REMEDIAL WORK PLAN
VOLUNTARY CLEANUP PROGRAM
INDEX NUMBER D2-0023-00-08
21-16 44TH ROAD
LONG ISLAND CITY, NEW YORK

Prepared For

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TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

LIST OF TABLE
(at end of report)

LIST OF FIGURES
(at end of report)

LIST OF PLATES
(at end of report)

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1.0 INTRODUCTION

The premises located at 21-16 44th Road, Long Island City, New York ("the Site") is the subject of a Voluntary Cleanup Program (VCP), Index Number D2-0023-00-08 by Virginia S. Peterson, as Trustee, Wendy Peterson Smithson, Judy Ann Sarkisian, Arthur Corey Sarkisian, David P. Close, as Successor Executor/Trustee, Gabrielle V. Sarkisian as Successor Executor/Trustee and Frederick Hanssen, as Successor Executor/Trustee pursuant to the New York State Department of Environmental Conservation (NYSDEC) VCP. Figure 1 shows the location of the Site in the Long Island City area. The Site consists of an approximately 30,000 sq. ft. (square feet) building with a basement area of 10,000 sq. ft. and approximately 5,000 sq. ft. parking lot. The implementation of the VCP is intended to allow the use of the former industrial building as a high school.

Previous uses of the Site included metal cleaning, painting, degreasing, plating and finishing. Advanced Cleanup Technologies, Inc. (ACT), 115 Rome Street, Farmingdale, New York conducted a Phase I and Phase II investigation and completed Interim Remedial Measures (IRM) between January 2000 and January 2002. Leggette, Brashears & Graham, Inc. (LBG), 110 Corporate Park Drive, Suite 112, White Plains, New York completed additional IRMs and a remedial investigation program for determination of soil and ground-water conditions beneath the Site and to obtain data for preparation of this Remedial Work Plan (RWP).

The remedial goals of the proposed work plan are the following:

- removal of residual contamination from the areas which were not addressed during the IRMs;

- protect and isolate the building from any potential impact by volatile organic compounds (VOCs) detected in soils and ground water under the building;
- remediate the ground water under the building and adjacent areas; and,
- remove soil with metals associated with the fill at the site.

In order to achieve these goals the following work will be completed at the site:

- installation of a soil vapor extraction (SVE) system under the building and the former drum storage area;
- removal of VOCs from under the slab area using the SVE system and prevent future buildup of VOC from any source onsite or offsite;
- install a soil vapor barrier under the building (first floor and basement);
- install and operate a pump and treat system to remove VOCs found in ground water under the building and adjacent areas; and,
- remove soil with concentrations of metals above agreed Site specific cleanup objective (SSCO).

The objective of the work plan is to ensure that all tasks are defined and completed adequately and safely. The plan includes:

- site background;
- procedures for drilling and constructing wells and piping;
- procedures for pilot testing and data analysis;
- Health and Safety Plan;
- description and specifications of proposed remedial systems; and,
- schedule.

The work will be conducted in accordance with applicable State and Federal regulations, rules and guidance.

2.0 SITE LOCATION AND DESCRIPTION

The Site is located in an industrial area in the northwest portion of the Borough of Queens in New York City. The Site is located on the southeast corner of the intersection of 44th Road and 21st Street. The East River is located approximately 2,000 feet to the west of the Site. A site map is presented as figure 2.

The Site consists of a vacant four-story masonry and stucco structure. The footprint of the building is approximately 30,000 square feet in area. A parking lot, approximately 5,000 square feet in area, is also present in the southwest corner of the Site. The ground surface of the parking lot is covered with asphalt. A small area to the immediate south of the building, formerly used for drum storage, remains unpaved.

Natural gas and water services enter the building underground along the western property boundary. The gas and water meters for the building are located in the western portion of the first floor. The electrical service enters the building along the northern property boundary. Electric meters are located in the northern portion of the basement and the southern portion of the ground floor. The Site is connected to the New York City municipal sewer system with the connection located at the southwest corner of the building tapping into the sewer on 21st Street.

The Site was previously used by a drapery hardware manufacturer and distributor. The eastern portion of the factory was dedicated to cleaning, degreasing, oil-extraction, powder coating and painting of metal drapery hardware. Prior to this usage, the Site is believed to have contained a metal plating and finishing facility. The Site is presently under reconstruction.

3.0 GEOLOGY AND HYDROGEOLOGY

3.1 Regional Geology and Hydrogeology

The Site is located in the Atlantic Coastal Plain physiographic province. The geology of this province is comprised of interbedded layers of sand, clay and marl. In Long Island the marine deposits are overlain by drift. The marine deposits are Cretaceous and Quaternary. The drift deposits are derived from glacial activity that occurred during the Pleistocene. The total thickness of the marine and glacial deposits in Queens County ranges from zero feet in northwestern Queens (Long Island City) to 1,100 feet in southeastern Queens.

The ground-water resources that underlie western Long Island is composed of a series of unconsolidated deposits of sand, gravel and clay of late Cretaceous and Pleistocene age. The principal water-bearing units that provide usable quantities of water are the Upper Glacial Aquifer, the Jameco Aquifer, the Magothy Aquifer and the Lloyd Aquifer. Except for the Upper Glacial Aquifer and Jameco Aquifer, these units are vertically separated from each other by confining clay units.

3.2 Site Specific Geology and Hydrogeology

The topography of the Site area is generally level. Ground surface elevations at the Site are approximately 15 feet above msl (mean sea level). As described in the geologic logs, the shallow sediments beneath the Site consist primarily of silt, and fill/ash material, underlain by fine to medium sand. A layer of ash material, approximately 0.5 to 1.0 foot thick was present beneath the concrete slabs for the first floor and basement. The upper silt layer is between 4 and 16 feet thick and it exists across most of the Site. The exception is beneath the basement on the east side of the building, which is approximately 11 feet lower in elevation relative to the first floor. The silt in this area was most likely removed during construction. In the parking lot area the silt is mixed with fill material, which includes bricks, wood, ash and sand and gravel. Beneath the silt is a layer of fine to medium sand, which was encountered in all areas of the Site. The sand extends down to the bedrock surface, which at the Site was encountered between 17 and 27 ft bg (feet below grade).

During drilling activities, ground water was encountered in the sand layer, approximately 4 feet beneath the basement slab and approximately 13 ft bg across the remainder of the Site. Water levels were measured in the monitor wells on September 12, 2002. Based on these measurements, the water-table elevation is approximately 2 feet above msl and the general direction of flow is towards the southwest. The data regarding ground-water measurements, elevations and direction of ground-water flow were submitted in Remedial Investigation Report (RIR) dated October 8, 2002.

4.0 BACKGROUND

4.1 ACT Phase I Environmental Site Assessment

ACT completed a report titled: "Phase I Environmental Site Assessment" for the Site which is dated May 14, 1997. The Phase I Environmental Site Assessment of the Site revealed numerous Recognized Environmental Conditions (REC). A summary of this report is presented in the LBG IRM report submitted on June 12, 2002.

4.2 ACT Phase II Environmental Site Assessment

ACT conducted a subsurface investigation and completed a report titled: "Phase II Environmental Site Assessment" for the Site dated July 14, 1997 which was submitted to NYSDEC. This investigation included drilling of soil borings and collection of soil samples from the metal plating and degreasing tank area, exterior drum storage area, 5,000-gallon fuel oil and underground storage tank (UST) area and oil pump area. Soil samples were analyzed for VOCs and metals. A summary of this report is presented in the June 12, 2002 IRM report.

4.3 ACT Revised Supplemental Investigation Report

ACT completed a report titled: "Revised Supplemental Investigation Report" for the Site dated August 23, 2001 which was also submitted to NYSDEC. A summary of this report is presented in the June 12, 2002 IRM report.

During this phase, twelve soil borings were drilled at the Site, both inside and outside of the building. Soil samples were collected from the borings and submitted to a laboratory for analysis. Summary information regarding the supplemental investigation is also included in the IRM report as a part of the supplemental investigation.

ACT supervised the construction of four PVC monitor wells along the exterior of the building and one PVC piezometer (MW-4) inside the building. Ground-water samples were collected from the wells and submitted to a laboratory for analysis. Due to Site constraints, the piezometer could not be constructed with a suitable sand pack surrounding the screened area. As a result, excessive sediment entered into the well.

ACT personnel collected one sediment sample from each of the sumps (SD-01 and SD-03) and drain (SD-02) at the Site. Two sumps are located within the building and one drain is located outside of the building. Each sample was submitted to a laboratory for analysis. Following NYSDEC approval, the piezometer (also identified as MW-4) was removed by LBG on February 12, 2002.

4.4 ACT Interim Remedial Measures

During the IRM, ACT supervised the excavation of approximately 15 cubic yards of soil from beneath the former drum storage area. Endpoint soil samples were collected from the east wall, south wall and north wall of the excavation; however, no endpoint soil samples were collected from the west wall or the bottom of the excavation.

ACT supervised the excavation of the sediments within two sumps (SD-01 and SD-03) inside the building and from the drain (SD-02) located outside of the building.

ACT supervised the removal of all of the sediment within SD-01 and SD-02. As reported by ACT, SD-01 was constructed with a concrete bottom and brick sidewalls and SD-02 was constructed of concrete. Due to the reported solid construction of SD-01 and SD-02, there were no endpoint sediment samples collected. Following the IRM, ACT completed a report entitled: "Closure Report" dated January 30, 2002 submitted to NYSDEC.

4.5 LBG Interim Remedial Measures

LBG was retained to supervise the re-excavation of backfill to the depth of the former excavation performed by ACT and to excavate remaining contaminated soils in the former drum storage area. Additionally, LBG supervised the enlargement of the sump (SD-03) excavation and the re-excavation of sediments beneath the sump until no staining was evident. The purpose of this work was to remove all the contaminated soil and sediment above the groundwater table in these areas of the Site, where feasible. The field activities were conducted to supplement excavation activities performed by ACT on December 17, 2001. The activities completed by LBG consisted of:

- excavation of contaminated soil from the former drum storage area;
- excavation of contaminated soil from the sump (SD-03) located in the northeast corner of the basement;
- collection for analysis of soil samples from the above-referenced excavations, the sump, the excavation soil stockpiles, and the three drums of sediment generated from the sump;
- disposal of the contaminated soil stockpile generated from the drum storage area excavation, and the three drums of sediment generated from the sump;
- removal and backfilling with sand of the piezometer located in the basement; and
- conducting community air monitoring for the work area.

4.6 Remedial Investigation

Between August 1 and October 8, 2002, LBG implemented, on behalf of the Volunteer, a remedial investigation program at the Site. The program consisted of vapor, soil and ground-water sampling from beneath the first floor and the basement. In addition, the work involved soil sampling for lead in the parking lot from the area of the identified hot spots.

The investigation was used to determine the ground-water flow direction, hydraulic gradient, depth of the bedrock, and to obtain data for ground-water remediation. The remedial investigation concluded the following:

1. The ground-water flow direction beneath the Site is to the west with a small component to the southwest. The hydraulic gradient between 0.0005 ft/ft (foot per foot) and 0.0017 ft/ft indicates slow ground-water movement beneath the area.
2. Semivolatile organic compounds (SVOCs) and inorganics were the only compounds detected above Technical and Administrative Guidance Memorandum (TAGM) recommended soil clean up guidelines. The same compounds detected in the soil were also detected in the ash material that was removed from the basement and first floor. Soil has been impacted by the historical use of fill material containing ash to at least 16 feet below the first floor and 6 feet below the basement, however, VOCs were not detected above TAGM cleanup guidelines in the soil, confirming that the IRM were effective in removal of source from the area.
3. The fill/ash material removed from beneath the first floor and basement indicated that the material can be disposed as non-hazardous material.
4. Samples collected from the temporary vapor points indicated the presence of VOC (PCE) beneath the first floor slab and basement slab. The highest

concentrations of vapors was detected in the vicinity of the former drum storage area.

5. Soil samples collected from the parking lot area and analyzed for total lead and Toxicity Characteristic Leaching Procedure (TCLP) lead showed at two locations an exceedance of the regulatory level of 5 ug/l (micrograms per liter) used for the characterization of hazardous waste (TCLP lead).

6. VOCs and metals were detected in the ground water above water-quality standards. PCE was the primary VOC compound detected above standards. The highest concentrations of VOCs were detected in the vicinity of the former drum storage area, which is the most likely source. The plume extends beneath the eastern half of the first floor and the basement, and the concentrations decrease with distance from the former drum storage area. VOCs were not detected beneath the western half of the first floor building or the parking lot nor were detected beneath the northern half of the Site. The source of metals in the ground water appears to be the historical fill material which contained elevated metals concentrations. The metals detections were fairly evenly distributed across the Site, consistent with the distribution in the soil.

7. The contamination beneath the Site which requires remediation and consists of VOC (PCE and other solvents) and metals located in soil and ground water beneath the Site.

Based on the IRM and remedial investigations conducted at the Site the following RWP was developed for this Site.

5.0 SCOPE OF WORK

5.1 Scope of Work Overview

The subsurface investigation and IRM work including soil excavation and disposal was used to evaluate the subsurface conditions for developing a RWP. Residual solvent contamination remains beneath the former drum storage area. As part of the IRM, the concrete slab of the first floor and basement has been removed. The concrete columns and outer walls of the building remain in place. Soil vapor monitoring has indicated an off gassing of soil-vapor contaminant concentrations as a result of floor removal. Because the accessible source material has been removed, the next step is to protect the future indoor air quality of the proposed school by preventing residual vapors from entering the school. In order to protect indoor air quality, SVE systems and a vapor barrier (impermeable liner) will be installed prior to and set below the new concrete slab floor. The liner will form a complete seal with the walls and columns, and will act as a vapor barrier to the soil beneath the liner. SVE pipes will be installed below the concrete floor and the vapor barrier. The SVE system under the basement floor will be separate from the system serving the first floor. Both systems will be situated in a layer of clean pea stone. After the vapor barrier is installed, a SVE pilot test will be conducted to size the blowers. The new concrete slab floor will be poured above the vapor barrier and SVE system to create the new slab on grade. In addition, a ground-water extraction system will be constructed and operated from the outside of the building in order to remediate the ground water. The work presented in the RWP will be completed in accordance with the site specific Health and Safety Plan (Appendix I). The objectives of the actions described in the RWP are as follows:

- control, and stop upward migration of residual vapors using an impermeable barrier in the basement and first floor areas;
- remediate the soil by removing VOC vapors from the unsaturated zone beneath the building;

- remediate the dissolved VOCs in ground water;
- remove soil containing lead from the parking lot area above the Site specific cleanup objective; and,
- remediate the soil and ground water from the former drum storage area.

5.2 Remediation of Soil in the Former Drum Storage Area

Analysis of vapors from the temporary points sampled on August 7, 15 and September 23, 2002 showed the highest concentration of vapors to exist in the GP-8 and GP-6 areas. These vapor points are located inside of the first floor of the building in the immediate vicinity of the building south wall and north of the former drum storage area. In addition, the highest concentration of dissolved VOCs was detected in a well located outside of this area (MW-6) (Plate 1).

Based on the remedial investigation results, the soil remediation in this area will be completed using four vertical vapor extraction wells located outside of the building and horizontal vapor extraction pipes located inside of the building. The vertical SVE wells will remove the residual vapors located beneath the south wall of the building. The locations of the vapor extraction wells (VE1-4) are shown on Plate 1.

Construction diagrams and geologic logs are included in Appendix II. Each SVE well is constructed with 4-inch diameter, schedule 40, 20-slot PVC screen, set from approximately 2.5 to 3 ft bg to the top of the bedrock. The four SVE wells will be connected to a blower which will be used to remove the vapor from the area. A SVE pilot test of the four wells will be conducted in order to determine the vacuum required and to select the permanent equipment.

5.3 Remediation of the First Floor

The remedial investigation of the first floor indicated the presence of vapors collected from the temporary vapor points. Soil sampled from the locations contained solvents including PCE below the TAGM soil cleanup guidelines. PCE was also detected in ground-water samples collected from temporary geoprobe points set beneath the eastern two thirds of the building.

5.3.1 Soil Vapor Extraction-First Floor

An SVE system will be installed beneath the vapor barrier in the first floor area. The system will be installed in a 6-inch layer of pea stone placed under the entire floor area. SVE pipes will be 2-inch diameter PVC installed horizontally at a 1 percent slope. At the highest point, the invert of the SVE pipes will be set 1 foot below the 6-inch first floor concrete slab finished floor elevation.

Eleven 20-foot sections of slotted SVE pipes will be installed with a minimum of 2 inches of pea stone above and below the pipes (Plate 2). The pea stone will be placed directly over the existing soil after compaction. The 20-foot sections of slotted PVC 2-inch diameter SVE pipes and 2-inch diameter solid pipes will connect to one 4-inch diameter solid header pipe, which will exit the building. The first floor SVE system will exit the southern side of the building.

The blower and vapor treatment system associated with the SVE system will be located outside of the building adjacent to the exit point of the header pipe. Required vapor treatment and flow will be designed based on the pilot test results. A conceptual design of the SVE treatment system is presented on Plate 2.

5.3.2 Vapor Barrier-First Floor

The subsurface will be sealed from the building with a HDPE (high density polyethylene) liner having a minimum thickness of 40 millimeters. The liner will be one unit and all seams will be sealed. The liner will be constructed above the SVE pipes. The vapor barrier will also be installed beneath the elevator shaft and connected to the first floor liner (Plate 1). A specification sheet for a HDPE geomembrane manufactured by GSE Lining Technology, Inc. is included in Appendix III.

The 40-mil HDPE liner will cover the first floor area and the liner will be secured to the existing concrete walls with a stainless steel batten. The liner will be secured to the columns with a banding strip. The batten will be constructed of stainless steel 3/8-inch thick and 1 1/2-inch wide. The liner will be secured to the batten with 3/8-inch diameter stainless steel cinch anchor bolts, 3 3/4-inch long, constructed at 6 inches on center. A 1/4-inch thick, 1 1/2-inch diameter neoprene gasket will be used to seal between the concrete and the liner. The banding strip will be prefabricated to fit the existing cylindrical columns, and will be installed in the same manner as the batten. The concrete anchor detail is shown on Plate 1.

To ensure against failure of the liner at bends between the horizontal and vertical surfaces, a 45 degree cove, filled with grout or polyfoam will be formed along the corners. The cove will be at least 2 inches in each the horizontal and vertical direction. See connection detail on Plate 1. The In-Line Plastics field installation quality assurance manual is included in Appendix III.

Penetrations through the liner for plumbing or electric conduits will also be sealed to the liner through installation of custom HDPE pipe boots. Pipe boots are custom-made HDPE sleeves with a lip that can be sealed to the liner. See utility conduit connection detail shown on Plate 2.

A non-woven geotextile filter fabric of 8 to 10 ounce per square yard weight, will be set over the entire pea stone surface area to prevent potential puncture of the liner by the pea stone. A product description sheet and specification sheets for non-woven geotextile manufactured by TC Mirafi are included as Appendix III.

5.4 Remediation of the Basement

Remedial investigation conducted in the basement showed low concentrations of VOC vapors in the soils beneath the former slab. PCE was also detected in ground-water samples collected from the temporary geoprobe points.

5.4.1 Soil Vapor Extraction-Basement

A SVE system consisting of horizontal piping will be installed beneath the vapor barrier in the basement area. This system will be installed in a 6-inch layer of pea stone. The vapor extraction piping will be 2-inch diameter which will be installed horizontally at a 1 percent slope. At the highest point the invert of the piping will be set at 1 foot below the 8-inch basement concrete floor.

Each pipe will be installed with a minimum 2 inches of pea stone above and below the pipe. The pea stone will be placed directly over the native soil after compaction. Six 20-foot sections of slotted PVC 2-inch diameter vapor extraction piping will be connected to 2-inch diameter solid PVC pipe, which will be connected to two 4-inch diameter solid header pipes, that exit the building. The blower and the treatment systems associated with the vapor extraction pipes will be located outside of the building (Plate 2).

5.4.2 Vapor Barrier-Basement

The vapor barrier in the basement area will consist of a 40-mil HDPE liner similar to that used under the first floor. The basement area will be completely sealed and the HDPE liner will be secured to the concrete walls and columns. The vapor barrier will be installed beneath the elevator shaft (Plate 1). The construction of the HDPE liner will be completed in a manner similar to the first floor. Plate 1 shows the details of the HDPE liners.

5.5 Soil Vapor Extraction Pilot Testing

An SVE pilot test will be conducted following installation of the vertical SVE wells and horizontal SVE pipes. Data collected during the pilot test will be used to size treatment system equipment. The pilot test will be used to: (1) determine the vacuum required to extract the maximum air flow from the formation; (2) determine the radius of influence of the SVE system; (3) determine the pneumatic conductivity of the formation; and, (4) model the potential contaminant recovery. Having knowledge of these important design parameters will ensure the blower(s) is sized correctly and the appropriate emission controls are specified. As the system will be installed in pea stone, a minimum radius of influence of 20 feet will be accomplished.

The pilot test will be conducted after the vapor barriers and SVE are installed. The SVE pilot test will consist of installing monitor points, connecting a temporary vacuum source to the wells and the horizontal extraction pipes, then measuring key parameters and monitoring air quality. Measurements that will be recorded include flow rates and pressures at the vacuum source, vacuum at monitor points and temperature. Air quality monitoring will include recording photoionization detector (PID) readings and explosivity percentages and sampling soil vapor for laboratory analysis. The monitor points will be temporarily installed through the vapor barrier. Vacuum influence will be measured from three dual screened (nested) monitoring points, spaced from 20 to 70 feet from the point of extraction. Each manifold will be tested individually, to account for Site inconsistencies. Following the completion of the pilot test the monitor points will be removed and a seal will be placed at these locations.

Based on the pilot test data the treatment system will be designed. SVE treatment system effluent will meet NYSDEC requirements. A conceptual design of the SVE treatment system is presented on Plate 2.

5.6 Ground-Water Remediation

In order to evaluate the feasibility of ground-water remediation using a pump and treat system a pumping test was conducted from a temporary 8-inch diameter well constructed inside of the basement in the vicinity of the new elevator shaft. The purpose of the test was to determine the aquifer parameters (transmissivity and storage coefficient) for designing the ground-water extraction system.

The temporary well used for testing was constructed inside of the basement at approximately 9 feet below the existing grade. The well was constructed of 8-inch diameter 20-slot PVC screen. A pumping test was conducted on October 18, 2002 from the temporary well at a rate of 9 gpm for approximately 8 hours. The ground water from the well was pumped in a 20,000 gallon fractionation tank. The water from the fractionation tank will be discharged into the New York City sewer system. Prior to the discharge a permit will be obtained from the New York City Department of Environmental Protection (NYCDEP). The discharge will meet the criteria of 20 ppb (parts per billion) for PCE. Prior to and during the pumping test, ground-water levels were measured in the pumping well and Monitor Wells MW-6, MW-7, MW-8, MW-9 and MW-10. Table 1 lists the depth to ground water, drawdown and ground-water elevations in pumping well and monitor wells at the end of the 8 hour pumping test.

Based on data from MW-10 and MW-9 the transmissivity of the aquifer was calculated to range between 7,700 gpd/ft (gallons per day per foot) and 15,800 gpd/ft. The storage coefficient was calculated to range between 0.016 and 0.039 (figures 3 and 4). Based on data observed during the pumping test, it was determined that ground-water pumping from an extraction well has the potential to induce a cone of depression which extends over 124 feet (figure 5).

The field data indicates a water-table aquifer in the overburden on top of surficial bedrock. The pumping test data were also used to calculate the optimum pumping rate for ground-water remediation at the Site. It was determined that ground water pumping at 15 gpm from a well located to the south of the building will induce sufficient drawdown beneath the first floor and the basement and will be capable of remediating the ground water (figure 6).

The pumping test results indicated that the ground-water remediation at the Site can be accomplished by the pump and treat technology. The proposed ground-water remedial system will consist of an extraction well constructed outside of the building in the existing access to the basement. The extraction well will be drilled to 30 feet below existing grade, and will be constructed with 6-inch diameter 20-slot PVC screen set from 5 ft to 25 ft bg. A 5-foot sump will be installed at the bottom of the well. The annular space between the well screen and the drilled boring will be filled with No. 2 grade filter sand. A 4-foot bentonite seal will be placed on top of the sand pack. The ground-water extraction well will be equipped with a submersible pump having a maximum capacity of 30 gpm (gallons per minute) at a total head of 50 feet. The ground water from the extraction well will be pumped into a treatment system consisting of a transfer tank, low profile air stripper, activated carbon filtration unit and discharge into the New York City sewer system. Prior to start up, the system will be tested and calibrated for maximum efficiency.

5.7 Ground-Water Monitoring Program

A ground-water monitoring program will be conducted quarterly at the Site. Ground-water samples will be collected from all onsite and offsite monitor wells. Prior to sampling, the depth to ground water will be measured using an electric tape.

Following water-level measurements, ground-water samples will be collected using the low-flow sampling method (EPA Low Flow Ground-Water Sampling Procedures, April 1996, Appendix IV). During sampling, onsite field parameters will be monitored continuously using a Horiba U-22XD multiparameter water-quality monitoring system. Measurements for pH, conductivity, turbidity, dissolved oxygen (DO), temperature, and oxygen reduction potential (ORP) will be obtained as the ground water will be purged through a flow-cell at a rate of 100 to 500 ml/minute (milliliter per minute). In addition, the turbidity of the water will be measured. Upon reaching stabilization of all parameters, a ground-water sample will be collected for laboratory analysis. The ground-water sample will be stored on ice in a cooler to maintain a constant temperature until delivery to the laboratory.

Quality Assurance and Quality Control (QA/QC) samples, including a field blank and a trip blank will accompany the ground-water sample shipment. The ground-water samples will be analyzed by a New York State Department of Health (NYSDOH) certified laboratory for VOCs by EPA Method 8260 and metals. The results of the quarterly ground-water monitoring program will be summarized in a quarterly report.

5.8 Parking Lot Soil Remediation

Lead impacted soil in the parking lot area will be addressed through excavation with offsite disposal. In accordance with 40 CFR Part 745, which became effective March 6, 2001, the EPA has identified dangerous levels of lead in soil for pre-1978 residences and child-occupied facilities. Child-occupied facilities may include, but are not limited to, daycare centers, preschools and kindergarten classrooms, which are occupied by children six years old or younger. This regulation is part of the Residential Lead-Based Paint Reduction Act of 1992 which establishes standards for lead based paint hazardous. As part of this act, standards were established for lead in soil. The regulation sets two standards for lead in bare (uncovered) soils which are predicated on preventing lead poisoning in children under the age of six. The first is 400 ppm (parts per million) or mg/kg (milligrams per kilogram) in play areas and the second is an average of 1,200 ppm in the remainder of the yard. In accordance with the regulation, soil with lead concentrations equal to or greater than these, in residential areas or child-occupied facilities, is considered lead contaminated soil. The regulation states in cases where these levels are exceeded, measures should be taken to reduce potential exposures. These measures could include, but are not limited to, covering the bare soils with pavement or concrete.

The soil in the parking lot area will be covered with pavement and will not be used as a play area. In considering this, as well as the EPA standards and the Site specific soil quality data for the parking lot, we propose a SSCO of 1,200 ppm. Because the parking lot will be covered and this standard is for bare soils, and the proposed use of the Site is not as a residence or child-occupied (under six years old) facility as defined by the regulation, we believe the SSCO is a conservative standard. The Site will be used as a high school facility.

Soil excavation will be conducted in conjunction with construction of the dry wells in the parking lot. The proposed area to be excavated for the dry wells is approximately 20 feet by 20 feet by 8 feet deep and it coincides with the areas impacted with lead. All excavated soil will be temporarily stockpiled onsite for later disposal. All stockpiled soil will be placed on and covered with plastic. During the excavation activities, water will be used to suppress dust and air monitoring will be conducted with a dust meter. To determine compliance with the SSCO, four confirmation soil samples will be collected from the excavation sidewalls and the bottom and analyzed for total lead and leachable lead by TCLP. Any area that fails to meet the SSCO, based on the confirmation sampling results, will be excavated further and resampled.

All excavated soil will be characterized and disposed of offsite at an appropriate facility in accordance with all applicable regulations.

5.9 General Operation and Maintenance

5.9.1 Soil Vapor Extraction System

The general operation and maintenance of the SVE system will be twofold: (1) the inspection of the mechanical equipment for undue wear and preventative maintenance; and, (2) monitoring to track the progress of remediation and performance of equipment according to the design parameters.

The operation of the blower and system air emissions will be monitored twice per month. The following items will be monitored during each Site visit: (1) weather conditions; (2) equipment operations; (3) system influent and effluent emissions; and, (4) status of extraction points. The weather parameters to be monitored include air temperature, wind direction, cloud cover, barometric pressure and precipitation status. The blower operations will be checked and the vacuum will be measured. The influent and effluent air flow rates, photoionization detector (PID) readings and temperature will be measured.

Upon equipment inspection, gauge readings will be recorded and the system will be temporarily deactivated. During this deactivation period the two moisture separators will be drained of any condensate that may have accumulated, air filters will be inspected and replaced, if necessary.

The system will then be reactivated and the gauge readings will be recorded again and compared with the pre-shutdown readings to ensure that the system is operating correctly.

The air discharged from the remediation system will be treated with vapor-phase carbon. During the operation and maintenance visit, the air stream will be sampled for volatile organic compounds by EPA Method TO-14 before and after treatment. In addition to the air samples, the airstream will also be monitored with a PID. The vapor-phase carbon will be changed out periodically in order to maintain the proper air emissions.

5.9.2 Ground-Water Pump and Treat

The operation of the pump and treat remediation system will be monitored twice per month. The following items will be monitored during each Site visit: (1) weather conditions; (2) equipment operation; and, (3) ground-water flow rate. The weather parameters to be monitored include air temperature, wind direction, cloud cover, barometric pressure and precipitation status. The status of the ground-water depression pump, air stripper, liquid phase carbon and transfer pump will be checked and appropriate gauges read and recorded. The water level in the recovery well(s) and all adjacent monitor wells will also be recorded.

Influent and effluent water samples will be collected once per month and analyzed by EPA Method 8260. The liquid-phase carbon will be changed out periodically in order to maintain proper effluent VOC concentrations.

6.0 LOADING, TRANSPORT AND DISPOSAL OF IMPACTED DEBRIS

6.1 Waste Characterization

Prior to the loading, transport and offsite disposal, contaminated material will be stockpiled and/or drummed and a sample will be collected and analyzed for waste characterization. The sampling protocol, laboratory selection and parameters to be analyzed will be in accordance with the permit issued by the regulatory agency overseeing the operation of the selected licensed disposal facility.

Onsite sampling for waste characterization will be conducted under the supervision of the Site Supervisor prior to offsite disposal and will follow accepted NYSDEC and industry protocols as summarized in this Work Plan, Quality Assurance/Quality Control. The Site Supervisor will maintain field notes of sample locations and copies of the chains of custody to be made available to the NYSDEC Project Manager for review.

The results of the laboratory analyses will be available to the NYSDEC Project Manager in a timely manner upon receipt of the analyses from the selected laboratory. Based on the results of the laboratory analyses, the waste will be characterized (i.e. hazardous, non-hazardous, etc.) and a determination of the ability of the licensed disposal facility to accept the contaminated material will be made.

6.2 Offsite Disposal of Contaminated Material

Upon approval for disposal at the selected disposal facility, the waste will be loaded into vehicles permitted by the New York State Department of Transportation (NYSDOT) and transported offsite under manifest by a licensed waste hauler. The loading and preparation of the manifest documents will be under the supervision of the Site Supervisor. Copies of the manifest(s) will be maintained by the Site Supervisor and made available to the NYSDEC Project Manager for review.

7.0 SCHEDULE

1. Remediation of Soil in the Former Drum Storage Area.
    - installation of SVE wells completed
    - SVE pilot test October 28 through November 8, 2002
2. Remediation of First Floor.
    - installation of SVE pipes November 1 through November 15, 2002
    - Installation of vapor barrier November 15 through November 27, 2002

3. Remediation of Basement.
   - installation of SVE pipes November 1 through November 15, 2002
   - installation of vapor barrier November 27 through December 15, 2002
4. Temporary SVE pilot testing, December 15 through December 30, 2002.
5. Installation of extraction well, November 15 through November 20, 2002.
6. Installation of permanent remediation system, December 15 through February 15, 2003
7. Start up of permanent operation, February 28, 2003.

8.0 REPORTING AND NO FURTHER ACTION REQUEST

After satisfactory completion of all onsite remedial activities, and review of the laboratory and disposal documentation, a Site Closure Report summarizing the success of the remediation effort will be prepared. No further action will be requested conditioned upon performance of an Operation, Maintenance and Monitoring (OM&M) Plan which will include quarterly ground-water monitoring and maintenance of engineering controls.

8.1 Evaluation of Field and Laboratory Data

8.1.1 Closure/Backfilling of Excavation

The Site Supervisor's field notes relating to the visual delineation and field screening of the material in the excavations will be summarized in the Report. Also included will be the laboratory results of the endpoint sampling in relationship to New York State Department of Environmental Conservation (NYSDEC) standards outlined in Technical and Administrative Guidance Memorandum #4046 (TAGM), Determination of Soil Cleanup Objectives and Cleanup Levels, January 24, 1994. This information in conjunction with a DUSR prepared for the samples, will support the approval for closure.

8.1.2 Reporting of Results of Onsite Air Monitoring

In compliance with the Site Health and Safety Plan, the report will include the results of the air monitoring of the workplace for detectable levels of organic vapors and dust. Also included will be field logs and a discussion of those actions, if necessary, that were taken to ensure no offsite migration of detected odors/vapors that might have been generated during intrusive onsite activities.

8.2 Verification of Disposal Documentation

All disposal documentation including the waste characterization results, completed waste manifests and weight tickets/quantity vouchers will be verified for accuracy, summarized and included in the Site closure report. Also included will be a copy of the current license and/or permit of the waste hauler(s) and disposal facility(s) selected and approved for the project.

8.3 Evaluation and Summary of the Remedial Action

The report will include an evaluation and summary of the remedial efforts taken in support of the project. These efforts will include the initial tasks required for the removal of impacted soil and sediment, efforts taken to define the extent of the excavations and those activities accomplished to complete the project such as backfilling, installation of the liner and passive venting system, and waste disposal.

8.4 Ground-Water Monitoring

Quarterly ground-water monitoring will be implemented and a report will be submitted to NYSDEC approximately one month after each sampling event. A copy of the laboratory analytical reports will also be included. Water-table elevation and flow data, including ground-water contour maps, will also be reported.

8.5 Request for Closure

Upon acceptance of the report regarding the remedial work by the NYSDEC, a petition to the NYSDEC for Site closure in the form of a No Further Action Letter will be prepared.

LEGGETTE, BRASHEARS & GRAHAM, INC.

Dan C. Buzea, CPG
Principal

Catherine Miceli
Environmental Engineer II

William K. Beckman, P.E.
Principal

dmd
October 24, 2002
reports\furman\Premier Storage\remedialworkplan rpt

TABLE

TABLE 1

VOLUNTARY CLEANUP PROGRAM INDEX # D2-0023-00-08
21-16 44TH ROAD
LONG ISLAND CITY, NEW YORK

PW-1 PUMPING TEST DATA
PW-1 Was Pumped For 8 Hours at 9 GPM
October 18, 2002

Well ID	Top of Casing Elevation (feet)	Distance From Pumping Well (feet)	Static Water Level (ft btoc) [1]	Static Water Level Elevation (feet)	Pumping Water Level (ft btoc)	Pumping Water Level Elevation (feet)	Drawdown (feet)
Pumping Well PW-1	6.88	NA	4.27	2.61	6.83	0.05	2.56
MW-6 (Cluster Well)	16.51	124	13.93	2.58	13.99	2.52	0.06
MW-7	15.63	115	13.02	2.61	13.09	2.54	0.07
MW-8	8.91	79	6.31	2.60	6.44	2.47	0.13
MW-9 (Cluster Well)	9.38	75	6.79	2.59	6.93	2.45	0.14
MW-10	15.91	75	13.28	2.63	13.57	2.34	0.29

1) - Feet below top of casing

FIGURES

SOURCE: USGS TOPOGRAPHIC QUADRANGLES BROOKLYN, NEW YORK (PHOTOREVISED 1979) AND CENTRAL PARK, NEW YORK (1995).

N

QUADRANGLE LOCATION

0 2000
SCALE IN FEET

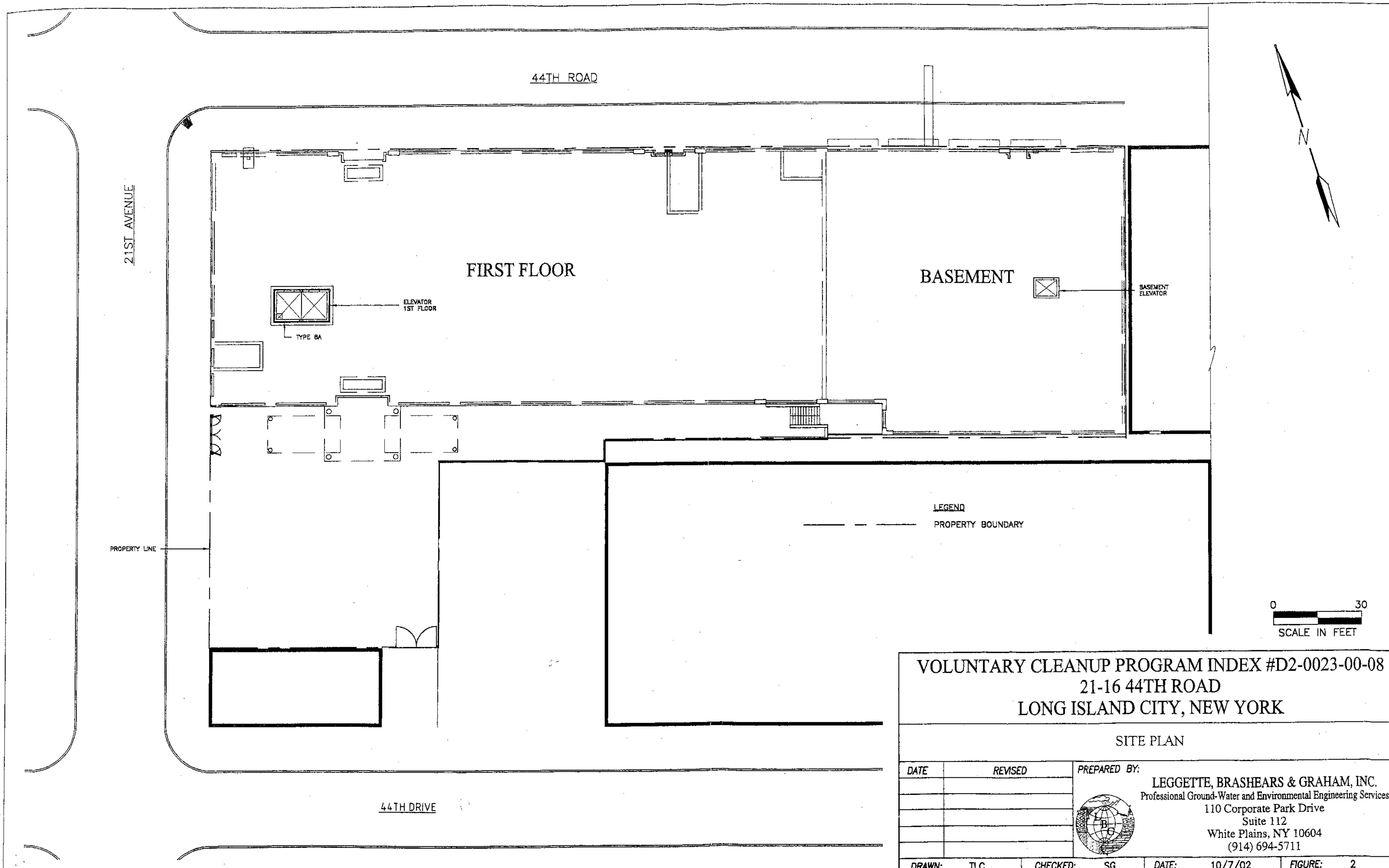
VOLUNTARY CLEANUP PROGRAM INDEX #D2-0023-00-08
21-16 44TH ROAD
LONG ISLAND CITY, NEW YORK

TOPOGRAPHIC / SITE LOCATION MAP

DATE	REVISED	PREPARED BY:
		LEGGETTE, BRASHEARS & GRAHAM, INC. Professional Ground-Water and Environmental Engineering Services 110 Corporate Park Drive Suite 112 White Plains, NY 10604 (914) 694-5711

DRAWN:	TLC	CHECKED:	SG	DATE:	2/27/02	FIGURE:	1

F:\DWG\Premier Storage\Additional Subinv\Remedial Investigation Report\FIGURES 1-9\#1.dwg



VOLUNTARY CLEANUP PROGRAM INDEX #D2-0023-00-08
21-16 44TH ROAD
LONG ISLAND CITY, NEW YORK

SITE PLAN

DATE	REVISED

PREPARED BY:

LEGGETTE, BRASHEARS & GRAHAM, INC.
Professional Ground-Water and Environmental Engineering Services
110 Corporate Park Drive
Suite 112
White Plains, NY 10604
(914) 694-5711

DRAWN:	TLC	CHECKED:	SG	DATE:	10/7/02	FIGURE:	2

\DWG\Premier Storage\Additional SubInv\Remedial Investigation Report\FIGURES 1-9\Fig2.dwg

Drawdown in MW-9 During PW-1 Pumping for 8 Hours at 9 gpm
October 18, 2002

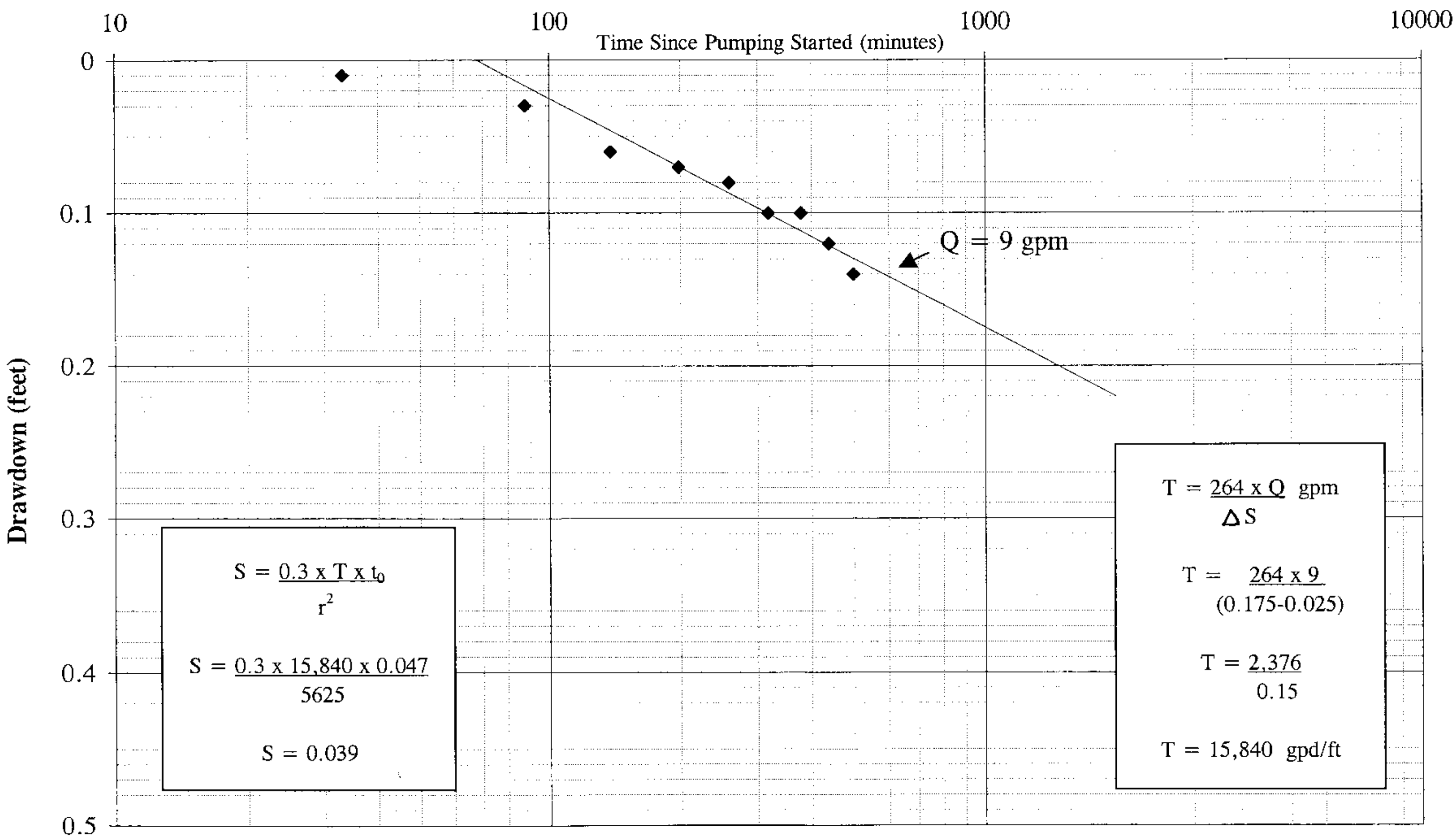


Figure 3

Drawdown in MW-10 During PW-1 Pumping for 8 Hours at 9 gpm
October 18, 2002

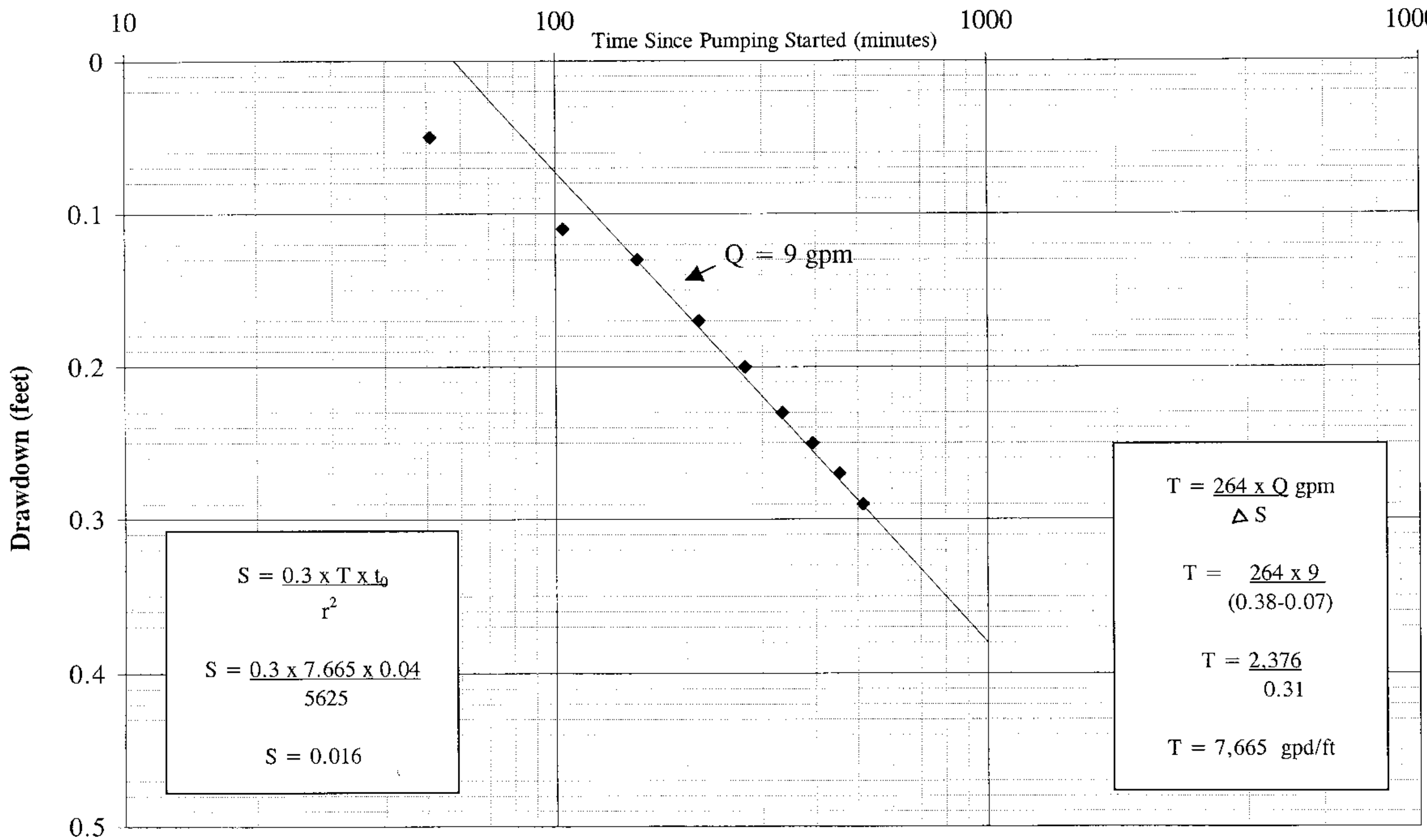
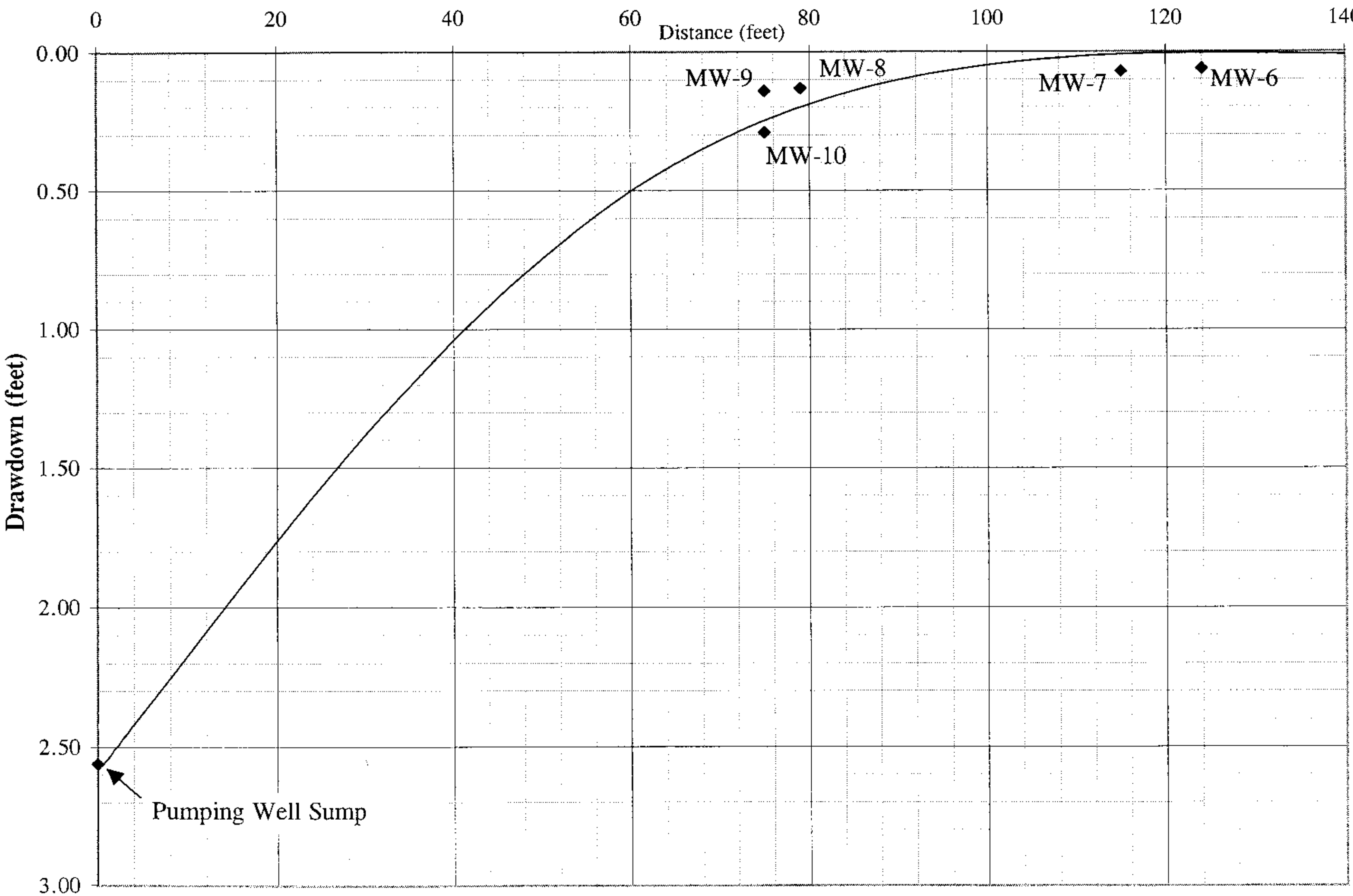


Figure 4

Figure 5

Distance Drawdown Graph for Basement Sump Pumping Test
October 18, 2002



Projected Drawdown Beneath the Basement and First Floor at 75 ft From an Imaginary Pumping Well Located Between MW-6 & MW-8. Pumping Rate is 15 GPM.

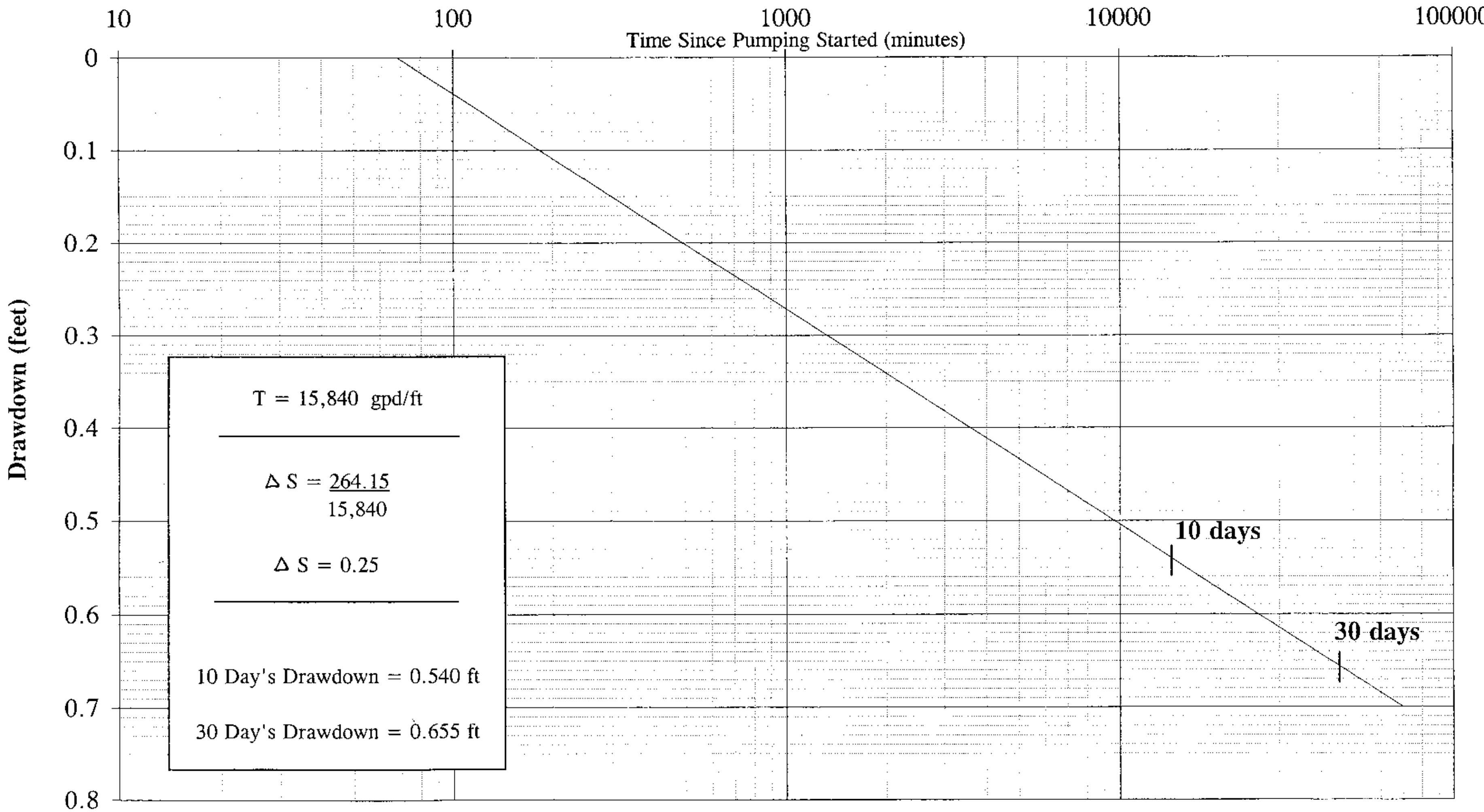


Figure 6

PLATES

APPENDIX I

HEALTH AND SAFETY PLAN
(COMMUNITY MONITORING PROGRAM)

SITE SPECIFIC HEALTH AND SAFETY PLAN
21-16 44th ROAD
LONG ISLAND CITY, NEW YORK

Prepared For

Virginia S. Peterson, as Trustee, Wendy Peterson Smithson,
Judy Ann Sarkisian, Arthur Corey Sarkisian, David P. Close,
as Successor Executor/Trustee, Gabrielle V. Sarkisian
as Successor Executor/Trustee and Frederick Hanssen,
as Successor Executor/Trustee

October 2002

LEGGETTE, BRASHEARS & GRAHAM, INC.
Professional Ground-Water and Environmental Engineering Services
110 Corporate Park Drive, Suite 112
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TABLE OF CONTENTS

Page

LIST OF TABLE

LEGGETTE, BRASHEARS & GRAHAM, INC.
110 CORPORATE PARK DRIVE, SUITE 112
WHITE PLAINS, NEW YORK 10604
(914) 694-5711

SITE SPECIFIC HEALTH AND SAFETY PLAN
21-16 44th ROAD
LONG ISLAND CITY, NEW YORK

This Health and Safety Plan (HASP) is intended to provide a basic framework for the Voluntary Cleanup Program (VCP), Index Number D2-0023-00-08 by Virginia S. Peterson, as Trustee, Wendy Peterson Smithson, Judy Ann Sarkisian, Arthur Corey Sarkisian, David P. Close, as Successor Executor/Trustee, Gabrielle V. Sarkisian as Successor Executor/Trustee and Frederick Hanssen, as Successor Executor/Trustee pursuant to the New York State Department of Environmental Conservation (NYSDEC) VCP. The procedures provided herein are intended as a guide for all Leggette, Brashears & Graham, Inc. (LBG) and subcontractor employees who will be involved in the performance of the project.

The primary objective of the HASP is to establish work-safety guidelines, requirements and procedures before field activities begin and during the field activities. The following information was prepared specifically for field operations by personnel to enforce and adhere to the established rules as specified in the HASP. The HASP will be provided to all personnel to aid in accomplishing the following objectives:

- monitoring the effectiveness of the HASP as it is conducted in the field by performing field operation audits;
- following up on any necessary corrective actions;
- interacting with regulatory agencies and/or client representatives regarding modifications of health and safety actions; and
- stopping work should conditions warrant such action.

All personnel will have had health and safety training in accordance with OSHA Interim Final Standard 29 CFR 1910 or as may be amended. A copy of LBG's Corporate Safety Policy and Drug and Alcohol Policy is attached in Appendix A.

1.0 ORGANIZATION AND RESPONSIBILITIES

The organization and responsibilities for implementing safe site-investigation procedures, and specifically for the requirements contained in this manual, are described in this section.

1.1 Project Manager

The LBG Project Manager will be responsible for the overall implementation and monitoring of the health and safety program by:

- ensuring appropriate protective equipment is available and properly used by all personnel, in accordance with the HASP;
- ensuring personnel health and safety awareness by providing them with proper training and familiarity with procedures and contingency plans;
- ensuring all personnel are apprised of potential hazards associated with the site conditions and operations;
- supervising and monitoring the safety performance of all personnel to ensure their work practices are conducted in accordance with the HASP;
- correcting any work practices or conditions that would expose personnel to possible injury or hazardous condition;
- communications with the onsite Health and Safety Officer (HSO);
- ensuring sufficient protective equipment is provided and used;
- promptly initiating emergency alerts; and,
- communicating with the client and/or regulatory agency representatives.

1.2 Onsite Health and Safety Officer

The LBG HSO will be onsite during all field activities. The HAO will be accountable for the direct supervision of personnel from the subcontractors and other LBG personnel with regard to:

- health and safety program compliance;
- maintaining a high level of health and safety consciousness among employees at the work site; and,
- reporting accidents within LBG jurisdiction and undertaking corrective action.

1.3 Field Personnel

All field personnel will report directly to the onsite HSO, and will be required to:

- be familiar with, and conform to, provisions of the HASP;
- ensure that they are well informed of potential hazards at the work site and exercise informed consent in their work;
- report any accidents or hazardous conditions to the onsite HSO; and,
- have complete familiarity with their job requirements and the health and safety procedures involved.

1.4 Reporting of Accidents and Unsafe Conditions

If an accident occurs, the HSO and the injured person(s) are to complete an Accident Report for submittal to the project manager, who will forward a copy to the principal-in-charge who should ensure that follow-up action is taken to correct the situation that caused the accident.

1.4.1 Disciplinary Actions for Safety Related Infractions

If an infraction of the Health and Safety Plan is discovered by the Project Manager or the onsite HSO, each case will be dealt with individually. The infraction will be investigated and a disciplinary meeting held with the offender. Disciplinary actions may include a performance deficiency evaluation entered into the employee's personnel file, correction of problem after the disciplinary meeting or removal of the offender from the project. Repeated infractions will not be tolerated and will be dealt with accordingly.

1.4.2 Safety Inspections

Safety inspections will be conducted periodically by the Project Manager. The Project Manager will be familiar with the Health and Safety Plan before performing an onsite visit. While onsite, the Project Manager will evaluate the effectiveness of the plan and offer any suggestion for improvement. Although Project Managers are responsible for periodic safety inspections and evaluation of the Health and Safety Plan, the onsite HSO is responsible for daily observation and evaluation of Health and Safety Plan effectiveness.

1.4.3 Safety Meetings

Prior to the start of field activities, a meeting will be held to discuss the potential hazards at the site, with a review of the required protective clothing and procedures observed at this site. As needed, daily meetings will be held to discuss any changes in the hazards. A site safety briefing form will be filled out each day the HSO holds a meeting and signed by all the attendees of the meeting.

2.0 HAZARD EVALUATION

The exposure limits of chemical constituents which may be encountered are listed in table 1. These constituents would possibly be encountered in ground water and/or soil and comprise the major concerns for personal health. The protection of personnel and the public from exposure to these substances by inhalation, oral ingestion, dermal absorption or eye contact is included as a primary purpose of this plan.

The onsite HSO is responsible for determining the level of personal protection equipment required. The HSO will perform a preliminary evaluation to confirm personal protective equipment requirements once the site has been entered. When work-site conditions warrant, the onsite HSO will modify the level of protection to be utilized. The existence of a situation more hazardous than anticipated will result in the suspension of work until the Project Manager and client representative has been notified and appropriate instructions have been provided to the field team.

3.0 COMMUNITY AIR MONITORING PLAN

A photoionization detector (PID) and a dust meter will be used to continuously monitor ambient air quality at the Site during all ground-intrusive activities. Records of these data will be maintained by the onsite HSO. During drilling operations, air quality will be monitored at each drilling or boring location, especially near the top of the boreholes as samples are taken. Work operations which involve handling of potentially hazardous substances will include continuous contaminant monitoring using the PID and the dust meter. In addition, field monitoring will be performed when work is initiated at different portions of the site, when a new operation is initiated and/or when potentially leaking drums or containers are going to be handled. When deemed necessary or desirable by the onsite HSO, area monitoring will be used in potentially hazardous zones. Area monitoring will be performed as plans and conditions dictate, and in accordance with the HASP and with the goal of accident and hazardous condition prevention in mind. Instrument calibration information is included in Appendix B.

For the compounds previously identified to be most prevalent, the lowest 8-hour exposure limit is listed on table 1.

3.1 Vapor Emission Response Plan

If the ambient air concentration of organic vapors exceeds 5 ppm above background at the perimeter of the work area, activities will be halted and monitoring continued. Work activities will also be halted if the downwind particulate level is 150 ug/m^3 greater than the upwind particulate level. If the organic vapor level decreases below 5 ppm above background, work activities can resume. If the organic vapor levels are greater than 5 ppm over background but less than 25 ppm over background at the perimeter of the work area, activities can resume provided:

- the organic vapor level 200 feet downwind of the work area or half the distance to the nearest residential or commercial structure, whichever is less, is below 5 ppm over background.

If the organic vapor level is above 25 ppm at the perimeter of the work area, activities will be shutdown. When work shutdown occurs, downwind air monitoring as directed by the Safety Officer will be implemented to ensure that vapor emission does not impact the nearest residential or commercial structure at levels exceeding those specified in the Major Vapor Emission section.

3.2 Major Vapor Emission

If any organic levels greater than 5 ppm over background are identified 200 feet downwind from the work area or half the distance to the nearest residential or commercial property, whichever is less, all work activities will be halted.

If, following the cessation of the work activities, or as the result of an emergency, organic levels persist above 5 ppm above background 200 feet downwind or half the distance to the nearest residential or commercial property from the work area, then the air quality will be monitored within 20 feet of the perimeter of the nearest residential or commercial structure (20 Foot Zone).

If efforts to abate the emission source are unsuccessful and if the following levels persist for more than 30 minutes in the 20 Foot Zone, then the Major Vapor Emission Response Plan shall automatically be placed into effect.

- if organic vapor levels are approaching 5 ppm above background.

However, the Major Vapor Emission Response Plan shall be immediately placed into effect if organic vapor levels are greater than 10 ppm above background.

3.3 Major Vapor Emission Response Plan

Upon activation, the following activities will be undertaken:

1. All Emergency Response Contacts as listed in the Health and Safety Plan of the Work Plan will be notified.
2. The local police authorities will immediately be contacted by the Safety Officer and advised of the situation.
3. Frequent air monitoring will be conducted at 30 minute intervals within the 20 Foot Zone. If two successive readings below action levels are measured, air monitoring may be halted or modified by the Safety Officer.

4.0 LEVELS OF PROTECTION

The level of protection anticipated to perform work on this investigation is Level D, unless otherwise upgraded. Only protective equipment deemed suitable by the onsite HSO for use at the work site will be worn. Any changes in protection levels shall be documented by the onsite HSO. Field personnel should exercise informed judgment on protective equipment requirements at active work sites or at work sites that have been repeatedly entered or occupied without apparent harm. In any case where doubt exists, the safest course of action must be taken. The protective equipment to be used by field personnel is listed below.

4.1 Level D

- hard hat;
- safety glasses, shatter-proof prescription glasses or chemical splash goggles;
- boots/shoes, leather or chemical-resistant, steel toe and shank;
- coveralls; and,
- chemical resistant gloves.

At a minimum, protective headgear, including protective hearing devices, eyewear and footwear will be worn at all times by personnel working around the drilling equipment.

4.2 Level C

- hard hat;
- boots, leather, steel toe and shank;
- outer boots, chemical resistant;
- chemical-resistant gloves (solvex);
- Tyvek or Saranex suit; and,
- Air purifying respirator with organic vapor cartridge and dust and mist filter.

4.3 Level B

- pressure-demand, self-contained breathing apparatus;
- standby escape pack;
- chemical resistant clothing (Saranex suit);
- outer gloves (Solvex);
- inner gloves (surgical);
- outer boots (chemical resistant);
- inner boots (leather, steel shank and toe); and,
- hard hat.

5.0 SAFE WORK PRACTICES AND HYGIENE

In addition to the use of protective equipment, other procedures will be followed to minimize risk:

- all consumptive activities including eating, drinking or smoking are prohibited during the drilling, sampling and decontamination activities;
- an adequate source of potable water for emergency use will be available at the drilling sites (two liters per person per day);
- fire extinguishers will be available at the work sites for use on equipment or small fires when appropriate; and,
- an adequately stocked first-aid kit will be maintained at the work site at all times during operational hours.

5.1 Heat Stress

In order to avoid heat stress several preventative measures will be observed:

- Workers will drink a 16-ounce glass of water prior to work (in the morning and after lunch). Water will be contained in a cooler, maintained at a temperature below 60°F. Workers will be encouraged to drink approximately every 20 minutes during days of extreme heat.
- Workers will be encouraged to wear long cotton underwear under the heat-retaining protective clothing required by Level C.
- In extreme hot weather, field activities will be conducted in the early mornings and late afternoons.
- Rest breaks in cool or shaded areas will be enforced as needed.
- Toilet facilities will be made available to site workers, unless transportation is readily available to nearby toilet facilities.
- Good hygiene practices will be encouraged, stressing the importance of allowing the clothing to dry during rest periods. Anyone who notices skin problems should receive medical attention immediately.
- If there are support personnel available outside the work zone, they should observe the workers in the exclusion zone to monitor signs of stress, frequency of breaks, etc.

5.2 Cold Stress and Exposure

In order to avoid cold stress, several preventative measures will be observed;

- work will not take place when the temperature falls below -20°F. (The wind chill factor should be a major consideration);
- clothing should be worn in layers, so that personnel can adapt to changing conditions and various levels of physical stress;
- if possible, breaks should be taken in a heated vehicle or building, but care should be taken to remove outer clothing during the break;
- have on hand extra inner clothing in case perspiration builds up;
- keep insulated containers of warm liquids available for breaks outside of the exclusion zone;
- be aware of the signs of frostbite and take immediate remedial measures; and,
- take extra precautions around areas subject to ice buildup, such as sanding slippery surfaces.

6.0 WORK ZONE

To prevent unauthorized personnel from entering areas where active operations are being performed, the area enclosing the operation will be marked.

Typically, VOC projects such as this one installation of monitor wells, monitoring of wells, installation and operation of treatment systems and observation of tank and trench excavation work. Safety issues with respect to this type of work are included in Appendix C.

7.0 DECONTAMINATION

An area will be set aside within the work zone for decontamination. The type of decontamination procedures used will be based on the level of protection required. Decontamination of Level D protective wear will consist of brushing heavily soiled boots to remove soils, rinsing gloves and safety glasses (and overboots, if worn) with water, and removing and storing coveralls in plastic bags before leaving the work zone, if heavily soiled or suspected of having been in contact with site contaminants. For detailed decontamination, equipment and procedures, refer to Appendix D.

8.0 CONTINGENCY PLAN FOR EMERGENCIES

In the event of a safety or health emergency, appropriate corrective measures must immediately be taken to assist those who have been injured or exposed and to protect others from hazard. The onsite HSO will be notified of the incident immediately. If necessary, first aid will be rendered.

dmd
October 24, 2002
reports\furman\premierstorage\general hsp2 rpt

TABLE

TABLE 1

Exposure Limits

COMPOUND	EXPOSURE STANDARDS			RECOGNITION QUALITIES		
	TLV PEL (a) (ppm)	STEL (b) (ppm)	IDLH (c) (ppm)	Odor/Threshold (ppm)	LEL (d) (%)	Ionization Potential (eV)
Gasoline[1/]	300	500	1,400	–	1.4	–
Alachlor[2/]	–	–	–	No odor	–	–
Benzene[1/]	0.1	1	500	12	1.2	9.24
Butane	800	–	–	2,700	1.6	10.63
Chlorobenzene	75[3/]	–	1,000	Almonds	1.3	–
1,1-Dichloroethane	100	Ca[5/]	3,000	Chloroform	5.4	11.06
1,2-Dichloroethylene	200	–	1,000	Chloroform	5.6	9.65
EDB (Ethylene dibromide)[1/]	0.045	0.13	100	Sweet	–	9.45
EDC (Ethylene dichloride)[1/]	1	2	50	Chloroform	6.2	11.05
Ethylbenzene	100	125	800	Aromatic	0.8	8.76
Heptane	85	440	750	150	1.05	9.90
N-Hexane	50	–	1,100	Gasoline/130	1.1	10.18
Hexanes	100	510	–	Mild gasoline	–	–
Methyl ethyl ketone (MEK)	0.2[4/]	–	–	Characteristic odor	–	–
Octane	75	385	1,000	Gasoline/150	1.0	9.82
Pentane	120	610	1,500	Gasoline/1000	1.5	10.34
TBA (Tert-butyl alcohol)	100	150	1,600	Camphor	2.4	9.70
Tetrachloroethylene[1/]	Ca[5/]	Ca[5/]	150	Chloroform	–	9.32
Tetraethyl Lead	0.075*	–	40*	Sweet	1.8	11.10
Tetramethyl Lead	0.075*	–	40*	Fruity	–	8.50
Toluene	100	150	500	Sweet benzene like/2.9	1.1	8.82

TABLE 1
(continued)

Exposure Limits

COMPOUND	EXPOSURE STANDARDS			RECOGNITION QUALITIES *		
	TLV/PEL (a) (ppm)	STEL (b) (ppm)	IDLH (c) (ppm)	Odor/Threshold (ppm)	LEL (d) (%)	Ionization Potential (eV)
1,1,2-Trichloroethane	Ca5/	10	100	Chloroform	6.0	11.00
Trichloroethylene	Ca5/	25	1,000	Chloroform	8.0	9.45
Vinyl Chloride	Ca5/	Ca5/	Not determined	Pleasant	3.6	9.99
Xylenes	100	150	900	Aromatic/1.1	0.9	8.56

Notes:

1/ Potential occupational carcinogen
2/ Alachlor manufacturer established internal exposure guideline of 10 ppb for 8-hour TWA
3/ OSHA guideline, NIOSH questions the adequacy of 75 ppm
4/ Ceiling REL, should not be exceeded at any time
5/ NIOSH recommends occupational exposures to carcinogens to be limited to the lowest feasible concentration
– = No published value
* mg/m3
(a) The more stringent of either: (1) Occupational Safety and Health Administration (OSHA) 1989 Permissible Exposure Limit (PEL), (2) American Conference Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV), or (3) National Institute for Occupational Safety and Health (NIOSH) recommended exposure limits (RELs), time-weighted average concentrations for up to a 10-hour work day.
(b) Short Term Exposure Limit - 15 minute exposure.
(c) Immediately dangerous to life and health.
(d) Lower Explosive Limit.

dmd
May 17, 2002
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FORMS

SITE SAFETY BRIEFING

Job Name: ______________________________

Date: April 2002

Site Location: 21-16 44th Road, Long Island City, New York

SAFETY ISSUES (Circle appropriate information)

Tasks:	Drilling, Ground-Water Monitoring, Treatment System O&M, UST or Trench Excavation
Protective Clothing/Equipment:	Level D, Level C, Level B, Level A
Chemical Hazards:	Gasoline, Diesel Fuel, Heating Oil, Number 2 Oil
Physical Hazards:	Car Traffic, Construction Equipment, Confined Space, Overhead Wires
Control Methods:	Cones, Restricted Access, Traffic Control Personnel
Other:	______________________________
Hospital Name/Address:	______________________________

ATTENDEES

Print Name:	Sign Name:
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________

Meeting conducted by: ______________________________

AIR MONITORING

General Information

Name(s): ____________ Background Level: ____________

Date: ____________ Weather Conditions: ____________

Time: ____________ ____________

Project: 21-16 44th Road
Long Island City, New York

Equipment Calibration

PID ____________ CGI ____________

Sample No.	Time	Location	PID Reading (ppm)	Comments	CGI Reading	
					$\%O_2$	%LEL
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

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Air Monitoring Data

General Information

Name(s): ______________________

Project/Location: ______________________

Equipment Used: MINIRAM

Background Level: ______________________

Date	Weather	Total Time (min)	SA (mg/m^3)	TWA (mg/m^3)

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CONTACT SHEET

Client:	Virginia S. Peterson, as Trustee, Wendy Peterson Smithson, Judy Ann Sarkisian, Arthur Corey Sarkisian, David P. Close, as Successor Executor/Trustee, Gabrielle V. Sarkisian as Successor Executor/Trustee and Frederick Hanssen,as Successor Executor/Trustee
Project:	21-16 44th Road
Location:	Long Island City, New York
Task:	
Client Contact:	Scott Furman, Esq. and Alicia A. Weissmeier, Esq.

Leggette, Brashears & Graham, Inc.

(914) 694-5711	(914) 694-5744 (fax)
Field Supervisor (HSO):	Sean Groszkowski
Project Manager:	Sean Groszkowski
Principal-in-Charge:	Dan C. Buzea

Local Police Headquarters:	108 Precinct, Long Island City, New York (718) 784-5411
Local Hospital:	Elmhurst Hospital, 79-01 Broadway (corner of Baxter), Elmhurst, New York
Emergency Room:	(718) 334-4000
State Police:	State Government Police, New York Marshalls Bureau, 80 Maiden Lane, Floor 17, New York, New York, (212) 825-5953
Miscellaneous:	New York State Department of Environmental Conservation (NYSDEC) Region 2, 1 Hunters Point Plaza, 47-40 21st Street, Long Island City, New York (718) 482-4900

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DIRECTIONS TO LOCAL HOSPITAL:

Elmhurst Hospital
79-01 Broadway
Elmhurst, New York

Total Distance:	2.0 miles
Total Estimated Time:	5 minutes

- Go east on 44th Drive to in Jackson Avenue
- Merge onto Jackson Avenue and proceed north
- Go east (right) on Queens Boulevard at the intersection
- Go northeast (left) on Greenpoint Avenue which changes to Roosevelt Avenue
- Make a right onto Broadway
- Elmhurst is two (2) blocks on the left at 41st Avenue

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May 17, 2002
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EXCLUSION ZONE LOG SHEET

LEGGETTE, BRASHEARS & GRAHAM, INC.
110 CORPORATE PARK DRIVE, SUITE 112
WHITE PLAINS, NEW YORK 10604

Client: Virginia S. Peterson, as Trustee, Wendy Peterson Smithson, Judy Ann Sarkisian, Arthur Corey Sarkisian, David P. Close, as Successor Executor/Trustee, Gabrielle V. Sarkisian as Successor Executor/Trustee and Frederick Hanssen, as Successor Executor/Trustee

Location: 21-16 44th Road, Long Island City, New York

Name	Date	Time In	Time Out	Elapsed Time

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APPENDIX A

LEGGETTE, BRASHEARS & GRAHAM, INC.

SAFETY POLICY

Job safety is a common-sense part of everyone's life, but requires constant alertness to possible dangers. When we work on industrial sites, LBG employees are expected to observe the safety rules of our Client hosts.

You are the first line of defense for your own personal safety. In the field, appropriate clothing should be worn at all times. Where appropriate, work shoes with hard toes and/or ankle protection should be worn at all times. **Sneakers/tennis shoes should never be worn in the field, regardless of the circumstances.**

LBG provides hard hats that should be worn around any drilling operations and in any other "hard hat zones". Where required, safety glasses, goggles, protective gloves, respirators, and other safety clothing or equipment should be worn and disposed of as specified by the Project Safety Officer.

Periodically, LBG provides special safety seminars which satisfy the OSHA requirements for work on hazardous waste sites. In-house safety training is conducted on an ongoing basis and as dictated by case-by-case needs. There is a Corporate Safety Officer in the Trumbull, Connecticut headquarters and a designated Safety Officer in each regional office to whom questions and problems relating to job safety should be referred.

Any project that involves or may involve hazardous or toxic waste or any potentially dangerous condition requires the preparation, filing, use and compliance with a Health and Safety Plan (HASP). LBG has a petroleum related work HASP that can be readily adapted to most petroleum jobs and has numerous site-specific HASPS that comply with state and federal CERCLA requirements that can be used for guidance in developing site-specific HASPS.

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LEGGETTE, BRASHEARS & GRAHAM, INC.
GENERAL DRUG AND ALCOHOL POLICY

In any company, certain common-sense rules of conduct and performance must be established for the employees to follow in order to avoid any misunderstanding and to protect the right of all concerned. Breaches of acceptable conduct which include, but are not limited to, abusive language, insubordination, intoxication, moral turpitude, or substance abuse/possession can lead to disciplinary action or to dismissal.

While performing any service for LBG or LBG's clients, employees, agents, and subcontractors of LBG shall not: (1) be under the influence of alcohol or any controlled substance; (2) use, possess, distribute, or sell illicit or unprescribed controlled drugs, drug paraphernalia, or alcoholic beverages; or (3) misuse legitimate prescription drugs.

LBG may remove from active project status any of its employees any time there is a reasonable basis for suspicion of alcohol/drug use, possession, or impairment involving such employee, and at any time an incident occurs where drug or alcohol use could have been a contributing factor. In such cases, employee may only be considered for return to work after LBG certifies as a result of a for-cause test, conducted immediately following removal, that said employee is in compliance with this policy.

LBG reserves the right to require drug and alcohol testing for its employees, either for its own purposes or at the direction of Clients. Such testing may take place periodically, or for specific projects. The testing will be in compliance with Department of Transportation drug testing regulations.

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APPENDIX B

LEGGETTE, BRASHEARS & GRAHAM, INC.
AIR MONITORING EQUIPMENT OPERATION

Instrument Calibration

All applicable instruments will be calibrated daily before use. Readings will be recorded on the Air Monitoring form.

Background Readings

Before any field activities commence, the background levels of the site must be read and noted. Daily background readings must be conducted away from areas of potential contamination to obtain accurate results.

Air Monitoring Frequency

All site readings must be noted on the Air Monitoring form along with the date, time, background level, weather conditions, wind direction and speed, and the location where the background level was recorded.

OVM 580B Calibration

- Turn the OVM on by pressing the ON/OFF switch.
- With the OVM running, press the MODE/STORE switch and then press the -/CRSR switch when the OVM reads if "logging is desired".
- Keep pressing the -/CRSR switch until OVM will display "reset to calibrate".
- Enter the calibration mode by pressing the RESET switch. The OVM will then display "restore backup + = Yes".
- Press the -/INC switch and the OVM will display "zero gas reset when ready".
- Connect zero gas to OVM and press RESET switch. The OVM will display "Model 580B zeroing".
- After the OVM calibrates the zero gas, it will display "span gas reset when ready".
- Connect span gas to OVM and press RESET switch.

- When OVM displays "reset to calibrate", the OVM has calibrated the span gas.
- To exit calibration mode, press MODE/STORE switch.

HNU PI-101 Calibration

- Battery check--The function switch should be turned to BATT. The needle should be in the green region; if not, recharge the battery.
- Zero set--The function switch should be turned to STANDBY. In this position, the lamp is OFF and no signal is generated. The zero point should be set with the ZERO set control.
- Gas standard--The standard should be connected to the probe. The function switch should be turned to the range position of the standard and the meter reading should be noted. The SPAN control setting should be adjusted, as required, to read the parts per million (ppm) concentration of the standard. The zero setting should be rechecked.
- Lamp cleaning--If the span setting from calibration is 0.0 or calibration cannot be achieved, then the lamp must be cleaned.
- Lamp replacement--If the lamp output is too low or if the lamp has failed, it must be replaced.

MSA Explosimeter Model 2A Calibration Instructions

Before the calibration can be checked, the instrument and its aspirator sampling bulb must be in operating condition, as described in the instrument instruction manual.

- The flow control should be attached to the calibration gas tank.
- The hose should be connected to the flow control and to the instrument inlet fitting.
- The control valve should be opened.
- The meter reading should be recorded after it stabilizes. Note: It is not necessary for the aspirator bulb to be operated for the calibration sample to be obtained. If the instrument does not read within the acceptable range, the detector filament unit should be replaced and the calibration check procedure should be repeated.
- The flow control valve should be closed.
- The hose should be removed from the flow control and from the inlet fitting on the

instrument.

- The flow control should be removed from the calibration gas tank.

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APPENDIX C

LEGGETTE, BRASHEARS & GRAHAM, INC.
VOLATILE ORGANIC COMPOUNDS
PROJECT WORK ZONE CONSIDERATIONS

1.0 EXCAVATION

The following requirements, which apply to all types of excavation operations, except tunnels and shafts, are taken from the U.S. Department of the Interior, Bureau of Reclamation's Construction Safety Standards. They are not intended to be an exhaustive set of requirements, but rather, a summary of current practices that are being enforced at construction activities by Federal and state government agencies and private industry. The requirements were assembled in cooperation with the Associated General Contractors of America, the American National Standards Institute, labor unions, and other interested in improving safety.

1.1 **Preliminary Inspection**

Prior to excavation, the site should be thoroughly inspected to determine conditions that require special safety measures. The location of underground utilities, such as sewer, telephone, gas, water, and electric lines, must be determined and plainly staked. Necessary arrangements must be made with the utility company or owner for the protection, removal, or relocation of the underground utilities. In such circumstances, excavation will be done in a manner that does not endanger the employees engaged in the work or the underground utility. Utilities left in place should be protected by barricading, shoring, suspension, or other measures, as necessary.

1.2 **Protection of the Public**

Necessary barricades, walkways, lighting, and posting should be provided for the protection of the public prior to the start of excavation. Excavation operations on or near state, county, or city streets, accessways, or other locations where there is extensive interface with the public and/or motorized equipment will not start until all of the following actions have been taken:

- The contractor has contacted the authority having jurisdiction and obtained written permission to proceed with protective measures required.

- The contractor, using the authority's instructions and these standards, has developed an extensive and detailed standard operating plan.
- The plan has been discussed with affected employees, and applicable protective measures are in place and functioning.

1.3 Access and Lighting

Safe access will be provided for employees, including installation of walkways, stairs, ladders, etc. When operations are conducted during hours of darkness, adequate lighting will be provided at the excavation, borrow pits, and waste areas.

Where employees are required to enter excavations over 4 feet in depth, stairs, ladders, or ramps must be provided, so as to require no more than 25 feet of lateral travel. When access to excavations exceeds 20 feet vertically, ramps, stairs, or personnel hoists should be provided. Ladders extending from the bottom of the trench to at least 3 feet above the top must be placed within 25 feet of workers in the trench.

1.4 Personal Protective Equipment

PPE will be provided and used in accordance with the specific requirements set forth in the plan. Drillers and helpers must wear approved safety goggles or safety glasses with side shields, hearing protection, hard hats, and safety shoes.

1.5 Removal of Trees and Brush

Prior to excavation, trees, brush, boulders, and other surface obstacles that present a hazard to employees should be removed.

1.6 Slide Prevention and Trenching Requirements

All trench excavations over 5 feet in depth must be shored, shielded, or sloped to the angle of repose from the bottom of the trench, but never less than 3/4 horizontal to 1 vertical (i.e., 37 degrees from vertical), or supported by structures designed by a professional engineer. Excavations should be inspected following rainstorms or other hazardous events. Additional protection against possible slides or cave-ins shall be provided, as necessary.

1.7 Angle of Repose

The determination of the angle of repose and design of supporting systems should be based on a thorough evaluation of all pertinent factors, including depth of cut; possible variation in water content of the material; anticipated changes in the material from exposure to air, sun, water, or freezing; loading imposed by structures, equipment, or overlying or stored material; and vibrations from sources such as traffic, equipment, and blasting. The angle of repose for all excavations, including trenching, should be determined by a professional engineer, but in no event should the slope be less than 3/4 horizontal to 1 vertical (i.e., 37 degrees from vertical) from the bottom of the excavation.

1.8 Support Systems

Materials used for support systems, such as sheeting, piling, cribbing, bracing, shoring, and underpinning, should be in good serviceable condition, and timbers should be sound and free of large or loose knots. The design of support systems should be based on calculations of the forces and their directions, with consideration for surcharges, the angle of internal friction of materials, and other pertinent characteristics of the material to be retained.

When tight sheeting or sheet piling is used; full loading due to the ground-water table should be assumed unless relieved by weep holes, drains, or other means. Cross braces and trench jacks should be placed in true horizontal position and secured to prevent sliding, falling, or kickouts. Additional stingers, ties, and bracing should be provided to allow for any necessary temporary removal of individual supports. Support systems should be planned and designed by a professional engineer competent in the field.

Backfilling and removal of trench support systems should progress together from the bottom of the trench. Jacks or braces should be released slowly. In unstable soil, ropes or other safe means will be used to remove the braces from the surface after workers have left the trench.

Special precaution must be taken in sloping or shoring the sides of excavations adjacent to a previously backfilled excavation or fill area. The use of compacted backfill as backforms on slopes that are steeper than the angle of repose of the compacted material in its natural state is prohibited.

1.9 Structural Foundations and Footings

Except in hard rock, excavations below the level of the base of any foundation, footing, or retaining wall will not be permitted unless the wall is underpinned and all necessary precautions are taken to ensure the stability of adjacent walls. If the excavation endangers the stability of adjacent buildings or structures, shoring, bracing, or underpinning designed by a qualified person will be installed. Such supporting systems must be inspected at least daily by qualified persons to ensure that protection is adequate and effectively maintained.

Small diameter footings that workers are required to enter, including bell-bottomed footings over 4 feet deep, must be provided with a steel casing or support system of sufficient strength to support the earth walls and prevent cave-ins. The casing or support system shall be provided for the full depth, except for the bell portion of bell footings.

Fixed or portable ladders must be provided for access. A lifeline, securely attached to a shoulder harness, should be worn by every employee entering the footing. The lifeline should be manned from above and should be separate from any line used to raise or lower materials.

1.10 Vertical Cuts and Slopes

Before a slope or vertical cut is undercut, the residual material must be adequately supported and the undercutting method and support system must be inspected.

When exposed to falling, rolling, or sliding rocks, earth, or other materials, employees working below or on slopes or cuts should be protected in the following manner:

- By effective <u>scaling</u> performed prior to exposure and at intervals necessary to eliminate the danger.
- By the installation of <u>rock bolting</u>, wire mesh, or equivalent support if the material continues to ravel and fall after scaling.
- By the installation of protective timber or wire mesh <u>barricades</u> at the slope of the cut and at necessary intervals down the slope. Wherever practical, benching sufficient to retain falling material may be used in lieu of barricades.
- By ensuring that personnel do not work above one another where there is danger of falling rock or earth. Personnel performing work on vertical cuts or slopes

where balance depends on a supporting system must wear appropriate safety equipment.

1.11 Ground Water

Ground water should be controlled. Freezing, pumping, draining, and other major control measures should be planned. Full consideration should be given to the existing moisture balance in surrounding soil and the effects on foundations and structures if it is disturbed. When continuous operation of ground-water control equipment is necessary, an emergency power source should be provided.

1.12 Surface Water

The accumulation of surface water in excavations must not be permitted and should be controlled by diversion ditches, dikes, dewatering sumps, or other effective means.

1.13 Excavated Materials

Excavated materials should be laced and retained at least 2 feet from the depth of the excavation, or at a greater distance when required to prevent hazardous loading on the face of the excavation.

1.14 Protective Devices

Guardrails, fences, barricades, and warning lights or other illumination systems will be maintained from sunset to sunrise on excavations adjacent to walkways, driveways, and other pedestrian or vehicle thoroughfares. Walkways or bridges that are protected by standard guardrails should be provided where employees are required or permitted to cross over excavations.

Wells, calyx holes, pits, shafts, and all similar hazardous excavations must be effectively barricaded or covered and posted. All temporary excavations of this type should be backfilled as soon as possible. When mobile equipment is permitted adjacent to excavations with steep slopes or cuts, substantial stoplogs or barricades should be installed.

1.15 Equipment Operation

Equipment that is operated on loading or waste areas must be equipped with an automatic backup alarm. Additionally, when employees are on foot or otherwise endangered by equipment in dumping or waste areas, a competent signalman should be used to direct traffic. The signalman must have no other assignment that interferes with signaling duties. If the equipment or truck cab is not shielded, the operator should stand clear of the vehicle during loading. Excavating or hoisting equipment should not be allowed to raise, lower, or swing loads over workers unless effective overhead protection is provided.

1.16 Drilling Operations

When drilling in rock or other dust-producing material, the dust should be controlled within the OSHA Permissible Exposure Limits (PELs). Except in shaft and tunnel excavation, dust control devices are not required on jackhammers as long as the operators wear approved dust respirators.

2.0 DRILLING SAFETY

2.1 Basic Requirements

Employees will not proceed with work on, or in the proximity of, hazardous equipment until they have been properly trained and have received a safety briefing. If drilling is at a hazardous substance site, the site-specific safety plan must be reviewed onsite and discussed in the safety briefing.

Potential hazards (e.g., overhead or underground power, oil, or gas lines in the immediate vicinity of the drilling location) must be removed, avoided by relocating the drill site, or adequately barricaded to eliminate the hazard.

The use of unsafe or defective equipment is not permitted. Equipment must be inspected regularly and, if found to be defective, must be immediately removed from use and either repaired or replaced.

Employees will be familiar with the location of first-aid kits and fire extinguishers. Telephone numbers for emergency assistance must be prominently posted and kept current.

2.2 General Requirements at Drilling Operations

2.2.1 Housekeeping

Good housekeeping conditions should be observed in and around the work area. Suitable storage places should be provided for all materials and supplies. Pipe, drill rods, etc., must be securely stacked on solid, level sills.

Work surfaces, platforms, stairways, walkways, scaffolding, and accessways will be kept free of obstructions. All debris will be collected and stored in piles or containers for removal and disposal.

2.2.2 Salamander Heaters

Salamanders will be used only with approved fuels (e.g., do not use gasoline). Salamander heaters must not be refueled or moved until they have been extinguished and permitted to cool. Heaters will be equipped with exhaust stacks and will not be set on or placed near combustible material. They should be equipped with metal stands that will provide adequate stability and permit at least a 2-inch clearance under the unit.

Burning salamanders must be attended at all times, with suitable fire extinguishers available to each attendant. If tarpaulins or other flexible materials and used to form a heating enclosure, they must be fire resistant and installed to prevent contact with the heater. Worn salamanders that have developed holes or have been otherwise damaged will be replaced and removed from service.

2.2.3 Lighting

In addition to providing required or recommended illumination intensities of at least 5 foot-candles, consideration should be given to the selection and placement of lighting equipment. Proper lighting should provided minimum glare, eliminate harsh shadows, and provide adequate illumination to perform work efficiently and safely.

Light bulbs should be of the heavy duty, outdoor, nonshattering type.

All lighting circuits, including drop cords, should be grounded and have ground fault interrupters. Lighting circuits will be inspected periodically, and defective wiring or fixtures will be removed from service.

2.2.4 Flammable Liquids

All highly flammable liquids should be stored and handled only in approved containers. Portable containers must be the approved red safety containers equipped with flame arresters and self-closing lids.

Approved hand pumps will be used to dispense gasoline from barrels. Gasoline must not be used for degreasing or to start fires. Also, gasoline containers should be clearly labeled, and storage areas should be posted with "No Smoking" signs. Fire extinguishers should be installed in all areas that contain flammable liquids.

2.2.5 Public Safety

Work areas will be regulated so that the public will be protected from injury or accident. Adequate danger signs, barriers, etc., will be placed to effectively warn the public of hazards as well as to restrict access to dangerous areas.

2.3 Off-Road Movement of Drill Rigs

The following rules apply to the off-road movement of drill rigs:

- Before moving a drill rig, an inspection should be made of the route of travel for depressions, slumps, gullies, ruts, and similar obstacles.
- The brakes of a drill rig carrier should always be checked before traveling, particularly on rough, uneven, or hilly ground.
- All passengers should be discharged before a drill rig is moved on rough or hilly terrain.
- The front axle of 4 x 4 or 6 x 6 vehicles or carriers should be engaged when traveling off-road on hilly terrain.
- Caution should be used when traveling on a hillside. The hillside capability of drill rigs should be evaluated conservatively, because the addition of drilling tools may raise the center of mass. When possible, travel should be made directly uphill or downhill.
- Obstacles such as small logs, small erosion channels, or ditches should be crossed squarely, not at an angle.

- When lateral or overhead clearance is close, someone on the ground should act as a guide.
- After the drill rig has been moved to a new drilling site, all brakes or locks should be set. Wheels should be blocked on steep grades.
- The mast (derrick) of the drill rig should not be in the raised or partially raised position during off-road travel.
- Loads on the drill rig and supporting trucks should be tied down during transport.

2.4 Drilling Equipment

2.4.1 Skid-Mounted Units

Labels clearly indicating the function and direction of control levers should be posted on the lower unit controls of all drills.

An emergency safety power shutoff device should be installed within reach of the operator on all units. The device should be clearly labeled or otherwise made readily identifiable and checked daily to ensure that it is operable. The power unit should be operated only by authorized and qualified personnel.

Equipment will be shut down during manual lubrication and while repairs or adjustments are being made. Equipment such as internal combustion engines will not be refueled while running. Where practical, the gasoline tank should be positioned or shielded to avoid accidental spillage of fuel on the engine or exhaust manifold during refueling operations. Hazardous gears and moving parts also should be shielded to prevent accidental contact.

A dry chemical or carbon dioxide fire extinguisher, rated 5 pounds or larger, should be carried on the unit and removed to a position within 25 feet of the work site during drilling operations. Extinguishers will be inspected and tagged at least once every 3 months.

Engine exhaust systems should be equipped with spark arresters when operated in areas where sparks constitute a fire hazard.

2.4.2 Overhead and Underground Utilities

Special precaution must be taken when using a drill rig on a site within the vicinity of electrical power lines and other utilities. Electricity can shock, burn, and cause death.

Overhead and underground utilities should be located, noted, and emphasized on all boring location plans and assignment sheets. When overhead electrical power lines exist at or near a drilling site, all wires should be considered dangerous.

A check should be made for sagging power lines before a site is entered. Power lines should not be lifted to gain entrance. The appropriate utility company should be contacted and a request should be made that it lift or raise and cut off power to the lines.

The area around the drill rig should be inspected before the drill rig mast (derrick) is raised at a site in the vicinity of power lines. The minimum distance from any point on the drill rig to the nearest power line should be determined when the mast is raised or is being raised. The mast should not be raised and the drill rig should not be operated if this distance is less than 20 feet, because hoist lines and overhead power lines can be moved toward each other by the wind.

The existence of underground utilities, such as electric power, gas, petroleum, telephone, sewer, and water lines, should always be suspected. These underground electric lines are as dangerous as overhead lines, so a utility locating service should always be contacted.

There are generally two types of utility locating services. One is a "free" service that is paid for by companies with underground pipes, lines, etc., to protect the public and to prevent costly repairs. However, these services have access only to drawings for primary pipes or lines, typically on public property or right-of-way easements, but not to drawings showing supply or feeder lines from a primary system to the interior of a property. Therefore, they are not required, and in fact hesitate, to locate interior lines. Sites can be cleared for drilling by such services, but without the drill operator's knowledge of the locations of underground feeder or supply lines.

A second type of locating service is provided by a paid subcontractor who physically sweeps or clears interior locations using locating equipment. Locating costs can be minimized by obtaining all available maps, drawings, and employee interview information before contracting with the locating company. This is especially important at large industrial plants or military bases, which can have an intricate network of underground utilities. It is important that every location be cleared, even those for hand-auger borings.

If a sign warning of underground utilities is located on a site boundary, it should not be assumed that underground utilities are located on or near the boundary or property line under the sign; they may be a considerable distance from the sign. The utility company should be contacted to check it out.

The owners of utility lines or the nearest underground utility location service should always be contacted before drilling is started. However, remember that some services provide information on utilities going to, but not within, a site. Metal detectors or other locating equipment may be necessary to determine the presence of shallow (surface) utilities onsite. The utility personnel should mark or flag the location of the underground lines and determine what specific precautions must be taken to ensure safety.

2.4.3 Site Selection and Working Platforms

In preparing a work site located on adverse topography, precautions must be taken against cave-ins, slides, and loose boulders. The drill platform should be stabilized by outriggers or adequate timbering.

Prior to drilling, adequate site clearing and leveling should be performed to accommodate the drill rig and supplies and to provide a safe working area. Drilling should not commence when tree limbs, unstable ground, or site obstructions result in unsafe tool-handling conditions.

Suitable storage locations should be provided that allow for the convenient handling of tools, materials, and supplies without danger that they could fall and injure anyone. Storing or transporting tools, materials, or supplies within or on the drilling mast (derrick) should be avoided. Pipes, drill rods, bits, casings, augers, and similar drilling tools should be securely stacked in an orderly manner on racks or sills.

Penetration hammers or other types of driving hammers should be placed at a safe location on the ground or secured when unattended on a platform. Work areas, platforms, walkways, scaffolding, and other accessways should be kept free of obstructions and substances such as ice, grease, or oil that could create a hazardous surface. All controls, control linkages, and warning and operation lights and lenses also should be kept free of ice, grease, or oil.

In the vicinity of power transmission or distribution lines, drills should be adequately grounded and set with at least a 15-foot clearance between any part of the drill or mast and the power lines.

Toilet facilities will be convenient to drill crews, or transportation will be readily available to nearby toilet facilities. Toilets will be either the chemical type or constructed over ground pits, which will be backfilled when abandoned. They should be fly tight and maintained in a sanitary condition.

Mud pits and drainage excavations should be safely sloped and located to provide minimum interference with work. Where necessary, suitable barricades, catwalks, etc., should be provided to reduce the possibility of personal injury. Ladders will be positioned in pits or excavations that are 5 or more feet deep. Such excavations should be periodically inspected to ensure safe operation and adequate maintenance.

Truck-mounted drills will be equipped with a "safetyline" or with clearly marked and conspicuously located emergency switches. The safetyline emergency stop consists of a taut wire that runs around the back of the machine and connects to a special switch that turns off the power unit when the line is contacted. When emergency switches are used in lieu of a safetyline, there should be a minimum of two switches--one located within easy reach of the operator, and one located within easy reach of workers at ground level near the drill or auger head.

Trucks should not be moved backward unless the driver has personally inspected the area behind the truck. In restricted or congested areas, or areas where workmen are located, the assistance of a "spotter" is mandatory. Also, trucks will be equipped with serviceable automatic backup alarms.

Before the mast is raised, personnel will be cleared from the immediate area--with the exception of the operator and a helper, when necessary. A check should be made to ensure safe clearance from energized power lines or equipment. Unsecured equipment must be removed from the mast, and cables, mud lines, and catline ropes must be adequately secured to the mast before raising. After it is raised, the mast must be secured to the rig in an upright position with steel pins.

Drill equipment will not be moved until a thorough inspection has been made to ensure that the mast, drill rods, tools, and other equipment are secured. A check will also be made of the steering mechanism, brakes, lights, load limits, and proper flagging and lighting of load extensions. Applicable traffic laws will be observed when moving drill equipment over public roads.

2.5 Surface Drilling Operations

Before the mast of a drill rig is raised and drilling is commenced, the drill rig must first be leveled and stabilized with leveling jacks and/or solid cribbing. The drill rig should be releveled if it settles after the initial setup. The mast should only be lowered when the leveling jacks are down, and the leveling jack pads should not be raised until the mast is completely lowered. Before drilling operations start, the mast should be secured or locked, if required by the drill's manufacturer.

Before the power unit is started, all gears should be disengaged, the cable drum brake should be set, and no rope should be in contact with the cathead.

Before the mast is raised, a check should be made for overhead obstructions. Everyone (with the exception of the operator) should be cleared from the areas immediately to the rear and sides of the mast and informed that the mast is being raised. The drill rig should not be driven from hole to hole with the mast in the raised position.

The drill rig should only be operated from the position of the controls. The operator should shut down the drill engine before leaving the vicinity of the drill. "Horsing around" in the vicinity of the drill rig and tool and supply storage areas is strictly prohibited, even when the drill rig is shut down. Caution should be taken when mounting/dismounting the platform.

Drill operations should be terminated during an electrical storm.

The consumption of alcoholic beverages, depressants, stimulants, or any other chemical substance while on the job is strictly prohibited. All unattended boreholes must be adequately covered or protected to prevent people or animals from stepping or falling into the hole. When the drilling project has been completed, all open boreholes should be adequately covered, protected, or backfilled, according to local or state regulations.

A safety chain and cable arrangement should be used to prevent water swivel and mud line whip. All water swivels and hoisting plugs should be checked for possible frozen bearings and should be properly lubricated before use. A frozen bearing could cause mud line whip, which could injure the operator.

Only drill operators should brake or set the chucks to prevent engagement of the transmission prior to removal of the chuck wrench. Also, the chuck jaws should be periodically checked and replaced as necessary.

A string of drill rods should not be braked by the chuck jaws during lowering into the hole. A catline or hoisting cable and plug should be used for braking prior to tightening of the chuck. Failure to follow this procedure could result in steel slivers on the rods, possible hand injuries, and loss of the rods into the hole. Following braking, drill rods should be allowed to drain completely before removal from the working area.

Drill rods will not be lowered into the hole with a pipe wrench. Serious back and hand injuries may result if the rods are lowered by this method.

When using drilling fluids, a rubber or other suitable wiper should be used to remove the material from the drill rods when removing them from the drill hole. When drilling with air, the exhaust and cuttings should be directed away from workers with devices such as diverter heads, the use of which should be stipulated on drilling agreements where appropriate.

Care must be exercised by the operator to avoid a sudden hoist release of the drill rod while the rod is being carried from the hole. The hoisting capacity and weight of the drill rod must be known to prevent collapse of the mast during drill string removal from the hole. The operating capacity of the mast and hoist also must be known and must not be exceeded.

When tool joints are broken on the ground or on a drilling platform, fingers should be positioned so they will not be caught between the wrench handle and the ground or the platform if the wrench slips or the joint suddenly lets go. Pipe wrench jaws should be checked periodically and replaced as they become worn.

2.6 Use of Augers

The use of mismatched auger sections should be avoided. Different brands and different weights should not be used in the same auger flight.

Because some pins lose their temper after very little use, causing the spring or clip section to fail, only tight-fitting pins designed for the auger should be used.

A daily inspection--to include a thorough check of the hydraulic hoses, connections, and valves--will be made before equipment is used. Deficiencies should be corrected or safe condition verified before the equipment is started.

A durable sign containing the following wording should be installed on all equipment in full view of the operator:

- All personnel must be clear before starting this machine
- Stop the auger to clean it
- Stop engine when repairing, lubricating, or refueling
- Do not wear loose-fitting clothing or gauntlet-type gloves.

The following general procedures should be used when advancing a boring with continuous flight or hollow-stem augers:

- An auger boring should be started with the drill rig level, the clutch or hydraulic rotation control disengaged, the transmission in low gear, and the engine running at low revolutions per minute (rpm).
- A system of responsibility should be established for the series of activities required for auger drilling, such as connecting or disconnecting auger sections and inserting or removing the auger fork. The operator must be sure that the tool handler is well away from the auger column and that the auger fork has been removed before rotation is started.
- Only the manufacturer's recommended method of securing the auger to the power coupling should be used. The coupling or the auger should not be touched with the hands, a wrench, or any other tool during rotation.
- Tool hoists should be used to handle auger sections whenever possible. Hands or fingers should never be placed under the bottom of an auger section when the auger is being hoisted over the top of the auger section in the ground or other hard surface, such as the drill rig platform. Feet should never be allowed to get under the auger section that is being hoisted.
- Workers should stay clear of the auger and other rotating components of the drill rig. Workers should never reach behind or around a rotating auger for any reason.
- Hands or feet should never be used to remove cuttings from the auger.
- Augers should be cleaned only when the drill rig is in neutral and the augers have stopped rotating. A special paddle should be designed for cleaning auger flights; if available, pressurized water is recommended for jet cleaning.

3.0 REMEDIATION SYSTEM EQUIPMENT

LBG operates remediation system equipment at various sites. Remediation equipment includes but is not limited to pump and treat, soil vapor extraction, two-phase vapor extraction, liquid and vapor phase granular activated carbon, thermal destruction and air stripping tower systems. This brief list of safety requirements cover hazards specific to this type of operation. The list assumes that safety requirements for standard operations inherent in SVE operations are already being followed, such as 29 CFR 1910.120 "Hazwoper" planning, training, and other requirements; or drilling, trenching, and shoring safety practices.

The components of a typical remediation system equipment can include an electric or gasoline powered motor, a carbo absorption bed, and various filters, piping, and controls.

3.1 Basic Requirements

3.1.1 General

Employees will not proceed with work on, or in the proximity of, the remediation equipment until they have been properly trained and have attended a safety briefing covering the hazards involved. This may in the form of a "tailgate" safety briefing or a more extensive session, depending upon the extent of the hazards, the employees' safety knowledge, and site-specific exposures.

The use of unsafe or defective equipment is not permitted. Equipment must be inspected regularly and, if found to be defective, immediately removed from use and repaired or replaced.

Employees should be familiar with the location of first-aid kits and fire extinguishers. Telephone numbers or radio frequencies for emergency assistance must also be prominently posted and kept current.

3.1.2 Housekeeping

Good housekeeping practices should be observed in and around the work area. Suitable storage should be provided for all materials and supplies.

Any work surfaces, platforms, stairways, walkways, scaffolding, or accessways should be kept free of obstructions. Any debris should be collected and stored in piles or containers for removal and proper disposal.

3.1.3 Flammable Liquids

All highly flammable liquids should be stored and handled only in approved containers. Portable containers must be of the approved, red safety container type, equipped with flame arresters and self-closing lids.

Approved hand pumps should be used to dispense gasoline from drums. Gasoline must not be used for degreasing or starting fires. Also, gasoline containers should be clearly labeled, and any storage areas should be posted with "No Smoking" signs. Fire extinguishers should be installed in all areas that contain flammable liquids.

3.1.4 Public Safety

Work areas should be regulated so that the public will be protected from injury or accident. Adequate danger signs, barriers, etc., should be placed to effectively warn the public of hazards as well as to restrict access to dangerous areas.

3.1.5 Drilling Safety

Construction of soil-vapor extraction systems requires installation of soil-vapor extraction wells and separate air inlet wells. Safety requirements for drilling operations should be followed.

3.2 Specific Requirements

3.2.1 Chemical Hazards

Some of the primary chemical hazards at remediation operations are site contaminants related to volatile organic compounds. Typically, contaminants are drawn from extraction wells and treated with carbon absorption units and/or are incinerated. Additional chemical hazards associated with these treatment technologies include fuel for the incinerator and activated carbon saturated with site contaminants. Manufacturers' Material Safety Data Sheets should be available on site for all neat chemical compounds used.

Personnel can be exposed to site contaminants during sampling and equipment maintenance. Because soil-vapor extraction systems are typically closed systems terminating in contaminant oxidization or absorption apparatus, chances of exposure incidents during normal operations are minimal. If chemical exposure occurs, however, it is most likely during sampling or equipment maintenance. Sampling typically includes sampling of site soils or ground water to measure the long-term effectiveness of remediation activities, or sampling process water or vapors to determine the efficiency of treatment technologies in capturing or destroying the contaminants.

A potential for exposure exists during maintenance procedures because of cleaning sediment from knockout pots and from general piping system repairs.

In order to minimize the potential hazards associated with chemical exposure, all site workers should have a knowledge of particular site hazards and contaminants. Based upon site conditions, proper personal protective equipment should be worn such as hard hats, chemical protective clothing, and safety shoes.

3.2.2 Physical Hazards

Physical hazards can be managed by general housekeeping in work areas and routine equipment maintenance. Scaffolding may be erected around water stripping towers and incinerators and should be inspected periodically, as part of a routine maintenance procedure.

3.2.3 Pressure

Remediation systems typically recover soil vapors or ground water from beneath the ground surface. Remedial equipment should be shut off when maintenance activities or repairs occur.

3.2.4 Electric Hazards

Because several types of equipment in remediation systems are commonly powered by electricity, electrical hazards exist at these remedial sites. Liquid ring vacuum pumps, knockout pumps, air stripper holding tanks and pumps, and other elements of the treatment units are frequently powered by electricity. General housekeeping and equipment maintenance are necessary to prevent electrical safety hazards. Worn switches and wiring should be quickly repaired, use of water should be controlled, and unnecessary spills prevented. Ground fault interrupters (GFI) should be used on all circuits carrying power from a nearby indoor source to outdoor equipment or from an outdoor portable generator to equipment. Equipment should also be properly grounded as a protection against shocks, static electricity, and lightning if an electrical storm occurs.

3.2.5 Lighting

In addition to providing required or recommended illumination intensities of at least 5 foot-candles for nighttime operation, consideration should be given to the selection and placement of lighting equipment. Proper lighting should provide minimum glare, eliminate harsh shadows, and provide adequate illumination to perform work efficiently and safely. Light bulbs should be of the heavy duty, outdoor, nonshattering type.

All lighting circuits, including extension cords, should be grounded and have GFI protection. Circuits and extension cords should be inspected periodically.

3.2.6 Incinerator/Treatment System

Thermal hazards exist with incinerators, and boundaries should be set up to prevent contact with headed surfaces. Additionally, proper thermal protection should be available for personnel working at the incinerator. Vapor extractor pumps should be set to shut off automatically if the incinerator shuts off, to prevent accumulation of high concentrations of volatile compounds that could result in an explosion hazard.

3.2.7 Carbon Bed Temperature

A hazard related to carbon absorption units is the heat of reaction, which is high for some materials, such as ketones, treated in high concentrations. SVE equipment should be designed to take this into account when carbon absorption is employed and the bed temperature must be monitored.

Typically, but not limited to, two carbon units will be piped in series to treat the recovered vapors. Carbon units will be changed out according to the air permit guidelines.

When carbon units are changed out, the primary unit will be taken off line, the secondary unit will become the primary unit, and a fresh carbon vessel will become the secondary unit.

All field activities will be initiated in Level D. If the action levels specified in Table 5-1 are reached, an upgrade will be made to Level C.

3.2.8 Vapor Emission Response Plan

If the air concentration of (chlorinated) organic vapors exceeds 5 ppm above background in the exhaust of the treatment system, the system exhaust will be continuously monitored and necessary actions will be taken to reduce system emissions to 5 ppm--for example, by bleeding air into the system, changing carbon canisters, etc. If the organic vapor levels measured in the treatment system exhaust are between 5 ppm and 50 ppm above background, continue site activities and perform continuous monitoring. If the organic vapor level exceeds 50 ppm above background in the treatment system exhaust, shut down work activities until the system is repaired.

Prior to beginning construction activities, notify fire departments and police as well as the local emergency facility of planned site activities. These organizations should be briefed on the nature of planned site work and given a schedule of the proposed tasks. Changes or modifications to the planned work or schedule which could affect the need for emergency services shall be communicated to these organizations. LBG shall communicate to the local hospital and fire department what types of materials may be encountered at the site.

Should the level of total (chlorinated) hydrocarbons exceed 100 ppm for any single reading, or should the explosimeter indicate in excess of 10 percent of the lower explosive limit on any single reading, work in that area will be shut down and personnel will be evacuated upwind. Work will not resume there until authorized by the Site Safety Officer.

3.2.9 System Start-Up and Initial Operating Period

The VE system is designed to operate unattended 24 hours per day, 7 days per week. Once the electrical connections are complete, LBG will begin system start-up.

LBG will monitor the system on a weekly basis during the month of operation. LBG field personnel will use a photoionization detector (PID) to monitor the VE system emissions before GAC treatment. LBG will monitor between GAC units and at the point of vapor emissions to determine GAC breakthrough and compare those concentrations to air emissions standards. These measurements will be used to estimate the amount of VOCs removed from the soil and the rate at which the GAC is being used to treat vapor phase emissions. As part of the daily monitoring, LBG will follow the Vapor Emission Response Plan.

3.2.10 Continued Operations and Maintenance

After the first month of operation, LBG will monitor the system biweekly for the second and third month. From the beginning of the fourth month to the remainder of the treatment period, LBG will monitor the system once a month. The following data will be recorded on each visit:

- Operating time
- Applied vacuum at blower inlet
- Induced vacuum at air inlet wells
- Vapor temperature at blower inlet
- Vapor temperature at blower outlet
- Pressure at blower outlet
- Concentrations of VOCs at blower outlet
- Concentrations of VOCs in treated emissions.

LBG field personnel will analyze and record the vapor-phase VOC concentrations before and after GAC treatment.

APPENDIX D

DECONTAMINATION PROCEDURES

Procedure for Level C Decontamination

Level C decontamination, if required, will take place on plastic sheeting so all contaminated material can be contained for proper disposal.

Station 1: Segregated Equipment Drop

Deposit equipment used onsite (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths or in different containers with plastic liners. Segregation at the drop reduces the probability of cross-contamination.

Equipment: various size containers
plastic liners
plastic drop cloths

Station 2: Suit/Safety Boot Wash

Thoroughly wash splash suit and safety boots. Scrub with long-handle, soft-bristle scrub brush and copious amounts of decon solution or detergent/water. Repeat as many times as necessary.

Equipment: container (30-50 gallons)
decon solution
or
detergent/water
2-3 long-handle, soft-bristle scrub brushes

Station 3: Suit/Safety Boot Rinse

Rinse off decon solution or detergent/water using copious amounts of water. Repeat as many times as necessary.

Equipment: container (30-50 gallons)

or

high-pressure spray unit

water

2-3 long-handle, soft-bristle scrub brushes

Station 4: Canister or Mask Change

If worker leaves Exclusion Zone to change canister (or mask), this is the last step in the decontamination procedure. Worker's canisters will be exchanged, depositing the old canisters in containers with plastic liners. The worker will enter the work area and return to duty.

Equipment: canister (or mask)

boot covers

gloves

Station 5:

Step 1 - Tape, Safety Boot and Outer Glove Removal

Remove safety boots and gloves and deposit in container with plastic liner.

Equipment: container (30-50 gallons)

plastic liners

bench or stool

boot jack

Step 2 - Splash Suit Removal

With assistance of helper, remove splash suit. Deposit in container with plastic liner.

Equipment: container (30-50 gallons)

bench or stool

liner

Step 3 - Facepiece Removal

Remove facepiece. Avoid touching face with gloves. Deposit facepiece in container with plastic liner.

Equipment: container (30-50 gallons)
plastic liners

Masks will be collected at a central location. Decontamination will be performed as follows:

- remove all cartridges, canisters and filters, plus gaskets or seals not affixed to their seats;
- remove elastic headbands;
- remove exhalation cover;
- remove speaking diaphragm or speaking diaphragm-exhalation valve assembly;
- remove inhalation valves;
- wash facepiece and breathing tube in cleaner mixed with warm water, preferably at 120°F to 140°F; wash components separately from the face mask; remove heavy soil from surfaces with a hand brush;
- remove all parts from the wash water and rinse twice in clean warm water;
- air dry parts in a designated clean area; and,
- wipe facepiece, valves and seats with a damp lint-free cloth to remove any remaining soap or other foreign materials.

Station 6: Inner Glove Removal

Remove inner gloves and deposit in container with plastic liner.

Equipment: container (20-30 gallons)
plastic liners

Station 7: Inner Clothing Removal (optional)

Remove clothing soaked with perspiration. Place in container with plastic liner. Do not wear inner clothing offsite if there is a possibility small amounts of contaminants might have been transferred in removing splash suit.

Equipment: container (30-50 gallons)
plastic liners

Station 8: Field Wash (optional)

Shower if highly toxic, skin-corrosive or skin-absorbable materials are known or suspected to be present. Wash hands and face if shower is not available.

Equipment: water
soap
tables
wash basins/buckets
field showers

Station 9: Redress

Put on clean clothes. A dressing trailer is needed in inclement weather.

Procedure for Level B Decontamination

Level B decontamination, if required, will take place on plastic sheeting so all contaminated material can be contained for proper disposal.

Station 1: Segregated Equipment Drop

Deposit equipment used onsite (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths or in different containers with plastic liners. Each will be contaminated to a different degree. Segregation at the drop reduces the probability of cross-contamination.

Equipment: various size containers
plastic liners
plastic drop cloths

<u>Station 2</u>: Suit/Safety Boot Wash

Thoroughly wash chemical-resistant splash suit, SCBA, gloves, and safety boots. Scrub with long-handle, soft-bristle scrub brush and copious amounts of decon solution or detergent/water. Wrap SCBA regulator (if belt-mounted type) with plastic to keep out water. Wash backpack assembly with sponges or cloths.

Equipment: container (30-50 gallons)
decon solution
or
detergent/water
2-3 long-handle, soft-bristle scrub brushes
sponges or cloths

<u>Station 3</u>: Suit/SCBA/Boot/Glove Rinse

Rinse off decon solution or detergent/water using copious amounts of water. Repeat as many times as necessary.

Equipment: container (30-50 gallons)
or
high-pressure spray unit
water
small buckets
2-3 long-handle, soft-bristle scrub brushes
sponges or cloths

Station 4: Tank Change

If worker leaves Exclusion zone to change air tank, this is the last step in the decontamination procedure. Worker's air tank is exchanged and worker returns to duty.

Equipment: air tanks
tape
boot covers
gloves

Station 5: Tape, Safety Boot and Outer Glove Removal

Remove safety boots and gloves and deposit in container with plastic liner.

Equipment: container (30-50 gallons)
plastic liners
bench or stool
boot jack

Station 6: SCBA Backpack Removal

While still wearing facepiece, remove backpack and place on table. Disconnect hose from regulator valve and proceed to next station.

Equipment: table

Station 7: Splash Suit Removal

With assistance of helper, remove splash suit. Deposit in container with plastic liner.

Equipment: container (30-to gallons)
plastic liners
bench or stool

Station 8: Facepiece Removal

Remove facepiece. Avoid touching face with gloves. Deposit in container with plastic liner.

Equipment: container (30-50 gallons)
plastic liners

Masks will be collected at a central location. Decontamination will be performed as follows:

- remove all cartridges, canisters and filters, plus gaskets or seals not affixed to their seats;
- remove elastic headbands;
- remove exhalation cover;
- remove speaking diaphragm or speaking diaphragm-exhalation valve assembly;
- remove inhalation valves;
- wash facepiece and breathing tube in cleaner mixed with warm water, preferably 120°F to 140°F; wash components separately from the face mask; remove heavy soil from surfaces with a hand brush;
- remove all parts from the wash water and rinse twice in clean warm water;
- air dry parts in a designated clean area; and,
- wipe facepiece, valves and seats with a damp lint-free cloth to remove any remaining soap or other foreign materials.

Station 9: Inner Glove Removal

Remove inner gloves and deposit in container with plastic liner.

Equipment: container (20-30 gallons)
plastic liners

Station 10: Inner Clothing Removal (optional)

Remove clothing soaked with perspiration. Place in container with plastic liner. Do not wear inner clothing offsite since there is a possibility small amounts of contaminants might have been transferred in removing fully encapsulating suit.

Equipment: container (30-50 gallons)
plastic liners

Station 11: Field Wash (optional)

Shower if highly toxic, skin-corrosive, or skin-absorbable materials are known or suspected to be present. Wash hands and face if shower is not available.

Equipment: water
soap
small tables
basins or buckets
field showers

Station 12: Redress

Put on clean clothes. A dressing trailer is needed in inclement weather.

Equipment: tables
chairs
lockers
clothes

Procedures for Level A Decontamination

(to be formulated on a case-by-case basis)

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May 17, 2002
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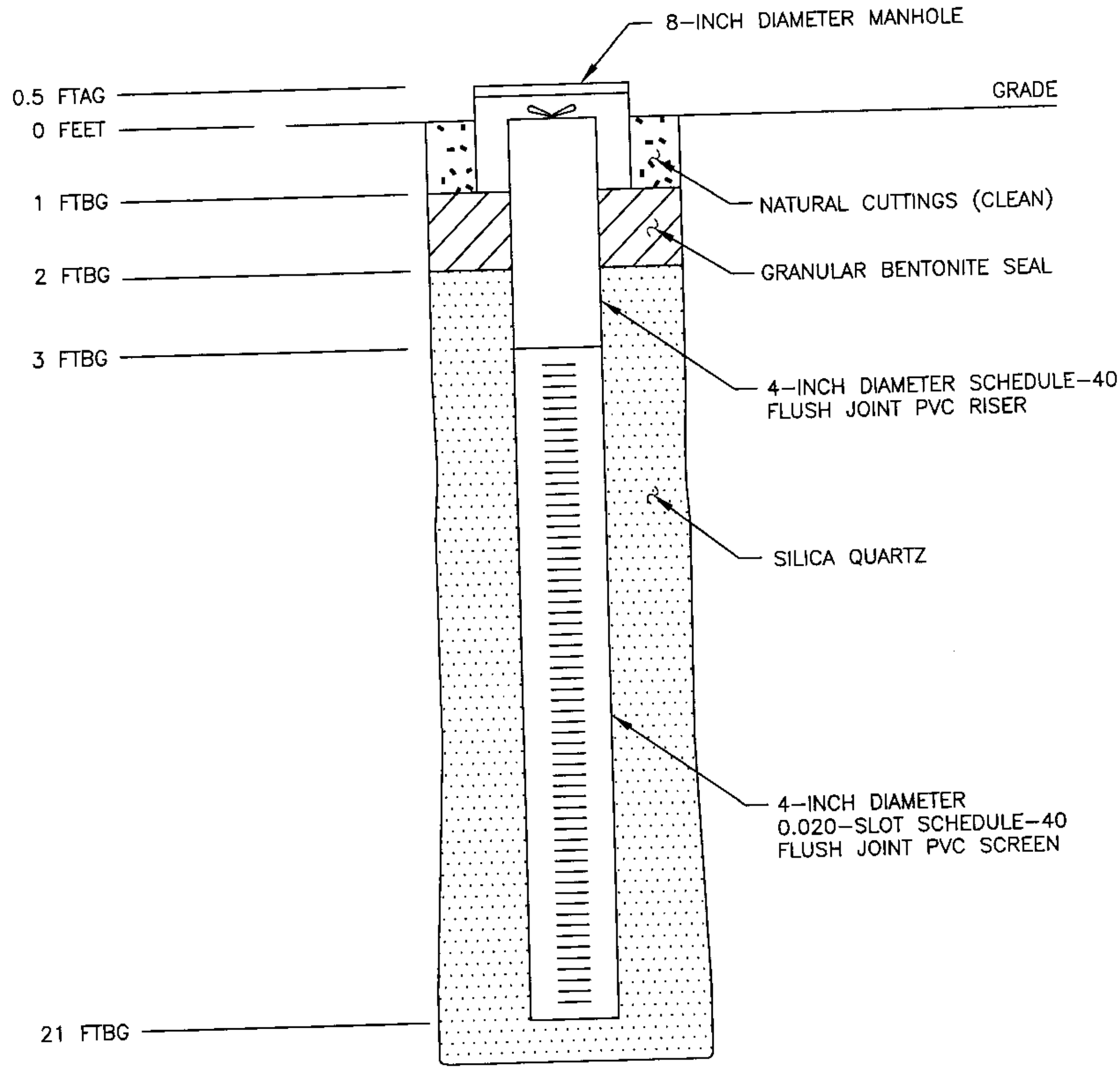
APPENDIX II

GEOLOGIC LOGS AND SOIL VAPOR EXTRACTION WELL CONSTRUCTION DIAGRAMS



NOT TO SCALE

VOLUNTARY CLEANUP PROGRAM INDEX #D2-0023-00-08
21-16 44TH ROAD
LONG ISLAND CITY, NEW YORK

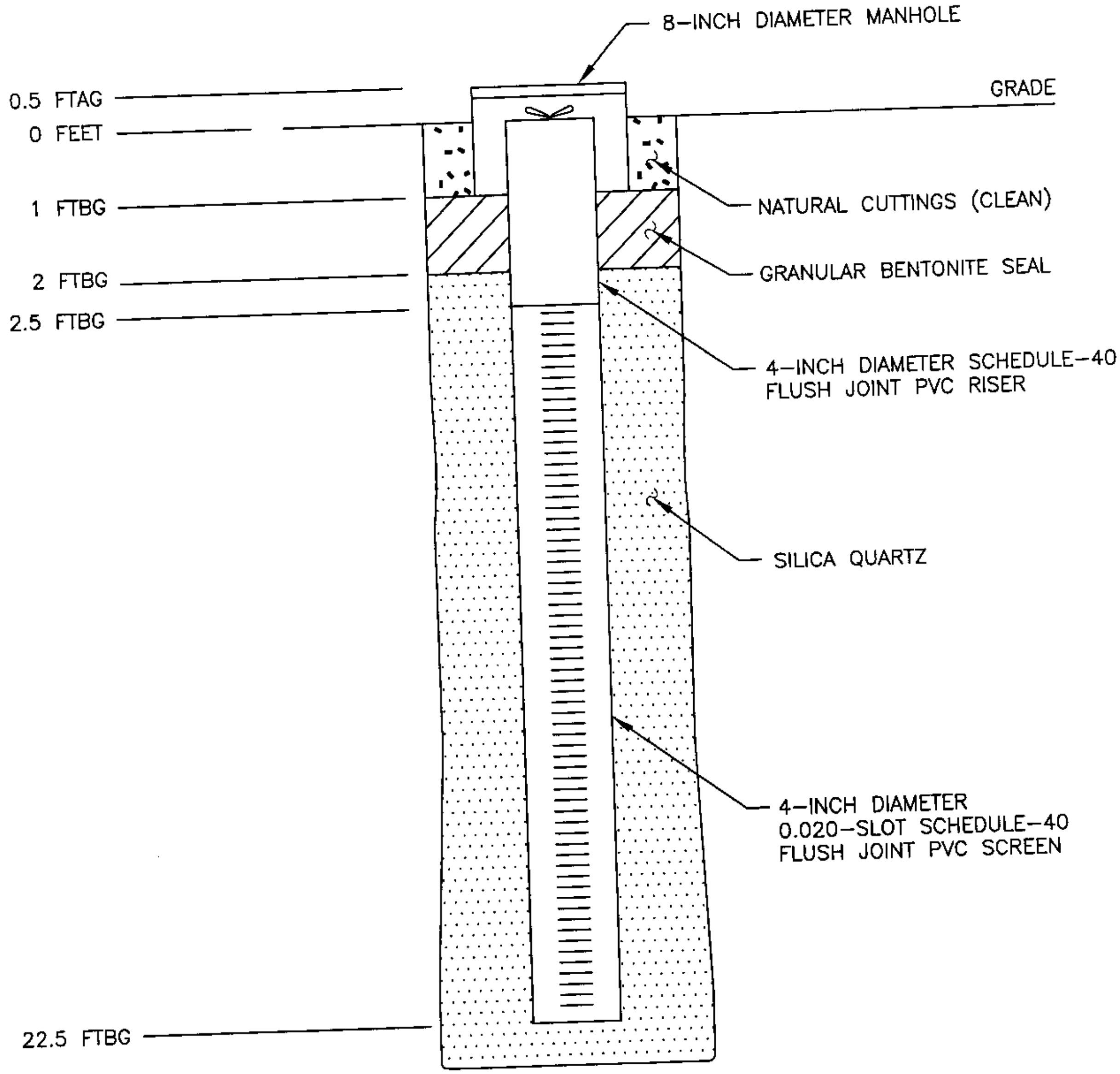
WELL CONSTRUCTION DIAGRAM OF VE-1

DATE	REVISED

PREPARED BY:

LEGGETTE, BRASHEARS & GRAHAM, INC.
Professional Ground-Water and Environmental Engineering Services
110 Corporate Park Drive
Suite 112
White Plains, NY 10604
(914) 694-5711

DRAWN: ---	CHECKED: DM	DATE: 10/21/02	FIGURE: ---



NOT TO SCALE

VOLUNTARY CLEANUP PROGRAM INDEX #D2-0023-00-08
21-16 44TH ROAD
LONG ISLAND CITY, NEW YORK

WELL CONSTRUCTION DIAGRAM OF VE-2

DATE	REVISED

PREPARED BY:

LEGGETTE, BRASHEARS & GRAHAM, INC.
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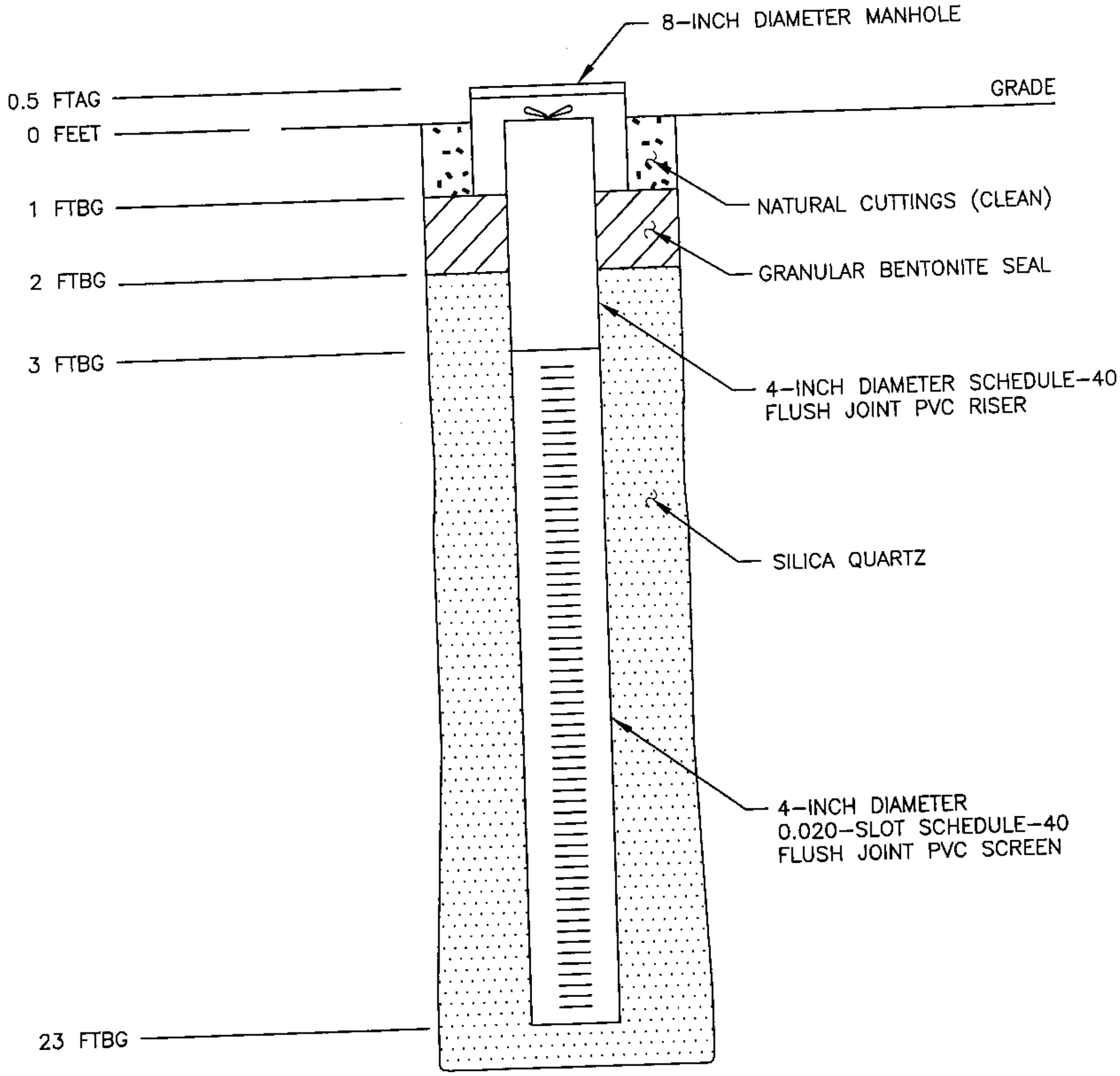
White Plains, NY 10604
(914) 694-5711

DRAWN: --- CHECKED: DM DATE: 10/21/02 FIGURE: ---



NOT TO SCALE

VOLUNTARY CLEANUP PROGRAM INDEX #D2-0023-00-08
21-16 44TH ROAD
LONG ISLAND CITY, NEW YORK

WELL CONSTRUCTION DIAGRAM OF VE-3

DATE	REVISED

PREPARED BY:

LEGGETTE, BRASHEARS & GRAHAM, INC.
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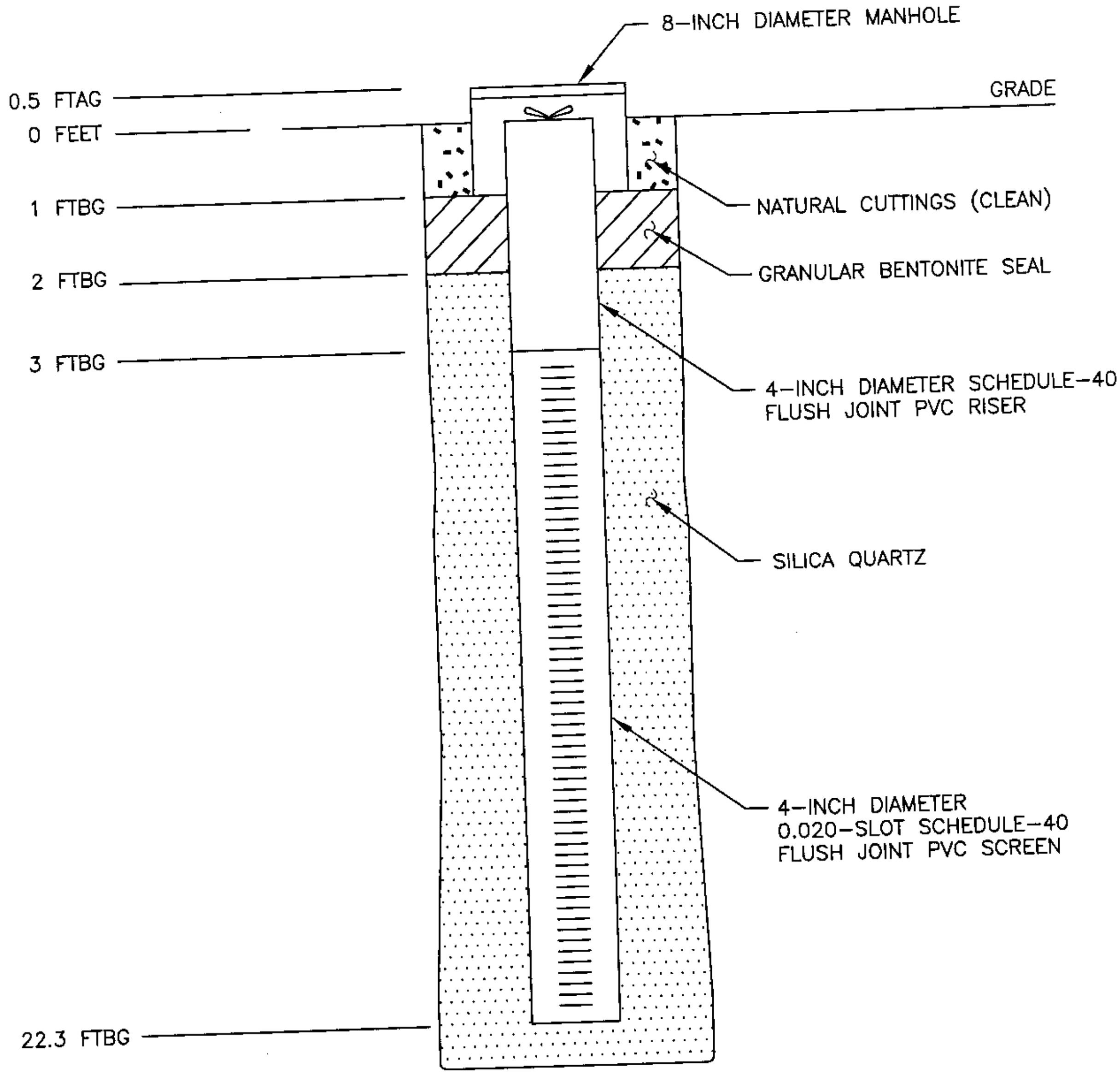
(914) 694-5711

DRAWN: --- | CHECKED: DM | DATE: 10/21/02 | FIGURE: ---



NOT TO SCALE

VOLUNTARY CLEANUP PROGRAM INDEX #D2-0023-00-08
21-16 44TH ROAD
LONG ISLAND CITY, NEW YORK

WELL CONSTRUCTION DIAGRAM OF VE-4

DATE	REVISED	PREPARED BY:
		LEGGETTE, BRASHEARS & GRAHAM, INC. Professional Ground-Water and Environmental Engineering Services 110 Corporate Park Drive Suite 112 White Plains, NY 10604 (914) 694-5711

DRAWN: --- | CHECKED: DM | DATE: 10/21/02 | FIGURE: ---

GEOLOGIC LOG HYDRO ENVIRONMENTAL SOLUTIONS, INC. SOMERS, NEW YORK	OWNER: WELL NO.: VE-1 PAGE: 1 OF 1 PAGES
SITE LOCATION: 21-16 44th Road Long Island City, New York	SCREEN SIZE & TYPE: 4-inch SCH 40 PVC SLOT NO.: 20 SETTING: 3-21 ft bg
DATE COMPLETED: October 12, 2002	SAND PACK SIZE & TYPE: Silica quartz SETTING: 2-21 ft bg
DRILLING COMPANY: ADT, Inc.	CASING SIZE & TYPE: 4-inch SCH 40 PVC SETTING: Grade - 3 ft bg
DRILLING METHOD: Hollow-stem auger 6 1/4-inch	
SAMPLING METHOD: Split spoon 2-inch	SEAL TYPE: Granular bentonite SETTING: 1-2 ft bg
OBSERVER: LM	
REFERENCE POINT (RP):	BACKFILL TYPE: Natural cuttings (clean)
ELEVATION OF RP:	STATIC WATER LEVEL:
STICK-UP:	DEVELOPMENT METHOD:
SURFACE COMPLETION:	DURATION: YIELD:

REMARKS: Start: 9:30 Finish: 10:30

ABBREVIATIONS: SS = split spoon W = wash C = cuttings G = grab ST = shelby tube
REC = recovery PPM = parts per million ft bg = feet below grade MC = macro core sampler

DEPTH (FEET)		SAMPLE TYPE	BLOW COUNT	REC. (FEET)	PID[1/] READING (PPM)	DESCRIPTION
FROM	TO					
0	12	G	–	–	0	Fill; composed of medium sand, brown, dry, no solvent, odor.
12*	14	SS	13-13-14-16	–	0	SAND, medium, brown, wet, no solvent odor.
14	21	G	–	–	0	SAND, as above, no odor.
						Well set at 21 ft bg
						* sample to lab

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October 24, 2002
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GEOLOGIC LOG HYDRO ENVIRONMENTAL SOLUTIONS, INC. SOMERS, NEW YORK	OWNER: WELL NO.: VE-2 PAGE: 1 OF 1 PAGES
SITE LOCATION: 21-16 44th Road Long Island City, New York	SCREEN SIZE & TYPE: 4-inch SCH 40 PVC SLOT NO.: 20 SETTING: 2.5-22.5 ft bg
DATE COMPLETED: October 12, 2002 DRILLING COMPANY: ADT, Inc.	SAND PACK SIZE & TYPE: Silica quartz SETTING: 2-22.5 ft bg
DRILLING METHOD: Hollow-stem auger 6 1/4-inch	CASING SIZE & TYPE: 4-inch SCH 40 PVC SETTING: Grade - 2.5 ft bg
SAMPLING METHOD: NS OBSERVER: LM	SEAL TYPE: Granular bentonite SETTING: 1-2 ft bg
REFERENCE POINT (RP):	BACKFILL TYPE: Natural cuttings (clean)
ELEVATION OF RP:	STATIC WATER LEVEL:
STICK-UP:	DEVELOPMENT METHOD:
SURFACE COMPLETION:	DURATION: YIELD:
REMARKS: Start: 10:45 Finish: 12:40	
ABBREVIATIONS: SS = split spoon W = wash C = cuttings G = grab ST = shelby tube REC = recovery PPM = parts per million ft bg = feet below grade MC = macro core sampler	

DEPTH (FEET) FROM	DEPTH (FEET) TO	SAMPLE TYPE	BLOW COUNT	REC. (FEET)	PID[1/] READING (PPM)	DESCRIPTION
0	23	G	—	—	0	Fill; composed of medium sand, overlying natural medium sand, brown, ground water at approximately 14 ft bg, no odor.
						Well set at 22.5 ft bg
						No sample for lab

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October 24, 2002
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GEOLOGIC LOG HYDRO ENVIRONMENTAL SOLUTIONS, INC. SOMERS, NEW YORK	OWNER: WELL NO.: VE-3 PAGE: 1 OF 1 PAGES
SITE LOCATION: 21-16 44th Road Long Island City, New York	SCREEN SIZE & TYPE: 4-inch SCH 40 PVC SLOT NO.: 20 SETTING: 3-23 ft bg
DATE COMPLETED: October 12, 2002 DRILLING COMPANY: ADT, Inc.	SAND PACK SIZE & TYPE: Silica quartz SETTING:
DRILLING METHOD: Hollow-stem auger 6 1/4-inch	CASING SIZE & TYPE: 4-inch SCH 40 PVC SETTING:
SAMPLING METHOD: NS OBSERVER: LM	SEAL TYPE: Granular bentonite SETTING:
REFERENCE POINT (RP):	BACKFILL TYPE: Natural cuttings (clean)
ELEVATION OF RP:	STATIC WATER LEVEL:
STICK-UP:	DEVELOPMENT METHOD:
SURFACE COMPLETION:	DURATION: YIELD:

REMARKS: Start: 12:45 Finish: 1:40

ABBREVIATIONS: SS = split spoon W = wash C = cuttings G = grab ST = shelby tube
REC = recovery PPM = parts per million ft bg = feet below grade MC = macro core sampler

DEPTH (FEET)		SAMPLE TYPE	BLOW COUNT	REC.	PID[1/] READING	DESCRIPTION
FROM	TO			(FEET)	(PPM)	
0	10	G	–	–	6.2	PEA STONE; moist, slight odor.
10	23	G	–	–	0.2	SAND; medium, brown, slight odor.
						Well set at 23 ft bg
						No sample to lab

dmd
October 24, 2002
reports\furman\premierstorage\hydroenvironmentallogsve1thruu4 log

GEOLOGIC LOG HYDRO ENVIRONMENTAL SOLUTIONS, INC. SOMERS, NEW YORK	OWNER: WELL NO.: VE-4 PAGE: 1 OF 1 PAGES
SITE LOCATION: 21-16 44th Road Long Island City, New York	SCREEN SIZE & TYPE: 4-inch SCH 40 PVC SLOT NO.: 20 SETTING: 3-22.3 ft bg
DATE COMPLETED: October 12, 2002	SAND PACK SIZE & TYPE: Silica quartz SETTING: 2-22.3 ft bg
DRILLING COMPANY: ADT, Inc.	CASING SIZE & TYPE: 4-inch SCH 40 PVC SETTING: Grade - 3 ft bg
DRILLING METHOD: Hollow-stem auger 6 1/4-inch	
SAMPLING METHOD: Split spoon 2-inch	SEAL TYPE: Granular bentonite SETTING: 1-2 ft bg
OBSERVER: LM	
REFERENCE POINT (RP):	BACKFILL TYPE: Natural cuttings (clean)
ELEVATION OF RP:	STATIC WATER LEVEL:
STICK-UP:	DEVELOPMENT METHOD:
SURFACE COMPLETION:	DURATION: YIELD:

REMARKS: Start: 1:45 Finish: 3:00

ABBREVIATIONS: SS = split spoon W = wash C = cuttings G = grab ST = shelby tube
REC = recovery PPM = parts per million ft bg = feet below grade MC = macro core sampler

DEPTH (FEET)		SAMPLE TYPE	BLOW COUNT	REC. (FEET)	PID[1/] READING (PPM)	DESCRIPTION
FROM	TO					
0	13	G	—	—	0.2	FILL; composed of medium sand, brown, dry, very slight odor.
13*	15	SS	9-12-11-13	1.0	2.0	SAND; medium, brown, some C&D material, very slight odor, moist.
15	23	G	—	—	0	SAND; as above, no odor.
						Well set at 22.3 ft bg
						* Sample to lab

dmd
October 24, 2002
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APPENDIX III

IN-LINE PLASTICS FIELD INSTALLATION QUALITY ASSURANCE MANUAL AND GEOTEXTILE SPECIFICATIONS

IN-LINE PLASTICS, LC

FIELD INSTALLATION

QUALITY ASSURANCE MANUAL

8615 Golden Spike Lane
Houston, Texas 77086
Phone 281-272-1660 Fax 281-272-1673

TABLE OF CONTENTS

1. INTRODUCTION

2. GEOMEMBRANE INSTALLATION

1.1.0 INTRODUCTION

1.1.1. Purpose

Quality assurance refers to means and actions employed by In-Line Plastics, LC (ILP) to assure conformity of the lining system installation with the Quality Assurance Plan, drawings and specifications.

This manual addresses the quality assurance of the installation of flexible membrane liners and other geosynthetic products used by ILP in waste disposal landfills, surface impoundments or other installations as specified by the owner and/or Engineer. This manual is a general guide and not site specific and delineates In-Line's quality procedures and standards for installation.

Commonly use geosynthetic components of a lining system is being discussed in this manual. This includes polyethylene geomembranes, geotextiles, geonets and geocomposites. This manual can be a useful guide in delineating the quality assurance procedures and requirements for the installation of all the above geosynthetic products. The site specific QA depends on job specifications and site conditions.

This manual does not address the quality assurance of soils, except in cases where soil placement may have an influence on the geosynthetics.

1.1.2. Scope of Quality Assurance

The scope of this manual includes the quality assurance applicable to shipment, handling, and installation of all geosynthetics. In particular, full time quality assurance of the installation of geomembranes and the installation of other geosynthetics is essential. (See exhibit A for QA Chart)

This manual does not address design guidelines, installation specifications, or selection of geomembranes or other geosynthetics (which includes compatibility between geosynthetic and contained material).

1.2.0 Construction Meetings

1.2.1 Progress Meetings

It is recommended an informal daily installation Progress Meeting be held among appropriate parties to discuss current progress.

1.3.0 Delivery, Storage, and handling

Membrane delivered to the site shall be unloaded prior to In-Line crew arrival and stored with a minimum of handling. Each roll will be uniquely labeled.

Inventory shall be taken at the time of delivery. As the membrane is unloaded, it shall be inspected for damage. Any damage will be noted and repaired per specification. The "inventory Report" form will be used as material is delivered. Any shortages shall be noted as missing items ordered.

Membrane material shall be handled with equipment that will not damage the membrane.
The storage area required shall be reasonably flat and well drained. The surface shall be free of sharp rocks or other objects that may damage the membrane.

The storage area must be as close as practical to the work area in order to minimize on site handling. The storage area must also be secure to prevent vandalism and theft and must be such that the membrane is not likely to be damaged by passing vehicles.

1.4.0 Equipment

1.4.1 Welding Equipment

Two practical types of welding equipment can be utilized: Wedge, and Extrusion.

A. Wedge Welding

For panel seaming with varying subgrade, the contractor shall provide automated welding equipment. The equipment shall be capable of measuring the temperature at the wedge and monitoring the automated equipment to assure it maintains a consistent pressure to achieve a passing field weld.

The power source shall be capable of providing constant voltage under a combined-line load.

B. Extrusion Welding

For extrusion welding, the contractor shall provide a field extrusion welder capable of adhering a continuous bead between the panels with a nominal width of one inch. Extrusion welders shall have a fixed preheat nozzle attached to the front of the extrusion welder.

1.4.2 Generators

Typically, a 6.5 kW or larger generator will be used at the work area and electrical extension cords will be used to power the welding equipment.

1.4.3 Miscellaneous Equipment

Small tools will include hook blade utility knives, scissors with rounded points, hand leister, grinders, and silicone or rubber rollers.

2.1.0 GEOMEMBRANE INSTALLATION

2.1.1 Earthwork

A. Surface Preparation
The Earthwork Contractor shall be responsible for preparing the subgrade according to the project specifications and the following minimum industry subgrade standard necessary to properly install the liner.

A.1 The surface to be lined has been prepared so as to be free of irregularities, protrusions, vegetation, excessive water, loose soil or abrupt changes in grade.

A.2 The supporting surface does not contain stones or other matter of such composition, shape or size which may be damaging to the geomembrane and

A.3 There are no excessively soft surface areas

Under no circumstances shall the installer deploy any geomembrane in areas not acceptable within these guidelines. A completed surface acceptance from shall be provided to the customer specifically indicating the areas accepted for geomembrane installation during each day's activities. This form shall be provided after installation activities within that area. If at any time during the installation of the geosynthetic lining system the prepared subgrade deteriorates, becomes damaged, or in any way is determine unacceptable by the Site Supervisor, all liner installation work shall stop in those areas and the condition of those areas brought to the attention of the appropriate party.

B. Anchor Trench

The anchor trenches shall be constructed by the Earthwork Contractor to the lines, widths and depths as shown on the drawings and specifications. This task should be performed prior to the geomembrane deployment. Pile excavated dirt away from the area to be lined.

The edges where the geosynthetics enter the trench should be free of irregularities, protrusions, etc. to avoid potential damage to the material. Backfilling of the anchor trench shall be the responsibility of the of the Earthwork Contractor in accordance with specifications. Backfilling should occur when the geosynthetic material is at its most contracted state to avoid potential bridging problems. Care must be taken to avoid damaging the geosynthetics during backfilling.

2.2.0 Geomembrane Deployment

The site supervisor, in conjunction with the customer shall agree upon the following issues. If any adverse situation or disagreement exists, the site supervisor shall delay deployment until issues are resolved.

2.2.1 Installation

The Site Supervisor shall proceed with deployment provided that:

- Deployment equipment does not damage the subgrade
- Personnel who are in contact with the liner do not smoke, wear damaging (non-soft sole) shoes or engage in other activities which risk damage to the liner

2.2.2 Use of a low ground pressure, rubber-tired all terrain vehicle (i.e. ATV) is allowed on the geosynthetic surface, provided proper care is taken to avoid damage and excessive traffic

2.2.3 Field panel placement installation sequence should take into account site drainage, wind direction, subgrade surface, access to the site, and production schedule of the project. Field panels should be seamed as soon as possible after deployment and all deployed material shall be marked with appropriate identification.

2.2.4 Visual Inspection

The Site Supervisor and/or the QA Technician and the designated Independent Inspector shall visually inspect each panel, as soon as possible after deployment, for damage or areas needing repair. Areas shall be marked for repair.

2.3.0 Field Seaming

Field seaming involves the bonding of adjacent panels using thermal methods.

2.3.1 Seam Layout

In general, seams shall be oriented parallel to the direction of maximum slope, i.e. oriented along, not across, the slope. In corners and odd-shaped geometric locations, the number of seams should be minimized. No horizontal seams should occur on a panel less the five lineal feet from the toe of the slope. On slopes of less that 10% (6L: 1H), this rule shall not apply. A cross slope seam may be utilized provided the panel ends are cut at an angle of approximately 45%.

A seam is considered a separate entity if it is the principal attachment that joins two or more panels. Repairs are not considered seams in this context.

A numbering system using adjacent panel numbers shall identify each seam.

2.3.2 Seaming Equipment and Products

Approved processes for field seaming and repairing are extrusion welding and fusion welding. All welding equipment shall have accurate temperature monitoring devices to insure proper measurement of the welder temperatures.

A. Fusion Process

This process shall be used for seaming panels together and is not generally used for patching or detailed work. The apparatus shall be of hot wedge type and is commonly equipped with a "split wedge" to allow air pressure seam testing.

Fusion welding equipment shall be self-propelled devices and shall be equipped with functioning wedge temperature and seaming speed controllers to assure proper control by the Welding Technician.

B. Extrusion Process

This process shall be used primarily for repairs, patching, and special detail fabrication. This method is also useful to connect new panels to previously installed liner that does not have an exposed edge capable of being fusion welded.

The extrusion welding apparatus (hand welder) shall be equipped with temperature monitoring devices.

2.3.3. Seam Preparation

The Welding Technician shall verify that prior to seaming the seam area is free of moisture, dust, sand, or debris of any nature; the seam is properly heat tacked and abraded when extrusion welding; and seams are performed to minimize "fishmouths".

2.3.4 Trial Seams (Trial Welds)

Prior to production seaming, trial seams shall be made and accepted using project specified criteria. Trial seams shall be made on appropriate sized pieces of identical or equivalent geomembrane material to verify that seaming conditions and procedures are adequate. Each trial seam sample shall be assigned a number and the test results recorded in the appropriate log.

- Trial seams shall be performed for each welder to be used and by each operator of extrusion welders, and by the primary operator of each fusion welder.
- A passing trial seam shall be made prior to the beginning of each seaming period. Typically this is at the start of the day and after lunch break.
- Fusion welded trial seam samples shall be approximately six feet long by one foot wide with the seam centered lengthwise. For extrusion welding, the trial seam sample size shall be approximately three feet long by one foot wide with the seam centered lengthwise.

2.3.5 Panel Seams (Production Seaming)

Upon Acceptance of the trial seams, work may begin on deployed panels. All seams shall be non-destructively tested. Each completed seam shall be labeled with pertinent information.

2.3.6 Non-Destructively Seam Testing.

ILP will only non-destructively test field seams for their full length using an air pressure test or a vacuum test, if required by Engineer's specifications. The purpose of non-destructively tests is to demonstrate the leak resistance of the seam.

The Site Supervisor shall schedule all non-destructively testing operations in order to ensure prompt demonstration of weld quality and the orderly progress of the project.

The QA Technician shall instruct the testing personnel regarding marking of repairs needed, leaks and sign-off marks on seam and repairs.

a) Vacuum Testing

Vacuum testing is routinely performed on extrusion welds and can be performed on the fusion welds. The equipment shall consist of a vacuum box assembly with a vacuum gauge, a pumping device, and a soap solution.

The following procedure shall be followed:

- Wet a section of the seam with the soap solution. The seam section must be longer that the vacuum box.
- Place the vacuum box over the wetted area and apply body weight to form a seal between the gasket and the liner.
- Evacuate air to create a negative pressure of approximately 3 to 5 psig.
- Observe the seam through the viewing window for pressure of soap bubbles emitting from the seam.
- If no bubbles are observed, reposition the box on the next wetted area for testing with slight overlap.
- If bubbles are detected, this indicates a leak in the seam, mark the area of the leak for repair and retest.

b) Air Pressure Testing

Air pressure testing is performed on seams made by a double-seam fusion welding apparatus.

The equipment shall be comprised of the following:

- An air pump, or air tank, capable of producing a minimum air pressure of 25 psig in the seam channel
- A sharp hollow needle to insert air into the air channel of the seam
- A hot air gun or other heating device to seal the ends of the air channel

The following procedures shall be followed:

- Seal both ends of the air channel of the seam to be tested.
- Insert the needle into the air chamber at either end of the seam to be tested.
- Pressurize the air channel to minimum of 15 psi. Allow the pressure to stabilize, and if necessary, re-pressurize to 15 psi and note the pressure.
- With a minimum pressure of 15 psi stabilized in the air channel, the time of day should be noted.
- After approximately 5minutes, the air pressure should be read again.
- If the difference between the two readings is more than 4 psi, the seam needs to be retested
- Upon completion of the air pressure test, the seam shall be marked and points requiring repair identified.

c) Procedures for Air Pressure Test Failure
Should the seam fail the air pressure test, the following procedure shall be followed:

- Reposition the apparatus and retest the same section
- While the seam air-channel is under pressure, traverse the length of the seam and listen for the leak
- While the seam air-channel is under pressure, apply a soapy solution to the seam edge (do not trim excess material from edge of seam) and observe for bubbles formed by escaping air
- Re-test the seam in progressively smaller increments, until the area of leakage is identified
- Repair the identified leak area by extrusion welding the excess material at the edge of the seam and then vacuum test
- In areas where the air channel is closed and the integrity of the weld is not suspect, vacuum testing is acceptable

2.3.7 Destructive Seam Testing
Destructive seam testing will only be performed at selected locations, if required by Engineer's specifications. The purpose of these tests is to evaluate bonded seam strength testing shall be performed as work progresses.

a) Location and Frequency
The frequency of sample removal is commonly no more that one sample per 500 lineal feet of seam. The sample can be taken at the end of a seam to avoid a repair.

b) Size of Samples
A sample segment twelve inches by twelve inches shall be cut with the seam centered lengthwise. Additional segments may be cut for independent lab testing, archival retain or other uses.

c) Sample Identification
The segment shall be marked with the appropriate destructive sample (D/S) number.

d) Field Testing
Sample shall be tested in peel and in shear using the following procedure:

- Ten specimens of one-inch width shall be cut.
- Five specimens shall be tested for peel. Fusion welds shall be tested from both sides.
- Five specimens shall be tested for shear.
- The specimens shall be hand pulled to see if the seams exhibit a film tear bond (FTB) (see Exhibits B & C). If specified samples can also be sent to In-Line Plastics for in house testing in a tensiometer. Testing will occur at a rate of two inches per minute.

e) Pass/Fail Criteria
Seam shall exhibit a film tear bond (FTB) (see Exhibits B & C). For projects that utilize a tensiometer, the following table provides minimum acceptable values.

Seam Strength ASTM D 4437					
		Shear		Peel	
Product Name	Thickness ASTM D 5199 Mm (mils)	Extrusion kN/m (Lb./in)	Fusion kN/m (Lb./in)	Extrusion kN/m (Lb./in)	Fusion kN/m (LB/in)
HDPE Smooth	0.75 (30)	9.4 (54)	9.4 (54)	6.3 (36)	7.3 (42)
HDPE Smooth	1.0 (40)	13.3 (76)	13.3 (76)	8.7 (50)	10.3 (59)
HDPE Smooth	1.5 (60)	20.4 (117)	20.4 (117)	12.7 (78)	15.9 (91)
HDPE Smooth	2.0 (80)	27.1 (155)	27.1 (155)	18.2 (104)	21.1 (121)
LLDPE Smooth	0.75 (30)	7.3 (42)	7.3 (42)	6.1 (35)	6.1 (35)
LLDPE Smooth	1.0 (40)	9.8 (56)	9.8 (56)	8.4 (48)	8.4 (48)
LLDPE Smooth	1.5 (60)	14.7 (84)	14.7 (84)	12.6 (72)	12.6 (72)
LLDPE Smooth	2.0 (80)	19.6 (112)	19.6 (112)	16.8 (96)	16.8 (96)

Seam Strength ASTM D 4437					
		Shear		Peel	
Product Name	Thickness ASTM D 5199 Mm (mils)	Extrusion kN/m (Lb./in)	Fusion kN/m (Lb./in)	Extrusion kN/m (Lb./in)	Fusion kN/m (Lb./in)
HDPE Textured	0.75 (30)	9.4 (54)	9.4 (54)	6.3 (36)	7.3 (42)
HDPE Textured	1.0 (40)	13.3 (76)	13.3 (76)	8.7 (50)	10.3 (59)
HDPE Textured	1.5 (60)	20.4 (117)	20.4 (117)	12.7 (78)	15.9 (91)
HDPE Textured	2.0 (80)	27.1 (155)	27.1 (155)	18.2 (104)	21.1 (121)
LLDPE Textured	0.75 (30)	5.9 (34)	5.9 (34)	5.0 (29)	5.0 (29)
LLDPE Textured	1.0 (40)	8.4 (48)	8.4 (48)	7.0 (40)	7.0 (40)
LLDPE Textured	1.5 (60)	13.0 (70)	13.0 (70)	11.0 (60)	11.0 (60)
LLDPE Textured	2.0 (80)	16.8 (96)	16.8 (96)	14.0 (80)	14.0 (80)

In addition to these values, the sample shall not fail within the seam area. Three out of five specimens meeting the above criteria will constitute a passing test.

If the seam fails the test, the following procedure shall be followed. Additional sample segments of the same size shall be removed approximately 10 lineal feet in each direction from the failed seam. Both of these sample segments shall be tested in accordance with the criteria listed above and each segment must pass. This procedure is repeated until a passing result is obtained. In lieu of taking an excessive number of samples, the entire seam may be repaired as outlined in Section 2.3.8.a.

2.3.8 Defects and Repairs

All seams and non-seam areas of the polyethylene lining system shall be examined for identification of defects. Identification of defects or repair may be made by marking on the sheet/seam with an appropriate marking device.

a) Repair Procedures

Any portion of the polyethylene lining system exhibiting a defect which has been marked for repair shall be repaired with any one or combination of the following methods:

- Patching: using to repair holes, tears

- Grind and re weld: used to repair small sections of extruded seams
- Spot welding: used to repair small minor, localized flaws
- Flap welding: used to extrusion weld the flap of a fusion weld in lieu of a full cap
- Capping: used to repair failed seams
- Topping: application of extrudate bead directly to exist

The suspected defect shall be demonstrable as out of specification and detrimental to the performance of the liner.

The following conditions shall apply to all the above methods:

- Surfaces of the polyethylene which are to be repaired shall be lightly abraded to assure cleanliness
- All surfaces intended to receive extrudate must be clean and dry at the time of the repair
- All patches and caps shall extend at least four inches beyond the edge of the defect, and all patches shall have rounded corners.

b) Verification of Repairs
Repairs shall be non-destructively tested according to the criteria established in Section 2.3.6.e.

Repairs, which pass the non-destructive test, will be taken as an indication of an adequate repair. Failed tests indicate that the repair must be re-done and re-tested until a passing test result.

2.4.0 Lining System Acceptance

After work is complete, the Site Supervisor and/or QA Technician shall conduct a final inspection (walk-down) of the area for confirmation that all repairs have been appropriately performed, all test results are acceptable and the area has all scrap, trash and debris removed. Only after careful evaluation by the Site Supervisor and acceptance by the Customer shall any material be placed upon the lining system.

The geosynthetic lining system will be accepted by the customer when:

- Installation of materials is completed.
- Verification of the adequacy of all seams and repairs, including associated testing and documentation is completed

Signing a Certificate of Acceptance (see Attached) will indicate acceptance by all parties. Partial area of the installation may be accepted in order to allow further construction of the project.

3.1.0 Handling

All geotextile, geonets, and geocomposites shall be handled in such a manner as to ensure they are not damaged.

- On Slopes, the geosynthetics shall be securely anchored in the anchor trench and then rolled down the slope in such a manner as to keep the material in tension.
- Sandbags shall be used to secure the edges of the material when the potential wind damage is significant.

- Cutting the material shall be done in such a manner as to prevent damage to any underlying or adjacent geomembrane.
- Care should be taken when deploying geosynthetic materials that stones, debris or other material is not trapped by the geonet, geocomposites, geotextile or geosynthetic clay liner and which might damage the geosynthetic or geomembrane.

3.2.0 Deployment and Installation

3.2.1 Geonet – Drainage Net
Geonet shall be overlapped approximately four inches and fastened together with plastic cable ties.

3.2.2 Geotextile/ Geonet Geocomposite
The geonet component shall be overlapped approximately four inches and fastened together with plastic cable ties. The unbonded edge of the geotextile component shall remain overlapped. Bonded edge of the geocomposite shall be overlapped approximately four inches and fastened with plastic cable ties.

3.2.3 Geotextile
Geotextile may be installed by overlapping, by heat bonding (spot or continual basis) as indicated in the specifications.

3.2.4 Geosynthetic Clay Liner
Seaming of GCLs is achieved by overlap the GCL panels approximately six inches. End-of-roll seams shall be overlapped a minimum of 12". Supplemental granular bentonite is required for reinforced GCL. The granular bentonite shall be applied at a rate of one quarter pound per lineal foot between the overlapping panels and at end-of-roll.

3.3.0 Geosynthetic Repair

3.3.1 Geonet – Drainage Net
Any tear larger than twelve inches shall be repaired. Patches shall extend at least six inches from all sides of the tear and shall be fastened with plastic cable ties.

3.3.2 Geotextile/ Geonet Geocomposite
Holes and tears in the composite material shall be repaired with a patch of identical or similar material extending at least 6" from all sides of the hole or tear and fastened with plastic cable ties.

3.3.3 Geotextile
Holes in geotextile material shall be repaired using a patch of identical or similar materials extending approximately six inches on all sides from the hole or tear and heat bonded to parent material.

3.3.4 Geosynthetic Clay Liner
The area to be repaired (patched) must be free of contamination by foreign matter. Patches should have approximately twelve inches overlaps around the damaged area. For fabric-encased GCLs, the patch is to be tucked into place with excess bentonite poured over the overlap. However, temporary attachment of patches is required to ensure that the patch is not dislodged by covering with geomembrane or soil.

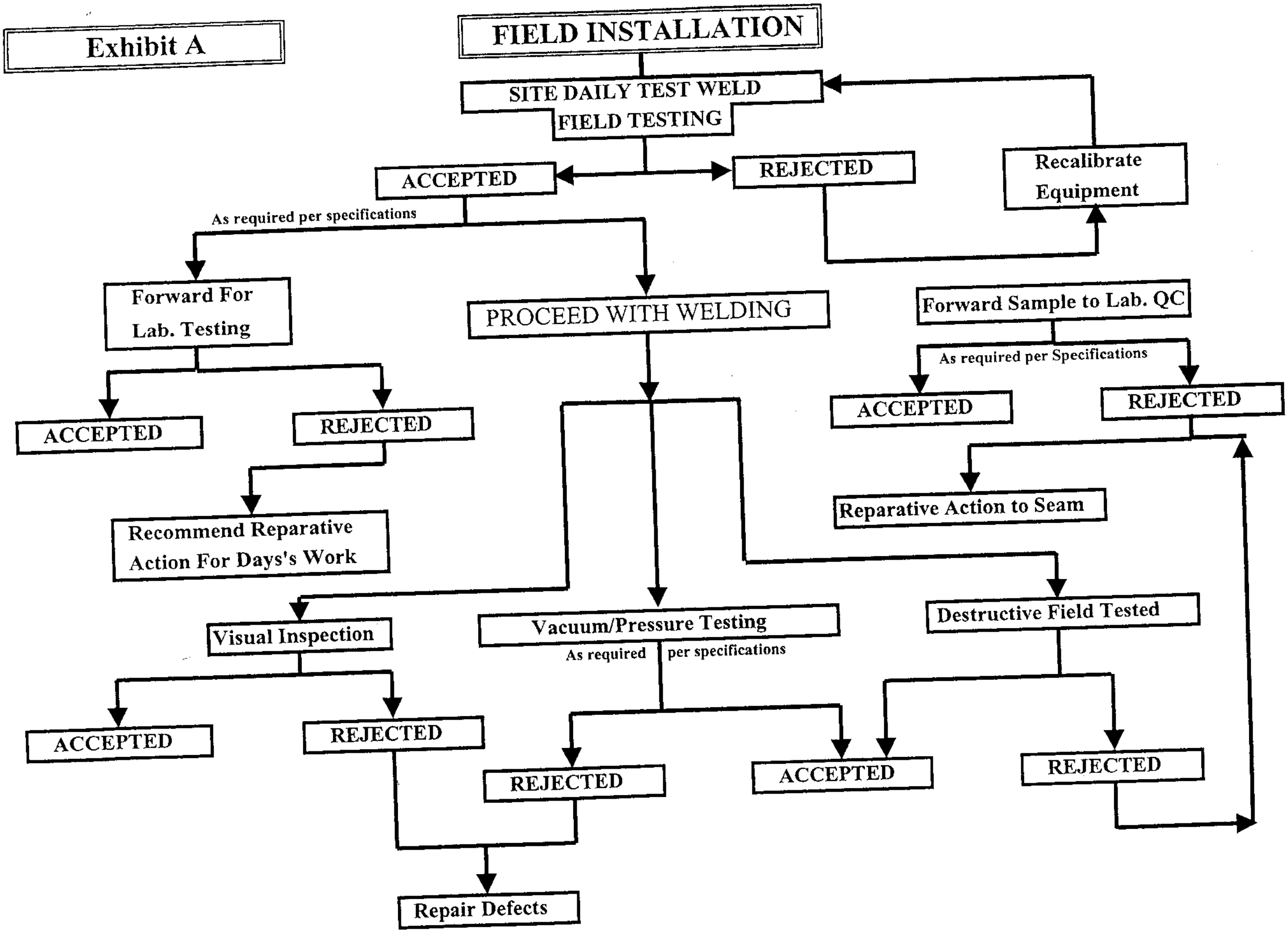
4.1.0 Exhibits

- A. QA Chart
- B. Pass / Fail Criteria – Hot Wedge Weld
- C. Pass / Fail Criteria – Extrusion Weld

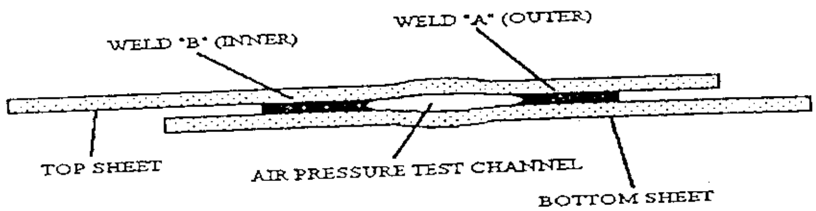
4.2.0 In-Line Plastic's Installation Forms

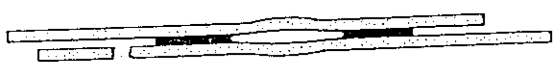
- D. Subgrade Acceptance
- E. Preweld Qualification
- F. Daily Progress Report Master
- G. Destructive Sample Report
- H. Certificate of Acceptance

Exhibit A

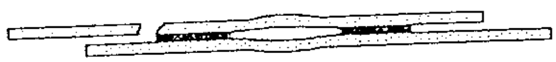

FIELD INSTALLATION
SITE DAILY TEST WELD FIELD TESTING
ACCEPTED
REJECTED
Recalibrate Equipment
As required per specifications
Forward For Lab. Testing
PROCEED WITH WELDING
Forward Sample to Lab. QC
As required per Specifications
ACCEPTED
REJECTED
ACCEPTED
REJECTED
Reparative Action to Seam
Recommend Reparative Action For Days's Work
Visual Inspection
Vacuum/Pressure Testing
As required per specifications
Destructive Field Tested
ACCEPTED
REJECTED
REJECTED
ACCEPTED
REJECTED
Repair Defects

DESTRUCTIVE TESTING OF DUAL HOT WEDGE WELD

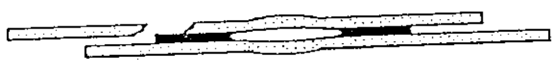


TEST STRIP	RESULTS
	FTB IN BOTTOM SHEETING ***(PASS)
	FTB IN TOP SHEETING ***(PASS)
	FTB IN BOTTOM SHEETING AT INNER EDGE OF SEAM. ***(PASS)

FTB = FILM TEAR BOND



FTB IN TOP SHEETING AT INNER EDGE OF SEAM.
***(PASS)



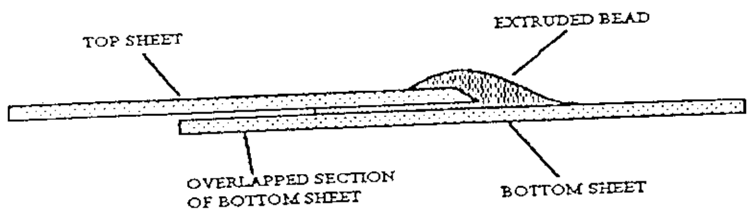
FTB IN TOP SHEETING OF SEAM AFTER SOME ADHESION FAILURE.
***(FAILURE)

FTB IN BOTTOM SHEETING OF SEAM AFTER SOME ADHESION FAILURE.
***(FAILURE)

FAILURE IN ADHESION.
***(FAILURE)

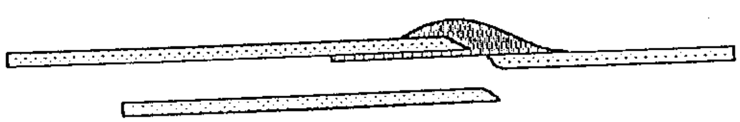
FTB = FILM TEAR BOND

VARIETIES OF SEAM FAILURES DURING DESTRUCTIVE TESTING OF EXTRUSION WELD

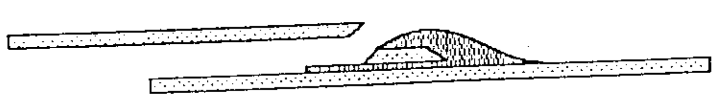


TEST STRIP

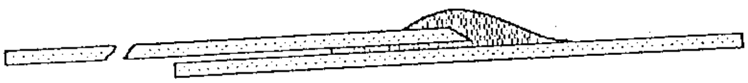
RESULTS



FTB SEPARATION IN BOTTOM SHEET AFTER SOME DELAMINATION.
***(PASS)

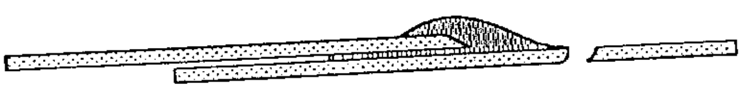


FTB SEPARATION IN TOP SHEET AT SEAM EDGE.
***(PASS)

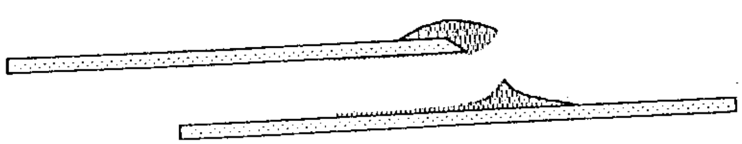


FTB SEPARATION IN TOP SHEET.
***(PASS)

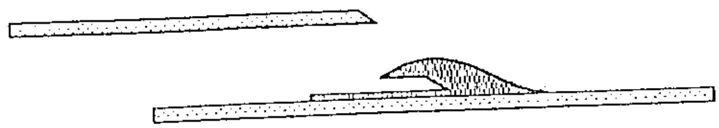
FTB SEPARATION IN BOTTOM SHEET.
***(PASS)



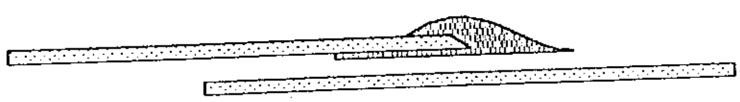
FTB SEPARATION IN BOTTOM SHEET AT OUTSIDE SEAM EDGE.
***(PASS)



FTB SEPARATION AT WELD (IF RECORDED STRESS MEETS SPEC).
***(PASS)



SEPARATION IN ADHESION.
***(FAILURE)



SEPARATION IN ADHESION.
***(FAILURE)

FTB = FILM TEAR BOND

IN-LINE PLASTICS, INC.

SUBGRADE SURFACE ACCEPTANCE

Customer:________________________ Date:________________________

Project Name:____________________ Project Number:________________

Location:________________________ Partial:________ Final:________

I, the undersigned duly authorized representative of In-Line Plastics, LC, certify that upon visual inspection the subgrade surface described below meets criteria for installation of:

____

By signing below, however, In-Line Plastics, LC acknowledges no responsibility for the subgrade design, degree of moisture or compaction, integrity, elevation, or maintenance thereof, in any way.

Approximate size of area accepted:________________________

Description of the area accepted: ________________________________

____

____

____

____

____

____

In-Line Representative **Owner/Contractor** **Inspector**

IN-LINE PLASTICS, INC.

PREWELD QUALIFICATION

Customer:____________________ Project Number::____________________

Project Name:____________________ Location:____________________

Material: ____________________

Test Method: One-inch specimens were used for Peel & Shear Testing of the welds.

Date	Machine #	Operator	Temperature	Speed	Weld Type	Result	Peel Stress	Shear Stress	Pass / Fail

IN-LINE PLASTICS, INC.

DAILY PROGRESS REPORT MASTER

Date:________ Project Name:________________ Job Number:________

Location:________________ Customer:________________

In-Line Representative:________________ Inspector:________________

DEPLOYMENT				WELDING					NON DESTRUCTIVE TEST					
Type	Panel #	Roll #	Length	Mach #	Tech	Test Type	Seam #	Seam Ft	Start	Stop	Repair Location	Date Repair	Date Retest	Tech

IN-LINE PLASTICS, INC.

DESTRUCTIVE SAMPLE REPORT

Customer:______________________ Project Number::______________________

Project Name:______________________ Location:______________________

Material: ______________________ Date: ______________________

Test Method: ASTM D4437 - One-inch specimens were used for Peel & Shear Testing of the welds.

Pond	Seam	Sample	Weld Type	Result Type	Peel Stress	Shear Stress

IN-LINE PLASTICS, INC.

CERTIFICATE OF ACCEPTANCE

Project Name:______________________________ In-Line Contract Number:_______________

Description of the Project: ____

Total Area: ____________________________ SF

I , the undersigned, duly authorized representative of ____ do hereby take over and accept the work described above from the date hereof and confirm that to the best of my knowledge, the work has been completed in accordance with the specifications and the terms and conditions of the contract. There appears no damage to the plastic lining nor any unacceptable interference within or without the surrounding works. Scrap and off-cuts have been removed and the works have been in clean and tidy condition. In-Line Plastics, LC undertakes to rectify any damage resulting from defective materials or workmanship within compliance of contract guarantees.

Name: ______________________________ Signature: ______________________________

Title: ______________________________ Date: ______________________________

Certified and accepted by In-Line Plastics, LC Representative

Name: ______________________________ Signature: ______________________________

Title: ______________________________ Date: ______________________________

Product Description MIRAFI®

Engineered Solutions for an Innovative World

product

Mirafi® N-Series NonWoven Polypropylene Geotextiles

for Soil Separation, Filtration, and Protection

TC Mirafi offers a wide range of nonwoven geotextiles for soil separation, filtration and protection. These geotextiles are cost-effective reinforcement elements which improve and enhance modern construction techniques in a variety of civil engineering applications.

PRODUCT DESCRIPTION

Mirafi® N-Series products are nonwoven geotextiles comprised of polypropylene staple fibers. Mirafi® N-Series Nonwoven Polypropylene Geotextiles provide excellent physical and hydraulic properties in addition to high tensile strengths.

FEATURES AND BENEFITS

- **Construction.** Mirafi® N-Series geotextiles easily conform to the ground or trench surface for trouble-free installation;
- **Strength.** Mirafi® N-Series geotextiles withstand severe installation stresses with high puncture and burst resistance;
- **Filtration.** High permeability properties provide high water flow rates while providing excellent filtration properties;
- **Environmental.** Mirafi® N-Series geotextiles are chemically stable in a wide range of aggressive environments;
- **Cost effective.** Mirafi® N Series geotextiles provide economical solutions to many civil engineering applications including a cost-effective alternative to graded aggregate filters.

APPLICATIONS

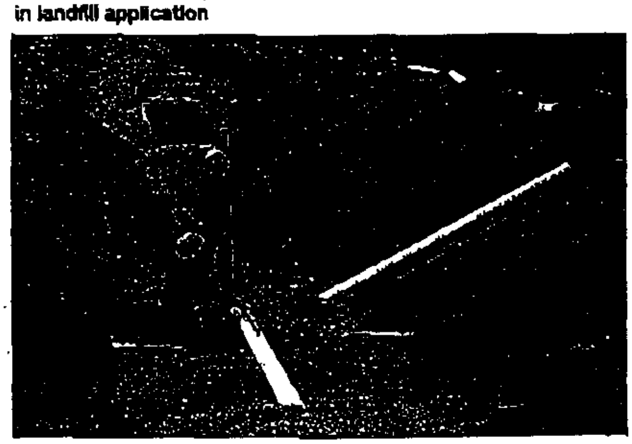
Mirafi® N-Series Nonwovens are used in a wide variety of applications including separation, filtration, and protection applications.

Lightweight nonwovens are predominantly used for subsurface drainage applications along highways, within embankments, under airfields, and athletic fields. For these drainage structures to be effective, they must have a properly designed protective filter. Mirafi® N-Series Nonwoven Geotextiles eliminate the problems of determining the aggregate gradation required to match soil conditions, finding a convenient and economical source of a specific aggregate gradation, transporting and placing graded aggregate, and assuring that the in place aggregate gradation provides effective filter performance.

Heavyweight nonwovens are use in critical subsurface drainage systems, soil separation, permanent erosion control, and geomembrane liner protection within landfills. These geotextiles provide the required strength and abrasion resistance to withstand installation and application stresses to create an effective, long-term solution.

Mirafi® N-Series heavyweight nonwoven used as a liner protection in landfill application

Mirafi® N-Series lightweight nonwoven used as protective filter in subsurface drainage application.



Mirafi® N-Series light weight nonwoven used as protective filter in an athletic field

TC Mirafi

Technical Data

MIRAFI®

Engineered Solutions for an Innovative Work

product

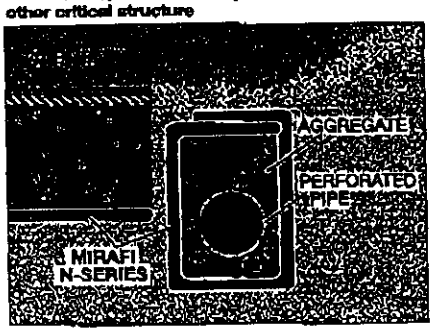
Mirafi® N-Series NonWoven Polypropylene Geotextiles

for Soil Separation, Filtration, and Protection

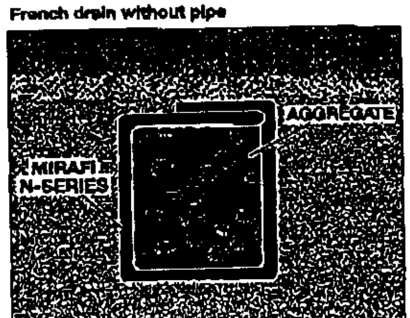
Property / Test Method	Units	140NL	140NC	140N	160N	170N	180N	1100N	1120N	1160N
MECHANICAL PROPERTIES										
Grab Tensile Strength										
ASTM D 4632										
Strength @ Ultimate	kN (lbs)	0.40 (90)	0.45 (100)	0.53 (120)	0.71 (160)	0.80 (180)	0.9 (205)	1.11(250)	1.34 (300)	1.69 (380)
Elongation @ Ultimate	%	50	60	50	50	50	50	50	50	50
Mullen Burst Strength	kPa	1309	1550	1654	2239	2412	2756	3514	4134	5167
ASTM D 3786	(psi)	(190)	(225)	(240)	(325)	(350)	(400)	(510)	(600)	(750)
Trapezoidal Tear Strength	kN	0.16	0.20	0.22	0.27	0.33	0.36	0.45	0.51	0.62
ASTM D 4355	(lbs)	(35)	(45)	(50)	(60)	(75)	(80)	(100)	(115)	(140)
Puncture Strength	kN	0.24	0.30	0.31	0.42	0.46	0.58	0.69	0.78	1.05
ASTM D 4833	(lbs)	(55)	(65)	(70)	(95)	(105)	(130)	(155)	(175)	(235)
UV Resistance after 500 hrs.	% strength	70	70	70	70	70	70	70	70	70
ASTM D 4355										
HYDRAULIC PROPERTIES										
Apparent Opening Size (AOS)	US Sieve	70	70	70	70	80	80	100	100	100
ASTM D 4751	mm	0.212	0.212	0.212	0.212	0.180	0.180	0.150	0.150	0.150
Permittivity ASTM D 4491	sec^{-1}	2.0	1.9	1.8	1.4	1.4	1.2	1.0	0.8	0.7
Flow Rate ASTM D 4491	$l/min/m^2$ ($gal/min/ft^2$)	6111 (150)	5698 (140)	5500 (135)	4477 (110)	4278 (105)	3866 (95)	3056 (75)	2648 (65)	2037 (50)
Packaging										
Roll Width	m(ft)	3.8 (12.5) 4.5 (15.0)	3.8 (12.5) 4.5 (15.0)	3.8 (12.5) 4.5 (15.0)	4.5 (15.0)	4.5 (15.0)	4.6 (15.0)	4.5 (15.0)	4.5 (15.0)	4.5 (15.0)
Roll Length	m(ft)	109.7 (360)	109.7 (360)	109.7 (360)	91.5 (300)	91.5 (300)	91.5 (300)	91.5 (300)	91.5 (300)	45.7 (150)
Est. Gross Weight	kg(lbs)	63 (138) 76 (165)	70 (154) 83 (184)	76 (167) 91 (200)	96 (215)	100 (225)	122 (270)	150 (330)	179 (393)	122 (268)
Area	m^2(yd^2)	418 (500) 501 (600)	418 (500) 501 (600)	418 (500) 501 (600)	418 (500)	418 (500)	418 (500)	418 (500)	418 (500)	209 (250)

NOTE: All Mechanical Properties and Hydraulic Properties shown are Minimum Average Roll Values (MARV).

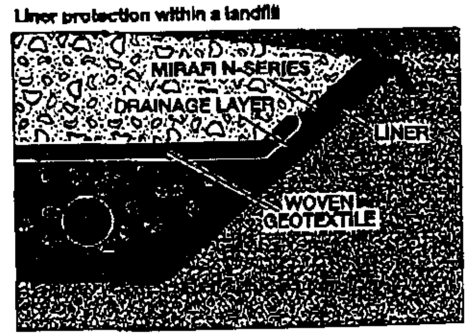
Cut-off/Inceptor drain along a roadway or other critical structure



French drain without pipe



Liner protection within a landfill



TC Mirafi

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Pendergrass, GA 30567
(888) 795-0808; (706) 693-2226
Fax (706) 693-4400

TC Mirafi

Mirafi 180N

Mirafi 180N is a nonwoven geotextile
stable network such that the fibers
degradation and resists naturally encou

Mechanical Properties
Grab Tensile Strength
Grab Tensile Elongation
Trapezoid Tear Strength
Mullen Burst Strength
Puncture Strength
Apparent Opening Size (AOS)
Permittivity
Permeability
Flow Rate
UV Resistance (at 500 hours)

Physical Properties	Test Met
Weight	ASTM D 5
Thickness	ASTM D 5
Roll Dimensions (width x length)	--
Roll Area	--
Estimated Roll Weight	--

DISCLAIMER: TC Mirafi warrants
when delivered to TC Mirafi's custom
Contact your local TC Mirafi Represe

180N.DOC
Revision: 2
Date: Jan. 1, 1999

TC Mirafi

Mirafi 1100N

Mirafi 1100N is a nonwoven geotextile composed of polypr
stable network such that the fibers retain their relative p
degradation and resists naturally encountered chemicals, alk

Mechanical Properties	Test Method
Grab Tensile Strength	ASTM D 4632
Grab Tensile Elongation	ASTM D 4632
Trapezoid Tear Strength	ASTM D 4533
Mullen Burst Strength	ASTM D 3786
Puncture Strength	ASTM D 4833
Apparent Opening Size (AOS)	ASTM D 4751
Permittivity	ASTM D 4491
Permeability	ASTM D 4491
Flow Rate	ASTM D 4491
UV Resistance (at 500 hours)	ASTM D 4355

Physical Properties	Test Method	Unit
Weight	ASTM D 5261	g/m² (oz/yd²)
Thickness	ASTM D 5199	mm (mils)
Roll Dimensions (width x length)	--	m (ft)
Roll Area	--	m² (yd²)
Estimated Roll Weight	--	kg (lb)

DISCLAIMER: TC Mirafi warrants our products to be f
when delivered to TC Mirafi's customers and that our pro
Contact your local TC Mirafi Representative for detailed

1100N.DOC
Revision: 2
Date: Jan. 1, 1999

GSE

GSE HD*
HDPE Geomembrane

GSE HD is a high quality, high density polyethylene (HDPE) geomembrane produced from specially formulated, virgin polyethylene resin. This polyethylene resin is designed specifically for flexible geomembrane applications. GSE HD contains approximately 97.5% polyethylene, 2.5% carbon black and trace amounts of antioxidants and heat stabilizers; no other additives, fillers or extenders are used. GSE HD has outstanding chemical resistance, mechanical properties, environmental stress crack resistance, dimensional stability and thermal aging characteristics. GSE HD has excellent resistance to UV radiation and is suitable for exposed conditions.

TESTED PROPERTY	TEST METHOD	MINIMUM VALUES		
Thickness, mils (mm)	ASTM D 5199	27 (0.69)	36 (0.91)	54 (1.4)
Density, g/cm^3	ASTM D 1505	0.94	0.94	0.94
Tensile Properties (each direction)	ASTM D 638, Type IV			
Strength at Break, lb/in-width (N/mm)	Dumbell, 2 ipm	122 (21)	162 (28)	243 (43)
Strength at Yield, lb/in-width (N/mm)		63 (11)	84 (15)	130 (23)
Elongation at Break, %	G.L. 2.0 in (51 mm)	700	700	700
Elongation at Yield, %	G.L. 1.3 in (33 mm)	13	13	13
Tear Resistance, lb (N)	ASTM D 1004	21 (93)	28 (124)	42 (187)
Puncture Resistance, lb (N)	ASTM D 4833	59 (263)	79 (352)	119 (530)
Carbon Black Content, %	ASTM D 1603	2.0	2.0	2.0
Carbon Black Dispersion	ASTM D 5596	+Note 1	+Note 1	+Note 1
Notched Constant Tensile Load, hrs	ASTM D 5397, Appendix	400	400	400

REFERENCE PROPERTY	TEST METHOD	NOMINAL VALUES		
Thickness, mils (mm)	ASTM D 5199	30 (0.75)	40 (1.0)	60 (1.5)
Roll Length** (approximate), ft (m)		952 (290)	650 (198)	420 (128)
Low Temperature Brittleness, °F (°C)	ASTM D 746, Cond. B	<-107 (<-77)	<-107 (<-77)	<-107 (<-77)
Oxidative Induction Time, minutes	ASTM D 3895, 200 °C; O_2, 1 atm	>100	>100	>100
Water Absorption, % wt. change	ASTM D 570	<0.01	<0.01	<0.01
Moisture Vapor Transmission, g/m^{2}day	ASTM E 96	<0.001	<0.001	<0.001
Dimensional Stability (each direction), %	ASTM D 1204, 100 °C, 1 hr	±2	±2	±2

+Note 1: Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.

GSE HD is available in rolls approximately 22.5 ft (6.9 m) and 34.5 ft (10.5 m) wide and weighing about 2,900 lb (1,315 kg) and 4,400 lb (1,995 kg) respectively. Other material thicknesses are available upon request.

** Roll lengths correspond to the 22.5 ft (6.9 m) wide roll goods.

This information is provided for reference purposes only and is not intended as a warranty or guarantee. GSE assumes no liability in connection with the use of this information. Check with GSE for current, standard minimum quality assurance procedures.

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Represented by:

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A Gundle/SLT Environmental, Inc. Company

www.gseworld.com

GSE

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GSE

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GSE

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Thickness, mils (mm)	ASTM D 5199	30 (0.75)	40 (1.0)	60 (1.5)
Roll Length** (approximate), ft (m)		952 (290)	650 (198)	420 (128)
Low Temperature Brittleness, °F (°C)	ASTM D 746, Cond. B	<-107 (<-77)	<-107 (<-77)	<-107 (<-77)
Oxidative Induction Time, minutes	ASTM D 3895, 200 °C; O_2, 1 atm	>100	>100	>100
Water Absorption, % wt. change	ASTM D 570	<0.01	<0.01	<0.01
Moisture Vapor Transmission, g/m²day	ASTM E 96	<0.001	<0.001	<0.001
Dimensional Stability (each direction), %	ASTM D 1204, 100 °C, 1 hr	±2	±2	±2

+Note 1: Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.

GSE HD is available in rolls approximately 22.5 ft (6.9 m) and 34.5 ft (10.5 m) wide and weighing about 2,900 lb (1,315 kg) and 4,400 lb (1,995 kg) respectively. Other material thicknesses are available upon request.

** Roll lengths correspond to the 22.5 ft (6.9 m) wide roll goods.

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GSE HD*
HDPE Geomembrane

GSE HD is a high quality, high density polyethylene (HDPE) geomembrane produced from specially formulated, virgin polyethylene resin. This polyethylene resin is designed specifically for flexible geomembrane applications. GSE HD contains approximately 97.5% polyethylene, 2.5% carbon black and trace amounts of antioxidants and heat stabilizers; no other additives, fillers or extenders are used. GSE HD has outstanding chemical resistance, mechanical properties, environmental stress crack resistance, dimensional stability and thermal aging characteristics. GSE HD has excellent resistance to UV radiation and is suitable for exposed conditions.

TESTED PROPERTY	TEST METHOD	MINIMUM VALUES		
Thickness, mils (mm)	ASTM D 5199	27 (0.69)	36 (0.91)	54 (1.4)
Density, g/cm^3	ASTM D 1505	0.94	0.94	0.94
Tensile Properties (each direction)	ASTM D 638, Type IV			
Strength at Break, lb/in-width (N/mm)	Dumbell, 2 ipm	122 (21)	162 (28)	243 (43)
Strength at Yield, lb/in-width (N/mm)		63 (11)	84 (15)	130 (23)
Elongation at Break, %	G.L. 2.0 in (51 mm)	700	700	700
Elongation at Yield, %	G.L. 1.3 in (33 mm)	13	13	13
Tear Resistance, lb (N)	ASTM D 1004	21 (93)	28 (124)	42 (187)
Puncture Resistance, lb (N)	ASTM D 4833	59 (263)	79 (352)	119 (530)
Carbon Black Content, %	ASTM D 1603	2.0	2.0	2.0
Carbon Black Dispersion	ASTM D 5596	+Note 1	+Note 1	+Note 1
Notched Constant Tensile Load, hrs	ASTM D 5397, Appendix	400	400	400

REFERENCE PROPERTY	TEST METHOD	NOMINAL VALUES		
Thickness, mils (mm)	ASTM D 5199	30 (0.75)	40 (1.0)	60 (1.5)
Roll Length** (approximate), ft (m)		952 (290)	650 (198)	420 (128)
Low Temperature Brittleness, °F (°C)	ASTM D 746, Cond. B	<-107 (<-77)	<-107 (<-77)	<-107 (<-77)
Oxidative Induction Time, minutes	ASTM D 3895, 200 °C; O_2, 1 atm	>100	>100	>100
Water Absorption, % wt. change	ASTM D 570	<0.01	<0.01	<0.01
Moisture Vapor Transmission, g/m^{2}day	ASTM E 96	<0.001	<0.001	<0.001
Dimensional Stability (each direction), %	ASTM D 1204, 100 °C, 1 hr	±2	±2	±2

+Note 1: Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.

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DS 005 R01/10/01

SOLMAX INTERNATIONAL

TECHNICAL DATA SHEET

SMOOTH HDPE GEOMEMBRANE

Properties	Test Method	Units Metric/(English)	SOLMAX 420	SOLMAX 430	SOLMAX 440	SOLMAX 460	SOLMAX 480	SOLMAX 500
Thickness*, Minimum Average	ASTM D5199	mm (mil)	0.50† (20)†	0.75† (30)†	1.00 (40)	1.50 (60)	2.00 (80)	2.50 (100)
Standard Roll Dimensions*‡	N/A	m (ft)	6.7 x 427 (22 x 1400)	6.7 x 305 (22 x 1000)	6.7 x 238 (22 x 780)	6.7 x 158 (22 x 520)	6.7 x 122 (22 x 400)	6.7 x 98 (22 x 320)
Resin Density	ASTM D1505	g/cm³	>0.932	>0.932	>0.932	>0.932	>0.932	>0.932
Melt Index	ASTM D1238 Condition E	g/10 min.	<0.5	<0.5	<0.5	<0.8	<0.5	<0.5
Oxidative Induction Time	ASTM D3895	min.	>100	>100	>100	>100	>100	>100
Sheet Density	ASTM D1505	g/cm³	>0.940	>0.940	>0.940	>0.940	>0.940	>0.940
Carbon Black Content	ASTM D4218	%	2.0 to 3.0	2.0 to 3.0	2.0 to 3.0	2.0 to 3.0	2.0 to 3.0	2.0 to 3.0
Carbon Black Dispersion (10 views)	ASTM D5596	Category	1 or 2	1 or 2	1 or 2	1 or 2	1 or 2	1 or 2
Tensile Strength • Yield Strength • Yield Elongation (1.3 in. Gage Length)	ASTM D638 Type IV	kN/m (ppi) %	7.0 (40) 12	11.0 (63) 12	14.7 (84) 13	23.1 (132) 13	30.8 (176) 13	38.5 (220) 13
• Break Strength • Break Elongation (2 in. Gage Length)	ASTM D638 Type IV	kN/m (ppi) %	13.3 (76) 600	20.0 (114) 700	28.0 (160) 700	42.0 (240) 700	56.1 (320) 700	70.0 (400) 700
Tear Resistance	ASTM D1004	N (lbs)	58 (13)	93.5 (21)	125 (28)	187 (42)	249 (56)	311 (70)
Puncture Resistance	ASTM D4833	N (lbs)	160 (36)	240 (54)	320 (72)	481 (108)	641 (144)	801 (180)
Stress Crack Resistance (SP-NCTL)	ASTM D5397 (Appendix)	hrs	>200	>200	>200	>200	>200	>200
Dimensional Stability	ASTM D1204	%	±3	±2	±2	±2	±2	±2

*Custom thicknesses and roll sizes are available
†Thickness ±10%
‡Roll length may vary ±1%

Data provided for informational purposes only. Solmax International, Inc. assumes no responsibility if the above data is used for design or other performance criteria.

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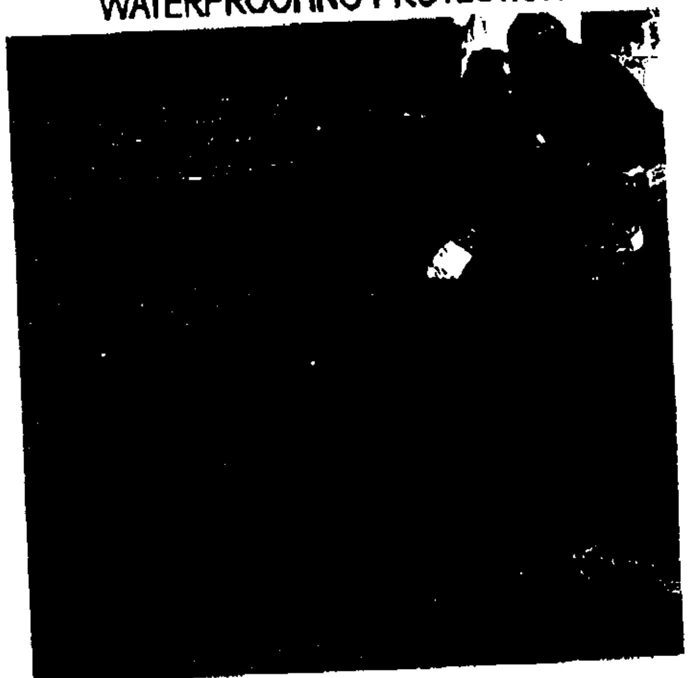
NO. 712

W. R. MEADOWS.
SEALTIGHT.

PROTECTION COURSE

WATERPROOFING PROTECTION



Effectively protects delicate waterproofing systems on vertical and horizontal surfaces.

SEALTIGHT PROTECTION COURSE products are tough, durable, lightweight panels specifically designed to protect delicate waterproofing materials from damage by normal construction traffic, movement of adjacent substrate and backfilling.

Technical Description

SEALTIGHT PROTECTION COURSE is a multi-ply semi-rigid core composed of a mineral-fortified asphaltic core formed between two outside layers of asphalt-impregnated fiberglass mat, manufactured in accordance with ASTM D 6506.

When properly applied by work personnel trained in good waterproofing techniques, SEALTIGHT PROTECTION COURSE will absorb the impact of aggregate shock and normal jobsite foot traffic. It also protects the membrane waterproofing from penetration by sharp aggregate during backfilling and later settlement.

SEALTIGHT PROTECTION COURSE is available in three types: PC-1, Light Duty; PC-2, Standard Duty and PC-3, Heavy Duty. All three types are economical and convenient to use.

Uses

SEALTIGHT PROTECTION COURSE is used in between-slab construction, such as plaza decks, roof terraces, promenade decks, pedestrian concourses, tunnels, floors of bathrooms, shower, kitchens and mechanical rooms, parking garage decks, planter boxes, reflective pools and foundation walls. SEALTIGHT PROTECTION COURSE is compatible with most currently popular dampproofing and waterproofing materials.

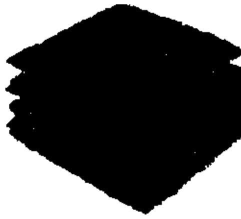
January 2001 (Supersedes A-6-51 1999)

07100 Waterproofing Membranes

PROTECTION COURSE

WATERPROOFING PROTECTION

W. R. MEADOWS. SEALTIGHT.



Packaging

4' x 8' (1.22m x 2.44m) panels

Precautions

1. Where PROTECTION COURSE is adhered to waterproofing membrane, use the adhesive recommended by the membrane manufacturer.
2. Where taped joints are desired with tape set in hot asphalt, consult membrane manufacturer.
3. PROTECTION COURSE is shipped on pallets with the polyethylene anti-stick sheet on the top or exposed side. PROTECTION COURSE should be stored on the pallets and placed on a level surface.
4. CAUTION...Do not apply the Protection Course over Liquid Waterproofing Membranes containing volatile solvents until all of the solvent has evaporated. Consult membrane manufacturer for specific application details prior to placing the Protection Course. Read and follow application information and precautions. Refer to Material Safety Data Sheet for complete Health and Safety information.

Features and Benefits

- Tough, durable and lightweight, panels are easily handled, quickly installed
- Full width fiberglass matting improves flexural strength
- Highly resistant to chemical action
- Performance is equally effective in above or below-grade installations
- Unique dual-facing offers compatibility with most currently popular waterproofing materials
- Economical and convenient to use

Application

NOTE: Prior to application, consult the waterproofing manufacturer to determine whether the polyethylene film facing on one side, or the asphalt-impregnated fiberglass mat on the other side of SEALTIGHT PROTECTION COURSE is approved as "compatible" to the specific waterproofing product being protected.

SEALTIGHT PROTECTION COURSE is installed to form a continuous protective layer over the membrane waterproofing. The sheets can be easily cut with a roofer's knife for fitting at protrusions.

SURFACE CONDITION: The waterproofing membrane must be free of sharp projections, dirt and dust. If water testing is desired, it should be made prior to placing the PROTECTION COURSE. NOTE: PROTECTION COURSE should be applied at the end of each day's waterproofing to both horizontal and vertical surfaces.

HORIZONTAL SURFACES: PROTECTION COURSE should be installed over the waterproofing membrane as soon as permissible by the membrane applicator or manufacturer. PROTECTION COURSE sheets should be butted together and cut to fit all intersecting surfaces and protrusions. If desired, joints may be covered with SEALTIGHT Detail strip or roofer's glass reinforced tape embedded in hot asphalt as a secondary waterproofing system. (see point 2 under Precautions).

VERTICAL SURFACES: For dampproofed and/or waterproofed vertical walls to receive backfill, the PROTECTION COURSE should be butt jointed and, if necessary, temporarily held in place while backfilling.

BACKFILLING: Backfilling against vertical walls should be done immediately using care and caution to avoid damaging the waterproofing application. Backfill material should not be dropped against the PROTECTION COURSE in such a manner that it could drag the sheet down as the backfill drops. For horizontal applications, the waterproofing and PROTECTION COURSE should be installed just prior to the installation of the wearing surface.

Application Tools

Trowel

Roofer's knife

ASTM D 6506
Protection Board Requirements

	Type 1	Type 2	Type 3
Puncture Strength (Classes A & B)	222 N (50 lbf) minimum	312 N (70 lbf) minimum	365 N (82 lbf) minimum
Thickness (Classes A & B)	1.3 to 1.8mm (0.050 to 0.070in.)	2.4 to 3.9mm (0.095 to 0.155in.)	5.6 to 7.1mm (0.220 to 0.280in.)
Water Absorption (Classes A & B)	10.0% maximum	10.0% maximum	10.0% maximum
Asphalt, % by weight (Class A)	65% minimum	65% minimum	65% minimum
Asphalt, % by weight (Class B)	40% minimum	40% minimum	40% minimum
Resistance to Decay (Classes A & B)	Meets puncture requirements after completion of test	Meets puncture requirements after completion of test	Meets puncture requirements after completion of test

Coverage:

TYPE	THICKNESS*	WIDTH	LENGTH
PC-1 Light Duty	62.5 mil-1/16" (1.59mm)	4' (1.22m)	8' (2.44m)
PC-2 Standard Duty	125 mil-1/8" (3.18mm)	4' (1.22m)	8' (2.44m)
PC-3 Heavy Duty	250 mil-1/4" (6.35mm)	4' (1.22m)	8' (2.44m)

*NOMINAL

To assist you in the specification of this product, Guide Specifications are available through your local SEALTIGHT Distributor, or contact your nearest W. R. Meadows Branch office.
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APPENDIX IV

LOW-FLOW (MINIMAL DRAWDOWN) GROUND-WATER SAMPLING PROCEDURES

United States Environmental Protection Agency | Office of Research and Development | Office of Solid Waste and Emergency Response | EPA/540/S-95/504 April 1996

EPA Ground Water Issue

LOW-FLOW (MINIMAL DRAWDOWN) GROUND-WATER SAMPLING PROCEDURES

by Robert W. Puls[1] and Michael J. Barcelona[2]

Background

The Regional Superfund Ground Water Forum is a group of ground-water scientists, representing EPA's Regional Superfund Offices, organized to exchange information related to ground-water remediation at Superfund sites. One of the major concerns of the Forum is the sampling of ground water to support site assessment and remedial performance monitoring objectives. This paper is intended to provide background information on the development of low-flow sampling procedures and its application under a variety of hydrogeologic settings. It is hoped that the paper will support the production of standard operating procedures for use by EPA Regional personnel and other environmental professionals engaged in ground-water sampling.

For further information contact: Robert Puls, 405-436-8543, Subsurface Remediation and Protection Division, NRMRL, Ada, Oklahoma.

I. Introduction

The methods and objectives of ground-water sampling to assess water quality have evolved over time. Initially the emphasis was on the assessment of water quality of aquifers as sources of drinking water. Large water-bearing units were identified and sampled in keeping with that objective. These were highly productive aquifers that supplied drinking water via private wells or through public water supply systems. Gradually, with the increasing awareness of subsurface pollution of these water resources, the understanding of complex hydrogeochemical processes which govern the fate and transport of contaminants in the subsurface increased. This increase in understanding was also due to advances in a number of scientific disciplines and improvements in tools used for site characterization and ground-water sampling. Ground-water quality investigations where pollution was detected initially borrowed ideas, methods, and materials for site characterization from the water supply field and water analysis from public health practices. This included the materials and manner in which monitoring wells were installed and the way in which water was brought to the surface, treated, preserved and analyzed. The prevailing conceptual ideas included convenient generalizations of ground-water resources in terms of large and relatively homogeneous hydrologic *units*. With time it became apparent that conventional water supply generalizations of *homogeneity* did not adequately represent field data regarding pollution of these subsurface resources. The important role of *heterogeneity* became increasingly clear not only in geologic terms, but also in terms of complex physical,

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Director

chemical and biological subsurface processes. With greater appreciation of the role of heterogeneity, it became evident that subsurface pollution was ubiquitous and encompassed the unsaturated zone to the deep subsurface and included unconsolidated sediments, fractured rock, and *aquitards* or low-yielding or impermeable formations. Small-scale processes and heterogeneities were shown to be important in identifying contaminant distributions and in controlling water and contaminant flow paths.

It is beyond the scope of this paper to summarize all the advances in the field of ground-water quality investigations and remediation, but two particular issues have bearing on ground-water sampling today: aquifer heterogeneity and colloidal transport. Aquifer heterogeneities affect contaminant flow paths and include variations in geology, geochemistry, hydrology and microbiology. As methods and the tools available for subsurface investigations have become increasingly sophisticated and understanding of the subsurface environment has advanced, there is an awareness that in most cases a primary concern for site investigations is characterization of contaminant flow paths rather than entire aquifers. In fact, in many cases, plume thickness can be less than well screen lengths (e.g., 3-6 m) typically installed at hazardous waste sites to detect and monitor plume movement over time. Small-scale differences have increasingly been shown to be important and there is a general trend toward smaller diameter wells and shorter screens.

The hydrogeochemical significance of colloidal-size particles in subsurface systems has been realized during the past several years (Gschwend and Reynolds, 1987; McCarthy and Zachara, 1989; Puls, 1990; Ryan and Gschwend, 1990). This realization resulted from both field and laboratory studies that showed faster contaminant migration over greater distances and at higher concentrations than flow and transport model predictions would suggest (Buddemeier and Hunt, 1988; Enfield and Bengtsson, 1988; Penrose et al., 1990). Such models typically account for interaction between the mobile aqueous and immobile solid phases, but do not allow for a mobile, reactive solid phase. It is recognition of this third *phase* as a possible means of contaminant transport that has brought increasing attention to the manner in which samples are collected and processed for analysis (Puls et al., 1990; McCarthy and Degueldre, 1993; Backhus et al., 1993; U. S. EPA, 1995). If such a phase is present in sufficient mass, possesses high sorption reactivity, large surface area, and remains stable in suspension, it can serve as an important mechanism to facilitate contaminant transport in many types of subsurface systems.

Colloids are particles that are sufficiently small so that the surface free energy of the particle dominates the bulk free energy. Typically, in ground water, this includes particles with diameters between 1 and 1000 nm. The most commonly observed mobile particles include: secondary clay minerals; hydrous iron, aluminum, and manganese oxides; dissolved and particulate organic materials, and viruses and bacteria. These reactive particles have been shown to be mobile under a variety of conditions in both field studies and laboratory column experiments, and as such need to be included in monitoring programs where identification of the *total* mobile contaminant loading (dissolved + naturally suspended particles) at a site is an objective. To that end, sampling methodologies must be used which do not artificially bias *naturally* suspended particle concentrations.

Currently the most common ground-water purging and sampling methodology is to purge a well using bailers or high speed pumps to remove 3 to 5 casing volumes followed by sample collection. This method can cause adverse impacts on sample quality through collection of samples with high levels of turbidity. This results in the inclusion of otherwise immobile artifactual particles which produce an overestimation of certain analytes of interest (e.g., metals or hydrophobic organic compounds). Numerous documented problems associated with filtration (Danielsson, 1982; Laxen and Chandler, 1982; Horowitz et al., 1992) make this an undesirable method of rectifying the turbidity problem, and include the removal of potentially mobile (contaminant-associated) particles during filtration, thus artificially biasing contaminant concentrations low. Sampling-induced turbidity problems can often be mitigated by using low-flow purging and sampling techniques.

Current subsurface conceptual models have undergone considerable refinement due to the recent development and increased use of field screening tools. So-called hydraulic *push* technologies (e.g., cone penetrometer, Geoprobe®, QED HydroPunch®) enable relatively fast screening site characterization which can then be used to design and install a monitoring well network. Indeed, alternatives to conventional monitoring wells are now being considered for some hydrogeologic settings. The ultimate design of any monitoring system should however be based upon adequate site characterization and be consistent with established monitoring objectives.

If the sampling program objectives include accurate assessment of the magnitude and extent of subsurface contamination over time and/or accurate assessment of subsequent remedial performance, then some information regarding plume delineation in three-dimensional space is necessary prior to monitoring well network design and installation. This can be accomplished with a variety of different tools and equipment ranging from hand-operated augers to screening tools mentioned above and large drilling rigs. Detailed information on ground-water flow velocity, direction, and horizontal and vertical variability are essential baseline data requirements. Detailed soil and geologic data are required prior to and during the installation of sampling points. This includes historical as well as detailed soil and geologic logs which accumulate during the site investigation. The use of borehole geophysical techniques is also recommended. With this information (together with other site characterization data) and a clear understanding of sampling objectives, then appropriate location, screen length, well diameter, slot size, etc. for the monitoring well network can be decided. This is especially critical for new in situ remedial approaches or natural attenuation assessments at hazardous waste sites.

In general, the overall goal of any ground-water sampling program is to collect water samples with no alteration in water chemistry; analytical data thus obtained may be used for a variety of specific monitoring programs depending on the regulatory requirements. The sampling methodology described in this paper assumes that the monitoring goal is to sample monitoring wells for the presence of contaminants and it is applicable whether mobile colloids are a concern or not and whether the analytes of concern are metals (and metalloids) or organic compounds.

II. Monitoring Objectives and Design Considerations

The following issues are important to consider prior to the design and implementation of any ground-water monitoring program, including those which anticipate using low-flow purging and sampling procedures.

A. Data Quality Objectives (DQOs)

Monitoring objectives include four main types: detection, assessment, corrective-action evaluation and resource evaluation, along with *hybrid* variations such as site-assessments for property transfers and water availability investigations. Monitoring objectives may change as contamination or water quality problems are discovered. However, there are a number of common components of monitoring programs which should be recognized as important regardless of initial objectives. These components include:

1) Development of a conceptual model that incorporates elements of the regional geology to the local geologic framework. The conceptual model development also includes initial site characterization efforts to identify hydrostratigraphic units and likely flow-paths using a minimum number of borings and well completions;

2) Cost-effective and well documented collection of high quality data utilizing simple, accurate, and reproducible techniques; and

3) Refinement of the conceptual model based on supplementary data collection and analysis.

These fundamental components serve many types of monitoring programs and provide a basis for future efforts that evolve in complexity and level of spatial detail as purposes and objectives expand. High quality, reproducible data collection is a common goal regardless of program objectives.

High quality data collection implies data of sufficient accuracy, precision, and completeness (i.e., ratio of valid analytical results to the minimum sample number called for by the program design) to meet the program objectives. Accuracy depends on the correct choice of monitoring tools and procedures to minimize sample and subsurface disturbance from collection to analysis. Precision depends on the repeatability of sampling and analytical protocols. It can be assured or improved by replication of sample analyses including blanks, field/lab standards and reference standards.

B. Sample Representativeness

An important goal of any monitoring program is collection of data that is truly representative of conditions at the site. The term *representativeness* applies to chemical and hydrogeologic data collected via wells, borings, piezometers, geophysical and soil gas measurements, lysimeters, and temporary sampling points. It involves a recognition of the statistical variability of individual subsurface physical properties, and contaminant or major ion concentration levels, while explaining extreme values. Subsurface temporal and spatial variability are facts. Good professional practice seeks to maximize representativeness by using proven accurate and reproducible techniques to define limits on the distribution of measurements collected at a site. However, measures of representativeness are dynamic and are controlled by evolving site characterization and monitoring objectives. An evolutionary site characterization model, as shown in Figure 1, provides a systematic approach to the goal of consistent data collection.

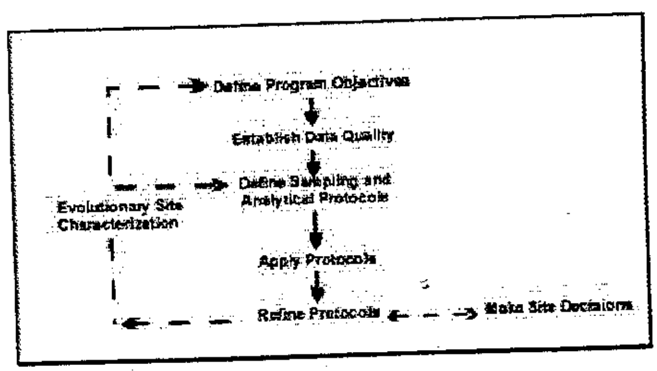

Figure 1. Evolutionary Site Characterization Model

The model emphasizes a recognition of the causes of the variability (e.g., use of inappropriate technology such as using bailers to purge wells; imprecise or operator-dependent methods) and the need to control avoidable errors.

1) Questions of Scale

A sampling plan designed to collect representative samples must take into account the potential scale of changes in site conditions through space and time as well as the chemical associations and behavior of the parameters that are targeted for investigation. In subsurface systems, physical (i.e., aquifer) and chemical properties over time or space are not statistically independent. In fact, samples taken in close proximity (i.e., within distances of a few meters) or within short time periods (i.e., more frequently than monthly) are highly auto-correlated. This means that designs employing high-sampling frequency (e.g., monthly) or dense spatial monitoring designs run the risk of redundant data collection and misleading inferences regarding trends in values that aren't statistically valid. In practice, contaminant detection and assessment monitoring programs rarely suffer these *over-sampling* concerns. In corrective-action evaluation programs, it is also possible that too little data may be collected over space or time. In these cases, false interpretation of the spatial extent of contamination or underestimation of temporal concentration variability may result.

2) Target Parameters

Parameter selection in monitoring program design is most often dictated by the regulatory status of the site. However, background water quality constituents, purging indicator parameters, and contaminants, all represent targets for data collection programs. The tools and procedures used in these programs should be equally rigorous and applicable to all categories of data, since all may be needed to determine or support regulatory action.

C. Sampling Point Design and Construction

Detailed site characterization is central to all decision-making purposes and the basis for this characterization resides in identification of the geologic framework and major hydro-stratigraphic units. Fundamental data for sample point location include: subsurface lithology, head-differences and background geochemical conditions. Each sampling point has a proper use or uses which should be documented at a level which is appropriate for the program's data quality objectives. Individual sampling points may not always be able to fulfill multiple monitoring objectives (e.g., detection, assessment, corrective action).

1) Compatibility with Monitoring Program and Data Quality Objectives

Specifics of sampling point location and design will be dictated by the complexity of subsurface lithology and variability in contaminant and/or geochemical conditions. It should be noted that, regardless of the ground-water sampling approach, few sampling points (e.g., wells, drive-points, screened augers) have zones of influence in excess of a few feet. Therefore, the spatial frequency of sampling points should be carefully selected and designed.

2) Flexibility of Sampling Point Design

In most cases *well-point* diameters in excess of 1 7/8 inches will permit the use of most types of submersible pumping devices for low-flow (minimal drawdown) sampling. It is suggested that *short* (e.g., less than 1.6 m) screens be incorporated into the monitoring design where possible so that comparable results from one device to another might be expected. *Short*, of course, is relative to the degree of vertical water quality variability expected at a site.

3) Equilibration of Sampling Point

Time should be allowed for equilibration of the well or sampling point with the formation after installation. Placement of well or sampling points in the subsurface produces some disturbance of ambient conditions. Drilling techniques (e.g., auger, rotary, etc.) are generally considered to cause more disturbance than *direct-push* technologies. In either case, there may be a period (i.e., days to months) during which water quality near the point may be distinctly different from that in the formation. Proper development of the sampling point and adjacent formation to remove fines created during emplacement will shorten this water quality *recovery* period.

III. Definition of Low-Flow Purging and Sampling

It is generally accepted that water in the well casing is non-representative of the formation water and needs to be purged prior to collection of ground-water samples. However, the water in the screened interval may indeed be representative of the formation, depending upon well construction and site hydrogeology. Wells are purged to some extent for the following reasons: the presence of the air interface at the top of the water column resulting in an oxygen concentration gradient with depth, loss of volatiles up the water column, leaching from or sorption to the casing or filter pack, chemical changes due to clay seals or backfill, and surface infiltration.

Low-flow purging, whether using portable or dedicated systems, should be done using pump-intake located in the middle or slightly above the middle of the screened interval. Placement of the pump too close to the bottom of the well will cause increased entrainment of solids which have collected in the well over time. These particles are present as a result of well development, prior purging and sampling events, and natural colloidal transport and deposition. Therefore, placement of the pump in the middle or toward the top of the screened interval is suggested. Placement of the pump at the top of the water column for sampling is only recommended in unconfined aquifers, screened across the water table, where this is the desired sampling point. Low-flow purging has the advantage of minimizing mixing between the overlying stagnant casing water and water within the screened interval.

A. *Low-Flow Purging and Sampling*

Low-flow refers to the velocity with which water enters the pump intake and that is imparted to the formation pore water in the immediate vicinity of the well screen. It does not necessarily refer to the flow rate of water discharged at the surface which can be affected by flow regulators or restrictions. Water level drawdown provides the best indication of the stress imparted by a given flow-rate for a given hydrological situation. The objective is to pump in a manner that minimizes stress (drawdown) to the system to the extent practical taking into account established site sampling objectives. Typically, flow rates on the order of 0.1 - 0.5 L/min are used, however this is dependent on site-specific hydrogeology. Some extremely coarse-textured formations have been successfully sampled in this manner at flow rates to 1 L/min. The effectiveness of using low-flow purging is intimately linked with proper screen location, screen length, and well construction and development techniques. The reestablishment of natural flow paths in both the vertical and horizontal directions is important for correct interpretation of the data. For high resolution sampling needs, screens less than 1 m should be used. Most of the need for purging has been found to be due to passing the sampling device through the overlying casing water which causes mixing of these stagnant waters and the dynamic waters within the screened interval. Additionally, there is disturbance to suspended sediment collected in the bottom of the casing and the displacement of water out into the formation immediately adjacent to the well screen. These disturbances and impacts can be avoided using dedicated sampling equipment, which precludes the need to insert the sampling device prior to purging and sampling.

Isolation of the screened interval water from the overlying stagnant casing water may be accomplished using low-flow minimal drawdown techniques. If the pump intake is located within the screened interval, most of the water pumped will be drawn in directly from the formation with little mixing of casing water or disturbance to the sampling zone. However, if the wells are not constructed and developed properly, zones other than those intended may be sampled. At some sites where geologic heterogeneities are sufficiently different within the screened interval, higher conductivity zones may be preferentially sampled. This is another reason to use shorter screened intervals, especially where high spatial resolution is a sampling objective.

B. *Water Quality Indicator Parameters*

It is recommended that water quality indicator parameters be used to determine purging needs prior to sample collection in each well. Stabilization of parameters such as pH, specific conductance, dissolved oxygen, oxidation-reduction potential, temperature and turbidity should be used to determine when formation water is accessed during purging. In general, the order of stabilization is pH, temperature, and specific conductance, followed by oxidation-reduction potential, dissolved oxygen and turbidity. Temperature and pH, while commonly used as purging indicators, are actually quite insensitive in distinguishing between formation water and stagnant casing water; nevertheless, these are important parameters for data interpretation purposes and should also be measured. Performance criteria for determination of stabilization should be based on water-level drawdown, pumping rate and equipment specifications for measuring indicator parameters. Instruments are available which utilize in-line flow cells to continuously measure the above parameters.

It is important to establish specific well stabilization criteria and then consistently follow the same methods thereafter, particularly with respect to drawdown, flow rate and sampling device. Generally, the time or purge volume required for parameter stabilization is independent of well depth or well volumes. Dependent variables are well diameter, sampling device, hydrogeochemistry, pump flow rate, and whether the devices are used in a portable or dedicated manner. If the sampling device is already in place (i.e., dedicated sampling systems), then the time and purge volume needed for stabilization is much shorter. Other advantages of dedicated equipment include less purge water for waste disposal, much less decontamination of equipment, less time spent in preparation of sampling as well as time in the field, and more consistency in the sampling approach which probably will translate into less variability in sampling results. The use of dedicated equipment is strongly recommended at wells which will undergo routine sampling over time.

If parameter stabilization criteria are too stringent, then minor oscillations in indicator parameters may cause purging operations to become unnecessarily protracted. It should also be noted that turbidity is a very conservative parameter in terms of stabilization. Turbidity is always the last parameter to stabilize. Excessive purge times are invariably related to the establishment of too stringent turbidity stabilization criteria. It should be noted that natural turbidity levels in ground water may exceed 10 nephelometric turbidity units (NTU).

C. *Advantages and Disadvantages of Low-Flow (Minimum Drawdown) Purging*

In general, the advantages of low-flow purging include:

- samples which are representative of the *mobile* load of contaminants present (dissolved and colloid-associated);
- minimal disturbance of the sampling point thereby minimizing sampling artifacts;
- less operator variability, greater operator control;

- reduced stress on the formation (minimal drawdown);
- less mixing of stagnant casing water with formation water;
- reduced need for filtration and, therefore, less time required for sampling;
- smaller purging volume which decreases waste disposal costs and sampling time;
- better sample consistency; reduced artificial sample variability.

Some disadvantages of low-flow purging are:

- higher initial capital costs,
- greater set-up time in the field,
- need to transport additional equipment to and from the site,
- increased training needs,
- resistance to change on the part of sampling practitioners,
- concern that new data will indicate a *change in conditions* and trigger an *action*.

IV. Low-Flow (Minimal Drawdown) Sampling Protocols

The following ground-water sampling procedure has evolved over many years of experience in ground-water sampling for organic and inorganic compound determinations and as such summarizes the authors' (and others) experiences to date (Barcelona et al., 1984, 1994; Barcelona and Helfrich, 1986; Puls and Barcelona, 1989; Puls et. al. 1990, 1992; Puls and Powell, 1992; Puls and Paul, 1995). High-quality chemical data collection is essential in ground-water monitoring and site characterization. The primary limitations to the collection of *representative* ground-water samples include: mixing of the stagnant casing and *fresh* screen waters during insertion of the sampling device or ground-water level measurement device; disturbance and resuspension of settled solids at the bottom of the well when using high pumping rates or raising and lowering a pump or bailer; introduction of atmospheric gases or degassing from the water during sample handling and transfer, or inappropriate use of vacuum sampling device, etc.

A. Sampling Recommendations

Water samples should not be taken immediately following well development. Sufficient time should be allowed for the ground-water flow regime in the vicinity of the monitoring well to stabilize and to approach chemical equilibrium with the well construction materials. This lag time will depend on site conditions and methods of installation but often exceeds one week.

Well purging is nearly always necessary to obtain samples of water flowing through the geologic formations in the screened interval. Rather than using a general but arbitrary guideline of purging three casing volumes prior to sampling, it is recommended that an in-line water quality measurement device (e.g., flow-through cell) be used to establish the stabilization time for several parameters (e.g., pH, specific conductance, redox, dissolved oxygen, turbidity) on a well-specific basis. Data on pumping rate, drawdown, and volume required for parameter stabilization can be used as a guide for conducting subsequent sampling activities.

The following are recommendations to be considered before, during and after sampling:

- use low-flow rates (<0.5 L/min), during both purging and sampling to maintain minimal drawdown in the well;
- maximize tubing wall thickness, minimize tubing length;
- place the sampling device intake at the desired sampling point;
- minimize disturbances of the stagnant water column above the screened interval during water level measurement and sampling device insertion;
- make proper adjustments to stabilize the flow rate as soon as possible;
- monitor water quality indicators during purging;
- collect unfiltered samples to estimate contaminant loading and transport potential in the subsurface system.

B. Equipment Calibration

Prior to sampling, all sampling device and monitoring equipment should be calibrated according to manufacturer's recommendations and the site Quality Assurance Project Plan (QAPP) and Field Sampling Plan (FSP). Calibration of pH should be performed with at least two buffers which bracket the expected range. Dissolved oxygen calibration must be corrected for local barometric pressure readings and elevation.

C. Water Level Measurement and Monitoring

It is recommended that a device be used which will least disturb the water surface in the casing. Well depth should be obtained from the well logs. Measuring to the bottom of the well casing will only cause resuspension of settled solids from the formation and require longer purging times for turbidity equilibration. Measure well depth after sampling is completed. The water level measurement should be taken from a permanent reference point which is surveyed relative to ground elevation.

D. Pump Type

The use of low-flow (e.g., 0.1-0.5 L/min) pumps is suggested for purging and sampling all types of analytes. All pumps have some limitation and these should be investigated with respect to application at a particular site. Bailers are inappropriate devices for low-flow sampling.

1) General Considerations

There are no unusual requirements for ground-water sampling devices when using low-flow, minimal drawdown techniques. The major concern is that the device give consistent results and minimal disturbance of the sample across a range of *low* flow rates (i.e., < 0.5 L/min). Clearly, pumping rates that cause minimal to no drawdown in one well could easily cause *significant* drawdown in another well finished in a less transmissive formation. In this sense, the pump should not cause undue pressure or temperature changes or physical disturbance on the water sample over a reasonable sampling range. Consistency in operation is critical to meet accuracy and precision goals.

2) Advantages and Disadvantages of Sampling Devices

A variety of sampling devices are available for low-flow (minimal drawdown) purging and sampling and include peristaltic pumps, bladder pumps, electrical submersible pumps, and gas-driven pumps. Devices which lend themselves to both dedication and consistent operation at definable low-flow rates are preferred. It is desirable that the pump be easily adjustable and operate reliably at these lower flow rates. The peristaltic pump is limited to shallow applications and can cause degassing resulting in alteration of pH, alkalinity, and some volatiles loss. Gas-driven pumps should be of a type that does not allow the gas to be in direct contact with the sampled fluid.

Clearly, bailers and other *grab* type samplers are ill-suited for low-flow sampling since they will cause repeated disturbance and mixing of *stagnant* water in the casing and the *dynamic* water in the screened interval. Similarly, the use of inertial lift foot-valve type samplers may cause too much disturbance at the point of sampling. Use of these devices also tends to introduce uncontrolled and unacceptable operator variability.

Summaries of advantages and disadvantages of various sampling devices are listed in Herzog et al. (1991), U. S. EPA (1992), Parker (1994) and Thurnblad (1994).

E. Pump Installation

Dedicated sampling devices (left in the well) capable of pumping and sampling are preferred over any other type of device. Any portable sampling device should be slowly and carefully lowered to the middle of the screened interval or slightly above the middle (e.g., 1-1.5 m below the top of a 3 m screen). This is to minimize excessive mixing of the stagnant water in the casing above the screen with the screened interval zone water, and to minimize resuspension of solids which will have collected at the bottom of the well. These two disturbance effects have been shown to directly affect the time required for purging. There also appears to be a direct correlation between size of portable sampling devices relative to the well bore and resulting purge volumes and times. The key is to minimize disturbance of water and solids in the well casing.

F. Filtration

Decisions to filter samples should be dictated by sampling objectives rather than as a *fix* for poor sampling practices, and field-filtering of certain constituents should not be the default. Consideration should be given as to what the application of field-filtration is trying to accomplish. For assessment of truly dissolved (as opposed to operationally *dissolved* [i.e., samples filtered with 0.45 µm filters]) concentrations of major ions and trace metals, 0.1 µm filters are recommended although 0.45 µm filters are normally used for most regulatory programs. Alkalinity samples must also be filtered if significant particulate calcium carbonate is suspected, since this material is likely to impact alkalinity titration results (although filtration itself may alter the CO_2 composition of the sample and, therefore, affect the results).

Although filtration may be appropriate, filtration of a sample may cause a number of unintended changes to occur (e.g. oxidation, aeration) possibly leading to filtration-induced artifacts during sample analysis and uncertainty in the results. Some of these unintended changes may be unavoidable but the factors leading to them must be recognized. Deleterious effects can be minimized by consistent application of certain filtration guidelines. Guidelines should address selection of filter type, media, pore size, etc. in order to identify and minimize potential sources of uncertainty when filtering samples.

In-line filtration is recommended because it provides better consistency through less sample handling, and minimizes sample exposure to the atmosphere. In-line filters are available in both disposable (barrel filters) and non-disposable (in-line filter holder, flat membrane filters) formats and various filter pore sizes (0.1-5.0 µm). Disposable filter cartridges have the advantage of greater sediment handling capacity when compared to traditional membrane filters. Filters must be pre-rinsed following manufacturer's recommendations. If there are no recommendations for rinsing, pass through a minimum of 1 L of ground water following purging and prior to sampling. Once filtration has begun, a filter cake may develop as particles larger than the pore size accumulate on the filter membrane. The result is that the effective pore diameter of the membrane is reduced and particles smaller than the stated pore size are excluded from the filtrate. Possible corrective measures include prefiltering (with larger pore size filters), minimizing particle loads to begin with, and reducing sample volume.

G. Monitoring of Water Level and Water Quality Indicator Parameters

Check water level periodically to monitor drawdown in the well as a guide to flow rate adjustment. The goal is minimal drawdown (<0.1 m) during purging. This goal may be difficult to achieve under some circumstances due to geologic heterogeneities within the screened interval, and may require adjustment based on site-specific conditions and personal experience. In-line water quality indicator parameters should be continuously monitored during purging. The water quality indicator parameters monitored can include pH, redox potential, conductivity, dissolved oxygen (DO) and turbidity. The last three parameters are often most sensitive. Pumping rate, drawdown, and the time or volume required to obtain stabilization of parameter readings can be used as a future guide to purge the well. Measurements should be taken every three to five minutes if the above suggested rates are used. Stabilization is achieved after all parameters have stabilized for three successive readings. In lieu of measuring all five parameters, a minimum subset would include pH, conductivity, and turbidity or DO. Three successive readings should be within ± 0.1 for pH, ± 3% for conductivity, ± 10 mv for redox potential, and ± 10% for turbidity and DO. Stabilized purge indicator parameter trends are generally obvious and follow either an exponential or asymptotic change to stable values during purging. Dissolved oxygen and turbidity usually require the longest time for stabilization. 'The above stabilization guidelines are provided for rough estimates based on experience.

H. Sampling, Sample Containers, Preservation and Decontamination

Upon parameter stabilization, sampling can be initiated. If an in-line device is used to monitor water quality parameters, it should be disconnected or bypassed during sample collection. Sampling flow rate may remain at established purge rate or may be adjusted slightly to minimize aeration, bubble formation, turbulent filling of sample bottles, or loss of volatiles due to extended residence time in tubing. Typically, flow rates less than 0.5 L/min are appropriate. The same device should be used for sampling as was used for purging. Sampling should occur in a progression from least to most contaminated well, if this is known. Generally, volatile (e.g., solvents and fuel constituents) and gas sensitive (e.g., Fe^{2+}, CH_4, H_2S/HS^-, alkalinity) parameters should be sampled first. The sequence in which samples for most inorganic parameters are collected is immaterial unless filtered (dissolved) samples are desired. Filtering should be done last and in-line filters should be used as discussed above. During both well purging and sampling, proper protective clothing and equipment must be used based upon the type and level of contaminants present.

The appropriate sample container will be prepared in advance of actual sample collection for the analytes of interest and include sample preservative where necessary. Water samples should be collected directly into this container from the pump tubing.

Immediately after a sample bottle has been filled, it must be preserved as specified in the site (QAPP). Sample preservation requirements are based on the analyses being performed (use site QAPP, FSP, RCRA guidance document [U. S. EPA, 1992] or EPA SW-846 [U. S. EPA, 1982]). It may be advisable to add preservatives to sample bottles in a controlled setting prior to entering the field in order to reduce the chances of improperly preserving sample bottles or introducing field contaminants into a sample bottle while adding the preservatives.

The preservatives should be transferred from the chemical bottle to the sample container using a disposable polyethylene pipet and the disposable pipet should be used only once and then discarded.

After a sample container has been filled with ground water, a Teflon™ (or tin)-lined cap is screwed on tightly to prevent the container from leaking. A sample label is filled out as specified in the FSP. The samples should be stored inverted at 4°C.

Specific decontamination protocols for sampling devices are dependent to some extent on the type of device used and the type of contaminants encountered. Refer to the site QAPP and FSP for specific requirements.

I. Blanks

The following blanks should be collected:

(1) field blank: one field blank should be collected from each source water (distilled/deionized water) used for sampling equipment decontamination or for assisting well development procedures.

(2) equipment blank: one equipment blank should be taken prior to the commencement of field work, from each set of sampling equipment to be used for that day. Refer to site QAPP or FSP for specific requirements.

(3) trip blank: a trip blank is required to accompany each volatile sample shipment. These blanks are prepared in the laboratory by filling a 40-mL volatile organic analysis (VOA) bottle with distilled/deionized water.

V. Low-Permeability Formations and Fractured Rock

The overall sampling program goals or sampling objectives will drive how the sampling points are located, installed, and choice of sampling device. Likewise, site-specific hydrogeologic factors will affect these decisions. Sites with very low permeability formations or fractures causing discrete flow channels may require a unique monitoring approach. Unlike water supply wells, wells installed for ground-water quality assessment and restoration programs are often installed in low water-yielding settings (e.g., clays, silts). Alternative types of sampling points and sampling methods are often needed in these types of environments, because low-permeability settings may require extremely low-flow purging (<0.1 L/min) and may be technology-limited. Where devices are not readily available to pump at such low flow rates, the primary consideration is to avoid dewatering of the well screen. This may require repeated recovery of the water during purging while leaving the pump in place within the well screen.

Use of low-flow techniques may be impractical in these settings, depending upon the water recharge rates. The sampler and the end-user of data collected from such wells need to understand the limitations of the data collected; i.e., a strong potential for underestimation of actual contaminant concentrations for volatile organics, potential false negatives for filtered metals and potential false positives for unfiltered metals. It is suggested that comparisons be made between samples recovered using low-flow purging techniques and samples recovered using passive sampling techniques (i.e., two sets of samples). Passive sample collection would essentially entail acquisition of the sample with no or very little purging using a dedicated sampling system installed within the screened interval or a passive sample collection device.

A. *Low-Permeability Formations (<0.1 L/min recharge)*

1. Low-Flow Purging and Sampling with Pumps

   a. "portable or non-dedicated mode" - Lower the pump (one capable of pumping at <0.1 L/min) to mid-screen or slightly above and set in place for minimum of 48 hours (to lessen purge volume requirements). After 48 hours, use procedures listed in Part IV above regarding monitoring water quality parameters for stabilization, etc., but do not dewater the screen. If excessive drawdown and slow recovery is a problem, then alternate approaches such as those listed below may be better.

   b. "dedicated mode" - Set the pump as above at least a week prior to sampling; that is, operate in a dedicated pump mode. With this approach significant reductions in purge volume should be realized. Water quality parameters should stabilize quite rapidly due to less disturbance of the sampling zone.

2. Passive Sample Collection

Passive sampling collection requires insertion of the device into the screened interval for a sufficient time period to allow flow and sample equilibration before extraction for analysis. Conceptually, the extraction of water from low yielding formations seems more akin to the collection of water from the unsaturated zone and passive sampling techniques may be more appropriate in terms of obtaining "representative" samples. Satisfying usual sample volume requirements is typically a problem with this approach and some latitude will be needed on the part of regulatory entities to achieve sampling objectives.

B. *Fractured Rock*

In fractured rock formations, a low-flow to zero purging approach using pumps in conjunction with packers to isolate the sampling zone in the borehole is suggested. Passive multi-layer sampling devices may also provide the most "representative" samples. It is imperative in these settings to identify flow paths or water-producing fractures prior to sampling using tools such as borehole flowmeters and/or other geophysical tools.

After identification of water-bearing fractures, install packer(s) and pump assembly for sample collection using low-flow sampling in "dedicated mode" or use a passive sampling device which can isolate the identified water-bearing fractures.

VI. Documentation

The usual practices for documenting the sampling event should be used for low-flow purging and sampling techniques. This should include, at a minimum: information on the conduct of purging operations (flow-rate, drawdown, water-quality parameter values, volumes extracted and times for measurements), field instrument calibration data, water sampling forms and chain of custody forms. See Figures 2 and 3 and "Ground Water Sampling Workshop -- A Workshop Summary" (U. S. EPA, 1995) for example forms and other documentation suggestions and information. This information coupled with laboratory analytical data and validation data are needed to judge the "useability" of the sampling data.

VII. Notice

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Figure 2. **Ground Water Sampling Log**

Project ______________ **Site** ______________ **Well No.** ____________ **Date** ______________

Well Depth ____________ **Screen Length** ___________ **Well Diameter** _________ **Casing Type** ___________

Sampling Device _____________ **Tubing type** ____________________ **Water Level** ______________

Measuring Point _________________ **Other Infor** ______________________________________

____

Sampling Personnel ____

Time	pH	Temp	Cond.	Dis.O_2	Turb.	[ ]Conc			Notes

Type of Samples Collected

____

Information: 2 in = 617 ml/ft, 4 in = 2470 ml/ft: $Vol_{cyl} = \pi r^2 h$, $Vol_{sphere} = 4/3\pi\, r^3$

Figure 3. **Ground Water Sampling Log** (with automatic data logging for most water quality parameters)

Project ________________ Site ________________ Well No. ____________ Date ____________________

Well Depth ____________ Screen Length __________ Well Diameter _________ Casing Type ___________

Sampling Device ________________ Tubing type ______________________ Water Level ______________

Measuring Point ____________________ Other Infor ____

____

Sampling Personnel ____

Time	Pump Rate	Turbidity	Alkalinity	[ ] Conc	Notes

Type of Samples Collected

____

Information: 2 in = 617 ml/ft, 4 in = 2470 ml/ft: $Vol_{cyl} = \pi r^2 h$, $Vol_{sphere} = 4/3\pi r^3$

LOW-FLOW PURGING AND SAMPLING/MICROPURGING

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