DAMES & MOORE

A DAMES & MOORE GROUP COMPANY

SAMPLING AND ANALYSIS PLAN

Field- and Bench-Scale Testing Program and Conceptual Design
Interim Remedial Groundwater Action
Liberty Industrial Finishing Site
Farmingdale, New Jersey

Prepared for:

Liberty PRP Group

Dames & Moore Job No. 35550-004
2325 Maryland Road Willow Grove, PA 19090
(215) 657-5000

June 2, 1998

CONTENTS

FIGURES

TABLES

1.0 INTRODUCTION

Dames & Moore has prepared this Sampling and Analysis Plan (SAP) for the field- and bench-scale testing program of proposed remedial technologies relative to the interim remedial groundwater action at the Liberty Industrial Finishing Site (site). The SAP incorporates the requirements of a Field Sampling Plan and Quality Assurance Project Plan (QAPP) based upon the analytical requirements for the completion of the Draft Final Field- and Bench-Scale Testing Program and Conceptual Design Work Plan (work plan), dated May 29, 1998.

The SAP in conjunction with the amended Health and Safety Plan (dated May 29, 1998, Revision 1) and the Draft Final Work Plan (dated May 29, 1998) will be used to complete the field- and bench-scale testing at the site.

2.0 BACKGROUND

2.1 OBJECTIVE AND SCOPE OF WORK

The purpose of the field- and bench-scale testing program is to confirm the feasibility and to complete the preliminary design of the interim remedial alternatives outlined in the U.S. Environmental Protection Agency (EPA) Proposed Remedial Action, Interim Groundwater Action, Liberty Industrial Finishing Site (EPA, December 1997).

Field-scale tests (i.e., those performed on-site under actual operating conditions) will involve:

- UVB-type GCW test
- DDC-type GCW test
- Aquifer Pumping Test
- Dipole Flow Test (optional based on applicability to site)

Bench-scale tests (i.e., those performed in a laboratory under simulated, scaled-down operating conditions) will involve:

- Metals Treatability Study by Chelation Technology
- Metals Treatability Study by Anion Exchange and Precipitation

2.2 SITE CONDITIONS

Location: The Liberty Industrial Finishing Site (site) is located in the unincorporated Village of Farmingdale, in the Town of Oyster Bay, Nassau County, New York. The site is bordered on the north by railroad tracks, on the east by Main Street, on the west by Ellsworth Allen Park and on the south by Motor Avenue. The surrounding area is primarily residential, however, several commercial facilities exist along Fulton Street and Main Street to the north, and along Motor Avenue to the south. Many of the original structures are no longer standing, but most former building locations can be still identified by the remains of their concrete floor slabs. All structures in the western portion of the site have been demolished, and the terrain is generally overgrown with the exception of a wood pallet storage area along Motor Avenue.

Hydrogeology: The site is underlain by sandy and gravelly outwash deposits of Pleistocene age. These unconsolidated deposits comprise the Upper Glacial aquifer, and are approximately 85 to 90 feet thick beneath the site. -The Upper Glacial deposits grade into stratified fine sands, silt, and clay of the Cretaceous-age Magothy Formation. The Upper Glacial aquifer and the underlying Magothy aquifer are separated by a sequence of finer-grained silty and clayey layers. Groundwater at the site occurs within two aquifers - the Upper Glacial aquifer and the Magothy aquifer. The aquifer of interest for the interim remedial groundwater action is the Upper Glacial aquifer. Presently, the seasonal depth to groundwater at the site is approximately 16 to 19 feet bgs. - Groundwater within the Upper Glacial aquifer exists under unconfined conditions and moves predominantly in a south-southwest direction. The average horizontal hydraulic gradient of the water table is reported to be 0.0022, the average horizontal groundwater velocity within the Upper Glacial Aquifer is reported to be 1.6 feet/day, and the hydraulic conductivity anisotropy is reported to be 10:1.

Constituents of Interest (COI): The COI include those compounds that were detected between 1992 and 1998 in on-site monitoring or groundwater screening at concentrations exceeding the appropriate maximum contaminant levels (MCLs) or New York State Department of Environmental Conservation (NYSDEC) Class GA Standard:

- The organic COI include trichloroethene (TCE), cis-1,2-Dichloroethene (cis-1,2-DCE), 1,1,1-Trichloroethane (1,1,1-TCA), 1,2-Dichloroethane (1,2-DCA), and tetrachloroethene (PCE). The extent of organic COI beneath the site is limited to the upper portion of the Upper Glacial aquifer to about 45 feet bgs.

- The inorganic COI include cadmium (Cd) and chromium (total and hexavalent). The extent of inorganic COI beneath the site may span the entire thickness of the Upper Glacial aquifer to about 90 feet bgs. However, the highest concentrations of inorganic COI are also limited to the upper portion of the aquifer.

3.0 FIELD TESTING AND ANALYSIS PLAN

3.1 WELL INSTALLATION

One groundwater circulation well (GCW-1) five observation well clusters (PZ-1 through PZ-5), two injection wells (IW-A and IW-B), and four observation wells (GM-1S, GM-2S, GM-3S, and GM-4D) will be installed at the locations shown in Figure 1. The well completion details of the planned wells are summarized in Table 1.

3.1.1 Groundwater Circulation Well

A pilot boring will be advanced to 90 feet bgs, using mud rotary methods and a 4-inch diameter roller bit or wing bit. Lithologic splitspoon samples will be collected from the anticipated screen intervals. The pilot hole will be reamed with a 16-inch diameter roller bit, using mud rotary methods. Upon completion of drilling, the 10-inch-diameter casing and stainless steel screen will be inserted into the borehole. The GCW will have an upper screen sectioned positioned at 17 to 22 feet bgs, a middle screen positioned at 47 to 60 feet bgs, and a lower screen positioned at 85 to 90 feet bgs. The GCW casing will consist of 10-inch-diameter PVC (Schedule 80) and will be brought above grade for the field-test. The screen sections of the GCW will consist of 10-inch-diameter stainless steel Johnson irrigator wire-wrap screen. The screen opening is anticipated to be 0.020 inches, however, a different screen opening size may be used depending on the lithologies encountered during the pilot boring. Artificial gravel pack will be placed from two feet below to two feet above each screen interval. The screen intervals will be separated from one another by bentonite slurry seals.

3.1.2 Observation Well Clusters

The observation wells PZ-1 through PZ-5 will be installed as well clusters, with each well cluster containing three 2-inch diameter wells that are screened at 17 to 22 ft bgs, 47 to 60 ft bgs, and 85 to 90 ft bgs, respectively. The well cluster borings will be advanced with nominal 8.5-inch OD hollow-stem augers to a depth of 90 ft bgs. The observation wells will be constructed of 2-inch-diameter PVC (Schedule 40) casing and 2-inch diameter, machine slotted PVC screen (screen opening is 0.020 inches). Artificial gravel pack will be placed from two feet below to two feet above each screen interval. The screen intervals will be separated from one another by bentonite slurry seals. The five observation well clusters will be installed at distances of approximately 5, 15, 25, 35, and 60 feet from the GCW, respectively.

3.1.3 Injection Wells

One shallow (IW-A) and one deep (IW-B) injection well will be installed. Well IW-A will be completed to a total depth of approximately 40 feet bgs with a screened interval from 20 to 40 feet bgs. Well IW-B will be completed to a total depth of approximately 90 feet bgs, with the screened interval extending from 40 to 90 feet bgs. The proposed locations of IW-A and IW-B are shown on Figure 1.

The injection wells will be constructed of 2-inch diameter schedule 40 polyvinyl chloride (PVC) well casing and well screen. The well screen will have a 0.020-inch slot size. Each well will be completed in a continuous 4.25-inch (inner diameter) hollow-stem auger boring which will extend to the prescribed well depth. Well materials will be installed within the augers. The annular space between the well screen and the borehole will be backfilled with an appropriately sized silica sand filter pack. The filter pack will be followed by a 2-foot thick bentonite seal. The balance of the annular space will be backfilled with cement-bentonite grout, and the well head will be completed in a 12-inch diameter, bolt-down, traffic rated manhole cover. Following installation of the wells, each well will be developed to remove fine material and ensure hydraulic communication with the surrounding aquifer.

3.1.4 Observation Wells

Four observation wells (GM-1S, GM-2S, and GM-3S and GM-4D) will be installed in the area downgradient of the injection wells, as shown in Figure 1. These four observation wells will supplement existing wells MW-2A and MW-2B, resulting in a total of six observation wells for use in the in-situ metals precipitation field test. Three of the new observation wells (GM-1S, GM-2S, and GM-3S) will be installed to a total depth of approximately 30 feet bgs and completed with screened intervals from 20 to 30 feet bgs. The other new observation well (GM-4D) will be installed to a total depth of approximately 80 feet bgs and completed with a screened interval from 70 to 80 feet bgs. The new observation wells will be installed, completed, and developed similarly to the injection wells.

3.1.5 Soil and Mud Disposal

The soil cuttings and drilling mud will be stored on-site in roll-off containers, characterized, and shipped off-site for disposal.

3.1.6 Well Development

The GCW will be developed employing a combination of flushing, surging, and pumping using a submersible pump to remove the drilling mud from the well screen, the gravel pack, and from the surrounding formation. The injection wells and observation wells will be developed using either a centrifugal pump or submersible pump (surging is not anticipated for these wells, because they are being installed using hollow-stem auger methods). The development water will be disposed to the ground surface at a location upgradient of the wells.

3.2 GCW WELL DESIGN

The overall design of the UVB-type and DDC-type GCW are illustrated in Figures 2 and 3, respectively. The following components will be installed as shown in the drawings:

Packers: The inflatable packer will have nitrile seals that are resistant to organic hydrocarbons. The packer will be placed just above the lower screen and between the upper and middle screen for the UVB-type GCW. The packer will have pressure gauges that will allow monitoring for constant pressure to evaluate if the packer is maintaining a seal between the screen zones. The packers for the DDC-type GCW test will be placed in the lower portion of the middle screen and between the middle and upper screens.

Recirculation Pumps, Piping, VOC-Stripper System, and Instrumentation for the UVB Test: An adjustable submersible groundwater pump (Grundfos or equivalent) will be used to pump groundwater from near the middle (inflow) screen to the top of the well during the UVB test. The water will be pumped through 2-inch-diameter aluminum or high-density polyethylene (HDPE) pipe from the pump to the top of the well, where the pipe will be connected to a flow meter above the well head.. After the initial flow meter, groundwater will be piped to one aboveground, high pressure GAC unit. The unit will consist of a 1,700-pound GAC vessel, with a rated pressure drop of 0.4 psi at 60 gpm. After the GAC unit, the groundwater will be distributed to two separate pipes, each with its own flow meter. Each pipe directs the discharge to the desired zone through aluminum or HDPE pipe to the appropriate circulation cell. The pipe will pass through the inflatable packer and a dual flow coupling, which will allow the recovered groundwater from the middle screen and the discharge to the lower screen to pass between the upper and middle screen zones.

Pressurized Air Header and Flow Measurement for the DDC Test: Pressurized air from a blower will be delivered to the GCW during the DDC-type test through a 1-inch diameter PVC pipe. The depth of the bottom of the pipe is anticipated to be approximately 35 feet bgs. Valves on the air header will allow the air-flow rate to be adjusted in the field. The in-well flow through will be measured using a in-well flow meter; however, in-well flow measurements in a DDC-type well may only be approximate.

Vapor Treatment System: The vapor stream from the well head during the DDC-type GCW test will be collected and passed through two 200-pound granular activated carbon (GAC) units in series. The discharge from the GAC units will be directed to the atmosphere.

Treatment Shed: A small shed will be installed near the GCW to accept the electrical service and a breaker panel. The electrical panel will be used to supply power to the required motors, lighting, and other electrical requirements. The shed will also house some of the equipment (e.g., air blower equipment, flow meters, and vapor phase GAC).

3.3 BASELINE SAMPLING

The overall sequence of the baseline sampling program and the analytical parameters are summarized in Table 2. The methodology of groundwater sample collection is summarized in Section 3.6 of this SAP.

3.3.1 Aquifer Pumping Tests

Prior to the commencement of the constant-rate aquifer pumping test, one baseline sample will be collected from the pumping well GCW-1, with the pump set at the middle screen section and the upper and the lower screen sections packed off. The baseline sample will be analyzed for:

- Metals: Cadmium, total chromium, hexavalent chromium, iron, manganese (unfiltered)
- Volatile organic compounds (VOCs)
- Total Suspended Solids (TSS)
- Biochemical Oxygen Demand (5-day) (BOD-5) and Chemical Oxygen Demand (COD)
- Other parameters, as specified by the Nassau County Department of Public Works discharge permit
- Field parameters (pH, redox potential, dissolved oxygen, temperature)

3.3.2 UVB-type GCW Test

Prior to commencement of the UVB-type GCW test, baseline samples will be collected as follows:

- One groundwater sample will be collected from each interval of PZ-1 and PZ-5 for analysis of dissolved (i.e., filtered) anionic and cationic species (iron, calcium, magnesium, bicarbonate, sulfate, sulfide, nitrate, nitrite, phosphorus, and chloride).

- One groundwater sample will be collected from each interval of PZ-1, PZ-3, and PZ-5 and analyzed for cadmium (total), chromium (total and hexavalent), iron and manganese (total), and VOCs.

- Field parameters (pH, redox potential, dissolved oxygen, temperature) for each interval of PZ-1, PZ-3, and PZ-5.

In addition, baseline measurements of static potentiometric head will be acquired from each interval of PZ-1, PZ-2, PZ-3, PZ-4, and PZ-5, using pressure transducers. Continuous baseline measurements of potentiometric head throughout the test will be acquired from monitoring well MW-7B, which is located outside the GCW zone of influence and therefore will reflect ambient conditions.

3.3.3 DDC-type GCW Test

The DDC-type GCW test will be performed subsequent to the conclusion of the UVB-type GCW test. Therefore, baseline sampling will not be required, because baseline conditions will have been sufficiently defined prior to and during the UVB-type test program.

3.3.4 Metals Precipitation Test

Prior to the start of the field test, an initial round of groundwater samples will be collected from each of the two injection wells and from the six field test observation wells (MW-2A, MW-2B, GM-1S, GM-2S, GM-3S, and GM-4D). These baseline samples will be analyzed for the following parameters:

- Bacteriological: Total Heterotrophic Plate Count (THPC), Iron Reducing Bacteria (IRB), and Sulfate Reducing Bacteria (SRB);

- Metals: Cadmium (filtered and unfiltered), Chromium (filtered and unfiltered), Hexavalent Chromium (filtered and unfiltered), Iron (total), Iron (ferrous), Manganese (total and filtered);

- Biogeochemical Parameters: Sulfate, Sulfide, Nitrate, Total Suspended Solids (TSS), Total Organic Carbon (TOC); and

- VOCs (except in IW-B, MW-2B and GM-4D)

- Field Parameters (pH, redox potential, dissolved oxygen, and temperature)

3.3.5 Metals Chelation Test

The baseline sample for the metals chelation bench-scale test will be collected from monitoring well MW-2A. Although MW-2A does not represent the aquifer portion from which groundwater would be withdrawn in a UVB-type system (water intake would be through the middle screen section of the UVB-type well), collecting the sample from MW-2A ensures that the chelating technology can be tested using the maximum metals concentrations at the site (lower concentrations will also be evaluated during the test; see Section 3.5.5). A batch of groundwater (approximately 40 liter) will be collected and split into two aliquots:

- The larger aliquot will be shipped to Metre-General of Westminster (Colorado). There the sample will be split into to perform two test series:
  - The baseline sample for first test series will be analyzed for metals (cadmium, chromium, calcium, and iron) and TSS.
  - The baseline sample for the second test series will be air-sparged and then analyzed for metals (cadmium, chromium, calcium, and iron) and TSS.
- The smaller aliquot (1 liter) will be shipped preserved to the site CLP-laboratory for standard analysis of metals (cadmium, chromium, calcium, and iron) and TSS.

3.3.6 Metals Treatability Test (Anion Exchange and Precipitation)

The sample for baseline analysis and the actual metals treatability test (anion exchange and precipitation) will be collected during the 24th hour effluent sampling (aquifer pumping test) and analyzed for cadmium, chromium, hexavalent chromium, iron, and manganese.

3.4 PERFORMANCE MONITORING

The overall sequence of the performance sampling program and the analytical parameters are summarized in Table 2. The methodology of groundwater sample collection is summarized in Section 3.6.

3.4.1 Aquifer Pumping Test

During the performance of the constant-rate aquifer pumping test, effluent samples will be collected at the 24th hour, the 48th hour, and at the conclusion of the test from the pumping well GCW-1, at a point upstream of any treatment (if any). These periodic effluent samples will be analyzed for:

- Metals: Cadmium, total chromium, hexavalent chromium, iron, manganese (unfiltered)
- Volatile organic compounds (VOCs)
- Total Suspended Solids (TSS)
- Biochemical Oxygen Demand (5-day) (BOD-5) and Chemical Oxygen Demand (COD)
- Other parameters, as specified by the Nassau County Department of Public Works discharge permit
- Field parameters (pH, redox potential, dissolved oxygen, temperature)

3.4.2 UVB-type GCW Test

Once the UVB-type GCW system is stabilized, monitoring of the operating and physical parameters (flow rate, cumulative water flow, potentiometric head, packer pressure) will be conducted periodically and on a daily basis.

Transducer Testing: The potentiometric head for a total of fifteen (15) pressure transducers in PZ-1 (A,B,C), PZ-2 (A,B,C), PZ-3 (A,B,C), PZ-4 (A,B,C), and PZ-5(A/B/C), as well as, in background well MW-7B, will be monitored continuously. The potentiometric head data for any given flow rate will be collected over a 3- to 5-day period.

Three-Dimensional Flow Velocity Testing: If the transducer testing indicates the development of potentiometric head differences due to the operation of the GCW, up to four (4) three-dimensional flow sensors will be installed and the perturbation of the induced temperature fields will be monitored periodically, using a PC-based software package from HydroTechnics of Albuquerque, New Mexico. The perturbation of the induced temperature field is proportional to the three-dimensional flow dimension and magnitude at each sensor location.

Well Sampling: As summarized in Table 2, performance sampling during the UVB-type test will be conducted on a weekly basis. The effluent from the UVB-type well (i.e., the influent to the liquid-phase GAC unit) will be collected during the first, second, and third week of testing and analyzed for:

- Metals: Cadmium, total chromium, hexavalent chromium, iron, manganese (unfiltered)
- Volatile organic compounds (VOCs)
- Field parameters (pH, redox potential, dissolved oxygen, temperature)
- In addition, other tracer parameters (selected major anions or cations) may be monitored in the influent groundwater to provide supporting evidence for groundwater recirculation and vertical flow (the potential for such natural occurring tracers will be evaluated during the baseline sampling – if major anions and cations appear to be distributed uniformly

throughout the Upper Glacial aquifer, then this component of the monitoring program will not be conducted).

The effluent from the liquid-phase GAC will be collected at the same time and analyzed for:

- Volatile ~~organic~~ compounds (VOCs)
- Field parameters (pH, redox ~~potential~~, dissolved oxygen, temperature)

3.4.3 DDC-type GCW Test

Once the DDC-type GCW system is stabilized, monitoring of the operating and physical parameters (flow rate, cumulative water flow, air temperature, air-flow, air humidity, and packer pressure) will be monitored periodically and on a daily basis.

Transducer Testing: The potentiometric head for a total of ten (10) pressure transducers in PZ-1 (A,B), PZ-2 (A,B), PZ-3 (A,B), PZ-4 (A,B), and PZ-5(A/B), as well as, in background well MW-7B, will be monitored continuously. The potentiometric head data for any given flow rate will be collected over a 3- to 5-day period.

Three-Dimensional Flow Velocity Testing: If the transducer testing indicates the development of potentiometric head differences due to the operation of the GCW, the perturbation of the temperature field induced by up to two (2) three-dimensional flow sensors (only the shallow flow sensors) will be monitored periodically, using a PC-based software package from HydroTechnics of Albuquerque, New Mexico. The perturbation of the induced temperature field is proportional to the three-dimensional flow dimension and magnitude at each sensor location.

Well Sampling: As summarized in Table 2, performance sampling during the DDC-type test will be conducted on a weekly basis. The influent to the DDC-type well (sampled via PZ-1B) and the effluent from the DDC-type well (sampled via PZ-1A) will be collected during the first, second, and third week of testing and analyzed for:

- Volatile organic compounds (VOCs)
- Field parameters (pH, redox potential, dissolved oxygen, temperature)
- In addition, at the conclusion of the DDC-type test (third week sampling event), one groundwater sample each will be collected from PZ-3A, PZ-3B, PZ-5A, and PZ-5B and analyzed for VOCs and field parameters.

3.4.4 Metals Precipitation Test

A summarized in Table 2, groundwater samples will be collected as the field test progresses and at the end of the field test. These samples will be collected during three sampling events (once every four weeks) from each of the two injection wells (final event only) and the six field test observation wells (all three events). These samples will be analyzed for the fóllowing parameters:

- Metals: Cadmium (filtered and unfiltered), Chromium (filtered and unfiltered), Hexavalent Chromium (filtered and unfiltered), Iron (total), Iron (ferrous), Manganese (total and filtered);
- Biogeochemical Parameters: Sulfate, Sulfide, Nitrate, Total Suspended Solids (TSS), Total Organic Carbon (TOC);
- Field Parameters (pH, redox potential, dissolved oxygen, and temperature); and
- Final event only: VOCs (except in IW-B, MW-2B and GM-4D), Total Heterotrophic Plate Count (THPC), Iron Reducing Bacteria (IRB), and Sulfate Reducing Bacteria (SRB).

3.4.5 Metals Chelation Test

As summarized in Table 3, two series of tests will be performed at Metre-General of Westminster, Colorado:

- The first series of tests at will involve a set of dilutions to evaluate the heavy metal removal efficiency corresponding to variable influent concentrations. Thus, undiluted groundwater and two dilutions (1:5 and 1:10 by volume) of the raw groundwater sample with clean, laboratory-grade water will be used during the bench-scale test. Two sub-sets of tests will be conducted: one set at a pH of 6.5 and one set at a pH of 8.5 (which should result in improved removal efficiency). The dilutions will be passed through the scaled-down Octolig™ MRP column at about 85 mL/min and the respective effluent will be split into two aliquots:
    - -- One aliquot will be analyzed for cadmium, chromium, iron, calcium and total suspended solids at Metre-General.
    - -- Another aliquot will be shipped to the site CLP-laboratory for control analysis of the same parameters.

3.4.6 Metals Treatability Test (Anion Exchange and Precipitation)

As summarized in Table 4, anion exchange treatability testing (for chromate removal) and precipitation and settling testing (for cadmium, iron, and manganese) removal will be conducted.

Chromium Treatability Test: A treatability test for chromium removal by ion exchange will use the following procedure:

1. Using a sample of approximately 2.5 gallons, adjust the pH to 5.0 using sulfuric acid, and mix for two minutes.
2. Pump the pH-adjusted sample through a column of chloride-form anion exchange resin at the hydraulic loading rate (gpm/sq.ft.) recommended by the resin manufacturer. Analyze the effluent from the ion exchanger for hexavalent chromium.

Metals Treatability Test: A treatability test for the remaining heavy metals of concern will use the following procedure:

1. Using samples of the treated effluent from the procedure described above, run jar tests by adjusting the pH of five 500 ml. samples to between 8.0 and 10.0 in 0.5 pH increments, to evaluate the optimum pH for maximum precipitant volume formation, using coagulant as needed to enhance solids settling.
2. Using 0.5 gallons of the water sample adjusted to the established optimum pH, add coagulant and polymer, as determined above to form a good, settleable floc and allow the solids to settle leaving a clear supernatant.
3. The supernatant is then decanted off, adjusted to neutral pH with sulfuric acid, treated with potassium permanganate, then fed to a dual-media filter consisting of manganese-form green-sand supporting a layer of anthracite filter media. The permanganate is fed by mixing until a slight pink color is maintained for at least 30 seconds.
4. The filter effluent will be analyzed for iron, manganese, cadmium and chromium, and the remaining concentrations of these constituents compared to the baseline metals concentrations.

3.5 GROUNDWATER SAMPLING METHODS

Groundwater sampling will proceed as follows:

- Prior to sample collection, water level measurements will be collected and all relevant information (time, personnel, weather, etc.) recorded on the sampling form.
- The wells that will be sampled will be purged by low-flow methods using a submersible pump (Grundfos Redi-flo or equivalent) at pumping rates not exceeding about 0.25 to 0.5 gallons per minute. Previous experience at the site indicates that the drawdown at such low pumping rates is generally less than 0.1 feet.
  - -- In wells without pressure transducers, the submersible pump and dedicated polyethylene discharge tubing will be lowered to the center of the screened interval of each well for the purging process.
  - -- In wells that contain pressure transducers, the submersible pump and dedicated polyethylene discharge tubing will be lowered to a safe distance above the transducer (note: it will be important to keep detailed time records during purging and sampling, as the water level in the well will be disturbed, and this disturbance must be clearly differentiated from the change in potentiometric head due to the operation of the GCW).
- Groundwater will then be extracted from each well and will be directed into a flow-through chamber (cell). This cell will contain dissolved oxygen, redox, pH, and temperature probes and will be constructed in such a manner as to preclude groundwater contact with atmospheric air until after the readings are made. Turbidity will also be monitored during well purging. All field parameter readings will be recorded on the sampling from.
- Groundwater will continue to be purged from the well until the field parameter values stabilize. At that time, the groundwater samples will be collected directly from the discharge tubing. For the analyses which require field filtering of groundwater samples, dedicated, 0.45 micron (nominal) filters will be affixed to the discharge of the submersible pump.
- All necessary labels, chain of custody forms, and custody seals will be completed in the field, the samples will be placed on ice and sent to the laboratory within 24 hours of sample collection.

3.6 QUALITY ASSURANCE AND QUALITY CONTROL

Blank Samples: QA/QC sampling for the baseline and performance monitoring will include, at a minimum, the collection of one trip blank per sample cooler in which VOC samples are shipped.

Because the samples will be collected by low-flow methods and directly from the dedicated discharge tubing, it is generally not necessary or practicable to collect a field/rinsate blank sample. However, the filtering device (dedicated in-line filter) and tubing (dedicated LDPE) may be subject to one field/rinsate blank per sampling event, at the discretion of the responsible project manager. The field/rinsate blank sample would be analyzed for filtered chromium and cadmium only.

Duplicate Samples: A blind duplicate sample will be collected at a frequency of one duplicate sample for every twenty (20) field samples, or one per sampling event (whichever occurs first). The duplicate sample will be analyzed for all specified parameters from that sampling event.

Decontamination Procedures: Disposable gloves must be worn by the sampling team and changed between sampling points. Non-dedicated sampling equipment will be cleaned before and between use by a combination of tap water rinses, 10% nitric acid rinses (if appropriate), 10% methanol rinses (if appropriate), and de-ionized water rinses. The cleaned equipment should be wrapped in aluminum foil for storage and transport (if appropriate).

Quality Assurance Objectives: Standard procedures will be used during sampling and analytical activities so that known and acceptable levels of accuracy, precision, representativeness, completeness, and comparability will be maintained.

Quality Assurance Levels: The data collected during baseline and performance sampling relative to the field- and bench-scale tests will be subject to Level 2 Quality Assurance (QA). Level 2 QA provides a sufficient level of confidence in the subsequent decision making and engineering design process. In general, the following QA requirements will be evaluated to assure that the data generated are analytically sound:

- Sample documentation (including field logs)
- Sample handling, custody, and storage
- Sample analysis holding time
- Instrument calibration data
- Method blank results
- Detection limits
- Analytical method compliance

As such, the laboratory data reports will not conform to full U.S. EPA CLP reports, but will provide sufficient information to evaluate the listed QA requirements.

Calibration Procedures: All testing equipment (including organic vapor analyzers, specific conductance meter, pH and E_h meter, thermometer, dissolved oxygen meter, turbidity meter, HACH colorimetric equipment, transducers, and flow velocity sensors) will be calibrated daily and according to the procedures suggested in the users' manuals.

3.7 ANALYITCAL METHODS

The analytical methods to be used during the implementation of the field- and bench-scale testing project are summarized below:

Parameter	Method Reference	Preservation	Holding Time
TCL VOC	SAMLCWOA or 601/602	HCL to pH<2, 4C	5 days/40 days to analysis
Cadmium	6010	HNO_3 to pH<2, 4C	180 days
Chromium	HACH Test Kit or 6010	HNO_3 to pH<2, 4C	180 days
Hex Chromium	HACH Test Kit or 7196A	4C	24 hours
Iron	6010	HNO_3 to pH<2, 4C	180 days
Ferrous Iron	HACH Test Kit		
Manganese	6010	HNO_3 to pH<2, 4C	180 days
Calcium	6010	HNO_3 to pH<2, 4C	180 days
Magnesium	6010	HNO_3 to pH<2, 4C	180 days
Sulfate	375.4	4C	28 days
Sulfide	HACH Test Kit or 376.1	NaOH, 4C	7 days
Nitrate	353.2	4C	48 hours
Nitrite	353.2	4C	48 hours
Chloride	325.3	4C	28 days
Phosphorus as PO4	365.1	H_2SO_4 to pH<2, 4C	28 days
Bicarbonate	SOW 2320B	4C	14 days
TOC	415.1	4C	28 days
TSS	160.2	4C	7 days
BOD-5	405.1	4C	48 hours
COD	410.1	H_2SO_4 to pH<2, 4C	28 days
Total Heterotroph Plate Count	HACH Test Kit		
Sulfide-Reducing Bacteria	HACH Test Kit		
Iron-Reducing Bacteria	HACH Test Kit		

Notes: Holding times are calculated from the end of the work day of the day of collection.
SAMLCWOA = Superfund Analytical Method for low concentrations (10/92).
Preservation for metals will occur after field filtration.

3.8 AQUIFER PUMPING TEST PROCEDURES

The aquifer pumping test during the field- and bench-scale testing program will include the following activities:

- Dipole flow test to evaluate the hydraulic conductivity anisotropy in the Upper Glacial aquifer; at this time, the implementation of the dipole flow test is optional based upon further discussion with research teams at Duke University and the University of Nebraska.
- Short-term stepped-rate test in the recovery well to determine the optimum pumping rate for the long-term aquifer pumping test;
- Antecedent and baseline water level monitoring in the recovery well and observation wells (including one background well outside the expected cone of depression), and monitoring of external influences such as barometric pressure and precipitation;
- Long-term (up to 72-hour) constant-rate pumping test;
- Collection of discharge samples (prior to treatment) at the 24th hour, 48th hour, and at the termination of the pumping test to evaluate groundwater quality during progressive pumping and to perform laboratory treatability testing (see Section 3.4 and 3.5 of the SAP).
- Data analysis using hydrographs and drawdown plots to determine transmissivity, storativity, specific yield, and, if possible, the hydraulic conductivity anisotropy using appropriate straight-line and curve-matching methods. The aquifer parameters will be used to calibrate an analytical flow model to predict the zone of capture under various remedial pumping scenarios.

3.8.1 Well Installation

The GCW installed for the UVB-type and DDC-type tests will be used as the pumping well for the aquifer test. To adapt the GCW well for use as an effective pumping well, an inflatable packer (monitored by pressure gauges) will be placed immediately below the middle screen of the GCW well (i.e., at approximately 61 feet bgs). The upper screen will be packed off as well, because it would otherwise de-watered during the initial stages of pumping.

Two or more of the observation well clusters described in Section 3.1.2 of this SAP will be utilized as observation wells, including PZ-1A/B/C and PZ-2A/B/C. Additional observation wells will include on-site well clusters MW-2A/2B and MW-7A/7B, on-site wells MW-3 and MW-4, and off-site wells MW-27B and MW-29B. Off-site well MW-31B will be used to collect baseline (or antecedent) water level measurements.

3.8.2 Dipole Flow Test

The dipole flow test, originally proposed by Kabala (1993), is a single well technique that creates a predominantly vertical flow regime (or dipole flow regime). The UVB-type GCW with installed packers above and below the middle intake screen and a submersible pump in the middle screen section, already contains the necessary equipment to perform a dipole flow test (each groundwater circulation cell in the UVB-type GCW essentially represents a dipole flow regime). In addition, pressure transducers need to be installed in one or both of the isolated well chambers. Analytical solutions for a radially symmetric anisotropic aquifer were presented by Kabala (1993) and, if horizontal hydraulic conductivity and specific storativity are already known from other tests, a simplified iteration approach may be used to estimate vertical hydraulic conductivity. Dames & Moore has contacted Dr. Z. Kabala of Duke University and Dr. V. Zlotnik of the University of Nebraska at Lincoln, who are actively involved in the development of the Dipole Flow Test from its model stage into a tool for applied field investigation. Based upon discussions with Drs. Kabala and Zlotnik, Dames & Moore will make a decision whether to perform the dipole flow test at the site.

3.8.3 Aquifer Pumping Test Equipment and Procedures

Test equipment required to conduct the stepped-rate and constant-rate pumping tests includes the following:

- Submersible pump rated for at least 200 gpm and power source;
- Drop line, safety cable, adjustable valve, flow meter with sampling tee, and flexible hose to covey water away from the recovery well to the discharge point. The effluent will be discharged to the Nassau County Department of Public Works (NCDPW) sanitary sewer, provided a discharge permit can be obtained;
- PVC drop pipe in the pumping well to house the pressure transducers;
- Pressure transducers and data loggers to continuously record water level changes in the pumping well and the critical observation wells. Electronic water level indicators will be used as back-up and to periodically gauge less critical observation wells; and
- Atmospheric pressure gauge and precipitation gauge.

The following, general procedures will be followed in performing the aquifer pumping tests:

Set-up: Clear access to and install lights at all observation wells and the pumping well; record the static water level in the observation wells and pumping well; connect the discharge lines and suspension wires to the pump and lower into the pumping well; set the pump intake in the middle of the screened section; place pressure transducers in the critical observation wells (those within a radius one aquifer thickness, and in selected background wells) and in the pumping well, approximately 6 feet above the pump intake; check power level and set-up information in data logger unit; calibrate piezometric pressure reading against static water level; assemble the adjustable valve, flow meter, discharge conveyance, and in-line monitoring equipment.

Pump, Piping, and Instrumentation: The pumping well will be fitted with a submersible pump capable of pumping at least 200 gallons per minute (gpm). The water will be pumped through a drop line to the top of the well, where a flow meter (with a sampling tee) will be used to monitor the flow rate and make appropriate adjustment to the pumping rate. After the flow meter, the pipe will transition to flexible hose leading to the discharge point.

Discharge Measurement: The pump discharge will be measured using a totalizing flow meter. The meter will be sized so that the pumping rate is no less than 25 percent of the flow meter capacity. An adjusting valve will be installed in the discharge line ahead of the flow meter to control the discharge rate. The discharge rate will be checked periodically (and adjusted, if necessary).

Atmospheric Pressure and Precipitation Measurements: Using a pressure gauge (barometer), fluctuations of atmospheric pressure will be measured once per hour throughout the drawdown and recovery phases of the pumping test. Using a precipitation gauge, the amount of rainfall before, during, and after the pumping test will be determined.

Disposal of Discharge Water: The effluent will be discharged to the NCDPW sanitary sewer system, pending approval. The discharge rate will be no less than 100 gpm and no more than 250 gpm. Discharge samples will be collected at the beginning of the test, the 24th hour, the 48th hour, and at the termination of the constant-rate pumping test and analyzed for parameters as specified by the NCDPW permit.

Aborted Test: Failure or shutdown of the pump for more than one percent of the elapsed pumping time will constitute an aborted test. If the test is aborted, pumping will not resume until: 1) the water level in the pumping well has returned to its original level; or 2) successive water level measurements spaced 20 minutes apart show no change greater than 0.02 feet; or 3) the well has been allowed to recover for a period of time greater than the elapsed pumping time of the aborted test.

3.8.4 Data Collection

Data collection and monitoring frequency during the stepped-rate pumping test and the constant-rate pumping tests is summarized in Table 5. The monitoring schedule includes the following elements:

Antecedent and Baseline Monitoring: Prior to conducting the stepped-rate and constant-rate pumping tests, water levels will be recorded in all on-site and off-site monitoring and observation wells to characterize the static water table conditions. One baseline observation well (i.e., located outside the expected or noticeable cone of depression) will be monitored continuously, using a pressure transducer, for one week prior to performing the pumping tests. Similarly, the baseline observation well will be monitored continuously for one week following the termination of pumping. The baseline monitoring will be used to evaluate local antecedent changes in the local piezometric surface and to assess other trends (e.g., those due to rainfall) prior, during, and following the pumping test.

Stepped-Rate Pumping Test: The well will be pumped at successively higher rates and the drawdown for each rate (or step) will be recorded. The initial discharge rate for each step will be based upon the results of well development or specific capacity data, but is anticipated to be no less than 75 gpm. Subsequent pumping rates may include 125 gpm, 150 gpm, and 200 gpm. Each pumping-step will last for about 30 minutes. The individual steps will be run consecutively (i.e., the aquifer will not be allowed to recover between each step). Drawdown in the pumping well will be monitored using a pressure transducer and electronic water level indicator. The response of nearby observation wells will also be monitored. Drawdown for each step will be plotted in the field versus elapsed time, and compared to the available drawdown projected to a 72-hour pumping test. Once a safe pumping rate is determined, the adjustable valve will be set to that pumping rate, and the power source to the pump will be shut off. Therefore, following aquifer recovery to the original state, the constant-rate pumping test can be initiated without further adjustments to the pump speed or valve setting.

Constant-Rate Pumping Test: The constant-rate pumping test will be conducted for up to 72 hours. The drawdown in the pumping well and the critical observation wells will be monitored with pressure transducers and data loggers at the approximate intervals summarized in Table 5, basically following a logarithmic schedule. The pumping well and the critical observation wells will also be monitored manually with electronic water level indicators to provide backup data. Observation wells that cannot be connected to a data logger or warrant less frequent monitoring, will be monitored exclusively using electronic water level indicators. Prior to the termination of the constant-rate test, the water level in all on-site and off-site monitoring and observation wells will be recorded.

Recovery Phase: At the termination of the constant-rate pumping test, recovery phase measurements will be collected using pressure transducers and data loggers, according to the same schedule as the drawdown measurements. At the end of the recovery phase (i.e., up to 72 hours following termination of pumping), the water level in all on-site and off-site monitoring and observation wells will be recorded.

TABLES

TABLE 1
Summary of Well Completion Details
Interim Groundwater Action
Liberty Industrial Finishing Site, Farmingdale, New York

Well ID	Status		Purpose	Elevation	Diameter	Material	Depth of Well	Screen Interval (feet bgs)		Distance from GCW-1	
	existing	planned		feet msl	inches		feet bgs	from	to	feet	d/AT
GCW-1		X	UVB-type and DDC-type GCW Test	64.5	10	Steel	90	17	22	0	0
			Dipole Flow Test			and		43	60		
			Pumping Well for Aquifer Test			PVC		85	90		
PZ-1 A		X	Observation Piezometer Cluster for	64.5	2	PVC	22	17	22	5	0.07
B		X	GCW Tests and Aquifer Pumping Test		2	PVC	60	43	60		
C		X			2	PVC	90	85	90		
PZ-2 A		X	Observation Piezometer Cluster for	64.5	2	PVC	22	17	22	15	0.21
B		X	GCW Tests and Aquifer Pumping Test		2	PVC	60	43	60		
C		X			2	PVC	90	85	90		
PZ-3 A		X	Observation Piezometer Cluster for	64.5	2	PVC	22	17	22	25	0.35
B		X	GCW Tests and Aquifer Pumping Test		2	PVC	60	43	60		
C		X			2	PVC	90	85	90		
PZ-4 A		X	Observation Piezometer Cluster for	64.5	2	PVC	22	17	22	35	0.49
B		X	GCW Tests and Aquifer Pumping Test		2	PVC	60	43	60		
C		X			2	PVC	90	85	90		
PZ-5 A		X	Observation Piezometer Cluster for	64.5	2	PVC	22	17	22	60	0.83
B		X	GCW Tests and Aquifer Pumping Test		2	PVC	60	43	60		
C		X			2	PVC	90	85	90		
MW-2 A	X		Observation Wells for Pumping Test and	63.6	4	PVC	26	11	26	185	2.6
B	X		Metals Precipitation Test		4	PVC	60	50	60		

TABLE 1
Summary of Well Completion Details
Interim Groundwater Action
Liberty Industrial Finishing Site, Farmingdale, New York

Well ID	Status		Purpose	Elevation	Diameter	Material	Depth of Well	Screen Interval (feet bgs)		Distance from GCW-1	
	existing	planned		feet msl	inches		feet bgs	from	to	feet	d/AT
MW-3	X		Observation Wells for Pumping Test	66.1	4	PVC	25	10	25	680	9.4
MW-4	X		Observation Wells for Pumping Test	65.6	4	PVC	29	14	29	910	12.6
MW-6 A	X		Observation Wells for Pumping Test	64.3	4	PVC	26	11	26	20	0.28
B	X				4	PVC	58	48	58	35	0.49
MW-7 A	X		Observation Wells for Pumping Test	64.1	4	PVC	26	11	26	250	3.5
B	X		Background Well for GCW Tests		4	PVC	60	50	60		
MW-21	X		Observation Wells for Pumping Test	64.5	4	PVC	29	14	29	300	4.2
MW-29 B	X		Observation Well for Pumping Test	57.5	4	PVC	50	40	50	930	12.9
MW-31 B	X		Observation Well for Pumping Test	55.0	4	PVC	65	55	65	2,610	36.3
IW- A		X	Injection Wells for Precipitation Test	63.5	2	PVC	40	20	40		
B		X			2	PVC	90	40	90		
GM-1 S		X	Observation Well for Precipitation Test	63.0	2	PVC	30	20	30		
GM-2 S		X	Observation Well for Precipitation Test	63.0	2	PVC	30	20	30		
GM-3 S		X	Observation Well for Precipitation Test	63.0	2	PVC	30	20	30		
GM-4 D		X	Observation Well for Precipitation Test	63.0	2	PVC	80	70	80		

Notes:
1. Feet bgs = feet below ground surface
2. Feet msl = feet relative to mean sea level (estimated for MW-29B and MW-31B).
3. d/AT = ratio of distance from GCW to aquifer thickness (72 feet).

TABLE 2
Baseline and Performance Monitoring Interim Groundwater Action
Liberty Industrial Finishing Site, Farmingdale, New York

		Number of Samples (Laboratory Analyses)														Field Parameters				Other		
		Cd (filtered)	Cd (total)	Cr (filtered)	Cr (total)	Chromium - hex	Fe	Mn	Sulfate	Nitrate	TOC	TSS	VOC	BOD and COD	RI	pH	Redox	D.O.	Temperature	Microbiology	Water level	Local Flow Field
In-situ Metals Precipitation																						
Baseline	IW-A, IW-B, MW-2A, MW-2B, GM-1S, GM 2S, GM-3S, GM-4D	8	8	8	8	8	8	8	8	8	8	8	5			8	8	8	8	8	X	
Week 4	MW-2A, MW-2B, GM-1S, GM-2S, GM-3S, GM-4D	6	6	6	6	6	6	6	6	6	6	6				6	6	6	6		X	
Week 8	MW-2A, MW-2B, GM-1S, GM-2S, GM-3S, GM-4D	6	6	6	6	6	6	6	6	6	6	6				6	6	6	6		X	
Week 12	IW-A, IW-B, MW-2A, MW-2B, GM-1S, GM 2S, GM-3S, GM-4D	8	8	8	8	8	8	8	8	8	8	8	5			8	8	8	8	8	X	
Aquifer Pumping Test																						
Baseline	Effluent from Pumping Well		1		1	1	1	1				1	1	1		1	1	1	1		X	
24th hour	Effluent from Pumping Well		1		1	1	1	1				1	1	1		1	1	1	1		X	
48th hour	Effluent from Pumping Well		1		1	1	1	1				1	1	1		1	1	1	1		X	
72nd hour	Effluent from Pumping Well		1		1	1	1	1				1	1	1		1	1	1	1		X	
Metals Chelation Test (see Table 3)																						
Bench-Scale Treatability Test (see Table 4)																						

TABLE 2

Baseline and Performance Monitoring Interim Groundwater Action

Liberty Industrial Finishing Site, Farmingdale, New York

		Number of Samples (Laboratory Analyses)														Field Parameters				Other		
		Cd (filtered)	Cd (total)	Cr (filtered)	Cr (total)	Chromium - hex	Fe	Mn	Sulfate	Nitrate	TOC	TSS	VOC	BOD and COD	RI	pH	Redox	D.O.	Temperature	Microbiology	Water level	Local Flow Field
UVB-type GCW Test																						
Baseline	PZ-1A/B/C, PZ-5A/B/C														6							
Baseline	PZ-1A/B/C, PZ-3A/B/C, PZ-5A/B/C		9		9	9	9	9					9			9	9	9	9			
Baseline	Transducer Testing using one background well (MW-7B) and fifteen sidegradient piezometers PZ-1 through PZ-5 (intervals A, B, and C)																				X	
Continuous	Transducer Testing using one background well (MW-7B) and fifteen sidegradient piezometers PZ-1 through PZ-5 (intervals A, B, and C)																				X	
Week 2 or 3	Verification of Groundwater Flow in Circulation Cell; locations of up to 4 flow sensors to be determined, based on transducer testing of UVB test																					X
Week 1	Influent prior to GAC		1		1	1	1	1					1			1	1	1	1			
Week 1	Effluent from GAC												1			1	1	1	1			
Week 2	Influent prior to GAC		1		1	1	1	1					1			1	1	1	1			
Week 2	Effluent from GAC												1			1	1	1	1			
Week 3	Influent prior to GAC		1		1	1	1	1					1			1	1	1	1			
Week 3	Effluent from GAC												1			1	1	1	1			

TABLE 2
Baseline and Performance Monitoring Interim Groundwater Action
Liberty Industrial Finishing Site, Farmingdale, New York

		Number of Samples (Laboratory Analyses)														Field Parameters				Other		
		Cd (filtered)	Cd (total)	Cr (filtered)	Cr (total)	Chromium - hex	Fe	Mn	Sulfate	Nitrate	TOC	TSS	VOC	BOD and COD	RI	pH	Redox	D.O.	Temperature	Microbiology	Water level	Local Flow Field
DDC-type GCW Test																						
Baseline	No baseline laboratory analyses for DDC-type test																					
Baseline	Transducer Testing using one background well (MW-7B) and ten sidegradient piezometers PZ-1 through PZ-5 (intervals A and B).																				X	
Continuous	Transducer Testing using one background well (MW-7B) and ten sidegradient piezometers PZ-1 through PZ-5 (intervals A and B).																				X	
Week 2 or 3	Verification of Groundwater Flow in Circulation Cell; locations of up to 4 flow meters to be determined, based on transducer testing of UVB test																					X
Week 1	Influent PZ-1B												1			1	1	1	1			
Week 1	Effluent PZ-1A												1			1	1	1	1			
Week 2	Influent PZ-1B												1			1	1	1	1			
Week 2	Effluent PZ-1A												1			1	1	1	1			
Week 3	Influent PZ-1B												1			1	1	1	1			
Week 3	Effluent PZ-1A; also from PZ-3A/B and PZ-5A/B												5			5	5	5	5			

1. Cd - Cadmium (Method 200.7), Cr - Chromium (Method 200.7), Cr6+ - hexavalent chromium (method 3060/7196A); Fe - Iron (Method 200.7); Mn - Manganese (Method 200.7); Sulfate by Method 375.4; Nitrate by Method 353.2; TOC - Total Organic Carbon (Method 5310B); TSS - Total Suspended Solids (Method 160.2); VOC - Volatile Organic Compounds (Method 601/602); BOD - Biochemical Oxygen Demand (Method 405.1); COD - Chemical Oxygen Demand (Method 410.4).
2. RI = Ryznar Index parameters: iron, calcium, magnesium, bicarbonate, sulfate, sulfide, nitrate, nitrite, chloride, and phosphate.
3. The UVB-type GCW performance sampling may include additional General Chemistry parameters, which would serve as naturally occuring tracers to evaluate the development of the circulation cells. Any additional parameters will only be included if the concentrations are not found to be homogeneous throughout the aquifer during the baseline sampling

TABLE 3
Bench-Scale Chelation Test Program
Interim Groundwater Action
Liberty Industrial Finishing Site, Farmingdale, New York

		Influent					Effluent				
		Cadmium	Chromium	Iron	Calcium	TSS	Cadmium	Chromium	Iron	Calcium	TSS
Test Series 1											
	Receive Groundwater Sample MW-2A	2	2	2	2	2					
at pH = 6.5	Set 1 (Undiluted Groundwater)						2	2	2	2	2
	Set 2 (5:1 Dilution)						2	2	2	2	2
	Set 3 (10:1 Dilution)						2	2	2	2	2
at pH = 8.5	Set 1 (Undiluted Groundwater)						2	2	2	2	2
	Set 2 (5:1 Dilution)						2	2	2	2	2
	Set 3 (10:1 Dilution)						2	2	2	2	2
Test Series 2											
	Receive Groundwater Sample and Air-Sparge to Simulate Air-Stripping	1	1	1	1	1					
at pH = 6.5	Undiluted sparged groundwater						2	2	2	2	2
st pH = 8.5	Undiluted sparged groundwater						2	2	2	2	2
Regenerate Testing											
	Regenerate the test columns and analyze regenerate						1	1	1	1	
Mass Balance Analysis											

1. Cadmium, chromium, iron, and calcium by Method 200.7, hexavalent chromium by method 3060/7196A.
   TSS - Total Suspended Solids (Method 160.2)
2. The "influent samples" will be analyzed at the site CLP-laboratory and at Metre-General; the "effluent samples" will also be analyzed at the site CLP-laboratory and at Metre-General. The "regenrate sample" and the "air-sparged sample" will only be analyzed at Metre-General.

TABLE 4
Bench-Scale Metals Treatability (Anion Exchange and Precipitation) Tests
Interim Groundwater Action
Liberty Industrial Finishing Site, Farmingdale, New York

		Influent						Effluent				
		Cadmium	Chromium	Hex Chromium	Iron	Manganese	pH	Cadmium	Chromium	Hex Chromium	Iron	Manganese
Baseline Sampling												
	24th hour effluent sample from aquifer pumping test (page 1 of Table 2)	1	1	1	1	1	1					
Anion Exchange Test												
at pH = 5.0	through chloride-form anion exchange resin to evaluate removal efficiency for chromate									1		
Precipitation/Flocculation Test												
at pH = 8.0 to 10.0	use effluent sample from anion exchange test and adjust to optimum pH						5					
adjust to pH = 7.0	adjust supernate of flocculation test under optimum pH, add $KMnO_4$ and pass through dual-media filter						1	1	1		1	1

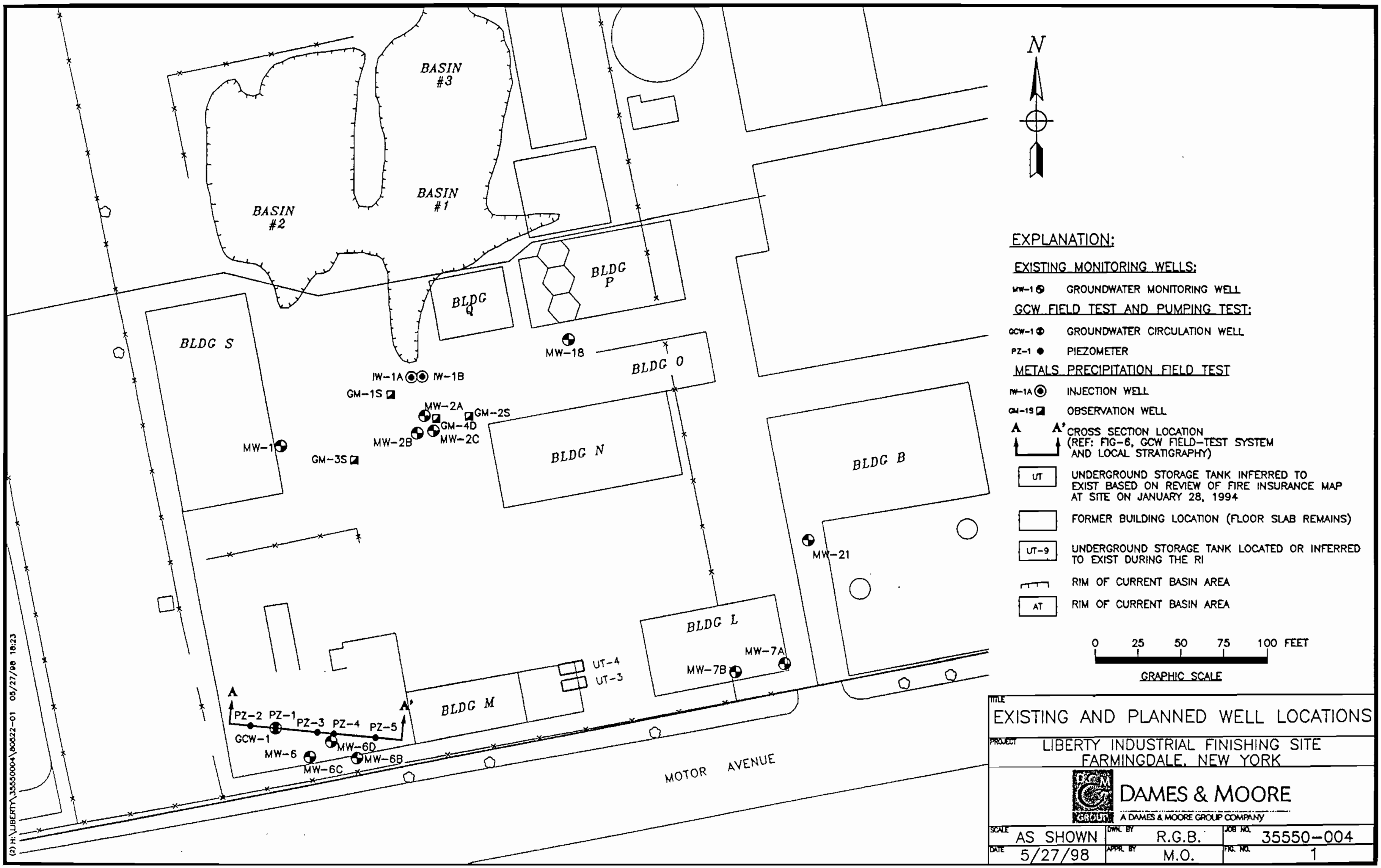
1. Cadmium, chromium, iron, and calcium by Method 200.7, hexavalent chromium by method 3060/7196A.
2. The flocculation test under optimum pH conditions will include coagulant and polymer to achieve a settleable floc.
3. $KMnO_4$ = potassium permanganate

TABLE 5
Aquifer Pumping Test Monitoring Schedule
Interim Groundwater Action
Liberty Industrial Finishing Site, Farmingdale, New York

Time interval	between measurements					
	Pumping Well	using	Observation Wells	using	Baseline Wells	using
Baseline Monitoring						
1 week prior to test	30 minutes	PT	----	---	30 minutes	PT
Static Water Levels						
1 day prior to test	1 measurement	EWI	1 measurement	EWI	1 measurement	EWI
Step Tests						
0 to 10 minutes	1 minute	EWI	5 minutes	EWI	----	---
10 to 30 minutes	5 minutes	EWI	5 minutes	EWI	----	---
Constant-Rate Test						
0 to 2 minute	5 seconds	PT	2 seconds	PT	----	---
2 to 5 minutes	20 seconds	PT	20 seconds	PT	----	---
5 to 15 minutes	60 seconds	PT	60 seconds	PT	----	---
15 to 60 minutes	5 minutes	PT	5 minutes	PT	----	---
1 to 2 hours	10 minutes	PT	30 minutes	PT	30 minutes	PT
2 hours to end	30 minutes	PT	30 minutes	PT	30 minutes	PT
Static Water Levels						
2 hrs before end of test	1 measurement	EWI	1 measurement	EWI	1 measurement	EWI
Recovery Monitoring						
0 to 2 minute	5 seconds	PT	2 seconds	PT	----	---
2 to 5 minutes	20 seconds	PT	20 seconds	PT	----	---
5 to 15 minutes	60 seconds	PT	60 seconds	PT	----	---
15 to 60 minutes	5 minutes	PT	5 minutes	PT	----	---
1 to 2 hours	10 minutes	PT	30 minutes	PT	30 minutes	PT
2 hours to end	30 minutes	PT	30 minutes	PT	30 minutes	PT
Static Water Levels						
at end of recovery	1 measurement	EWI	1 measurement	EWI	1 measurement	EWI
Baseline Monitoring						
1 week following test	30 minutes	PT	----	---	30 minutes	PT

1. PT = pressure transducer and data logger; EWI = electronic water level meter.
2. Pumping Well = GCW-1; observation wells = selected wells with PT's, other wells at less frequent intervals with EWI
   Baseline Well = MW-31B.

FIGURES

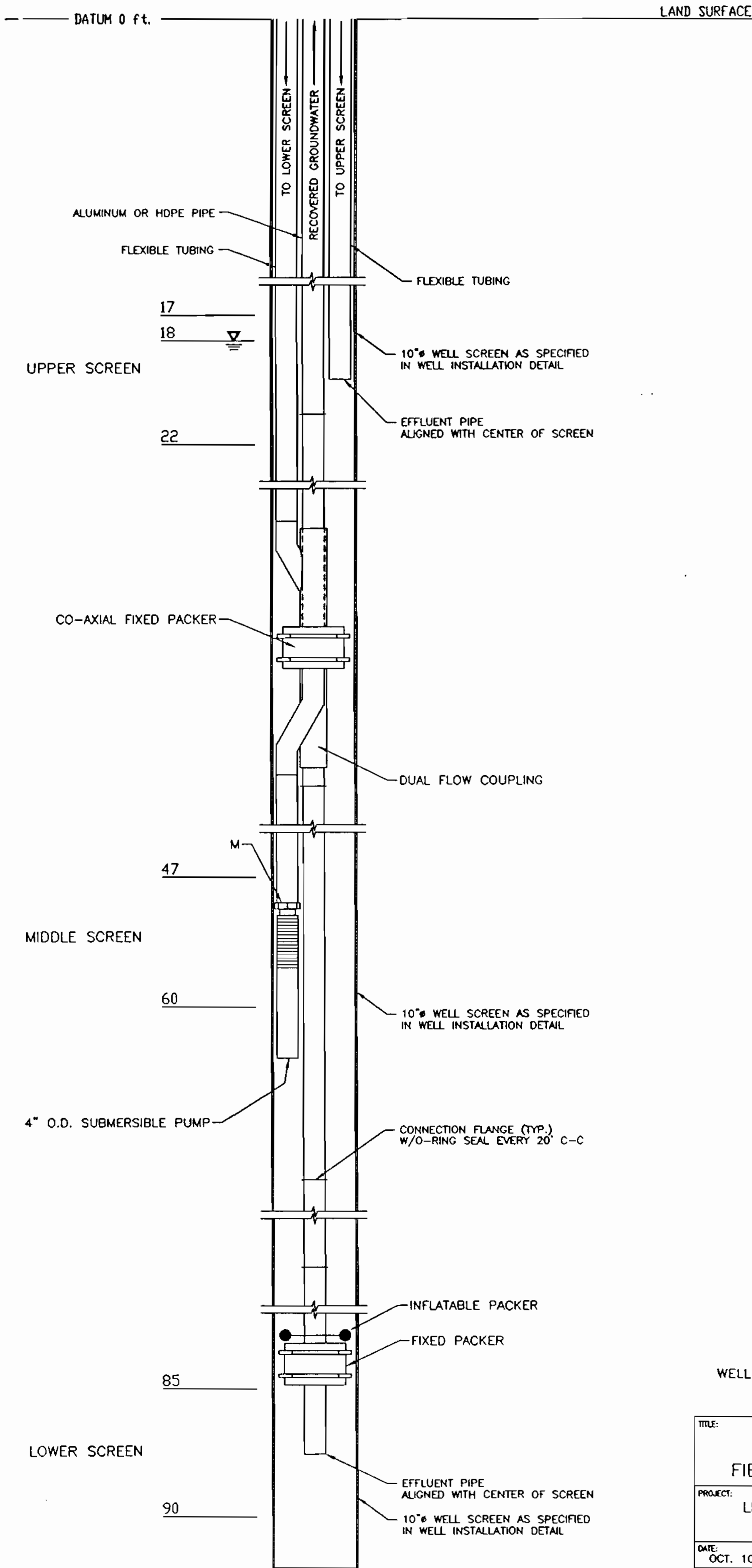


TITLE: EXISTING AND PLANNED WELL LOCATIONS

PROJECT: LIBERTY INDUSTRIAL FINISHING SITE
FARMINGDALE, NEW YORK

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

SCALE	DWN. BY	JOB NO.
AS SHOWN	R.G.B.	35550-004
DATE	APPR. BY	FIG. NO.
5/27/98	M.O.	1



GCW INSTALLATION DETAIL

0 2 4 8

VERTICAL SCALE IN FEET

0 .5 1 2

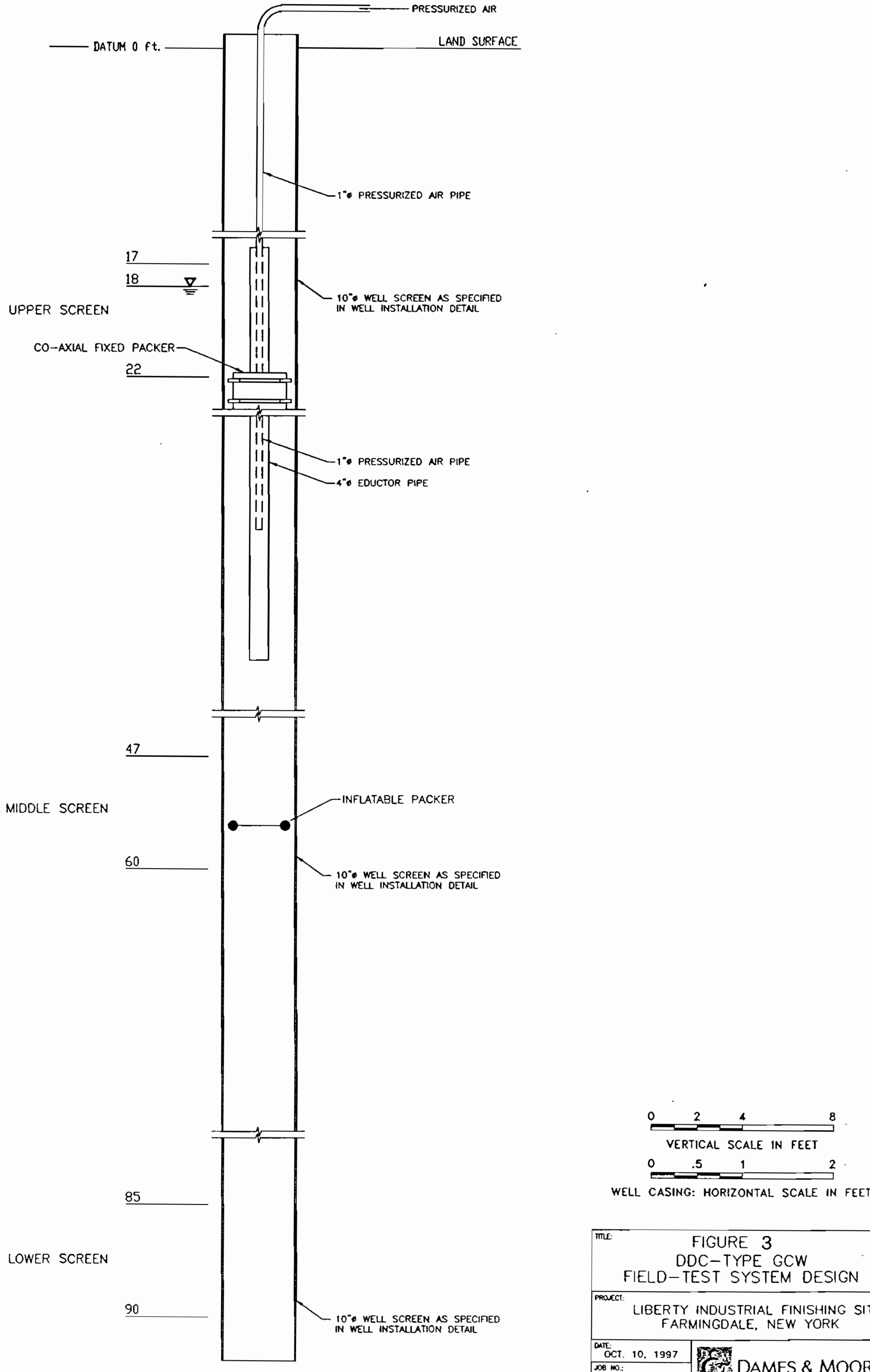
WELL CASING: HORIZONTAL SCALE IN FEET

TITLE: FIGURE 2
UVB-TYPE GCW
FIELD-TEST SYSTEM DESIGN

PROJECT: LIBERTY INDUSTRIAL FINISHING SITE
FARMINGDALE, NEW YORK

DATE: OCT. 10, 1997	DAMES & MOORE
JOB NO.: 18804-334-118	A DAMES & MOORE GROUP COMPANY
DRAWN BY: MAR / CHK'D BY: JM	2325 MARYLAND ROAD WILLOW GROVE, PENNSYLVANIA 19090 PHONE: 215.657.5000 FAX: 215.657.5454
SCALE: 1"=4'	

(2):H:\LIBERTY\35550001\UBER-F 02/10/98 11:48



GCW INSTALLATION DETAIL

TITLE: FIGURE 3
DDC-TYPE GCW
FIELD-TEST SYSTEM DESIGN

PROJECT: LIBERTY INDUSTRIAL FINISHING SITE
FARMINGDALE, NEW YORK

DATE: OCT. 10, 1997
JOB NO.: 18804-334-118
DRAWN BY: MAR
CHK'D BY: JM
SCALE: 1"=4'

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY
2325 MARYLAND ROAD
WILLOW GROVE, PENNSYLVANIA 19090
PHONE: 215.657.5000
FAX: 215.657.5454

(2) H:\LIBERTY\35550001\LIBER-G 02/10/98 12:58