Pittsfield/Housatonic River Site, On-Plant Consolidation Areas - Addendum to June 1999 Detailed Work Plan, August 12, 1999

Transmitted Via Federal Express

August 12, 1999

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Re: Pittsfield/Housatonic River Site,
On-Plant Consolidation Areas -
Addendum to June 1999 Detailed Work Plan

Dear Mr. Nalipinski:

This letter addresses several comments identified by the United States Environmental Protection Agency (EPA) stemming from its review of a document entitled *Detailed Work Plan for On-Plant Consolidation Areas* (Detailed Work Plan). That document, prepared by the General Electric Company (GE), expanded upon prior submittals related to the design, construction, operation, closure, and post-closure monitoring of two, and possibly three, consolidation areas located within GE's Pittsfield, Massachusetts facility. The consolidation areas will be utilized for the permanent consolidation of materials (e.g., soil, sediment, debris, etc.) generated during the performance of response actions associated with the Pittsfield/Housatonic River Site. In the Detailed Work Plan, submitted to the EPA in June 1999, GE provided technical details related to two on-plant consolidation areas proposed for use beginning in 1999 -- the Hill 78 and Building 71 Consolidation Areas -- and also provided conceptual design information related to a possible third future consolidation area -- the New York Avenue/Merrill Road Consolidation Area. In a letter dated July 6, 1999, the EPA provided conditional approval of the Detailed Work Plan, but required that GE submit additional information to further describe or modify certain aspects of the proposed work. This letter addresses the specific EPA comments contained in their July 6, 1999 letter and, in doing so, serves as an addendum to the Detailed Work Plan (the Addendum).

The contents of this letter are organized to generally correlate to the format of the EPA's July 6, 1999 letter, in that a GE response is provided for each EPA comment. In addition, several attachments to this letter provide additional information to supplement GE's responses provided in this letter. Certain of the responses contained herein were discussed with the EPA and the Massachusetts Department of Environmental Protection (together, the Agencies) during a conference call held on July 8, 1999, as well as subsequent meetings held in Pittsfield on July 27 and August 4, 1999. Finally, discussions with the Agencies regarding Applicable or Relevant and Appropriate Regulations (ARARs) concerning the on-plant consolidation areas are currently ongoing; we expect to provide updated ARAR tables (reflecting the outcome of these discussions) in the next few days.

I. Responses to EPA "Significant Issues"

EPA Comment 1:

[GE shall perform] A geophysical evaluation around the current "perimeter" of Hill 78 prior to determining the "final" footprint of the consolidation area in order to define the exact extent of the existing landfill.

GE Response:

Since receipt of EPA's July 6, 1999 conditional approval letter, GE and the EPA have jointly developed and agreed to a scope of work for a geophysical survey related to the Hill 78 Consolidation Area. The scope of this survey is summarized below:

1. A geophysical survey (Geonics EM-31) will be conducted along the perimeter of the final configuration of the Hill 78 Consolidation Area. Along this perimeter, the geophysical survey will include a 50-foot-wide strip (approximate) located so that approximately 25 feet of the survey area is located within the areas subject to future consolidation. A figure depicting the general areas subject to the geophysical survey is provided in Attachment A. The areas shown on that figure are subject to field modification based on accessibility or site conditions (e.g., large trees and/or heavy vegetative growth). To the extent possible, GE will avoid clearing large amounts of vegetation in order to perform the geophysical survey. Note that, in addition to a 50-foot wide area around the perimeter of the future area, GE will conduct the geophysical survey for the area in the vicinity of existing monitoring well H78B-8R. As shown on the figure included in Attachment A, an approximate 25-foot by 25-foot area (centered around H78B-8R) will be subject to geophysical survey.

2. The results of the geophysical survey will be evaluated to identify potential anomalies. If such anomalies are identified and depending on their location, GE will consider and implement one of the two options discussed below:

    a. GE may install a soil boring downgradient of the anomaly. The boring will be advanced until the water table is encountered, with representative soil samples collected at two-foot intervals for visual classification and screening for organic vapors using a photoionization detector (PID). In the event that a possible source of contamination is identified (e.g. foreign materials, visual evidence of non-aqueous phase liquids or elevated PID readings) GE will review existing hydrogeologic information that is available for the area in question to assess downgradient migration potential. If the existing information is not sufficient to support such an assessment, GE will install a monitoring well downgradient of the area and/or extend the cover system over the area containing the anomaly.

    b. In lieu of subsurface investigations in response to a detected anomaly, GE may elect to extent the final cover system into the area of question.

    Based on discussion with EPA, GE will not be required to conduct excavation activities in such an area, unless soil removal actions would otherwise be required to meed the Performance Standards to be set forth in the parties' Consent Decree or accompanying Statement of Work or unless the "reopener" conditions to be set forth in the Consent Decree are satisfied.

With EPA concurrence regarding the above scope of activities, GE will conduct the geophysical survey and present the results (including any assessment activities that may be needed in response to detected anomalies) in a separate submittal to the EPA. The timing of the survey will be such that it will be conducted prior to placement of materials in the area of interest.

EPA Comment 2:

The Work Plan Addendum needs to include a contingency to address the NAPL that was detected in well H78B-8R on the south side of Hill 78.

GE Response:

Monitoring and assessment activities conducted by GE since NAPL was detected in Well H78B-8R were summarized in an Immediate Response Action Completion Report transmitted to the Agencies on July 19, 1999. Specifically, that report described the activities conducted by GE as of that date, including NAPL recovery/monitoring activities; analytical testing of the NAPL; investigations related to the source and extent of NAPL; and groundwater elevations and flow direction. In addition, GE has performed several additional assessment activities based on comments contained in the EPA's July 6, 1999 letter conditionally approving the Detailed Work Plan. These include the continuation of NAPL monitoring; sampling and analysis for physical properties of the NAPL; and an assessment of NAPL recovery into well H78-8R (following bailing). The results of the physical property testing and NAPL recovery are included in Attachment B. An additional request from the EPA was a map of the underlying till contours. That map is provided in Attachment C. Responses to other EPA comments related to the NAPL detected at well H78B-8R are presented elsewhere in this Addendum.

EPA Comment 3:

Revise to include a section in the Detailed Work Plan text and figures which discusses how surface runoff will be managed. Discuss the interim and final drainage patterns/retention basins as appropriate.

GE Response:

Several sections of the Detailed Work Plan provide information concerning the management of stormwater during construction and active operation of the consolidation areas (i.e., Sections 5.9, 6.11, 6.13, and 6.14 of the work plan). In general, stormwater management during the construction and operation phases of the on-plant consolidation areas will utilize erosion control measures (e.g., hay bales, silt control fences, drainage swales, etc.), operational measures (e.g., daily and interim surface covers, work stoppage during heavy rainfall events, etc.) and routine monitoring. The collective goal of these activities is to minimize the potential for rainfall to contact the materials that have been placed within the consolidation areas, and, if such contact does occur, to minimize the potential for subsequent migration of these materials via rainfall runoff. In addition, efforts will be implemented to minimize the potential for rainfall run-on to occur during these active phases of the project.

Similar to the design and construction of the consolidation areas, final stormwater management measures will be addressed in a phased manner to correlate with future expansions to the consolidation areas. For instance, to support the near-term use of the Building 71 Consolidation Area, certain stormwater management components have been designed and will be constructed. With respect to the anticipated final configuration of the Building 71 and Hill 78 Consolidation Areas, <u>preliminary</u> evaluations have been conducted to understand the type, magnitude, and location of the stormwater management components that may be needed in the future. A summary of these preliminary evaluations is provided below.

In general, rainfall runoff from the surface of the final consolidation areas will be collected by mid-slope drainage swales and/or perimeter ditches, routed into one or more stormwater retention basins, and ultimately discharged to a location along the southern edge of the Hill 78 Area. The stormwater retention basins will allow for the retention of rainfall runoff to attenuate/control the peak runoff flow rate and attain, to the extent possible, conditions that are compatible with the existing stormwater management system associated with the larger watershed area containing the consolidation areas. It is anticipated that the design of the stormwater retention basins will, to the extent practicable, accommodate the rainfall runoff associated with the 25-year, 24-hour storm event. However, the rainfall runoff resulting from this storm event will likely exceed the capacity of the existing stormwater management facilities that currently serve the Hill 78 Area and adjacent areas. Specifically, a report entitled *Revised Drainage Analysis Altresco Cogeneration* (HMM Associates, Inc.; April 1990) provides information concerning the characteristics of the approximately 130-acre watershed area within which the consolidation areas are located. This report includes information that has been considered as part of the conceptual stormwater design for the consolidation areas. In that report, it is determined that the discharge point of the watershed area is located along Merrill Road south of the Hill 78 Area, and that the hydraulic capacity at that location is approximately 45 cubic feet per second (cfs) (as compared to a flow of approximately 177 cfs corresponding to the 10-year, 24-hour storm event for the watershed area). Based on this information, although the future stormwater retention basins will be designed to accommodate (to the extent practicable) the 25-year, 24-hour storm event, some modifications may be necessary in consideration of the overall hydrology of the watershed area. A further description of the conceptual stormwater management facilities expected to be included as part of the future consolidation areas is presented below.

As presented in the Detailed Work Plan, one stormwater basin has been identified and will be located at the southern end of the Building 71 Consolidation Area (as shown on Technical Drawing A-4 of the Detailed Work Plan). Discharge from this basin will be routed into an existing storm sewer pipe located along the Pittsfield Generating Company, LLP property (as shown on Technical Drawing A-6 of the Detailed Work Plan). A second basin will likely be located in a low-lying area along the northern perimeter of the Hill 78 Consolidation Area. Discharge from this basin will probably be routed into an existing storm sewer pipe located on the western edge of the Hill 78 Consolidation Area via a new inlet structure. Finally, a third basin may be located in a low-lying area along the southern perimeter of the Hill 78 Consolidation Area. Discharge from this basin will most likely be routed into the existing drainage ditch located north of Merrill Road.

EPA Comment 4:

The Detailed Work Plan shall include a section which discusses options to temporarily close the Consolidation Areas if the area will be closed for an extended period of time (e.g., greater than 1 month). This would provide protection if the Consolidation Areas close during the winter.

GE Response:

Section 6.14 of the Detailed Work Plan describes the actions that will be performed when temporarily closing the consolidation areas. This information was reviewed with the Agencies in the July 8, 1999 conference call and is summarized as follows. In general, three types of surface covers are envisioned in conjunction with the consolidation areas -- daily, interim, and final surface covers. Daily and interim covers are described below.

In areas subject to ongoing and day-to-day use, daily covers (consisting of polyethylene sheeting or similar materials) will be installed over the active portions of the consolidation areas at the end of each working day, while an interim surface cover is anticipated to be installed under three scenarios. First, an interim cover will be installed once a portion of the consolidation area reaches the final design height, but is not large enough to warrant installation of a final cover. Second, an interim cover will be installed when the consolidation activities are completed for a given year and final design heights have not been achieved. Finally, an interim cover will be installed when portions of the consolidation areas will be inactive for an extended period of time (e.g., 3 to 4 months).

The interim cover will consist of a three- to six-inch thick layer of clean soil capable of supporting vegetative growth. Depending on the season that the interim cover is installed, the cover may be seeded with a quickly germinating rye grass to establish an erosion resistant vegetative cover. If the growing season has passed (i.e., October 15), polyethylene sheeting or similar materials will be installed over the closed/inactive portions of the consolidation areas.

II. Responses to EPA "Specific Comments"

EPA Comment 1:

Page 1-3, 1st full para., Line 11: Revise to "....appropriate composite/averaging..."

GE Response:

Agreed. As discussed with the EPA, pertinent evaluations and decisions regarding the disposition of materials generated at a given Removal Action Area (RAA) will be addressed in the technical submittals (e.g., RD/RA Work Plan) specific to that RAA.

EPA Comment 2:

Page 1-5, last paragraph: "New" consolidation areas include only New York/Merrill Road area. Also, we should stipulate the size constraints of the consolidation area.

GE Response:

Agreed. Size constraints related to the consolidation areas (i.e., approximate horizontal extent and maximum elevation) are provided Section 2.2 of the Detailed Work Plan.

EPA Comment 3:

Page 2-5, Section 2.4.1, Item 3: Define the permeability of the GDC that GE is proposing to use.

GE Response:

The specified permeability of the GDC is 2 x 10^{-3} m^2/sec.

EPA Comment 4:

Page 3-1, Pre-Design Activities: The Work Plan Addendum shall include further evaluation of the NAPL discovered at well location H78B-8R. At a minimum, the evaluation of the NAPL should include the following: 1) NAPL bailing/recovery test at well H78B-8R, 2) Appendix IX+3 analysis and physical property analysis (i.e., specific gravity, viscosity, etc.) of NAPL, 3) Extent of NAPL through installation of additional wells to till surface.

GE Response:

As previously indicated, the results of assessment activities related to the NAPL detected at well H78B-8R are contained in the IRA Completion Report recently submitted by GE. Additional information specific to this EPA comment (e.g., physical properties of the NAPL and recovery testing) are provided in Attachment B. An updated top of till contour map is provided in Attachment C to this Addendum.

EPA Comment 5:

Page 3-2, Section 3.4.1: The purpose of the pre-design soil data is unclear. The data are presented, yet no evaluation of the data is presented. The Work Plan should combine the historical data and new data and provide an evaluation of these data. The objective of the pre-design soil data collection shall include the acquisition of geotechnical parameters which will be required for designing the landfill cap stability, etc. The permeability of the in-situ material at Hill 78 and underneath Building 71 shall be evaluated by using ASTM D-5084 with an appropriately specified confining stress.

GE Response:

The pre-design field investigations described in Section 3.4 of the Detailed Work Plan were implemented pursuant to a proposal contained in the March 1999 Conceptual Work Plan, which was approved by the EPA. The primary focus of the pre-design investigations was to obtain supplemental information concerning the presence of PCBs and other hazardous constituents that are present in the soils associated with the on-plant consolidation areas. The results of these investigations were provided in the Detailed Work Plan. With respect to the portion of the above EPA comment concerning geotechnical parameters (e.g., landfill cap stability, permeability of in-situ material, etc.), no specific pre-design activities were proposed by GE, required by EPA, or conducted. However, information concerning the general geologic and hydrogeologic conditions within the area are available from prior investigations and were supplemented by the recent pre-design activities related to groundwater conditions (i.e., monitoring well installation). This information will be considered as appropriate during future design activities associated with the consolidation areas.

EPA Comment 6:

Page 3-3: Provide a discussion regarding the current groundwater flow direction.

GE Response:

Attachment B to this Addendum, *Proposal for Future Groundwater Monitoring - Hill 78 and Building 71 Consolidation Areas* (Future Groundwater Monitoring Proposal), provides a discussion regarding the current groundwater flow direction in the vicinity of the consolidation areas, including maps depicting generalized groundwater flow direction.

EPA Comment 7:

Page 4-2, Section 4.3: GE shall perform pre-characterization sampling for the new storm sewer utility corridor in accordance with GE's Protocols for the Management of Excavation Activities, updated November 1996.

GE Response:

GE has completed the above-referenced pre-characterization sampling for the new storm sewer. The results of the sampling activities are included in Attachment D to this Addendum.

EPA Comment 8:

Page 4-3, Section 4.4: GE shall discuss with the Agencies Project Managers the well abandonment procedures prior to abandoning the Hill 78 wells. Eventually, the Sampling Analysis Plan (May 1994) Appendix I will have to be updated by GE to revise the well abandonment procedures.

GE Response:

Per the July 8, 1999 discussions with the EPA, GE will use the Massachusetts Department of Environmental Protection Standard References, Section 4.6 - Decommissioning of Monitoring Wells, when abandoning the Hill 78 wells. These procedures are included in Attachment E to this Addendum.

EPA Comment 9:

Page 5-1, Section 5.2.1: The appropriate mail code for Michael Nalipinski is (HBT). Please revise.

GE Response:

Agreed.

EPA Comment 10:

Page 5-11, Section 5.12: Reevaluate the diameter of deleterious material allowable in the consolidation area. Typically, the geotextile vendor has size requirements that should also be adhered to. The puncture requirements shall be evaluated using GRI test methods.

GE Response:

With respect to the preparation of the subgrade surface beneath the base liner system for the Building 71 Consolidation Area, all objects protruding from the prepared subgrade (e.g., stones, sticks, roots, etc.) will be removed. The overlying geotextile will not be installed until a compacted, smooth, uniform surface free from protruding objects that could damage the overlying geosynthetics is achieved.

EPA Comment 11:

Page 5-13, Section 5.15: Provide an estimated volume for the leachate storage facility at the Building 71 area. The collected leachate shall be periodically sampled and those results need to be compared to the groundwater analysis.

GE Response:

As discussed in the July 8, 1999 conference call with the EPA and subsequent meetings, the Detailed Work Plan focuses on those activities that are necessary to support the anticipated construction and use of the consolidation areas beginning in 1999, while future activities related to design and/or operation of the consolidation areas will be addressed in subsequent submittals to the EPA. This type of approach is evident in GE's proposed method for handling leachate that may be generated from the Building 71 consolidation area. In 1999, as part of the construction of portions of the Building 71 consolidation area, GE will install certain components of the future leachate management system, including collection laterals and a below-grade collection sump. From an operational standpoint, these components will be used, in combination with temporary collection pumps/piping and appropriate tanks, to collect and transfer any accumulated liquids to GE's existing 64-G groundwater treatment facility. As part of this operation, GE will document the rates/volumes of liquid that are transferred, as well as the characteristics of these liquids. Based on the information collected during this initial operational period, GE will assess the need for, scope, and timing for the installation of additional leachate management facilities.

EPA Comment 12:

Page 6-2, Section 6.3: The "elevated levels of Appendix IX+3 constituents" is too vague. GE should make this consistent with the Appendix IX+3 data review for Allendale School which specifies a screening evaluation for TCLP (i.e., 20x rule).

GE Response:

As discussed in Section 6.3 of the Detailed Work Plan, materials generated as a result of the response action activities will be characterized prior to transport to the consolidation areas. Accordingly, waste characterization activities will be consistent with the work plans developed for each RAA (e.g., Allendale School Property, Upper ½-Mile Reach, etc.).

EPA Comment 13:

Page 6-2, Section 6.3: The Work Plan should identify the procedures to be used to ensure consolidation of materials at the proper area (i.e., Hill 78 vs Bldg. 71).

GE Response:

Similar to a prior response, the characterization of materials for subsequent disposition will be conducted as part of the technical evaluations associated with each RAA. As discussed with the Agencies during the July 8, 1999 conference call, this approach allows pre-project evaluation and coordination and optimizes (to the extent possible) the activities to be conducted within the on-plant consolidation areas. At each RAA, protocols will be developed (e.g., colored cards, truck placarding, etc.) to ensure that TSCA materials are delivered to the Building 71 Consolidation Area, and non-TSCA materials are delivered to the Hill 78 Consolidation Area.

EPA Comment 14:

Page 6-3, Section 6.3: Question: Is the standard paint filter test based on a specific moisture content or should a standard be identified for moisture content for soils prior to placement? What will the disposition of the materials that exceed the moisture test?

GE Response:

The procedures for the Paint Filter Liquids Test (Method 9095A) are provided as Attachment F to this Addendum. Materials generated as a result of the response actions that contain visible free liquid or fail the Paint Filter Liquids Test will require dewatering (or other activities to lower the moisture content of the materials) prior to their transport to the consolidation areas. Again, this approach is anticipated to streamline operations to be conducted at the on-plant consolidation areas.

EPA Comment 15:

Page 6-4, Section 6.7: Wind direction shall be monitored and air monitors shall be placed such that a minimum of one monitor is downwind at all times. The air monitoring program shall also be designed considering the air intakes at the U.S. Generating Facility.

GE Response:

As discussed during the July 8, 1999 conference call and consistent with the Detailed Work Plan, GE will conduct ambient air particulate monitoring at several locations around the consolidation areas. These locations were intended to provide downwind coverage in the event that wind direction shifts from its predominant easterly direction. As discussed during the conference call, in consideration of concerns related to the air intakes associated with Pittsfield Generating Company, LLP's facility, one ambient air monitoring location will be added at a location representative of the air subject to intake into the facility, while the remaining locations may be adjusted as necessary based on prevailing wind conditions in the area. A figure identifying the current air monitoring locations (in consideration of ongoing response activities at the Allendale School Property) is provided in Attachment G to this Addendum.

EPA Comment 16:

Section 6-8: The proposal to allow materials greater than 6-inches in the first lift seems excessive. Puncture calculations shall be provided that substantiate the appropriate particulate size which will not cause damage to the geosynthetic material. Use the GRI method to evaluate.

GE Response:

Design calculations supporting the installation of material with a maximum particle size of six inches in the first lift are provided in Attachment H of this Addendum. It should be noted that operational measures will be taken to prevent puncture of the underlying geosynthetics, including:

- Using only soil materials (i.e., no vegetative materials or building debris) during placement of the first lift;
- Using low-ground pressure equipment (e.g., bull dozers) to place the soil materials; and

- Maintaining a minimum two-foot lift thickness to ensure that large stones are supported by soil and point-loading conditions on the underlying geosynthetics are avoided.

<u>EPA Comment 17:</u>

Page 6-6, Section 6.10: Add a paragraph which discusses how dust generated from truck traffic will be addressed.

<u>GE Response:</u>

As shown on revised Figure 9 included as Attachment I to this Addendum, many of the site roads to be used during consolidation activities will be paved to control dust. Additionally, temporary access roads will be surfaced with a geotextile and 6 inches of gravel to aid in minimizing dust generation. However, as with any earthwork activity, dust may be generated that will require active mitigative measures. These measures may include:

- Spraying water on excavation faces, dozer blades during grading, and soil when unloading transport vehicles;
- Spraying water on backfill stockpiles and on backfill materials that have been placed in fill areas;
- Spraying water on access roads;
- Hauling soil materials in tarped vehicles;
- Sweeping roadways when visible amounts of soil begin collecting on the roadways;
- Restricting vehicle speeds to 5 miles per hour; and
- Covering soil piles with a layer of polyethylene after work activities cease for the day.

It should be noted that only the minimum amount of water necessary to control dust will be used in order to prevent potential erosion of the site soils.

<u>EPA Comment 18:</u>

Page 6-6, Section 6.11: Add a paragraph and modify the drawings as appropriate to address the flow of the surface water runoff and location of the retention basins.

<u>GE Response:</u>

See GE's response to EPA Comment 3.

<u>EPA Comment 19:</u>

Page 6-7, Section 6.14: The interim cover will not prevent the infiltration of precipitation. The interim cover should also include a design feature (i.e., 20 mil polyethylene sheeting) to prevent infiltration of precipitation to the degree practicable. See Significant Comment #4.

<u>GE Response:</u>

As discussed in an earlier response, depending on the time of year that an interim cover is installed, the cover will be seeded with a quickly germinating rye grass and covered with hay/straw to provide an erosion resistant vegetative cover that will promote runoff. If construction extends beyond October 15, polyethylene sheeting or similar materials will be installed over the closed portions of the consolidation areas to minimize infiltration of precipitation.

EPA Comment 20:

Page 7-1, Section 7.2: The Restoration Activities Section shall be revised to include tasks which address NRD enhancements.

GE Response:

As a supplement to the forthcoming *Consent Decree* (CD) for the Pittsfield/Housatonic River Site, a *Statement of Work for Removal Actions Outside the River* (SOW) is also being prepared. The CD and SOW establish requirements related to NRD enhancement activities for the Hill 78 Consolidation Area. These requirements will be incorporated into future design activities related to that consolidation area (i.e., future submittals related to the final capping and restoration of the consolidation area).

Comment 21:

Page 8-1, Section 8.1: A submittal date for the "baseline" groundwater investigation and groundwater monitoring program proposal shall be specified.

GE Response 21:

The results of the "baseline" groundwater monitoring activities and a proposal for future monitoring are included as Attachment B to this Addendum (Future Groundwater Monitoring Proposal).

EPA Comment 22:

Page 8-1, Section 8.1: 1st para. 2nd sentence: the purpose of the program includes, "to assess what the base line groundwater conditions are at the areas". Also, same sentence add at the end, "....now and in the future, if necessary".

GE Response:

Agreed. These comments have been incorporated into the Future Groundwater Monitoring Proposal presented in Attachment B to this Addendum.

EPA Comment 23:

Page 8-1, 4th para.: Consistent with SOW Attachment H, GW-3 shall be used as a benchmark for consolidation area wells. The groundwater monitoring program proposal shall identify the statistical methods to be used to analyze groundwater data and shall propose when response actions are required to address "statistically significant" increases in groundwater concentrations.

GE Response:

Discussions regarding the future groundwater monitoring program are provided in Attachment B to this Addendum.

EPA Comment 24:

Page 8-2, Section 8.2: Any GE proposed response action shall be implemented subject to Agency approval. Include a response to Significant Issue #2 in this Section.

GE Response:

Information pertaining to the NAPL detected in Well H78B-8R was provided in the Immediate Response Action Completion Report transmitted to the Agencies on July 19, 1999. Additional information is also presented in Attachment B to this Addendum.

EPA Comment 25:

Table 1: The EPA will be providing comments relating to the ARARs Tables shortly in a future correspondence.

GE Response:

No response at this time.

EPA Comment 26:

Include a figure (or two) that depicts the overburden and bedrock water table maps. Also, include a figure identifying the till elevation contours beneath the Consolidation Areas.

GE Response:

A till elevation contour map is presented in Attachment C to this Addendum. Overburden groundwater elevation contour maps are presented in Attachment B to this Addendum (Future Groundwater Monitoring Proposal). There is insufficient bedrock well spacing and data to produce reliable bedrock water table maps.

EPA Comment 27:

Figure 1: The Site Location Map does not identify the facility per the definition of the CD.

GE Response:

A revised Figure 1 is included as Attachment J to this Addendum.

EPA Comment 28:

Figure 3: Define the thickness of the flexible membrane liner and sub base material. The EPA has recommended a 60 mil. flexible membrane.

GE Response:

Sixty-mil-thick HDPE FML will be used as shown in Attachment K to this Addendum.

EPA Comment 29:

Figure 7: Identify in the figure and text the inclusion of the Altresco well in the groundwater monitoring program.

GE Response:

The Altresco (currently Pittsfield Generating Company, LLP) well (i.e., ASWW-5) to be included in future groundwater monitoring has been identified in the proposed groundwater monitoring program provided in Attachment B to this Addendum. Note that as previously discussed with the Agencies, GE's proposal for groundwater monitoring in this area of the GE Plant Site calls for including the results of monitoring conducted by the Pittsfield Generating Company, LLP (in accordance with their operations/permit) and not GE's separate sampling and analysis of that well.

EPA Comment 30:

Figure 9: Define the proposed truck route for depositing material in the consolidation areas.

GE Response:

A revised Figure 9 depicting the proposed truck routes at the consolidation areas is included as Attachment I.

EPA Comment 31:

Attachment A, Technical Drawings, A-5: A low permeability soil plug is shown on the northwest side of the Consolidation Area but none is shown for a similar condition at the south end near the Storm Basin shall be included.

GE Response:

The low permeability soil plug at the northwest side of the Building 71 Consolidation Area is necessary to prevent stormwater from entering the consolidation area where the FML dips to accommodate the leachate collection piping network. The low permeability soil is used to form a continuous containment berm along the northwestern side of the consolidation area. A low permeability soil plug is not necessary at the southern corner since this is a permanent sidewall penetration for the leachate collection header pipe. A watertight HDPE boot will be fabricated for this penetration as shown on Technical Drawing 8.

EPA Comment 32:

Attachment A, Technical Drawings, A-5: Leachate pipes are shown which are 6-inch diameter with minimum slopes of 0.5%. No calculations are provided to substantiate pipe sizing or transmissivity of the drainage geocomposite for predicted leachate flows. In addition, pipe strength calculations should be provided for Consolidation Area loading either at a final grade or due to vehicular and equipment loads during construction or operations.

GE Response:

The above-referenced technical calculations are provided as Attachment L to this Addendum.

EPA Comment 33:

Provide calculations to demonstrate that adequate veneer stability exists between the respective interface layers of the components of the final cover systems on the 33% slope. The calculated requirements should be verified using proposed materials by testing in accordance with ASTM D-5321. The tests to evaluate the interface friction requirements may include Koerner, Hwu, Giroud, Bachus and Bonabarte methods.

GE Response:

The above-referenced technical calculations are provided as Attachment M to this Addendum.

EPA Comment 34:

At this time, there is a minimal potential that gas will be generated from the Consolidation Areas but this issue should be evaluated and discussed in the Detailed Work Plan.

GE Response:

As discussed with the EPA during our July 8, 1999 conference call, there is minimal potential for gas generation at the consolidation areas due to the limited amount of high-organic material that will be consolidated during the response action activities. Organic materials placed within the consolidation areas will generally be limited to materials cleared during the response actions (e.g., trees, roots, etc.) and wood debris generated during building demolition. To further minimize the potential for gas build-up, organic materials placed within the consolidation areas will be placed in such a manner as to avoid large pockets of organic matter. For example, the material will be placed in thin lifts (i.e., less than 3-inches thick) and spread out over the entire active area, and the size (diameter and/or length) of tree trunks and stumps will be minimized to the extent practicable.

EPA Comment 35:

Groundwater east of Building 71 (along the General Dynamics parking lot) needs to be monitored. GE's groundwater flow maps show an easterly component to groundwater flow. Also, the bedrock monitoring well shall be a component of evaluating the Consolidation Areas impact on groundwater.

GE Response:

Groundwater monitoring activities are discussed in the Attachment B to this Addendum. Updated groundwater flow maps incorporating data collected from new wells in the Building 71 area indicate that groundwater flow is predominantly from northeast to southwest.

EPA Comment 36:

As previously commented, there are not calculations provided to substantiate that the proposed thickness (e.g., min. 2 feet) of the final cover system will provide adequate protection from frost damage of the underlying geosynthetics. The preferred method to evaluate the frost protection issue is the Modified Berggren Equation.

GE Response:

The components and thickness of the final cap for the on-plant consolidation areas has been the subject of several discussions between GE and the Agencies over the last several months. From these discussions, a two-foot thick cap was agreed to and this information was presented in the March 1999 Conceptual Work Plan. The geosynthetic materials included within the final cover system consist of GDC, 60-mil-thick HDPE FML, and a GCL. These materials have demonstrated a resistance to frost penetration and freeze/thaw cycles, and therefore do not require the cover thicknesses typically associated with a compacted clay liner system. In support of the proposed two-foot-thick cover system, several relevant articles from the material manufacturers, as well governmental agencies, are included as Attachment N to this Addendum (note that pertinent information is underlined). In light of this information, GE will maintain a 2-foot thick cap thickness.

We trust that the contents of this letter will be sufficient to address the EPA's comments and allow GE to proceed with full-scale implementation of those on-plant consolidation activities necessary to support 1999 response actions. However, should additional information be necessary, please contact me with such a request.

Sincerely,

John F. Novotny / Bruno

John F. Novotny, P.E.
Remediation Project Engineer

U:\PLH99\85691543.WPD

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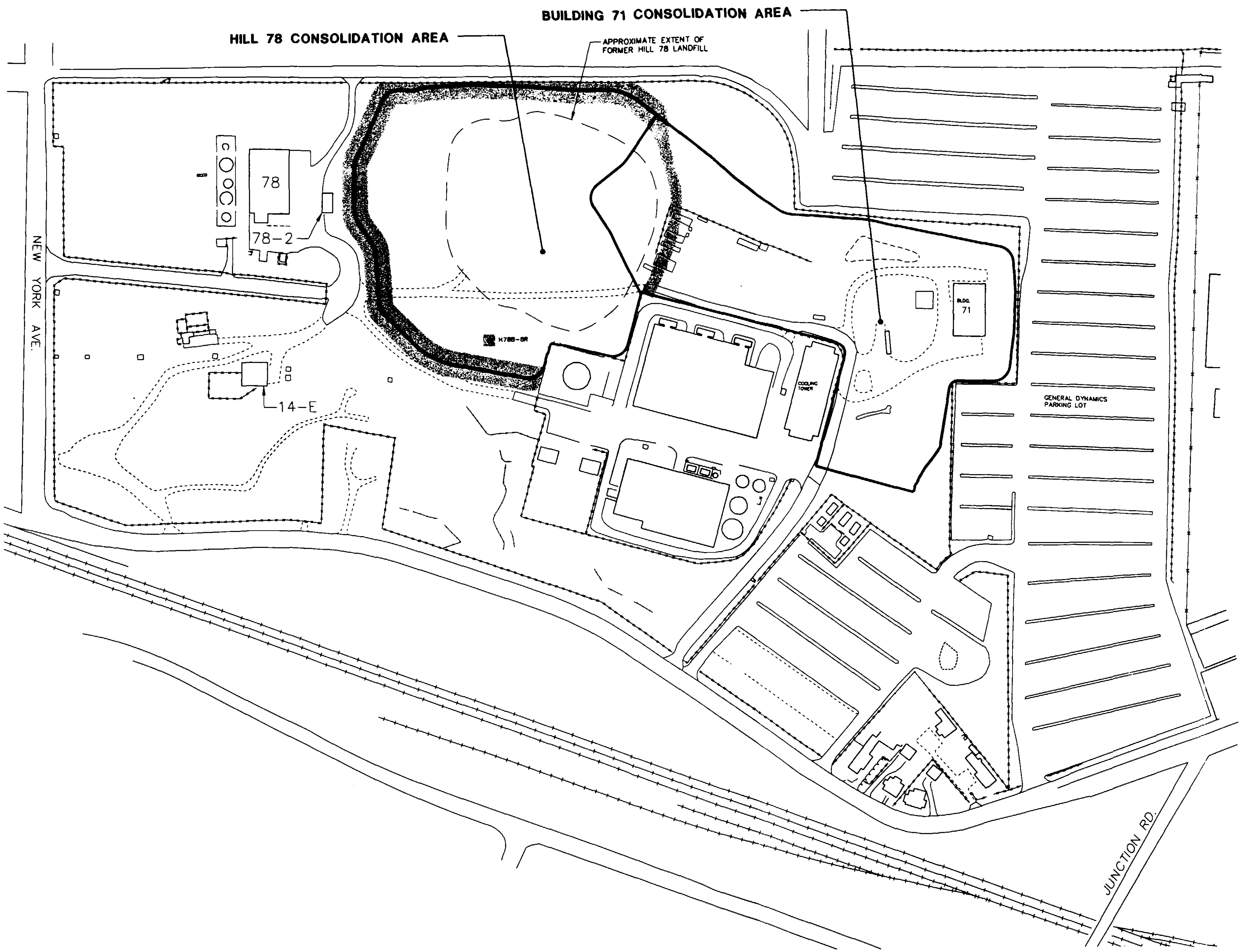
Public Information Repositories ECL-I-P-IV(A)(1)

Attachments

Attachment A

BLASLAND, BOUCK & LEE, INC.
engineers & scientists

Area Subject to Geophysical Survey - Hill 78 Consolidation Area



LEGEND:

- APPROXIMATE AREA OF PROPOSED CONSOLIDATION ACTIVITIES
- EXISTING SECURITY FENCE
- AREA SUBJECT TO GEOPHYSICAL SURVEY

NOTES:

1. MAPPING IS BASED ON AERIAL PHOTOGRAPHS AND PHOTOGRAMMETRIC MAPPING BY LOCKWOOD MAPPING, INC. -FLOWN IN APRIL 1990; DATA PROVIDED BY GENERAL ELECTRIC COMPANY; AND BLASLAND, BOUCK & LEE, INC (BBL) CONSTRUCTION PLANS, AND ON OBSERVATIONS DURING A SITE VISIT BY BBL PERSONNEL ON DECEMBER 3, 1997.
2. SITE BOUNDARIES ARE APPROXIMATE.
3. NOT ALL PHYSICAL FEATURES SHOWN.

100' 0 100' 200'
GRAPHIC SCALE

Original includes color coding.

GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS
ADDENDUM TO DETAILED WORK PLAN FOR ON-PLANT CONSOLIDATION AREAS

AREA SUBJECT TO GEOPHYSICAL SURVEY

BBL BLASLAND, BOUCK & LEE, INC. *engineers & scientists*

FIGURE **1**

X: 20185X01.DWG
L: ON=*, OFF=*REF*
P: STD-PCP/DL.PCP
6/11/99 SYR-54-GMS YCC
20185003/REPORT/20185B12.DWG

Attachment B

BLASLAND, BOUCK & LEE, INC.
engineers & scientists

Proposal for Future Groundwater Monitoring - Hill 78 and Building 71 Consolidation Areas

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1. Introduction

1.1 General

This *Proposal for Future Groundwater Monitoring - Hill 78 and Building 71 Consolidation Areas* (Future Groundwater Monitoring Proposal) describes the future groundwater monitoring activities proposed by the General Electric Company (GE) for two consolidation areas located within GE's Pittsfield, Massachusetts facility. Beginning in July 1999, GE initiated construction and use of these areas for the permanent consolidation of materials (soil, sediment, debris, etc.) generated during the performance of response actions within and around Pittsfield (henceforth referred to as the Pittsfield/Housatonic River Site, or the Site.) Prior to the initial construction/use of these consolidation areas, GE conducted a "baseline" groundwater monitoring program to supplement information available for the area of interest and further characterize current hydrogeologic conditions. That program was conducted in accordance with the protocols presented in a document entitled *Conceptual Work Plan for Future On-Plant Consolidation Areas* (Pre-Design Work Plan), which was submitted to and conditionally approved by the United States Environmental Protection Agency (EPA) and Massachusetts Department of Environmental Protection (together, the Agencies).

The "baseline" groundwater sampling program, conducted between June 14 and 17, 1999, involved a total of twelve monitoring wells selected to provide spatial representation of groundwater conditions on all sides of the consolidation areas (i.e., upgradient, downgradient, and cross-gradient) prior to construction of the consolidation areas. The locations of the wells are shown on Figure 1. Included in this program were four existing wells (78-1, 78-6, H78B-15, and NY-4) and eight new wells (OPCA-MW-1 to OPCA-MW-8) installed specifically for this monitoring program.

Based on the results of the "baseline" groundwater monitoring program (summarized in this document), GE has developed this Future Groundwater Monitoring Proposal for EPA review, comment, and approval. The primary objective of the future groundwater monitoring program is to periodically assess groundwater conditions at the site, compare these conditions with those observed during past monitoring activities, and identify potential changes in groundwater conditions which may be related to consolidation activities. This Future Groundwater Monitoring Proposal describes the scope and results of the "baseline" groundwater monitoring activities, and presents and discusses the proposed groundwater monitoring program to be conducted in conjunction with ongoing and future consolidation activities.

In addition to presenting the results of the "baseline" groundwater sampling program and the proposed future groundwater monitoring program, this Attachment also provides information pertaining to other ancillary groundwater-related issues in this area. This information, prepared at the request of the EPA, consists of a summary of supplemental investigations related to the occurrence of LNAPL in well H78B-8R (located within the horizontal extent of the future Hill 78 Consolidation Area).

2. Summary of "Baseline" Monitoring Program

2.1 General

The activities conducted as part of the "baseline" groundwater monitoring program involved well installation and development, the measurement of groundwater elevations, and the collection of groundwater samples from select monitoring wells. Figure 1 presents the well locations included in the baseline monitoring activities described in this report, as well as other monitoring locations in the area. This section discusses the field procedures used to install new wells, measure site groundwater elevations and collect groundwater samples, and also presents the results of these investigations.

In addition, the results of supplemental investigations regarding the detection of LNAPL at well H78B-8R are presented in Section 2.6. These investigations, consisting of analysis of physical characteristics of the LNAPL and a field test of LNAPL recovery rates, were proposed as a follow-up to an Immediate Response Action conducted at this location. Although these activities were conducted separately from the "baseline" groundwater monitoring program, the results are summarized in this document in response to a request by EPA.

2.2 Monitoring Well Installation and Development

Eight new monitoring wells (OPCA-MW-1 through OPCA-MW-8) were installed between May 26 and June 8, 1999. Each well was constructed with 2-inch diameter Schedule 40 PVC casing and 10-feet of well screen placed to intercept the water table. The water table was encountered at depths of between 10 and 18 feet during well installation. Soil samples were collected continuously during the drilling of each well boring. Each soil sample was screened with a photoionization detector (PID), and the lithological characteristics of each sample was described in the field by a geologist. Well construction information for each of the new and existing monitoring wells included in the groundwater sampling program is presented in Table 1, and well installation logs for the new wells are included in Appendix A.

Following installation, the eight new wells were developed to clear fine-grained materials from the well screens and surrounding sand packs. Well development activities were conducted between June 4 and 10, 1999. A surface inertial pump, dedicated polyethylene tubing, and surge blocks were utilized. Each well was surged in 2-foot intervals over the entire saturated portion of the well screen to force water in and out of the well screen and surrounding sand pack. Groundwater was then removed from the wells until the discharge was relatively free of sediment. Following development, the wells were allowed to stabilize for several days prior to sample collection.

2.3 Groundwater Elevations

Groundwater elevations were recently measured in this area on two occasions: on May 25, 1999 from several wells across the Hill 78 Area and the adjacent (to the north) Allendale School Property; and on June 17, 1999 from the twelve "baseline" groundwater monitoring wells surrounding the future on-plant consolidation areas. The groundwater elevation contours derived from the earlier round of measurements are presented on Figure 2. Table 1 summarizes the June 17, 1999 "baseline" investigation groundwater level data and the associated groundwater elevations. These data were used to generate the groundwater elevation contours which are presented on Figure 3.

Groundwater elevations ranged from an approximate elevation of 1,015 feet (above mean sea level) north of the site to approximately 994 feet south of the site. The groundwater flow patterns appear to generally correlate with the site surface and top of till topography, with the general flow direction being from northeast to southwest. The groundwater elevation contours collected during the "baseline" monitoring program activities (June 17, 1999) also correlate with data obtained on May 25, 1999 from several wells at the Hill 78 Area and the Allendale School Property.

2.4 Groundwater Sample Collection

Prior to groundwater sample collection, each well was screened for organic vapors with a PID. The resulting PID readings ranged from 0 to 0.3 PID units, which were consistent with background readings measured in the vicinity prior to the well screening.

Following PID screening, each monitoring well was purged utilizing low-flow purging techniques. Each well was purged until the measured field parameters (including temperature, pH, specific conductivity, oxidation-reduction potential, dissolved oxygen, and turbidity) stabilized, or the well was pumped dry. Table 2 presents a summary of the field measurement results.

Following well purging, groundwater samples were collected from each well using low-flow sampling techniques. Each of the samples was packed on ice and submitted for laboratory analysis of those constituents listed in Appendix IX of 40 CFR 264, plus 2-chloroethyl vinyl ether, benzidene, and 1,2-diphenylhydrazine (Appendix IX+3), excluding herbicides and pesticides. The results of these analyses are summarized in Section 2.5. Field sampling records are presented in Appendix B. Field sampling procedures were conducted in accordance with GE's Sampling and Analysis Plan/Data Collection and Analysis Quality Assurance Plan (SAP/DCAQAP) (draft dated October 1998, pending revisions requested by the USEPA).

2.5 Groundwater Analytical Results

Table 3 provides a summary of the results of the groundwater sample analyses for each sampling location. This information is summarized below:

- PCBs were detected (Aroclor 1254 only) in 6 of the 12 monitoring wells at total concentrations ranging from 0.000035 parts per million (ppm) to 0.00089 ppm;

- No volatile or semi-volatile organic compounds were detected in any of the groundwater samples;

- One sample (OPCA-MW-1) exhibited estimated concentrations or total tetrachlorodibenzofuran and heptachlorodibenzofuran of 0.000009 parts per billion (ppb) and 0.0000078 ppb, respectively. One other sample (OPCA-MW-2) exhibited an estimated concentration of heptachlorodibenzofuran of 0.0000013 ppb, but the duplicate of this sample did not exhibit a presence of this constituent. No other polychlorinated dibenzofurans were detected in any of the groundwater samples;

- Barium was detected in all 12 samples at concentrations ranging from 0.0095 ppm to 0.086 ppm;

- Zinc was detected in 4 of the 12 samples at concentrations between 0.029 ppm and 0.088 ppm; and

- Arsenic was detected in one sample (78-6) at a 0.032 ppm.

PCBs were detected in excess of the MCP GW-3 Standard of 0.0003 ppm at only one location, OPCA-MW-4. It should be noted that the groundwater collected from this well was not filtered prior to analysis and that particulate matter surrounding the well screen may have contributed to the concentration of the PCBs detected in the sample.

All inorganics which were detected in the groundwater samples were observed at concentrations less than the respective MCP GW-3 Standards.

2.6 LNAPL Monitoring and Assessment

On May 27, 1999, GE obtained knowledge of, and provided oral notification to the Massachusetts Department of Environmental Protection (MDEP), that approximately 0.5 feet of LNAPL was present in monitoring well H78B-8R, (in response, the MDEP assigned Release Tracking Number 1-12954 to this specific release notification). As a follow-up to the oral notification, GE has conducted several activities as part of an Immediate Response Action (IRA), pursuant to Part 40.0410 of the Massachusetts Contingency Plan (MCP). LNAPL samples were submitted for laboratory analysis and monitoring and recovery of LNAPL from this well has been performed manually on a weekly basis since it's initial detection. During each monitoring event, groundwater level and LNAPL thickness measurements were recorded, and any accumulations of LNAPL were removed. The recovered LNAPL was transported to GE's Building 78 RCRA/TSCA permitted storage facility for subsequent off-site disposal. The details of these activities were summarized in an IRA Completion Report, submitted to the Agencies on July 19, 1999.

In addition to summarizing the results of the monitoring/assessment activities conducted by GE up until the date that the IRA Completion Report was submitted, GE identified several future activities that would be performed:

- Continue weekly monitoring and LNAPL removal at well H78B-8R;
- Further define potential LNAPL recovery rates and volumes by performing a multiple-day LNAPL recovery test;
- Implement a monthly monitoring program at wells H78B-8, OPCA-MW-2, and OPCA-MW-3; and
- Collect additional LNAPL samples to be analyzed for physical characteristics, including specific gravity and viscosity.

The results of the LNAPL physical property analysis and the LNAPL recovery test assessment are contained in this report and discussed below, while the results of future weekly and monthly monitoring will be presented to the Agencies in the monthly progress reports for the Hill 78 Site.

Based on the results of analyses conducted during the IRA activities, the LNAPL observed at this site contains PCBs and PAHs (with lesser amounts of other constituents), and is present at a limited volume, confined to the immediate vicinity of well H78B-8R. The presence of LNAPL has not been observed at the nearest monitoring locations downgradient of this well, and downgradient groundwater analytical results do not show any indications of an impact to the dissolved phase water quality.

To supplement the existing chemical data collected from the H78B-8R LNAPL, GE has collected additional LNAPL samples for physical properties testing. These samples were collected on July 19, 1999 and allowed to sit undisturbed for several days prior to analysis, to permit the LNAPL to completely separate from the aqueous phase portion of the sample. The specific gravity of the LNAPL sample, measured with an Anton Parr Density Meter (Model DMA 35) at 23.5 degrees Centigrade, was 0.934. Viscosity was measured with a Cannon-Fenske viscometer mounted in a constant temperature bath at 100 degrees Fahrenheit. The results of the initial test, as well as from a duplicate test, showed a dynamic viscosity of 11.1 centistokes for the LNAPL sample.

An LNAPL recovery test assessment was conducted at well H78B-8R from July 19 to 21, 1999 in order to evaluate the feasibility of installing an automated LNAPL recovery system at this location. The test involved manual removal of LNAPL from well H78B-8R and observations of the rate at which LNAPL returned to the well. LNAPL monitoring and removal was initially conducted on an hourly basis. Adjustments to the LNAPL removal schedule were made following the first several monitoring intervals, based on the limited LNAPL recovery observed. For the final two days of the test, monitoring was generally conducted at two-hour intervals for a seven-hour period each day. The data from this LNAPL recovery test is summarized in Table 4, and discussed below.

At the start of the recovery test, an LNAPL thickness of 0.06 feet was present in the well. A volume of 0.04 liters of LNAPL was removed to clear the well and initiate monitoring of the recovery. After a period of one hour, an LNAPL thickness of 0.02 feet was measured in the well, and 0.02 liters were removed from the well. The next one-hour interval showed an LNAPL recovery of 0.01 feet (and corresponding removal of 0.01 liters). Following this removal, no LNAPL accumulations were detected in the well for between 29 and 46 hours, as no LNAPL was present at the end of the second day of testing (29 hours later), but a thickness of 0.01 feet was observed during the first observation period on the third day (46 hours since the previous removal interval). This thin layer of LNAPL was allowed to remain in the well to allow observations of recovery rates. The LNAPL thickness remained constant for a period of 5 to 6 hours, at which time a thickness of 0.02 feet was observed. After this accumulated LNAPL was removed (0.02 liters), no LNAPL returned to the well for the duration of the test.

Overall, approximately 0.09 liters of LNAPL were removed from the well over a 55-hour period during the recovery test. However, approximately half of this LNAPL had already accumulated in the well before the test began. Utilizing only LNAPL which accumulated in the well during the recovery test, the average LNAPL recovery rate over the length of the test was calculated at approximately 0.00576 gallons per day.

Based on the limited quantities of LNAPL that was recovered during this test, the installation of an automated LNAPL removal system would not be a practical approach to address this LNAPL occurrence. Rather, GE proposes to continue the ongoing weekly monitoring program in place at this location, and to remove any accumulations of LNAPL.

3. Proposed Groundwater Monitoring Program

3.1 General

This section describes the groundwater monitoring program proposed by GE during the active use of the consolidation areas. The overall purpose of this program is to assess potential changes in groundwater conditions due to consolidation activities at these areas. In addition, the results of the monitoring program will provide a groundwater data set that can support evaluations concerning the need for further response actions or modifications to future monitoring activities, now and in the future, if necessary. This proposal identifies the particular monitoring wells to be sampled, the frequency of groundwater monitoring for these wells, and the list of constituents for which the groundwater samples will be analyzed. All monitoring wells that were utilized during the "baseline" monitoring investigation will initially be included in this monitoring program.

The following sections present a summary of the proposed groundwater monitoring program, including the proposed procedures and criteria for evaluating the sampling data from each monitoring event, as well as the response actions that GE will consider and propose to the EPA, as appropriate, in the event that a potentially significant increase in dissolved-phase constituents is detected in the sampling results from a given event, relative to prior data. This program shall be enacted during the period of active use of the consolidation areas. Upon closure of the consolidation areas, the results of this monitoring program will be utilized to develop a post-closure groundwater monitoring program.

3.2 Groundwater Monitoring During Active Consolidation Activities

Initially, each of the twelve wells monitored during the "baseline" program will be sampled during active consolidation operations. Groundwater samples will be collected utilizing low-flow sampling techniques on a semi-annual basis, beginning in October 1999. This sampling will be conducted in the spring and fall of each year, generally during the months of April and October. All samples will be analyzed for PCBs and the volatile organic compounds, semivolatile organic compounds, and metals listed in Appendix IX of 40 CFR 264, plus 2-chloroethyl vinyl ether, benzidene, and 1,2-diphenylhydrazine (Appendix IX+3). Both filtered and unfiltered samples will be analyzed for PCBs and metals. Additionally, groundwater samples from wells OPCA-MW-1 and OPCA-MW-2 will be analyzed for PCDDs/PCDFs. In future monitoring rounds, other parameters and locations may be proposed to be added or deleted from the program by GE, based on the results of subsequent sampling events and potential modifications to the usage of the on-plant consolidation areas. Any such changes to the groundwater monitoring program would be proposed in the reporting associated with each monitoring event, but would not be implemented until approved by the EPA.

To provide information on overall groundwater flow patterns near the consolidation areas, depth to water data will be taken at each of the 12 wells proposed for the monitoring program at a minimum, regardless of any potential reductions to the list of wells which are proposed for sampling and analysis in any particular round.

3.3 NAPL Monitoring

LNAPL has been observed in one monitoring well (H78B-8R) located within the limits of the on-plant consolidation areas. The groundwater elevation and LNAPL thickness is currently measured in this well on a weekly basis, and any observed quantities of LNAPL are removed. In addition, in the July 19, 1999 IRA Completion Report, GE proposed to monitor three other wells (H78B-8, OPCA-MW-2, and OPCA-MW-3) for the presence of LNAPL on a monthly basis. These programs will continue for the time being, and the results will be reported in the monthly progress reports for overall work at the Hill 78 Area.

In the event that any new occurrences of NAPL are detected during the course of the on-plant consolidation area groundwater monitoring program, GE shall add any such well to the proposed plant-wide groundwater and NAPL monitoring program which is outlined in Attachment H to the SOW. All subsequent notification and response activities will be conducted under the procedures approved for that program.

3.4 Groundwater Performance Standards

The proposed groundwater quality Performance Standards to be utilized in this program are based on the groundwater classification categories designated in the MCP (310 CMR 40.0932) that are relevant to the consolidation areas. These categories are as follows:

- GW-2: Groundwater that is a potential source of hazardous vapors to indoor air; groundwater shall be classified as GW-2 if located within 30 feet of an existing occupied building or structure and the average annual depth to groundwater is 15 feet or less. These locations shall be GW-2 compliance points. Although none of the wells included in this groundwater monitoring program fit this criteria, data from three wells (OPCA-MW-4, OPCA-MW-5, and H78B-15) which are positioned slightly over 30 feet upgradient of buildings shall be used as a benchmark against the GW-2 standards.

- GW-3: All groundwater at the consolidation areas shall be classified as GW-3 because it is a potential source of discharge to surface water. The GW-3 standard shall be used as a benchmark to evaluate the groundwater data at locations within the interior of the GE facility. A separate groundwater monitoring program (Technical Attachment H to *Statement of Work for Removal Actions Outside the River*) is proposed to monitor for compliance with the GW-3 standards at the perimeter of the GE site.

The MCP specifies certain default "Method 1" groundwater standards for both GW-2 and GW-3 groundwater. It also allows for the establishment of alternative, site-specific GW-2 and GW-3 groundwater standards, based on a site-specific risk assessment. GE shall initially utilize the Method 1 standards set out in the MCP to evaluate groundwater quality in this program. Specifically, GE shall initially utilize the Method 1 GW-2 standards to evaluate GW-2 groundwater and the Method 1 GW-3 standards to evaluate GW-3 groundwater.

No volatile organic compounds were detected in groundwater during the "baseline" sampling event. However, if in future monitoring, volatile organic compounds are detected in GW-2 groundwater at the consolidation areas for which Method 1 GW-2 standards do not exist, or alternative standards have not been approved by EPA, GE shall propose to develop a Method 2 GW-2 groundwater standard for such compounds using the general procedures set forth in 310 CMR 40.0983, an alternative procedure approved by EPA, or provide a rationale of why a Method 2 GW-2 standard should not be developed.

For compounds detected in GW-3 groundwater for which Method 1 GW-3 standards do not exist or alternative standards have not been approved by EPA, GE shall not develop a Method 2 GW-3 standard unless the presence of the compound is shown to be attributable to consolidation activities at the consolidation areas following evaluation of the groundwater results (as discussed in Section 3.5). However, if necessary, GE shall propose to develop a Method 2 GW-3 groundwater standard for such compounds using the general procedures set forth in 310 CMR 40.0983, or an alternative procedure approved by EPA. It should be noted that no such compounds were detected in groundwater during the "baseline" sampling event.

In the event that the Method 1 (or 2) groundwater standards are exceeded for any constituent(s) during the course of this program, or other groundwater monitoring programs in effect at the site (i.e., programs proposed under the SOW) GE may develop and propose to EPA for approval risk-based alternative GW-2 and/or GW-3 standards, based on a site-specific (e.g., Method 3) risk evaluation, taking into account relevant factors including but not limited to, for GW-

2 standards, an evaluation of the risks due to potential volatilization of constituents in groundwater into the indoor air of nearby buildings and, for GW-3 standards, impacts to adjacent surface waters, sediments, and biota. Upon EPA approval, such alternative risk-based GW-2 and/or GW-3 standards shall be utilized in lieu of the Method 1 GW-2 standards or Method 1 (or 2) GW-3 standards.

The Performance Standards for groundwater quality for the consolidation areas shall consist of the following:

1. For groundwater located within 15 feet or less from the ground surface and within 30 feet of an existing occupied building, achievement of the Method 1(or 2) GW-2 standards or, upon Agency approval, alternative risk-based GW-2 standards or a demonstration that constituents in the groundwater do not pose an unacceptable risk to occupants of such building via volatilization and transport to the indoor air of such building. These Performance Standards shall apply to wells OPCA-MW-4, OPCA-MW-5, and H78B-15, which although located slightly more than 30 feet from occupied buildings, are positioned in the closest practical locations upgradient of these buildings and will be utilized as GW-2 sentinel wells.

2. For all groundwater at consolidation areas, achievement of the Method 1 (or 2) GW-3 standards or, upon Agency approval, alternative risk-based GW-3 standards at the perimeter of the property boundary (i.e. wells 78-1, 78-6, and NY-4, as specified in Technical Attachment H to *Statement of Work for Removal Actions Outside the River*). The results of groundwater monitoring conducted under this program at wells not located along the property shall be evaluated against the applicable GW-3 standards as a benchmark.

3.5 Evaluation of Groundwater Results

Upon receipt of sampling data from each monitoring event, GE shall evaluate whether or not the applicable GW-2 Performance Standards/benchmarks have been exceeded at the sentinel monitoring wells. Further, in its report on the monitoring event, GE shall propose appropriate interim response actions to address any exceedance of the GW-2 Performance Standards. Such interim response actions may include resampling of the groundwater, increase in sampling frequency, additional well installation near potentially-impacted buildings (including sampling and analysis), and/or soil gas sampling. Upon Agency approval, GE shall implement the approved interim response actions.

Upon obtaining knowledge of sampling data from a well containing Category GW-2 groundwater within 30 feet of a school or occupied residential structure (should such wells be installed in response to data obtained from a GW-2 sentinel well) and having a total VOC concentration of equal to or greater than 5 parts per million, GE shall notify the Agencies within seventy-two hours unless such exceedance was previously observed and reported to EPA. GE will provide the data from each such event in the next monthly progress report for overall work at the Site. Subsequent exceedances for a given well will also be indicated in the next monthly progress report for the site. Further, in its report on the monitoring event, GE shall propose appropriate interim response actions to address any exceedance of the GW-2 Performance Standards. Such interim response actions may include resampling of the groundwater, increase in sampling frequency, additional well installation near potentially-impacted buildings (including sampling and analysis), soil gas sampling, desk-top modeling of potential volatilization of chemicals from the groundwater to the indoor air of nearby occupied buildings, sampling of the indoor air of such buildings, an evaluation of the potential risks related to volatilization to such indoor air, and/or the development and proposal of a risk-based alternative GW-2 standard (if not already established). Upon Agency approval, GE shall implement the approved interim response actions.

Upon receipt of sampling data from each monitoring event, GE shall also evaluate whether or not the applicable GW-3 Performance Standards/benchmarks have been exceeded at the monitoring wells. GE shall provide notification of any previously unobserved exceedance of the applicable GW-3 Performance Standard/benchmark from each such event in the next monthly progress report for overall work at the Site. An evaluation of potential response actions relating to any exceedances of the GW-3 Performance Standards/benchmarks shall be made in the summary report for the monitoring event.

If an exceedance of a UCL is indicated in a groundwater sample from a given well, and such exceedance was not previously observed, GE shall notify the Agencies within fourteen days. GE will also provide the data from each such event in the next monthly progress report for overall work at the Site. Subsequent exceedances of a UCL for a given well shall be identified in the next monthly report. The monthly progress report for overall work at the site shall also identify any wells and provide the sampling results for all constituents which exceeded the applicable GW-2 or GW-3 standards.

Finally, upon receipt of data from each monitoring event, GE shall, on a location-by-location basis, compare the data from the current monitoring event with the prior monitoring data and evaluate using an appropriate statistical approach. Specifically, during the first year of the monitoring program, GE shall compare the results from each event with the "baseline" monitoring data. Thereafter, as the groundwater database is updated, GE shall compare the results from each monitoring event to the entire prior database, focusing on long-term temporal or spatial trends. These comparisons shall be performed, using appropriate statistical techniques (based on the data distribution), to identify instances in which the current data indicate an anomalous increase in the concentrations of dissolved-phase constituents relative to prior monitoring results. In making these comparisons, GE shall focus in particular on whether the data indicate that the increase is likely attributable to activities at the consolidation areas.

The statistical analysis shall focus on intra-well comparisons for selected critical parameters (i.e., parameters of concern). As sufficient data becomes available, statistical evaluations shall be made regarding the presence or absence of seasonality and trends. In wells exhibiting no trends, data means and variances shall be computed for parameters of concern for which there are greater than 50 percent detections for a particular constituent. Once trends occur, plotting of the data and regression analysis shall be performed. A moving average presentation of regularly spaced data may be utilized as an alternate to directly correlating data for seasonality.

If a statistically significant increase in dissolved-phase constituents is detected at any well in the most recent sampling results relative to prior data and the applicable groundwater quality Performance Standards/benchmarks are exceeded at the location in question, GE shall conduct the following activities:

- An evaluation of overall groundwater conditions within the consolidation areas to ascertain if the elevated sampling data were detected elsewhere and uniformly or if the elevated data are isolated to a specific monitoring location;

- A review of the recent sampling results with respect to the sampling data available from comparable sampling periods (i.e., results from sampling conducted during a similar time of year); and

- An evaluation of the potential presence of an upgradient "source" that could explain the increase in groundwater concentrations.

In its report on the monitoring event, GE shall provide a possible explanation(s) for any such observed increase in concentrations in the sampling data. If the Agencies determine that the elevated sampling data are likely attributable to consolidation activities and not due to inherent variations in the field or laboratory procedures or to historical variations in the monitoring results, GE shall propose to the Agencies for approval one of more of the following actions, and shall implement the Agency-approved actions:

- Resampling of the location and constituent(s) of interest;

- Soil sampling of recent fill deposited at the consolidation areas in locations upgradient of the affected wells;

- Increasing the frequency of monitoring at the location(s) in question;

- Additional evaluation activities in the area of interest, including but not limited to, the installation and sampling of new permanent or temporary monitoring wells;

- Evaluation of whether the groundwater in which the increase has been found is affecting any adjacent groundwater, surface waters, sediments and/or biota, including, if appropriate, sampling of such waters, sediments, sediment pore water (using seepage meters), and biota, including toxicity testing;

- Evaluation of active response actions to contain and/or recover the affected groundwater or to address potential sources if identified; and/or

- Work stoppage at the consolidation areas.

3.6 U.S. Generating Company Well Monitoring Program

Non-contact cooling water for the U.S. Generating Company's Pittsfield co-generation plant is supplied by four wells located near the proposed on-plant consolidation areas. Well ASW-5 is the primary source of this cooling water. Groundwater from well ASW-5, as well as three cooling water discharge samples, are sampled by U.S. Generating Company on a semi-annual basis in accordance with an existing permitted program. The ASW-5 sample is collected as a grab sample, while the cooling water discharge samples consist of three 24-hour composite samples. Each of these samples are analyzed for PCBs by USEPA Method 608 (Organochlorine Pesticides and PCBs) and for volatile organic compounds using USEPA Method 624 (Purgable Organics).

3.7 Reporting

Upon receipt from the laboratory, the groundwater monitoring data collected by GE shall be presented in the next monthly progress report for overall work at the site, as previously stated. In addition, following each monitoring event, GE will prepare and submit to The Agencies a summary report describing the field activities, presenting the sampling results, and presenting the results of the required evaluations of the monitoring data.

GE shall provide an evaluation of any exceedances of Performance Standards/benchmarks, if detected, and discuss the potential that the exceedance may be attributable to activities at the consolidation areas. If necessary, GE may also propose response actions if the data indicate an exceedance which is likely attributable to activities at the consolidation areas. In such reports, GE may also propose modifications to the groundwater monitoring program, including, but not limited to, changes in the wells to be monitored or constituents to be analyzed for.

In addition, GE shall provide the analytical results from deep water supply well ASW-5, which is monitored by the U.S. Generating Company on a semi-annual basis, as discussed in the previous section. These results will be presented in the next monthly progress report for overall work at the site following the receipt of the analytical data by GE, and will also be included in the next semi-annual on-plant consolidation area groundwater monitoring report.

3.8 Groundwater Monitoring During Post-Closure Period

Following the completion of consolidation activities and closure of the consolidation areas, GE will submit a proposal to The Agencies for a post-closure groundwater monitoring program for the consolidation areas. That proposal will include a statistical assessment of all prior monitoring data, and will present an evaluation of, and proposed plan for, post-closure future groundwater monitoring. It will also identify, for the post-closure monitoring program, the specific monitoring well locations, the frequency of future monitoring and reporting, the constituents slated for analysis, the procedures for evaluation of the groundwater data, and the criteria for further response actions.

Tables

TABLE 1

GENERAL ELECTRIC COMPANY - PITTSFIELD, MASSACHUSETTS
DETAILED WORK PLAN FOR ON-PLANT CONSOLIDATION AREAS
PROPOSED GROUNDWATER MONITORING PROGRAM

SUMMARY OF MONITORING WELL SPECIFICATIONS

WELL ID	WELL DIAMETER (Inches)	GROUND ELEVATION (Feet AMSL)	MEASURING POINT ELEVATION (Feet AMSL)	DEPTH TO TOP OF SCREEN (Feet BGS)	SCREEN LENGTH (Feet)	TOP OF SCREEN ELEVATION (Feet AMSL)	BASE OF SCREEN ELEVATION (Feet AMSL)	DEPTH TO WATER (Feet BMP)	DEPTH TO WATER (Feet BGS)	GROUND-WATER ELEVATION (Feet AMSL)
OPCA-MW-1	2	1,017.1	1,019.65	20.1	10	997.0	987.0	10.27	7.72	1,009.38
OPCA-MW-2	2	1,017.3	1,019.58	13	10	1,004.3	994.3	17.58	15.30	1,002.00
OPCA-MW-3	2	1,015.3	1,014.87	18	10	997.3	987.3	20.59	20.97	994.28
OPCA-MW-4	2	1,019.2	1,018.71	12	10	1,007.2	997.2	11.91	12.42	1,006.80
OPCA-MW-5	2	1,017.6	1,017.07	9.8	10	1,007.8	997.8	12.64	13.20	1,004.43
OPCA-MW-6	2	1,022.7	1,022.10	15	10	1,007.7	997.7	17.03	17.62	1,005.07
OPCA-MW-7	2	1,026.9	1,026.40	14	10	1,012.9	1,002.9	14.89	15.42	1,011.51
OPCA-MW-8	2	1,027.9	1,027.57	13.5	10	1,014.4	1,004.4	12.66	12.97	1,014.91
78-1	4	1,027.4	1,026.34	8	15	1,019.4	1,004.4	11.39	12.45	1,014.95
78-6	4	1,013.1	1,011.99	3	15	1,010.1	995.1	8.65	9.76	1,003.34
H78B-15	0.75	1,009.8	1,012.73	6	10	1,003.8	993.8	15.07	12.14	997.66
NY-4	4	1,024.8	1,024.53	17	15	1,007.8	992.8	9.91	10.18	1,014.62

NOTES:

1. Depth to groundwater measurements collected by Blasland, Bouck & Lee, Inc. on June 17, 1999.
2. NA: Not Available.
3. Feet AMSL: Feet above Mean Sea Level.
4. Feet BGS: Feet Below Ground Surface.
5. Feet BMP: Feet Below Measuring Point.

TABLE 2

GENERAL ELECTRIC COMPANY - PITTSFIELD, MASSACHUSETTS
DETAILED WORK PLAN FOR ON-PLANT CONSOLIDATION AREAS

FIELD PARAMETER MEASUREMENTS

Well Number	PID Headspace (PID Units)	Turbidity Measurement (NTU)	Temperature (degrees Celsius)	pH	Specific Conductivity (ms/cm)	Oxidation-Reduction Potential (mV)	Dissolved Oxygen (mg/L)
OPCA-MW-1	0.2	16.6	12.67	7.33	0.426	118.5	8.41
OPCA-MW-2	0.2	46.7	12.51	6.75	0.960	127.1	2.41
OPCA-MW-3	0.2	46.6	13.29	6.66	0.735	91.5	0.61
OPCA-MW-4	0.2	13.1	13.86	6.87	0.869	111.7	2.23
OPCA-MW-5	0.1	44.6	14.84	6.91	0.636	-6.9	3.65
OPCA-MW-6	0.1	28.6	13.31	7.32	0.522	90.2	9.56
OPCA-MW-7	0.2	7.8	14.14	6.90	1.344	15.15	6.33
OPCA-MW-8	0.2	22.2	14.93	7.22	2.003	98.9	7.47
78-1	0.1	16.8	13.47	6.68	0.672	134.8	2.99
78-6	0.3	101.4	16.75	6.70	2.209	-100.0	2.73
H78B-15	0.3	17.0	13.82	6.34	2.443	205.6	5.17
NY-4	0.0	38.8	13.07	7.62	0.380	155.2	2.04

Notes:

1. Well parameters were monitored continuously during purging by low-flow techniques. Final parameter readings are presented.

TABLE 3

GENERAL ELECTRIC COMPANY - PITTSFIELD, MASSACHUSETTS
ADDENDUM TO DETAILED WORK PLAN FOR ON-PLANT CONSOLIDATION AREAS

SUMMARY OF APPENDIX IX+3 CONSTITUENTS DETECTED IN GROUNDWATER SAMPLES - JUNE 1999
(Results are presented in dry-weight parts per million, ppm)

Sample ID Date Collected	MCP GW-3 Standard	78-1 06/14/99	78-6 06/16/99	H78B-15 06/16/99	NY-4 06/14/99
Volatile Organics					
None Detected	--	--	--	--	--
Semivolatile Organics					
None Detected	--	--	--	--	--
PCBs					
Aroclor-1254	--	ND(0.00010)	ND(0.000050)	0.000035 J	0.00012
Total PCBs	0.0003	ND(0.00010)	ND(0.000050)	0.000035	0.00012
Furans					
2,3,7,8-TCDF	--	ND(0.00000000060)	ND(0.0000000032)	ND(0.0000000015)	ND(0.0000000020)
TCDFs (total)	--	ND(0.00000000060)	ND(0.0000000032)	ND(0.0000000015)	ND(0.0000000020)
1,2,3,7,8-PeCDF	--	ND(0.0000000021)	ND(0.0000000079)	ND(0.0000000036)	ND(0.0000000074)
2,3,4,7,8-PeCDF	--	ND(0.0000000020)	ND(0.0000000083)	ND(0.0000000034)	ND(0.0000000069)
PeCDFs (total)	--	ND(0.0000000021)	ND(0.0000000083)	ND(0.0000000036)	ND(0.0000000074)
		ND(0.0000000060)	ND(0.0000000042)	ND(0.0000000017)	ND(0.000000021)
1,2,3,6,7,8-HxCDF	--	ND(0.0000000062)	ND(0.0000000043)	ND(0.0000000017)	ND(0.000000022)
1,2,3,7,8,9-HxCDF	--	ND(0.0000000059)	ND(0.0000000051)	ND(0.0000000023)	ND(0.000000021)
2,3,4,6,7,8-HxCDF	--	ND(0.0000000064)	ND(0.0000000044)	ND(0.0000000018)	ND(0.000000023)
HxCDFs (total)	--	ND(0.0000000064)	ND(0.0000000051)	ND(0.0000000023)	ND(0.000000023)
1,2,3,4,6,7,8-HpCDF	--	ND(0.000000011)	ND(0.000000029)	ND(0.000000032)	ND(0.000000054)
1,2,3,4,7,8,9-HpCDF	--	ND(0.000000011)	ND(0.000000029)	ND(0.000000015)	ND(0.000000054)
HpCDFs (total)	--	ND(0.000000011)	ND(0.000000029)	ND(0.000000032)	ND(0.000000054)
OCDF	--	ND(0.000000011)	ND(0.000000017)	ND(0.0000000076)	ND(0.000000067)
Total Furans	--	ND(0.000000011)	ND(0.000000029)	ND(0.000000032)	ND(0.000000067)
Dioxins					
2,3,7,8-TCDD	--	ND(0.00000000090)	ND(0.0000000035)	ND(0.0000000035)	ND(0.0000000030)
TCDDs (total)	--	ND(0.00000000090)	ND(0.0000000035)	ND(0.0000000035)	ND(0.0000000030)
1,2,3,7,8-PeCDD	--	ND(0.0000000071)	ND(0.000000034)	ND(0.0000000071)	ND(0.000000031)
PeCDDs (total)	--	ND(0.0000000071)	ND(0.000000034)	ND(0.0000000071)	ND(0.000000031)
1,2,3,4,7,8-HxCDD	--	ND(0.0000000069)	ND(0.000000014)	ND(0.0000000056)	ND(0.000000032)
1,2,3,6,7,8-HxCDD	--	ND(0.0000000086)	ND(0.000000017)	ND(0.0000000070)	ND(0.000000040)
1,2,3,7,8,9-HxCDD	--	ND(0.0000000077)	ND(0.000000015)	ND(0.0000000062)	ND(0.000000036)
HxCDDs (total)	--	ND(0.0000000086)	ND(0.000000017)	ND(0.0000000070)	ND(0.000000040)
1,2,3,4,6,7,8-HpCDD	--	ND(0.000000013)	ND(0.000000029)	ND(0.000000011)	ND(0.000000082)
HpCDDs (total)	--	ND(0.000000013)	ND(0.000000029)	ND(0.000000011)	ND(0.000000082)
OCDD	--	ND(0.000000017)	ND(0.000000020)	ND(0.0000000090)	ND(0.000000084)
Total Dioxins	--	ND(0.000000017)	ND(0.000000034)	ND(0.000000011)	ND(0.000000084)
Total TEQs (MDEP TEFs)	0.0001	ND(0.000000017)	ND(0.000000034)	ND(0.000000032)	ND(0.000000084)
Total TEQs (EPA TEFs)	3E-8 (MCL)	ND(0.000000017)	ND(0.000000034)	ND(0.000000032)	ND(0.000000084)
Inorganics					
Arsenic	0.4	ND(0.00600)	0.0320	ND(0.00600)	ND(0.00600)
Barium	30	0.0250	0.0830	0.0570	0.0200
Zinc	0.9	0.0290	0.0330	0.0830	ND(0.0260)

(See Notes on Page 5)

TABLE 3

GENERAL ELECTRIC COMPANY - PITTSFIELD, MASSACHUSETTS
ADDENDUM TO DETAILED WORK PLAN FOR ON-PLANT CONSOLIDATION AREAS

SUMMARY OF APPENDIX IX+3 CONSTITUENTS DETECTED IN GROUNDWATER SAMPLES
(Results are presented in dry-weight parts per million, ppm)

Sample ID Date Collected	MCP GW-3 Standard	OPCA-MW-1 06/16/99	OPCA-MW-2 06/15/99	OPCA-MW-3 06/16/99
Volatile Organics				
None Detected	--	--	--	--
Semivolatile Organics				
None Detected	--	--	--	--
PCBs				
Aroclor-1254	--	0.000054	ND(0.000050) [ND(0.000050)]	0.000040 J
Total PCBs	0.0003	0.000054	ND(0.000050) [ND(0.000050)]	0.000040
Furans				
2,3,7,8-TCDF	--	ND(0.0000000011)	ND(0.00000000080) [ND(0.00000000060)]	ND(0.0000000035)
TCDFs (total)	--	0.0000000090 J**	ND(0.00000000080) [ND(0.00000000060)]	ND(0.0000000035)
1,2,3,7,8-PeCDF	--	ND(0.0000000025)	ND(0.0000000038) [ND(0.0000000021)]	ND(0.0000000041)
2,3,4,7,8-PeCDF	--	ND(0.0000000024)	ND(0.0000000040) [ND(0.0000000023)]	ND(0.0000000039)
PeCDFs (total)	--	ND(0.0000000025)	ND(0.0000000040) [ND(0.0000000023)]	ND(0.0000000041)
1,2,3,4,7,8-HxCDF	--	ND(0.0000000011)	ND(0.000000011) [ND(0.0000000051)]	ND(0.0000000013)
1,2,3,6,7,8-HxCDF	--	ND(0.0000000011)	ND(0.000000011) [ND(0.0000000052)]	ND(0.0000000013)
1,2,3,7,8,9-HxCDF	--	ND(0.0000000016)	ND(0.000000017) [ND(0.0000000049)]	ND(0.0000000018)
2,3,4,6,7,8-HxCDF	--	ND(0.0000000012)	ND(0.000000011) [ND(0.0000000054)]	ND(0.0000000013)
HxCDFs (total)	--	ND(0.0000000016)	ND(0.000000017) [ND(0.0000000054)]	ND(0.0000000018)
1,2,3,4,6,7,8-HpCDF	--	ND(0.0000000073)	ND(0.000000048) [ND(0.000000011)]	ND(0.0000000080)
1,2,3,4,7,8,9-HpCDF	--	ND(0.0000000090)	ND(0.000000031) [ND(0.000000013)]	ND(0.0000000099)
HpCDFs (total)	--	0.0000000078 J**	ND(0.000000048) [0.000000013 J**]	ND(0.0000000099)
OCDF	--	ND(0.0000000037)	ND(0.000000022) [ND(0.000000010)]	ND(0.0000000041)
Total Furans	--	0.000000017	ND(0.000000048) [0.000000013]	ND(0.0000000099)
Dioxins				
2,3,7,8-TCDD	--	ND(0.0000000012)	ND(0.0000000015) [ND(0.0000000011)]	ND(0.0000000020)
TCDDs (total)	--	ND(0.0000000012)	ND(0.0000000015) [ND(0.0000000011)]	ND(0.0000000020)
1,2,3,7,8-PeCDD	--	ND(0.0000000046)	ND(0.000000015) [ND(0.0000000076)]	ND(0.0000000089)
PeCDDs (total)	--	ND(0.0000000046)	ND(0.000000015) [ND(0.0000000076)]	ND(0.0000000089)
1,2,3,4,7,8-HxCDD	--	ND(0.0000000034)	ND(0.000000014) [ND(0.0000000068)]	ND(0.0000000058)
1,2,3,6,7,8-HxCDD	--	ND(0.0000000042)	ND(0.000000017) [ND(0.0000000085)]	ND(0.0000000072)
1,2,3,7,8,9-HxCDD	--	ND(0.0000000038)	ND(0.000000015) [ND(0.0000000076)]	ND(0.0000000064)
HxCDDs (total)	--	ND(0.0000000042)	ND(0.000000017) [ND(0.0000000085)]	ND(0.0000000072)
1,2,3,4,6,7,8-HpCDD	--	ND(0.0000000070)	ND(0.000000036) [ND(0.000000013)]	ND(0.0000000077)
HpCDDs (total)	--	ND(0.0000000070)	ND(0.000000036) [ND(0.000000013)]	ND(0.0000000077)
OCDD	--	ND(0.0000000044)	ND(0.000000033) [ND(0.000000015)]	ND(0.0000000048)
Total Dioxins	--	ND(0.0000000070)	ND(0.000000036) [ND(0.000000015)]	ND(0.0000000089)
Total TEQs (MDEP TEFs)	0.0001	0.00000000017	ND(0.000000048) [0.00000000013]	ND(0.0000000099)
Total TEQs (EPA TEFs)	3E-8 (MCL)	ND(0.000000017)	ND(0.000000048) [ND(0.000000015)]	ND(0.0000000099)
Inorganics				
Arsenic	0.4	ND(0.00600)	ND(0.00600) [ND(0.00600)]	ND(0.00600)
Barium	30	0.0620	0.0320 [0.0340]	0.00950
Zinc	0.9	ND(0.0260)	ND(0.0260) [ND(0.0260)]	0.0880

(See Notes on Page 5)

TABLE 3

GENERAL ELECTRIC COMPANY - PITTSFIELD, MASSACHUSETTS
ADDENDUM TO DETAILED WORK PLAN FOR ON-PLANT CONSOLIDATION AREAS

SUMMARY OF APPENDIX IX+3 CONSTITUENTS DETECTED IN GROUNDWATER SAMPLES
(Results are presented in dry-weight parts per million, ppm)

Sample ID Date Collected	MCP GW-3 Standard	OPCA-MW-4 06/15/99	OPCA-MW-5 06/15/99	OPCA-MW-6 06/15/99	OPCA-MW-7 06/15/99
Volatile Organics					
None Detected	--	--	--	--	--
Semivolatile Organics					
None Detected	--	--	--	--	--
PCBs					
Aroclor-1254	--	0.00089	ND(0.000051)	0.00012	ND(0.000051)
Total PCBs	0.0003	0.00089	ND(0.000051)	0.00012	ND(0.000051)
Furans					
2,3,7,8-TCDF	--	ND(0.00000000070)	ND(0.00000000080)	ND(0.00000000090)	ND(0.00000000080)
TCDFs (total)	--	ND(0.00000000070)	ND(0.00000000080)	ND(0.00000000090)	ND(0.00000000080)
1,2,3,7,8-PeCDF	--	ND(0.0000000043)	ND(0.0000000028)	ND(0.0000000033)	ND(0.0000000030)
2,3,4,7,8-PeCDF	--	ND(0.0000000040)	ND(0.0000000027)	ND(0.0000000031)	ND(0.0000000028)
PeCDFs (total)	--	ND(0.0000000043)	ND(0.0000000028)	ND(0.0000000033)	ND(0.0000000030)
1,2,3,4,7,8-HxCDF	--	ND(0.0000000090)	ND(0.0000000050)	ND(0.0000000089)	ND(0.0000000069)
1,2,3,6,7,8-HxCDF	--	ND(0.0000000092)	ND(0.0000000051)	ND(0.0000000092)	ND(0.0000000070)
1,2,3,7,8,9-HxCDF	--	ND(0.0000000087)	ND(0.0000000049)	ND(0.0000000087)	ND(0.0000000067)
2,3,4,6,7,8-HxCDF	--	ND(0.0000000095)	ND(0.0000000053)	ND(0.0000000096)	ND(0.0000000073)
HxCDFs (total)	--	ND(0.0000000095)	ND(0.0000000053)	ND(0.0000000095)	ND(0.0000000073)
1,2,3,4,6,7,8-HpCDF	--	ND(0.000000020)	ND(0.0000000088)	ND(0.000000020)	ND(0.000000013)
2,3,4,7,8,9-HpCDF	--	ND(0.000000020)	ND(0.0000000088)	ND(0.000000020)	ND(0.000000013)
HpCDFs (total)	--	ND(0.000000020)	ND(0.0000000088)	ND(0.000000020)	ND(0.000000013)
OCDF	--	ND(0.000000020)	ND(0.0000000078)	ND(0.000000020)	ND(0.000000012)
Total Furans	--	ND(0.000000020)	ND(0.0000000088)	ND(0.000000020)	ND(0.000000013)
Dioxins					
2,3,7,8-TCDD	--	ND(0.0000000013)	ND(0.0000000012)	ND(0.0000000012)	ND(0.0000000013)
TCDDs (total)	--	ND(0.0000000013)	ND(0.0000000012)	ND(0.0000000012)	ND(0.0000000013)
1,2,3,7,8-PeCDD	--	ND(0.000000018)	ND(0.000000014)	ND(0.000000012)	ND(0.000000010)
PeCDDs (total)	--	ND(0.000000018)	ND(0.000000014)	ND(0.000000012)	ND(0.000000010)
1,2,3,4,7,8-HxCDD	--	ND(0.000000013)	ND(0.0000000062)	ND(0.000000012)	ND(0.0000000097)
1,2,3,6,7,8-HxCDD	--	ND(0.000000016)	ND(0.0000000077)	ND(0.000000015)	ND(0.000000012)
1,2,3,7,8,9-HxCDD	--	ND(0.000000014)	ND(0.0000000068)	ND(0.000000013)	ND(0.000000011)
HxCDDs (total)	--	ND(0.000000016)	ND(0.0000000077)	ND(0.000000015)	ND(0.000000012)
1,2,3,4,6,7,8-HpCDD	--	ND(0.000000027)	ND(0.000000012)	ND(0.000000026)	ND(0.000000017)
HpCDDs (total)	--	ND(0.000000027)	ND(0.000000012)	ND(0.000000026)	ND(0.000000017)
OCDD	--	ND(0.000000030)	ND(0.000000012)	ND(0.000000029)	ND(0.000000018)
Total Dioxins	--	ND(0.000000030)	ND(0.000000014)	ND(0.000000029)	ND(0.000000018)
Total TEQs (MDEP TEFs)	0.0001	ND(0.000000030)	ND(0.000000014)	ND(0.000000029)	ND(0.000000018)
Total TEQs (EPA TEFs)	3E-8 (MCL)	ND(0.000000030)	ND(0.000000014)	ND(0.000000029)	ND(0.000000018)
Inorganics					
Arsenic	0.4	ND(0.00600)	ND(0.00600)	ND(0.00600)	ND(0.00600)
Barium	30	0.0370	0.0290	0.0300	0.0270
Zinc	0.9	ND(0.0260)	ND(0.0260)	ND(0.0260)	ND(0.0260)

(See Notes on Page 5)

TABLE 3

GENERAL ELECTRIC COMPANY - PITTSFIELD, MASSACHUSETTS
ADDENDUM TO DETAILED WORK PLAN FOR ON-PLANT CONSOLIDATION AREAS

SUMMARY OF APPENDIX IX+3 CONSTITUENTS DETECTED IN GROUNDWATER SAMPLES
(Results are presented in dry-weight parts per million, ppm)

Sample ID Date Collected	MCP GW-3 Standard	OPCA-MW-8 06/14/99
Volatile Organics		
None Detected	--	--
Semivolatile Organics		
None Detected	--	--
PCBs		
Aroclor-1254	--	ND(0.00010)
Total PCBs	0.0003	ND(0.00010)
Furans		
2,3,7,8-TCDF	--	ND(0.00000000070)
TCDFs (total)	--	ND(0.00000000070)
1,2,3,7,8-PeCDF	--	ND(0.0000000029)
2,3,4,7,8-PeCDF	--	ND(0.0000000027)
PeCDFs (total)	--	ND(0.0000000029)
1,2,3,4,7,8-HxCDF	--	ND(0.0000000097)
1,2,3,6,7,8-HxCDF	--	ND(0.0000000099)
1,2,3,7,8,9-HxCDF	--	ND(0.0000000094)
2,3,4,6,7,8-HxCDF	--	ND(0.000000010)
HxCDFs (total)	--	ND(0.000000010)
1,2,3,4,6,7,8-HpCDF	--	ND(0.000000022)
1,2,3,4,7,8,9-HpCDF	--	ND(0.000000022)
HpCDFs (total)	--	ND(0.000000022)
OCDF	--	ND(0.000000025)
Total Furans	--	ND(0.000000025)
Dioxins		
2,3,7,8-TCDD	--	ND(0.0000000011)
TCDDs (total)	--	ND(0.0000000011)
1,2,3,7,8-PeCDD	--	ND(0.000000011)
PeCDDs (total)	--	ND(0.000000011)
1,2,3,4,7,8-HxCDD	--	ND(0.000000013)
1,2,3,6,7,8-HxCDD	--	ND(0.000000016)
1,2,3,7,8,9-HxCDD	--	ND(0.000000014)
HxCDDs (total)	--	ND(0.000000016)
1,2,3,4,6,7,8-HpCDD	--	ND(0.000000030)
HpCDDs (total)	--	ND(0.000000030)
OCDD	--	ND(0.000000037)
Total Dioxins	--	ND(0.000000037)
Total TEQs (MDEP TEFs)	0.0001	ND(0.000000037)
Total TEQs (EPA TEFs)	3E-8 (MCL)	ND(0.000000037)
Inorganics		
Arsenic	0.4	ND(0.00600)
Barium	30	0.0860
Zinc	0.9	ND(0.0260)

(See Notes on Page 5)

GENERAL ELECTRIC COMPANY - PITTSFIELD, MASSACHUSETTS
ADDENDUM TO DETAILED WORK PLAN FOR ON-PLANT CONSOLIDATION AREAS

SUMMARY OF APPENDIX IX+3 CONSTITUENTS DETECTED IN GROUNDWATER SAMPLES - JUNE 1999

Notes:

1) Samples were collected by Blasland, Bouck & Lee, Inc., and were submitted to CT&E Environmental Services, Inc. for analysis of Appendix IX+3 constituents (excluding herbicides and pesticides).
2) Only constituents detected in one or more samples are shown.
3) ND - Analyte was not detected. The number in parentheses is the associated detection limit.
4) J - Indicates an estimated value less than the CLP-required quantitation limit.
5) J** - Indicates an estimated value between the lower calibration limit and the target detection limit.
6) Total dioxins/furans determined as the sum of the total homolog concentrations; non-detect values considered as zero.
7) Total 2,3,7,8-TCDD toxicity equivalents (TEQs) were calculated using both MDEP's and EPA's Toxicity Equivalency Factors (TEFs) for all PCDD/PCDF congeners, although GE does not accept the validity of these TEFs.
8) Duplicate results are presented in brackets.

(See Notes on Page 5)

TABLE 4

GENERAL ELECTRIC COMPANY - PITTSFIELD, MASSACHUSETTS
ADDENDUM TO DETAILED WORK PLAN FOR ON-PLANT CONSOLIDATION AREAS

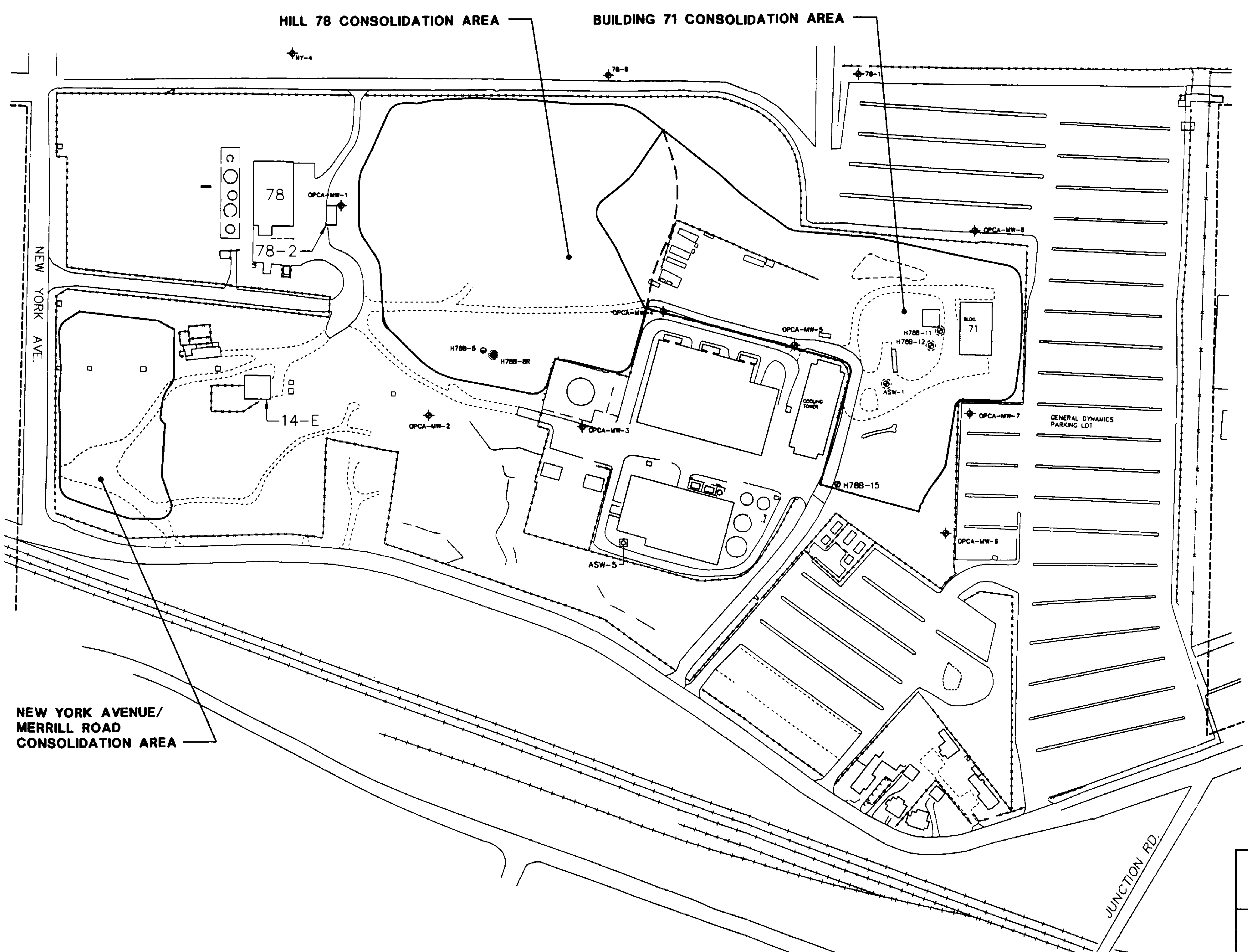
LNAPL RECOVERY TEST RESULTS

DATE	TIME	ELAPSED TIME (hours)	DEPTH TO WATER	DEPTH TO LNAPL	LNAPL THICKNESS	LNAPL VOLUME REMOVED (liters)		RECOVERY RATE (gallons per minute)
						INTERVAL	CUMULATIVE	
07/19/99	09:00 AM	0	29.75	29.69	0.06	0.04	0.04	---
07/19/99	10:00 AM	1	29.72	29.7	0.02	0.02	0.06	0.000088
07/19/99	11:00 AM	2	29.71	29.7	0.01	0.01	0.07	0.000044
07/19/99	12:00 PM	3	29.72	---	0	---	0.07	---
07/19/99	01:00 PM	4	29.7	---	0	---	0.07	---
07/19/99	02:00 PM	5	29.67	---	0	---	0.07	---
07/19/99	04:00 PM	7	29.69	---	0	---	0.07	---
07/20/99	09:00 AM	24	29.7	---	0	---	0.07	---
07/20/99	10:00 AM	25	29.7	---	0	---	0.07	---
07/20/99	12:00 PM	27	29.71	---	0	---	0.07	---
07/20/99	02:00 PM	29	29.71	---	0	---	0.07	---
07/20/99	04:00 PM	31	29.71	---	0	---	0.07	---
07/21/99	09:00 AM	48	29.78	29.77	0.01	---	0.07	---
07/21/99	11:00 AM	50	29.78	29.77	0.01	---	0.07	---
07/21/99	01:00 PM	52	29.77	29.76	0.01	---	0.07	---
07/21/99	03:00 PM	54	29.78	29.76	0.02	0.02	0.09	0.000002
07/21/99	04:00 PM	55	29.77	---	0	---	0.09	---

Average Recovery Rate for Test: 0.000004 gallons per minute

Figures

BLASLAND, BOUCK & LEE, INC.
engineers & scientists



LEGEND:

- APPROXIMATE AREA OF PROPOSED CONSOLIDATION AREAS
- EXISTING SECURITY FENCE
- 78-6 — WELL PROPOSED AS PART OF CONSOLIDATION AREA MONITORING PROGRAM
- ASW-5 — DEEP WATER SUPPLY WELL MONITORED BY U.S. GENERATING COMPANY
- H78B-12 — EXISTING MONITORING WELL TO BE ABANDONED PRIOR TO 1999 CONSOLIDATION ACTIVITIES
- H78B-8R — MONITORING WELL INCLUDED IN LNAPL MONITORING PROGRAM
- MEASURABLE LNAPL IN WELL

NOTES:

1. MAPPING IS BASED ON AERIAL PHOTOGRAPHS AND PHOTOGRAMMETRIC MAPPING BY LOCKWOOD MAPPING, INC. -FLOWN IN APRIL 1990; DATA PROVIDED BY GENERAL ELECTRIC COMPANY; AND BLASLAND, BOUCK & LEE, INC. (BBL) CONSTRUCTION PLANS, AND ON OBSERVATIONS DURING A SITE VISIT BY BBL PERSONNEL ON DECEMBER 3, 1997.
2. SITE BOUNDARIES ARE APPROXIMATE.
3. NOT ALL PHYSICAL FEATURES SHOWN.
4. THE LOCATIONS OF WELLS H78B-8 AND H78B-8R WERE SLIGHTLY MODIFIED IN ORDER TO MORE CLEARLY DELINEATE THE EXTENT OF MEASURABLE LNAPL AT THE SCALE OF THIS DRAWING.
5. WELLS OPCA-WM-2 AND OPCA-WM-3 ARE ALSO INCLUDED IN THE LNAPL MONITORING PROGRAM.

100' 0 100' 200'
GRAPHIC SCALE

Original includes color coding.

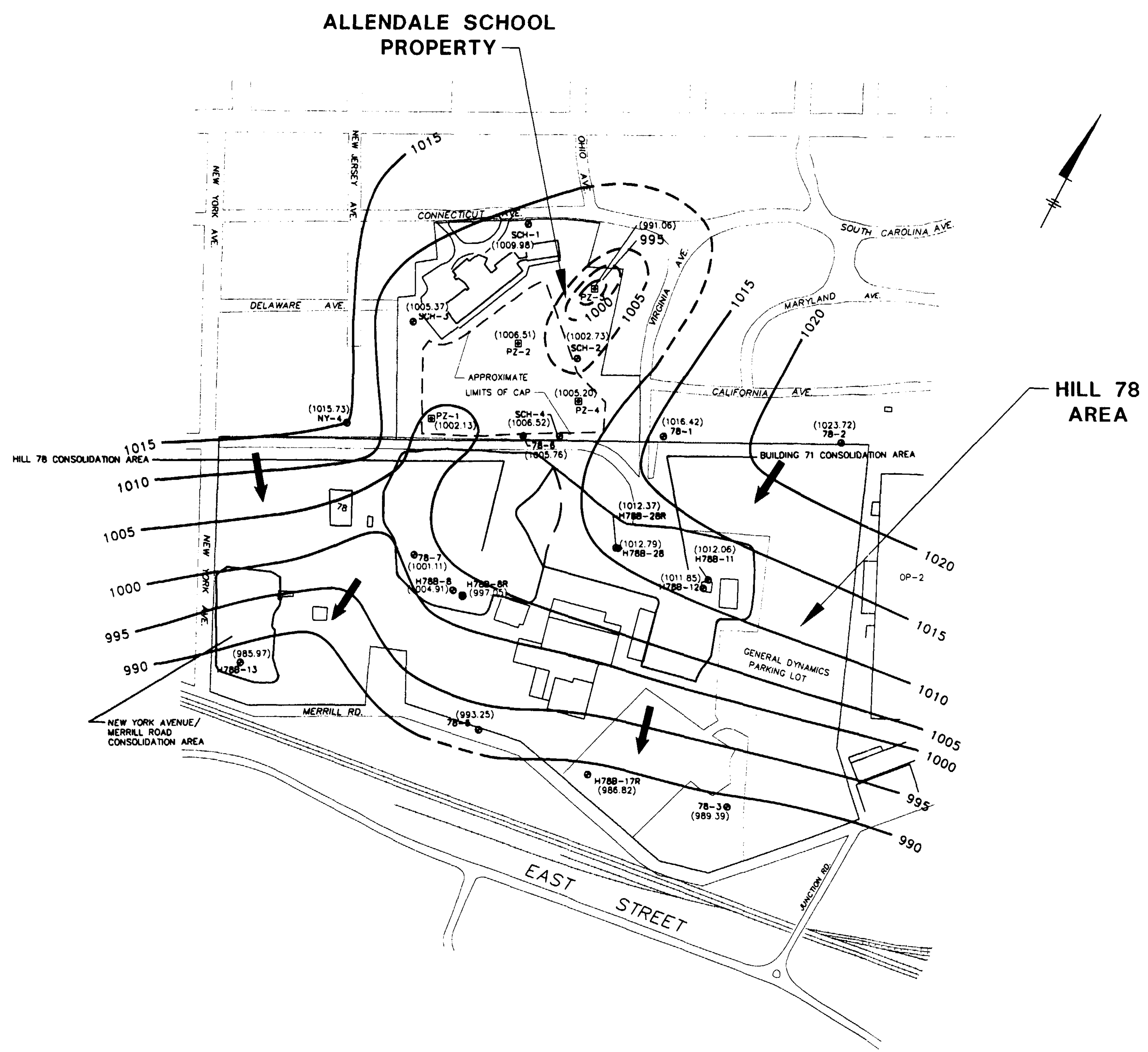
GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS
DETAILED WORK PLAN FOR
ON-PLANT CONSOLIDATION AREAS

GROUNDWATER MONITORING PROGRAM

BBL BLASLAND, BOUCK & LEE, INC. engineers & scientists

FIGURE 1

X: 20185X01.DWG
L: ON=*, OFF=*REF*
P: STD-PCP/DL.PCP
7/30/99 SYR-54-GMS CBM GMS
20185003/REPORT/20185B09.DWG



LEGEND

- EXISTING PIEZOMETER LOCATION
- EXISTING MONITORING WELL LOCATION
- MEASURABLE LNAPL IN WELL
- 1000 — GROUNDWATER ELEVATION CONTOUR LINE IN FEET (5 FT INTERVAL), DASHED WHERE INFERRED
- (1002.13) 5/25/99 GROUNDWATER ELEVATION (IN FEET)
- GROUNDWATER FLOW DIRECTION
- CONSOLIDATION AREAS

NOTES:

1. MAPPING IS BASED ON AERIAL PHOTOGRAPHS AND PHOTOGRAMMETRIC MAPPING BY LOCKWOOD MAPPING, INC. - FLOWN IN APRIL 1990; DATA PROVIDED BY GENERAL ELECTRIC COMPANY; AND BLASLAND & BOUCK ENGINEERS, P.C. CONSTRUCTION PLANS.
2. NOT ALL PHYSICAL FEATURES SHOWN.
3. SITE BOUNDARIES/LIMITS ARE APPROXIMATE.
4. GROUNDWATER CONTOURS ARE BASED ON GROUNDWATER ELEVATION DATA COLLECTED BY BLASLAND, BOUCK & LEE, INC. ON MAY 25, 1999.
5. THE LOCATIONS OF WELLS H78B-8 AND H78B-8R WERE SLIGHTLY MODIFIED IN ORDER TO MORE CLEARLY DELINEATE THE EXTENT OF MEASURABLE LNAPL AT THE SCALE OF THIS DRAWING.

Original includes color coding.

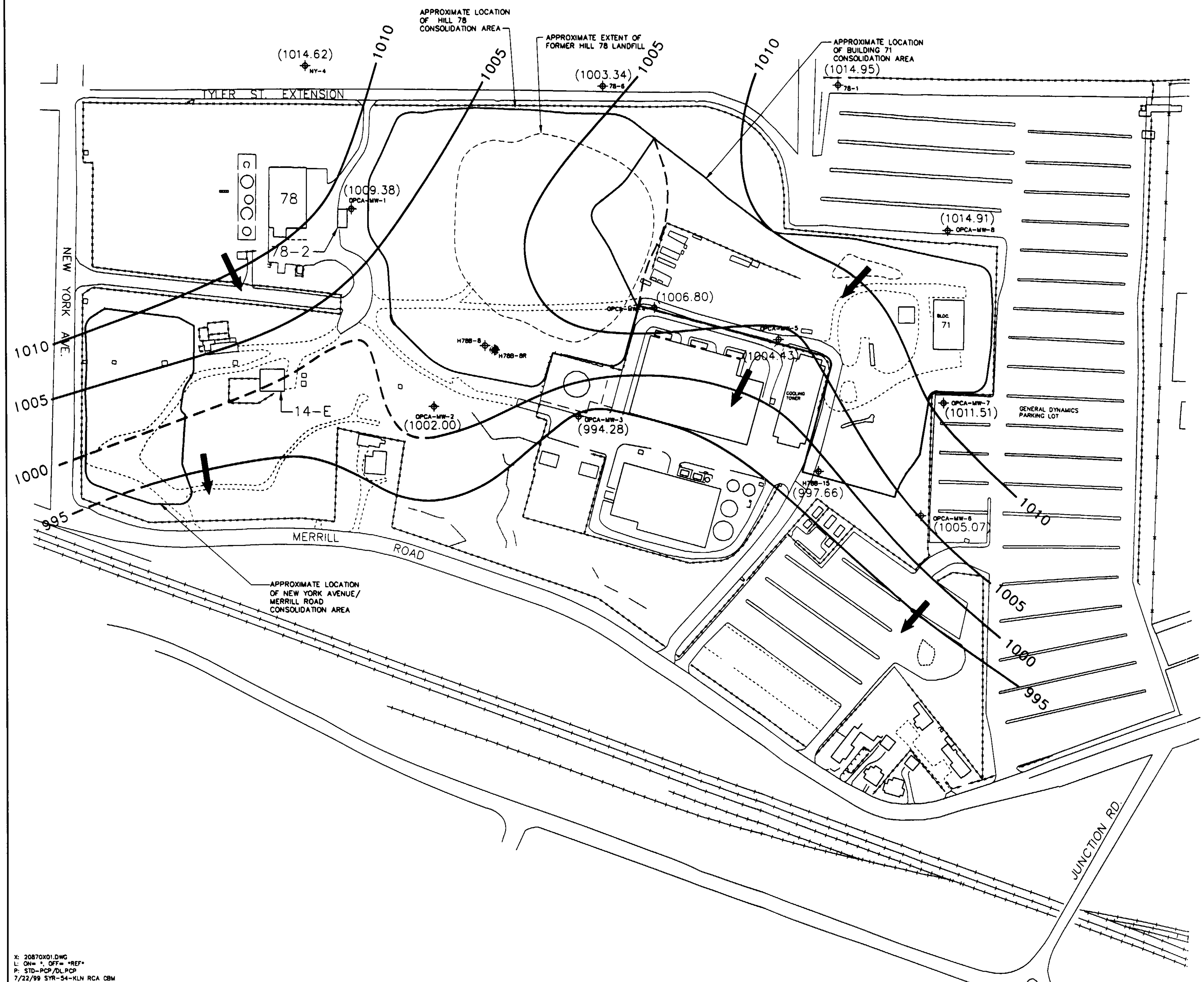
X: (NONE)
L: ON= *, OFF= *REF*
P: STD-PCP/DL
8/4/99 SYR-54-GMS CBM KLN
20185003/REPORT/20185B10.DWG

GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS
DETAILED WORK PLAN FOR ON-PLANT CONSOLIDATION AREAS

GROUNDWATER ELEVATION CONTOURS - MAY 25, 1999

BBL BLASLAND, BOUCK & LEE, INC. engineers & scientists

FIGURE 2



LEGEND:

- FENCE
- EXISTING MONITORING WELL LOCATION
- MEASURABLE LNAPL IN WELL
- 1000 — GROUNDWATER ELEVATION CONTOUR LINE IN FEET (5 FT INTERVAL), DASHED WHERE INFERRED
- (997.66) 6/17/99 GROUNDWATER ELEVATION (IN FEET)
- GROUNDWATER FLOW DIRECTION

NOTES:

1. MAPPING IS BASED ON AERIAL PHOTOGRAPHS AND PHOTOGRAMMETRIC MAPPING BY LOCKWOOD MAPPING, INC. – FLOWN IN APRIL 1990; DATA PROVIDED BY GENERAL ELECTRIC COMPANY; AND BLASLAND AND BOUCK ENGINEERS, P.C. CONSTRUCTION PLANS.
2. SITE BOUNDARIES ARE APPROXIMATE.
3. NOT ALL PHYSICAL FEATURES SHOWN.
4. GROUND WATER CONTOURS ARE BASED ON GROUND WATER ELEVATION DATA COLLECTED BY BLASLAND, BOUCK & LEE, INC. ON JUNE 17, 1999.
5. THE LOCATIONS OF WELLS H78B-8 AND H78B-8R WERE SLIGHTLY MODIFIED IN ORDER TO MORE CLEARLY DELINEATE THE EXTENT OF MEASURABLE LNAPL AT THE SCALE OF THIS DRAWING.

Original includes color coding.

100' 0 100' 200'

GRAPHIC SCALE

GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS
DETAILED WORK PLAN FOR ON-PLANT CONSOLIDATION AREAS

GROUND WATER ELEVATION CONTOURS - JUNE 17, 1999

BBL BLASLAND, BOUCK & LEE, INC. engineers & scientists

FIGURE 3

X: 20870X01.DWG
L: ON=*, OFF=*REF*
P: STD-PCP/DL.PCP
7/22/99 SYR-54-KLN RCA CBM
20185003/REPORT/20185b11.DWG

Appendix A

BLASLAND, BOUCK & LEE, INC.
engineers & scientists

Monitoring Well Boring Logs and Installation Records

Date Start/Finish: 5-28-99 / 5-28-99 **Drilling Company:** Parratt Wolff, Inc. **Driller's Name:** J. Lansing **Drilling Method:** Hollow Stem Auger **Bit Size:** 4.25" **Auger Size** : 4.25" **Rig Type:** CME-55 **Spoon Size:** 2-in.	**Northing:** 535457.84790 **Easting:** 135580.12538 **Well Casing Elev.:** ft. **Corehole Depth:** ft. **Borehole Depth:** 30.1 ft. **Ground Surface Elev.:** ft. **Geologist:** Leanne Sanders	**Well No.** OPCA-MW-1 **Client:** General Electric Company **Site:** Hill 78/ Building 71 Consolidation Area Pittsfield, Massachusetts

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Blows/6 In.	N	Recovery (ft.)	PID (ppm) Headspace	Geotechnical Test	Geologic Column	Stratigraphic Description	Well Construction
gs elevation ft										GROUND SURFACE	Locking stick up steel protective casing installed to 2.8' above ground surface.
		(0-2')		4 5 4 4	9	1.4	0.1			Dark brown fine SAND and SILT, trace organics, moist. (Topsoil) Brown fine to coarse SAND, and fine to medium GRAVEL, moist.	Concrete pad: 0.0' to 0.5' bgs.
		(2-4')		5 6 10 12	16	1.3	0.0			Brown fine SAND and SILT, wet. Brown fine SAND and SILT, little to some fine to medium Gravel, moist.	
5		(4-6')		20 14 15 12	29	0.2	0.2				5% Bentonite cement grout: 0.5' to 15.11' bgs.
		(6-8')		11 11 9 11	20	0.8	0.1			Olive-brown fine to coarse SAND and SILT, loose, wet. Olive-brown SILT, trace fine to coarse Sand and fine Gravel, dense, moist.	
		(8-10')		8 9 9 12	18	1.3	0.1				
10		(10-12')		8 8 10 12	18	1.6	0.0			Same as above with trace Clay, moist.	2-in diameter Sch. 40 PVC riser: 2.5'ags to 20.1' bgs.
		(12-14')		9 14 15 17	29	1.7	0.0				
15		(14-16')		5 9	21	1.0	0.0			Olive-brown SILT, trace Clay and fine Gravel, dense, moist.	

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Remarks:
NA = Not Available. bgs = Below Ground Surface. ags = Above Ground Surface.

Water Levels

Date / Time	Elevation	Depth
6-4-99 / 12:00		9.45
6-17-99		10.27

Site:
Hill 78/ Building 71 Consolidation Area
Pittsfield, Massachusetts

Client:
General Electric Company

Well No. OPCA-MW-1

Total Depth = 30.1 ft.

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Blows/6 In.	N	Recovery (ft.)	PID (ppm) Headspace	Geotechnical Test	Geologic Column	Stratigraphic Description	Well Construction
		(14-16')		12 13	21	1.0	0.0			Olive-brown SILT, trace Clay and fine Gravel, dense, trace fine Sand in stringers, wet.	Bentonite seal: 15.11' to 18.1' bgs.
		(16-18')		11 18 28 29	46	1.3	0.0				
		(18-20')		8 14 13 16	27	1.6	0.0				Grade #00N Sand Pack: 18.1' to 30.1' bgs.
20		(20-22')		2 11 29 33	40	1.8	0.0				
		(22-24')		25 16 22 21	38	2.0	0.0			Olive-brown fine SAND and SILT, trace medium to coarse Sand and fine Gravel, loose, saturated. Olive-brown SILT, trace fine to coarse Sand and fine Gravel, dense, moist. Trace fine Sand stringers, wet.	
25		(24-26')		16 21 31 30	52	1.7	0.1				2-in diameter Sch. 40 PVC 0.010" slot screen: 20.1' to 30.1' bgs.
		(26-28')		17 31 41 39	72	1.6	0.2			Olive-brown SAND and SILT, trace medium to coarse Sand and fine to medium Gravel, loose, saturated. Olive-brown SILT, some fine Sand, trace medium to coarse Sand and fine to medium Gravel, dense, wet.	
		(28-30')		10 18 19 20	37	1.8	0.0			Olive-brown SILT, trace fine to coarse Sand, Clay, and fine Gravel, dense, moist.	
30										Boring terminated at 30.1' bgs.	
35											

BBL
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Remarks:

Water Levels

Date / Time	Elevation	Depth
6-4-99 / 12:00		9.45
6-17-99		10.27

Project: 20185

Script: BBL-well
Date: 07/10/99

Date Start/Finish: 5-28-99 / 6-1-99
Drilling Company: Parratt Wolff, Inc.
Driller's Name: J. Lansing
Drilling Method: Hollow Stem Auger
Bit Size: 4.25" **Auger Size** : 4.25"
Rig Type: CME-55
Spoon Size: 2-in.

Northing: 535180.56712
Easting: 135917.71542
Well Casing Elev.: ft.
Corehole Depth: ft.
Borehole Depth: 23.5 ft.
Ground Surface Elev.: ft.

Geologist: Leanne Sanders

Well No. OPCA-MW-2

Client:
General Electric Company

Site:
Hill 78/ Building 71 Consolidation Area
Pittsfield, Massachusetts

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Blows/6 In.	N	Recovery (ft.)	PID (ppm) Headspace	Geotechnical Test	Geologic Column	Stratigraphic Description
gs elevation ft.										GROUND SURFACE
		(0-2')		3 3 5 7	8	1.7	0.0			Dark brown fine SAND and SILT, trace organics, moist. (Topsoil)
										Dark Brown fine to medium SAND, some Silt, trace coarse Sand, moist.
		(2-4')		11 16 19 17	35	2.0	0.0			Olive-brown fine SAND and SILT, trace medium to coarse Sand and fine to medium Gravel, dense, moist.
5		(4-6')		6 8 5 4	13	1.5	0.1			Olive-brown fine Sand, some medium Sand, loose, moist.
		(6-8')		3 2 3 3	5	0.7	0.1			
		(8-10')		3 2 2 3	4	1.2	0.0			Olive-brown fine SAND, some Silt, trace medium to coarse Sand and fine Gravel, loose moist.
10		(10-12')		2 2 2 1	4	2.0	0.0			Brown fine SAND and SILT, wet.
										Brown fine SAND little to some Silt, loose, saturated.
		(12-14')		4 3 5 7	8	1.9	0.3			Gray fine SAND and SILT, trace black organic staining, medium-dense, wet.
15		(14-16')		16 14	28	1.5	0.2			Rusty brown fine to coarse SAND, some Silt, trace fine Gravel, wet.

Well Construction

- Locking stick up steel protective casing installed to 2.7' above ground surface.
- Concrete pad: 0.0'to 0.5' bgs.
- 5% Bentonite cement grout: 0.5' to 9.0' bgs.
- 2-in diameter Sch. 40 PVC riser: 2.4' ags to 13' bgs.
- Bentonite seal: 9.0' to 11.0' bgs.

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engineers & scientists

Remarks:
NA = Not Available. bgs = Below Ground Surface. ags = Above Ground Surface.

Water Levels

Date / Time	Elevation	Depth
6-7-99 / 9:35		17.42
6-17-99		17.58

Site:
Hill 78/ Building 71 Consolidation Area
Pittsfield, Massachusetts

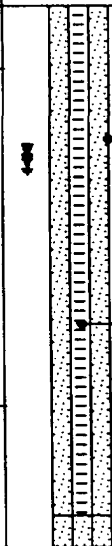
Client:
General Electric Company

Well No. OPCA-MW-2

Total Depth = 23.5 ft.

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Blows/6 In.	N	Recovery (ft.)	PID (ppm) Headspace	Geotechnical Test	Geologic Column	Stratigraphic Description
		(14-16')		14 19	28	1.5	0.2			Rusty brown fine to coarse SAND, some Silt and fine to medium Gravel, loose, moist.
		(16-18')		6 5 9 19	14	1.6	0.0			Olive-brown fine SAND, some Silt, trace medium to coarse Sand and fine to medium Gravel, medium-dense, saturated.
		(18-20')		50/	NA	0.3	0.0			
20		(20-22')		8 9 10 16	19	1.9	0.0			Olive-brown fine SAND and SILT, trace medium to coarse Sand and fine Gravel, dense, wet.
		(22-24')		NA NA NA NA	NA	NA	NA			Boring terminated at 23.5' bgs.
25										
30										
35										

Well Construction



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BLASLAND, BOUCK & LEE, INC.
engineers & scientists

Remarks:

Water Levels

Date / Time	Elevation	Depth
6-7-99 / 9:35		17.42
6-17-99		17.58

Project: 20185

Script: BBL-well
Date: 07/10/99

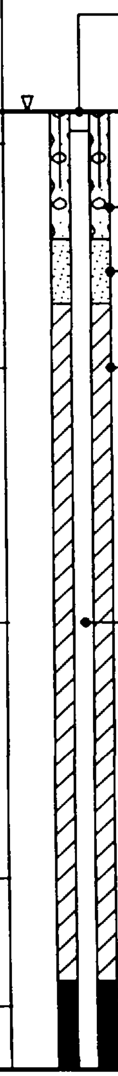
Date Start/Finish: 6-2-99 / 6-2-99 **Drilling Company:** Parratt Wolff, Inc. **Driller's Name:** J. Lansing **Drilling Method:** Hollow Stem Auger **Bit Size:** 4.25" **Auger Size** : 4.25" **Rig Type:** CME-55 **Spoon Size:** 2-in.	**Northing:** 535300.34271 **Easting:** 136189.15795 **Well Casing Elev.:** 1014.87 ft. **Corehole Depth:** ft. **Borehole Depth:** 28.0 ft. **Ground Surface Elev.:** 1015.3 ft. **Geologist:** Leanne Sanders	**Well No. OPCA-MW-3** **Client:** General Electric Company **Site:** Hill 78/ Building 71 Consolidation Area Pittsfield, Massachusetts

gs elevation 1015.3 ft.

GROUND SURFACE

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Blows/6 In.	N	Recovery (ft.)	PID (ppm) Headspace	Geotechnical Test	Geologic Column	Stratigraphic Description
	1015	(0-2')		NA 11 18 16	29	0.5	0.0			Asphalt Pavement Olive-brown SAND, some Silt and fine to medium gravel, loose, moist.
		(2-4')		36 34 29 20	63	1.7	0.0			
5	1010	(4-6')		6 8 7 8	15	1.1	0.0			Olive-brown fine SAND, some Silt, trace medium to coarse Sand, fine to medium Gravel, and slag, loose, moist.
		(6-8')		75/ 0.2 NA NA	NA	0.2	0.0			Cobble Zone at 6.2-8.0' bgs
		(8-10')		4 3 4 4	7	1.8	0.0			Olive-brown fine SAND, little Silt, trace medium to coarse Sand and fine to medium Gravel, loose, moist.
10	1005	(10-12')		4 3 4 3	7	1.5	0.0			
		(12-14')		4 4 4 4	8	1.7	0.0			Light olive-brown fine SAND, trace Silt, medium to coarse Sand, and fine Gravel, moist.
15		(14-16')		3 4	9	1.3	0.0			

Well Construction



BBL
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

Remarks:
NA = Not Available. bgs = Below Ground Surface. ags = Above Ground Surface.

Water Levels

Date / Time	Elevation	Depth
6-7-99 / 11:40		20.37
6-17-99		20.97

Project: 20185
Script: BBL-well
Date: 07/10/99

Site:
Hill 78/ Building 71 Consolidation Area
Pittsfield, Massachusetts

Client:
General Electric Company

Well No. OPCA-MW-3

Total Depth = 28.0 ft.

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Blows/6 In.	N	Recovery (ft.)	PID (ppm) Headspace	Geotechnical Test	Geologic Column	Stratigraphic Description	Well Construction
	1000	(14-16')		5 5	9	1.3	0.0			Olive-brown fine SAND and SILT, trace medium to coarse Sand, fine to medium Gravel, and Clay, moist.	
		(16-18')		3 3 5 6	8	1.5	0.0			Dark brown SILT, some fine Sand, trace organics, interbedded with fine Sand (layers approximately 0.02' thick), moist.	Grade #00N Sand Pack: 15.9' to 28' bgs.
		(18-20')		7 9 8 7	17	2.0	0.0			Olive -rusty brown fine SAND, trace Silt and medium to coarse Sand, medium-dense, moist.	
20	995	(20-22')		5 4 3 6	7	2.0	0.0			Olive-brown fine to coarse SAND, trace Silt, trace iron staining, wet. Olive-brown and rusty brown interbedded fine SAND and SILT, laminated, wet.	
		(22-24')		7 9 13 11	22	2.0	0.0			Olive-brown fine to medium SAND, trace Silt, saturated.	
25	990	(24-26')		5 5 6 5	11	1.5	NA			Olive-brown interbedded fine SAND and SILT, laminated, saturated.	2-in diameter Sch. 40 PVC, 0.010" slot screen: 18.0' to 28.0' bgs.
		(26-28')		6 8 8 9	16	1.0	0.0				
										Boring terminated at 28.0' bgs.	
30	985										
35											

BBL
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

Remarks:

Water Levels

Date / Time	Elevation	Depth
6-7-99 / 11:40		20.37
6-17-99		20.97

Project: 20185
Script: BBL-well
Date: 07/10/99

Date Start/Finish: 6-1-99 / 6-1-99 **Drilling Company:** Parratt Wolff, Inc. **Driller's Name:** J. Lansing **Drilling Method:** Hollow Stem Auger **Bit Size:** 4.25" **Auger Size** : 4.25" **Rig Type:** CME-55 **Spoon Size:** 2-in.	**Northing:** 535570.22488 **Easting:** 136222.54800 **Well Casing Elev.:** 1018.71 ft. **Corehole Depth:** ft. **Borehole Depth:** 22.0 ft. **Ground Surface Elev.:** 1019.2 ft. **Geologist:** Leanne Sanders	**Well No.** OPCA-MW-4 **Client:** General Electric Company **Site:** Hill 78/ Building 71 Consolidation Area Pittsfield, Massachusetts

gs elevation 1019.2 ft.

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Blows/6 In.	N	Recovery (ft.)	PID (ppm) Headspace	Geotechnical Test	Geologic Column	Stratigraphic Description	Well Construction
										GROUND SURFACE	8" diameter Stainless steel flush mount box.
		(0-2')		5 5 6 8	11	0.5	0.0			Olive-brown fine SAND and SILT, trace medium to coarse Sand and fine to medium Gravel, medium-dense, moist.	Concrete pad: 0.0' to 0.8' bgs.
		(2-4')		6 6 7 9	13	1.8	0.1				Sand drain: 0.8' to 2.0' bgs.
5	1015	(4-6')		4 2 1 2	3	1.2	0.0				5% Bentonite cement grout: 2.0' to 8.0' bgs.
		(6-8')		2 2 4 8	6	0.5	0.1			Color change to dark gray-black from 7.1' to 7.2' bgs.	2-in diameter Sch. 40 PVC riser: 0.0' to 12' bgs.
	1010	(8-10')		9 6 4 4	10	1.5	0.0			Olive-brown fine Sand, trace Silt, medium to coarse Sand, and fine to medium Gravel, loose, moist.	Bentonite seal: 8.0' to 10.0' bgs.
10		(10-12')		3 3 20 8	23	1.0	0.0			Olive-brown fine SAND, some Silt, trace medium to coarse Sand and fine to medium Gravel, wet. Saturated at 12' bgs.	Grade #00N Sand Pack: 10.0' to 22.0' bgs.
		(12-14')		6 6 7 7	13	1.3	0.0			Olive-brown fine SAND, little Silt, trace medium to coarse Sand, wet.	
15	1005	(14-16')		3 3	7	1.2	0.0				

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Remarks:
NA = Not Available. bgs = Below Ground Surface. ags = Above Ground Surface.

Water Levels

Date / Time	Elevation	Depth
6-8-99 / 8:45		11.55
6-17-99		12.42

Site:
Hill 78/ Building 71 Consolidation Area
Pittsfield, Massachusetts

Client:
General Electric Company

Well No. OPCA-MW-4
Total Depth = 22.0 ft.

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Blows/6 In.	N	Recovery (ft.)	PID (ppm) Headspace	Geotechnical Test	Geologic Column	Stratigraphic Description	Well Construction
		(14-16')		4 3	7	1.2	0.0			Dark olive-brown fine SAND and SILT, trace medium to coarse Sand, fine Gravel, and Clay, pliable, wet.	Grade #00N Sand Pack: 10.0' to 22.0' bgs.
		(16-18')		2 3 7 10	10	1.4	0.0				
	1000	(18-20')		4 2 8 8	10	1.8	8.0			Dark olive-brown to gray fine SAND and SILT, trace medium to coarse Sand, loose, saturated.	2-in diameter Sch. 40 PVC 0.010", slot screen: 12.0' to 22.0' bgs.
20		(20-22')		6 7 7 8	14	1.3	10.0				
										Boring terminated at 22.0' bgs.	
25	995										
30	990										
35	985										

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Remarks:

Water Levels

Date / Time	Elevation	Depth
6-8-99 / 8:45		11.55
6-17-99		12.42

Project: 20185
Script: BBL-well
Date: 07/10/99

Date Start/Finish: 6-3-99 / 6-3-99 **Drilling Company:** Parratt Wolff, Inc. **Driller's Name:** J. Lansing **Drilling Method:** Hollow Stem Auger **Bit Size:** 4.25" **Auger Size** : 4.25" **Rig Type:** CME-55 **Spoon Size:** 2-in.	**Northing:** 535630.67759 **Easting:** 136477.97793 **Well Casing Elev.:** 1017.07 ft. **Corehole Depth:** ft. **Borehole Depth:** 20.0 ft. **Ground Surface Elev.:** 1017.6 ft. **Geologist:** Leanne Sanders	**Well No.** OPCA-MW-5 **Client:** General Electric Company **Site:** Hill 78/ Building 71 Consolidation Area Pittsfield, Massachusetts

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Blows/6 In.	N	Recovery (ft.)	PID (ppm) Headspace	Geotechnical Test	Geologic Column	Stratigraphic Description	Well Construction
gs elevation 1017.6 ft.										GROUND SURFACE	10 X 10 X 12" Stainless steal flush mount curb box.
		(0-2')		13 17 24 40	42	1.2	NA			Olive-brown fine SAND, some medium to coarse, Sand, little fine to medium Gravel, moist.	Concrete pad: 0.0' to 1.0' bgs.
	1015	(2-4')		26 24 25 20	49	0.8	0.0			Dark gray fine to coarse SAND, some fine to medium gravel, trace asphalt, brick and slag, moist (Fill).	5% Bentonite cement grout: 1.0' to 6.0' bgs.
5		(4-6')		15 21 14 14	35	0.7	0.0			Olive-brown fine SAND and SILT, trace medium to coarse Sand and fine to medium Gravel, dense, moist.	2-in diameter Sch. 40 PVC riser: 0.3' to 9.8' bgs.
	1010	(6-8')		9 11 15 13	26	2.0	0.0			Olive-brown to dark brown fine SAND and SILT, trace medium to coarse Sand, mottled, dense, moist.	Bentonite seal: 6.0' to 8.0' bgs.
		(8-10')		6 7 7 8	14	1.1	0.0			Olive-brown fine SAND, moist.	
10		(10-12')		5 6 6 7	12	2.0	0.0			Dark brown fine SAND and SILT, trace medium to coarse Sand and Organics, moist. Olive-rusty brown fine to medium SAND, coarsening downward, moist, wet at 11.5' bgs.	Grade #00N Sand Pack: 8.0' to 20.0' bgs.
	1005	(12-14')		8 9 11 13	20	1.8	0.0			Olive brown fine to medium SAND, trace Silt and medium Gravel, saturated.	2-in diameter Sch. 40 PVC, 0.010" slot screen: 9.8' to 19.8' bgs.
15		(14-16')		5 6	13	0.2	NA			Olive-brown SILT, little fine to medium Gravel,	

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Water Levels

Date / Time	Elevation	Depth
6-8-99 / 10:40		10.18
6-17-99		13.20

Project: 20185
Script: BBL-well
Date: 07/10/99

Site:
Hill 78/ Building 71 Consolidation Area
Pittsfield, Massachusetts

Client:
General Electric Company

Well No. OPCA-MW-5

Total Depth = 20.0 ft.

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Blows/6 In.	N	Recovery (ft.)	PID (ppm) Headspace	Geotechnical Test	Geologic Column	Stratigraphic Description	Well Construction
		(14-16')		7 7	13	0.2	NA			trace fine to coarse Sand, dense, wet.	Grade #00N Sand Pack: 8.0' to 20.0' bgs.
	1000	(16-18')		6 6 6 11	12	1.8	0.0			Olive-brown fine SAND and SILT, trace medium to coarse Sand and fine to medium Gravel, medium-dense, saturated.	
		(18-20')		3 1 2 2	3	0.1	0.0			Olive-brown fine to medium SAND and SILT, little Clay, soft, saturated.	2-in diameter Sch. 40 PVC, 0.010" slot screen: 9.8' to 19.8' bgs.
20										Boring terminated at 20.0' bgs.	
	995										
25											
	990										
30											
	985										
35											

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Remarks:

Water Levels

Date / Time	Elevation	Depth
6-8-99 / 10:40		10.18
6-17-99		13.20

Project: 20185

Script: BBL-well
Date: 07/10/99

Date Start/Finish: 6-8-99 / 6-8-99 **Drilling Company:** Parratt Wolff, Inc. **Driller's Name:** J. Lansing **Drilling Method:** Hollow Stem Auger **Bit Size:** 4.25" **Auger Size** : 4.25" **Rig Type:** CME-55 **Spoon Size:** 2-in.	**Northing:** 535449.43636 **Easting:** 136901.92354 **Well Casing Elev.:** 1022.10 ft. **Corehole Depth:** ft. **Borehole Depth:** 25.0 ft. **Ground Surface Elev.:** 1022.7 ft. **Geologist:** Leanne Sanders	**Well No.** OPCA-MW-6 **Client:** General Electric Company **Site:** Hill 78/ Building 71 Consolidation Area Pittsfield, Massachusetts

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Blows/6 In.	N	Recovery (ft.)	PID (ppm) Headspace	Geotechnical Test	Geologic Column	Stratigraphic Description	Well Construction
gs elevation 1022.7 ft.										GROUND SURFACE	8" diameter steel flushmount curb box
		(0-2')		6 7 8 8	15	1.5	0.0			Orange brown fine SAND and SILT, some medium to coarse Sand, trace fine to medium Gravel, loose, moist. Brown fine SAND, little medium to coarse Sand, loose, moist.	Concrete pad: 0.0' to 0.5' bgs.
	1020	(2-4')		6 5 5 4	10	1.0	0.1			Orange-brown fine SAND, loose, moist.	
5		(4-6')		5 4 4 4	8	1.3	0.0			Light orange-brown medium SAND, little fine and coarse Sand, loose, moist.	5% Bentonite cement grout: 0.5' to 10.0' bgs.
	1015	(6-8')		7 5 4 5	9	1.6	0.0			Brown medium SAND, some fine Sand, little coarse Sand, trace fine to medium Gravel, loose, moist.	2-in diameter Sch. 40 PVC riser: 0.5' to 15.0' bgs.
10		(8-10')		2 3 3 4	6	1.7	0.0				
		(10-12')		4 3 3 3	6	0.3	0.0			Olive-brown fine SAND, some Silt, moist to wet.	Bentonite seal: 10.0' to 13.0' bgs.
	1010	(12-14')		35 50/ 0.1 NA	NA	1.5	0.0			Olive-brown fine SAND and fine to medium GRAVEL, some cobbles, moist.	
15		(14-16')		1 1	3	1.7	0.0			Olive-brown SILT, some fine Sand, trace Gravel, wet.	

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Water Levels

Date / Time	Elevation	Depth
6-10-99 / 9:28		16.98
6-17-99		17.62

Site:
Hill 78/ Building 71 Consolidation Area
Pittsfield, Massachusetts

Client:
General Electric Company

Well No. OPCA-MW-6

Total Depth = 25.0 ft.

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Blows/6 In.	N	Recovery (ft.)	PID (ppm) Headspace	Geotechnical Test	Stratigraphic Description
		(14-16')		2 1	3	1.7	0.0		Brown fine to medium SAND, wet.
	1005	(16-18')		3 11 14 16	25	1.3	0.0		Olive-brown fine SAND and SILT, trace to little medium to coarse Sand, Silt, and fine to medium Gravel, pliable, wet.
20		(18-20')		3 12 11 10	23	1.6	0.0		Olive-brown fine SAND, trace medium to coarse Sand, Silt, and fine to medium Gravel saturated.
									Olive-brown fine SAND and SILT, trace medium to coarse Sand and fine to medium Gravel, pliable, saturated.
		(20-22')		4 6 13 14	19	1.5	0.0		Light brown fine SAND, trace to little medium to coarse Sand, Silt, and fine Gravel, saturated.
	1000	(22-24')		23 19 26 26	45	1.5	0.0		Light brown fine SAND, trace medium Sand, saturated, layered with olive-brown fine SAND and SILT, saturated, layers approximately 0.4' thick.
25		(24-25)		NA NA	NA	NA	NA		
									Boring terminated at 25' bgs.
	995								
30									
	990								
35									

Well Construction

Grade #00N Sand Pack: 13.0' to 25.0' bgs.

2-in diameter Sch. 40 PVC, 0.010" slot screen: 15.0' to 25.0' bgs.

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Remarks:

Water Levels

Date / Time	Elevation	Depth
6-10-99 / 9:28		16.98
6-17-99		17.62

Date Start/Finish: 5-26-99 / 5-26-99 **Drilling Company:** Parratt Wolff, Inc. **Driller's Name:** J. Lansing **Drilling Method:** Hollow Stem Auger **Bit Size:** 4.25" **Auger Size** : 4.25" **Rig Type:** CME-55 **Spoon Size:** 2-in.	**Northing:** 535673.73391 **Easting:** 136835.85600 **Well Casing Elev.:** 1026.40 ft. **Corehole Depth:** ft. **Borehole Depth:** 24.0 ft. **Ground Surface Elev.:** 1026.9 ft. **Geologist:** Leanne Sanders	**Well No.** OPCA-MW-7 **Client:** General Electric Company **Site:** Hill 78/ Building 71 Consolidation Area Pittsfield, Massachusetts

gs elevation 1026.9 ft.

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Blows/6 In.	N	Recovery (ft.)	PID (ppm) Headspace	Geotechnical Test	Geologic Column	Stratigraphic Description	Well Construction
										GROUND SURFACE	8" X 12" Flush mount steel curb box
		(0-2')		21 9 6 5	15	1.2	0.0			Asphalt Pavement Brown fine SAND, trace Silt, loose, moist.	Concrete pad: 0.0 to 2.0' bgs.
	1025									Same as above with trace fine to medium Gravel.	
		(2-4')		6 7 8 5	15	1.9	0.0			Light to medium brown fine SAND, trace medium to coarse Sand and fine Gravel, loose, moist.	5% Bentonite cement grout: 2.0' to 10.0' bgs.
5		(4-6')		5 5 4 5	9	1.6	0.0				
	1020	(6-8')		5 6 9 19	15	1.7	0.0			Light to medium brown fine SAND, moist.	2-in diameter Sch. 40 PVC riser: 0.3' to 14' bgs.
		(8-10')		7 17 22 27	39	1.9	0.0			Olive-brown fine SAND and SILT, trace medium to coarse Sand and fine to medium Gravel, moist.	
10		(10-12')		10 15 17 23	32	1.8	0.1				Bentonite seal: 10.0' to 11.8' bgs.
	1015	(12-14')		13 17 50/ 0.3	67	0.6	0.0				Grade #00N Sand Pack: 11.8' to 24.0' bgs.
15		(14-16')		6 8	19	1.7	0.0			Wet at 13.9' bgs.	

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Water Levels		
Date / Time	Elevation	Depth
6-7-99 / 13:50		14.52
6-17-99		15.42

Project: 20185 Script: BBL-well Date: 07/10/99

Site:
Hill 78/ Building 71 Consolidation Area
Pittsfield, Massachusetts

Client:
General Electric Company

Well No. OPCA-MW-7
Total Depth = 24.0 ft.

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Blows/6 In.	N	Recovery (ft.)	PID (ppm) Headspace	Geotechnical Test	Geologic Column	Stratigraphic Description	Well Construction
		(14-16')		11 20	19	1.7	0.0			Light olive-brown fine SAND and SILT, wet.	Grade #00N Sand Pack: 11.8' to 24.0' bgs.
	1010	(16-18')		13 10 31 30	41	2.0	0.0			Light olive-brown fine SAND and SILT, trace medium to coarse Sand and fine to medium Gravel, dense, wet to moist.	2-in diameter Sch. 40 PVC, 0.010" slot screen: 14.0' to 24.0' bgs.
		(18-20')		26 24 23 29	47	1.8	0.0				
20		(20-22')		16 32 39 59	71	1.0	0.0				
	1005	(22-24')		86/ 0.5 NA NA	NA	0.3	0.0				
25										Boring terminated at 24.0' bgs.	
	1000										
30											
	995										
35											

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Remarks:

Water Levels

Date / Time	Elevation	Depth
6-7-99 / 13:50		14.52
6-17-99		15.42

Project: 20185
Script: BBL-well
Date: 07/10/99

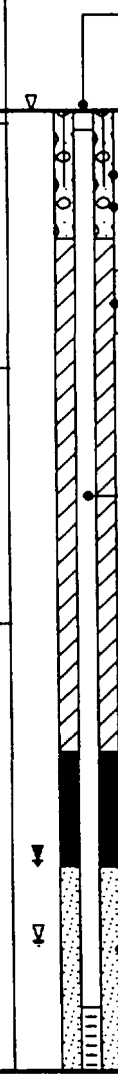
Date Start/Finish: 5-27-99 / 5-27-99 **Drilling Company:** Parratt Wolff, Inc. **Driller's Name:** J. Lansing **Drilling Method:** Hollow Stem Auger **Bit Size:** 4.25" **Auger Size** : 4.25" **Rig Type:** CME-55 **Spoon Size:** 2-in.	**Northing:** 535989.21494 **Easting:** 136679.67704 **Well Casing Elev.:** 1027.57 ft. **Corehole Depth:** ft. **Borehole Depth:** 23.7 ft. **Ground Surface Elev.:** 1027.9 ft. **Geologist:** Leanne Sanders	**Well No.** OPCA-MW-8 **Client:** General Electric Company **Site:** Hill 78/ Building 71 Consolidation Area Pittsfield, Massachusetts

gs elevation 1027.9 ft.

GROUND SURFACE

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Blows/6 In.	N	Recovery (ft.)	PID (ppm) Headspace	Geotechnical Test	Geologic Column	Stratigraphic Description
		(0-2')		8 7 9 9	16	1.2	0.0			Asphalt Pavement Olive-brown fine SAND and SILT, trace medium to coarse Sand and fine to medium Gravel, dense, moist.
	1025	(2-4')		59 29 22 22	51	1.3	0.0			
5		(4-6')		18 29 54 40	83	1.2	0.0			Olive-brown SILT, little fine Sand, trace medium to coarse Sand, dense, moist. Little fine to medium Gravel, 5.0' to 5.4' bgs.
		(6-8')		44 59 NA NA	103	0.7	0.0			Cobble Zone at 7.0-8.0' bgs
	1020	(8-10')		16 32 36 44	68	1.0	0.0			Olive-brown fine SAND and SILT, trace-little fine to medium Gravel, trace medium to coarse Sand, dense, moist.
10		(10-12')		13 32 58 49	90	1.6	0.0			
	1015	(12-14')		54 NA NA NA	NA	0.5	0.0			Wet at 12.0' bgs.
15		(14-16')		15 33	69	1.7	0.0			

Well Construction



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Remarks:
NA = Not Available. bgs = Below Ground Surface. ags = Above Ground Surface.

Water Levels

Date / Time	Elevation	Depth
6-7-99 / 15:20		11.71
6-17-99		12.97

Site:
Hill 78/ Building 71 Consolidation Area
Pittsfield, Massachusetts

Client:
General Electric Company

Well No. OPCA-MW-8

Total Depth = 23.7 ft.

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Blows/6 In.	N	Recovery (ft.)	PID (ppm) Headspace	Geotechnical Test	Geologic Column	Stratigraphic Description	Well Construction
		(14-16')		36 41	69	1.7	0.0			Olive-brown fine SAND and SILT, trace-little fine to medium Gravel, trace medium to coarse Sand, dense, moist.	Grade #00N Sand Pack: 11.5' to 23.7' bgs.
	1010	(16-18')		55/ 0.3 NA NA	NA	0.3	NA				
20		(18-20')		19 29 27 33	56	1.8	0.0			Olive-brown SILT, some fine Sand, trace medium to coarse Sand and fine to medium Gravel, pliable, wet to saturated.	2-in diameter Sch. 40 PVC, 0.010" slot screen: 13.5' to 23.5' bgs.
		(20-22')		16 24 34 29	58	1.7	0.0			Olive-brown SILT, some fine Sand, trace medium to coarse Sand, pliable, saturated.	
	1005	(22-24')		34 29 42 50	71	0.9	0.0			Olive-brown fine SAND and SILT, trace medium to coarse Sand, dense, wet.	
25										Boring terminated at 23.7' bgs.	
	1000										
30											
	995										
35											

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Remarks:

Water Levels

Date / Time	Elevation	Depth
8-7-99 / 15:20		11.71
8-17-99		12.97

Project: 201.85
Script: BBL-well
Date: 07/10/99

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SAMPLE/CORE LOG

Well 78-1 Project/No. AY05502 Page 1 of 1

Hill 78 Area, Pittsfield, MA Drilling Started 1-2-90 Drilling Completed 1-2-90

Depth Drilled 23 feet Hole Diameter 6.65 inches Type of Sample/ Coring Device Split-spoon

Length And Diameter of Coring Device (2' X 2") Sampling Interval 2 feet

Land Surface Elev. 1027.4 feet ☒ Surveyed ☐ Estimated Datum USGS 1929

Drilling Fluid Used None Drilling Method Hollow-stem Auger

Drilling Contractor Clean Berkshires, Inc. Driller Ed Helper George Ron

Prepared By A. LaBarge Hammer Weight 140# Hammer Drop 30 inches

Sample/Core Depth (feet below land surface) To	Core Recovery (feet)	Time/Hydraulic Pressure or Blows per 6 inches	SAMPLE ID	Sample/Core Description
2	1.0	11-10-12-12	PH01B0002	SAND (75%) brown, medium to coarse; Gravel (15%); fine to
				medium, poorly sorted.
4	0.2	8-8-5-4	PH01B0204	SAND (50%) brown, medium; Gravel (50%) fine, well-sorted.
6	1.2	2-9-5-4	PH01B0406	SAND (85%) light-brown, fine, moist; Gravel (10%)
				fine, well-sorted; Abrupt change to black organic peat material
				with roots at base of spoon, ~ 5.8'.
8	0.7	2-1-2-5	PH01B0608	SAND (95%) light-brown, fine, moist;Gravel (5%) very fine.
10	1.6	5-5-4-5	PH01B0810	SAND (95%) brown-grey, fine, moist; Gravel (5%) fine.
12	1.8	8-10-7-12	PH01B1012	SAND (95%) light-brown to red-brown, moist, fine, includes
				roots and reeds; Gravel (5%) fine.
14	1.9	6-7-10-11	PH01B1214	SAND (90%) light-brown to grey, fine, moist; Gravel
				(10%) fine to medium, rounded to subangular.
16	1.8	7-9-10-8	PH01B1416	Same as above, wet.
18	1.9	15-20-13-15	PH01B1618	Same as above, wet.
20	2.0	18-41-36-40	PH01B1820	Same as above, wet.
22	0.8	25-31-100/R	PH01B2022	SAND (85%) red-brown, medium to coarse; Rock fragments (15%);
				refusal at ~ 22 feet
23				No recovery, pushing boulder; Augured to 23 feet
				TD = 23 feet.
				DTW = 9.5 feet.

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Environmental Services

SAMPLE/CORE LOG

Boring/Well 78-6 Project/No. AY05502 Page 1 of 1

Site Location Hill 78 Area, Pittsfield, MA Drilling Started 1-3-91 Drilling Completed 1-3-91

Total Depth Drilled 18 feet Hole Diameter 6.65 inches Type of Sample/ Coring Device Split-spoon

Length and Diameter of Coring Device (2' x 2") Sampling Interval 2 feet

Land-Surface Elev. 1013.1 feet x☐ Surveyed ☐ Estimated Datum USGS 1929

Drilling Fluid Used None Drilling Method Hollow-stem Auger

Drilling Contractor Clean Berkshires, Inc. Driller Ed Helper George Ron

Prepared By A. LaBarge Hammer Weight 140# Hammer Drop 30 inches

Sample/Core Depth (feet below land surface) From	To	Core Recovery (feet)	Time/Hydraulic Pressure or Blows per 6 inches	SAMPLE ID	Sample/Core Description
0	2	0.5	4-6-5-5	PH06B002	SAND (80%) brown, fine, dry; Grass, roots (15%) top humus
					layer; Gravel (5%) very fine, rounded.
2	4	0.2	4-3-2-7	PH06B0204	SAND (90%) light brown to brown, fine to medium, dry;
					Gravel (10%) fine, subangular.
	6	0.8	7-8-5-6	PH06B0406	Same as above.
6	8	1.3	6-10-6-7	PH06B0608	SAND (95%) light brown to reddish brown, fine, moist;
					Gravel (5%) fine, subrounded. Trace of plastic material.
8	10	1.5	2-1-3-5	PH06B0310	SAND (95%) brown to light grey, fine, wet; Gravel (5%) fine
					to medium, subrounded.
10	12	1.9	11-11-6-5	PH06B1012	SAND (95%) light-grey, fine, wet; Gravel (5%) fine,
					rounded.
12	14	1.8	3-7-13-16	PH06B1214	SAND (50%) light-grey, fine, wet; Abrupt change to black
					peat (30%), natural organic material at 13 feet, with roots;
					SAND (20%) grey, fine, dry at base, tight.
14	16	1.6	5-6-10-16	PH06B1416	SAND (95%) light-grey to brown, fine, moist; Trace silt, grey.
16	18	2.0	21-20-23-20	PH06B1618	SAND (85%) light-grey, fine at top, coarsening and yellow-brown
					at base; Gravel (15%) fine at top, coarse at base, wet.
					Bottom of boring TD = 18 feet
					DTW = 7.5

GERAGHTY & MILLER, INC.

SAMPLE CORE LOG

BORING: B-15 PROJECT NO: NY05505 PAGE: 1 of 1

SITE LOCATION: GE - Altresco Pittsfield, MA DRILLING STARTED: 10/31/89 DRILLING COMPLETED: 10/31/89

TOTAL DEPTH DRILLED: 8 ft HOLE DIAMETER: 6 in. TYPE OF SAMPLE/ CORING DEVICE: Split Spoon Core

LENGTH & DIAMETER OF CORING DEVICE: 2 ft x 2 in. SAMPLING INTERVAL: 2 ft

LAND-SURFACE ELEVATION: ( ) SURVEYED ( ) ESTIMATED DATUM:

DRILLING FLUID USED: None DRILLING METHOD: Hollow-Stem Auger

DRILLING CONTRACTOR: Soil and Material Testing DRILLER: Gilley HELPER: Weasel

PREPARED BY: W. Gray HAMMER WEIGHT: 140 lb. HAMMER DROP: 30 inches

SAMPLE DEPTH (FT BELOW LAND SURFACE) FROM	TO	CORE RECVRY (FT)	BLOW COUNTS PER 6 INCHES	SAMPLE/CORE DESCRIPTION
0	2	1.4	6-6-4-3	1-1/2 in. Asphalt. Fill, sand and gravel, brown.
2	4	1.3	4-4-7-8	Sand and gravel, brown (natural sediments).
4	6	1.6	7-8-8-9	Same.
6	8	1.5	8-8-7-7	Same.

SAMPLE/CORE LOG

WELL: NY-4　PROJECT NO: New York Ave. NY360NY01　PAGE: 1 of 1

SITE LOCATION: General Electric Pittsfield, MA　DRILLING STARTED: 5/2/88　DRILLING COMPLETED: 5/2/88

TOTAL DEPTH DRILLED: 33 ft　HOLE DIAMETER: 8 in.　TYPE OF SAMPLE/ CORING DEVICE: Split Spoon

LENGTH & DIAMETER OF CORING DEVICE: 2 ft x 2 in.　SAMPLING INTERVAL: continuous

LAND-SURFACE ELEVATION:　( ) SURVEYED ( ) ESTIMATED　DATUM:

DRILLING FLUID USED: None　DRILLING METHOD: Hollow Stem Auger

DRILLING CONTRACTOR: Soil & Mat'l. Testing　DRILLER: Tom　HELPER: Bob

PREPARED BY: J. Duminuco　HAMMER WEIGHT: 140 lb　HAMMER DROP: 30 in.

SAMPLE NO	SAMPLE DEPTH FROM	SAMPLE DEPTH TO	CORE RECVRY	BLOW COUNTS	SAMPLE/CORE DESCRIPTION
	0	2	1.0	1-2-	Sand, fine to medium, trace gravel, silt, vegetation,
				2-2	brown.
	2	4	1.1	3-3-	Sand, fine to coarse, some gravel, trace silt,
				3-4	brown-gray.
	4	6	1.2	6-9-	Interlayered: sand, fine to coarse, some gravel,
				6-7	trace silt; sand, fine, silty; silt, sandy; brown.
	6	8	1.4	9-18-	Sand, fine to medium, silty and gravel, brown (damp).
				16-18	
	8	10	1.4	15-15-	Silt, sandy, trace gravel, brown; (wet).
				19-14	
	10	12	0.0	20-25-	No recovery - pushing cobbles - augered to 14.0 ft.
				40-120	
	14	16	1.0	11-9-	(Interlayered) Sand, fine, silty and silt, sandy,
				12-17	brown; (damp).
	16	18	0.9	16-20-	Silt, some fine sand, trace gravel, brown.
				22-27	
	18	20	0.8	29-50-	Sand, fine, some silt, trace gravel, brown; (damp).
				45-45	
	20	22	1.8	70-75-	Do
				50-70	
	22	24	1.1	11-16-	Sand, fine, trace silt, brown; (damp).
				32-37	

Appendix B

BLASLAND, BOUCK & LEE, INC.
engineers & scientists

Field Sampling Data

GROUNDWATER SAMPLING FIELD LOG

Well No. OPCA-MW-1
Key No.: FX-37
PID Background (ppm) 0.0
Well Headspace (ppm) 0.2

Site Name On-Site Consolidation Area
Sampling Personnel SLL SDR
Date 6/16/99 **Time In / Out** 0750
Weather Partly cloudy 60°F

WELL INFORMATION

	TIC	BGL
Reference Point Marked on Casing	X	
Height of Ref. Pt. Relative to Grade		
Well Diameter	2"	
Well Depth	32.40'	
Screen Interval Depth	20.1 - 30.1	
Water Table Depth	10.48'	
Intake Depth of Pump/Tubing	25'	

Pump Start Time 0805
Pump Stop Time ~~[illegible]~~ 0910
Sample Time 0830
Sample ID OPCA-MW-1
Sampled for:
APPENDIX IX+3 EXCLUDING PESTICIDES and HEI
(X) VOCs / HCL, 2-40ml VOAs
(X) SVOCs /1 L Amber
(X) Dioxin / 1L Amber
(X) Metals (Total) / HNO3, 500ml Plastic
(X) Cyanide / NaOH, 500ml Plastic
(X) Sulfide / NaOH,ZnAc; 500ml glass - no headspac
(X) PCBs (Total) / 1L Amber

Redevelop? Y N

WELL WATER INFORMATION

Length of Water Column	21.92
Volume of Water in Well	3.57 Gallon
Minutes of Pumping	65 min

EVACUATION INFORMATION

Volume of water removed from well 5 Gallons
Did well go dry? Y N
Evacuation Method: Bailer ( ) Pump (X)
Pump Type GRUNDFOS
Water Quality Meter Type(s) / Serial Numbers: YSI and HACH Turbidimeter

Time	Pump Rate (L/min.)	Total Gallons Removed	Water Level (TIC)	Depth to Water	Temp. (Celcius)	pH	Cond. (mS/cm)	Turbidity (NTU)	DO (mg/l)	ORP (mV)
0806	.400		11.41'		10.40	7.62	0.430	59.6	9.66	129.3
0809	.400		13.77'		10.70	7.64	0.428	45.5	9.02	129.6
0812	.400		14.57'		10.80	7.53	0.426	29.6	8.88	127.4
0815	.400		[illegible]22'		11.47°	7.47	0.425	153.2	8.66	123.3
0818	.400		16.12'		[illegible]	7.44	0.426	[illegible]	[illegible]	118.6
0821	.400		—		11.78	7.40	0.427	[illegible]	[illegible]	117.5
0824	[illegible]		[illegible]		[illegible]2.27	7.36	[illegible].426	24.8	[illegible].52	118.5
0827	.400		19.22		[illegible]2.67	7.32	0.426	16.6	8.44	118.5
Final	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

MISCELLANEOUS OBSERVATIONS/PROBLEMS [illegible]
[illegible]

SAMPLE DESTINATION

Laboratory: CT+E Environmental
Delivered Via: Fed Ex
Airbill #:

Field Sampling Coordinator:

GROUNDWATER SAMPLING FIELD LOG

Well No. OPCA-MW-2
Key No. EX-37
PID Background (ppm) 0.0
Well Headspace (ppm) 0.2

Site Name On-Site Consolidation Area
Sampling Personnel SLL, SPE
Date 6/15/99 Time In / Out 1630
Weather Partly cloudy 70°F

WELL INFORMATION

	TIC	BGL
Reference Point Marked on Casing	X	
Height of Ref. Pt. Relative to Grade		
Well Diameter	2"	
Well Depth	25.10'	
Screen Interval Depth	13-25	
Water Table Depth	17.62'	
Intake Depth of Pump/Tubing	20'	

Redevelop? Y (N)

Pump Start Time 1440
Pump Stop Time 1545
Sample Time 1515
Sample ID OPCA-MW-2
Sampled for:
APPENDIX IX+3 EXCLUDING PESTICIDES and HE
(X) VOCs / HCL, 2-40ml VOAs
(X) SVOCs /1 L Amber
(X) Dioxin / 1L Amber
(X) Metals (Total) / HNO3, 500ml Plastic
(X) Cyanide / NaOH, 500ml Plastic
(X) Sulfide / NaOH,ZnAc; 500ml glass - no headspa
(X) PCBs (Total) / 1L Amber

WELL WATER INFORMATION

Length of Water Column	7.48
Volume of Water in Well	1.22 gallons.
Minutes of Pumping	65 mins.

EVACUATION INFORMATION

Volume of water removed from well 6 gallons
Did well go dry? Y N
Evacuation Method: Bailer ( ) Pump (X)
Pump Type: COLUMBUS
Water Quality Meter Type(s) / Serial Numbers: YSI and HACH Turbidimeter

Time	Pump Rate (L/min.)	Total Gallons Removed	Water Level (TIC)	Depth to Water	Temp. (Celcius)	pH	Cond. (mS/cm)	Turbidity (NTU)	DO (mg/l)	ORP (mV)
1443	0.400		18.32'		9.77	7.09	0.911	267.8	5.39	139.5
1446	0.400		18.67'		10.45	6.94	0.913	657.7	4.05	133.9
1449	0.400		18.74'		10.51	6.76	0.919	302.8	3.32	132.7
1452	0.400		18.87'		11.56	6.78	0.925	229.4	3.00	131.4
1455	0.400		19.03		11.71	6.76	0.928	124.1	2.64	129.1
1458	0.400		19.16		11.69	6.74	0.930	63.1	2.47	129.8
1501	0.400		19.24		11.71	6.74	0.938	59.5	2.41	131.4
1504	0.400		19.49		12.02	6.75	0.942	53.6	2.38	127.2
1507	0.400		19.63		11.81	6.73	0.955	53.1	2.35	130.6
1510	0.400		19.72		12.40	6.74	0.956	54.7	2.37	129.0
1513	0.400		19.88		12.51	6.75	0.960	46.7	2.41	127.1
Final	0.400		19.88		12.51	6.75	0.960	46.7	2.41	127.1

MISCELLANEOUS OBSERVATIONS/PROBLEMS

* DUP-1 TAKEN HERE.

SAMPLE DESTINATION

Laboratory: CT+E Environmental
Delivered Via: Fed Ex
Airbill #:

Field Sampling Coordinator:

GROUNDWATER SAMPLING FIELD LOG

Well No. OPCA-MW-3
Key No.: —
PID Background (ppm) 0.0
Well Headspace (ppm) 0.2

Site Name On-Site Consolidation Area
Sampling Personnel SLL SPR
Date 6/12/99 **Time In / Out** 1000
Weather Partly cloudy 60°F

WELL INFORMATION

	TIC	BGL
Reference Point Marked on Casing	x	
Height of Ref. Pt. Relative to Grade	Flush	
Well Diameter	2"	
Well Depth	26.75'	
Screen Interval Depth	18'-26.75'	
Water Table Depth	20.71'	
Intake Depth of Pump/Tubing	24'	

Pump Start Time 1017
Pump Stop Time 1100
Sample Time 1050
Sample ID OPCA-MW-3
Sampled for:
APPENDIX IX+3 EXCLUDING PESTICIDES and HE!
(x) VOCs / HCL, 2-40ml VOAs
(x) SVOCs /1 L Amber
(x) Dioxin / 1L Amber
(x) Metals (Total) / HNO3, 500ml Plastic
(x) Cyanide / NaOH, 500ml Plastic
(x) Sulfide / NaOH,ZnAc; 500ml glass - no headspac
(x) PCBs (Total) / 1L Amber

Redevelop? Y N

WELL WATER INFORMATION

Length of Water Column	6.04
Volume of Water in Well	.98 Gallons
Minutes of Pumping	43

EVACUATION INFORMATION

Volume of water removed from well 7 gallons
Did well go dry? Y N

Evacuation Method: Bailer ( ) Pump (✓)
Pump Type: GRUNFOS

Water Quality Meter Type(s) / Serial Numbers: YSI and HACH Turbidimeter

Time	Pump Rate (L/min.)	Total Gallons Removed	Water Level (TIC)	Depth to Water	Temp. (Celcius)	pH	Cond. (mS/cm)	Turbidity (NTU)	DO (mg/l)	ORP (mV)
1018	.400		21.21'		11.80	7.49	0.626	240	2.56	152.0
1021	.400		21.24'		12.26	6.99	0.632	1236.7	1.38	108.5
1024	.400		21.46'		13.42	6.74	0.676	543.2	1.03	91.5
1027	.400		21.65'		12.52	6.70	0.696	318.9	0.75	93.0
1030	.400		21.72'		12.74	6.68	0.694	2800	0.67	87.3
1033	.400		21.78'		12.37	6.67	0.717	2704	0.65	96.5
1036	.350		21.71		13.27	6.65	0.741	337	0.66	88.5
1039	.350		21.75		13.40	6.65	0.741	68.6	0.64	90.0
1042	.350		21.77		13.16	6.66	0.723	73.2	0.62	90.3
1045	.350		21.79		13.16	6.66	0.731	54.8	0.60	91.0
1048	.350		21.79		13.29	6.66	0.735	46.6	0.61	91.5
Final	.350		21.78		13.29	6.66	0.735	46.6	0.61	91.5

MISCELLANEOUS OBSERVATIONS/PROBLEMS CHANGED D.O. MEMBRANE

SAMPLE DESTINATION

Laboratory: CT+E Environmental
Delivered Via: Fed Ex
Airbill #:

Field Sampling Coordinator: [signature]

GROUNDWATER SAMPLING FIELD LOG

Well No. OPCA-MW-4
Key No. ——
PID Background (ppm) 0.0
Well Headspace (ppm) 0.2

Site Name On-Site Consolidation Area
Sampling Personnel SLL, SPR
Date 6/15/99 **Time In / Out** 1320
Weather Partly cloudy ~~~~ 70°F

WELL INFORMATION

	TIC	BGL
Reference Point Marked on Casing	X	
Height of Ref. Pt. Relative to Grade	Flush	
Well Diameter	2"	
Well Depth	21.25'	
Screen Interval Depth	12 - 21.25	
Water Table Depth	12.01	
Intake Depth of Pump/Tubing	17'	

Pump Start Time 1336
Pump Stop Time 1410
Sample Time 1400
Sample ID OPCA - MW - 4
Sampled for:
APPENDIX IX+3 EXCLUDING PESTICIDES and HEI
(X) VOCs / HCL, 2-40ml VOAs
(X) SVOCs /1 L Amber
(X) Dioxin / 1L Amber
(X) Metals (Total) / HNO3, 500ml Plastic
(X) Cyanide / NaOH, 500ml Plastic
(X) Sulfide / NaOH,ZnAc; 500ml glass - no headspac
(X) PCBs (Total) / 1L Amber

Redevelop? Y N

WELL WATER INFORMATION

Length of Water Column	9.24
Volume of Water in Well	1.51 Gallons
Minutes of Pumping	34 min.

EVACUATION INFORMATION

Volume of water removed from well 4 gallons
Did well go dry? Y N
Evacuation Method: Bailer ( ) Pump (X)
Pump Type: Grundfos
Water Quality Meter Type(s) / Serial Numbers: YSI and HACH Turbidimeter

Time	Pump Rate (L/min.)	Total Gallons Removed	Water Level (TIC)	Depth to Water	Temp. (Celcius)	pH	Cond. (mS/cm)	Turbidity (NTU)	DO (mg/l)	ORP (mV)
1337	.480		12.68'		11.85	7.37	0.871	77.2	6.09	132.5
1340	.400		13.01'		10.83	6.92	0.856	48.8	3.82	130.3
1343	.400		13.03'		11.71	6.87	0.865	57.8	2.86	129.2
1346	.400		13.14'		12.77	6.86	0.871	87.6	2.61	126.0
1349	.350		13.23'		13.48	6.87	0.871	171.0	2.40	120.4
1352	.350		13.37'		13.63	6.87	0.871	127	2.31	116.2
1355	.350		13.51		13.82	6.87	0.870	15.9	2.29	113.4
1358	.350		13.69		13.86	6.87	0.869	13.1	2.23	111.7
Final	.350		13.69		13.86	6.87	0.869	13.1	2.23	111.7

Cleaned turbidity

MISCELLANEOUS OBSERVATIONS/PROBLEMS

SAMPLE DESTINATION

Laboratory: CT+E Environmental
Delivered Via: Fed Ex
Airbill #:

Field Sampling Coordinator: [signature]

GROUNDWATER SAMPLING FIELD LOG

Well No. OPCA-MW-5
Key No. —
PID Background (ppm) 0.0
Well Headspace (ppm) 0.1

Site Name On-Site Consolidation Area
Sampling Personnel SLL, SPR
Date 6/8/99 Time In / Out 1050
Weather Sunny, 70°F

WELL INFORMATION

	TIC	BGL
Reference Point Marked on Casing	X	
Height of Ref. Pt. Relative to Grade	Flush	
Well Diameter	2"	
Well Depth	19.13'	
Screen Interval Depth	9.8 - 19	
Water Table Depth	10.80'	
Intake Depth of Pump/Tubing	15'	

Pump Start Time 1100
Pump Stop Time 1220
Sample Time 1210
Sample ID OPCA-MW-5
Sampled for:
APPENDIX IX+3 EXCLUDING PESTICIDES and HEI
(X) VOCs / HCL, 2-40ml VOAs
(X) SVOCs /1 L Amber
(X) Dioxin / 1L Amber
(X) Metals (Total) / HNO3. 500ml Plastic
(X) Cyanide / NaOH. 500ml Plastic
(X) Sulfide / NaOH.ZnAc: 500ml glass - no headspac
(X) PCBs (Total) / 1L Amber

Redevelop? Y N

WELL WATER INFORMATION

Length of Water Column	8.33
Volume of Water in Well	1.36 gallons
Minutes of Pumping	80 min.

EVACUATION INFORMATION

Volume of water removed from well 8 gallons
Did well go dry? Y N
Evacuation Method: Bailer ( ) Pump (X)
Pump Type Grundfos.
Water Quality Meter Type(s) / Serial Numbers. YSI and HACH Turbidimeter

Time	Pump Rate (L/min.)	Total Gallons Removed	Water Level (TIC)	Depth to Water	Temp. (Celcius)	pH	Cond. (mS/cm)	Turbidity (NTU)	DO (mg/l)	ORP (mV)
1103	0.400		11.16'		10.99	7.59	0.655	158.6	2.19	-79.8
1106	0.400		11.21'		11.86*	7.16	0.645	280.5	1.37	-80.0
1109	0.400		11.27'		12.17*	7.04	0.635	607.9	1.15	-70.0
1112	0.400		11.39'		12.55	6.99	0.639	296.0	1.04	-66.2
1115	0.400		11.51'*		12.89	6.97	0.647	178.8	1.04	-77.6
1118	0.400		11.61		13.62	6.95	0.645	184.6	1.20	-79.3
1121	0.400		11.81		13.74	6.94	0.649	187.5	1.45	-70.8
1124	0.400		12.07		13.42	6.90	0.640	232.8	1.90	-63.1
1127	0.400		12.17		14.02	6.89	0.641	279.5	2.21	-52.0
11.30	0.400		12.56		13.47	6.89	0.637	242.9	2.42	-47.7
1133	0.300		12.84		13.35	6.86	0.632	187.4	2.49	-35.5
Final 1136	0.300		12.92		13.73	6.86	0.633	266.6	2.42	-33.8

MISCELLANEOUS OBSERVATIONS/PROBLEMS * changed DO membrane.

SAMPLE DESTINATION

Laboratory: CT+E Environmental
Delivered Via Fed Ex
Airbill #:

Field Sampling Coordinator: [signature]

GROUNDWATER SAMPLING FIELD LOG

Well No. OPCA-MW-5
Key No.: —
PID Background (ppm) 0.0
Well Headspace (ppm) 0.1

Site Name On-Site Consolidation Area
Sampling Personnel SU, SPR
Date 6/15/99 Time In / Out 1050
Weather Sunny ~70°F

WELL INFORMATION

	TIC	BGL
Reference Point Marked on Casing	X	
Height of Ref. Pt. Relative to Grade	Flush	
Well Diameter	2"	
Well Depth	19.13'	
Screen Interval Depth	9.3-19'	
Water Table Depth	10.80'	
Intake Depth of Pump/Tubing	15'	

Pump Start Time 1100
Pump Stop Time 1220
Sample Time 1210
Sample ID OPCA-MW-5
Sampled for:
APPENDIX IX+3 EXCLUDING PESTICIDES and HE
(✓) VOCs / HCL, 2-40ml VOAs
(✓) SVOCs /1 L Amber
(✓) Dioxin / 1L Amber
(✓) Metals (Total) / HNO3, 500ml Plastic
(✓) Cyanide / NaOH, 500ml Plastic
(✓) Sulfide / NaOH,ZnAc; 500ml glass - no headspac

(✓) PCBs (Total) / 1L Amber

Redevelop? Y N

WELL WATER INFORMATION

Length of Water Column	8.33
Volume of Water in Well	1.36 gallons
Minutes of Pumping	80 min

EVACUATION INFORMATION

Volume of water removed from well 8 gallons
Did well go dry? Y N

Evacuation Method: Bailer ( ) Pump (X)
Pump Type: Grundfos

Water Quality Meter Type(s) / Serial Numbers: YSI and HACH Turbidimeter

Time	Pump Rate (L/min.)	Total Gallons Removed	Water Level (TIC)	Depth to Water	Temp. (Celcius)	pH	Cond. (mS/cm)	Turbidity (NTU)	DO (mg/l)	ORP (mV)
1139	0.250		13.05'		13.90	6.86	0.633	2836	2.04	-36.6
1142	0.250		13.13'		14.12	6.87	0.630	250.7	2.00	-34.7
1145	0.250		13.16'		14.57	6.87	0.628	222.3	2.06	-29.7
1148	0.100		13.17'		14.53	6.88	0.632	199.5	2.18	-25.5
1151	0.100		13.17'		14.60	6.88	0.632	184.2	2.39	-23.0
1154	0.100		13.18'		14.53	6.89	0.633	146.6	2.69	-19.2
1157	0.100		13.18'		14.68	6.90	0.635	100.4	2.97	-16.7
1200	0.100		13.18		14.70	6.90	0.636	82.2	3.20	-15.6
1203	0.100		13.18		14.75	6.91	0.636	60.0	3.45	-11.1
1206	0.100		13.18		14.84	6.91	0.636	44.6	3.65	-6.9
1209										
Final	0.100		13.18		14.84	6.91	0.636	44.6	3.65	-6.9

MISCELLANEOUS OBSERVATIONS/PROBLEMS

SAMPLE DESTINATION

Laboratory: CT+E Environmental
Delivered Via: Fed Ex
Airbill #:

Field Sampling Coordinator: [signature]

GROUNDWATER SAMPLING FIELD LOG

Well No. OPCA-MW-6
Key No. —
PID Background (ppm) 0.0
Well Headspace (ppm) 0.1

Site Name On-Site Consolidation Area
Sampling Personnel SLL SPR
Date 6/15/99 Time In / Out 0910
Weather Sunny ~65°F

WELL INFORMATION

	TIC	BGL
Reference Point Marked on Casing	X	
Height of Ref. Pt. Relative to Grade	Flush	
Well Diameter	2"	
Well Depth	23.80'	
Screen Interval Depth	13-23.80	
Water Table Depth	17.14	
Intake Depth of Pump/Tubing	20'	

Pump Start Time 0925
Pump Stop Time 1000
Sample Time 0955
Sample ID OPCA-MW-6
Sampled for:
APPENDIX IX+3 EXCLUDING PESTICIDES and HEI
(X) VOCs / HCL, 2-40ml VOAs
(X) SVOCs /1 L Amber
(X) Dioxin / 1L Amber
(X) Metals (Total) / HNO3, 500ml Plastic
(X) Cyanide / NaOH, 500ml Plastic
(X) Sulfide / NaOH,ZnAc: 500ml glass - no headspac
(X) PCBs (Total) / 1L Amber

Redevelop? Y N

WELL WATER INFORMATION

Length of Water Column	6.66'
Volume of Water in Well	1.06 Gallons
Minutes of Pumping	45 minutes

EVACUATION INFORMATION

Volume of water removed from well 5 Gallons
Did well go dry? Y N
Evacuation Method Bailer ( ) Pump (X)
Pump Type Grunfos
Water Quality Meter Type(s) / Serial Numbers: YSI and HACH Turbidimeter

Time	Pump Rate (L/min.)	Total Gallons Removed	Water Level (TIC)	Depth to Water	Temp. (Celcius)	pH	Cond. (mS/cm)	Turbidity (NTU)	DO (mg/l)	ORP (mV)
0926	.400		17.39'		11.61	7.61	0.583	479.2	11.03	160.4
0929	0.400		17.86'		10.70	7.37	0.540	436.3	10.13	131.1
0932	0.400		17.91'		10.91	7.33	0.544	192.9	9.99	119.9
0935	0.400		18.02		11.44	7.32	0.537	161.9	9.89	109.4
0938	0.400		18.05		11.92	7.32	0.534	183.7	9.74	101.2
0941	0.400		18.05		12.31	7.32	0.534	176.0	9.67	100.1
0944	0.400		18.00		12.83	7.32	0.536	127.3	9.60	97.4
0947	0.300		18.00		13.18	7.32	0.534	71.6	9.58	94.7
0950	0.300		18.00		13.27	7.32	0.526	34.5	9.57	91.0
0953	0.300		18.00		13.31	7.32	0.522	28.6	9.56	90.2
Final										

MISCELLANEOUS OBSERVATIONS/PROBLEMS DO seems to be too high, will check DO probe after sampling.

SAMPLE DESTINATION

Laboratory: CT+E Environmental
Delivered Via: Fed Ex
Airbill #:

Field Sampling Coordinator: [signature]

GROUNDWATER SAMPLING FIELD LOG

Well No. OPCA-MW-7
Key No. —
PID Background (ppm) 0.0
Well Headspace (ppm) 0.2

Site Name On-Site Consolidation Area
Sampling Personnel SLL
Date 6/15/99 **Time In / Out** 0800
Weather sunny, 65°F

WELL INFORMATION

	TIC	BGL
Reference Point Marked on Casing	X	
Height of Ref. Pt. Relative to Grade	Flush	
Well Diameter	2"	
Well Depth	23.43'	
Screen Interval Depth	14-23'	
Water Table Depth	15.02'	
Intake Depth of Pump/Tubing	19'	

Pump Start Time 0800
Pump Stop Time 0850
Sample Time 0845
Sample ID OPCH-MW-7
Sampled for:
APPENDIX IX+3 EXCLUDING PESTICIDES and HE
(X) VOCs / HCL, 2-40ml VOAs
(X) SVOCs /1 L Amber
(X) Dioxin / 1L Amber
(X) Metals (Total) / HNO3, 500ml Plastic
(X) Cyanide / NaOH, 500ml Plastic
(X) Sulfide / NaOH.ZnAc; 500ml glass - no headspac
(X) PCBs (Total) / 1L Amber

Redevelop? Y (N)

WELL WATER INFORMATION

Length of Water Column	8.41'
Volume of Water in Well	1.37 Gallons
Minutes of Pumping	50 min.

EVACUATION INFORMATION

Volume of water removed from well 5 Gallons
Did well go dry? Y (N)
Evacuation Method: Bailer ( ) Pump (X)
Pump Type: GRUNDFOS.
Water Quality Meter Type(s) / Serial Numbers: YSI and HACH Turbidimeter

Time	Pump Rate (L/min.)	Total Gallons Removed	Water Level (TIC)	Depth to Water	Temp. (Celcius)	pH	Cond. (mS/cm)	Turbidity (NTU)	DO (mg/l)	ORP (mV)
0823	0.400		15.25'		13.09	7.97	1.363	28.6	8.27	165.9
0826	0.400		16.07'		11.31	7.17	1.310	20.3	6.92	168.3
0829	0.400		16.46		12.30	7.01	1.307	24.7	6.63	164.1
0832	0.400		16.73		13.28	6.97	1.305	17.1	6.53	161.4
0835	0.400		16.92		14.22	6.94	1.320	13.1	6.31	158.9
0838	0.400		17.24		14.64	6.93	1.333	9.2	6.18	155.6
0841	0.400		17.44		14.14	6.90	1.344	7.8	6.33	151.5
Final	0.400		17.44		14.14	6.90	1.344	7.8	6.33	15.15

MISCELLANEOUS OBSERVATIONS/PROBLEMS

SAMPLE DESTINATION

Laboratory CT+E Environmental
Delivered Via Fed Ex
Airbill #

Field Sampling Coordinator: [signature]

GROUNDWATER SAMPLING FIELD LOG

Well No. OPCA-MW-8
Key No.
PID Background (ppm) 0.0
Well Headspace (ppm) 0.2

Site Name On-Site Consolidation Area
Sampling Personnel SLL SPR
Date 6/14/99 **Time In / Out** 1530 / 1620
Weather cloudy, 80°F

WELL INFORMATION

	TIC	BGL
Reference Point Marked on Casing	X	
Height of Ref. Pt. Relative to Grade	Flush	
Well Diameter	2"	
Well Depth	23.04'	
Screen Interval Depth	13.5-23'	
Water Table Depth	12.66'	
Intake Depth of Pump/Tubing	20.'	

Redevelop? Y N

Pump Start Time 1540
Pump Stop Time 1610
Sample Time 1605
Sample ID OPCA-MW-8
Sampled for:
APPENDIX IX+3 EXCLUDING PESTICIDES and HE
(X) VOCs / HCL, 2-40ml VOAs
(X) SVOCs /1 L Amber
(X) Dioxin / 1L Amber
(X) Metals (Total) / HNO3, 500ml Plastic
(X) Cyanide / NaOH, 500ml Plastic
(X) Sulfide / NaOH,ZnAc; 500ml glass - no headspac

(X) PCBs (Total) / 1L Amber

WELL WATER INFORMATION

Length of Water Column	10.38
Volume of Water in Well	1.70 Gallons
Minutes of Pumping	30 min

EVACUATION INFORMATION

Volume of water removed from well 4 Gallons
Did well go dry? Y N

Evacuation Method: Bailer ( ) Pump (X)
Pump Type GRUNFOS

Water Quality Meter Type(s) / Serial Numbers: YSI and HACH Turbidimeter

Time	Pump Rate (L/min.)	Total Gallons Removed	Water Level (TIC)	Depth to Water	Temp. (Celcius)	pH	Cond. (mS/cm)	Turbidity (NTU)	DO (mg/l)	ORP (mV)
1540	0.400		13.25'		13.84	7.36	1.953	189.3	9.10	136.1
1543	0.400		13.86'		12.97	7.29	1.948	193.3	8.34	126.8
1546	0.400		14.17'		14.17	7.22	1.935	228.6	7.94	122.2
1549	0.400		14.42'		15.11	7.23	1.923	175.0	7.84	118.3
1552	0.400		14.79'		14.61	7.22	1.915	130.2	7.69	110.0
1555	0.400		14.99		15.17	7.22	1.949	136.9	7.52	105.6
1558	0.400		15.44		14.75	7.22	1.993	26.7	7.58	100.8
1601	0.400		15.84		14.93	7.22	2.003	22.2	7.47	98.9
Final	0.400		15.84		14.93	7.22	2.003	22.2	7.47	98.9

cleaned turbidity meter.

MISCELLANEOUS OBSERVATIONS/PROBLEMS

SAMPLE DESTINATION

Laboratory: CT+E Environmental
Delivered Via: Fed Ex
Airbill #:

Field Sampling Coordinator: [signature]

GROUNDWATER SAMPLING FIELD LOG

Well No. 78-1
Key No.: —
PID Background (ppm) 0.0
Well Headspace (ppm) 0.1

Site Name On-Site Consolidation Area
Sampling Personnel SK, SOR
Date 6/4/99 **Time In / Out** 14:30
Weather Cloudy, 80°F

WELL INFORMATION

	TIC	BGL
Reference Point Marked on Casing	X	
Height of Ref. Pt. Relative to Grade	Flush	
Well Diameter	4"	
Well Depth	22.91'	
Screen Interval Depth	8'-23'	
Water Table Depth	11.39'	
Intake Depth of Pump/Tubing	15'	

Pump Start Time 1440
Pump Stop Time 1510
Sample Time 1505
Sample ID 78-1
Sampled for:
APPENDIX IX+3 EXCLUDING PESTICIDES and HE
(X) VOCs / HCL, 2-40ml VOAs
(X) SVOCs /1 L Amber
(X) Dioxin / 1L Amber
(X) Metals (Total) / HNO3, 500ml Plastic
(X) Cyanide / NaOH, 500ml Plastic
(X) Sulfide / NaOH,ZnAc; 500ml glass - no headspac
(X) PCBs (Total) / 1L Amber

Redevelop? Y N

WELL WATER INFORMATION

Length of Water Column	11.52
Volume of Water in Well	7.6 gallons
Minutes of Pumping	30 min

EVACUATION INFORMATION

Volume of water removed from well 4 Gallons
Evacuation Method: Bailer ( ) Pump (X)
Did well go dry? Y N
Pump Type: GRUNFOS
Water Quality Meter Type(s) / Serial Numbers: YSI and HACH Turbidimeter

Time	Pump Rate (L/min.)	Total Gallons Removed	Water Level (TIC)	Depth to Water	Temp. (Celcius)	pH	Cond. (mS/cm)	Turbidity (NTU)	DO (mg/l)	ORP (mV)
1445	0.350		11.61'		12.60	6.97	0.690	264.5	4.28	138.9
1448	0.350		11.78		12.78	6.74	0.680	167.2	3.28	137.1
1451	0.350		11.85		13.77	6.71	0.679	270.4	3.13	134.6
1454	0.350		12.03		13.78	6.70	0.682	218.1	3.05	132.6
1457	0.350		12.22		12.64	6.68	0.678	66.2	3.05	132.9
1500	0.350		12.43		12.95	6.67	0.670	35.4	3.00	133.8
1503	0.350		12.54		13.47	6.68	0.672	16.8	2.99	134.8
Final	0.350		12.54		13.47	6.68	0.672	16.8	2.99	134.8

MISCELLANEOUS OBSERVATIONS/PROBLEMS

SAMPLE DESTINATION

Laboratory: CT+E Environmental
Delivered Via: Fed Ex
Airbill #:

Field Sampling Coordinator: [signature]

GROUNDWATER SAMPLING FIELD LOG

Well No. 78-6
Key No: —
PID Background (ppm) 0.0
Well Headspace (ppm) 0.3

Site Name On-Site Consolidation Area
Sampling Personnel RL SPR
Date 8/14/99 **Time In / Out** 1430
Weather Sunny ~75°F

WELL INFORMATION

	TIC	BGL
Reference Point Marked on Casing	Y	
Height of Ref. Pt. Relative to Grade	flush	
Well Diameter	4"	
Well Depth	9.31	
Screen Interval Depth	3'-15'	
Water Table Depth	9.05	
Intake Depth of Pump/Tubing	9.55'	

Pump Start Time 1645 / 1515
Pump Stop Time 1655 / 1545
Sample Time 1515
Sample ID 78-6
Sampled for:
APPENDIX IX+3 EXCLUDING PESTICIDES and HEI
(|) VOCs / HCL, 2-40ml VOAs
(|) SVOCs /1 L Amber
(|) Dioxin / 1L Amber
(|) Metals (Total) / HNO3, 500ml Plastic
(|) Cyanide / NaOH, 500ml Plastic
(|) Sulfide / NaOH,ZnAc: 500ml glass - no headspac
(( ) PCBs (Total) / 1L Amber

Redevelop? Y N

WELL WATER INFORMATION

Length of Water Column	0.76
Volume of Water in Well	0.50 gallons.
Minutes of Pumping	10

EVACUATION INFORMATION

Volume of water removed from well 1 gallon
Did well go dry? Y N

Evacuation Method: Bailer ( ) Pump (X)
Pump Type PERISTALTIC

Water Quality Meter Type(s) / Serial Numbers: YSI and HACH Turbidimeter

Time	Pump Rate (L/min.)	Total Gallons Removed	Water Level (TIC)	Depth to Water	Temp. (Celcius)	pH	Cond. (mS/cm)	Turbidity (NTU)	DO (mg/l)	ORP (mV)
1648	.300	—	9.31'		15.46	6.80	2.211	118.5	1.17	-121.7
1651	.300	—	9.48'		14.67	6.65	2.175	60.3	0.98	-113.6
1654	.150		9.52'		16.75	6.70	2.209	101.4	2.73	-100.0
~~1705~~										
~~1710~~										
Final										

MISCELLANEOUS OBSERVATIONS/PROBLEMS *Well went dry @ 1655, will let recovery and ~~[illegible]~~ sample well.

SAMPLE DESTINATION

Laboratory: CT+E Environmental
Delivered Via: Fed Ex
Airbill #:

Field Sampling Coordinator: [signature]

GROUNDWATER SAMPLING FIELD LOG

Well No. H78B-15
Key No. EX-37
PID Background (ppm) 0.0
Well Headspace (ppm) 0.3

Site Name On-Site Consolidation Area
Sampling Personnel SL SPR
Date 6/16/99 Time In / Out 1230
Weather Sunny ~70°F

WELL INFORMATION

	TIC	BGL
Reference Point Marked on Casing	α	
Height of Ref. Pt. Relative to Grade		
Well Diameter	3/4"	
Well Depth	17.98'	
Screen Interval Depth	6-16'	
Water Table Depth	15.14'	
Intake Depth of Pump/Tubing	17'	

Pump Start Time 1310 / 1330
Pump Stop Time 1322 / 1405
Sample Time ~~1405~~ 1345
Sample ID H78B-15
Sampled for:
APPENDIX IX+3 EXCLUDING PESTICIDES and HEI
( ) VOCs / HCL, 2-40ml VOAs
( ) SVOCs /1 L Amber
( ) Dioxin / 1L Amber
( ) Metals (Total) / HNO3, 500ml Plastic
( ) Cyanide / NaOH, 500ml Plastic
( ) Sulfide / NaOH.ZnAc: 500ml glass - no headspac
( ) PCBs (Total) / 1L Amber

Redevelop? Y N (N circled)

WELL WATER INFORMATION

Length of Water Column	2.84'
Volume of Water in Well	
Minutes of Pumping	45 min

EVACUATION INFORMATION

Volume of water removed from well 3 gallons
Did well go dry? Y N (Y circled)
Evacuation Method: Bailer ( ) Pump ✓
Pump Type: Peri. pump
Water Quality Meter Type(s) / Serial Numbers: YSI and HACH Turbidimeter

Time	Pump Rate (L/min.)	Total Gallons Removed	Water Level (TIC)	Depth to Water	Temp. (Celcius)	pH	Cond. (mS/cm)	Turbidity (NTU)	DO (mg/l)	ORP (mV)
1315	0.400		—	—	16.34	6.54	2.493	358.7	4.84	181.1
1318	0.400		—	—	16.61	6.72	2.515	363.2	4.97	183.1
1321	.350		—	—	13.71	6.51	2.343	116.3	5.88	190.5
~~1324~~	~~.250~~									
1333	.250				14.77	6.43	2.461	151.0	5.75	193.0
1336	.250		—	—	13.70	6.39	2.451	58.6	5.47	199.2
1339	.250		—	—	13.72	6.37	2.447	21.6	5.37	203.4
1342	.250				13.82	6.34	2.443	17.0	5.17	205.6
[illegible]										
Final										

MISCELLANEOUS OBSERVATIONS/PROBLEMS Well went dry @ 1322, will let recovery and start again.

SAMPLE DESTINATION

Laboratory: CT+E Environmental
Delivered Via: Fed Ex
Airbill #:

Field Sampling Coordinator: [signature]

GROUNDWATER SAMPLING FIELD LOG

Well No. NY-4
Key No. —
PID Background (ppm) 0.0
Well Headspace (ppm) 0.0

Site Name On-Site Consolidation Area
Sampling Personnel SLL, SPR
Date 6/14/99 **Time In / Out** 1200 / 1300
Weather Partly cloudy, 80°F

WELL INFORMATION

	TIC	BGL
Reference Point Marked on Casing	X	
Height of Ref. Pt. Relative to Grade	Flush	
Well Diameter	2"	
Well Depth	31.37	
Screen Interval Depth	17'-31'	
Water Table Depth	9.91'	
Intake Depth of Pump/Tubing	25'	

Pump Start Time 1205
Pump Stop Time 1240
Sample Time 1235
Sample ID NY-4
Sampled for:
APPENDIX IX+3 EXCLUDING PESTICIDES and HEI
(X) VOCs / HCL, 2-40ml VOAs
(X) SVOCs /1 L Amber
(X) Dioxin / 1L Amber
(X) Metals (Total) / HNO3, 500ml Plastic
(X) Cyanide / NaOH, 500ml Plastic
(X) Sulfide / NaOH,ZnAc; 500ml glass - no headspac
(X) PCBs (Total) / 1L Amber

Redevelop? Y N

WELL WATER INFORMATION

Length of Water Column	21.46
Volume of Water in Well	3.50
Minutes of Pumping	35 min

EVACUATION INFORMATION

Volume of water removed from well 4 Gallons
Did well go dry? Y N
Evacuation Method: Bailer ( ) Pump (X)
Pump Type: GRUNFOS
Water Quality Meter Type(s) / Serial Numbers: YSI and HACH Turbidimeter

Time	Pump Rate (L/min.)	Total Gallons Removed	Water Level (TIC)	Depth to Water	Temp. (Celcius)	pH	Cond. (mS/cm)	Turbidity (NTU)	DO (mg/l)	ORP (mV)
1210	.400	.25	11.90		10.27	7.73	0.385	313.2	4.30	134.4
1213	.400		12.90		10.60	7.51	0.390	191.6	2.98	142.9
1216	.400		14.33		10.42	7.48	.394	59.5	2.41	146.0
1219	400		14.31		11.16	7.49	[illegible]	57.3	2.22	148.4
1221	.400	15.37	~~[illegible]~~		12.11	7.52	0.387	46.5	2.04	151.0
1224	0.400		[illegible]		12.52	7.51	0.385	41.7	2.01	153.0
1227	0.400		16.47		12.81	7.57	0.385	39.0	1.95	155.3
1230	0.400		17.93		13.07	7.62	0.380	38.8	2.04	155.2
Final	400		17.93		13.07	7.62	0.380	38.8	2.04	155.2

MISCELLANEOUS OBSERVATIONS/PROBLEMS

SAMPLE DESTINATION

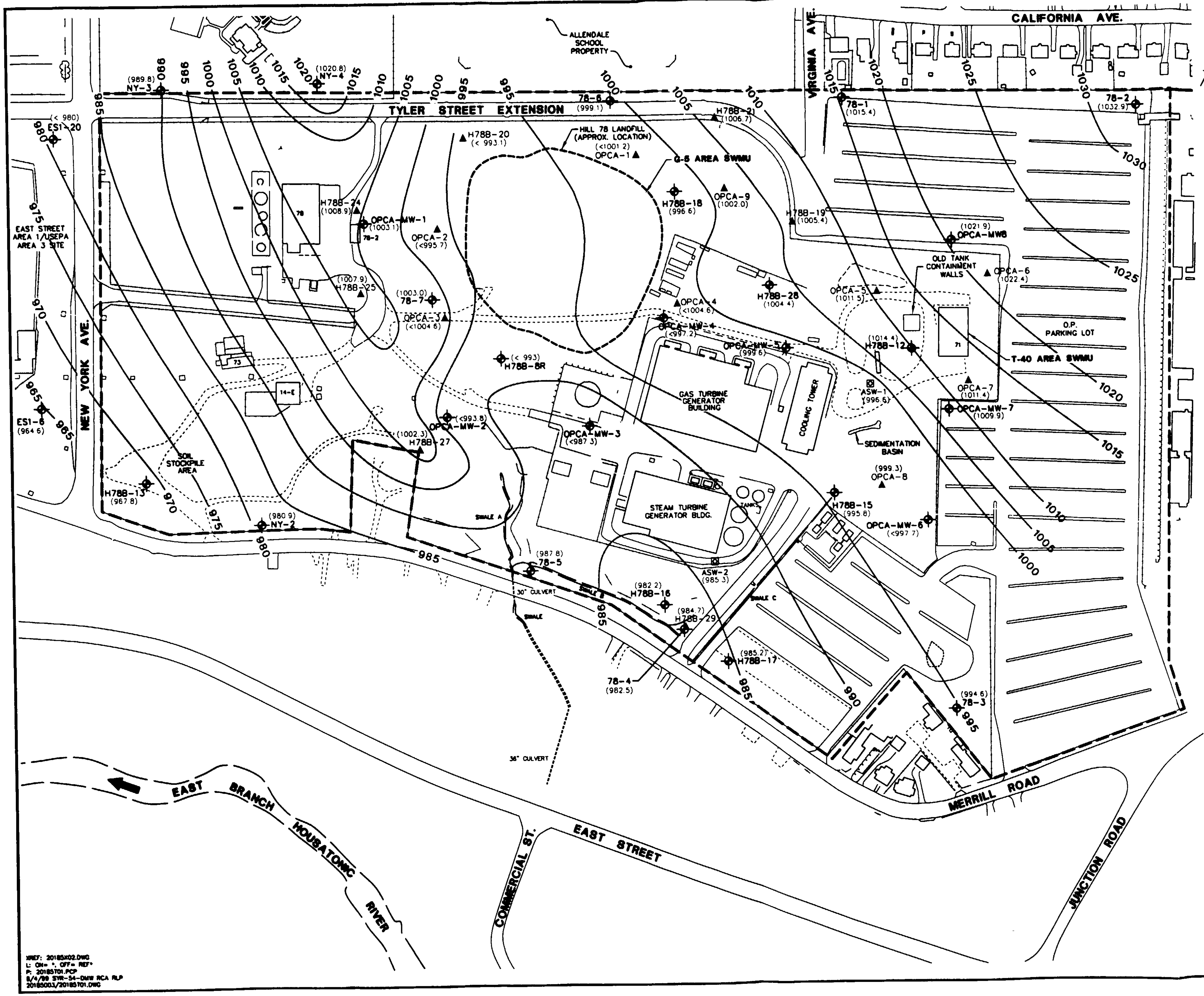
Laboratory: CT+E Environmental
Delivered Via: Fed Ex
Airbill #:

Field Sampling Coordinator: [signature]

Attachment C

BLASLAND, BOUCK & LEE, INC.
engineers & scientists

Hill 78 Area - Top of Till Contours



LEGEND:

- APPROXIMATE SITE BOUNDARY
- FENCELINE
- H78B-15 EXISTING MONITORING WELL LOCATION
- ASW-4 DEEP WATER SUPPLY WELL LOCATION (INSTALLED SEPT. 1988 - MAY 1991)
- ▲ OPCA-8 EXISTING SOIL BORING LOCATION
- (995.8) TOP OF TILL ELEVATION (FEET)
- (< 993) THE TILL UNIT WAS NOT ENCOUNTERED WITHIN THE TOTAL DEPTH OF THE BORING. THE ELEVATION GIVEN WITH A LESS THAN SIGN (<) IS THE ELEVATION OF THE BASE OF BORING AND THE TOP OF TILL UNIT IS INTERPRETED TO BE BELOW THAT DEPTH
- 995 TOP OF TILL ELEVATION CONTOUR LINE (FEET)

Original includes color coding.

NOTES:

1. MAPPING BASED ON AUTOCAD DRAWING FILE (PLANT3.CAD) AS PROVID D BY GE AND ADDITIONAL INFORMATION FROM THE MCP PHASE II SCOPE OF WO K AND PROPOSAL FOR RCRA FACILITY INVESTIGATION (O'BRIEN & GERE ENGIN ERS, INC., FEBRUARY 1996) AS WELL AS SUPPLEMENTAL SITE SURVEY INFO MATION OBTAINED BY HILL ENGINEERS, PLANNERS & ARCHITECTS (WEEK OF M. Y 29, 1997). LOCATIONS SOUTH OF MERRILL ROAD DIGITIZED FROM AUGUST 1990 AIR PHOTO AND ARE APPROXIMATE.
2. SITE BOUNDARY IS APPROXIMATE.
3. PRE-1996 SAMPLE LOCATIONS ARE APPROXIMATE. POST-1996 SAMPLE LOCATIONS SURVEYED BY HILL ENGINEERS, PLANNERS & ARCHITECTS OR BLASLAND, BOUCK AND LEE, INC.
4. ELEVATIONS REFERENCED TO NGVD OF 1929.

100' 0 100' 200'
SCALE

GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS
HILL 78 AREA/USEPA AREA 2

TOP OF TILL CONTOURS

BBL BLASLAND, BOUCK & LEE, INC. engineers & scientists

FIGURE 1

XREF: 20185X02.DWG
L: ON=*, OFF=REF*
P: 20185T01.PCP
6/4/99 SYR-54-DMW RCA RLP
20185003/20185T01.DWG

Attachment D

BLASLAND, BOUCK & LEE, INC.
engineers & scientists

Storm Sewer Soil Sampling Results

GENERAL ELECTRIC COMPANY - PITTSFIELD, MASSACHUSETTS
HILL78/USEPA AREA 2

ON PLANT CONSOLIDATION AREA STORM SEWER RELOCATION SAMPLING
SOIL BORING DATA
Results in parts per million(ppm), dry-weight

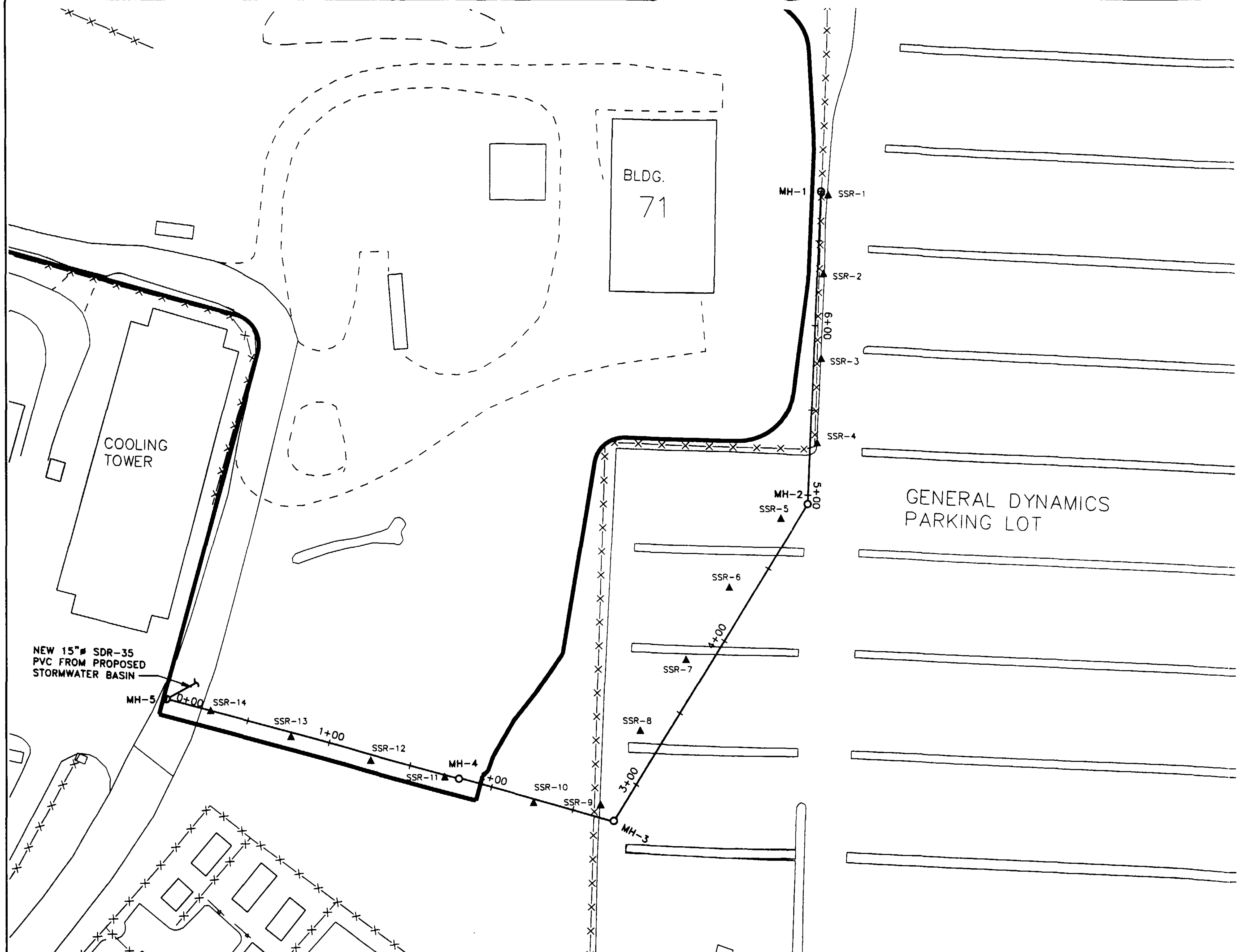
Sample ID	Depth (feet)	Date Collected	Aroclor-1254	Aroclor-1260	Total PCBs
SSR-1	0 - 2	6/3/99	ND(0.036)	0.34	0.34
	2 - 4	6/3/99	ND(0.042)[ND(0.038]	0.037 J [ND(0.038]	0.037 J [ND(0.038]
	4 - 6	6/3/99	ND(0.037)	ND(0.037)	ND(0.037)
	6 - 8	6/3/99	ND(0.037)	ND(0.037)	ND(0.037)
	8 - 10	6/3/99	ND(0.037)	ND(0.037)	ND(0.037)
	10 - 12	6/3/99	ND(0.037)	ND(0.037)	ND(0.037)
SSR-2	0 - 2	6/3/99	0.10	ND(0.036)	0.10
	2 - 4	6/3/99	ND(0.039)	ND(0.039)	ND(0.039)
	4 - 6	6/3/99	ND(0.036)	0.039	0.039
	6 - 8	6/3/99	ND(0.046)	0.029 J	0.029 J
	8 - 10	6/3/99	ND(0.036)	0.014 J	0.014 J
	10 - 12	6/3/99	ND(0.036)	0.013 J	0.013 J
	12 - 14	6/3/99	ND(0.037)	ND(0.037)	ND(0.037)
SSR-3	0 - 2	6/3/99	ND(0.036)	0.040	0.040
	2 - 4	6/3/99	ND(0.036)	ND(0.036)	ND(0.036)
	4 - 6	6/3/99	ND(0.036)	ND(0.036)	ND(0.036)
	6 - 8	6/3/99	ND(0.036)	ND(0.036)	ND(0.036)
	8 - 10	6/3/99	ND(0.037)	ND(0.037)	ND(0.037)
	10 - 12	6/3/99	ND(0.037)	0.020 J	0.020 J
	12 - 14	6/3/99	ND(0.037)	ND(0.037)	ND(0.037)
SSR-4	0 - 2	6/3/99	0.074	ND(0.034)	0.074
	2 - 4	6/3/99	ND(0.036) [ND(0.036]	ND(0.036) [0.018 J]	ND(0.036) [0.018 J]
	4 - 6	6/3/99	ND(0.035)	ND(0.035)	ND(0.035)
	6 - 8	6/3/99	ND(0.036)	ND(0.036)	ND(0.036)
	8 - 10	6/3/99	ND(0.037)	ND(0.037)	ND(0.037)
	10 - 12	6/3/99	ND(0.039)	ND(0.039)	ND(0.039)
	12 - 14	6/3/99	ND(0.037)	0.019 J	0.019 J
SSR-5	0 - 2	6/3/99	ND(0.036)	ND(0.036)	ND(0.036)
	2 - 4	6/3/99	ND(0.034)	ND(0.034)	ND(0.034)
	4 - 6	6/3/99	ND(0.037)	0.054	0.054
	6 - 8	6/3/99	ND(0.039)	ND(0.039)	ND(0.039)
	8 - 10	6/3/99	ND(0.038)	0.024 J	0.024 J
	10 - 12	6/3/99	ND(0.037)	ND(0.037)	ND(0.037)
SSR-6	0 - 2	6/3/99	ND(0.035)	ND(0.035)	ND(0.035)
	2 - 4	6/3/99	ND(0.036)	ND(0.036)	ND(0.036)
	4 - 6	6/3/99	ND(0.036)	0.015 J	0.015 J
	6 - 8	6/3/99	ND(0.037)	ND(0.037)	ND(0.037)
	8 - 10	6/3/99	ND(0.038)	0.051	0.051
	10 - 12	6/3/99	ND(0.038)	ND(0.038)	ND(0.038)
SSR-7	0 - 2	6/3/99	ND(0.037)	ND(0.037)	ND(0.037)
	2 - 4	6/3/99	ND(0.036) [ND(0.037]	ND(0.036) [ND(0.037]	ND(0.036) [ND(0.037]
	4 - 6	6/3/99	ND(0.035)	ND(0.035)	ND(0.035)
	6 - 8	6/3/99	ND(0.034)	ND(0.034)	ND(0.034)
	8 - 10	6/3/99	ND(0.034)	ND(0.034)	ND(0.034)
	10 - 12	6/3/99	ND(0.036)	ND(0.036)	ND(0.036)

GENERAL ELECTRIC COMPANY - PITTSFIELD, MASSACHUSETTS
HILL78/USEPA AREA 2

ON PLANT CONSOLIDATION AREA STORM SEWER RELOCATION SAMPLING
SOIL BORING DATA
Results in parts per million(ppm), dry-weight

Sample ID	Depth (feet)	Date Collected	Aroclor-1254	Aroclor-1260	Total PCBs
SSR-8	0 - 2	6/4/99	ND(0.037)	ND(0.037)	ND(0.037)
	2 - 4	6/4/99	ND(0.038)	0.040	0.040
	4 - 6	6/4/99	ND(0.035)	ND(0.035)	ND(0.035)
	6 - 8	6/4/99	ND(0.037)	ND(0.037)	ND(0.037)
	8 - 10	6/4/99	ND(0.035)	ND(0.035)	ND(0.035)
	10 - 12	6/4/99	ND(0.037)	ND(0.037)	ND(0.037)
SSR-9	0 - 2	6/4/99	ND(0.036)	0.19	0.19
	2 - 4	6/4/99	ND(0.034)	ND(0.034)	ND(0.034)
	4 - 6	6/4/99	ND(0.034)	ND(0.034)	ND(0.034)
	6 - 8	6/4/99	ND(0.035)	ND(0.035)	ND(0.035)
	8 - 10	6/4/99	ND(0.036)	ND(0.036)	ND(0.036)
	10 - 12	6/4/99	ND(0.037)	ND(0.037)	ND(0.037)
SSR-10	0 - 2	6/4/99	ND(0.035)	0.26	0.26
	2 - 4	6/4/99	ND(0.037)	ND(0.037)	ND(0.037)
	4 - 6	6/4/99	ND(0.036)	ND(0.036)	ND(0.036)
	6 - 8	6/4/99	ND(0.035)	ND(0.035)	ND(0.035)
	8 - 10	6/4/99	ND(0.035)	ND(0.035)	ND(0.035)
SSR-11	0 - 2	6/4/99	ND(0.036)	0.053	0.053
	2 - 4	6/4/99	ND(0.034)	ND(0.034)	ND(0.034)
	4 - 6	6/4/99	ND(0.035)	ND(0.035)	ND(0.035)
	6 - 8	6/4/99	ND(0.035)	ND(0.035)	ND(0.035)
	8 - 10	6/4/99	ND(0.034)	ND(0.034)	ND(0.034)
SSR-12	0 - 2	6/4/99	0.28	ND(0.035)	0.28
	2 - 4	6/4/99	ND(0.034)	ND(0.034)	ND(0.034)
	4 - 6	6/4/99	ND(0.035)	ND(0.035)	ND(0.035)
	6 - 8	6/4/99	ND(0.034) [ND(0.034)]	ND(0.034) [ND(0.034)]	ND(0.034) [ND(0.034)]
	8 - 10	6/4/99	ND(0.034)	ND(0.034)	ND(0.034)
SSR-13	0 - 2	6/4/99	8.6	ND(0.70)	8.6
	2 - 4	6/4/99	ND(0.035)	ND(0.035)	ND(0.035)
	4 - 6	6/4/99	ND(0.035)	ND(0.035)	ND(0.035)
	6 - 8	6/4/99	ND(0.034)	ND(0.034)	ND(0.034)
	8 - 10	6/4/99	ND(0.036)	ND(0.036)	ND(0.036)
SSR-14	0 - 2	6/4/99	ND(1.8) [ND(0.70)]	43 [6.6]	43 [6.6]
	2 - 4	6/4/99	4.9	ND(0.34)	4.9
	4 - 6	6/4/99	0.94	ND(0.037)	0.94
	6 - 8	6/4/99	ND(0.035)	ND(0.035)	ND(0.035)
	8 - 10	6/4/99	0.41	ND(0.036)	0.41

Notes:
1. Samples were collected by Blasland, Bouck & Lee, Inc., and were submitted to CT&E Environmental Services, Inc. for analysis of PCBs.
2. ND - Analyte was not detected. The value in parentheses is the associated detection limit.
3. Duplicate results are presented in brackets.
4. J - Indicates an estimated value less than the CLP-required quantitation limit.



LEGEND:

- APPROXIMATE BOUNDARYOF PROPOSED BUILDING 71 CONSOLIDATION AREAS
- EXISTING SECURITY FENCE
- SSR-1 SAMPLE LOCATION
- MH-1 PROPOSED STORM SEWER PIPING AND MANHOLE

NOTES:

1. MAPPING IS BASED ON AERIAL PHOTOGRAPHS AND PHOTOGRAMMETRIC MAPPING BY LOCKWOOD MAPPING, INC. -FLOWN IN APRIL 1990; DATA PROVIDED BY GENERAL ELECTRIC COMPANY; AND BLASLAND, BOUCK & LEE, INC. (BBL) CONSTRUCTION PLANS, AND ON OBSERVATIONS DURING A SITE VISIT BY BBL PERSONNEL ON DECEMBER 3, 1997.
2. SITE BOUNDARIES ARE APPROXIMATE.
3. NOT ALL PHYSICAL FEATURES SHOWN.

Original includes color coding.

0 30' 60'
GRAPHIC SCALE

GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS
DETAILED WORK PLAN FOR
ON-PLANT CONSOLIDATION AREAS

STORM SEWER RELOCATION
SAMPLING LOCATIONS

BBL BLASLAND, BOUCK & LEE, INC.
engineers & scientists

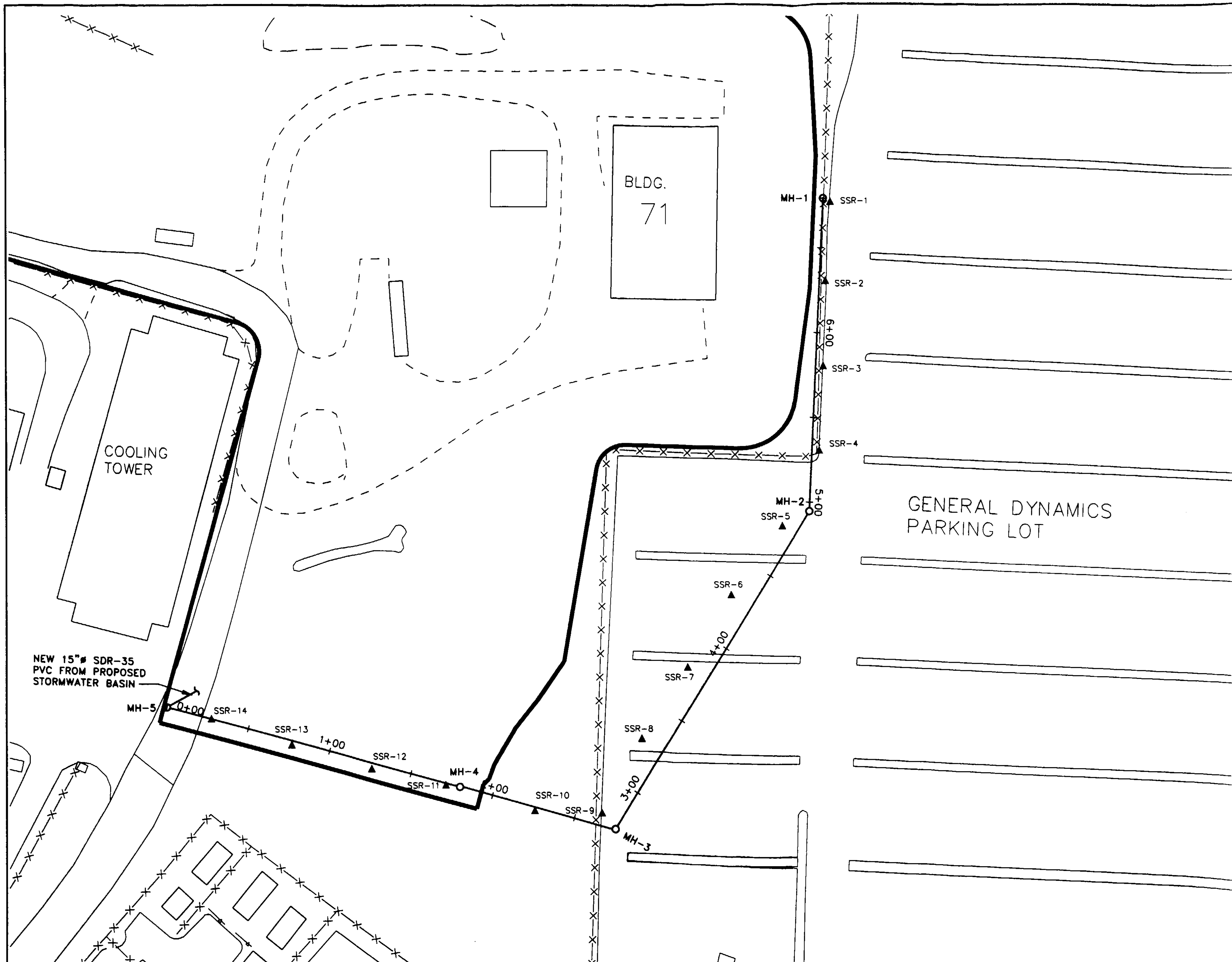
FIGURE
2

X: 20185X01.DWG
L: ON=*, OFF=*REF*
P: STD-PCP/DL.PCP
8/4/99 SYR-54-GMS RLP
20185003/REPORT/20185B08.DWG

Attachment E

BLASLAND, BOUCK & LEE, INC.
engineers & scientists

MDEP Protocols for Well Decommissioning



LEGEND:

APPROXIMATE BOUNDARYOF PROPOSED BUILDING 71 CONSOLIDATION AREAS

EXISTING SECURITY FENCE

SSR-1 SAMPLE LOCATION

MH-1 PROPOSED STORM SEWER PIPING AND MANHOLE

NOTES:

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3. NOT ALL PHYSICAL FEATURES SHOWN.

Original includes color coding.

0 30' 60'
GRAPHIC SCALE

GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS
DETAILED WORK PLAN FOR
ON-PLANT CONSOLIDATION AREAS

STORM SEWER RELOCATION SAMPLING LOCATIONS

BBL BLASLAND, BOUCK & LEE, INC. engineers & scientists

FIGURE 2

X: 20185X01.DWG
L: ON=*, OFF=*REF*
P: STD-PCP/DL.PCP
8/4/99 SYR-54-GMS RLP
20185003/REPORT/20185B08.DWG

COMMONWEALTH OF MASSACHUSETTS

DEPARTMENT OF ENVIRONMENTAL PROTECTION

STANDARD REFERENCES FOR MONITORING WELLS

SECTION 4.6 DECOMMISSIONING OF MONITORING WELLS

SECTION 4.6
DECOMMISSIONING OF MONITORING WELLS

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4.6 DECOMMISSIONING OF MONITORING WELLS

4.6-1 PURPOSE

Any abandoned monitoring well that is no longer in use or that is unfit for its intended purposes should be decommissioned. Plugging the well and surface restoration are the central features of the decommissioning process. Plugging consists of constructing a low permeability cylinder or plug within that portion of the subsurface occupied by the well and its annulus, including the uncased portion of bedrock wells as well as the cased portion. Surface restoration consists of the removal of the upper three to four feet of the well and backfilling the area with an effective seal. An abandoned monitoring well has been defined for the purpose of these Standard References (SRs) as "a well whose use has been permanently discontinued; as used in these References it includes a monitoring well, piezometer, or observation well that is no longer suitable for use either for water-level measurements or water quality sampling."

Proper plugging of such wells will:

- Eliminate physical hazards
- Prevent ground water contamination
- Conserve the yield and hydrostatic head of confined aquifers
- Prevent the intermingling of potable and non-potable ground water, and
- Prevent the migration of contamination through a confining layer separating aquifers.

It should be noted that the objective in Massachusetts differs markedly from the goals established by the American Water Works Association and the statutes, regulations, or guidelines of most other states. Many documents contain the following language: "The basic concept of proper sealing of abandoned wells is restoration, as far as feasible, of the controlling hydrogeological conditions that existed before the well was drilled and constructed. If this restoration can be accomplished, all the objectives of plugging wells will be adequately fulfilled." To accomplish this goal some states have suggested the placement of sand and gravel opposite the more permeable subsurface zones and clay opposite less permeable zones. While that goal is an admirable one, it is also one which, in DEP's opinion, is unattainable in practice. In order to meet the objectives of proper plugging as stated above, DEP has tried to develop a simple, workable approach that will solve the existing and potential problems from unsafe abandoned wells.

Some examples of the types of unsafe wells that may cause problems include:

- Buried uncapped wells: contaminants may enter the well through the buried top of the casing, travel down the well casing, and enter the aquifer through the well screen and wall of the annulus;
- Wells with cracked or corroded casing: surface water may enter the well;
- Improperly constructed wells: an unsealed or improperly sealed annular space around the outside of a well casing or between an inner and outer casing may serve as a channel for surface water to migrate into an aquifer and/or ground water may be transferred from one aquifer to another;
- Open hole wells in bedrock: may serve to interconnect aquifers in different formations;
- Unplugged abandoned flowing artesian wells: this can result in a loss of water, reduction of regional artesian head and localized surface flooding; and
- Uncovered and unplugged abandoned wells with large inside diameter: these may represent a physical hazard to human beings and animals, as well as a disposal receptacle for contaminants, waste, and debris.

4.6-2 PRELIMINARY WORK TO BE PERFORMED BEFORE UNDERTAKING WELL PLUGGING

4.6-2.1 Who Can Perform Proper Well Decommissioning?

One should be a registered well driller in Massachusetts or a person knowledgeable with the installation of wells in order to decommission them. There is no nationally recognized or state-approved examination or certification process for well decommissioning and plugging. However, it is obvious that a well contractor or person who is familiar with well construction and the geologic conditions of the region is preferable to a person who does not routinely perform such work. If the existing well must be "over drilled" then a registered Massachusetts well driller must perform the work. It is expected that an experienced well contractor will be familiar with the correct procedures to follow. That experience should provide substantial savings to the property owner in the long run.

The property owner should ask the well contractor about his qualifications. Some drillers or contractors specialize in rock wells; others in overburden wells. Some have worked extensively with multi-level wells at sites with contaminated ground water; others have only worked with single-level, cased water wells.

4.6-2.2 Location and Inspection

Locating the abandoned well is the first step in decommissioning. While some wells are easily located, others may be buried or otherwise concealed. It may be possible to find the location of abandoned wells through contact with past land owners, occupants, retired workers, neighbors, or well contractors. Regulatory officials and hydrogeologic reports may have useful information. The well records maintained by the United States Geological Survey (USGS), Water Supply Division, Massachusetts Section, with headquarters in Marlborough, Massachusetts, all have been assigned coordinates of latitude and longitude. For well locations, historic documents may be used, such as aerial photo and assessing maps, insurance company maps or photographs. Metal detectors may be of value in locating buried metal casings.

Obtaining accurate information on the well's original construction and present condition is the next step in decommissioning. This information is best obtained from monitoring well drilling records. Recent well records may be obtained from local Boards of Health, the Water Resources Division of the Department of Environmental Management (DEM), USGS Water Resources Division, or DEP.

Next a site inspection is necessary to ascertain the condition of the well and to note if the well is accessible, located in a pit or buried, if a dedicated pump is in place, or if the well is currently operating. The inspection should also note if the well has been damaged or obstructed. A downhole TV camera survey can sometimes provide valuable information as it can verify the current well depth, condition, construction, and the presence or absence of well casing in rock wells.

4.6-2.3 Clearing the Well

Decommissioning a well starts with removal of any obstructions, such as drop pipes, check valves and pumps, and clearing any obstacles or debris that may have entered the well.

When the well is obstructed by pumps or other equipment have been dropped down the well, the debris must be removed or "fished" out before the well can be sealed. A variety of fishing tools are used to remove obstructions. Threaded taps on the end of a drill rod may be run into the hole in an attempt to screw into the top of a pump or drop pipe. An other type of equipment used is an "over shot" (a casing with inner teeth that is run over the obstacle to be removed). Corkscrews and spears also have been used to hook the obstacle for removal.

In some instances the driller may chop or grind up the obstacles in an attempt to clear the well. Debris or other materials such as rock, sand, clay, stones, and wood is usually drilled out or washed out of the hole. This technique appears to be suitable for destroying multi-level wells installed within a single borehole.

4.6-2.4 Casing Removal or Destruction

Assuming the original well did not have an adequate seal in the annular space outside the well casing, in most cases the original well casing should be destroyed in place or pulled out of the ground.

However, if the As-Built Notes and Records indicate that the annular space contains an adequate seal, this information should enable the well contractor to design a simpler and less costly decommissioning procedure. The procedure should not require destruction or removal of the entire well casing, but would require adequate perforation of any well screen to allow the grout to penetrate the filter pack. Insert neat cement grout (or its equivalent) into the uncased portion of a bedrock well or into the filter pack around the well screen and fill the riser pipe with the same grout material. Figures 4.6-1 through 4.6-3 show the zones to be plugged through the well riser for three types of well installation where the annular space contains an adequate seal. Terminate the well casing at a minimum of 3 to 4 feet below the land surface or at the water table, which ever is encountered first. Finally, finish off the well at the land surface in a manner as described in Section 4.6-4. Figures 4.6-1 through 4.6-3 also show the zones to be prepared for a new surface finish. This procedure is appropriate for monitoring wells installed under all types of hydrogeologic conditions.

In instances where a well has penetrated a confining layer separating aquifers and there is no evidence that the annular space around the casing was adequately sealed during installation, the most conservative approach is to destroy or remove the casing by over drilling. Simply pulling the casing in this situation may result in the collapse of the formation before an adequate seal can be placed across the confining layer. The easiest way to over drill and keep the cutting bit in line with the hole (rather than straying off the hole) would be to spin casing over and around the existing observation well. The observation well will help hold the casing in line with the borehole as opposed to roller-bitting operations where an in-place casing will tend to deflect the cutting bit. Augers would probably also work in lieu of spinning casing, but spinning casing would probably be better as it is less likely to damage the observation well and, therefore, continue down the hole rather than veering off.

If, however, vertical contaminant migration across aquifers is not a concern, such as a shallow (15-30 feet) water table well in glacial sands and gravels, a choice may be made to either over drill the well, pull the well casing out of the ground or to plug the well in place. In this case, the presence or absence of annular seal is not a factor. If attempts are made to pull the casing out of the ground and the hole collapses, care must be taken to compact the materials in the hole to avoid future subsidence at the surface. Regardless of which method is chosen, the most important consideration is to seal the well from possible surface infiltration. This is accomplished by plugging the well/boring (Section 4.6-3) and terminating the well 3 to 4 feet below grade then backfilling with concrete or other appropriate seal (Section 4.6-4).

If asbestos well casing is encountered or suspected, plugging the well is the only choice. No attempt should be made to destroy or remove this material from the ground as the risk of creating a friable asbestos problem outweighs the potential negative impact from the well.

4.6-3 PLUGGING THE WELL

Neat cement (or its equivalent) should be inserted into the open portion of the well bore, whether the opening is in bedrock or overburden. As noted above, special care must be exercised if the well penetrates a confined aquifer. The low permeability layer that creates the confined aquifer must be sealed so that there is no chance of leakage between aquifers. If the hydrostatic head is large, this may present an extreme challenge to the well contractors.

4.6-3.1 Grouting Material

There are a large number of grouts available that can be used to plug abandoned wells. Each grout has certain special characteristics and distinctive properties. Therefore, one grout may be especially suited for doing a particular job. The selection of the most appropriate material or combination of materials is dependant on the construction of the well, the nature of the formation penetrated, the material and equipment available, the location of the well with respect to sources of contamination, and the cost of doing the work.

At the present time, a neat cement grout possesses most of the advantages that DEP looks for in a plug for abandoned wells where the grout will be inserted through the well riser. It may be used as grout for abandoned wells installed in all geologic formations. Neat cement is superior for sealing small openings, for penetrating any annular space outside of casings, and for filling voids in the surrounding formation. When applied under pressure, it is strongly favored for sealing wells under artesian pressure or those encountering more than one aquifer. Neat cement is also superior to other grouts as it avoids the danger of separation.

The use of bentonite pellets to plug the saturated portions of a well with a neat cement plug above is an acceptable but, less satisfactory method. The use of bentonite pellets is recommended solely for plugging shallow (15-30 feet) water table wells in highly permeable aquifers where there is no threat of vertical migration of contamination and where bridging is less likely. Care must be taken to compact the bentonite to avoid bridging of the pellets in the casing. See Section 4.2 Specifications for Wells, Screen, Filters, and Seals, for a more thorough treatment of this subject.

If the original well was not properly sealed or if there is not sufficient information available to determine whether a well was properly sealed, the most appropriate grout for such purposes appears to be a bentonite/cement grout, such as is recommended in Section 3.9 Plugging Boreholes.

4.6-3.2 Grout Placement

After clearing of the well bore, the well is ready for sealing. Grout slurries must be placed from the bottom to the top and not from the top to the bottom. In other words, slurries cannot be poured from the land surface into the borehole, annular space, or well to be sealed. When grout is placed at the bottom of the space to be grouted and finally appears at the surface or top, the integrity of the plug is assured. Methods involving pouring grout from the surface into the annular space are not reliable because bridging may occur and the depth of grout descent cannot be easily verified. However, pouring grout through a tremie tube is sometimes a satisfactory alternative to pumping through a tremie tube. An improperly sealed well may be as much a threat to ground water quality as an unsealed well.

The well contractor should calculate the volume of slurry that will be needed as described below in Section 4.6-3.3. He should have enough mixed slurry ready for placement so that it will not be necessary to stop the grouting process in order to prepare more slurry. Due to borehole irregularities, it is advisable to have on hand 25 to 50% more slurry than the calculated volume.

Grouting methods are discussed in detail in Section 4.3, Installation of Monitoring Wells. The grout pipe (or tremie pipe) method, either with or without a grout pump, appears to be a method of grout placement that will achieve all the objectives of the well plugging program.

A vigorous preventative maintenance program for mixing and pumping equipment, compressors, hoses and fittings, is essential. This includes adequate clean-up of equipment after each grout job. Failure of equipment in the field can result in: waste of grouting material, lost labor and equipment costs, property damage, contamination of the grout, and/or an unsuccessful or incomplete grout job.

4.6-3.3 Calculations and Measurements

To assure that a well is properly plugged and that there has been no bridging of the material, verification calculations and measurements are made by the well contractor to determine whether the volume of material placed in the well equals or exceeds the volume of the casing or the hole that has been plugged and/or filled. Some useful formulas for calculating well volumes are shown below:

- Gallons per 100 feet = 4.08 x (Inside Hole or Casing Diameter)^2

- Cubic feet of grout per 100 feet = 0.55 x (Inside Hole or Casing Diameter)^2

- 7.48 gallons = 1 cubic foot

- 202.0 gallons = 1 cubic yard

4.6-4 FINAL SURFACE FINISH

The contractor should return to the well no sooner than 24 hours after sealing to allow time for settlement. A proper surface seal is the final step in decommissioning a well. Where a concrete surface seal is appropriate, the remaining 3 to 4 feet at the top of the well should be filled with concrete. Form the top to create a concrete slab at least six inches thick above grade, and with a diameter at least two feet greater than the borehole wall. This procedure is more fully described in Section 4.3 Installation of Wells.

Where a concrete surface seal is not compatible with the existing land-uses (i.e., agriculture, shopping malls, residential areas, etc.) the borehole or well riser should be terminated with a minimum 1 foot thick concrete plug. The remaining 3 to 4 foot portion of the borehole should be filled to grade with materials compatible with the abutting land surface and properly compacted to minimize subsidence.

4.6-5 RECORD OF DECOMMISSIONING

Complete, accurate records of the entire decommissioning procedure should be maintained by the property owner and well contractor. The following items are especially noteworthy:

- <u>Depth sealed</u> The depth of all plugging materials should be recorded.
- <u>Quantity of sealing material used</u> The quantity of sealing material used should be recorded. Measurements of static levels and depths should be recorded.
- <u>Changes recorded</u> Any changes in the well made during the plugging, such as perforating casing, should be recorded in detail.

Examples of Abandoned Well Reports required by the states of Minnesota and Iowa are included as Figures 4.6-4 and 4.6-5.

4.6-6 PROHIBITIONS

The use of explosives in well-plugging operations is strictly prohibited.

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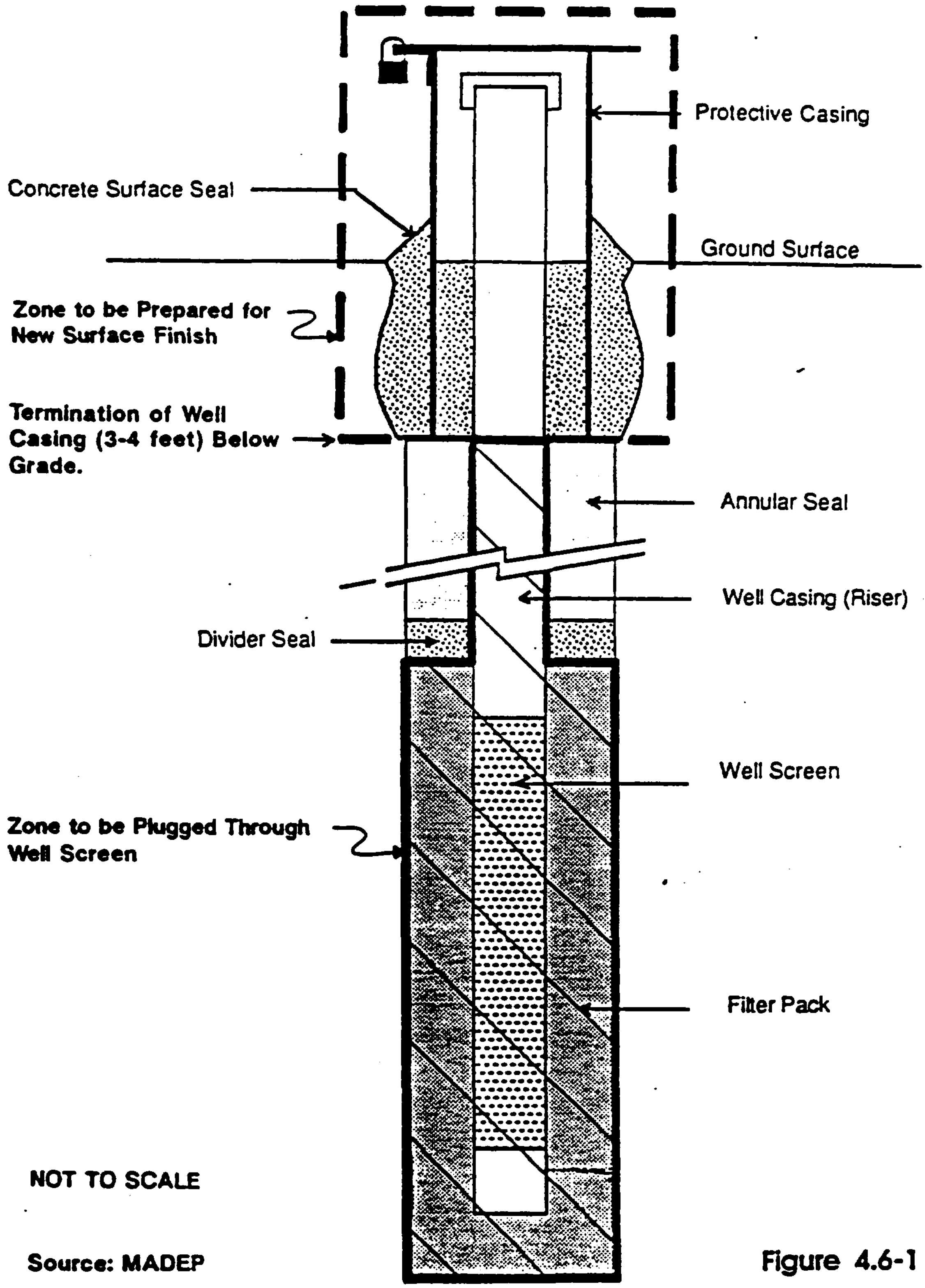
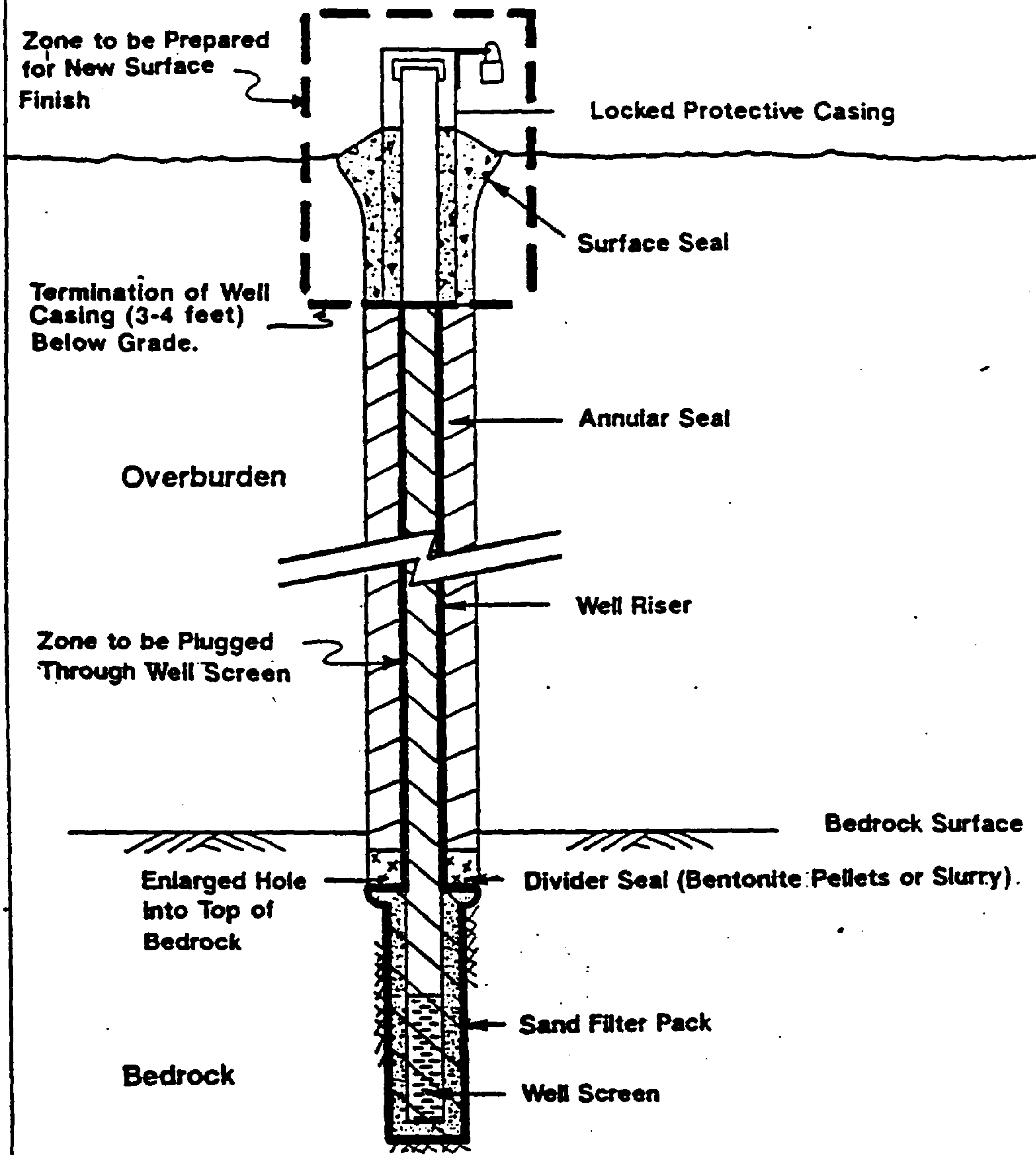
4.6.3	Diagram of an Abandoned Well (Open Hole Well in Bedrock)	11
4.6-4	Example of Minnesota Abandoned Well Report	12
4.6-5	Example of Iowa Abandoned Water Well Plugging Record	13



Source: MADEP

Figure 4.6-1

Diagram of an Abandoned Overburden Well.

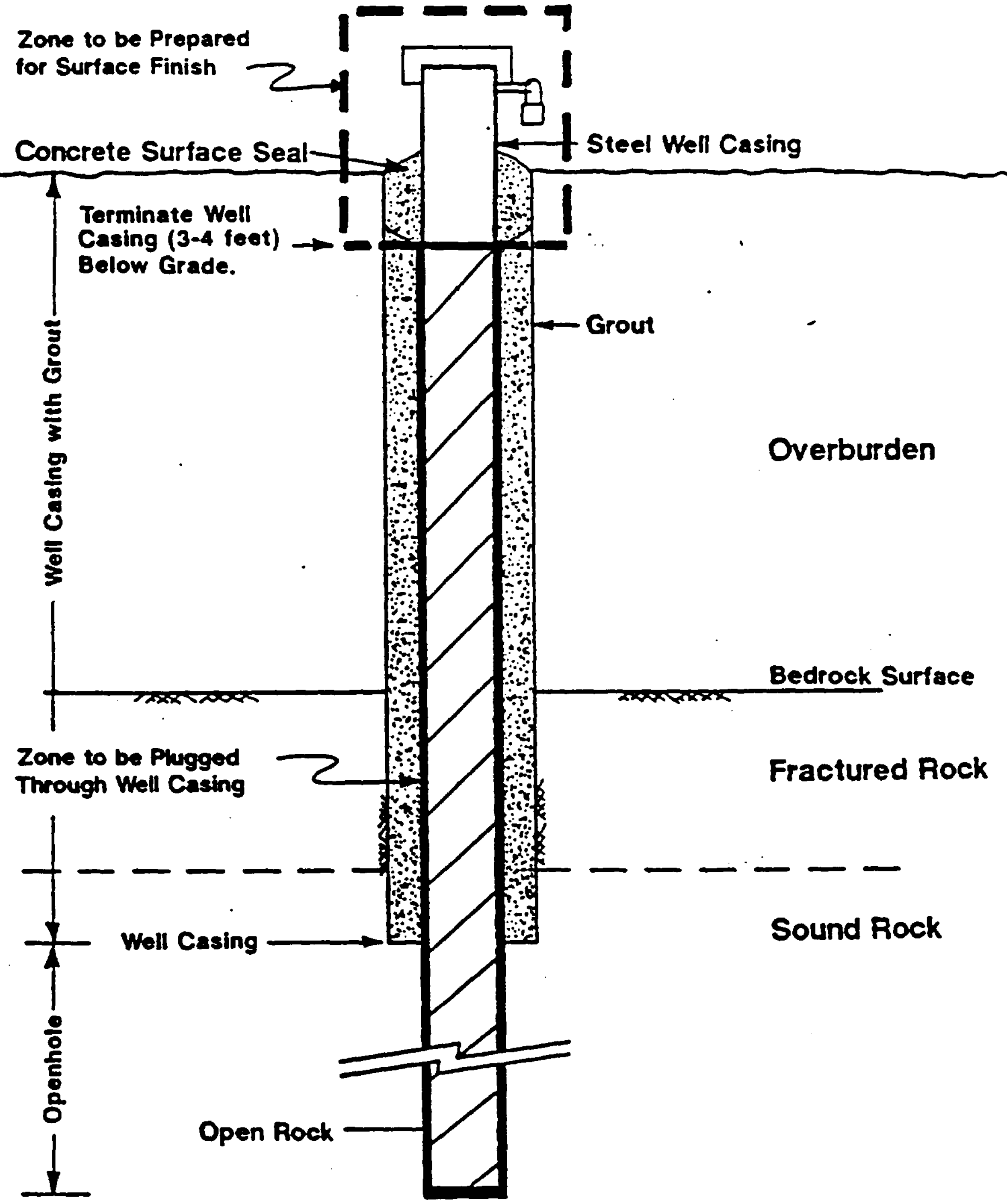


Source: MADEP

NOT TO SCALE

Figure 4.6-2

Diagram of an Abandoned Bedrock Well with Screen.



NOT TO SCALE

Source: MADEP

Figure 4.6-3

Diagram of an Abandoned Bedrock Well-Open Hole.

WATER WELL RECORD

ABANDONED

County: Anoka

Township Name	Township	Range	Section	Fraction
Oaktree	120	22	16	NW SE SE

Well Depth: 126'

Date of Completion: drilled 1948

100' East of Co. Rd 9, 200' South of Co Rd 2

Addition Name: Red Oaks
Block Number: 2
Lot Number: 1

Co Rd 2
well
Co Rd 9

Property Owner's Name: John Jones
Address: RR1 Box 23, Gillman, Mn 55297

Formation Log	Color	Hardness of Formation	From	To
*Sand	brown	soft	0	10
Clay	green	med	10	50
Clay and Sand	grey	med	50	98
Clay	blue	med	98	115
Sand	brown	med	115	126

* formation log estimated from well nearby (#101057)

Casing: 4 in. to 122 ft. Height: 1 ft.

Screen: Brass mesh, Dia. 4 inch, Slot/Gauze 15, Length 4 feet, Set between 122 ft. and 126 ft.

Static Water Level: 52 ft. Date Measured 1/7/87

Well Grouted: Cement, from 2 to 126 ft., 1 1/4 yds

Pump: Removed 1/7/87
Manufacturer's name: Dooks Pump Company
Model number: B-12, HP 1/2, Volts 110
Length of drop pipe: 72 ft.

Remarks: pump removed from well. 1 1/4 yds neat cement installed thru tremie pipe. Casing cut off 2 feet below grade. Top 2' filled with native soil.

Water Well Contractor's Certification:
Gopher State Well Co. 74999
Box 382 Rt 1 Gillman Mn
Henry Ramsey 1/7/87
Ralph Sibley 1/7/87

WORK COPY

F-10

Figure 4.6-4

Examples of Minnesota Abandoned Well Report.

INSTRUCTIONS

Submit one completed copy of this form for each abandoned well that is plugged to the Department of Natural Resources, Wallace Building, 900 E. Grand Ave., Des Moines, Iowa 50319-0034 within thirty (30) days of completion of plugging operations.

Provide all of the information requested for Items 1 through 6 so far as it is known or can be obtained. If the date of construction or date of abandonment in Item 6 cannot be determined, provide the best estimate possible, such as "more than 20 years ago" or "prior to 1950."

Certification of plugging by the owner of the abandoned well in Item 7 is required for the plugging of all abandoned water wells.

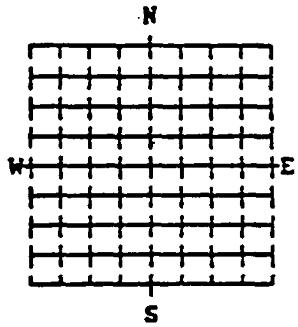
Certification of plugging by a registered well driller in Item 8 is required for all wells except large diameter (18" diameter or more) wells 100' or less in depth which are plugged by the well owner. If a registered well driller plugs this type of well, certification by the well driller is required.

1. Property Owner Name ______________________________

2. Property Owner Address ______________________________
Number and Street or RR

____
City

____
State Zip Code



LOCATE ABANDONED WELL ON THIS SECTION PLAT-640 ACRES

3. Address of property on which abandoned well is located (if different from above)

____
Number and Street or RR

____
City Zip Code

4. Legal description of property on which abandoned well is located:

Location ____1/4 ____1/4 ____1/4, Sec.____ T.____N., ____R. ____E.W.; ________County

5. Type of Well *(check one)*

[] Large diameter (18" or more) well 100 feet or less in depth
[] Well less than 18" diameter or greater than 100 feet in depth
[] Sandpoint well
[] Bedrock well in a single confined aquifer
[] Bedrock well in a single unconfined aquifer
[] Bedrock well in multiple aquifers
[] Well of unknown type

Figure 4.6-

Examples of Iowa Abandoned Water Well Plugging Recorc

6. Detailed Information: Page 2 of 2

Diameter at Top of Casing ______ inches Date Constructed ______________

Depth to Static Water Level ______ feet Date Abandoned ______________

Total Depth ______ feet Date Plugged ______________

Distance from nearest active well supplying potable water (check one):
[] More than 200 feet [] Less than 200 feet

Distance from nearest point source of potential contamination (check one):
[] More than 660 feet [] Less than 660 feet

If distance is less than 660 feet, indicate type of nearest point source of potential contamination (check one):
- [] industrial waste site
- [] uncontrolled hazardous waste site
- [] petroleum storage area
- [] hazardous waste treatment, storage or disposal area
- [] agricultural chemical storage area
- [] animal feedlot
- [] wastewater treatment facility
- [] other potential contamination source (describe) ______

7. Certification by owner. I hereby certify that the abandoned well described has been plugged in accordance with the requirements of Chapter 39 of the rules implementing 1987 Iowa Code Supplement section 455B.190:

____
Signature of Owner Date

8. Certification by a registered well driller. This is required for all wells except large diameter (18" diameter or more) wells 100 feet or less in depth in Quaternary sediments.

____
Company Name

____
Address

____
City State Zip Code

I hereby certify that the abandoned well described was plugged under my supervision in accordance with the requirements of Chapter 39 of the rules implementing 1987 Iowa Code Supplement section 455B.190:

____
Name of Registered Well Driller Registration No.

____
Signature Date

Figure 4.6-5
(continued)
Examples of Iowa Abandoned Water Well Plugging Record.

Attachment F

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Paint Filter Liquids Test Protocol

PAINT FILTER LIQUIDS TEST

1.0 SCOPE AND APPLICATION

1.1 This method is used to determine the presence of free liquids in a representative sample of waste.

1.2 The method is used to determine compliance with 40 CFR 264.314 and 265.314.

2.0 SUMMARY OF METHOD

2.1 A predetermined amount of material is placed in a paint filter. If any portion of the material passes through and drops from the filter within the 5-min test period, the material is deemed to contain free liquids.

3.0 INTERFERENCES

3.1 Filter media were observed to separate from the filter cone on exposure to alkaline materials. This development causes no problem if the sample is not disturbed.

3.2 Temperature can affect the test results if the test is performed below the freezing point of any liquid in the sample. Tests must be performed above the freezing point and can, but are not required to, exceed room temperature of 25° C.

4.0 APPARATUS AND MATERIALS

4.1 Conical paint filter: Mesh number 60 +/- 5% (fine meshed size). Available at local paint stores such as Sherwin-Williams and Glidden.

4.2 Glass funnel: If the paint filter, with the waste, cannot sustain its weight on the ring stand, then a fluted glass funnel or glass funnel with a mouth large enough to allow at least 1 in. of the filter mesh to protrude should be used to support the filter. The funnel should be fluted or have a large open mouth in order to support the paint filter yet not interfere with the movement, to the graduated cylinder, of the liquid that passes through the filter mesh.

4.3 Ring stand and ring, or tripod.

4.4 Graduated cylinder or beaker: 100-mL.

5.0 REAGENTS

5.1 None.

6.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1 All samples must be collected according to the directions in Chapter Nine of this manual.

6.2 A 100-mL or 100-g representative sample is required for the test. If it is not possible to obtain a sample of 100 mL or 100 g that is sufficiently representative of the waste, the analyst may use larger size samples in multiples of 100 mL or 100 g, i.e., 200, 300, 400 mL or g. However, when larger samples are used, analysts shall divide the sample into 100-mL or 100-g portions and test each portion separately. If any portion contains free liquids, the entire sample is considered to have free liquids. If the sample is measured volumetrically, then it should lack major air spaces or voids.

7.0 PROCEDURE

7.1 Assemble test apparatus as shown in Figure 1.

7.2 Place sample in the filter. A funnel may be used to provide support for the paint filter. If the sample is of such light bulk density that it overflow the filter, then the sides of the filter can be extended upward by taping filter paper to the inside of the filter and above the mesh. Settling the sample into the paint filter may be facilitated by lightly tapping the side of the filter as it is being filled.

7.3 In order to assure uniformity and standardization of the test, material such as sorbent pads or pillows which do not conform to the shape of the paint filter, should be cut into small pieces and poured into the filter. Sample size reduction may be accomplished by cutting the sorbent material with scissors, shears, knife, or other such device so as to preserve as much of the original integrity of the sorbent fabric as possible. Sorbents enclosed in a fabric should be mixed with the resultant fabric pieces. The particles to be tested should be reduced smaller than 1 cm (i.e., should be capable of passing through a 9.5 mm (0.375 inch) standard sieve). Grinding sorbent materials should be avoided as this may destroy the integrity of the sorbent and produce many "fine particles" which would normally not be present.

7.4 For brittle materials larger than 1 cm that do not conform to the filter, light crushing to reduce oversize particles is acceptable if it is not practical to cut the material. Materials such as clay, silica gel, and some polymers may fall into this category.

7.5 Allow sample to drain for 5 min into the graduated cylinder.

7.6 If any portion of the test material collects in the graduated cylinder in the 5-min period, then the material is deemed to contain free liquids for purposes of 40 CFR 264.314 and 265.314.

8.0 QUALITY CONTROL

8.1 Duplicate samples should be analyzed on a routine basis.

9.0 METHOD PERFORMANCE

9.1 No data provided.

10.0 REFERENCES

10.1 None provided.

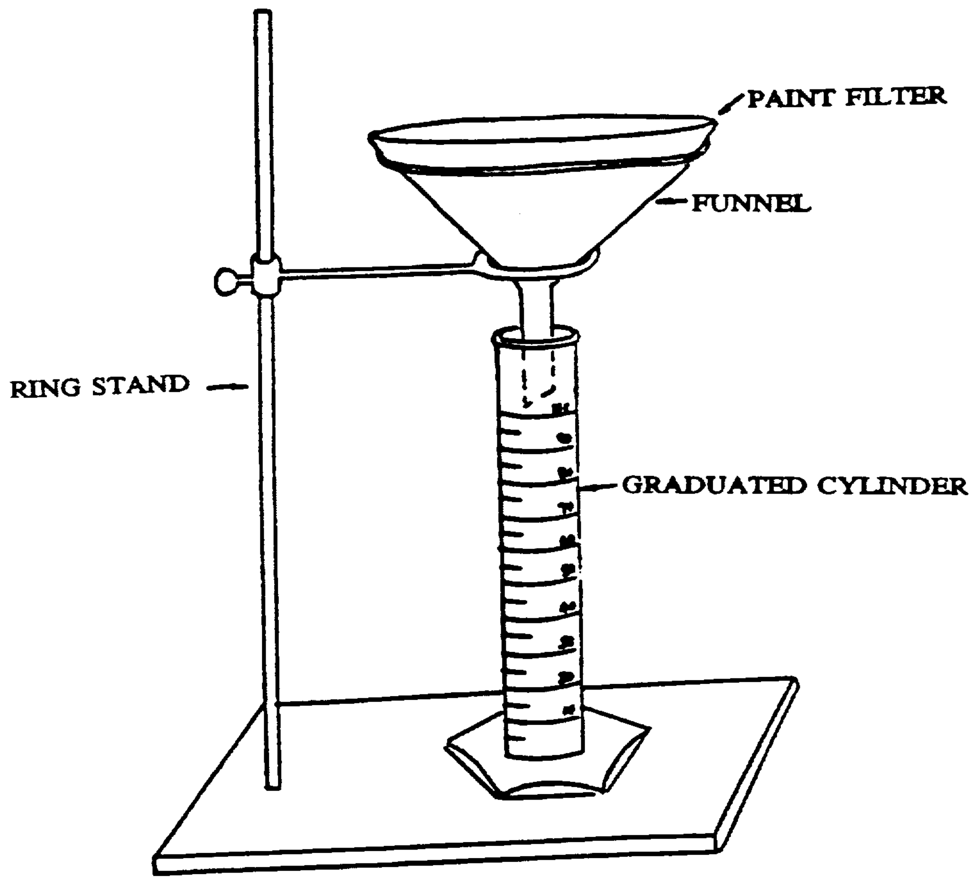
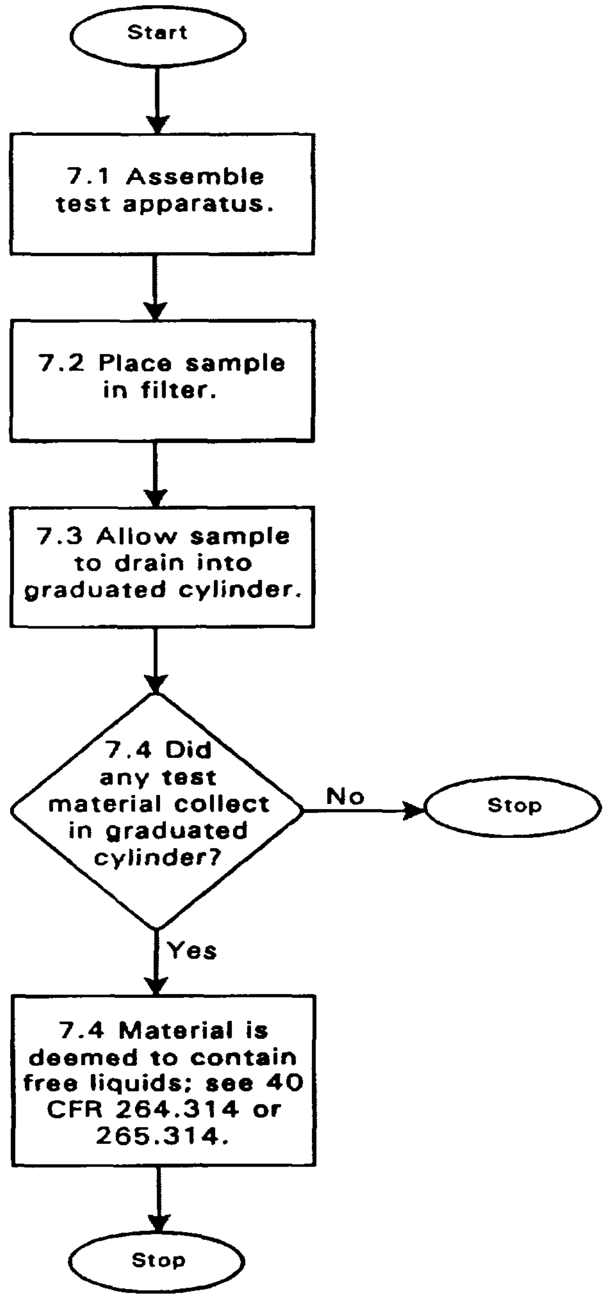


Figure 1. Paint filter test apparatus.


Start
7.1 Assemble test apparatus.
7.2 Place sample in filter.
7.3 Allow sample to drain into graduated cylinder.
7.4 Did any test material collect in graduated cylinder?
No
Stop
Yes
7.4 Material is deemed to contain free liquids; see 40 CFR 264.314 or 265.314.
Stop

Attachment G

BLASLAND, BOUCK & LEE, INC.
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Current Ambient Air Monitoring Locations

Attachment H

BLASLAND, BOUCK & LEE, INC.
engineers & scientists

Puncture Calculations of Geotextile in Base Liner System

On-Plant Consolidation Area
Puncture of Geotextile in Base Liner System
Project # 201.85.003
7/29/99

Largest diameter (ϕ) stone for puncture of upper geotextile of Geosynthetic Drainage Composite (GDC).

$F_{allow} / FS = F_{req'd} = p'd_a^2 S_1 S_2 S_3$

$20\# = (14\#/in^2)(d_a)^2(1)(0.31/d_a)(0.3)$
$20\# = (1.3\#/in^2)(d_a)$
$15'' = d_a$

where: $p' = 7psi$ (low ground pressure dozer) Note: Conservative since 2' of fill between tracks and GDC. Use $FS=2 \Rightarrow 14psi$
$S_1 = 1$ Conservative
$S_2 = 0.31/d_a$
$S_3 = 1\text{-}0.7(\text{ROB gravel}) \Rightarrow 0.3$
$F_{allow} = 80\#/2.0 = 40\#$
$FS = 2.0 \therefore F_{req'd} = 20\#$

Check: 6"ϕ

$F_{req'd} = p'd_a^2 S_1 S_2 S_3$
$= 14(6'')^2(1)(0.31/6'')(0.3)$
$F_{req'd} = 7.8$

$FS = (40\#/2) / 7.8$
$= 2.6 \therefore O.K.$

Notes:
- Must use LGP equipment during placement
- No vehicles allowed on lift until at least 2' of soil is placed
-Must use soil only in first lift (i.e., no vegetation, debris, etc.)

Third Edition

Designing with Geosynthetics

Robert M. Koerner, Ph.D., P.E.

H. L. Bowman Professor of Civil Engineering
and Director, Geosynthetic Research Institute
Drexel University

Prentice Hall
Englewood Cliffs, New Jersey 07632

Solution: (a) Using a maximum strain of 33%, the value of $f(\epsilon) = 0.52$. Thus the required grab tensile strength is as follows:

$$\begin{aligned} T_{\text{reqd}} &= p'(d_v)^2(0.52) \\ &= p'(0.33\, d_a)^2(0.52) \\ &= 0.057\, p'd_a^2 \\ &= 0.057(100)(2.0)^2 \\ &= 22.6 \text{ lb.} \end{aligned}$$

(b) The global factor of safety on a 125-lb. ultimate grab tensile geotextile with partial factors of safety of 2.5 is as follows:

$$\begin{aligned} FS &= \frac{T_{\text{allow}}}{T_{\text{reqd}}} \\ &= \frac{125/2.5}{22.6} \\ &= 2.2, \text{ which is acceptable.} \end{aligned}$$

2.5.4 Puncture Resistance

Although not only related to the separation function, the geotextile during its placement must survive the installation process. Indeed, fabric survivability is critical in all types of applications; without it, the best of designs are futile (recall Section 2.2.5.1). In this regard, sharp stones, tree stumps, roots, miscellaneous debris, and other things on the ground beneath the geotextile could puncture through the geotextile after stone base and traffic loads are imposed above it. The design method suggested for this situation is shown schematically in Figure 2.29. For these conditions, the vertical force exerted on the geotextile (which is gradually tightening around the protruding object) is as follows:

$$F_{\text{reqd}} = p'd_a^2 S_1 S_2 S_3 \tag{2.30}$$

where F_{reqd} = the required vertical force to be resisted,
p' = the pressure exerted on the geotextile (approximately 100% of tire inflation pressure at the ground surface for small stone thicknesses),
d_a = the average diameter of the puncturing aggregate or sharp object,
S_1 = protrusion factor = h_h/d_a,
h_h = protrusion height $\le d_a$,
S_2 = scale factor to adjust ASTM D4833 test value using 5/16-in.-diameter puncture probe to actual puncturing object = $0.31/d_a$,
S_3 = shape factor to adjust flat puncture probe of ASTM D4833 to actual shape of puncturing object = $1 - A_p/A_c$ (values of A_p/A_c to be used

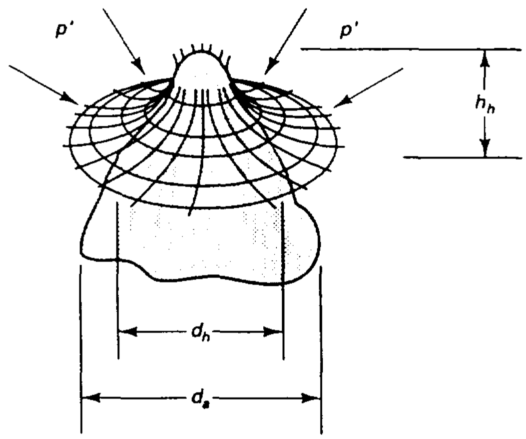


Figure 2.29 Visualization of a stone puncturing a geotextile as pressure is applied from above.

range from 0.8 for Ottawa sand, 0.7 for run-of-bank gravel, 0.4 for crushed rock, and 0.3 for shot rock),

A_p = projected area of particle, and

A_c = area of smallest circumscribed circle.

Example:

What is the factor of safety against puncture of a geotextile from a 2.0-in. stone by a loaded truck with tire inflation pressure of 80 lb./in.^{2} traveling on the surface of the stone base? The geotextile has an ultimate puncture strength of 45 lb. according to ASTM D4833.

Solution: Using the full stress on the geotextile of 80 lb./in.^{2} and factors of 0.33, 0.155, and 0.6 for S_1, S_2, and S_3, respectively,

$$
\begin{aligned}
F_{\text{reqd}} &= p' d_a^2 S_1 S_2 S_3 \\
&= 80 \times (2.0)^2(0.33)(0.155)(0.6) \\
&= 9.82 \text{ lb.}
\end{aligned}
$$

Assuming that the cumulative partial factor of safety is 2.0, the global factor of safety is as follows:

$$
\begin{aligned}
FS &= \frac{F_{\text{allow}}}{F_{\text{reqd}}} \\
&= \frac{45/2.0}{9.82} \\
&= 2.3, \text{ which is acceptable.}
\end{aligned}
$$

Using some assumptions (which can be modified as desired), a design guide can be developed as shown in Figure 2.30. It was developed on the basis that the geotextile had an angular subgrade above it such that $S_1 = 0.33$, $S_2 = 0.31/d_a$, and $S_3 = 0.5$. The cumulative partial factor of safety is 2.0 and the global factor of safety is 2.0.

$$F_{\text{reqd}} = p'd_a^2(0.33)(0.31/d_a)(0.5)$$
$$= 0.0512p'd_a$$
$$FS = \frac{F_{\text{ult}}/FS_p}{F_{\text{reqd}}}$$
$$2.0 = \frac{F_{\text{ult}}/2.0}{0.0512p'd_a}$$
$$F_{\text{ult}} = 0.204\,p'd_a$$

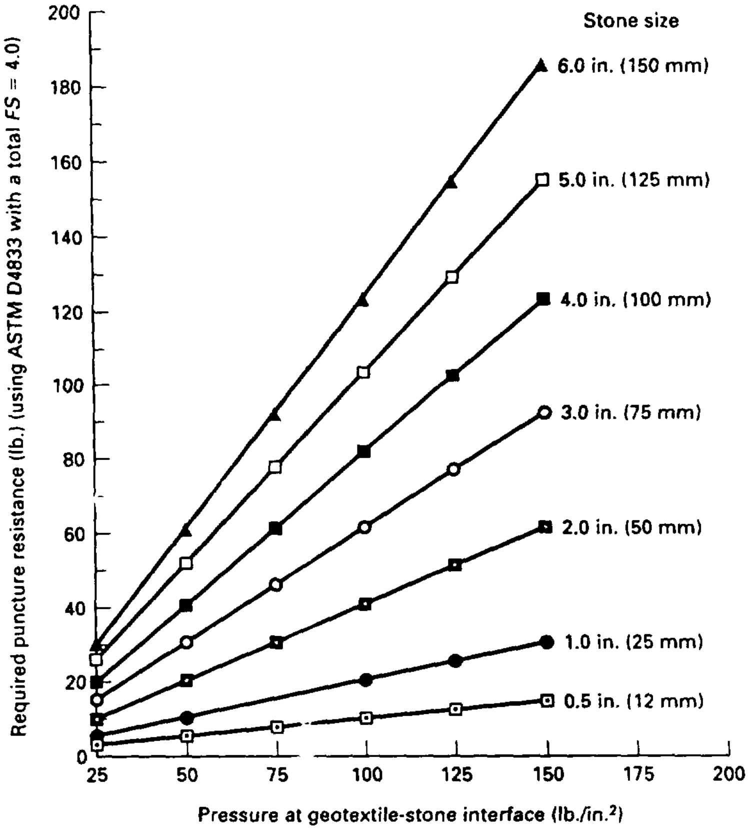


Figure 2.30 Puncture resistance design guide based on $FS_p = 2.0$ $FS_g = 2.0$ and conditions stated in text.

MATERIALS AND PERFORMANCE - SECTION 02219

GEOSYNTHETIC DRAINAGE COMPOSITE

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. National Seal Company;
B. GSE Lining Technology, Inc.; or
C. Equal.

2.02 MATERIALS

A. The geosynthetic drainage composite shall be comprised of a high density polyethylene (HDPE) drainage net composited with two (2), 6 oz/yd^2 non-woven geotextiles. The geotextiles shall be heat bonded to both sides of the drainage net.

1. The drainage net to be utilized in the composite shall be a profiled mesh made by extruding two sets of high density strands together to form a diamond shaped, three-dimensional net to provide planar fluid flow. The drainage net shall be made of HDPE containing carbon black, anti-oxidants and heat stabilizers which shall be manufactured from resin provided from one resin supplier.

2. The geotextile shall be a non-woven, needle punched polymeric material.

B. The geosynthetic drainage composite shall meet the following specifications:

1. Drainage Net

Property	Test Method	Test Value
Specific Gravity (g/cm^3)	ASTM D1505	0.94 minimum
Melt Flow Index (g/10 min)	ASTM D1238 - Condition E	0.3 maximum
Percent Carbon Black (%)	ASTM D1603	2.0 minimum
Transmissivity (m^2/sec)	ASTM D4716	2 x 10^{-3} minimum
Thickness (mil)	ASTM D374 at Strand Intersection	200 - 265 minimum

2. Geotextile

Property	Test Method	Test Value
Fabric Weight (oz/yd^2)	ASTM D-3776	5.7
Thickness (mils)	ASTM D-1777	75
Grab Strength (lbs.)	ASTM D-4632	150
Grab Elongation (%)	ASTM D-4632	50
Mullen Burst (psi)	ASTM D-3786	275

MATERIALS AND PERFORMANCE - SECTION 02219

GEOSYNTHETIC DRAINAGE COMPOSITE

Property	Test Method	Test Value
Puncture (lbs.)	ASTM D-4833	80
A.O.S. (U.S. Sieve)	ASTM D-4751	70
Trapezoidal Tear (lbs.)	ASTM D-4533	65
Permittivity (gal/min/ft^2/sec^{-1})	ASTM D-4491	90/1.7
Permeability (cm/sec)	ASTM D-4491	.2

2.03 DELIVERY, STORAGE AND HANDLING

A. The geosynthetic drainage composite shall be packaged and shipped by appropriate means so as to prevent damage. Materials shall be delivered only after the required submittals have been received and reviewed by GE or GE's Representative.

B. The geosynthetic drainage composite shall be furnished in rolls, marked or tagged with the following information:

1. Manufacturer's Name
2. Product Identification
3. Lot/Batch Number
4. Roll Number
5. Roll Dimensions

C. The geosynthetic drainage composite shall be stored in an area approved by GE or GE's Representative which prevents damage to the product or packaging.

D. The geosynthetic drainage composite shall be kept clean and free from dirt, dust, mud and any other debris.

E. Any geosynthetic drainage composite found to be damaged shall be replaced with new material at the Contractor's expense.

2.04 QUALITY ASSURANCE

A. Field delivered material shall meet the specifications values according to the manufacturer's specification sheet. The Contractor shall submit written certification that the delivered material meets the manufacturer's specifications. The Contractor shall submit to GE or GE's Representative certified quality control test results conducted by the manufacturer during the manufacturing of the geosynthetic drainage composite delivered to the project site. The results must identify the sections of field delivered geosynthetic drainage composite they represent.

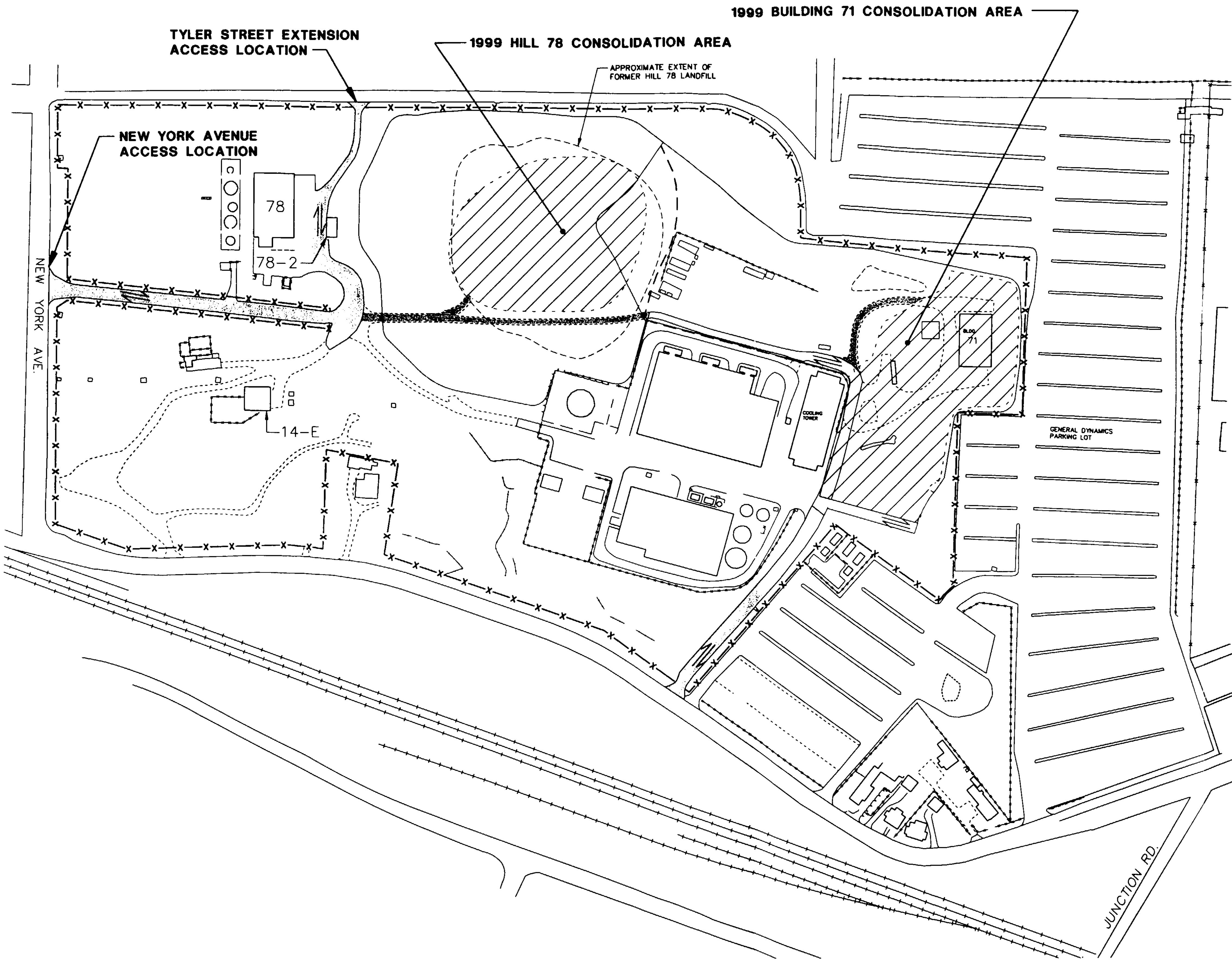
B. The manufacturer shall have developed and shall adhere to their own quality assurance program in the manufacture of the geosynthetic drainage composite.

C. The installer shall verify in writing prior to installation that the geosynthetic drainage composite has not been damaged due to improper handling or storage.

Attachment I

BLASLAND, BOUCK & LEE, INC.
engineers & scientists

Revised Work Plan Figure 9



LEGEND:

- EXISTING PAVED SITE ROAD
- APPROXIMATE LOCATION OF PROPOSED TEMPORARY ACCESS ROAD
- APPROXIMATE LOCATION OF PROPOSED PAVED PERMANENT ACCESS ROAD
- APPROXIMATE AREA OF 1999 CONSOLIDATION ACTIVITIES
- —X—X— EXISTING SECURITY FENCE
- DIRECTION OF TRUCK FLOW

NOTES:

1. MAPPING IS BASED ON AERIAL PHOTOGRAPHS AND PHOTOGRAMMETRIC MAPPING BY LOCKWOOD MAPPING, INC. -FLOWN IN APRIL 1990; DATA PROVIDED BY GENERAL ELECTRIC COMPANY; AND BLASLAND, BOUCK & LEE, INC. (BBL) CONSTRUCTION PLANS, AND ON OBSERVATIONS DURING A SITE VISIT BY BBL PERSONNEL ON DECEMBER 3, 1997.
2. SITE BOUNDARIES ARE APPROXIMATE.
3. NOT ALL PHYSICAL FEATURES SHOWN.

100' 0 100' 200'
GRAPHIC SCALE

Original includes color coding.

GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS
DETAILED WORK PLAN FOR
ON-PLANT CONSOLIDATION AREAS

SITE FENCING, ACCESS, AND ROAD LOCATIONS

BBL BLASLAND, BOUCK & LEE, INC. engineers & scientists

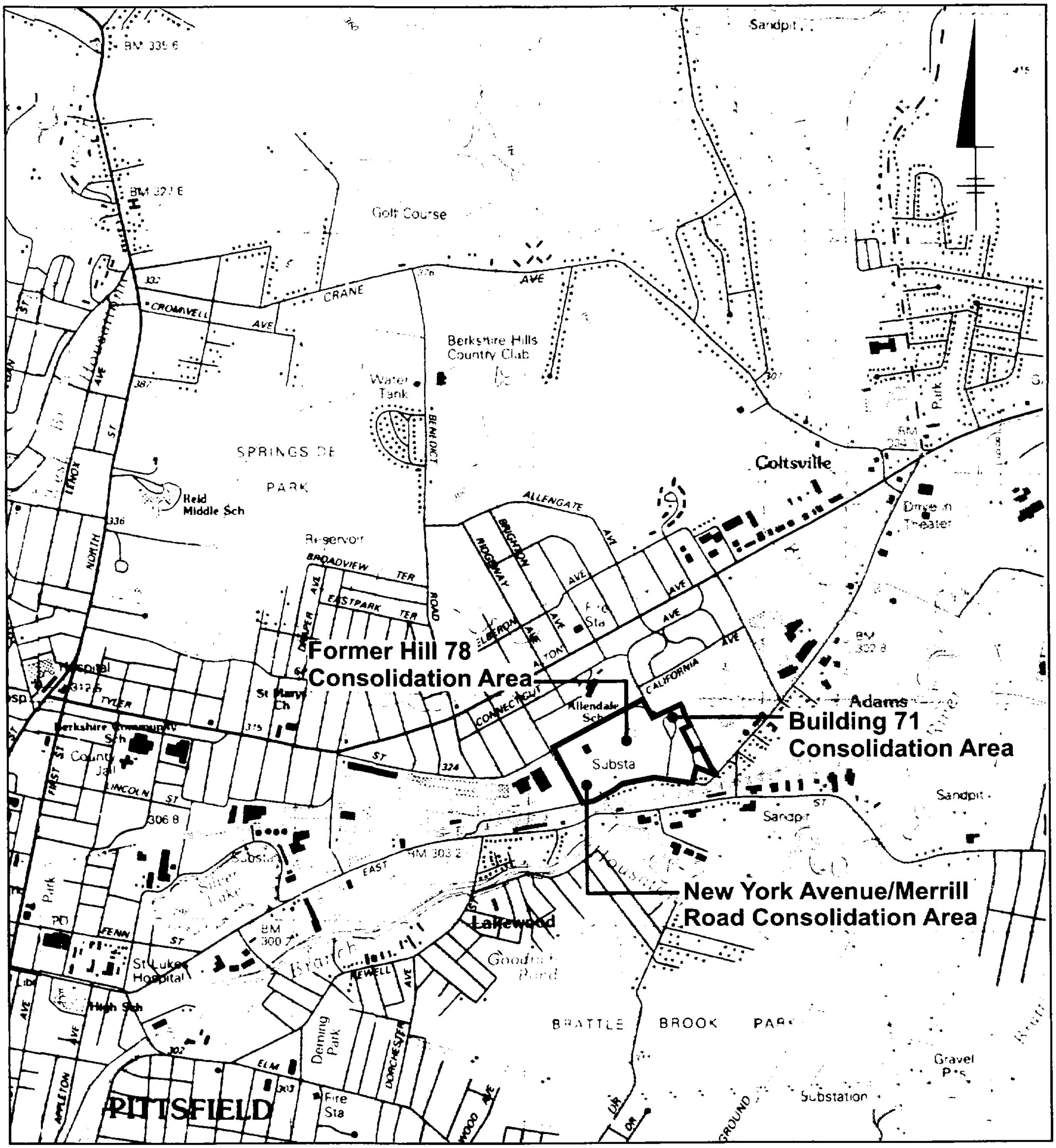
FIGURE 9

X: 20185X01.DWG
L: ON=*, OFF=*REF*, PER-FENCE
P: STD-PCP/DL.PCP
6/10/99 SYR-54-GMS KLN GMS
20185003/REPORT/20185B05.DWG

Attachment J

BLASLAND, BOUCK & LEE, INC.
engineers & scientists

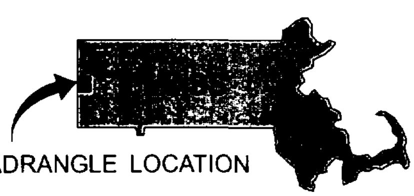
Revised Work Plan Figure 1



REFERENCE: PITTSFIELD EAST, MASS. USGS QUADS., 7.5 MIN. SERIES, 1988

2000' 0 2000'

APPROXIMATE SCALE: 1" = 2000'



QUADRANGLE LOCATION

GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS

DETAILED WORK PLAN
FOR ON-PLANT CONSOLIDATION AREAS

SITE LOCATION MAP

BBL BLASLAND, BOUCK & LEE, INC. *engineers & scientists*

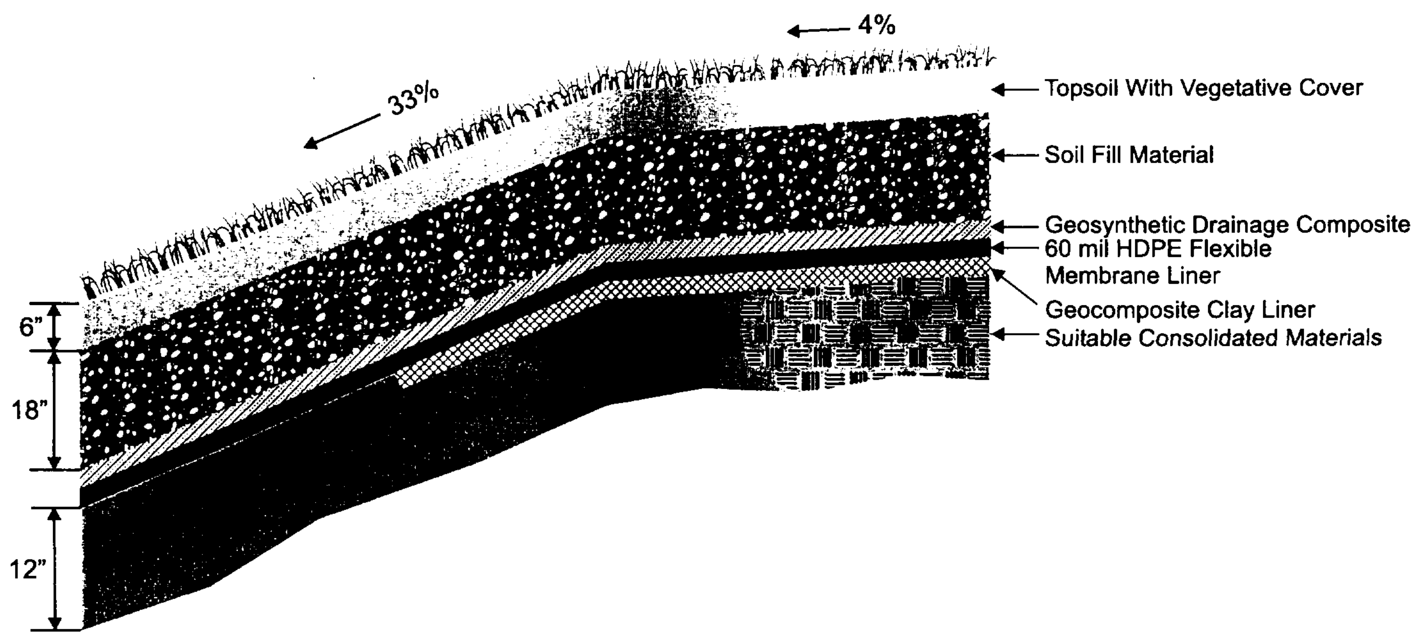
FIGURE
1

07/99 SYR-D54-DJH
20185003/20185n03.CDR

Attachment K

BLASLAND, BOUCK & LEE, INC.
engineers & scientists

Revised Work Plan Figures 3 and 4



FINAL COVER SYSTEM

NOT-TO-SCALE

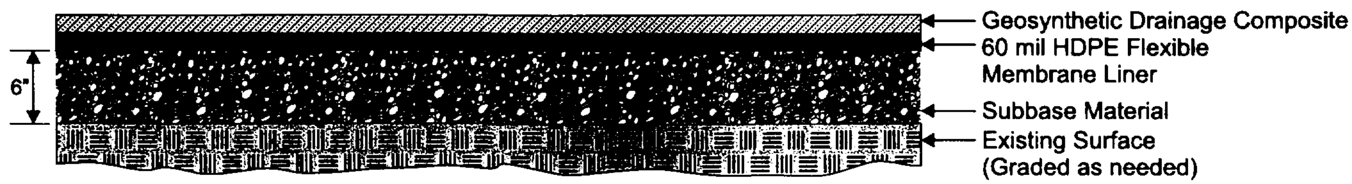
GENERAL ELECTRIC COMPANY
PITTSFIELD/HOUSATONIC RIVER SITE
DETAILED WORK PLAN FOR ON-PLANT CONSOLIDATION AREAS

FINAL COVER SYSTEM

BBL BLASLAND, BOUCK & LEE, INC.
engineers & scientists

FIGURE
3

05/99 SYR-D54-DJH ycc
20185003/20185n09.cdr



BASE LINER SYSTEM

NOT-TO-SCALE

GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS
DETAILED WORK PLAN FOR ON-PLANT CONSOLIDATION AREAS

BASE LINER SYSTEM FOR BUILDING 71 CONSOLIDATION AREA

BBL BLASLAND, BOUCK & LEE, INC. engineers & scientists

FIGURE 4

07/99 SYR-D54-DJH YCC
20185003/20185g08.cdr

Attachment L

BLASLAND, BOUCK & LEE, INC.
engineers & scientists

Leachate Collection System Design Calculations

BBL

CALCULATION SHEET

Project No.: 20185

CLIENT: General Electric Company — Prepared By: KFP Date: 07-28-99
PROJECT: Pittsfield RD/RA Work Plan -1999 — Checked By: DMB Date: 08-30-99
On-Plant Consolidation Areas
SUBJECT: Leachate Collection Pipe Size Calculations

TASK:

1. Determine the required size for the leachate collection pipe to adequately convey the leachate generated during the peak leachate production period. Estimated peak leachate flow generated during the peak production period must be equal to or less than the maximum flow capacity of the collection pipe.

REFERENCES:

1. "Detailed Work Plan for On-Plant Consolidation Areas" drawings, prepared by Blasland, Bouck, & Lee, Inc., dated July 1999.
2. Hydraulic evaluation of Landfill Performance (HELP) Model Version 3.05a. (RUNINF2.OUT and RUNINF50.OUT)

ASSUMPTIONS:

1. Collection pipe slope is 0.5% minimum (actual slope may be equal to or greater than 0.5%).
2. Inflow to the collection pipe is based on the estimated GDC flow capacity.
3. The collection pipe is perforated, SDR 17, 6-inch diameter, smooth-walled HDPE.

METHODOLOGY:

1. Calculate the peak inflow to the collection pipe from the GDC within the leachate management system assuming a worst case scenario of a combination of the following two conditions:

   Condition A.) Approximately 80-percent of the consolidation area has been filled to capacity with waste (maximum waste depth of 27-feet) and graded according to the top of waste grading plan. However, no components of the final cover system have been installed.

   Condition B.) The remaining 20-percent of the consolidation area has been constructed, and the first lift of consolidtion material (2-foot thick) has been placed within this portion of the area. Utilize the HELP Model (RUNINF50.OUT) to determine the infiltration rate due to a peak daily rain event (as estimated by the HELP Model). All the leachate generated by this event will be collected by the GDC and conveyed to the leachate collection pipe.

2. Calculate the minimum pipe size required based on the estimated peak inflow.

JENT: General Electric Company Prepared By: KFP Date: 07-28-99
PROJECT: Pittsfield RD/RA Work Plan -1999 Checked By: _____ Date: _______
On-Plant Consolidation Areas
SUBJECT: Leachate Collection Pipe Size Calculations

DEFINITIONS:

$A_A := 4.1 \cdot \text{acre}$	Approximate total area for Condition A
$A_B := 1.0 \cdot \text{acre}$	Approximate total area for Condition B
$q_A := 0.076453 \cdot \frac{\text{in}}{\text{day}}$	Peak Infiltration Rate for Condition A - From HELP Model
$q_B := 4.89 \cdot \frac{\text{in}}{\text{day}}$	Peak Infiltration Rate for Condition B - From HELP Model
$n := 0.011$	Manning's friction coefficient for the collection pipe
$S_{pipe} := 0.5 \cdot \%$	Minimum Pipe Slope

CALCULATIONS:

1. Determine the peak inflow (Q_p) into the collection pipe from the GDC Layer.

For Condition "A":

$Q_A := A_A \cdot q_A$ $\qquad Q_A = 0.013 \cdot \frac{ft^3}{sec}$

For Condition "B":

$Q_B := A_B \cdot q_B$ $\qquad Q_B = 0.205 \cdot \frac{ft^3}{sec}$

Total Worst Case Peak Inflow into the Leachate Collection Pipe:

$Q_{total} := Q_B + Q_A$ $\qquad Q_{total} = 0.219 \cdot \frac{ft^3}{sec}$

2. Calculate the minimum required collection pipe diameter (D_{min}) size to convey the expected peak flow.

$$D_{min} := \left[\frac{2.159 \cdot Q_{total} \cdot n}{S_{pipe}^{\frac{1}{2}}} \right]^{\frac{3}{8}}$$

$D_{min} = 0.376\,ft$ $\qquad D_{minr} := D_{min} \cdot 12 \cdot in$ $\qquad D_{minr} = 4.5 \cdot in$

pipetest.MC

BBL

CALCULATION SHEET

Project No.: 20185

.IENT: General Electric Company Prepared By: KFP Date: 07-28-99
PROJECT: Pittsfield RD/RA Work Plan -1999 Checked By: ____ Date: ______
On-Plant Consolidation Areas
SUBJECT: Leachate Collection Pipe Size Calculations

CONCLUSIONS:

The selected pipe diameter of 6-inches is greater than the calculated minimum required pipe diameter of 4.5-inches, therefore the selected 6-inch diameter pipe is adequate.

CONDITION 'A'
HELP RESULTS

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                   HELP MODEL VERSION 3.05a  (5 JUNE 1996)                 **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                     USAE WATERWAYS EXPERIMENT STATION                     **
**            FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP3\ge2\weather\PREC1.D4
TEMPERATURE DATA FILE:       c:\help3\ge2\weather\TEMP1.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\ge2\weather\SOLAR1.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\ge2\weather\EVAP1.D11
SOIL AND DESIGN DATA FILE:   c:\help3\ge2\soil\INFIL2.D10
OUTPUT DATA FILE:            C:\HELP3\ge2\output\runinf2.OUT


TIME:  15:23      DATE:   7/15/1999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     TITLE:  GE Pittsfield - Building 71 Consolidation Area -
             Infiltration model for GDC transmissivity and Pipe Size Calculations
******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
               COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   8
          THICKNESS                    =    324.00   INCHES
          POROSITY                     =      0.4630 VOL/VOL
          FIELD CAPACITY               =      0.2320 VOL/VOL
          WILTING POINT                =      0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2758 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.369999994000E-03 CM/SEC


                    GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                    ----------------------------------------

          NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
                   SOIL DATA BASE USING SOIL TEXTURE # 8 WITH BARE
                   GROUND CONDITIONS, A SURFACE SLOPE OF 18.% AND
                   A SLOPE LENGTH OF  140. FEET.

        SCS RUNOFF CURVE NUMBER            =      91.30
        FRACTION OF AREA ALLOWING RUNOFF   =     100.0    PERCENT
        AREA PROJECTED ON HORIZONTAL PLANE =       1.000  ACRES
        EVAPORATIVE ZONE DEPTH             =       8.0    INCHES
        INITIAL WATER IN EVAPORATIVE ZONE  =       2.961  INCHES
        UPPER LIMIT OF EVAPORATIVE STORAGE =       3.704  INCHES
        LOWER LIMIT OF EVAPORATIVE STORAGE =       0.928  INCHES
        INITIAL SNOW WATER                 =       0.000  INCHES
        INITIAL WATER IN LAYER MATERIALS   =      89.351  INCHES
        TOTAL INITIAL WATER                =      89.351  INCHES
        TOTAL SUBSURFACE INFLOW            =       0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
PLAINFIELD MASSACHUSETTS

STATION LATITUDE	=	42.00 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	109
END OF GROWING SEASON (JULIAN DATE)	=	277
EVAPORATIVE ZONE DEPTH	=	8.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	10.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	64.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	65.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	70.00 %

NOTE: PRECIPITATION DATA FOR PLAINFIELD MASSACHUSETTS
WAS ENTERED FROM THE DEFAULT DATA FILE.

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PLAINFIELD MASSACHUSETTS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
26.50	24.20	32.20	51.40	63.20	60.10
73.40	75.20	65.30	45.00	30.70	28.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PLAINFIELD MASSACHUSETTS
AND STATION LATITUDE = 42.00 DEGREES

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1977

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	2.21	3.10	7.33	4.56	3.93	2.56
	3.52	4.75	7.39	6.32	5.40	4.16
RUNOFF	1.445	0.538	7.391	0.785	1.419	0.017
	0.261	0.589	1.191	1.229	0.493	1.920
EVAPOTRANSPIRATION	0.554	0.763	0.557	2.988	2.342	2.078
	3.042	3.626	3.173	2.539	1.516	0.445
PERCOLATION/LEAKAGE THROUGH	0.5555	0.8272	0.4207	0.5021	0.3205	0.9975
LAYER 1	1.0722	0.8107	0.5059	0.3199	0.6884	1.4032

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ANNUAL TOTALS FOR YEAR 1977

	INCHES	CU. FEET	PERCENT
PRECIPITATION	55.23	200484.891	100.00
RUNOFF	17.276	62713.504	31.28

EVAPOTRANSPIRATION	23.622	85749.672	42.77
PERC./LEAKAGE THROUGH LAYER 1	8.423923	30578.479	15.25
CHANGE IN WATER STORAGE	5.907	21443.232	10.70
SOIL WATER AT START OF YEAR	89.351	324343.000	
SOIL WATER AT END OF YEAR	95.258	345786.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.010	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1978

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	12.84	0.67	2.77	1.55	3.97	5.70
	2.34	6.34	1.14	3.11	2.43	4.94
RUNOFF	0.042	0.000	13.991	0.432	0.223	0.391
	0.010	2.622	0.052	0.116	0.094	0.000
EVAPOTRANSPIRATION	0.604	0.765	0.415	2.004	3.388	3.916
	2.999	2.377	1.534	2.195	1.152	0.808
PERCOLATION/LEAKAGE THROUGH	2.1326	1.6116	1.4494	0.7035	0.9898	0.6641
LAYER 1	0.8889	0.6552	0.7350	0.8709	0.7287	0.4148

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ANNUAL TOTALS FOR YEAR 1978

	INCHES	CU. FEET	PERCENT
PRECIPITATION	47.80	173514.000	100.00
RUNOFF	17.973	65241.180	37.60
EVAPOTRANSPIRATION	22.157	80431.023	46.35
PERC./LEAKAGE THROUGH LAYER 1	11.844440	42995.320	24.78
CHANGE IN WATER STORAGE	-4.175	-15153.548	-8.73
SOIL WATER AT START OF YEAR	95.258	345786.250	
SOIL WATER AT END OF YEAR	87.113	316220.187	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	3.970	14412.515	8.31
ANNUAL WATER BUDGET BALANCE	0.0000	0.024	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1979

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	12.29	2.96	4.07	4.93	6.78	1.58
	5.37	6.65	4.29	4.66	3.74	2.30
RUNOFF	2.313	0.420	4.861	13.842	1.859	0.066
	1.124	1.188	0.905	0.875	0.389	1.389
EVAPOTRANSPIRATION	0.730	0.838	0.930	2.280	3.899	1.399
	4.003	3.614	3.272	2.376	1.202	0.463
PERCOLATION/LEAKAGE THROUGH	0.5347	0.6840	0.7294	0.6132	0.1919	0.1877
LAYER 1	0.7548	0.4280	0.1809	0.4156	0.4929	0.6877

ANNUAL TOTALS FOR YEAR 1979

	INCHES	CU. FEET	PERCENT
PRECIPITATION	59.62	216420.625	100.00
RUNOFF	29.229	106100.398	49.03
EVAPOTRANSPIRATION	25.007	90774.883	41.94
PERC./LEAKAGE THROUGH LAYER 1	5.900738	21419.678	9.90
CHANGE IN WATER STORAGE	-0.516	-1874.347	-0.87
SOIL WATER AT START OF YEAR	87.113	316220.187	
SOIL WATER AT END OF YEAR	90.567	328758.344	
SNOW WATER AT START OF YEAR	3.970	14412.515	6.66
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.010	0.00

MONTHLY TOTALS (IN INCHES) FOR YEAR 1980

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.96	1.58	8.14	5.09	1.95	3.63
	3.43	1.54	3.09	3.88	3.40	1.56
RUNOFF	0.312	0.899	5.189	5.422	0.096	0.556
	0.106	0.000	0.087	0.861	0.000	0.492
EVAPOTRANSPIRATION	0.494	0.478	0.818	1.569	2.692	1.626
	3.524	1.969	2.978	1.761	1.229	0.737
PERCOLATION/LEAKAGE THROUGH	1.1624	1.0497	0.9603	0.6732	0.4502	0.7388
LAYER 1	0.5720	0.5581	0.6328	0.6289	0.2183	0.2982

ANNUAL TOTALS FOR YEAR 1980

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.25	138847.484	100.00
RUNOFF	14.019	50888.277	36.65
EVAPOTRANSPIRATION	19.876	72148.875	51.96
PERC./LEAKAGE THROUGH LAYER 1	7.942742	28832.152	20.77
CHANGE IN WATER STORAGE	-3.587	-13021.840	-9.38
SOIL WATER AT START OF YEAR	90.567	328758.344	
SOIL WATER AT END OF YEAR	85.147	309083.031	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	1.833	6653.474	4.79
ANNUAL WATER BUDGET BALANCE	0.0000	0.021	0.00

MONTHLY TOTALS (IN INCHES) FOR YEAR 1981

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.59	11.08	0.81	2.91	4.34	2.59
	3.91	1.96	3.74	4.84	1.62	4.24
RUNOFF	1.319	4.531	5.752	0.033	0.777	0.051
	0.171	0.020	0.327	0.922	0.005	0.139
EVAPOTRANSPIRATION	0.712	0.483	1.079	2.921	2.506	3.071
	3.107	2.632	2.089	2.106	1.571	1.022
PERCOLATION/LEAKAGE THROUGH	0.5604	0.4975	0.5514	0.1585	0.3213	0.1200
LAYER 1	0.3890	0.3824	0.5115	0.4391	0.1082	0.2471

ANNUAL TOTALS FOR YEAR 1981

	INCHES	CU. FEET	PERCENT
PRECIPITATION	42.63	154746.922	100.00
RUNOFF	14.048	50995.859	32.95
EVAPOTRANSPIRATION	23.300	84577.500	54.66
PERC./LEAKAGE THROUGH LAYER 1	4.286201	15558.909	10.05
CHANGE IN WATER STORAGE	0.996	3614.619	2.34
SOIL WATER AT START OF YEAR	85.147	309083.031	
SOIL WATER AT END OF YEAR	86.549	314172.937	
SNOW WATER AT START OF YEAR	1.833	6653.474	4.30
SNOW WATER AT END OF YEAR	1.427	5178.195	3.35
ANNUAL WATER BUDGET BALANCE	0.0000	0.029	0.00

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1977 THROUGH 1981

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	5.78	3.88	4.62	3.81	4.19	3.21
	3.71	4.25	3.93	4.56	3.32	3.44
STD. DEVIATIONS	6.23	4.15	3.08	1.53	1.72	1.57
	1.09	2.40	2.27	1.20	1.43	1.44
RUNOFF						
TOTALS	1.086	1.278	7.437	4.103	0.875	0.216
	0.334	0.884	0.512	0.801	0.196	0.788
STD. DEVIATIONS	0.919	1.847	3.791	5.866	0.759	0.243
	0.451	1.087	0.510	0.411	0.229	0.832
EVAPOTRANSPIRATION						
TOTALS	0.619	0.666	0.760	2.353	2.965	2.418
	3.335	2.843	2.609	2.195	1.334	0.695
STD. DEVIATIONS	0.101	0.171	0.272	0.606	0.656	1.055
	0.428	0.747	0.761	0.295	0.194	0.244
PERCOLATION/LEAKAGE THROUGH LAYER 1						
TOTALS	0.9891	0.9340	0.8222	0.5301	0.4547	0.5416
	0.7354	0.5669	0.5132	0.5349	0.4473	0.6102
STD. DEVIATIONS	0.6921	0.4292	0.4049	0.2215	0.3127	0.3758
	0.2665	0.1737	0.2086	0.2187	0.2769	0.4749

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1977 THROUGH 1981

	INCHES	CU. FEET	PERCENT
PRECIPITATION	48.71 (8.786)	176802.8	100.00
RUNOFF	18.509 (6.2606)	67187.84	38.002
EVAPOTRANSPIRATION	22.792 (1.9210)	82736.39	46.796
PERCOLATION/LEAKAGE THROUGH LAYER 1	7.67959 (2.85694)	27876.908	15.76723
CHANGE IN WATER STORAGE	-0.275 (4.0642)	-998.38	-0.565

PEAK DAILY VALUES FOR YEARS 1977 THROUGH 1981

	(INCHES)	(CU. FT.)
95 = $\boxed{\text{PRECIPITATION} \quad 4.64}$		16843.199
RUNOFF	4.117	14944.2520
91-4 = $\boxed{\text{PERCOLATION/LEAKAGE THROUGH LAYER 1} \quad 0.076453}$		277.52417
SNOW WATER	15.05	54646.8750

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4332

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1160

FINAL WATER STORAGE AT END OF YEAR 1981

LAYER	(INCHES)	(VOL/VOL)
1	86.5490	0.2671
SNOW WATER	1.427	

TIPE SIEG
CONDITION 'B'
HELP RESULTS

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                  HELP MODEL VERSION 3.05a  (5 JUNE 1996)                 **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:      C:\HELP3\ge2\weather\PREC1.D4
TEMPERATURE DATA FILE:        c:\help3\ge2\weather\TEMP1.D7
SOLAR RADIATION DATA FILE:    C:\HELP3\ge2\weather\SOLAR1.D13
EVAPOTRANSPIRATION DATA:      C:\HELP3\ge2\weather\EVAP1.D11
SOIL AND DESIGN DATA FILE:    c:\help3\ge2\soil\INFIL50.D10
OUTPUT DATA FILE:             C:\HELP3\ge2\output\runinf50.OUT


TIME:   9:13     DATE:   7/30/1999


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     TITLE:  GE Pittsfield - Building 71 Consolidation Area
             Infiltration Calculation for 2' thick first lift

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   8
            THICKNESS                     =     24.00   INCHES
            POROSITY                      =      0.4630 VOL/VOL
            FIELD CAPACITY                =      0.2320 VOL/VOL
            WILTING POINT                 =      0.1160 VOL/VOL
            INITIAL SOIL WATER CONTENT    =      0.3392 VOL/VOL
            EFFECTIVE SAT. HYD. COND.     =  0.369999994000E-03 CM/SEC
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 150. FEET.

SCS RUNOFF CURVE NUMBER	=	90.80	
FRACTION OF AREA ALLOWING RUNOFF	=	0.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	8.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.704	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	3.704	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.928	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	8.140	INCHES
TOTAL INITIAL WATER	=	8.140	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM PLAINFIELD MASSACHUSETTS

STATION LATITUDE	=	42.00	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	109	
END OF GROWING SEASON (JULIAN DATE)	=	277	
EVAPORATIVE ZONE DEPTH	=	8.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	64.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	65.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	70.00	%

NOTE: PRECIPITATION DATA FOR PLAINFIELD MASSACHUSETTS WAS ENTERED FROM THE DEFAULT DATA FILE.

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR PLAINFIELD MASSACHUSETTS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC

26.50	24.20	32.20	51.40	63.20	60.10
73.40	75.20	65.30	45.00	30.70	28.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR PLAINFIELD MASSACHUSETTS AND STATION LATITUDE = 42.00 DEGREES

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1977

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	2.21	3.10	7.33	4.56	3.93	2.56
	3.52	4.75	7.39	6.32	5.40	4.16
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.554	0.763	0.557	2.991	2.460	2.080
	3.028	3.642	3.175	2.541	1.514	0.445
PERCOLATION/LEAKAGE THROUGH	1.5219	2.4718	6.3127	4.0525	2.4793	0.3194
LAYER 1	0.3526	1.2289	2.8538	4.5558	2.1390	3.1925

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ANNUAL TOTALS FOR YEAR 1977

	INCHES	CU. FEET	PERCENT
PRECIPITATION	55.23	200484.891	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	23.750	86212.211	43.00
PERC./LEAKAGE THROUGH LAYER 1	31.480085	114272.711	57.00
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	8.140	29547.492	

SOIL WATER AT END OF YEAR	8.140	29547.492	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.021	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1978

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	12.84	0.67	2.77	1.55	3.97	5.70
	2.34	6.34	1.14	3.11	2.43	4.94
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.604	0.765	0.415	2.004	3.457	4.088
	3.062	2.384	1.534	2.262	1.154	0.808
PERCOLATION/LEAKAGE THROUGH	0.5434	0.1792	13.4203	2.7847	0.5986	0.6096
LAYER 1	0.2625	3.3939	0.2514	0.2420	0.1799	0.8510

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ANNUAL TOTALS FOR YEAR 1978

	INCHES	CU. FEET	PERCENT
PRECIPITATION	47.80	173514.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	22.538	81814.219	47.15
PERC./LEAKAGE THROUGH LAYER 1	23.316563	84639.125	48.78
CHANGE IN WATER STORAGE	1.945	7060.649	4.07
SOIL WATER AT START OF YEAR	8.140	29547.492	

SOIL WATER AT END OF YEAR	6.114	22195.627	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	3.970	14412.515	8.31
ANNUAL WATER BUDGET BALANCE	0.0000	0.007	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1979

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	12.29	2.96	4.07	4.93	6.78	1.58
	5.37	6.65	4.29	4.66	3.74	2.30
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.730	0.838	0.930	2.236	3.939	1.380
	4.246	3.607	3.227	2.434	1.204	0.463
PERCOLATION/LEAKAGE THROUGH	0.8978	1.1005	4.5534	16.1521	3.2701	0.8105
LAYER 1	0.8238	2.0010	2.5805	2.3077	1.1592	0.8514

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ANNUAL TOTALS FOR YEAR 1979

	INCHES	CU. FEET	PERCENT
PRECIPITATION	59.62	216420.625	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	25.234	91599.656	42.32
PERC./LEAKAGE THROUGH LAYER 1	36.508083	132524.344	61.23
CHANGE IN WATER STORAGE	-2.122	-7703.367	-3.56
SOIL WATER AT START OF YEAR	6.114	22195.627	

SOIL WATER AT END OF YEAR	7.963	28904.773	
SNOW WATER AT START OF YEAR	3.970	14412.515	6.66
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.014	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1980

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.96	1.58	8.14	5.09	1.95	3.63
	3.43	1.54	3.09	3.88	3.40	1.56
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.494	0.478	0.818	1.565	2.862	1.801
	3.550	2.201	2.956	1.759	1.228	0.737
PERCOLATION/LEAKAGE THROUGH	0.4244	0.9014	4.6877	8.0494	0.3651	0.1648
LAYER 1	0.6536	0.2107	0.0640	0.5565	0.8258	0.2165

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ANNUAL TOTALS FOR YEAR 1980

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.25	138847.484	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	20.448	74227.969	53.46
PERC./LEAKAGE THROUGH LAYER 1	17.119667	62144.391	44.76
CHANGE IN WATER STORAGE	0.682	2475.142	1.78
SOIL WATER AT START OF YEAR	7.963	28904.773	

SOIL WATER AT END OF YEAR	6.812	24726.441	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	1.833	6653.474	4.79
ANNUAL WATER BUDGET BALANCE	0.0000	-0.021	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1981

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.59	11.08	0.81	2.91	4.34	2.59
	3.91	1.96	3.74	4.84	1.62	4.24
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.712	0.483	1.079	2.951	2.485	3.212
	3.005	2.699	2.519	2.107	1.572	1.022
PERCOLATION/LEAKAGE THROUGH	0.3066	4.5409	7.8260	0.5928	1.2784	0.3602
LAYER 1	0.2957	0.2377	0.2172	1.5383	0.9852	1.1711

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ANNUAL TOTALS FOR YEAR 1981

	INCHES	CU. FEET	PERCENT
PRECIPITATION	42.63	154746.922	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	23.847	86563.156	55.94
PERC./LEAKAGE THROUGH LAYER 1	19.350096	70240.844	45.39
CHANGE IN WATER STORAGE	-0.567	-2057.105	-1.33
SOIL WATER AT START OF YEAR	6.812	24726.441	

SOIL WATER AT END OF YEAR	6.651	24144.615	
SNOW WATER AT START OF YEAR	1.833	6653.474	4.30
SNOW WATER AT END OF YEAR	1.427	5178.195	3.35
ANNUAL WATER BUDGET BALANCE	0.0000	0.021	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1977 THROUGH 1981

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	5.78	3.88	4.62	3.81	4.19	3.21
	3.71	4.25	3.93	4.56	3.32	3.44
STD. DEVIATIONS	6.23	4.15	3.08	1.53	1.72	1.57
	1.09	2.40	2.27	1.20	1.43	1.44
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.619	0.666	0.760	2.350	3.040	2.512
	3.378	2.907	2.682	2.221	1.334	0.695
STD. DEVIATIONS	0.101	0.171	0.271	0.616	0.644	1.112
	0.535	0.679	0.700	0.306	0.194	0.244
PERCOLATION/LEAKAGE THROUGH LAYER 1						
TOTALS	0.7388	1.8387	7.3600	6.3263	1.5983	0.4529
	0.4776	1.4145	1.1934	1.8401	1.0578	1.2565
STD. DEVIATIONS	0.4905	1.7234	3.6421	6.1258	1.2444	0.2559
	0.2479	1.3351	1.3962	1.7238	0.7087	1.1364

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1977 THROUGH 1981

	INCHES		CU. FEET	PERCENT
PRECIPITATION	48.71	(8.786)	176802.8	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	23.163	(1.7930)	84083.45	47.558
PERCOLATION/LEAKAGE THROUGH LAYER 1	25.55490	(8.21193)	92764.281	52.46766
CHANGE IN WATER STORAGE	-0.012	(1.5060)	-44.94	-0.025

PEAK DAILY VALUES FOR YEARS 1977 THROUGH 1981

	(INCHES)	(CU. FT.)
PRECIPITATION	4.64	16843.199
RUNOFF	0.000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 1	4.894302	17766.31640
SNOW WATER	15.05	54646.8750
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4630	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1160	

FINAL WATER STORAGE AT END OF YEAR 1981

LAYER	(INCHES)	(VOL/VOL)
1	6.6514	0.2771
SNOW WATER	1.427	

CLIENT: General Electric Company Prepared By: KFP Date: 07-28-99
PROJECT: Pittsfield RD/RA Work Plan -1999 Checked By: PHB Date: 07-30-99
On-Plant Consolidation Areas
SUBJECT: Geosynthetic Drainage Composite Minimum Required Transmissivity

TASK:

1. Determine the minimum required flow capacity (transmissivity) of the geosynthetic drainage composite (GDC) within the base liner system.
2. Determine the maximum normal stress (σ_N) and hydraulic gradient (I) to be utilized during laboratory conformance testing of the GDC for transmissivity (ASTM D-4716).

REFERENCES:

1. "Design of Waste Containment Liner and Final Closure Systems", ASCE Seminar Manual, 1998.
2. Hydraulic evaluation of Landfill Performance (HELP) Model Version 3.05a. - (File = RUNINF50.OUT)
3. "Detailed Work Plan for On-Plant Consolidation Areas" drawings, prepared by Blasland, Bouck, & Lee, Inc., dated July 1999.

ASSUMPTIONS:

1. Base Liner GDC must be able to handle stormwater infiltration for the following conditions:

   Condition A: The first lift of consolidation material (uniform 24-inch lift) has been placed within the Building 71 Consolidation Area. Use the HELP Model to determine the infiltration rate.

2. The worst case slope conditions for the baseliner GDC are 150-feet at 2%.
3. Use the soil and climatological parameters from the HELP Model.
4. Maximum head allowable above the FML in the baseliner system is 12-inches, and the location of this head (H) occurs at the midpoint between the top of the baseliner perimeter berm and the leachate collection pipe. Therefore, the distance from the leachate collection pipe to the location of the maximum head (B) is equal to 1/2 the drainage length (L).
5. When calculating the required normal stress to be utilized during laboratory testing, assume the consolidation material is at the design full depth thickness of 27-feet.
6. The unit weight of the consolidation material above the GDC is 157 lb/ft^3.

METHODOLOGY:

1. Estimate the stormwater infiltration rate (q) into the GDC Layer utilizing the HELP Model (See attached HELP Model output) for the conditions stated above:

   A.) For Condition "A", determine the infiltration rate by running the HELP Model with only one layer (2' thick first lift). The infiltration rate into the GDC will be equal to the peak daily percolation through "Layer 1" in the HELP Model.

2. Determine the minimum allowable transmissivity for the conditions stated above.
3. Determine the maximum normal stress (σ_N) and hydraulic gradient (I) to be utilized during laboratory conformance testing of the GDC for transmissivity.

CLIENT: General Electric Company | Prepared By: KFP | Date: 07-28-99
PROJECT: Pittsfield RD/RA Work Plan -1999 | Checked By: ____ | Date: ______
On-Plant Consolidation Areas
SUBJECT: Geosynthetic Drainage Composite Minimum Required Transmissivity

DEFINITIONS:

$S_c := 2 \cdot \%$ (Waste Slope Grade)

$L_c := 150 \cdot ft$ (Waste Slope Length)

$S_b := 2 \cdot \%$ (Base Liner Slope)

$\theta_b := atan(S_b)$ $\quad \theta_b = 1.1 \cdot deg$ (Base Liner Slope Angle)

$L_b := 150 \cdot ft$ (Base Liner Drainage Length)

$B := \frac{1}{2} \cdot L_b$ $\quad B = 75 \cdot ft$ (Distance from Leachate Collector Pipe to Location of Maximum Head)

$h_{max} := 1 \cdot ft$ (Maximum Allowable Head)

$\gamma := 157 \cdot \frac{lb}{ft^3}$ (Assumed Unit Weight of Waste above GDC)

$t_{waste} := 27 \cdot ft$ (Depth of waste above GDC)

CALCULATIONS:

1. Determine the stormwater infiltration rate (q) into the GDC Layer for the conditions listed above.

From the attached HELP model, the expected maximum infiltration rate for Condition "A" is:

$q_A := 4.8943 \cdot \frac{in}{day}$ $\qquad q_A = 0.408 \cdot \frac{ft}{day}$

CLIENT: General Electric Company Prepared By: KFP Date: 07-28-99
PROJECT: Pittsfield RD/RA Work Plan -1999 Checked By: _____ Date: _______
On-Plant Consolidation Areas
SUBJECT: Geosynthetic Drainage Composite Minimum Required Transmissivity

2. Calculate the minimum required transmissivity for the conditions listed above.

The minimum required transmissivity for Condition "A" is:

$$T_A := \frac{B^2 \cdot q_A}{h_{max} + B \cdot \sin(\theta_b)}$$

$$T_A = 917.791 \cdot \frac{ft^2}{day}$$

$$T_A = 9.9 \cdot 10^{-4} \cdot \frac{m^2}{sec}$$

Apply a factor of saftey (FS) to ensure GDC performance:

$$FS_{min} := 2.0$$

$$T_{minA} := T_A \cdot FS_{min}$$

$$T_{minA} = 2 \cdot 10^{-3} \cdot \frac{m^2}{sec}$$

3. Calculate the maximum normal stress (σ_N) and hydraulic gradient (I) to be utilized during laboratory conformance testing of the GDC for transmissivity for the conditions listed above.

In order to ensure the GDC will handle peak flow under worst case conditions, calculate the Maximum normal stress for the waste at full design depth (27-feet).

The Maximum Normal Stress and Hydraulic Gradient for Condition "A" is:

Maximum Normal Stress (σ_{NA}):

$$\sigma_{NA} := \gamma t_{waste} \qquad \sigma_{NA} = 4239 \cdot \frac{lb}{ft^2}$$

Hydraulic Gradient (I_A):

$$I_A := \frac{h_{max} + B \cdot \sin(\theta_b)}{\left(\frac{B}{\cos(\theta_b)}\right)} \qquad I_A = 0.033$$

CLIENT: General Electric Company — Prepared By: KFP Date: 07-28-99
PROJECT: Pittsfield RD/RA Work Plan -1999 — Checked By: _____ Date: _______
On-Plant Consolidation Areas
SUBJECT: Geosynthetic Drainage Composite Minimum Required Transmissivity

CONCLUSIONS:

Laboratory test results of the selected GDC must meet the minimum transmissivity for the conditions listed above when tested according to ASTM D-4716. A list of the test requirements to be utilized for the selection of the GDC is presented below:

TEST REQUIREMENTS FOR CONDITION "A"

1. The substrate material (underlying the GDC) will be 60-mil textured HDPE geomembrane

2. The superstrate material (overlying the GDC) will be 6-inches (minimum) of representative consolidation material gathered from Pittsfield, Massachusetts

3. The applied normal compressive stress will be: $\sigma_{NA} = 4239 \cdot \frac{lb}{ft^2}$

4. The seating period will be 2-hours minimum

5. The hydraulic gradient will be: $I_A = 0.033$

6. The water utilized during the test will be maintained at 70° F (+/- 4° F)

7. The minimum required transmissivity for the selected GDC tested under requirements 1 through 6 will be:
$T_{minA} = 2 \cdot 10^{-3} \cdot \frac{m^2}{sec}$

GDC TRANSMISSIVITY
CONDITION 'A'
HELP RESULTS

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                  HELP MODEL VERSION 3.05a  (5 JUNE 1996)                  **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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```
PRECIPITATION DATA FILE:     C:\HELP3\ge2\weather\PREC1.D4
TEMPERATURE DATA FILE:       c:\help3\ge2\weather\TEMP1.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\ge2\weather\SOLAR1.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\ge2\weather\EVAP1.D11
SOIL AND DESIGN DATA FILE:   c:\help3\ge2\soil\INFIL50.D10
OUTPUT DATA FILE:            C:\HELP3\ge2\output\runinf50.OUT
```

TIME: 9:13 DATE: 7/30/1999

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******************************************************************************

     TITLE:  GE Pittsfield - Building 71 Consolidation Area
             Infiltration Calculation for 2' thick first lift

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NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 8

```
THICKNESS                  =     24.00   INCHES
POROSITY                   =      0.4630 VOL/VOL
FIELD CAPACITY             =      0.2320 VOL/VOL
WILTING POINT              =      0.1160 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.3392 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.369999994000E-03 CM/SEC
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 150. FEET.

SCS RUNOFF CURVE NUMBER	=	90.80	
FRACTION OF AREA ALLOWING RUNOFF	=	0.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	8.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.704	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	3.704	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.928	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	8.140	INCHES
TOTAL INITIAL WATER	=	8.140	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM PLAINFIELD MASSACHUSETTS

STATION LATITUDE	=	42.00	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	109	
END OF GROWING SEASON (JULIAN DATE)	=	277	
EVAPORATIVE ZONE DEPTH	=	8.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	64.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	65.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	70.00	%

NOTE: PRECIPITATION DATA FOR PLAINFIELD MASSACHUSETTS WAS ENTERED FROM THE DEFAULT DATA FILE.

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR PLAINFIELD MASSACHUSETTS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC

26.50	24.20	32.20	51.40	63.20	60.10
73.40	75.20	65.30	45.00	30.70	28.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PLAINFIELD MASSACHUSETTS
AND STATION LATITUDE = 42.00 DEGREES

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1977

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	2.21	3.10	7.33	4.56	3.93	2.56
	3.52	4.75	7.39	6.32	5.40	4.16
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.554	0.763	0.557	2.991	2.460	2.080
	3.028	3.642	3.175	2.541	1.514	0.445
PERCOLATION/LEAKAGE THROUGH	1.5219	2.4718	6.3127	4.0525	2.4793	0.3194
LAYER 1	0.3526	1.2289	2.8538	4.5558	2.1390	3.1925

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ANNUAL TOTALS FOR YEAR 1977

	INCHES	CU. FEET	PERCENT
PRECIPITATION	55.23	200484.891	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	23.750	86212.211	43.00
PERC./LEAKAGE THROUGH LAYER 1	31.480085	114272.711	57.00
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	8.140	29547.492	

SOIL WATER AT END OF YEAR	8.140	29547.492	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.021	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1978

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	12.84	0.67	2.77	1.55	3.97	5.70
	2.34	6.34	1.14	3.11	2.43	4.94
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.604	0.765	0.415	2.004	3.457	4.088
	3.062	2.384	1.534	2.262	1.154	0.808
PERCOLATION/LEAKAGE THROUGH	0.5434	0.1792	13.4203	2.7847	0.5986	0.6096
LAYER 1	0.2625	3.3939	0.2514	0.2420	0.1799	0.8510

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ANNUAL TOTALS FOR YEAR 1978

	INCHES	CU. FEET	PERCENT
PRECIPITATION	47.80	173514.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	22.538	81814.219	47.15
PERC./LEAKAGE THROUGH LAYER 1	23.316563	84639.125	48.78
CHANGE IN WATER STORAGE	1.945	7060.649	4.07
SOIL WATER AT START OF YEAR	8.140	29547.492	

SOIL WATER AT END OF YEAR	6.114	22195.627	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	3.970	14412.515	8.31
ANNUAL WATER BUDGET BALANCE	0.0000	0.007	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1979

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	12.29	2.96	4.07	4.93	6.78	1.58
	5.37	6.65	4.29	4.66	3.74	2.30
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.730	0.838	0.930	2.236	3.939	1.380
	4.246	3.607	3.227	2.434	1.204	0.463
PERCOLATION/LEAKAGE THROUGH	0.8978	1.1005	4.5534	16.1521	3.2701	0.8105
LAYER 1	0.8238	2.0010	2.5805	2.3077	1.1592	0.8514

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ANNUAL TOTALS FOR YEAR 1979

	INCHES	CU. FEET	PERCENT
PRECIPITATION	59.62	216420.625	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	25.234	91599.656	42.32
PERC./LEAKAGE THROUGH LAYER 1	36.508083	132524.344	61.23
CHANGE IN WATER STORAGE	-2.122	-7703.367	-3.56
SOIL WATER AT START OF YEAR	6.114	22195.627	

SOIL WATER AT END OF YEAR	7.963	28904.773	
SNOW WATER AT START OF YEAR	3.970	14412.515	6.66
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.014	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1980

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.96	1.58	8.14	5.09	1.95	3.63
	3.43	1.54	3.09	3.88	3.40	1.56
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.494	0.478	0.818	1.565	2.862	1.801
	3.550	2.201	2.956	1.759	1.228	0.737
PERCOLATION/LEAKAGE THROUGH	0.4244	0.9014	4.6877	8.0494	0.3651	0.1648
LAYER 1	0.6536	0.2107	0.0640	0.5565	0.8258	0.2165

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ANNUAL TOTALS FOR YEAR 1980

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.25	138847.484	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	20.448	74227.969	53.46
PERC./LEAKAGE THROUGH LAYER 1	17.119667	62144.391	44.76
CHANGE IN WATER STORAGE	0.682	2475.142	1.78
SOIL WATER AT START OF YEAR	7.963	28904.773	

SOIL WATER AT END OF YEAR	6.812	24726.441	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	1.833	6653.474	4.79
ANNUAL WATER BUDGET BALANCE	0.0000	-0.021	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1981

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.59	11.08	0.81	2.91	4.34	2.59
	3.91	1.96	3.74	4.84	1.62	4.24
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.712	0.483	1.079	2.951	2.485	3.212
	3.005	2.699	2.519	2.107	1.572	1.022
PERCOLATION/LEAKAGE THROUGH	0.3066	4.5409	7.8260	0.5928	1.2784	0.3602
LAYER 1	0.2957	0.2377	0.2172	1.5383	0.9852	1.1711

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ANNUAL TOTALS FOR YEAR 1981

	INCHES	CU. FEET	PERCENT
PRECIPITATION	42.63	154746.922	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	23.847	86563.156	55.94
PERC./LEAKAGE THROUGH LAYER 1	19.350096	70240.844	45.39
CHANGE IN WATER STORAGE	-0.567	-2057.105	-1.33
SOIL WATER AT START OF YEAR	6.812	24726.441	

SOIL WATER AT END OF YEAR	6.651	24144.615	
SNOW WATER AT START OF YEAR	1.833	6653.474	4.30
SNOW WATER AT END OF YEAR	1.427	5178.195	3.35
ANNUAL WATER BUDGET BALANCE	0.0000	0.021	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1977 THROUGH 1981

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	5.78	3.88	4.62	3.81	4.19	3.21
	3.71	4.25	3.93	4.56	3.32	3.44
STD. DEVIATIONS	6.23	4.15	3.08	1.53	1.72	1.57
	1.09	2.40	2.27	1.20	1.43	1.44
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.619	0.666	0.760	2.350	3.040	2.512
	3.378	2.907	2.682	2.221	1.334	0.695
STD. DEVIATIONS	0.101	0.171	0.271	0.616	0.644	1.112
	0.535	0.679	0.700	0.306	0.194	0.244
PERCOLATION/LEAKAGE THROUGH LAYER 1						
TOTALS	0.7388	1.8387	7.3600	6.3263	1.5983	0.4529
	0.4776	1.4145	1.1934	1.8401	1.0578	1.2565
STD. DEVIATIONS	0.4905	1.7234	3.6421	6.1258	1.2444	0.2559
	0.2479	1.3351	1.3962	1.7238	0.7087	1.1364

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1977 THROUGH 1981

	INCHES		CU. FEET	PERCENT
PRECIPITATION	48.71	(8.786)	176802.8	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	23.163	(1.7930)	84083.45	47.558
PERCOLATION/LEAKAGE THROUGH LAYER 1	25.55490	(8.21193)	92764.281	52.46766
CHANGE IN WATER STORAGE	-0.012	(1.5060)	-44.94	-0.025

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PEAK DAILY VALUES FOR YEARS 1977 THROUGH 1981

	(INCHES)	(CU. FT.)
PRECIPITATION	4.64	16843.199
RUNOFF	0.000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 1	4.894302	17766.31640
SNOW WATER	15.05	54646.8750
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4630	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1160	

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FINAL WATER STORAGE AT END OF YEAR 1981

LAYER	(INCHES)	(VOL/VOL)
1	6.6514	0.2771
SNOW WATER	1.427	

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ENT: General Electric Company — Prepared By: KFP Date: 07-28-99

ROJECT: Pittsfield RD/RA Work Plan -1999 — Checked By: [handwritten initials] Date: 07-28-99

On-Plant Consolidation Areas

SUBJECT: Required Leachate Collection Pipe Wall Thickness Calculations

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TASK:

1. Determine the required wall thickness for the 6-inch diameter HDPE leachate collection pipe to withstand the maximum compressive loading due to overburden pressure from the consolidation material and final cover.

REFERENCES:

1. "Detailed Work Plan for On-Site Consolidation Areas" drawings prepared by Blasland, Bouck, & Lee, Inc., dated July 1999.
2. Driscopipe Systems Design Guide.
3. "An Introduction to Geotechnical Engineering", page 105, Holtz, R.D. (1981).

ASSUMPTIONS:

1. Collection pipe is SDR 17, 6-inch diameter smooth walled perforated HDPE.
2. The consolidation material is a saturated silty sand and gravel having a wet density of 157 lb/ft^3 (Reference 3, pg 105).
3. The final cover system soil is a saturated silty sand and gravel having a wet density of 157 lb/ft^3 (Reference 3, pg 105).
4. The total height of the soil mass above the pipe is 29 feet (includes 27 feet of consolidation material and 2 feet of cap soil). The pipe is surrounded by a loose crushed gravel.

METHODOLOGY:

1. Determine the factor of safety (FS) of the selected SDR with respect to "wall crushing".
2. Determine the acceptability of the selected SDR with respect to the manufacturer's recommended allowable "ring deflection".
3. Determine the factor of safety (FS) of the selected SDR with respect to "wall buckling".

DEFINITIONS:

$SDR := 17$	Assumed SDR
$\gamma_{wc} := 157 \cdot \frac{lb}{ft^3}$	Wet density of consolidation material
$t_c := 27 \cdot ft$	Thickness of consolidation material
$\gamma_{wf} := 157 \cdot \frac{lb}{ft^3}$	Wet density of final cover soil
$t_f := 2 \cdot ft$	Thickness of final cover soil

IENT: General Electric Company Prepared By: KFP Date: 07-28-99
. ROJECT: Pittsfield RD/RA Work Plan -1999 Checked By: ____ Date: ______
On-Plant Consolidation Areas
SUBJECT: Required Leachate Collection Pipe Wall Thickness Calculations

CALCULATIONS:

1. Determine the FS for Wall Crushing

Calculate the total vertical soil pressure at the top of the pipe (P_t):

$$P_t := \gamma_{wc} \cdot t_c + \gamma_{wf} \cdot t_f \qquad P_t = 31.6 \cdot \frac{lb}{in^2}$$

Calculate the actual maximum compressive stress in the pipe (S_A):

$$S_A = \frac{SDR - 1}{2} \cdot P_t \qquad S_A = 252.9 \cdot \frac{lb}{in^2}$$

According to Reference 2, pg. 37, the actual compressive yield strength of Driscopipe is:

$$S_{act} := 1500 \cdot \frac{lb}{in^2}$$ (Reference 2, pg. 37)

Calculate the factor of safety (FS):

$$FS_{wc} := \frac{S_{act}}{S_A} \qquad FS_{wc} = 5.93$$ <== OK

2. Calculate the adequacy of the pipe with respect to ring deflection

Due to the "bridging" effect of the crushed stone used to backfill the collection pipe, the vertical elastic strain (i.e. - ring deflection) experienced by the pipe will be equal to the vertical elastic strain experienced the granular fill due to the overburden pressure of the consolidation material.

Calculate the granular fill vertical elastic strain (ε):

$$\varepsilon := \frac{P_t}{E'}$$ Where: $E' := 1000 \cdot \frac{lb}{in^2}$ (Reference 2, pg 36; assuming Soil Type I: crushed stone, loosely placed)

$$\varepsilon = 3.2 \cdot \%$$

Allowable ring deflection (ε_{rd}) for SDR 17 pipe is:

$$\varepsilon_{rd} := 4.2 \cdot \%$$ (Reference 2, Chart 27, pg. 38)

Therefore:

$$\varepsilon < \varepsilon_{rd}$$

3.2% < 4.2% <== OK

CLIENT: General Electric Company — Prepared By: KFP Date: 07-28-99
PROJECT: Pittsfield RD/RA Work Plan -1999 — Checked By: _____ Date: _____
On-Plant Consolidation Areas
SUBJECT: Required Leachate Collection Pipe Wall Thickness Calculations

2. Determine the FS for Wall Buckling

Determine the pipe's modulus of elasticity (E) according to Chart 25 of Reference 2, page 37

$$E := 26500 \cdot \frac{lb}{in^2}$$ (With $S_A = 252.9 \cdot \frac{lb}{in^2}$; and a Design Life = 50 years)

Calculate the pipe's hydrostatic, critical-collapse differential pressure (P_c):

$$P_c := \frac{2.32 \cdot E}{SDR^3} \qquad P_c = 12.5 \cdot \frac{lb}{in^2}$$

Calculate the critical buckling soil pressure at the top of the pipe (P_{cb}):

$$P_{cb} := 0.8 \cdot \left(E' \cdot P_c\right)^{\frac{1}{2}} \qquad P_{cb} = 89.5 \cdot \frac{lb}{in^2}$$

Calculate the factor of safety with respect to wall buckling:

$$FS_{wb} := \frac{P_{cb}}{P_t} \qquad FS_{wb} = 2.8$$

The recommended FS for wall buckling is:

$$FS_{wbrec} := 2.0$$ (Reference 2, pg. 38)

Therefore:

$$FS_{wb} > FS_{wbrec}$$

2.8 > 2.0 <== OK

CONCLUSIONS:

The selected SDR 17, 6-inch diameter pipe meets the manufacturer recommended design requirements, therefore, the selected SDR is acceptable.

Attachment M

BLASLAND, BOUCK & LEE, INC.
engineers & scientists

Slope Stability Calculations

On-Plant Consolidation Area
Infinite Slope Analysis
Project # 201.85.003
7/29/99

Infinite Slope Analysis:

3H:1V $\beta = 18.4°$

$$FS = (c'/\gamma d)\sec\beta\,\mathrm{cosec}\beta + (\tan\phi/\tan\beta)$$

where: c' = cohesion(psf)
γ = unit weight (pcf)
ϕ = angle of internal friction
β = slope angle
d = overburden thickness

Bentomat (GCL):

Interface between woven slit-film geotextile/textured HDPE geomembrane:

$\phi = 23°$
$c' = 0$

From Daniel, D.E., R.M. Koerner, R. Bonaparte, R.E. Landreth, D.A. Carson, and H.B. Scranton. "Slope stability of Geosynthetic Clay Liner Test Plots." *Journal of Geotechnical and Geoenvironmental Engineering*, Vol. 124, No.7. pp 628-637.

$FS = \tan 23° / \tan 2.3$
$FS = 10.6$

Tex-net Ultra TN 3002/1620 (GDC):

Interface between needlepunched geotextile (polyester) / textured HDPE geomembrane:

$\phi = 21°$
$c' = 50$ psf
$d = 2'$

From *Geosynthetics '93 - Vancouver, Canada.* "Use of Increased Frictional Resistance in Landfill Liner System Design and Construction" E.D. Chiado and S.D. Walker (pp. 1215-1228).

$FS = (50/(125*2))\sec 18.4\,\mathrm{cosec} 18.4 + (\tan 21°/\tan 18.4°)$
$FS = 0.67 + 1.15$
$FS = 1.82$

Attachment N

BLASLAND, BOUCK & LEE, INC.
engineers & scientists

Available Literature on Geosynthetic Materials Resistance to Frost Damage

Chamberlain, E.J., Erickson, A.E., and C.H. Benson, "Frost Resistance of Cover and Liner Materials for Landfills and Hazardous Waste Sites," *US Army Corps of Engineers,* CRREL, December 1997.

Frost Resistance of Cover and Liner Materials for Landfills and Hazardous Waste Sites

Edwin J. Chamberlain, Allan E. Erickson, and Craig H. Benson

December 1997

Abstract: The common method of preventing the contamination of groundwater by landfills and hazardous waste is to encapsulate the waste material in a compacted clay liner and cover system. The frost resistance of compacted clay in landfills has been the subject of controversy for many years. Laboratory studies have frequently shown that freezing and thawing significantly increase the hydraulic conductivity of compacted clay soils. However, there has not been any corroborating field evidence. This study more closely examines this problem, and identifies cover and liner materials that would be frost resistant to increase construction productivity and save costs under a CPAR (Construction Productivity Advancement Research) cooperative agreement between CRREL and five private companies. The effects of freezing and thawing on the hydraulic conductivity of two compacted natural clay soils, one compacted sand–bentonite mixture, and three geosynthetic clay liners (GCLs) were examined. Both field and laboratory tests were performed on these materials. The field test site consisted of five test pads (four of clay and one of sand–bentonite), and nine test pans containing three different GCLs. Results showed that freeze–thaw caused large increases (greater than 1000×) in hydraulic conductivity in compacted natural clay, but little measurable change in hydraulic conductivity of the GCLs or the sand–bentonite mixture. GCLs and sand–bentonite mixtures are suitable frost resistant substitutes for compacted clay soils. Considerable cost savings can result if compacted clay soils are replaced with GCLs or sand–bentonite mixtures.

Special Report 97-29

US Army Corps of Engineers®
Cold Regions Research & Engineering Laboratory

Frost Resistance of Cover and Liner Materials for Landfills and Hazardous Waste Sites

Edwin J. Chamberlain, Allan E. Erickson, and Craig H. Benson

December 1997

Prepared for
OFFICE OF THE CHIEF OF ENGINEERS

Approved for public release; distribution is unlimited.

EXECUTIVE SUMMARY

The common method of preventing the contamination of groundwater by landfill and hazardous waste is to encapsulate the waste material in a compacted clay liner and cover system. The Environmental Protection Agency has proposed guidelines for the design of disposal sites under their jurisdiction. These guidelines generally call for a system of components, including compacted clay layers and geosynthetic membranes, encapsulating the waste material. The EPA usually requires that the hydraulic conductivity of the compacted clay be less than 1×10^{-7} cm/s and that the clay be protected from freezing.

The frost resistance of compacted clay covers and liners for landfills and hazardous waste sites has been the subject of controversy for many years. Laboratory studies have frequently shown that freezing and thawing significantly increase the hydraulic conductivity of compacted clay soils. However, there has not been any corroborating field evidence. Moreover, when "undisturbed" samples from clay liners, which have frozen and thawed in the field, have been examined in the laboratory, little or no change in hydraulic conductivity has been observed. Nonetheless, the persistent laboratory evidence has led the EPA and many other regulatory agencies to set guidelines requiring frost protection for compacted clay covers and liners. The cost and questionable necessity for the frost protection have resulted in considerable controversy among regulators, designers, and owners of landfills.

This study more closely examines this problem. Since the overwhelming evidence in the literature convinced us that careful study in the laboratory and in the field would confirm that frost action was a problem for compacted clay soils, we decided to also look at alternatives to the standard clay cover and liner materials. The ultimate purpose of this study was to identify cover and liner materials that would be frost resistant, or find a way to make frost-susceptible materials frost resistant, and at the same time increase construction productivity and save costs.

We developed a field and laboratory program under a CPAR (Construction Productivity Advancement Research) cooperative agreement between CRREL and five private companies involved in the waste management field. The lead in the private sector was taken by CH2M Hill, Inc., a leading consulting engineering firm in the environmental geotechniques field. The other partners included WMX, Inc., one of the largest owners and operators of landfills in the U.S., and James Clem Corporation, Colloid Environmental Technologies Company, and Gundle Lining Systems, Inc., three companies that produce GCL (geosynthetic clay liner) systems and promote their use as alternatives to compacted clay soils.

We examined the effects of freezing and thawing on the hydraulic conductivity of two compacted natural clay soils, one compacted sand–bentonite mixture, and three GCLs. These materials were tested both in the field and laboratory. A field test site was constructed at a WMX, Inc., landfill near Milwaukee, Wisconsin. The field test site consisted of five test pads (four of clay and one of sand–bentonite), and nine test pans containing three different GCLs.

Results of the investigation showed that freeze–thaw caused large increases (greater than 1000x) in the hydraulic conductivity of compacted natural clay, but little measurable change in the hydraulic conductivity of the GCLs or the sand–bentonite mixture. This study also showed that past soil sampling and laboratory testing practices were probably errant in their findings that freezing and thawing did not damage compacted clay soils. Test samples of clay taken with the standard thin-walled tube samplers showed little or no change in hydraulic conductivity after freezing and thawing, while carefully carved block samples and samples taken while the clay was frozen with a special coring auger showed the large increases in hydraulic conductivity after freezing and thawing.

The findings show that GCLs and sand–bentonite mixtures are suitable frost-resistant substitutes for compacted clay soils. The cost of a GCL liner in place is approximately the same as 2 ft (0.6 m) of compacted clay, and a sand–bentonite liner may cost a little more, so there are little cost savings associated just with the material purchase and placement. However, considerable cost savings can result if compacted clay soils are replaced with GCLs or sand–bentonite mixtures. These result from the elimination of the cost of the construction of the frost protection layer and the added value of the increased storage space resulting from the elimination of the frost protection and compacted clay layers. In much of the highly populated areas of the U.S., these cumulative cost savings can exceed $200,000 per acre or $4,000,000 for a typical 20-acre disposal site ($494,000/ha or $4,000,000 for an 8-ha site) and represent 3 to 16% of the fixed costs.

This report chronicles the work accomplished and the findings. Appropriate laboratory freezing test methods are discussed, as are the field sampling methods. Contour maps are provided to show the thickness of frost protection required for compacted clay covers. The potential cost savings obtainable using GCLs and sand-bentonite in place of clay are also given.

course, is the increase caused by the chlorine bleach. The consequences of those results are important reminders of the care required in conducting tests on GCLs and in using them in landfills.

GCL field test pond test results

The three ponds constructed in 1992 did not have working seepage collection systems because of unrepairable leaks in the leachate collection systems. Nonetheless, some useful observations were made of how they held water. When constructed, each pond had a seam and a slice that was located over the seepage collection system. The slice was placed to investigate the effectiveness of self-healing of the bentonite in the GCL after freezing and thawing.

The slice in the Gundseal product allowed a high rate of seepage immediately upon filling of the pond. Initial attempts to fill the Gundseal GCL pond showed that it would not hold water. The sliced area was uncovered, and the slice was found to have widened from a slit to roughly 1.5 cm across. It appears that after the warm HDPE was buried and water was added, it cooled and subsequently contracted, causing the slice area to open, allowing water to seep out. A 10-cm-wide Gundseal GCL patch strip was placed over the slice, and the gravel cover was replaced. After the patch was placed, the pond retained water.

The pond lined with Bentomat GCL did not hold water soon after construction. We found that some seams were constructed without sufficient bentonite in the overlap. An attempt to excavate and repair the seams was made, but it was ineffective, and the pond continued to leak.

The Claymax GCL pond held water for the summer of 1993 (the summer after the first winter), but did not hold water after the second winter. A reason for this change could not be found.

The three GCL pond studies reveal some of the problems of conducting field studies with GCL barrier systems. Because the hydraulic conductivity of the hydrated GCL is so low, no leaks in the leachate collection system can be tolerated. Furthermore, these studies show the limitations of using the GCL systems under field conditions. Any imperfections in the seams or stress on cuts or defects can lead to significant leaks.

COST SAVINGS USING GCLs

Cost savings rationale

We have shown that the hydraulic conductivities of both GCLs and sand–bentonite mixtures, under ideal conditions in the laboratory and in the field, are not adversely affected by freezing and thawing. This is in sharp contrast to the behavior of compacted clay soils. Thus, there appears to be an advantage of using a GCL or a sand–bentonite mixture in place of a compacted clay in that much of the frost protection layer can be eliminated. However, the advantages of using sand–bentonite mixtures are not so great as using the GCL systems. With sand–bentonite mixtures, costs will be saved by eliminating the frost protection layer, but costs will also increase because bentonite clay and the bentonite with sand will have to be purchased. The sand–bentonite mixtures require 10 to 20 times as much bentonite as there is in a GCL system, and the mixture must be very uniform, as any regions of low bentonite content can be a path of low resistance for water flow. Thus, special equipment is needed to thoroughly mix the sand, bentonite, and water prior to its being compacted in place.

Thus, the advantage of using a GCL in place of a compacted clay soil is not just in the frost resistance, but it is also in the cost savings resulting from the elimination of much of the frost protection layer and from the increased storage capacity for waste material achieved. Geosynthetic clay liner systems can cost in place about the same as compacted clay liners, depending on the local price of compacted clay. Therefore, there may not be any savings in the hydraulic barrier itself. It is the experience of the second author (AEE) that a GCL liner may cost more or less in place than a compacted clay layer, generally a little more. So, for this discussion, we assume that the costs are the same.

With a GCL, all but about 1 ft (0.3 m) of the soil normally required for the frost protection layer can be eliminated. Some soil is still needed above the cover barrier as a medium to grow grass and to protect the GCL from mechanical and ultraviolet damage. This layer is still protective, but its primary enemy is not frost. The GCLs are also much thinner than the compacted clay layer for which they can be substituted: the hydrated GCL is about 0.5 in. (13 mm) thick and the normal compacted clay layer is 2 ft (0.6 m) thick. Figure 15 schematically illustrates the increased storage capacity gained by the elimination of the compacted clay and most of the frost protection layer.

Frost protection layer thickness required for a compacted clay barrier

We first determined how much frost protection is required over the U.S. We used a freezing index map from TM 5-818-2, *Pavement Design for Seasonal*

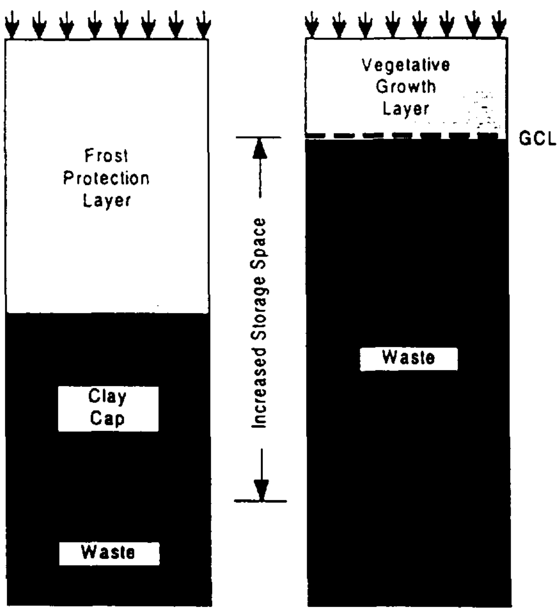

Figure 15. Increased storage space resulting from the use of a GCL and the elimination of the frost protection layer.

Frost Conditions (U.S. Army 1985), which shows contours of freezing index for the coldest year in 10 years of record or the 90th percentile (Fig. 3-1 and 3-2 in TM 5-818-2). Examination of longer records of freezing index data showed that using a 95th or greater percentile did not result in a significantly greater freezing index.

The thickness of frost protection required to prevent frost from penetrating into the hydraulic barrier was determined using the freezing index data in a frost depth model developed at CRREL (Aitken and Berg 1968). We assumed that a silt soil would be used as a frost protection layer, that the density of this layer would be about 110 lb/ft^3 (758 kPa), that the water content would be 17%, and that the surface would have a grass cover. The resulting map showing contours of equal frost protection layer thickness is given in Figure 16. It can be seen that the range of frost protection required is 1–6 ft (0.3–1.8 m) in the U.S., with anywhere between 1 and 3 ft (0.3 and 1 m) of frost protection being required over the highly populated northern regions of the U.S.

Calculation of potential cost savings using a GCL liner system

Cost of frost protection

We have calculated these potential cost savings for different regions of the U.S. Our calculations assume that only 1 ft (0.3 m) of cover soil is needed as the medium in which to grow grass and any remaining space gained by eliminating the frost protection layer can be used to store waste material. This means that only 1 ft of protective soil cover is required everywhere. This 1 ft of soil thickness could only be used if a shallow-rooted grass was the turf cover, and if there was assurance that burrowing animals would not be a problem. Our calculations also assume that all of the space gained by eliminating a compacted clay layer and using a GCL layer can be used to store waste material, the thickness of the GCL being insignificant. We assume that the cost of obtaining, excavating, hauling, placing, and compacting fill for a frost protection layer would cost \$10/yd^3 (\$13/m^3). That figure is an average for several projects at CH2M Hill.

Value of storage space

The value of the storage space gained by using a GCL in place of a compacted clay layer was estimated from data published by the National Solid Wastes Management Association (Repa 1990). Table 4 summarizes data taken from this report for five studies of landfills with clay or clay-composite cover systems. Only the early development, construction, closure, after-closure and other costs, such as interest on borrowed money and profit, are included in this cost estimate. The operating costs, which do not add value to the storage space, are not included. The lower right corner of Table 4 shows that the average value of the storage space for the five studies is about \$21/ton (\$19/tonne) of waste.

Calculation of cost savings

To calculate the cost savings achieved by using a GCL in place of a compacted clay liner, we assumed the cost of the frost protection layer to be \$10/yd^3 (\$13/m^3) and the value of the storage space to be \$21/ton (\$19/tonne) of waste. The density of the waste is assumed to be 40 lb/ft^3 (276 kPa). On an acre-foot basis, the cost of the frost protection then is about \$16,000/acre-ft (\$13/m^3) and the value of the waste fill space is about \$17,500/acre-ft (\$14/m^3).

The estimated resulting cost savings are given in Table 5 for the range of 1–6 ft (0.3–1.8 m) of frost protection. Under the fourth column heading, we can see that the cost savings attributable to the reduction in thickness of the protective cover ranges from \$0 across middle latitudes of America to \$80,000/acre (\$200,000/ha) in the north-central

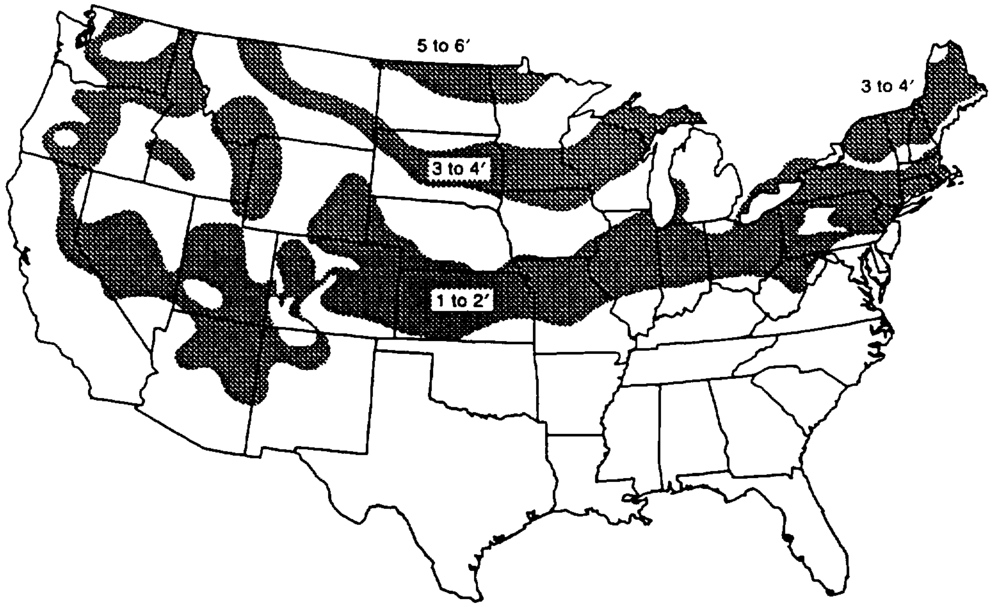

Figure 16. Thickness of protective soil layer required for compacted clay covers.

Table 4. Analysis of the value of waste storage space.

Category	Glebs* 1988a	Glebs* 1988b	SCS* 1989	SCS* 1990	Dell* 1989	Average for five studies
	Cost of storage space ($1000)					
Before development	2,785	592	7,260	6,681	891	3,642
Construction	8,728	5,690	25,565	77,910	4,171	24,413
Closure	2,475	147	2,452	9,777	1,315	3,233
After closure	9,120	1,835	5,526	5,526	7,500	5,901
Other†	7,150	407	69,949	119,369	0	39,375
Total fixed costs**	30,258	8,671	110,752	219,263	13,877	76,564
Capacity (million tons)	2.86	1.42	6	5.4	2.6	3.7
Capacity (10^9 kg)	2.59	1.29	5.4	4.9	2.4	3.4
Size (acres)	74	50	80	80	14.7	59.7
Size (ha)	30	20	32	32	5.9	24.2
Fixed costs ($/ton)	10.58	6.11	18.46	40.60	5.34	20.94
Fixed costs ($/tonne)	9.60	5.54	16.74	38.62	4.84	18.99
Fixed costs ($1000/acre)	409	173	1,384	2,741	944	1,282
Fixed costs ($1000/ha)	1,010	428	3,421	6,775	2,333	3,169

* From Repa (1990).
† Includes interest on debt, profit, etc.
** Excludes operating costs

Canadian border region. Under the fifth column heading is shown a cost savings of about $35,000/acre ($87,000/ha), attributable to the increased storage space caused by the reduction in thickness of the hydraulic barrier, even when there is no decrease in the thickness of the protective layer. Also under the fifth column heading in Table 5, we can see that, for the most northern part of the U.S., the cost savings attributable the increased storage space exceeds $70,000/acre ($173,000/ha) of landfill. The cost savings range from $35,000/acre ($87,000/ha) to $123,000/acre ($304,000/ha) for the region of the U.S. normally requiring 1–6 ft (0.3–1.8 m) of frost protection. Under the sixth column heading, we see that the total cost saving is greater than $100,000 in the populated regions of the northern States and that it can exceed $200,000/acre ($504,000/ha). Finally, under the last column heading it is shown that the cost savings for a 20-acre (8-ha) landfill can be $2,000,000 in a region just by eliminating 2 ft (0.6 m) of frost protection and using a GCL hydraulic barrier system in place of a compacted clay barrier.

The cost savings in terms of the total fixed costs

This study has also shown that the hydraulic conductivity of sand-bentonite mixtures can be resistant to freeze-thaw if the sand is uniformly mixed with an adequate amount of bentonite. The hydraulic conductivity in the sand-bentonite test pad appeared to remain unchanged after two winters of freezing. The sand-bentonite test pad also showed no visible cracks. However, the performance of the sand-bentonite is very sensitive to incomplete mixing of its ingredients. Further study of the effect of freeze-thaw, with sufficient control to ensure uniform mixing of the sand and bentonite, should be undertaken. In addition, conditions that limit the problem of piping of bentonite should also be explored.

The test results show that the hydraulic conductivity of the GCL materials is also frost resistant, with hydraulic conductivities remaining below 1×10^{-8} cm/s after freezing and thawing. However, there is some uncertainty about the performance of seams, the sealing of construction damage (cuts), and the effects of the water quality on the hydration of the bentonite in the GCL materials. Additional large-scale field tests are needed to further examine these problems and to develop specific construction guidelines and methods for the use of GCLs.

The cost benefits of using GCL hydraulic barriers in place of compacted clay barriers are significant. These benefits result from the elimination of the soil required for frost protection above the hydraulic barrier and from the decrease of the thickness of the hydraulic barrier. The value added to a waste disposal site by substituting a GCL for a compacted clay layer can exceed $200,000/acre ($494,000/ha) or nearly 16% of the fixed costs of the disposal site.

Finally, this study has shown that the sampling and test methods are important for forensic analysis of frost damage to the hydraulic conductivity of compacted clay liners. The conventional thin-walled tube sampler is not acceptable for frost-damaged soils, as it compresses the soil and masks the damage. Furthermore, the hydraulic conductivity test cannot be done at high stress levels. The stress level must be commensurate with the in-situ stress. For a cover system, the maximum effective stress in the hydraulic conductivity test should not exceed 2 lb/in.^{2} (13.8 kPa).

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HYDRAULIC CONDUCTIVITY OF GEOSYNTHETIC CLAY LINERS AFTER FREEZE-THAW

By Robert D. Hewitt[1] and David E. Daniel[2]

ABSTRACT: Hydraulic conductivity tests were performed in large tanks on intact (single panel) and overlapped samples of three geosynthetic clay liners (GCLs) that had been subjected to freeze-thaw cycles. The compressive stress applied to the GCLs (7.6–12.4 kPa) was selected to simulate final cover systems for landfills. Laboratory flexible-wall permeameter tests were also performed. With the exception of one overlapped GCL, all three GCLs withstood three freeze-thaw cycles without a significant change in hydraulic conductivity. An overlapped, geotextile-encased, stitch-bonded GCL did undergo a 1,000-fold increase in hydraulic conductivity after one freeze-thaw cycle, but the overlapped area contained stitches, which are left off the edges of the full-sized material that is deployed in the field. In general, the tests showed that GCLs can withstand at least three freeze-thaw cycles without significant changes in hydraulic conductivity.

INTRODUCTION

Geosynthetic clay liners (GCLs) are thin hydraulic barriers containing 5 kg/m^2 (1 lb/ft^2) of sodium bentonite, sandwiched between two geotextiles or attached with an adhesive to a geomembrane (Daniel and Estornell 1991; Daniel 1991, 1993; Daniel and Boardman 1993; Koerner 1994). GCLs are manufactured in panels and are installed by unrolling and overlapping the panels. Overlaps self-seal when the bentonite hydrates (Estornell and Daniel 1992). Geosynthetic clay liners are receiving increased use in bottom liners for landfills and impoundments (Schubert 1987; Daniel and Koerner 1991; Trauger 1991, 1992; Clem 1992), in final covers for landfills and remediation projects (Koerner and Daniel 1992; Daniel and Richardson 1995; Woodward and Well 1995), and as a liner for secondary containment around liquid storage tanks (Brunton 1991).

An important issue on some projects is whether freeze-thaw affects GCLs, either during or after construction. Freeze-thaw causes moisture migration, cracking, and increased hydraulic conductivity in natural clays and silts (Chamberlain and Gow 1979; Konard 1989). As discussed by Othman et al. (1994), compacted clay liners are vulnerable to damage from freeze-thaw (Chamberlain et al. 1990; Zimmie and LaPlante 1990; Zimmie 1992; Chamberlain 1992; Othman and Benson 1992, 1993; Kim and Daniel 1992; Benson and Othman 1993; Bowders and McClelland 1994).

Bentonite appears to be less vulnerable to freeze-thaw damage than other types of soil. Wong and Haug (1991) found that the hydraulic conductivity of compacted sand-bentonite mixtures did not increase after five freeze-thaw cycles. Published information on the effects of freeze-thaw on GCLs are summarized in Table 1. All tests summarized in Table 1 were performed on small (~100 mm diameter) test specimens without overlaps. The hydraulic conductivity after freeze-thaw has been found to be approximately the same as before freeze-thaw (Table 1). The ability of GCLs to withstand freeze-thaw is apparently the result of the swelling and self-sealing characteristics of bentonite.

Only one published case involving field performance of GCLs could be found in the literature. At a location near Milwaukee, Wisconsin, Erickson et al. (1994) placed three GCLs (with and without overlaps) over an underdrain system and covered them with 250 mm of gravel. The GCLs went through one winter of freeze-thaw. In general, the hydraulic conductivity of the GCLs underwent little or no change. Of the nine tests, the one that produced the greatest seepage was beneath an overlap of a geotextile-encased, stitch-bonded GCL; before freeze-thaw, the average hydraulic conductivity was 3×10^{-10} m/s, and after freeze-thaw, the hydraulic conductivity was 4×10^{-9} m/s.

The purpose of this study was to perform carefully controlled tests to evaluate the effect of several freeze-thaw cycles on the hydraulic conductivity of GCLs. Tests were performed on small-scale samples of the parent GCL materials in the laboratory, and large-scale tests were performed on the parent materials and on overlapped panels of GCLs. Conclusions are drawn concerning the hydraulic integrity of GCLs subjected to freeze-thaw cycles.

EFFECTS OF FREEZE-THAW ON SOILS

Mechanisms

As the temperature drops below 0°C, soil begins to freeze and ice crystals nucleate in the center of the largest pores of the soil. Water outside the larger pore spaces freezes at lower temperatures; capillary forces acting on the surface of the soil particles and electrolytes in the pore water depress the freezing point of the pore water. Konrad (1989) found that free water in the pore space froze at −0.4°C to −0.7°C; this zone where freezing is actively occurring consists of soil particles, ice, and water. As water changes to ice, it increases in volume by about 9% due to the expansion of the hexagonal ice crystals. Ice crystals exert pressure on each other and the surrounding soil (Andersland and Anderson 1978), inducing structural changes within the soil.

If the temperature remains below 0°C, the freezing front advances into the soil. Water is drawn to the freezing zone from the unfrozen soil (Tsytovich 1975). As water moves to the freezing front, it crystallizes onto existing ice, forming ice lenses oriented parallel to the freezing front. The size and spacing of ice lenses depend on the relative magnitude of the availability of water and the freezing rate (Andersland and Anderson 1978).

The term open system refers to the presence of an external water supply available to the soil during freezing. Likewise, when soil is isolated from external sources of water, freezing is said to occur in a closed system. Experiments with closed-system freezing verify that water contents increase in the frozen zone and decrease in the unfrozen zone (Benson and Othman 1993), indicating that moisture migration occurs within the soil. Whether the system is open or closed appears to have

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of barrier material, better withstand the effects of freeze-thaw than ordinary compacted clay liners. With few exceptions, all of the data at laboratory, bench, and field scales indicate that most GCLs can withstand freeze-thaw cycling without undergoing a significant increase in hydraulic conductivity.

GCLs may be exposed to freeze-thaw during construction or, if they are located near the ground surface (e.g., in a landfill cover system), during service. Construction-related freeze-thaw should not be of much concern; the data consistently show that most GCLs can withstand several freeze-thaw cycles without damage.

An important issue is whether it is appropriate to design a final cover system that locates a GCL in the freeze-thaw zone. Although there is a high probability that a GCL subjected to repeated freeze-thaw cycles over a long period of time would continue to function effectively, too few data are available to demonstrate long-term hydraulic integrity conclusively. It appears that the most appropriate design approach is to assume that the GCL will probably remain undamaged by freeze-thaw but to recognize that there is a risk of long-term damage. In many situations, the GCL is placed beneath a geomembrane, and the effect of increased hydraulic conductivity of the bentonite in a GCL on the overall performance of the system (if any) would not be very large. Also, in many situations, the final cover has a specific design life during which time leachate is collected from the underlying waste; again, the effects of an unexpected, increased hydraulic conductivity would not be large. In some situations, the consequences of increased hydraulic conductivity in the bentonite component of a GCL as a result of possible freeze-thaw damage might be severe, in which case the designer would be encouraged to locate the GCL below the freeze-thaw zone.

One special case warrants discussion. Some GCLs are designed with the bentonite sandwiched between two geomembranes with the intent of keeping the bentonite essentially dry, except at locations of leaks in the geomembrane or its seams. Dry GCLs are not damaged by freeze-thaw because of the tremendous swelling and self-healing ability of bentonite when it hydrates. For instance, Shan and Daniel (1991) showed that large punctures made in dry GCLs self seal when the bentonite hydrates. If a GCL is used in a situation where the bentonite can reasonably be expected to remain dry, there should be no concern about the effects of freeze-thaw upon the hydraulic integrity of the dry bentonite.

CONCLUSIONS

The objective of this study was to assess the impact of freeze-thaw cycling on the hydraulic conductivity of GCLs. Hydraulic conductivity tests were performed on intact and overlapped GCLs that were subjected to up to three freeze-thaw cycles. Three commercial GCLs were tested.

The geotextile-encased, needle-punched GCL that was tested maintained a low hydraulic conductivity ($<1 \times 10^{-9}$ m/s, which is a common regulatory maximum) even after three freeze-thaw cycles. Neither the parent GCL material nor overlaps between GCL panels were damaged by three freeze-thaw cycles.

Results of tests on a geotextile-encased, stitch-bonded GCL were different for the parent material and overlapped panels of the material. The parent material was essentially unaffected by three freeze-thaw cycles and maintained a low hydraulic conductivity (well below 1×10^{-9} m/s) even after freeze-thaw. Overlapped panels of this type of GCL were affected by freeze-thaw and underwent approximately a 1,000-fold increase in hydraulic conductivity (final value after freeze thaw $\sim 1 \times 10^{-7}$ m/s). However, the test panels contained stitching in the overlapped area. The manufacturer leaves the edges of full-sized panels unstitched so that overlapped zones will not contain stitching. It is possible that the stitching may somehow have influenced the results of these tests, although Erickson et al. (1994) found similar results in field-scale tests on larger panels. Larger-scale tests are recommended to evaluate the issue of stitches in the overlap.

No outflow occurred from overlapped panels of the geomembrane-supported GCL. Due to the presence of the geomembrane, flow could only occur through the overlapped area or the edge seal. The bentonite in the overlap was hydrated about 50 mm into the 225-mm-wide overlapped seam. Freeze-thaw cycling did not alter the hydraulic integrity of the overlap. A sample of the bentonite component of this GCL tested in a flexible-wall permeameter did not undergo any increase in hydraulic conductivity after freeze-thaw cycling.

It is concluded that under the conditions of these tests, most GCLs (intact and overlapped panels) can withstand at least three freeze-thaw cycles without undergoing a significant increase in hydraulic conductivity.

The reader is cautioned not to inappropriately extrapolate the results of these tests. The tests were performed under carefully controlled conditions in laboratory devices at a compressive stress of about 8 kPa. The GCLs were subjected to only three freeze-thaw cycles, and the conditions of freeze-thaw were not superimposed with other environmental stresses (e.g., differential settlement and desiccation). The data in this paper will hopefully provide useful information, but ultimately, field data are needed to understand how GCLs perform in the field.

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Hull, J.H. and J.M., Jersak, "Resiliency of Different Clay Mineral-Based Hydraulic-Barrier Materials to Climatic and Other Environmental Stresses," ***Hull & Associates, Inc.***

RESILIENCY OF DIFFERENT CLAY MINERAL-BASED HYDRAULIC-BARRIER MATERIALS TO CLIMATIC AND OTHER ENVIRONMENTAL STRESSES

by John H. Hull, P.E., D.E.E., Joseph M. Jersak, Ph.D., CPSS

ABSTRACT: The processes of wetting-drying and/or freeze-thaw have the potential for substantially reducing the efficacy of clay mineral-based hydraulic landfill barriers. These climatically induced stresses can result in an increase in hydraulic conductivity due to alteration of soil-structural fabric and the development of secondary porosity, largely through crack formation. The inherent ability of a clay mineral-based barrier material to "heal" from physical alterations over the short term (one climatic stress cycle) and long term (many cycles), that is, its resiliency, will depend primarily on the type and amount of clay minerals present, as well as factors related to material construction. Through considering a variety of laboratory and field-derived data, the relative resiliencies of different types of clay mineral-based hydraulic-barrier materials to climatic and other environmental stresses were examined and qualitatively compared within the context of their usage within landfill liner and cover systems. Clay mineral-based barrier materials considered in this study include geosynthetic clay liners, compacted clayey soils, and a composite aggregate particle system. The overall short- and long-term efficacy and practicality of the clay mineral-based barrier materials was also considered in terms of relative resistance to erosion and destruction by burrowing animals, inherent ability to attenuate dissolved contaminants, adaptability to chemical/mineralogical modification for particular waste-attenuating needs, ease of deployment, level of quality assurance needed to insure adequate deployment, and cost.

INTRODUCTION

Clay mineral-based hydraulic barriers can be key components of engineered landfill liner or cover systems. The principal functions of hydraulic landfill barriers are to:

- minimize the rate and extent of leachate movement from the landfill and to facilitate removal of leachate via a leachate collection system, or
- minimize the rate and extent of infiltration of precipitation and other surface waters into the landfill, thereby minimizing leachate generation

RCRA Subtitle D regulations have established performance standards for the permeability of barrier components of liner and cover systems in landfills at hydraulic conductivities values of equal to or less than 1 x 10-7 cm/sec (USEPA 1991). In addition to minimizing flow, other (non-regulated) characteristics inherent to hydraulic-barrier materials, such as their ability to attenuate mobile contaminants or their long-term resiliency to physically and climatically induced stresses, will also dictate the success of a given barrier material in performing its stated function.

Hydraulic barriers can be comprised of a variety of naturally occurring and/or synthetic materials, separately, or in combination. Primarily because of their inherently low hydraulic conductivities, availability, and constructability, clay mineral-based earthen materials, either in the form of compacted clayey soils (CCLs) or as a component in manufactured composite liners (e.g., geosynthetic clay membranes, or GCLs), are commonly used in landfills as part of liner or cover systems. Clay mineral-based barrier material has also been used as a principal component of subaqueous liner systems in surface-water impoundments and lagoons.

The overall effectiveness of clay mineral-based barriers in maintaining acceptably low hydraulic conductivities depends on the material's ability to retain its physical integrity and

The expected effectiveness of a given clay mineral-based barrier material was evaluated within the context of its use as a component of either a landfill liner or cover system. This was done through qualitatively reconciling a material's inherent resiliency and construction with its expected response to various environmental stresses uniquely related to each landfill usage scenario. In particular, the following hypothetical question was posed for each type of clay mineral-based barrier as it would exist within either a liner or cover system: "in response to a given environmental stress (e.g., wetting-drying), what is the potential for the effectiveness of the barrier material to be reduced because of its inherent level of resiliency, the nature of its construction, or both?" A reply of "low", "medium", "high", or "not applicable" is then applied, which indicates the potential for reduced barrier effectiveness relative to that likely displayed by other barrier materials under the same stress.

The environmental stresses that a barrier material may be exposed to will depend on the usage scenario being considered as well as the phase of barrier-system construction (i.e., during and after). Seasonal exposure of clay mineral-based barrier materials to freeze-thaw and wetting-drying processes were of primary interest in this study. However, other environmental stresses are also considered herein and include:

- burrowing animals
- overburden pressure
- differential settlement
- water erosion

In addition to considering the effectiveness of different barrier materials in either liner or cover systems under various environmental stresses, an evaluation was also completed (both qualitative and relative) of the additional effects that versatility and deployment-related factors may have on the efficacy and overall usability a given barrier material within liner or cover systems. These additional factors include:

- ability to attenuate contaminants
- adaptability to site-specific, contaminant-attenuation needs
- level of quality assurance required for adequate deployment
- availability of barrier material
- seasonal restrictions on barrier deployment
- volume of barrier material upon deployment
- potential for loss of facility operations during barrier deployment and maintenance
- relative cost

RESULTS AND DISCUSSION

Inherent Resiliencies of Barrier Materials to Climatical Stresses

As stated previously, numerous laboratory studies have been conducted to evaluate freeze-thaw effects on a variety of clay mineral-based barrier materials. Results of representative studies using GCLs and CCLs are summarized in Table 2. In contrast, few such studies, with the exception of those involving GCLs (Shan and Daniel 1991, USEPA 1996, Boardman 1993), appear to have been conducted to date on clay barrier response to wetting-drying effects. Instead, wetting-drying affects on barrier materials appear to have been evaluated primarily within field situations, and mostly through visual inspection. Finally, research is currently being conducted into the inherent resiliency to freeze-thaw and wetting-drying of the composite aggregate particle system (CAPS). Laboratory information available to date for this particular barrier material is presented.

Resiliency to Freeze-Thaw Stress

Short- and long-term cyclic effects of freeze-thaw stress on the hydraulic conductivity and physical structure of clay mineral-based hydraulic-barrier materials, as determined under controlled laboratory conditions, are summarized in Table 2. A review of available published information in this regard indicates that:

- GCLs typically display relatively high resiliency to freeze-thaw stress, based on the lack of significant effects on physical structure or hydraulic conductivity after numerous freeze-thaw cycles.
- the CAPS also appears to display relatively high resiliency to freeze-thaw stress, based on the material's ability to heal following sample thawing. Laboratory studies are currently underway to determine the potential effect, if any, of freeze-thaw stress on the conductive characteristics of this material.
- CCLs typically display relatively low resiliencies to freeze-thaw, as manifested by the formation of cracks (originating at soil surfaces) as well as significantly increased hydraulic conductivities, when cracks completely penetrate a sample.

Generally speaking, the relatively high resilience (i.e., healing ability) of GCLs and the CAPS, which enables maintenance of low hydraulic conductivities, is largely attributable to the significant bentonite component within both barrier-material types (Table 1). Furthermore, it is also worth noting in regards to resiliency of the CAPS that the cracks that did form did not penetrate the entire thickness of the hydrated sample; thus, the effectiveness of this material may not be compromised in field application, even with some degree of cracking, and before the material has completely healed.

Conversely, the relatively low resiliency typically displayed by CCLs is likely attributable to a relative lack of smectite clay minerals, despite the high total clay content present in some of the soils (Table 1). This relative lack of expansive clay minerals does not allow for soil healing upon sample thawing, thus resulting in significant reductions in hydraulic conductivity. Furthermore, the impact of freeze-thaw stress on hydraulic conductivities of CCLs is particularly apparent when a higher quantity of water is present in the sample upon freezing (Kim and Daniel 1992).

Resiliency to Wetting-Drying Stress

A review of available data related to wetting-drying testing of GCLs (Shan and Daniel 1991, USEPA 1996, Boardman 1993) indicates that GCLs are as resilient to wetting- drying effects as they are to freeze-thaw effects. In particular, although significant cracking was observed following sample desiccation by drying, complete healing was observed upon subsequent rehydration. As a result, hydraulic conductivity values following wetting-drying were comparable to pre-treatment values - not only after a single wetting-drying treatment, but after several such cycles (Shan and Daniel 1991, Boardman 1993). The behavior of a typical compacted clayey soil to wetting-drying stress under laboratory conditions has not been established. Nevertheless, in a technical equivalency assessment of GCLs versus CCLs and in regards to wetting-drying effects, Koerner and Daniel (1995) state that "GCLs appear to be superior to CCLs in terms of ability to self-heal if the material is wetted, dried, and rewetted."

Laboratory studies are currently underway to determine the potential effect, if any, of wetting-drying stress on the structural and conductive characteristics of the CAPS. It is anticipated that, given the high bentonite content of this aggregate material (Table 1), its resiliency will be comparable to that of GCLs.

In regards to material resiliency to wetting-drying stress, it appears that the most critical issues for smectite-poor soil materials as well as for manufactured, bentonite-rich materials are: (1) the amount of water available to bring about complete clay re-hydration, and (2) the rate at which healing will occur upon rewetting. First, the issue of water availability should not be critical for the response of a clay mineral-based material to freeze-thaw stresses in that an adequate amount of water should already be present to affect complete re-

Similar parameters should be considered when comparing a CAPS to a GCL application. For landfill applications, material costs, duration of project, installation conditions and the level of CQA are probably the most significant cost parameters to consider when making this comparison. A typical GCL installation rate is on the order of an acre or two per day, including subgrade preparation, GCL placement, and FML placement. Installed costs for the components individually are on the order of $0.65/sf and $0.45/sf, respectively. Commercial products are available which combine a FML with granular bentonite and typical installations use 30- to 60-mil High Density or Low Density Polyethylene, depending on the application. Similar materials could also be used for lagoons, although Polyvinyl Chloride or Polypropylene are more commonly used; these products could range in price from $0.45 to $0.75/sf. When difficult GCL installation conditions are expected (due to undulating or variable terrain, numerous slope breaks, submerged conditions, etc.), implementation of a CAPS might provide a cost savings, owing to reduced installation time and, ultimately, improved overall performance of the liner system.

SUMMARY AND CONCLUSIONS

This study consisted of a qualitative review and comparison of the relative effectiveness of different clay mineral-based materials - GCLs, CCLs, and CAPS - as components of typical landfill liner or cover systems. The relative effectiveness of a given clay mineral- based barrier material in acting as a hydraulic, physical, and/or chemical barrier in either capacity is a function of two primary factors: (1) properties inherent to the barrier material itself, which include its resiliency to physical change as well as the nature of its construction; and (2) a myriad of environmental stresses related to either landfill application, and barrier response to each of these stresses. Such environmental stresses could range from the actual degree of barrier exposure to freeze-thaw or wetting-drying to differential settlement occurring within a landfill's cover system. Finally, additional factors related to the logistical implementation and adaptability of a given clay mineral- based barrier material were also considered; these factors ranged from the adaptability of a barrier material to site-specific contaminant-attenuation needs to seasonal restrictions on barrier deployment.

In general, results of this comparative study indicate that landfill cover and liner systems incorporating either GCL or CAPS materials would likely maintain much or most of their functional effectiveness as hydraulic and physical barriers under exposure to climatic, biotic, and physical stresses by virtue of their high bentonite content and gravelly or geosynthetic makeup. However, the potential lag time in complete GCL healing upon rehydration (following wetting-drying stress) may represent some drawbacks to the use of this barrier material in some situations; pending additional research, it is uncertain as to whether a thicker CAPS layer will experience the same potential drawback. When compared to GCLs and CAPS, barrier systems incorporating CCL material would likely show decreased barrier effectiveness under the same environmental stresses due to a relative lack of resilient clay minerals, gravel, and geosynthetics.

Finally, in regards to overall implementability of these clay mineral-based barrier materials within landfill liner or cover systems: GCLs and CAPS have clear advantages over CCLs in terms of availability, chemical attenuating capacity, adaptability to modification for particular attenuating needs, and the limited mass of material needed to affect these functions. Furthermore, CAPS-based barrier systems have additional advantages over those incorporating GCLs in terms of the relatively low level of QA needed for CAPS implementation and the lack of seasonal restrictions on CAP implementation.

ADDITIONAL RESEARCH ACTIVITIES

The physical characteristics of GCL and CCL barriers and how they react to external climatological and artificially induced stresses are generally well understood and accepted amongst the regulatory and engineering community. On the other hand, the CAPS barrier system is new technology that will require additional extensive laboratory and field studies

Husan, Y.G., Sculli, M.L., Guan, Z.C., and A.I. Comer, "Effects of Freeze-Thaw Cycling on Geomembrane Sheets and Their Seams - Part II Cold Temperature Tensile Behavior and Thermal Induced Cyclic Stress," ***Geosynthetics '97.***

Effects of Freeze-Thaw Cycling on Geomembrane Sheets and Their Seams - Part II
Cold Temperature Tensile Behavior and Thermal Induced Cyclic Stress

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ABSTRACT

Geomembranes are widely used as liquid barrier materials in rehabilitation of dams, canals, and waste containment facilities. In many locations such geomembranes are subjected to freeze-thaw cycling. However, the impact of the cyclic temperature effect on the long-term behavior of geomembranes is largely unknown. This study, sponsored by the Bureau of Reclamation and the Environmental Protection Agency evaluates the effects of cold temperature and freeze-thaw cycling on nineteen geomembrane sheets and 31 combinations of seams.

Regarding the effect of freeze-thaw cycling between +30°C and -20°C, after 200 cycles under unconstrained conditions, results showed no statistically significant changes in either geomembrane sheets or seams at tensile test temperatures of +20°C and -20°C. While under constrained conditions, test specimens were subjected to thermal induced cyclic stress as well as freeze-thaw action, the tensile behavior of geomembrane sheets and seams still remained unchanged even after 500 freeze-thaw cycles.

The cold temperature induced stress during the cold cycle of freeze-thaw cycles varied with polymer types. The magnitude of the stress is a factor of modulus and coefficient of thermal expansion of the material. Furthermore, the induced stress was the same for each freezing cycle and it remained unchanged until the temperature was increased. Regarding the initial stress caused by straining, it relaxed rapidly. The nonreinforced geomembranes exhibited a higher relaxation rate than the reinforced geomembranes.

For the effect of cold temperature on the tensile behavior of geomembrane sheets and seams, tensile strength increased and elongation decreased at the lower testing temperature. In addition, for each geomembrane, the shear strength responded differently than the peel strength. The majority of the hot wedge seams showed a lower increase in the peel strength than the corresponding shear strength.

INTRODUCTION

The effects of freeze-thaw cycling and cold temperature on mechanical behavior of any type of engineered barrier material should be a concern at locations where ground freezing conditions exist. Othman and Benson (1993) observed an approximately 9% increase in volume when the pore water within the compacted clay liner (CCL) froze. The expansion caused the formation of ice lenses which became channels for water to flow. Zimmie and La Plante (1990) found that CCL's become friable and experience an increase in their permeability after 10 to 15 freeze-thaw cycles. For this reason, CCLs are recommended to be placed beneath the depth of maximum frost penetration in areas where freezing conditions exist. Contrary, Hewitt and Daniel (1996) found that the hydraulic conductivity remained almost the same after three freeze-thaw cycles for three different geosynthetic clay liners (GCL). Regarding the overlapped seams, although one of the GCL seams showed a significant increase in the conductivity value after only one freeze-thaw cycle, the other two seams exhibited no changes.

Comparatively, for alternate barrier materials such as geomembranes, limited information is available regarding performance under freeze-thaw cycling. LaFleur et al. (1985) performed a freeze-thaw study on four different types of geomembrane seams which included solvent seamed ethylene propylene diene monomer (EPDM) rubber, solvent seamed isobutylene rubber, solvent seamed chlorosulfonated polyethylene (CSPE), and hot air seamed polyvinyl chloride (PVC). The seamed samples were strained to 10% strain and subjected to 150 freeze-thaw cycles. There was no change in the strength of any of the seamed geomembranes. For high density polyethylene (HDPE) geomembranes, Budiman (1994) conducted a freeze-thaw study on three geomembranes with thicknesses of 1.0, 1.5 and 2.0 mm. The test coupons were restrained in both the uniaxial direction and biaxial directions while subjected to freeze-thaw cycles between temperatures of 65°C and -20°C. After incubation, dumbbell shaped specimens were taken from coupons for the tensile test evaluation. No significant change in the tensile load-elongation characteristics were determined after 150 freeze-thaw cycles.

Another concern for geomembranes installed in areas where freezing conditions exist is the effect of cold temperature on their tensile behaviors. Many researchers (Rollin et al., 1984, LaFleur et al., 1985, Richards et al., 1985, Peggs et al., 1990, Giroud et al, 1993 and Budiman, 1994) found that as the temperature decreases, the strength (either the yield strength or the break strength) of geomembranes increases and break elongation decreases. This behavior was observed in geomembranes made from various types of polymers, including PVC, CSPE, and HDPE.

Although the above references studied the changes in tensile behavior of selected types of geomembrane sheets under freeze-thaw and cold temperature conditions, the behavior of many current geomembrane seam types were not included in these studies. Additionally, new types of geomembranes were not evaluated. Thus, the Bureau of Reclamation and the Environmental Protection Agency jointly initiated an extensive research study on a variety of geomembrane sheets and seams in September, 1993. The early results of this freeze-thaw study was presented in two papers, Hsuan et al., 1993 and Comer et al., 1995. A detailed final report of the study was published by the Bureau of Reclamation as R-96-3 (Reclamation, 1996). This paper presents a summary of all results of the study.

Kraus, J.F., Benson, C.H., Erickson, A.E., and E.J., Chamberlain, "Freeze-Thaw Cycling and Hydraulic Conductivity of Bentonitic Barriers," *Journal of Geotechnical and Geoenvironmental Engineering,* March 1997.

Freeze-Thaw Cycling and Hydraulic Conductivity of Bentonitic Barriers

By Jason F. Kraus,[1] Craig H. Benson,[2] Allan E. Erickson,[3] and Edwin J. Chamberlain,[4] Members, ASCE

Abstract: Hydraulic conductivity tests were conducted in the laboratory and field on geosynthetic clay liners (GCLs) and a sand-bentonite mixture to determine if their hydraulic conductivity is affected by freezing and thawing. In the laboratory, specimens of three GCLs were frozen and thawed 20 times, and no increase in hydraulic conductivity was measured. The hydraulic conductivity of the compacted sand-bentonite also did not increase after freezing and thawing. In the field, two types of GCLs and a sand-bentonite test pad (constructed with the same mixture used in the laboratory) were exposed to one or two winters of freeze-thaw cycling. No large increase in hydraulic conductivity was measured for the field test conducted with the sand-bentonite mixture. An increase in hydraulic conductivity was observed in only one of the field tests with GCLs. Examination of thawed GCLs and specimens of the sand-bentonite mixture showed no evidence of cracking that is commonly found in thawed compacted clays.

INTRODUCTION

Designers of hydraulic barriers are considering materials that are more cost-effective and resilient than compacted clay. One characteristic of alternative materials that is of particular importance in cold regions is resistance to increases in hydraulic conductivity caused by freeze-thaw cycling. Numerous studies have shown that compacted clays undergo large increases in hydraulic conductivity when exposed to freeze-thaw cycling [e.g., Zimmie and La Plante (1990); Chamberlain et al. (1990); Benson and Othman (1993); Othman et al. (1994); Chamberlain et al. 1995)]. However, the results of recent laboratory studies indicate that the hydraulic conductivity of geosynthetic clay liners (GCLs) and sand-bentonite mixtures are not affected by freeze-thaw cycling [e.g., Wong and Haug (1991); Shan and Daniel (1991)].

The objective of the present study is to conduct laboratory tests that confirm the findings of others and to assess whether the laboratory results are representative of field conditions. To meet this objective, three types of GCLs and one sand-bentonite mixture were exposed to freeze-thaw cycling using laboratory procedures, and were then tested for hydraulic conductivity. Field tests were conducted by exposing two types of GCLs and a test pad constructed of the sand-bentonite mixture to freeze-thaw cycling. Field and laboratory hydraulic conductivity tests were then conducted on GCLs and the sand-bentonite mixture.

BACKGROUND

In several laboratory and field studies, freezing and thawing has been shown to have a detrimental impact on the hydraulic conductivity of compacted clays. For compacted clays having an initial hydraulic conductivity less than 1×10^{-9} m/s, freezing and thawing generally increases the hydraulic conductivity one to three orders of magnitude [e.g., Zimmie and La Plante (1990); Kim and Daniel (1992); Othman et al. (1994); Chamberlain et al. (1995); Benson et al. (1995)]. Cracks induced by desiccation incurred as water migrates to the freezing front, and the formation of ice lenses are the primary causes of these increases in hydraulic conductivity (Chamberlain et al. 1995; Othman and Benson 1993a). After thawing, these cracks become preferential conduits for flow that result in increases in hydraulic conductivity (Othman and Benson 1993b; Benson and Othman 1993).

Not all barrier soils become cracked and more conductive when frozen and thawed. Wong and Haug (1991) show that compacted mixtures of Ottawa sand and sodium-bentonite do *not incur increases in hydraulic conductivity when frozen* and thawed. In fact, a decrease in hydraulic conductivity occurred for all specimens. Wong and Haug (1991) hypothesize that the hydraulic conductivity decreases because freeze-thaw cycling promotes additional hydration, and during thaw consolidation, the bentonite particles compress into gaps existing between the sand grains.

Several testing programs have shown that GCLs are resistant to damage caused by freeze-thaw cycling. GCLs are geocomposites consisting of a thin layer of dry bentonite sandwiched between two geotextiles or glued to a geomembrane. When exposed to water, the bentonite in the GCL hydrates and swells to form a thin layer having low hydraulic conductivity. GCLs are manufactured in large sheets that are delivered to the site on rolls. The GCLs are unrolled on-site, and seams are made by overlapping adjacent GCLs. In some cases, dry powdered bentonite is added in the seam between adjacent GCLs. A detailed description of GCLs can be found in Estornell and Daniel (1992).

Geoservices (1989) evaluated how freeze-thaw cycling affects the hydraulic conductivity of the GCL Claymax. They conducted laboratory tests on 76 mm diameter specimens using flexible-wall permeameters. An initial hydraulic conductivity of 4×10^{-12} m/s was measured at an effective confining pressure of 196 kPa and a hydraulic gradient of 1,000. The saturated specimen was then repeatedly frozen and thawed three-dimensionally. After 10 freeze-thaw cycles, the hydraulic conductivity was 1.5×10^{-12} cm/s. Similar findings for Claymax have been reported by Shan and Daniel (1991) and Chen-Northern (1988). A detailed summary of these studies can be found in Kraus (1994).

GeoSyntec (1991) studied how freeze-thaw cycling affects the hydraulic conductivity of the GCL Bentomat. Specimens of GCL 71 mm in diameter were permeated in flexible-wall permeameters under an effective confining pressure of 35 kPa and a hydraulic gradient of 30. The specimens were subjected to four freeze-thaw cycles, with the hydraulic conductivity of

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[4]Res. Civ. Engr., U.S. Army Cold Regions Res. and Engrg. Lab., Hanover, NH 03755.

Note. Discussion open until August 1, 1997. To extend the closing date one month, a written request must be filed with the ASCE Manager of Journals. The manuscript for this paper was submitted for review and possible publication on September 29, 1995. This paper is part of the *Journal of Geotechnical and Geoenvironmental Engineering*, Vol. 123, No. 3, March, 1997. ©ASCE, ISSN 1090-0241/97/0003-0229-0238/ $4.00 + $.50 per page. Paper No. 11718.

each specimen measured after each cycle. The hydraulic conductivity of the Bentomat specimens ranged between 1×10^{-11} and 6×10^{-11} m/s after each cycle, with no increasing or decreasing trends.

Tests to evaluate the effect of freeze-thaw cycling on Bentomat have also been performed by Robert L. Nelson and Associates (1993). Two sets of tests were conducted. In the first set, six specimens were permeated after undergoing up to six freeze-thaw cycles with no initial hydration (i.e., no initial saturation or permeation). In the second set, only one specimen was tested. It was exposed to 10 freeze-thaw cycles, with its hydraulic conductivity being measured after each thaw. No significant increase or decrease in hydraulic conductivity was observed in either set of tests. The hydraulic conductivity ranged between 1.1×10^{-11} and 4.0×10^{-11} m/s for the specimens in the first set of tests, and 1.9×10^{-11} and 3.3×10^{-11} m/s for the second set.

The findings of these studies suggest that bentonitic barriers are resistant to damage caused by freeze-thaw cycling. The study described herein, which includes laboratory and field testing, shows similar results.

MATERIALS USED IN THIS STUDY

Sand-Bentonite Mixture

One sand-bentonite mixture was used. The sand-bentonite mixture was prepared in the field using a pugmill prior to construction of the test pad used for field testing. The sand component is a poorly graded, clean, medium to fine sand that is classified as SP in the Unified Soil Classification System. More than 90% of the sand passed the No. 30 sieve, and less than 5% passed the No. 200 sieve. The bentonite component is CG-50, a granular sodium bentonite with no polymer additives that was supplied by American Colloid Corporation. Methylene blue titration tests performed on grab samples of the mixture showed the average bentonite content was 12% by weight (Kraus 1994). Compaction curves corresponding to standard and modified Proctor compaction (ASTM 1993) are shown in Fig. 1(a). Other characteristics of the mixture are described in Kraus (1994).

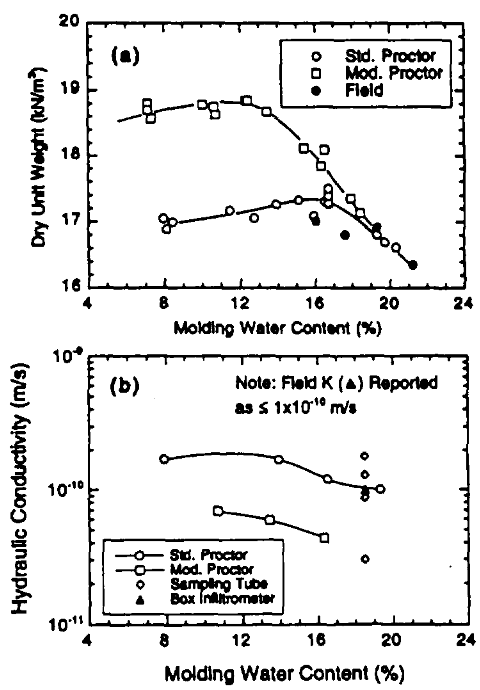


FIG. 1. Curves for Sand-Bentonite: (a) Compaction Curves; (b) Hydraulic Conductivity Curves

Geosynthetic Clay Liners

Three GCLs were used in the laboratory portion of this study: Claymax 200R, Bentomat CS, and Bentofix. Schematics of these GCLs are shown in Fig. 2. The field tests were conducted using Claymax 500SP (a stitched version of 200R), Bentomat CS, and Gundseal. Results of the tests on Gundseal are not described in the present paper, but are discussed in detail by Erickson et al. (1994). For the laboratory tests, two rolls of each GCL (2 m wide and 4 m long) were shipped to the University of Wisconsin-Madison, Madison, Wisc., by the manufacturers. The rolls were wrapped in plastic to minimize uptake of water.

METHODS: SAND-BENTONITE MIXTURE

Hydraulic Conductivity Water-Content Relationship

Some of the specimens of sand-bentonite compacted to determine compaction curves [Fig. 1(a)] were also used to determine the hydraulic conductivity water-content relationships. The specimens were tested in flexible-wall permeameters using an effective stress of 21 kPa, backpressure of 345 kPa, and hydraulic gradient of 30. Tap water from Madison was used as the permeant. Results of the hydraulic conductivity tests are shown in Fib. 1(b). The hydraulic conductivity is nearly insensitive to molding water content, and is moderately sensitive to compactive effort. Similar results have been reported by Haug and Wong (1992).

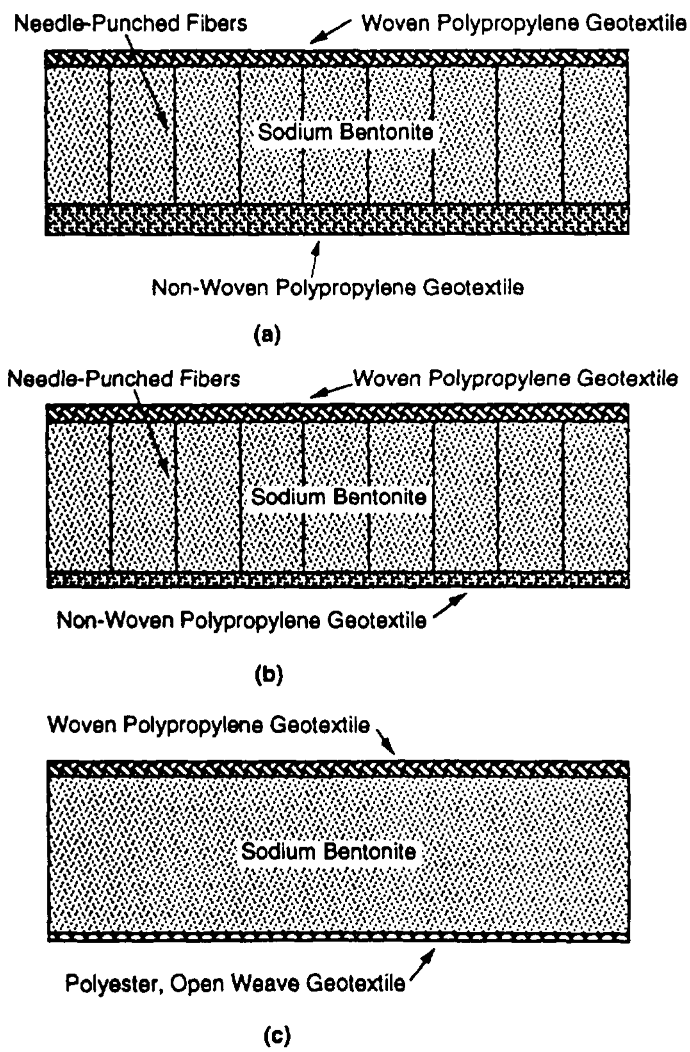
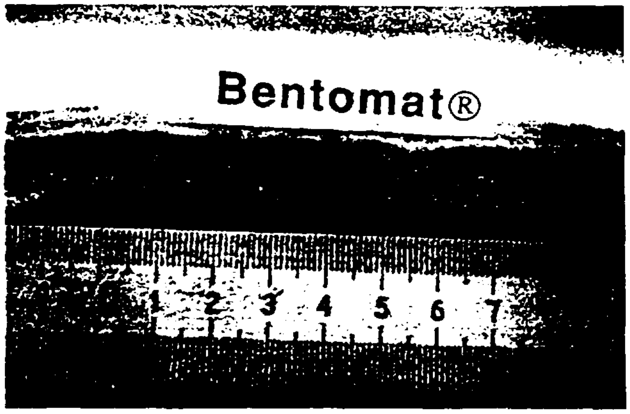
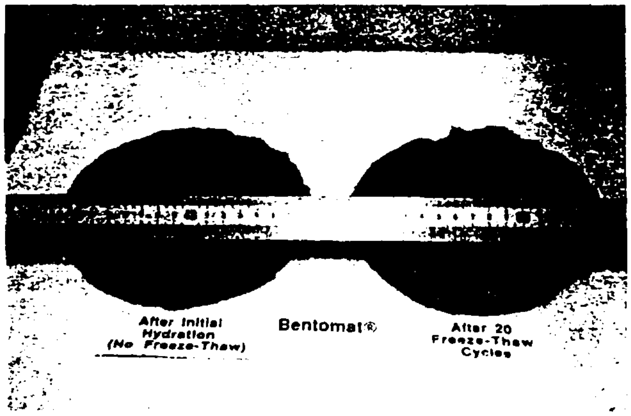


FIG. 2. Geosynthetic Clay Liners: (a) Bentofix; (b) Bentomat; (c) Claymax



(a)



(b)

FIG. 10. Hydrated and Thawed Geosynthetic Clay Liners: (a) Cross Section of Frozen Geosynthetic Clay Liner; (b) Bentonite Component

Geosynthetic Clay Liners

The GCLs frozen and thawed in the laboratory were also examined to determine why their hydraulic conductivity did not increase. Vertical and horizontal sections of frozen specimens of GCLs were prepared using the same procedure used to prepare the frozen specimens of sand-bentonite.

Small randomly oriented lenses of segregated ice existed on the horizontal and vertical [Fig. 10(a)] sections. These lenses undoubtedly caused cracking of the clay matrix when they formed. However, examination of thawed specimens revealed that they are devoid of cracks like those commonly encountered in thawed compacted clays and appear identical to specimens hydrated but never frozen [Fig. 10(b)]. The specimens removed from the lagoons also were devoid of cracks. Apparently, because the hydrated bentonite is very soft after thawing, the cracks created when the segregated ice melts close on thawing. This is in direct contrast to compacted clays, which are relatively stiff when thawed and thus retain the cracks formed during freezing.

SUMMARY AND CONCLUSIONS

The results of the laboratory and field tests show that the sand-bentonite mixture and GCLs that were tested are not adversely affected by freezing and thawing in a closed system. Nearly identical hydraulic conductivities were measured in the field and laboratory for the sand-bentonite mixture after freezing and thawing. For the GCLs lower hydraulic conductivities were measured in the laboratory. However, in the laboratory and field, freezing and thawing did not cause an increase in hydraulic conductivity. The only exception is one GCL field test, which contained a seamed section of Claymax GCL. The hydraulic conductivity of this GCL increased by a factor of 25. However, a replicate of this test showed no increase in hydraulic conductivity.

Examination of the sand-bentonite mixture and GCLs, while frozen, and after thawing revealed why these materials do not incur the increases in hydraulic conductivity typical of compacted clays. For the sand-bentonite mixture, ice segregation does not occur during freezing, and thus no cracks form. Consequently, the macrostructure after thawing appears identical to the macrostructure observed before thawing, and no large increase in hydraulic conductivity occurs. In contrast, ice segregation does occur in GCLs, but the cracks formed during ice segregation close when the bentonite thaws because the thawed bentonite is very soft and compressible. Consequently, GCLs also do not undergo increases in hydraulic conductivity.

Although the findings of this study are encouraging, the writers recommend that designers carefully consider the use of sand-bentonite mixtures and GCLs in situations where freezing will occur. This is particularly important in applications where the GCL or sand-bentonite mixture is the sole hydraulic barrier. Only long-term field tests, where GCLs and sand-bentonite mixtures are monitored for a extended number of years, will provide the definitive information regarding the long-term performance of GCLs and sand-bentonite mixtures subjected to freezing conditions.

ACKNOWLEDGMENTS

Support for the portion of this study conducted at the University of Wisconsin was provided by the U.S. Environmental Protection Agency (EPA) under cooperative agreement No. CR 821024-01-0. Robert Landreth was the Project Officer for EPA. The field portion of the project was completed as a cooperative effort between the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) and CH2M Hill Inc. CRREL participation was sponsored under the Construction Productivity Advancement Research (CPAR) Program. Financial and in-kind assistance matching the amount spent by CRREL was provided by the CPAR industrial partners: CH2M Hill, Inc.; WMX, Inc.; James Clem Corporation; Colloid Environmental Technologies Company; and Gundle Lining Systems, Inc. The opinions expressed in this paper are solely those of the writers and are not necessarily consistent with the policies of the sponsors. This paper has not been reviewed by the sponsors and no endorsement by the sponsors should be implied. Appreciation is also extended to Gary Foose, Tarek Abichou, James Tinjum, Laura Payne, and Jeffrey Meerdink, who assisted in the field and laboratory.

APPENDIX. REFERENCES

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Daniel, D. (1994). "State-of-the-art: laboratory hydraulic conductivity

USEPA Draft Document Section 2.2.2.2.2 and 2.4.2.5. received from Carmo Environmental Systems, Inc.

CARMO ENVIRONMENTAL SYSTEMS, INC.

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FAX

TO : Corie Leonard
CO : BBL
FROM : Joe Carmo
DATE : 7-14-99
RE : GCLs in the frost zone
PAGES : 3

The documentation demonstration that geosynthetic clay liners are not adversely effected when subjected to freeze thaw cycles is quite extensive. Research by CETCO, Dr. David Daniel, Army Corp of Engineers Cold Region Lab and others have provided confirmation that GCL can be placed within the frost zone without the usual concerns of natural clay liners. In fact the US EPA is presently putting together a draft document confirming that "Neither geosynthetic clay liners nor geomembranes appear to be vulnerable to freeze-thaw damage" as stated in section 2.2.2.2.2 of the attached EPA draft document pages.

Please advise if you require further documentation demonstrating the ability of GCL to remain unaffected when subjected to freeze/thaw cycles.

Joe Carmo

penetration into underlying materials.

- Need to protect underlying layers from desiccation.
- Need to provide other types of protection unique to a particular waste (e.g., attenuate radon emissions if the underlying waste emits radon).
- Need for a capillary barrier, if this is a design strategy.

2.2.2.2.1 Adequate Thickness to Support Growth of Vegetation

The total depth of soil required to support the growth of vegetation depends on numerous site-specific factors. Normally, final covers are seeded with a mixture of grasses that are well suited to the area. The plants should have relatively shallow roots so that the roots do not penetrate too deep into the cover because deep penetration threatens the integrity of underlying components. However, roots should be deep enough to enable the plants to extract moisture from a sufficient depth to be effective in transpiring water to the atmosphere. Most grasses are thought to have effective rooting depths of about 150 to 450 mm. Thus, the minimum total thickness of the protection layer (assuming that the surface layer is 150 mm thick) is often 150 to 450 mm to accommodate the roots of grasses. Over time, deeper-rooted plants may become established and displace the grasses that were initially planted. The thickness of the protection layer may need to be increased to accommodate plant species that will eventually become established. The combined thickness of the topsoil plus protection layer is typically 450 to 600 mm to accommodate plant roots.

2.2.2.2.2 Adequate Thickness to Provide Frost Penetration

The protection layer is generally designed with the intent of preventing underlying layers from freezing in northern climates. The most vulnerable material to freeze-thaw damage is compacted clay, as discussed in Section 2.4.5. To avoid damage, the compacted clay liner should be placed below the maximum depth of frost penetration. Neither geosynthetic clay liners (Hewitt and Daniel, 1997) nor geomembranes (Comer et al., 1995) ~~appear to be~~ are vulnerable to freeze-thaw damage.

It is advisable to prevent the drainage layer (if one is present) from freezing, as well, particularly on relatively steep side slopes. If the drainage layer freezes, its function is destroyed for part of the year. During the thaw period, it is particularly important that the drainage layer function properly, i.e., drain from the toe, and that the protection layer be sufficiently thick to provide the protection that is required.

There are several techniques available for estimating depth of frost penetration. One technique is to use frost penetration maps, such as the one in Figure 2.7. Local experience is sometimes used, as are computer simulations, to estimate the maximum depth of frost penetration.

may not be "impermeable" to gas at the long-term moisture content of the clay. In any event the need to contain gases should be considered because this need may impact the selection of materials for the hydraulic barrier layer.

2.4.2.4 *Cyclic Wetting and Drying*

Cyclic wetting and drying can have a major impact on clay soils, and particularly compacted clay liners, which are severely damaged within a few years if the CCL is buried beneath 150 mm to 450 mm of soil, but without a covering geomembrane (Montgomery and Parsons, 1989; Melchior et al., 1994; Maine Bureau of Remediation and Waste Management, 1997; and Melchior, 1997). Geosynthetic clay liners ~~appear to be~~ much less vulnerable to permanent damage from desiccation, probably because of the swelling and self-healing capability of bentonite (Boardman and Daniel, 1996). are

The potential for wet-dry cycles to affect the integrity of CCLs and, to a lesser extent, GCLs, should be considered. Water balance analyses, such as those described in Chapter 4, can be helpful, but judgment should play an important role in the evaluation process. If there is judged to be a risk of damage to CCLs or GCLs, the normal solution is to use a composite geomembrane/CCL or geomembrane/GCL hydraulic barrier layer. The geomembrane appears to protect the clay from desiccation damage (Corser et al., 1992; Melchior et al., 1994; and Melchior, 1997).

2.4.2.5 *Freeze-Thaw*

The potential for freeze-thaw to damage a CCL or GCL should be considered. Available information indicates that CCLs will not maintain a hydraulic conductivity of 1×10^{-7} cm/s or less if subjected to freeze-thaw at the level of overburden stress normally encountered in landfill final cover systems (Othman et al., 1994). Soil-bentonite CCLs (Wong and Haug, 1991) and GCLs (Hewitt and Daniel, 1997) appear to be unaffected by freeze-thaw.

The potential for freeze-thaw should be considered, as discussed in Section 2.2.2.2.2. If the hydraulic barrier is below the maximum depth of frost penetration, then the layer is usually assumed to be adequately protected from long-term frost damage. If the hydraulic barrier layer is within the zone of frost penetration, then the impacts of frost upon those materials should be considered. Frost is generally assumed to have no effect on geomembranes and little or no effect on GCLs. It is principally CCLs for which concern over frost action is focused.

2.4.2.6 *Accidental or Intentional Intrusion*

Depending on the thickness of the topsoil and protection soil, the possibility of an accidental or intentional breach of the barrier layer might be considered. In this regard the thinness of both geomembranes and GCLs is a disadvantage in contrast to the significantly thicker CCLs. In favor of GCLs, however, is the excellent sealing potential of bentonite. This is not the case for the geomembrane, thus a composite GM/GCL should be considered if intrusion is a possibility.

<u>Specific References</u>--Consists of published articles, case studies, and technical papers. Where possible, includes items compiled within the general references.

Boardman, B.T., and D.E. Daniel (1996), "Hydraulic Conductivity of Desiccated Geosynthetic Clay Liners," *Journal of Geotechnical Engineering*, Vol. 122, No. 3, pp. 204-209.

The effects of wetting and drying on the permeability of three different GCLs were studied. Both intact panels and overlap panels were used, and it was found that there is essentially no changed in permeability after one to three such wet-dry cycles.

Daniel, D.E., and G.N. Richardson (1995), "The Role of Geomembranes and Geosynthetic Clay Liners in Landfill Covers," *Geotechnical Fabrics Report,* Vol. 13, No. 1, pp. 44-49.

The authors discuss the rules for municipal solid waste landfills set forth in US EPA in "Subtitle D" and suggest that geomembranes or GCLs be considered for landfill closures due to their ability to minimize infiltration of water through the cover system and thereby resulting in less potential for groundwater contamination. It is also shown that geomembranes/GCLs are more cost effective than CCLs (compacted clay liners), more effective at controlling the release of landfill gases than CCLs, and more resistant to differential settlement, freeze-thaw, and desiccation than CCLs.

Erickson, A.E., Chamberlain, E.J., and C.H. Benson (1994), "Effects of Frost Action on Covers and Liners Constructed in Cold Environments," *Proceedings of the Seventeenth International Madison Waste Conference,* University of Wisconsin at Madison, pp. 198-220.

The effects of freezing and thawing on the hydraulic conductivity of two compacted natural clay soils, one compacted sand-bentonite mixture, and three GCLs were studied through both field and laboratory tests. The testing showed that freezing and thawing increased the hydraulic conductivity of the compacted clay soils due to the cracks caused by shrinkage. The results also showed that the sand-bentonite mixture was freeze-thaw resistant with an adequate bentonite content and adequate mixing. The GCLs were found to be frost-resistant.

Erickson, R.B., and J.D. Anderson (1994), "The Manufacturing and Application of a Geomembrane Supported Geosynthetic Clay Liner," *Proceedings of the 8th Annual GRI Seminar, Geosynthetic Resins, Formulations, and Manufacturing,* Geosynthetic Research Institute, Drexel University, Philadelphia, PA, (supplemental paper).

Application and installation of a geomembrane-supported GCL is discussed. The GCL may be installed with the geomembrane side facing down (usually the case for bottom liner applications), or with the geomembrane side facing up (usually the case for cap applications). The attributes of the lining system in both of these orientations is discussed, with emphasis on "intimate contact," slope stability, and the possibility for bentonite hydration.

Estornell, P., and D.E. Daniel (1992), "Hydraulic Conductivity of Three Geosynthetic Clay Liners," ***Journal of Geotechnical Engineering,*** **Vol. 118, No. 10, pp. 1592-1606.**

Hydraulic conductivity tests were performed on three different GCLs. The tests were performed in large tanks 1.2 m wide and 2.5 m long in order to minimize the potential for scale effects. Testing was performed to determine whether the overlapped seams of a GCL are indeed self-sealing and to determine whether the bentonite provides intimate contact when placed beneath a punctured geomembrane. It was found that the GCLs had low hydraulic conductivity and that intimate contact under these conditions was best with the geomembrane-supported GCL.

Hewitt, R.D., and D.E. Daniel (1997), "Hydraulic Conductivity of Geosynthetic Clay Liners after Freeze-Thaw, ***Journal of Geotechnical and Geoenvironmental Engineering,*** **Vol. 123, No. 4, April 1997, pp. 305-313.**

Hydraulic conductivity tests were performed in large tanks on intact and overlapped GCL specimens. The compressive stress applied ranged from 7-12 kPa to simulate final cover conditions for landfills. All of the currently marketed GCLs withstood the three freeze/thaw cycles without significant changes in hydraulic conductivity.

Kraus, J.F., Benson, C.H., Erickson, A.E., and E.J. Chamberlain (1997), "Freeze-Thaw Cycling and Hydraulic Conductivity of Bentonitic Barriers," ***Journal of Geotechnical Engineering,*** **Vol 123, No. 3, March 1997, American Society of Civil Engineers, New York.**

A wide variety of laboratory and field tests were performed to determine if repeated freeze/thaw cycles affected the permeability of GCLs and a soil/bentonite barrier. No increase in GCL permeability was measured after 20 laboratory freeze/thaw cycles. The soil/bentonite barrier was also not affected. Field testing of the GCLs after exposure to one or two winters showed a marginal increase in permeability of one of the products (possibly due to sample preparation procedures), but no cracks were observed in the bentonite layers in any of the GCLs.

Letter RE: Supplemental Addendum to June 1999 Detailed Work Plan (containing updated ARARs tables), September 8, 1999

GE Corporate Environmental Programs
General Electric Company
100 Woodlawn Avenue, Pittsfield, MA 01201

September 8, 1999

Transmitted Via Federal Express

Mr. Richard Cavagnero
Chief, Emergency Planning & Response Branch
Office of Site Remediation and Restoration
U.S. Environmental Protection Agency
One Congress Street, Suite 1100 - HBR
Boston, Massachusetts 02203-2211

Re: Pittsfield/Housatonic River Site
On-Plant Consolidation Areas –
Supplemental Addendum to June 1999 Detailed Work Plan

Dear Mr. Cavagnero:

Enclosed is a revised Supplemental Addendum to the General Electric Company's *Detailed Work Plan for On-Plant Consolidation Areas*. This Supplemental Addendum replaces the Supplemental Addendum that was sent to you on August 25, 1999. It contains updated ARARs tables for the On-Plant Consolidation Areas, which incorporate EPA's comments on prior versions. We would appreciate receiving EPA's formal approval of this Supplemental Addendum.

Sincerely,

Andrew T. Silfer (TJH)

Andrew T. Silfer, P.E.
Senior Technical Manager

Enclosure

cc: John Kilborn, Esq., EPA
Tim Conway, Esq., EPA
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TABLE 1

ARARs for Hill 78 Consolidation Area

Regulation	Citation	Requirements	Applicability/Appropriateness	Determination Re Attainment
Federal ARARs				
TSCA Regulations (PCB Remediation Waste)	40 CFR 761.61	Establishes cleanup options for PCB remediation waste, including PCB-contaminated soils. Options include risk-based approval by EPA. Parties seeking risk-based approval must demonstrate that cleanup plan will not pose an unreasonable risk of injury to health or the environment.	Applicable to the extent Hill 78 Consolidation Area contains preexisting materials with PCBs ≥ 50 ppm.	Materials subject to this regulation will not be added to Hill 78 Consolidation Area. However, to the extent this area already contains TSCA-regulated wastes, this requirement will be attained based on EPA finding that construction and use of this Consolidation Area per Work Plan will not pose an unreasonable risk of injury to health or the environment.
TSCA Regulations (Decontamination)	40 CFR 761.79	Establishes decontamination standards and procedures for removing PCBs from non-porous surfaces.	Applicable to decontamination of equipment used in consolidation excavation activities.	Will be attained in the event that equipment used in Hill 78 Consolidation Area requires decontamination for PCBs by implementing equipment cleaning procedures in accordance with Section 6.15 of Work Plan.
Clean Water Act NPDES Regulations (Stormwater Discharges)	40 CFR 122.26(c)(ii)(C) 40 CFR 122.44(k) 40 CFR 125.100-.104	Discharges of stormwater associated with construction activities are required to implement best management practices to control pollutants in stormwater discharges during and after construction activities.	Applicable to discharges of stormwater.	Will be attained by implementing erosion and sedimentation controls and stormwater management measures in accordance with Sections 4.7, 5.9, 6.11, and 6.13 of Work Plan.

TABLE 1

ARARs for Hill 78 Consolidation Area

Regulation	Citation	Requirements	Applicability/Appropriateness	Determination Re Attainment
Federal ARARs (cont'd)				
RCRA Regulations Hazardous Waste Management/Disposal Facilities (Landfill Operation)	40 CFR 264.301(g)-(j)	Certain design and operating standards for hazardous waste landfills, including requirements to have run-on and run-off control systems for 25-year storm, manage stormwater control systems, and apply cover if landfill contains particulate matter subject to wind dispersal. These standards do not include liner and leachate collection requirements.	Relevant and appropriate to consolidation of waste to the extent Consolidation Area already contains materials that constitute hazardous waste.	Will be attained.
RCRA Regulations for Hazardous Waste Management/Disposal Facilities (Landfill Closure and Post-Closure Care)	40 CFR 264.111 40 CFR 264.117 40 CFR 264.310(a) 40 CFR 264.310(b)(1) & (5)	Standards for closure and final cover of hazardous waste landfills. Also, requirements for post-closure monitoring and maintenance. Does not include leachate collection and liner requirements.	Relevant and appropriate for capping and post-capping monitoring and maintenance of Consolidation Area to the extent it already contains materials that constitute hazardous waste.	Will be attained. Final cover will meet standards in 264.310(a) for cover design/construction. Post-closure monitoring and maintenance will be conducted in accordance with Sections 8 and 9 of Work Plan and will meet requirements of 264.310(b)(1) & (5).

TABLE 1

ARARs for Hill 78 Consolidation Area

Regulation	Citation	Requirements	Applicability/Appropriateness	Determination Re Attainment
Federal ARARs (cont'd)				
RCRA Regulations for Hazardous Waste Management/Disposal Facilities (Groundwater Monitoring and Protection)	40 CFR 264, Subpart F	Regulated units must monitor groundwater and comply with groundwater protection standards; hazardous constituents that exceed maximum concentration levels or alternative concentration levels must be removed or treated.	Relevant and appropriate to the extent Consolidation Area already contains materials that constitute hazardous waste.	Groundwater monitoring by upgradient and downgradient monitoring wells will be conducted in accordance with Attachment B to August 12, 1999 Addendum (and any additional addenda) to the Work Plan, as approved or conditionally approved by EPA, and in conjunction with the groundwater monitoring program to be described in Statement of Work for Removal Actions Outside the River (SOW). Criteria for further response actions to meet groundwater protection standards will be as set forth in above-referenced Addendum (and any additional addenda), as approved or conditionally approved by EPA, and in the SOW. To the extent these measures do not meet all requirements in the cited regulations, EPA has determined that attainment is not practicable.

TABLE 1

ARARs for Hill 78 Consolidation Area

Regulation	Citation	Requirements	Applicability/Appropriateness	Determination Re Attainment
State ARARs				
Mass. Hazardous Waste Management Facility Regulations (Landfill Operation)	310 CMR 30.622 (5)-(11)	Certain design and operating standards for hazardous waste landfills, including requirements to have run-on and run-off control systems for 100-year storm, manage stormwater control systems, apply cover if landfill contains particulate matter subject to wind dispersal, control migration of harmful emissions, maintain access roads, and use channeling devices to prevent run-off that could interfere with natural drainage of adjacent lands. These standards do not include liner and leachate collection requirements.	Relevant and appropriate to consolidation of waste to the extent Consolidation Area already contains materials that constitute hazardous waste.	Will be attained, except that requirement to have run-on and run-off control systems to control 100-year storm will be attained only to the extent practicable.
Mass. Hazardous Waste Management Facility Regulations (Landfill Closure and Post-Closure Care)	310 CMR 30.582 310 CMR 30.592 310 CMR 30.633(1) 310 CMR 30.633(2)(a) & (e)	Standards for closure and final cover of hazardous waste landfills. Also, requirements for post-closure monitoring and maintenance. Does not include leachate collection and liner requirements.	Relevant and appropriate to the extent Consolidation Area already contains materials that constitute hazardous waste.	Will be attained. Final cover will meet standards in 30.633(1) for cover design/construction. Post-closure monitoring and maintenance will be conducted in accordance with Sections 8 and 9 of Work Plan and will meet requirements of 30.633(2)(a) & (e).

TABLE 1

ARARs for Hill 78 Consolidation Area

Regulation	Citation	Requirements	Applicability/Appropriateness	Determination Re Attainment
State ARARS (cont'd)				
Mass. Hazardous Waste Management Facility Regulations (Groundwater Monitoring and Protection)	310 CMR 30.672	Regulated units must monitor groundwater and comply with groundwater protection standards; hazardous constituents that exceed maximum concentration levels or alternative concentration levels in groundwater must be removed or treated.	Relevant and appropriate to the extent that Consolidation Area already contains materials that constitute hazardous waste.	Groundwater monitoring by upgradient and downgradient monitoring wells will be conducted in accordance with Attachment B to the August 12, 1999 Addendum (and any additional addenda) to the Work Plan, as approved or conditionally approved by EPA, and in conjunction with the groundwater monitoring program to be described in the SOW. Criteria for further response actions to meet groundwater protection standards will be as set forth in above-referenced Addendum (and any additional addenda), as approved or conditionally approved by EPA, and in the SOW. To the extent these measures do not meet all requirements in the cited regulation, EPA has determined that attainment is not practicable.
Mass. Air Pollution Control Requirements	310 CMR 7.09	Prohibition against creating condition of air pollution in connection with dust generating activities.	Applicable to construction and site alteration activities generating dust.	Will be attained by implementing dust control measures and air monitoring in accordance with Sections 6.7 and 6.10 of Work Plan and with the August 12, 1999 Addendum (and any additional addenda) to the Work Plan, as approved or conditionally approved by EPA.

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TABLE 2

ARARs for Building 71 Consolidation Area
and Potential Consolidation Area at New York Ave./Merrill Road

Regulation	Citation	Requirements	Applicability/Appropriateness	Determination Re Attainment
Federal ARARs				
TSCA Regulations (PCB Remediation Waste)	40 CFR 761.61	Establishes disposal options for PCB remediation waste, including PCB-contaminated soils and sediments. Options include risk-based approval by EPA. Parties seeking risk-based approval must demonstrate that method will not pose an unreasonable risk of injury to health or the environment.	Applicable to disposal of PCB remediation waste, which includes soils and sediments at concentrations $\geq$ 50 ppm PCBs that were contaminated prior to April 18, 1978 and any PCB waste contaminated after that date where the original source was $\geq$ 500 ppm beginning on April 18, 1978, or $\geq$ 50 ppm beginning on July 2, 1979.	Will be attained based on EPA finding that construction and use of these on-plant consolidation areas per Work Plan will not pose an unreasonable risk of injury to health or the environment.
TSCA Regulations (Decontamination)	40 CFR 761.79	Establishes decontamination standards and procedures for removing PCBs from non-porous surfaces.	Applicable to decontamination of equipment used in consolidation activities.	Will be attained by implementing equipment cleaning procedures in accordance with Section 6.15 of Work Plan.
RCRA Regulations for Hazardous Waste Management/Disposal Facilities (Preparedness and Prevention)	40 CFR 264, Subpart C	Various requirements for design and operation of a hazardous waste facility to minimize possibility of fire, explosion, or sudden release.	Relevant and appropriate to consolidation of hazardous waste (if any) in these on-plant consolidation areas.	Will be attained. Operation of on-plant consolidation areas will comply with Section 6.17 of Work Plan and with the Health, Safety, and Contingency Plan that will be prepared by the contractor selected to perform the project.

TABLE 2

ARARs for Building 71 Consolidation Area
and Potential Consolidation Area at New York Ave./Merrill Road

Regulation	Citation	Requirements	Applicability/Appropriateness	Determination Re Attainment
Federal ARARs (cont'd)				
RCRA Regulations Hazardous Waste Management/Disposal Facilities (General)	40 CFR 264.13-.19	Various requirements relating to waste analysis, security, inspections, personnel training, precautions to prevent accidental ignition or reaction of wastes, location standards, and construction quality assurance program.	Relevant and appropriate to consolidation of hazardous waste (if any) in these on-plant consolidation areas.	Will be attained. On-plant consolidation areas will be operated in accordance with Section 6.2 and Appendix C of Work Plan and with the Health, Safety, and Contingency Plan that will be prepared by contractor selected to perform the project.
RCRA Regulations Hazardous Waste Management/Disposal Facilities (Landfill Operation)	40 CFR 264.301(g)-(j)	Certain design and operating standards for hazardous waste landfills, including requirements to have run-on and run-off control systems for 25-year storm, manage stormwater control systems, and apply cover if landfill contains particulate matter subject to wind dispersal. These standards do not include liner and leachate collection requirements.	Relevant and appropriate to consolidation of hazardous waste (if any) in these on-plant consolidation areas.	Will be attained.

TABLE 2

ARARs for Building 71 Consolidation Area
and Potential Consolidation Area at New York Ave./Merrill Road

Regulation	Citation	Requirements	Applicability/Appropriateness	Determination Re Attainment
Federal ARARs (cont'd)				
RCRA Regulations for Hazardous Waste Management/Disposal Facilities (Landfill Closure and Post-Closure Care)	40 CFR 264.111 40 CFR 264.117 40 CFR 264.310(a) 40 CFR 264.310(b)(1) & (5)	Standards for closure and final cover of hazardous waste landfills. Also, requirements for post-closure monitoring and maintenance. Does not include leachate collection and liner requirements.	Relevant and appropriate to closure and post-closure care of these on-plant consolidation areas.	Will be attained. Final covers will meet standards in 264.310(a) for cover design/construction. Post-closure monitoring and maintenance will be conducted in accordance with Sections 8 and 9 of Work Plan and will meet requirements of 264.310(b)(1) & (5). Although not required by the ARAR, GE will install a liner and leachate collection system at these consolidation areas as described in the Work Plan.
RCRA Hazardous Waste Regulations (Storage of Hazardous Waste)	40 CFR 264, Subparts I and J 40 CFR 262.34(a)	Subparts I and J of Part 264 identify design, operating, monitoring, closure, and post-closure care requirements for long-term storage of RCRA hazardous waste in containers and tank systems, respectively. However, 262.34(a) allows accumulation of RCRA hazardous wastes for up to 90 days in containers or tanks provided generator complies with requirements of Subparts I and J of Part 265 for containers and tanks.	Relevant and appropriate to storage of leachate collected prior to treatment, to the extent that leachate is a hazardous waste.	Will be attained. Leachate collected may be stored temporarily for 90 days or less in tanker trucks that will meet the standards for up to 90-day accumulation in containers. Alternatively, leachate will be stored in containers or tanks that will meet requirements for long-term storage.

TABLE 2

ARARs for Building 71 Consolidation Area
and Potential Consolidation Area at New York Ave./Merrill Road

Regulation	Citation	Requirements	Applicability/Appropriateness	Determination Re Attainment
Federal ARARs (cont'd)				
RCRA Regulations for Hazardous Waste Management/Disposal Facilities (Groundwater Monitoring and Protection)	40 CFR 264, Subpart F	Regulated units must monitor groundwater and comply with groundwater protection standards; hazardous constituents that exceed maximum concentration levels or alternative concentration levels in groundwater must be removed or treated.	Relevant and appropriate to consolidation of hazardous waste (if any) in these on-plant consolidation areas.	Groundwater monitoring by upgradient and downgradient monitoring wells will be conducted in accordance with Attachment B to the August 12, 1999 Addendum (and any additional addenda) to the Work Plan, as approved or conditionally approved by EPA, and in conjunction with the groundwater monitoring program to be described in Statement of Work for Removal Actions Outside the River (SOW). Criteria for further response actions to meet groundwater protection standards will be as set forth in above-referenced Addendum (and any additional addenda), as approved or conditionally approved by EPA, and in the SOW. To the extent these measures do not meet all requirements in the cited regulations, EPA has determined that attainment is not practicable.

TABLE 2

ARARs for Building 71 Consolidation Area
and Potential Consolidation Area at New York Ave./Merrill Road

Regulation	Citation	Requirements	Applicability/Appropriateness	Determination Re Attainment
Federal ARARs (cont'd)				
Clean Water Act NPDES Regulations (Stormwater Discharges)	40 CFR 122.26(c)(ii)(C) 40 CFR 122.44(k) 40 CFR 125.100-.104	Discharges of stormwater associated with construction activities are required to implement best management practices to control pollutants in stormwater discharges during and after construction activities.	Applicable to discharges of stormwater.	Will be attained by implementing erosion and sedimentation controls and stormwater management measures in accordance with Sections 4.7, 5.9, 6.11, and 6.13 of Work Plan.
State ARARs				
Mass. Hazardous Waste Management Facility Regulations (General)	310 CMR 30.513-30.516	Various requirements relating to waste analysis, security, inspections, and personnel training.	Relevant and appropriate to consolidation of hazardous waste in these on-plant consolidation areas.	Will be attained. On-plant consolidation areas will be operated in accordance with Section 6.2 of Work Plan and the Health, Safety, and Contingency Plan that will be prepared by the contractor selected to perform the project.

TABLE 2

ARARs for Building 71 Consolidation Area
and Potential Consolidation Area at New York Ave./Merrill Road

Regulation	Citation	Requirements	Applicability/Appropriateness	Determination Re Attainment
State ARARs (cont'd)				
Mass. Hazardous Waste Management Facility Regulations (Landfill Operation)	310 CMR 30.622 (5)-(11)	Certain design and operating standards for hazardous waste landfills, including requirements to have run-on and run-off control systems for 100-year storm, manage stormwater control systems, apply cover if landfill contains particulate matter subject to wind dispersal, control migration of harmful emissions, maintain access roads, and use channeling devices to prevent run-off that could interfere with natural drainage of adjacent lands. These standards do not include liner and leachate collection requirements.	Relevant and appropriate to consolidation of hazardous waste in these on-plant consolidation areas.	Will be attained, except that requirement to have run-on and run-off control systems to control 100-year storm will be attained only to the extent practicable.
Mass. Hazardous Waste Management Facility Regulations (Ignition/Reaction)	310 CMR 30.560	Various requirements relating to precautions to prevent accidental ignition or reaction of wastes.	Relevant and appropriate to consolidation of hazardous waste in these on-plant consolidation areas.	Will be attained. On-plant consolidation areas will be operated in accordance with the Health, Safety, and Contingency Plan that will be prepared by the contractor selected to perform the project.

TABLE 2

ARARs for Building 71 Consolidation Area
and Potential Consolidation Area at New York Ave./Merrill Road

Regulation	Citation	Requirements	Applicability/Appropriateness	Determination Re Attainment
State ARARs (cont'd)				
Mass. Hazardous Waste Management Facility Regulations (Landfill Closure and Post-Closure Care)	310 CMR 30.582 310 CMR 30.592 310 CMR 30.633(1) 310 CMR 30.633(2)(a) & (e)	Standards for closure and final cover of hazardous waste landfills. Also, requirements for post-closure monitoring and maintenance. Does not include leachate collection and liner requirements.	Relevant and appropriate to consolidation of hazardous waste in these on-plant consolidation areas.	Will be attained. Final covers will meet standards in 30.633(1) for cover design and construction. Post-closure monitoring and maintenance will be conducted in accordance with Sections 8 and 9 of Work Plan and will meet requirements of 30.633(2)(a) & (e). Although not required by the ARAR, GE will install a liner and leachate collection system at these consolidation areas as described in the Work Plan.

TABLE 2

ARARs for Building 71 Consolidation Area
and Potential Consolidation Area at New York Ave./Merrill Road

Regulation	Citation	Requirements	Applicability/Appropriateness	Determination Re Attainment
State ARARs (cont'd)				
Mass. Hazardous Waste Management Facility Regulations (Groundwater Monitoring and Protection)	310 CMR 30.672	Regulated units must monitor groundwater and comply with groundwater protection standards; hazardous constituents that exceed maximum concentration levels or alternative concentration levels in groundwater must be removed or treated.	Relevant and appropriate to consolidation of hazardous waste in these on-plant consolidation areas.	Groundwater monitoring by upgradient and downgradient monitoring wells will be conducted in accordance with Attachment B to the August 12, 1999 Addendum (and any additional addenda) to the Work Plan, as approved or conditionally approved by EPA, and in conjunction with the groundwater monitoring program to be described in SOW. Criteria for further response actions to meet groundwater protection standards will be as set forth in above-referenced Addendum (and any additional addenda) to the Work Plan, as approved or conditionally approved by EPA, and in the SOW. To the extent these measures do not meet all requirements in the cited regulation, EPA has determined that attainment is not practicable.

TABLE 2

ARARs for Building 71 Consolidation Area
and Potential Consolidation Area at New York Ave./Merrill Road

Regulation	Citation	Requirements	Applicability/Appropriateness	Determination Re Attainment
State ARARs (cont'd)				
Mass. Hazardous Waste Regulations (Storage of Hazardous Waste)	310 CMR 30.680, 30.690 310 CMR 30.340	30.680 and 30.690 identify requirements for long-term storage of RCRA hazardous waste in containers and tank systems, respectively, that are similar to federal RCRA storage requirements identified above. 30.340 allows on-site accumulation of hazardous waste by generator for up to 90 days in containers and tanks provided that generator complies with certain container and tank standards, and is also similar to federal RCRA storage requirements identified above.	Relevant and appropriate to accumulation and storage of leachate prior to treatment, to the extent that leachate is considered a hazardous waste.	See discussion of federal RCRA Hazardous Waste Regulations (Storage of Hazardous Waste) above.
Mass. Air Pollution Control Requirements	310 CMR 7.09	Prohibition against creating condition of air pollution in connection with dust-generating activities.	Applicable to construction and site alteration activities generating dust.	Will be attained by implementing dust control measures and air monitoring in accordance with Sections 6.7 and 6.10 of Work Plan and with the August 12, 1999 Addendum (and any additional addenda) to the Work Plan, as approved or conditionally approved by EPA.

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EPA's Approval Letter Dated September 17, 1999 for GE'sSupplemental Addendum to June 1999 Detailed Work Plan (containing updated ARARs tables), September 8, 1999

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 1
JOHN F. KENNEDY FEDERAL BUILDING
BOSTON, MASSACHUSETTS 02203-0001

September 17, 1999

Mr. Andrew T. Silfer, P.E.
Senior Technical Manager
GE Corporate Environmental Programs
General Electric Company
100 Woodlawn Ave.
Pittsfield, MA 01201

Via Facsimile and U.S. Mail

Re: Approval of September 8, 1999 ARAR's
Pittsfield/Housatonic River Site
On-Plant Consolidation Areas

Dear Mr. Silfer:

The Environmental Protection Agency (EPA) has reviewed and hereby approves the Supplemental Addendum to June 1999 Detailed Work Plan ARARs tables that was submitted by General Electric on September 8, 1999. The September 8th revision incorporates the Agency's comments from prior versions and concludes discussion for On-Plant Consolidation Areas ARARs.

Regards,

Richard Cavagnero
GE Team Leader
Office of Site Remediation and Restoration
U.S. Environmental Protection Agency

cc: John Kilborn, Esq., EPA
Tim Conway, Esq., EPA
Bryan Olson, EPA
Michael Nalipinski, EPA
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Alan Weinberg, DEP
Betsy Harper, Esq., MAAG
Cynthia Huber, Esq., DOJ
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