

10.4.1 Sample Desorption for Wide-Bore Capillary Column

Undre most conditions,this type of column must be interfaced to MS through a all-glass jet separator

10.4.1.1 After the 11-minute purge, attach the trap to the chromatograph, adjust the purge and trap system to the desorb mode and initiate the temperature program sequence of the gas chromatograp and start data aquisition. Introduce the trapped materials to the GC column by rapidly heating the trap to 180^0C while backflushing the trap with an iner gas at 15 ml/min for 4.0 ± 0.1 min. While the extracted sample is being introduced into the gas chromatograph, empty the purging device using the sampl syringe and wash the chamber with two 25-ml flushes of reagent water. After the purging device has been emptied, leave the syringe valve open to allow the purge gas to vent through the sample introduction needle.

10.4.1.2 Gas Chromatography - Hold the column temperature at 10^0C for 5 minutes, then program at 6^0C/min to 160^0C and hold until all analytes eluted.

10.4.1.3 Trap Reconditioning - After desorbing the sample for 4 min, recondition the trap by returning the purge and trap system to the purge mode. Wait 15 seconds, then closed the syringe valve on the purging device to begin gas flow through the trap. Maintain the trap temperature at 180^0C. After approximately 7 minutes, turn off the trap heater and open the syringe valve to stop the gas flow through the trap. When the trap is cool, the next sample can be analyzed.

10.4.2 Sample Desorption for Narrow-Bore Capillary Column

Under normal operating conditions, most narrow-bore capillary columns can be interfaced directly to the MS without a jet separator.

10.4.2.1 Sample Desorption

After the 11 minutes purge, attach the trap to the cyrogenically cooled interface at -15^{0}C and adjust the purge and trap system to the desorb mode. Introduce the trapped materials to the interface by rapidly heating the trap to 180^{0}C while backflusing the trap with an inert gas at 4 ml/min for 5.0+0.1 min. While the extracted sample is being introduced into the interface,empty the purging device using the sample syringe and rinse the chamber with two 25-ml flushes of reagent water. After the purging device has been emptied, leave the syringe valve open to allow the purge gas to vent through the sample introduction needle. After desorbing for 5 minutes, flash heat the interface to 250^{0}C and quickly introduce the sample onto the chromatographic column. Start the temperature program sequence, and initiate data acquisition.

10.4.2.2 Gas Chromatograph

Hold the column temperature at 10^{0}C for 5 minutes, then program at 6^{0}C/min to 70^{0}C and then at 15^{0}C/min to 145^{0}C.

10.4.2.3 Trap Reconditioning

After desorbing the sample for 5 minutes, recondition the trap by returning the purge and trap system to the purge mode. Wait 15 seconds, then close the syringe valve on the purging device to begin gas flow through the trap. Maintain the trap temperature at 180^{0}C. After approximately 15 minutes, turn off the trap heater and open the syringe valve to stop the gas flow through the trap. When the trap is cool, the next sample can be analyzed

10.5 TERMINATION OF DATA ACQUISITION

When sample components have eluted from the GC, terminate MS data acquisition and store data files on the data syste storage device. Use appropriate data output software to display full range mass spectra and appropriate EICPs. If any ion abundance exceeds the system working range, dilute the sample aliquot in the second syringe with reagent water and analyze the diluted aliquot.

11.0 QUALITATIVE IDENTIFICATION

11.1 IDENTIFICATION PROCEDURES CRITERIA

Tentatively identify a sample component by comparison of its mass spectrum (after background substraction) to a reference spectrum in a collection. Use the follwoing criteria to confirm a tentative identification:

11.1.1 The GC retention time of the sample component must be within 10 seconds of the time observed for that sample compound when a calibration solution was analyzed.

11.1.2 All ions that are present above 10% relative abundance in the mass spectrum of the standard must be present in the mass spectrum of the sample component and should agree within absolute 10%. For example, if an ion has a relative abundance of 30% in the standard spectrum, its abundance in the sample component should be in the range of 20 to 40%.

11.1.3 Identification is hampered when sample components are not resolved chromatographically and produce mass spectra containing ions contributed by more than one analyte. Because purgeable organic compounds are relatively small molecules and produce comparatively simple mass spectra, this is not a significant problem for most method analytes. When GC peaks obviously represent more than one sample component (i.e., broadened peak with shoulder(s) or valley between two or more maxima), appropriate analyte spectra and backgroun spectra can be selected by examining EICPs of characteriztic ions for tentatively identified components. When analytes coelute (i.e., only one GC peak is apparent), the identification criteria described in Section 11.1.2 can be met but each analyte spectrum will contain extraneous ions contributed by the coeluting compound.

11.1.4 Structural Isomers that produce very similar mass spectra can be explicity identified only if they have sufficiently different GC retention times. Acceptable resolution is achieved if the height of the valley between two isomer peaks i less than 25% of the sum of the two peak heights. Otherwise, structural isomers are identified as isomeric pairs.

12.0 CALCULATION

12.1 When an analyte has been identified, the quantitation of that analyte should be based on the integrated abundance from the EICPs of the primary characteristic m/z given in Table 2. If the sample produces an interference for the primary m/z, use a secondary characteristic m/z to quantitate. Instrument calibration for secondary ions is performed, as necessary, using the data and procedures described in Section 8.2.

12.2 Calculate the concentration in the sample using the calibration curve or average response factor (RF) determined in Section 8.2.2 and Equation 3 :

$$\text{Concentration (ug/L)} = \frac{(A_s)\ (C_{is})}{(A_{is})\ (RF)} \qquad \text{Equ. 3}$$

Where,

A_s = Area of the characteristic m/z for the analyte to be measured;

A_{is} = Area of the characteristic m/z for the internal standard;

C_{is} = Concentration of the internal standard, in ug/L.

12.3 Report results in ug/L. All QC data obtained should bereported with the sample results.

13.0 DATA REPROTING REQUIREMENTS

13.1 All reports and documentation must be legible,single-sided, and clearly labelled and paginated.

13.2 The sample data package must be consecutively paginated and shall include the cover pages, sample data, and the raw data as they are described in the following:

13.2.1 Cover Pages for the data package, including the project name; laboratory name; field sample number cross-referenced with laboratory ID number ; comments describing in details any problems encountered in processing the samples in the data package; and validation and signature by the Laboraotry Manager.

13.2.2 Sample Data

Sample data shall be reported using the Organic Analysis Data Reporting Forms (Attachment I) for all samples, arranging in increasing alphanumeric sample number order, followed by the QC analysis data, Quarterly verification of instrument parameters forms, raw data, and copies of the sample preparation logs.

13.2.2.1 FORM I (Organic Analysis Data Sheet)

13.2.2.2 FORM I (Tentatively Identified Compounds

13.2.2.3 FORM II (Surrogate Recovery)

13.2.2.4 FORM III (Matrix Spike/Matrix Spike Duplicate Recovery)

13.2.2.5 FORM IV (Method Blank Summary)

13.2.2.6 FORM V (GC/MS Tuning and Mass

Calibration)

13.2.2.7 FORM VI (Initial Calibration Data)

13.2.2.8 FORM VII (Continuing Calibration Data)

13.2.2.9 FORM VIII (Internal Standard Area Summary)

13.2.2.10 Raw Data

Raw data shall includes Reconstructed Ion Current (RIC) Chromatogram, Mass spectrum (with and without background substraction for all compounds quantified,mass spectrum of tentatively identified compound including the most matched library standard spectra, any instrument printouts, etc.

14.0 REFERENCES

14.1 A. Alford-Stevens, J.W. Eichelberger, W.L. Budde, "Purgeable Organic Compounds in Water by Gas Chromatography/Mass Spectrometry, Method 524." Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio, February 1983.

14.2 Glaser, J. A., D. L. Foerst, G.D. McKee, S.A. Quave, and W.L.Budde, "Trace Analyses for Wastewaters," Environ. Sci. Technol., 15, 1426, 1981.

14.3 "The Determination of Halogenated Chemicals in Water by the Purge and Trap Method, Method 502.1, "Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio 45268, April, 1981.

14.4 "Volatile Aromatic and Unsaturated Organic Compounds in Water by Purge and Trap Gas Chromatography, Method 503.1,' Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio, April, 1981.

14.5 Bellar, T.A. and J.J. Lichtenberg, "The determination of Synthetic Organic Compounds in Water by Purge and Sequential Trapping Capillary Column Gas Chromatography," U.S.Environmental Protection Agency, Environmental

Monitoring and Support Laboratory, Cincinnati, Ohio,45268.

14.6 Ho. J.S. Method Performance Data for Method 502.2, Unpublished Report, September, 1986.

14.7 "Gas Chromatographic Analysis of Purgeable Halocarbon and Aromatic Compounds in Drinking Water Using Two Detectors in series," Kingsley, B.A., Gin, C., Coulson, D.M., and Thomas, R.F., Water Chlorination, Environmental Impact and Health Effects, Volume 4, Ann Arbor Science.

14.8 "EPA Method Validation Study 23, Method 601 (Purgeable Halocarbon)," U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio 45268.

VOLATILE ORGANICS ANALYSIS DATA SHEET

Lab Name: ____________________

Field Sample Number ____________.

Matrix: water

Sample vol: ________ mL

Level: (low/med) _____

Column: (pack/cap) _____

Lab Sample ID: ____________

Lab File ID: ____________

Date Received: __________

Date Analyzed: __________

Dilution Factor: ________

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L	Q
74-87-3	Chloromethane		
74-83-9	Bromomethane		
75-01-4	Vinyl Chloride		
75-00-3	Chloroethane		
75-09-2	Methylene Chloride		
67-64-1	Acetone		
75-15-0	Carbon Disulfide		
75-35-4	1,1-Dichloroethene		
75-34-3	1,1-Dichloroethane		
540-59-0	1,2-Dichloroethene (total)		
67-66-3	Chloroform		
107-06-2	1,2-Dichloroethane		
78-93-3	2-Butanone		
71-55-6	1,1,1-Trichloroethane		
56-23-5	Carbon Tetrachloride		
108-05-4	Vinyl Acetate		
75-27-4	Bromodichloromethane		
78-87-5	1,2-Dichloropropane		
10061-01-5	cis-1,3-Dichloropropene		
79-01-6	Trichloroethene		
124-48-1	Dibromochloromethane		
79-00-5	1,1,2-Trichloroethane		
71-43-2	Benzene		
10061-02-6	trans-1,3-Dichloropropene		
75-25-2	Bromoform		
108-10-1	4-Methyl-2-Pentanone		
591-78-6	2-Hexanone		
127-18-4	Tetrachloroethene		
79-34-5	1,1,2,2-Tetrachloroethane		
108-88-3	Toluene		
108-90-7	Chlorobenzene		
100-41-4	Ethylbenzene		
100-42-5	Styrene		
1330-20-7	Xylene (total)		

VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

Lab Name: ______________________________

Lab Sample I.D. __________________. Field Sample Number _________________.

Matrix: water

Sample Vol: ________ mL

Lab File ID: ________________

Level: (low/med) _____

Date Received: ___________

Date Analyzed: ___________

Column: (pack/cap) _____

Dilution Factor: _________

Number TICs found: ______

CONCENTRATION UNITS:
(ug/L

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				
26.				
27.				
28.				
29.				
30.				

FORM I VOA-TIC

WATER VOLATILE SURROGATE RECOVERY

Lab Name:______________________________

	Field SAMPLE NO.	S1 (TOL) #	S2 (BFB) #	S3 (DCE) #	OTHER	TOT OUT
01						
02						
03						
04						
05						
06						
07						
08						
09						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

	QC LIMITS
S1 (TOL) = Toluene-d8	(88-110)
S2 (BFB) = Bromofluorobenzene	(86-115)
S3 (DCE) = 1,2-Dichloroethane-d4	(76-114)

 # Column to be used to flag recovery values

* Values outside of contract required QC limits

D Surrogates diluted out

page __ of __

FORM II VOA-1

WATER VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Lab Name: ____________________

Lab Sample I.D. ______________. Field Sample Number ____________.

Matrix Spike - EPA Sample No.: __________

COMPOUND	SPIKE ADDED (ug/L)	SAMPLE CONCENTRATION (ug/L)	MS CONCENTRATION (ug/L)	MS % REC #	QC LIMITS REC.
1,1-Dichloroethene					61-145
Trichloroethene					71-120
Benzene					76-127
Toluene					76-125
Chlorobenzene					75-130

COMPOUND	SPIKE ADDED (ug/L)	MSD CONCENTRATION (ug/L)	MSD % REC #	% RPD #	QC LIMITS RPD	QC LIMITS REC.
1,1-Dichloroethene					14	61-145
Trichloroethene					14	71-120
Benzene					11	76-127
Toluene					13	76-125
Chlorobenzene					13	75-130

Column to be used to flag recovery and RPD values with an asterisk

* Values outside of QC limits

RPD: ______ out of ______ outside limits
Spike Recovery: ______ out of ______ outside limits

COMMENTS: ____
____

FORM III VOA-1

VOLATILE METHOD BLANK SUMMARY

Lab Name: ______________________

Lab File ID: ____________ Lab Sample ID: ____________

Date Analyzed: ________ Time Analyzed: ________

Matrix: water Level:(low/med) _____

Instrument ID: ________

THIS METHOD BLANK APPLIES TO THE FOLLOWING SAMPLES, MS AND MSD:

	Field SAMPLE NO.	LAB SAMPLE ID	LAB FILE ID	TIME ANALYZED
01				
02				
03				
04				
05				
06				
07				
08				
09				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				

COMMENTS: ______________________________

page __ of __

FORM IV VOA

VOLATILE ORGANIC GC/MS TUNING AND MASS CALIBRATION - BROMOFLUOROBENZENE (BFB)

Lab Name: ____________________

Lab Sample I.D. ____________. Field Sample Number ____________.

Lab File ID: ____________ BFB Injection Date: __________

Instrument ID: __________ BFB Injection Time: __________

Matrix: water Level:(low/med) _____ Column:(pack/cap) _____

m/e	ION ABUNDANCE CRITERIA	% RELATIVE ABUNDANCE
50	15.0 - 40.0% of mass 95	
75	30.0 - 60.0% of mass 95	
95	Base peak, 100% relative abundance	
96	5.0 - 9.0% of mass 95	
173	Less than 2.0% of mass 174	( )1
174	Greater than 50.0% of mass 95	
175	5.0 - 9.0% of mass 174	( )1
176	Greater than 95.0%, but less than 101.0% of mass 174	( )1
177	5.0 - 9.0% of mass 176	( )2

1-Value is % mass 174 2-Value is % mass 176

THIS TUNE APPLIES TO THE FOLLOWING SAMPLES, MS, MSD, BLANKS, AND STANDARDS:

	Field SAMPLE NO.	LAB SAMPLE ID	LAB FILE ID	DATE ANALYZED	TIME ANALYZED
01					
02					
03					
04					
05					
06					
07					
08					
09					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					

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VOLATILE ORGANICS INITIAL CALIBRATION DATA

Lab Name: ______________________________

Instrument ID: ___________ Calibration Date(s): ___________ ___________

Matrix: water ___ Level: (low/med) _____ Column: (pack/cap) _____

Min $\overline{RRF}$ for SPCC(#) = 0.300 (0.250 for Bromoform) Max %RSD for CCC(*) = 30.0%

LAB FILE ID: RRF20 = ______________ RRF50 = ______________

RRF100= ______________ RRF150= ______________ RRF200= ______________

COMPOUND	RRF20	RRF50	RRF100	RRF150	RRF200	$\overline{RRF}$	% RSD
Chloromethane #							#
Bromomethane							
Vinyl Chloride *							*
Chloroethane							
Methylene Chloride							
Acetone							
Carbon Disulfide							
1,1-Dichloroethene *							*
1,1-Dichloroethane #							#
1,2-Dichloroethene (total)							
Chloroform *							*
1,2-Dichloroethane							
2-Butanone							
1,1,1-Trichloroethane							
Carbon Tetrachloride							
Vinyl Acetate							
Bromodichloromethane							
1,2-Dichloropropane *							*
cis-1,3-Dichloropropene							
Trichloroethene							
Dibromochloromethane							
1,1,2-Trichloroethane							
Benzene							
trans-1,3-Dichloropropene							
Bromoform #							#
4-Methyl-2-Pentanone							
2-Hexanone							
Tetrachloroethene							
1,1,2,2-Tetrachloroethane #							#
Toluene *							*
Chlorobenzene #							#
Ethylbenzene *							*
Styrene							
Xylene (total)							
Toluene-d8							
Bromofluorobenzene							
1,2-Dichloroethane-d4							

FORM VI VOA

VOLATILE CONTINUING CALIBRATION CHECK

Lab Name:________________________

Instrument ID: __________ Calibration Date:_________ Time:_________

Lab File ID: ______________ Init. Calib. Date(s):__________ __________

Matrix: water ___ Level:(low/med) _____ Column:(pack/cap) _____

Min RRF50 for SPCC(#) = 0.300 (0.250 for Bromoform) Max %D for CCC(*) = 25.0%

COMPOUND	$\overline{RRF}$	RRF50	%D
Chloromethane #			#
Bromomethane			
Vinyl Chloride *			*
Chloroethane			
Methylene Chloride			
Acetone			
Carbon Disulfide			
1,1-Dichloroethene *			*
1,1-Dichloroethane #			#
1,2-Dichloroethene (total)			
Chloroform *			*
1,2-Dichloroethane			
2-Butanone			
1,1,1-Trichloroethane			
Carbon Tetrachloride			
Vinyl Acetate			
Bromodichloromethane			
1,2-Dichloropropane *			*
cis-1,3-Dichloropropene			
Trichloroethene			
Dibromochloromethane			
1,1,2-Trichloroethane			
Benzene			
trans-1,3-Dichloropropene			
Bromoform #			#
4-Methyl-2-Pentanone			
2-Hexanone			
Tetrachloroethene			
1,1,2,2-Tetrachloroethane #			#
Toluene *			*
Chlorobenzene #			#
Ethylbenzene *			*
Styrene			
Xylene (total)			
Toluene-d8			
Bromofluorobenzene			
1,2-Dichloroethane-d4			

FORM VII VOA

VOLATILE INTERNAL STANDARD AREA SUMMARY

Lab Name:____________________________

Lab File ID (Standard): _______________ Date Analyzed:__________

Instrument ID: ___________ Time Analyzed:__________

Matrix: water ___ Level:(low/med) _____ Column:(pack/cap) _____

	IS1(BCM) AREA #	RT	IS2(DFB) AREA #	RT	IS3(CBZ) AREA #	RT
12 HOUR STD						
UPPER LIMIT						
LOWER LIMIT						
FieldSAMPLE NO.						
01						
02						
03						
04						
05						
06						
07						
08						
09						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						

IS1 (BCM) = Bromochloromethane
IS2 (DFB) = 1,4-Difluorobenzene
IS3 (CBZ) = Chlorobenzene-d5

UPPER LIMIT = + 100% of internal standard area.
LOWER LIMIT = - 50% of internal standard area.

Column used to flag internal standard area values with an asterisk

Page __ of __

FORM VIII VOA

COVER PAGE - INORGANIC ANALYSES DATA PACKAGE

Lab Name: ____________________________

Field Sample No.	Lab Sample ID.

Were ICP interelement corrections applied?	Yes/No	___
Were ICP background corrections applied?	Yes/No	___
If yes-were raw data generated before application of background corrections?	Yes/No	___

Comments:

____

____

____

____

Release of the data contained in this hardcopy data package and in the computer-readable data submitted on floppy diskette has been authorized by the Laboratory Manager or the Manager's designee, as verified by the following signature.

Lab Manager: ____________________________

Date: ____________

COVER PAGE - IN

STANDARD OPERATING PROCEDURE
FOR
THE ANALYSIS OF SEMIVOLATILE ORGANICS IN DRINKING WATER WITH LOW DETECTION LIMITS USING GAS CHROMATOGRAPHY/MAS SPECTROMETRY
BY COMPUCHEM

Prepared December, 1988
Revised May, 1990

Quality Assurance Notice

CompuChem follows the attached Semivolatile SOP with modification to Section 6.11.1 of the SOP, continuing calibration check standard solution. CompuChem Laboratories will use the 80 ng/ul concentration for the continuing calibration check standard solution for benzoic acid, 2,4,5-trichlorophenol, 4,6-dinitro-2-methylphenol, 4-nitrophenol, pentachlorophenol and 3 isomers of nitroanaline instead of 40 ng/ul originally specified.

APPENDIX B-3

PROCEDURE FOR GRAIN SIZE DISTRIBUTION

4. Apparatus

4.1 *Balance*, sensitive to 0.1 g.

4.2 *Mortar and Rubber-Covered Pestle*, suitable for breaking up the aggregations of soil particles.

4.3 *Sieves*, No. 10 (2.00-mm) and No. 40 (425-μm), of square mesh woven-wire cloth, conforming to Specification E 11.

4.4 *Sampler*—A riffle sampler or sample splitter for quartering the samples.

4.5 *Drying Apparatus*—Thermostatically controlled drying oven for use at 140°F (60°C) or below and at 230°F (110°C), infrared lamps; air drier; or other suitable device for drying samples.

4.6 *Filter Funnels or Candles*—Büchner funnels 10 in. (254 mm) in diameter and filter paper or filter candles.

4.7 *Miscellaneous Equipment*—Pans 12 in. (304.8 mm) in diameter and 3 in. (76.2 mm) in depth; a suitable container that will prevent loss of moisture during storage of the moist test sample prepared in Procedure B.

PROCEDURE A

5. Sampling

5.1 Dry the soil sample as received from the field, using one of the following methods: (*1*) in air at room temperature, (*2*) in a drying oven at a temperature not exceeding 140°F (60°C), or (*3*) using any warming device that will not raise the temperature of the sample above 140°F. Break up thoroughly any aggregations of particles using the mortar and rubber-covered pestle or other suitable device (Note 1). Select a representative portion by the method of quartering or by use of the sampler. This portion must be sufficient to provide samples for particle-size analyses of material retained on and passing the No. 10 (2.00-mm) sieve, and to provide an adequate amount of material passing the No. 40 (425-μm) sieve for the tests to determine soil constants. The amounts of material required to perform the individual tests are as follows:

Particle-Size Analysis of Material Retained on No. 10 (2.00-mm) Sieve:	
Gravelly soils, g	4 000 to 10 000
Sandy soils, g	1 500
Silty or clayey soils, g	400
Particle Size Analysis of Material Passing No. 10 (2.00-mm) Sieve:	
Sandy soils, g	115
Silty or clayey soils, g	65
Tests for Determination of Soil Constants:	
Liquid limit, g	100
Plastic limit, g	15
Centrifuge moisture equivalent, g	10
Shrinkage factors, g	30
Check tests, g	65

NOTE 1—When the sample contains particles of shale or sandstone or similar weak material, proper care must be exercised to avoid excessive reduction in the size of the particles.

6. Preparation of Test Samples

6.1 *For Particle-Size Analysis:*

6.1.1 Weigh the portion of the test sample selected for particle-size analysis and record the weight of test sample uncorrected for hygroscopic moisture. Separate this material into two portions using the No. 10 (2.00-mm) sieve. Set aside the portion passing for later recombination with additional material washed from the portion retained on the No. 10 (2.00-mm) sieve.

6.1.2 Place the material retained on the No. 10 (2.00-mm) sieve in a pan, cover with water, and allow to soak until the particle aggregations become soft. After soaking, wash the material on a No. 10 (2.00-mm) sieve in the following manner: Place an empty No. 10 (2.00-mm) sieve on the bottom of a clean pan and pour the water from the soaked sample into the sieve. Add sufficient water to bring the level approximately ½ in. (12.7 mm) above the mesh of the sieve. Transfer the soaked material to the sieve in increments not exceeding 1 lb (0.45 kg), stirring each increment with the fingers while agitating the sieve up and down. Crumble or mash any lumps that have not slaked, using the thumb and fingers. Raise the sieve above the water in the pan and complete the washing operation using a small amount of clean water. Transfer the washed material on the sieve to a clean pan before placing another increment of soaked material on the sieve.

6.1.3 Dry the material retained on the No. 10 (2.00-mm) sieve at a temperature of 230 ± 9°F (110 ± 5°C), sieve on the No. 10 (2.00-mm) sieve, and add the material passing the sieve to similar material obtained in 6.1.1. Set aside the material retained on the sieve for use in the particle-size analysis.

6.1.4 Set aside the pan containing the washings for a period of several hours or until the water above the particles is clear. Decant, pipet, or siphon off as much of the clear water as possible (Note 2). Dry the soil remaining in the pan at a temperature not exceeding 140°F (60°C). Grind the dried soil in the mortar with the rubber-covered pestle or other suitable device, and combine with similar material obtained in 6.1.1.

6.1.5 Alternatively, after all the soaked material has been washed, remove most of the water by filtering the wash water on one or more Büchner funnels fitted with filter paper or by using filter candles. Remove the moist soil from the filter paper or filter candles, combine with any sediment remaining in the pan, and dry at a temperature not exceeding 140°F (60°C). Grind the dried soil in the mortar with a rubber-covered pestle or other suitable device and combine with similar material obtained in 6.1.1.

NOTE 2—In some instances, the wash water will not become clear in a reasonable length of time; in this case the entire volume must be evaporated.

6.2 *For Determination of Soil Constants*—Proceed in accordance with 6.1, substituting a No. 40 (425-μm) sieve for the No. 10 (2.00-mm) sieve.

NOTE 3—In some areas it is possible that the cations of salts present in the tap water may exchange with the natural cations in the soil and alter significantly the values of the soil constants should tap water be used in the soaking and washing operations. Unless it is known that such cations are not present in the tap water, distilled or demineralized water should be used. The soaking and washing operation will remove soluble salts contained in the soil. When soluble salts are present in the soil, the wash water should be saved and evaporated, and the salts returned to the soil sample.

7. Test Samples

7.1 Keeping each portion separate from the other portion, mix thoroughly the portions of the soil sample passing the No. 10 (2.00-mm) sieve and the No. 40 (425-μm) sieve. By the method of quartering or by the use of the sampler, select and weigh out test samples of the weights indicated in Section 5, as may be needed to make the required tests.

PROCEDURE B

8. Samples

8.1 Samples prepared in accordance with this procedure must be shipped from the field to the laboratory in sealed containers and must contain all their natural moisture. Samples obviously containing only particles passing the No. 10 (2.00-mm) sieve may be tested in the particle-size analysis without first washing on the No. 10 (2.00-mm) sieve. Samples obviously containing only particles passing the No. 40 (425-μm) sieve may be used in the tests to determine soil constants without first washing on the No. 40 (425-μm) sieve.

9. Preparation of Test Samples

9.1 *For Particle-Size Analysis:*

9.1.1 Select and weigh a representative portion of the moist sample estimated to contain 50 g of particles passing the No. 10 (2.00-mm) sieve for silty and clayey soil, or 100 g for sandy soil. For samples containing particles not passing the No. 10 (2.00-mm) sieve for which a particle-size analysis is required, select and weigh a representative sample estimated to contain the required amounts of particles both passing and not passing the No. 10 (2.00-mm) sieve. Determine the moisture content at 230 ± 9°F (110 ± 5°C) using an auxiliary sample, for use in Method D 422.

9.1.2 Soak the moist sample and wash on a No. 10 (2.00-mm) sieve as described in 6.1.2. After washing, dry the material retained on the No. 10 (2.00-mm) sieve in an oven at a temperature of 230 ± 9°F (110 ± 5°C), weigh, and retain for the particle-size analysis. If the volume of the wash water and soil is too large for use in the sedimentation procedure of the test for particle-size analysis, evaporate excess water by exposure to air at room temperature, by heating in an oven at a temperature not exceeding 230°F (110°C), or by boiling. Regardless of the method of evaporation used, the following precautions must be taken: (*1*) stir the slurry from time to time to prevent a dry soil ring from forming on the walls of the evaporation vessel, and (*2*) return the temperature of the sample to room temperature before testing.

9.2 *For Determination of Soil Constants*—Select a representative portion of the moist sample estimated to contain sufficient particles passing the No. 40 (425-μm) sieve to make the required tests for determination of soil constants. Soak this selected portion of the moist sample and wash on the No. 40 (425-μm) sieve as described in 6.2 (Note 2). Reduce the moisture content of the material passing the No. 40 (425-μm) sieve until the mass reaches a putty-like consistency (such as 30 to 35 drops of the cup in the liquid limit test) but never below the natural moisture

GRAIN SIZE ANALYSIS OF SOIL

Scope and Application: This method is applicable to soil samples collected as part of the Spickler Landfill site RI/FS. A total of forty soil cover and soil boring samples are anticipated. The Spickler Landfill site RI/FS is a PRP lead investigation.

Method: Particle size analysis of soil.

Reference: ASTM Methods D421, and D422 and D2217 (see attached).

Detection Limit: 2 percent by weight.

Sample Handling: Samples will be air dried at 60°C upon receipt. After drying, the sample, or a representative portion of the sample, will be separated into fractions passing and retained on a 2mm sieve per ASTM Method D421 or D2217. The fractions will then be stored until analysis.

Reagents and Apparatus:

1. Balance (0.01 g sensitivity)
2. Dispersion cup
3. Hydrometer
4. Sedimentation cylinder
5. Thermometer (0.5° sensitivity)
6. Sieves (see ASTM D422 Section 3.6)
7. Temperature controlled room (±°C)
8. 4% Sodium hexametaphosphate solution

Reagent Preparation:

The sodium hexametaphosphate solution is to have been prepared within 30 days of use.

Procedures:

1. The sample fraction greater than 2mm is fractioned by sieving using sieves and procedures as outlined in Section 6 of ASTM D422. The sum of the masses of the sieved fractions should be within ±2g of the original fraction mass.

2. Determine the hygroscopic moisture content of the less than 2mm fraction by drying a minimum of 10 to 15 g subsample to constant weight at 110 plus or minus 5 degree C.

3. Disperse a 50 g sample if the sample is primarily silt and clay or a 100 g sample is primarily sand for one minute using a dispersion cup as outlined in Section 9 of ASTM D422.

4. Transfer the dispersed sample to a sedimentation cylinder, suspend the sample by successive inversions and record hydrometer readings after sedimentation times of 1, 2, 3, 6, 15, 60, 120, 300, 420 and 1440 minutes.

5. After hydrometer readings are complete, the hydrometer and hygroscopic moisture specimens are combined with the remaining P10 and R10 material for sieving.

Reportables:

1. Submit all raw data including container tare weights, hydrometer readings (along with any correction factor associated with the hydrometer used) and temperatures.

2. A data summary will be provided as described in Sections 17 and 18 of ASTM Method D422.

Quality Control:

1. Laboratory duplicates will be run at a frequency of one per ten investigative samples and at least one per sample set. Duplicates should agree within 10 percent.

2. If performance criteria for duplicates is exceeded, the Warzyn project manager (Tim Melka, 608-273-0440) should be notified as soon as possible so a determination regarding reanalysis can be made.

[jpl-602-84b]

NOTE 9—Other *in situ* test procedures are being prepared by ASTM Committee D-18.

9.2 The soil and rock investigation should consist of the following steps.

9.2.1 A review of all available information on the geologic history and formation of rock, or soil, or both, and ground-water conditions occurring at the proposed location and in the immediate vicinity.

9.2.2 On-site investigation of the surface and subsurface materials by either wash borings, hand- or power-auger borings, test pits, rotary or cable-tool (churn) drilling, and geophysical methods.

9.2.2.1 A determination of the depths to water table and firm foundation material, either bedrock or satisfactory load-bearing soils.

9.2.2.2 Field identification of soil and rock types with depth records of their occurrence, and location of their structural discontinuities.

9.2.2.3 The recovery of representative disturbed samples for laboratory classification tests of soil, rock, and local construction material. These should be supplemented by undisturbed specimens suitable for the determination of those engineering properties pertinent to the investigation.

9.2.3 An evaluation of performance of existing installations in the immediate vicinity of the proposed site, relative to their foundation material and environment.

10. Classification of Material

10.1 Treat samples of soils and rock submitted to the laboratory for identification and classification tests in accordance with one of the following:

10.1.1 Test Method D 2487.

10.1.2 Practice D 3282.

10.1.3 Descriptive Nomenclature C 294. This is a brief, useful description of the more common minerals and rocks as they occur in nature.

11. Interpretation of Results

11.1 Interpret the results of an investigation only in terms of actual findings and make every effort to collect and include all field and laboratory data from previous investigations in the same area. Extrapolation of data into local areas not surveyed and tested can be done only where geologically uniform subsurface disposition of soil and rock are known to exist. Engineering properties of the soils and rocks encountered on important projects should not be predicted wholly on field identifications or classification but should be checked by laboratory and field tests made on samples collected in accordance with 8.1 and 9.1.

11.2 The recommendations for design parameters can be made only by professional engineers or geologists who have specialized in the field of soils and foundations or highway engineering, and who are familiar with the problems for which the study is being made. Soil mechanics, rock mechanics, and geomorphological concepts must be combined with a knowledge of structural or pavement engineering in order to make a complete application of the results of the soil and rock survey. A more detailed study than that envisioned by this recommended practice may be necessary before design recommendations can be made.

12. Report

12.1 A subsurface investigation report should:

12.1.1 Locate the area investigated in terms pertinent to the project. This may include sketch maps or aerial photos on which the test holes, pits, and sample areas are located, as well as topographic items relevant to the determination of the various soil and rock types, such as contours, streambeds, pot holes, cliffs, etc. Where feasible, include a geologic map of the area investigated in the report.

12.1.2 Include copies of all borings and test-hole logs and of all laboratory test results.

12.1.3 Describe and relate the findings obtained under Sections 3, 4, 5, and 6, using the subhead titles for the respective sections.

Designation: D 421 – 85

Standard Practice for
DRY PREPARATION OF SOIL SAMPLES FOR PARTICLE-SIZE ANALYSIS AND DETERMINATION OF SOIL CONSTANTS[1]

This standard is issued under the fixed designation D 421; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the dry preparation of soil samples as received from the field for particle-size analysis and the determination of the soil constants.

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

2. Applicable Documents

2.1 *ASTM Standards:*

D2217 Practice for Wet Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants[2]

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[3]

3. Significance and Use

3.1 This practice can be used to prepare samples for particle-size and plasticity tests where it is desired to determine test values on air-dried samples, or where it is known that air drying does not have an effect on test results relative to samples prepared in accordance with Practice D 2217.

4. Apparatus

4.1 *Balance*, sensitive to 0.1 g.

4.2 *Mortar and Rubber-Covered Pestle*, suitable for breaking up the aggregations of soil particles.

4.3 *Sieves*—A series of sieves, of square mesh woven wire cloth, conforming to Specification E 11. The sieves required are as follows:

No. 4 (4.75-mm)
No. 10 (2.00-mm)
No. 40 (425-μm)

4.4 *Sampler*—A riffle sampler or sample splitter, for quartering the samples.

5. Sampling

5.1 Expose the soil sample as received from the field to the air at room temperature until dried thoroughly. Break up the aggregations thoroughly in the mortar with a rubber-covered pestle. Select a representative sample of the amount required to perform the desired tests by the method of quartering or by the use of a sampler. The amounts of material required to perform the individual tests are as follows:

5.1.1 *Particle-Size Analysis*—For the particle-size analysis, material passing a No. 10 (2.00-mm) sieve is required in amounts equal to 115 g of sandy soils and 65 g of either silt or clay soils.

5.1.2 *Tests for Soil Constants*—For the tests for soil constants, material passing the No. 40

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[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.03 on Texture, Plasticity, and Density Characteristics of Soils.

Current edition approved July 26, 1985. Published September 1985. Originally published as D 421 – 35 T. Last previous edition D 421 – 58 (1978)$^{\epsilon1}$.

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

[3] *Annual Book of ASTM Standards*, Vol 14.02.

drometer 152H it is the difference between the reading and zero. Bring the liquid and the hydrometer to the other temperature to be used, and secure the composite correction as before.

8. Hygroscopic Moisture

8.1 When the sample is weighed for the hydrometer test, weigh out an auxiliary portion of from 10 to 15 g in a small metal or glass container, dry the sample to a constant mass in an oven at 230 ± 9°F (110 ± 5°C), and weigh again. Record the masses.

9. Dispersion of Soil Sample

9.1 When the soil is mostly of the clay and silt sizes, weigh out a sample of air-dry soil of approximately 50 g. When the soil is mostly sand the sample should be approximately 100 g.

9.2 Place the sample in the 250-mL beaker and cover with 125 mL of sodium hexametaphosphate solution (40 g/L). Stir until the soil is thoroughly wetted. Allow to soak for at least 16 h.

9.3 At the end of the soaking period, disperse the sample further, using either stirring apparatus A or B. If stirring apparatus A is used, transfer the soil - water slurry from the beaker into the special dispersion cup shown in Fig. 2, washing any residue from the beaker into the cup with distilled or demineralized water (Note 9). Add distilled or demineralized water, if necessary, so that the cup is more than half full. Stir for a period of 1 min.

NOTE 9—A large size syringe is a convenient device for handling the water in the washing operation. Other devices include the wash-water bottle and a hose with nozzle connected to a pressurized distilled water tank.

9.4 If stirring apparatus B (Fig. 3) is used, remove the cover cap and connect the cup to a compressed air supply by means of a rubber hose. A air gage must be on the line between the cup and the control valve. Open the control valve so that the gage indicates 1 psi (7 kPa) pressure (Note 10). Transfer the soil - water slurry from the beaker to the air-jet dispersion cup by washing with distilled or demineralized water. Add distilled or demineralized water, if necessary, so that the total volume in the cup is 250 mL, but no more.

NOTE 10—The initial air pressure of 1 psi is required to prevent the soil - water mixture from entering the air-jet chamber when the mixture is transferred to the dispersion cup.

9.5 Place the cover cap on the cup and open the air control valve until the gage pressure is 20 psi (140 kPa). Disperse the soil according to the following schedule:

Plasticity Index	Dispersion Period, min
Under 5	5
6 to 20	10
Over 20	15

Soils containing large percentages of mica and be dispersed for only 1 min. After the dispersion period, reduce the gage pressure to 1 psi preparatory to transfer of soil - water slurry to the sedimentation cylinder.

10. Hydrometer Test

10.1 Immediately after dispersion, transfer the soil - water slurry to the glass sedimentation cylinder, and add distilled or demineralized water until the total volume is 1000 mL.

10.2 Using the palm of the hand over the open end of the cylinder (or a rubber stopper in the open end), turn the cylinder upside down and back for a period of 1 min to complete the agitation of the slurry (Note 11). At the end of 1 min set the cylinder in a convenient location and take hydrometer readings at the following intervals of time (measured from the beginning of sedimentation), or as many as may be needed, depending on the sample or the specification for the material under test: 2, 5, 15, 30, 60, 250, and 1440 min. If the controlled water bath is used, the sedimentation cylinder should be placed in the bath between the 2- and 5-min readings.

NOTE 11—The number of turns during this minute should be approximately 60, counting the turn upside down and back as two turns. Any soil remaining in the bottom of the cylinder during the first few turns should be loosened by vigorous shaking of the cylinder while it is in the inverted position.

10.3 When it is desired to take a hydrometer reading, carefully insert the hydrometer about 20 to 25 s before the reading is due to approximately the depth it will have when the reading is taken. As soon as the reading is taken, carefully remove the hydrometer and place it with a spinning motion in a graduate of clean distilled or demineralized water.

NOTE 12—It is important to remove the hydrometer immediately after each reading. Readings shall be taken at the top of the meniscus formed by the suspension around the stem, since it is not possible to secure readings at the bottom of the meniscus.

10.4 After each reading, take the temperature of the suspension by inserting the thermometer into the suspension.

11. Sieve Analysis

11.1 After taking the final hydrometer reading, transfer the suspension to a No. 200 (75-μm) sieve and wash with tap water until the wash water is clear. Transfer the material on the No. 200 sieve to a suitable container, dry in an oven at 230 ± 9°F (110 ± 5°C) and make a sieve analysis of the portion retained, using as many sieves as desired, or required for the material, or upon the specification of the material under test.

CALCULATIONS AND REPORT

12. Sieve Analysis Values for the Portion Coarser than the No. 10 (2.00-mm) Sieve

12.1 Calculate the percentage passing the No. 10 sieve by dividing the mass passing the No. 10 sieve by the mass of soil originally split on the No. 10 sieve, and multiplying the result by 100. To obtain the mass passing the No. 10 sieve, subtract the mass retained on the No. 10 sieve from the original mass.

12.2 To secure the total mass of soil passing the No. 4 (4.75-mm) sieve, add to the mass of the material passing the No. 10 sieve the mass of the fraction passing the No. 4 sieve and retained on the No. 10 sieve. To secure the total mass of soil passing the 3/8-in. (9.5-mm) sieve, add to the total mass of soil passing the No. 4 sieve, the mass of the fraction passing the 3/8-in. sieve and retained on the No. 4 sieve. For the remaining sieves, continue the calculations in the same manner.

12.3 To determine the total percentage passing for each sieve, divide the total mass passing (see 12.2) by the total mass of sample and multiply the result by 100.

13. Hygroscopic Moisture Correction Factor

13.1 The hydroscopic moisture correction factor is the ratio between the mass of the oven-dried sample and the air-dry mass before drying. It is a number less than one, except when there is no hygroscopic moisture.

14. Percentages of Soil in Suspension

14.1 Calculate the oven-dry mass of soil used in the hydrometer analysis by multiplying the air-dry mass by the hygroscopic moisture correction factor.

14.2 Calculate the mass of a total sample represented by the mass of soil used in the hydrometer test, by dividing the oven-dry mass used by the percentage passing the No. 10 (2.00-mm) sieve, and multiplying the result by 100. This value is the weight W in the equation for percentage remaining in suspension.

14.3 The percentage of soil remaining in suspension at the level at which the hydrometer is measuring the density of the suspension may be calculated as follows (Note 13): For hydrometer 151H:

$$P = [(100\,000/W) \times G/(G - G_1)](R - G_1)$$

NOTE 13—The bracketed portion of the equation for hydrometer 151H is constant for a series of readings and may be calculated first and then multiplied by the portion in the parentheses.

For hydrometer 152H:

$$P = (Ra/W) \times 100$$

where:

a = correction faction to be applied to the reading of hydrometer 152H. (Values shown on the scale are computed using a specific gravity of 2.65. Correction factors are given in Table 1),

P = percentage of soil remaining in suspension at the level at which the hydrometer measures the density of the suspension,

R = hydrometer reading with composite correction applied (Section 7),

W = oven-dry mass of soil in a total test sample represented by mass of soil dispersed (see 14.2), g,

G = specific gravity of the soil particles, and

G_1 = specific gravity of the liquid in which soil particles are suspended. Use numerical value of one in both instances in the equation. In the first instance any possible variation produces no significant effect, and in the second instance, the composite correction for R is based on a value of one for G_1.

15. Diameter of Soil Particles

15.1 The diameter of a particle corresponding to the percentage indicated by a given hydrometer reading shall be calculated according to Stokes' law (Note 14), on the basis that a particle of this diameter was at the surface of the suspension at the beginning of sedimentation and had settled to the level at which the hydrometer is measuring the density of the suspension. Accordg to Stokes' law:

$$D = \sqrt{[30n/980(G - G_1)] \times L/T}$$

here:

= diameter of particle, mm,

= coefficient of viscosity of the suspending medium (in this case water) in poises (varies with changes in temperature of the suspending medium),

= distance from the surface of the suspension to the level at which the density of the suspension is being measured, cm. (For a given hydrometer and sedimentation cylinder, values vary according to the hydrometer readings. This distance is known as effective depth (Table 2)),

T = interval of time from beginning of sedimentation to the taking of the reading, min,

G = specific gravity of soil particles, and

G_1 = specific gravity (relative density) of suspending medium (value may be used as 1.000 for all practical purposes).

Note 14—Since Stokes' law considers the terminal velocity of a single sphere falling in an infinity of liquid, the sizes calculated represent the diameter of spheres that would fall at the same rate as the soil particles.

15.2 For convenience in calculations the above equation may be written as follows:

$$D = K\sqrt{L/T}$$

where:

K = constant depending on the temperature of the suspension and the specific gravity of the soil particles. Values of K for a range of temperatures and specific gravities are given in Table 3. The value of K does not change for a series of readings constituting a test, while values of L and T do vary.

15.3 Values of D may be computed with sufficient accuracy, using an ordinary 10-in. slide rule.

Note 15—The value of L is divided by T using the *A*- and *B*-scales, the square root being indicated on the *D*-scale. Without ascertaining the value of the square root it may be multiplied by K, using either the *C*- or *CI*-scale.

16. Sieve Analysis Values for Portion Finer than No. 10 (2.00-mm) Sieve

16.1 Calculation of percentages passing the various sieves used in sieving the portion of the sample from the hydrometer test involves several steps. The first step is to calculate the mass of the fraction that would have been retained on the No. 10 sieve had it not been removed. This mass is equal to the total percentage retained on the No. 10 sieve (100 minus total percentage passing) times the mass of the total sample represented by the mass of soil used (as calculated in 14.1) and the result divided by 100.

16.2 Calculate next the total mass passing the No. 200 sieve. Add together the fractional masses retained on all the sieves, including the No. 10 sieve, and subtract this sum from the mass of the total sample (as calculated in 14.2).

16.3 *Calculate next the total masses passing* each of the other sieves, in a manner *similar to* that given in 12.2.

16.4 Calculate last the total percentages passing by dividing the total mass passing (as calculated in 16.3) by the total *mass of sample* (as calculated in 14.2), and multiply the result by 100.

17. Graph

17.1 When the *hydrometer analysis* is performed, a graph of the test results shall be made, plotting the diameters of the particles on a logarithmic scale as the abscissa and the percentages smaller than the corresponding diameters to an arithmetic scale as the *ordinate*. When the hydrometer analysis is not made on a portion of the soil, the preparation of the graph is optional, since values may be secured directly from tabulated data.

18. Report

18.1 The report shall include the following:

18.1.1 Maximum size of particles,

18.1.2 Percentage passing (or retained on) each sieve, which may be tabulated or presented by plotting on a graph (Note 16),

18.1.3 Description of sand and gravel particles:

18.1.3.1 Shape—rounded or angular,

18.1.3.2 Hardness—hard and durable, soft, or weathered and friable,

18.1.4 Specific gravity, if unusually high or low,

18.1.5 *Any difficulty in dispersing* the fraction passing the No. 10 (2.00-mm) sieve, indicating any change in type and amount of dispersing agent, and

18.1.6 The dispersion device used and the length of the dispersion period.

Note 16—This tabulation of graph represent gradation of the sample tested. If particles larger those contained in the sample were removed before testing, the report shall so state giving the amount and maximum size.

18.2 For materials tested for compliance with definite specifications, the fractions called for in such specifications shall be reported. The fractions smaller than the No. 10 sieve shall be read from the graph.

18.3 For materials for which compliance with definite specifications is not indicated and when the soil is composed almost entirely of particles passing the No. 4 (4.75-mm) sieve, the results read from the graph may be reported as follows:

(1) Gravel, passing 3-in. and retained on No. 4 sieve ..... %
(2) Sand, passing No. 4 sieve and retained on No. 200 sieve ..... %
  (a) Coarse sand, passing No. 4 sieve and retained on No. 10 sieve ..... %
  (b) Medium sand, passing No. 10 sieve and retained on No. 40 sieve ..... %
  (c) Fine sand, passing No. 40 sieve and retained on No. 200 sieve ..... %
(3) Silt size, 0.074 to 0.005 mm ..... %
(4) Clay size, smaller than 0.005 mm ..... %
  Colloids, smaller than 0.001 mm ..... %

18.4 For materials for which compliance with definite specifications is not indicated and when the soil contains material retained on the No. 4 sieve sufficient to require a sieve analysis on that portion, the results may be reported as follows (Note 17):

SIEVE ANALYSIS

Sieve Size	Percentage Passing
3-in.	....
2-in.	....
1½-in.	....
1-in.	....
¾-in.	....
⅜-in.	....
No. 4 (4.75-mm)	....
No. 10 (2.00-mm)	....
No. 40 (425-μm)	....
No. 200 (75-μm)	....
HYDROMETER ANALYSIS	
0.074 mm	....
0.005 mm	....
0.001 mm	....

Note 17—No. 8 (2.36-mm) and No. 30 (300-μm) sieves may be substituted for No. 10 and No. 40 sieves.

TABLE 1 Values of Correction Factor, *a*, for Different Specific Gravities of Soil Particles[A]

Specific Gravity	Correction Factor[A]
2.95	0.94
2.90	0.95
2.85	0.96
2.80	0.97
2.75	0.98
2.70	0.99
2.65	1.00
2.60	1.01
2.55	1.02
2.50	1.03
2.45	1.05

[A] For use in equation for percentage of soil remaining in suspension when using Hydrometer 152H.

TABLE 2 Values of Effective Depth Based on Hydrometer and Sedimentation Cylinder of Specified Sizes[A]

Hydrometer 151H		Hydrometer 152H			
Actual Hydrometer Reading	Effective Depth, *L*, cm	Actual Hydrometer Reading	Effective Depth, *L*, cm	Actual Hydrometer Reading	Effective Depth, *L*, cm
1.000	16.3	0	16.3	31	11.2
1.001	16.0	1	16.1	32	11.1
1.002	15.8	2	16.0	33	10.9
1.003	15.5	3	15.8	34	10.7
1.004	15.2	4	15.6	35	10.6
1.005	15.0	5	15.5		
1.006	14.7	6	15.3	36	10.4
1.007	14.4	7	15.2	37	10.2
1.008	14.2	8	15.0	38	10.1
1.009	13.9	9	14.8	39	9.9
1.010	13.7	10	14.7	40	9.7
1.011	13.4	11	14.5	41	9.6
1.012	13.1	12	14.3	42	9.4
1.013	12.9	13	14.2	43	9.2
1.014	12.6	14	14.0	44	9.1
1.015	12.3	15	13.8	45	8.9
016	12.1	16	13.7	46	8.8
017	11.8	17	13.5	47	8.6
018	11.5	18	13.3	48	8.4
019	11.3	19	13.2	49	8.3
020	11.0	20	13.0	50	8.1
021	10.7	21	12.9	51	7.9
022	10.5	22	12.7	52	7.8
023	10.2	23	12.5	53	7.6
024	10.0	24	12.4	54	7.4
025	9.7	25	12.2	55	7.3
026	9.4	26	12.0	56	7.1
027	9.2	27	11.9	57	7.0
028	8.9	28	11.7	58	6.8
029	8.6	29	11.5	59	6.6
030	8.4	30	11.4	60	6.5

TABLE 2 Continued

Hydrometer 151H		Hydrometer 152H			
Actual Hydrometer Reading	Effective Depth, *L*, cm	Actual Hydrometer Reading	Effective Depth, *L*, cm	Actual Hydrometer Reading	Effective Depth, *L*, cm
1.031	8.1				
1.032	7.8				
1.033	7.6				
1.034	7.3				
1.035	7.0				
1.036	6.8				
1.037	6.5				
1.038	6.2				

[A] Values of effective depth are calculated from the equa

$$L = L_1 + \tfrac{1}{2}\left[L_2 - (V_B/A)\right]$$

where:

L = effective depth, cm,

L_1 = distance along the stem of the hydrometer from the t of the bulb to the mark for a hydrometer reading, cm,

L_2 = overall length of the hydrometer bulb, cm,

V_B = volume of hydrometer bulb, cm³, and

A = cross-sectional area of sedimentation cylinder, cm²

Values used in calculating the values in Table 2 are as follo

For both hydrometers, 151H and 152H:

L_2 = 14.0 cm

V_B = 67.0 cm³

A = 27.8 cm²

For hydrometer 151H:

L_1 = 10.5 cm for a reading of 1.000

= 2.3 cm for a reading of 1.031

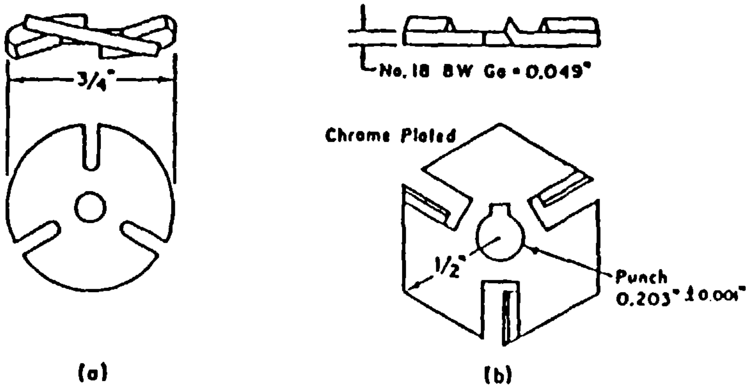
For hydrometer 152H:

L_1 = 10.5 cm for a reading of 0 g/litre

= 2.3 cm for a reading of 50 g/litre

TABLE 3 Values of *K* for Use in Equation for Computing Diameter of Particle in Hydrometer Analysis

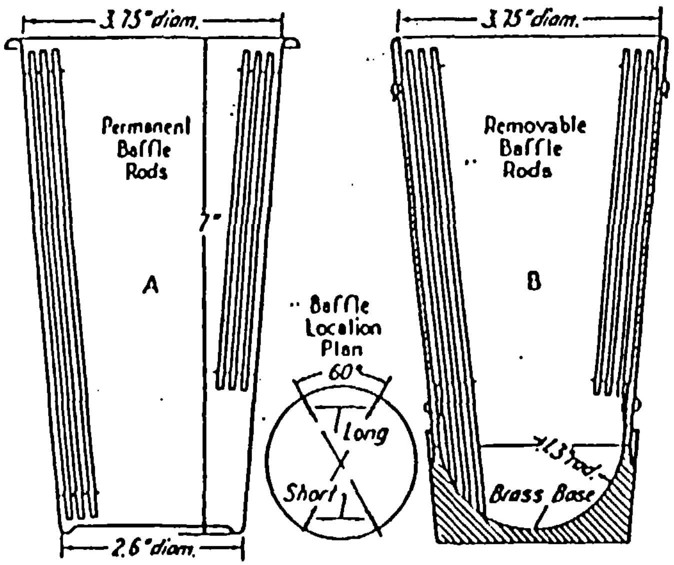
Temperature, °C	Specific Gravity of Soil Particles								
	2.45	2.50	2.55	2.60	2.65	2.70	2.75	2.80	2.85
16	0.01510	0.01505	0.01481	0.01457	0.01435	0.01414	0.01394	0.01374	0.01356
17	0.01511	0.01486	0.01462	0.01439	0.01417	0.01396	0.01376	0.01356	0.01338
18	0.01492	0.01467	0.01443	0.01421	0.01399	0.01378	0.01359	0.01339	0.01321
19	0.01474	0.01449	0.01425	0.01403	0.01382	0.01361	0.01342	0.1323	0.01305
20	0.01456	0.01431	0.01408	0.01386	0.01365	0.01344	0.01325	0.01307	0.01289
21	0.01438	0.01414	0.01391	0.01369	0.01348	0.01328	0.01309	0.01291	0.01273
22	0.01421	0.01397	0.01374	0.01353	0.01332	0.01312	0.01294	0.01276	0.01258
23	0.01404	0.01381	0.01358	0.01337	0.01317	0.01297	0.01279	0.01261	0.01243
24	0.01388	0.01365	0.01342	0.01321	0.01301	0.01282	0.01264	0.01246	0.01229
25	0.01372	0.01349	0.01327	0.01306	0.01286	0.01267	0.01249	0.01232	0.01215
26	0.01357	0.01334	0.01312	0.01291	0.01272	0.01253	0.01235	0.01218	0.01201
27	0.01342	0.01319	0.01297	0.01277	0.01258	0.01239	0.01221	0.01204	0.01188
28	0.01327	0.01304	0.01283	0.01264	0.01244	0.01225	0.01208	0.01191	0.01175
29	0.01312	0.01290	0.01269	0.01249	0.01230	0.01212	0.01195	0.01178	0.01162
30	0.01298	0.01276	0.01256	0.01236	0.01217	0.01199	0.01182	0.01165	0.01149



Metric Equivalents

in.	0.001	0.049	0.203	½	¾
mm	0.03	1.24	5.16	12.7	19.0

FIG. 1 Detail of Stirring Paddles



Metric Equivalents

in.	1.3	2.6	3.75
mm	33	66	95.2

FIG. 2 Dispersion Cups of Apparatus

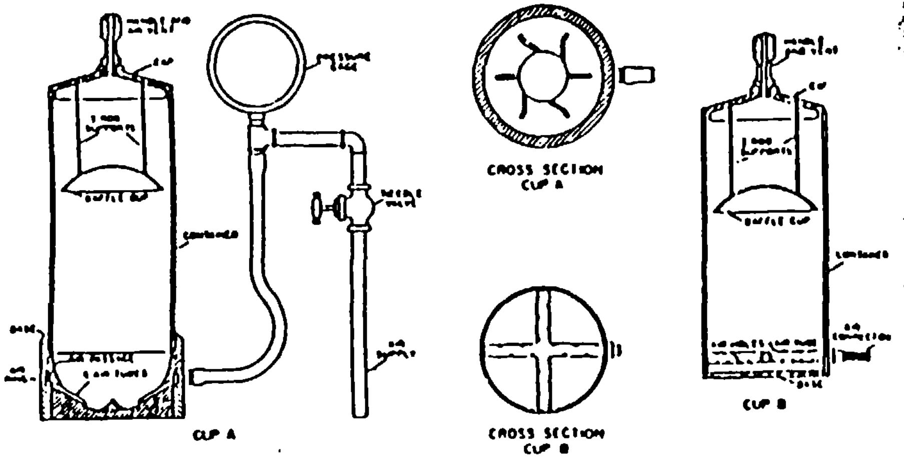
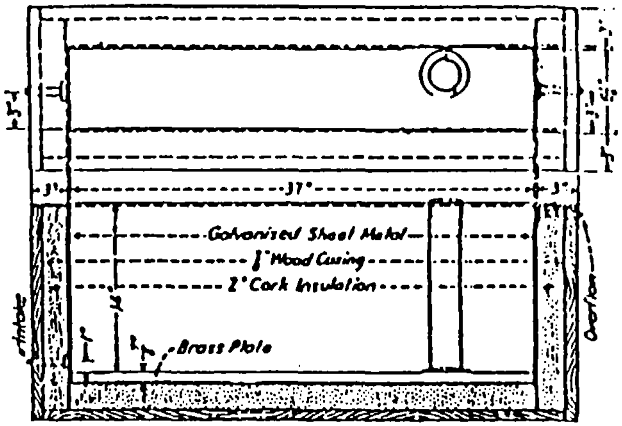


FIG. 3 Air-Jet Dispersion Cups of Apparatus B



Metric Equivalents

in.	7/8	1	3	6¼	14	37
mm	22.2	25.4	76.2	158.8	356	940

FIG. 4 Insulated Water Bath

ent. Reduction of moisture content may be
mplished as follows: by exposure to air at
nary room temperature, by heating in an
at a temperature not exceeding 230°F
°C), by boiling, by filtering on a Büchner
nel, or by use of filter candles. During evap-
ion and cooling, stir the sample often enough
revent overdrying of the fringes and soil

pinnacles on the surface. Cool the heated samp
to normal room temperature before testing fo
soil samples containing soluble salts, us
method of water reduction that will not elimina
the soluble salts from the test sample. Protect
prepared sample in a suitable container for
further drying until all required tests have be
performed.

Designation: D 2325 – 68 (Reapproved 1981)[ε1]

Standard Test Method for
CAPILLARY-MOISTURE RELATIONSHIPS FOR COARSE- AND MEDIUM-TEXTURED SOILS BY POROUS-PLATE APPARATUS[1]

This standard is issued under the fixed designation D 2325; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

[ε1] Note—Section 2 was added editorially and editorial changes were made throughout in October 1984.

1. Scope

1.1 This test method covers the determination of capillary-moisture relationships for coarse- and medium-textured soils as indicated by the soil-moisture tension relations for tensions between 10 and 101 kPa (0.1 and 1 atm). Under equilibrium conditions, moisture tension is defined as the equivalent negative gage pressure, or suction, corresponding to a soil moisture content. This test method determines the equilibrium moisture content retained in a soil subjected to a given soil-water tension. This test method is not suitable for very fine-textured soils.

Note 1—For determination of capillary-moisture relationships for fine-textured soils, refer to Test Method D 3152.

2. Applicable Documents

2.1 *ASTM Standards:*

D421 Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants[2]

D698 Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5-lb (2.49-kg) Rammer and 12-in. (305-mm) Drop[2]

D3152 Test Method for Capillary Moisture Relationships for Fine-Textured Soils by *Pressure-Membrane Apparatus*[2]

3. Summary of Method

3.1 Saturated soil samples are placed in contact with a saturated porous plate installed within a pressure chamber. The bottom of each plate is covered by a rubber membrane, or otherwise sealed to be airtight. The bottom of each plate is maintained at atmospheric pressure by means of a small drain tube or opening through the side of the pressure chamber. A desired air pressure admitted to the pressure chamber, and consequently to the top of the porous plate, creates a pressure drop across the porous plate. The saturated soil samples on the plates establish equilibrium with the water in the plate. The water, held at a tension less than the pressure drop across the porous plate, will then move out of the soil, through the plate, and out through the drain tube. When water has ceased to flow from the sample and porous plate, (indicating equilibrium for that particular tension), the moisture content of each sample is determined. A series of these tests at various tensions is required to prepare a complete curve of the capillary-moisture relationship for any particular soil.

4. Apparatus

4.1 An assembly of the apparatus is shown in Fig. 1.

4.1.1 *Porous Plate Apparatus,* consisting of the following:

4.1.1.1 *Pressure Container,* (such as a pressure cooker), of approximately 15-L (16-qt) capacity.

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[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.04 on Hydrologic Properties of Soils and Rocks.

Current edition approved Sept. 13, 1968. Originally issued as D 2325 – 64 T. Last previous edition D 2325 – 64 T.

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

4. Apparatus

4.1 *Balance*, sensitive to 0.1 g.

4.2 *Mortar and Rubber-Covered Pestle*, suitable for breaking up the aggregations of soil particles.

4.3 *Sieves*, No. 10 (2.00-mm) and No. 40 (425-μm), of square mesh woven-wire cloth, conforming to Specification E 11.

4.4 *Sampler*—A riffle sampler or sample splitter for quartering the samples.

4.5 *Drying Apparatus*—Thermostatically controlled drying oven for use at 140°F (60°C) or below and at 230°F (110°C), infrared lamps; air drier; or other suitable device for drying samples.

4.6 *Filter Funnels or Candles*—Büchner funnels 10 in. (254 mm) in diameter and filter paper or filter candles.

4.7 *Miscellaneous Equipment*—Pans 12 in. (304.8 mm) in diameter and 3 in. (76.2 mm) in depth; a suitable container that will prevent loss of moisture during storage of the moist test sample prepared in Procedure B.

PROCEDURE A

5. Sampling

5.1 Dry the soil sample as received from the field, using one of the following methods: (*1*) In air at room temperature, (*2*) in a drying oven at a temperature not exceeding 140°F (60°C), or (*3*) using any warming device that will not raise the temperature of the sample above 140°F. Break up thoroughly any aggregations of particles using the mortar and rubber-covered pestle or other suitable device (Note 1). Select a representative portion by the method of quartering or by use of the sampler. This portion must be sufficient to provide samples for particle-size analyses of material retained on and passing the No. 10 (2.00-mm) sieve, and to provide an adequate amount of material passing the No. 40 (425-μm) sieve for the tests to determine soil constants. The amounts of material required to perform the individual tests are as follows:

Particle-Size Analysis of Material Retained on No. 10 (2.00-mm) Sieve:	
Gravelly soils, g	4 000 to 10 000
Sandy soils, g	1 500
Silty or clayey soils, g	400
Particle-Size Analysis of Material Passing No. 10 (2.00-mm) Sieve:	
Sandy soils, g	115
Silty or clayey soils, g	65
Tests for Determination of Soil Constants:	
Liquid limit, g	100
Plastic limit, g	15
Centrifuge moisture equivalent, g	10
Shrinkage factors, g	30
Check tests, g	65

NOTE 1—When the sample contains particles of shale or sandstone or similar weak material, proper care must be exercised to avoid excessive reduction in the size of the particles.

6. Preparation of Test Samples

6.1 *For Particle-Size Analysis:*

6.1.1 Weigh the portion of the test sample selected for particle-size analysis and record the weight of test sample uncorrected for hygroscopic moisture. Separate this material into two portions using the No. 10 (2.00-mm) sieve. Set aside the portion passing for later recombination with additional material washed from the portion retained on the No. 10 (2.00-mm) sieve.

6.1.2 Place the material retained on the No. 10 (2.00-mm) sieve in a pan, cover with water and allow to soak until the particle aggregations become soft. After soaking, wash the material on a No. 10 (2.00-mm) sieve in the following manner: Place an empty No. 10 (2.00-mm) sieve on the bottom of a clean pan and pour the water from the soaked sample into the sieve. Add sufficient water to bring the level approximately ½ in. (12.7 mm) above the mesh of the sieve. Transfer the soaked material to the sieve in increments not exceeding 1 lb (0.45 kg), stirring each increment with the fingers while agitating the sieve up and down. Crumble or mash any lumps that have not slaked, using the thumb and fingers. Raise the sieve above the water in the pan and complete the washing operation using a small amount of clean water. Transfer the washed material on the sieve to a clean pan before placing another increment of soaked material on the sieve.

6.1.3 Dry the material retained on the No. 10 (2.00-mm) sieve at a temperature of 230 ± 9°F (110 ± 5°C), sieve on the No. 10 (2.00-mm) sieve, and add the material passing the sieve to similar material obtained in 6.1.1. Set aside the material retained on the sieve for use in the particle-size analysis.

6.1.4 Set aside the pan containing the washings for a period of several hours or until the water above the particles is clear. Decant, pipet, or siphon off as much of the clear water as possible (Note 2). Dry the soil remaining in the pan at a temperature not exceeding 140°F (60°C). Grind the dried soil in the mortar with the rubber-covered pestle or other suitable device, and combine with similar material obtained in 6.1.1.

6.1.5 Alternatively, after all the soaked material has been washed, remove most of the water by filtering the wash water on one or more Büchner funnels fitted with filter paper or by using filter candles. Remove the moist soil from the filter paper or filter candles, combine with any sediment remaining in the pan, and dry at a temperature not exceeding 140°F (60°C). Grind the dried soil in the mortar with a rubber-covered pestle or other suitable device and combine with similar material obtained in 6.1.1.

NOTE 2—In some instances, the wash water will not become clear in a reasonable length of time; in this case the entire volume must be evaporated.

6.2 *For Determination of Soil Constants*—Proceed in accordance with 6.1, substituting a No. 40 (425-μm) sieve for the No. 10 (2.00-mm) sieve.

NOTE 3—In some areas it is possible that the cations of salts present in the tap water may exchange with the natural cations in the soil and alter significantly the values of the soil constants should tap water be used in the soaking and washing operations. Unless it is known that such cations are not present in the tap water, distilled or demineralized water should be used. The soaking and washing operation will remove soluble salts contained in the soil. When soluble salts are present in the soil, the wash water should be saved and evaporated, and the salts returned to the soil sample.

7. Test Samples

7.1 Keeping each portion separate from the other portion, mix thoroughly the portions of the soil sample passing the No. 10 (2.00-mm) sieve and the No. 40 (425-μm) sieve. By the method of quartering or by the use of the sampler, select and weigh out test samples of the weights indicated in Section 5, as may be needed to make the required tests.

PROCEDURE B

8. Samples

8.1 Samples prepared in accordance with this procedure must be shipped from the field to the laboratory in sealed containers and must contain all their natural moisture. Samples obviously containing only particles passing the No. 10 (2.00-mm) sieve may be tested for the particle-size analysis without first washing on the No. 10 (2.00-mm) sieve. Samples obviously containing only particles passing the No. 40 (425-μm) sieve may be used in the tests to determine soil constants without first washing on the No. 40 (425-μm) sieve.

9. Preparation of Test Samples

9.1 *For Particle-Size Analysis:*

9.1.1 Select and weigh a representative portion of the moist sample estimated to contain 50 g of particles passing the No. 10 (2.00-mm) sieve for silty and clayey soil, or 100 g for sandy soil. For samples containing particles not passing the No. 10 (2.00-mm) sieve for which a particle-size analysis is required, select and weigh a representative sample estimated to contain the required amounts of particles both passing and not passing the No. 10 (2.00-mm) sieve. Determine the moisture content at 230 ± 9°F (110 ± 5°C) using an auxiliary sample, for use in Method D 422.

9.1.2 Soak the moist sample and wash on a No. 10 (2.00-mm) sieve as described in 6.1.2. After washing, dry the material retained on the No. 10 (2.00-mm) sieve in an oven at a temperature of 230 ± 9°F (110 ± 5°C), weigh, and retain for the particle-size analysis. If the volume of the wash water and soil is too large for use in the sedimentation procedure of the test for particle-size analysis, evaporate excess water by exposure to air at room temperature, by heating in an oven at a temperature not exceeding 230°F (110°C), or by boiling. Regardless of the method of evaporation used, the following precautions must be taken: (*1*) stir the slurry from time to time to prevent a dry soil ring from forming on the walls of the evaporation vessel, and (*2*) return the temperature of the sample to room temperature before testing.

9.2 *For Determination of Soil Constants*—Select a representative portion of the moist sample estimated to contain sufficient particles passing the No. 40 (425-μm) sieve to make the required tests for determination of soil constants. Soak this selected portion of the moist sample and wash on the No. 40 (425-μm) sieve as described in 6.2 (Note 2). Reduce the moisture content of the material passing the No. 40 (425-μm) sieve until the mass reaches a putty-like consistency (such as 30 to 35 drops of the cup in the liquid limit test) but never below the natural moisture

10. Precision and Accuracy

10.1 Requirements for the precision and accuracy of this test method have not yet been developed.

Designation: D 2217 – 85

Standard Practice for
WET PREPARATION OF SOIL SAMPLES FOR PARTICLE-SIZE ANALYSIS AND DETERMINATION OF SOIL CONSTANTS[1]

This standard is issued under the fixed designation D 2217; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This practice has been approved for use by agencies of the Department of Defense and for listing in the DoD Index of Specifications and Standards.

1. Scope

1.1 This practice covers the wet preparation of soil samples as received from the field for particle-size analysis and determination of soil constants.

1.2 Procedure A provides for drying the field sample at a temperature not exceeding 140°F (60°C), making a wet separation on the No. 10 (2.00-mm) sieve, or No. 40 (425-μm) sieve, or both, as needed, and finally drying at a temperature not exceeding 140°F. Procedure B provides that the sample shall be kept at a moisture content equal to or greater than the natural water content. The procedure to be used should be indicated in the specification for the material being tested. If no procedure is specified, the provisions of Procedure B shall govern.

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

2. Applicable Documents

2.1 *ASTM Standards:*

D 421 Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants[2]

D 422 Method for Particle-Size Analysis of Soils[2]

E 11 Specification for Wire Cloth Sieves for Testing Purposes[3]

3. Significance and Use

3.1 Procedure A is used to prepare soil samples for plasticity tests and particle-size analysis when the coarse-grained particles of a sample are soft and pulverize readily, as in Practice D 421, or when the fine particles are very cohesive and tend to resist removal from the coarse particles.

3.2 Some soils never dry out in nature and may change their characteristics greatly when dried. If the true natural gradation and plasticity characteristics of such soils are desired, these soils should be shipped to the laboratory in sealed containers and processed in accordance with Procedure B of this practice.

3.3 Liquid limit and plasticity index values derived from samples containing their natural moisture are usually, but not always, equal to or higher than values derived from similar samples of the dried soil. In the case of fine-grained organic soil, there is a radical drop in plasticity due to oven drying.

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[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.03 on Texture, Plasticity, and Density Characteristics of Soils.

Current edition approved July 26, 1985. Published September 1985. Originally published as D 2217 – 63 T. Last previous edition D 2217 – 66 (1978)$^{\epsilon 1}$.

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

[3] *Annual Book of ASTM Standards*, Vol 14.02.

APPENDIX B-4

PROCEDURE FOR THE ANALYSIS OF GAS SAMPLES FOR VOCS

STANDARD
OPERATING
PROCEDURE

Subject or Title: Page 1 of 22

The Determination of Volatile Organics (VOCS)
in Ambient Air by GC/MS - Scan Mode

SOP NO: CRL-LM-7001	Revision No.: 2.0	Effective Date: March 1, 1990

Supercedes: Revision 1.0

1. Scope and Application

1.1 Analytes (See Table 1)

1.2 Detection limit (See Table 1)

1.3 Applicable matrices - air

1.4 Dynamic range (See Table 1)

1.5 Approximate analytical time

4 min. - cool down of cryo trap
2 min. - flush of inlet system on trap
10 min. - collection of 500 mL sample on trap
2 min. - flush of inlet system with internal std.
2 min. - collection of 100 mL of internal std on trap
2 min. - flush of trap with HP Helium
32 min. - GC run time

When running multiple samples, steps can be overlapped to reduce run time to 40 min.

Prepared by: Steve Harris Steve D Harris	Date: 6/04/90
Management Approval: Steve D Harris	Date: 6/04/90
QA Officer Approval: Paul Christ	Date: 6/5/90

TABLE 1. VOC Target Compounds

	Compound	R.T.	Detection Limits MDL (ppbv)	Dynamic Range (ppbv)
2)	Dichlorodifluoromethane (Freon 12)	1.49	0.87	0.87-300
3)	Chloromethane	2.48	1.2	1.2-300
4)	1,2-Dichloro-1,1,2,2-tetrafluoroethane (Freon 114)	2.52	1.0	1.0-300
5)	Vinyl chloride	2.86	1.2	1.2-300
6)	Bromomethane	3.58	1.5	1.5-300
7)	Chloroethane	3.93	2.5	2.5-300
8)	Trichlorofluoromethane (11)	4.54	0.55	0.55-300
9)	cis-1,2-Dichloroethene	5.63	0.84	0.84-300
10)	Carbon disulfide	5.63	6.2	6.2-1200
11)	1,1,2-Trichloro- 1,2,2-trifluoroethane (Freon 113)	5.87	0.96	0.96-300
12)	Acetone	6.10	6.6	6.6-300
14)	Methylene chloride	6.89	1.9	1.9-300
15)	trans-1,2-Dichloroethene	7.36	1.9	1.9-300
16)	Hexane	7.98	4.0	4.0-300
17)	1,1-Dichloroethane	8.22	1.2	1.2-300
18)	Vinyl Acetate	8.71	1.3	1.3-300
19)	1,1-Dichloroethene	9.43	1.1	1.1-300
20)	2-Butanone	9.68	1.4	1.4-300
21)	Chloroform	10.27	1.1	1.1-300
22)	1,1,1-Trichloroethane	10.27	0.45	0.45-300
23)	Carbon tetrachloride	10.53	0.55	0.55-300
24)	Benzene	11.00	1.6	1.6-300
25)	1,2-Dichloroethane	11.19	0.53	0.53-300
26)	Trichloroethene	12.44	1.2	1.2-300
27)	1,2-Dichloropropane	12.87	3.9	3.9-300
28)	1,4-Dioxane	13.34	3.5	3.5-300
29)	Bromodichloromethane	13.68	0.90	0.90-300
30)	cis-1,3-Dichloropropene	14.61	1.5	1.5-300
31)	4-Methyl-2-pentanone	15.14	1.6	1.6-300
32)	Toluene	15.16	1.5	1.5-300
33)	trans-1,3-Dichloropropene	16.00	1.6	1.6-300
34)	1,1,2-Trichloroethane	16.34	1.4	1.4-300
35)	Tetrachloroethene	16.28	1.4	1.4-300
36)	2-Hexanone	17.10	3.0	3.0-300
37)	Dibromochloromethane	17.06	1.4	1.4-300
38)	1,2-Dibromoethane	17.08	1.0	1.0-300
39)	Chlorobenzene	18.28	1.3	1.3-300
40)	Ethylbenzene	18.73	1.3	1.3-300
41)	1,4-and 1,3-(p,m) Xylene	19.04	2.6	2.6-600

TABLE 1. VOC Target Compounds
(Continued)

	Compound	R.T.	Detection Limits MDL (ppbv)	Dynamic Range
42)	1,2-(ortho) Xylene	19.94	1.1	1.1-300
43)	Styrene	20.02	3.5	3.5-300
44)	Bromoform	20.37	1.0	1.0-300
45)	1,1,2,2-Tetrachloroethane	21.99	1.9	1.9-300
46)	Benzyl chloride	21.90	1.0	1.0-300
47)	4-Ethyltoluene	22.31	2.0	2.0-300
48)	1,3,5-Trimethylbenzene	22.48	1.3	1.3-300
49)	1,2,4-Trimethylbenzene	23.37	1.5	1.5-300
50)	1,3-Dichlorobenzene	23.04	1.7	1.7-300
51)	1,4-Dichlorobenzene	24.13	2.2	2.2-300
52)	1,2-Dichlorobenzene	24.97	2.4	2.4-300
53)	1,2,4-Trichlorobenzene	29.28	3.6	3.6-300
54)	Hexachlorobutadiene	29.93	2.4	2.4-300

2. Summary of Method

2.1 A pressurized air sample is metered through a mass flow controller onto a cryogenically cooled trap. After 500 mL of the sample has been trapped, a valve is switched and the trap is heated to purge the trap's contents onto the gas chromatography column. The target compounds are analyzed with a mass spectrometer operated in the scan mode.

3. Comments

3.1 Interferences

3.1.1 Gas regulators are cleaned by the manufacturer using Freon 113, which is one of the target compounds. Before using ultra high purity (UHP) Nitrogen (N_2), Hydrocarbon (HC) free air, Internal Standard (I.S.), or a target compound standard mix, each regulator should be purged a minimum of three times with the appropriate gas.

3.1.2 Contamination may occur in the sampling system if canisters are not properly cleaned prior to use. Canisters used to collect source samples should not be used for the collection of ambient air samples until a blank analysis indicates that no target compounds are present above the MDL. All other sampling equipment including pumps, flow controllers and filters must be thoroughly cleaned to ensure that the filling apparatus will not contaminate samples.

3.2 Helpful Hints

None

4. Safety Issues

4.1 In order to prevent contamination of the lab air by the samples, the vent line must be connected to the system outlet and the fume hood must be on.

4.2 While making standards, the fume hood must be running. When finished valves must be closed and lines vented.

4.3 All compressed gas cylinders must be securely fastened to a bench or wall.

4.4 Normal precautions should be used in the handling of liquid nitrogen (LN_2) (do not touch transfer lines as burns can result).

4.5 Sampling canisters should never be pressurized over 40 psig.

5. Sample Collection, Preservation, Containers and Holding Times

5.1 Samples should be collected in precleaned and batch analyzed SUMMA passivated canisters. A 7 micron filter should be placed on the inlet of the can to protect the valve from particulates. Canisters should never be pressurized over 40 psig.

5.2 The absolute pressure of the canister must be recorded before and after sample collection.

5.3 Samples must be kept at <25°C.

5.4 Samples should be analyzed within 14 days of collection.

6. Apparatus and Materials

6.1 Gas chromatograph - capable of subambient temperature programming for the oven and with the jet separator option (Hewlett Packard 5890).

6.2 Mass-selective detector - equipped with computer and appropriate software (Hewlett Packard 5970B with HP-1000 RTE-A data system).

6.3 Cryogenic trap with temperature control assembly (Nutech 8533). See Figure 1.

6.4 Electronic mass flow controller - for maintaining constant sample flow (Unit Instruments)

6.5 Chromatographic grade stainless steel tubing and stainless steel plumbing fittings.

6.6 Chromatographic column - DB-624 0.53 ID, 30 meter length (J&W Scientific).

6.7 Stainless steel vacuum/pressure gauge capable of measuring from 30" of mercury (Hg) to 40 psig. (Span Instruments)

6.8 High precision vacuum gauge - for making daily standards. (Wallace & Tiernan Pennwalt)

6.9 Pressure regulators for carrier gas and standards - 2 stage, stainless steel diagram.

6.10 SUMMA passivated canisters 6 L (Scientific Instrumentation Specialists)

6.11 7 micron filters (Nupro), or equivalent.

7. Reagents and Standards

7.1 4-bromofluorobenzene, 50 ng/mL in methanol (for tuning of mass spectrometer).

7.2 High purity helium for carrier gas.

7.3 Standards at a nominal concentration of 1 ppmv (CS_2 is not as stable and so the concentration is 5 ppmv). Standards are prepared in a balance gas of nitrogen and are analytically certified by the supplier (Scott-Marrin and Scott Specialty). To facilitate certification by vendor, the standards were divided into 5 cylinders. (See Tables 2-7.)

7.4 Internal standard mix of bromochloromethane, 1,4-difluorobenzene, and chlorobenzene-d5 at 1000 ug/ml each in methanol (Supelco). (See Table 6.)

TABLE 4. Standard Cylinder No. CC72063

Component	Concentration (v/v)
Vinyl Chloride	1.00 ± 0.05 ppm
1,1-Dichloroethene	1.08 ± 0.05 ppm
1,1-Dichloroethane	1.06 ± 0.05 ppm
2-Butanone	1.02 ± 0.05 ppm
cis-1,2-Dichloroethene	1.07 ± 0.05 ppm
Benzene	1.07 ± 0.05 ppm
4-Methyl-2-pentanone	1.09 ± 0.05 ppm
1,1,2-Trichloroethane	1.06 ± 0.05 ppm
Toluene	1.08 ± 0.05 ppm
2-Hexanone	1.18 ± 0.05 ppm
Chlorobenzene	1.08 ± 0.05 ppm
m-Xylene	1.11 ± 0.05 ppm
o-Xylene	1.12 ± 0.05 ppm
1,2-Dichlorobenzene	1.25 ± 0.05 ppm
Acetone	0.99 ± 0.05 ppm
1,4-Dichlorobenzene	1.04 ± 0.05 ppm
Nitrogen	Balance

TABLE 5. Standard Cylinder No. CC12390

Component	Concentration (v/v)
Freon-12	1.015 ± 0.05 ppm
Freon-114	0.95 ± 0.05 ppm
Freon-11	0.94 ± 0.05 ppm
Freon-113	0.99 ± 0.05 ppm
n-Hexane	1.02 ± 0.05 ppm
1,2-Dibromoethane	0.99 ± 0.05 ppm
4-Ethyltoluene	0.89 ± 0.05 ppm
1,3,5-Trimethylbenzene	0.95 ± 0.05 ppm
1,2,4-Trimethylbenzene	0.92 ± 0.05 ppm
Nitrogen	Balance

TABLE 6. Internal Standard Liquid Mix

Component	Concentration (ug/ml)
Bromochloromethane	1000
1,4-Difluorobenzene	1000
Chlorobenzene-d5	1000

FIGURE 1. Nutech 8533 Flow Diagram

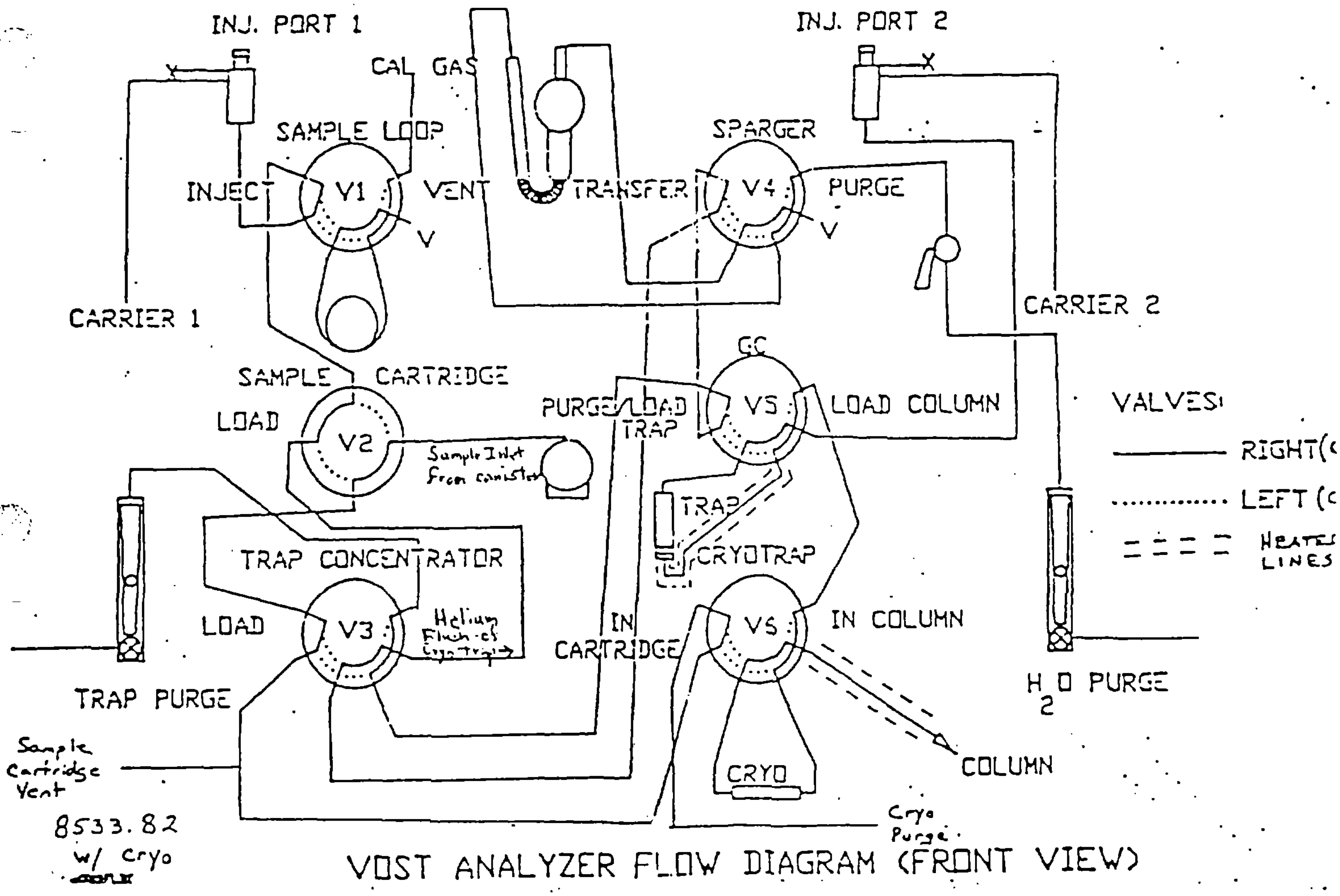

TABLE 2. Cylinder No. CC72069

Component	Concentration (v/v)
Chloromethane	0.98 ± 0.05 ppm
Bromomethane	1.00 ± 0.05 ppm
Chloroethane	0.96 ± 0.05 ppm
Dichloromethane	1.08 ± 0.05 ppm
trans-1,2-Dichloroethylene	1.08 ± 0.05 ppm
Trichloroethane	1.07 ± 0.05 ppm
1,2-Dichloroethane	1.10 ± 0.05 ppm
1,1,1-Trichloroethane	0.99 ± 0.05 ppm
Tetrachloromethane	1.01 ± 0.05 ppm
1,2-Dichloropropane	1.08 ± 0.05 ppm
cis-1,3-Dichloropropene	1.03 ± 0.05 ppm
trans-1,3-dichloropropene	1.20 ± 0.06 ppm
Dibromochloromethane	1.13 ± 0.05 ppm
Tetrachloroethylene	1.14 ± 0.05 ppm
Ethylbenzene	1.20 ± 0.06 ppm
p-Xylene	1.20 ± 0.06 ppm
Styrene	1.25 ± 0.06 ppm
1,1,2,2-Tetrachloroethane	1.24 ± 0.06 ppm
Bromodichloromethane	1.08 ± 0.05 ppm
Trichloroethene	0.82 ± 0.05 ppm
Acetonitrile	1.00 ± 0.05 ppm
Nitrogen	Balance

TABLE 3. Standard Cylinder No. CC72058

Component	Concentration (v/v)
Carbon Disulfide	4.86 ± 0.1 ppm
Nitrogen	Balance

TABLE 7. Standard Cylinder No. ALM 002636

Component	Concentration (v/v)
Benzyl chloride	0.737 ppm
1,3-Dichlorobenzene	0.768 ppm
1,4-Dioxane	0.895 ppm
Hexachloro-1,3-butadiene	0.804 ppm
Bromoform	0.84 ppm
1,2,4-Trichlorobenzene	0.898 ppm
Vinyl acetate	0.838 ppm
Nitrogen	

8. Procedure

8.1 Sample Preparation

8.1.1 The pressure of the sample canister is checked and recorded by attaching a vacuum/pressure gauge to the top valve of the canister (the gauge should be rinsed for few seconds with HC free air by physically holding against the air outlet and flushing). The canister valve is opened briefly and the pressure is recorded. If the pressure is less than 10 psig, pressurize the canister to 10 psig with HC free air.

8.1.2 If the canister pressure is increased, a dilution factor (DF) is calculated and recorded.

$$DF = \frac{Y_a}{X_a}$$

Where: X_a = absolute canister pressure absolute before dilution

Y_a = absolute canister pressure absolute after dilution

8.2 Daily GC/MS Tuning

8.2.1 At the beginning of each day or prior to a calibration, the GC/MS system must be tuned to verify that acceptable performance criteria are achieved. If any of the key ions fail the abundance criteria listed in Table 8, the system must be retuned using 4-Bromofluorobenzene (BFB).

8.2.2 For daily tuning, the relays on the Nutech controller (see Figure 1) should be in the right hand position, with the cryo trap at 150°C (alternatively valves 2 and 6 could be placed in the left hand position with the auxiliary He flow set at 10 ml/min or greater). The GC program is initiated by using the Datac command in file manager (FMGR). The GC program is named "GCBFB1." This downloads the program from the data system to the GC. Once the oven has stabilized, the remote start light will turn on and the system is ready for injection.

1 uL of a 50 ng/uL 4-bromofluorobenzene (BFB) standard is injected into injection port 2 of the Nutech 8533 and the remote start button is activated.

TABLE 8. 4-Bromofluorobenzene Key Ions and Ion Abundance Criteria

Mass	Ion Abundance Criteria
50	15 to 40% of mass 95
75	30 to 60% of mass 95
95	Base Peak, 100% Relative Abundance
96	5 to 9% of mass 95
173	<2% of mass 174
174	>50% of mass 96
175	5 to 9% of mass 174
176	>95% but <101% of mass 174
177	5 to 9% of mass 176

8.2.3 Once the tuning run is complete (~ 8 minutes), review a scan close to the center of the BFB peak. If it looks close to passing, type in the command TRF, TUNVOA, data file. This will start a program that will find a scan that will pass the tuning and print out the required information automatically. If the BFB tuning criteria cannot be met on 2-3 injections, retuning the instrument with PFTBA may be required.

TABLE 9. BFB Tuning Method

```
Enter the name of the method file: GCBFB1

                    M E T H O D   F I L E   L I S T

Method file:  GCBFB1          GC type: 5890             Run type: SCAN, GC, E1
                              Column: Cap               Splitless: Yes

Temperature:         Inj.P            Intfc             Source
                     90.0             250.0             0.0

GC/DIP                          LEVEL A       LEVEL B       POST RUN

Temp 1       30.0                 100.0         0.0            0.0
Time 1        1.0                  15.0         0.0            0.0
Rate         35.0                   0.0         0.0
Temp 2      100.0                   0.0         0.0
Time 2       15.0                   0.0         0.0

Oven equilibration Time     .10 min

Run time:  6.00
Scan Start time:  2.50
Splitless valve time:  .80

                             ON            OFF            ON                OFF

Relay #1:                  327.0          327.0          327.0             327.0
Relay #2:                  327.0          327.0          327.0             327.0
Triac #0:                  327.0          327.0          327.0             327.0
Triac #1:                  327.0          327.0          327.0             327.0

Scan Parameters:    Mass Range  35 to 260
                    Multiplier voltage:  2244     Number of A/D samples:  8
                    GC Peak threshold:  20000 counts
                    Threshold:  100 counts
```

TABLE 10. Analytical Method

```
Enter the name of the method file: GCT014

                         M E T H O D   F I L E   L I S T

Method file:  GCT014          GC type: 5890                Run type: SCAN, GC, E1
                              Column: Cap                  Splitless: Yes

Temperature:           Inj.P           Intfc               Source
                       90.0            250.0               0.0

GC/DIP                            LEVEL A       LEVEL B      POST RUN

Temp 1       -50.0                 -20.0         127.0          0.0
Time 1         2.0                   0.0          20.0          0.0
Rate          70.0                   5.0           0.0
Temp 2       -20.0                 127.0           0.0
Time 2         0.0                  20.0           0.0

Oven equilibration Time     .10 min

Run time:  32.10
Scan Start time:  .10
Splitless valve time:  0.00

                                  ON            OFF             ON               OFF

Relay #1:                        327.0         327.0           327.0            327.0
Relay #2:                        327.0         327.0           327.0            327.
Triac #0:                        327.0         327.0           327.0            327.0
Triac #1:                        327.0         327.0           327.0            327.0

Scan Parameters:      Mass Range  35 to 260
                      Multiplier voltage:  2244     Number of A/D samples:  8
                      GC Peak threshold:  20000 counts
                      Threshold:  10 counts
```

8.3 Calibration

8.3.1 A static dilution of the stock standard gas mixtures is made in a 6 liter canister. The high precision vacuum gauge is flushed with HC free air and attached to the top valve of a clean, evacuated canister. After recording the absolute pressure, 2 psi of each of the 5 standard mixtures is added to the canister (each regulator and the transfer line must be flushed several times before transfer of standard to the canister). Close the canister valves and replace the high precision gauge with a vacuum/pressure gauge. Pressurize the can with HC free air to 30 psig. This will yield a standard with a nominal concentration of 44 ppbv for most compounds (see Table 11).

8.3.2 An initial 5 point curve is run in the linear working range of the system. The nominal concentration of the 5 standards will be 18 ppbv, 67 ppbv, 90 ppbv, 224 ppbv and 287 ppbv.

8.3.3 On a daily basis, a one point midrange standard (500 ml of 44 ppbv) is run to verify the 5 point curve. 90% of the target compounds must be within 30% of the 5 point curve, or a new 5 point must be run. The daily, one point check standard is used to calculate the concentration of the samples.

PC
6/5/90

8.3.4 After the calibration runs and the QA/QC sample runs, an HC free air blank is run. This must be < the MDL for each target compound.

8.4 Analysis

8.4.1 The daily check standard and the QA/QC samples are analyzed the same as samples. The HC free air blank is a system blank and differs only in that it is not transferred to a canister, but run directly from the cylinder regulator to the sample inlet system.

8.4.2 The sample canister is connected to the sample inlet system. The Nutech controller should have valves 2 and 6 in the left hand position, while valves 1 and 3-5 should be in the right hand position. The auxiliary He flow should be set at 40 ml/minute. The canister valve is opened and the pressurized sample is allowed to flow through the mass flow controller (set at 50 ml/min) and out the vent line.

8.4.3 The cryogenic trap is cooled to its lower set point of -170° C. When the cryo trap reaches -170° C, the Nutech valve #2 is switched to the right hand position and a timer is started. After 10 minutes (500 mL) valve #2 is switched back to the left hand position. Thus 500 ml of blank, standard or sample is concentrated on the cryo trap.

8.4.4 The valve on the sample canister is closed and the remaining line pressure is allowed to drop to ambient. The 3-way valve is then switched to the internal standard canister and the I.S. canister valve is opened and allowed to flush for at least 2 minutes. (The internal standard is made by injecting 20 ul of the liquid mix in an evacuated canister and pressurizing to 30 psi(44.6 psia). Valv is then switched to the right hand position and a timer is starte After 2 minutes, Valve 2 is switched back to the left hand positi Thus 100 ml of 200 ppbv nominal internal standard mix is inje[illegible]d the cryotrap with each blank, standard or sample.

8.4.5 The GC is cooled to its' initial set point of -50°C by using Datac in file manager. The name of the GC program is "GCTO14." This takes about 2.5 minutes. During this time valves 2 and 6 remain in the left hand position, allowing He to sweep the trap and remove most oxygen, nitrogen and other permanent gases.

8.4.6 When the GC has reached equilibrium the red remote start light will turn on. Switch valve #6 to the right hand position. Wait at least 10 seconds to allow flow through the trap to equilibrate. The blue "cool" button on the Nutech controller and remote start button should be pressed simultaneously. This will heat the cryo trap to 150°C and start the GC program.

9. Data Interpretation

9.1 Qualitative Analyses

9.1.1 An analyte (e.g., those listed in Table 1) is identified by comparison of the sample mass spectrum with the mass spectrum of a standard of the suspected compound (standard reference spectrum). Mass spectra for standard reference should be obtained on the user's GC/MS within the same 12 hours as the sample analysis. These standard reference spectra may be obtained through analysis of the calibration standards. Two criteria must be satisfied to verify identification. (1) elution of sample component at the same GC relative retention time (RRT) as those of the standard component; and (2) correspondence of the sample component and the standard component mass spectrum.

9.1.1.1 The sample component RRT must compare within ± 0.06 RRT units of the RRT of the standard component. For reference, the standard must be run within the same 12 hours as the sample. If coelution of interfering components prohibits accurate assignment of the sample component RRT from the total ion chromatogram, the RRT should be assigned by using extracted ion current profiles for ions unique to the component of interest.

9.1.1.2 (1) All ions present in the standard mass spectra at a relative intensity greater than 10% (most abundant ion in the spectrum equals 100%) must be present in the sample spectrum. (2) The relative intensities of ions specified in (1) must agree within plus or minus 20% between the standard and sample spectra. (Example: For an ion with an abundance of 50% in the standard spectra, the correspondin sample abundance must be must be between 30 and 70 percent.

9.1.2 For samples containing components not associated with the calibration standards, a library search may be made for the purpose of tentative identification. The necessity to perform this type of identification will be determined by the type of analyses being conducted. Guidelines for making tentative identification are.

(1) Relative intensities of major ions in the reference spectrum (ions >10% of the most abundant ion) should be present in the sample spectrum.

(2) The relative intensities of the major ions should agree within ± 20%. (Example: For an ion with an abundance of 50% in the standard spectrum, the corresponding sample ion abundance must be between 30 and 70%).

(3) Molecular ions present in the reference spectrum should be present in the sample spectrum.

(4) Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contamination or presence of coeluting compounds.

(5) Ions present in the reference spectrum but not in the sample spectrum should be reviewed for possible subtraction from the sample spectrum because of background contamination or coeluting peaks. Data system library reduction programs can sometimes create these discrepancies.

Computer generated library search routines should not use normalization routines that would misrepresent the library or unknown spectra when compared to each other. Only after visual comparison of sample with the nearest library searches will the mass spectral interpretation specialist assign a tentative identification.

9.2 Quantitative Analysis:

When a compound has been identified, the quantification of that compound will be based on the integrated abundance from the EICP of the primary charateristic ion. Quantification will take place using the internal standard technique.

10. QA/QC Requirements

10.1 The mass spectrometer must meet the tuning criteria described in Section 8.2.

10.2 After tuning, a single point check standard must be analyzed. Ninety percent of the target compound concentrations must be within ± 30% of the ~~three~~ five point calibration curve. If the check standard fails to meet this criterion, a new ~~three~~ five point calibration curve must be run.

pL
6/5/90

10.3 A laboratory control sample (LCS) must be analyzed after the check standard. This sample will consist of the target VOCs prepared in a separate canister at a concentration that differs from that of the check standard. Five compounds will be used to assess control for the LCS: methylene chloride, 1,1-dichloroethene, trichloroethene, toluene and 1,1,2,2-tetrachloroethane. The percent recovery for the five control compounds must be within a window of 80-115%.

10.4 For each lot of 20 samples analyzed, a duplicate control sample (DCS) must be analyzed after the LCS. The DCS sample is identical to the LCS in composition and source. The 80-115% recovery criterion must be met. In addition, the relative percent difference (RPD) for the LCS and DCS must be ≤ 20%.

10.5 A system blank of HC free air must be analyzed after the LCS or DCS. The blank results must indicate that there are no target compounds present above the MDL.

10.6 If any of the above criteria are not met, corrective actions must be implemented before analyses can proceed.

11. Calculations

11.1 The HP data system automatically quantitates the sample results based on a 500 mL sample size. The results are in ppbv. If the canister was pressurized before analysis, the results must be multiplied by the dilution factor DF (see Section 8.1.2).

11.2 If a sample size other than 500 mL was used, the result must be adjusted as shown below:

$$\text{result ppbv} \times \frac{\text{sample volume injected}}{500 \text{ mL}}$$

12. Reporting

12.1 Reporting units are ppbv. If results are to be reported in ng/L use the following equation:

$$\text{result ppbv} \times \frac{\text{Molecular weight of compound}}{24.5} = \text{ng/L}$$

Note: 24.5 is the standard volume of ideal gas at 25 degrees Centigrade and 1 atm.

12.2 Reporting limits

See Table 12

12.3 Significant figures

12.3.1 All results should be reported to two significant figures.

12.3.2 Only report results below detection limit as ND(DL).

12.4 No conversion of the analytical results to the standard conditions is made.

13. References

13.1 Method Source

"EPA Compendium Method TO-14. The Determination of Volatile Organic Compounds (VOCs) in Ambient Air using SUMMA Passivated Canister Sampling and Gas Chromatographic Analysis."

13.2 Deviations from Method

13.2.1 Dry HC free air is used for the daily blank and for dilution purposes.

13.2.2 TO-14 recommends the use of a .32 mm column coupled directly to the MSD. With the HP system, the MSD can only handle flow of 1 mL/min or less. The .32 mm column provides ~ 3 mL/min. Enseco uses a .53 mm column through a jet separator.

13.2.3 TO-14 describes an inlet system that uses a vacuum to pull a slip stream sample through the trap. Enseco uses the pressure of the sample canister to drive the sample through the trap.

TABLE 11. Concentration of Daily Check Standard

	Compound	Concentration (ppbv)
2)	Dichlorodifluoromethane (Freon 12)	45.42
3)	Chloromethane	43.84
4)	1,2-Dichloro-1,1,2,2-tetrafluoroethane (Freon 114)	42.50
5)	Vinyl chloride	44.74
6)	Bromoethane	44.74
7)	Chloroethane	42.96
8)	Trichlorofluoromethane (11)	42.06
9)	cis-1,2-Dichloroethene	47.88
10)	Carbon disulfide	217.44
11)	1,1,2-Trichloro- 1,2,2-trifluoroethane (Freon 113)	44.30
12)	Acetone	44.30
14)	Methylene chloride	48.32
15)	trans-1,2-Dichloroethene	48.32
16)	Hexane	45.64
17)	1,1-Dichloroethane	47.42
18)	Vinyl Acetate	37.50
19)	1,1-Dichloroethene	48.32
20)	2-Butanone	45.64
21)	Chloroform	47.82
22)	1,1,1-Trichloroethane	44.30
23)	Carbon tetrachloride	45.20
24)	Benzene	47.82
25)	1,2-Dichloroethane	49.22
26)	Trichloroethene	36.68
27)	1,2-Dichloropropane	48.32
28)	1,4-Dioxane	40.04
29)	Bromodichloromethane	48.32
30)	cis-1,3-Dichloropropene	46.08
31)	4-Methyl-2-pentanone	48.76
32)	Toluene	48.32
33)	trans-1,3-Dichloropropene	53.70
34)	1,1,2-Trichloroethane	53.70
35)	Tetrachloroethene	51.00
36)	2-Hexanone	52.80
37)	Dibromochloromethane	50.56
38)	1,2-Dibromoethane	44.30
39)	Chlorobenzene	48.32
40)	Ethylbenzene	53.70
41)	1,4-and 1,3-(p,m) Xylene	103.36

TABLE 11. Concentration of Daily Check Standard

	Compound	Concentration (ppbv)
42)	1,2-(ortho) Xylene	50.12
43)	Styrene	55.92
44)	Bromoform	37.58
45)	1,1,2,2-Tetrachloroethane	55.48
46)	Benzyl chloride	32.98
47)	4-Ethyltoluene	39.82
48)	1,3,5-Trimethylbenzene	42.50
49)	1,2,4-Trimethylbenzene	41.16
50)	1,3-Dichlorobenzene	34.36
51)	1,4-Dichlorobenzene	46.54
52)	1,2-Dichlorobenzene	55.92
53)	1,2,4-Trichlorobenzene	40.18
54)	Hexachlorobutadiene	35.98

Table 12. VOC Reporting Limits

	Compound	Reporting Limits (ppbv)
2)	Dichlorodifluoromethane (Freon 12)	2.0
3)	Chloromethane	2.5
4)	1,2-Dichloro-1,1,2,2-tetrafluoroethane (Freon 114)	2.0
5)	Vinyl chloride	2.5
6)	Bromoethane	3.0
7)	Chloroethane	5.0
8)	Trichlorofluoromethane (11)	1.0
9)	cis-1,2-Dichloroethene	2.0
10)	Carbon disulfide	10
11)	1,1,2-Trichloro- 1,2,2-trifluoroethane (Freon 113)	2.0
12)	Acetone	10
14)	Methylene chloride	4.0
15)	trans-1,2-Dichloroethene	4.0
16)	Hexane	8.0
17)	1,1-Dichloroethane	2.5
18)	Vinyl Acetate	2.5
19)	1,1-Dichloroethene	2.0
20)	2-Butanone	3.0
21)	Chloroform	2.0
22)	1,1,1-Trichloroethane	2.0
23)	Carbon tetrachloride	2.0
24)	Benzene	3.0
25)	1,2-Dichloroethane	2.0
26)	Trichloroethene	2.5
27)	1,2-Dichloropropane	8.0
28)	1,4-Dioxane	7.0
29)	Bromodichloromethane	2.0
30)	cis-1,3-Dichloropropene	3.0
31)	4-Methyl-2-pentanone	3.0
32)	Toluene	3.0
33)	trans-1,3-Dichloropropene	3.0
34)	1,1,2-Trichloroethane	3.0
35)	Tetrachloroethene	3.0
36)	2-Hexanone	5.0
37)	Dibromochloromethane	3.0
38)	1,2-Dibromoethane	2.0
39)	Chlorobenzene	2.5
40)	Ethylbenzene	2.5
41)	1,4-and 1,3-(p,m) Xylene	5.0

Table 12. VOC Reporting Limits

	Compound	Reporting Limits (ppbv)
42)	1,2-(ortho) Xylene	2.0
43)	Styrene	7.0
44)	Bromoform	2.0
45)	1,1,2,2-Tetrachloroethane	4.0
46)	Benzyl chloride	2.0
47)	4-Ethyltoluene	4.0
48)	1,3,5-Trimethylbenzene	2.5
49)	1,2,4-Trimethylbenzene	3.0
50)	1,3-Dichlorobenzene	3.0
51)	1,4-Dichlorobenzene	4.0
52)	1,2-Dichlorobenzene	5.0
53)	1,2,4-Trichlorobenzene	7.0
54)	Hexachlorobutadiene	5.0

Enseco - Air Toxics Laboratory
9537 Telstar Avenue, Suite 118 • El Monte, CA 91731
(818) 442-8400 • FAX: (818) 442-3758

Preventive Maintenance on Hewlett Packard 5890 Gas Chromatograph with HP 5970B mass selective detector and Nutech 8533 cryogenic trap concentrator.

This system is used in Enseco SOP No. CRL-LM-7001 for the analysis of VOC's in air (EPA Method T0-14).

Preventive Maintenance	Schedule
Inspect/change injector septa	every week
Check column head pressure at 30°c	every week
Clean source on MSD	every 3 months
HP preventive maintenance - HP service technician changes oil in rough pumps and checks turbo pump. Runs checks on MSD (eg. autotune)	every 6 months

Enseco

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Check column head pressure at 30°c	every week
Clean source on MSD	every 3 months
HP preventive maintenance - HP service technician changes oil in rough pumps and checks turbo pump. Runs checks on MSD (eg. autotune)	every 6 months

Enseco
A Corning Company

Enseco – Air Toxics Laboratory
9537 Telstar Avenue, Suite 118 • El Monte, CA 91731
(818) 442-8400 • FAX: (818) 442-3758

Cleaning Procedure For SUMMA Passivated Canisters

I. Method

A. Source

"EPA Compendium TO-14. The Determination of VolatileOrganic Compounds (VOCs) in Ambient Air Using SUMMA Passivated Canister Sampling and Gas Ghromatographic Analysis".

B. Description

A Group of8 canisters is evacuated to <5 x 10^{-5} torr. With the canisters under a continuous vacuum, they are heated to 150 degrees Centigrade for three hours. The canisters are then rinsed with humidified hydrocarbon free air and evacuated three times. Finally, the canisters are heated under vacuum for an additional two hours.

C. Deviations from Source Method

TO-14 recommends either humid air rinses, or heating under vacuum for canistercleaning. The Ensecoprocedure uses both humid air rinses and heating undervacuum to ensure thorough cleaning.

The method recommends testing the canisters for leaks by pressurizing to 30 psig andchecking for a pressure decrease 24 hours later. The Enseco procedure specifies that the canisters must maintain avacuum of 30 in. of Hg in order to pass a leak check.

II. Equipment

Oven with manifold pumping system and liquid nitrogen cold trap (S.I.S.).

III. QA/QC Requirements

A permanent logbook is maintained which documents canister serial number, cleaning date, previous contamination, absolute pressure after cleaning and date checked, date absolute pressure rechecked, and date screened.

One canister from each batch of 8 is analyzed to check the effectiveness of thecleaning procedure. Tobe accepted, the results must indicate no target compounds above 0.2 ppbv.

Before use, the absolute pressure of each canister is checked. The pressure must be ± 2 psi of the reading that was taken immediately after cleaning.

WARZYN

Volume 3 of 5

Planning Document
Project No. 60721

Quality Assurance Project Plan
Blackwell Landfill NPL Site

Prepared for:
Forest Preserve District
DuPage County, Illinois

Prepared by:
Warzyn Engineering Inc.
Chicago, Illinois

January 1991

C

APPENDIX C

FIELD EQUIPMENT PROCEDURES

APPENDIX C-1

FIELD MEASUREMENT OF pH

pH

Scope and Application: This method is applicable to surface water, wastewater and groundwater.

Method: Potentiometric

Reference: EPA 1983, p. 150.1

Sensitivity: 0.01 pH unit

Optimum Range: pH 1.00 to 12.00

Sample Handling: Determine on-site, if possible

Reagents and Apparatus:

1. pH meter
2. Combination pH electrode.
3. Magnetic stirrer and stir bars
4. Beakers or plastic cups.
5. pH buffer solutions, pH 4.00, 7.00, and 10.00. (Certified buffer solutions)
6. Deionized water in squirt bottle.

Calibration:

1. Place combination electrode in pH 7.00 buffer solution.
2. After allowing several minutes for meter to stabilize, turn calibration dial until reading of 7.00 is obtained.
3. Rinse electrode with deionized water and place in pH 4.00 or pH 10.00 buffer solution. Use pH 7.00 and 4.00 for samples with pH <8, and buffers 7.00 and 10.00 for samples with pH >8.
4. Wait several minutes and then turn slope adjustment dial until reading of 4.00 or 10.00 is obtained.
5. Rinse electrode with deionized water and place in pH 7.00 buffer. If meter reading is not 7.00, follow Steps 2-5 again.

Procedure:

1. Calibrate meter using calibration procedure.
2. Pour the sample into clean beaker or plastic cup.

3. Place stir bar in beaker and put on magnetic stirrer (low speed) for lab measurement of pH. Swirl cup gently for field measurement of pH.

4. Check temperature of sample. It should be ± 2°C of the buffer solutions.

5. Rinse electrode with deionized water.

6. Immerse electrode in sample. The white KCl junction on side or bottom of electrode must be fully immersed in solution. Allow sufficient time for reading to stabilize. Record pH. Rinse electrode with deionized water.

7. Recheck calibration with pH 7.00 buffer solution after every 20 samples and at the end of the analytical run.

Quality Control:

1. Duplicate 1 out of 10 samples. If less than 10 samples are analyzed, a duplicate is still required. Duplicates should be ± 0.2 pH units. Average the results.

2. All glassware is to be soap and water washed, tap rinsed and deionized water rinsed prior to analyses.

Notes:

1. The pH test is temperature dependent. Therefore, temperatures of buffers and samples should be within 2°C of each other. For refrigerated or cool samples, use refrigerated buffers to calibrate meter.

2. Interferences in pH measurements occur with presence of weak organic and inorganic salts, and oil and grease. If oil and grease are visible, note on data sheet. Clean electrode with soap and water, followed by 10% HCl and deionized water. Then recalibrate meter before analysis of next sample.

3. Electrode should be stored in pH 4.00 buffer.

4. Before leaving laboratory for field work:

   a. Check batteries.
   b. Do quick calibration at pH 7.00 and 4.00 to check electrode response and batteries.
   c. Obtain fresh pH buffer solutions.

5. Following field measurements:

    a. Report any problems with meter or electrode.
    b. Clean meter and meter case.
    c. Make sure electrode is stored in pH 4.00 buffer.

Approved 7/22/86

Michael Linskens

Michael J. Linskens
Laboratory Manager

[ALM-1-26]

BECKMAN

Φ™10 pH Meter
Φ™11 pH Meter
Φ™12 pH/ISE Meter

ISSC:

WARRANTY

Your Φ™ (pHI™) 10, 11, or 12 pH Meter is warranted to be free of manufacturing defects for one (1) year from the date of purchase. This does not include any defects that are the result of abuse or misuse of the instrument. Beckman Instruments, Inc., will, at Beckman's option, repair or replace your instrument with a comparable unit. This is a limited warranty. You may have additional rights under your state laws. Batteries are not included in this warranty.

WARNING: *This equipment generates, uses, and can radiate radio frequency energy and may cause interference to radio communications. Improper installation or modification of the equipment may increase interference. It has been tested and found to comply with the limits for a Class A computing device pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference when operated in a commercial environment.*

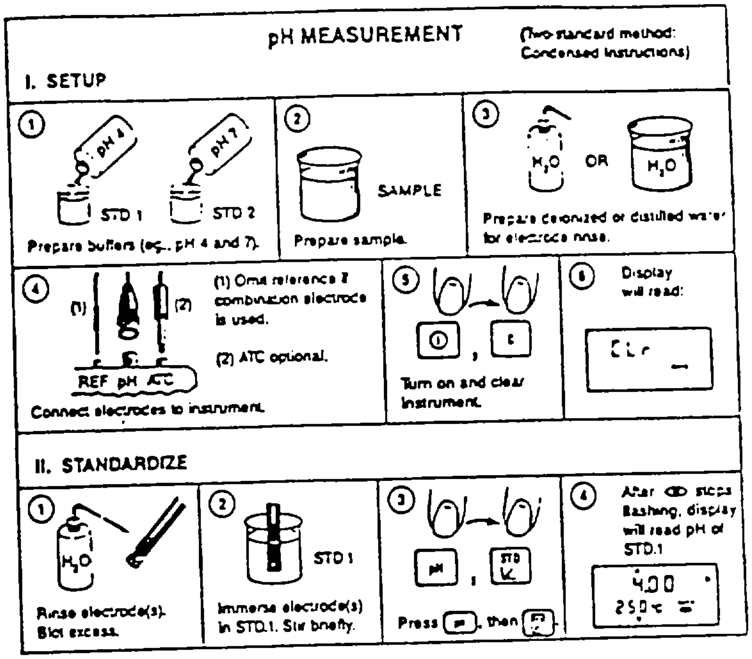
Operation of this equipment in a residential area may cause interference, in which case the user at his own expense will be required to take whatever measures may be required to correct the interference.

Beckman Instructions 015-246800-B

BECKMAN

Φ™10 pH Meter
Φ™11 pH Meter
Φ™12 pH/ISE Meter

Beckman Instruments, Inc. • Scientific Instruments Division • Fullerton, CA 92634-3100



pH MEASUREMENT

(Two-standard method: Condensed Instructions)

I. SETUP

① Prepare buffers (eg., pH 4 and 7).

② Prepare sample.

③ Prepare deionized or distilled water for electrode rinse.

④ Connect electrodes to instrument.

(1) Omit reference if combination electrode is used.

(2) ATC optional.

⑤ Turn on and clear instrument.

⑥ Display will read:

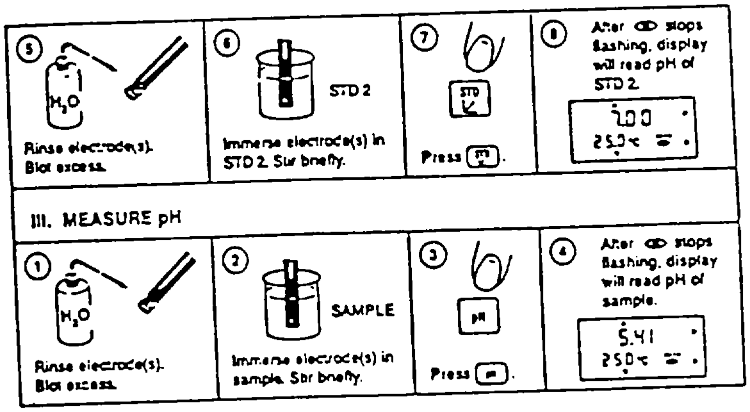
II. STANDARDIZE

① Rinse electrode(s). Blot excess.

② Immerse electrode(s) in STD.1. Stir briefly.

③ Press pH, then STD.

④ After ⊂⊃ stops flashing, display will read pH of STD.1



⑤ Rinse electrode(s). Blot excess.

⑥ Immerse electrode(s) in STD 2. Stir briefly.

⑦ Press STD.

⑧ After ⊂⊃ stops flashing, display will read pH of STD 2.

III. MEASURE pH

① Rinse electrode(s). Blot excess.

② Immerse electrode(s) in sample. Stir briefly.

③ Press pH.

④ After ⊂⊃ stops flashing, display will read pH of sample.

FOR MORE DETAILED INSTRUCTIONS ON pH MEASUREMENT, SEE NEXT PAGE.

MEASURING mV AND RELATIVE mV (Φ11, Φ12)

MEASURING CONCENTRATION (Φ12)

INSTRUMENT FUNCTIONS AND FEATURES

ELECTRODES, BUFFERS, AND ACCESSORIES

BATTERY REPLACEMENT, SERVICE
AND TROUBLESHOOTING

SPECIFICATIONS

pH MEASUREMENT: DETAILED INSTRUCTIONS

METHODS: The pHI 10, 11, and 12 can measure pH from 0 to 15.99. They will perform one- or two-point standardization automatically, using any buffer listed below, at any temperature between −5°C and 100°C.

STANDARD pH BUFFERS RECOGNIZED BY THE pHI 10, 11, AND 12:

1.68, 4.00, 7.00, 10.01, 12.45.

TWO-POINT STANDARDIZATION METHOD:

Two-point standardization, the preferred and more accurate method of pH measurement, should be used when pH accuracy of beyond ± 0.1 pH is required. Use buffers as close to the sample pH as possible: one above, and one below. (For example, if sample pH is about 8.5, use 7.00 and 10.01 pH buffers).

ONE-POINT STANDARDIZATION METHOD:

One-point standardization, a somewhat faster procedure, is recommended only if (a), accuracy of ± 0.1 pH unit is acceptable, and (b), sample pH is within 1.5 pH of that of the buffer used for standardization.

pH MEASUREMENT PROCEDURE:

1. Connect electrode(s) to appropriate input(s):
   a. *If a combination electrode* is used, connect it to the input *marked "pH"*.
   b. If an *electrode pair* is used, connect the indicating electrode to the input marked "pH" and the reference electrode to the input marked "REF".
   c. For better accuracy, or when measuring and/or standardizing at a temperature of other than 25°C, connect a Beckman 598115 Automatic Temperature Compensator probe to input marked "ATC".
2. Press ⏻ to turn on instrument, then press C to clear. Display will show [Clr, AUTO].
3. Rinse electrode(s) (and ATC if used) with deionized water. Blot excess.
4. Immerse electrode(s) (and ATC if used) in first standard. Stir briefly with electrodes to remove bubbles from electrode surfaces. Press pH. Displayed pH value will have a resolution of 0.01. If 0.1 resolution is desired, press ½.
5. *Press* STD. When [⊂⊃] stops flashing, display will show [pH value locked, ⊂⊃, ▶ m].
6. Rinse electrode(s) (and ATC probe if used) with deionized water. Blot excess. Proceed to appropriate step, according to desired type of standardization:
   a. If ONE-POINT standardization is to be used, instrument is ready for sample measurement; proceed to Step 9.
   b. *If TWO-POINT standardization is desired, proceed to Step 7.*
7. Immerse electrode(s) (and ATC if used) in second standard. Stir briefly with electrodes to remove bubbles from electrode surfaces. Press STD. When [⊂⊃] stops flashing, display will show [pH value locked, ⊂⊃, ▶ m, ▶ m].
8. Rinse electrode(s), (and ATC probe if used) with deionized water. Blot excess.
9. Immerse electrode(s) (and ATC if used) in sample. Stir briefly with electrodes. Press pH. When [⊂⊃] stops flashing, display will show [pH value locked, ⊂⊃]. Measurement is now complete. Repeat Steps 8 and 9, above, for additional samples.
10. If continuous pH monitoring is desired, press auto to turn off Auto Read function.

MEASURING mV AND RELATIVE mV (Φ11, Φ12)

MEASURING CONCENTRATION (Φ12)

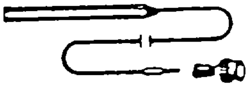
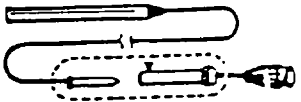
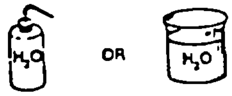
INSTRUMENT FUNCTIONS AND FEATURES

ELECTRODES, BUFFERS, AND ACCESSORIES

BATTERY REPLACEMENT, SERVICE
AND TROUBLESHOOTING

SPECIFICATIONS

FOR ACCURATE mV MEASUREMENTS WITH THE Φ11 OR Φ12, THE FOLLOWING ITEMS ARE RECOMMENDED:

1.		pH indicating electrode, Futura II. Futura II cable with BNC connector. NOTE: If combination pH electrode is used, omit separate reference electrode (item 2, below).
OR		
1a.		Metallic electrode with 2 mm pin connector + pin-to-BNC adaptor.
OR		
1b.		Ion-Selective electrode with BNC connector (or U.S. standard connector + U.S. standard-to-BNC adaptor).
2.		Reference electrode, Futura II. Cable with 2 mm pin connector, Futura II. NOTE: Omit reference electrode if combination pH electrode is used.
3.		Standard solution(s) appropriate to the application.
4.		Clean beaker(s) or equivalent container(s), 100–250 mL for containing standard solution(s).
5.		Squirt bottle or beaker containing deionized or distilled water for rinsing electrodes.
6.		Clean towels, "Kimwipes™", etc., for blotting electrodes.
7.		The sample to be measured.

For part numbers, see "Electrodes, Buffers, and Accessories."
For mV measurement procedures, see next page.

MEASURING mV AND RELATIVE mV (Φ11, Φ12)

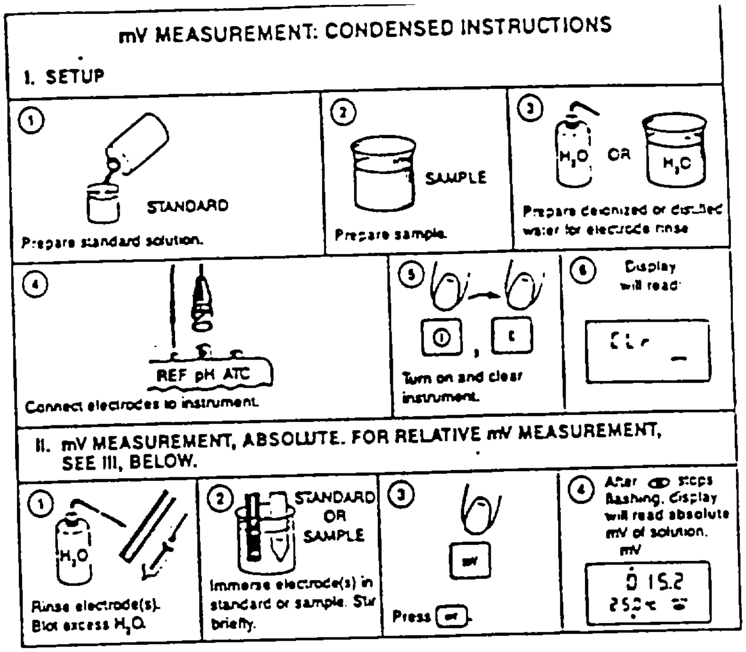
MEASURING CONCENTRATION (Φ12)

INSTRUMENT FUNCTIONS AND FEATURES

ELECTRODES, BUFFERS, AND ACCESSORIES

BATTERY REPLACEMENT, SERVICE
AND TROUBLESHOOTING

SPECIFICATIONS



mV MEASUREMENT: CONDENSED INSTRUCTIONS

I. SETUP

① Prepare standard solution.

② Prepare sample.

③ Prepare deionized or distilled water for electrode rinse

④ Connect electrodes to instrument.

⑤ Turn on and clear instrument.

⑥ Display will read:

II. mV MEASUREMENT, ABSOLUTE. FOR RELATIVE mV MEASUREMENT, SEE III, BELOW.

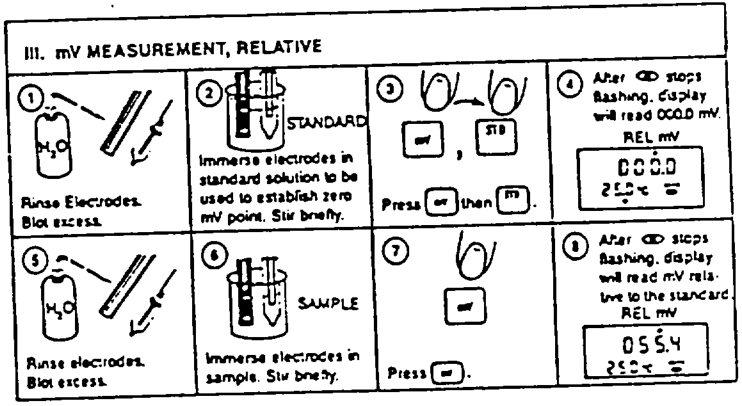
① Rinse electrode(s). Blot excess H_2O.

② Immerse electrode(s) in standard or sample. Stir briefly.

③ Press mV.

④ After ◐ stops flashing, display will read absolute mV of solution.

For RELATIVE mV Measurement, Proceed with following steps:



III. mV MEASUREMENT, RELATIVE

① Rinse Electrodes. Blot excess.

② Immerse electrodes in standard solution to be used to establish zero mV point. Stir briefly.

③ Press mV then STD.

④ After ◐ stops flashing, display will read 000.0 mV.

⑤ Rinse electrodes. Blot excess.

⑥ Immerse electrodes in sample. Stir briefly.

⑦ Press mV.

⑧ After ◐ stops flashing, display will read mV relative to the standard.

NOTE
INSTRUMENT WILL REMAIN IN RELATIVE mV MODE UNTIL EITHER [illegible], [illegible], OR [illegible] IS PRESSED.

FOR MORE DETAILED INSTRUCTIONS ON mV MEASUREMENT, PROCEED TO NEXT PAGE.

MEASURING CONCENTRATION (Φ12)

INSTRUMENT FUNCTIONS AND FEATURES

ELECTRODES, BUFFERS, AND ACCESSORIES

BATTERY REPLACEMENT, SERVICE
AND TROUBLESHOOTING

mV MEASUREMENT: DETAILED INSTRUCTIONS

mV MEASUREMENT: TYPICAL USES

Some uses of the mV mode are monitoring chemical reactions, quantifying ions, and determining the oxidizing-reducing potential (ORP) of a given sample. Because such measurements are usually not specific for a particular ion or species, readings must be interpreted carefully to obtain meaningful results. The user should have an understanding of the reaction that is occurring, or is desired, and of any sample components that could potentially interfere. For more detailed information, refer to the Beckman Handbook of Applied Electrochemistry (Beckman Bulletin 7739).

The mV mode may also be used with ion-selective electrodes. The relative mV mode can be used in the standard addition or standard subtraction method of ion analysis.

STANDARD SOLUTION(S)

Make up appropriate standard solution(s) to provide known voltage(s), depending on the reference electrode used and the temperature. For example, common standards used in redox measurements are pH 4 and pH 7 buffers saturated with quinhydrone.

mV MEASUREMENT PROCEDURE

1. Connect electrodes to appropriate inputs:
    a. Connect indicating electrode to input marked "pH". A Pin-to-BNC Adaptor may be required as most metallic electrodes have a pin connector.
    b. Connect reference electrode to input marked "REF".
2. Press ⏻ to turn on instrument, then press ▭ to clear. Display will show [Clr, AUTO].
3. Rinse electrodes with deionized water. Blot excess.
4. Immerse electrodes in desired solution. Press ▭. Displayed value is absolute mV, as indicated by display of [$^{mV}_{A}$]. When [⊂⊃] stops flashing, display will show [mV reading locked, ⊂⊃].

RELATIVE mV MEASUREMENT PROCEDURE

1. Perform Steps 1 through 3 of mV MEASUREMENT PROCEDURE, above.
2. Immerse electrodes in standard solution to be used to establish the zero mV point. Press ▭, then ▭. When [⊂⊃] stops flashing, display will read [000.0 mV]. Note that, in mV mode, pressing ▭ causes the instrument to establish the zero mV point at the value of the current reading. If desired, this step may be repeated at any time to re-establish the zero mV point.
3. Rinse electrodes with deionized water. Blot excess.
4. Immerse electrodes in sample. Press ▭. Displayed value is relative mV, as indicated by display of [$\mathrm{REL}_{A}\,mV$]. When [⊂⊃] stops flashing, display will show [sample relative mV value locked, ⊂⊃]. Absolute mV reading of the standard solution is automatically subtracted from the absolute mV reading of the sample, resulting in a relative mV reading for the sample.
5. If continuous readout of relative mV is desired, press ▭ to turn off Auto Read function.

NOTE

VOLTAGE DIFFERENCE BETWEEN STANDARD SOLUTION AND SAMPLE MUST NOT EXCEED 1000 mV. MAXIMUM DISPLAY RANGE IN mV MODE IS ± 999.9 mV.

NOTE

IN mV MODE, THE 598115 AUTOMATIC TEMPERATURE COMPENSATOR PROBE MAY BE USED FOR TEMPERATURE *MEASUREMENT* AND *DISPLAY*, BUT DOES NOT HAVE ANY *TEMPERATURE-COMPENSATING* EFFECT.

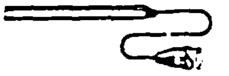
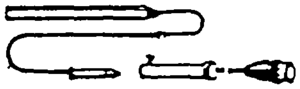
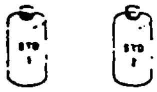
MEASURING CONCENTRATION (Φ12)

INSTRUMENT FUNCTIONS AND FEATURES

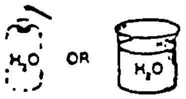
ELECTRODES, BUFFERS, AND ACCESSORIES

BATTERY REPLACEMENT, SERVICE
AND TROUBLESHOOTING

FOR ACCURATE CONCENTRATION MEASUREMENTS WITH THE Φ12, THE FOLLOWING ITEMS ARE RECOMMENDED:

1.		Ion-Selective electrode with BNC connector
OR		
1a.		Ion-Selective electrode with U.S. standard connector + U.S. standard-to-BNC adaptor.
2.		Reference electrode, Futura II. Futura II cable with 2 mm pin connector. NOTE: Depending on the application, a salt-bridge or double-junction electrode may be required.
3.		Two standard solutions of appropriate concentration, selected from the following values: 1.00, 2.50, 5.00, 10.00, 25.0, 50.0, 100.0, 250.0, 500, and 1000 units. Concentration can be expressed in any desired units such as ppm, mM, mg/L, and gr/gal. Make up these solutions per procedure or by diluting a stock solution to suit your requirements.

NOTE
CONCENTRATION UNITS FOR BOTH STANDARD SOLUTIONS MUST BE THE SAME AS DESIRED FOR SAMPLE READINGS.

4.		Two clean beakers or equivalent containers, approximately 100–250 mL, for containing the two standard solutions.
5.		Squirt bottle or beaker containing deionized or distilled water for rinsing electrodes.
6.		Clean towels, "Kimwipes"™, etc., for blotting electrodes.
7.		The sample to be measured.

For part numbers, see "Electrodes, Buffers, and Accessories."
For concentration measurement procedure, see next page.

MEASURING CONCENTRATION (Φ12)

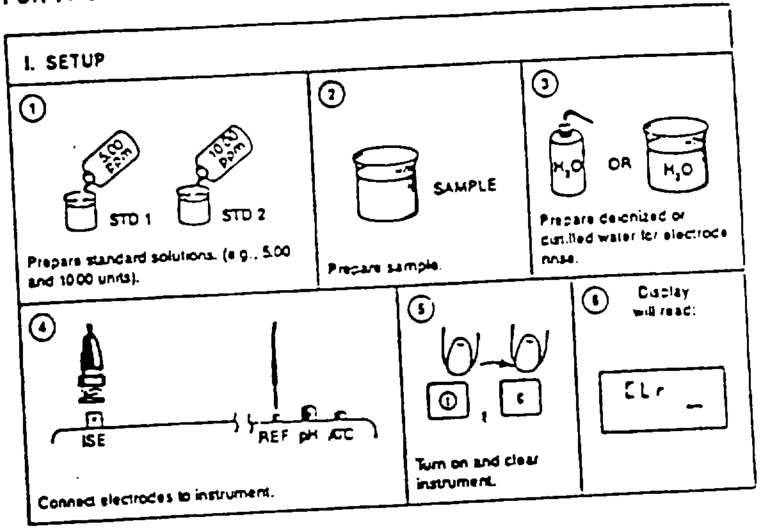
INSTRUMENT FUNCTIONS AND FEATURES

ELECTRODES, BUFFERS, AND ACCESSORIES

BATTERY REPLACEMENT, SERVICE AND TROUBLESHOOTING

FOR TWO-STANDARD OPERATION

I. SETUP



① Prepare standard solutions. (e.g., 5.00 and 10.00 units).

② Prepare sample.

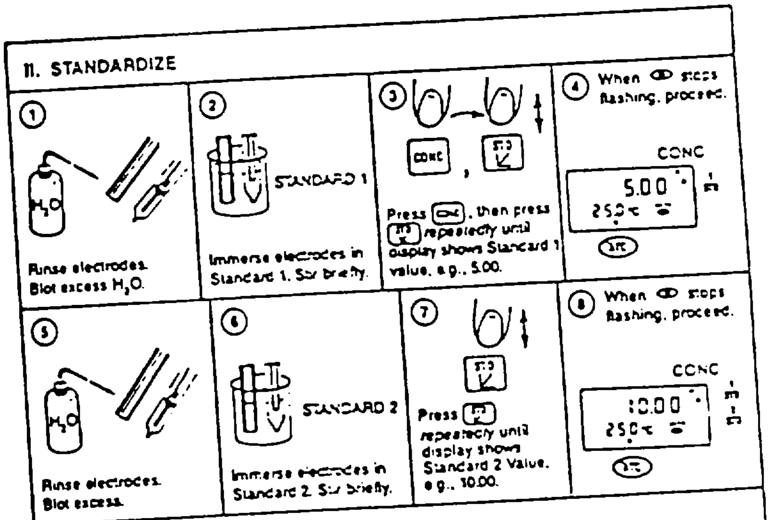
③ Prepare deionized or distilled water for electrode rinse.

④ Connect electrodes to instrument.

⑤ Turn on and clear instrument.

⑥ Display will read:

II. STANDARDIZE



① Rinse electrodes. Blot excess H_2O.

② Immerse electrodes in Standard 1. Stir briefly.

③ Press CONC, then press STD repeatedly until display shows Standard 1 value, e.g., 5.00.

④ When ⊂⊃ stops flashing, proceed.

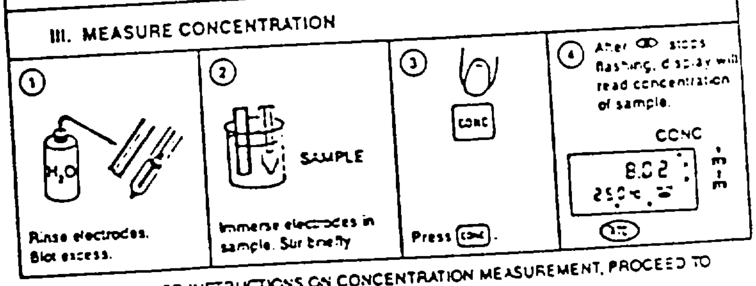
⑤ Rinse electrodes. Blot excess.

⑥ Immerse electrodes in Standard 2. Stir briefly.

⑦ Press STD repeatedly until display shows Standard 2 Value, e.g., 10.00.

⑧ When ⊂⊃ stops flashing, proceed.

III. MEASURE CONCENTRATION



① Rinse electrodes. Blot excess.

② Immerse electrodes in sample. Stir briefly.

③ Press CONC.

④ After ⊂⊃ stops flashing, display will read concentration of sample.

FOR MORE DETAILED INSTRUCTIONS ON CONCENTRATION MEASUREMENT, PROCEED TO NEXT PAGE.

INSTRUMENT FUNCTIONS AND FEATURES

ELECTRODES, BUFFERS, AND ACCESSORIES

The following procedure, utilizing two-point standardization, can be used to measure concentrations of ions in almost any desired units.

STANDARD SOLUTIONS:

Standards can be made from any type of solution, with concentrations selected from the following values: 1.00, 2.50, 5.00, 10.00, 25.0, 50.0, 100.0, 250.0, 500, and 1000 units.

Units of concentration may be any that the user finds convenient. CONCENTRATION UNITS FOR BOTH STANDARD SOLUTIONS MUST BE THE SAME AS DESIRED FOR SAMPLE READINGS.

Some examples of units are: parts per million, percent, moles per liter, parts per billion, milliequivalents per liter, and ounces per gallon.

Select two standard values as close as possible to the anticipated sample value, preferably with one standard value below and one standard value above the sample. For example, if sample solution is about 150 millimoles per liter (mM), make up standards of 100 mM and 250 mM. If sample concentration varies widely, for example, between 10 molal and 75 molal, make up standards of 10 molal and 100 molal.

Standards and samples should be at the same temperature to avoid temperature-dependent variations in readings.

NOTE

> Standard and sample solutions may require ionic strength adjustment or interfering ion removal. Consult electrode instructions for details.

CONCENTRATION MEASUREMENT PROCEDURE:

1. Connect electrodes to appropriate inputs:
    a. Connect ion-selective electrode to input marked "ISE".
    b. Connect reference electrode to input marked "REF".

NOTE

> If, in addition to the ion-selective electrode, a combination pH electrode is connected to the instrument AND is to be immersed in the same solution, DO NOT use a separate reference electrode.

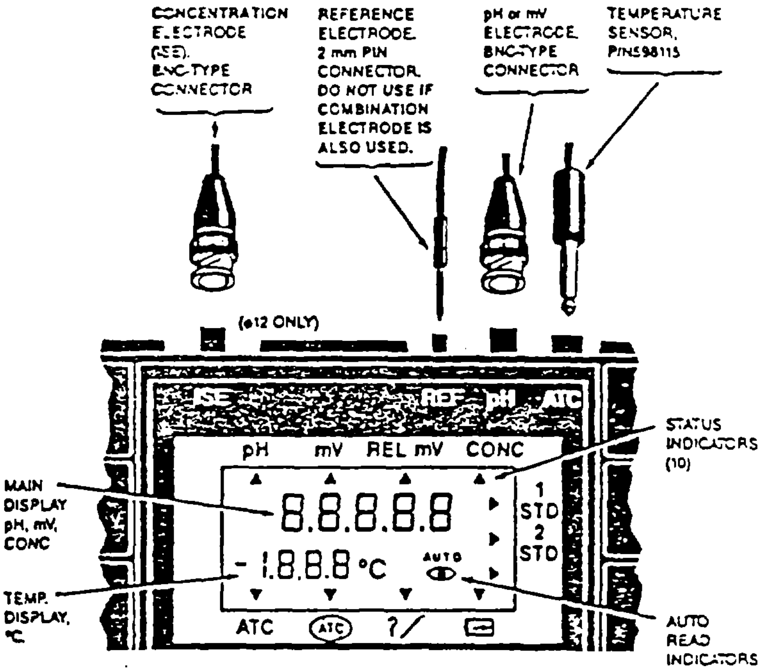
2. Press (⓪) to turn on instrument, then press (I) to clear. Display will show [Clr, AUTO].
3. Rinse electrodes with deionized water. Blot excess.
4. Immerse electrodes in first standard solution. Press (CONC), then press (↑) as many times as needed for the concentration value of the first standard to show on the display. When (↑) is pressed repeatedly, the display steps through the following values: 1.00, 2.50, 5.00, 10, 25, 50, 100, 250, 500, and 1000 concentration units. For example, if the concentration of the standard is 100 units, press (↑) seven times and the display will show [100]. When [ↀ] stops flashing, display will show [100 locked, ↀ , ▶ $\overset{1}{\text{m}}$].
5. Rinse electrodes with deionized water. Blot excess.
6. Immerse electrodes in second standard solution. The first and second standards must be different, but can be measured in any order. Press (↑) as many times as needed for the display to show the concentration value of the second standard, e.g., 250. When [ↀ] stops flashing, display will show [250 locked, ↀ , ▶ $\overset{2}{\text{m}}$].
7. Rinse electrodes with deionized water. Blot excess.
8. Immerse electrodes in sample. Press (CONC). When [ↀ] stops flashing, display will show [sample value locked, ↀ]. Measurement is now complete. Repeat Steps 7 and 8, above, for additional samples.
9. If continuous concentration readout is desired, press (AUTO) to turn off Auto Read function.

INSTRUMENT FUNCTIONS AND FEATURES

ELECTRODES, BUFFERS, AND ACCESSORIES

BATTERY REPLACEMENT SERVICE

ELECTRODE CONNECTIONS



DISPLAY FEATURES AND STATUS INDICATORS

DISPLAY

Main Display The large digits show the following:

1. Readout of the measured variable: pH, mV, or concentration.
2. [Clr] is displayed, indicating that instrument is cleared, when (c) is pressed.
3. Error message:

   [Er] indicates an excessive, potentially damaging, input voltage, typically caused by static electricity when the electrode pair is not in solution. In this case, immerse electrodes in solution, press (c), and proceed with measurement. If [Er] again appears, check connections and electrodes for possible open circuit.

Temperature Display (°C) The small digits display temperature in °C. Will read 25°C if ATC not plugged in.

AUTO AUTO READ ON/OFF Indicator for AUTO READ ON/OFF *Key*, described subsequently

◉ AUTO READ Status Indicator (eye symbol). Functions during standardization and when instrument [illegible] TO mode. During standardization, the eye symbol starts flashing when [illegible] is pressed, and locks on when the reading has stabilized. During sample *measurement in AUTO mode*, the eye symbol starts flashing when a mode key is pressed, and locks on when the reading has stabilized. The reading remains locked until a mode key is pressed. If an interval of approximately 30 minutes elapses without a key being pressed, the instrument turns off automatically to conserve the batteries, but retains all standardization data in memory

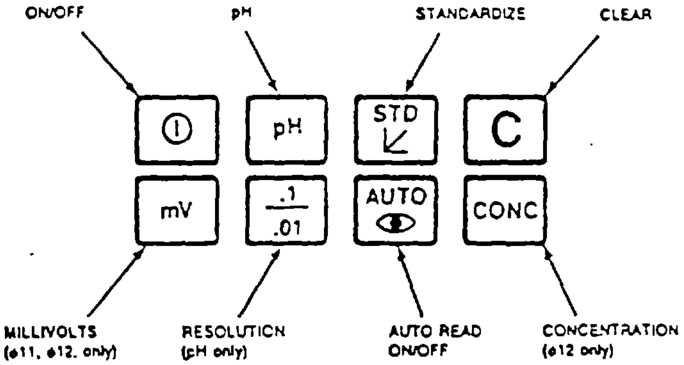
STATUS INDICATORS

▼ ATC	Indicates that ATC is plugged in. The instrument measures and displays temperature within the range of -5°C and 100°C. Display of [Er] indicates that the temperature sensed is outside the measurement range, or the ATC is nonfunctional.	
▼ (ATC)	Indicates that ATC is *not* plugged in. The temperature reading defaults to 25°C	
pH ▲	Indicates that instrument is in pH mode.	
mV ▲	Indicates that instrument is in mV mode.	*Φ11 and Φ12 only*
REL mV ▲	Indicates that instrument is in relative mV mode.	
CONC ▲	Indicates that instrument is in concentration mode. Φ12 only	
▶ 1 STD	Indicates that one standard has been used to standardize for the selected measurement mode (pH or CONC).	
▶ 2 STD	Indicates that two standards have been used to standardize for the selected measurement mode (pH or CONC).	
▼ ?/	Indicates a questionable electrode and/or standardization.	
▼ ▭	Indicates that batteries should be replaced.	

INSTRUMENT FUNCTIONS AND FEATURES

ELECTRODES, BUFFERS, AND ACCESSORIES

KEYPAD



KEYPAD FUNCTIONS

KEY	
①	Instrument ON/OFF Key. When OFF, the instrument retains the standardization data in memory Instrument shuts off automatically after 30 minutes of inactivity if AUTO READ is ON. (See below)
C	Clear Key. Clears instrument, resetting all standardization data to default values, and returning Instrument to AUTO Mode.
AUTO 👁	Auto Read Key. Turns Auto Read function ON and OFF: 1. When Auto Read is ON: a. The word [AUTO] appears on the display b. The instrument tests the electrode signal for stability. During this test, [👁] flashes ON and OFF. When the signal has met the stability requirement (see SPECIFICATIONS), [👁] remains on continuously, and the digital display locks onto the reading. No further measurements are made until a key is pressed. c. After 30 minutes without keypad input, the instrument turns off automatically but retains all standardization data. 2. When Auto Read is OFF. a. [AUTO] disappears from display b. The instrument continuously measures and displays in the selected mode: pH, mV, or CONC. c. After 1 to 2 hours without keypad input, the instrument turns off automatically but retains all standardization data.
.1/.01	pH Resolution Selection Key. Changes resolution of the displayed pH reading from 0.01 to 0.1 pH unit, or vice versa. At the lower resolution (0.1), time required for the Auto Read to lock is shorter. (See SPECIFICATIONS).
pH	Selects the pH measurement mode.
mV	Selects the mV mode (pHI 11, pHI 12), for measurement of either absolute or relative millivolts. See MEASURING mV AND RELATIVE mV.
CONC	Selects the concentration measurement mode (pHI 12). Used with specific ion electrodes
STD ↙	Standardize Key. Standardizes instrument. Depends upon mode. a. pH Mode. [STD ↙] Key causes the instrument to automatically identify the pH value of the buffer from any one of the following: 1.68, 4.00, 7.00, 10.01, and 12.45. b. mV Mode (pHI 11, pHI 12): [STD ↙] Key causes the instrument to establish the zero-millivolt level at the value of the current reading. Instrument is now in Relative mV mode c. CONC Mode (pHI 12): Repeated pressing of [STD ↙] Key causes the instrument to step through the following sequence of values: 1.00, 2.50, 5.00, 10, 25, 50, 100, 250, 500, and 1000 concentration units.

COMBINATION ELECTRODES:

	Standard 5" x 1/2"	Probe 8-12" x 3/8"	Test-Tube 8-9" x 5-6mm
Glass Body Ag/AgCl, Refillable	39520	39521	39522
Glass Body Calomel, Refillable	39527	39528	39525, 39526 (7")
Epoxy Body Calomel, Refillable	39838	—	39839
Epoxy Body Ag/AgCl, Refillable	39831	39533	39835
Epoxy Body Ag/AgCl, Gel Filled	39836	39832	39834
Epoxy Body, Star Ag/AgCl Refillable	39837		
Glass Body, Star Ag/AgCl Refillable	39524		
Flat Bulb, Epoxy Body	39523		

ELECTRODE PAIRS:

pH INDICATING ELECTRODES:		METALLIC ELECTRODES	
0-14 pH, Spherical Bulb	39314	Silver Billet	39251
0-11 pH, Dome Bulb (Durable)	39318	Platinum Inlay	39273

REFERENCE ELECTRODES:

Calomel Half Cell, Quartz Fiber Junction	39416
Calomel Half Cell, Ceramic Frit Junction	39417
Ag/AgCl Half Cell, Quartz Fiber Junction	39418
Calomel Half Cell, Sleeve Double Junction	39419
Calomel Half Cell, Inverted Sleeve Junction	39420
Ag/AgCl Half Cell, Inverted Sleeve Junction	39421

2. FUTURA II KEEPER CABLES

COMBINATION AND INDICATING ELECTRODE CABLES			REFERENCE ELECTRODE KEEPER CABLES		
1m,	BNC Connector	597578	1m,	2mm Pin Connector	598982
2m,	BNC Connector	597579	2m,	2mm Pin Connector	598983
6m,	BNC Connector	597580	6m,	2mm Pin Connector	598984

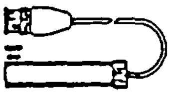
3. SALT BRIDGE: 563853

4. SUBMERSIBLE COMBINATION pH ELECTRODE WITH ATC: 39530

5. AUTOMATIC TEMPERATURE COMPENSATOR, 598115:

Permits temperature measurement and display, and temperature compensation of pH and ion-selective electrodes, within range of -5°C to 100°C. Epoxy body. For use with standard 5-inch (13-cm) electrodes. Includes 39" (1 meter) cable with miniature phone jack.

6. ELECTRODE ADAPTORS:



592362 Standard to BNC Adaptor

Adapts Glass Electrode (GE) BNC terminal on pHI Series pH Meters to accommodate electrodes with U.S. Standard Connectors.

592367 PIN to BNC Adaptor

Adapts Glass Electrode (GE) BNC terminal on pHI Series pH Meters to accommodate electrodes with PIN Connectors.

Typically used to connect metallic electrodes.

7. BUFFERS

	6 Pack of Pints	1 Gallon	5 Gallons	Powder (Colorless)
pH 4 Buffer (red)	582517	566001	582522	3005
pH 7 Buffer (green)	582521	566003	582523	3007
ph 10 Buffer (blue)	582525	566005	582524	3019
pH 12.45				3010

8. FILLING SOLUTIONS

Description	Quantity	Part No
Combination Electrode Filling Solution or Ag/AgCl Reference Electrode Filling Solution (4M KCl/AgCl saturated: to be used with Ag/AgCl internals)	4-pack of 100 mL bottles	566467
Reference Electrode Filling Solution (saturated KCl to be used with Calomel internals)	4-pack of 100 mL bottles	566468
Electrode Soaking Solution	4-pack of 100 mL bottles	566576
Salt Bridge Solution, Contains Sodium Nitrate and Sodium Acetate	4-pack of 100 mL bottles	566469
Filling Solution, 1M, KCl Saturated with AgCl (Star-Series electrodes only)	4-pack of 100 mL	598943

9. pHI START-UP KIT:

	Part No.
39831 Electrode, Cable, Thermocompensator, Sample Buffers, Filling solution	123135

10. pHI STAND LAB ORGANIZER 123136

11. pHI DELUXE FIELD CASE 123129

12. pHI SOFT CASE 123127

13. pHI MOUNT, WALL/SHELF BRACKET 559190

FOR PRICE AND DELIVERY INFORMATION, CALL 1-800-742-2345.

Your Φ10, 11, or 12 is powered by two 3.6 volt lithium batteries. Expected battery life is over 1,000 hours of continuous operation. Replacement batteries can be obtained by ordering Part No. 945754 from your local Beckman office. (In U.S. call 1-800-742-2345).

945574

Acceptable replacement batteries are also available on a world-wide basis:

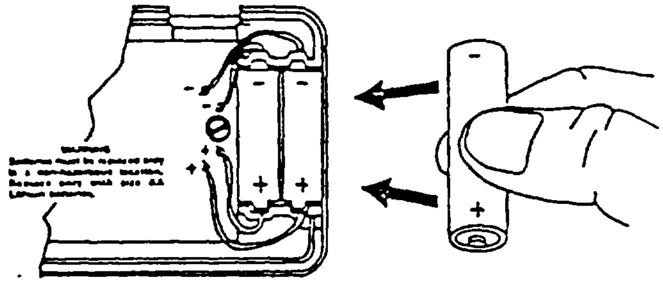
Mfr	Part No.
Electrochem Industries	3B940-TC
Power Conversion Inc.	TC6-41
Saft Advanced Battery Div.	LS6
Tadiran	TL-2100 AA/S

Local suppliers may be found in your telephone directory.

> Note that these batteries are 3.6 volt lithium cells. Do not attempt to replace them with 1.5 volt alkaline or carbon-zinc cells.

If instrument display indicates low battery voltage ⟨▼▭⟩ or if display is blank when instrument is turned on, batteries should be replaced:

1. Remove 2 Phillips screws and bottom cover from instrument.
2. Lift out old batteries.
3. Note (+) and (−) markings in battery compartment.
4. Check (+) and (−) markings on batteries and insert as shown:



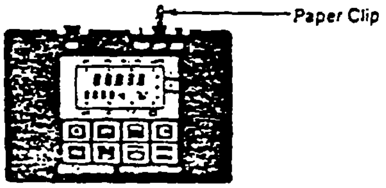
5. Replace back cover and screws.

> IMPORTANT: A "BREAK-IN" PERIOD OF UP TO 30 MINUTES IS REQUIRED WHEN SOME NEW LITHIUM BATTERIES ARE FIRST PLACED INTO SERVICE. DURING THIS PERIOD, THE LOW BATTERY SYMBOL AND SOME "GHOSTING" MAY APPEAR ON THE DISPLAY. IF SO, LEAVE INSTRUMENT ON FOR 20–30 MINUTES AND THEN PRESS [c]. THE LOW BATTERY SYMBOL AND "GHOSTING" SHOULD DISAPPEAR.

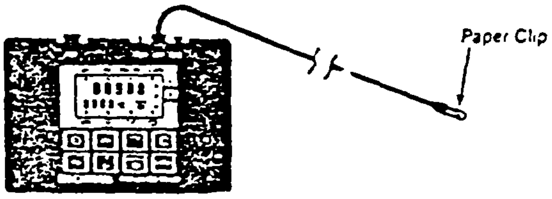
TROUBLESHOOTING PROCEDURE

1. Disconnect electrode cable(s) from instrument. Press [⓪] to turn on instrument, then press [c] to clear. Display should show [Clr, AUTO]. If not, replace batteries per BATTERY REPLACEMENT, above. *If instrument is still inoperative, call Service Hot Line: 1-800-662-6217.*

2. Insert one end of a paper clip into the small hole in the center of the "pH" input connector. Hold the other end of the clip to the inside barrel of the same connector as shown.



3. Press [▭], then [▭]. The display should lock at pH 7.00, indicating a one-point standardization.
   a. *If instrument passes test, go to Step 4.*
   b. If instrument fails test, call Service Hot Line: 1-800-662-6217.
4. Reconnect pH electrode cable to "pH" input connector. Short the input connector of the cable.



Press [▭] and then [▭]. Display should lock at pH 7.00. *Press* [▭], *then remove paper clip.* Reading should drift.
   a. If instrument passes test, go to Step 5.
   b. If instrument fails test, call Beckman Electrochemistry Applications:
      1-800-854-8067 Outside California
      714-871-4848 Within California
5. Reconnect pH electrode(s). Immerse electrode(s) in pH 4 buffer and perform one-point standardization. Then immerse electrode(s) in pH 10 buffer and take pH reading. At 25°C, the reading should be between 9.7 and 10.1 pH.
   a. If the test is passed, the pH meter, cable, and electrode(s) are functioning properly.
   b. If test is failed, the pH electrode(s) must be rejuvenated or replaced. The electrode rejuvenation

INSTRUMENT BECKMAN PART NO.	pHI 10 123132	pHI 11 123133	pHI 12 123134
pH MEASUREMENT			
Range	0 to 15.99 pH	0 to 15.99 pH	0 to 15.99 pH
Resolution (Selectable)	0.01, 0.1 pH unit	0.01, 0.1 pH unit	0.01, 0.1 pH unit
Relative Accuracy	± 0.01 pH	± 0.01 pH	± 0.01 pH
Auto Read Mode	0.1 pH Resolution: Display locks after reading is stable within 1.0 mV for 4 seconds. 0.01 pH Resolution: Display locks after reading is stable within 0.5 mV for 8 seconds.		
Buffers Recognized by Instrument: 1.68, 4.00, 7.00, 10.01, 12.45 pH.			
MILLIVOLT MEASUREMENT			
Range	—	−999.9 to + 999.9 mV	−999.9 to + 999.9 mV
Resolution	—	0.1 mV	0.1 mV
Accuracy	—	± 0.2 mV ± 0.02% of reading, relative mV	± 0.2 mV ± 0.02% of reading, relative mV
Auto Read Mode	—	Display locks after reading is stable within 0.5 mV for 8 seconds.	
CONCENTRATION MEASUREMENT			
mV Accuracy	—	—	± 0.1 mV
Auto Read Mode	—	—	Display locks after reading is stable within 0.25 mV for 8 seconds.
Useable Standard Values	—	—	Two values, in any desired units, selected from the following: 1.0, 2.5, 5.0, 10, 25, 50, 100, 250, 500, and 1000.

TEMPERATURE MEASUREMENT (ALL MODELS)

Range: −5°C to 100°C
Resolution: 0.1°C
Accuracy (with Beckman 598115 Probe): ± 0.5°C

MISCELLANEOUS (ALL MODELS)

Input Connections:
1. BNC input for pH, mV, and concentration.
2. 2-mm pin connector for reference electrode.
3. Miniature phone jack for Beckman 598115 Automatic Temperature Compensator

Operating Temperature: 15°C to 40°C, ambient, non-condensing.
Power Source: Two lithium cells, 3.5 volts each, AA Size.

Error Indications:
1. Input overvoltage (all modes)
2. Temperature compensation non-functional
3. Low batteries
4. Questionable electrode/standardization.

Size: 5.2 inches x 3.9 inches x 1.3 inches.

Beckman Inc
National
1 West Poplar Ave
ile, CA 93257

APPENDIX C-2

FIELD MEASUREMENT OF SPECIFIC CONDUCTANCE AND TEMPERATURE

CONDUCTIVITY
(YSI METER)

Scope and Application: This method is applicable to surface water, wastewater and groundwater.

Method: Specific Conductance (Electrical Conductivity), umhos/cm @ 25*C

Reference: EPA 1983, Method 120.1

Detection Limit: 10 umhos/cm @ 25*C

Sample Handling: Determine on-site

Reagents and Apparatus:

1. Conductivity meter, YSI Model 33SCT
2. Deionized Water
3. Conductivity standards, 1,000 and 10,000 umhos/cm @ 25*C standards (commercially available).

Notes:

1. All conductivity readings must be corrected to 25*C.

Procedure:

1. All glassware is to be soap and water washed, tap rinsed and deionized rinsed prior to analysis.

2. With mode switch of the meter in the OFF position. Check the zero setting. If not at zero, use meter adjusting screw to zero (on front of the meter).

3. Plug probe into jack located on side of meter.

4. Turn mode switch to red line and turn red line knob until needle aligns with red line on dial. Change the batteries if meter cannot be aligned.

5. Analyze both of the conductivity standards. If the results are within the specified control ranges (90-110%), analyze the samples. A standard should be analyzed after every 10 samples and at the end of the analytical run. Table 1 lists non-temperature compensated values for both of the standards. Use this table as a reference when a calculator is not available to perform temperature correction on the standards.

6. Totally immerse and suspend the probe in the water sample. Do not allow probe to touch the sides of the sample container. Allow the probe to equilibrate before proceeding to the next step.

7. While gently agitating the probe, take the sample temperature (*C) to the nearest 0.5*C and record.

8. Turn mode switch to the appropriate conductivity scale (X100, X10, or X1). Use the scale that produces a mid-range output on the meter.

9. Wait for needle to stabilize (about 15 seconds) and record conductivity. Multiply the conductivity reading by the scale setting.

10. Rinse probe with deionized water.

11. *Record specific conductivity and temperature.*

12. Store probe in DI water between uses whenever possible.

13. Turn mode switch to the off position when finished.

Quality Control:

1. Both quality control calibration standards are to be analyzed, initially and after every 10 samples. If less than 10 samples are analyzed, the calibration standards are still required. The last sample analyzed in the run is to be a calibration standard. These standards must be within acceptable ranges or the samples run after the last acceptable check standard are to be reanalyzed. Record the calibration standards in the quality control book. The confidence limits are noted in the quality control book.

2. Duplicate a minimum of 1 out of 10 samples. If less than 10 samples are analyzed, a duplicate is still required. Duplicate values are to be within acceptable ranges.

Calculations:

1. Calculate specific conductivity at 25*C using following formula:

$$G_{25} = \frac{G_T}{[1 + 0.02\ (T-25)]}$$

G_{25} = Specific conductivity at 25*C, umhos/cm

T = Temperature of sample, *C

G_T = Conductivity of sample at temperature T, umhos/cm

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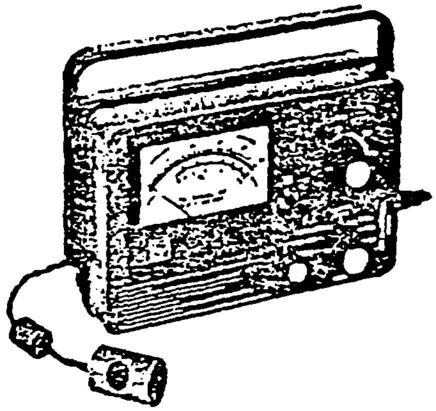
Revised Date
09-06-86
04-27-87
02-17-88

TABLE 1

NON-TEMPERATURE COMPENSATED CONDUCTIVITY STANDARD READINGS FOR 1,000 AND 10,000 mm hos/cm STANDARDS

Conductivity Standard 1000 umhos/cm			Conductivity Standard 10,000 umhos/cm		
Conductivity Standard Should Read	at	Degrees C*	Conductivity Standard Should Read	at	Degrees C*
500		0	5000		0
520		1	5200		1
540		2	5400		2
560		3	5600		3
580		4	5800		4
600		5	6000		5
620		6	6200		6
640		7	6400		7
660		8	6600		8
680		9	6800		9
700		10	7000		10
720		11	7200		11
740		12	7400		12
760		13	7600		13
780		14	7800		14
800		15	8000		15
820		16	8200		16
840		17	8400		17
860		18	8600		18
880		19	8800		19
900		20	9000		20
920		21	9200		21
940		22	9400		22
960		23	9600		23
980		24	9800		24
1000		25	10,000		25
1020		26	10,200		26
1040		27	10,400		27
1060		28	10,600		28
1080		29	10,800		29
1100		30	11,000		30
1120		31	11,200		31
1140		32	11,400		32
1160		33	11,600		33
1180		34	11,800		34
1200		35	12,000		35

YSI MODELS 33 AND 33M S-C-T METERS INSTRUCTIONS



GENERAL DESCRIPTION

The YSI Model 33 and 33M S-C-T Meters are portable, battery powered, transistorized instruments designed to accurately measure salinity, conductivity and temperature. They use a probe consisting of a rugged, plastic conductivity cell and a precision YSI thermistor temperature sensor combined in a single unit.

Conductivity with the Model 33 is expressed as micromhos/centimeter; with the 33M, it is millisiemens/meter (mS/m). These are measurements of the electrical conductance the sample would show if measured between opposite faces of a 1 cm cube. (Conversion information: 1 micromho/cm = 0.1 mS/m.) Salinity is the number of grams of salt/kilogram of sample (ppt = parts per thousand). This measurement assumes the sample contains a "standard" sea water salt mixture. The sample temperature is measured in degrees Celsius.

Salinity measurements are manually temperature compensated by direct dial. Conductivity measurements are not temperature compensated; however, a temperature function is provided on the instrument to aid with calculation of corrections. When temperature and conductivity are known, it is possible to calculate salinity; and when only temperature and salinity are known, it is possible to calculate conductivity. This is discussed in the secion on Recalibration.

SPECIFICATIONS

Model 33 Conductivity

Ranges: 0 to 500 (x1), 0 to 5,000 (x10), and 0 to 50,000 micromho-/cm (x100) with YSI 3300 Series Probes. (Note: The "micromho" designations on the meter are a shorthand form for "micromho/cm".)

Accuracy: (See Error Section)
±2.5% max. error at 500, 5,000 and 50,000 plus probe.
±3.0% max. error at 250, 2,500 and 25,000 plus probe.

Readability:
2.5 micromhos/cm on 500 micromho/cm range.
25 micromhos/cm on 5,000 micromho/cm range.
250 micromhos/cm on 50,000 micromho/cm range.

Temperature Compensation: None.

Model 33M Conductivity

Ranges:
0 to 50 (x1), 0 to 500 (x10), and 0 to 5,000 (x100) mS/m with YSI 3300 Series Probes.

Accuracy: (See Error Section)
±2.5% max. error at 50, 500, and 5,000 plus probe.
±3.0% max. error at 25, 250, and 2,500 plus probe.

Readability:
0.25 mS/m on 50 mS/m range.
2.5 mS/m on 500 mS/m range.
25.0 mS/m on 5,000 mS/m range.

Temperature Compensation: None.

Salinity

Range: 0-40 ppt in temperature range of -2 to +45°C, within specified conductivity range of 0 to 50,000 micromho/cm (0 to 5.000 mS/m). See chart in section on Recalibration.

Accuracy (See Error Section)
Above 4°C: ±0.9 ppt at 40 ppt and ±0.7 ppt at 20 ppt plus conductivity probe.

Below 4°C: ±1.1 ppt at 40 ppt and ±0.9 ppt at 20 ppt plus conductivity probe.

Readability: 0.2 ppt on 0-40 ppt range.

Temperature Compensation: Manual by direct dial from -2 to +45°C.

Temperature Range: -2 to +50°C.

Accuracy: ±0.1°C at -2°C, ±0.6°C at 45°C plus probe (See Error Section)

Readability: ±0.15°C at -2°C to ±0.37°C at 45°C.

Power Supply: Two D-size alkaline batteries, Eveready E95 or equivalent, provide approximately 200 hours of operation.

Instrument Ambient Range: -5 to +45°C. A maximum error of ±0.1% of the reading per °C change in instrument temperature can occur. This error is negligible if the instrument is readjusted to redline for each reading.

YSI Scientific
Yellow Springs, Ohio 45387 USA • Phone 513 767-7241 • 800 343-HELP

Salinity Error

The salinity readings are a function of temperature and conductivity, therefore the accuracy is a function of both.

The temperature scale and temperature control have been designed to minimize the temperature error contribution to the salinity error. The error shown in Figure 3 is the total of the temperature and conductivity probe, the temperature scale and the salinity scale error.

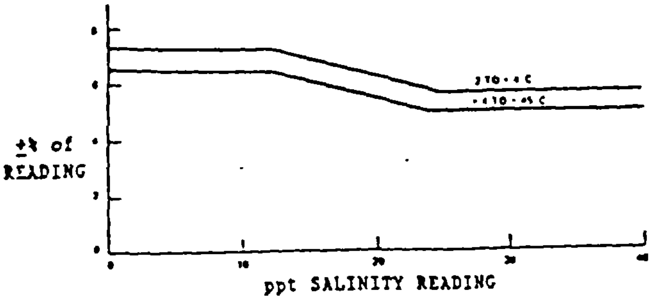


FIGURE 3

Example
Meter Reading: 10 ppt, @ 10°C
% of Reading Error: 6.5%
Accuracy: 10 ppt ±0.65 ppt for all errors, combined worst case.

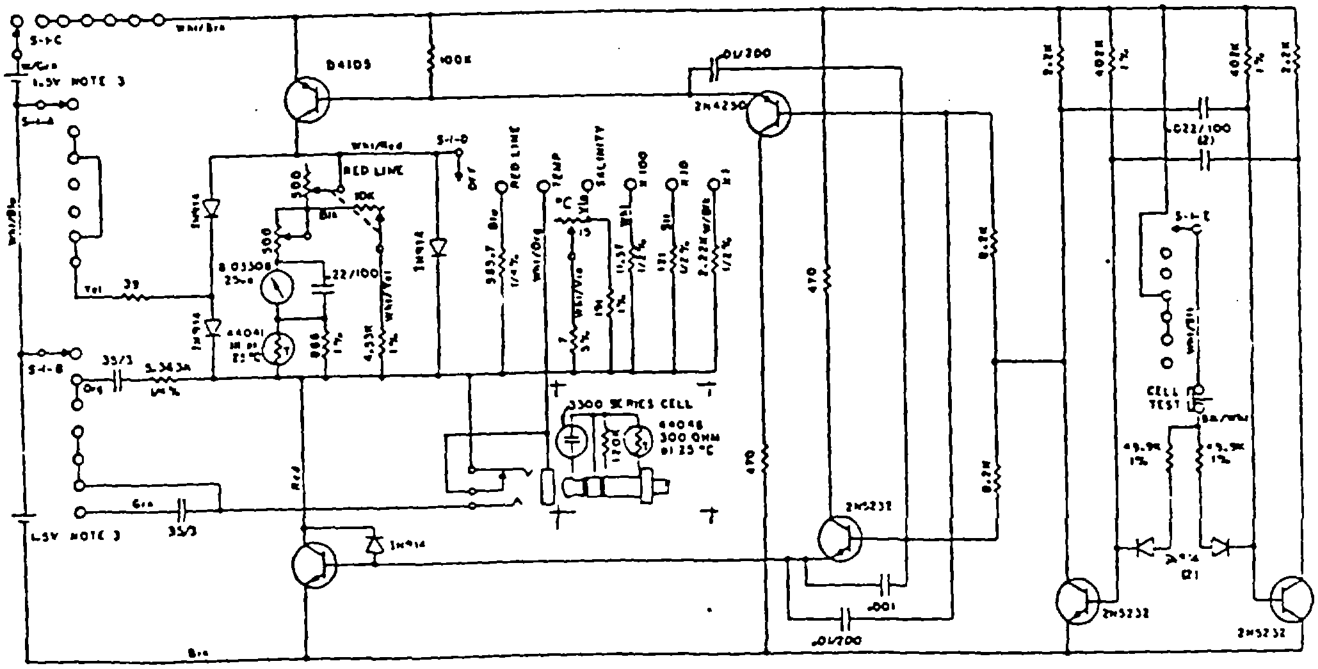
CIRCUIT DESCRIPTION

The circuit is composed of two parts; a multivibrator and switching transistors. The multivibrator produces a square waveform voltage. The square wave is applied to two switching transistors. They alternately apply two batteries of opposite polarity to the probe thus providing AC power which minimizes polarization effects. The meter is in series with one battery and measures the current from it. The current from the battery is proportional to the conductance of the cell. Salinity is measured in a special range conductivity circuit which includes a user-adjusted temperature compensator. In the temperature, redline and X1 positions, the multivibrator operates at 100Hz. In the salinity, X100 and X10 positions the multivibrator operates at 600Hz; in these ranges, pushing the CELL TEST button drops the frequency to 100Hz, allowing the operator to test for probe polarization.

INSTRUMENT MAINTENANCE

The only maintenance required is battery replacement. Two "D" size alkaline flashlight cells, such as Eveready E95 or equivalent, will provide 200 hrs. of operation. Accuracy will not be maintained if zinc-carbon "D" cells are used. Battery replacement is indicated when the redline adjustment cannot be accomplished.

Replace batteries every six months to reduce the danger of corrosion due to leaky batteries. To replace batteries, remove the screws from the rear cover. The battery holders are color coded. The positive end must go on red.



NOTES:
Resistance values in ohms. K = 1,000. Resistors are 1/2 W, 10%, unless otherwise specified.

Battery is D size, alkaline only. Eveready E-95 or equivalent.

This schematic is representative and may be slightly different from the circuit in your instrument.

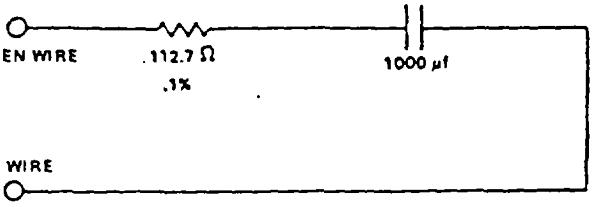
YSI MODEL 33 AND 33M SCHEMATIC

2. You may use the resistor and capacitor hookup shown in the sketch to substitute for the probe in the following recalibration procedure.

a. Set the instrument for a salinity measurement as normal.

b. Substitute a 1000 microfarad capacitor and 112.7 ohm 0.1% tolerance resistor for the probe.

Connect the resistor and capacitor between the green wire and red wire on the jack connections inside the instrument.



c. Turn the temperature dial until the meter reads redline.

d. Reinstall the temperature knob with the arrow at 25°C.

This is a temporary calibration only. Return the instrument to the factory for proper recalibration.

YSI 3300 SERIES CONDUCTIVITY/TEMPERATURE PROBES

Description

These probes are designed and constructed for rugged, accurate service in field use. The conductivity cell constant is 5.0/cm (500.0/m) ±2%. Each probe contains a precision YSI thermistor temperature sensor of ±0.1°C accuracy at 0°C and ±0.3°C at 40°C. The low capacitance cable assembly terminates in a three terminal 0.25" dia. phone plug.

The 3310 has a 10 foot cable and the 3311 a 50 foot cable. Other lengths are available on special order.

The probe has a rigid P.V.C. body, platinized pure nickel electrodes, and a rugged cable.

Cleaning and Storage

Cleaning

When the cell test indicates low readings the probable cause is dirty electrodes. Hard water deposits, oils and organic matter are the most likely contaminants.

For convenient normal cleaning soak the electrodes for 5 minutes with a locally available bathroom tile cleaning preparation such as Dow Chemical "Bathroom and Chrome Cleaner," Johnson Wax "Envy, Instant Cleaner," or Lysol Brand "Basin, Tub, Tile Cleaner."

For stronger cleaning a 5 minute soak in a solution made of 10 parts distilled water, 10 parts isopropyl alchol and 1 part HCl can be used.

Always rinse the probe thoroughly in tap water, then in distilled or deionized water after cleaning and before storage.

CAUTION: Do not touch the electrodes inside the probe. Platinum black is soft and can be scraped off.

If cleaning does not restore the probe performance, replatinizing is required.

Storage

It is best to store conductivity cells in deionized water. Cells stored in water require less frequent platinization. Any cell that has been stored dry should be soaked in deionized water for 24 hours before use.

Replatinization

1. Clean the probe.

2. Place the cell in a 50 ml (approximate) jar or beaker and add enough YSI 3140 Platinizing Solution to cover the electrodes. Do not cover the top of the probe.

3. Plug the probe into the Model 33 or 33M, switch to the X100 scale to platinize the electrodes. Move the probe slightly to obtain the highest meter reading and continue platinizing for the approximate time shown below:

Meter Reading		Time in
micromhos/cm	mS/m	minutes
30,000	3,000	5
25,000	2,500	6
20,000	2,000	8
15,000	1,500	11
10,000	1,000	16

4. After the elapsed time, remove the probe and rinse in tap water, then in distilled or deionized water.

5. Return the solution to its container. 2 oz. of solution should be sufficient for 50 treatments.

Probe Use and Precautions

1. Obstructions near the probe can disturb readings. At least two inches of clearance must be allowed from non-metallic underwater objects. Metallic objects such as piers or weights should be kept at least 6 inches from the probe.

2. Weights are attached to the cable of the YSI 3310 and 3311 Probes. The YSI 3327 Weights are supplied in pairs with a total weight of 4 ounces per pair. Should it become necessary to add more weight to overcome water currents, we suggest limiting the total weight to two pounds (8 pairs). For weights in excess of two pounds use an independent suspension cable. In either case, weights must be kept at least 6 inches away from the probe.

3. Gentle agitation by raising and lowering the probe several times during a measurement insures flow of specimen solution through the probe and improves the time response of the temperature sensor.

Conductivity and Salinity Corrections for Long Cables

The additional length of wire in long cables adds capacitance and resistance which will effect readings. The recommended way to correct for these influences is by use of YSI Conductivity Calibrator Solutions (see *below), which will permit an estimate of correction* factors. If these solutions are not available, the following tables can be used for the correction of errors caused by cable resistance and capacitance on special length versions of the 3310, 3311, S-17933 and S-16120 probes.

APPENDIX D

INTERNAL CHAIN-OF-CUSTODY PROCEDURES

APPENDIX D-1

WARZYN CHAIN-OF-CUSTODY PROCEDURES

CHAIN-OF-CUSTODY
Superfund Level

Scope and Application: Chain-of-custody procedures are used to maintain and document sample possession. This particular procedure is applicable when full chain-of-custody procedures are required for enforcement driven investigations.

Reference: NEIC Policies and Procedures, May, 1978 (Revised March, 1986).
EPA-330/9-78-001-R.
U.S. EPA Central Regional Laboratory (10/15/82).

Procedure: Due to the legal nature of enforcement driven investigations, possession of samples must be traceable from the time the samples are collected until introduced as evidence in legal proceedings or destroyed. To maintain and document sample possession, strict chain-of-custody procedures are followed.

A sample is under your custody if:

1) it is in your possession, or
2) it is in your view, after being in your possession, or
3) it was in your possession and you locked it up, or
4) it is in a designated secure area.

Field Custody:

1. As few people as possible should handle samples.
2. The field sampler is personally responsible for the care and custody of the samples collected until they are properly transferred or dispatched to the appropriate laboratory.
3. Sample tags and labels shall be completed for each sample, using water proof ink (unless prohibited by weather conditions). For example: a log book notation would explain that a pencil was used to fill out the sample tag/label because a ball point pen would not function in freezing weather.
4. The field project coordinator determines whether proper custody procedures were followed during the field work and decides if additional samples are required.

Transfer of Custody and Shipment

1. Samples will be packaged properly for shipment and dispatched to the appropriate laboratory for analysis, with a separate custody record accompanying each shipment. The method of shipment, courier name, and other pertinent information is entered in the "Remarks" (#14) section of the custody record (see Figure 3). Shipping containers are "sealed" with numbered chain-of-custody seals. The seal numbers are also noted in the "Remarks" section of the custody record.

2. Samples are accompanied by a chain-of-custody record (see Figure 3). When transferring the possession of samples, field personnel will complete the information required for #1 through #11 on the chain-of-custody. Any remarks pertaining to shipping are included in #14. This information is required prior to the field personnel relinquishing custody of the samples. This record documents sample custody transfer from the sampler, to the mobile laboratory or a distant laboratory.

3. Each shipping container will be accompanied by a chain-of-custody record identifying the contents. The original record will accompany the shipment, and a copy will be retained by the field project coordinator.

Sample Receipt and Sample Log-In Procedures

Safety Precautions: All samples received should be considered hazardous and appropriate precautions should be taken when handling these samples. Under no circumstances should any personnel other than the sample custodian or project leader open coolers. If damage or leakage is noted, stay clear of the coolers and notify the sample custodian or project leader immediately. All samples will be opened in a hooded area!

Procedure:

1.0 The project leader will notify the sample custodian in writing of incoming samples.

2.0 The custodian will receive the samples and deliver them to a hood located in the analytical laboratory. The procedures described below will be followed by the sample custodian:

2.1 Examine the shipping container and record the following information on the project log form (Refer to Figure 1). A separate project log form is required for each shipping container.

- The presence/absence of custody seal on the shipping container.
- The condition of the custody seal (i.e., intact, not intact).

2.2 Open the shipping container in a hooded area, remove the enclosed sample documents, and record the following information on the project log form.

- The presence/absence of the chain-of-custody record(s).
- The presence/absence of airbills and/or bills of lading documenting shipment of the samples.

2.3 Remove the samples from the container and record the following information in the project log form.

- Condition of samples (intact, broken, leaking, cold, etc).
- The presence/absence of sample tags.
- Sample tag numbers. Compare these numbers with the chain-of-custody record(s) (Figure 3). If sample tag numbers do not match. Record this fact on both the chain-of-custody record and project log form and contact the data management supervisor so that the discrepancy can be resolved.

2.4 Compare the following documents to verify agreement of the information contained on them.

- Chain-of-custody records.
- Sample tags.
- Airbills or bills of lading.

2.5 Sign the Chain-of-Custody (Figure 3 - #12 and #13), project log form and airbills.

3.0 Login the samples (refer to the "Chain-of-Custody, Log-In and Tracking Procedures" SOP Parts 2-7):

3.1 Each sample is assigned a unique sequential laboratory number. The laboratory number is entered on the chain-of-custody (#15), sample labels and sample tags.

3.2 The sample custodian will remove the sample tags. All tags will be placed in sealed envelopes and placed in the appropriate project file.

4.0 Sample Storage:

4.1 Samples and extracts will be stored in a secure area designated for strict chain-of-custody samples.

4.2 Damaged samples will be disposed of in an appropriate manner and the method of disposal documented.

4.3 The laboratory and sample storage areas are secure with strict limited access by only laboratory personnel.

4.4 Whenever samples are removed from storage, the removal will be documented. All transfers of samples will be documented on the internal chain-of-custody records. (Refer to Figure 2).

4.5 Samples and extracts will be stored after completion of analysis in accordance with the contract or until sample custodian is instructed otherwise by the enforcement Project Officer.

4.6 The location of stored organic extracts will be recorded.

4.7 VOA samples will be stored separately from organic extracts.

4.8 Standards are stored separate from samples.

4.9 Samples requiring refrigeration are stored in the walk-in coolers. refrigerator. Metal samples are stored in the black cabinets in log-in. Metal digestates are stored on shelves in the metals lab.

5.0 Sample Security:

5.1 Samples will be stored in a secure area.

5.2 Access to the laboratory will be through a monitored area. Other outside-access doors to the laboratory will be kept locked.

5.3 Visitors will sign a visitors log (located at the reception area and will be escorted while in the laboratory area.

5.4 Refrigerators, freezers, and other sample storage areas are secure as they are located within the laboratory.

5.5 Only laboratory personnel have access to the laboratory.

5.6 Samples will remain in secure sample storage until removed for sample preparation or analysis. All transfers of samples into and out of storage will be documented on an internal chain-of-custody record. An example of an internal chain-of-custody record used for this procedure is attached. (See Figure 2).

5.7 These internal custody records will be maintained in the project file.

5.8 After a sample has been requested from storage by the analyst, the analyst is responsible for the custody of the samples. Each analyst must return the samples to the storage area before the end of the working day.

Internal Chain-of-Custody Procedure:

The following procedure for documentation of internal chain-of-custody for samples requiring continuous custody.

1. Samples requiring refrigeration will be stored in the walk-in coolers located in the sample entry area. Metal samples are stored in the black cabinets in log-in. Metals digestates are located in the metals lab. A list of sample numbers will be maintained by the sample custodian.

2. *Only the laboratory personnel will have access to the walk-ins.*

3. Samples will remain in the designated walk-ins until removed for sample preparation and/or analysis.

4. All transfer of samples into or out of the walk-ins will be documented on an internal chain-of-custody record (see Figure 2). These records are maintained by the sample custodian.

5. Once a sample is removed from a walk-in by the sample custodian, he/she will then give it to the analyst, who is then responsible for the custody of the sample. Each analyst must return samples to the walk-in before the end of the working day. Samples are not allowed to sit on the bench overnight.

6. The next morning, sample custodian will put samples back in their proper place on the shelves. Sample custodian is responsible for signing sample request sheet that samples were returned properly. Any remarks will also be noted by the sample custodian.

7. When sample analyses and necessary quality assurance checks have been completed by the laboratory or after a 3 month time period whichever is longer, the unused portion of the sample should be disposed of properly. All identifying tags, data sheets, and laboratory records shall be retained as part of the permanent documentation of the project. Tags and forms are never discarded!

Michael Linskens

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Director, Technical Services

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Kim D. Finner
Laboratory Manager

Revision Date
9-26-87
8-18-88
3-16-90

[DMSOP]

FIGURE 1

Sample Custodian Signature: ______________________
Date: ______________________

(Circle Appropriate Response)

Custody Seal present/absent
intact/not intact

Chain-of-Custody present/absent

Sample Tags present/absent
Sample Tag Numbers listed/not listed on chain-of-custody

Project Number: ______________________

Airbill Number: ______________________

Date Rec'd	Time Rec'd	Chain-of Custody Record No.	Corresponding		pH <2	pH >9	pH >12	Does info. on Custody Records, Traffic and Sample Tags Agree	Remarks Condition of Samples
			Sample Tag Nos.	Assigned Nos.					

FIGURE 2

WARZYN SAMPLE REQUEST SHEET

Need Samples By:

Requested By: ____________________ Date: __________

Date/Time Submitted: ______________ Time: __________

I am requesting:

Project No.	Sample No(s)	Parameter	Matrix	Remarks

I am returning: Date/Time:

Project No.	Sample No(s)	Remarks

University Research Park
P.O. Box 5385
Madison, Wisconsin 53705
(608) 273-0440

FIGURE 3

CHAIN OF CUSTODY RECORD

PROJ. NO. #1	PROJECT NAME # 2A LOCATION: # 2B					NO. OF CON-TAINERS #8							REMARKS
SAMPLERS: (Signature) #3													
LAB NO. #15	DATE #4	TIME #5	COMP.	#6 GRAB	#7 STATION LOCATION								#9

Relinquished by: (Signature) #10	Date / Time #11A	#11B	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) #12		Date / Time #13A	#13B	

Remarks
#14

PROJECT MANAGER: #15

[illegible] — Coordinator Field Files

NO 8 2716

CHAIN-OF-CUSTODY, LOG-IN AND TRACKING PROCEDURES

Scope and Application: This procedure is applicable to the log-in of samples and addresses such areas as: sample custody, log-in, labeling and preservation of samples. This procedure begins as the samples enter the laboratory and follows the samples to their destruction.

Procedure:

1. Chain-of-Custody Procedure: Samples arriving in the laboratory are accompanied by some type of custody record. The most common type of record is that shown in Figure 1. Follow the instructions below for all levels of chain-of-custody.

   A. Superfund Level Chain-of-Custody:

      1. Refer to the "Chain-of-Custody - Superfund Level" SOP.

   B. Routine Chain-of-Custody:

      1. Samples arriving in the laboratory are accompanied by a chain-of-custody record (refer to Figure 1).
      2. Review the custody form with the samples received and see that the spaces marked #1 - #12 have been accurately completed by the sampler.
      3. Any discrepancies with the chain-of-custody record or the samples should be immediately brought to the attention of the customer service relations person so that the problems can be solved in an efficient manner.
      4. If samples were shipped, note the courier name in the remarks section (#15) of the chain-of-custody record.
      5. Record any other comments such as: temperature upon receipt, preservation (if done in lab), problems, etc, in the remarks section (#15).
      6. Fill in the lab numbers in the section marked #16 (refer to the log-in portion of this procedure for how to obtain lab numbers).
      7. Sign and date the chain-of-custody record (#13 - #14).
      8. Route the custody record to the data management office when log-in is complete.

NOTE: The laboratory is a secured area with strict limited access. Any samples arriving to the laboratory during "off hours" are stored in the laboratory refrigerator until they are logged in. Laboratory personnel are responsible for the care and custody of the samples during the analysis stage and until the samples are removed from the refrigerator and properly disposed of.

2. Log-In Procedure: Samples are logged in as follows (Refer to Figure 2):

A. Sample Information:

Care should be taken to document the condition of samples upon receipt. Anomalies such as broken or leaking bottles, expired holding times, improper labeling or preservation, and air bubbles in VOA vials should be noted on the chain-of-custody. It should also be noted whether the samples arrived cold.

B. Numbering Samples:

Number the samples on the chain-of-custody form. Record lab numbers used in the black lab book. If no chain-of-custody form accompanied the samples, the sampler must be contacted and one must be filled out. Blank forms are available in the log-in area.

NOTE:
- Sample preparation is required if the samples need to be filtered and/or preserved in the lab.
- If metals are requested, metal digestion is required for all matrices except filtered groundwaters or private well.

Sample compositing is required if the lab is instructed to composite a series of samples received into one sample for analysis.

C. Subcontracted Work Required:

Refer to the subcontracting SOP for further instructions on subcontracting samples.

D. Special Accounting Notes:

If there is a discount or a special proposal for the sample analyses to be charged, record that information on the chain-of-custody.

E. Labeling Bottles:

1. Record the lab number on the sample bottle label and caps using a water-proof marker.

2. Check that the appropriate preservation and preparation has been circled.

3. If metals and total hardness are both required, using a red water-proof marker, place a dot on the bottle cap of that bottle to be used for those analyses.

F. Preserving Samples:

1. Samples which have been preserved in the field must be checked via pH paper in the laboratory to insure they were preserved to the correct pH. Check preserved samples as follows:

   a. Acid-preserved (HNO_3 or H_2SO_4) samples must be preserved to a pH <2. Using a pH stick, check the pH. If the pH is not <2, note this on the chain-of-custody, then add additional acid until a pH is obtained. IT IS CRITICAL THAT THE CORRECT TYPE OF ACID BE ADDED.

   b. Base-preserved NaOH samples must be preserved to a pH > 12. Using a pH stick, check the pH. If the pH is not > 12, note this on the chain-of-custody, then add additional 10N NaOH until a pH > 12 is obtained.

   c. Base-preserved NaOH with ZnAc samples must be preserved to a pH > 9. Using a pH stick, check the pH. If the pH is not > 9, note this on the chain-of-custody, then add additional 10N NaOH until a pH > 9 is obtained.

2. Samples which have not been preserved in the field need to be preserved in the laboratory. Record any preservation done in the lab on the field sheets or custody records. Refer to Figure 3 for preservation requirements and preserve accordingly. It is important that samples arrive in appropriate containers (see Figure 3). If they do not, contact the inorganic/organic supervisor. They will determine which analyses, if any, can be run.

3. It is important that samples be received and maintained cold for most analyses. If a sample was received warm, make note of this on the field sheet or custody record.

G. Computer Log-In:

Analysis requests are entered into the Laboratory Information Management System (LIMS). The LIMS database is used for scheduling of analytical work and to produce accounting invoices. Analysis requests are entered into the LIMS database as follows:

1. Turn on the computer terminal.
2. Enter: C CHICO (return).
3. Enter: ASCORA (return).
4. Enter: Password (return).
5. At the VMS $ prompt, enter LABMENU (return).
6. Enter: LOGIN (return).
7. Enter: Password (return).
8. The Log-In screen will appear as shown in Figure 2. Using information on the chain-of-custody, proceed as follows:
   a. Enter project number (return). Account number and name will be filled in automatically. If the information matches the chain-of-custody, press return.
   b. Sample date automatically defaults to yesterday's date. If this is correct, press return or over ride with correct date.
   c. Enter sample identification from station location on the chain-of-custody and press return.
   d. Enter proper matrix number and press return.
   e. Desc: This is used if sample identification is longer than the number of characters in the sample identification field. (Return to over ride or enter information and return.)
   f. Date received automatically defaults to today's date. If correct, press return or over ride with correct date.
   g. Days to process automatically defaults to 14 days. If this is correct (standard turnaround time) press return or if rush work, over ride with the number of days until due.
   h. Duedate: First date listed is report date, second date is the lab due date which can be changed if necessary.

i. *Comments: Enter special tests or other information needed to* analyze samples correctly and press return.

j. Manager: Filled in automatically; press return if correct or over ride.

k. Price/Cost: Return if correct or over ride.

l. % Markup/Discount: For accounting. Enter a negative number for a discount (i.e. -15 for 15%) and a positive number for markups (i.e. 100 for 2 x price). Check accounting sheets for projects with special pricing.

m. To enter parameters, press **Next Screen** (see Figure 2A).

n. Matrix automatically defaults to matrix entered above (return or override).

o. Enter the proper code name for the test to be run from report MF01. Use parent codes if applicable for quicker entry. (Press the down arrow key, return.)

p. To enter address for the report, press **Next Screen** (see Figure 2B).

q. Type: Report (return).

r. If an address has already been entered and matches the chain-of-custody press **Commit** and return.

s. If no address appears, press return until cursor is in the City field. Type in the city and press return.

t. Type in state (press **Commit** and return). After city and state has been entered for the first sample, it will automatically be copied for the rest of the sample numbers in a single log-in.

9. To duplicate the entry for another sample on the same chain-of-custody:

   a. If next sample to be entered has all the same information as the previous sample entered, press **Duplicate Record** key (F7).

   b. Enter sample identification and press **Commit** key, return.

10. To duplicate only the information in the upper block of the log-in screen (sample date, matrix etc.):

    a. Press **Create Record** key (Insert Here) and enter sample identification.

b. Press **Previous Screen** (F12) if sample date needs to be changed.

c. Press **Next Screen**, return. Then press **Next Screen** again to enter new product codes for the analyses requested.

d. Press **Previous Screen** to enter new sample or to quit.

e. Press **Clear Form** (F17) to enter a new chain-of-custody.

f. Press **Exit/Cancel** (PF4) to exit from the log-in screen.

   1. Press **Exit/Cancel** to exit from the LIMS system.
   2. At the VMS $ prompt, enter LO (return) to log off the VAX computer.
   3. Enter N (return).

13. If in Step 8a. the computer says project number is invalid:

a. Press **Exit/Cancel** (PF4).

b. Enter "Y" (return).

c. On the LIMS Main menu, use the up arrow key to position the cursor on "Seedpak Management". Press Commit key.

d. Use the down arrow key to move to project entry. Press **Commit** key.

e. Enter project number (return).

f. Enter account number (9999) and return.

g. Enter description for chain of custody (project name).

h. Enter manager from chain-of-custody (i.e. Finner, K).

i. Press **Exit/Cancel** (PF4), twice.

j. At the LIMS main menu, select log-in and press **Commit**.

14. To print daily log-in reports:

a. Print out the appropriate FS02 reports for only the samples logged in that day. The computer printout must be checked against the custody record or field sheets by the inorganic/organic supervisors so that any errors can be corrected. Print a report as follows:

b. Select "Seedpak Reporting" from the main menu, and press **Commit**.

c. Select FS02 and press **Commit**.

d. Enter today's date, press **Commit** and return.

e. The inorganic/organic supervisors are responsible for updating and printing lab schedules as they require them.

f. Any "rush" work is to be brought to the inorganic/organic supervisors' attention immediately.

15. Sample Storage:

a. Proper handling and storage is necessary in order to maintain the integrity of the samples. Refer to Figure 3 for storage requirements.

b. Refrigerated Storage:

1. Store routine custody samples in the walk-in refrigerator. Separate samples by preservative type. Samples with organic analyte requests are stored on a separate shelf in the walk-in.

c. Non-Refrigerated Storage:

1. Metal samples are stored in the log-in area in the appropriate cabinets.

2. Other samples not requiring refrigeration are stored on the appropriate shelves next to the walk-in refrigerator.

d. Any samples removed for analysis must be put back in the original location when the analysis is complete.

16. Sample Handling:

a. Samples are handled in and out of the walk-in coolers and black cabinets by the sample custodian.

b. Analysts are responsible for filling out sample request forms (see Figure 4) to request needed samples.

c. Forms are given to the sample custodian.

d. Sample custodian gathers requested samples and leaves yellow copy of form with samples, and keeps the white copy.

e. Analysts return samples to the walk-in accompanied by the yellow copy of the request form.

f. Next morning, sample custodian puts samples back in their proper place on the shelves.

g. Sample custodian signs off on white sheet that samples were returned. Any remarks are also noted on the white sheet.

17. Storage/Disposal:

Due to limited sample storage facilities available, the following guidelines have been created for sample storage/disposal. Sample storage time may be extended upon client's request.

a. One week after the report issue date, inorganic samples which are in cold storage are to be transferred to warm storage.

b. One month after the report issue date, organic samples which are in cold storage are to be transferred to warm storage.

c. Samples in warm storage should be disposed of as follows:

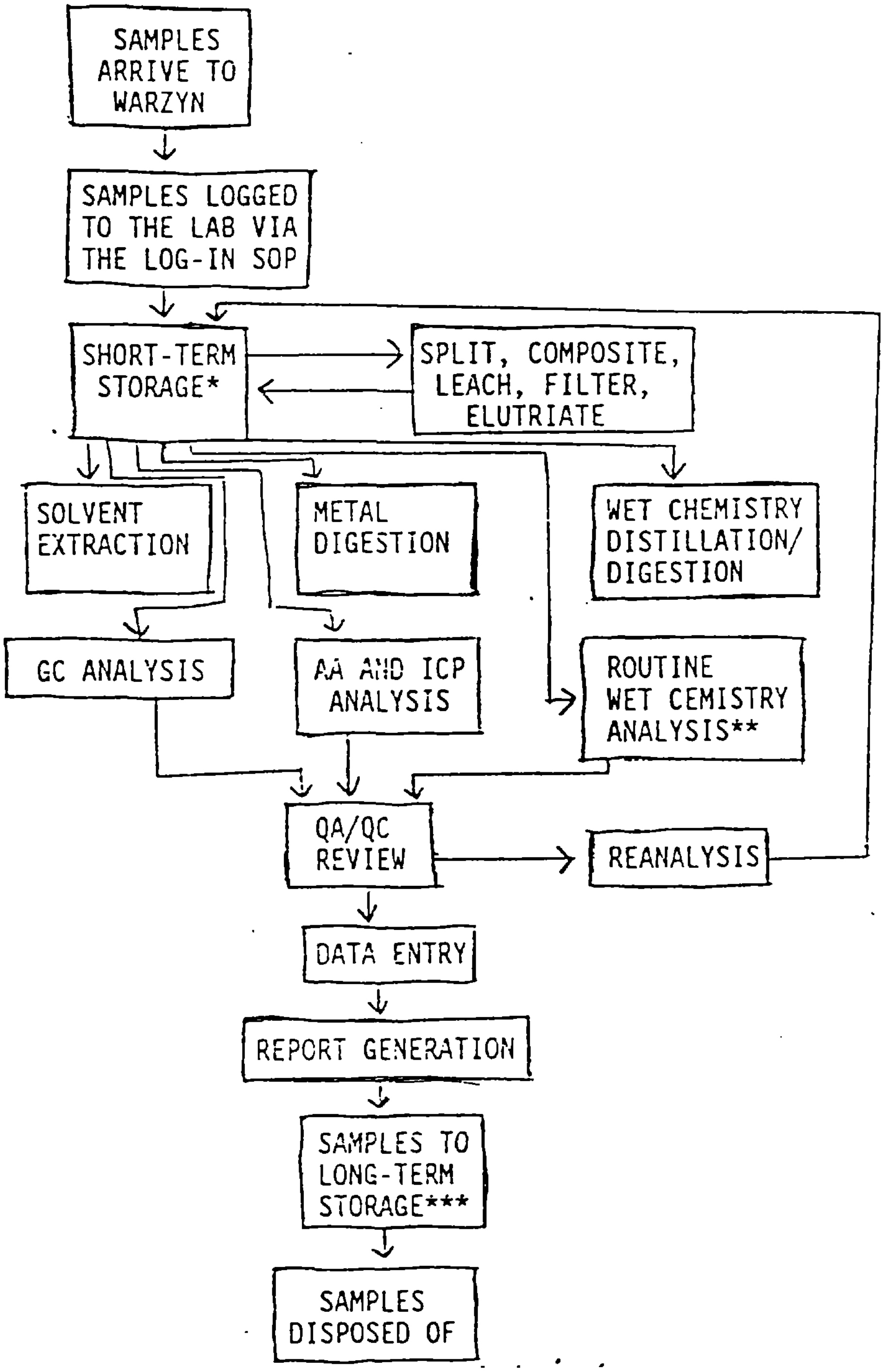
- Aqueous Samples: Dispose 1 month after report issue date.
- Non-Aqueous Samples: Dispose 6 months after report issue date.

Michael Linskens
Michael J. Linskens
Director, Technical Services

Kim Finner
Kim D. Finner
Laboratory Manager

Revision Date
08/18/87
08/15/88
3-18-90

WARZYN ENGINEERING INC.
ANALYTICAL SERVICES
SAMPLE FLOW DIAGRAM



* SHORT TERM STORAGE: WALK-IN REFRIGERATOR FOR SAMPLES REQUIRING REFRIGERATION, BLACK CABINETS IN SAMPLE LOG-IN AREA FOR SAMPLES NOT REQUIRING REFRIGERATION, WALK--INS FOR SAMPLES REQUIRING "SUPERFUND LEVEL CHAIN-OF-CUSTODY".

** ROUTINE WET CHEMISTRY ANALYSES INCLUDE BOTH AUTOMATED AND MANUAL TESTS.

*** LONG TERM STORAGE: NON-REFRIGERATED STORAGE IS LOCATED IN THE FIELD STORAGE ROOM.

WARZYN

FIGURE 1

Warzyn Engineering Inc.
One Science Court
University Research Park
P.O. Box 5385
Madison, Wisconsin 53705
(608) 273-0440

CHAIN OF CUSTODY RECORD

PROJ. NO. #1	PROJECT NAME #2 LOCATION: #2 also	
SAMPLERS: *(Signature)* #3		

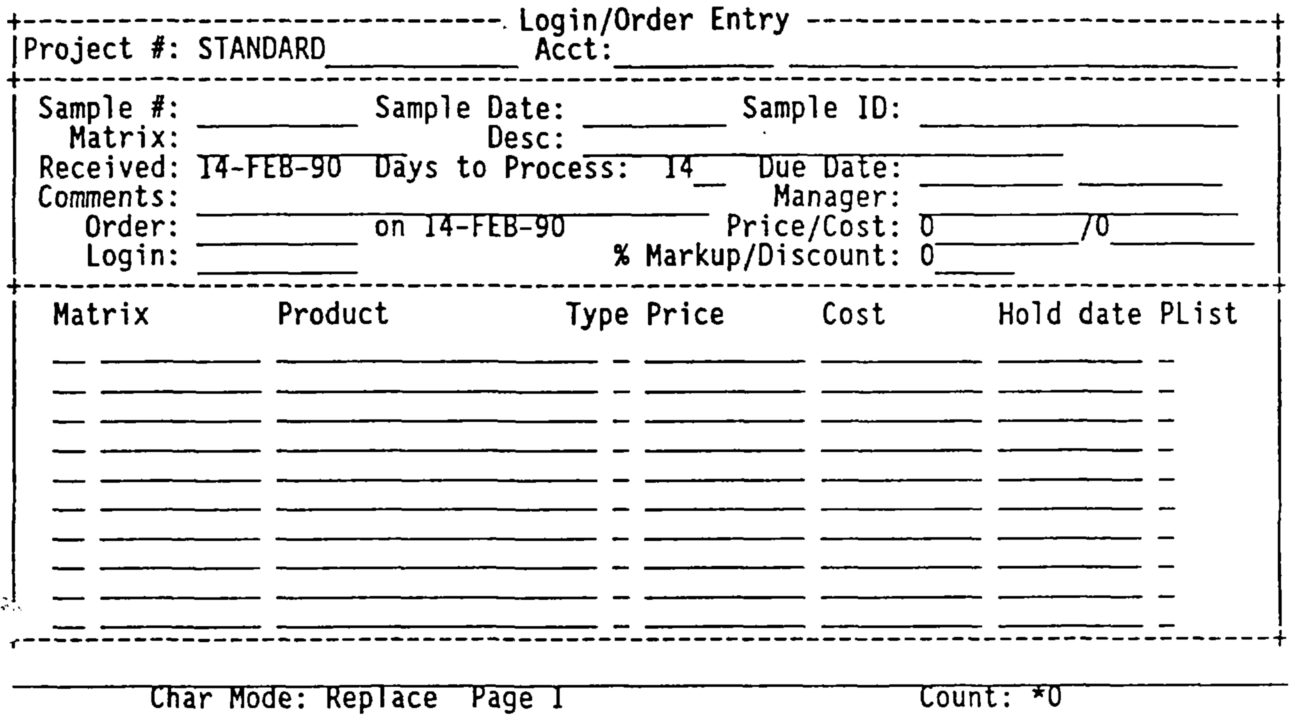
#16 LAB NO.	DATE	#4 TIME	#5. COMP.	#6 GRAB	#7 STATION LOCATION	NO. OF CONTAINERS #8								REMARKS #9

Relinquished by: *(Signature)* #10	Date / Time #11	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)* #13		Date / Time #14	

Remarks
#15

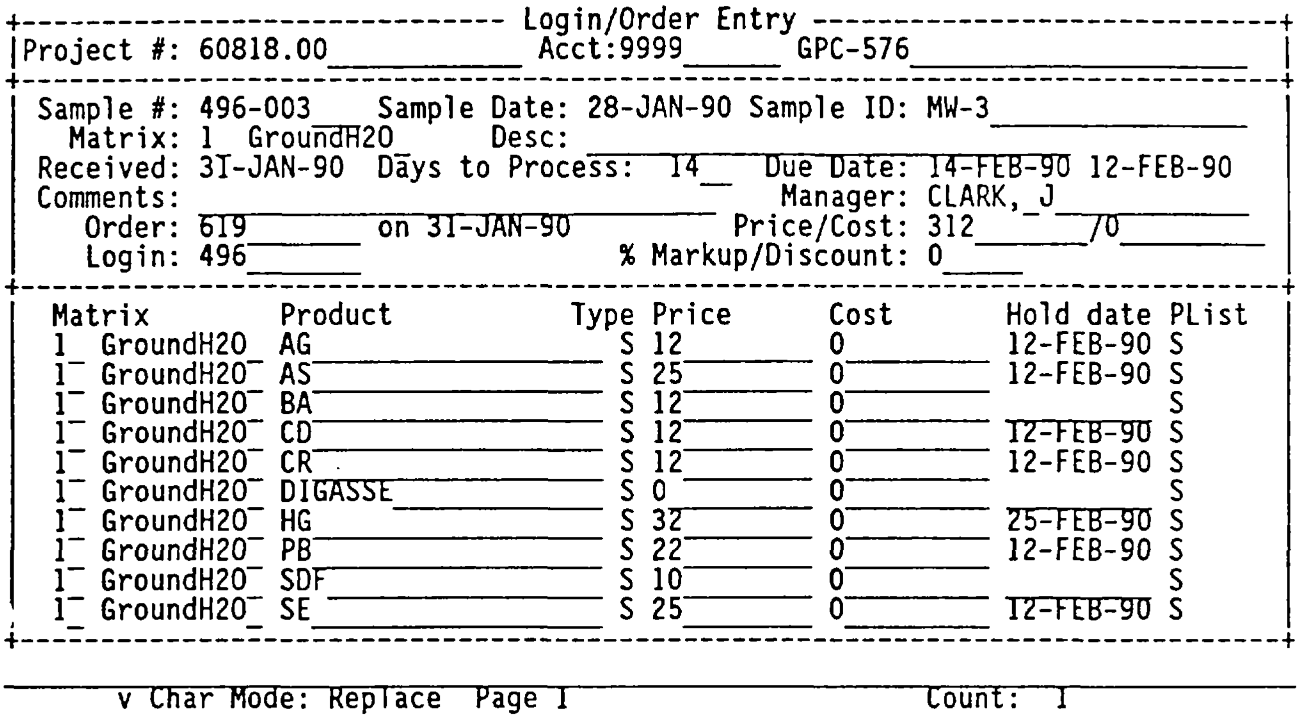
PROJECT MANAGER: #12

FIGURE 2



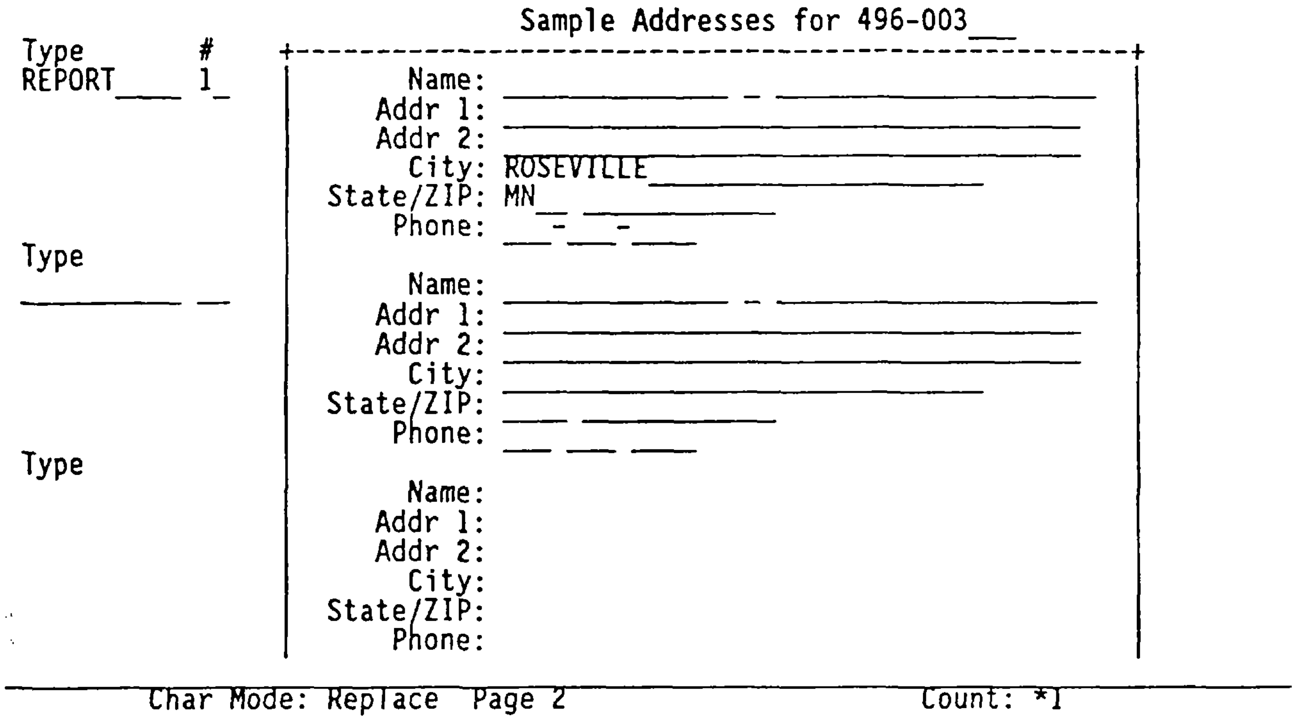
```
+------------------------------- Login/Order Entry ------------------------------+
|Project #: STANDARD____________ Acct:__________ ____________________________   |
+-------------------------------------------------------------------------------+
| Sample #: __________ Sample Date: _________ Sample ID: ____________________   |
|   Matrix: _____________     Desc: ______________________________            |
| Received: 14-FEB-90  Days to Process:  14_  Due Date: _________ _________     |
| Comments: ________________________________     Manager: ____________________  |
|    Order: __________ on 14-FEB-90         Price/Cost: 0_________/0_________   |
|    Login: __________                % Markup/Discount: 0_____                 |
+-------------------------------------------------------------------------------+
|  Matrix        Product              Type Price      Cost        Hold date PList|
|  __ __________ ____________________ _ __________ __________ _________ _        |
|  __ __________ ____________________ _ __________ __________ _________ _        |
|  __ __________ ____________________ _ __________ __________ _________ _        |
|  __ __________ ____________________ _ __________ __________ _________ _        |
|  __ __________ ____________________ _ __________ __________ _________ _        |
|  __ __________ ____________________ _ __________ __________ _________ _        |
|  __ __________ ____________________ _ __________ __________ _________ _        |
|  __ __________ ____________________ _ __________ __________ _________ _        |
|  __ __________ ____________________ _ __________ __________ _________ _        |
|  __ __________ ____________________ _ __________ __________ _________ _        |
+-------------------------------------------------------------------------------+
_________________________________________________________________________________
         Char Mode: Replace  Page 1                       Count: *0
```

FIGURE 2A



```
+------------------------------ Login/Order Entry ------------------------------+
|Project #: 60818.00____________ Acct:9999_____ GPC-576____________________     |
+-------------------------------------------------------------------------------+
| Sample #: 496-003___ Sample Date: 28-JAN-90 Sample ID: MW-3_______________    |
|   Matrix: 1  GroundH2O      Desc: ______________________________              |
| Received: 31-JAN-90  Days to Process:  14__  Due Date: 14-FEB-90 12-FEB-90    |
| Comments: ________________________________         Manager: CLARK, J________  |
|    Order: 619_______   on 31-JAN-90            Price/Cost: 312_______/0_______ |
|    Login: 496_______                    % Markup/Discount: 0_____             |
+-------------------------------------------------------------------------------+
|  Matrix          Product             Type Price        Cost       Hold date PList|
|  1_ GroundH2O_ AG__________________ S 12________ 0_________ 12-FEB-90 S       |
|  1_ GroundH2O_ AS__________________ S 25________ 0_________ 12-FEB-90 S       |
|  1_ GroundH2O_ BA__________________ S 12________ 0_________           S       |
|  1_ GroundH2O_ CD__________________ S 12________ 0_________ 12-FEB-90 S       |
|  1_ GroundH2O_ CR__________________ S 12________ 0_________ 12-FEB-90 S       |
|  1_ GroundH2O_ DIGASSE_____________ S 0_________ 0_________           S       |
|  1_ GroundH2O_ HG__________________ S 32________ 0_________ 25-FEB-90 S       |
|  1_ GroundH2O_ PB__________________ S 22________ 0_________ 12-FEB-90 S       |
|  1_ GroundH2O_ SDF_________________ S 10________ 0_________           S       |
|  1_ GroundH2O_ SE__________________ S 25________ 0_________ 12-FEB-90 S       |
+-------------------------------------------------------------------------------+
_________________________________________________________________________________
       v Char Mode: Replace  Page 1                         Count:  1
```

FIGURE 2B



```
                                        Sample Addresses for 496-003___
Type         #       +----------------------------------------------------+
REPORT____   1_      |        Name: ______________ _ ____________________ |
                     |      Addr 1: ____________________________________  |
                     |      Addr 2: ____________________________________  |
                     |        City: ROSEVILLE______________________       |
                     |   State/ZIP: MN__ ____________                     |
                     |       Phone: ___-___-___                           |
Type                 |                                                    |
                     |        Name: ______________ _ ____________________ |
__________ __        |      Addr 1: ____________________________________  |
                     |      Addr 2: ____________________________________  |
                     |        City: ______________________________        |
                     |   State/ZIP: ____ ____________                     |
                     |       Phone: ___ ___ ___                           |
Type                 |                                                    |
                     |        Name:                                       |
                     |      Addr 1:                                       |
                     |      Addr 2:                                       |
                     |        City:                                       |
                     |   State/ZIP:                                       |
                     |       Phone:                                       |
-------------------------------------------------------------------------------
        Char Mode: Replace  Page 2                          Count: *1
```

FIGURE 3

(Page 1 of 3)

SAMPLE COLLECTION AND PRESERVATIVE REQUIREMENTS

Parameter	Container, (size in mls)		Preservation	Maximum Holding Time
Wet Chemistry				
Acidity	P,G	(A)	Cool, 4°C	14 days
Alkalinity	P,G	(A)	Cool, 4°C	14 days
BOD$_5$	P,G	(1000)	Cool, 4°C	48 hours
Boron	P	(A)	Cool, 4°C	
Bromide	P,G	(A)	None Required	28 days
Carbon, Total Organic	P,G	(B)	Cool, 4°C, H_2SO_4 to pH<2	28 days
Chemical Oxygen Demand	P,G	(B)	Cool, 4°C, H_2SO_4 to pH<2	28 days
Chloride	P,G	(A)	None Required	28 days
Chlorine, Residual	P,G	(A)	None Required	Analyze Immediately
Cyanide, Amenable	P,G	(1000)	Cool, 4°C, NaOH to pH>12 (I)	14 days (I)
Cyanide, Total	P,G	(1000)	Cool, 4°C, NaOH to pH>12 (I)	14 days (I)
Density/Specific Weight	P,G		Cool, 4°C	
Fluoride	P,G	(A)	None Required	28 days
Hardness	P,G	(C)	HNO_3 to pH<2	6 months
Nitrogen, Ammonia	P,G	(B)	Cool, 4°C, H_2SO_4 to pH<2	28 days
Nitrogen, Nitrate	P,G	(B)	Cool, 4°C, H_2SO_4 to pH<2	28 days
Nitrogen, Nitrite	P,G	(A)	Cool, 4°C	48 hours
Nitrogen, Total Kjeldahl	P,G	(B)	Cool, 4°C, H_2SO_4 to pH<2	28 days
Nitrogen, Total Organic	P,G	(B)	Cool, 4°C, H_2SO_4 to pH<2	28 days
Oil and Grease	G	(1000)	Cool, 4°C, H_2SO_4 to pH<2	28 days
pH	P,G	(A)	None Required	Analyze Immediately
Phenolics, Total	G	(500)	Cool, 4°C, H_2SO_4 to pH<2	28 days
Phosphorous, Ortho	P,G	(A)	Filter Immediately, Cool 4°C	48 hours
Phosphorous, Total	P,G	(B)	Cool, 4°C, H_2SO_4 to pH<2	28 days
Silica, Dissolved	P	(A)	Cool, 4°C	28 days
Solids, Dissolved	P,G	(D)	Cool, 4°C	7 days
Solids, Settleable	P,G	(1000)	Cool, 4°C	48 hours
Solids, Suspended	P,G	(D)	Cool, 4°C	7 days
Solids, Total	P,G	(D)	Cool, 4°C	7 days
Solids, Volatile	P,G	(D)	Cool, 4°C	7 days
Specific Conductance	P,G	(A)	Cool, 4°C	28 days
Sulfate	P,G	(A)	Cool, 4°C	28 days
Sulfide	P,G	(500)	Cool, 4°C, add 2 mL 2N Zinc acetate/1000 mL plus NaOH to pH>9	7 days
Surfactant (MBAS)	P,G	(1000)	Cool, 4°C	48 hours
Thiocyanate	P,G	(500)	Cool, 4°C	
Total Organic Halides (TOX)	Amber Glass	(E)	Cool, 4°C	14 days
Turbidity	P,G	(A)	Cool, 4°C	48 hours
Metals				
Hexavalent Chromium	P,G	(A)	Cool, 4°C	24 hours
Mercury	P,G	(C)	HNO_3 to pH<2	14 days in plastic, 28 days in glass
Metals (all, except above)	P,G	(C)	HNO_3 to pH<2	6 months
Organics				
Gas Chromatography				
Volatile Organics	VOC vial	(2 ea, 40)	Cool, 4°C (J)	14 days (J)
Phenols	Amber glass	(M)	Cool, 4°C (K)	7 days (O)
Pesticides and PCBs	Amber glass	(M)	Cool, 4°C (L)	7 days (O)
Pesticides	Amber glass	(M)	Cool, 4°C (L)	7 days (O)
PCBs	Amber glass	(M)	Cool, 4°C	7 days (O)
Polynuclear Aromatics	Amber glass	(M)	Cool, 4°C (K), Store in Dark	7 days (O)
Organophosphorus Pesticides	Amber glass	(M)	Cool, 4°C, Store in Dark	7 days (O)
Chlorinated Herbicides	Amber glass	(M)	Cool, 4°C	7 days (O)
Total Hydrocarbon Screen	Amber glass	(M)	Cool, 4°C	7 days (O)
GC/MS				
Priority Pollutants/HSL				
Volatiles	VOC vial	(2 ea, 40)	Cool, 4°C	
Semi-volatiles	Amber glass	(N)	Cool, 4°C	
Pesticides/PCBs	Amber glass	(N)	Cool, 4°C	
CLP Protocol				
Volatiles	VOC vial	(2 ea, 40)	Cool, 4°C	
Semi-volatiles	Amber glass	(N)	Cool, 4°C	
Pesticides/PCBs	Amber glass	(N)	Cool, 4°C	
Radiological Tests				
Alpha, Beta	P,G	(250)	HNO_3 to pH<2	6 months
Radium	P,G	(1 gal)	HNO_3 to pH<2	6 months
Bacterial Tests				
Coliform, Fecal and Total	P,G	(F)	Cool, 4°C (F)	6 hours
Fecal Streptococci	P,G	(F)	Cool, 4°C (F)	6 hours
Solids				
RCRA Classification	P,G	(1000) (G)	Cool, 4°C	--
Volatile Organics	VOC vial	(140) (H)	Cool, 4°C	--
Semi-volatile Organics	G	(8 oz)	Cool, 4°C	--
Metals	P,G	(8 oz)	Cool, 4°C	--
Inorganics	P,G	(8 oz)	Cool, 4°C	--

EHH/cac
[cac-700-93]

FIGURE 3

(Page 2 of 3)

Notes

(A) 1-3 Analyses; 250 mL required
4-7 Analyses; 500 mL required
>8 Analyses; 1000 mL required

(B) 1-3 Analyses; 250 mL required
4-7 Analyses; 500 mL required

(C) The metals selenium, arsenic, silver, mercury and hardness require additional volume. Use the following bottle scenario;
- One 250 mL bottle for all metals excluding above
- One 250 mL bottle for all metals plus two of the above analytes (except mercury). If mercury is required, an additional 250 mL is required. Label bottle for mercury analyses.
- One 500 mL bottle for all metals, including all five of the above analytes. Two 250 mL bottles may be used instead.

(D) Dissolved solids require 100 mL of sample. This volume can be included in the (A) unpreserved bottle.
The volume required for suspended, total and volatile solids depends on the nature of the sample. Dirty samples require 100-250 mL, clean require 1000 mL. Sample accordingly.

(E) Collect sample in either a 250 mL amber bottle with inverted cap or 250 or 500 mL amber bottle with teflon septa. Collect with no headspace.

(F) Collect 250 mL using either sterilized Whirl-Pak bag or nalgene bottle. Collect in Whirl-Pak bags with sodium thiosulfate ($Na_2S_2O_3$) additive if the sample is chlorinated.

(G) Collect the sample in a 1-liter wide-mouth jar. Collect at least 500 grams for analysis.

(H) Volatile organics may also be collected using two 40-mL VOC vials.

(I) Add 0.6 g ascorbic acid if residual chlorine is present.
Maximum holding time is 24 hours when sulfide is present. Optionally all samples may be tested with lead acetate paper before pH adjustments in order to determine if sulfide is present. If sulfide is present, remove by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is then filtered and NaOH is added to pH >12.

(J) Preserve chlorinated samples with 1 crystal of sodium thiosulfate ($Na_2S_2O_3$) per vial.
Samples can be either preserved with 1:1 HCl or left unpreserved.
Samples receiving no pH adjustment must be analyzed within 7 days of sampling.
Samples that contain hydrocarbons (samples from gasoline or fuel oil contaminated sources) must be preserved with 1 drop of 1:1 hydrochloric acid (HCl).
If either acrolein and acrylonitrile are to be analyzed, the pH should be adjusted to 4-5 with 1:1 hydrochloric acid (HCl). Samples receiving no pH adjustment must be analyzed within 3 days of sampling.

(K) Add 0.008% sodium thiosulfate ($Na_2S_2O_3$) if residual chlorine is present.

(L) Adjust pH to 5-9 with sulfuric acid (H_2SO_4). The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of Aldrin, add 0.008% sodium thiosulfate ($Na_2S_2O_3$) to the sample.

(M) Collect two (2) 1000 mL amber glass bottles with teflon-lined caps per analysis.

(N) Collect two (2) 80 oz amber glass bottles with teflon-lined caps for one or both analyses listed. Alternatively, four (4) 1-liter amber bottles with teflon-lined caps may be used.

(O) The holding time is 7 days until extraction, 40 days after extraction.

EJH/cac
[cac-700-93A]

FIGURE 4

WARZYN SAMPLE REQUEST SHEET

Requested By: ____________________
Date/Time Submitted: ______________

Need Samples By:
Date: ____________
Time: ____________

I am requesting:

Project No.	Sample No(s)	Parameter	Matrix	Remarks

I am returning:

Date/Time:

Project No.	Sample No(s)	Remarks

APPENDIX D-2

COMPUCHEM CHAIN-OF-CUSTODY PROCEDURES

Production Planning & Control SOP 1.1: Logging In Samples

The following steps are completed for all samples as they are received by CompuChem Laboratories. (If for any reason a sample requires special handling upon receipt, the Manager of Production Planning and Control is consulted for directions as to the proper handling and documentation of the samples.)

- Before opening and while inspecting each sample, each employee is required to wear protective clothing (lab coat and gloves). These items need to be worn at all times when in the marked areas (blue line).
- Inspect each sample container before opening, making sure that it has not been damaged or opened during shipment. For those clients using padlocks, sealing tape, or custody seals, inspect these items to make sure that they are intact and record this observation on the chain-of-custody form (see Example 1, at the end of this SOP). If the custody seals, tapes, or padlocks are broken, contact Customer Service (for commercial samples) or the Sample Mangement Office (for EPA samples) for permission to continue processing the sample.
- Each container is opened under the hood and checked for breakage. Check for the condition of the refrigerant (whether any ice remains or whether the cooling packs are solid) and obtain the temperature of a representative sample (liquid samples only) by immersing a clean thermometer in the sample. Record the temperature on the Sample Record (see Example 2, at the end of this SOP).
- The temperature and pH are recorded on the log sheet. See Ex. 1 and 2 lab notices if a variance occurs.
- Receiving personnel must sign and date all chain-of-custody documentation upon sample receipt and record any discrepancies (sample matrix, for instance) on the chain-of-custody form.
- The Supervisor of Sample Receiving must verify that the Receiving Clerk has signed and dated the chain-of-custody form.
- When a CompuChem SampleSaver® is received, record this receipt (on the file card) in the CLMS and insert the file card (contained in the SampleSaver®) into the file-card storage box, according to the date received.

* Remove samples from the shipping container and compare the sample identification information on the sample bottles to the sample information on the traffic sheets, packing lists, and chain-of-custody form included in the container (see Examples 3A and 3B, at the end of this SOP). If discrepancies exist, note the problem on the chain-of-custody form and notify Customer Service (for commercial samples) or SMO (for EPA samples).

* Each water VOA is checked for air bubbles and headspace, and noted on the chain-of-custody form.

* On each complete and correct EPA Chain of Custody and Traffic Report the statement 'Received in Good Condition' is written or stamped, initialed and dated by the receiving individual.

* On each complete and correct Commercial Chain-of-Custody the statement 'Received in Good Condition' is written or stamped, initialed and dated by the receiving individual.

  'Received in Good Condition' is intended to indicate that the sample or samples were received intact with all associated sample tags (if applicable), custody seals (if applicable), pH for inorganics, and corresponding documentation in order. If there are any discrepancies in the documentation or other problems (such as breakage of the containers or chain of custody seals), the exceptions are noted on the appropriate documents, initialed and dated.

* The statement 'Received in Good Condition' does not, however, include sample temperature since EPA samples are generally received at temperatures above the recommended 4°C. The temperature is noted on the sample Log-In Sheets and the gray envelope.

* Check incoming samples against SMO scheduled receipts (for EPA samples).

* Log the sample in on the Accessioning Log, noting the following items:

Case number	Temperature
CompuChem sample ID	Client name or order number
Receiving date (RD)	Sampling date (SD)
Analysis codes	Matrix
Volume received	pH (Inorganics Samples Only, see PP&C SOP 3.1)

- For EPA samples, enter the samples' account data into the marketing section of the CLMS in order to generate the order number and associated requisition numbers. For commercial samples, contact customer service to check for the existence of the order. Then complete the order in the CLMS, and complete the EPA Scheduling Log (Example 4, at the end of this SOP).

- Enter sample into sample receipt portion of CLMS in order to generate a CompuChem number for each sample. Fill in the CompuChem number on the accessioning log sheet (this completes the log sheet).

- A CompuChem label is generated in numerical sequence.

- Label samples with the CompuChem number by wrapping each sample bottle with its computer - generated CompuChem sample label. Sample labels are color coded, and are to be rotated with a different color every 2 week period by the Supervisor of Receiving or the Supervisor designee.

- Each log sheet is reviewed by the Supervisor of Environmental Receiving to ensure information is documented. After review each log sheet is stamped as reviewed and initialed and dated.

- Transfer the labelled samples to the secure, locked walk-in cooler facility.

- The CompuChem number is listed on the original Chain-of-Custody next to the associated client ID when possible.

- Access the Quiz portion of the CLMS to produce the worksheets for EPA sample analyses. For EPA samples the system will generate volatile, semi-volatile, and pesticide worksheets. For commercial and inorganic samples, pull the appropriate worksheets from the worksheet files; the analysis codes for these samples should have been included with the packing information and confirmed with customer service. Note the following destinations for the various worksheets:

  Pesticide/Herbicide Worksheets: GC Lab Volatiles that do not require compositing: GC/MS Lab Inorganics: Inorganics Preparation Lab Volatiles requiring compositing, all EPA volatiles, acid/base-neutrals (commercial), semi-volatiles (EPA), and commercial TCDD's: Production Planning and Control for scheduling.

- To produce EPA quality control worksheets for the QC samples associated with a batch of samples, access the EPA Water or EPA Solid programs of Quiz in the CLMS and enter the samples' CompuChem Numbers; copy these worksheets on green paper. To assemble commercial QC worksheets, pull the appropriate green fraction worksheets from the trays in the Shipping and Receiving area. Separate QC Sample Records are used to document the analysis of the QC samples associated with a particular batch. These are printed after the entry of sample numbers into the system and are put into green QC folders for Report Integration. Included in the commercial folder are the Sample Record (generated by the CLMS), a copy of the order form, and, if necessary a copy of the Chain-of-Custody Record.

- Assemble commercial file folders for Report Integration; include in the production sample's folder the Sample Record, Customer Sample Information Sheet and Chain-of-Custody Record; in the green quality-control folder include the QC Sample Record, which also goes to Report Integration.

- Assemble EPA file folders for Report Integration; EPA only has the Sample Record in the file folder. A gray envelope contains all materials for the case including: yellow copy of the OTR (Organic Traffic Report), Chain-Of-Custody, original air-bill, a copy of the Log Sheet (also called Accessioning Report), a copy of the EPA scheduling Log (see Example 4A, at the end of this SOP), Custody Tags (if received) and a grey envelop contents sheet (See 4b). The white copy of the OTR is returned with a cover sheet to the EPA/SMO (Sample Management Office) (See Attachments 4c and 4d). The original EPA Scheduling Log is put in the EPA Book (kept in the Receiving area).

- If problems arise concerning received samples, contact Customer Service (for commercial samples) or the Technical Management Staff (for EPA samples).

Attachment # 1

LABORATORY NOTICE

CompuChem # __________

Sample ID __________

Case # __________

Type of Analysis __________

Receipt Date __________

The pH reading for the sample listed above was _____, the required pH level is ____.

The Client was contacted by a member of CompuChem's Environmental Marketing Department. The Environmental Receiving Department was instructed to:

___ Preserve In-House by Inorganics Prep Lab

___ Analyze As Received, and Qualify with this Notice

___ Dispose - Client will resample

___ Subcontract Lab to Preserve

Supervisor Signature ____________

Date ____________

Attachment # 2

LABORATORY NOTICE

CompuChem # _ _ _ _ _ _ _ _ _

Sample ID _ _ _ _ _ _ _ _ _

Case # _ _ _ _ _ _ _ _ _

Sample Type _ _ _ _ _ _ _ _ _

Receipt Date _ _ _ _ _ _ _ _ _

The required temperature for Environmental samples requiring Organic/Inorganic Analysis is 4C(+/-2C). The temperature of the sample listed above was _ _ _ _ .

The Client was contacted by a member of CompuChem's Environmental Marketing Department. The Environmental Receiving Department was instructed to:

_ _ _ Analyze As Received, and Qualify with this Notice

_ _ _ Dispose - Client will resample

Supervisor Signature _ _ _ _ _ _ _ _ _ _ _

Date _ _ _ _ _ _ _ _ _ _ _

ROJ. NO.	PROJECT NAME
MPLERS: *(Signature)*	

. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CON-TAINERS								REMARKS

quished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*
quished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*
quished by: *(Signature)*	Date / Time	Received for Laboratory by: *(Signature)*	Date / Time	Remarks	

Distribution: Original Accompanies Shipment; Copy to Field Files

Example 1

Example 2

Sample Record

Requisition Number: CompuChem Number:
Case: Account Number:
Turnaround: Priority: Due:
Analysis Codes:

Lab Instructions

Receiving Data

Sample Identification: SS Code:
SS Number: Receiving Codes:
Date Received: Time:
Receiving Information:
Containers Received:
Matrix: Temp: Sampling Date(s):

Deliverables

Deliverables Code:

Lab Requirements

Laboratory Completion Date	Repeat Date	
________	____	( )
________	____	( )
________	____	( )
________	____	( )

Company Name:

Example 2 (Cont.)

Sample Record

Requisition Number:
Case:

CompuChem Number:
Account Number:

FOOTNOTES:

Applicable QA Notices:

Company Name:

COMPUCHEM LABORATORIES

EPA/CASE RECEIVING Sheet for: ______________ Sheet 1 of 1

☐ ORGANIC
☐ INORGANIC

Case #: ______________ Order #: ______________

Case ID: ______________ Tags: [YES] [NO] ______

Account #: __________ Region #: ______ TAT: ____ Chain of Custody: [YES] [NO] ______

Delivered By: ______________ Freight Bill #: ______________

	COMMENTS/REMARKS	SAMPLE ID	CC #	SD	ANALYSIS CODE	MATRIX	VOLUME	RQ	C/pH
01									
02									
03									
04									
05									
06									
07									
08									
09									
10									
11									
12									
12									
13									
15									
16									
17									
18									
19									
20									

Logged In By: ______________
(Signature)

Reviewed By:

Received By: ______________
(Signature)

COMPUCHEM LABORATORIES

Date Samples Received at Laboratory ____________________ SHEET ____ OF ____

Client ____________________ Order # ____________________ Chain of Custody (Yes) or (no) ____

Case ID: ____________________ TAT ________ SSa's: ___ ___ ___ ___ ___ ___ ___ ___ ___

Delivered By: ____________ Freight Bill # ______________ Subcontract # ____________________

#	COMMENTS REMARKS	REC	SAMPLE ID	CC #	SD	pH	Temp	Analysis Code	Matrix	Volume
01										
02										
03										
04										
05										
06										
07										
08										
09										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										

Logged In By: ____________________ Reviewed By:
(Signature)

Received By: ____________________
(Signature)

Example 3A

COMPUCHEM LABORATORIES

date shipped
to consignee: ______________ date received
from consignee: ______________

number of sample: ______________________________

consignee name: ______________________________

address: ______________________________

____

____

DO NOT REMOVE: FOR COMPUCHEM USE ONLY

Example 3B

PLEASE NOTE THAT ANY AND ALL PRESERVATIVE(S) ARE TO
BE ADDED BY THE CUSTOMER AT THE TIME OF SAMPLE COLLECTION

At the end of the sampling period, it is vital to ship the sample via express transportation. To insure proper follow-up and prompt analysis, please call 1/800-334-8525 and provide us with the following information:

1. Date Shipped
2. Time Shipped
3. Freight Carrier
4. Freight Bill of Lading Number

Sampling Period

From:

Date ______________________

Time ______________________

To:

Date ______________________

Time ______________________

Company ______________________

Address ______________________

City & State ______________________ Zip Code ____________

Sample Name/Number ______________________

Return this form in the envelope provided and return with the SAMPLESAVER.

Thank you.

PLEASE NOTE THAT ANY AND ALL PRESERVATIVE(S) ARE TO
BE ADDED BY THE CUSTOMER AT THE TIME OF SAMPLE COLLECTION.

Example 4A

EPA SCHEDULING LOG FOR WEEK ENDING SATURDAY ______________
(DATE)

CASE NUMBER: ________ NEW CASE: ________ OLD CASE: ________ COMPLETED CASE ________
REGION: ____________ ESTIMATED SHIPPING DATE: ____________
DELIVERABLES CODE: ____________ TURN-AROUND-TIME: ____________
ACCOUNT #: ____________ CONTRACT #: ____________ PRICE CODE: ____________

QUANTITY EXPECTED: ____________: WATERS ORDER #: ____________
____________: SEDIMENTS/SOILS
____________: EXTRACTS
____________: DIOXINS AIRBILL #: ____________

CONCENTRATION: ________: LOW ________: MEDIUM ________: HIGH

DATE SHIPMENT RECEIVED: ____________ TEMPERATURE: ____________
QUANTITY RECEIVED: ____________: WATERS
____________: SEDIMENTS/SOILS TAGS: YES/NO
____________: EXTRACTS ____________
____________: DIOXINS

CONCENTRATION: ________: LOW ________: MEDIUM ________: HIGH

PROBLEMS/COMMENTS: ________________________________

SMO CONTACTED AT (TIME): ____________ SPOKE TO: ____________
RESOLUTION FROM SMO: ________________________________

EXAMPLE 4B

DATE: ____________

CONTENTS FOR GRAY ENVELOPES

EPA: ☐ ORGANIC CASE
☐ INORGANIC CASE
☐ DIOXIN CASE

COMMERCIAL: ☐ ____________ CLIENT

CASE#: ____________

ORDER#: ____________

NO. OF TRAFFIC REPORTS: ____________

	YES	NO	N/A	ITEM	COMMENTS
1.	☐	☐		CHAIN-OF-CUSTODY	
2.	☐	☐		AIRBILL	
3.	☐	☐		DAILY LOG SHEET	
4.	☐	☐	☐	TRAFFIC REPORT (EPA)	
5.	☐	☐	☐	SHIPMENT RECORD (EPA)	
6.	☐	☐	☐	TAGS	
7.	☐	☐	☐	DAILY pH CHECK SHEET	
8.	☐	☐	☐	SMO COVER LETTER	
9.	☐	☐	☐	EPA SCHEDULING LOG	
10.	☐	☐	☐	COMMERCIAL SCHED. LOG	
11.	☐	☐	☐	SIS (#____-____)	
12.	☐	☐	☐	____________	

COMMENTS: ____________

	SIGNATURES/INITALS	DATE
SAMPLE RECEIPT/SCHEDULING:		
QA SECTION (IF REQUIRED):		
DOCUMENTATION CONTROL:		

DATE:____________________ .

Dear Linda,

Enclosed are the SMO and/or Regional copies of the Organic Traffic Reports (OTR) for Case #____, received by CompuChem Laboratories on ________________________.

If you should have any problems or question concerning this package, please do not hesitate to contact Richard Bloom at extension #215, or myself at #219/220.

Thank you,

____

Natalie Carter

Additional Comments:

Section No. 3.2/QA
Revision No. 1
Date: June 12, 1986
Page 2 of 2

Documentation Form For:

Revising or Creating Standard Operating Procedures (SOPs): Including Designated
ersonnel Responsibilities

✓ Revised Procedure ______ New Procedure ______ Procedure Attached

PRODUCTION PLANNING & CONTROL #1.1
rea and SOP#

LOGGING IN SAMPLES	05-01-89
tle Of Procedure	Effective Date
	5-1-89
ocedure Prepared By	Date
	5-1/89
ocedure Read, Understood, and Approved By ppr ate Laboratory Station Manager	Date
	5/15/89
ocedure Read, Understood, and Approved By irector, Quality Assurance	Date
Melody Enmore	6-8-89
ocedure Distributed By	Date

These procedures describe how tasks are performed in this specific area. a question arises concerning the proper procedure to follow for an activity this area, these SOPs should be consulted to resolve the question. Also, e SOPs are a valuable source of material for training purposes.

After the manager of this area believes the person responsible for these s[illegible]s mastered these SOPs, both the manager and the employee should sign and this form, assuring that these SOPs are understood and will be followed in e daily operations of CompuChem Laboratories. Please forward a copy of this vised or created SOP and a completed form to Quality Assurance.

Employee's name: ______________ Date: 5-1-89 ME
Employee's title: Supv. Ev. Receiving
Employee's name: ______________ Date: ______
Employee's title: ______________
Employee's name: ______________ Date: ______
Employee's title: ______________
Manager's name: ______________ Date: ______
Manager's title: ______________

Production Planning and Control SOP 2.0: The Extraction Worksheet (Sample Custodian)

The Extraction Worksheet records information concerning the sample preparation processes (an example of this form and an explanation of its completion are contained in Sample Preparation SOP number 2.3.). The Sample Custodian uses this sheet to pull and check extracted samples. For the sample to leave the extraction lab, the Custodian must complete the following checks:

* Comparison of CompuChem sample numbers appearing on worksheet to those on extract vials;
* Match the preparation code on the worksheet to the code on the sample;
* Check for the initiation and completion date on the worksheet;
* Check for the listing of a blank associated with the samples listed on the worksheet;
* If a Quality Control Duplicate or Sample Spike is listed on the worksheet, check for the CompuChem number of the Duplicate's or Spike's original;
* Check the Extraction Worksheet for the sample's original volume/weight and for the extract's volume/weight;
* Check the volume of the extract vial against the volume indicated on the worksheet.

Once these checks are completed, the Sample Custodian stores samples properly and securely in the reach-in refrigerator. The Custodian then makes a copy of the worksheet, giving the copy to the Scheduling Control Clerk and the original to the Extraction Lab Supervisor.

Initial Documentation for SOPs: Including Designated Personnel Responsibilities

This Standard Operating Procedure, Production Planning and Control, number 1.7 through 2.0, was written from an interview conducted by William J. Gargan with Bernard with Ann Marie Flaherty during the period from December 17, 1984 to January 21, 1985. The Director of Quality Assurance and the Manager, Production Planning and Control, have read and approved this procedure.

SOPs approved by: ______________________ Date: ____________
Director of Quality Assurance

SOPs approved by: Richard L [illegible] Date: 7/2/86
Manager, Production Planning and Control

These procedures describe how tasks are performed in the Production Planning and Control area. If a question arises concerning the proper procedure to follow for an activity in this area, these SOPs should be consulted to resolve the question. Also, these SOPs are a valuable source of material for training purposes.

After the manager of this area believes the person responsible for these tasks has mastered these SOPs, both the manager and the employee should sign and date this form, assuring that these SOPs are understood and will be followed in the daily operations of CompuChem Laboratories. Please forward a copy of this signed and dated form to Quality Assurance.

Employee's name: ______________________ Date: ____________

Employee's title: ______________________

Employee's name: ______________________ Date: ____________

Employee's title: ______________________

Employee's name: ______________________ Date: ____________

Employee's title: ______________________

Manager's name: ______________________ Date: ____________

Manager's title: ______________________

Production Planning and Control SOP 2.9: Document Control

The Document Control Clerk is responsible for maintaining an inventory of completed EPA and commercial folders. From this inventory the Control Clerk is often asked to pull Cases and folders for data inquiries. In addition, the Clerk stores the documentation of completed samples in the local warehouses used by CompuChem Laboratories and ships completed EPA Cases to the EPA warehouse in Lakewood, Colorado. In performing these duties, the Clerk does well to remember that the documents relation to a completed sample are sometimes needed in legal proceedings or when clients which to make inquiries about a Final Report. Therefore, the ability to produce report results and data when requested is of the utmost importance of CompuChem and its clients.

Inventorying Sample Folders

When the Document Control Clerk receives completed EPA Case folders from Report Integration, he or she checks the covering Chain-of-Custody for release of EPA Case for Document Inventory Form (Example 6, at the end of SOP) against the folders with which it arrives. Each pair of CompuChem and EPA Numbers should correspond to a sample folder. A completed EPA Case should contain the following items:

- Receiving Documents
- Sample Data Folders (may include duplicate sample spikes)
- QC Case Summary Report
- Standards Package (per contract Deliverables Index)
- Raw QC Data (per contract Deliverables Index)
- Document Inventory Control Summary Form
- Chain-of-Custody For Release of EPA Case for Document Inventory Form

The receipt of the Case is also recorded in the Document Control Log. The Clerk then transfers possesion of the folders to Turner Components for pagination. Page numbers in each case, except for the receiving documents (which inludes the Sample Data Folders, the QC Case Summary, the Standards Package, and the Raw QC Data), begin with page numer six and continue to the end of the document. The receiving documents (consisting of five previously mentioned sections) are not numbered but are identified by quantity per section. To document this conveyance the Chain-of-Custody form is signed and data by the Clerk and a representative of Turner Components. An entry of this transaction is also made in the Control Log.

When the EPA folders return from Turner Components (the Chain-of-Custody Form is again signed and dated), the Control Clerk checks the paination andmakes sure that the folders are complete; a Document Inventroy Control Summary Form (Example 7, at the end of this SOP) if filled out to record this check and the log is updated. Then EPA Cases are taken by the clerk to the Jiffy Warehouses for temporary storage (this, too, is recorded in the log).

One hundred and twenty days after mailing of the Case Report, an EPA Case is sent via UPS to the EPA warehouse. Before sending the cases to EPA, the clerk once again checks the pagination and completeness of the folders and then includes, for shipping, a copy of the Inventory Summary Form. The UPS receipt is kept at CompuChem. Copies of this paperwork are kept in the UPS Record Book. Again, the Control Log records this step of the inventory.

When the EPA receives the case, they send back a copy of the Inventory Summary Form with a receiving signature; this is filed by Case Number in the EPA Warehouse Notebook.

Since commercial documentation is stored by CompuChem for possible Data Inquiries, less record keeping is required for its storage. The Control Clerk keeps a separate log for commercial storage, noting when and where commercial samples are stored.

Storing Documents

The Document Control Clerk is responsible for the orderly storage of sample documents in the warehouses used by CompuChem. EPA Cases are kept in boxes having the EPA Case Number on them; commercial samples are boxed in production, QC Blank, and QC spike/duplicate containers. The Clerk keeps separate logs for EPA Case storage and commercial storage, noting the Case or samples contained in each box. Commercial folders are stored in either the Jiffy Warehouse (these are more recent samples) or in the C & O Warehouse; a log is kept for each of these warehouses. EPA Cases, except for very old data, are stored in the Jiffy Warehouse.

Data Inquiries

A Data Inquiries Form (Example 8, at the end of this SOP) notifies the Document Control Clerk of the need to pull samples or Cases form storage. The form lists the Case or samples requested and records, among other things, the pull-date and refiling data for the folder requested. If an EPA case is being paginated when a request comes in, the clerk relays this information to the person who made the request and sends the requested folders to this person once they return. After pulling a folder, the Control Clerk dates and signs the Inquiry Form, keeping three copies (white, pink, and light yellow) in the Cases and Folders Pulled notebook and gives the dark yellow copy to the person making the request. After a folder or sample has returned from a data inquiry, copies of the Data Inquiry Forms are kept in the "Cases and Folders Pulled" record book.

Example 6

CHAIN-OF-CUSTODY FOR RELEASE OF EPA CASE FOR DOCUMENT INVENTORY

I, ______________________________, RELEASE CONTENTS OF EPA CASE # __________ TO ______________________________ ON ______________. CONTENTS OF THIS CASE ARE AS LISTED:

1. RECEIVING DOCUMENTS
2. CASE SUMMARY
3. STANDARDS
4. RAW QC DATA

	EPA #	CC #		EPA #	CC #
5.			19.		
6.			20.		
7.			21.		
8.			22.		
9.			23.		
10.			24.		
11.			25.		
12.			26.		
13.			27.		
14.			28.		
15.			29.		
16.			30.		
17.			31.		
18.			32.		

I, ______________________________, RECEIVED INTO MY CUSTODY THE ABOVE LISTED DOCUMENTS ON __________________.

I, __________________________, AFTER COMPLETING THE DOCUMENT INVENTORY CONTROL REQUIREMENTS AS STATED IN COMPUCHEM'S STANDARD OPERATING PROCEDURES, RELEASE THE ABOVE LISTED DOCUMENTS TO ________________________ ON ____________________.

I, __________________________, RECEIVED INTO MY CUSTODY THE ABOVE LISTED DOCUMENTS.

Example 7

Figure 1

DOCUMENT INVENTORY CONTROL SUMMARY FORM

I. Receiving Documents

Quantity ________ a. Chain-of-Custody Records
Quantity ________ b. Organic Triffic Reports
Quantity ________ c. Sample Tags
Quantity ________ d. Shipping Records
Quantity ________ e. Sample Receipt Logbook Page(s)

(Quantity _____) II. Sample Data Folder (Includes Duplicate Sample Spikes)

a. Sample Record
b. Data Report (if applicable)
Pages _____ - _____ c. Volatile Fraction (if required)
d. Semi-Volatile Fraction (if required)
e. Pesticide Fraction (if required)
f. Miscellaneous Correspondence/Memos (if applicable)
g. Manual Worksheets GC Chromatograms (if required)

(Quantity _____) III. QC Case Summary Report

a. Case Summary Tracking Form
b. QC Cross Reference
c. Case Summary Narrative
Pages _____ - _____ d. Quality Control Notices
e. Surrogate Recovery Forms
f. Reagent Blank Summary Forms
g. Matrix Spike/Duplicate Recovery Forms
h. BFB and DFTPP Tune and Performance Forms
i. Deliverables Checklist

(Quantity _____) IV. Standards Package (per Contract Deliverables Index)*

a. Detection Limit Study
b. Case Summary Reference Guide
c. Chromatogram(s)
d. Quantitation Report(s)
Pages _____ - _____ e. Instrument Run Log
f. SPCC/CCC Calibration Standards Forms

*Sequence repeated for each fraction, as required.

Example 7 (Cont.)

Figure 1 - DOCUMENT CONTROL SUMMARY FORM

g. Internal Standard Response Verification Report
h. Initial Calibration Data
i. Calibration Check Data

(Quantity _____) V. Raw QC Data (per Contract Deliverables Index)*

a. Spectrum
b. M/Z Listing
c. Blank Raw Data
  . Tentative ID List
  . Chromatogram(s)/Quantitation Report
d. Duplicate Spike Raw Data
  . Tentative ID List
  . Chromatogram(s)/Quantitiation Report
e. GC Screen Data Sheets

Pages _____ - _____

*Sequence repeated for each fraction, as required.

Example 8

COMMERCIAL ______________

DATE REQUESTED: ______________ EPA ______________

COMPUCHEM® LABORATORIES

DATA INQUIRIES

REFERENCE TO CASE NO.: ______________

SAMPLE NUMBER(S) ______ ______ ______ ______

DATE PULLED ______________ BY ______________

DATE REVIEWED ______________ BY ______________

DATE AMENDED/MAILED ______________ BY ______________

DATE REFILED ______________ BY ______________

PP&C - 1st Copy
QA - 2nd Copy
Report Deliverables - 3rd Copy
Inventory Control - 4th Copy

Initial Documentation for SOPs: Including Designated Personnel Responsibilities

This Standard Operating Procedure, Production Planning and Control, number 2.9 was written from an interview conducted by William J. Gargan with Bernard Bass on January 28, 1985. The Director of Quality Assurance and the Manager, Production Planning and Control, have read and approved this procedure.

SOPs approved by: ______________________ Date: __________
Director of Quality Assurance

SOPs approved by: Richard J Bloom Date: 7/2/86
Manager, Production Planning and Control

These procedures describe how tasks are performed in the Production Planning and Control area. If a question arises concerning the proper procedure to follow for an activity in this area, these SOPs should be consulted to resolve the question. Also, these SOPs are a valuable source of material for training purposes.

After the manager of this area believes the person responsible for these tasks has mastered these SOPs, both the manager and the employee should sign and date this form, assuring that these SOPs are understood and will be followed in the daily operations of CompuChem Laboratories. Please forward a copy of this signed and dated form to Quality Assurance.

Employee's name: ______________________ Date: __________

Employee's title: ______________________

Employee's name: ______________________ Date: __________

Employee's title: ______________________

Employee's name: ______________________ Date: __________

Employee's title: ______________________

Manager's name: ______________________ Date: __________

Manager's title: ______________________

APPENDIX D-3

ENSECO CHAIN-OF-CUSTODY PROCEDURES

7. SAMPLE CUSTODY

Upon receipt by Enseco, samples proceed through an orderly processing sequence specifically designed to ensure continuous integrity of both the sample and its documentation.

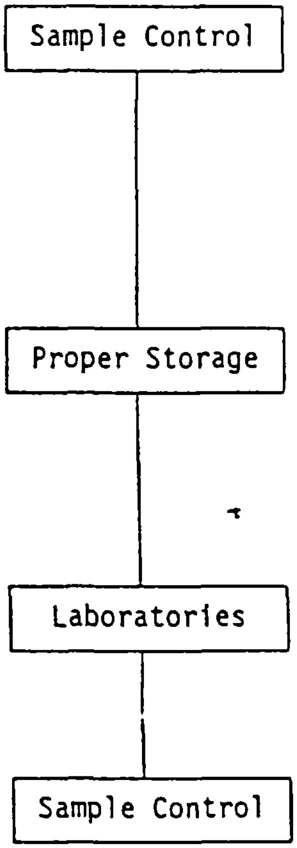
All samples are received by Enseco's Sample Control Group and are carefully checked for label identification, and completed, accurate chain-of-custody records. Photographs document the condition of samples and each sample is then assigned a unique laboratory identification number through a computerized Laboratory Information Management System (LIMS) that stores all identifications and essential information. The LIMS system tracks the sample from storage through the laboratory system until the analytical process is completed and the sample is returned to the custody of the Sample Control Group for disposal. This process is summarized in Figure 7-1. Access to all Enseco laboratories is restricted to prevent any unauthorized contact with samples, extracts, or documentation.

An example of the Enseco Chain-Of-Custody Record used to transmit samples from the client to the laboratory is given in Figure 7-2. The Chain-Of-Custody Record (Interlaboratory Analysis Form) used to transmit samples between laboratories within Enseco is given in Figure 7-3.

Sample bottles provided to the client by Enseco are transmitted under custody using the Enseco "Sample Safe^{TM}".

Figure 7-1

ENSECO SAMPLE PROCESSING FLOW CHART



- Check and document physical condition of sample
- Verify documentation and parameter assignment
- Log into LIMS
- Send acknowledgement letter to client

- Store sample according to preservation guidelines
- Transfer sample to lab with proper documentation

- Document analytical work
- Return unused samples to Sample Control

- Return sample to client or arrange for sample disposal

Ensceo

CHAIN OF CUSTODY

No. 5068

Attn: ______

Enseco Client ______

Project ______

Sampling Co. ______

Sampling Site ______

Team Leader ______

SAMPLE SAFE™ CONDITIONS

1. Packed by: ______ Seal # ______
2. Seal Intact Upon Receipt by Sampling Co.: Yes No
3. Condition of Contents: ______
4. Sealed for Shipping by: ______
5. Initial Contents Temp.: ______ °C Seal # ______
6. Sampling Status: Done Continuing Until ______
7. Seal Intact Upon Receipt by Laboratory: Yes No
8. Contents Temperature Upon Receipt by Lab: ______ °C
9. Condition of Contents: ______

Date	Time	Sample ID/Description	Sample Type	No. Containers	Analysis Parameters	Remarks

CUSTODY TRANSFERS PRIOR TO SHIPPING

Relinquished by. (signed)	Received by (signed)	Date	Time
1			
2			
3			

SHIPPING DETAILS

Delivered to Shipper by: ______

Method of Shipment: ______ Airbill # ______

Received for Lab: ______ Signed. ______ Date/Time ______

Enseco Project No. ______

FIGURE 7-2

FIGURE 7-3

Page ________ of ________
File Index ________

Enseco

INTERLABORATORY ANALYSIS

SHIP TO: *(circle one)*

CAL ERCO CLE GAS MAR HOU

Attention:

SEND RESULTS TO:
Rocky Mountain Analytical Laboratory
4955 Yarrow Street
Arvada, CO 80002
(303) 421-6611 FAC: (303) 431-7171
Attention:

CLIENT NAME

PROJECT NO.

Relinquished by: *(Signature)* Received by: *(Signature)* Date Time

Relinquished by: *(Signature)* Received by: *(Signature)* Date Time

Import ab ID	Enseco ID	Client ID	Matrix (a, s, w)	Date Sampled	Date Rec'd	Date Auth.	Analysis Requested/ P.L. Item #	Sample Condition Upon Receipt

a. Written results required by (date): ________________ Verbal results required by (date): ________________

b. QC: ☐ Standard Enseco ☐ CLP Protocol ☐ Project-Specific ________________

c. Sample Disposal: ☐ Enseco ☐ Return to Client ☐ Phone RMAL

d. Raw Data Copies Needed: ☐ Yes ☐ No

e. Detection Limits: ☐ Standard Product ☐ Other*

f. Holding Times: ☐ Enseco ☐ EPA-CLP ☐ Other*

g. *Special Instructions: ____

h. Intercompany Rebate: *(circle one)* 0% 5% 10% i. P.O. Number ________________

APPENDIX E

DOCUMENT CONTROL AND THE EVIDENTIARY FILE

DOCUMENT CONTROL AND THE EVIDENTIARY FILE
SYSTEM FOR BLACKWELL LANDFILL SITE

ACCOUNTABLE DOCUMENTS

Accountable documents will include all logbooks, field data records, correspondence, sample tags, graphs, chain-of-custody records, and other sample documentation forms used, original data including laboratory bench sheets, photographic prints and planning documents.

FILE STRUCTURE

Documents will be arranged in the evidentiary file using the format attached.

LOGGING OF DOCUMENTS

Documents will be received by the Document Control Officer who will log them and assign a number to each such that documents within each document subclass are separately serialized. An exception to this will be sample tags, chain-of-custody forms or other documents that are numbered prior to assignment for use.

DOCUMENT ACCESS

Project documents will be secured in a separate, locked file cabinet. Access will be limited by the Document Control Officer to project personnel. A check-out log will be maintained as a record of access.

EVIDENCE FILE AUDIT

Upon project completion, the Warzyn Quality Assurance Officer will audit the evidence file for completeness. Results of the audit will be documented on the attached form and kept in the Final Evidence file.

FINAL DISPOSITION OF FILE CONTENTS

The Final Evidence file will be maintained by Warzyn as described in Section XXII, Record Preservation, of the Consent Order. The file will be maintained during the Pendancy of the Consent Order and for a minimum of five years after its termination. The PRP shall notify the U.S. EPA in writing within thirty (30) calendar days prior to the destruction of such documents at the end of the five year period.

CAW/caw/PJV

[05/24/89]

PROJECT SINGLE-FILE STORAGE SYSTEM - FILE CHECKLIST SHEET

CATEGORY	FILE	COMMENTS	REQUIRED CATEGORIES[1,2]
File Index		List of all files: copy of this sheet is acceptable	X
Contracts/Proposals/Bids	A	Proposals, contracts, purchase orders, specifications-COPIES ONLY	X
Financial	B	Summary of invoice status: invoices correspondence re: accounts receivable: copy of budget and project task setup; COPIES ONLY	X
Correspondence	C	Various incoming and outgoing letters, memorandums, diary notes.	
		C1-All inhouse correspondence; diary notes and memos	X
		C2-All outgoing letters/memos	X
		C3-All incoming correspondence	X
		C4-Telephone conversation records	X
		C5-Chronological file - all correspondence	
		C6-Miscellaneous	
Planning Documents	D	Documents other than proposals: Health and Safety plans, Sampling plans, QAPPs, permit plans; special instructions/outlines for conducting the project; Work Plans; WEI plans and specifications	X
Quality Assurance	E	A work plan and budget; project history file; etc.	X
Field Data	F	Original field data/notebooks	X
		F1-Field boring logs	
		F2-Well construction details	
		F3-Geotechnical testing	
		F4-Geophysical testing	
		F5-Water Quality testing and water level measurements	
		F6-Daily field logs	
		F7-Baildown testing	
		F8-Structural testing	
		F9-Miscellaneous/Other	
		F10-Surveying/Warzyn Field Reports/Notebooks	

WARZYN

PROJECT SINGLE-FILE STORAGE SYSTEM - FILE CHECKLIST SHEET

(Continued)

CATEGORY	FILE	COMMENTS	REQUIRED CATEGORIES[1,2]
Laboratory Data	G	Laboratory test data: chemical, geotechnical, materials: original data and quality control data G1-Analytical laboratory data G2-Geotechnical laboratory data G3-Materials testing laboratory data G4-Subcontracted laboratory data	X
Calculations	H	Calculations, quantity estimates, computer printouts of tabularized data; sets of data should be bound separately	X
Photographs/Maps	I	Photographs, stereo pairs, site maps (published), zoning, topography, geology, groundwater, bedrock, negatives	X
Originals	J	Warzyn original reports or drafts	X
Warzyn Reports	K	Copies of the project report or previous pertinent WEI reports	X
Warzyn Drawings	L	Reference list of report drawings; copies or reduced copies of original drawings. Note: original or reduced mylars will be stored separately	X
Other Reports/Drawings	M	Non-Warzyn reports and drawings	X
Miscellaneous	N	Other file information which does not fit into other categories; file must be named.	X
Checkprint	O	TEMPORARY FILE of checkprints, draft reports or other work in progress. File must be removed upon job completion.	X

---

[1] Main file categories indicated with an X are standard on all projects, but will not be set up by Records until category-specific data is generated.

[2] Subcategories may be established by the Project Manager on a project-specific basis (e.g., Superfund projects).

SS/kjw/KEB/DWH
[ckb-400-98]

WARZYN

DOCUMENT AUDIT CHECKLIST*

PROJECT NO. ______________________ DATE OF AUDIT ______________

PROJECT LOCATION __________________ SIGNATURE OF AUDITOR __________

FILE LOCATION _____________________

Yes__ No__ 1. Have individual files been assembled (field investigation, laboratory, other)?

Comments:____________________________________

____

____

Yes__ No__ 2. Is each file inventoried?

Comments:____________________________________

____

____

Yes__ No__ 3. Is there a list of accountable documents?

Comments:____________________________________

____

____

Yes__ No__ 4. Are all accountable documents present or accounted for?

Comments:____________________________________

____

____

---

* From NEIC Procedure Manual for the Evidence Audit of Enforcement Investigations by Contractor Evidence Audit Teams, EPA-300/9-81-003-R, April, 1984.

Yes__ No__ 5. Is a document numbering system used?

Comments:______________________________

____

____

Yes__ No__ 6. Has each document been assigned a document control number?

Comments:______________________________

____

____

Yes__ No__ 7. Are all documents listed on the inventory accounted for?

Comments:______________________________

____

____

Yes__ No__ 8. Are there any documents in the file which are not on the inventory?

Comments:______________________________

____

____

Yes__ No__ 9. Is the file stored in a secure area?

Comments:______________________________

____

____

Yes__ No__ 10. Are there any project documents which have been declared confidential?

Comments:______________________________

____

____

Yes__ No__ 11. Are confidential documents stored in a secure area separate from other project documents?

Comments:______________________________

____

____

Yes__ No__ 12. Is access to confidential files restricted?

Comments:______________________________

____

____

Yes__ No__ 13. Have confidential documents been marked or stamped "Confidential"?

Comments:______________________________

____

____

Yes__ No__ 14. Is confidential information inventoried?

Comments:______________________________

____

____

Yes__ No__ 15. Is confidential information numbered for document control?

Comments:______________________________

____

____

Yes__ No__ 16. Have any documents been claimed confidential under TSCA?

Comments:______________________________

____

____

APPENDIX F

INTERNAL FIELD INVESTIGATIONS AND LABORATORY AUDIT PROCEDURES

APPENDIX F-1

INTERNAL AUDIT PROCEDURES FOR FIELD METHODS

INTERNAL FIELD INVESTIGATIONS AUDIT

This describes a procedure for auditing activities performed during field investigations or remedial actions. The audit addresses the adherence to procedures documented in project plans. These plans may include the project Work Plan, Sampling Plan, Quality Assurance Project Plan and Health and Safety Plan.

WORK ASSIGNMENT

The Warzyn Quality Assurance Manager (QAM) will schedule each audit performed. Audits may be performed by the QAM or by personnel under his/her direction. Audits may be announced or unannounced.

AUDIT PREPARATION

The auditor will review project plans, standard operating procedures, safety plans, or other pertinent project documents for background information. Equipment that may be required for the audit, including safety equipment, will be obtained for use during the audit. The Warzyn Project Manager will be informed that the audit is to take place in order for the auditor to obtain updated information on site conditions.

ON-SITE AUDIT

A briefing is scheduled with the sampling team prior to initiating the audit. The auditor shall briefly describe the audit process and obtain updated information on the field tasks. The audit is the evaluation of adherence to project planning documents and of sample identification and control, chain-of-custody procedures, field documentation, security of evidence and sampling operations. The evaluation is based primarily on the project planning documents.

The auditor will maintain a record of all activities performed during the audit, which may include logbooks, work papers and checklists. The checklists are attached. The auditor must accurately track the dates and times of audit activities and the document numbers that have been reviewed. Included in the record will be the project codes, project location, identification of the investigators assigned to the project and auditor's name. The checklists must be completed in their entirety and any other pertinent information should be recorded in the "comments" section.

Sample Control

The field audit addresses handling of samples from time of collection through shipping or delivery to the performing laboratory. A sample is typically identified as to the location, date, time and name of person collecting it. A sample tag is used for this purpose. Samples are also typically listed in a Chain-of-Custody record. The auditor should evaluate adherence to sample documentation and control procedures outlined in the project planning documents.

Data from on-site measurements and observations made by field personnel are typically recorded directly into a field logbook or field data record. The auditor should observe this activity or the results.

Sample Tag

Samples are removed from the sample location and transferred to a laboratory or other location for analysis. Before removal, however, each is preserved in accordance with prescribed procedures and the sample is identified with a sample tag. The information recorded in the sample tag typically includes:

Project Code	- An assigned number
Station Number	- A two-digit number assigned by the Project Leader and listed in the project Plan
Date	- A six-digit number indicating the year, month and day of collection
Time	- A four-digit number indicating the clock time of collection, for example: 0954.
Station Location	- The sampling station description, as specified in the project plan

Samplers	- Each sampler's name is listed
Tag number	- A unique serial number is stamped on each tag
Remarks	- The samplers record of pertinent observations

The sample tag contains an appropriate place for designating the sample as a grab or composite and identifying the type of sample collected for analysis. The sample tags are securely attached to each sample.

After collection, separation, identification and preservation, the sample is typically maintained under chain-of-custody procedures. If the composite or grab sample is to be split, it is aliquoted into similar sample containers. Identical information is recorded on the tag of each split. This identifies the split sample for the appropriate government agency, facility, laboratory or company. In a similar fashion, tags on blank or duplicate samples are marked "Blank" or "Duplicate," respectively, unless otherwise directed.

The auditor will examine a selected number of sample tags for completeness and accuracy. The auditor will determine if the station number and location are identified; the date and time collected are indicated; the type of sample and analysis are specified, the preservative, if used, is identified, and the sampler('s) signature(s) appear on the tag. The auditor will also determine if the station location accurately identifies where the sample was taken and that the sampling methods used were as specified in the project planning documents.

Chain-of-Custody Record

Possession of samples collected during investigations typically must be traceable from the time collected until introduced as evidence in legal proceedings. Chain-of-Custody Records are used for this purpose.

A sample is in your custody if the following criteria are met:

1. It is in your possession; or

2. It is in your view, after being in your possession; or

3. It was in your possession and then locked up to prevent tampering; or

4. It was in your possession and then transferred to a designated secure area.

The auditor will select a predetermined number of Chain-of-Custody records to be audited in the field. The records must be reviewed to determine if the station number and description correspond to the sample tag, if the date and time correspond, if the parameters to be analyzed have been properly identified, and if all custody transfers have been documented and the date and time of transfer recorded.

The auditor will also determine if samples are kept in custody at all times and are handled to prevent tampering. Sampling equipment should also be checked for security and to detect tampering.

Traffic Forms

If samples are analyzed under the Contract Laboratory Program (CLP), Organics and Inorganics Traffic Report forms must also be used. The Organic and Inorganic Traffic Reports are to be executed by the field sampling team and are subject to audit as are the previously discussed documents. This portion of the audit is to observe that the information recorded on the forms is correct and that it coincides with the information on the sample tags and on the Chain-of-Custody Record.

Field Documentation

Observations and measurements during field investigations must be recorded in bound logbooks. These records are intended to provide sufficient data and observations to enable participants to reconstruct events that occurred during the project and to refresh the memory of the investigators, if called upon to give testimony during legal proceedings.

Logbooks: Project logbooks will be reviewed by the auditor during the field investigation audit to see that each is signed and entries are dated. Logbook entries must be legible, written in ink and contain accurate and inclusive documentation of an individual's project activities. Because the logbook forms the basis for reports written later, it must contain only facts and observations. Language should be objective, factual and free of personal feelings or other terminology which might prove inappropriate. Pertinent information should be recorded in these logbooks from the time each individual is assigned to the project until the project is completed. Entries made by individuals other than the person to whom the logbook was assigned must be dated and signed by the individual making the entry.

Photographs: The auditor will review field logbooks to determine if photographs taken are properly documented. When movies, slides or photographs are taken which show sampling sites or provide other documentation, they are numbered to correspond to the logbook entries. The name of the photographer, date, time, site location and site description are entered sequentially in the logbook as photos are taken.

Corrections to Documentation: As previously noted, unless prohibited by weather conditions, original data recorded in logbooks, sample tags, custody records and other data sheet entries are written with waterproof ink. None of the documents listed above are to be destroyed or thrown away, even if they are illegible or contain inaccuracies which require a replacement document.

If an error is made on a document, the individual may make corrections simply by drawing a line througn the error and entering the correct information. The erroneous information should not be obliterated.

Sampling Operations

The auditor will review sampling operations to determine if they are performed as stated in project planning documents. The proper number of samples should be collected at the assigned locations. The auditor will check to determine that the samples are in prescribed containers and are preserved in accordance with project plans. The auditor will determine if the required field measurements and quality assurance checks are performed and documented as directed.

A closing briefing shall be held with the field team leader to verbally review observations. Unresolved problems will be discussed with the Warzyn Project Manager and Quality Assurance Manager.

Reporting

A written audit report is submitted to the Warzyn QAM after completion of the audit. The report shall include copies of checklists. A copy of the report will be given to the Warzyn Project Manager and will become part of the project file.

RCW/bcn/DWH
[bcn-800-70]

FIELD CHECKLIST

Briefing with Project Manager

SIGNATURE OF AUDITOR ____________________ DATE OF AUDIT ______________

PROJECT MANAGER ________________________ PROJECT NO. ______________

PROJECT LOCATION ____

TYPE OF INVESTIGATION ____
(authority, agency)

Yes__ No__ N/A__ 1. Was a project plan prepared? If yes, what items are addressed in the plan?

____

____

____

Yes__ No__ N/A__ 2. Were additional instructions given to project participants (i.e., changes in project plan)? If yes, describe these changes.

____

____

____

Yes__ No__ N/A__ 3. Is there a written list of sampling locations and descriptions? If yes, describe where documents are.

____

____

____

Yes__ No__ N/A__ 4. Is there a map of sampling location? If yes, where is the map?

____

____

____

Yes__ No__ N/A__ 5. Do the investigators follow a system of accountable documents? If yes, what documents are accountable?

____

____

____

FIELD CHECKLIST

Field Observations

Yes__ No__ N/A__ 1. Are the number, frequency and types of field measurements and observations taken as specified in the project plan or as directed by the project manager? If yes, where are they recorded?

Yes__ No__ N/A__ 2. Are samples collected in the types of containers specified for each type of analysis? If no, what kind of sample containers were used?

Yes__ No__ N/A__ 3. Are samples preserved as required? If no or N/A, explain.

Yes__ No__ N/A__ 4. Are the number, frequency and types of samples collected as specified in the project plan or as directed by the project manager? If no, explain why not.

Yes__ No__ N/A__ 5. Are samples packed for preservation when required (i.e., packed in ice, etc.)? If no or N/A, explain why.

Yes__ No__ N/A__ 6. Is sample custody maintained? How?

FIELD CHECKLIST

Document Control

Yes__ No__ N/A__ 1. Have unused and voided accountable documents been returned to the coordinator by the team members?

Yes__ No__ N/A__ 2. Were any accountable documents lost or destroyed? If yes, have document numbers of lost of destroyed accountable documents been recorded and where are they recorded?

Yes__ No__ N/A__ 3. Are samples identified with sample tags? If no, how are samples identified?

Yes__ No__ N/A__ 4. Are sample tags completed (e.g., station no., location, date, time, analyses, signatures or samples, type, preservatives, etc.)? If yes, describe types of information recorded.

Yes__ No__ N/A__ 5. Are samples collected listed on a chain-of-custody record? If yes, describe the type of chain-of-custody record used and what information is recorded.

Yes__ No__ N/A__ 6. If used, are the sample tag numbers recorded on the chain-of-custody documents?

Yes__ No__ N/A__ 7. Does information on sample tags and Chain-of-Custody Records match?

Yes__ No__ N/A__ 8. Does the Chain-of-Custody Record indicate the method of sample shipment?

Yes__ No__ N/A__ 9. Is the Chain-of-Custody Record included with the samples in the shipping container?

Yes__ No__ N/A__ 10. If used, do the sample traffic reports agree with the sample tags?

Yes__ No__ N/A__ 11. If used, are blank samples identified?

Yes__ No__ N/A__ 12. If collected, are duplicate samples identified on sample tags and Chain-of-Custody Records?

Yes__ No__ N/A__ 13. If used, are spiked samples identified?

Yes__ No__ N/A__ 14. Are logbooks signed by the individual who checked out the logbook from the project coordinator?

Yes__ No__ N/A__ 15. Are logbooks dated upon receipt from the project coordinator?

Yes__ No__ N/A__ 16. Are logbooks project-specific (by logbook or by page)?

Yes__ No__ N/A__ 17. Are logbook entries dated and identified by author?

Yes__ No__ N/A__ 18. Are photographs documented in logbooks (e.g., time, date, description of subject, photographer, etc.)?

Yes__ No__ N/A__ 19. If film from a self-developing camera is used, are photos matched with logbook documentation?

Yes__ No__ N/A__ 20. Are sample tag numbers recorded? If yes, described where they are recorded.

Yes__ No__ N/A__ 21. Are calibration of pH meters, conductivity meters, etc., documented? If yes, describe where this is documented.

Yes__ No__ N/A__ 22. Are amendments to the project plan documented? If yes, describe where the amendments are documented.

FIELD CHECKLIST

Debriefing with Project Manager

Yes__ No__ N/A__ 1. Was a debriefing held with project manager and/or other participants?

____

____

____

Yes__ No__ N/A__ 2. Were any recommendations made to the project participants during the debriefing? If yes, list recommendations?

____

____

____

____

____

____

____

____

____

____

____

____

APPENDIX F-2

INTERNAL AUDIT PROCEDURES FOR LABORATORY METHODS

WARZYN

INTERNAL AUDITS

Scope:

Internal audits are performed on a quarterly basis. The auditor reviews each area of the laboratory using the attached check list. The quality assurance specialists are responsible for auditing and they report to the director of Technical Services. The auditor prepares a final audit report summarzing their findings and fowards the report to the laboratory manager. The laboratory manager informs upper management of the contents of the audit report, and outline plans to address recommendations or deficiencies.

BLH/rff/KDF

[rff-SOPs-99]
99198.20

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University Research Park
PO Box 5385
Madison, Wisconsin 53705
(608) 273-0440

LABORATORY CHECKLIST

Yes__ No__ 1. Is there a laboratory procedures manual?

Comments:____

____

Yes__ No__ 2. Is there a laboratory quality control procedure?

Comments:____

____

Yes__ No__ 3. Is there a person who reviews that QC and QA in the lab (i.e., QC Officer)?

Comments:____

____

Yes__ No__ 4. Is there a procedure for the development and review of laboratory procedures?

Comments:____

____

Yes__ No__ 5. Are procedures updated/reviewed at a set interval?

Comments:____

____

Yes__ No__ 6. Is the procedure status log current?

Comments:____

____

Yes__ No__ 7. Is there documentation that each analyst has read and understood each procedure that is applicable to their job requirements?

Comments:____

____

Yes__ No__ 8. Is there a documentation system that records the analyst's proficiency in the manipulation of laboratory equipment and techniques required in analyses, and that he is knowledgeable and skilled in performing the analyses for which he is responsible?

Comments:____

____

Yes__ No__ What is the system?

Comments:____

____

Yes__ No__ 9. Is there a written training procedure for new analysts?

Comments:____

____

Yes__ No__ 10. Does the laboratory have QC charts for each parameter for each type of control sample?

a. Duplicate
b. Split
c. Spiked
d. Preservative blanks

Comments:____

____

Yes__ No__ 11. Are the QC chart limits ± 2SD for warning limits; x ± 3SD for control limits?

Comments:____

____

Yes__ No__ 12. Are replicate analyses (7) run annually for all parameters?

a. Precision
b. Accuracy

Comments:____

____

Yes__ No__ 13. Are charts current?

Comments:____

____

Yes__ No__ 14. The percent of laboratory resources devoted to QC and QA is:

a. 0 - 5%
b. 5 - 10%
c. 10 - 20%
d. >20%

Comments:____

____

Yes__ No__ 15. Does the laboratory participate in any "round robin" split and/or performance sample programs?
Note: List and indicate results.

Comments:____

____

Yes__ No__ 16. Are externally prepared performance standards obtained from the EPA analyzed yearly for each parameter?
List.

Comments:____

____

Yes__ No__ 17A. Is there a written procedure for cleaning sampling equipment and containers?

Comments:____

____

Yes__ No__ 17B. Does this procedure include the collection of blank samples from collection equipment to assure/document that equipment will not contaminate samples?

Comments:____

____

Yes__ No__ 17C. Are blank samples collected routinely from cleaned sample containers to assure/document efficiency of cleaning?

Comments:____

____

Yes__ No__ 18. Is there a procedure for data reporting?

Comments:____

____

Yes__ No__ 19. Do the final data reports indicate if there were variations in the parameter-specific holding times?

Comments:____

____

Yes__ No__ 20. Is there a written procedure for:

a. Significant figures?
b. Rounding off?
c. Calculation rounding?

Comments:____

____

Yes__ No__ 21. Are data and laboratory records kept for a specified length of time (i.e., NPDES: 3 years)?

Comments:____

____

Yes__ No__ 22. Are log books:

a. bound?
b. pages numbered?
c. dated and signed?
d. reviewed?

Comments:____

____

Yes__ No__ 23. Are laboratory notebooks:

a. properly stored?
b. properly labelled?
c. complete/accurate?

Comments:____

____

Yes__ No__ 24. Are the field data logbooks complete and current?

Comments:______________________________

____

Yes__ No__ 25. Are the receiving logbooks complete and current?

Comments:______________________________

____

Yes__ No__ 26. Are calibration reagents of unimpeachable purity and product quality as required by each analysis?

Sources List (NBS)

a. weights
b. certified thermometers
c. filter, etc.

Comments:______________________________

____

Yes__ No__ 27. Is there a procedure to assure that reagents and chemicals Reagent blanks, method blanks checked 100% against specification quality?

Comments:______________________________

____

Yes__ No__ 28. Are NBS standard reference N/A to most environmental analyses materials used as a routine part of calibration and QC program?

Comments:______________________________

____

Yes__ No__ 29. Are chemicals properly stored to assure quality?

Comments:______________________________

____

Yes__ No__ 30. Are there written requirements for all analytical instruments for:

a. daily warmup?
b. standardization?
c. calibration?
d. optimization procedures
e. maintenance?
f. documentation (logs)?
g. replacement, cleaning, checks, adjustment by laboratory staff and/or service personnel?

Yes__ No__ 31A. Is there a written calibration procedure for all measuring and test equipment?

B. Does this procedure specify use criteria?

C. Are calibration standard, reagents, and accessory equipment listed?

D. Does the procedure specify the documentation used in maintenance logbook?

Comments:____

____

Yes__ No__ 32. Are all instruments tagged with date of last calibration, calibrator, and due date for next calibration?

Comments:____

____

LABORATORY CUSTODY AND DOCUMENTATION CHECKLIST

SIGNATURE OF AUDITOR ________________ DATE OF AUDIT ________________

LABORATORY ________________

LABORATORY LOCATION ________________

PROJECT IN EFFECT ________________

1. Name of Sample Custodian and other personnel responsible for sample receipt and document control.

   ____

   ____

2. Where are the Sample Custodian's procedures and responsibilities documented?

   ____

   ____

3. Where are written Standard Operating Procedures (SOPs) pertaining to receipt of samples documented (laboratory manual, written instructions, etc.)?

   ____

   ____

4. Where is the receipt of Chain-of-Custody Record(s) with samples being documented?

   ____

   ____

5. Review sample receipt documentation to assure that the nonreceipt of Chain-of-Custody record(s) with samples being documented.

   ____

   ____

6. Where is the integrity of the shipping container(s) being documented (custody seal(s) intact, container locked or sealed properly, etc.)?

   ____

   ____

7. Review the sample receipt documentation to assure that the lack of integrity of the shipping container(s) is being documented (i.e., evidence of tampering, custody seals broken or damaged, locks unlocked or missing, etc.)?

____

____

8. Determine by asking the Sample Custodian or reviewing the laboratory SOP manual, if agreement among forms, Chain-of-Custody records, and sample tags is being verified? State source of information.

____

____

9. Where is the agreement or nonagreement verification (#8) being documented?

____

____

10. Review sample receipt documentation to assure that sample tag numbers are recorded by the Sample Custodian?

____

____

11. Where are written Standard Operating Procedures (SOPs) pertaining to sample storage documented (laboratory manual, written instructions, etc.)?

____

____

12a. Do written SOPs and actual laboratory practices demonstrate laboratory security?

____

____

12b. Describe sample storage area (upright refrigerator in GC lab, walk-in cooler in sample receiving area, etc.).

____

____

13. How is sample identification maintained?

____

____

14. How is sample extract (or inorganics concentrate) identification maintained?

____

____

15. How are samples that require preservation stored to maintain their preservation?

____

____

16. Are written Standard Operating Procedures (SOPs) pertaining to sample handling and tracking documented?

____

____

17. What laboratory records are used to record personnel receiving and transferring samples in the laboratory?

____

____

18. Affirm that each instrument used for sample analysis (GC, GC/MS, AA, etc.) has an instrument log? List those instruments which do not.

____

____

19. Determine where analytical methods are documented and ask if methods are available to the analysts?

____

____

20. Determine where quality assurance procedures are documented and ask if procedures are available to the analysts?

____

____

21. How are written Standard Operating Procedures (SOPs) for compiling and maintaining sample document files documented?

22. How are sample documents filed (by project number, internal laboratory number, batch number, sample number, etc.)?

23. Review sample document files to determine if a document file inventory is prepared for each project file.

24. Review sample document files to determine if all documents in the case files are consecutively numbered according to the file inventories.

25. Observe the document file storage area to determine if the laboratory document files are stored in a secure area.

26. Has the laboratory received any confidential documents?

Complete questions 27, 28 and 29 <u>ONLY</u> if the response to question 26 was <u>yes</u>.

27. Review the project files to assure that confidential documents are segregated from other laboratory documents.

28. Review the project files to assure that confidential documents are stored in a secure manner.

29. Review recommendations from the previous audit to determine if the recommendations have been implemented. If not, the recommendations should be repeated and the laboratory director and the Project Officer should be notified.

____

____

10.0 Corrective Action

10.1 Introduction

Generally, there are two types of corrective actions that may be required when data quality falls below specified limits. The first type, and the simplest to implement and document, is corrective action required because routine data quality assessments are out-of-control. Surrogate and spike standard recoveries, relative percent differences between duplicates, internal standard response variations, and unacceptable blank contamination are some of these assessments in the first category. These are all performed on a sample-by-sample and/or batch basis, and corrective action is limited to evaluating the data with respect to SOP criteria, and accepting or rejecting the sample/batch. The decision that is made is clearly indicated on analytical worksheets, and unless a trend is observed during the course of data validation, additional corrective action or documentation is not necessary.

The second type of corrective action is that required when other, more global QC/QA assessments, are made. The assessments might typically indicate systematic deficiences or those affecting data useability for more than one batch (i.e., glassware contamination checks, standards preparation errors, etc.). In most cases, assessments of this nature are made by reviewing peripheral QC/QA documentation, observing procedures for comparison with SOPs or GLPs, or receiving feedback from data reviewers, management or those external to the organization (clients, auditors).

The following sections describe the QA reporting and feedback channels designed to ensure that early and effective corrective action is taken in such instances.

In many cases, depending on the nature of the deficiency and the urgency for remedial action, a Corrective Action Report (following this section) will be completed. The report serves to document the deficiency, the required corrective action, and accountability for the action.

For observations made over longer periods of time, the QA Department issues formal summary reports to management on a monthly or quarterly basis. Following is a brief discussion of the types of reports issued to management to assess the overall effectiveness of the QA Program and to reinforce the application of Good Laboratory Practices (GLPs).

CORRECTIVE ACTION REPORT

DATE:____________

PROBLEM / DEFICIENCY:

IDENTIFIED BY: ______________________________

REFERRED TO: ______________________________ (QA)

CORRECTIVE ACTION TO BE TAKEN: TARGET DATE:____________

FOLLOW-UP AUDIT FINDINGS:

RESOLVED? ________ DATE: ____________

SOP REQUIRED TO BE WRITTEN/MODIFIED? YES [ ] NO [ ] TARGET DATE:________

This form to be filed with the Quality Assurance Clerk for permanent record.

10.2 Routine QC Check Reports

The following routine quality control checks (also discussed in section 9.2 of the QA Plan) are performed to verify that samples are not contaminated during transportation, preparation, analysis or storage, and that standards prepared internally are traceable to certified sources.

-- Vendor-Supplied Glassware Checks
-- Glassware Decontamination Checks
-- Water Purification Systems Checks
-- Glassware Storage Cabinet Checks
-- Refrigerated Storage Systems Checks
-- Reagent Purity Checks
-- Standards Prepartion and Traceability Checks

The criteria for these QC checks and corrective action steps are detailed in the QA SOP Manual. Results are tabulated and/or plotted on control charts, and records reviewed by the QA staff. A series of quarterly reports to management summarize this information and the status of these programs.

10.3 Monthly QA Activity Reports

These reports are produced by all members of the QA staff, and summarize key QA activities during the previous month. The reports are distributed to the Director of QA, and are provided as an attachment and referenced in the Director's report to the CEO, the Executive Staff and senior laboratory management.

Included in these reports is a summary of significant quality problems observed during the period, and the corrective actions taken to remove deficiencies. The report stresses proactive measures that are being taken to improve quality or ensure compliance with QA program requirements.

Laboratory management uses the report to quantitatively measure monthly performance in terms of the number of samples processed, the frequency of repeated sample analyses due to unacceptable QC performance, and the cause of the unacceptable performance. These data are all presented in tables, Pareto control charts or attribute control charts, based on the characterization of each analysis in the Computerized Laboratory Management System (CLMS) using a system of analytical "condition codes."

The Condition Code System is used to monitor sources of data failures. Condition code definitions are provided in an SOP to data generators and reviewers who are responsible for assigning the appropriate code to each analysis (see Appendix D). Each two-letter code is used to characterize the cause of a sample failure or the final status of the data package prior to release to the client.

Various computer programs may be used to sort condition code data according to sample matrix and method. This system is used to pinpoint sources of error, provide feedback to management, reinforce good laboratory practices, and document laboratory performance over time. The QA staff also note in the Monthly QA Activities Report any corrective actions taken or necessary procedural changes, based on the application of condition codes.

Other items included in this report are:

-- Summary of any changes in certification/accreditation status

-- Involvements in resolution of quality issues with clients or agencies

-- QA organizational changes

-- Notice of the distribution of revised documents controlled by the QA Department (i.e., SOPs, QA Plan)

-- Training and safety issues, if not already covered in audit reports during the period

-- Performance of subcontractor laboratories (also communicated in separate, detailed subcontractor audit report to management)

-- Positive feedback for acceptable performance on interlaboratory or intralaboratory tests or successful completion of audits.

10.4 Laboratory Performance Reports

This quarterly report presents a statistical and graphical summary of the laboratory's performance on batch-associated quality control samples analyzed over the period. Included are tables, Shewhart control charts and I-charts (for individual data points) for all surrogate and spike standard recoveries. Additionally, a monthly report to the Director of QA presents control charts and tables for all Laboratory Control Sample (Blank Spike) and Blank recoveries. The charts and tables are used primarily to document historical performance, update recovery control limits, and monitor long-range trends that might not be apparent to data reviewers evaluating data on a sample/batch basis.

10.5 Laboratory Audit Reports

Quarterly audit reports are written by a member of the QA staff and distributed to management, and summarize the results of internal laboratory Performance Audits, Systems Audits and Security/Access Audits. When external auditors are involved in Performance or System Audits, a report is written within the next week by the QA staff member coordinating the audit. The report, summarizing audit results as discussed in the debriefing as well as other observations, is distributed to the CEO and senior lab management. The report includes corrective actions required as a result of the audit, and a schedule for implementation. A follow-up audit, usually within three weeks of the distribution of this report, is conducted to verify that corrective actions have been implemented.

Performance Audits

Performance Audits are checks made by a QA staff member or other independent auditors to evaluate the quality of the data produced by the analytical system. These audits are performed independent of an in addition to routine quality control checks, and reflect as closely as possible lab performance under normal operating conditions.

These audits involve the review of approximately 10% of all analytical data reports generated by the lab for calculation and data validation procedures, and overall data quality. Errors observed during the audit are characterized as "critical" or "correctable" and tabulated. If necessary, based on audit findings, an amended data report may be sent to the customer. Following this section is a copy of the QA Audit Summary used by auditors to tabulate the data for summary into the Quarterly Performance Audit report. A thorough discussion of these audits is included in the QA SOPs. The reports are used by laboratory managers to provide feedback to staff members and establish goals for improved performance.

A number in interlaboratory and intralaboratory tests are conducted routinely at CompuChem©, and the results are included in individual Performance Audit reports specific to each test. When new methods are available to the laboratory or new personnel are being trained, Laboratory Proficiency Tests are performed. These tests consist of quadruplicate blank spikes, containing a full complement of tests parameters to be analyzed by the method. The replicate results are analyzed by a QA staff member, who generates a summary report to the Director of QA. This report includes the standard deviation and mean recovery for each of the replicate parameters, and the data are used to statistically validate method and/or personnel proficiency. For a thorough discussion of the method validation procedures used, refer to Appendix A of the QA Plan.

On a quarterly basis, blind intralaboratory check samples are introduced into the system by the QA Department. Parameters and methods are chosen for these studies based upon independent (interlaboratory) tests from certifying agencies (including the U.S. EPA and various state agencies), Laboratory Proficiency Test results, Method Validation studies, or results from routine batch-related QC samples. The existence of these check samples in the system is known only to those personnel involved in preparing the samples and scheduling the analytical requirements into the CLMS. A thorough report, detailing the entire data generation and support functions, is completed by the QA staff and reviewed by the Director of QA before distribution to the CEO and senior laboratory management.

CompuChem® also participates in a number of external, interlaboratory performance studies. These are required as part of various agencies' certification/accreditation programs. As a member of the USEPA's Contract Laboratory Program (CLP), the laboratory is required to successfully analyze quarterly, blind proficiency samples for both organic and inorganic parameters. The CLP program also requires an annual on-site inspection by principals from the USEPA (and their contracted agents). These audits generally follow the same format described below, Systems Audits.

CompuChem® also participates in a number of state certification programs, including those for North Carolina, New Jersey, New York and Florida. All of these programs require the laboratory to submit to annual on-site inspections in order to maintain certification to perform testing on samples originating in the state. All states also require successful performance on interlaboratory check samples, submitted at least annually, though some reciprocity with the two NC programs (one for drinking water and one for wastewater certification) and USEPA-CLP is allowed under certain circumstances.

Several states utilize the laboratory's performance on the annual Water Supply (WS) and Water Pollution (WP) proficiency testing series, orginating out of the EPA Environmental Monitoring and Support Laboratory's performance on all interlaboratory and intralaboratory check samples, tabulated by parameter and method, so negative performance trends can be readily pinpointed.

System Audits

A System Audit is an on-site inspection and review of the QA Program for the total laboratory. While Performance Audits are a quantitative appraisal, System Audits are for the most part qualitative in nature. The System Audit may be either scheduled or unannounced before it is conducted, but occurs routinely on at least a quarterly basis. The auditor reviews the laboratories' SOPs to verify compliance with procedures and activities actually in place. Personnel and facilities are also evaluated during the System Audit. The auditor is required to investigate anything which seems in conflict with the QA Plan, the laboratory or QA SOPs, or Good Laboratory Practices.

If deficiencies are observed during a Performance Audit, and if deemed necessary, the QA Department initiates a System Audit. The audit emphasizes the actions necessary to correct deficiencies noted in the Performance Audit. A Corrective Action Report is completed, detailing all remedial actions taken, and reviewed by the Director of QA. The report must indicate the proposed implementation date and the individual(s) responsible for the action.

Many of the objectives of a routine System Audit are similar to those a client or independent auditor would hope to accomplish during an On-Site Laboratory Evaluation and Data Audit. These goals include ensuring the following:

1. The quality control, including necessary corrective actions , are being applied
2. Adequate facilities and equipment are available to perform the client's required scope-of-work
3. The personnel are qualified to perform the assigned tasks
4. Complete documentation is available, including sample chain-of-custody

12. PERFORMANCE AND SYSTEM AUDITS

Enseco laboratories participate in a variety of federal and state certification programs, (including the U.S. EPA CLP), that subject each of the laboratories to stringent system and performance audits on a regular basis. A <u>system audit</u> is a review of laboratory operations conducted to verify that the laboratory has the necessary facilities, equipment, staff and procedures in place to generate acceptable data. A <u>performance audit</u> verifies the ability of the laboratory to correctly identify and quantitate compounds in blind check samples submitted by the auditing agency. The purpose of these audits is to identify those laboratories that are capable of generating scientifically sound data. Enseco is certified to perform environmental analyses under programs administered by the U.S. EPA, U.S. Army, U.S. Navy, and over 15 states. The most current list of Enseco certifications is available upon request.

In addition to external audits conducted by certifying agencies or clients, Enseco regularly conducts the following internal audits:

- Quarterly systems audits conducted by the Divisional QA Director.
- Periodic (at least yearly) audits conducted by the Corporate QA Office.
- Special audits by the Divisional QA Director or Corporate QA Office when a problem is suspected.

Enseco laboratories also routinely analyze check samples as described below:

- Laboratory Control Samples (DCS, SCS, and method blanks) are analyzed at a frequency equal to at least 10% of the total number of samples analyzed (see Section 11).
- All Enseco laboratories participate in the analyses of EPA check samples provided under the Water Supply (WS) and Water Pollution (WP) Performance Evaluation Studies. The results of these PE samples are tabulated by the Corporate QA Office to identify performance trends within the Enseco laboratories.

- The majority of the Enseco laboratories are CLP labs and thus analyze organic and/or inorganic CLP PE samples on a quarterly basis. The results of these analyses are also tabulated and evaluated by the Corporate QA Office.
- The laboratories participate in multiple state certification programs (including New York, New Jersey and California) which require that PE samples be analyzed periodically.
- Blind check samples from an independent commercial firm are sent to the laboratories periodically by the Corporate QA Office. The frequency and type of samples sent is based on problem areas identified by evaluation of tabulated PE results.

The results of these check samples are used to identify areas where additional training is needed or clarification of procedures is required.

15. CORRECTIVE ACTION

When errors, deficiencies, or out-of-control situations exist, the QA program provides systematic procedures, called "corrective actions," to resolve problems and restore proper functioning to the analytical system.

Laboratory personnel are alerted that corrective actions may be necessary if:

- QC data are outside the acceptable windows for precision and accuracy;
- Blanks, DCS or SCS contain contaminants above acceptable levels;
- Undesirable trends are detected in spike recoveries or RPD between duplicates;
- There are unusual changes in detection limits;
- Deficiencies are detected by the QA department during internal or external audits or from the results of performance evaluation samples; or
- Inquiries concerning data quality are received from clients.

Corrective action procedures are often handled at the bench level by the analyst, who reviews the preparation or extraction procedure for possible errors, checks the instrument calibration, spike and calibration mixes, instrument sensitivity, and so on. If the problem persists or cannot be identified, the matter is referred to the laboratory supervisor, manager and/or QA department for further investigation. Once resolved, full documentation of the corrective action procedure is filed with the QA department. Corrective action documentation is routinely reviewed by the VP of QA.

APPENDIX G

DATA VALIDATION PROCEDURE FOR EVALUATING INORGANIC DATA

DATA VALIDATION PROCEDURE FOR EVALUATING INORGANIC DATA

Scope and Application:

This standard operating procedure (SOP) describes Warzyn's procedure for evaluating inorganic data according to procedures specified in a Quality Assurance Project Plan (QAPP). Each analytical procedure is specific to a project and is found or referenced in the QAPP. The reviewer must evaluate whether the procedure was adhered to and that the required Quality Control (QC) requirements were met as described in the QAPP and evaluate the usability of the data.

References:

1. Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses, Hazardous Site Evaluation Division, U.S. EPA, July, 1988 (or most current).

2. Statement of Work for Inorganics Analysis, U.S. EPA Contract Laboratory Program, SOW No. 788, July, 1988 (or most current).

3. Quality Assurance Project Plan (QAPP) containing the analytical procedures required for evaluation. Each QAPP is specific to a project.

Requirements:

1. It is recommended that the reviewer be familiar with the RAS Inorganics validation process (refer to the Validation Guidelines and Statement of Work above) prior to evaluating this data. The evaluation and action criteria described in this SOP are very similar to the RAS Inorganics validation process.

2. All completed validated data packages must include the following:

   a. Data Validation Narrative
   b. Validated Results; with data qualifiers added and pages stamped "VALIDATED".

NOTE: It is not necessary to include the raw data with the completed validated data package, since a copy of the raw data package already exists in the project file. Only include raw data if there are major concerns or deficiencies with the data set.

Procedure:

1. Screen the data package to see that the samples and analytes undergoing evaluation concur with what was requested on the "Request for Data Validation" form (refer to Figure 1). If discrepancies occur, contact the data management coordinator for clarification prior to continuing.

2. Review the QAPP and the specific analytical procedure for the analyte undergoing evaluation. They will contain:

   a. A summary of the method required and method reference,
   b. The applicable matrices and recommended hold times,
   c. An approximate number of samples and matrix,
   d. Special technical instructions,
   e. Required deliverables,
   f. Data Requirements (Detection Limits, Precision, etc.), and
   g. Quality Control Requirements.

3. The reviewer must evaluate the data according to the quality control criteria specified in the QAPP. The evaluation of each analyte, in most cases, will include a review of the following criteria:

   a. Methodology,
   b. Raw Data/Quality Control Deliverables,
   c. Detection Limits,
   d. Holding Times,
   e. Calibration (Initial and Continuing),
   f. Blanks (Calibration and Preparation),
   g. Laboratory Control Samples (EPA Reference Samples),
   h. Laboratory Duplicates,
   i. Matrix Spikes,
   j. Sample Result Verification,
   k. Field Duplicates,
   l. Other (as specified in the procedure),
   m. Overall Assessment for a Case.

4. Evaluate the data for the criteria above as follows:

A. METHODOLOGY

<u>Evaluation</u>
1. Examine the data to determine if the acceptable analytical methodology was used as indicated in the QAPP.

2. Determine if the analytical procedure was followed.

<u>Action</u>
1. If an acceptable analytical method was not used, contact the Project Manager. It is the Project Manager's responsibility to inform the reviewer to continue the validation process of the data as received, or to reject the data. In some cases reanalysis or

resampling may be required, however the decision is left up to the Project Manager. The Project Manager may require that the reviewer determine the "usability" of the data package as submitted prior to deciding what formal action should be taken.

2. If the analytical procedure was not followed as stated, use professional judgement in determining whether the data should be qualified as estimated or unusable.

B. RAW DATA/QUALITY CONTROL DELIVERABLES

Evaluation

1. The QAPP will specify what information should be submitted as part of the data package. Determine whether the data package submitted is complete as described in the QAPP. Usually the following will be required:
   - Method used,
   - Calibration/standardization information,
   - Bench records tabulating the order of analysis of samples, standards, blanks, duplicates and spikes with the resulting instrument readouts and final concentrations. Records submitted should be complete enough such that all results could be recalculated from this raw data.
   - Photocopy of all instrument readouts (strip charts, printer tapes, etc.)
   - Reference (QC) samples to be identified by source, lot number and sample number, with corresponding true values and 95% confidence limits provided.
   - Custody records

Action

1. If the data package is not complete, contact the data management coordinator. The data management coordinator will contact the appropriate laboratory or project manager and obtain the information necessary to complete the evaluation process.

C. DETECTION LIMITS

Evaluation

1. Evaluate whether the detection limits required in the QAPP were achieved by the method used.

Action

1. If detection limits were not reported at least to what was required in the QAPP, review the raw data to determine if the detection limits were achievable. If they were, recalculate the data and report results to the required detection limits.

2. If detection limits were not achievable by the laboratory, determine why (laboratory sensitivity problem or detection limits unobtainable for the method used. Inform the project manager of

the situation. The project manager will determine whether the evaluation should be completed.

D. HOLDING TIMES

Evaluation

1. Determine whether the established holding times were met. The holding time is established by comparing the DATE SAMPLED with the DATE OF ANALYSIS found on the raw data. Required hold times should be noted in the QAPP.

2. Examine the digestion/distillation logs to determine if samples were preserved at the proper pH.

Action

1. If hold times were not noted in the QAPP, use the EPA-recommended hold times and apply these hold times to both water and soil samples.

2. If holding times and preservation criteria are not met, qualify all results $>$ Instrument Detection Limit (IDL) and estimated (J) and results $<$ IDL as estimated (UJ).

3. Use professional judgement in cases where the holding time is grossly exceeded. The expected bias would be low and the reviewer may determine that results $<$ IDL are unusable (R).

E. CALIBRATION

Evaluation

1. Verify that the instrument was calibrated daily and each time the instrument was set up using the correct number of standards and blank. In cases where a curve set-up is not applicable (i.e. a titrimetric procedure), verify that the titrants were standardized as required in the procedure.

2. Verify that the correlation coefficient is ≥ 0.995 (unless otherwise specified).

3. Verify that the calibration verification standards (ICV/CCV) were run at the appropriate frequency and that results were within acceptable limits as stated in the QAPP.

4. Recalculate approximately 10% of the ICV/CCV using the following equation:

$$\%R = \frac{\text{Found}}{\text{True}} \times 100$$

Due to possible rounding discrepancies, allow results to fall within 1% of the contract windows.

Action

1. If the minimum number of standards as required in the QAPP were not used for initial calibration, or if the instrument was not calibrated daily and each time the instrument was set up, qualify the data as unusable (R).

2. If the correlation coefficient is < 0.995 (or as specified in the QAPP), qualify results > IDL as estimated (J) and results > IDL as estimated (UJ).

3. If standardization of titrants was required and not performed, use professional judgement in qualifying the data. The reviewer should review ICV/CCV, EPA reference sample results and other criteria prior to determining if the data should be qualified as estimated (J if > IDL; UJ if < IDL) or unusable (R).

4. If the ICV/CCV %R falls outside the acceptable limits, use professional judgement to qualify associated samples. If possible, indicate the bias in the review. The following guidelines may assist the reviewer in qualifying the data:

   - If the ICV/CCV %R is significantly greater than the upper control limit (UCL), qualify associated results > IDL as unusable (R); results < IDL are acceptable.

   - If the ICV/CCV %R is significantly lower than the lower control limit (LCL), qualify all associated data as unuseable (R)

   - If the ICV/CCV %R are outside the acceptable limits, yet relatively close to the limits, qualify associated results as estimated (J if > IDL; UJ if < IDL and the %R is below the LCL).

F. BLANKS

Evaluation

1. Review the raw data for all blanks and verify the results were accurately reported.

2. No contaminants should be found in the blanks (i.e. all blank results should be < IDL).

3. Positive blank results must not be corrected by subtracting off the blank value from the sample results.

Action

1. Sample results ≥ IDL but less than 5 times the maximum concentration found in any blank should be qualified as not detected (U).

2. Any blank with a negative result whose absolute value is > IDL must be carefully evaluated to determine if the sample data is biased in any way.

G. LABORATORY CONTROL SAMPLES (EPA REFERENCE SAMPLES)

Evaluation

1. The laboratory control sample (LCS) serves as a monitor of the overall performance of the analysis including all preparation steps. Review the LCS and verify that the results fall within the control limits required. (If no limits noted, use 80-120% for the control limits.)

2. Check the raw data to verify the reported recoveries. Recalculate one or more recoveries (%R) using the following equation:

$$\text{LCS }\%R = \frac{\text{LCS Found}}{\text{LCS True}} \times 100$$

Action

1. If results are < IDL and the LCS recovery is above the UCL, the data are acceptable.

2. If the LCS recovery for any analyte falls within the range of 50-LCL, or > UCL, qualify results > IDL as estimated (J).

3. If results are < IDL and the LCS recovery falls within the range of 50-LCL, qualify the affected results as estimated (UJ).

4. If the LCS recovery results are < 50%, qualify the data for the affected analytes as unusable (R).

5. If a LCS was required and not run, use professional judgement to determine whether the data is estimated (J) or unusable (R).

H. LABORATORY DUPLICATES

Evaluation

1. Review the duplicate data and verify that the results fall within the criteria required. If no criteria exist, use the limits of 20% for the Relative Percent Difference (RPD) or ± IDL if results are < 5x IDL (35 RPD or ± 2x IDL if > 5x IDL for soils).

2. Review the data and verify that the duplicate analysis was <u>not</u> performed on a field blank.

3. Check the raw data and recalculate one or more RPD using the following:

$$RPD = \frac{|S-D|}{(S+D)/2} \times 100$$

where, S = Original sample value
D = Duplicate sample value.

Action

1. If duplicate analysis results for a particular analyte fall outside the appropriate control windows, qualify the results for that analyte in all associated samples of the same sample matrix as estimated (J).

2. If the field blank was used for duplicate analysis, carefully evaluate all other quality control data and use professional judgement in evaluating the data.

I. MATRIX SPIKES

Evaluation

1. Review the matrix spike data and verify that the results fall within the limits specified. If no criteria exists, use the limits of 75-125% for both water and soil matrices.

2. Check the raw data and recalculate the % Recovery of at least 10% of the data. Use the following equation to verify that the results were calculated correctly:

$$\%R = \frac{(SSR - SR)}{SA} \times 100$$

Where, SSR = Spiked Sample Result
SR = Sample Result
SA = Spike Added

3. Review the data and verify that the field blank was not used for the spike analysis.

Action

1. If the spike recovery is > 125% (or > UCL stated in the procedure) and the sample results are < IDL, the data is acceptable for use.

2. If the spike recovery is > 125% or < 75% (> UCL or < LCL stated in the procedure) and the sample results are > IDL, qualify the data for these samples as estimated (J).

3. If the spike recovery falls within the range of 30-74% (30-LCL) and the sample results are < IDL, qualify the data for these samples as estimated (UJ).

4. If any spike recovery results are < 30% and the sample results are < IDL, qualify the data for these samples as unusable (R).

5. In cases where more than one spike analysis was performed and one or more %R results were outside acceptable ranges, use professional judgement when qualifying the data. Matrix spikes should be performed on each sample matrix. Qualify data of similar matrix as the spiked sample if different matrices in the data package.

6. If the field blank was used for the spike analysis, carefully evaluate all other quality control criteria and use professional judgement in evaluating the data.

J. SAMPLE RESULT VERIFICATION

Evaluation

1. Examine the raw data to verify the analyte quantitation was calculated as stated in the procedure. Re-calculate a minimum of 10% of the sample results to verify results were calculated correctly.

2. Examine the raw data for anomalies such as baseline drift, negative absorbances (indicative of interfences), omissions, etc.

3. Verify there are no transcription or reduction errors (dilutions, percent solids, sample weights) on at least 10% of the samples.

4. Verify that all results fall within the calibrated range.

Action

1. If any discrepancies are found and can be corrected, make the corrections and note. Increase the level of quality control if necessary. If the discrepancy cannot be resolved by the reviewer, contact the data management coordinator. The laboratory or appropriate agency will be contacted and the information necessary to complete the evaluation will be requested. The project manager should be informed of the delay in the validation process. If any discrepancy remains unresolved, use professional judgement in qualifying the data.

K. FIELD DUPLICATES

Evaluation

1. Field duplicate samples measure field and lab precision and therefore the results may have more variability than lab duplicates. Review the field duplicate data and calculate the RPD. No criteria exists for evaluating the data.

Action

1. If the RPD is > 50%, note in the narrative. Use professional judgement in qualifying any data. Review the raw data to verify that no reduction errors exist. This is to verify that the discrepancy is due to sampling techniques (sampling, preservation,

filtering, etc.) rather than laboratory error. Make notation of the discrepancy in the narrative.

L. OTHER (as specified in the procedure)

Evaluation

1. Review the procedure for any other quality control criteria not covered under the above sections. Examples of additional information required may be: ICP interference check samples, special AA quality control checks, distilled/digested blanks and standards, standardization, specific methodology requests for different concentration levels, etc..

Action

1. If specific quality control criteria were required and not followed, the project manager should be informed.

2. If the data was outside the acceptable ranges, use professional judgement in qualifying the data. Clearly identify your action and justification of the action in the narrative.

M. OVERALL ASSESSMENT FOR A CASE

1. It is appropriate for the reviewer to make professional judgements and express concerns and comments on the validity of the overall data package. This is particularly appropriate when several QC criteria are outside specifications. It is the reviewers responsibility to thoroughly document and explain all data validation qualifiers added to the data.

2. The following is a summary of data validation qualifier definitions which can be used in evaluating the data:

U	The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.
J	The associated value is an estimated quantity due to quality control criteria not being met.
R	The data are unusable. The analyte may or may not be present.
UJ	The material was analyzed for, but was not detected. The associated value is an estimate and may be inaccurate or imprecise.

5. Once the data has been evaluated against all of the points described in part 4, the evaluator can prepare the data validation narrative.

The data validation narrative should be a summary of the data quality indicating any problems or deficiencies found with the data set. If possible, on data qualified as estimated, note if the data is biased high or low. It is easiest to discuss each analyte separately. Refer to Figure 2 for the form to be used when writing the data validation narrative.

6. Record any data validation qualifiers (DVQ) to the left of the results on the analytical report. The laboratory qualifiers (LQ) will usually recorded to the right of the result by the laboratory who performed the analytical work. A copy of the lab qualifier definitions should be supplied with the data. Data entry people need to be able to distinguish between DVQ and LQ, so note location of qualifiers if located other than above.

7. Record the sample ID and date sampled as noted on the Chain of Custody on the analytical report.

8. Hilight POSITIVE-HIT data with a hilighter.

9. Stamp all of the analytical reports "VALIDATED". A "VALIDATED" stamp can be obtained from the data management coordinator.

10. Sign and date the Data Validation Request Form.

11. A quality control review needs to be performed on the validated data package. The entire validated data package (including raw data, evaluator's notes and narrative) should be submitted to the QC reviewer for a final review.

Quality Control Review:

1. The purpose of this quality control review is to verify that the data were validated according to the guidelines above, that all data validation qualifiers were added and also that the narrative is complete.

2. Review the validated data package for completeness. The data package should contain the following:

   - Data Validation Request Form
   - Inorganic Data Validation Narrative
   - Validated Analytical Results

3. Verify that results exist for all samples and all analytes requested in the data package.

4. Review the data validation narrative with the validated results for consistency, i.e., if the narrative stated that a particular analyte was qualified, verify that the qualifier has been recorded with the associated data. Check approximately 10% of the qualifiers. If discrepancies are found, increase the level of QC checks.

5. Review the narrative; check that the data has been evaluated according to the quality control criteria specified in the QAPP.
6. Verify that all positive-hit data have been hilighted and that the sample descriptions and sampling dates have been recorded on every result page.
7. Verify that the reviewer has signed and dated the validated data package.
8. If no discrepancies exist, sign and date the Data Validation Request Form. If the data package requires clarification, review the raw data and/or obtain clarification from the reviewer.
9. Deliver the final validated data package to the Data Management Coordinator when the quality control review is completed.
10. Recycle any raw data. Raw data is not submitted with the final validated data package.

APPROVED BY:	REVISION DATE:
Kevin J. Domack Environmental Scientists Section Leader	______________
	______________
	______________
	______________
Daniel W. Hall Environmental Division Director	

INORGANICS
DATA VALIDATION NARRATIVE

Site Name ______________________ Project # ______________

SMO Case # (SAS #) ________________ #Samples/Matrix __________

Laboratory ______________________ Hours for Review __________

SOW # ______________ EPA Validation Guidelines # ______________

Sample Numbers ____

Validated By ______________________ Date ______________

Reviewed By ______________________ Date ______________

SUMMARY OF REVIEW:

CAW/dlk/KJD
[dlk-601-22]
60721-MD

APPENDIX H

WARZYN'S PREVENTATIVE MAINTENANCE PROCEDURE

INORGANIC - DAILY QUALITY CONTROL PROCEDURE

Scope and Application: Daily check of dessicants, instruments, refrigerators and freezer, deionized and Milli-Q water systems to ensure data produced each day is of top quality.

Dessicant: Dri-Rite, an anhydrous compound, is kept in the bottom of each dessicator. When Dri-Rite is blue, it is ready to use, but when a pink shade begins to form, it must be dried in an oven set at 103-105°C until no pink color can be detected. Record date dried in comments section. Record initials and date of daily check in the log book.

frigerators and Freezer: Temperature of each of the refrigerators are to be recorded in the equipment record book daily.

Instrument	Acceptable Range
Walk-in cooler #1	4.0°C ± 2.5°C
Walk-in cooler #5	4.0°C ± 2.5°C
Silver Raetone #2	4.0°C ± 2.5°C
Gold General Electric #3	4.0°C ± 2.5°C
White Frigidaire #4	4.0°C ± 2.5°C
BOD Incubator	20.0°c ± 1.0°C

Notes:

1. Each of the refrigerators, freezers and incubators should routinely be defrosted when ice build-up occurs.

2. If fluctuations in temperature do occur, report the occurance to the lab superivisor immediately. Note in maintenance records.

Instruments: In-lab balances, pH meter, and conductivity meter are to be checked daily against known standards. An Instrument Operating Procedure (IOP) is located in each of the instruments representative log book.

Balance: The Sartorius and Cahn balances are calibrated with standard weights kept in a dessicator. The weights are to be handled with plastic forceps. Each weight is to be recorded in its representative place in the log book. Acceptable ranges are listed in each IOP.

pH Meter: The pH meters are calibrated with fresh buffers daily according to the pH SOP. Record the reading of the pH 10.00 buffer in the log book also. The acceptable range for the pH 10.00 buffer is 9.90 - 10.10.

<u>Note</u>: The inner electrode solution should be checked periodically to ensure accurate readings.

<u>Conductivity Meter</u>: The Lab-Line or the YSI conductivity meter is checked daily against a KCL standard of known concentration. Check the meter according to the IOP located in the log book. The acceptable range is 90-110% of the true value.

<u>Deionized and Milli-Q Water Systems</u>:

<u>D.I.</u>: The D.I. system functions with ion-exchange cartridges located in the sample storage room. Two warning lights are attached to the tanks to ensure they are operating properly. Each day, these lights must be checked. If one or both are out, the supplier must be notified to replace the tanks. Record tank change dates in the log book.

<u>Note</u>: If both lights are out, D.I. water cannot be used until tanks are replaced.

<u>Milli-Q</u>: The Milli-Q water should be checked with a conductivity meter. Conductivity should be no greater than 1 umhos/cm @25°C. The Milli-Q system calibration must also be checked daily. This is done by turning on system and letting pressure build, then depress test button. Reading should be at least 10 megohms/cm. Record in log book. (16 megohms/cm maximum load).

<u>Revision Date</u>

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8-18-87

2-5-90

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WARZYN

Planning Document
Project No. 60721

Volume 4 of 5
Field Sampling Plan
Blackwell Landfill NPL Site

Prepared for:
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DuPage County, Illinois

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January 1991

FIELD SAMPLING PLAN
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
BLACKWELL LANDFILL NPL SITE
DUPAGE COUNTY, ILLINOIS
(January 28, 1991)

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SECTION 1
INTRODUCTION

A Work Plan (WP), a Field Sampling Plan (FSP), a Quality Assurance Project Plan (QAPP), and a Site Specific Health and Safety Plan (HSP) have been developed for conducting the Remedial Investigation/Feasibility Study (RI/FS) at the Blackwell Landfill NPL Site (Blackwell Site) in DuPage County, Illinois. Each of the plans has a specific purpose, and efforts have been made to avoid duplication of focus in the documents.

This document is the FSP. Section 1 presents a brief review of the site background. Section 2 identifies the scope and objectives of the FSP toward conducting an RI/FS at the Blackwell Site. Section 3 provides the detailed listing of the sampling locations and sampling frequency. Section 4 describes the sample designations which will be used during the field investigation. Section 5 lists the sampling equipment and describes procedures for use during the RI. Section 6 describes the decontamination procedures which will be followed during all site activities, and Section 7 summarizes the sample handling and analysis procedures.

Site Description and Site History

The Blackwell Landfill NPL Site is located within the limits of the Roy. C. Blackwell Forest Preserve near the intersection of Butterfield and Warrenville Roads in Section 26, Township 39 North, Range 9 East, DuPage County, Illinois (Figure 1).

The landfill was developed by the DuPage County Forest Preserve District, and covers approximately 40 acres. Approximately 1.5 million cubic yards of refuse were disposed of in the landfill over the period 1965 to 1973. The landfill accepted mainly household refuse, yard wastes, and light industrial wastes.

The original design of the landfill consisted of a series of overlapping cells, constructed with clay side berms and liners. Some doubt exists as to how strictly the original design criteria were adhered to during construction.

Geologic information for the site has been documented by soil borings made for the more than 50 monitoring wells which have been constructed in several previous investigations. Boring logs exist for each of the monitoring wells, and are included as an Appendix to the Work Plan. Geologic cross sections have been developed and are also included in a Work Plan Appendix.

Quarterly groundwater monitoring was initiated at the site monitoring wells in 1983; the analytical parameters included volatile organic compounds and several inorganic water quality indicators. The sampling procedure was developed in consultation with representatives of the IEPA to assure a sampling procedure matching the U.S. EPA protocols. It included the purging of each well prior to sampling, collection and preservation of samples, chain- of-custody procedures, and the collection of field duplicates and blanks.

A total of twenty-one different volatile organic compounds (VOCs) have been detected in groundwater at the Blackwell Site at one time or another, but five have been most commonly detected:

Abbreviation	Compound
1,2-DCA	1,2-Dichloroethane
1,1-DCA	1,1-Dichloroethane
1,2-C-DCE	1,2-Cis-Dichloroethylene
1,2-T-DCE	1,2-Trans-Dichloroethylene
TCE	Trichloroethylene

Volatile organic concentrations within the groundwater have exhibited stable or decreasing trends since first sampled in 1983.

The Site was assigned a Hazard Ranking System (HRS) score of 35.57 by the U.S. EPA in March, 1986. Final listing on the National Priorities List (NPL) occurred on February 21, 1990.

A more detailed description of the Site history and background is contained in the Work Plan.

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SECTION 2
SCOPE AND OBJECTIVES

Scope

This Sampling Plan describes the procedures and practices to be used in obtaining site investigation data for use in the Remedial Investigation/Feasibility Study (RI/FS). These procedures include a description of the sample designation system, personnel and their responsibilities, and the sampling methods to be employed. The activities discussed in subsequent sections of this Sampling Plan include:

- exploratory drilling;
- surface water, monitoring well, and leachate well liquid level measurements;
- groundwater, surface water, soil and sediment sampling;
- monitoring well installation and aquifer testing;
- meteorological data collection;
- sampling of water supply wells;
- leachate sampling; and
- landfill gas sampling.

Objectives

The primary objective of the sampling activities described below is to obtain representative data to be used for the RI/FS analysis. Sampling activities described in this plan will be performed to complete the site investigation subtasks of the RI.

Data use objectives of the site investigation subtasks include:

- Characterization of source areas;
- Delineation of potential migration pathways off-site;
- Description of the site hydrogeological and hydrologic settings;
- Collection of sufficient data to support an endangerment assessment; and
- Collection of sufficient data to complete a Feasibility Study.

SECTION 3
SAMPLING LOCATIONS AND NUMBERS OF SAMPLES

Field activities will include investigation activities and sampling to characterize the geology and hydrogeology in the landfill vicinity, analyze leachate characteristics and groundwater characteristics, and evaluate surface water quality and the potential for contamination of bottom sediments by discharging groundwater.

Table 1 summarizes the data generating activities which will be conducted during the RI. Table 2 lists the estimated number of samples of each sample type to be collected during the RI. Table 3 lists the sample quantities, container types, preservatives and packaging procedures.

Regional and Local Geology

Existing site and regional data will be evaluated to develop the geologic characterization for the site. Additional work will be conducted in this investigation to determine the extent and thickness of the clay confining layer west of the landfill.

Geophysical Investigation

A geophysical investigation utilizing shallow seismic reflection will be performed to evaluate the extent of the clay confining layer and the depth to bedrock in the area of uncertainty west of the landfill. The area over which this investigation will be performed is illustrated in Figure 2.

Exploratory Drilling

A program of exploratory drilling will be performed to confirm the results of the geophysical survey. Hollow stem auger probes will be used to verify the elevation of the top of the clay, clay thickness, and depth to bedrock determined with the shallow seismic reflection method. The results of the geophysical survey will be used to choose the locations where auger probes will be performed. The results of the auger probe drilling program will be used in conjunction with the geophysical investigation results to determine monitoring well nest locations.

Soils and Vadose Zone

Soil Sampling

Two soil samples will be obtained in the area of past leachate seeps to determine if soil contamination is present. An additional soil sample will be obtained in a Site drainageway. The sampling locations are illustrated in Figure 3.

Each soil sample will be analyzed for full TCL/TAL parameters.

Surface Water Hydrology

The surface water investigations at the Site involve obtaining water level measurements, and surface water and sediment samples for chemical analysis.

Water Level Measurements

Staff gages will be installed in Silver Lake, the closed Swim Lake, the Supply Lake, Spring Brook, and the West Branch of the DuPage River. Silver Lake, the Swim Lake, and the Supply Lake, will each have one gage installed. Four gages will be installed along Spring Brook; and two will be installed along the West Branch of the DuPage River. Figure 4 illustrates the gage locations.

During the course of the investigation, water levels will be measured four times at the staff gages, in the monitoring wells identified and constructed for the investigation, and in the piezometers (Table 4).

Piezometer Installation

Three piezometers will be installed along Spring Brook adjacent to surface water level monitoring points. One piezometer will be installed between Silver Lake and the Swim Lake. Piezometer locations are illustrated in Figure 4.

Surface Water/Sediment Sampling

Surface water and sediment samples will be collected from the following locations. At Silver Lake, samples will be collected at three locations. At the Swim Lake and Spring Brook, samples will be collected at two locations. The sample collected at the southeast corner of Silver Lake will be obtained to represent background conditions. One sample will be collected at the Supply Lake.

Each surface water sample will be analyzed for full TCL/TAL and indicator parameters; each sediment sample will be analyzed for full TCL/TAL parameters. The surface water/sediment sampling locations are illustrated in Figure 5.

One round of sampling is anticipated for surface water and sediment sampling locations. A second round may be performed, with a reduced parameter list, if contamination is found and water levels indicate that groundwater is discharging to the surface water body where contamination is found.

Hydrogeology

Additional activities to be performed to characterize the hydrogeologic conditions at the site include the installation of monitoring wells, sampling of existing and newly-installed wells, collection of aquifer and aquitard samples for physical testing, and bail testing of selected wells.

Monitoring Well Construction

Nested monitoring wells will be installed at two locations identified by the auger probe and geophysical surveys as being within the "window" where the clay confining layer may be absent. Each nest will contain two wells. In each nest, a well will be screened at the base of the sand and gravel zone, and a well will be screened just below the bedrock surface. Each well will have a five-foot screen. Each well in a nest will be installed in a separate borehole.

Groundwater Sampling, Monitoring Wells

Two rounds of sampling and analysis will be performed at 25 wells. These 25 wells consist of 21 existing wells, and the four new wells to be installed during the RI/FS.

Each sample will be analyzed for the following parameters during the first sampling event:

- U.S. EPA CLP TCL and TAL parameters;
- Alkalinity;

- Chloride;
- Sulfate;
- Nitrate + Nitrite;
- Ammonia;
- Total Kjeldahl Nitrogen; and
- Total Dissolved Solids (TDS).

The parameter list may be reduced during the second round of sampling, if certain classes of contaminants are found to be absent during the first sampling round.

Field measurements which will be obtained at the monitoring wells include:

- Temperature;
- pH; and
- Specific Conductance.

Groundwater samples collected for U.S. EPA CLP TAL metals analysis will be field filtered at the wellhead with 0.45 micron filters prior to preservation. Groundwater samples collected for cyanide, organics, and indicator parameters will not be filtered.

Figures 6 and 7 illustrate the locations of the wells to be sampled. Table 5 summarizes information regarding the screened formation of each well, and the position of the well with respect to site groundwater flow directions.

Appropriate sample containers, preservatives, and packaging are described in Table 3.

Four rounds of water level measurements will be obtained at the 25 selected groundwater monitoring wells. These rounds will coincide with the measuring of water levels at the staff gages and piezometers described previously. Figures 6 and 7 illustrate the locations of the wells which will be utilized for water level measurements. Table 4 lists the locations and dates for water level measurements.

Aquifer Tests

Two samples will be collected during drilling at each of the new monitoring wells for physical testing. The physical testing to be performed will consist of grain-size analysis, and if applicable, Atterberg limits, cation exchange capacity, and moisture content. One sample at each location will be collected at approximately five feet above the bedrock surface to represent the upper aquifer material. The second sample at each location will be taken of the material directly overlying the bedrock. Approximately two to four pounds of sample are needed for these physical tests. In order to ensure that adequate sample volume is obtained, samples will be obtained with a 3-inch diameter continuous sampling device where possible, or a 3-inch diameter split spoon.

Bail testing will be performed at ten of the Site monitoring wells. Four of the wells tested will be the monitoring wells installed for the RI/FS; the remaining six will be pre-existing wells. Locations of the wells selected for bail testing are shown in Figure 8.

Meteorological Data Collection

During the course of the RI, daily temperature and precipitation amounts will be recorded at the FPD nursery. The nursery is located about one mile north of the landfill. Wind direction and velocity records will be obtained over the same time interval from the DuPage Airport.

Groundwater Sampling, Water Supply Wells

Twenty-six water supply wells in the Site vicinity have been identified for water sampling. One of the wells is located east (upgradient) of the Site; four of the wells are located southwest of the Site; and 21 wells are located west (downgradient) of the Site.

The wells will be sampled for volatile organic compounds.

The locations of the 26 wells that have been tentatively identified for sampling are illustrated in Figure 9.

Identify and Quantify Sources of Contamination

Activities which will be performed to aid in the characterization and quantification of existing contaminant sources include the measurement of leachate levels in existing headwells, collection of leachate samples, and sampling of the landfill gas at the existing headwells.

Leachate Volume Evaluation

Leachate levels at all existing headwells will be measured six times during the course of the remedial investigation (Table 4).

Landfill Leachate Sampling

Leachate sampling will be performed at four of the existing headwells at the Site. The following parameters will be analyzed at each well:

- U.S. EPA CLP TCL and TAL parameters;
- Alkalinity;
- Chloride;
- Sulfate;
- Nitrate + Nitrite;
- Ammonia;
- Total Kjeldahl Nitrogen; and
- Total Dissolved Solids (TDS).

Field measurements which will be obtained at the leachate wells include:

- Temperature;
- pH; and
- Specific Conductance.

Figure 10 illustrates the locations of the headwells to be sampled.

Landfill Gas Sampling

Gas flow will be measured at each of the existing headwells/vents on two separate occasions. Two high flow vents will be selected and sampled. The gas samples will be analyzed for VOCs. Vents will be selected to represent different areas of the landfill, (i.e., if two adjacent vents exhibit the highest flow rates, only one will be sampled, and another vent at least 500 feet away will be sampled).

Quality Assurance Sampling

Quality Control samples will be collected during sampling activities associated with the chemical characterization of leachate, groundwater, surface water, soil, and sediment. Quality control samples will consist of sample duplicates, field blanks, trip blanks and matrix spike/matrix spike duplicate (MS/MSD) samples as described below.

Field Blanks (FB)

For sediment samples and soil samples, no field blanks will be collected due to the unavailability of suitable blank material. For water samples, field blanks will be prepared for each matrix type and container size. Field blanks will be prepared according to the following schedule for each sampling activity:

- One field blank for every 10 or fewer samples of water collected.
- For each sampling period, a minimum of one blank for each group of parameters per sample matrix will be collected.

The field blank samples will be prepared using "Milli-Q" water. The water will be routed through the decontaminated bailer or sampling pump for monitoring well sampling blanks before it is transferred to the sample container. If appropriate, the sample will be passed through the filtration equipment before placing it in the sample container.

Trip Blanks (TB)

A trip blank for volatile organic analysis (VOA) will be included in each sample shipment containing water matrix samples for VOA analysis. The trip blank will consist of 2 40-ml VOA vials filled with "Milli-Q" water. It will be prepared in the office or laboratory, transported to the field and shipped with the other samples to the designated laboratory without being opened. It will be packaged using standard procedures as for other sample bottles.

Matrix Spike and Matrix Spike Duplicates (MS/MSD)

For water samples, one sample per group of 20 or fewer samples collected for organics analysis during each sampling activity will be selected for matrix spike/matrix spike duplicate (MS/MSD) analysis. For VOCs, triple the normal sample volume will be collected. Extractable organics will require double the normal sample volume.

Sample Duplicate

Sample duplicates will be collected at the following frequency. One duplicate sample will be collected for each increment of 10 or fewer samples collected from each matrix during each sampling event. Double the normal sample volume will be collected at the location where the duplicate sample is being obtained, and will be split between the original sample and the duplicate. The duplicate sample will be collected utilizing the same sampling device as the original sample.

SECTION 4
SAMPLE DESIGNATION

A sample numbering system will be used to identify each investigative and quality control sample. Each sample identified will include the project identified code, sample type and location code, and a sampling event code. The sampler will maintain a log book containing the sample identification listings.

Project Identified Code

A two-letter designation will be implemented to identify the sampling site. The project identifier will be "BW" to signify this site investigation.

Sample Type and Location Code

Each sample collected will be identified by a two-letter code corresponding to the sample type. Sample type codes to be used for the subtasks covered in this Sampling Plan include:

- GW - groundwater sample from monitoring well
- LL - leachate sample from leachate head well
- LG - landfill gas sample from leachate head well
- SB - split spoon or soil boring sample
- SD - sediment sample
- SS - soil sample
- SW - surface water sample
- PW - groundwater from a private residential well
- FB - field blank
- TB - trip blank

Other letter designators may be added for sample activities of later subtasks.

The location code will follow the sample type code. The location code consists of a two-to-five-digit numeric or alpha-numeric code that indicates the sample location. Surface water, sediment, field blanks, trip blanks and air samples will use a consecutive numbering system starting at 01, assigned in the field.

Sampling Round Code/Duplicate Code

A two-digit numerical code will be used to designate additional location information. Duplicate samples will be designated by the Round code preceded by a 9. Matrix spike and matrix spike duplicate samples are collected as additional sample volume at selected locations.

Although identified as such on chain-of-custody records, specific sampling codes will not be provided for matrix spikes or matrix spike duplicate samples.

Examples of Sample Numbers

Examples of sample number codes are as follows:

Sample Number	Sample Description
· BW-GWMW01A-01	Blackwell, groundwater sample from monitoring well MW01A, first round sample.
· BW-GWMW01A-91	Blackwell, duplicate groundwater sample from monitoring well MW01A, first round sample.
· BW-LLW05-01	Blackwell, groundwater sample from leachate well LW05, first round sample.
· BW-SW02-01	Blackwell, surface water sample from location number 2, first round sample.
· BW-SD03-01	Blackwell, sediment sample from location number 3, first round sample.

SECTION 5
SAMPLING EQUIPMENT AND PROCEDURES

Regional and Local Geology

Geophysical Investigation

Objectives. The objectives of the geophysical investigation are to: (1) evaluate the thickness and extent of the clay confining layer in the area of uncertainty west of the landfill, and (2) provide information to assist in the placement of monitoring well nests.

Personnel and Responsibilities. A team of three individuals will be responsible for performing the geophysical survey. The geologist/engineer will operate the instruments and the assistants will lay out geophone arrays and download data files.

Methods. A shallow high resolution seismic reflection survey will be performed in an attempt to define two stratigraphic contacts within the subsurface materials at the site. The stratigraphic contacts to be located are the contact between the sand/gravel aquifer and the underlying clay confining layer and the contact between the clay confining layer and the underlying dolomite bedrock. The basic premise behind the shallow high resolution seismic reflection method is that there must be detectable seismic velocity changes between the geologic units of interest. This should be the case at the Blackwell Site.

Equipment required for the seismic survey includes: (1) a high frequency energy source, (2) an internal floating point (IFP) seismograph, and (3) an array of geophones. The areas over which the survey will be performed are illustrated in Figure 2.

The following method will be followed in performing the survey:

- Geophones will be laid out along lines with an appropriate spacing, based upon an initial survey of the area.
- A high frequency energy source will generate the signal to be reflected by the geologic strata and recorded by the geophones.

- A 24-channel seismograph will be used to record the reflected signal.
- The records generated by the seismograph will be processed utilizing appropriate methods.

Exploratory Drilling

Objectives. The objectives of the auger probes are: (1) to confirm the results of the geophysical survey, (2) to map the bedrock surface in the area west of the landfill where the clay confining layer may be absent, and (3) to determine the presence or absence, and the thickness, of the clay confining layer in this area.

Personnel and Responsibilities. Auger probes will be installed by a two person drilling crew. The drilling crew will be supervised by a geologist or field engineer. The geologist/engineer will be responsible for logging borings and collecting soil samples.

Methods. A series of hollow stem auger probes will be performed down to bedrock in the area illustrated in Figure 2. The number of auger probes performed, and their location, will be chosen on the basis of the geophysical investigation. Assuming that hollow stem augers can be utilized to advance the boreholes, the following procedure will be followed:

- The borings will be advanced with 4 1/4-inch inner diameter (I.D.) hollow stem augers, or augers of other suitable diameter.
- A split spoon sample will be attempted at each 2 1/2-foot interval to a depth of 10 feet above the anticipated bedrock surface. Split spoons will be driven 2 feet, unless site conditions do not allow a full 2-foot drive (e.g., refusal after a drive of lesser length in sand and gravel deposits). Either a 2- or 3-inch diameter split spoon, or a 3-inch diameter continuous sampling device, will be used to retrieve samples.
- Split spoon samples will be obtained continuously over the remainder of each boring until the bedrock surface is encountered.
- Cuttings will be containerized and tested by the FPD for proper disposal. Each borehole will be sealed with a bentonite slurry after termination at the bedrock surface.

If site conditions prevent the use of augers, rotary drilling with an appropriate drilling mud or clean water may be used, in combination with driven temporary casing. The following procedures will be utilized if these methods are needed to complete the auger probes:

- A drilling fluid consisting of either clean water or a clean water/drilling mud mixture will be prepared.
- The boreholes will be advanced with either a 3 7/8-inch diameter or a 4 7/8-inch diameter roller rock bit. Samples will be obtained on 2 1/2-foot intervals with a split spoon sampling device until a depth of 10 feet above the anticipated bedrock surface. Continuous split spoon samples will be obtained over the remainder of the borehole down to the bedrock surface. Split spoons will be driven 2 feet, unless site conditions do not allow a full 2-foot drive (e.g., refusal after a drive of lesser length in sand and gravel deposits). Either a 2- or 3-inch diameter split spoon will be used to retrieve samples.
- A temporary casing will be installed to retain an open borehole and limit the movement of drilling fluids into the surrounding aquifer materials. It is expected that 4-inch or 5-inch diameter steel casing will be used. After each 2 1/2 foot interval is sampled, the casing will be driven over the sampled interval, field conditions permitting, and the interval will be washed out with a roller rock bit. Over the continuously sampled portion of the borehole, the casing will be driven after each sample is obtained, if field conditions permit.
- Cuttings will be containerized, and tested by the FPD for proper disposal. After each borehole is terminated at the bedrock surface, it will be backfilled with a bentonite slurry.

Soils observed during drilling will be described utilizing the Unified Soil Classification System (USCS). Appendix A contains a description of the USCS, and other descriptive terms used by Warzyn for soil sampling purposes. A copy of Warzyn's field soil boring log form is also included. Samples retained from each split spoon will be scanned with an HNu or OVA. It is anticipated that the borings will be approximately 40 to 50 feet in depth.

Auger probe locations will be surveyed by a licensed surveyor.

Soils and Vadose Zone

Soil Sampling

Objectives. The objective of the soil sampling task is to characterize possible soil contamination present areas of past leachate seeps and in a Site drainageway.

Personnel and Responsibilities. Soil sampling will be performed by a geologist/engineer or a technician.

Methods. Soil samples will be obtained over the interval 0-12 inches beneath the ground surface. The following procedure will be followed to obtain the samples:

- A hand auger will be used to obtain the samples over the desired interval.
- After acquisition, sample material will be placed in a stainless steel pan. Samples obtained for VOA analysis will immediately be placed in the appropriate sample jars and sealed. Samples for other constituents may be composited in the pan with a stainless steel scoop before being placed in sample jars.

Surface Water Hydrology

Water Level Measurements

Objective. Surface water level measurements will be obtained to provide information regarding surface water/groundwater interactions at the Site.

Personnel and Responsibilities. One individual, either a geologist or a technician, will be responsible for obtaining surface water level measurements.

Methods. Staff gages will be constructed by driving five to six-foot lengths of fence post T-bar at each monitoring location. The elevation and location of each gage will be surveyed and plotted on the base map. Surveying will be performed by a licensed surveyor relative to the National Geodetic Vertical Datum (NGVD) of 1929. An attempt will be made to make water level measurements to ±0.01 ft at the staff gages; if this is not possible, measurements will be made to ±0.05 ft. Water elevations will be referenced to the NGVD datum, and plotted on the Site map, along with piezometric elevations, to determine the configuration of the water table.

Piezometer Installation

Objectives. The objectives of the piezometer installations are: (1) to provide information on groundwater elevations in the immediate vicinity of Spring Brook, and (2) to provide information regarding groundwater elevations between Silver Lake and the Swim Lake. The information on groundwater elevations obtained from the piezometers will allow analyses of the recharge/discharge relationship between Spring Brook and the groundwater flow system. The information will also assist in the interpretation of the flow system between Silver Lake and the Swim Lake.

Personnel and Responsibilities. Piezometers will be installed by a two person drilling crew. The drilling crew will be under the supervision of a geologist or a field engineer. The geologist/engineer will be responsible for directing the installation of the piezometers.

Methods. Piezometers will be installed adjacent to three of the staff gages installed in Spring Brook (See Figure 4). Each piezometer will be constructed of 1 1/2-inch I.D Schedule 40 PVC casing and screen. Screens will be five feet in length. The piezometers will be installed only for the purpose of obtaining groundwater elevations, and will not be sampled.

It is anticipated that the following procedures will be employed during the installation of the piezometers. Procedures may be modified based on field conditions encountered.

- The boring for each piezometer will be blind drilled with hollow stem augers to the desired depth.
- Each piezometer will be installed such that the top of the five-foot screen is at the top of the water table.
- No. 30 flint sand or equivalent will be placed in the annular space around the screen and to an elevation two feet above the top of the screen.
- A bentonite pellet seal at least two feet in thickness will be placed over the sand pack and hydrated.

- The remainder of the annular space will be filled with a bentonite slurry utilizing a tremie pipe. A cement/bentonite grout may be used in the upper portion of the borehole to provide stability for the well riser.

- Each piezometer will be equipped with a locking cap.

Surface Water/Sediment Sampling

Objective. The objective of the surface water/sediment sampling is to document the potential effects of the discharge of groundwater to surface water bodies at the Site.

Personnel and Responsibilities. Either one person (geologist or technician) or a two person team, consisting of either a geologist or engineer and a technician, will collect surface water and sediment samples. The number of staff required will depend on the location to be sampled. Where necessary, a rowboat will be provided by the FPD for sampling in the lakes. The sampling personnel will provide their own site safety monitoring.

Methods. At each location, the surface water sample will be obtained prior to the sediment sample. Where appropriate, the sampling sequence will be from the most distal downstream location to the furthest upstream location. As the concern for the surface water bodies at the site regards the effect of discharging groundwater through the bottom sediments, surface water samples will be obtained as near the bottom of the surface water bodies as possible without disturbing the sediment. Locations of surface water and sediment samples will be marked for later surveying. When samples are obtained in deep water where it is difficult to place a marker, locations will be marked nearshore. When necessary, samples will be obtained from a rowboat supplied by the FPD.

Surface water samples will be obtained in the following manner:

- A weighted tape or calibrated rod will be used to determine the depth to the bottom at the selected sampling location.

- A sufficient time period will be allowed prior to sampling to allow settling of any sediment disturbed by the depth measurement.

- A Kemmerer sampler will be lowered to an appropriate depth, and the sampling port will be opened to collect the surface water sample.

- Surface water samples will not be filtered prior to containerization.

The sediment samples will be collected in the following manner:

- Sediment samples will be collected at the same locations as surface water samples.

- A sediment sampling tube equipped with a check valve and steel catcher will be lowered to the bottom of the surface water body.

- The weight of the sampling tube will drive the unit into the bottom sediments. Upon impact with the bottom, the check valve at the top of the tube will close to prevent the escape of water and the finer fraction of the sediments sampled.

- The steel catcher in the bottom of the tube will prevent sampled material from falling out of the tube as it is raised to the surface.

- If necessary, the tube will be lowered more than once. Samples may be composited to acquire sufficient sample volume; however, volatile organic samples will not be composited. Volatile organic samples will be immediately placed in jars and sealed.

- Organic materials and rocks will be removed from the sediment samples collected for analyses other than volatile organics. Headspace screening of the samples will be performed with an HNu or OVA for volatile organic compounds.

If difficulties are encountered in retrieving adequate sample volume with the sediment sampling method described above, the method will be modified with U.S. EPA approval.

Both the surface water and sediment sampling devices will be decontaminated between sampling locations. Decontamination procedures are outlined in Section 6.

Hydrogeology

Monitoring Well Construction

Objectives. The objectives of the additional monitoring well installations are: (1) to provide vertical gradient information in the area where the confining layer is thin or absent and (2) to provide information on groundwater quality where hydraulic connection between the upper and lower aquifer may occur.

Personnel and Responsibilities. Soil borings and groundwater monitoring wells will be installed by a two person drilling crew. The drilling crew will be supervised by a geologist or field engineer. The geologist/engineer will be responsible for logging borings and collecting soil samples, directing the installation of monitoring wells, conducting aquifer tests, and acting as Site Safety Officer.

Methods. Two monitoring well nests will be installed at locations chosen on the basis of the geophysical exploration and auger probe drilling programs. Each well nest will consist of two wells: one well will be installed with a five-foot screen located at the base of the sand and gravel; the second well will be installed with a five-foot screen set just below the bedrock surface. Wells will not be attempted in the confining layer, because it is expected to be thin in this area.

Difficult drilling conditions are anticipated at the Site, based on past drilling activities. Boulders and cobbles are not uncommon in the sand and gravel aquifer, and will probably prevent the use of hollow stem augers. Due to the difficulty expected in completing boreholes at the site, the exact method of borehole advancement for the monitoring wells is unknown. Field conditions will ultimately determine the drilling method chosen. In the past, however, the most successful drilling endeavors have utilized rotary wash techniques in combination with a drilling mud. It is most likely, therefore, that the boreholes will be advanced through a rotary wash method utilizing either clean water or a drilling mud. A temporary or permanent steel casing may be used to stabilize the borehole and reduce the migration of drilling fluids into the surrounding aquifer. Permanent steel casing may be used during drilling of the deeper wells to seal off the upper aquifer.

Assuming that a rotary wash technique will be utilized to advance the boreholes, it is anticipated that the following procedures will be followed. Alternative procedures may be necessary, based on conditions encountered during drilling.

- A drilling fluid consisting of either clean water or a drilling mud/clean water mixture will be prepared.
- The boreholes for the wells will be advanced with an appropriate size roller rock bit.
- The deeper boring in each well nest will be sampled on 2 1/2-foot intervals with a split spoon sampling device to a depth of about 10 feet above the anticipated bedrock surface. From that point until the top of rock is encountered, the borehole will be continuously sampled. Sampling will follow ASTM D1536 methods. The shallower boring in each nest will only be sampled over the anticipated screened interval.
- A temporary or permanent steel casing of appropriate diameter will be used. After each 2 1/2-foot interval is sampled, the casing will be driven over the sampled interval, field conditions permitting, and the interval will be washed out with a roller rock bit. Over the continuously sampled portion of each borehole, the casing will be driven after each sample is obtained, if possible.
- If it is determined that a permanent casing is needed to seal the lower aquifer off from the upper aquifer, the casing will be grouted in place and allowed to set up overnight.
- The bedrock will be cored over the anticipated screened interval of the well in the deeper borings. It is expected that either an NQ (3-inch diameter cored hole) or HQ (4-inch diameter cored hole) core barrel will be used. The length of core sections obtained will vary, depending upon the length of the core barrel used and characteristics of the bedrock.
- Cuttings that are generated by drilling activities will be containerized, and tested by the FPD for proper disposal.

Final soil boring logs will be prepared based on field observations, soil testing, and laboratory sample classification. Soil samples will be retained by Warzyn Engineering Inc. until termination of the RI/FS Investigation, and a signed release is provided by the

Respondents to properly dispose of the samples. Procedures for sample handling are presented in the QAPP.

The monitoring wells will be constructed of 2 inch I.D. Schedule 40 PVC casing and screen. The screens will be 5 feet in length, with a 0.010 inch slot size (No. 10 slot).

Monitoring wells will be installed utilizing the following procedures, field conditions permitting:

- No. 30 flint sand or equivalent will be placed in the annular space around the screen and to an elevation 2 feet above the top of the screen.
- A bentonite pellet seal at least 2 feet in thickness will be placed over the sand pack and hydrated.
- The remainder of the annular space will be filled with a bentonite slurry utilizing a tremie pipe. A cement/bentonite grout may be used in the upper portion of the borehole to provide stability for the well riser.
- A locking steel protective casing will be installed at the surface in a concrete or cement surface seal which extends below the frost line.

Monitoring well construction and installation will conform with the RCRA Technical Enforcement Guidance Document (TEGD).

Air monitoring will be used during drilling to monitor air quality for site safety purposes. Parameters to be monitored include:

- VOCs (HNu photoionization meter);
- Methane gas ("Gas-Tech" or other similar instrument);
- HCN (Monotox cyanide meter); and
- Radiation (Mini-Rad).

Samples retained from each split spoon will be scanned with a HNu meter or an OVA.

To minimize potential inadvertent contamination by drilling equipment and/or interborehole contamination, steam cleaning will be used. A temporary decontamination pad will be constructed, which will allow collection of decontamination fluids. The drill rig and drilling tools will be steam cleaned before mobilization onto the site. The drilling tools coming into contact with the site soils will be steam cleaned between each boring. The drill rig will be steam cleaned between drilling locations. Water from steam cleaning will be collected and disposed of in the municipal sewer.

The split spoon sampler will be cleaned in a Liquinox or nonphosphate detergent solution between samples. Water from split spoon sampler cleaning will be collected and disposed of in the municipal sewer. Well pipe, screen and protective casings will be steam cleaned prior to use. Water from steam cleaning will not be collected. Additional decontamination procedures are discussed in Section 6 of this Sampling Plan.

Monitoring wells will be developed in accordance with RCRA Guidelines. Well development will be conducted a minimum of three days after the well is installed to allow the annular space seal to setup, reducing the likelihood of drawing the slurry into the well screen during development.

Development of the monitoring wells will proceed in the following manner:

- The wells will be alternately surged and purged using a bailer for a minimum of 30 minutes, or until pH and conductivity measurements stabilize.
- After the surge and purge cycle is completed, the well will be further developed using either a Brainard-Kilman hand pump or another appropriate method until 10 well volumes of water are removed.

Purged water will not be collected.

Groundwater Sampling, Monitoring Wells

Objectives. The objectives of monitoring well sampling and measurement of water levels are: (1) to characterize the groundwater quality at the Site, and (2) to characterize the groundwater flow regime within the upper and lower aquifers, including surface water interactions.

Personnel and Responsibilities. Groundwater quality sampling will be performed by a two member team comprised of a geologist/chemist and a sampling technician. Water level measurements will be obtained by a geologist or field technician.

Methods.

Monitoring Well Sampling

Groundwater samples will be collected at 25 wells. The sequence of sampling will proceed from wells expected to have the lowest contaminant concentrations, (based on observations made during drilling and historical groundwater quality information) to wells suspected of having the greatest contaminant concentrations.

Groundwater sampling will proceed in the following manner:

- Sampling equipment will be decontaminated as described in Section 6, page 35, prior to sampling at each well.
- Water levels will be measured at each well prior to purging and sampling.
- Prior to sampling, each well will be purged using a submersible sampling pump or a stainless steel bailer attached to stainless steel cable. The volume of water removed during the purging of each well will be measured; a minimum of three well volumes will be removed. The pH, temperature, and specific conductivity will be measured with field instruments before purging and after three well volumes have been removed to determine that these parameters have stabilized prior to sample collection. Judgements as to stabilization will be made by an experienced field technician.
- After well purging has been completed, the samples will be collected directly with a submersible bladder pump or stainless steel bailer. Care will be taken not to agitate the water column when sampling for volatile organics with the stainless steel bailer. Sample containers will be filled for analytes in order of decreasing volatilization potential. Samples to be analyzed for VOCs will be collected first to minimize volatilization.
- Purged water from the monitoring wells will be collected and disposed of in the municipal sewer.

The sampling equipment and water level measurement tape will be cleaned between wells with a Liquinox or another non-phosphate detergent solution and rinsed with deionized water.

Groundwater sample blanks will be collected by pouring "Milli-Q" water through the sampling device into the sample bottles. Matrix spike/matrix spike duplicate samples will be collected using the same sampling device. Duplicate samples for volatile organics analysis will be obtained by alternately filling VOC vials from the bailer or submersible pump. The remainder of the sample volume will be split between the principle sample and the duplicate sample.

Trip blanks for VOA analysis will be prepared at the office or laboratory. "Milli-Q" water will be used to prepare the trip blanks.

Water Level Measurements

Water level measurements will be made at 25 wells, utilizing an electronic water level indicator or a measuring tape with an attached sounding device. The measurement device will be lowered into the well until the water level is reached. Water levels will be measured to ± 0.01 ft at the monitoring wells, utilizing the highest part of the top of the inner well casing as the point of reference. Three replicate water level measurements will be made. Water level elevations will be referenced to the NGVD of 1929 and plotted on the Site map to determine the configuration of the water table in the upper aquifer, the potentiometric surface of the lower aquifer, and groundwater flow directions.

Aquifer Tests

Bail Testing

Objective. Bail-down tests will be performed at ten monitoring wells to provide information regarding the hydraulic conductivity of aquifer materials. Four of these tests will be performed on the nested wells being installed as part of this investigation, in order that hydraulic conductivities may be evaluated in the area where the upper and lower aquifers may be hydraulically connected. Bail tests will also be conducted at six other previously-existing monitoring wells.

Personnel and Responsibilities. Bail-down tests will be performed by a geologist or hydrogeologist and a technician.

Method. The hydraulic conductivity of the saturated zone at the Blackwell Site will be calculated by conducting bail-down tests at ten monitoring wells. The basic concept behind these tests is that the rate of rise of the water level in a well after "instantaneous" removal of a volume of water is a function of aquifer hydraulic conductivity. One of two methods may be used to produce the necessary "instantaneous" removal of water. The first method is the direct removal of a volume of water with a bailer. In the second method, displacement of water from the well into the surrounding materials is accomplished through pressurization of the well casing with breathing-quality air.

The following procedures will be followed when conducting hydraulic conductivity testing with either method of water removal:

- Site conditions, test number, etc. will be recorded in the field notebook.
- Equipment to be used for the hydraulic conductivity testing will be decontaminated in accordance with Section 6.
- Measurements of depth to water and total well depth will be made with an electronic water level indicator. Measurements will be recorded to ± 0.01 foot.
- Water level and well depth measurements will be repeated and recorded in the field notebook.
- The Hermit Data Logger or equivalent instrument, pressure transducer, and electronic water level indicator, will be prepared for use.

If the bailer method is to be used to remove a volume of water, the following procedures will be implemented:

- The pressure transducer will be placed down the well.
- The bailer will be placed down the well to a depth at least one foot above the pressure transducer.

- The depth to water will be measured with an electronic water level indicator to determine when the water level in the well has returned to static level after insertion of the bailer.
- The data logger will be started, and the bailer will be pulled from the well. Water removed with the bailer will be placed in a bucket.
- The test will be continued until at least 90% recovery of the static water level has been achieved or, in low permeability formations, until sufficient recovery has been achieved to provide data representative of the strata being tested.
- The final water level will be measured with the electronic water level indicator and recorded in the field notebook. The volume of water removed during the test will also be recorded.

If the pressurization method is to be used to displace a volume of water from the well, the following procedure will be followed:

- The pressurization equipment will be assembled. The regulator will be attached to the pressure tank, and the connecting hose will be attached to the regulator.
- The pressure transducer wire, electronic water level indicator tape, and pressure hose will be threaded into the well pipe fitting.
- The pressure transducer and water level indicator tape will be lowered down the well pipe to the appropriate depth. The depth to water will be measured.
- The electronic water level tape will be lowered to the target depth with the alarm activated.
- The regulator valve will be slowly opened allowing the well to pressurize. The system will be checked for leaks.
- Air will be allowed to enter the well until the target level is reached (audio signal from electronic water level indicator ceases).
- The data logger will be started. The air supply will be turned off, and the hose disconnected from the regulator to "instantaneously" release air pressure from the well.
- The test will be continued until at least 90% recovery of the static water level has been achieved or, in low permeability formations, until sufficient recovery has been achieved to provide data representative of the strata being tested.

- The final water level will be measured with the electronic water level indicator and recorded in the field notebook. The volume of water removed during the test will also be recorded.

If recharge rates are slow, it may not be desirable to use the data logger with the bailer method. As an alternative, recovering water levels may be measured with the electronic water level indicator.

Analysis of the test data will be made using a computational method presented by H. Bouwer, and R. Rice, 1977, "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells", Water Resources Research, Vol. 12, No.3, pp. 423-428, or by other appropriate methods.

Physical Testing of Aquifer Materials

Objectives. Physical testing of the aquifer materials will be performed to determine the retardative nature of the materials tested, and their potential to act as an aquitard, based on grain-size analysis and other characteristics.

Personnel and Responsibilities. The geologist/engineer on-site during monitoring well installation will obtain the samples for physical testing.

Methods. Samples will be collected for grain-size analysis from the split- spoon sampling device, and will be placed in glass jars. Grain-size analysis will be performed in accordance with ASTM Methods D421, D422, and D2217.

Meteorological Data Collection

Objectives. Meteorological data will be collected to: (1) evaluate prevailing wind patterns at the site as a possible air migration pathway, and (2) characterize relationships between precipitation patterns and corresponding responses in site monitoring wells and staff gages.

Personnel and Responsibilities. Daily records of temperature and precipitation will be kept by FPD personnel. A geologist or engineer will be responsible for obtaining wind direction and velocity records from the DuPage Airport.

Methods. During the course of the Remedial Investigation, daily temperature and precipitation recordings will be obtained at the FPD nursery located about one mile north of the landfill. Over the same time period, wind direction and velocity records will be obtained from DuPage Airport.

Groundwater Sampling, Water Supply Wells

Objectives. Water supply wells which draw from the lower aquifer downgradient of the site will be sampled to determine water quality and potential Site impacts.

Personnel and Responsibilities. Water supply wells will be sampled by a technician.

Methods. It is anticipated that the wells sampled will be in constant use; therefore, the purge volume will be limited to the volume between the well head and the sampling point. The following procedure will be followed during private well sampling:

- A sampling point will be chosen that is as close as possible to the wellhead, and does not undergo any treatment(i.e., water softeners, filters, etc.) If necessary, the sampling port will be cleaned prior to use.
- The water will be allowed to run at the sampling point at a rapid rate to purge the well. A measurement of the amount of water purged will be calculated with a 5-gallon pail. During the time period over which the well is purged, field measurements of temperature, pH, and specific conductivity will be taken at five minute intervals to determine stabilization.
- After purging, the discharge rate from the sampling point will be reduced. The same collection and handling procedures will be followed as those specified for groundwater samples. Samples obtained from private wells will not be filtered.

Field blanks will be prepared by pouring "Milli-Q" water directly into sample containers. Trip blanks will be prepared in the same manner as practiced for groundwater samples. Private well samples will be analyzed with different methods utilizing lower detection limits, as detailed in the QAPP.

Identify and Quantify Sources of Contamination

Leacnate Volume Estimation

Objective. To provide information on leachate levels for estimation of leachate volume and leachate generation rates.

Personnel and Responsibilities. Leachate level monitoring will be performed by a geologist or field technician.

Methods. Measurements of leachate levels in headwells will be obtained in the following manner:

- An electronic water level indicator or a measuring tape with an attached sounding device will be lowered into the headwell until the leachate level is reached. These instruments will be dedicated to leachate wells only.
- Leachate levels will be measured to ±0.01 ft.

Landfill Leachate Sampling

Objective. To characterize the composition of leachate within the landfill.

Personnel and Responsibilities. Leachate sampling will be performed by a two member team consisting of a geologist/chemist and a sampling technician.

Methods. Leachate sampling will be performed utilizing the following procedures:

- Initial purging of the leachate wells will be performed with equipment normally used by landfill personnel for leachate removal. Three well volumes will be purged from each well if possible. At wells where it is not possible to remove three well volumes, the well will be purged dry, and allowed to recover prior to sampling. Leachate well sampling will be coordinated with normal leachate level maintenance activities at the landfill, in order that purged leachate may be pumped into a tanker truck for routine disposal.
- Samples will be collected with equipment dedicated to leachate sampling only. The equipment required is a stainless steel bailer suspended from a stainless steel cable. Field measurements of pH, temperature, and specific conductivity will be made. The bailer will be decontaminated between sampling locations.

- Sample containers will be filled for analytes in order of decreasing volatilization potential. Samples to be analyzed for VOCs will be collected first to minimize volatilization.

Landfill Gas Sampling

Objective. Landfill gas will be sampled and analyzed to determine the VOC characteristics of gas within the landfill.

Personnel and Responsibilities. A geologist, hydrogeologist, or field engineer, and a technician, will be responsible for obtaining landfill gas samples.

Methods. Samples of landfill gas will be collected in the following manner:

- Samples will be collected in canisters provided by the analytical laboratory. Each canister is under vacuum, and has a valve opening.
- One end of a five-foot length of tygon tubing will be attached to the canister; the other end will be placed inside the leachate headwell.
- The valve connecting the canister to the tubing will be opened for two minutes, allowing the sample to collect in the canister.
- The valve will then be closed, and the tygon tubing disconnected.
- The canister will be stored in a cooler for shipment to the laboratory.

SECTION 6
DECONTAMINATION PROCEDURES

Procedures to be followed to decontaminate equipment and personnel are described in the Site Health and Safety Plan. The procedures are summarized below.

Site Personnel Decontamination Procedure

- Dispose of outer latex booties;
- Wash boots in Liquinox bootwash;
- Clean outer gloves in Liquinox wash solution (discard if too soiled to clean thoroughly);
- Dispose of polycoated tyvek suits;
- Dispose of surgical gloves;
- Wash hands in hand wash;
- Wash face and neck in face wash; and
- Clean and sanitize face mask.

Site personnel will perform the above mentioned decontamination procedure prior to leaving the site.

Discarded clothing and other articles will be collected in double-lined, heavy duty garbage bags. Filled garbage bags will be disposed of as normal garbage.

Equipment and Vehicle Decontamination Procedure

- Decontamination will be performed prior to site entry;
- Decontamination will be performed on-site;
- Gross contamination will be removed with a brush and Liquinox solution; and
- Steam cleaning will follow.

The drilling equipment will be steam cleaned between boring locations and prior to exiting the site. Another area, located away from the equipment decon areas, will be designated as a site personnel decon area.

Decontamination will include steam-cleaning the drilling equipment and tools between boreholes and detergent washing and water rinsing the split spoon samplers after each collected sample. The drill rig and equipment may also require scrubbing of accessible parts with a detergent/water solution. Well materials will also be steam-cleaned and wrapped in plastic until installed. The bailer, bailer cable, trowels, spatulas, stainless steel bucket and water level measurement tape will be cleaned with Liquinox or another non-phosphate detergent solution, and rinsed with deionized water. If evidence of contamination is observed during monitoring well sampling, e.g., HNu readings above background or visible oily/organic contaminants, a methanol rinse will be performed prior to the final rinse with deionized water.

Equipment remaining on-site overnight will be decontaminated at the end of the day, if not done earlier in the day.

SECTION 7
SAMPLE HANDLING AND ANALYSIS

Parameters

Leachate and groundwater samples collected for chemical analysis will be analyzed by a laboratory approved by the U.S. EPA Region V Contract Program Management Section (CPMS), Central Regional Laboratory (CRL). Chemical parameters for which groundwater and leachate are to be analyzed are summarized below:

- U.S. EPA CLP TCL and TAL parameters;
- Alkalinity;
- Chloride;
- Sulfate;
- Nitrate + nitrite;
- Ammonia-nitrogen;
- Total Kjeldahl nitrogen; and
- Total Dissolved Solids.

Measurement of pH, specific conductivity and temperature will be performed in the field. The groundwater samples obtained from site monitoring wells to be analyzed for U.S. EPA TAL parameters will be field filtered with 0.45 micron filters.

Sample Preservation

Samples will be collected and preserved in a manner appropriate for the analyses they receive (Table 3). The portion of groundwater samples requiring field filtering prior to analysis will be filtered using a pressure filtration device, through a 0.45 micron filter, as soon as possible after collection. Filtered portions of the samples will be preserved, as appropriate, immediately after filtration. Sample fractions will be preserved before shipment according to the procedures shown in Table 3. Preservatives added to the samples will be prepared using reagent grade chemicals. Table 3 should be consulted for details regarding sample packaging and shipping.

SECTION 8
SAMPLE DOCUMENTATION

Field sampling activities will be documented using a bound notebook/logbook. Information recorded in the field notebook will include date of sampling, sampler, weather conditions, observations and methods of preservation. Additional data pertaining to sampling may also be included in the logbook.

Samples will be collected under chain-of-custody procedures. Standard forms including sample labels, sample tags, chain-of-custody forms, and custody seals used for sample tracking will be maintained (Figures 5-8 of QAPP). A brief description of sample documents follow:

A. Chain-of-Custody Form

  1. One form per shipping container (cooler).
  2. Carrier service does not need to sign form, if custody seals remain intact.
  3. Use for all samples.

B. Chain-of-Custody Seals

  1. Two seals per shipping container to secure the lid and provide evidence that samples have not been tampered with.
  2. Cover seals with clear tape.
  3. Record seal numbers on Chain-of-Custody Form.
  4. Use for all samples.

C. Sample Tags

  1. Each sample container must have a sample tag affixed to it.
  2. Sample tag numbers are recorded on the Chain-of-Custody forms.
  3. Use for all samples.

D. Sample Labels

1. Each sample container must have a sample label affixed to it.

2. Use for all samples.

E. Sample Identification Record Form will:

1. Provide means of recording crucial sample shipping and tracking information.

2. Contain information such as:

   - Sample number
   - Sample matrix
   - Sample location code
   - Sample round
   - Chain-of-custody number
   - Lab code
   - Date sampled
   - Date shipped
   - Airbill number(s)
   - Sampling tag number

Paperwork accompanying the samples being shipped to the laboratory will be sealed in a plastic bag that is taped to the inside of the cooler lid. Copies of the chain-of-custody forms, and other paperwork (if possible), will be retained for the field files.

Two sample seals will be placed on the opposite sides of the lid and extended down the sides of the cooler. The lid will be securely taped shut prior to shipment.

TABLES

TABLE 1
SUMMARY OF DATA GENERATING ACTIVITIES AND ASSOCIATED DATA QUALITY OBJECTIVES
BLACKWELL LANDFILL SITE

ACTIVITY	TASK	DESCRIPTION	INTENDED DATA USAGES	ANALYSIS PARAMETERS	DATA QUALITY OBJECTIVE (ANALYTICAL LEVEL)	ANTICIPATED NO. OF INVESTIGATIVE SAMPLES
DEFINE NATURE AND EXTENT OF CONTAMINATION						
Confining Layer Mapping	1	Conduct shallow seismic investigation; make auger probes to bedrock southwest of landfill.	Determine the depth to the bedrock surface and delineate the existence of the clay confining layer in the area west of the landfill.		Level I Data	0
Soil Sampling	2	Conduct soil sampling in areas of past leachate seeps.	To characterize any soil contamination resulting from past leachate seeps.	Analysis of soil samples for TCL and TAL parameters.	Level IV Data for TCL, TAL	3
Surface Water Hydrology	3	Water Level Measurements and Piezometer Installation	To better define the interactions between surface water and groundwater.		Level I Data	0
Surface Water/ Sediment Sampling	4	Surface water and sediment samples taken at locations on Silver, Swim and Supply Lakes and Springbrook.	To document surface water quality surrounding the site and to evaluate the potential contamination effects of discharging groundwater on bottom sediments in surface water bodies surrounding the site.	Analysis of surface water samples for TCL, TAL, indicators and field pH and conductivity. Analysis of sediments for TCL and TAL parameters.	Level IV Data for TCL, TAL Level III Data for Indicators Level I Data for pH and conductivity.	8 Surface Water 8 Sediments
Monitoring Well Construction	5	Installation of 2 additional monitoring well nests (total of 4 monitoring wells).	To better define the "window" where the clay layer may be missing and allowing migration between the upper and lower aquifers.			0
Groundwater Sampling	6	Sampling of 21 existing and the 4 new monitoring wells. Measurement of water levels four times during the investigation.	To evaluate potential groundwater flow paths, assess the groundwater contamination migration pathway, and to characterize the groundwater quality.	Analysis of groundwater samples for TCL, TAL, indicators and field pH and conductivity.	Level IV Data for TCL, TAL Level III Data for Indicators Level I Data for pH and conductivity.	25 Groundwaters
Aquifer Tests	7	Collection of 2 soil samples at each new monitoring well nest location. Samples will represent the upper aquifer and material directly overlying the bedrock.	The upper aquifer samples will be used to assess the upper aquifer material. The material directly over the bedrock will be used to assess the retardative nature of the material and assess its potential to act as an aquitard.	Analysis of soil samples for grain size distribution.	Level III Data	4 Soil Borings

TABLE 1
(CONTINUED)

ACTIVITY	TASK	DESCRIPTION	INTENDED DATA USAGES	ANALYSIS PARAMETERS	DATA QUALITY OBJECTIVE (ANALYTICAL LEVEL)	ANTICIPATED NO. OF INVESTIGATIVE SAMPLES
DEFINE NATURE AND EXTENT OF CONTAMINATION (CONTINUED)						
Meteorological Data Collection	8	Collection of daily temperature, precipitation, wind direction and wind velocity data.	Precipitation records will represent the original source of groundwater, surface water and leachate. Wind directions and velocity data will be used construct wind rose diagrams and will represent probable air migration routes from the site.			0
Additional Water Level Measurements	9	Water levels collected at lower aquifer monitoring wells.	To verify the hydraulic gradient of the lower aquifer.			0
Water Supply Sampling	9	Sampling of 26 water supply wells.	To characterize the water quality and determine if water supply wells have been affected by the contaminant plume.	Analysis of water supply wells for VOCs with low level detection limit requirements.	Level V Data for VOCs	26 Water Supply Wells
IDENTIFY AND QUANTIFY SOURCES OF CONTAMINATION						
Leachate Volume Evaluation	~~10~~ 11	Leachate level measurements at all headwells six times during the investigation.	To estimate leachate volume and generation rate.			0
Landfill Leachate Sampling	~~11~~ 12	Sampling of 4 leachate headwells.	To identify the characteristics of the leachate within the landfill.	Analysis of leachate samples for TAL, TCL, COD and indicator parameters.	Level IV Data for TAL, TCL Level III Data for COD and Indicators	4 Leachates
Landfill Gas Sampling	~~12~~ 13	Sampling of 2 high flow vents. Measurement of gas flow volume from 24 headwell/vents.	To provide an indication of gas production in various areas of the site. To characterize the landfill gas and to provide for modeling of probable air migration.	Analysis of leachate gas samples for VOCs.	Level V Data	2 Landfill Gas Samples

TABLE 2
SAMPLE TYPE AND ESTIMATED SAMPLE NUMBERS
BLACKWELL LANDFILL SITE

SAMPLE (1) MATRIX	LAB (2)	NO. OF SAMPLES	FIELD DUPLICATES	FIELD (3) BLANKS	MS/MSD (4)	TOTAL NO. SAMPLES	TEST (5,7) PARAMETERS
DEFINE NATURE AND EXTENT OF CONTAMINATION							
Soil Sampling	Warzyn	3	1	0	-	4	TAL Inorganics
	Compuchem	3	1	0	-	4	TCL Volatiles
	Compuchem	3	1	0	-	4	TCL Semivolatiles
	Compuchem	3	1	0	-	4	TCL Pest/PCBs
Surface Water Sampling	Warzyn	8	1	1	-	10	TAL-Inorganics
	Compuchem	8	1	1	1	10	TCL-Volatiles
	Compuchem	8	1	1	1	10	TCL-Semivolatiles
	Compuchem	8	1	1	1	10	TCL-Pest/PCBs
	Warzyn	8	1	1	-	10	Alk,Cl,SO4,TKN, NH3,NO3+NO2,TDS
Sediment Sampling	Warzyn	8	1	0	-	9	TAL-Inorganics
	Compuchem	8	1	0	-	9	TCL-Volatiles
	Compuchem	8	1	0	-	9	TCL-Semivolatiles
	Compuchem	8	1	0	-	9	TCL-Pest/PCBs
Groundwater Monitoring	Warzyn	25	3	3	-	31	TAL-Inorganics
	Compuchem	25	3	3	2	31	TCL-Volatiles
	Compuchem	25	3	3	2	31	TCL-Semivolatiles
	Compuchem	25	3	3	2	31	TCL-Pest/PCBs
	Warzyn	25	3	3	-	31	Alk,Cl,SO4,TKN, NH3,NO3+NO2,TDS
Soil Borings	EWI Eng.	4	1	0	-	5	Grain Size
Water Supply Sampling	Compuchem	26	3	3	2	32	TCL-Volatiles(6)
IDENTIFY AND QUANTIFY SOURCES OF CONTAMINATION							
Leachate Headwell Sampling	Warzyn	4	1	1	-	6	TAL-Inorganics
	Compuchem	4	1	1	1	6	TCL-Volatiles
	Compuchem	4	1	1	1	6	TCL-Semivolatiles
	Compuchem	4	1	1	1	6	TCL-Pest/PCBs
	Warzyn	4	1	1	-	6	Alk,Cl,SO4,TKN, NH3,NO3+NO2,TDS, COD
Landfill Gas Vent Sampling	Enseco	2	1	1	-	4	Volatile Organics

TABLE 2
(Continued)

Notes

(1) Samples will be considered low or medium concentration.

(2) Compuchem
3308 Chapel Hill/Nelson Hwy
Research Triangle Park, NC 27709

Warzyn Engineering Inc.
One Science Court
Madison, WI 53705

EWI Engineering
505 Science Court
Madison, WI 53705

Enseco, Inc.
9537 Telstar Ave.
Suite 118
El Monte, CA 91731

(3) A trip blank for VOC analysis will be included with each cooler shipped for aqueous (leachate, groundwater, surface water and water supply wells) samples. One trip blank (pre-cleaned SUMMA passivated canister) is required for the sampling of landfill gas vents for volatiles.

(4) *EXTRA VOLUME REQUIREMENT:* Extra volume is required for the TCL organic MS/MSD quality control requirement (triple volume for VOC, double volume for BNAs and Pesticides/PCBs). TAL inorganics and general water quality indicator parameters require MS/MSD analysis, however, do not require additional sample volume to meet the specified QC.

(5) See Appendix A for EPA TCL and TAL analyte lists.

(6) Low level detection limits required for water supply wells (see Appendix D).

(7) Groundwater samples for metals analysis will be field filtered through a 0.45 micron filter prior to the addition of preservatives.

TABLE 3

SAMPLE QUANTITIES, CONTAINERS, PRESERVATIVES AND PACKAGING FOR SAMPLES FROM THE BLACKWELL LANDFILL SITE RI/FS

Analysis	Bottles and Jars	Preservation	Holding Time(2)	Volume of Samples	Shipping	Normal Packaging (1)
Low Concentration (Organics)						
Groundwater Samples						
Extractable, Base/neutral, and acids	Two 1-Liter amber glass bottles	Iced to 4°C	5 days from VTSR to extraction, analysis within 40 days after extraction	Fill bottle to neck	Shipped daily by overnight carrier	Vermiculite
Pesticides/PCBs	Two 1-Liter amber glass bottles	Iced to 4°C	5 days from VTSR to extraction, analysis within 40 days after extraction	Fill bottle to neck	Shipped daily by overnight carrier	Vermiculite
Volatiles	Two 40-mL volatile organic analysis (VOA) vials.	1:1 HCL (2 drops/vial), iced to 4°C.	10 days from VTSR	Fill completely no headspace	Shipped daily by overnight carrier	Vermiculite
Water Supply Well Samples						
Volatiles	Four 40-mL VOA vials	Iced to 4°C.	7 days	Fill completely no headspace	Shipped daily by overnight carrier	Vermiculite
Surface Water Samples						
Extractable, Base/neutral, and acids	Two 1-Liter amber glass bottles	Iced to 4°C	5 days from VTSR to extraction, analysis within 40 days after extraction	Fill bottle to neck	Shipped daily by overnight carrier	Vermiculite
Pesticides/PCBs	Two 1-Liter amber glass bottles	Iced to 4°C	5 days from VTSR to extraction, analysis within 40 days after extraction	Fill bottle to neck	Shipped daily by overnight carrier	Vermiculite
Volatiles	Two 40-mL VOA vials	1:1 HCL (2 drops/vial), iced to 4°C.	10 days from VTSR	Fill completely no headspace	Shipped daily by overnight carrier	Vermiculite

TABLE 3
(Continued)

Analysis	Bottles and Jars	Preservation	Holding Time(2)	Volume of Samples	Shipping	Normal Packaging (1)
Leachate Samples						
Extractable, Base/neutral, and acids	Two 1-Liter amber glass bottles	Iced to 4°C	5 days from VTSR to extraction, analysis within 40 days after extraction	Fill bottle to neck	Shipped daily by overnight carrier	Vermiculite
Pesticides/PCBs	Two 1-Liter amber glass bottles	Iced to 4°C	5 days from VTSR to extraction, analysis within 40 days after extraction	Fill bottle to neck	Shipped daily by overnight carrier	Vermiculite
Volatiles	Two 40-mL VOA vials	Iced to 4°C.	7 days	Fill completely no headspace	Shipped daily by overnight carrier	Vermiculite
Low Concentration (Inorganics)						
Groundwater Samples						
Metals	One 1-liter high density polyethylene bottle	Field filter through 0.45 um filter. HNO_3 to pH<2. Iced to 4°C.	180 days from VTSR (26 days from VTSR for mercury)	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
Cyanide	One 1-liter high density polyethylene bottle	Add NaOH to pH>12. Iced to 4°C	12 days from VTSR	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
Surface Water Samples						
Metals	One 1-liter high density polyethylene bottle	HNO_3 to pH<2. Iced to 4°C.	180 days from VTSR (26 days from VTSR for mercury)	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
Cyanide	One 1-liter high density polyethylene bottle	Add NaOH to pH>12. Iced to 4°C	12 days from VTSR	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
Leachate Samples						
Metals	One 1-liter high density polyethylene bottle	HNO_3 to pH<2. Iced to 4°C.	180 days from VTSR (26 days from VTSR for mercury)	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite

TABLE 3
(Continued)

Analysis	Bottles and Jars	Preservation	Holding Time (2)	Volume of Samples	Shipping	Normal Packaging (1)
Cyanide	One 1-liter high density polyethylene bottle	Add NaOH to pH>12. Iced to 4°C	12 days from VTSR	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
Water Quality Parameters						
Groundwater Samples						
TKN, Nitrate + Nitrite-N and Ammonia	One 1-liter high density polyethylene bottle	H_2SO_4 to pH<2. Iced to 4°C.	28 days	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
Alkalinity, Chloride, Sulfate	One 500-mL polyethylene bottle	Iced to 4°C.	28 days (14 days alkalinity)	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
TDS	One 500-mL polyethylene bottle	Field filter through 0.45 um filter. Iced to 4°C	7 days	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
Surface Water Samples						
TKN, Nitrate + Nitrite-N and Ammonia	One 1-liter high density polyethylene bottle	H_2SO_4 to pH<2. Iced to 4°C.	28 days	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
Alkalinity, Chloride, Sulfate	One 500-mL polyethylene bottle	Iced to 4°C.	28 days (14 days alkalinity)	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
TDS	One 500-mL polyethylene bottle	Iced to 4°C.	7 days	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
Leachate Samples						
TKN, Nitrate+Nitrite-N, Ammonia and COD	One 1-liter high density polyethylene bottle	H_2SO_4 to pH<2. Iced to 4°C.	28 days	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
Alkalinity, Chloride, Sulfate	One 500-mL polyethylene bottle	Iced to 4°C.	28 days (14 days alkalinity)	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite
TDS	One 500-mL polyethylene bottle	Iced to 4°C.	7 days	Fill to shoulder of bottle	Shipped daily by overnight carrier	Vermiculite

TABLE 3
(Continued)

Analysis	Bottles and Jars	Preservation	Holding Time(2)	Volume of Samples	Shipping	Normal Packaging (1)
Low or Med Concentration (Organics)						
Soil and Sediment Samples						
Extractable, Base/neutral and acids	One 8-oz wide mouth glass jar	Iced to 4°C	10 days from VTSR to extraction, analysis within 40 days after extraction.	Fill 3/4 full	Shipped daily by overnight carrier	Vermiculite (Med in cans/ vermiculite)
Pesticides/PCBs	One 8-oz wide mouth glass jar	Iced to 4°C	10 days from VTSR extraction, analysis within 40 days after extraction.	Fill 3/4 full	Shipped daily by overnight carrier	Vermiculite (Med in cans/ vermiculite)
Volatiles	Two 4-oz wide mouth glass jars	Iced to 4°C	10 days from VTSR	Fill Completely no headspace	Shipped daily by overnight carrier	Vermiculite (Med in cans/ vermiculite)
Low or Med Concentration (Inorganics)						
Soil and Sediment Samples						
Metals and Cyanide	One 8-oz wide mouth glass jar	Iced to 4°C	180 days from VTSR (26 days from VTSR for mercury and 12 days from VTSR for cyanide)	Fill 3/4 full	Shipped daily by overnight carrier	Vermiculite (Med in cans/ vermiculite)
Physical Analysis						
Soil Samples						
Grain Size Distribution	Two 8-oz wide mouth glass jars	NONE	Not established	Fill 3/4 full	Ship by carrier	Vermiculite

TABLE 3
(Continued)

Analysis	Bottles and Jars	Preservation	Holding Time(2)	Volume of Samples	Shipping	Normal Packaging (1)
Landfill Gas Analysis						
Volatiles	One 6-liter SUMMA passivated canister	Iced to 4°C.	Not established	Fill as described in procedure.	Shipped daily by overnight carrier	Vermiculite

Notes
(1) The packing material should completely cushion the sample bottles - botttom, sides and top.
(2) VTSR - verified time of sampling receipt. Unless otherwise noted the holding time is from the date sampled.

Table 4
Water Level Measurement Points and Sampling Dates
Blackwell Landfill NPL Site

QUARTERLY WATER LEVEL MEASUREMENTS:

Measurement Dates: April 1991 July 1991
October 1991 January 1992

Lower Aquifer Wells

G-103D
G-107D
G-115D
G-120D
G-128D
G-131D
G-132D
G-133D
G-134D
G-135D
G-136D
G-137D
G-138D
G-139D

Upper Aquifer Wells

G-101S
G-102S
G-103S
G-105S
G-106S
G-107S
G-108S
G-109S
G-111S
G-113S
G-114S
G-115S
G-116S
G-117S
G-118D
G-118S
G-119S
G-121S
G-122S
G-123S
G-124S
G-125S
G-126S
G-127S
G-128S
G-129S
G-130S
G-133S

Staff gages and Piezometers

SG-1
SG-2
P-1
SG-3
SG-4
P-2
SG-5
SG-6
P-3
SG-7
SG-8
P-4

LEACHATE MEASUREMENT DATES:

April 1991 June 1991
July 1991 August 1991
September 1991 January 1992

Leachate Head Wells

SV-1
SV-2
SV-3
SV-4
SV-5
SV-6
SV-7
SV-8
SV-9
SV-10
SV-11
SV-12
DV-2
DV-3
DV-4
DV-5
DV-6
DV-7
DV-8
DV-9
DV-10
DV-11
DV-12
DV-13

Table 5

Site Monitoring Wells Designated For Sampling
Blackwell Landfill NPL Site

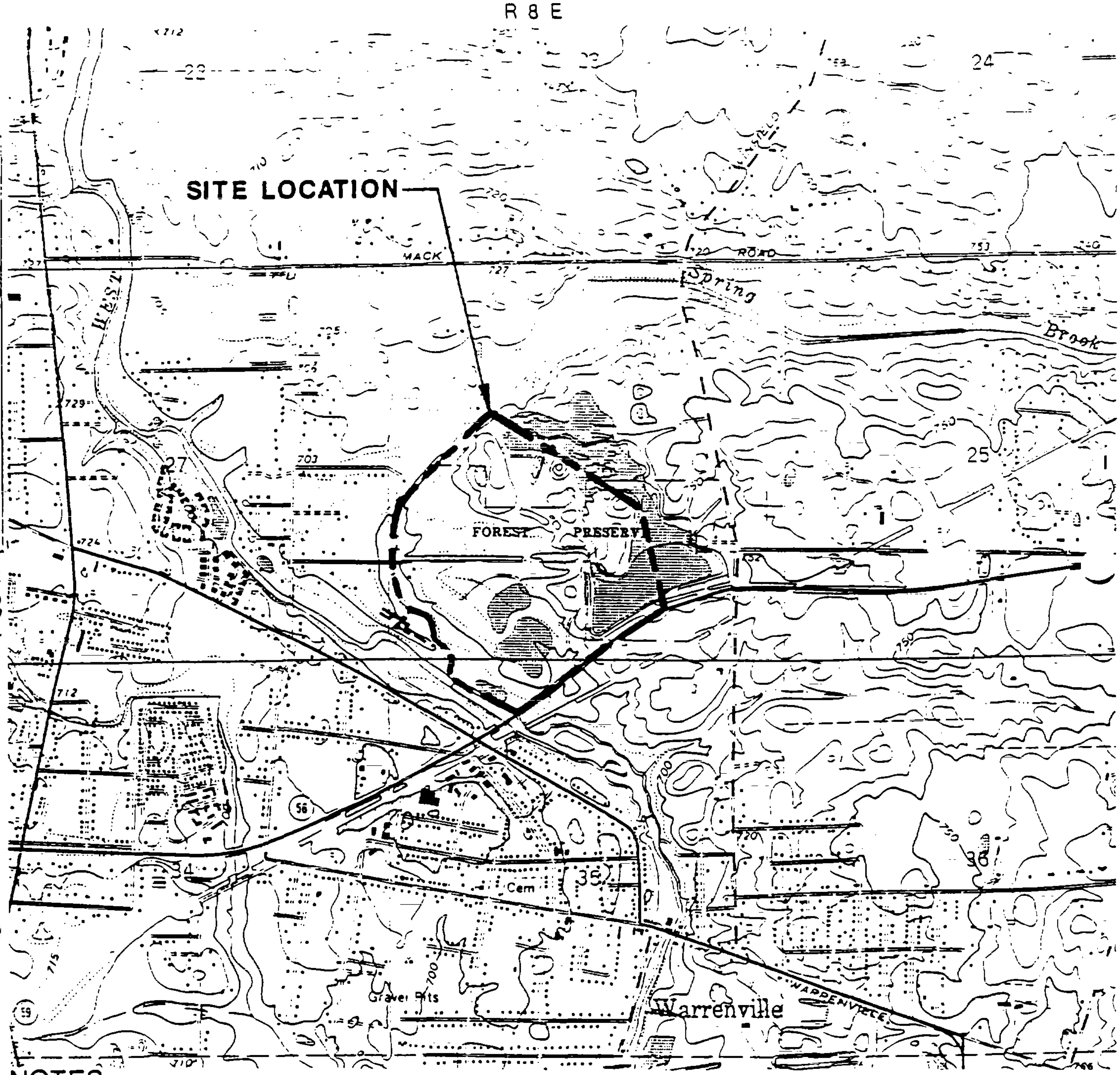
LOWER AQUIFER MONITORING WELLS

Number	Location	Geologic Unit
G-134D	Upgradient	Dolomite
G-128D	Downgradient	Dolomite
G-133D	Downgradient	Dolomite
G-135	Downgradient	Dolomite
G-136	Downgradient	Dolomite
G-138	Downgradient	Dolomite
G-139	Downgradient	Dolomite

UPPER AQUIFER MONITORING WELLS

Number	Location	Geologic Unit
G-121	Upgradient	Henry Formation
G-130	Upgradient	Henry Formation
G-108	Downgradient	Henry Formation
G-117	Downgradient	Henry Formation
G-118S	Downgradient	Henry Formation
G-118D	Downgradient	Malden/Tiskilwa Till
G-119	Downgradient	Henry Formation
G-122	Downgradient	Henry Formation
G-123	Downgradient	Henry Formation
G-126	Downgradient	Henry Formation
G-127	Downgradient	Henry Formation
G-128S	Downgradient	Henry Formation
G-129	Downgradient	Henry Formation
G-133S	Downgradient	Henry Formation

FIGURES



Drafting Standards ____ PM ____
Professional ____ Division ____
Other

NOTES

1. BASE MAP DEVELOPED FROM NAPERVILLE, ILLINOIS 7.5 MINUTE USGS TOPOGRAPHIC QUADRANGLE MAP DATED 1962, PHOTOREVISED 1972 AND 1980.

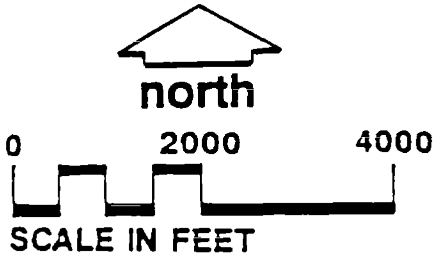


FIGURE 1

WARZYN

SITE LOCATION MAP

FIELD SAMPLING PLAN
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

Drawn

Checked JAW

App'd. Julie R. Weidman

Revisions

Date 4/12/90

60721 A1

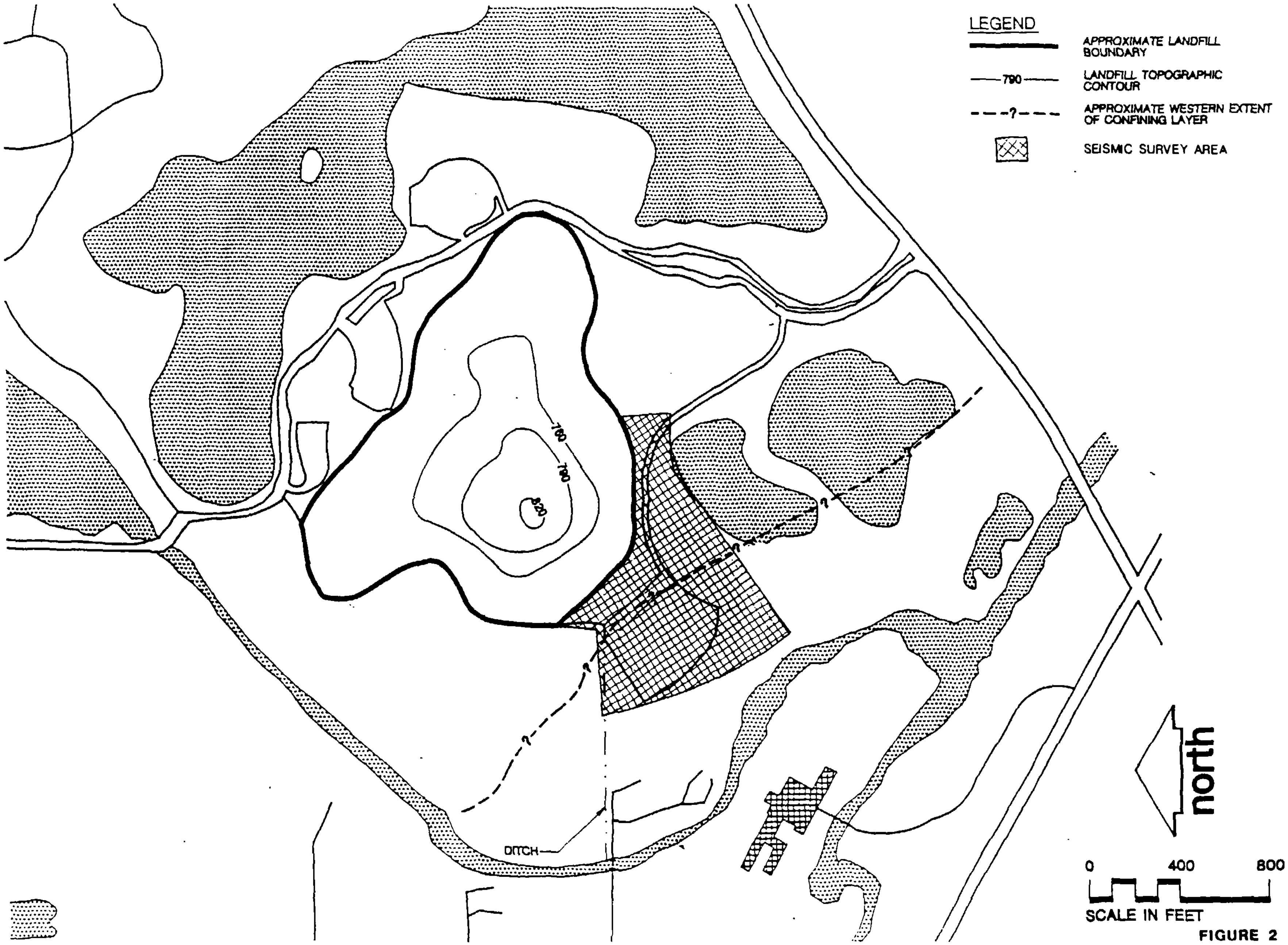


FIGURE 2

REFLECTION SEISMIC SURVEY AREA

FIELD SAMPLING PLAN
REMEDIAL INVESTIGATION / FEASIBILTY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

WARZYN

Drawn By ELR
Checked By TAW
Approved By Julie A. Widmer
Date 4/12/90

60721 B10

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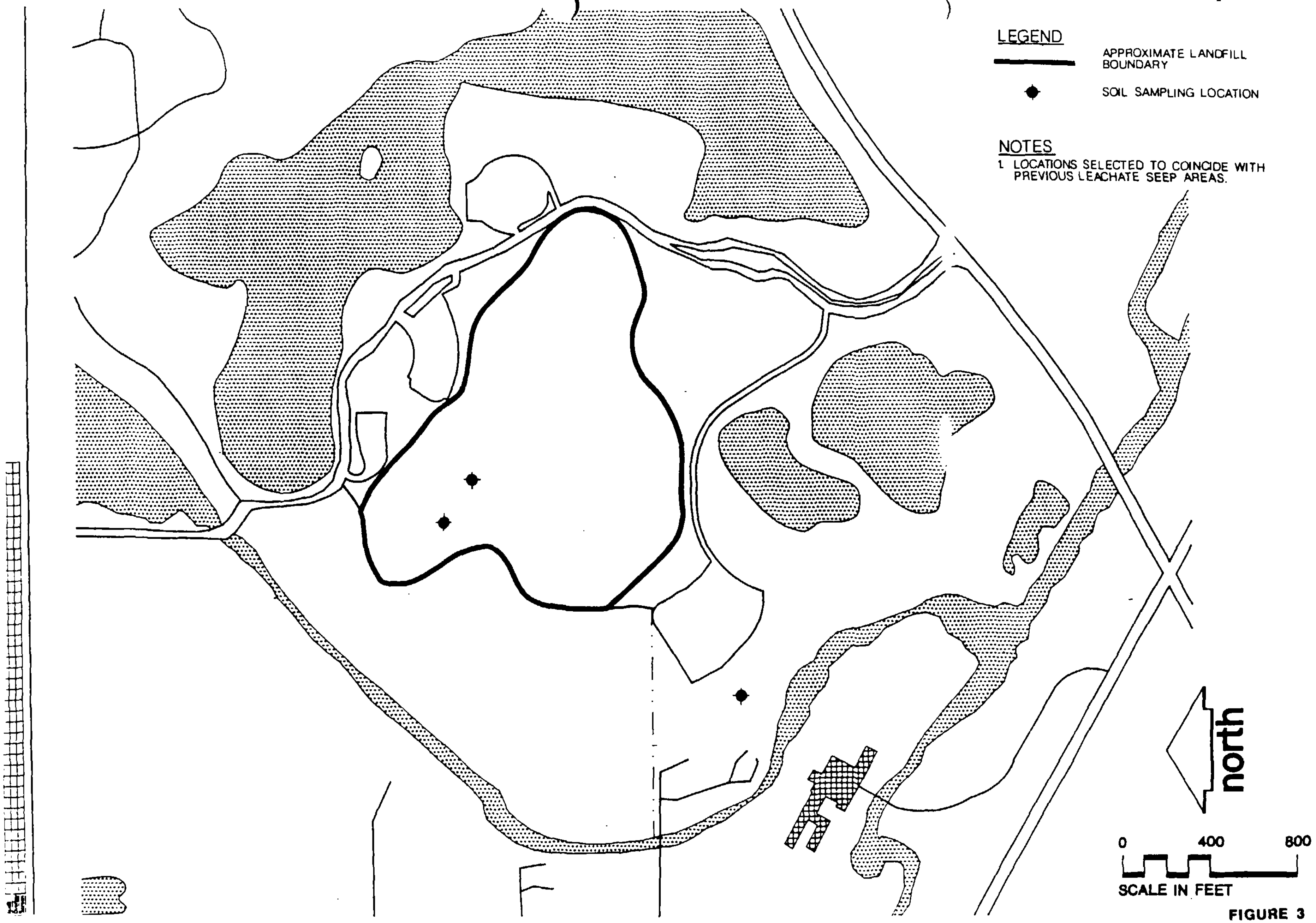

LEGEND

▬	APPROXIMATE LANDFILL BOUNDARY
●	SOIL SAMPLING LOCATION

NOTES

1. LOCATIONS SELECTED TO COINCIDE WITH PREVIOUS LEACHATE SEEP AREAS.

FIGURE 3

Drawn By ELR
Checked By JAW
Approved By Julie A. Wilkinson
Date 8-9-86

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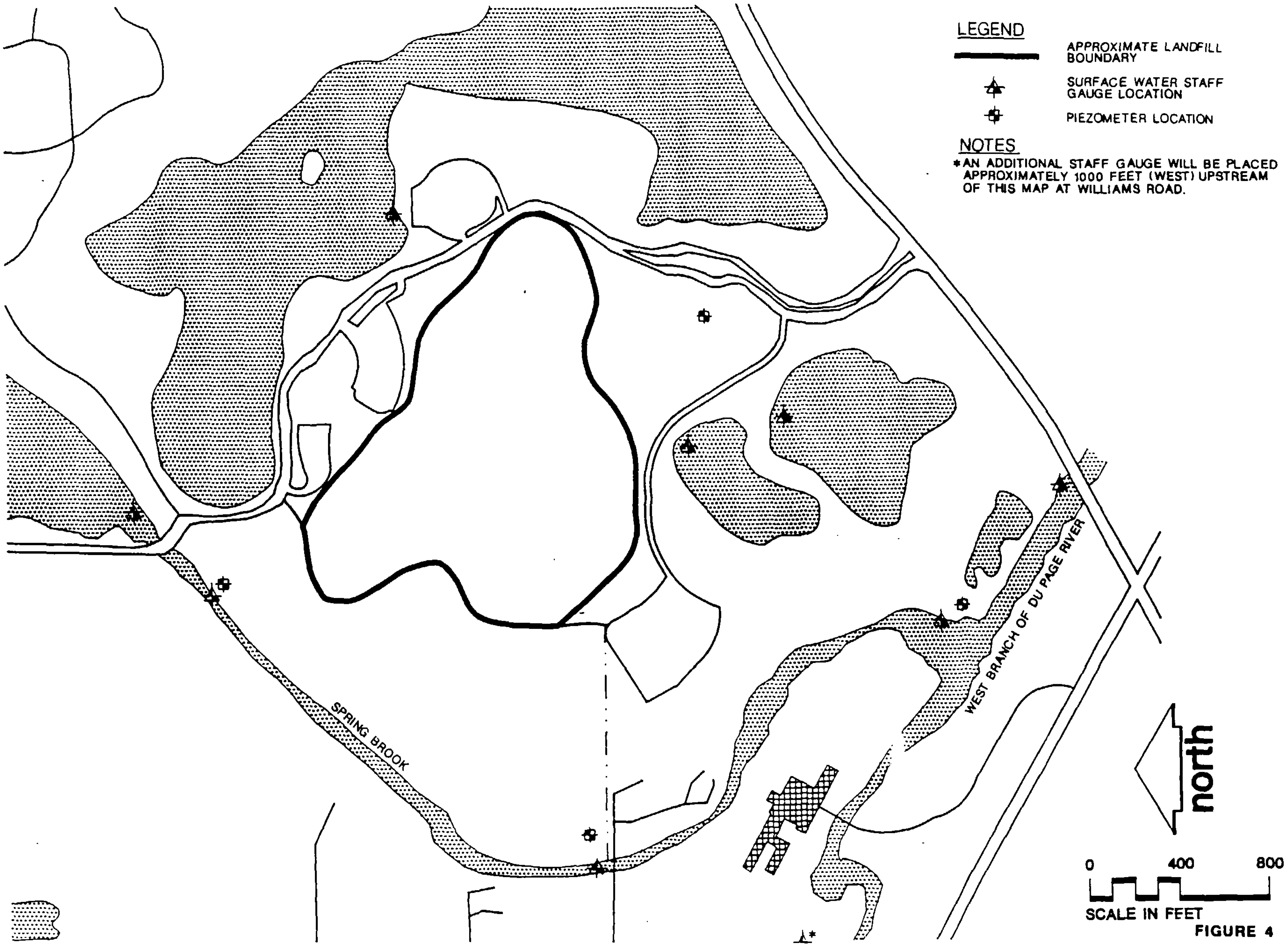
WARZYN ENGINEERING INC.

SOIL SAMPLING LOCATIONS
FIELD SAMPLING PLAN
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

60721 B18



NOTES

*AN ADDITIONAL STAFF GAUGE WILL BE PLACED APPROXIMATELY 1000 FEET (WEST) UPSTREAM OF THIS MAP AT WILLIAMS ROAD.

FIGURE 4

SURFACE WATER & PIEZOMETER MEASUREMENT LOCATIONS

FIELD SAMPLING PLAN
REMEDIAL INVESTIGATION / FEASIBILTY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

WARZYN

Drawn By: ELR
Checked By: JAW
Approved By: Julie A Widman
Date: 4/12/90

60721B11

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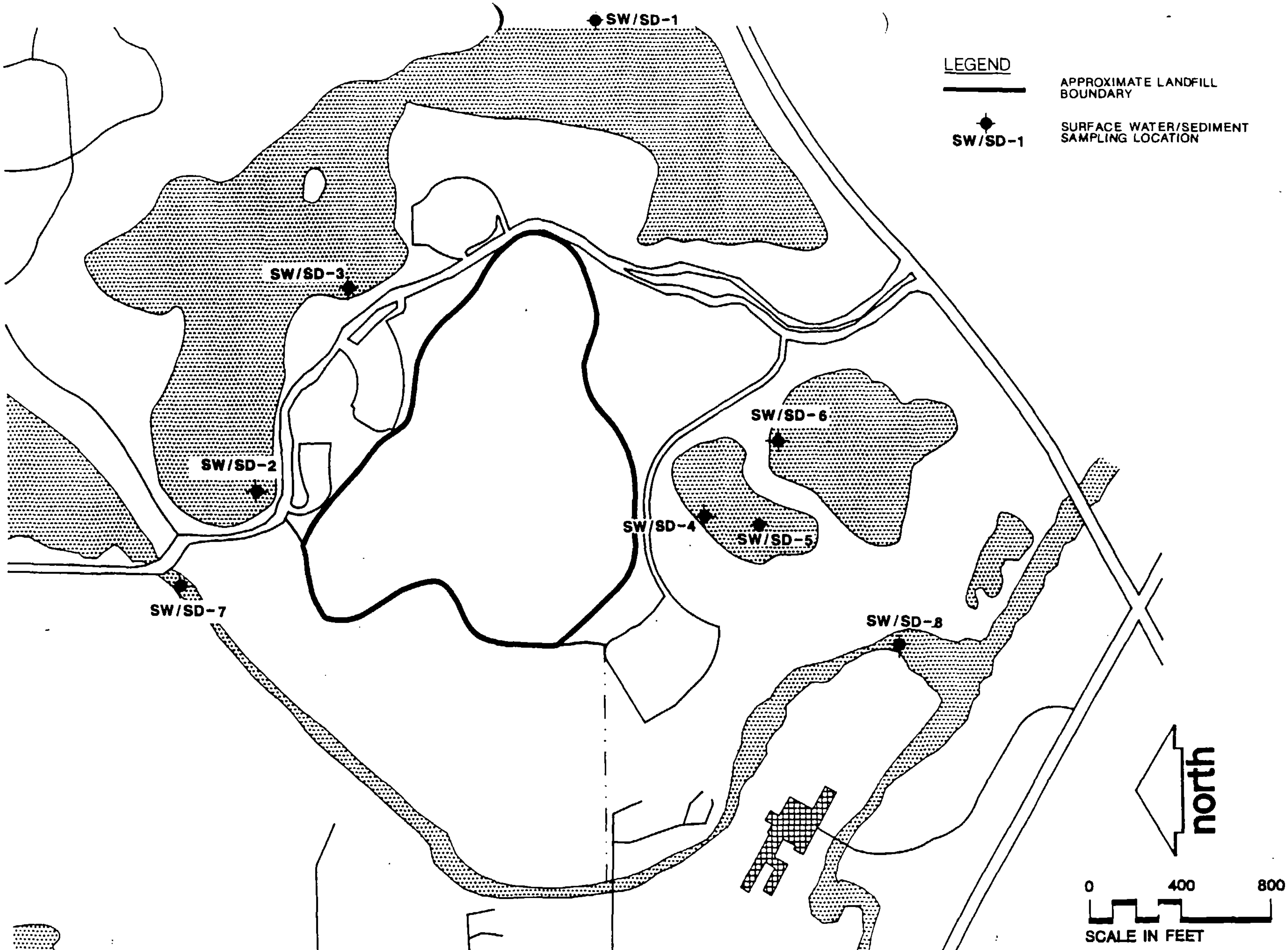

FIGURE 5

SURFACE WATER/SEDIMENT SAMPLING LOCATIONS

FIELD SAMPLING PLAN
REMEDIAL INVESTIGATION / FEASIBILTY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

60721B12

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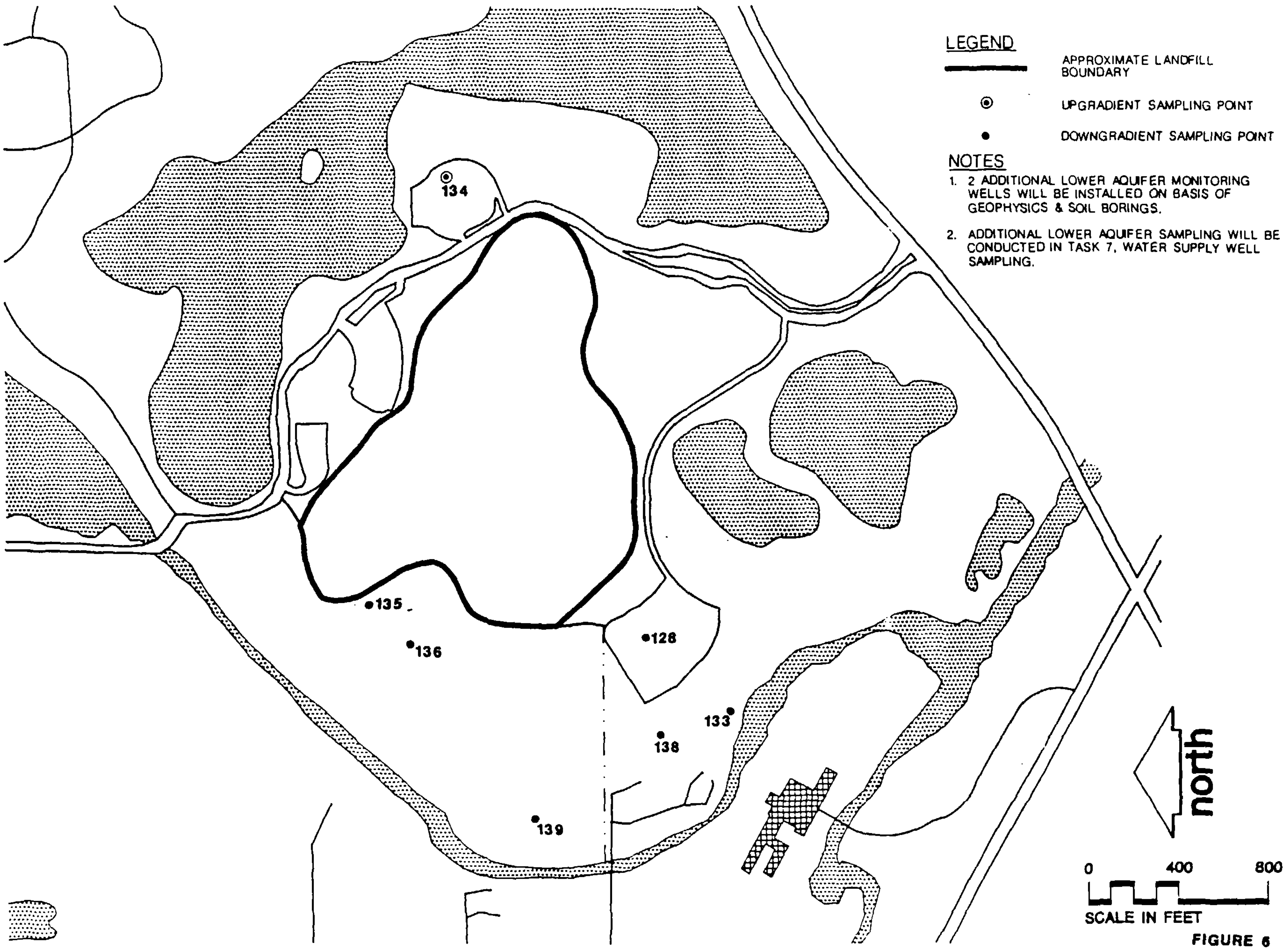
Drawn By ELR
Checked By JAH
Date 4/12/90
Approved By Julie A. Widmer



LEGEND

▬	APPROXIMATE LANDFILL BOUNDARY
⊙	UPGRADIENT SAMPLING POINT
●	DOWNGRADIENT SAMPLING POINT

NOTES

1. 2 ADDITIONAL LOWER AQUIFER MONITORING WELLS WILL BE INSTALLED ON BASIS OF GEOPHYSICS & SOIL BORINGS.
2. ADDITIONAL LOWER AQUIFER SAMPLING WILL BE CONDUCTED IN TASK 7, WATER SUPPLY WELL SAMPLING.

FIGURE 6

LOWER AQUIFER GROUNDWATER SAMPLING POINTS

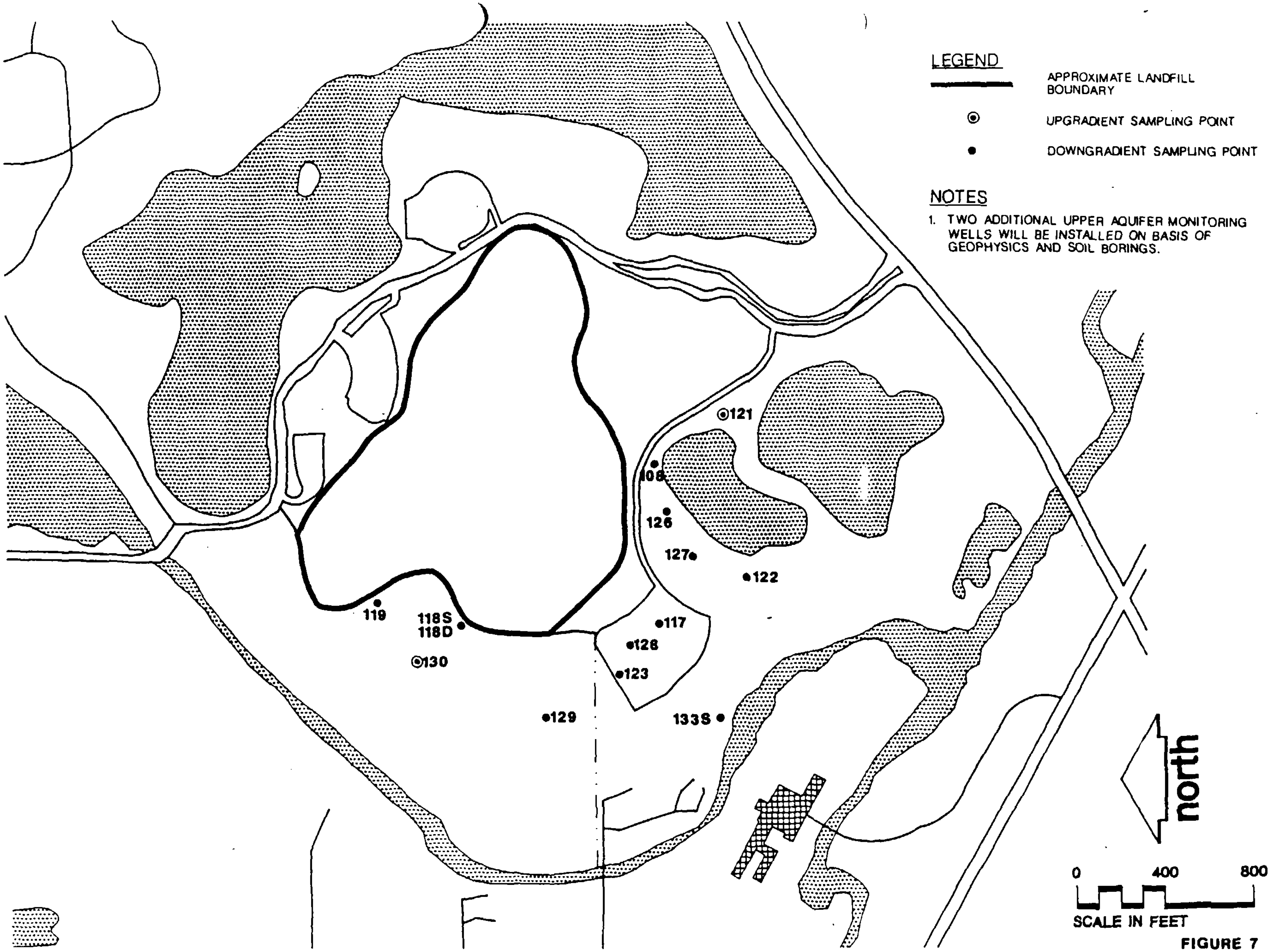
FIELD SAMPLING PLAN
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

WARZYN

Drawn By ELR
Checked By JAW
Date 8-5-90

60721 B19

WARZYN



LEGEND

- APPROXIMATE LANDFILL BOUNDARY
- ◎ UPGRADIENT SAMPLING POINT
- ● DOWNGRADIENT SAMPLING POINT

NOTES

1. TWO ADDITIONAL UPPER AQUIFER MONITORING WELLS WILL BE INSTALLED ON BASIS OF GEOPHYSICS AND SOIL BORINGS.

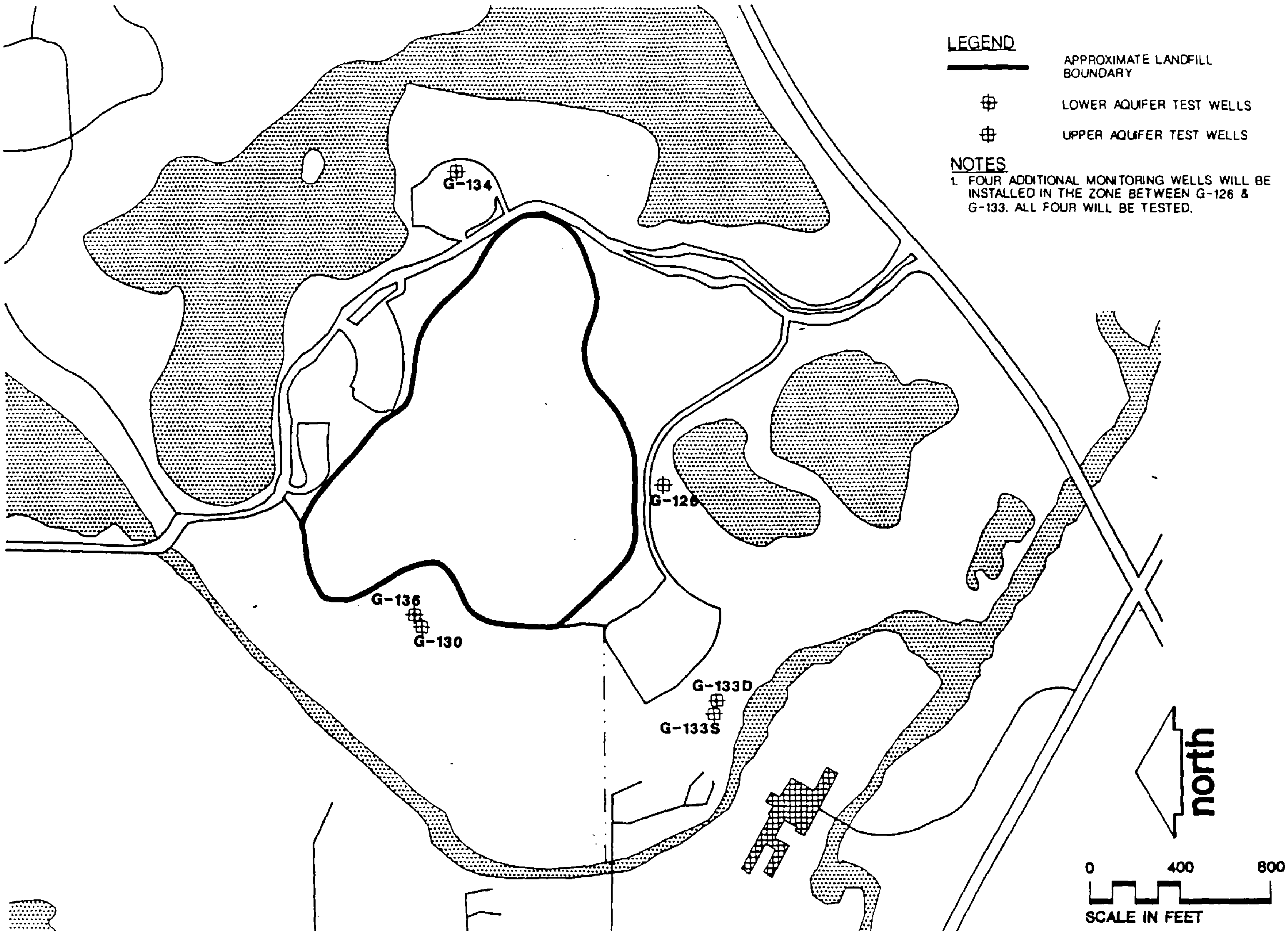
FIGURE 7

UPPER AQUIFER GROUNDWATER SAMPLING POINTS
FIELD SAMPLING PLAN
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

WARZYN

Drawn By ELR
Checked By JAW
Approved By Julie A Wideman
Date 8-9-90

60721B20



NOTES
1. FOUR ADDITIONAL MONITORING WELLS WILL BE INSTALLED IN THE ZONE BETWEEN G-126 & G-133. ALL FOUR WILL BE TESTED.

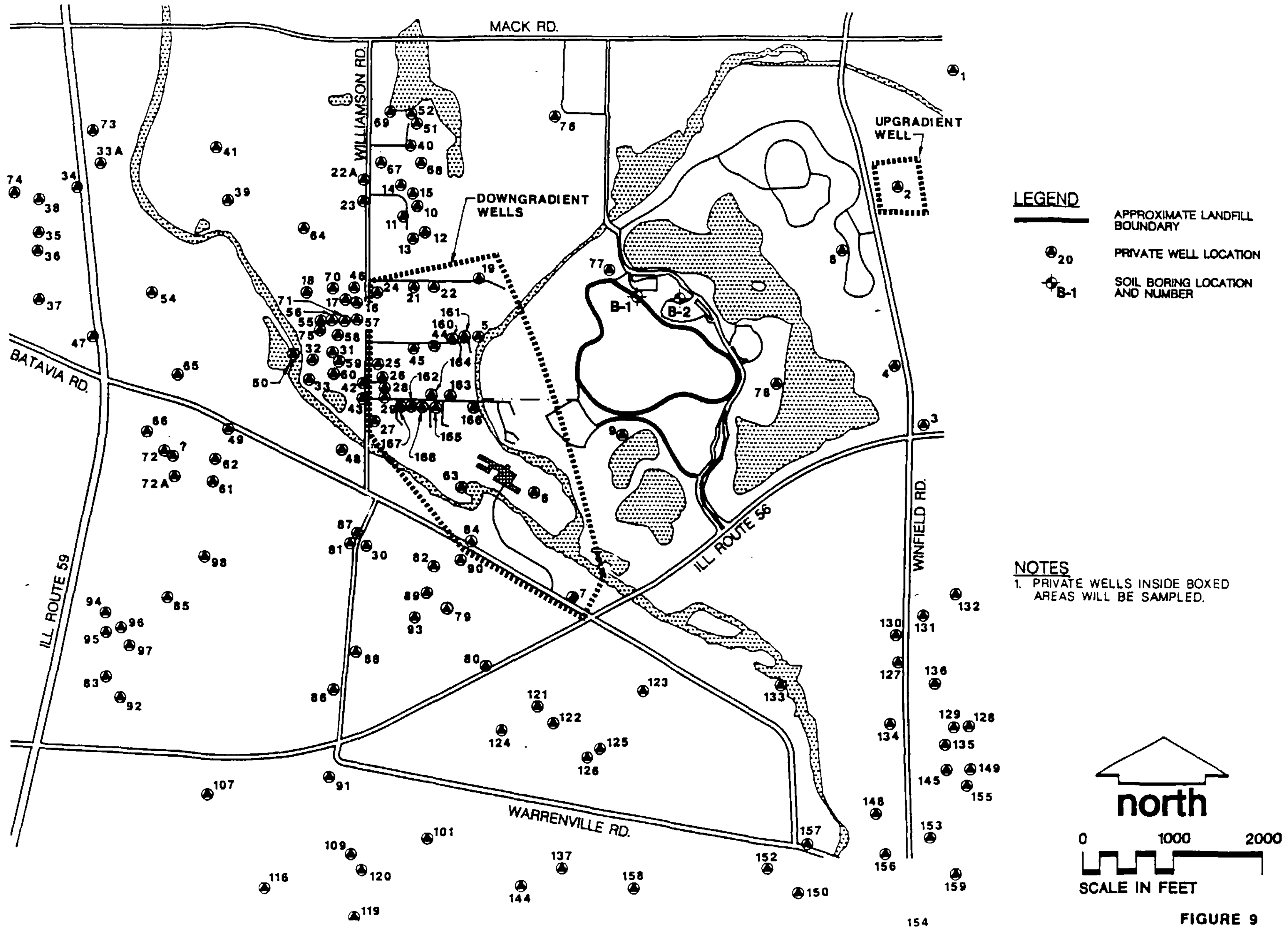
FIGURE 8

AQUIFER TEST LOCATIONS
FIELD SAMPLING PLAN
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

WARZYN

Drawn By ELR
Checked By JAW
Date 8-9-90

60721 B2-



NOTES
1. PRIVATE WELLS INSIDE BOXED AREAS WILL BE SAMPLED.

FIGURE 9

PRIVATE WELL SAMPLING LOCATIONS

FIELD SAMPLING PLAN
REMEDIAL INVESTIGATION / FEASIBILTY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

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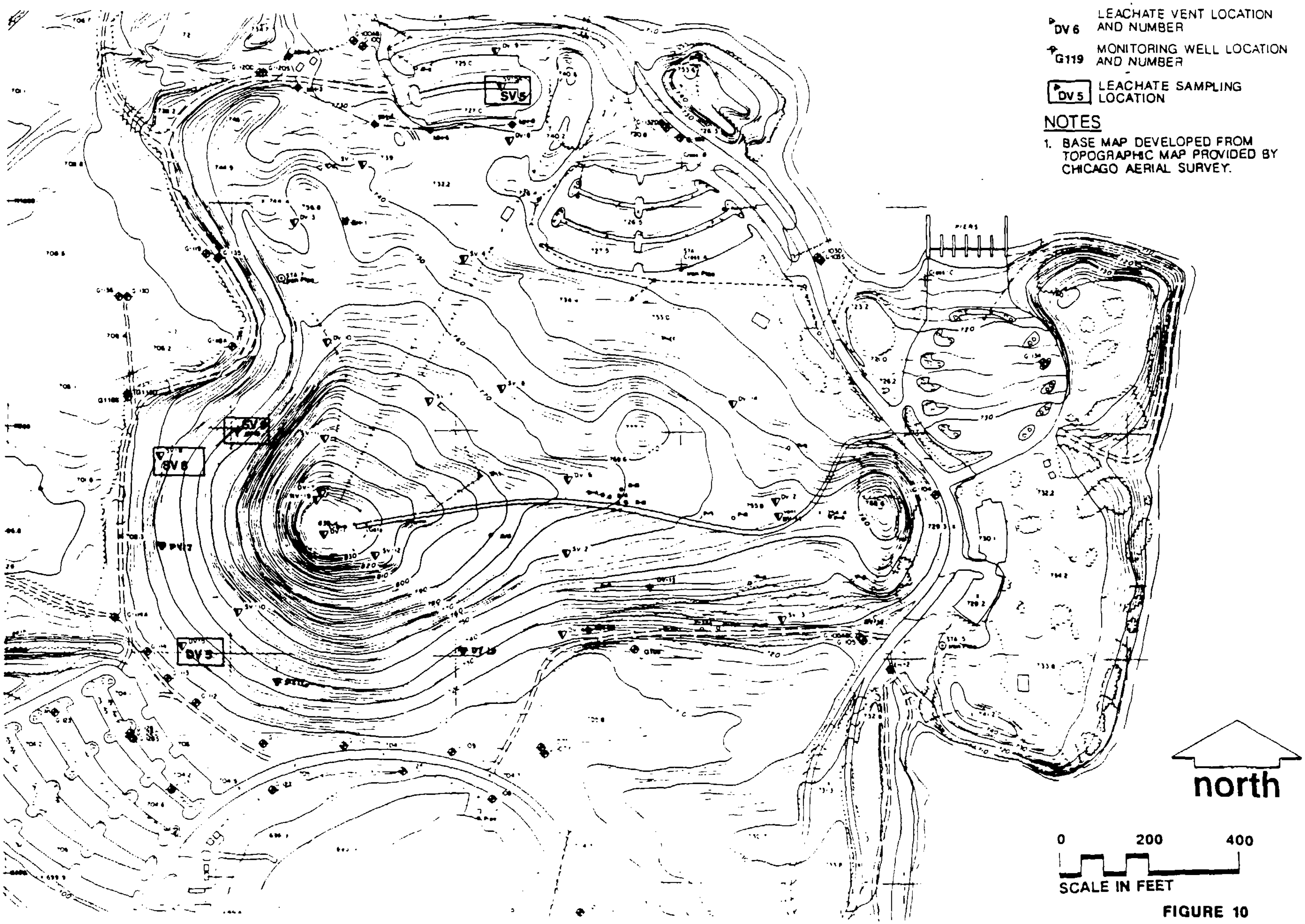
WARZYN ENGINEERING INC

Drawn By ELR
Checked By JAW
Approved By Julie A. Widman
Date 4/12/90

60721B22



LEGEND

DV 6 LEACHATE VENT LOCATION AND NUMBER

G119 MONITORING WELL LOCATION AND NUMBER

DV 5 LEACHATE SAMPLING LOCATION

NOTES

1. BASE MAP DEVELOPED FROM TOPOGRAPHIC MAP PROVIDED BY CHICAGO AERIAL SURVEY.

FIGURE 10

LEACHATE SAMPLING LOCATIONS

FIELD SAMPLING PLAN
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
BLACKWELL LANDFILL NPL SITE
DU PAGE COUNTY, ILLINOIS

WARZYN

Checked By JAW
Date 8 9 96
Approved By Julie A. Widman

OF

60721B23

WARZYN

A

APPENDIX A

SOIL CLASSIFICATION AND FIELD BORING LOG FORM

UNIFIED SOIL CLASSIFICATION SYSTEM

COARSE-GRAINED SOILS

(More than half of material is larger than No. 200 seive size.)

GRAVELS More than half of coarse fraction larger than No. 4 sieve size	**Clean Gravels** (Little or no fines)	
	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
	Gravels with Fines (Appreciable amount of fines)	
	GM^{d}_{u}	Silty gravels, gravel-sand-silt mixtures
	GC	Clayey gravels, gravel-sand-clay mixtures
SANDS More than half of coarse fraction smaller than No. 4 sieve size	**Clean Sands** (Little or no fines)	
	SW	Well-graded sands, gravelly sands, little or no fines
	SP	Poorly graded sands, gravelly sands, little or no fines
	Sands with Fines (Appreciable amount of fines)	
	SM^{d}_{u}	Silty sands, sand-silt mixtures
	SC	Clayey sands, sand-clay mixtures

FINE-GRAINED SOILS

(More than half of material is smaller than No. 200 sieve.)

SILTS AND CLAYS Liquid limit less than 50%	ML	*Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity*
	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	OL	Organic silts and organic silty clays of low plasticity
SILTS AND CLAYS Liquid limit greater than 50%	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
	CH	Inorganic clays of high plasticity, fat clays
	OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS	PT	Peat and other highly organic soils

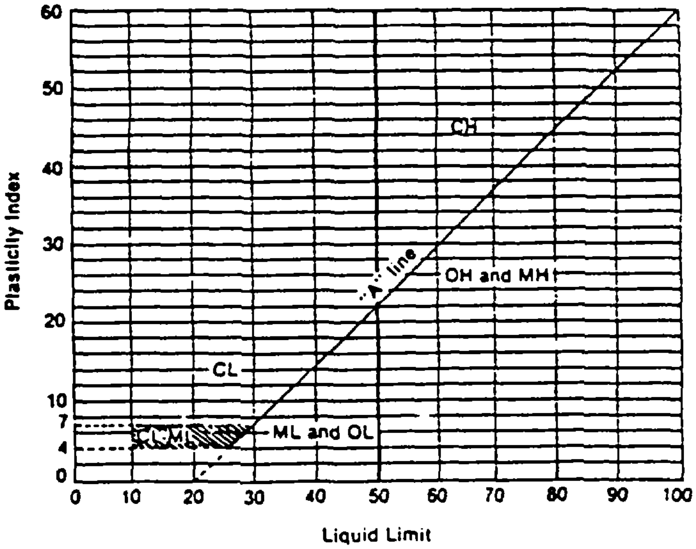
LABORATORY CLASSIFICATION CRITERIA

GW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
GP	*Not meeting all gradation requirements for GW*	
GM	Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
GC	Atterberg limits above "A" line with P.I. greater than 7	
SW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
SP	Not meeting all gradation requirements for SW	
SM	Atterberg limits below "A" line or P.I. less than 4	Limits plotting in hatched zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols.
SC	Atterberg limits above "A" line with P.I. greater than 7	

Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:

Less than 5 per cent	GW, GP, SW, SP
More than 12 per cent	GM, GC, SM, SC
5 to 12 per cent	Borderline cases *requiring dual symbols*

PLASTICITY CHART



For classification of fine-grained soils and fine fraction of coarse-grained soils.

Atterberg Limits plotting in hatched area are borderline classifications requiring use of dual symbols.

Equation of A-line: PI = 0.73 (LL - 20)

LOG OF TEST BORING

General Notes

Descriptive Soil Classification

GRAIN SIZE TERMINOLOGY

Soil Fraction	Particle Size	U.S. Standard Sieve Size
Boulders	Larger than 12"	Larger than 12"
Cobbles	3" to 12"	3" to 12"
Gravel: Coarse	¾" to 3"	¾" to 3"
Fine	4.76 mm to ¾"	#4 to ¾"
Sand: Coarse	2.00 mm to 4.76 mm	#10 to #4
Medium	0.42 mm to 2.00 mm	#40 to #10
Fine	0.074 mm to 0.42 mm	#200 to #40
Silt	0.005 mm to 0.074 mm	Smaller than #200
Clay	Smaller than 0.005 mm	Smaller than #200

Plasticity characteristics differentiate between silt and clay.

GENERAL TERMINOLOGY

Physical Characteristics
Color, moisture, grain shape, fineness, etc.
Major Constituents
Clay, silt, sand, gravel
Structure
Laminated, varved, fibrous, stratified, cemented, fissured, etc.
Geologic Origin
Glacial, alluvial, eolian, residual, etc.

RELATIVE DENSITY

Term	"N" Value
Very Loose	0-4
Loose	4-10
Medium Dense	10-30
Dense	30-50
Very Dense	Over 50

RELATIVE PROPORTIONS OF COHESIONLESS SOILS

Proportional Term	Defining Range By Percentage of Weight
Trace	0%- 5%
Little	5%-12%
Some	12%-35%
And	35%-50%

CONSISTENCY

Term	q_u-tons/sq. ft.
Very Soft	0.0 to 0.25
Soft	0.25 to 0.50
Medium	0.50 to 1.0
Stiff	1.0 to 2.0
Very Stiff	2.0 to 4.0
Hard	Over 4.0

ORGANIC CONTENT BY COMBUSTION METHOD

Soil Description	Loss on Ignition
Non Organic	Less than 4%
Organic Silt/Clay	4-12%
Sedimentary Peat	12-50%
Fibrous and Woody Peat	More than 50%

PLASTICITY

Term	Plastic Index
None to Slight	0-4
Slight	5-7
Medium	8-22
High to Very High	Over 22

The penetration resistance, N, is the summation of the number of blows required to effect two successive 6" pentrations of the 2" split-barrel sampler. The sampler is driven with a 140 lb. weight falling 30" and is seated to a depth of 6" before commencing the standard penetration test.

Symbols

DRILLING AND SAMPLING

CS—Continuous Sampling
RC—Rock Coring: Size AW, BW, NW, 2" W
RQD—Rock Quality Designator
RB—Rock Bit
FT—Fish Tail
DC—Drove Casing
C—Casing: Size 2½", NW, 4", HW
CW—Clear Water
DM—Drilling Mud
HSA—Hollow Stem Auger
FA—Flight Auger
HA—Hand Auger
COA—Clean-Out Auger
SS—2" Diameter Split-Barrel Sample
2ST—2" Diameter Thin-Walled Tube Sample
3ST—3" Diameter Thin-Walled Tube Sample
PT—3" Diameter Piston Tube Sample
AS—Auger Sample
WS—Wash Sample
PTS—Peat Sample
PS—Pitcher Sample
NR—No Recovery
S—Sounding
PMT—Borehole Pressuremeter Test
VS—Vane Shear Test
WPT—Water Pressure Test

LABORATORY TESTS

q_p—Penetrometer Reading, tons/sq. ft.
q_u—Unconfined Strength, tons/sq. ft.
W—Moisture Content, %
LL—Liquid Limit, %
PL—Plastic Limit, %
SL—Shrinkage Limit, %
LI—Loss on Ignition, %
D—Dry Unit Weight, lbs./cu. ft.
pH—Measure of Soil Alkalinity or Acidity
FS—Free Swell, %

WATER LEVEL MEASUREMENT

▽—Water Level at time shown
NW—No Water Encountered
WD—While Drilling
BCR—Before Casing Removal
ACR—After Casing Removal
CW—Caved and Wet
CM—Caved and Moist

Note: Water level measurements shown on the boring logs represent conditions at the time indicated and may not reflect static levels, especially in cohesive soils.

WARZYN

LOG OF BORING ________

SHEET 1 OF ________

PROJECT	Project No.
LOCATION	Borehole Backfill.
Drilling Agency	Date Started / Date Finished
Drilling Equipment	Completion Depth / Rock Depth
Casing Size	Water Level / First / Compl / 24hr
Size and Type of Bit	
Sampler	Driller / Logged By
Sampler Hammer / Weight / Drop	Driller / Drilling fluid

Sample Depth	DESCRIPTION	Moisture	DEPTH FT	SAMPLES PP	 Serial No	 Rec ft	 Pen Rs bl/6 in	 HNu ppm	REMARKS

WARZYN

Planning Document
Project No. 60721

Volume 5 of 5
Health and Safety Plan
Blackwell Landfill NPL Site

Prepared for:
Forest Preserve District
DuPage County, Illinois

Prepared by:
Warzyn Engineering Inc.
Chicago, Illinois

August 1990

SITE HEALTH AND SAFETY PLAN
REMEDIAL INVESTIGATION AND FEASIBILITY STUDY
BLACKWELL LANDFILL NPL SITE
DUPAGE COUNTY, ILLINOIS

Prepared by:

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August 10, 1990

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SECTION 1
INTRODUCTION

The objective of this plan is the accomplishment of necessary on-site remedial investigation field work to achieve the objectives of the Remedial Investigation/Feasibility Study at the Blackwell Landfill in DuPage County, Illinois in a manner which minimizes any potential for accident, and which is adequately protective of the environment and of the health of project workers. In order to achieve these goals, all of the operations conducted at this site will be in accordance with the requirements of the Hazardous Waste Operations and Emergency Response Standard, OSHA 29 CFR 1910.120, and with all of the applicable subparts of the OSHA Construction and General Industry Standards, 29 CFR 1926. these subparts include Subpart C - General Safety and Health Provisions, Subpart D - Occupational Health and Environmental Controls, Subpart E - Personal Protective and Life Saving Equipment, Subpart F - Fire Protection and Prevention, Subpart G - Signs, Signals and Barricades, Subpart I - Tools - Hand Power, Subpart K - Electrical, Subpart L - Ladders and Scaffolding, Subpart O - Motor Vehicles, Mechanized Equipment and Marine Operations and Subpart P - Excavations Trenching and Shoring of the OSHA Construction Standards. Additional OSHA Construction and General Industry Standards may apply, depending on the nature of the operations which might evolve on the site during the course of the Remedial Investigation and Feasibility Study.

SECTION 2
SITE SUMMARY

Site Description

The Blackwell site is located approximately six miles southwest of downtown Wheaton, Illinois in Section 26, T39N, R9E, DuPage County, Illinois, as shown in Figure 1. The investigation area is bounded on the west by Spring Brook between the bridge to the north and the Cenacle property to the south at which point the boundary extends south to the West branch of the DuPage River; the DuPage River and Butterfield Road (Route 56) form the southern boundary; the eastern and northern boundaries are located through Silver Lake, as shown in Figure 2.

The site is currently part of DuPage County, Illinois Forest Preserve District (FPD) and is called the Roy C. Blackwell Forest Preserve. The forest preserve consists of a large hill formed from the landfill, three artificially constructed lakes including Silver Lake, Swim Lake, and Supply Lake, campgrounds, picnic areas, hiking trails, and roads.

Description of Disposal Activities

A review of past records indicated that the users of the landfill were primarily municipal waste haulers and scavenger companies located in or serving DuPage County. The Metropolitan Sanitary District of the Greater Chicago deposited 8,000 tons of dry sludge in 1968. Owens - Illinois, St. Charles, Illinois deposited daily trash from their glass manufacturing facility. The weight of the trash deposited was estimated at 3 to 4 tons per day. Kroehler Manufacturing, Naperville, Illinois, also used the landfill for plan trash of undermined origin. Burnt tree cuttings and grass clippings were also deposited, resulting in several fires over the course of active operation of the landfill.

Discussion of Possible Contaminants

As a result of interpretation of available information sources pertinent to disposal practices or isolated disposal events at the Blackwell Landfill, the following hazardous chemical contamination might be expected to be potentially encountered at the landfill during intrusive and sampling activities: cyanides, hydrogen cyanide, metals, municipal sewage sludges, chlorinated hydrocarbons, and possibly, vinyl chloride. Vinyl chloride is listed only generically as certain studies have indicated it as prevalent at least in very limited concentrations in the landfill gas sampled at most landfills. There exists the possibility of identification of a wider range of contaminants on-site once initial sampling results are obtained and interpreted.

SECTION 3
HAZARD EVALUATION

Substances of Concern

As a result of the available information base referencing site history and disposal practices at the Blackwell Landfill the following substances are expected to be potentially present at concentrations which could represent hazards to unprotected project workers.

A total of twenty-one different volatile organic compounds (VOCs) have been detected in groundwater at the Blackwell site at one time or another, but five have been most commonly detected:

1,2-DCA	1,2-Dichloroethane
1,1-DCA	1,1-Dichloroethane
1,2-C-DCE	1,2-Cis-Dichloroethylene
1,2-T-DCE	1,2-Trans-Dichloroethylene
TCE	Trichloroethylene

Additionally, 1,2-Dichloropropane (1,2-DCP), was detected in well G-128S and was used by the U.S. EPA to calculate a Hazard Ranking Score (HRS) for the site. 1,2-DCP is not found consistently in high concentrations at the site.

Also other hazards of concern are from:

- Sewage sludges (possibly containing residual infectious organisms hazards); and
- Landfill gas (potential for explosion or fire along with possibility of vinyl chloride at low concentrations).

The potential health hazards of the listed parameters and substituents of the above waste streams, including routes of exposure, PELs, TLVs, target organs, and symptoms of overexposure are discussed in the subsections which immediately follow.

Chlorinated Hydrocarbons

These compounds are highly mobile, migrating easily through water, air, and soil. They are persistent in the underground environment, although they may degrade at the surface under the influence of ultra-violet light. These compounds can decompose thermally to toxic phosgene gas.

Chlorinated hydrocarbons may act on the central nervous system, either as a stimulant or depressant. Mild exposure may cause such symptoms as dizziness, nausea, abdominal pain, and vomiting. In chronic (long-term) exposure, loss of weight and appetite may occur. Moderately severe exposure presents those symptoms given above followed by severe irritability, convulsive seizures, and coma.

Compounds from this class of chemicals found at the site are:

> 1,2-Dichloroethane - a clear, flammable liquid used primarily as a raw material in the production of vinyl chloride. It is also used as a cleaning solvent and sealant. It can be absorbed through the airways, the skin and the gastrointestinal tract. It has an odor threshold that varies from 2 to 6 ppm. In high concentrations it is immediately irritating to the eyes, nose, throat and skin. OSHA recommends a PEL of 50 ppm and the ACGIH recommends a TLV of 10 ppm. It is also a suspected carcinogen.
>
> 1,1-Dichloroethane - a colorless, aromatic liquid. Use primarily as an extraction solvent and a fumigant. It can be absorbed through the airways, the skin and the gastrointestinal track. The OSHA PEL is 100 ppm; the ACGIH recommends a TLV of 200 ppm and a STEL of 250 ppm. Symptoms of exposure are skin irritation, drowsiness, unconscious; liver and kidney damage.
>
> SYM-Dichloroethylene - It exists as CIS- and TRANS- . It is a colorless, low boiling liquid. It is primarily used as solvent; it is moderately toxic by ingestion, inhalation and skin contact; irritant and a narcotic in high concentrations. The OSHA PEL for this compound is 200 ppm. ACGIH recommends a TLV of 200 ppm
>
> Trichloroethylene (TCE) - a colorless, non-flammable liquid with a sweet odor like chloroform. Can be adsorbed through the skin. Inhalation and ingestion are also routes of exposure. Symptoms of exposure include headaches, dizziness, disturbed vision, nausea, vomiting, and eye irritation. Fatalities have occurred following severe, acute exposures. It has been known to cause cancer in laboratory animals. OSHA recommends a PEL of 100 ppm; ACGIH recommends a TLV of 50 ppm, and a STEL of 200 ppm. Odor threshold is 50 ppm.
>
> Vinyl Chloride - an easily liquefied gas with a faintly sweet odor. It may affect the central nervous system, liver, respiratory system and lymphatic system. It is a known carcinogen. OSHA recommends a PEL of 1 ppm; The ACGIH recommends a TLV of 5 ppm.

Some of the common metals that can be found at the site include:

Chromium

Ingestion or inhalation of chromium may lead to histologic fibrosis of the lungs. The OSHA PEL for Chromium metal and insoluble salts is 1 mg/cubic meter as Cr; for chromic acid and chromates, the PEL is 0.1 mg/cubic meter as CrO3; and for chromium, soluble chromic acid and chromous salts (as Cr), 0.5 mg/cubic meter.

The NIOSH REL for carcinogenic chromium (VI) compounds is 1 ug/cubic meter Cr(VI). The TLV for chromium (VI) is 0.05 mg/cubic meter, and the IDLH Level is 500 mg/cubic meter. This element is also a suspected carcinogen. Chromium poses a potential health risk by inhalation, ingestion, or skin absorption. Its allowable airborne concentration has been established at 0.5 milligrams per cubic meter of air. Exposure to chromium may cause an allergic type reaction producing dermatitis or lung irritation. Symptoms of exposure may include coughing, wheezing, headaches, difficult breathing, and fever. The skin may become red, inflamed, itch, and ulceration may occur.

Nickel

Nickel and soluble nickel compounds are capable of producing sensitization dermatitis and/or allergic asthma in certain individuals. Furthermore, inhalation of many nickel compounds via their presence on airborne dusts can produce severe irritation of the nasal cavities and pneumonitis. Some of these compounds have been proved to be cancer producing in humans via inhalation. Care should be taken to prevent any skin contact with and/or inhalation of dusts containing such compounds. The recommended OSHA PEL for Nickel, metal and soluble compounds as Ni, is 1 mg/cubic meter. The TLV for soluble compounds of nickel is 0.1 mg/cubic meter while the TLV for nickel or its insoluble compounds is 1 mg/cubic meter.

Cyanide

Most cyanide compounds and hydrogen cyanide (HCN) gas can be readily absorbed through the skin. Inhalation of HCN or dust of cyanide compounds and ingestion of cyanide compounds are also a route of entry. Skin absorption is accelerated by sweating and the presence of open wounds. Once cyanide has entered the body, it acts as a very rapid acting blood poison interrupting the transport of oxygen.

Cyanide and cyanide compounds are mainly of concern in regard to the respiratory dangers they present. Hydrogen cyanide gas and volatile cyanides are all highly toxic by brief, high level exposures and can cause death. Cyanide is a noncumulative poison, and therefore chronic toxicity is not a major concern. Acute exposure to hydrogen cyanide may result in symptoms such as headache, weakness, changes in taste and smell, irritation of throat, vomiting, difficulty breathing, abdominal colic, and nervous instability. Hydrogen cyanide has the characteristic faint odor of bitter almond. The OSHA PEL for cyanides as CN is 5 mg/cubic meter. The TLV for cyanide as CN is 5 mg/cubic meter.

Other concern for workers at the site is:

Sewage Sludge

Possible negative health effects from direct contact with or possible inhalation or ingestion of dusts containing residual septic potential. Prudent work practices, use of personal protective equipment, and use of respiratory protection incorporating HEPA filters during any dusty conditions should minimize the potential for exposure to such biological hazards.

Physical Hazards

The hazard of possible injuries due to trips or falls exist on this project due to the inherent physical nature of the work being performed and to the general topography of the landfill. The physical hazards of drilling activities include possible accidental contact with rotating drill augers or moving equipment in general, the potential for contacting active utility lines, and the potential for fire or explosion when encountering methane or other flammable gas concentrations in the boreholes.

In general, proper use of personal protective equipment, safe work practices and standard operating procedures as described in the Site health and Safety Plan will minimize the potentials for accidental injury or overexposure of project personnel to hazardous substances present at this site.

SECTION 4
WORK PLAN SUMMARY

General

The scope of work expected to be completed on-site in accordance with the approved site Work Plan addresses interdependent objectives and requirements of the RI and of the FS. The primary objective of the RI is determination of the nature and extent of site contamination in order to support the activities of the FS. The primary objective of the FS is to develop and activate appropriate remedial action alternatives based on the RI data. This scope of on-site work includes the following major task areas:

- Investigate Site Characteristics
- Define Sources of Contamination
- Determine the Nature and Extent of Contamination

Preliminary Site Evaluation

Preliminary site evaluation will be conducted via monitoring of ambient air for general levels of toxic gases, volatile organic compounds, explosive/oxygen deficient atmospheres, and other parameters as determined to be appropriate.

The site will be initially survey with the instruments indicated below. All readings from each instrument will be taken at the breathing level when applicable or near a possible source; all the readings will also be documented in the field logbook (refer to page 11-12 for action levels). Instruments will be calibrated at the beginning and at the end of eacn work day.

An HNu photoionization detector (with a 10.2 eV lamp or equivalent) will be used to monitor the total volatile organic compounds. Explosive atmospheres will be detected with a Gastech 1939OX percent gas and oxygen indicator (or equivalent); and a Radiation Alert Monitor 4 (or equivalent) will be used to detect the presence of radioactive materials.

Drager (or equivalent) detector tubes, will be used for detection of hydrogen cyanide and vinyl chloride.

Source Characterization Activities

Source characterization activities will include conducting geophysical surveys of the site and adjacent to the landfill, soil gas screening, test borings in the landfill, and constructing and sampling of leachate wells.

The geophysical investigation will be accomplished via electromagnetic (EM) surveys conducted by a subcontractor of Warzyn, with oversight by Warzyn personnel. Geophysical surveys will be scheduled and performed over a five day period prior to initiation of any intrusive field activities. Final surveys conducted will utilize 15 or 20-foot grid layouts.

Numerous field activities will be conducted to complete the hydrogeologic characterization. These may include: the placement of staff gages to document surface water levels; the construction and sampling of 4 leachate head wells in the landfill; and the construction of 4 new monitoring wells and sampling of up to 30 monitoring wells surrounding the landfill. Water levels will be measured at the staff gages, headwells, and monitoring wells on several occasions, and bail down tests will be conducted at 10 monitoring wells to provide estimates of the hydraulic properties of the aquifer.

The installation and sampling of the wells will be sequenced to make optimal use of all sampling locations. Four monitoring wells will be installed in two-well nests at the two locations. The water levels will be used to construct plan view and cross-sectional potentiometric maps to evaluate potential groundwater flow paths.

The following tasks will be conducted during the investigation to make optimal use of the monitoring well locations and sampling rounds.

- Two leachate samples will be collected at the landfill wells. Analyses will include the TAL, TCL, and inorganic indicator compounds including: chloride, sulfate, total Kjeldahl nitrogen, ammonia, nitrate plus nitrite, total phosphorus, and total dissolved solids.
- Four monitoring wells will be installed at 2 locations southwest of the landfill locations will be determined from the results of auger probes in the area southwest of the landfill. Monitoring well nests will be constructed by completing two wells at each location, screened at different depths. At each location, a shallow well will be constructed with a 5-foot screen placed at the base of the sand and gravel zone and a second well, with a 5-foot screen will be located just below the bedrock surface.

- Aquifer properties will be tested by slug test methods at the 4 new monitoring wells.
- Staff gages (elevation reference markers) will be placed in Silver Lake, the closed Swim Lake, the Supply Lake; at four locations along Spring Brook, and at two locations along the west branch of the DuPage River.
- Reference elevations will be surveyed and water levels will be measured at the monitoring wells, leachate head wells, and staff gages.
- One round of samples will be collected at 26 monitoring wells and analyzed. Analysis will include the TCL and TAL parameters, and inorganic indicator compounds including: chloride, sulfate, total Kjeldahl nitrogen, ammonia, nitrate plus nitrite, and phosphorus. (Semi-volatile organic analyses may be eliminated from the parameter list if they were not detected in the leachate samples).
- The water level data, water quality data, and aquifer property data from monitoring wells and landfill wells will be evaluated to assess potential migration pathways, fate and transport, in the landfill vicinity.

Contamination Characterization

Based upon analytical results of samplings and air monitoring conducted during previous investigations, an identification of contamination will be made which targets a limited number of substances from the total contaminants detected at the site. This group of high risk substances would then be the objective of further characterization efforts. Factors in this identification process include screening initial sample information and potential exposure pathways, intrinsic toxicity of compound. Ultimately, through exposure assessments and risk characterizations, an Endangerment Assessment (EA) will be completed which will identify and characterize immediate and potential risks to public health and the environment associated with any identified hazardous substance release. The EA assesses the baseline risks at the site assuming "no action" to remediate the site.

Surveillance Activities and Action Levels

The air monitoring program will begin with an air monitoring survey of the site to assess the ambient conditions. The frequency of on-going air monitoring, for tasks which do not disturb the ground, will be determined in part based on this survey. Other factors such as temperature and windspeed will also be considered.

Air monitoring will be conducted during tasks which disturb any in-situ conditions of the site environment. A minimum frequency of once every two hours will be the protocol for this monitoring. Examples of such tasks would be sediment sampling and groundwater sampling.

Continuous air monitoring will be conducted during highly intrusive activities such as drilling. This will include monitoring for relative levels of VOCs, levels of methane and hydrogen cyanide.

An HNu Photoionizer (with 10.2 ev lamp) will be used by the Site Safety Officer for monitoring of air quality at the work sites. This will be done to assess the relative levels of organic airborne contaminants, aiding in site assessment.

A Gastech Model 1939-OX Percent Gas and Oxygen Indicator will be used to detect any presence of explosive landfill gases and determine available oxygen levels.

A Monitox hydrogen cyanide detector will be used to detect hydrogen cyanide during waste characterization operations.

A Radiation Alert Monitor 4 will be used to detect the presence of radioactive materials.

Selected "Draeger-type" tubes will be available for utilization in testing for the presence of particular volatile toxic compounds such as hydrogen cyanide or vinyl chloride.

The following action levels will be observed during general on-site activities. Minimum requirements for protection levels for specific tasks which were described earlier in this section must be adhered to even though monitored levels may be below action levels.

EXPLOSIMETER (Ambient Air Measurements)

0-10% LEL -	proceed w/caution
10-25% LEL -	proceed w/caution, be prepared to shut-down quickly

over 25% LEL -	shut-down immediately and evacuate. Do not resume excavation until LEL falls below 10%. If LEL remains above 25%, the site safety officer will consult with the USEPA Remedial Project Manager (RPM) to determine appropriate actions in response to such changing conditions.

NOTE: In the event that Confined Space Entry would apply to a given work activity and location, do not follow these action levels, but refer to Section 11 and Appendix E for action levels.

HNu (Breathing Zone)

- Enter Site at Level D
- If task requires a minimum protection level upgrade to that level before entry into work area
- 5 ppm or greater detected, upgrade to Level C
- 50 ppm or greater detected, discontinue operations or upgrade to Level B
- Monitor ambient air as continuously as is possible to detect changes in relative volatile organic compounds levels

MONITOX

- A level of 10 ppm hydrogen cyanide will require immediate evacuation of the work area.
- The Site Safety Officer will verify the monitor reading by back-up sampling the area with hydrogen cyanide "Draeger-Type" tubes. If the results are positive, the hydrogen cyanide contingency plan (Appendix G of this plan) will be initiated.

RADIATION ALERT MONITOR 4

- A level of 0.02 MR/hr will be used as background reading.
- Action level established at Warzyn is 0.05 MR/hr. Should the readings go above this action level, work is to stop immediately and the site safety officer notified.
- If the readings during intrusive operations exceed background at the site, the RPM is to be consulted and made aware of the higher readings. Upon noticing any higher than background readings, it may be useful to use the radiation alert monitor to locate any possible source areas (by use of equipotential contour mapping) to ensure a minimum of exposure to radioactive source materials.

VINYL CHLORIDE When working in the areas where vinyl chloride has been detected, if at any time, the HNu readings exceeds 5 ppm, a vinyl chloride tube will be utilized to detect the presence of it. If the concentration suggested by readings on tube exceeds 5 ppm of vinyl chloride, work will immediately cease. The site safety officer will upgrade level of protection to Level B or, delay restart of such operations until vinyl chloride levels are below 1 ppm as indicated on detector tubes. Any time work is stopped due to elevated monitox or HNu readings, respirator cartridges will be changed prior to re-initiation of project work at Level C.

Some of the subtasks outlined in the work plan will be initiated in Level D personal protection. Level D has been selected because those activities appear to have low potential for exposure of field personnel to hazardous materials. The Site Safety Officer is responsible for upgrading Level D activities to Level C or B based on soil moisture conditions and wind factors or on action levels being reached as determined by instrument readings.

Standard Operating Procedures

Personal Precautions

- Eating, drinking, chewing gum or tobacco, smoking, or any practice that increases the probability of hand-to-mouth transfer and ingestion of material is prohibited in any area designated contaminated.
- Hands and face must be thoroughly washed upon leaving the work area.
- Whenever decontamination procedures for outer garments are in effect, the entire body should be thoroughly washed as soon as possible after the protective garment is removed.
- No facial hair which interferes with a satisfactory fit of the mask-to-face-seal is allowed on personnel required to wear respirators.
- Contact with contaminated or suspected contaminated surfaces should be avoided. Whenever possible, do not walk through puddles, leachate, discolored surfaces, kneel on ground, lean, sit, or place equipment on drums, containers, or the ground.

- Medicine and alcohol can potentiate the effects from exposure to toxic chemicals. Prescribed drugs should not be taken by personnel at hazardous waste operations where the potential for absorption, inhalation, or ingestion of toxic substances exists unless specifically approved by a qualified physician.

- All personnel must be familiar with standard operating safety procedures and any additional instructions and information contained in the Site Safety Plan.

- All personnel must adhere to the information contained in the Site Safety Plan.

- Contact lenses cannot be worn when the hazard of a splash exists, or where wearing a respirator.

- Personnel will be aware of symptoms of exposure to toxic chemicals on site and for heat or cold stress.

- Respirators shall be cleaned and disinfected after each day's use or more often, if necessary.

- Use, maintenance and storage of respiratory equipment is the ultimate responsibility of each user. All personnel wearing respiratory protection must follow the Site Respiratory Protection Program (Appendix D of this plant).

- Prior to donning, respirators will be inspected for worn or deteriorated parts. Emergency respirators and self-contained breathing devices will be inspected at least once a month and after each use.

- The employee will be familiar with all sections of the established respiratory protection program.

Operations

- All personnel going on-site must be adequately trained and thoroughly briefed on anticipated hazards, equipment to be worn, safety practices to be followed, emergency procedures, and communications. All personnel must read the Health and Safety Plan prior to beginning of project work.

- Site health and safety briefings must be conducted on a daily basis or as necessary, as changes in site conditions occur. Health and Safety Plans will be given to contractors and subcontractors to become familiar with the hazards at the site.

- Health and Safety plan will be amended as site conditions change.

- Any required respiratory protective devices and clothing must be worn by all personnel going into areas designated for wearing protective equipment.

- Personnel on-site must use the buddy system when wearing respiratory protective equipment. As a minimum, an extra person, suitably equipped as a safety back-up, is required during extremely hazardous entries.

- Visual contact must be maintained between pairs on-site and safety personnel. Entry team members should remain close together to assist each other during emergencies.

- During continual operations, on-site workers act as safety back-up to each other. Off-site personnel provide emergency assistance other than first-aid for manageable injuries.

- Personnel should practice unfamiliar operations prior to doing the actual procedure.

- Entrance and exit locations must be designated and emergency escape routes delineated. Warning signals for site evacuation must be established.

- Communications using radios, hand signals, or other means must be maintained between initial entry members at all times. Emergency communications will be prearranged for situations involving radio failure, necessity for evacuation of site, or other reasons.

- Wind indicators visible to all personnel will be strategically located throughout the site.

- Personnel and equipment in the contaminated area should be minimized, consistent with effective site operations.

- A site "sign in and out" log will be used to control and monitor site areas. All personnel accessing site must utilize this log.

- Access controls including warning signs and barriers will be utilized at excavations, control zones and areas known to have dangerous contamination levels of known carcinogens.

- If at all possible, personnel will refrain from entry into any excavations. If personnel entry into an excavation greater than 5 feet deep is necessary all applicable OSHA requirements must be met. The excavation must be evaluated for applicability of confined space entry requirements prior to entry.

- Prior to mobilization at the site, personal contact is to be made with emergency room personnel, the Poison Control Center, the local fire department and police. If outside of an established town, contact shall be made with county officials and local emergency services.

- Eye wash fountains, toilet facilities, and first aid equipment will be readily available on-site; potable water will be provided throughout all site work activities. Warzyn personnel are to have current first aid and medical emergency training.

- Provisions for the rapid identification of the substance to which the worker has been exposed. This information must be given to medical personnel.

- Procedures for decontamination of injured workers and preventing contamination of medical personnel, equipment, and facilities.

- Sufficient water and/or dry chemical fire extinguishers and neutralizing agents will be maintained on site to aid in initial containment of any fire or release before emergency services can arrive.

SECTION 5
DECONTAMINATION PROCEDURES

Personnel Decontamination

Every attempt with be made to prevent direct contact with contaminated materials. The sequential removal and decontamination or disposal of potentially contaminated personal protective equipment is required to prevent the migration of contaminants to support where personal protective equipment is not required.

All personal equipment and vehicles coming into direct contact with contaminated materials or areas will be required to go through decontamination procedures.

Site personnel decontamination procedures are as follows:

- Prior to entering the contamination reduction zone, removed gross contamination from protective garments and footwear;
- Remove and store outer latex booties in heavy duty polyethylene bags;
- Wash inner boots in a phosphate free detergent solution (i.e., Liqui-Nox or equivalent) in bootwash tub using circular motion of each foot alternately under water surface; brush as necessary with soft bristled long handled brush;
- Clean outer gloves in a phosphate free detergent solution (i.e., Liqui-Nox or equivalent); discard if too soiled to clean thoroughly;
- Remove and store polycoated tyvek suits in heavy duty polyethylene bags;
- If applicable, remove respirator or SCBA and perform decontamination procedures on respirator per manufacturer's recommendations;
- Remove and store surgical gloves in heavy duty polyethylene bags;
- Wash hands in hand wash;
- Upon reaching washroom facilities, wash face and hands thoroughly. (Recommend showering at end of each work day at first opportunity).

All site personnel involved with work activities in the contamination zones will abide by the aforementioned decontamination procedures. Contamination and contamination reduction zones will be established each time that intrusive operations initially occur at a given location.

Equipment Decontamination

All equipment entering the contamination zone and directly contacting the surface of the ground or any contaminated materials must follow the decontamination procedures described below.

- All equipment decontamination is to occur on-site;
- Gross contamination will be removed with a brush and a phosphate free detergent solution in the contamination zones;
- Steam cleaning will follow at the designated equipment decontamination station;
- Any equipment left on-site at the end of the day in a contaminated status will be left on the contaminated portion of the equipment decon station.

All sampling equipment, including spilt-spoons, shelby tubes, augers, trowels, spoons, water sampling equipment, etc., will be decontaminated after each use. Special care will be taken that all split-spoons and shelby tubes are thoroughly decontaminated prior to use at the site. Similarly, any paint or split-spoons will be thoroughly removed prior to use. Decontamination of sampling equipment must include a wash with a phosphate free detergent solution and a triple rinse with distilled water.

Bags of used personal protective equipment, decontamination wash waters and cuttings from the drilling activities will be stored on-site as separate waste streams in DOT approved 55-gallon hazardous waste drums. These will be staged on visqueen and the storage area bermed. Tarping will be utilized as necessary.

Prior to drill rigs or other heavy equipment leaving site, such equipment will undergo full decontamination procedures as described in this section of the Health and Safety Plan.

SECTION 6
DISPOSAL OF INVESTIGATION DERIVED WASTE MATERIALS

Used wash water generated at the Personnel Decontamination Area will be considered non-hazardous, not warranting special waste disposal. This water will be disposed at the site where it was generated. Contaminants brushed off or removed by steam cleaning from equipment and vehicles will be stored in DOT approved 55-gallon drums.

Personal protective equipment will be decontaminated at the site, and then bagged and disposed of off-site as a non-hazardous waste.

Soil, waste cuttings, and purge water from soil boring, well installations, and sampling will remain on-site and stored in DOT approved 55-gallon drums. These materials will be handled in accordance with the approved RI report and disposed at the completion of the RI/FS activities pending the analytical findings of the RI/FS sampling and/or remediation alternative selection.

SECTION 7

THERMAL STRESS CONDITIONS

Special care will be taken to insure that work crew personnel do not suffer physical distress as a result of working under hot or cold weather conditions. This is particularly a concern where work activity is conducted at Level C or Level B personal protection during warm or hot weather. This is discussed in Appendix C. Guidelines presented in that discussion will be generally followed. Individual physical differences and varying susceptibilities to heat stress must be considered in scheduling work activities and break periods.

SECTION 8
WORK LIMITATIONS

In general, all field activities will be restricted to daylight hours. No drilling or other heavy machinery will be operated after daylight hours. High winds or lightning conditions will necessitate shut-down of drilling operations. In the event of rain, the Site Safety Officer will evaluate the need for suspending drilling operations. The Site Safety Officer and Site Supervisor will be responsible for determining continuance/shut-down of field activities during adverse weather conditions.

SECTION 9
PERSONAL PROTECTIVE EQUIPMENT

A minimum level of protection for site personnel performing activities as defined under the scope of work as outlined in this plan will be Level D. The following levels of personal protection are applicable to this site:

Level D Protection
Work uniform
Steel-toed and steel-shanked chemical resistant boots
Safety glasses
Hardhat

Modified Level D Protection
Work uniform
Durable and disposable chemical resistant outer gloves (nitrile/neoprene)
Disposable inner gloves (latex)
Steel-toed and steel-shanked chemical resistant boots
Disposable pullover booties
Safety glasses
Hardhat (with faceshield, if handling hazardous liquids)
Disposable tyvek (or similar chemical resistant) coverall
Earplugs (as required)

Level C Protection
Work uniform
Durable and disposable chemical resistant outer gloves (nitrile/neoprene)
Disposable inner gloves (latex)
Steel-toed, and steel-shanked chemical resistant boots
Disposable pullover booties
Hardhat
Earplugs (as required)
Full-face air purifying respirator, NIOSH approved with high efficiency combination organic vapors/HEPA cartridges
Disposable tyvek (or similar chemical resistant) coverall
(duct tape seams between suit and gloves/boots) if working in wet areas, areas of concentrated hazardous contaminants or waste)

NOTE: All project personnel working immediately adjacent to operating drill rig must not wear loose clothing. If wearing tyvek, it must be securely taped at seams and pulled flat to body with extra taping. Be alert at all times when working adjacent to or directly with drilling equipment. Never directly contact any rotating auger. Respirator cartridges will be changed at least each day, with more frequent changes based upon the levels of any detected concentrations of vinyl chloride.

Level B Protection

Same as Level C, except replace the air purifying respirator with a NIOSH approved self-contained breathing apparatus with full face piece and operating in either pressure-demand or positive pressure mode. Level B protection would only be available as emergency equipment to respond to an emergency situation on-site involving an incapacitating accidental injury of a project worker due to unknown cause or chemical release.

Protection Levels for Specific Tasks

Specific Field Tasks

Site Survey - Surveying personnel will wear Level D protection.

Geophysical Survey - Surveying personnel will wear Level D protection.

Surface Water and Sediment Sampling - Sampling personnel will begin activities at Level D with possible upgrade or downgrade by the Site Safety Officer based upon site conditions and air monitoring results.

Install Leachate Wells - Level C protection will be worn during installation of wells into the landfill, with possible upgrade or downgrade of level of protection by the Safety Officer as appropriate with air monitoring results and changing site conditions.

Install Perimeter Landfill Gas Probes - Activity will be conducted at Level C with possible upgrade or downgrade of level of personal protection by Safety Officer as appropriate with air monitoring results and changing site conditions.

Test Near Surface Hydraulic Properties - Activity will begin at level D with possible upgrade or downgrade of level of personal protection by the Safety Officer as appropriate with air monitoring results and changing site conditions.

Groundwater Sampling for Perimeter Wells and Leachate Wells - A minimum of modified Level D protection will be worn for sampling perimeter wells and leachate wells, with possible upgrade of level of protection by the Safety Officer where appropriate with monitored conditions.

Soil Borings and Surface Soil Sampling - Level C protection will be worn during surface soil sampling and soil borings, with possible upgrade or downgrade by the Site Safety Officer based on air monitoring and changing site conditions.

Well Installation and Aquifer Testing - Level C will be initially worn with possible upgrade or downgrade by the Site Safety Officer based upon air monitoring results and changing site conditions.

SECTION 10
PERSONNEL RESPONSIBILITIES AND TRAINING

Site Organizational Structure

Corporate
H&S Manager

Project Manager

Site H&S Officer

Site Supervisor

Staff

The Organizational Structure shall be reviewed and updated as necessary to reflect any changes at the site.

Key Personnel

Site Health and Safety Officer: ____________________
Alternate: ________________________________

Project Manager: ____________________________
Alternate: ________________________________

Site Supervisor: ____________________________
Alternate: ________________________________

The following individual(s) located on site will have the authority and responsibility to change levels of protection and, when necessary, shut down the operation:

1. Site Health and Safety Officer
2. Site Supervisor

Personnel Roles

Site Health and Safety Officer - The Site Health and Safety Officer (HSO) is responsible for interfacing with Warzyn's Health and Safety Manager.

The HSO may be required to perform various types of area or personnel monitoring for purposes of verifying worker exposure and proper selection of personal protective equipment. The HSO is to be consulted before any changes in the recommended procedures or levels of protective clothing are made. The HSO implements all health and safety policies according to the H&S Plan; responds to site emergencies and contacts the appropriate emergency personnel and informs immediately Warzyn's Health and Safety Manager. The HSO must be at the site at all times; should he/she need to be away from the site, the project manager will appoint another site safety officer.

Project Managers - The project manager has the primary responsibility for the fulfillment of the terms of the contract. He must oversee operations and verify that all legal and safety requirements are met. It is his duty to keep the project on schedule, within budget and to communicate daily with the client regarding the progress toward the specified goals.

Site Supervisor - The site supervisor is the on-site coordinator and overseer of operations. It is his duty to maintain site security, supervise the laborers and technicians, and implement all procedures (health and safety, decontamination, protective equipment, etc.).

Employee Education and Training

All operational employees participate in routine health and safety education and training programs. These programs, directed by the Warzyn Corporate Health and Safety Manager, are designed to provide these employees with a thorough knowledge of hazardous materials, health and safety hazard potentials and compliance with federal OSHA 29 CFR 1910.120(e): 40 hours initial instruction, 8 hours refresher training, supervisor's additional 8 hours specialized training, and EPA requirements. In addition, 3 days of field experience under a trained, experienced supervisor are required. As a minimum, this training includes the following:

- General Safety Rules
- Basics of Chemistry
- Basics of Toxicology/Physiology
- Hazardous Materials (types/characteristics)
- Hazard Communication Information

- Respiratory Protection
- Respirator Training
- Chemical Protective Clothing
- Decontamination Procedures/Personal Hygiene
- Fire Prevention/Protection
- First Aid/CPR
- Atmospheric Testing/Sampling Procedures
- Emergency Response Procedures
- Federal and State Regulations
- Electrical Hazards

Prior to beginning of on-site project activities, or changes in the phases of site work, the site health and safety officer must make sure that all site personnel are familiarized with this document and expected hazards; standard operating procedures and safe work practices are discussed with these personnel. These orientations will be repeated for newly assigned project personnel as such personnel arrive on-site for later phases of project work. The site health and safety officer's name will be given to all workers at the site and it will be posted along with hospital route and map information. In case of his/her absence, the project manager will appoint a replacement.

SECTION 11
CONFINED SPACE ENTRY

Under the scope of on-site project work as expected to be accomplished during the conductance of the RI/FS, confined space entry work is not anticipated. Should the scope of work change or unexpected site conditions develop which necessitate confined space entry, Warzyn personnel will follow the procedures and protocols contained in Appendix E of the Health and Safety Plan. These procedures and protocols address the following categories of concern with relation to permitted, confined-space entry work:

- Application of Warzyn confined space entry procedures;
- Training of individuals involved;
- Air monitoring protocols within confined space;
- Additionally required air monitoring instrumentation (if applicable); and
- Additional PPE requirements (if applicable).

SECTION 12
MEDICAL SURVEILLANCE

Warzyn employees involved with this project work will participate in a medical surveillance program under the direction of an Occupational Physician, following requirements under the 40 CFR 1910.120 (f) Section. This program includes baseline, annual and exit examinations. The typical annual physical examination protocol includes:

- Comprehensive Health and Exposure History
- Physical Evaluation
- Urinalysis
- Stool Occult Blood
- Blood Chemistry Profile
- Hematology Profile
- Pulmonary Function Testing
- Audiometry
- Vision Testing

Additionally, each Warzyn employee is evaluated to determine if they are physically able to perform work while using respiratory protective equipment in compliance with 29 CFR Part 1910.134 and ANSI Z88.2 - 1980.

At the completion of the exam, the physician provides Warzyn and the employee with a written evaluation including:

- Physician's opinion on the employee health and medical condition to perform work at hazardous waste site operations.
- Recommended limitations upon the employee assigned work.
- The results of the medical examination and tests.
- A statement that the physician has informed the employee of any medical conditions which require further examination or treatment.

Recordkeeping

All medical records are kept for the duration of employment plus thirty years. Each employee's record contains:

- name and social security number
- physician's written opinions, recommended limitations, and results of examination and tests, and
- any employee medical complaints related to exposure to hazardous substances.

SECTION 13
SITE SECURITY AND CONTROL ZONES

Areas of active intrusive operations such as drilling/boring, plus a circumferential buffer zone of 25-foot radius will define each contamination or exclusion zone. These zones are restricted to essential operators and monitoring personnel only. Personnel decontamination (or contamination reduction) zones will be constructed adjacent to each contamination zone. One equipment decontamination station will be constructed at an operationally practical location which minimizes possible cross-contamination of support areas. All zones will be clearly defined with physical demarcation devices in accordance with prudent practices and applicable guidelines. Only personnel involved in project work or oversight will enter zones other than support zones during these project operations. Project personnel on-site each day will check in with appropriate facility management as applicable, and will log in and log out in the site log book. All project personnel will enter and leave the site by the facility main gate. All boreholes or any excavations which are not "backfilled" or "plugged" at the end of the work day, must be clearly marked with hazard signage including lighted warning barriers.

SECTION 14
CONTINGENCY PLAN/EMERGENCY RESPONSE

(Copies of the following will be in all field operations vehicles.)

Emergency Action - Standard Operation Procedures

- Name, address, and telephone number of the nearest medical treatment facility will be conspicuously posted. A map and directions for locating the medical facility, will be readily available. This route will be verified by the HSO or alternate prior to beginning work activities.
- Telephone numbers and procedures for obtaining ambulance, emergency, fire and police services will be conspicuously posted.
- An emergency eye wash fountain, toilet facilities and first aid equipment shall be readily available on-site.
- Project personnel will be familiarized with emergency routes of egress and assembly points.
- Every attempt to rapidly identify substances to which the worker has been exposed shall be made. This information will be given to medical personnel in the event of an emergency.
- Procedures for decontamination of injured workers and preventing contamination of medical personnel, equipment, and facilities shall be communicated to workers.
- Warzyn will have personnel on-site who are trained and certified in first aid and CPR.
- Sufficient water and/or dry chemical fire extinguishers and neutralizing agents will be maintained on site to cope with any situation until emergency services can arrive.

Emergency Actions

Should conditions exist which cause the cessation of work, Warzyn personnel shall immediately leave the work area and perform decontamination in the nearest safe location. Immediately telephone the Health and Safety Coordinator, Project Manager or Corporate Health and Safety Manager to determine further appropriate actions once the area and personnel are secure and stable. Any necessary medical attention, beyond first aid, is to be requested from one of the emergency facilities listed under "Emergency Contact Numbers" in this document. In the event of a fire or explosion, follow procedures in subsection Fire or Explosion of this Contingency Plan.

Medical Emergencies

Anyone being transported to a clinic or hospital for treatment will have accessibility to information on any potential chemical(s) to which they could have been exposed at the site. Toxicological information and/or specific medical records may be secured through the Warzyn Health and Safety Manager or from Warzyn's medical consultant in the event of a medical emergency. If determined as prudent or absolutely necessary, first aid should be administered while waiting for arrival of emergency medical services. Warzyn personnel trained and certified in first aid and CPR methods will be on-site to deliver such care in an emergency.

General On-Site First Aid

The following discusses general on-site First Aid procedures for exposure to contaminants on-site:

- Contaminated Material in Eyes - *wash with copious amounts of water for at least* 15 minutes. Lift upper and lower lids occasionally. Seek medical attention immediately. (Eye wash will be available on-site).
- Prior to mobilization at the site, personal contact is to be made with emergency room personnel, the Poison Control Center, the local fire department and police. If outside of an established town, contact shall be made with county officials and local emergency services.
- Sufficient water and/or dry chemical fire extinguishers and neutralizing agents will be maintained on site to aid in initial containment of any fire or release before emergency services can arrive.
- Contaminated Materials Contact Skin - For organic materials, promptly wash area with soap or mild detergent and water. For corrosive materials, flush with water for at least 5 minutes. Do not rub. Check for signs of skin irritation. Seek medical attention if unusual appearance of skin or sensation is noted.
- Contaminated Materials Penetrate Protective Clothing - discard protective clothing and underlying clothing. Wash skin as described above. Confer with HSO in selection of new protective clothing.
- Inhalation of Contaminated Air - move person to well ventilated area at once. If individual is not noticeably effected, and has no side effects after 15 minutes, returning to work is allowed providing the work area is no longer contaminated.

If individual has not fully recovered, continue to monitor for 15 to 20 additional minutes and seek medical attention if necessary. Use artificial respiration if breathing has stopped. In such instances, seek medical attention after victim has resumed breathing. If possible have someone seek medical attention while person is being resuscitated.

- Ingestion of Contaminated Materials - flush mouth with water, being careful not to swallow. Contact local poison center (see telephone number in Emergency Response and Information section). When called for, induce vomiting and give fluids (preferably water) to drink. (DO NOT induce vomiting or give fluids to any unconscious persons). Seek medical attention promptly.

If at any time, personnel feel fatigued, dizzy, nauseous, or experience headaches, they are to be moved to a well ventilated area and allowed to rest for 15 to 30 minutes. If symptoms do not subside, seek medical attention. Should personnel exhibit symptoms of temperature stress, follow the guidelines for treatment contained in Appendix C of this plan.

On-Site Communication System

On-site communication procedures will be established in the field during the initial site briefing or whenever there is a change of site personnel. All emergency signals will be designated and discussed during such briefing. All employees will be made aware of exit routes and assembly points to be used in the event of an emergency. A telephone will be accessible to site personnel during all project field activities defined under the scope of work.

Work Site Emergency Procedures

In the event of a medical emergency at a work site, work crew personnei will act quickly and reasonably to remedy the situation. The Site Health and Safety Officer shall give directions as to how to proceed. If the HSO is incapacitated, the alternate HSO will direct necessary first aid and contact the appropriate local emergency response agency.

Any rescue attempts are to be directed by the HSO, or a designated alternate. Under no circumstances is a rescue attempt to be made without the proper PPE. Any rescuer going into an exclusion zone should have a level of protection equal to or greater than that worn by the victim.

Emergency Equipment

The following emergency equipment shall be maintained at the station or in the operations vehicle as most prudent.

- Fire Extinguisher
- Eye Wash
- First-Aid Kit
- 5 Gallons of Fresh Water (for flushing of skin, general washing)

Fire or Explosion

In the event of a fire or explosion, the local fire department should be summoned immediately. Upon their arrival the Site Supervisor will advise the fire commander of the location, nature and identification of the hazardous materials on-site.

If it is safe to do so, employees may

1. Use fire extinguishers available on site to control or extinguish an incipient fire.
2. Remove or isolate flammable or other hazardous materials which may contribute to the incipient fire.
3. Extinguish other ignitable sources.

Evacuation Routes

Evacuation routes shall be established and updated as necessary during all phases of project work. Evacuation should be conducted immediately, without regard for equipment, under conditions of extreme emergency.

Personnel should preferably exit out through the decontamination station. Personnel should decon if possible; otherwise, doff PPE in a predescribed manner. If exit must be made from alternate exit personnel shall doff PPE before leaving the site.

Emergency Decontamination

Primary concern: Prevent severe injury or loss of life.

When is decontamination to be delayed? If immediate medical treatment is required to save a life, delay decontamination until the victim is stabilized.

When is decontamination to be performed immediately?

- If decontamination can be performed without interfering with essential life-saving techniques or first aid.
- If a worker has been contaminated with an extremely toxic or corrosive material which could cause severe injury or loss of life.
- **Heat-related illnesses:** Remove protective clothing from victim as soon as possible. Treat victim for heat exhaustion or heat stroke as appropriate to the symptoms exhibited by the victim. Refer to Appendix C.
- **Cold-related illnesses:** Remove outer layer of clothing upon entering sheltered area with adequate heat. If clothing is wet, replace all such clothing with dry clothing. Allow body temperature to warm up slowly. If symptoms of hypothermia exist, give no food or drink. Monitor person closely. If frostbite is evident, warm affected parts in warm water (100-105 degrees Fahrenheit). Loosely wrap affected body parts with sterile gauze.

Emergency Contact Numbers

Wheaton Fire Department (Ambulance)	911
Wheaton Police	911
Central DuPage Hospital	(708) 682-1600
IEPA - Land Pollution Control Division	(217) 782-6761
IEPA Emergency Removal Unit	(217) 782-3637
Illinois Emergency Service Disaster Agency	(800) 782-7860
National Poison Center	(800) 942-5969
National Response Center	(800) 424-8802
CHEMTREC	(800) 424-9300
U.S. Environmental Protection Agency	
Emergency Environmental Response (Chicago)	(312) 353-2318
Hazardous Waste Hotline	(800) 621-3191
Elsa Krauss, Health and Safety Coordinator - Warzyn Engineering Inc.	
Office	(708) 691-5068
Home	(708) 668-6850
Peter Vagt, Project Manager - Warzyn Engineering Inc.	
Office	(708) 691-5058
Home	(708) 232-2810
Mary Ann Latko, Warzyn Health and Safety Manager	
Office	(608) 274-0558
Home	(608) 455-3191

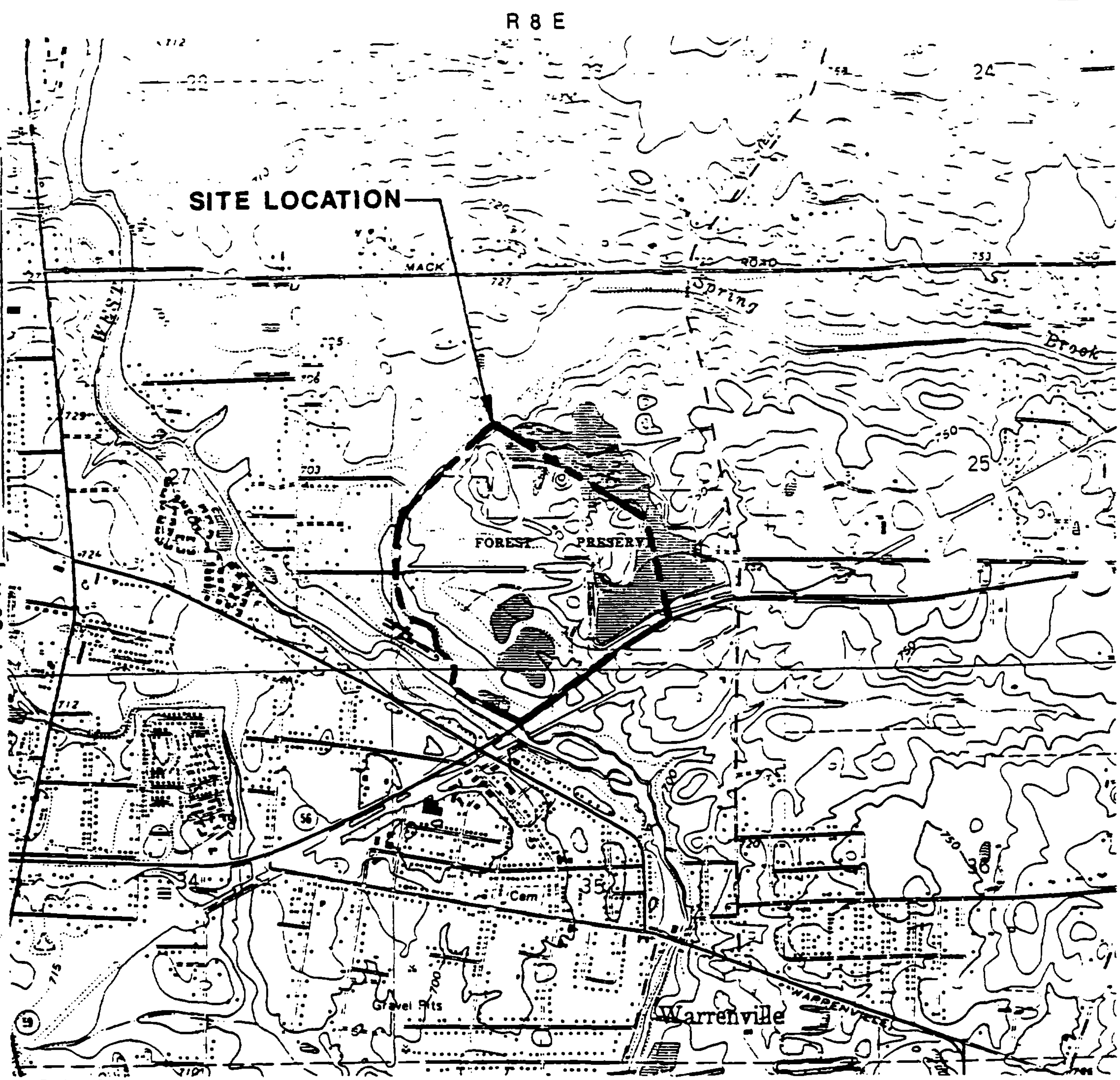
Hospital Address: Central DuPage Hospital
25 North Winfield Road
Winfield, Illinois

V721HSP01EVK/gmg/PJV

APPENDICES

APPENDIX A

SITE MAPS



NOTES

1. BASE MAP DEVELOPED FROM NAPERVILLE, ILLINOIS 7.5 MINUTE USGS TOPOGRAPHIC QUADRANGLE MAP DATED 1962, PHOTOREVISED 1972 AND 1980.

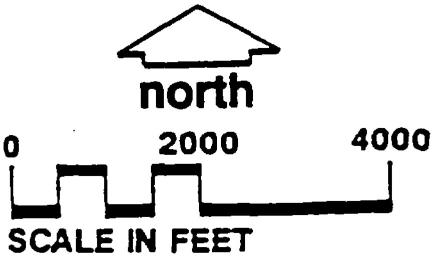
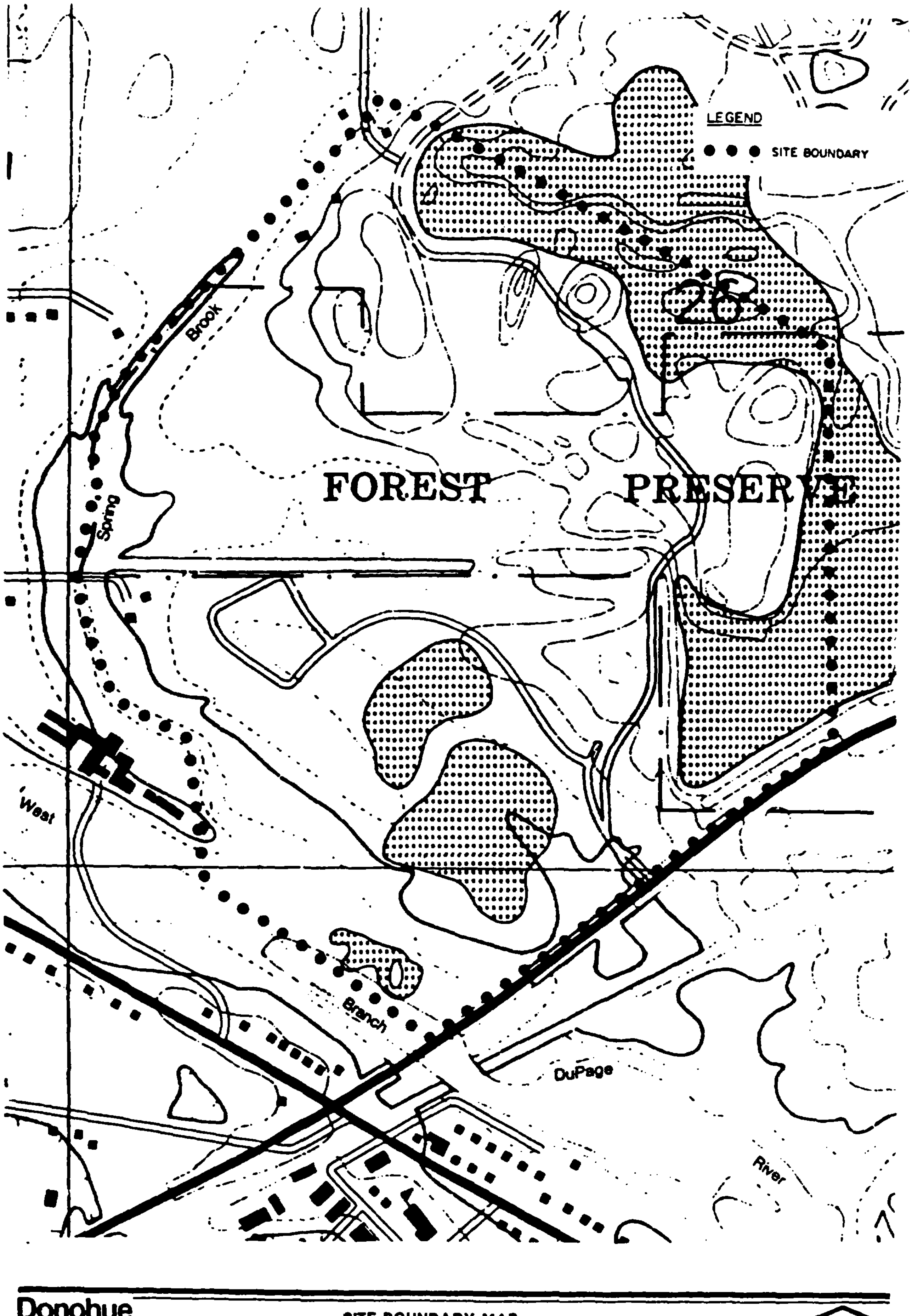


FIGURE 1

WARZYN	SITE LOCATION MAP	Drawn ELR	Checked JHW
	WORK PLAN REMEDIAL INVESTIGATION / FEASIBILITY STUDY BLACKWELL LANDFILL NPL SITE DU PAGE COUNTY, ILLINOIS	Revisions	App'd. Julie A. Widman Date 4/12/90 60721 **A5**



Donohue
PROJECT NO. 15759
Engineers & Architects

SITE BOUNDARY MAP

BLACKWELL SITE
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
DuPAGE COUNTY, ILLINOIS

N
0 200 400

FIGURE 3-2

APPENDIX B

HEALTH AND SAFETY COMPLIANCE AGREEMENT

NAMES AND SIGNATURES

All Warzyn employees working on or visiting this site are to sign below, indicating that they have read this Site Health and Safety Plan (SSP), understand its contents, have been given opportunity to discuss its contents with the Site Safety Officer (SSO) and agree to abide by its requirements.

The supervisors of all sub-contractors working under this SSP are to sign below, indicating that they have read this Site Health and Safety Plan (SSP), understand its contents, have been given opportunity to discuss its contents with the Site Safety Officer (SSO) and agree to abide by its requirements and enforce compliance with the SSP among their work crews.

Date	**Name**	**Employer**	**Title**	**Signature**

APPENDIX C

THERMAL STRESS

TEMPERATURE STRESS

Cold stress reduction - engineering controls.

- Use general or spot heating to increase temperature at work site if this does not create a hazardous situation.
- Shield work area from wind.
- Cover metal handles of tools and equipment with thermal insulating materials.
- Do not sit on unprotected metal chair seats.
- Heated rest areas are to be available if work is to be performed in an equivalent chill temperature of 20°F or below.
- Encourage workers to use heated rest areas regularly.

Cold stress reduction - work practice controls.

- Develop and adhere to work-rest schedule.
- Encourage frequent intake of warm, caffeine-free, sweet, non-alcoholic drinks or soup.
- Schedule work for warmest part of the day.
- Allow and encourage workers to pace themselves and take extra breaks when needed.
- Use of buddy system.
- Allow new workers time to adjust before working full time.
- Arrange work to minimize standing or sitting still for long periods of time.
- Reorganize work procedures so as much of a job as possible can be done in a warm environment.
- Avoid overtime.
- Send worker to warm shelter immediately if any of the following symptoms are noted:
    - Onset of heavy shivering.
    - Frostnip (skin turns white).
    - Feeling of excessive fatigue.
    - Drowsiness.
    - Euphoria.
- Remove outer layer of clothing when entering warm shelter.
- If clothes are wet, change to dry work clothes before returning to work in cold. If not possible, loosen clothing to facilitate evaporation of sweat.

Heat stress reduction - work practice controls.

- Develop and adhere to work-rest schedule. Take breaks in cool areas.
- Encourage hourly intake of fluids.
- Schedule work for coolest part of the day (early morning, early evening).
- Allow and encourage workers to pace themselves and take extra breaks when needed.
- Allow new workers time to adjust before working full time: 20% Day 1 with a 20% increase on each successive day.
- Avoid overtime.
- Use buddy system.

Heat stress monitoring.

- Heart rate: count pulse during 30 second period as early as possible in the rest period.

    - If heart rates exceeds 110 beats per minute (BPM) at beginning of rest period, shorten next work cycle by 1/3 and keep the rest period the same.
    - If heart rate still exceeds 110 BPM at next rest period, shorten the following work cycle by 1/3.

- Body water loss: measure weight, ± 0.25 LB, at beginning and end of each work day, wearing similar clothes. Should not exceed 1.5% of total body weight in a work day.

Heat stress - signs and symptoms.

- Heat rash.
- Heat cramps.

    - Muscle spasms.
    - Pain in hands, feet or abdomen.

- Heat exhaustion.

    - Pale, cool moist skin.
    - Heavy sweating.
    - Dizziness.
    - Nausea.
    - Fainting.

- Heat stroke.

    - Red, hot, usually dry skin.
    - Lack of or reduced perspiration.
    - Nausea.
    - Dizziness, confusion.
    - Strong, rapid pulse.
    - Coma.

ACTIVITY/METABOLISM RATE ESTIMATES

Work Classification	Activity	Metabolic Rate (kcal/hr)
light	typing	113 - 140
	driving car	140 - 160
moderate	walking with lifting/pulling	250 - 350
heavy	pick/shovel work	380 - 500

COLD STRESS WORK/WARM-UP SCHEDULE

Air Temp. (°F)	WORK/BREAK SCHEDULE (MINUTES) No Wind	5 MPH Wind	10 MPH Wind	15 MPH Wind	20 MPH Wind
-15 to -19	110/10	110/10	75/10	55/10	40/10
-20 to -24	110/10	75/10	55/10	40/10	30/10
-25 to -29	75/10	55/10	40/10	30/10	cease
-30 to -34	55/10	40/10	30/10	cease	cease
-35 to -39	40/10	30/10	cease	cease	cease
-40 to -44	30/10	cease	cease	cease	cease
-45 & below	cease	cease	cease	cease	cease

NOTES

Cold stress schedule applies to moderate - heavy work activities. For light - moderate work activities, apply work/break schedule one step lower.

5 MPH wind:	light flag moves
10 MPH wind:	light flag fully extended
15 MPH wind:	raises newspaper sheet
20 MPH wind:	bowing and drifting snow

HEAT STRESS
MONITORING SCHEDULE (MINUTES)

Adjusted Temp (°F)	Normal Work Clothes	Impermeable Work Clothes
above 90	45	15
88 - 90	60	30
83 - 87	90	60
78 - 82	120	90
72 - 78	150	120

NOTES

Adjusted temperature = measured temperature + (13 * % sunshine)

Schedule applies to moderate work levels. For heavy work levels, apply monitoring schedule one step lower.

D

APPENDIX D

RESPIRATORY PROTECTION PROGRAM

RESPIRATORY PROTECTION PROGRAM

I. Introduction

Warzyn Engineering Inc. (Warzyn) has developed its Respiratory Protection Program (RPP) to meet the Occupational Safety and Health Administration's (OSHA) Safety and Health Standards, 29 CFR Part 1910.134, 30 CFR Part II and the American National Standards Institute (ANSI) Standard Z88.2: "Practices for Respiratory Protection" (1980 Revision).

As required in these regulations, Warzyn is responsible for the establishment and maintenance of a respiratory protection program. Warzyn will provide respirators to its employees when such equipment is necessary to protect the employee's health. The respirators provided by Warzyn are approved by NIOSH/MSHA and are applicable/suitable for their intended use.

Employees of Warzyn must agree to use the provided respiratory protection equipment in accordance with Warzyn's instructions and training. Each Warzyn employee has prime responsibility for the daily care and maintenance of respiratory equipment issued to him/her by Warzyn.

II. Purpose

The purpose of this document is to establish written Standard Operating Procedures (SOPs) to be followed by Warzyn employees to optimize their respiratory protection during work on hazardous waste sites and other locations. These SOPs contain the information needed to maintain effective respiratory protection in situations where dangerous atmospheres such as harmful dust, fumes, sprays, mists, fogs, smokes, vapors, or gases are present and engineering controls can not adequately protect Warzyn personnel.

III. Scope

The Warzyn RPP provides four types of respiratory protection to the employee, depending on the type and concentration of the contaminants.

1. Air Purifying Respirators (APR)
    - Shall be used in designated areas as per site-specific Health and Safety Plan.

2. Powered Air Purifying Respirators (PAPR)
   - Shall be used for asbestos-related work.
3. Self-Contained Breathing Apparatus (SCBA)
   - Shall be used at sites where the level of airborne organic vapors or oxygen requires this level of protection.
4. Supplied airline respirators (with 5-minute escape packs)
   - Shall be used at sites where the level of airborne organic vapors or oxygen requires this level of protection.

Warzyn will generally only allow employees to utilize full face respirators. However, half-face respirators can be used if asbestos is the only contaminant present (i.e. no organic or other vapors). The selection and issuance of such protective equipment will be uniform to all field employees. Selection of brands and models of respiratory equipment utilized will be based upon initial and periodic reviews of such equipment by the Warzyn Health and Safety management. These reviews will combine available test data, available literature and field evaluation of the performance and effectiveness of such equipment. Respirator cartridges will be selected on the basis of the hazard known, or expected, to be present.

Employees expected to wear respiratory protection are instructed in the proper use and the limitations of the respirators. The training is based on manufacturer's instructions and includes, but is not limited to:

1. Preparing for fitting
2. Fit testing
3. Inspection procedures
4. Proper use and wearing instructions
5. Maintenance and sanitation instructions
6. The nature of potential airborne exposure hazards

When possible, respirators are assigned to individual employees for their exclusive use for the duration of the project. Employees are responsible for maintenance and sanitation of respirators assigned to them. Periodic spot checks are made by supervisory personnel to ensure compliance. When respirators are transported, they are to be kept in a clean, sanitary place and protected from damage. They are to be stored in a dry, clean, sealable plastic bag.

IV. Responsibility and Authority

The Warzyn Health and Safety Manager designates Warzyn personnel who have the responsibility of implementation of the program. Program maintenance, implementation and review are the responsibilities of the Warzyn Health and Safety Manager. The program will undergo an annual re-evaluation by the Warzyn Health and Safety Management.

Warzyn will have available all necessary respiratory equipment as specified in this plan. These respirators will in no way be modified by Warzyn or its employees.

V. Medical Surveillance

It is Warzyn's policy that no employee will be assigned to those tasks requiring the use of respirators until that employee has been certified as medically fit to wear the designated respirators under working conditions. A physician, designated by Warzyn, will make the determination as to whether or not an employee is fit to wear the respirator and as to under what conditions that employee may use the respirator. This medical determination will be made at least annually, and at other such times as may be deemed necessary.

Guidance for Selection of Approved Respirators for Protection Against Hazardous Atmospheres

Respirator protection equipment is selected on the basis of the hazards to which workers are exposed and in accordance with all OSHA standards. The selection of respiratory protection equipment for use in response to hazardous waste site work considers risk to life and health, the nature of the equipment available, and relative comfort and ease with which work may be performed while still achieving an appropriate level of protection. This section summarizes the criteria used for equipment selection and the conditions under which each type of equipment is to be used.

The selection of the proper type of respiratory protection equipment for Warzyn-use is based upon the following criteria.

1. The nature of the hazardous situation encountered.

2. The type of respiratory hazards, including physical properties, physiological effects on the body, concentration of toxic material (or airborne radioactivity level), established permissible time-weighted exposure levels for toxic materials, and any established or suspected presence of atmospheres which are immediately dangerous to life and health (IDLH).
3. The location of the hazardous area in relation to the nearest area having acceptable respirable air.
4. The period of time for which respiratory protection must be provided.
5. The activities of Warzyn employees in the hazardous area.
6. The physical characteristics, functional capabilities and limitations of the various types of respirators.
7. Extenuating local environmental conditions including temperature, humidity, precipitation, etc.
8. Respiratory protection factors.

A. Unknown Atmospheres

In some instances, it may not be known in advance what toxic or hazardous substance may be present at the work location, what the airborne concentration(s) of these substances at the site are, or if an oxygen deficient atmosphere is present. In these instances, it will be assumed that the unknown atmosphere is immediately dangerous to life and health. In these situations, 29 CFR 1910.134 and ANSI Z88.2 (1980) require that an air supplied respirator, such as a pressure-demand or positive-pressure SCBA or supplied airline respirator with escape bottle, be used.

Therefore, when Warzyn employees are working at a site with unknown air contaminant concentrations, such Warzyn personnel will use only these types of air supplied respirators. Respiratory protection may be downgraded as appropriate after the atmosphere has been tested.

B. Known Atmospheres

There are response activities or sites where the contaminants, the concentrations and the oxygen level are known. In these situations, the OSHA regulations and ANSI Z88.2 (1980) guidelines prescribe specifical respiratory protection. The following details respiratory protection which will be provided by Warzyn in such instances:

- Atmospheres which are oxygen deficient (less than 19.5% oxygen): only respirators which provide an independent source of respirable air can be used (i.e., SCBAs, SCBAs with air-line sources, supplied air-line respirators, etc.) In instances when an employee knows that an atmosphere is oxygen deficient, then he/she will utilize one of the above mentioned types of respiratory protective equipment as directed by the Warzyn site safety officer.
- Atmospheres in which contaminant levels are IDLH, only respirators which provide an independent source respirable air under positive pressure can be used.
- Atmospheres which are not IDLH: in atmospheres encountered that contain adequate oxygen (19.5% oxygen or more), contaminants with good warning properties (taste, smell, irritating) at level below TLV and no contaminants on list of specifically-excluded materials published by respirator manufacturer, air purifying respirators are acceptable.

The full-face, air-purifying respirator is the style of respirator mask which Warzyn will generally utilize for its employees. Half-face respirators can only be used when asbestos is the sole contaminant.

In the selection of the appropriate air-purifying respirator, OSHA requires that a fit test be used. At a minimum, a qualitative fit test must be used with negative-pressure respirators to determine if there is a proper respirator-to-face seal. The results of this fit test are used to select the specific types, makes, and models of negative-pressure respirators which can be used by each employee. If an employee cannot be fitted properly with the brand of respirator routinely utilized by Warzyn, an effort will be made to find an acceptable substitute model or brand.

Because of the wide variety of facial characteristics of employees and the wide array of respirator manufacturers, no respirator will be issued without a proper fit test of the individual employee. Each employee who will use an air-purifying respirator must successfully complete a qualitative fit test using isoamyl acetate and an irritant smoke.

The following policies apply to the fitting and use of respirators:

- Fit testing for positive-pressure SCBAs is not required.

- A Warzyn employee is not allowed to use a respirator of any type if a good seal cannot be achieved. This means no facial hair or glasses can be worn that will interfere with the attainment of a good seal. Beards are not allowed on employees wearing respirators.
- Persons requiring glasses to function safely shall be provided with specially mounted inserts inside full-face mask air-purifying or SCBA respirators.
- If it is found that an employee cannot obtain a good seal because of facial or medical characteristics whether with the air-purifying respirator or positive-pressure SCBA, that employee will not use, or enter an atmosphere that requires the use of, that equipment.
- An employee is allowed to use only the specific make(s) and model(s) of air-purifying respirators for which the person has completed a successful qualitative fit test. Under no circumstances shall a person be allowed to use respirator not previously fit-tested if the results of the fit test indicate that the person is unable to obtain a satisfactory fit.

Warzyn's qualitative fit test procedures involve two stages of testing. Stage I is a simple respirator negative- and positive-pressure seal check for face-piece fit. Stage II is the exposure of the respirator wearer to test atmosphere. This includes two separate atmosphere tests to check the adequate fit of the respirator.

Note: During any fit test, the respirator headstraps must be as comfortable as possible. Over-tightening the straps will sometimes reduce face piece leakage, but the wearer may not be able to tolerate the mask for any period of time.

Stage I - Negative Pressure Sealing Checks for Air Purifying Respirators

The wearer can perform this test by himself or herself in the field or office after donning the air-purifying respirator. Close off the inlet opening of the respirator's cartridges by covering them with the palm of the hands so as to block the passage of air, inhale gently and hold for at least ten seconds. If the face-piece collapses slightly and no inward leakage of air is detected, the fit of the respirator to the wearer is satisfactory for this test.

Positive Pressure Sealing Check for Air Purifying Respirators

This test is performed after donning the air purifying respirator and conducted by closing off the exhalation valve and exhaling gently. The fit of a respirator equipped with a face piece is considered to be satisfactory if a slight positive pressure can be built up inside the face-piece for at least ten seconds without detection of any outward leakage of air.

These tests are also to be used as gross determination of fit just prior to entering any toxic atmosphere.

Stage II

A person wearing an air-purifying respirator will be exposed to two test agents: isoamyl acetate (an odorous vapor) and an irritant smoke. The air-purifying respirator will be equipped with a cartridge which effectively removes the test agents from respired air. If the respirator wearer is unable to detect penetration of the test agent into the respirator, *the respirator wearer has achieved a satisfactory fit.*

Procedures for the Isoamyl Acetate Test

Isoamyl acetate of banana oil is a chemical which produces a pleasant banana-smelling organic vapor. It is an easily detectable odor. The isoamyl acetate fit-test will be conducted in an enclosure. Inside the enclosure will be an isoamyl acetate saturated material. This will produce a concentration of approximately 100 ppm inside the enclosure. Most people can detect isoamyl acetate at 1 to 10 ppm.

The following isoamyl acetate fit tests will be performed as follows:

1. Put on the air-purifying respirator in a normal manner. The respirator must be equipped with cartridges specifically designed for protection against organic vapors.
2. Enter the test enclosure so that the head and shoulders are well inside.
3. If the banana-like odor is detected, return to clean air and readjust the face-piece and/or adjust the headstraps without unduly tightening them.
4. Repeat step 2. If the banana-like odor is not detected, a satisfactory fit has been obtained. If the vapor is detected, an attempt should be made to find the leakage point. If the leak cannot be located, another respirator of the same type and brand should be tried. If the leak remains, another brand or size respirator with a face-piece of the same type, should be tried.

During the test, the subject is to make movements that approximate a normal working situation. These may include, but not necessarily limited to, the following:

1. Normal breathing.
2. Deep breathing, as during heavy exertion. This should not be done long enough to cause hyperventilation.
3. Side-to-side and up-and-down head movements. These movements should approximate those that take place on the job.
4. Talking. This is most easily accomplished by reading a prepared text loud enough to be understood by someone standing nearby.
5. Other exercises may be added depending upon the situation. For example if the wearer is going to spend a significant part of his time bent over at some task, it may be desirable to include an exercise approximating this bending.

Procedures for the Irritant Smoke Test

This qualitative test involves exposing the respirator wearer to an irritating smoke such as produced by stannic chloride.

In this test, the wearer usually reacts involuntarily to leakage by coughing or sneezing. The likelihood of a false indication of proper fit is reduced. It is advisable to have good ventilation in the room where the testing is to be conducted.

The irritant smoke test is to be conducted by using an enclosure over the breathing space of the employee being tested. A small hole is made in the top portion of the enclosure so that the irritant smoke can be introduced to the enclosure during the test.

The air-purifying respirator to be used in this test must be equipped with a high-efficiency particulate cartridge.

The irritant smoke fit test will be performed as follows:

1. Put on the respirator normally, taking care not to tighten the headstraps uncomfortably. Once the respirator is on, enter the suspended enclosure so that the head and shoulders are well inside the enclosure.

2. Once inside the enclosure, the irritant smoke shall be added in small quantities by an attendant, pausing between puffs from the applicator, listening for a reaction.

3. If no leakage is detected, the smoke density may be increased.

4. At this point, if no leakage has been detected, cautiously begin the head movements and exercises mentioned in the isoamyl acetate test. The attendant is to remain especially alert and be prepared to stop producing smoke immediately and remove the subject from the bag should be subject begin any adverse reactions.

5. If leakage is detected at any time, stop inducing the smoke and let the wearer out of the enclosure to readjust the face piece or headstrap tension. Repeat the procedure from Step 2 once the respirator is readjusted.

6. If, at the end of all movements and exercise, no penetrations of the irritant smoke into the respirator were detected, the respirator wearer has a satisfactory fit.

7. Remove the subject from the test atmosphere.

Warzyn's training procedures are divided into two phases: Initial respiratory protection training instruction and refresher training sessions. The following is an explanation of each phase of Warzyn's training procedures.

Initial Respiratory Protection Training Instruction

Each employee, upon entry into Warzyn's hazardous waste investigation program, will receive, from a qualified instructor, training on the proper and safe use of the respiratory equipment. The initial training course, a subsection of the required 40-hour initial training course:

- Regulations and laws concerning use
- Reasons for the need of respiratory protection
- Basic respiratory protection practices and equipment
- Nature, extent and effects of respiratory hazards to which employees may be exposed
- A general explanation of available respiratory protection equipment and devices and their uses and limitations

- Selection parameters to be followed in choosing respiratory protection equipment
- How to don and wear properly, check face piece-to-face seal, qualitative fit test
- Explanation of how to perform proper maintenance and storage
- Classroom and operational instruction in how to recognize and cope with emergency respiratory protection requirements during response activities

Training Review Sessions

It is the policy of Warzyn that all employees who will use respiratory protection equipment shall receive at least annual review training. These sessions will be conducted by qualified individuals. SCBA or airline respirator use will not be permitted unless review training has been completed within the previous six months.

Issuance of Respirators

Warzyn will maintain sufficient quantities of respiratory protective equipment for employee use. Where they are required, respirators will be issued to employees for the duration of site work. During that time period, the employee has specific responsibilities for its care, use and maintenance. Upon return of the equipment to the company storeroom, it will be cleaned and serviced prior to storage.

The appropriate, approved cartridges will be provided by Warzyn for any brand of respirator which Warzyn makes available to employees.

Respirator Maintenance, Inspection, Cleaning and Storage

An integral part of Warzyn's RPP is a conscientious maintenance program for all respiratory equipment used by company personnel. It is the responsibility of each respirator user to inspect his/her respirator for defects before and after each use, to clean and sanitize his/her respirator after each use, and to store the respirator properly so that it will retain its original shape and effectiveness. If defects are noted, the user is responsible for delivering the respirator to the designated Warzyn technician for appropriate repairs. A designated Warzyn employee shall monitor that respirator users are complying with the RPP requirements, periodically inspect respiratory equipment for needed repairs, and inspect all supplied-air respiratory protection equipment, SCBAs and escape packs monthly.

Cleaning and Sanitization

Each respirator will be cleaned and sanitized after each use by the person to whom it has been issued.

The cleaning and sanitizing of the units will be accomplished in the following manner:

1. Break the apparatus down to its components. Thoroughly inspect each of the components for any defects, excessive wear and tear, etc. Discard any used canisters. Replace any defective or worn parts.
2. Thoroughly wash the face-piece and mask components in a cleaning and sanitizing solution made according to manufacturer's directions. Scrub components with a sponge or soft brush to remove dust, dirt, or other contaminants.
3. Thoroughly rinse all component pieces in warm water. Residuals of the cleaning and sanitizing solution can cause dermatitis in some individuals.
4. Air dry all components thoroughly, inspect them again for any defects, reassemble the unit, and store properly until the next use.

Inspection for Defects

The inspection of the respirator will identify damaged or malfunctioning components before use in a hazardous atmosphere. All respiratory equipment will be inspected before the apparatus is used and during the cleaning process.

The inspection of respiratory equipment will include a check of tightness of all connections; the condition of respirator inlets and outlet coverings, head harness and assembly, valves and connecting tubes; shelf-life dates on all filters, canisters, and cartridges; and a thorough check of any regulators, alarms and other warning systems. All rubber and elastomeric parts of the respirator will be checked for pliability, proper sealing and signs of deterioration. Each air cylinder will be checked for integrity, currency of inspection, and readiness for use.

Maintenance and Repair

All parts replacement and repair of respirators will be performed by persons properly trained in respirator assembly and defect identification. Valves and regulators will be returned to the manufacturer for repair/or adjustment. IT IS STRICTLY FORBIDDEN TO SUBSTITUTE ANY PART OF THE RESPIRATOR ASSEMBLY FOR ANY OTHER BRAND OR TYPE OF RESPIRATOR PART. TO DO SO WILL INVALIDATE THE CERTIFICATION OF THE RESPIRATOR AND COULD SIGNIFICANTLY COMPROMISE THE HEALTH/LIFE OF THE USER.

It is the responsibility of a designated Warzyn employee at each Warzyn office to maintain records of all repairs, mechanical adjustment, and replacement of parts, noting the date, manufacturer and model number, part number, and technician's name.

Storage of Equipment

All respiratory equipment will be stored to protect it from dust, sunlight, excessive heat, extreme cold, excessive moisture, damaging chemical, and mechanical damage. Respirators will be stored individually, not stacked one upon the other or in cramped spaces, to prevent distortion of rubber or other elastomeric parts. Respirators are to be stored in sealed plastic bags.

Evaluation of Respirator Program Effectiveness

It is the policy of Warzyn, in compliance with 29 CFR 1910.134 and ANSI Z88.2, to regularly inspect and re-evaluate the effectiveness of the company's respiratory protection program. All employees involved are to be provided with effective respiratory protection. As further assurance of this protection, periodic monitoring of the user will be done. The respiratory program will be evaluated annually by the Warzyn Health and Safety Manager, the written operating procedures may be modified, and corrective actions will be taken to correct any discovered defects in the program, noting target dates for implementation.

APPENDIX E

CONFINED SPACE ENTRY

Definition of permit entry confined space

- An enclosed space which meets all of the following criteria:
  - Is large enough and laid out in such a way that a worker could enter and perform work.
  - Has limited means of entry and exit such as a storage bin, hopper, vault, pit or diked area.
  - Is not designed for continuous occupancy of the worker.
  - Has one or more of the following characteristics:
    - Contains or may contain a hazardous atmosphere.
    - Contains potential for engulfment by loose particles.
    - Has an internal lay-out such that someone entering could be trapped or asphyxiated by inwardly converging walls or a floor which slopes downward and tapers to a smaller cross-section.
    - Contains any other recognized serious safety or health hazard.
- Even the act of placing your face through the opening of a permit entry confined space is considered an "entry."

Proposed regulatory requirements

- Entry permit shall authorize entry:
  - Only by authorized workers.
  - Into a specific permit entry confined space.
  - For a specific purpose.
  - With entry by a specific shift or work crew for a period not to exceed 24 hours.
- Entry permit shall include the following items:
  - The minimum environmental conditions which are acceptable for entry and working in the space.
  - A means for assuring and certifying that all pre-entry requirements have been met.
  - The name or job title of the person authorizing or in charge of the entry.
  - The name of the attendant.
  - The means for assuring that the on-site rescue team is available. If no on-site rescue team has been formed, then the permit must carry the means for assuring that predesignated outside assistance can be summoned.

  - Any known hazards or those which could reasonably be expected to be present in the space.

- The following requirements may be covered in the permit or by a checklist which is then attached to the permit:

  - All means of isolation, cleaning, purging or bringing motion to rest has been done prior to entry to remove the hazards identified.
  - Description of any additional hazards that the activities of the workers in the space could be reasonably expected to generate. If any special work practices or procedures must be followed, they must be listed.
  - Any personal protective equipment that is necessary for the entry or rescue of the workers in the confined space, should that be necessary.
  - Any testing of the atmosphere in the space which must be done immediately prior to and during the entry period. Person responsible for this testing must be listed.
  - If hot work will be necessary in the space, it must be authorized here or on a separate hot work permit attached to, and noted on, the entry permit.
  - Any rescue equipment which must be readily available. If entry will be into an atmosphere which is actually or potentially immediately endangering to life or health (IDLH), NIOSH approved positive pressure atmosphere supplying breathing apparatus or a positive pressure airline respirator equipped with a minimum of 5-minute emergency escape bottle must be available at the point of entry.

Pre-entry testing requirements

- Test atmosphere in confined space for:

  - Oxygen levels.
  - Flammability.
  - Other contaminants that have potential to be present.

- Testing performed by Site Safety Officer or designated alternate.

- Equipment calibrated, according to manufacturer's procedures, before and after testing.

- Testing conducted throughout entire portion of space that workers will occupy during entry, without the use of ventilation systems.

- For vertical entries, use remote probes to measure atmospheres at various levels.

- Test atmosphere outside confined space to make sure surrounding air is not contaminated.
- Atmospheric conditions which are not acceptable include:

  - Oxygen levels <19.5% or >23.5%.
  - Flammable gas, vapor or mist concentration >10% lower explosive limit (LEL).
  - Airborne combustible dust concentration which reduces visibility to <5 feet.
  - Atmospheric concentration >PEL, STEL, TLV or recommended limit from MSDS.

- If test results indicate that atmospheric conditions in the confined space are not acceptable, entry is prohibited until atmospheric condition is brought into acceptable limits by purging, cleaning or ventilating the space.

Isolation

- Confined must be in a "zero energy state" with respect to chemical, electrical, gravitational, hydraulic, pneumatic, etc. sources.

- All energy sources must be de-energized, relieved, secured, disconnected and/or restrained.

  - Disconnect belt/chain drives and mechanical linkages.
  - Secure moving parts.
  - Depressurize and disconnect supply lines. Use a blank or cap.
  - Lock and tag in-line valves.

Site Safety Officer responsibilities

- Confirm need to enter confined space. Review tasks that might eliminate need to enter confined space.

- Review site health and safety plan to confirm that the identity of each confined space on-site has been noted. A confined space is defined as any tank, vessel, silo, storage bin, hopper, vault, pit, trench, diked area or any other enclosed space with limited means of egress or entry that meets one or more of the following criteria:

  - Contains an actually or potentially hazardous atmosphere or other recognized safety or health hazard.
  - Contains the potential for engulfment by particulate matter or liquid.
  - Has an internal lay-out such that someone entering could be trapped or asphyxiated by inwardly converging walls or a floor which slopes downward and tapers to a smaller cross- section.
  - Contains any other recognized serious safety or health hazard.

- Prior to the start of site activities:

  - Inform site workers of the location of each confined space to prevent inadvertent entry.
  - Assure the availability and use of all personal protective equipment and clothing necessary for safe entry.
  - Assure that rescue and safety related equipment, such as lifting or retrieval devices, are readily available prior to entry. Provide for and require the use of retrieval lines, or equivalent equipment, to make non-entry rescues possible.

- Provide appropriate vehicle and pedestrian guards, barriers or other means to protect the entry party and attendants from local traffic hazards and to protect non-entering employees from hazards arising from the confined space.

- Do not authorize or allow employees who have not been trained in permit entry confined space to enter any confined space.

- Determine actual and potential hazards associated with the space at the time of entry. Choose the appropriate means to execute a safe entry.

- Assure all necessary control measures are completed:

  - Isolation (i.e., lock-out, blanking, disconnections, etc.).
  - Space preparation (i.e., cleaning, purging, inert atmosphere in place, etc.).

- Assure, by appropriate testing, that the control measures used are effective. Assure proper calibration of test and/or monitoring equipment.
- Determine and evaluate the source (e.g., residue to be removed from space, leaking valve or pipe in space) of any atmospheric the contamination found at the time of entry.
- Provide an attendant for each permit entry of confined space.
- Complete the Confined Space Entry Isolation/ Preparation Checklist. Identify by job title or name those persons who must sign the entry permit and the duties of each, including the person in charge of entry.

Persons authorizing/in charge of entry and/or Site Safety Officer responsibilities

- Verify that the necessary pre-entry conditions exist. Record conditions and measured atmospheric gas levels on a Confined Space Entry Permit
- Verify that an on-site rescue team is available if it is to be used. Record on Confined Space Entry Permit.
- Verify that the means for summoning the on-site rescue team or other emergency assistance is operable. Record on Confined Space Entry Permit.
- Complete all portions of Confined Space Entry Permit. Assure that pre-entry and authorizing signatures portions of the permit are completed before any employee enters a permitted-entry confined space.
- Terminate the entry upon becoming aware of a non-permitted condition or conditions which exceed entry permit limits.
- May serve as attendant.

Attendant responsibilities

- Remain outside the permitted-entry confined space. UNDER NO CIRCUMSTANCES ENTER THE CONFINED SPACE, EVEN IN AN EMERGENCY, UNTIL HELP ARRIVES. Do not leave for any reason while entry continues, except for self-preservation, unless replaced by a qualified individual.

- Maintain continuous communication with all authorized entrants within the permitted-entry confined space by voice, radio, telephone, visual observation or other equally effective means.

- Order entrants to exit the space at the first indication of a non-permitted condition, unexpected hazard, indication of a toxic reaction, unusual conduct of entrants, external situation that could pose a hazard to the entrants.

- Know the procedure and have the means to summon immediate emergency assistance.

- Do not allow any one to enter the confined space to affect a rescue unless that person is wearing appropriate PPE, including safety harness with life line and necessary respiratory protection.

- Warn unauthorized persons not to enter, or to exit immediately if they have entered.

- Assist in handling tools and materials, relaying messages. Prevent fouling of air hoses and life lines in use.

OSHA imposed attendant training requirements

- Emergency Action plan (SSP).

- Duties of attendant as outlined in company permitted-entry confined space procedure.

- Proper use of communication equipment used to keep in contact with workers in confined space.

- Early warning signs and symptoms of exposure to contaminants that could be in confined space.

Additional imposed restrictions

- Allow entry into confined only if <u>all</u> of the following criteria are met:

  - No other non-entry procedure can be used to complete the necessary work.
  - There is no danger of engulfment.
  - The atmosphere can not become IDLH.
  - At least one of the following items is in place:

    - The space has been ventilated using a mechanically powered ventilator for a period of time not less than that specified in the ventilation nomograph for that ventilator and that the ventilation continues throughout the entry.

- A combination of appropriate atmospheric testing and mechanically powered ventilation is used.
- Appropriate continuous atmospheric testing assures that permit conditions are maintained.

- Do not permit non-attendant confined space entries.

Special considerations

- Certain work being performed in a confined space, such as welding, drilling or sludge removal, could cause the atmosphere in the space to change. Under these conditions, air monitoring of the confined space is to be conducted on a continuous basis throughout the time of entry.

- If workers leave the confined space for any significant period of time, such as for lunch or other break, the atmosphere of the confined space must be re-tested before the workers can re-enter the confined space.

APPENDIX F

EQUIPMENT MAINTENANCE AND CALIBRATION

HNu PI 101

CALIBRATION AND MAINTENANCE

SECTION 3

CALIBRATION

3.1 INTRODUCTION

The PI 101 Analyzer is designed for trace gas analysis in ambient air and is calibrated at HNU with certified standards of benzene, vinyl chloride and isobutylene. Other optional calibrations are available (e.g., ammonia, ethylene oxide, H2S, etc.). Calibration data is given in the data sheet. If a special calibration has been done, the data is given in the Application Data Sheet, which notes the sample source, type of calibration (see Section 8, Appendix), and other pertinent information.

Good instrumentation practice calls for calibration on the species to be measured in the concentration range to be used. This procedure assures the operator that the analyzer is operating properly and will generate reliable data.

Some general points to consider when calibrating the PI 101 are that the analyzer is designed for operation at ambient conditions and therefore the gas standards used for calibration should be delivered to the analyzer at ambient temperatures and pressure and at the proper flow rates.

WARNING:

The PI 101 is a non-destructive analyzer; calibrations using toxic or hazardous gases must be done in a hood.

The frequency of calibration should be dictated by the usage of the analyzer and the toxicity of the species measured. If the analyzer has been serviced or repaired, calibration should be done to verify operation and performance. It is recommended that calibration be checked frequently at first (daily or every other day) and then regularly based on the confidence level developed.

The normal meter scaleplate is 0 to 20. If the scaleplate is different, refer to the Application Data Sheet. If there are questions, consult the HNU representative before proceeding with calibration check.

An accurate and reliable method of calibration check is to use an analyzed gas cylinder in a test setup as shown in Figure 3-1 and described below. Additional material on calibration is given in Section 8, Appendix.

3.2 ANALYZED GAS CYLINDER

a. Concentration - The calibration gas cylinder is to contain the species of interest made up in an air matrix at or near the concentration to be analyzed. If the component is unstable in air, another matrix is to be used. The final calibration mixture should be similar to the sample the PI 101 will analyze. If the expected concentration is not known then a concentration should be chosen that will cause a scale displacement of 50 to 80% on the X10 range. Calibration on X10 range will provide accurate values on the X1 range as well.

For use on the 0-2000 range, a two-standard calibration is preferred: one at 70 to 85% of the linear range and the other at 25 to 35% of the linear range. With the linear range of approximately 600 ppm for most compounds these points would lie between 420 to 510 ppm and 150 to 210 ppm, respectively.

b. Stability - The calibration gas must be stable within the cylinder during the period of use. If the calibration is required in the field, then use of a small cylinder is recommended. In addition, the choice of cylinder material in contact with the gas must be considered (steel, aluminum or teflon). If there are any questions, the operator should request stability and usage information from the gas supplier.

WARNING

Extreme care must be taken in the handling of gas cylinders. Contents are under high pressure. In some cases, the contents may be hazardous. Many gas suppliers will provide data sheets for the mixtures upon request.

c. Delivery - The cylinder containing the calibration mixture must be connected to a proper regulator.

WARNING

Never open the valve on a gas cylinder container without a regulator attached.

Leak test all tank/regulator connections as well as the main cylinder valve to prevent toxic or hazardous materials from leaking into the work area. Care must be taken that the materials of construction of the regulator will not interact with the calibration gas.

One method of sampling the calibration gas is illustrated in Figure 3-1. Connect the cylinder to one leg of the tee, a flow meter to the opposite leg, and the probe to the third leg. The flow meter does not require a valve. If there is a valve, it must be left wide open. the flowmeter is only to indicate excess flow. Adjust the flow from the regulator such that only a little excess flow is registered at the flowmeter.

This insures that the PI 101 sees the calibration gas at atmospheric pressure and ambient temperature.

d. Usage - Generally, a gas cylinder should not be used below 200-300 psi as pressure effects could cause concentration variations. The cylinder should not be used past the recommended age of the contents as indicated by the manufacturer. In case of difficulty, verify the contents and concentration of the gas cylinder.

e. Alternate means of calibration are possible. For more information, contact the HNU Service Department.

3. PROBE

a. Identify the probe by the lamp label. If a question exists, disassemble the probe and inspect the lamp. The energy of the lamp is etched into the glass envelope.

b. Connect the probe to the readout assembly, making sure the red interlock switch is depressed by the ring on the connector.

c. Set the SPAN pot to the proper value for the probe being calibrated. Refer to the calibration memo accompanying the probe.

d. Check the Ionization Potential (IP) of the calibration gas to be used. The IP of the calibration gas must be at or below the IP of the lamp.

e. Proceed with the calibration as described in Section 3.4. Check the calibration memo for specific data. If any questions develop, call the HNU representative.

f. NOTE: The 11.7eV lamp has a special cleaning compound. Do not use water or any other cleaning compound with the 11.7 eV lamp. Do not interchange ion chambers, amplifier boards or lamps between probes. (See Section 5.2).

3.4 PROCEDURE

a. Battery check - Turn the function switch to BATT. The needle should be in the green region. If not, recharge the battery.

b. Zero set - Turn the function switch to STANDBY. In this position the lamp is OFF and no signal is generated. Set the zero point with the ZERO set control. The zero can also be set with the function switch on the X1 position and using a "Hydrocarbon-free" air. In this case "negative" readings are possible if the analyzer measures a cleaner sample when in service.

c. 0-20 or 0-200 range - For calibrating on the 0-20 or 0-200 range only one gas standard is required. Turn the function switch to the range position and note the meter reading. Adjust the SPAN control setting as required to read the ppm concentration of the standard. Recheck the zero setting (step b.). If readjustment is needed, repeat step c. This gives a two-point calibration; zero and the gas standard point. Additional calibration points can be generated by dilution of the standard with zero air if desired (see Section 8).

d. 0-2000 range - For calibrating on the 0-2000 range, use of two standards is recommended as cited in Section 3.2a. First calibrate with the higher standard using the SPAN control for setting. Then calibrate with the lower standard using the ZERO adjustment. Repeat these several times to ensure that a good calibration is obtained. The analyzer will be appoximately linear to better than 600 ppm, (see Figure 3-2). If the analyzer is subsequently to be used on the 0-20 or 0-200 range, it must be recalibrated as described in steps b. and c. above.

e. Lamp cleaning - If the span setting resulting from calibration is 0.0 or if calibration cannot be achieved, then the lamp must be cleaned (see Section 5.2).

f. Lamp replacement - If the lamp output is too low or if the lamp has failed, it must be replaced (see Section 5.3).

3.5 CALIBRATION CHECKING

Rapid calibration checking in the field can be accomplished by use of a small disposable cylinder containing isobutylene. Immediately after a calibration has been completed, a reading is taken on a special isobutylene standard. This provides a reference concentration measurement for later checking in the field. This can be done at any time with a portable cylinder containing this same special standard, using this reference reading as a check, and making adjustments to the analyzer if necessary. In effect, this is an indirect method of calibration, one maintaining the calibration to give direct readings for the original gas mixture, but using the portable isobutylene cylinder. Details are given in Section 8.2 of the Appendix.

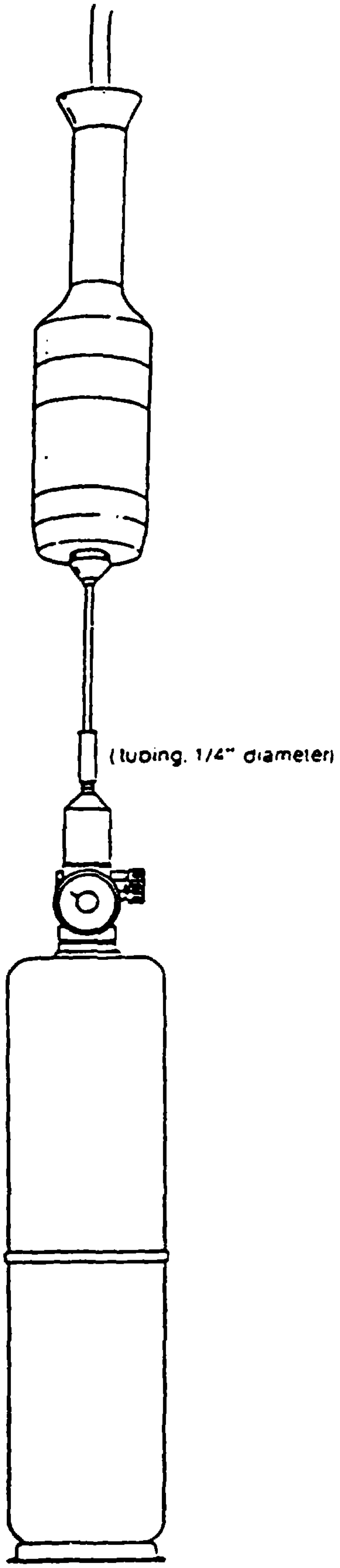


FIGURE 3-1
CALIBRATION TEST SET UP

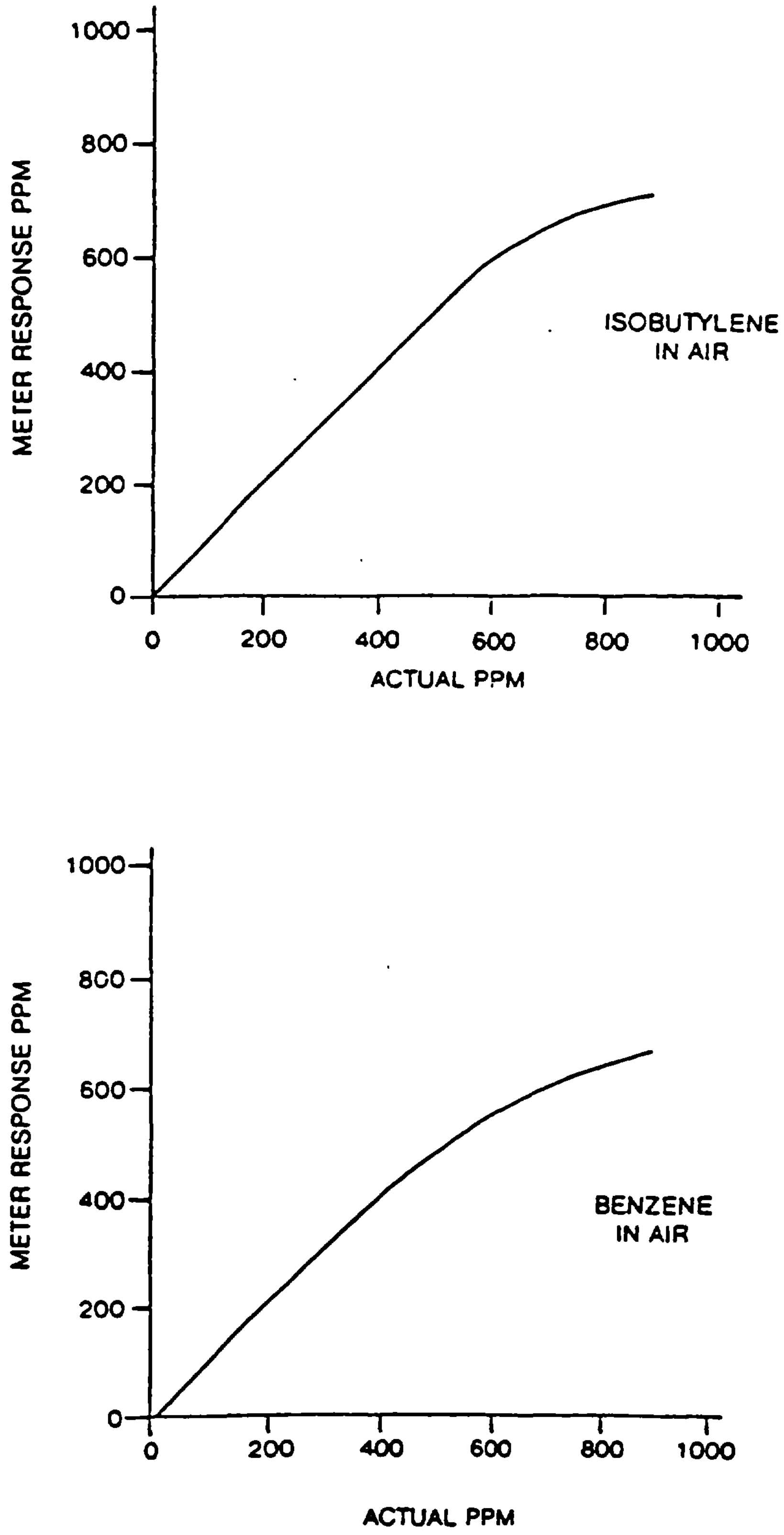


FIGURE 3-2
TYPICAL CALIBRATION CURVES (10.2 eV)

SECTION 5

MAINTENANCE

5.1 INTRODUCTION

Maintenance of the analyzer consists of cleaning the lamp and ion chamber, replacement of the lamp or other component parts or subassemblies.

WARNING: Turn the function switch on the control panel to the OFF position before any disassembly. Otherwise, high voltage of 1200 V DC will be present.

WARNING: Use great care when operating the analyzer with the readout assembly outside its case due to the presence of 1200 V DC.

WARNING: Do not look at the light source from any closer than 6 inches with unprotected eyes. Observe only briefly. Continued exposure to ultraviolet energy generated by the light source can be harmful to eyesight.

CAUTION: Do not interchange lamps of different eV ratings in a probe. Amplifier and components are selected for a specific eV lamp. A probe with the wrong lamp will not operate properly.

5.2 UV LAMP AND ION CHAMBER CLEANING

During periods of operation of the analyzer, dust or other foreign matter could be drawn into the probe forming deposits on the surface of the UV lamp or in the ion chamber. This condition is indicated by meter readings that are low, erratic, unstable, non-repeatable, or drifting, or show apparent moisture sensitivity. These deposits interfere with the ionization process and cause erroneous readings. Check for this condition monthly or as required. Cleaning can be accomplished as follows:

a. Disassemble the probe and remove the lamp and ion chamber (see Section 5.5). Exercise great care in doing so to prevent inadvertent damage to these components.

b. First check the lamp window for fouling by looking at the surface at an incident angle. Any deposits, films or discoloration may interfere with the ionization process. Clean the window as follows:

1) 9.5 and 10.2 eV lamps

   a) First clean by rubbing gently with lens tissue dipped in a detergent solution.

   b) If this does not remove deposit, apply a small amount of HNU cleaning compound (PA101534) directly onto the lens of the lamp and spread evenly over surface with a non-abrasive tissue (e.g. Kim-Wipe) or a lens tissue.

   c) Wipe off compound with a new tissue.

   d) Rinse with warm water (about 80 degrees F) or damp tissue to remove all traces of grit or oils and any static charge that may have built up on the lens. Dry with new tissue.

   e) Reinstall lamp in detector and check analyzer operation.

   f) If performance is still not satisfactory replace the lamp. See Section 5.3 and Section 6.

2) 11.7 eV lamp

   a) Clean by putting a freon or chlorinated organic solvent on a tissue and rubbing gently.

   b) DO NOT CLEAN THIS LAMP WITH WATER OR ANY WATER MISCIBLE SOLVENTS (methanol or acetone). It will damage the lamp.

   c) DO NOT USE THE CLEANING COMPOUND used for the 9.5 and 10.2 eV lamps under any circumstances on the 11.7 eV lamp.

c. Then inspect the ion chamber for dust or particulate deposits. If such matter is present, the chamber can be cleaned by removing the outer Teflon ring, and the four screws holding the retaining ring. Carefully move the retaining ring aside (NOTE: this is soldered) and remove the screen. A tissue or cotton swab, dry or wetted with methanol, can be used to clean off any stubborn deposits. The assembly can also be gently swirled in methanol and dried gently at 50-60 degrees C for approximately a half hour. No liquid must be present at reassembly as this would affect the performance. Do not clean the ion chamber with the HNU cleaning compound cited above in para. b.1)b).

d. Reassemble the probe and check analyzer operation.

e. If performance is still not satisfactory replace the lamp. See Section 5.3.

5.3 LAMP REPLACEMENT

To replace the lamp, disassemble the probe, remove the old lamp, install a new one of the same eV rating and reassemble.

WARNING

Turn the function switch on the control panel to the OFF position before disassembly. Otherwise, high voltage of 1200 V DC will be present.

CAUTION

Do not exchange lamps of different eV ratings in a probe. Amplifier and components are selected for a specific eV lamp. A probe with the wrong lamp will not operate properly.

Set the SPAN pot to 9.8 for the 10.2 eV lamp. Remove the readout assembly case (see Section 5.6). Locate the gain control potentiometer, R48, on the power supply board as shown on Figure 6-1. Recalibrate the analyzer adjusting this potentiometer, R48, with a small screwdriver to obtain the specified ppm reading, leaving the SPAN pot set at 9.8.

For the 9.5 and 11.7 eV lamps see the Application Data Sheet or calibrations memo for the proper span pot settings and readings.

WARNING

Use great care when operating the analyzer with the readout assembly outside its case due to the presence of 1200 V DC.

When calibration is accomplished, turn the analyzer OFF and replace the readout assembly in its case.

Adjustment of R48 potentiometer is used only when a new lamp is installed. At all other times adjustment is accomplished using the SPAN control potentiometer.

If calibration cannot be achieved, see Section 6, Troubleshooting.

5.4 LAMP SIZE CHANGE

If different applications for the analyzer would require different size lamps, separate probes, each with its own eV lamp, must be used. A single readout assembly will serve for any of the probes. A change in probe will require resetting of the zero control and the span pot. Calibration should be checked to verify proper operation.

5.5 PROBE DISASSEMBLY/ASSEMBLY

WARNING

Turn the function switch on the control panel to the off position before disassembly. Otherwise high voltage of 1200 V DC will be present.

Disconnect the probe cable connector at the readout assembly. Disassemble the probe by first removing the exhaust screw at the base of the probe adjacent to the handle (see Figure 5-1). Grasp the end cap in one hand and the probe shell in the other, gently pull to separate the end cap and the lamp housing from the shell.

Hold the lamp housing with the black end cap upright. Loosen the screws on the top of the end cap, separate the end cap and ion chamber from the lamp and lamp housing.

CAUTION

> Care must be taken so that the ion chamber does not fall out of the end cap or the light source does not fall out of the lamp housing.

Turn the end cap over in the hand. Tap lightly on the top. The ion chamber should fall out of the end cap into the hand.

Place one hand over the top of the lamp housing and tilt slightly. The light source will slide out of the housing.

The amplifier board can be removed from the lamp source housing assembly (see Figure 5-2) by unsnapping the coaxial connector, J1, and then removing the retaining screw. The amplifier board will then slide out of the housing assembly.

Reassemble the probe by first sliding the lamp back into the lamp housing. Place the ion chamber on top of the lamp housing, making sure that the contacts are properly aligned. The ion chamber fits only one way.

If the ion chamber is to be replaced always use one identical to the one being removed. Check the aperture (small: 3.0 mm; large: 6.0 mm) at the top of the ion chamber and materials of construction (gold-plated or Teflon) to ensure proper replacement. See Parts List, Section 7.

Place the end cap on top of the ion chamber and replace the two screws. Tighten the screws only enough to seal the O-ring.

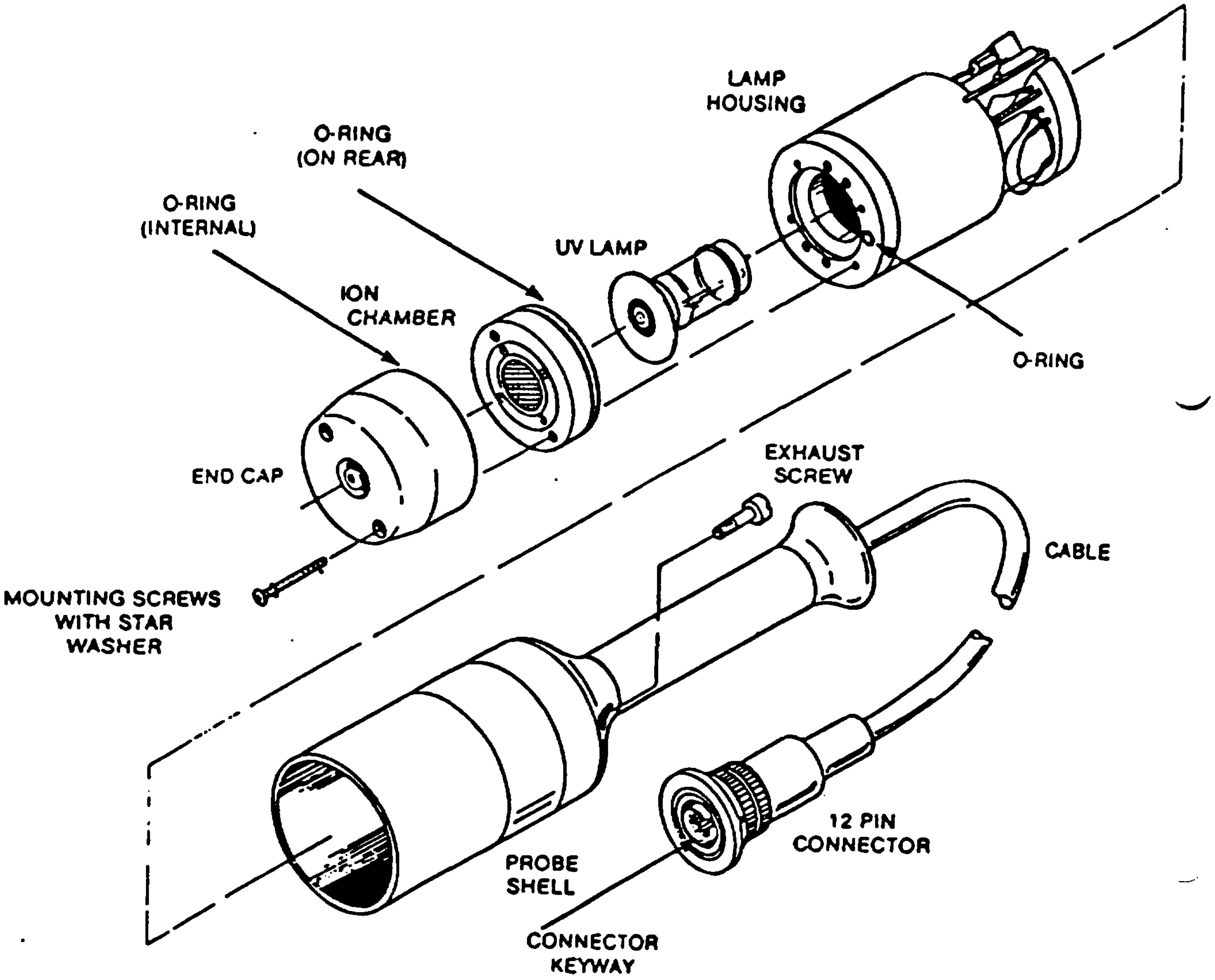


FIGURE 5-1
PROBE ASSEMBLY

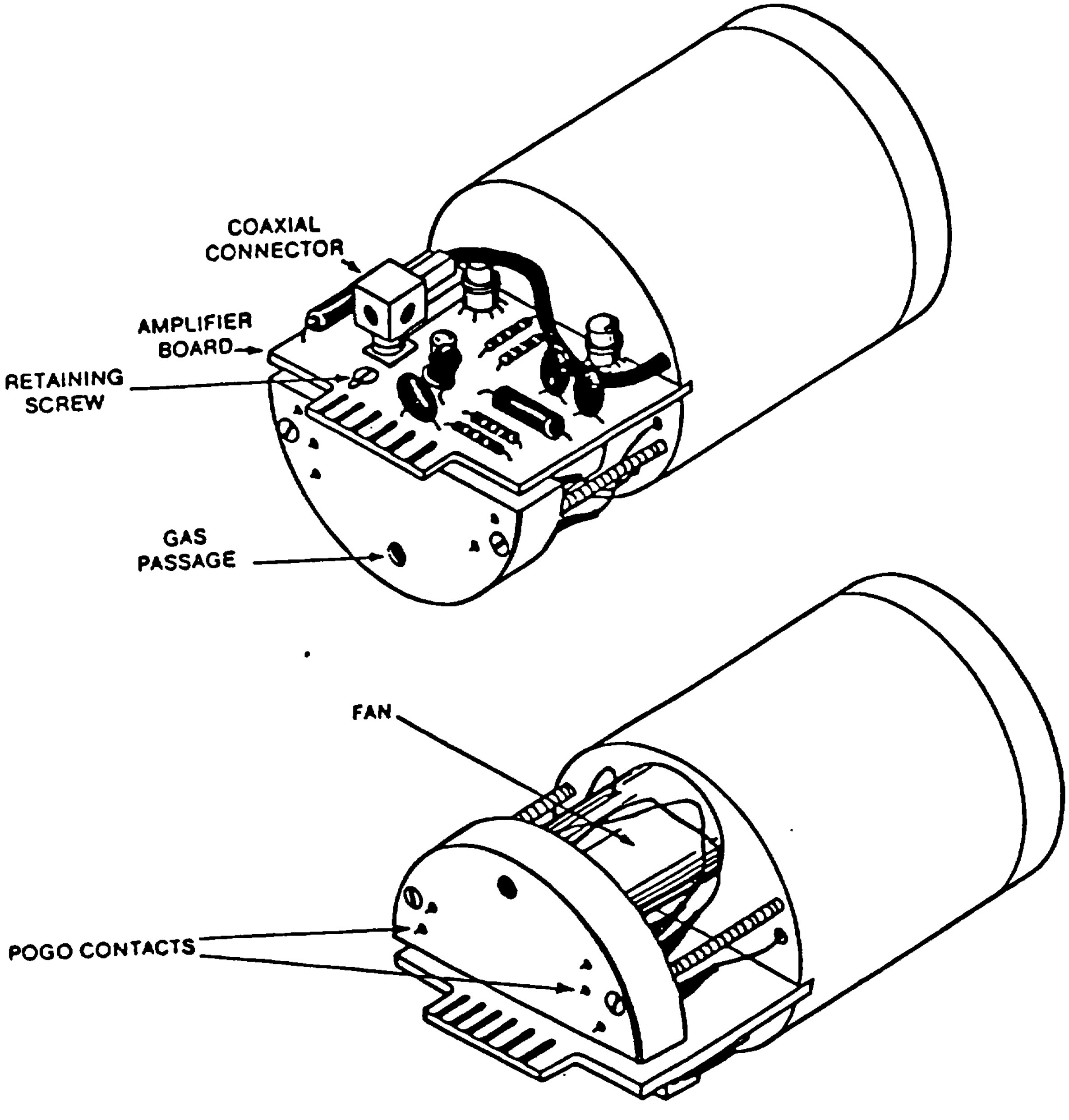


FIGURE 5-2
LAMP HOUSING ASSEMBLY

CAUTION

Do not over-tighten these screws.

Line up the pins (pogo contacts) on the base of the lamp housing with the pins inside the probe shell. Gently slide the housing assembly into the probe shell.

The end cap should meet the probe shell evenly after final assembly. If not, the ion chamber may be installed wrong.

CAUTION

DO NOT FORCE the assembly into the shell. It fits only one way.

If it does not reassemble readily, remove and check pin alignment. Check to ensure pogo contacts are not bent. Refasten the exhaust screw at the base of the probe.

Align the 12 pin probe connector to the readout assembly and reconnect with a twisting motion until a click occurs. Check to ensure the high voltage microswitch is properly depressed. The lamp should light if the function switch is turned to any position except STANDBY.

5.6 READOUT DISASSEMBLY/ASSEMBLY

WARNING

Turn the function switch on the control panel to the OFF position before disassembly. Otherwise, high voltage of 1200 V DC will be present.

Disconnect the probe cable connection. Remove recorder jacks and cable or the plastic plug cap. Loosen the screw on the botton of the case and, holding the instrument by the bezel, remove the case (see Figure 5-3).

a. The control assembly consisting of the Printed Circuit Board (PCB) and control panel can be separated from the readout assembly by the following steps:

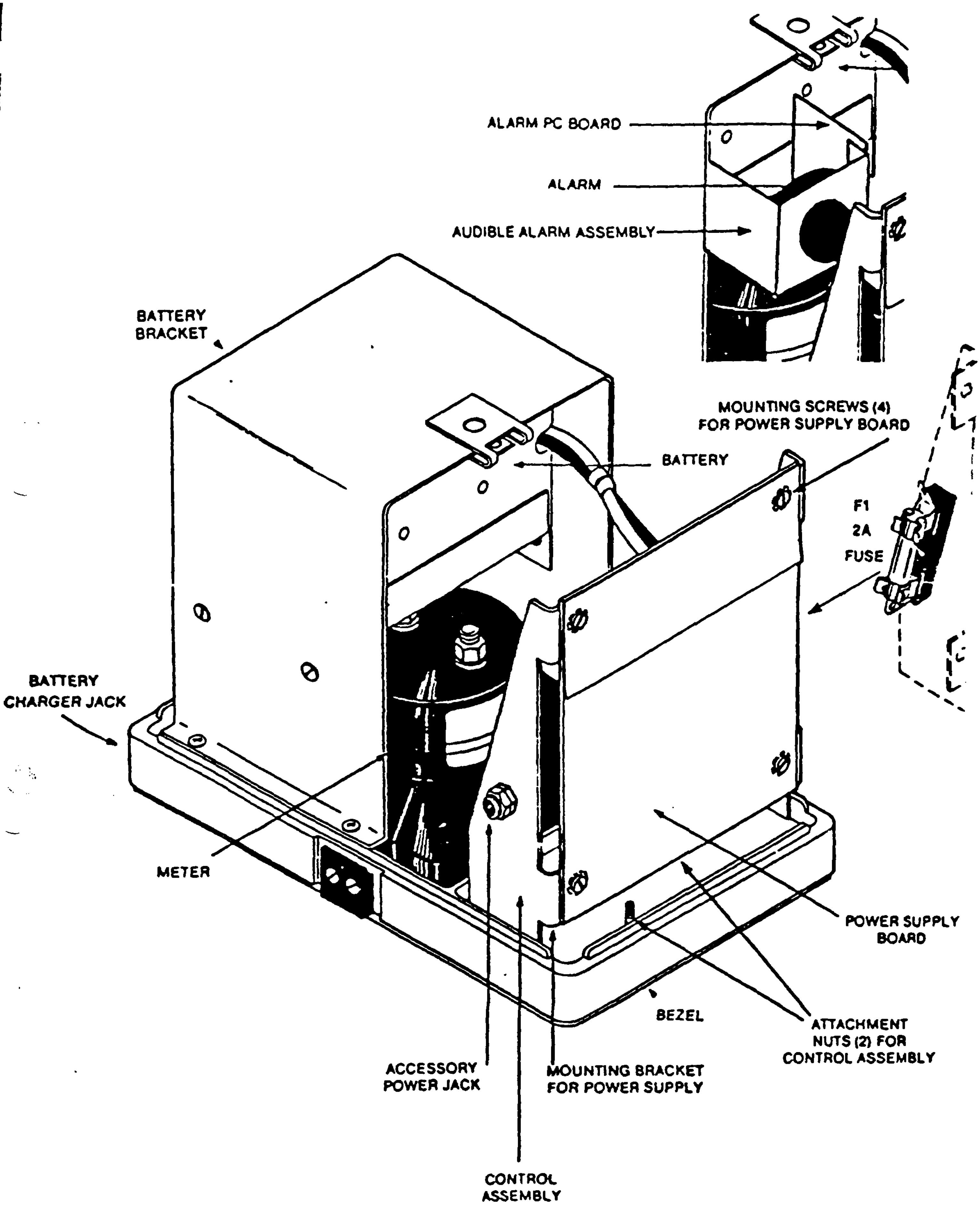


FIGURE 5-3
READOUT ASSEMBLY

1) Separate the Molex connectors in the cables to the control assembly.

2) Remove the two attachment nuts at the base of the assembly.

3) Remove the two screws at the top of the power supply board holding it to the assembly brackets.

4) Compress the brackets and slide the assembly thru the bezel. Remove a third screw at the lower corner of the board, if necessary.

b. The optional alarm assembly can be separated as follows

1) Disconnect the cable (P6/J6 of Figure 4-5)

2) Remove the two screws holding the alarm assembly to the battery bracket

Reassembly is accomplished by reversing the above procedure.

NOTE: Be sure the function switch on the control panel is in the OFF position before inserting the control module into the case. If not, the fuse can be blown or damage can result.

DETECTOR FOR HCN
COMPUR 4100 SD MONITOX

OPERATION AND MAINTENANCE

MPUR 4100 SD Monitox Gas
n and Warning System comprises

tector	(alarm unit with digital display)
nerator	(test unit)
ln	(recommended accessory)
ning	(recommended accessory)

tem is especially designed to
the TLV of HCN.

ON!

h the 4100 SD Monitox for HCN has
ghly simplified for ease of operation
ser, it is nevertheless a complex
ing instrument which will operate
only if these operating instructions
efully observed and if the instrument
ked regularly by the safety officer.

This applies in particular to the regular replacement of the cells and daily functional tests. The responsibility for any changes made in the alarm threshold settings must be borne entirely by the operator; COMPUR recommends the strict observance of the TLV. Since the unit is designed to be intrinsically safe, all repairs must be made by the manufacturer or other approved personnel.

COMPUR offers the instrument with the following factory settings:
first alarm threshold = at TLV = 10 ppm
second alarm threshold = at 2 TLV = 20 ppm

The detector cell will be destroyed if the detector is permanently exposed to a HCN-concentration exceeding 1000 ppm. In this case the cell has to be replaced.

COMPUR 4100 SD Monitox Detector for HCN

1.1.

Applications

The COMPUR 4100 SD Monitox is a personal monitor for HCN.

It is designed to be worn attached to the clothing near the breathing zone of the person to be protected. The detector produces an audible first alarm when the HCN-concentration exceeds the TLV (factory setting: 10 ppm) and a second alarm, when it exceeds 2 x TLV.

Independent of the alarm setting, the digital display shows the actual HCN-concentration in ppm (parts per million) in the nominal range of 0 – 100 ppm HCN.

In conjunction with the COMPUR 4102 Dosimeter, the unit can be employed to register HCN-concentrations at confined spaces ranging from 0 to 10 x TLV.

The COMPUR 4100 SD Monitox cannot be used to measure process gas streams or in presence of continuous high HCN-concentrations.

Ambient air diffuses through the filter insert (a dust filter) (5) to the measuring cell. The measuring cell, a dual-electrode electrochemical cell with an organic electrolyte gel, generates an output current proportional to the partial pressure of HCN in the air.

A series of electronic amplifiers supply a voltage signal which is fed to the comparator for the alarm threshold. If the first alarm threshold is exceeded, an intermittent tone is produced; if the second alarm threshold has been exceeded a dual tone signal is produced by the tone generator and loudspeaker (or earphone in very loud areas). The standardised analog signal corresponding to the actual HCN-concentrations (the TLV corresponds to 80 mV) can be fed to the Dosimeter.

The same signal is fed to the AD-converter driving the digital display. The display is adjusted to give a reading of 10 ppm at 80 mV input.

The 4100 SD Monitox consists of two separate power circuits (via two miniature batteries); the circuit for the analogue part is separated from that for the alarm-generation.

When the „on-off" switch is moved to the „Batt." position, the batteries will be tested before the instrument is turned on. In this switch position, the batteries are electronically tested under the high load of the final tone stages. If one of the batteries fails to reach the predetermined lower theoretical limit, no alarm will be heard

ınical Data for the COMPUR 4100 SD Monitox for HCN

ɔrmity certificate		BVS 82.013
·y class		EEx ib II C T 6
:nsions		104,4 x 62 x 24 mm
,ht (with batteries)		approx. 150 g
er supply		2 x PX 23 (5,6 V)
ury service life		approx. 1000 h.
ılay range		0 – 100 ppm
m volume		min. 80 dBA / 30 cm
m levels		2 alarms, adjustable
ponse time		$T_{20} < 10$ s $T_{90} < 3$ min.
ıe to alarm	20 ppm	< 15 s
	50 ppm	< 3 s
ınection possibilities		earphone, dosimeter
nperature range		0 – 50 °C
lative humidity		10% – 95%
ro point drift		< 1 ppm / 6 months
nsitivity drift		< 15% / 6 months
ıvice life of the cell		min. 6 months (dependant on dose)

1.4.

Cross-sensitivities

Test components	Test concentration	Indication in ppm HCN
SO_2	5000 ppm / 40% rH	10
NO_2	10 ppm	- 6
NH_3	1000 ppm	10
CO	1000 ppm	—
CO_2	1000 ppm	—
H_2	1000 ppm	—
$CH_2{:}CHCN$	10 ppm	—
CH_3CN	200 ppm	—
$(CH_3)N$	500 ppm	17
CH_3OH	200 ppm	—
$COCl_2$	5 ppm	10
Cl_2	10 ppm	5
HCl	10 ppm	7
H_2S	2 ppm	10
Hydrocarbons, saturated	2% vol.	—
Hydrocarbons, unsaturated	1% vol.	—
Aromatic compounds (also alcylated)	200 ppm	—

2.

Technical Description of the COMPUR 4100 SD Monitox Gas Generator for HCN

2.1.

Applications

The HCN gas generator serves to enhan the reliability of the Monitox gas detectio and warning system. The Monitox detect must undergo a functional test by placin on the generator before each use. The generation of a gas concentration exceeding the TLV ensures that the detec will respond reliably during use (picture 2

The gas generator, however, is not design to generate a calibration gas of known concentration. Daily testing of the Monit detector does not mean that the user is n recommended to change cell sequentiall

The COMPUR 4100 Gas Generator must not be exposed to or used in explosive atmospheres.

N.B.: The generator cell may dry out at very low relative humidity in the air this case, it is necessary to put th moisture cap delivered with the generator on top of the generator always when it is not in use.

This ensures a correct gas concentration for the detector tes

2.

de of Operation

switch on the generator is activated by
ing the detector in the matching recess
the generator head.

mall fan feeds a flow of air past the
nerator cell directly to the detector cell.
the same time, gas is generated
trolytically in the generator cell in such
amount that the gas concentration is
h enough to cause the detector to
pond within 10 seconds (alarm threshold
ppm). The period of gas generation is
licated by the green LED.

The red LED indicates when the battery must be replaced.

After a 10 seconds interval, gas production is terminated and the fan conveys pure air until the detector is removed.

This functional test of the detector checks any of the following defects:

- clogging of the dust filter
- a malfunctioning cell
- a malfunctioning electronics system
- a malfunctioning generator.

3.

chnical Data of the COMPUR 4100 SD Monitox as Generator for HCN

nensions	133 x 65 x 40 mm
ight (incl. batteries)	approx. 250 g
mperature range	0 °C – 50 °C
wer supply	9 volt alkali battery, leakproof, e.g. Mallory 1604
nerator cell service life	approx. 3000 tests or for 1 year
ttery service life	approx. 3000 tests

3.

Use of the detector and generator

3.1.

Detector actuation and functional test

Battery Test

Turn the switch on the COMPUR 4100 SD Monitox to "Batt.". If the battery has sufficient power to operate the detector for eight hours, an audible (intermittent) tone will be heard. The LCD-display is switched off at the "Batt." test position. If no tone is emitted, this indicates that at least one of the batteries is exhausted. For safety reasons both batteries should be replaced (refer to section 5.1.).

When the audible tone has been heard (to preserve batteries, the test should be as short as possible), the switch is moved to "ON". The tone will cease. The LCD-display is operating now. It must show "0" ppm after some seconds.

Functional Test (picture 2)

Place the detector on top of the generator as illustrated.

As soon as the detector sounds its alarm, it must be removed from the generator. The detector is ready for operation once the alarm has ceased.

If the detector alarm does not sound wit
ten seconds the detector has to be check
and serviced. If necessary, the filter cap h
to be replaced (see point 5.2.)

It is advisable to record the test and assignment of the gas detector in the detectolog.

The battery test and functional test mu
performed prior to each use to thus ens
maximum safety.

During the gas test the LCD-display mu
show the response of the cell to HCN-
concentration as well. As the alarm
threshold is factoryset at 10 ppm the ala
should sound at 10 ppm. As the display
reads a new value every second, the tim
for alarm and display of 10 ppm may be
different.

of the Gas Detector

s detector must be worn in the ing zone of the person to be protected e filter cap (5) should not be covered way.

ibber lip on the carrying clip makes it ble to securely attach the Monitox to s of clothing (e.g. the breast pocket).

is not deemed adequately secure, the supplied with the Monitox can be ked in the holes of the carrying clip. enables the Monitox to be worn around eck.

all possible, the filter cap should be cted from water, dust-laden air or dirt. the battery and functional tests (refer int 3.1.) should be performed before etector is put into operation.

N gas concentration in the vicinity of ensor exceeds the set alarm value, the will sound after a delay dependent on as concentration (The higher the centration, the more quickly the MPUR 4100 SD Monitox will respond).

alarm sounds at a level of at least 80 dB distance of about 30 centimeters nches).

3.3.

Connecting the Earphone

When the detector is being utilised in an area with high background noise, the optional earphone should be used to be sure that the alarm will not go unnoticed. The earphone is connected to the earphone socket (9) on the detector. This socket disconnects the internal loudspeaker. If the earphone is being used, it is important that the tests also be conducted with the earphone plugged into the detector *(refer to* point 3.1.). When the earphone is not being used, the socket should be closed with the plastic plug.

3.4.

Connecting the Dosimeter

The COMPUR 4102 Mini-Dosimeter can be connected to the 4100 SD (refer to operating instructions for the 4102).

The generator test can also be carried out with the Dosimeter connected to the COMPUR 4100 SD if the detector is turned 180° about its longitudinal axis relative to the position shown in point 3.1. and then placed on the generator in that way, that the cell fits into the recess on the generator. The functional test is then started by pushing the generator button with one's finger.

The plug should be replaced in the Dosimeter socket whenever the Dosimeter is not being used.

3.5.

Digital Display

Additional to the warning-function of the COMPUR 4100 SD Monitox its digital display (6) gives a direct reading of the actual HCN concentration.

Thus it is possible to determine HCN-concentrations below and above the TLV-level, giving the skilled worker and industrial hygienist the means to detect unusual conditions of HCN-concentrations with high accuracy and resolution.

The COMPUR 4100 SD Monitox is, however, even with its digital display, primary a measuring and warning device for personal protection.

It has not been designed for measurement in process-control; moreover exposures to high HCN-concentrations for any length of time must be avoided, as the accuracy of the reading will suffer.

3.6.

Detector Deactivation and Storage

a) brief period of inactivity (up to a month

the detector is deactivated
(switch to "OFF")

b) Prolonged inactivity and storage

It is advisable to open the Monitox and remove both the cell and batteries, to provide them from leaking and corrodin the interior of the Monitox (refer to the sections on cell and battery replacem 5.3.).

Before reutilizing the Monitox a new c has to be installed.

bration Instruction for the ector COMPUR 4100 SD nitox

hance the intrinsic accuracy of the ctor for HCN it is necessary to calibrate tector either with a HCN nitrogen ure with definite concentration of HCN ake an electronic adjustment by means e COMPUR current generator 00 023.

cessories required

1\.
libration with gas

calibration cap to place onto Monitox

flow meter

millivoltmeter 0 – 2000 mV;
input resistance $\geq$ 1 MΩ

tubing, set of test cables, screw-driver

calibration gas, known concentration,
about 10 ppm HCN in pure N_2

mark: The generation and above all the stability time of HCN calibration gas is not without problems. So if only a small number of detectors are to be calibrated, the electronic method should be prefered.

1 2.
libration – Electronical Method cture 6 and 7)

calibration unit (current generator)

millivoltmeter 0 – 2000 mV,
input resistance $\geq$ 1 MΩ

set of test cables, screw-driver

4.2.

Zero calibration and gain adjustment with calibration gas

4.2.1.
Preparation

The Monitox is opened and positioned with the electronic components upward on a non-slip surface. The cover with the digital display is carefully put aside with the display upward.

Then the unit is switched on via "Batt." position to "ON". The LCD-display should read 00 ppm after several seconds.

The excellent zero-point stability of the cells will normally make unnecessary to adjust the zero-point. Deviations from zero are caused mostly by fault sensor cells.

For zero-checking remove sensor cell.

4.2.2.
Zero-Adjustment

Connect Millivoltmeter to tie down point (MP 2) and GND (MP 1) (picture 6). If the *reading is not zero in clean air, and also is* not zero without sensor cell, potentiometer (R 9) (offset voltage) has to be varied until the reading is zero.

Note: If reading is zero without cell and not zero with the cell, it may need up to one hour to stabilize the cell. If a cell has been removed for a longer period without short-circuiting the two connectors, the time to stabilize may be up to one day. A new cell therefore has short-circuit on the small pcb, that must be broken away *before inserting the cell.*

4.2.3.
Gain Adjustment with gas

The special calibration adaptor is tightly put onto the dust filter on top of the detector cell.

Adjust a calibration-gas flow through the calibration cap; flow rate should be approx. 100 ccm per minute and the inlet must be the smaller pipe; to avoid pressure *variations the outlet should be free of* obstacles. After 5 minutes the display of the Monitox has reached its final value.

Connect millivoltmeter to tie down point (MP 2) and GND (MP 1). Depending on the concentration of the calibration gas the following voltage should be displayed: (adjust by means of pot R 7)

$$U = \frac{[c]\text{ in ppm}}{10\text{ ppm}} \times 80\text{ mV}$$

The display of the Monitox must show the gas concentration. In the opposite, adjust pot (R 15) until correct *reading* is shown.

4.2.4.
Gain-Adjustment with the current calibrator

Each detector cell produced by COMPUR is supplied with an indication of the output current at 10 ppm HCN. (Never throw away packings of replacement cells before *having noted this indication!!!)*

Remove detector cell. Insert calibration cable with the plug board into plug connector for detector cell. The gold contacts must touch the spring contacts. Connect other side of the cable to the current generator.

Make sure of correct polarity of plugs. Switch on generator, turn button till generator display shows output current of detector cell.

Remark: Display always shows actual value of current. If it is zero, check the contacts!

Connect voltmeter to tie down point (MP and GND. Adjust sensibility by means of pot (R 7) until 80 mV is displayed. Monit must now display 10 ppm. In opposite, adjust pot (R 15).

4.3.

Setting the Alarm thresholds

The alarms of the standard version are to set on 10 ppm (first alarm 1 TLV) and 20 p (second alarm 2 x TLV).

To set the alarm levels, push the 2 mini- switches (S 1) to the right. The display of Monitox shows now the level of the 1st alarm threshold. This can be adjusted by means of the potentiometer (R 30)

To adjust the 2nd alarm level, push the upper switch to the left. The display sho now the 2nd alarm threshold. This can b adjusted by means of the potentiometer (R 29).

After having adjusted the alarm levels, p both mini switches to the left. The Monit display shows now the actual concentra of HCN.

4.4.

Concluding the adjustment operations

After the settings have been made, turn switch on the pcb to "OFF"-position. M sure that the switch-handle on the cove also in the "OFF"-position. Then carefu replace the cover and fold the connect cable between pcb and display so that neither squeezed in nor cracked. Tight the screws. The Monitox is now ready operation.

aintenance and Servicing structions

.1.

attery Replacement

Turn switch (7) to "OFF".

Remove three screws (12).

Turn detector over and remove front cover.
Attention: Do not attempt to remove the cable between front panel and pbc!

Lift out battery housing, disconnect plug.

Unscrew and remove battery lids.
Replace batteries with +pole towards lid.
Replace lids.

Plug-in battery plug. Ensure cable and cable socket in right position.

Replace battery housing and front cover, carefully adjust the cable of the front panel, so that it is not damaged by fixing the front panel; then tighten the screws.

Repeat battery test.

.2.

ilter Cap Replacement

1. Remove screws (7) (picture 4) and open detector.
2. Carefully remove sensor cell together with filter cap (5). Pull cap off cell (4).
3. Attach new filter cap (with identical gas label HCN) and return sensor cell to original position.
   Filter cap order number appears on plate attached to inside of front panel and is listed in section 6.

Replace front cover and tighten screws

Repeat performance test.

5.3.

Sensor Cell Replacement

1. Open detector (see 5.1.).
2. Remove cell together with filter cap.
3. Remove new cell and filter cap from storage container, pull transparent cap off the cell and replace this by the new filter cap. Correct position of filter cap is shown in illustration.
   Remove short-circuit protection attached to pcb by breaking it away.
4. Proceed current calibration (4.2.4.).
5. Replace sensor cell with filter cap in proper position.
6. Close Monitox.

5.4.

Generator Cell Replacement

(picture 5)

1. Open housing
   (as when replacing battery)
2. Unsolder fan leads (10).
3. Loosen four screws (11) and three screws (12).
4. Remove outlet, gas cell and fan through the front.
5. Carefully insert replacement unit U 5820 300 consisting of outlet, cell and fan and tighten screws (12).
6. Tighten screws (11). Align circuit board so that pin (13) reliably actuates switch (14) when gas detector attached.
7. Resolder fan leads (10).
8. Reassemble generator and tighten screws.
9. Testing: Use properly functioning gas detector for same gas. Switch to "ON", attach. Alarm must sound after about eight seconds.

5.5.

Generator Battery Replacement

Loosen four screws on rear housing panel. Carefully remove front cover. For correct positioning of battery, refer to illustration 5.

5.6.

Troubleshooting

Malfunction	Remedy
Battery test: no response	Replace batteries (5.1.)
Generator test: no response	a) Repeat test using 2nd detector, if no response, b) b) Replace filter cap (5.2.), if not dirty, c) c) Insert new sensor cell (5.3.)
Generator does not supply enough gas	Use moisturizing cap for several days, otherwise replace generator cell (5.4.).
Red LED lights up during test	Replace generator batteries (5.5.).

6.

Accessories and consumabl

Part Numbers

1. Gas detector digital display, 2 alarm thresholds with Dosimeter output	U 5306
2. HCN cell with filter cap	U 5800
✓3. HCN filter cap (10 pcs.)	U 5810
4. Battery PX 23 (1 pc.)	U 4990
✓5. HCN gas generator	U 5390
✓6. HCN generator cell	U 5820
7. Calibration gas adapter	U 5900
8. Measuring cable: calibration	U 5900
9. Digital Voltmeter	U 5900
10 Current calibrator	U 5900
11. Calibration cable used in connection with current calibrator	U 5900
12. Detectolog	U 5900
13. Earphone	U 5900

GASTECHTOR
MODEL 1314

OPERATION AND MAINTENANCE

GASTECHTOR

HYDROCARBON SUPER SURVEYOR

MODEL 1314

PPM/LEL GAS INDICATOR WITH OXYGEN SECTION

AND

MODEL 1238

PPM/LEL GAS INDICATOR

SERIAL NO.: ______________
CALIBRATED FOR: ______________
LEL Alarm: ______________ %LEL
PPM Alarm: ______________ ppm
Oxygen Alarm: ______________ $\%O_2$ (Falling)
______________ $\%O_2$ (Rising)

CONTENTS

MADE BY:

GASTECH, INC.
8445 CENTRAL AVENUE
NEWARK, CALIFORNIA 94560
TELEPHONE: (415) 794-6200
TELEX: 334-462

VI. MAINTENANCE

A. Batteries

1. Check battery voltage periodically by pressing BATTERY CHECK switch. Recharge before voltage reaches minimum.

   When connecting charger, always follow these steps:

   a) Confirm that the plug is inserted in the correct way, with the THIS SIDE UP label upwards. The socket is polarized, with the pins offset below the centerline, but can sometimes be forced on the wrong way, particularly if it has become worn with use.

   b) Verify that a charge is actually entering battery. To do this, turn instrument on and check meter reading while BATTERY CHECK button is pressed. Observe reading while charger is plugged and unplugged at wall socket. If reading increases when charger is connected, and decreases when unplugged, battery is receiving a charge. If no change is observed, then probably charger or power circuit is at fault. If charger is defective, return it for repair or replacement.

   After verifying that instrument is accepting a charge, turn instrument switch off. Do not attempt to charge while instrument is turned on.

2. If sufficient voltage cannot be obtained after charging, open instrument and:

   a) Check voltage output with a voltmeter, between red and black wires (unplug connector to gain access to pins). Voltage should be about 8.5 volts.

   If voltage is acceptable, but volt check reading is too low, meter or switch could be at fault. If voltage is too low, battery is at fault.

   b) If <u>no</u> output voltage can be obtained, check fuse by unscrewing recessed cap, marked "FUSE", and removing fuse. It can be checked visually or with an ohmmeter. If burned out, replace with a new one, but be sure to attempt to identify the cause of the overload or short circuit. Fuse must be type 3AG-1A.

   c) If battery voltage is too low, and cannot be brought up by overnight charging, it probably needs replacement. To remove, take out the two screws holding it to bottom of case, and unplug black and orange wire connector at charging end.

3. [illegible] the replaceable cell [illegible] [illegible] defective [illegible] the [illegible] and [illegible] check the voltage of each individual cell with a voltmeter. Remove two screws on the top of the pack with a 1/8" Allen wrench. The lid is spring loaded and may be held down by hand to ease the screw removal. Carefully remove the lid and the individual cells.

   a) The cells supplied are the Stock No. 49-1501 rechargeable D-size nickel-cadmium type, 3.5-4.0 AH, and when charged, measure about 1.35 volts. Discard and replace faulty cells.

   b) Examine the battery cavity and carefully clean out all foreign substances. Re-insert the cells into the pack in accordance with the diagram on the lid. (Negative end to springs, button end to rivets.) Leave the proper space open for the fuse cartridge.

   c) Place the lid onto the cells, press down firmly and insert screws. The convoluted case will assure cell alignment. Tighten the screws snugly, do not overtorque. It may be necessary to spring sides of instrument case apart slightly to clear battery lid.

   d) Join all loose connectors, re-assemble instrument and charge battery as required.

   e) If normal operation from disposable batteries is desired, use the Stock No. 45-8052 battery pack instead of the 49-8051 pack. This assembly has a quick change feature, a retainer strap which can be pushed aside with thumb pressure to release the lid and give access to the cells. Duracell* type disposable batteries are recommended for a proper fit.

   This battery pack has no charger connection, so there is no danger of inadvertent charging of disposable cells. It can be used with rechargeable cells, but they must be charged separately.

---

*Duracell is a trade name for Duracell Inc., Bethel, CT 06801.

1. Sensor assembly may require replacement if:

   a) Meter cannot be set to zero within range of ZERO potentiometer. (Including COARSE ZERO)

   b) Meter cannot be set to desired level within range of SPAN Adjust, either range.

2. To replace detector:

   a) Open instrument case.

   b) Unscrew the red, green and white wires at terminals on main circuit board, noting color coding.

   c) Unscrew knurled retaining cap at reaction chamber.

   d) Pull out original detector and install new one, being sure that O-ring is in place, under flange of detector.

   e) Connect wires to terminals, turn power on, and adjust COARSE ZERO as in Sect. V.A.3.

C. Oxygen Detector

1. Oxygen sensor assembly may require repair if:

   a) Meter cannot be set to desired level within range of OXY CAL Adjust.

   b) Meter cannot be set to zero within range of ZERO potentiometer.

2. If oxygen sensor assembly requires repair, it should be sent to factory for reactivation. Alternatively, a complete new detector can be ordered, on an exchange basis.

   Oxygen cell is an electrochemical device similar to a battery, which gradually depletes itself, regardless of usage of the cell. It requires periodic reactivation, consisting of replacement of the electrolyte and the membrane, plus cleaning and inspection of the electrodes. This is most economically done at the factory.

   New and reactivated oxygen cells carry a factory guarantee based on length of time from date of original shipment, and are date-coded. Cells returned for reactivation are inspected and in-warranty cells are tested for operability. Any that fail prematurely receive a warranty allowance.

To replace oxygen sensor:

   a) Open instrument case. Locate oxygen cell.

   b) Swing retainer clamp clockwise and remove it to release cell.

   c) Tilt cell upward and pull it out of case. Unplug cell wire at socket.

   d) Reinstall new or newly reactivated cell in same position. Before installing, remove protective seal from face of cell, and shake out any drops of water that may be found under seal.

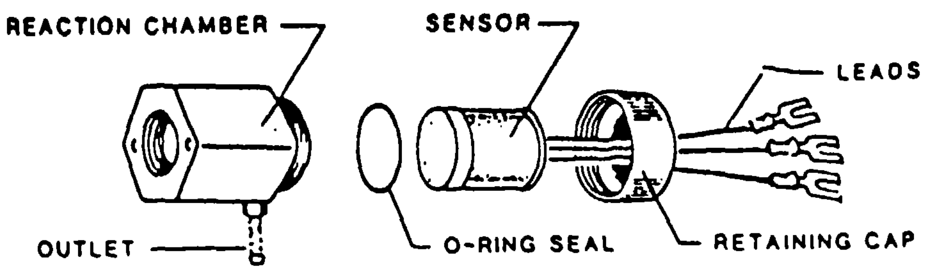


FIGURE 12. COMBUSTIBLES DETECTOR

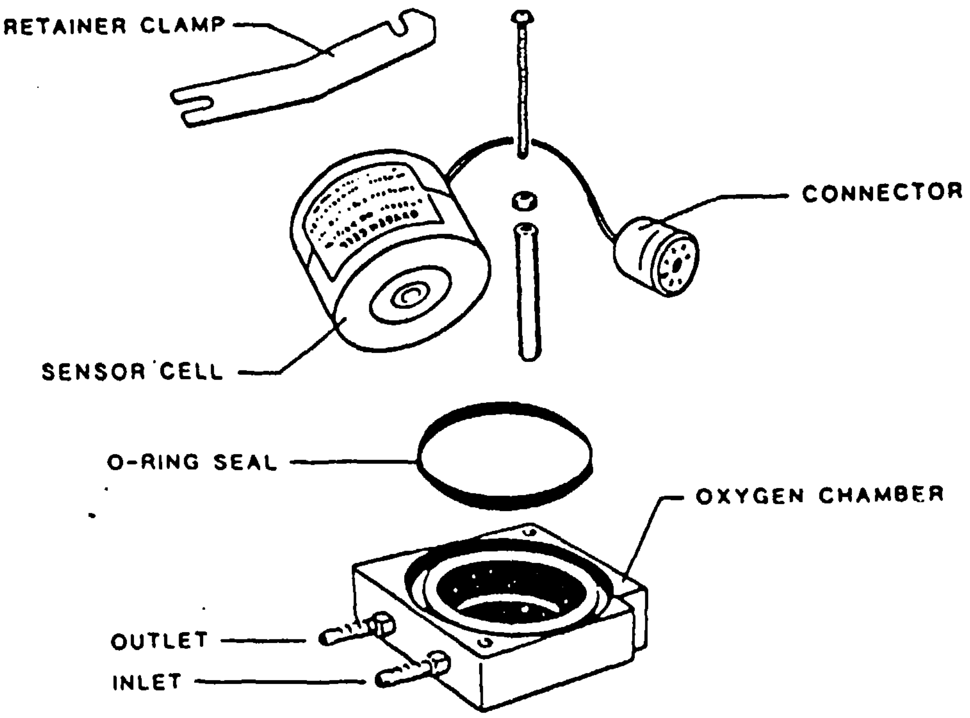


FIGURE 13. OXYGEN DETECTOR

D. Meter

If meter is damaged, it can be removed for repair or replacement, as follows:

1. With upper half of instrument removed from lower half and inverted, loosen internal lock nuts from POWER and BATTERY CHECK switch bushings and PPM/LEL ZERO potentiometer bushing.
2. Remove external lock nut from PPM/LEL ZERO potentiometer. (First remove knob, if one is used.)
3. Remove external face nuts from switch bushings.
4. Remove three screws holding circuit board into case.
5. Remove two nuts from meter studs.
6. Pull circuit board out of case as far as connecting wires permit.
7. Lift out meter.

E. Buzzer

If buzzer fails, it can be removed by first taking out circuit board (Steps D.1-D.6) and unsoldering red and black wires at board. Then remove retaining screws and nuts.

Note: Before removal, first verify that buzzer is actually defective. Connect to a 6 volt battery (Red +, Black -). A good buzzer will give a steady tone.

F. Circuit Board

Main circuit board can be removed by steps D.1-D.6, plus E, plus disconnection of pump and detector wires at terminals. This allows the board to be pulled out of the case and put aside for access to the oxygen circuit board. However, it will remain connected to the oxygen board until the interconnecting wires are unsoldered.

Preferably, both boards will be removed as a unit, and returned to factory for repairs. To complete removal, loosen internal lock nuts, remove external lock nuts from remaining controls, and take off the hex plastic spacers which hold oxygen board in place.

G. Filter

The filter element in inlet fitting is pressed in but can be pushed out and replaced. When necessary, the complete fitting can be replaced.

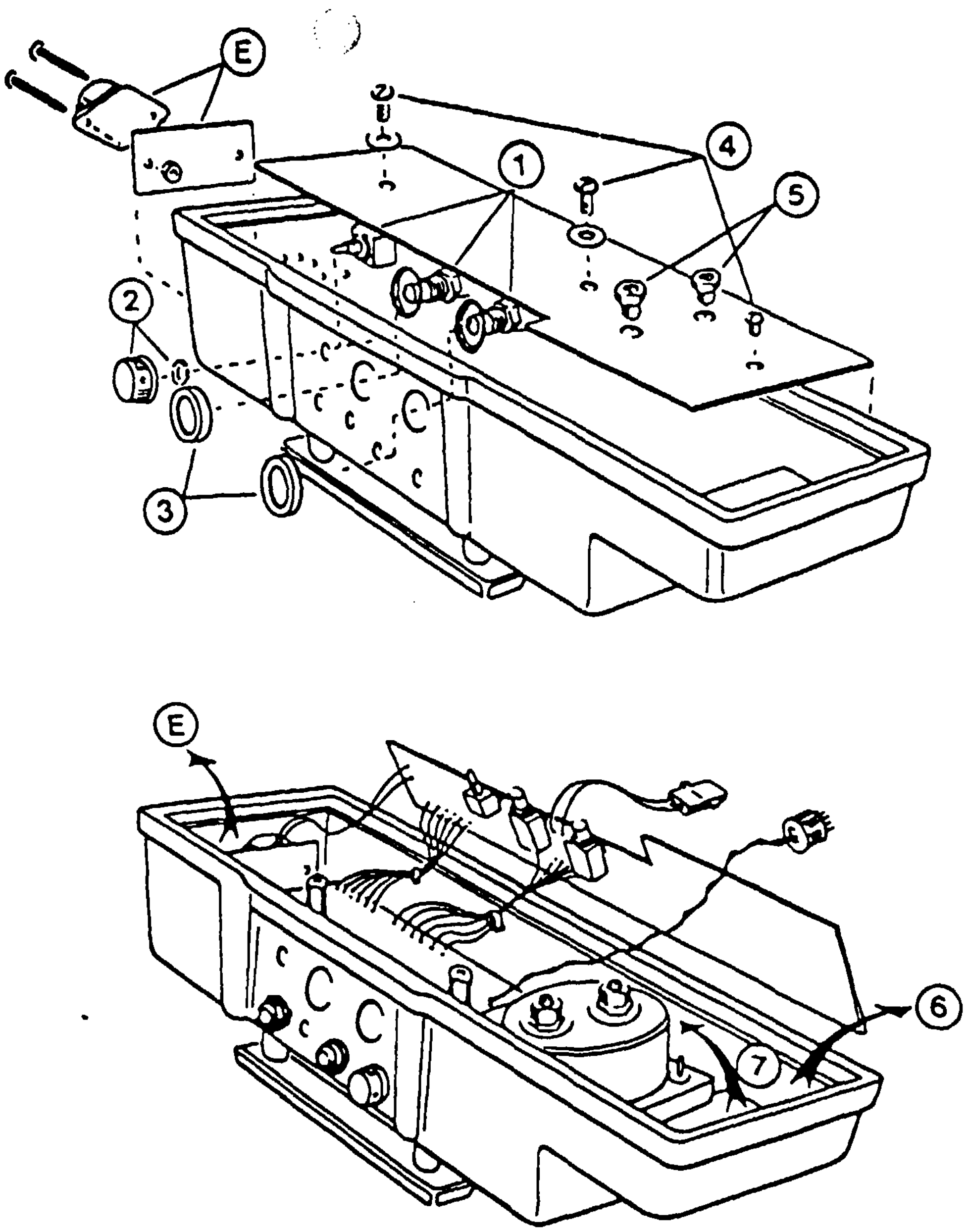


FIGURE 14. METER, BUZZER AND CIRCUIT BOARD REMOVAL / REPLACEMENT

Pump [illegible] is a diaphragm type, [illegible] [illegible] DC motor. It should have long life, several years in normal operation, but it may lose efficiency if dirt is drawn in and collects under the valves. Verify proper pump operation periodically by taking a sample and observing time for initial gas response to occur. This should be within 5 seconds for a 10' hose. It may also be checked with the flowmeter provided as a calibration accessory. Flow should be 2.0 cfh or greater.

If pump needs servicing, it can be removed by taking out the clamp retaining screw which extends through case bottom. Pump can be returned for repair on an exchange basis or it can be disassembled and cleaned. Replacement pump head assemblies and diaphragms are available.

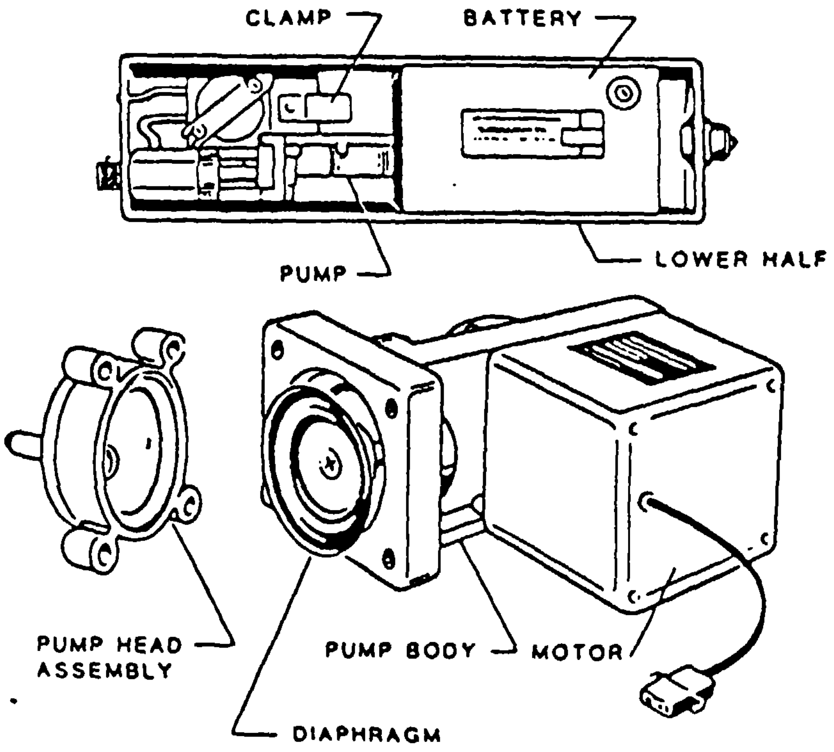
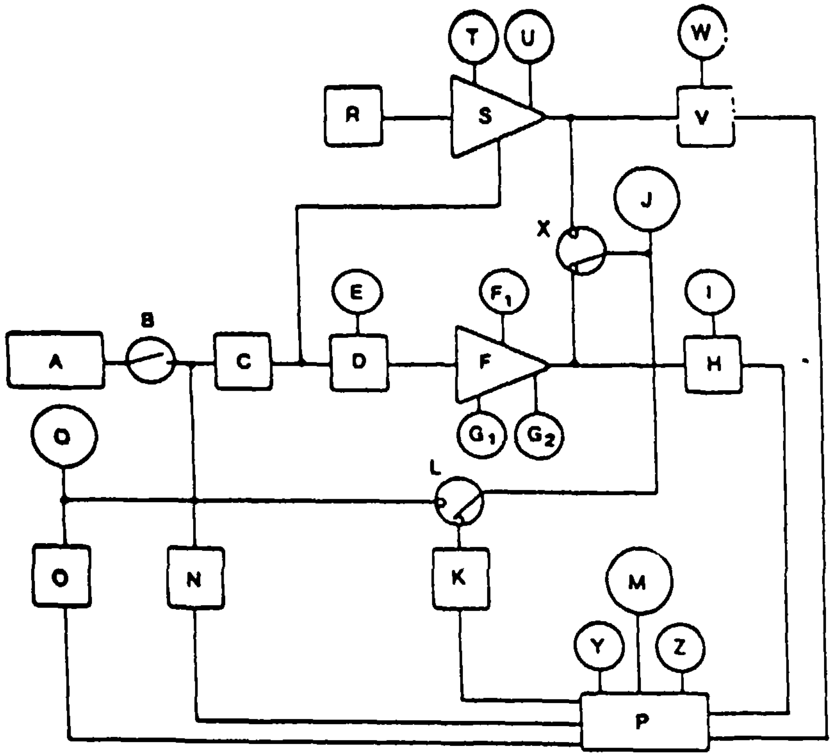


FIGURE 15. PUMP ASSEMBLY FOR MODEL 1314

[illegible] IT [illegible] PTI[illegible]

Referring to block diagram:



A. Battery pack, rechargeable, nickel-cadmium, giving 8 hours of operation.

B. On-off switch, push on/push off.

C. Voltage regulator, input 8.0 - 10 volts, output 6.0 volts ± .05.

D. Combustibles detector, with active (catalytic) and reference (non-catalytic) elements, forming half of Wheatstone bridge measuring circuit. Two fixed resistors complete bridge.

E. Zero Adjust, a potentiometer in the fixed side of the bridge used to bring the bridge to balance in the absence of gas. Two potentiometers are used, a coarse and fine adjustment.

F. Amplifier, Signal differential, to increase output of bridge to a suitable level for indication and alarm actuation.

F1. Range switch, alternate-action pushbutton, to select LEL or PPM ranges by change of amplifier gain.

[illegible]. Adj[illegible] to [illegible] [illegible]ing [illegible] [illegible]esi[illegible] [illegible]alue a known sample. Two adjust[illegible], G1 [illegible] G2, [illegible] PP[illegible] LEL range respectively.

H. Alarm switching circuit, to turn on combustibles alarm signal when amplifier output reaches a predetermined point.

I. Alarm threshold adjustment, to set the point at which combustibles alarm is actuated. (One each for LEL and PPM ranges)

J. Meter, reads output of amplifier, in units of percent explosibility, in PPM, or in percent oxygen depending upon range.

K. Malfunction alarm switching circuit, turns on alarm due to amplifier output below zero.

L. Batt. Test switch, to connect meter as a voltmeter momentarily, to check battery voltage.

M. Buzzer, a solid-state electronic sounder which delivers a continuous tone when energized.

N. Multi-Vibrator, an oscillating circuit to give a pulsating signal to buzzer, as an identification of alarm condition.

O. Voltage-sensing circuit, to detect low battery voltage and actuate alarm signal.

P. Logic circuit, to accept signals of various types and direct them to buzzer circuit.

Q. Pump, vibratory diaphragm type, to draw sample continuously through sample system and over detector.

R. Oxygen Sensor, which supplies a signal voltage proportional to oxygen concentration.

S. Amplifier, oxygen, to increase output of sensor to a suitable level for indication and alarm actuation.

T. Zero, oxygen, a potentiometer used to balance output of amplifier to zero in the absence of oxygen.

U. Span, oxygen, a potentiometer used to set gain of amplifier to give desired sensitivity on a known calibrating sample.

V. Alarm switching circuit to turn on oxygen alarm signal when amplifier output drops or rises to a preset point.

W. Alarm Threshold adjustment, to set the point at which oxygen alarm comes on. (One each for falling and rising alarm.)

X. Range switch, to select range for readout of meter, either oxygen or combustibles.

Y. Alarm light, oxygen, which blinks on and off whenever system is in oxygen alarm condition.

Z. Alarm light, LEL, which blinks on and off whenever system is in combustibles alarm condition.

When sampling spaces such as hot tanks that [illegible] than the instrument, remember that condensation can occur as the sample passes through the cooler sample line. Water vapor condensed in this way can block the flame arrestor and interfere with pump operation.

If heated hydrocarbon vapors of the heavier hydrocarbons (flash point 90°F or above) are present, they may also condense in the sample line and fail to reach the filament. Thus an erroneous low reading may be obtained.

B. Filament Poisoning

Certain substances have the property of desensitizing the catalytic surface of the platinum filament. These substances are termed "catalyst poisons" and can result in reduced sensitivity or in failure to give a reading on samples containing combustible gas. The most commonly encountered catalyst poisons are the silicone vapors, and samples containing such vapors even in small proportions should be avoided.

Occasional calibration checks on known gas samples are desirable, especially if the possibility exists of exposure to silicones. Where persistent poisoning action occurs, special silicone-resistant elements are available.

C. Other Gases and Vapors

The instrument is designed and calibrated specifically for the gas specified in the original order. It can be recalibrated and used on other gases and vapors, by proper use of the calibration control while sampling a known gas-air mixture.

D. Rich Mixtures

When sampling rich mixtures, on the 100% LEL range, the following instrument action may be expected:

1. mixtures up to 100% L.E.L. - Reading on scale

2. mixtures between L.E.L. and Upper Explosive Limit (U.E.L) - Readings at top of meter

3. mixtures above U.E.L. - As sampling continues, the meter first goes to top of scale, then comes back down on scale. Very rich mixtures will give close to a zero reading.

E. Oxygen Deficient Mixtures

Samples which do not have the normal proportion of oxygen may tend to read low, as there is not enough oxygen to react with all combustible gas present in the sample. As a general rule, samples containing 10% oxygen or more have enough oxygen to give a full reading on any combustible gas sample up to the L.E.L.

[illegible]mable [illegible]quid[illegible] ([illegible]sol[illegible], kerc[illegible] or [illegible] so[illegible]) are [illegible]ed in starting intentional fires. Investigation of such fires can be greatly aided if the presence and location of such liquids can be determined at the site, as soon as possible after the fire is extinguished. The Hydrocarbon Surveyor can be of great assistance in making this determination.

In testing for residual flammable liquids, look for places where the liquid could have been trapped and where it might remain even after the fire. Naturally, if the entire structure has been consumed there is little likelihood of any liquid or vapors remaining. Conversely, the earlier the fire has been extinguished, the greater the chance of finding significant amounts of liquid remaining.

In checking for residual volatile liquids, set the instrument up in accordance with the preceding instructions, allowing it to run for at least 5 minutes, in the LEL range. Then turn to ppm range and balance zero carefully immediately before taking the test.

Hold end of hose or probe at point where vapors may be present, and watch meter carefully for any sign of a deflection. Check at joints or cracks between boards, for example under baseboards or plates in contact with flooring. Pry boards up to form a small crack where hose or probe may be inserted. Check also under unburned portions of rug or upholstery, or any point where liquid might logically have soaked in and remained.

If a positive indication is obtained, trace it to the point of maximum reading. This is the point where samples should be taken for further lab analysis.

IX. PARTS LIST

Stock No.	Description
06-5012	Hose, Polyurethane, inlet, 5'
07-6010	O-Ring Seal, hose (probe end)
07-6011	O-Ring Seal, hose (instrument end)
07-6014	O-Ring Seal, inlet fitting
07-6115	O-Ring Seal, combustibles detector
07-6216	O-Ring Seal, oxygen cell cavity
17-0434	Inlet fitting w/filter
33-1016	Filter disk only, inlet fitting
30-0016	Pump, rotary DC
30-0340	Pump head, replacement
30-0342	Pump valves, replacement, set of 2
43-4140	Fuse, battery, 3AG 1A
45-8051	Battery Pack, replaceable, rechargeable cell, less batteries
45-8052	Battery Pack, replaceable, disposable cell, less batteries
49-1201	Battery, alkaline size D disposable (for use in 45-8052)
49-1501	Battery, Ni-Cad, rechargeable (for use in 45-8051)
49-1571	Battery Pack, encapsulated with Ni-Cad batteries
49-2033	Battery Charger, 115 volts, for Ni-Cad batteries
49-2034	Battery Charger, 230 volts, for Ni-Cad batteries
49-8051	Battery Pack, replaceable, rechargeable cell, with batteries
50-1229	Meter, PPM/LEL/O_2 Scale
52-1005	Buzzer
61-0120	Detector Ass'y, wired for Surveyor
65-0601	Oxygen cell, new
65-0601E	Oxygen cell, reactivated (exchange)
71-0115	Instruction Manual, Model 1314/1238
80-0150	10' Probe
80-0204	Moisture Trap

Relative Response of New GasTechtor
to Various Gases (Referenced to Hexane or Toluene)

GAS	LEL Scale			PPM Scale		
	LEL in %*	Conversion Factor		TLV in ppm**	Conversion Factor	
		Hexane	Toluene		Hexane	Toluene
Acetone	2.15	0.65	0.63	1000	1.55	1.30
Acrylonitrile	3.0	-	-	1	1.31	1.1
Benzene	1.3	0.87	0.84	10	1.11	0.93
Butadiene	2.0	0.88	0.85	1000	2.0	1.7
Chloroform	-	-	-	50	8.0	6.7
Carbon Monoxide	12.5	0.60	0.58	50	4.4	3.7
Ethyl Acetate	2.0	0.81	0.79	400	1.61	1.35
Ethyl Alcohol	3.3	0.60	0.58	1000	2.0	1.67
Formaldehyde***	7.0	1.96	1.9	3	7.4	6.2
Heptane	1.0	1.03	1.00	500	0.98	0.82
Hexane	1.1	1.00	0.97	500	1.00	0.84
Hydrogen Sulfide	4.0	1.96	1.9	20	5.0	4.2
Methyl Chloroform	-	-	-	350	3.7	3.1
Methyl ethyl Ketone	1.7	0.84	0.81	200	1.3	1.09
Methylene Chloride	3.3	2.78	2.7	500	4.4	3.7
Methane	5.0	0.42	0.41	-	2.4	2.0
Pentane	1.5	0.71	0.69	1000	1.81	1.52
Perchloroethylene	-	-	-	100	4.5	3.8
n-Propyl Acetate	1.7	0.77	0.75	200	1.36	1.14
n-Propyl Alcohol	2.1	0.80	0.78	200	1.52	1.28
Styrene	1.1	1.24	1.2	100	1.31	1.1
Toluene	1.2	1.03	1.00	200	1.19	1.00
Trichloroethylene	12.5	0.59	0.57	25	4.4	3.7

Please note, that response varies from one sensor to another and t relative response of a sensor can change with age, so these data should used for estimation purposes only.

Assuming an instrument calibrated directly for hexane or toluene, t used to observe a different gas, the equivalent response in %LEL (or p for that gas is secured by multiplying the observed %LEL (or ppm) read by the LEL (or ppm) scale conversion factor.

* Values from National Fire Protection Association, NFPA 325M, 19 except for methylene chloride and n-propyl alcohol for which 1969 N 325M values were used.

** Values from Federal Register 40,23072, May 28, 1975 and current as November 1979, except for trichloroethylene where a CAL/OSHA Novem 1980 value is listed.

*** Methanol free.

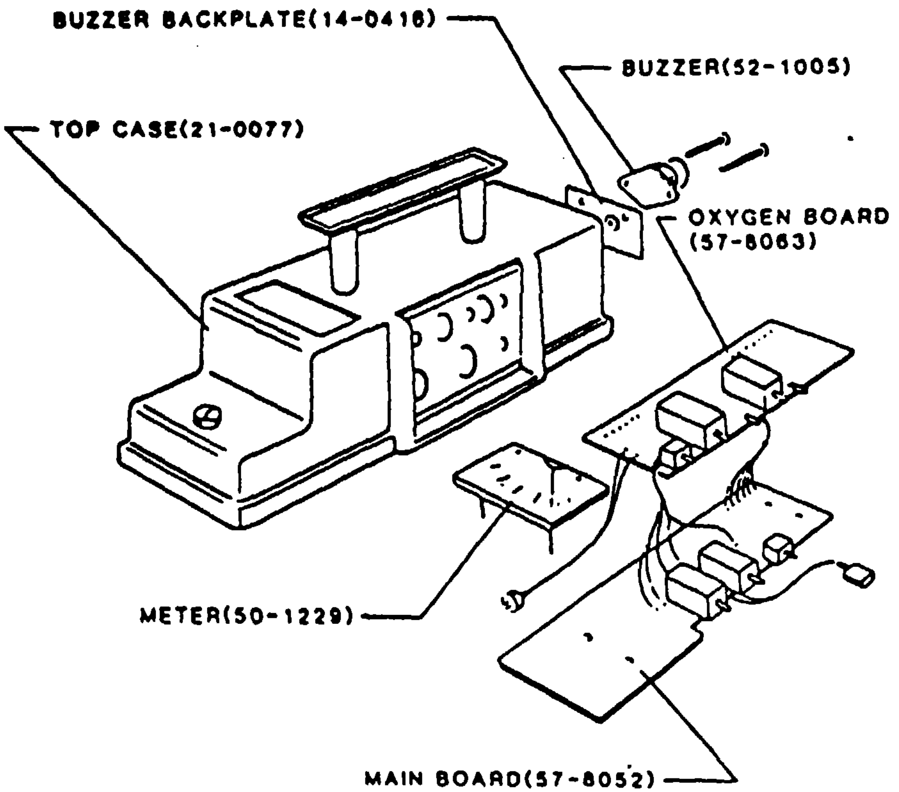


FIGURE 16. PARTS LOCATION-TOP HALF

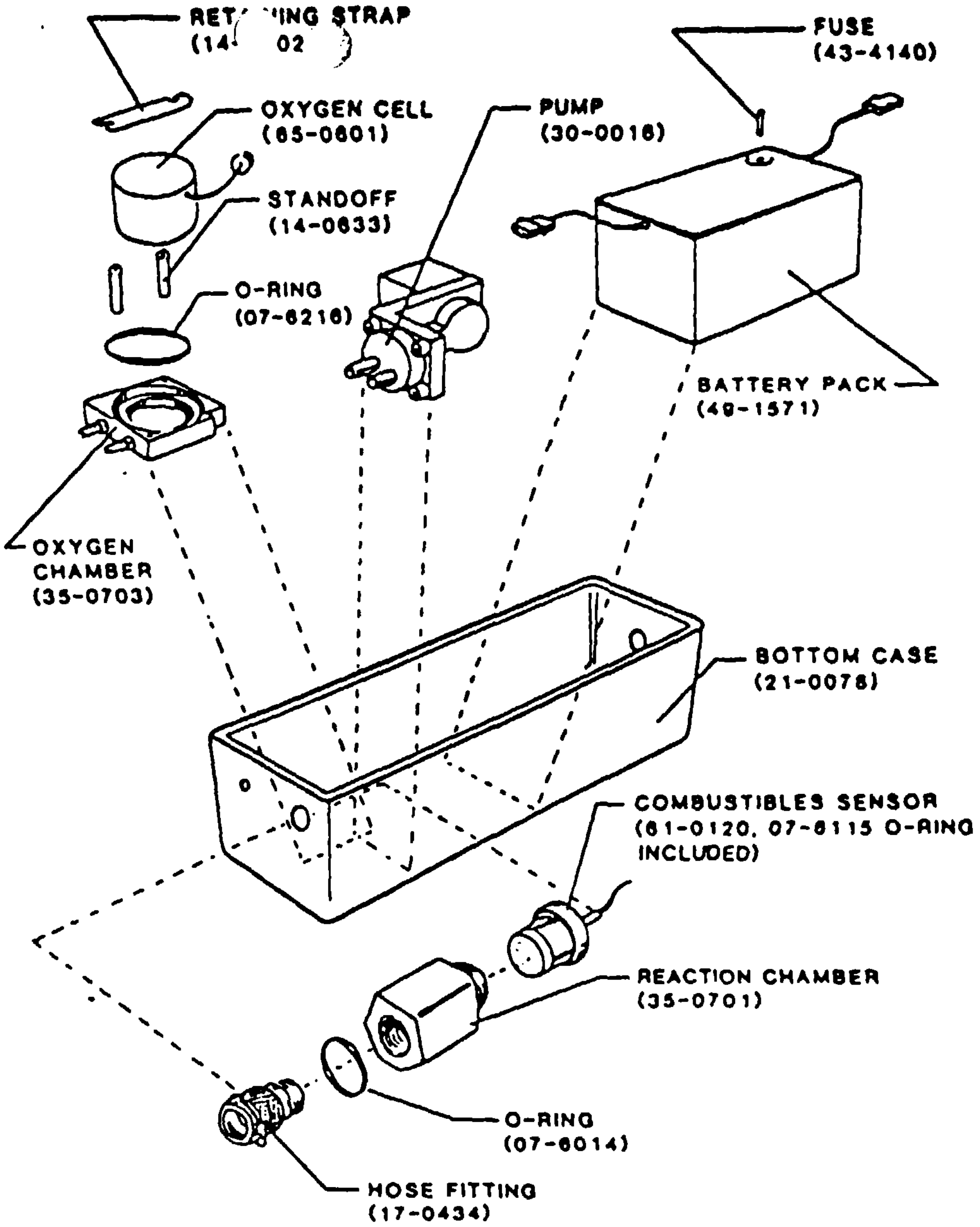
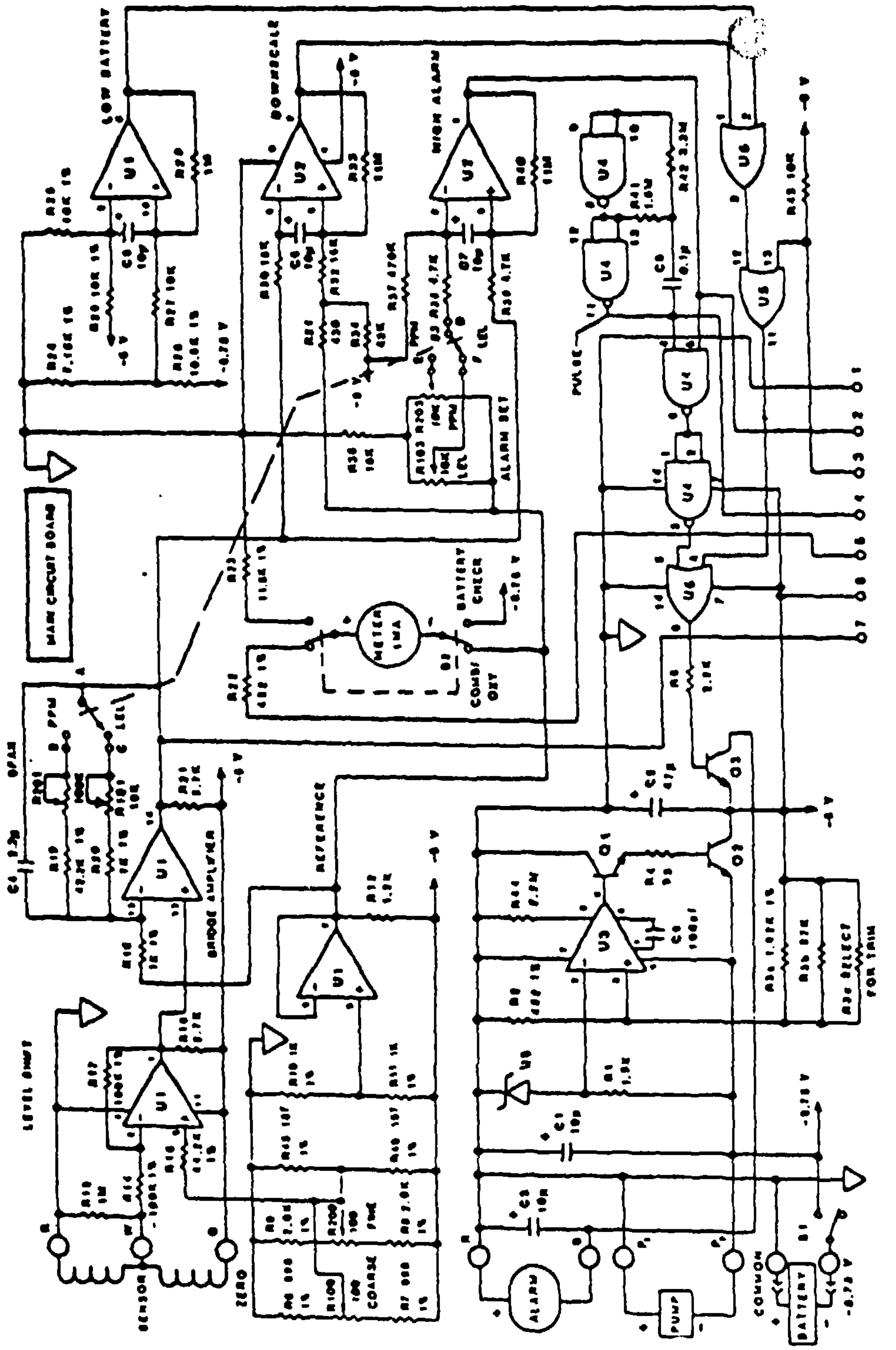
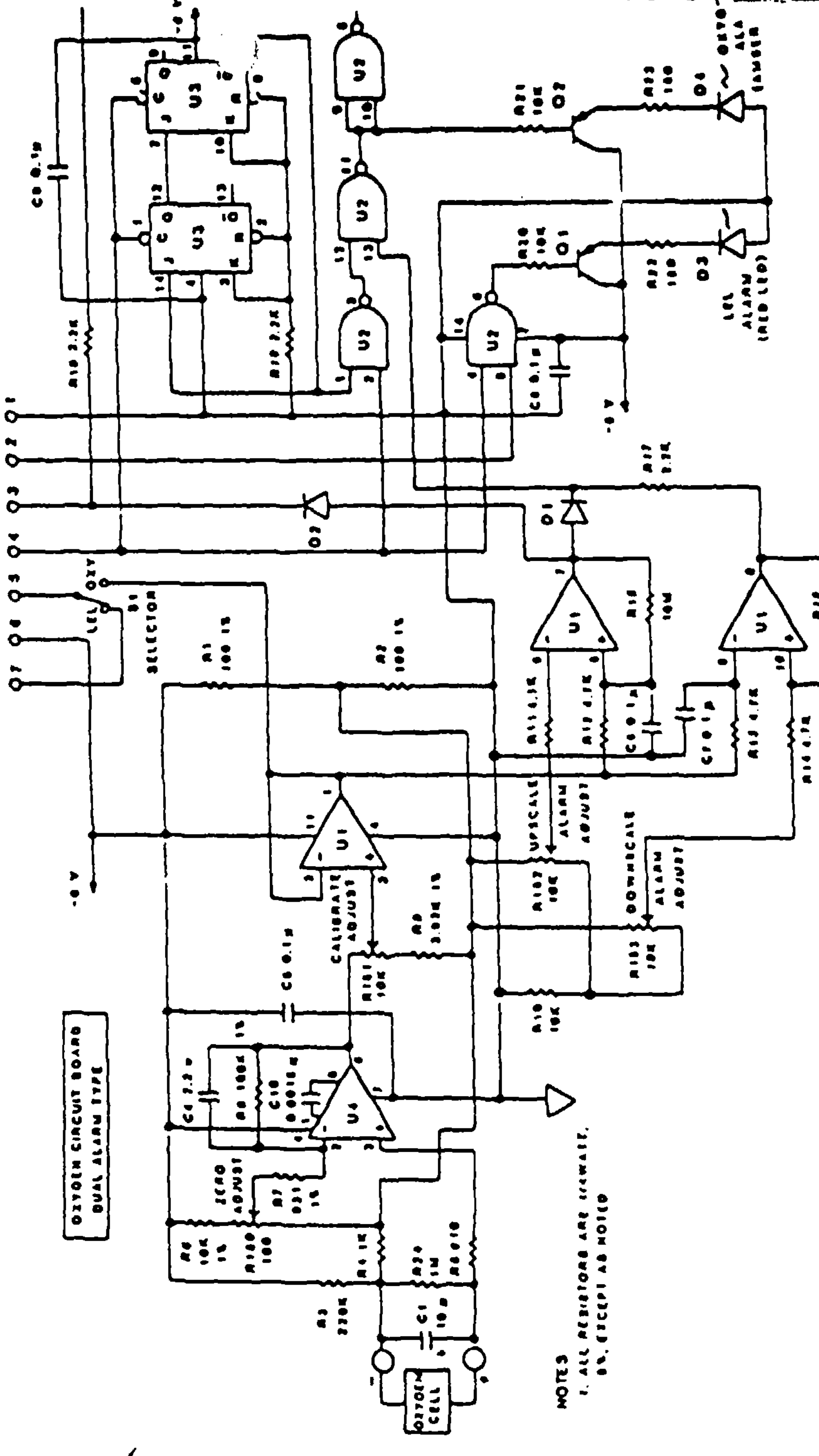


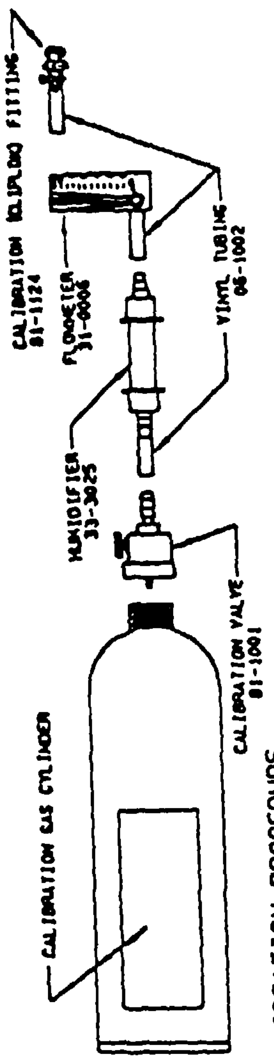
FIGURE 17. PARTS LOCATION-LOWER HALF





NOTES
1. ALL RESISTORS ARE 1/4 WATT, 5%, EXCEPT AS NOTED

MODEL 1314 SCHEMATIC DIAGRAM



CALIBRATION PROCEDURE

(A) PPM RANGE
1. TURN ON INSTRUMENT. ALLOW TO WARM UP AND ADJUST ZERO IN NORMAL WAY.
2. ADD A FEW DROPS OF WATER TO GLASS WOOL PACKING INSIDE HUMIDIFIER. GLASS WOOL SHOULD BE MOIST BUT NOT DRIPPING.
3. COUPLE FLOWMETER TO CLIPLOK FITTING, AND HUMIDIFIER TO FLOWMETER INLET, AS SHOWN.
4. COUPLE CLIPLOK FITTING TO INSTRUMENT INLET.
5. READJUST ZERO AS REQUIRED AFTER INSTRUMENT STABILIZES.
6. NOTE FLOWMETER READING.
7. CONNECT CALIBRATION VALVE TO PPM-RANGE CYLINDER. OPEN VALVE SLIGHTLY TO PRODUCE A SMALL FLOW.
8. COUPLE VALVE OUTLET TO HUMIDIFIER INLET.
9. ADJUST VALVE TO GIVE SAME FLOW ON FLOWMETER AS OBSERVED IN 6.
10. WATCH METER AS GAS ENTERS INSTRUMENT. OBSERVE HIGHEST READING.
11. COMPARE READING WITH MARKED GAS CONCENTRATION ON CYLINDER.
12. IF NOT CORRECT, ADJUST CALIBRATION AS SHOWN IN CALIBRATION SECTION OF INSTRUCTION MANUAL.
13. TURN OFF VALVE AND DISCONNECT CALIBRATION COMPONENTS.

(B) LEL RANGE
USE SAME PROCEDURE AS ABOVE, BUT IN LEL RANGE. HOWEVER, OMIT HUMIDIFIER AS IT IS NOT NECESSARY IN LEL RANGE. USE LEL RANGE CYLINDER.

LTR	REVISION
B	REDRAW ON CAD KHC 5-23-86

DO NOT SCALE DRAWING
DEBURR | BREAK EDGES ± .010 R
TOLERANCES & FINISHES UNLESS OTHERWISE NOTED:
.XX ± .010 ANGLES ± 0°30'
.XXX ± .005 CONC .010 TIR
FRACTIONS ± .015 FINISH 125
FINISH FOR RING GROOVES 3 SIDES 32

GASTECH INC.
NEWARK, CALIFORNIA 94560

TITLE
CALIBRATION GAS - FLOW DIAGRAM

SCALE NONE | DR BY KHC | DRAWING NO. 2127-A14 | REV B
DATE 5-23-86 | CKD BY DJJ

A[illegible]venient calibration kit is available for accurate [illegible] adjustment, without the use of special tools or fixtures. The 81-0222 Calibration Kit is designed expressly for use with the models 1314 and 1238, and consists of the following:

20-0110	Padded carrying case
81-1124	Calibration fitting
31-0006	Flowmeter
33-3025	Humidifier
81-1001	Calibration gas dispensing valve
81-0007	Calibration gas cylinder 40% LEL hexane
81-0091	Calibration gas cylinder 400 ppm toluene
06-1002	Vinyl plastic tubing

To check and adjust calibration on a known gas sample, assemble the various calibration kit items in accordance with GasTech Drawing 2127-A14, but do not attach the calibration system to the instrument or gas cylinder until the corresponding steps are completed:

1. Turn instrument on and allow it to warm up and stabilize, preferably for 5 minutes. Be sure batteries are charged sufficiently to read above the check mark.

2. Add water to humidifier, thoroughly moistening the glass wool, and shake out any excess liquid.

3. Open instrument case by loosening captive screw at front. Lift upper half of case slightly, move 1/4" to rear to disengage rear clamp; then separate the two halves. Locate COARSE ZERO potentiometer on underside of circuit board (marked "ZERO").

4. Turn external zero control to center of its span. Then turn COARSE ZERO potentiometer to bring meter to zero reading.

5. To calibrate in PPM range, press the LEL-PPM switch to the ppm range. Attach the flowmeter and the humidifier to the instrument. Readjust zero as necessary with the external zero adjustment. Note flow reading on flowmeter.

6. Connect PPM-range cylinder to humidifier inlet and slowly open the calibration valve until the same flow is indicated on the flowmeter as observed previously. Watch meter and note highest reading. If it is not the same as indicated on the calibration cylinder, turn PPM SPAN potentiometer to give desired reading.

7. For LEL calibration, follow steps 1 through 5 with range switch in LEL position, and use LEL SPAN potentiometer. However, humidifier is not necessary and may be omitted.

8. If zero cannot be adjusted, or if reading cannot be set high enough, replace detector.

9. Disassemble and store the calibration kit.

V. [illegible]BRAT[illegible] AND A[illegible]MENT

A. Combustibles Calibration

To check and adjust calibration on a known gas samp[illegible]

1. Turn instrument on and allow it to warm up and stabilize, preferably for 5 minutes. Be sure batteries are charged sufficiently to read above the check mark.

2. Open instrument case by loosening captive screw at front. Lift upper half of case slightly, move 1/4" to rear to disengage rear clamp; then separate the two halves. Locate COARSE ZERO potentiometer on underside of circuit board (marked "ZERO").

3. Turn external PPM/LEL ZERO control to center of its span. Then turn COARSE ZERO potentiometer to bring meter to zero reading.

4. To calibrate the LEL range, insert sample inlet tube into a vessel or other source of known calibrating gas. Watch meter and note highest reading. If it is incorrect, turn LEL SPAN potentiometer to give desired reading.

5. For PPM calibration, follow same procedure with range switch in PPM position, and use PPM SPAN potentiometer. Before making this adjustment, allow system to warm up and stabilize thoroughly, and zero carefully in the PPM range.

<u>NOTE</u>

In the sensitive ppm range it is important that the humidity of the sample be the same as that of the air used for zero adjustment. If they are different, a significant offset in zero reading may be observed. To overcome this, a humidifier may be used for both zero and calibration tests, providing the calibrating gas is one that will not be absorbed in water. The GasTech Calibration Kit is supplied complete with humidifier and accessories for this effect. See Appendix A.

6. If zero cannot be adjusted, or if reading cannot be set high enough, replace detector.

B. Combustibles Alarm Threshold

The reading at which the alarm is actuated in each range can be set by use of the corresponding ALARM Threshold potentiometer.

To Set:

1. With instrument in range to be set, turn PPM/LEL ZERO adjust to bring meter to desired alarm setting. It may be necessary to use the COARSE ZERO to reach this point, in LEL range.

2. Turn corresponding (LEL or PPM) ALARM Threshold potentiometer to the point where alarm just operates. Clockwise rotation will lower alarm setting. Verify setting by turning PPM/LEL ZERO control to bring meter indication into and out of alarm zone.

3. When the combustibles Alarm Threshold has been satisfactorily set, readjust the zero potentiometers to establish a zero meter reading as in A.3 above.

[illegible] to[illegible]ng [illegible] [illegible] [illegible]carr[illegible] out [illegible]th OXY-PPM/LEL switch on OXY (in) position. To check and adjust ze[illegible]n a known oxygen-free sample:

1. While instrument case is open, identify ZERO potentiometer, which is located on oxygen (upper) circuit board and which can be reached through the rearmost of the two clearance holes in the main circuit board.

2. Allow instrument to sample a known oxygen-free sample, such as nitrogen, argon, or helium.

3. Watch meter carefully. If reading does not go exactly to zero, adjust it by turning ZERO potentiometer. Counterclockwise rotation will decrease reading.

4. If zero adjustment cannot be made, have oxygen cell reactivated.

5. After zero adjustment has been completed, return hose inlet to normal atmospheric air. Readjust OXY CAL control as necessary to bring meter reading to 21.

6. If reading cannot be set high enough, have oxygen cell reactivated.

D. Oxygen Alarm Threshold

The reading at which the oxygen alarm is actuated can be set by use of the ALARM Threshold potentiometer.

To Set:

1. Turn OXY CAL to bring meter to desired alarm setting.

2. Locate oxygen alarm threshold potentiometer, on oxygen circuit board, which is accessible through the hole adjacent to the LEL Alarm adjustment.

3. Turn ALARM Threshold potentiometer to the point where alarm just operates. Clockwise rotation will raise alarm setting. Verify setting by turning OXY CAL control to bring meter into and out of alarm zone.

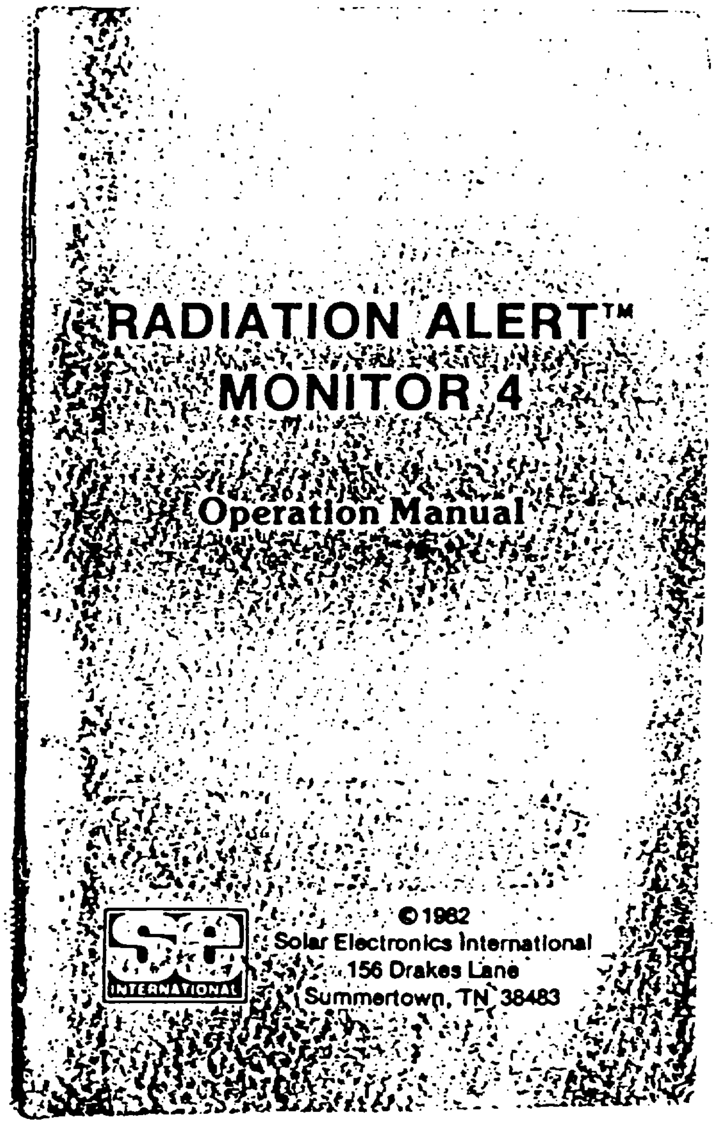
4. When the oxygen Alarm Threshold has been satisfactorily set, readjust the OXY CAL potentiometer to bring the meter reading to 21% (O_2 CAL).

E. Oxygen High Alarm (25%)

This alarm point is factory set and generally need not be changed. It can be readjusted to some other level, by trial, but this can only be done when the main board is loosened and pulled aside (see Section VI.D. steps 1-6). The high alarm potentiometer is the one closest to the rear, without an access hole.

RADIATION ALERT
MONITOR 4

OPERATION AND MAINTENANCE



RADIATION ALERT™ MONITOR 4

Operation Manual

Solar Electronics International
156 Drakes Lane
Summertown, TN 38483

RADIATION ALERT™
MONITOR 4

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MONITOR 4 is a miniaturized Geiger Counter with added features. It is an accurate scientific instrument that can serve as a useful tool for research, education and personal protection in laboratories, hospitals, schools and homes.

For maximum user protection, MONITOR 4 is sensitive to a broad spectrum of ionizing radiation including alpha, beta, gamma and x-rays.

New electronic techniques, developed by Solar Electronics, have made this instrument very affordable, while providing features that are not found in other Geiger Counters costing two to three times its price. One 9 volt battery will power the instrument for up to one year.*

To obtain maximum benefit from the use of this instrument please read this manual thoroughly.

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*Based on using the instrument 8 hours per day, 5 days per week for one year at normal background radiation levels, with an alkaline type battery.

The liability of the company arising out of the supplying of this instrument, or its use, whether on warranties or otherwise, shall not in any case exceed the cost of correcting defects in the instrument, and after the said 90-day period, all such liability shall terminate. Any implied warranty is limited to the duration of this written warranty.

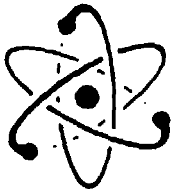
PROCEDURE FOR OBTAINING PERFORMANCE OF WARRANTY: In the event that the product does not conform to this warranty, the product should be mailed prepaid or delivered to the Warrantor at address above. Please include proof of purchase and a written explanation of the problem.

Before using this instrument, the user must determine the suitability of the product to his or her intended use. The user assumes all risk and liability connected with such use.

ROENTGEN: The basic unit of measurement of the ionization produced in air by gamma or x radiation. One Roentgen (abbreviated R) is the exposure to gamma or x radiation that will produce one electrostatic unit of charge in one cubic centimeter of dry air. 1,000 mR = 1 R. This unit is not defined for alpha and beta radiation.

RADIOISOTOPE: A naturally occurring or artificially produced radioactive form of an element.

X-RAYS: Electromagnetic radiation (Photons) of higher frequency and energy than visible and ultraviolet light, usually produced by bombarding a metallic target with high speed electrons in a vacuum. X-rays refer to photons emitted by interactions involving orbital electrons rather than atomic nuclei, as with gamma rays. X-rays and gamma rays have the same basic characteristics. The only difference between them is their source of origin.



WARRANTY

WARRANTOR: Solar Electronics International, Instrumentation Division, 156 Drakes Lane, Summertown, Tennessee 38483, USA.

ELEMENTS OF WARRANTY: Solar Electronics International warrants, for the duration of this warranty, its product to be free from defects in materials and craftsmanship with only the limitations or exclusions set out below.

WARRANTY DURATION: This warranty shall terminate and be of no further effect 90 days after the original date of purchase of the product or at the time the product is: a) damaged or not maintained as reasonable and necessary, b) modified, c) repaired by someone other than the Warrantor for a defect or malfunction covered by this Warranty, or d) used in a manner or purpose for which the product was not intended or contrary to Solar Electronics' written instructions. Warranty does not apply to any product subjected to corrosive elements, misuse, abuse, or neglect.

STATEMENT OF REMEDY: In the event that the product does not conform to this warranty at any time while this warranty is effective, Warrantor will repair the defect and return the instrument to you prepaid, without charge for parts or service

Please note that while the product will be remedied under this warranty without charge, this warranty does not cover or provide for the reimbursement or payment of incidental or consequential damage arising out of the use of or inability to use this product.

very light particles (about 2,000 times less mass than a proton) and have a charge of -1. Because of their light mass and single charge, beta particles can penetrate more deeply into matter than alpha particles can. When a beta particle's energy exceeds 70 keV it can penetrate human skin. A few millimeters of aluminum will stop most beta particles.

ELECTRON VOLTS: The amount of energy in a given particle or ray is expressed in electron Volts. One electron Volt (abbreviated eV) is equivalent to the energy gained by an electron when it is accelerated through an electrical field of 1 volt. 1,000 eV = 1 keV. 1,000,000 eV = 1 MeV. The higher the eV rating of a particle or ray the greater the penetration it can achieve. Example: 150 keV x-rays can penetrate a lead apron that shields 10 keV x-rays.

GAMMA RAYS: Short wavelength electromagnetic radiation higher in frequency and energy than visible and ultraviolet light. Gamma rays are emitted from the nucleus of an atom and have energies ranging from 10 keV to 9 MeV. These high energy photons are much more penetrating than alpha and beta particles.

ION: An atomic particle, atom, or molecule that has acquired an electrial charge, either positive or negative, by gaining or losing electrons.

IONIZATION: The process by which neutral atoms or molecules are divided into pairs of oppositely charged particles known as ions.

IONIZATION PATH: The trail of ion pairs produced by an ionizing radiation as it passes through matter.

IONIZING RADIATION: Radiation capable of producing ionization by breaking up atoms or molecules into oppositely charged particles called ions.

RAD: The radiation absorbed dose, or rad, is a measurement of the quantity of radiation required for 100 ergs of energy to be absorbed by one gram of body tissue. When measuring gamma and x radiation, 1 rad is approximately equivalent to 1 Roentgen. Therefore if a person were exposed to 1 Roentgen per hour (1 R/hr) of gamma or x radiation for 1 hour, he or she would have received a dose of 1 Roentgen or approximately 1 rad. 1 millirad (mrad) = .001 rad.

RADIATION: The emission and propagation of energy through space or through matter in the form of particles or waves.

RADIOACTIVE: A term commonly used to refer to a source of ionizing radiation.

REM: The radiation dose equivalent in man, or rem. A special unit of dose equivalence that measures the dose received in terms of its estimated biological effect. The rem value can be calculated by multiplying the rad value by a quality factor (QF) that has been determined for the various forms of radiation (rems = rads x QF). For gamma and x radiation QF = 1; for beta below 30 keV, QF = 1; for beta above 30 keV QF = 1.7; and for alpha QF = 10. One mrem = .001 rem.

SPECIFICATIONS

CALIBRATION: Cesium 137 gamma source, National Bureau of Standards traceable. Calibrated with the instrument held in a vertical position, back side of instrument pointing toward the radiation source. The calibration point is to the center of the Geiger tube (see Illustration 2).

SENSOR: Industry Standard halogen-quenched Geiger-Mueller tube with thin mica end window, 1.5 to 2.0 mg/cm^2 in thickness.

AUDIO: Built-in piezo electric transducer gives audible indication of each count when OFF-ON-AUDIO switch is in AUDIO position. Frequency is approximately 3 kHz.

ENERGY SENSITIVITY: (Typical Specifications) Detects alpha down to 2.5 MeV; detection efficiency at 3.6 MeV is greater than 80%. Detects Beta at 50 keV with 35% detection efficiency. Detects Beta at 150 keV with 75% detection efficiency. Detects gamma and x radiation down to 10 keV through the end window, 40 keV through the case.

VOLTAGE REGULATION: Dual regulation of high and low voltages.

POWER REQUIREMENT: One 9-volt alkaline battery, NEDA #1604A or equivalent.

POWER CONSUMPTION: Less than 3 milliwatts in a low radiation field. 250 milliwatts maximum in a high radiation field.

BATTERY LIFE: Up to 2,000 hours at normal background radiation levels.

TEMPERATURE RANGE: 0° to 50° C

WEIGHT: 245 grams (8.8 oz.) including battery.

SIZE: 145 mm x 72 mm x 38 mm (5.7" x 2.8" x 1.5")

GLOSSARY

ALPHA PARTICLES: Positively charged particles emitted from the nucleus of an atom. Alpha particles are relatively large, and very heavy. Due to its strong charge (+) and large mass, an alpha particle cannot penetrate far into any material. A sheet of paper or an inch or two of air is usually sufficient to stop most alpha particles. However, the alpha particle's charge produces a high level of ionization along its path, and that can be very damaging to living tissue. It can be very dangerous to inhale or ingest sources of alpha radiation.

BACKGROUND RADIATION: Naturally occurring radiation that is always present. Sources of background radiation include: 1) high energy gamma rays from the sun and outer space, and 2) alpha, beta, and gamma radiation emitted from radioactive elements in the earth.

BETA PARTICLES: Negatively charged particles emitted from an atom. Beta particles have a mass and charge equal to that of an electron. They are

Static Eliminators—Static eliminators for reducing static on film and records commonly use radioactive polonium, a strong alpha emitter.

PRECAUTIONS

1. Avoid exposing this instrument to liquids, moisture and corrosive gases.
2. Avoid exposure to extreme temperatures or direct sunlight for extended periods.
3. If the instrument will not be used for long periods (one month or more) remove battery to prevent leakage.
4. The Geiger tube Alpha Window can be damaged if struck directly. Do not insert any pointed objects through the Alpha screen.
5. Extremely high radiation fields can cause overload in any Geiger counter, including MONITOR 4. Approach suspected high level radiation sources cautiously with the instument turned on watching the meter and the count light carefully and/or listening to the beeper, for the Geiger tube can jam, causing an erroneous reading or no reading at all. The instrument will function normally when removed from the source of high radiation.
6. To avoid contamination of your MONITOR 4, do not touch the instrument to the surface being tested.

CAUTION: MONITOR 4 has high voltage inside (500 volts DC required to operate the Geiger tube). Return to factory for servicing.

SOLAR ELECTRONICS RECOMMENDS THAT CONTACT WITH ANY RADIOACTIVE MATERIALS AND/OR OTHER SOURCES OF RADIATION BE AVOIDED WHENEVER POSSIBLE.

SERVICE AND CALIBRATION

Your MONITOR 4 radiation detector is a quality state-of-the-art instrument designed to provide years of useful service. Should it ever need servicing outside of warranty, Solar Electronics offers factory calibration and repair at reasonable rates.

To maintain the highest degree of accuracy we recommend annual calibration at the factory or a check with a known radioactive source.

For factory service or calibration, send unit postpaid to:

Solar Electronics International
Instrumentation Division
Service Department
156 Drakes Lane
Summertown, Tennessee 38483
USA

Please enclose a letter of request indicating what kind of service is needed. For servicing during the time period covered by Warranty, see Warranty on the last page of this manual.

Note: Solar Electronics will not accept contaminated instruments for repair or calibration under warranty or otherwise.

TO DETECT BETA RADIATION, point the ALPHA WINDOW toward the source of radiation. Beta radiation has a longer range through air than alpha particles but can usually be shielded by a few millimeters of aluminum.

TIPS FOR MEASURING LOW LEVEL RADIATION

In some cases it is desirable to detect subtle changes in radioactivity. One example is detecting radiation in the home due to radon gas that is emitted from some building materials.

Here is a good method for doing this: first find out the normal background radioactivity for your location by determining the number of Counts-per-Minute you can expect from natural background radiation. You can do this by counting incoming counts on your MONITOR 4 while using a watch to time yourself. Usually in a one minute period you can expect 5 to 25 counts, depending on your location and altitude. For a good average, count for five minutes and divide the number of counts by 5. This will give you your average background radiation in Counts-per-Minute. Do this out-of-doors in an open area away from possible radiation sources. Now do the same thing in areas of your home that have poor ventilation or possible sources of radioactivity. If your average Counts-per-Minute are significantly higher in your home, you might have a radon buildup or other sources of radiation present.

This same method can be used to check your television set for excess x radiation. Any x-rays emitted by your TV would probably be low in energy so check all around your set using the Alpha window on your MONITOR 4.

OTHER HOUSEHOLD SOURCES OF RADIATION

Smoke Detectors—Many smoke detectors contain a radioactive isotope as part of the smoke sensing mechanism. While these smoke detectors are relatively safe when installed properly, it is recommended that they be returned to the manufacturer for proper disposal.

Pottery—Some pottery and crockery is glazed with a compound containing Uranium oxide, usually orange or red in color.

Camping Lantern Mantles—Some lantern mantles are made with radioactive Thorium. If you must use these mantles, it is recommended not to use them in enclosed areas with poor ventilation. Take care to dispose of the ashes without inhaling or ingesting the fine powder that is left when they've burned out.

Clocks, Watches and Timers—Many old timepieces have dials painted with radioactive Radium, causing them to glow in the dark. This practice has been abandoned because of the health hazards posed by it. Tritium is now commonly used to obtain the same effect. Tritium is also radioactive but emits low energy beta radiation which cannot easily penetrate the glass lens of the timepiece.

MEASURING RADIATION

MONITOR 4 detects the four main types of ionizing radiation: alpha, beta, gamma and x-rays. It is calibrated to gamma rays from a Cesium 137 source, but also serves as an excellent indicator of relative intensities from most sources of ionizing radiation.

The position of the Geiger tube sensor is shown in Illustration 2. The end of the tube has a thin mica window built into it. This mica window can be broken if struck directly, and is protected by the screen on the end of the instrument. This ALPHA WINDOW (see Illustration 1) allows alpha particles to penetrate the tube and be detected, and will also sense low energy beta, gamma, and x radiation that cannot penetrate the side of the tube.*

Unless you expect to be measuring high levels of radiation, always keep the range switch in the x1 position. If you are making a measurement and the meter goes off scale to the right, move the range switch to the next higher setting, x10 or x100 if necessary.

The "count" flashes and beeps are shorter in the x10 and x100 ranges, and this is entirely normal. One count is still registered for each particle or ray detected.

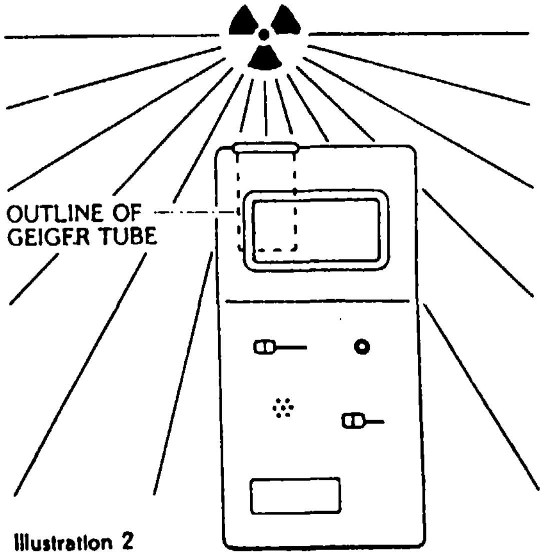


Illustration 2

TO MEASURE GAMMA AND X-RAYS, hold MONITOR 4 in a vertical position with the back side of the instrument pointing toward the source of radiation (see Illustration 2). Low energy gamma and x-rays (below 40 keV) cannot penetrate the side of the Geiger tube, but can be detected through the ALPHA WINDOW.

TO DETECT ALPHA RADIATION, position the suspected source of radiation next to the ALPHA WINDOW. Alpha radiation will not travel far through air so place the source as close as possible (within ¼ inch) without contaminating the instrument. Most alpha radiation can be shielded with a sheet of paper.

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*Note: Some very low energy radiation cannot penetrate the alpha window either. See SPECIFICATIONS for Geiger tube sensitivity.

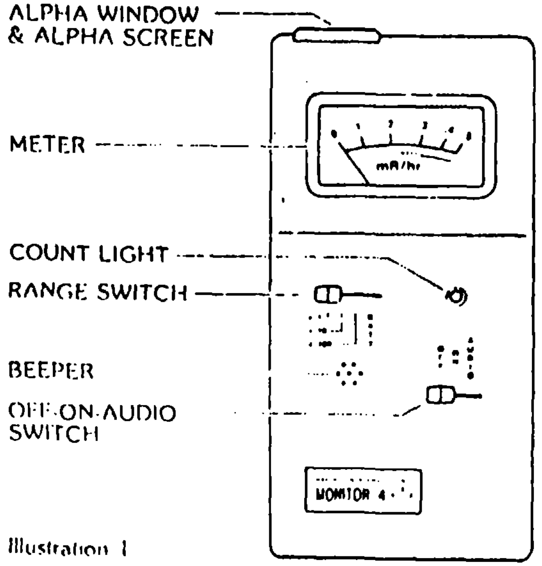

Illustration 1

MONITOR 4 senses radiation by means of a GEIGER MUELLER tube built into the instrument. This is the same type of sensor used in all geiger counters and many other scientific instruments.

When a ray or particle of IONIZING RADIATION passes through this tube, it is sensed electronically and displayed by flashing the COUNT LIGHT on the instrument face. When the OFF-ON-AUDIO switch (see Illustration 1) is in the AUDIO position the instrument will also "beep" each time radiation is sensed and counted.

About 5 to 25 of these counts, at random intervals, can be expected every minute from naturally occurring "background" radiation, depending on location and altitude. The meter pointer on MONITOR 4 will rise and fall slightly with each count.

When a strong source of radiation is present, the meter pointer will rise dramatically, indicating the level of radiation being measured in milliRoentgens per hour (mR/hr). A milliRoentgen is one thousandth of a Roentgen (see Glossay for details).

The Range Switch selects the range of radiation intensity measured. In x1 (times one) the meter reads from 0 to .5 mR/hr as indicated on the meter scale. In x10 the reading is multiplied by 10, indicating levels up to 5 mR/hr. In x100 the reading is mulitiplied by 100, reading up to 50 mR/hr.

Installing and Testing the Battery

To operate MONITOR 4, first install a fresh 9-volt alkaline battery (NEDA #1604A or equivalent). The battery compartment is located at the bottom rear side of the instrument, and is accessible by pushing down on the finger grip provided. Snap in the battery and slide the cover back into position.

To test the battery, turn the instrument on and slide the RANGE SWITCH to the BATT position. The meter pointer should now reach the BATT line on the bottom meter scale. When the pointer fails to reach this line it's time to replace the battery.

Always turn the instrument off before installing the battery. Battery life is up to 2,000 hours at normal background radiation levels.

APPENDIX G

HYDROGEN CYANIDE CONTINGENCY PLAN

APPENDIX G - HYDROGEN CYANIDE CONTINGENCY PLAN

Should hydrogen cyanide levels in excess of 10 ppm be encountered, workers will withdraw upwind. If not on-site, the Site Safety Officer will be contacted. The excavation/drill hole will be allowed to vent and then be rechecked by the Site Safety Officer. If levels are below 10 ppm, work will be continued, with close HCN monitoring.

If levels do not fall below 10 ppm within 20 to 30 minutes, the area will be covered as best as possible with available materials. Workers will remain upwind at all times during this closure operation. The Site Safety Officer will be in charge of this operation. Re-entry of a "closed" area will not be performed until after consultation with the client as well as with Warzyn Health and Safety Management personnel.

In case that a worker becomes exposed to cyanide, follow the procedures below.

Hydrogen Cyanide First Aid

The SSO will notify the local medical facility that the potential for hydrogen cyanide exposure exists at the Site. This will allow emergency personnel to have the necessary equipment in the event of a cyanide exposure emergency.

INHALATION

Symptoms of Very Acute Poisoning

- Victim cries out before losing consciousness
- Victim falls to the ground
- Wheezing
- Foaming at mouth
- Violent convulsions
- Almost immediate death

Signs and Symptoms of Acute Poisoning

- Excitement phase
  - headache
  - breath smells of bitter almond
  - dizziness
  - nausea, occasionally vomiting
  - rapid breathing
  - anxiety and excitement

- Depression Phase
  difficulty in breathing
  chest pain
  drowsiness

- Convulsion phase
  convulsions
  jaws clenched together
  foaming at mouth
  loss of consciousness

- Paralysis phase
  deep coma
  dilated pupils
  weak and irregular pulse
  breathing stops
  death

If the subject survives, there is a risk of permanent nervous system damage.

Signs and Symptoms of Slight Poisoning

- Headache
- Dizziness
- Anxiety
- Difficulty in breathing

INGESTION

Signs and Symptoms

- Burning tongue and mouth
- Salivation
- Nausea

SKIN CONTACT

Signs and Symptoms

The gaseous and liquid compounds are quickly absorbed by the skin and cause symptoms described under INHALATION, acute to slight poisoning.

Depending on their nature, they can be very or only slightly irritating.

SPLASHING IN EYES

When absorbed by mucous membranes of the eyes, these compounds can cause the same symptoms described in INHALATION, slight poisoning.

Immediate Signs and Symptoms

- Irritation
- Watering of eyes

Inhalation First Aid

- Remove the victim from the contaminated area only after protecting yourself from exposure.
- Have someone call the Emergency Medical Service and arrange for transport to a medical facility. Inform them of the nature of the exposure.
- Remove contaminated clothing and equipment while wearing appropriate protective clothing.

If the Victim has Stopped Breathing:

- Open his airway, loosen his collar and belt, and administer artificial respiration using a bag-valve mask.
- Check the pulse. If the heart stops, administer CPR.
- Continue your efforts until help arrives or the victim starts to breathe on this own.
- Keep the victim warm and quiet.

If the Victim is Unconscious but Breathing:

- Lay him on his back. If he is vomiting, turn his head to the side.
- Clear his airway and loosen tight clothing.
- Keep him warm and quiet.
- Do not leave him unattended.
- Never give an unconscious person anything to drink.

If the Victim is Conscious:

- Lay him down, cover him with a blanket and keep him quiet.
- Loosen tight clothing.

Ingestion First Aid

Your Goal is: To start lifesaving treatment, call for help and, if possible, empty the stomach and prevent further injury caused by absorption. PROMPT TREATMENT IS LIFESAVING.

- Ask someone to call a poison control center, inform them of the chemical swallowed and follow their advice.
- Ask someone to call the Emergency Medical Service and arrange for transport to a medical facility.

If the Victim is Unconscious or Unresponsive:

- Lay him on his left side and loosen his collar and belt.
- Check the airway for obstruction.

If the Victim Stops Breathing:

- Administer artificial respiration using a bag-valve mask.

If the Victim is Conscious and Alert:

- Remove him from the contaminated area to a quiet, well ventilated area.
- Loosen tight clothing around the neck and waist.
- Have him rinse his mouth several times with cold water and spit out.
- Give him 1 or 2 cups of water or milk to drink.
- Induce vomiting by touching the back of the throat with your finger, a spoon handle or a blunt object.
- Have the victim sit up and lean forward while vomiting.
- Save vomitus for analysis later. Avoid skin contact with it.
- Do not leave the victim alone.

DO NOT give an unconscious person or a person who is having a convulsion anything to drink.

DO NOT give alcohol, drugs or stimulants like tea or coffee.

DO NOT continue to try to induce vomiting in someone who doesn't gag when you touch the back of his throat.

First Aid in Case of Skin Contact

- Remove the victim from the source of contamination and take him IMMEDIATELY to the nearest shower or source of clean water.
- Remove clothing, shoes, socks and jewelry from the affected areas as quickly as possible, cutting them off if necessary. Be careful not to get any of the chemical on your skin or clothing.
- Wash the affected area under tepid running water using a mild soap.
- Thoroughly rinse the affected area with tepid water.
- Dry the skin gently with a clean, soft towel.
- Notify a physician, emergency room, or poison control center and inform them of the nature of the substance and the accident.
- Arrange for transport to the nearest medical facility.
- Do not leave the victim alone. Watch for signs of systemic toxicity.

If the Skin is Inflamed or Painful:

- Put the painful part in cold water or apply cold wet dressings on the burned area.

First Aid in Case of Eye Contact

Your goal is: To remove all the chemical from the eye(s) quickly.

- Remove the victim from the source of contamination and take him to the nearest eye wash, shower, or other source of clean water.
- Gently rinse the affected eye(s) with clean, lukewarm water for at least 15 minutes. Have the victim lie or site down and tilt his head back. Hold the eyelid(s) open and pour water slowly over the eyeball(s) at the inner corners, letting the water run out the outer corners.
- Ask the victim to look up, down and side to side as your rinse in order to better reach all parts of the eye(s). Have the victim remove contact lenses if he is wearing them.
- Arrange for transport to the nearest medical facility for examination and treatment by a physician as soon as possible. Tell the Emergency Medical Service personnel the name of the chemical and the nature of the accident.

Even if there is no pain and vision is good, a physician should still examine the eye(s) since delayed damage may occur.

- If the victim cannot tolerate light, protect his eye(s) with a clean, loosely tied handkerchief or strip of clean, soft cloth or bandage. Be sure to maintain verbal communication and physical contact with the victim.

DO NOT let the victim rub his eye(s).
DO NOT let the victim keep his eyes tightly shut.
DO NOT introduce oil or ointment into the eye(s) without medical advice.
DO NOT use hot water.

GENERAL ON-SITE FIRST AID

The following discusses general on-site First Aid procedures for exposure to contaminants other than cyanide on-site:

- Contaminated Material in Eyes - Wash with copious amounts of water for at least 15 minutes. Lift upper and lower lids occasionally. Seek medical attention immediately. (Eye wash will be available on-site).

- Contaminated Materials Contact Skin - Promptly wash area with soap or mild detergent and water for organics, just use water for corrosives. Flush well with water. Check for signs of skin irritation. Seek medical attention if unusual appearance of skin or sensation is noted.

- Contaminated Materials Penetrate Protective Clothing - Discard protective clothing and underlying clothing. Wash skin as described above. Confer with Site Safety Officer in selection of new protective clothing.

- Inhalation of Contaminated Air - Move person to well ventilated are at once. If individual is not noticeably affected and has no side affects after about fifteen minutes, returning to work is allowed providing the work area is no longer contaminated. If individual has not fully recovered, continue to monitor for 15 to 20 additional minutes and seek medical attention if necessary. Use artificial respiration if breathing has stopped. In such instances, seek medical attention after victim has resumed breathing. If possible have someone seek medical attention while person is being resuscitated.

- Ingestion of Contaminated Materials - If conscious, flush mouth with water, being careful not to swallow. Contact local poison center (see telephone number in Emergency Response and Information section). When called for, induce vomiting by physical means or syrup if ipecac (DO NOT induce vomiting in unconscious persons). Seek medial attention promptly. Attachment (Hydrogen cyanide)