02-0226
SDMS 24993

Corporate Environmental Programs
General Electric Company
100 Woodlawn Avenue, Pittsfield, MA 01201

JAN 08 2001

Transmitted Via Federal Express

January 4, 2001

Bryan Olson
EPA Project Coordinator
U.S. Environmental Protection Agency
One Congress Street, Suite 1100
Boston, MA 02214-2023

Re: GE-Pittsfield/Housatonic River Site
Upper ½-Mile Reach Removal Action (GECD800)
Results of Cell G3 DNAPL Investigation and Proposal to Address
Presence of DNAPL in Cell G3
Project #: 201.97.073

Dear Mr. Olson:

Enclosed is a document entitled *Results of Cell G3 DNAPL Investigation and Proposal to Address Presence of DNAPL in Cell G3*. This document presents the results of the recent investigations and excavations to delineate the extent of dense non-aqueous-phase liquid (DNAPL) encountered in Cell G3 during the Upper ½-Mile Reach Removal Action. This submittal additionally sets forth General Electric's proposal and schedule for further response actions to address the DNAPL encountered in the center portion of Cell G3. In general, this proposal involves installation of a new sheetpile barrier wall and DNAPL monitoring/recovery wells.

Similar to the previous agreement with EPA for Cell G2, for the Cell G3 wall GE proposes to utilize a portion of the sheeting intended for the Lyman Street source control barrier wall that was to be installed this fall as part of GE's ongoing source control program. As previously discussed, use of this sheetpile should reduce the sheetpile procurement process by about two weeks. GE will replace the Waterloo sheetpile used at Cell G2, and to be used at Cell G3, so that the appropriate amount of sheetpiling is available for use to construct the Lyman Street source control barrier.

Please call me if you have any questions.

Sincerely yours,

Andrew T. Silfer, P.E.
GE Project Coordinator
F:\USERS\MCG1\DMN01\00311550.WPD

ATS/dmn

Enclosure

cc: Mark Barash, DOI
Robert Bell, MDEP
Jeffrey Bernstein, Bernstein, Cushner & Kimmel
James Bieke, Shea & Gardner
Michael Carroll, GE
Tim Conway, USEPA
J. Lyn Cutler, MDEP (2 copies)
Mayor Gerald Doyle, City of Pittsfield
Charles Fredette, CDEP
Anton Giedt, NOAA
Ray Goff, USACE
Samuel Gutter, Sidley & Austin
Nancy E. Harper, MA AG
William Horne, GE
Holly Inglis, USEPA
Thomas La Rosa, MA EOEA
Stuart Messur, BBL
K. C. Mitkevicius, USACE
Susan Steenstrup, MDEP
Dean Tagliaferro, USEPA
Andrew Thomas, GE
Dawn Veilleux, Weston
Alan Weinberg, MDEP
Public Information Repositories ECL I-P-IV(A) (1)
GE Internal Repositories

GENERAL ELECTRIC COMPANY – PITTSFIELD, MASSACHUSETTS
UPPER ½-MILE REACH REMOVAL ACTION

RESULTS OF CELL G3 DNAPL INVESTIGATION AND PROPOSAL TO ADDRESS PRESENCE OF DNAPL IN CELL G3

I. INTRODUCTION

On November 28, 2000, during the performance of remediation activities in Cell G3, the General Electric Company (GE) visually observed a small amount of non-aqueous phase liquid (NAPL) of unknown composition in soil/sediment along the banks of that cell. The observation was reported to the National Response Center (NRC), U.S. Environmental Protection Agency (EPA), and the Massachusetts Department of Environmental Protection (MDEP). A sample of NAPL-impacted material was obtained on November 29, 2000 (HR-G3-SED-1) and analyzed for polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), and semi-volatile organic compounds (SVOCs). The results indicated the presence of coal-tar-related wastes, with low-level PCBs also being detected. Details pertaining to this are discussed in Section II.

On December 6, 2000, GE, with verbal approval of the EPA, began excavating bank soils within Cell G3 in an attempt to remove the coal-tar impacted materials. This excavation led to the removal of approximately 200 cubic yards (cy) of soil; however, NAPL-impacted materials were still observed in the bank. In response, GE implemented an investigation program to further delineate the extent of NAPL-impacted materials. Details pertaining to this investigation program and results of investigative borings previously installed in Cell G3 are discussed in Section II. Sections III, IV, and V present GE's proposal to address the coal-tar-impacted materials and Section VI presents the proposed schedule.

II. SUMMARY OF COAL-TAR DNAPL INVESTIGATION AND RESULTS

In October, 2000, five soil borings were installed along the bank of Cell G3 (HR-G3-SB1, HR-G3-SB2, HR-G3-SB3, HR-G3-SB4, and HR-G3-SB5) to proactively determine the potential presence of NAPL adjacent to Cell G3 and the potential for additional activities in this area. Information pertaining to these borings was discussed in a document titled *Results of Cell G2 NAPL Investigation and Proposal to Address Presence of LNAPL in Cell G2* submitted to EPA on November 17, 2000. The boring locations are shown on Figure 1 and the boring logs have also been included in Attachment A. In general, based on staining and/or odors, three soil samples were collected from these borings (HR-G3-SB3, HR-G3-SB4, and HR-G3-SB5) and analyzed for PCBs, VOCs, and SVOCs. The analytical results indicated the presence of PCBs ranging from 6.2 ppm to 11 ppm, as well as the presence of polycylic aromatic hydrocarbons (PAHs), such as benzo(a)anthracene up to 2.3 ppm, benzo(a)pyrene up to 1.8 ppm, benzo(b)fluoranthene up to 1.7 ppm, and indeno(1,2,3-cd)pyrene up to 0.73 ppm (see Table 1 for a complete list of detected constituents). NAPL was not observed in these five soil borings. Since the results of these Cell G3 borings did not indicate a potential NAPL source, remediation activities in Cell G3 were initiated on November 16, 2000.

On November 28, 2000, during the performance of remediation activities in Cell G3, GE visually observed a small amount of NAPL of unknown composition in soil/sediment along the banks of that cell. A sample of NAPL-impacted material was obtained on November 29, 2000 (HR-G3-SED-1) and analyzed for PCBs, VOCs, and SVOCs. The results indicated the presence of PAHs, such as acenapthene at 41 ppm, anthracene at 23 ppm, benzo(a)anthracene at 10 ppm, benzo(a)pyrene at 7.8 ppm, benzo(b)fluoranthene 6.1 ppm, indeno(1,2,3-cd)pyrene at 2.5 ppm, naphthalene at 32 ppm, phenanthrene at 86 ppm, and pyrene at 40 ppm (see Table 2 for a complete list of detected constituents). These constituents are indicative of coal-tar-related wastes. Low-level PCBs (10.3 ppm) also were detected in this sample. A geologic cross-section of this area has been developed using these borings and is shown on Figure 2.

On December 6, 2000, in an attempt to remove the coal-tar-impacted materials, GE, with oversight from EPA representatives, performed bank excavation activities. This excavation led to the removal of approximately 200 cy of bank soil. NAPL-impacted materials were observed above a peat layer at the base of the excavation. Although the NAPL-impacted materials were removed in the excavation area, NAPL-impacted material was observed extending further into the bank, beyond the excavation area. Following completion of excavation activities, on December 8, 2000, dense NAPL (DNAPL) was observed seeping from the bank above the peat layer and accumulating in the bottom of the excavation. A sample of the DNAPL was obtained (G3-OIL-1) and analyzed for PCBs, VOCs, SVOCs, density, kinematic viscosity, and specific gravity. The results indicated the presence of PAHs, such as 2-methylnaphthalene at 11,700 parts per million (ppm), acenapthene at 13,600 ppm, naphthalene at 25,100 ppm, phenanthrene at 24,600 ppm, and pyrene at 8,630 ppm (see Table 3 for a complete list of detected constituents). PCBs were not detected in this sample. Additionally, on December 8, 2000, GE installed a boring (HR-G3-SB6) at the top of the bank in the area where the DNAPL was observed to determine whether the DNAPL extended further into the bank. DNAPL was observed in this boring above the peat layer (see boring logs in Attachment A) confirming that DNAPL extended further into the bank. Subsequently, on December 12th and 13th, GE performed additional excavation within Cell G-3 (with EPA oversight) to confirm the lateral limits of DNAPL-impacted materials along the bank and to investigate other potential DNAPL sources. These activities provided visual confirmation that the lateral extent of DNAPL was limited to the bank excavation area (a conclusion with which EPA concurred), and no other DNAPL sources were identified in Cell G-3.

On December 13, 2000, based on the presence of DNAPL along the bank, a sand bag berm was constructed within the bank excavation area (Figure 1) and keyed into the peat layer (which appears to be acting as a confining layer, see Attachment A and Figure 3) to isolate the DNAPL and prevent migration to the river. On December 17, 2000, the cell overtopped due to a rain event. On December 19, hydraulic control of Cell G-3 was regained. The bermed area will be monitored and pumped (i.e., 24-hours) to eliminate the potential for the DNAPL to pool and potentially overtop the sand bag berm until completion of the proposed containment barrier installation activities (further discussed in Section IV).

Between December 14 and 20, 2000, 3 deep soil borings (HR-G3-SB7, HR-G3-SB9, and HR-G3-SB10) were installed at the top of bank to determine the till elevation. The surveyed soil boring locations are shown on Figure 1. The recovered soils were continuously logged and boring logs were developed (included in Attachment A to this document). Soils were characterized with regard to the potential presence of DNAPL based on visual descriptions and/or odors. A geologic cross-section of this area has been developed and is shown on Figure 3. As indicated, no DNAPL was observed in soil borings HR-G3-SB7 or HR-G3-SB10. During the advancement of HR-G3-SB9, a strong odor and sheen were observed above the approximate location of the peat layer (approximated at elevation 970). Based on visual observations, HR-G3-SB9 was terminated, prior to drilling through the peat layer. Borings SB7 and SB10 indicate that till is present at an approximate elevation ranging from 935 to 936 feet above mean sea level (AMSL) (see Figure 3 and boring logs in Attachment A).

III. ADDITIONAL EXCAVATION ACTIVITIES

Based on visual observations and investigative excavation activities, DNAPL-impacted materials above the peat layer have been removed within and immediately adjacent to the river through the excavation activities in this area; therefore, additional excavation activities are not anticipated. However, due to the loss of hydraulic control in Cell G3, GE will confirm the excavated grade elevations and visually observe the base of Cell G-3 for residual DNAPL. Additional removal will be conducted as warranted prior to the installation of the proposed containment barrier wall (further discussed in Section IV).

IV. PROPOSED SHEETPILE BARRIER WALL INSTALLATION

Based on the excavation and investigation activities within Cell G3, supplemental containment measures are proposed to further address the known or potential presence of coal-tar DNAPL within subsurface soils in this area. The primary component of the proposed supplemental containment measure is the installation of a physical containment barrier along and parallel to a portion of the Housatonic River riverbank. Specifically, GE proposes the installation of an approximately 107-foot long steel sheetpile wall parallel to and along the edge of the river, as shown on Figure 1. In addition, as shown on Figure 4, the proposed containment barrier will be lined with a 1-foot thick, 2-foot wide grout seal on top of the peat confining layer (for the section along the edge of the river) to limit the potential for vertical DNAPL migration along the containment barrier wall since the wall will be installed through the peat confining layer.

The proposed containment barrier will be constructed of a steel sheetpile wall with sealable joints. This type of steel sheetpiling has been installed at three previous locations along this ½-Mile Reach of River: GE's Building 68 area; East Street Area 2 – South; and adjacent to 64W-oil/water separator as part of activities to address DNAPL in Cell G1. This sheetpile is also currently being installed in Cell G2. The sheetpile wall will be constructed of Waterloo brand, heavy-wall, sealable sheetpiling (WEZ95) manufactured by Canadian Metal Rolling Mills under license to the University of Waterloo. The sheeting will be driven into place with a vibratory or impact hammer. Structural calculations regarding the long-term stability of the sheetpile wall are provided in Attachment B. These calculations show that the sheetpile wall will be stable under long-term (restored) conditions.

The location and depth of the proposed containment barrier were conservatively selected, based on visual observations following excavation activities, and boring information to include those areas (both vertically and horizontally) where coal-tar DNAPL has been identified. Once this area was determined, several other technical and operational factors were considered in the detailed design activities. These factors include possible impacts to the existing hydrogeologic conditions in the area, possible effects of future river flooding on the migration/containment of DNAPL, laboratory analytical results, historic groundwater elevations, typical river elevations, and existing bank geometry. The actual alignment of the containment barrier may be adjusted somewhat during construction based on actual field conditions. These field adjustments are not anticipated to be significant.

Horizontal and Vertical Extent

The horizontal extent of the proposed containment barrier is shown on Figure 1. The wall will be located parallel to the river approximately 5 feet up the bank measured horizontally from the water edge (at elevation 972). This location has been selected based on a review of information obtained from the recent investigation activities summarized in Section II. Using this information, the location of the proposed containment barrier was established to include known areas of DNAPL that could potentially migrate toward the river.

Wing walls angled at 45° will extend up the bank approximately 30 feet at both ends of the proposed barrier wall. Based on these design parameters, the length of the proposed containment barrier along the riverbank will be approximately 47 feet. With the addition of the wing walls, the overall length of the proposed containment barrier will be approximately 107 feet.

Several considerations were taken into account in selecting the vertical extent of the proposed containment barrier, including the results from recent investigations; historic, current, and predicted groundwater hydraulics; and geotechnical considerations. From this information, it is anticipated that the vertical extent of the containment barrier will extend to approximately elevation 956. This bottom of sheetpile elevation was primarily selected based on the fact that the DNAPL is present above the peat layer, which appears to be acting as a confining layer. Therefore, it is not necessary to extend the barrier wall to the till layer (which is greater than 30 feet below the peat layer). The proposed upper elevation of the containment barrier is 976 feet. This top of sheetpile elevation was selected based on the existing bank elevations in this area. The upper elevation of the containment barrier for the wing walls will be sloped and range between approximately elevation 976 and elevation 982 based on site topography (i.e., a minimum of two feet below final grade). However, the lower elevation of the containment barrier for the wing walls will remain at approximately elevation 956.

In addition to the presence of DNAPL, groundwater hydraulics were factored into the selection of the location and configuration (e.g., vertical extent) of the proposed containment barrier. The groundwater hydraulics associated with typical hydrogeologic conditions in this area were modeled by BBL using the publicly available and well-documented MODFLOW program (Attachment C). The results of the modeling effort indicate that the groundwater mounding caused by the installation of the sheetpile wall would be minor (less than approximately 0.5 feet). As a result, no significant change in the groundwater hydraulics is anticipated in the area of the wall.

V. PROPOSED FUTURE MONITORING/RECOVERY ACTIVITIES

Following the installation of the proposed containment barrier and restoration of Cell G3, GE proposes to install monitoring wells on the landward side (i.e., north) of the proposed containment barrier, as shown on Figure 1. GE proposes to install 2 perimeter monitoring wells at the east and west ends of the proposed containment barrier, respectively, as well as one 6-inch diameter monitoring/recovery well between the ends of the containment barrier. The center monitoring/recovery well will be used to monitor DNAPL thickness, and manual removal will be performed if the DNAPL thickness exceeds 0.5 feet. This well will be installed during the restoration of the bank and placement of backfill, and its construction is shown on Figure 4.

The installation of the remaining two monitoring wells will be accomplished using a truck-mounted drill rig and hollow-stem auger (HSA) methods. A standard truck-mounted 4-inch HSA will be used to install the 2-inch diameter wells. Also, a minimum distance of 10 feet will be maintained undisturbed between the containment barrier and the edge of the auger. During well installation, construction details and actual field measurements will be recorded by a supervising geologist and all materials used (e.g., screen and riser footage, bags of bentonite, cement, and sand) will be tabulated in a field logbook. The monitoring well will be installed using 2-inch diameter PVC risers and slotted screens with stick-up or flush-mount surface completions, depending on location (i.e., paved or bank area). A monitoring well construction detail will be prepared for each well following installation. The wells will be advanced to the top of the peat layer at an approximate elevation of 968 feet AMSL and the screens will extend from an elevation of approximately 968 feet to 978 feet AMSL. Following well installation, the wells will be locked and the area will be restored to its existing condition. After a period of at least 24 hours after well installation, the wells will be developed using alternating surging and pumping methods. Well installation and development activities will be performed in accordance with GE's approved *Field Sampling Plan/Quality Assurance Project Plan* (FSP/QAPP).

Immediately upon construction, GE will initiate weekly monitoring of the center well for the presence of DNAPL and will perform manual recovery if the DNAPL thickness exceeds 0.5 feet. Following development, GE will initially monitor the perimeter monitoring wells on a weekly basis to confirm that DNAPL is not present near the limits of the containment barrier. GE anticipates that installation of all wells will be completed within two weeks after the installation of the proposed containment barrier wall and completion of restoration activities associated with Cell G3. Also, GE will submit an evaluation of the results of the first four complete weekly monitoring events (i.e., all three wells) and the potential need for additional investigative or response actions in this area within 6 weeks following initiation of weekly monitoring of all three wells. In addition, monitoring results will be included in monthly status reports for the GE-Pittsfield/Housatonic River Site.

VI. SCHEDULE

In order to minimize the delay associated with DNAPL in the bank of Cell G-3, GE requested approval (letter dated December 19, 2000) for the installation of an intermediate cut-off wall so restoration activities in the downstream portion of Cell G3 could proceed. Approval has not yet been received for installation of this wall. Based on the results of the till borings, some modifications have been made to the location of the proposed containment barrier wall and the intermediate cut-off wall, as depicted in the December 19, 2000 letter. The revised locations are shown on Figure 1 of this submittal.

The proposed activities outlined herein will be implemented following EPA's approval of this proposal. It is anticipated that, following EPA's approval of this proposal, sheetpile wall installation and restoration activities within Cell G3 will be completed within a 6 – 8 week time frame. Monitoring activities will then follow as described in Section V.

Tables

BLASLAND, BOUCK & LEE, INC.

engineers & scientists

TABLE 1

GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS

REMOVAL ACTION - UPPER 1/2-MILE REACH HOUSATONIC RIVER

CELL G3 SOIL BORING SAMPLE DATA RESULTS

(Results are presented in dry-weight parts per million, ppm)

Parameter — Sample ID: / Sample Depth(Feet): / Date Collected:	HR-G3-SB-3 5.5 - 6 10/20/00	HR-G3-SB-4 5.5 - 6 10/20/00	HR-G3-SB-5 4 - 5.5 10/20/00
Volatile Organics			
Chlorobenzene	0.11	0.017	0.060 [0.084]
PCBs			
Aroclor-1260	7.3	6.2	11 [10]
Total PCBs	7.3	6.2	11 [10]
Semivolatile Organics			
2-Methylnaphthalene	0.76	ND(0.63)	ND(0.58) [ND(0.58)]
Acenaphthene	4.4	ND(0.63)	ND(0.58) [ND(0.58)]
Anthracene	3.9	ND(0.63)	ND(0.58) [ND(0.58)]
Benzo(a)anthracene	2.3	ND(0.63)	ND(0.58) [ND(0.58)]
Benzo(a)pyrene	1.8	ND(0.63)	ND(0.58) [ND(0.58)]
Benzo(b)fluoranthene	1.7	ND(0.63)	ND(0.58) [ND(0.58)]
Benzo(g,h,i)perylene	0.60	ND(0.63)	ND(0.58) [ND(0.58)]
Benzo(k)fluoranthene	0.81	ND(0.63)	ND(0.58) [ND(0.58)]
Chrysene	2.4	ND(0.63)	ND(0.58) [ND(0.58)]
Dibenzofuran	0.56	ND(0.63)	ND(0.58) [ND(0.58)]
Fluoranthene	4.1	ND(0.63)	ND(0.58) [ND(0.58)]
Fluorene	3.1	ND(0.63)	ND(0.58) [ND(0.58)]
Indeno(1,2,3-cd)pyrene	0.73	ND(0.63)	ND(0.58) [ND(0.58)]
Naphthalene	0.80	ND(0.63)	ND(0.58) [ND(0.58)]
Phenanthrene	9.4	ND(0.63)	ND(0.58) [ND(0.58)]
Pyrene	6.3	ND(0.63)	ND(0.58) [ND(0.58)]

Notes:

1. Samples were collected by Blasland, Bouck & Lee, Inc. and submitted to CT&E Environmental Services, Inc. for analysis of PCBs, volatiles, and semivolatiles.
2. Only constituents detected in at least one sample are summarized.
3. ND - Analyte was not detected. The value in parentheses is the associated detection limit.
4. Duplicate results are presented in brackets.

TABLE 2

GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS

REMOVAL ACTION - UPPER 1/2-MILE REACH OF HOUSATONIC RIVER

CELL G3 SEDIMENT SAMPLE DATA RESULTS

(Results are presented in dry-weight parts per million, ppm)

Parameter — Sample ID: / Date Collected:	HR-G3-SED-1 11/29/00
Volatile Organics	
Chlorobenzene	3.4
Ethylbenzene	2.0
PCBs	
Aroclor-1254	5.98 AF
Aroclor-1260	4.28
Total PCBs	10.3
Semivolatile Organics	
2-Methylnaphthalene	4.3
Acenaphthene	41
Acenaphthylene	1.6
Anthracene	23
Benzo(a)anthracene	10
Benzo(a)pyrene	7.8
Benzo(b)fluoranthene	6.1
Benzo(g,h,i)perylene	2.7
Benzo(k)fluoranthene	1.8
Carbazole	0.88
Chrysene	7.7
Dibenzo(a,h)anthracene	1.0
Dibenzofuran	0.96
Fluoranthene	24
Fluorene	20
Indeno(1,2,3-cd)pyrene	2.5
Naphthalene	32
Phenanthrene	86
Pyrene	40

Notes:

1. Samples were collected by Blasland, Bouck & Lee, Inc. and submitted to Northeast Analytical, Inc. for analysis of PCBs, volatiles, and semivolatiles.
2. Only detected constituents are summarized.
3. AF - Aroclor 1254 is being reported as the best Aroclor match. The sample exhibits an altered PCB pattern.

PRELIMINARY ANALYTICAL DATA
SUBJECT TO VERIFICATION

TABLE 3

GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS

REMOVAL ACTION - UPPER 1/2-MILE REACH OF HOUSATONIC RIVER

CELL G3 DNAPL OIL SAMPLE DATA RESULTS

Parameter — Sample ID: / Date Collected:	HR-G3-OIL-1 / 12/08/00
Volatile Organics (ppm)	
Chlorobenzene	180
Ethylbenzene	332
m&p-Xylene	120
PCBs (ppm)	
None Detected	ND(1.00)
Semivolatile Organics (ppm)	
2-Methylnaphthalene	11700
Acenaphthene	13600
Naphthalene	25100
Phenanthrene	24600
Pyrene	8630
Conventional Parameters	
Density (g/mL)	1.0462
Kinematic Viscosity @ 60° (cSt)	27.274
Specific Gravity	1.077

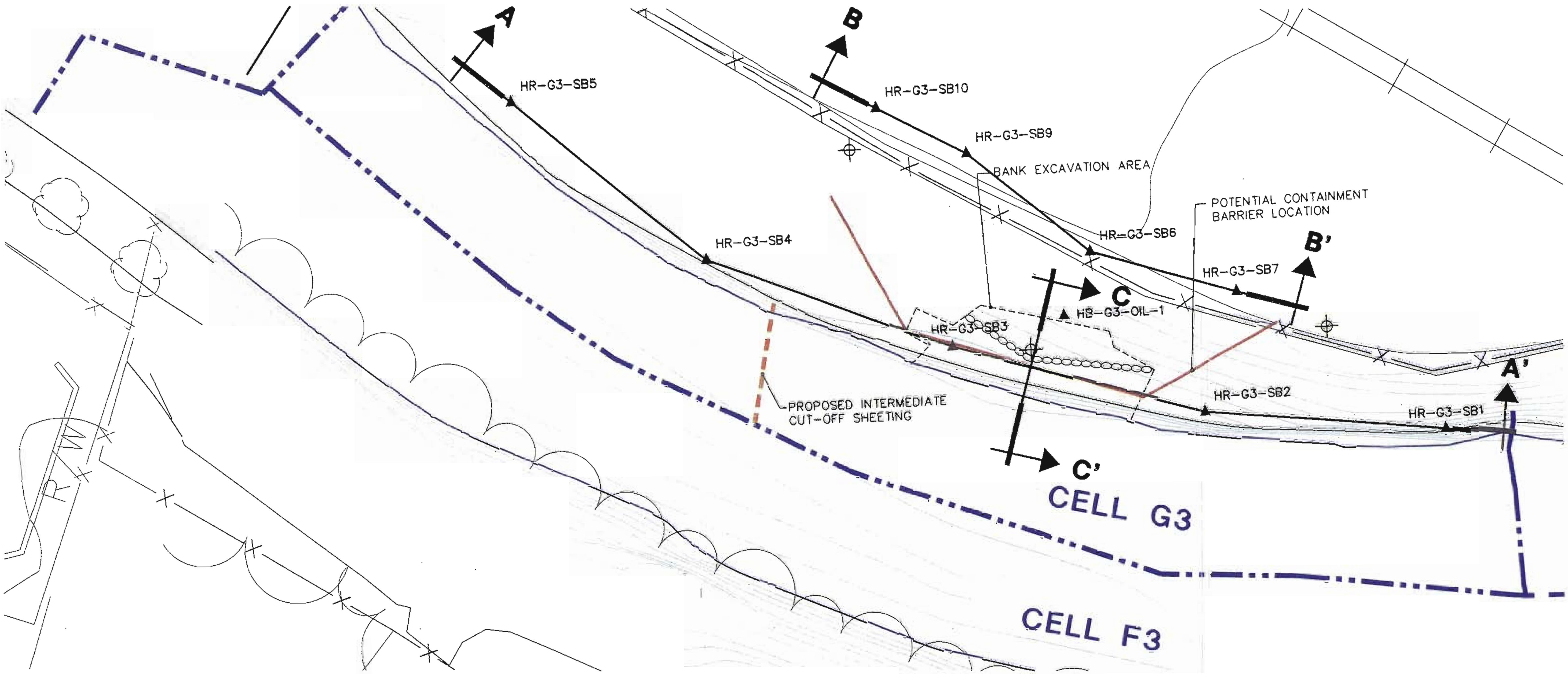
Notes:

1. Samples were collected by Blasland, Bouck & Lee, Inc. and submitted to Northeast Analytical, Inc. for analysis of PCBs, volatiles, semivolatiles and specific gravity and were submitted to Adirondack Environmental Services, Inc. for analysis of density and kinematic viscosity.
2. Only detected constituents are summarized.

Figures

BLASLAND, BOUCK & LEE, INC.

engineers & scientists



NOTES:

1. MAPPING IS BEST AVAILABLE INFORMATION AS OF 12/10/98 BASED ON MAPPING PROVIDED BY LOCKWOOD MAPPING, INC. PREPARED FROM 1990 AERIAL PHOTOGRAPHY; DATA PROVIDED BY GENERAL ELECTRIC; AND BLASLAND AND BOUCK, P.C. CONSTRUCTION PLANS. RIVERBANK AND RIVER BED TOPOGRAPHIC INFORMATION PROVIDED BBL FROM OCTOBER 12-23, 1998 FIELD SURVEY.
2. CELL LOCATIONS AND DISTANCES ARE APPROXIMATE.

LEGEND:

- REMOVAL CELL
- ▲HR-G3-SB1 SOIL BORING LOCATION
- PROPOSED MONITORING WELL LOCATION
- APPROXIMATE LOCATION OF SANDBAG BERM

0 20' 40'
GRAPHIC SCALE

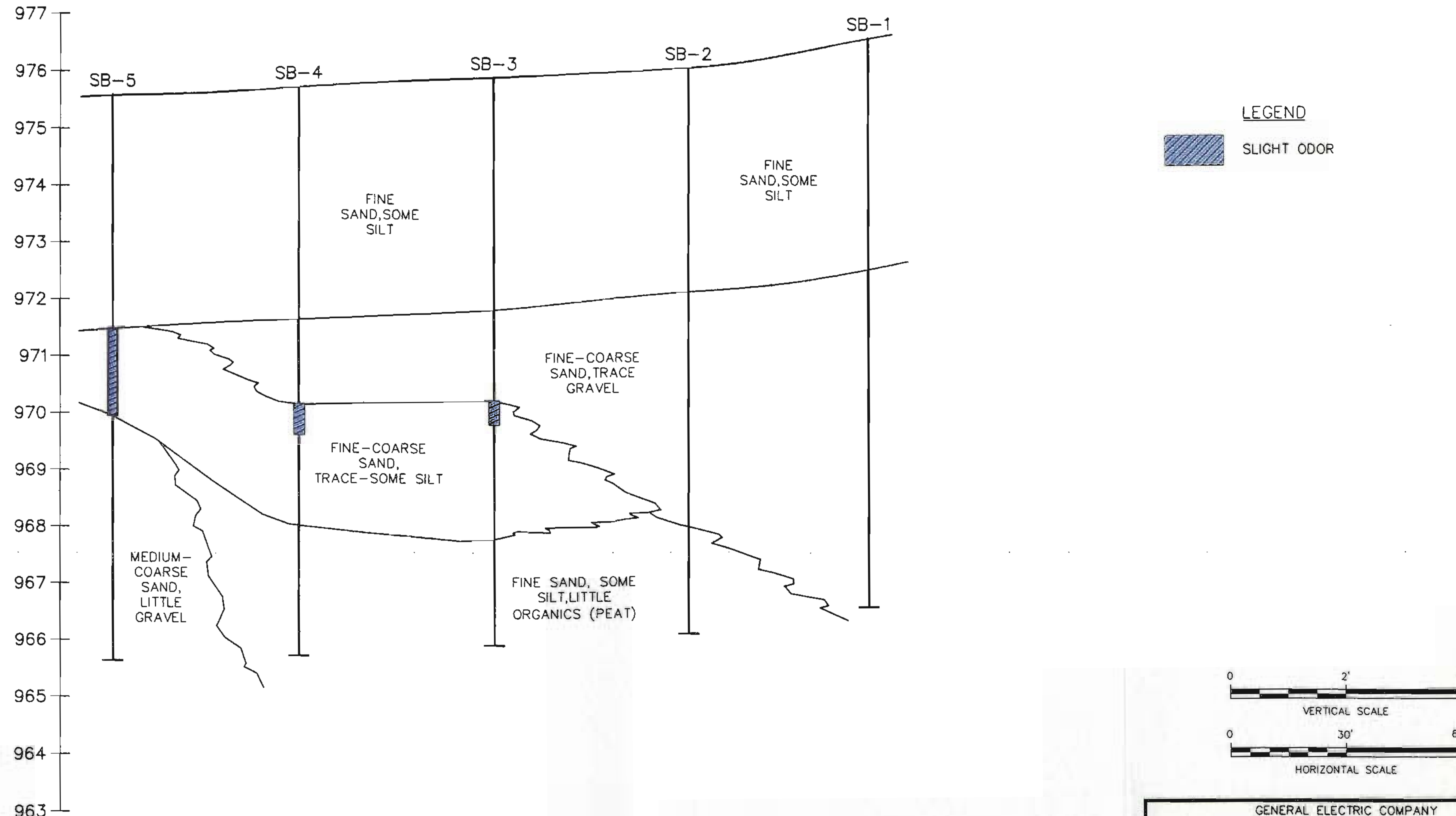
GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS
REMEDIAL ACTION - UPPER 1/2-MILE REACH OF HOUSATONIC RIVER

CELL G3
NAPL INVESTIGATION AREA

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

FIGURE 1

20197X1B, 20197X20.DWG
L: ON=• OFF= REF•
P: STD-BL.PCP
1/4/01 SYR-54-GMS NES RCA
20197073/20197B01.DWG



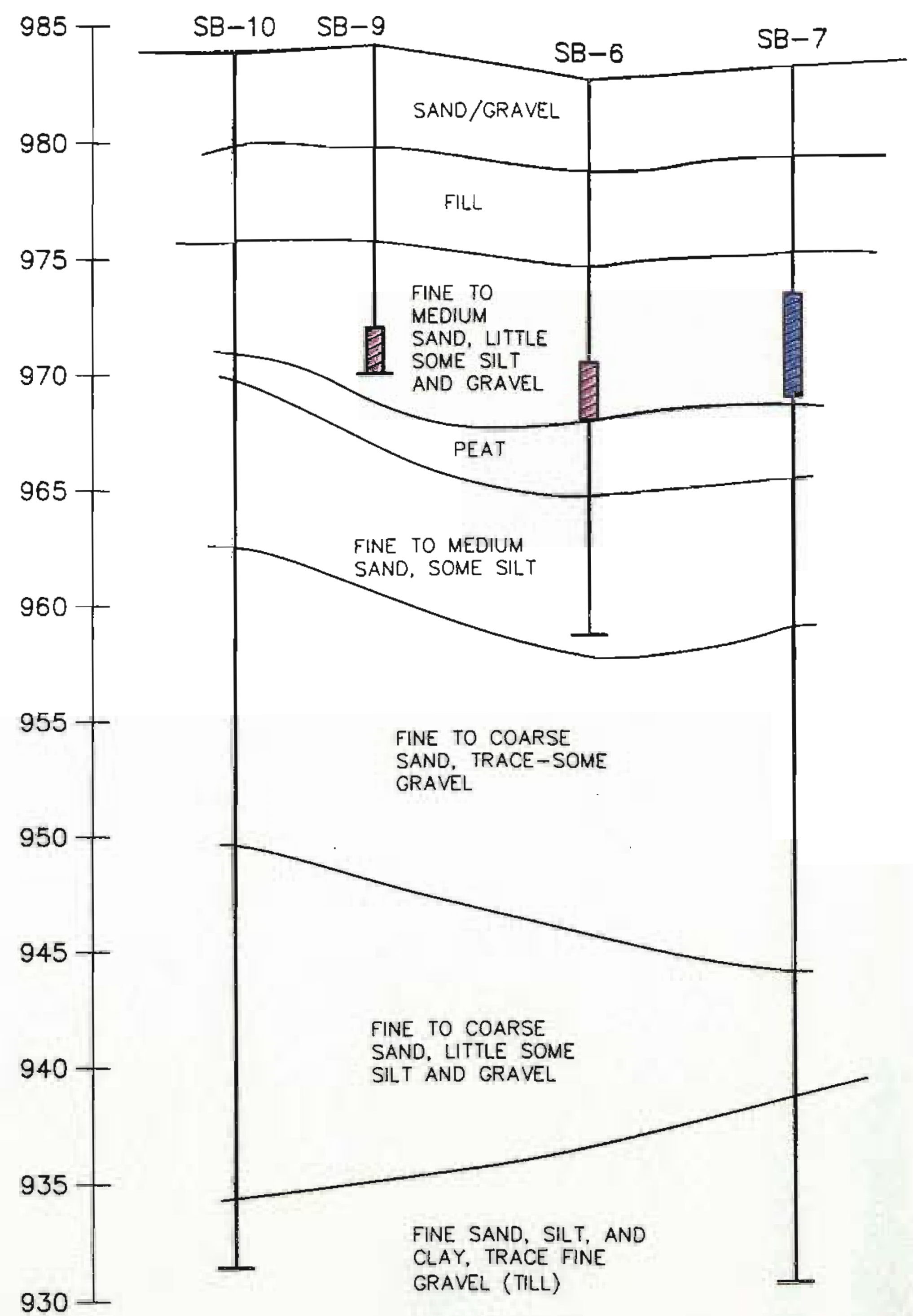
GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS
REMEDIAL ACTION - UPPER 1/2-MILE REACH OF HOUSATONIC RIVER

GEOLOGIC CROSS-SECTION A-A'

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

FIGURE
2

X: (NONE)
P: STD-BLPCP
L: ON= • OFF= REF•
1/4/01 SYR-54-YCC RCB RCA
20197073/20197V03.DWG



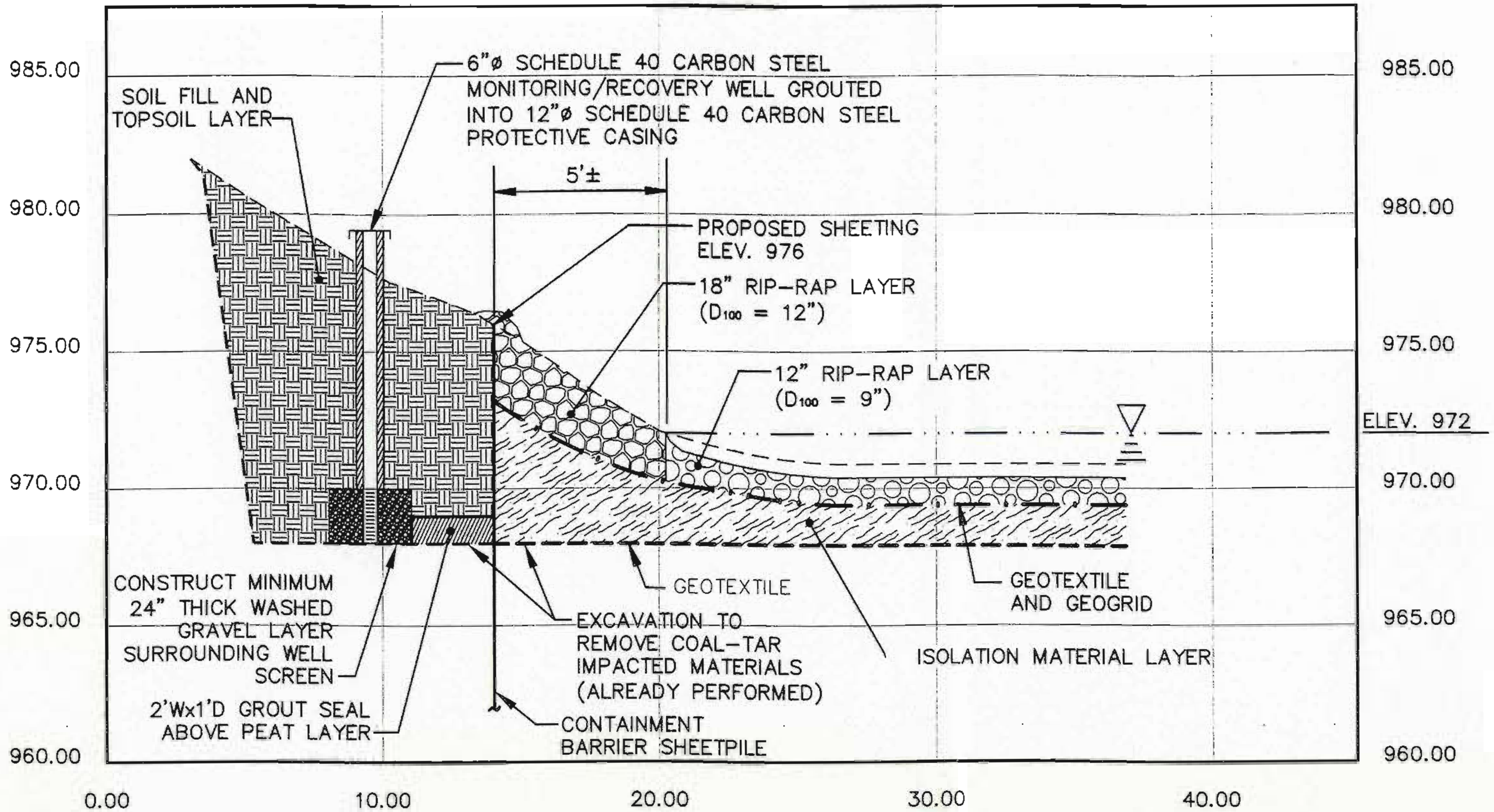
X: (NONE)
P: STD-BL.PCP
L: ON= * OFF= REF*
1/4/01 SYR-54-YCC RCB RCA
20197073/20197V01.DWG

GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS
REMEDIAL ACTION – UPPER 1/2-MILE REACH OF HOUSATONIC RIVER

GEOLOGIC CROSS-SECTION B-B'

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

FIGURE 3



SECTION C-C'

SCALE: HORIZ. 1"=5'
VERT. 1"=5'

GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS
REMOVAL ACTION
UPPER 1/2-MILE REACH OF HOUSATONIC RIVER

RESTORATION CROSS-SECTION C-C'

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

FIGURE 4

X: (NONE)
P: STD-BL.PCP
L: ON= * OFF= REF*
1/4/01 SYR-54-RCB NES RCA
20197073/20197V02.DWG

Attachments

BLASLAND, BOUCK & LEE, INC.

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Attachment A

BLASLAND, BOUCK & LEE, INC.

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Soil Boring Logs

DATE STARTED: 10/20/2000 **DATE FINISHED:** 10/20/2000 **DRILLING COMPANY:** BBL **DRILLING METHOD:** Direct Push **BIT SIZE:** 2 Inch X 4 Feet **RIG TYPE:** Jackhammer	**BOREHOLE DEPTH:** 10.0 Feet **DESCRIPTIONS BY:** Alex Marconi **NORTHING:** 532895.24 **EASTING:** 132473.54 **GROUND ELEVATION:** 976.57	**BORING ID:** HR-G3-SB-1 **CLIENT:** General Electric Company Pittsfield, MA **SITE:** Housatonic River

DEPTH (ft)	ELEVATION (ft)	SAMPLE DEPTH INTERVAL (ft)	RECOVERY (ft)	SCREENING DEPTH INTERVAL (ft)	PID HEADSPACE (ppm)	SHAKE TEST	STRATIGRAPHIC DESCRIPTION
0	976.57	0-4	4.0				Light brown fine SAND, some Silt, trace fine-medium Gravel.
1	975.57						
2	974.57						
3	973.57						
4	972.57	4-8	4.0				4.0' (972.57')
							Light brown medium-coarse SAND, trace Organics.
5	971.57						
6	970.57						6.0' (970.57')
							Light gray medium-coarse SAND trace-little fine-coarse Gravel.
7	969.57						
8	968.57	8-10	2.0				
9	967.57						
10	966.57						Boring terminated at 10.0 feet (966.57 feet)

REMARKS:
No analytical samples collected.

DATE STARTED: 10/20/2000
DATE FINISHED: 10/20/2000
DRILLING COMPANY: BBL
DRILLING METHOD: Direct Push
BIT SIZE: 2 Inch X 4 Feet
RIG TYPE: Jackhammer

BOREHOLE DEPTH: 10.0 Feet
DESCRIPTIONS BY: Alex Marconi
NORTHING: 532874.60
EASTING: 132431.14
GROUND ELEVATION: 976.10

BORING ID: HR-G3-SB-2
CLIENT: General Electric Company
Pittsfield, MA
SITE: Housatonic River

DEPTH (ft)	ELEVATION (ft)	SAMPLE DEPTH INTERVAL (ft)	RECOVERY (ft)	SCREENING DEPTH INTERVAL (ft)	PID HEADSPACE (ppm)	SHAKE TEST	STRATIGRAPHIC DESCRIPTION
0	976.10	0-4	4.0				Light brown fine SAND, some Silt, trace Organics and fine Gravel.
1	975.10						
2	974.10						
3	973.10						
							4.0' (972.10')
4	972.10	4-8	4.0				Light gray medium-coarse SAND, little fine Gravel.
5	971.10						
6	970.10						
7	969.10						
							8.0' (968.10')
8	968.10	8-10	2.0				Dark brown fine SAND, some Silt, little Organics.
9	967.10						
10	966.10						Boring terminated at 10.0 feet (966.10 feet)

REMARKS:
No analytical samples collected.

DATE STARTED: 10/20/2000
DATE FINISHED: 10/20/2000
DRILLING COMPANY: BBL
DRILLING METHOD: Direct Push
BIT SIZE: 2 Inch X 4 Feet
RIG TYPE: Jackhammer

BOREHOLE DEPTH: 10.0 Feet
DESCRIPTIONS BY: Alex Marconi
NORTHING: 532860.73
EASTING: 132382.11
GROUND ELEVATION: 975.90

BORING ID: HR-G3-SB-3
CLIENT: General Electric Company
Pittsfield, MA
SITE: Housatonic River

DEPTH (ft)	ELEVATION (ft)	SAMPLE DEPTH INTERVAL (ft)	RECOVERY (ft)	SCREENING DEPTH INTERVAL (ft)	PID HEADSPACE (ppm)	SHAKE TEST	STRATIGRAPHIC DESCRIPTION
0	975.90	0-4	4.0				Light brown fine SAND and SILT, trace Organics and fine Gravel.
1	974.90						
2	973.90						
3	972.90						
4	971.90	4-8	4.0				4.0' (971.90') Light brown fine-coarse SAND, trace fine-medium Gravel.
5	970.90						5.5' (970.40') Dark gray fine SAND and SILT, trace fine-medium Gravel, slight odor.
6	969.90						6.0' (969.90') Light gray fine-coarse SAND, some Silt.
7	968.90						
8	967.90	8-10	2.0				8.0' (967.90') Dark brown fine SAND, some Silt, little Organics.
9	966.90						
10	965.90						Boring terminated at 10.0 feet (965.90 feet)

REMARKS:
Analytical samples collected from 5.5 - 6.0 feet.

DATE STARTED: 10/20/2000 **DATE FINISHED:** 10/20/2000 **DRILLING COMPANY:** BBL **DRILLING METHOD:** Direct Push **BIT SIZE:** 2 Inch X 4 Feet **RIG TYPE:** Jackhammer	**BOREHOLE DEPTH:** 10.0 Feet **DESCRIPTIONS BY:** Alex Marconi **NORTHING:** 532851.68 **EASTING:** 132331.90 **GROUND ELEVATION:** 975.71	**BORING ID:** HR-G3-SB-4 **CLIENT:** General Electric Company Pittsfield, MA **SITE:** Housatonic River

DEPTH (ft)	ELEVATION (ft)	SAMPLE DEPTH INTERVAL (ft)	RECOVERY (ft)	SCREENING DEPTH INTERVAL (ft)	PID HEADSPACE (ppm)	SHAKE TEST	STRATIGRAPHIC DESCRIPTION
0	975.71	0-4	4.0				Light brown fine SAND, some Silt, trace fine-medium Gravel.
1	974.71						
2	973.71						
3	972.71						
4	971.71	4-8	4.0				4.0' (971.71')
							Light brown coarse SAND, trace fine-medium Gravel.
5	970.71						
							5.5' (970.21')
6	969.71						Dark gray fine SAND and SILT, trace fine Gravel and Organics, odor. 6.0' (969.71')
							Light gray fine-coarse SAND, trace Silt.
7	968.71						
							7.5' (968.21')
8	967.71	8-10	2.0				Dark brown fine SAND, some Silt, little Organics.
9	966.71						
10	965.71						
							Boring terminated at 10.0 feet (965.71 feet)

REMARKS:
Analytical samples collected from 5.5 - 6.0 feet.

DATE STARTED: 10/20/2000 **DATE FINISHED:** 10/20/2000 **DRILLING COMPANY:** BBL **DRILLING METHOD:** Direct Push **BIT SIZE:** 2 Inch X 4 Feet **RIG TYPE:** Jackhammer	**BOREHOLE DEPTH:** 10.0 Feet **DESCRIPTIONS BY:** Alex Marconi **NORTHING:** 532858.86 **EASTING:** 132283.65 **GROUND ELEVATION:** 975.64	**BORING ID:** HR-G3-SB-5 **CLIENT:** General Electric Company Pittsfield, MA **SITE:** Housatonic River

DEPTH (ft)	ELEVATION (ft)	SAMPLE DEPTH INTERVAL (ft)	RECOVERY (ft)	SCREENING DEPTH INTERVAL (ft)	PID HEADSPACE (ppm)	SHAKE TEST	STRATIGRAPHIC DESCRIPTION
0	975.64	0-4	4.0				Light brown fine-medium SAND, trace fine Gravel.
1	974.64						
2	973.64						
3	972.64						4.0' (971.64')
4	971.64	4-8	4.0				Light brown medium-coarse SAND, trace Organics, slight odor. 4.5' (971.14') Light gray fine SAND, some Silt, slight odor.
5	970.64						5.5' (970.14') Light brown medium-coarse SAND, little fine-medium Gravel.
6	969.64						
7	968.64						
8	967.64	8-10	2.0				
9	966.64						
10	965.64						Boring terminated at 10.0 feet (965.64 feet)

REMARKS:
Analytical samples collected from 4 - 5.5 feet.

Date Start/Finish: 12/8/00 **Drilling Company:** BBL **Driller's Name:** Alex Marconi **Drilling Method:** Direct Push **Bit Size:** 1.5-inch x 4 feet **Auger Size:** NA **Rig Type:** Tractor Mounted AMS Power Probe **Sampling Method:** Macrocore	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 24' below grade **Surface Elevation:** 982.90 **Geologist:** Alex Marconi	**Boring ID:** HR-G3-SB-6 **Client:** General Electric Company **Location:** Housatonic River 1/2 Mile Removal Area - Cell G3

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	Blows / 6 Inches	N - Value	Stratigraphic Description	Boring Construction
	985							
0		1	0-4	2.0	NA	NA	Dark to light brown coarse SAND, some fine Gravel. Dark brown medium SAND, some coarse Gravel and Organic Material.	Boring backfilled with Bentonite to grade
5	980	2	4-8	2.0	NA	NA	Light brown SAND, some Silt, little Concrete, Metal, and fine Gravel.	
10	975	3	8-12	2.0	NA	NA	Light brown/white medium SAND, little medium to coarse Gravel, trace Wood, stained black.	
15	970	4	12-16	2.8	NA	NA	Dark brown/black fine to medium SAND, some fine Gravel, trace Wood. Dark brown medium SAND, some fine Gravel, strong odor, NAPL. Dark brown fine SAND, some Silt and Organic Material (Peat).	

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Remarks: NA = Not Available

Client:
General Electric Company

Site Location:
Housatonic River 1/2 Mile
Removal Area - Cell G3

Boring ID: HR-G3-SB-6

Borehole Depth: 24' below grade

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	Blows / 6 Inches	N - Value	Stratigraphic Description	Boring Construction
							Dark brown fine SAND, some Silt and Organic Material (Peat).	
	965	5	16-20	3.0	NA	NA	Light brown fine SAND, some Silt and Organic Material.	Boring backfilled with Bentonite to grade.
20							Light brown fine to medium SAND, some Silt.	
		6	20-24	3.5	NA	NA		
	960							
25								
	955							
30								
	950							
35								

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Remarks: NA = Not Available

Date Start/Finish: 12/14/00-12/15/00 **Drilling Company:** Maxymillian Technologies **Driller's Name:** Dick LaPointe **Drilling Method:** Hollow Stem Auger **Bit Size:** NA **Auger Size:** 4 1/4" ID **Rig Type:** Truck Mounted B-57 Mobil Drill **Sampling Method:** 2' Split Spoon	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 52' below grade **Surface Elevation:** 983.68 **Geologist:** Alex Marconi	**Boring ID:** HR-G3-SB-7 **Client:** General Electric Company **Location:** Housatonic River 1/2 Mile Removal Area - Cell G3

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	Blows / 6 Inches	N - Value	Stratigraphic Description	Boring Construction
	985							
0		1	0-2	-	Aug.	-	Light brown medium to coarse SAND, some coarse Gravel.	Boring backfilled with Bentonite to grade.
	980	2	2-4	-	Aug.	-	Dark brown medium to coarse SAND, some coarse GRAVEL.	
5		3	4-6	1.0	2 3 3 4	6	Dark brown medium to coarse SAND, little to some Debris (Ash, Slag, Glass, and Metal fragments).	
		4	6-8	1.0	3 2 4 5	6	Dark brown medium to coarse SAND, litte to some Debris (Ash, Slag, Porcelain, Chert), trace fine to medium Gravel.	
	975	5	8-10	1.0	4 5 4 3	9	Light brown medium to coarse SAND, some Silt and fine Gravel.	
10		6	10-12	1.0	4 5 6 6	11	Brown fine to medium SAND, some Silt, trace fine to medium Gravel, odor.	
	970	7	12-14	1.5	2 3 5 6	8	Dark brown to light gray fine to medium SAND, trace Silt and Organic Material, slight odor.	
15		8	14-16	1.5	2 3 3 5	6	Light gray coarse SAND, trace fine to medium Gravel. Dark brown, Organic Material (Peat), no odor.	

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Remarks:

Client:
General Electric Company

Site Location:
Housatonic River 1/2 Mile
Removal Area - Cell G3

Boring ID: HR-G3-SB-7

Borehole Depth: 52' below grade

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	Blows / 6 Inches	N - Value	Stratigraphic Description	Boring Construction
		9	16-18	2.0	2 3 3 5	6	Dark brown fine SAND, some Silt and Organic Material (Peat), no odor.	Boring backfilled with Bentonite to grade.
	965	10	18-20	2.0	1 2 2 3	4	Dark brown fine SAND, some Silt, trace Organic Material.	
20		11	20-22	2.0	3 4 4 4	8	Dark brown to gray fine SAND, some Silt, trace Organic Material; some fine Gravel from 20'-21', saturated, no odor.	
	960	12	22-24	1.5	2 2 2 4	4	Light gray fine to medium SAND, some Silt, saturated, no odor.	
25		13	24-26	1.8	3 5 5 5	10	Light gray/brown fine to coarse SAND, trace Silt, saturated, no odor.	
		14	26-28	1.2	4 3 5 4	8	Light gray fine to medium SAND, trace Silt, saturated, no odor.	
	955	15	28-30	1.2	3 4 6 6	10	Light brown fine to medium SAND, saturated, no odor.	
30		16	30-32	1.5	5 5 5 6	10	Light brown medium to coarse SAND, trace fine Gravel, saturated, no odor.	
	950	17	32-34	1.4	4 4 5 6	9	Light brown medium to coarse SAND, little fine to medium Gravel, saturated, no odor.	
35		18	34-36	1.6	6 7 7 7	14	Medium brown medium to coarse SAND, some fine to medium Gravel, saturated, no odor.	

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Remarks:

Project: 201.97.073 Template:J:/Rockware/Logplot2001/Logfiles/20197/SB_Well.ldf
Data File:HR-G3-SB-7.dat Date:12/18/00

Client:
General Electric Company
Site Location:
Housatonic River 1/2 Mile
Removal Area - Cell G3

Boring ID: HR-G3-SB-7

Borehole Depth: 52' below grade

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	Blows / 6 Inches	N - Value	Stratigraphic Description	Boring Construction
		19	36-38	0.0	1, -, -, -	-	No Recovery.	Boring backfilled with Bentonite to grade.
	945	20	38-40	1.2	3, 9, 15, 18	24	Light gray coarse SAND, some fine Gravel. Gray fine to medium SAND, some Silt, little Clay and medium to coarse Gravel, saturated, no odor.	
40		21	40-42	1.0	8, 6, 6, 7	12	Light gray coarse SAND and fine to medium GRAVEL. Light brown fine SAND, some Silt, saturated, no odor.	
	940	22	42-44	0.8	15, 15, 29, 40	44	Light brown, medium to coarse SAND, some Silt and medium to coarse Gravel, saturated, no odor.	
45		23	44-46	1.0	7, 18, 21, 61	39	Light brown/olive brown, CLAY and fine to medium SAND, little medium to coarse Gravel, saturated, no odor.	
		24	46-48	1.0	21, 50, 29, 34	79	Light brown/olive brown, CLAY and fine to medium SAND, some Silt and medium to coarse Gravel, saturated, no odor.	
	935	25	48-50	1.2	7, 30, 15, 28	45	Light brown/olive brown, fine CLAY and SAND, some Silt, little fine to medium Gravel, damp, no odor (TILL).	
50		26	50-52	1.0	21, 30, 44, 40	74	Light brown/olive brown fine SAND and CLAY, some Silt, little fine Gravel (TILL).	
	930							
55								

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Remarks:

Date Start/Finish: 12/18/00 **Drilling Company:** Maxymillian Technologies **Driller's Name:** Dick LaPointe **Drilling Method:** Hollow Stem Auger **Bit Size:** NA **Auger Size:** 4 1/4" ID **Rig Type:** Truck Mounted B-57 Mobil Drill **Sampling Method:** 2' Split Spoon	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 52' below grade **Surface Elevation:** 984.22 **Geologist:** Alex Marconi	**Boring ID:** HR-G3-SB-9 **Client:** General Electric Company **Location:** Housatonic River 1/2 Mile Removal Area - Cell G3

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	Blows / 6 Inches	N - Value	Stratigraphic Description	Boring Construction
	985							
0		1	0-2	-	Aug.	-	Dark brown medium to coarse SAND, some medium to coarse Gravel.	Boring backfilled with Bentonite to grade.
		2	2-4	-	Aug	-	Dark brown to light brown medium to coarse SAND, some Silt, little medium Gravel.	
5	980	3	4-6	0.5	Aug.	-	Dark brown medium to coarse SAND, some Silt, trace Roots, Brick, and Glass, no odor.	
		4	6-8	0.8	10 8 4 4	12	Dark to light brown medium to coarse SAND, some Silt, trace Roots and Glass, no odor.	
	975	5	8-10	1.5	2 1 1 1	2	Dark brown to black fine to medium SAND, some Silt, saturated, no odor.	
10		6	10-12	1.5	1 4 4 1	8	Medium to light brown medium to coarse SAND, some Silt, saturated, slight odor at bottom.	
		7	12-14	1.0	2 3 4 10	7	Dark brown fine SAND, some Silt, little fine to medium Gravel. Black medium to coarse SAND, strong odor and sheen, saturated.	
15	970							

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Remarks: Aug.=Auger

Date Start/Finish: 12/19/00-12/20/00 **Drilling Company:** Maxymillian Technologies **Driller's Name:** Dick LaPointe **Drilling Method:** Hollow Stem Auger **Bit Size:** NA **Auger Size:** 4 1/4" ID **Rig Type:** Truck Mounted B-57 Mobil Drill **Sampling Method:** 2' Split Spoon	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 52' below grade **Surface Elevation:** 984' (est.) **Geologist:** Alex Marconi	**Boring ID:** HR-G3-SB-10 **Client:** General Electric Company **Location:** Housatonic River 1/2 Mile Removal Area - Cell G3

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	Blows / 6 Inches	N - Value	Stratigraphic Description	Boring Construction
	985							
0		1	0-2	-	Aug.	-	Dark brown medium to coarse SAND, some medium to coarse Gravel.	Boring backfilled with Bentonite to grade.
		2	2-4	-	Aug.	-	As above.	
5	980	3	4-6	1.0	1 2 1 1	3	Dark brown medium to coarse SAND, some Silt, little corase Gravel.	
		4	6-8	0.8	2 2 2 10	4	Dark brown fine SAND, some Silt, trace black Slag and medium Gravel.	
	975	5	8-10	0.0	- - - -	-	No Recovery.	
10		6	10-12	1.2	3 4 4 5	8	Light brown fine to medium SAND, some Silt, trace Roots saturated, no odor.	
		7	12-14	1.5	2 4 4 12	8	Light brown fine to medium SAND, some Silt. Dark brown fine SAND and SILT, highly organic, saturated, no odor (Peat).	
15	970	8	14-16	1.0	4 4 5 1	9	Light gray medium to coarse SAND, some Silt, little medium to coarse Gravel, saturated, no odor.	

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Remarks:

Client:
General Electric Company
Site Location:
Housatonic River 1/2 Mile
Removal Area - Cell G3

Boring ID: HR-G3-SB-10

Borehole Depth: 52' below grade

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	Blows / 6 Inches	N - Value	Stratigraphic Description	Boring Construction
		9	16-18	1.4	1, 2, 2, 3	4	Light gray medium to coarse SAND, some medium to coarse Gravel. / Light brown fine SAND, some Silt, saturated, no odor.	
	965	10	18-20	1.8	1, 2, 2, 3	4	Light gray fine SAND, some Silt, saturated, no odor.	Boring backfilled with Bentonite to grade.
20		11	20-22	1.2	3, 2, 1, 3	3	Light gray fine SAND, some Silt, trace fine Gravel. / Light brown fine to medium SAND, saturated, no odor.	
		12	22-24	1.2	2, 4, 4, 4	8	Light brown-gray medium to coarse SAND, trace fine Gravel, saturated, no odor.	
25	960	13	24-26	1.4	1, 3, 5, 7	8	Light brown medium to coarse SAND, some fine to medium Gravel, saturated, no odor.	
		14	26-28	1.8	7, 12, 20, 56	32	Light brown medium to coarse SAND, some medium to coarse Gravel, saturated, no odor.	
	955	15	28-30	1.4	3, 4, 5, 7	9	Light brown medium to coarse SAND, trace fine Gravel.	
30		16	30-32	1.8	3, 4, 7, 27	12	Light brown medium to coarse SAND, trace fine to medium Gravel, saturated, no odor.	
		17	32-34	1.0	4, 6, 6, 12	12		
35	950	18	34-36	1.2	9, 7, 8, 10	15	Light brown medium to coarse SAND, some Silt, little fine to medium Gravel, saturated, no odor.	

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Remarks:

Client:
General Electric Company

Site Location:
Housatonic River 1/2 Mile
Removal Area - Cell G3

Boring ID: HR-G3-SB-10

Borehole Depth: 52' below grade

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	Blows / 6 Inches	N - Value	Stratigraphic Description	Boring Construction
		19	36-38	1.0	8 9 10 12	19	Light brown medium to coarse SAND, some Silt, little medium to coarse Gravel, saturated, no odor.	Boring backfilled with Bentonite to grade.
	945	20	38-40	1.0	7 7 5 8	13		
40		21	40-42	1.2	4 6 6 7	12	Light gray medium to coarse GRAVEL. Light brown medium to coarse SAND, some Silt and medium Gravel, saturated, no odor.	
		22	42-44	0.0	- - - -	-	No Recovery (running Sands).	
45	940	23	44-46	0.8	6 7 8 8	15	Gray brown fine SAND, little Silt, coarse to medium Sand and fine Gravel, trace medium to coarse Gravel, wet.	
		24	46-48	0.9	8 8 10 14	18	Gray fine SAND, little Silt and medium Sand, trace fine to coarse Gravel, wet, interbedded with brown Silt, trace fine to coarse Sand and Gravel, wet.	
	935	25	48-50	1.55	12 17 12 18	29	Gray fine SAND, little medium Sand, trace coarse Sand, wet. Olive brown SILT, trace fine to coarse Sand and fine Gravel, wet (Till).	
50		26	50-52	0.8	12 12 25 60	37	Olive-brown fine to medium SAND and SILT, trace coarse Gravel (Till). Olive-brown SILT, trace coarse Sand and fine Gravel (Till).	
55	930							

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Remarks:

Attachment B

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Structural Calculations

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CALCULATION SHEET

CLIENT: GE SUBJECT: Sheetpile Design Calculations PREPARED BY: SM DATE: 12/19/2000
REVIEWED BY: DATE:
PROJECT: Cell G3 NAPL Area, Upper 1/2-Mile Reach of Housatonic River

TASK

To calculate the required embedment depth, maximum moment, and section modulus for a sheetpile wall supporting a slope with crest elevation of 984 feet with a slope at 2 horizontal: 1 vertical (2H:1V). The sheetpile wall has a top elevation of 976 feet. The river (water level) is assumed to be at elevation 972 feet.

REFERENCES

1. NAVFAC DM-7, March 1971.

2. Das, B. M. (1990). Principles of Foundation Engineering, 2nd Edition, PWS-Kent Publishing Company.

ASSUMPTIONS AND PARAMETERS

Soil friction angle, ϕ =	35	degree
Soil unit weight, γ =	125	pcf
Buoyant soil unit weight, γ' =	62.6	pcf
Unit weight of water =	62.4	pcf
U/S contact elevation =	976	feet
Groundwater elevation =	976	feet
Riverside contact elevation =	971	feet

FIGURES

Figure 1 - Typical Net Pressure Diagram

ATTACHMENTS

Attachment 1 - Reference Material from References 1 and 2 listed above.

CALCULATIONS

References	Calculations		Unit
	Global parameters:		
	Soil unit weight, γ	125	pcf
	Buoyant soil unit weight, γ'	62.6	pcf
	Calculate coefficient of passive pressure, Kp:		
Refer to Sheet 9, Attachment 1 (Ref. 1)	Wall friction angle, δ	14	degree
	Soil internal friction angle, ϕ	35	degree
	Slope angle on the riverside, β	0	degree
Refer to Figure 6, Sheet 10, Attachment 1 (Ref. 1)	for β/ϕ	0.00	
	for δ/ϕ	-0.4	
	Reduction factor, R	0.603	
	Kp for δ/ϕ = -1	6.5	
	Therefore, Kp = R*(Kp for δ/ϕ = -1)	[redacted]	
	Calculate coefficient of active pressure, Ka		
	Soil internal friction angle, ϕ	0.61	radians
	Slope angle on the u/s side, β	0.46	radians
Refer to Sheet 9, Attachment 1 (Ref. 1)	Wall friction angle, δ	0.24	radians
Refer to Sheet 11, Attachment 1 (Ref. 1)	Slope of wall against vertical, θ	0	radians
	$ka = \cos^2\phi / \cos\delta * [1 + ((\sin(\phi+\delta) * \sin(\phi-\beta)/(\cos\delta * \cos(-\beta)))^{0.5}]^2$	[redacted]	
Refer to Figure 1	**Active pressures and forces acting on wall:**		
	Exposed wall height, L1	5	feet
	p1= p2 = γ*L1*Ka	[redacted]	psf
	Location of zero net pressure, L3 = p2/(γ' *(Kp-Ka))	[redacted]	feet
	P = 0.5p1*L1 + 0.5p1*L3	[redacted]	lb
	location, z1 = (0.5*(p1*L1*(L3 + L1/3) + 0.5*p1*L3*(2/3*L3))/P	[redacted]	feet
	p5 = γ*L1*Kp + γ' *L3*(Kp-Ka)	[redacted]	psf
	A1 = p5/(γ' *(Kp-Ka))	12.06	
	A2 = 8*P/(γ' *(Kp - Ka))	25.13	

CLIENT: GE SUBJECT: Sheetpile Design Calculations PREPARED BY: SM DATE: 12/19/2000
REVIEWED BY: DATE:
PROJECT: Cell G3 NAPL Area, Upper 1/2-Mile Reach of Housatonic River

A3 = 6*P*(2*z1*γ' *(kp-Ka)+p5)/(γ')^2*(Kp-Ka)^2 316.3

A4 = P*(6*z1*p5+4P)/((γ')^2*(Kp-Ka)^2) 576.01

L4^4 + A1*L4^3 - A2*L4^2 -A3*L4 - A4 = 0

By Trial and error:

L4	Equation for L4
8	5555.99
5.62	-9.05545
4	-1215.45

Therefore, L4 5.62 feet

References

Global Parameters		Unit
p3 = L4*(Kp-Ka)*γ'	[redacted]	psf
p4 = p5 + γ' *L4*(Kp-Ka)	[redacted]	psf
L5 = (0.5P3L4-P)/(0.5(p3+p4))	[redacted]	feet

Embedment depth, D = L3+L4	[redacted]	feet
Sheetpile botoom elevation at FS =1	[redacted]	feet
Increase embedment depth by 40 percent for FS = 2.0	[redacted]	feet
Sheetpile bottom elevation at FS = 2.0	961.68	feet

Calculate maximum bending moment

Location of maximum bending moment, z' = (2*P/((Kp-Ka)*γ')^0.5)	[redacted]	feet
Maximum bending moment, Mmax = P*(z1+z') - (0.5*γ' *(z')^2*(Kp-Ka))*1/3*z'	2814	lb-ft/ft
	[redacted]	lb-in/ft
Required Section Modulus, S = Mmax/fb	[redacted]	in^3

Where, fb = 25 ksi for allowable stress on σy = 36 ksi steel.

Conclusions

For an u/s bank contact elevation of 976 feet and the riverside elevation elevation of 971 feet, the required sheeting bottom elevations are 964.3 feet for FS=1 and 961.6 feet for FS=2.0. Therefore, the required bottom elevation of the sheeting based on limit equilibrium considerations is 961.0, which is greater than the planned sheeting bottom of 956 feet.

Figures

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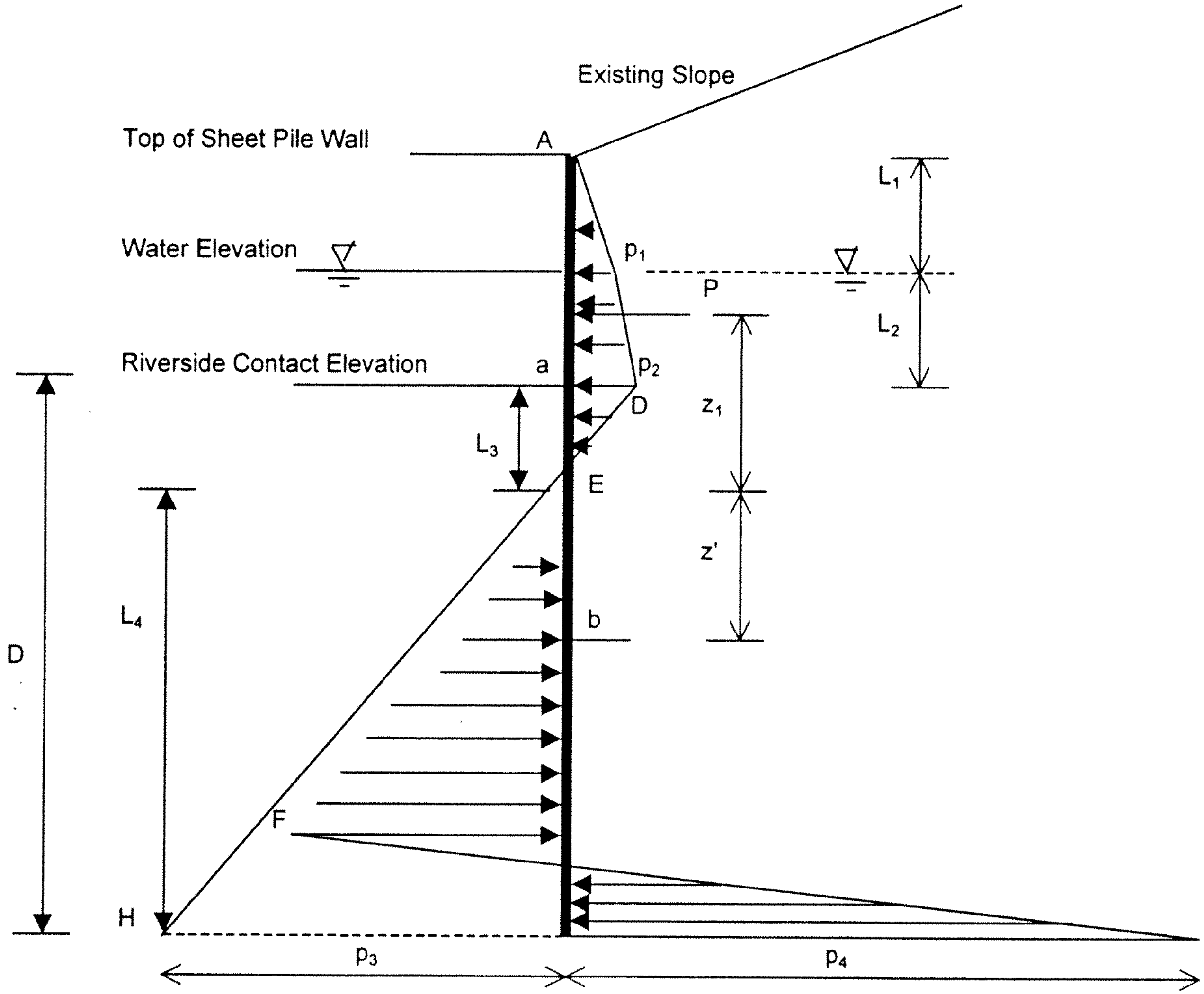

Typical Net Pressure Diagram for a Cantilever Sheetpile wall

Attachment 1

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Photocopies of Pages from Ref. 1

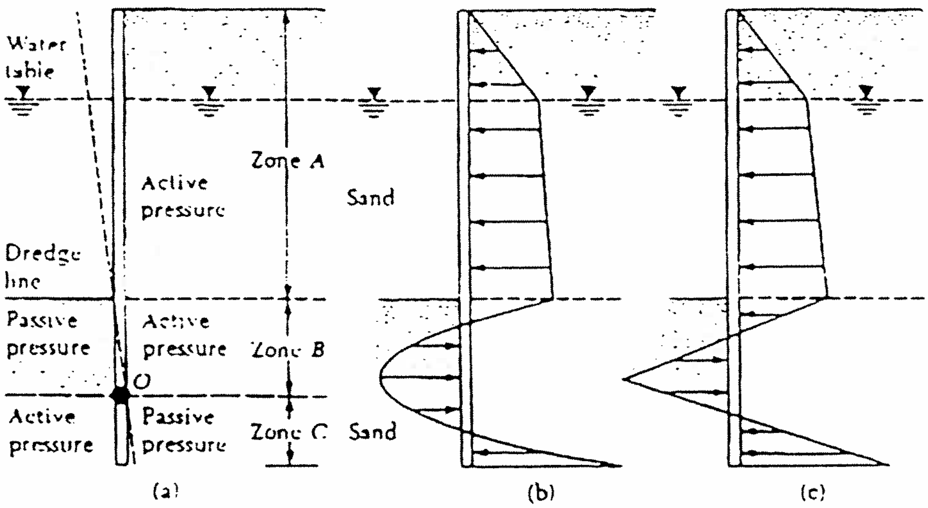


Figure 6.6 Cantilever sheet pile penetrating sand

The following sections (Sections 6.3 through 6.6) present the mathematical formulation of the analysis of cantilever sheet pile walls. Note that, in some waterfront structures, the water level may fluctuate as the result of tidal effects. Care should be taken in determining the water level that will affect the net pressure diagram.

6.3 Cantilever Sheet Piling Penetrating Sandy Soils

To develop the relationships for the proper depth of embedment of sheet piles driven into a granular soil, we refer to Figure 6.7a. The soil retained by the sheet piling above the dredge line is also sand. The water table is located at a depth of L_1 below the top of the wall. Let the angle of friction of the sand be ϕ. The intensity of the active pressure at a depth $z = L_1$ can be given as

$$p_1 = \gamma L_1 K_a \tag{6.1}$$

where K_a = Rankine active pressure coefficient = $\tan^2(45 - \phi/2)$
γ = unit weight of soil above the water table

Similarly, the active pressure at a depth of $z = L_1 + L_2$ (that is, at the level of the dredge line) is equal to

$$p_2 = (\gamma L_1 + \gamma' L_2)K_a \tag{6.2}$$

where γ' = effective unit weight of soil = $\gamma_{sat} - \gamma_w$

Note that, at the level of the dredge line, the hydrostatic pressures from both sides of the wall are of the same magnitude and cancel each other.

2/11

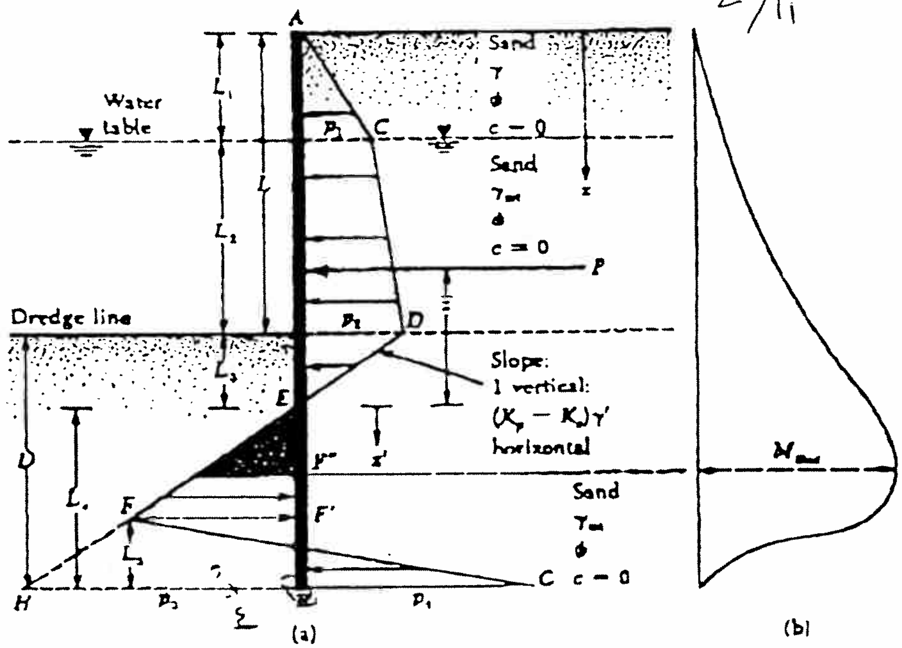


Figure 6.7 Cantilever sheet pile penetrating sand: (a) variation of net pressure diagram. (b) variation of moment

In order to determine the net lateral pressure below the dredge line up to the point of rotation O, as shown in Figure 6.6a, one has to consider the passive pressure acting from the left side (water side) toward the right side (land side) and also the active pressure acting from the right side toward the left side of the wall. For such cases, ignoring the hydrostatic pressure from both sides of the wall, the active pressure at a depth z can be given as

$$p_a = [\gamma L_1 + \gamma' L_2 + \gamma'(z - L_1 - L_2)]K_a \quad (6.3)$$

Also, the passive pressure at that depth z is equal to

$$p_p = \gamma'(z - L_1 - L_2)K_p \quad (6.4)$$

where K_p = Rankine passive pressure coefficient = $\tan^2(45 + \phi/2)$

Hence, combining Eqs. (6.3) and (6.4), the net lateral pressure can be obtained as

$$\begin{aligned} p = p_a - p_p &= (\gamma L_1 + \gamma' L_2)K_a - \gamma'(z - L_1 - L_2)(K_p - K_a) \\ &= p_2 - \gamma'(z - L)(K_p - K_a) \end{aligned} \quad (6.5)$$

where $L = L_1 + L_2$

3/11

The net pressure, p, becomes equal to zero at a depth L_3 below the dredge line; or

$$p_2 - \gamma'(z - L)(K_p - K_a) = 0$$

or

$$(z - L) = L_3 = \frac{p_2}{\gamma'(K_p - K_a)} \tag{6.6}$$

From the preceding equation, it is apparent that the slope of the net pressure distribution line DEF is 1 vertical to $(K_p - K_a)\gamma'$ horizontal. So, in the pressure diagram

$$\overline{HB} = p_3 = L_4(K_p - K_a)\gamma' \tag{6.7}$$

At the bottom of the sheet pile, passive pressure (p_p) acts from the right toward the left side, and active pressure acts from the left toward the right side of the sheet pile. So, at $z = L + D$

$$p_p = (\gamma L_1 + \gamma' L_2 + \gamma' D)K_p \tag{6.8}$$

At the same depth

$$p_a = \gamma' D K_a \tag{6.9}$$

Hence, the net lateral pressure at the bottom of the sheet pile is equal to

$$\begin{aligned} p_p - p_a = p_4 &= (\gamma L_1 + \gamma' L_2)K_p + \gamma' D(K_p - K_a) \\ &= (\gamma L_1 + \gamma' L_2)K_p + \gamma' L_3(K_p - K_a) + \gamma' L_4(K_p - K_a) \\ &= p_5 + \gamma' L_4(K_p - K_a) \end{aligned} \tag{6.10}$$

where $p_5 = (\gamma L_1 + \gamma' L_2)K_p + \gamma' L_3(K_p - K_a)$ (6.11)

$D = L_3 + L_4$ (6.12)

For the stability of the wall, the principles of statics can now be applied; or

$$\sum \text{horizontal forces per unit length of wall} = 0$$

and

$$\sum \text{moment of the forces per unit length of wall about point } B = 0$$

For summation of the horizontal forces,

area of the pressure diagram $ACDE$ − area of $EFHB$ + area of $FHBG = 0$

or

$$P - \tfrac{1}{2}p_3 L_4 + \tfrac{1}{2}L_5(p_3 + p_4) = 0 \tag{6.13}$$

where P = area of the pressure diagram $ACDE$

4/11

Summing the moment of all the forces about point B

$$P(L_4 + \bar{z}) - \left(\frac{1}{2} L_4 p_3\right)\left(\frac{L_4}{3}\right) + \frac{1}{2} L_5(p_3 + p_4)\left(\frac{L_5}{3}\right) = 0 \tag{6.14}$$

From Eq. (6.13)

$$L_5 = \frac{p_3 L_4 - 2P}{p_3 + p_4} \tag{6.15}$$

Combining Eqs. (6.7), (6.10), (6.14), and (6.15) and simplifying them further, one obtains the following fourth-degree equation in terms of L_4.

$$\boxed{L_4^4 + A_1 L_4^3 - A_2 L_4^2 - A_3 L_4 - A_4 = 0} \tag{6.16}$$

where

$$A_1 = \frac{p_5}{\gamma'(K_p - K_a)} \tag{6.17}$$

$$A_2 = \frac{8P}{\gamma'(K_p - K_a)} \tag{6.18}$$

$$A_3 = \frac{6P[2\bar{z}\gamma'(K_p - K_a) + p_5]}{\gamma'^2(K_p - K_a)^2} \tag{6.19}$$

$$A_4 = \frac{P(6\bar{z}p_5 + 4P)}{\gamma'^2(K_p - K_a)^2} \tag{6.20}$$

Step-by-Step Procedure for Obtaining the Pressure Diagram

Based on the preceding theory, the step-by-step procedure for obtaining the pressure diagram for a cantilever sheet pile wall penetrating a granular soil is as follows:

1. Calculate K_a and K_p.
2. Calculate p_1 [Eq. (6.1)] and p_2 [Eq. (6.2)]. *Note:* L_1 and L_2 will be given.
3. Calculate L_3 [Eq. (6.6)].
4. Calculate P.
5. Calculate $\bar{z}$ (that is, the center of pressure for the area $ACDE$) by taking the moment about E.
6. Calculate p_5 [Eq. (6.11)].
7. Calculate A_1, A_2, A_3, and A_4 [Eqs. (6.17) to (6.20)].
8. Solve Eq. (6.16) by trial and error to determine L_4.
9. Calculate p_4 [Eq. (6.10)].

5/11

10. Calculate p_5 [Eq. (6.7)].
11. Obtain L_5 from Eq. (6.15).
12. Now the pressure distribution diagram as shown in Figure 6.7a can easily be drawn.
13. Obtain the theoretical depth [Eq. (6.12)] of penetration as $L_3 + L_4$. The actual depth of penetration is increased by about 20–30%.

Note: Some designers prefer to use a factor of safety on the passive earth pressure coefficient at the beginning. In that case, in Step 1

$$K_{p(design)} = \frac{K_p}{FS}$$

where FS = factor of safety (usually between 1.5 to 2)

For this type of analysis, follow Steps 1 through 12 with the value of $K_a = \tan^2(45 - \phi/2)$ and $K_{p(design)}$ (instead of K_p). The actual depth of penetration can now be determined by adding L_3, obtained from Step 3, and L_4, obtained from Step 8.

Calculation of Maximum Bending Moment

The nature of variation of the moment diagram for a cantilever sheet pile wall is shown in Figure 6.7b. The maximum moment will occur between the points E and F. To obtain the maximum moment (M_{max}) per unit length of the wall, one must determine the point of zero shear. Adopting a new axis z' (with origin at point E) for zero shear

$$P = \tfrac{1}{2}(z')^2(K_p - K_a)\gamma'$$

or

$$z' = \sqrt{\frac{2P}{(K_p - K_a)\gamma'}} \tag{6.21}$$

Once the point of zero shear force is determined (point F'' in Figure 6.7a), the magnitude of the maximum moment can be obtained as

$$M_{max} = P(\bar{z} + z') - [\tfrac{1}{2}\gamma' z'^2(K_p - K_a)](\tfrac{1}{3})z' \tag{6.22}$$

The sizing of the necessary profile of the sheet piling is then made according to the allowable flexural stress of the sheet pile material, or

$$S = \frac{M_{max}}{\sigma_{all}} \tag{6.23}$$

6/11

where S = section modulus of the sheet pile required per unit length of the structure

σ_{all} = allowable flexural stress of the sheet pile

Example 6.1

Refer to Figure 6.7. For a cantilever sheet pile wall penetrating a granular soil, given: $L_1 = 2$ m, $L_2 = 3$ m. The granular soil has the following properties:

$$\phi = 32^\circ$$
$$c = 0$$
$$\gamma = 15.9 \text{ kN/m}^3$$
$$\gamma_{sat} = 19.33 \text{ kN/m}^3$$

Make the necessary calculations to determine the theoretical and actual depth of penetration. Also determine the miminum size of sheet pile (section modulus) necessary.

Solution

The step-by-step procedure given in Section 6.3 will be followed here.

Step 1

$$K_a = \tan^2\left(45 - \frac{\phi}{2}\right) = \tan^2\left(45 - \frac{32}{2}\right) = 0.307$$

$$K_p = \tan^2\left(45 + \frac{\phi}{2}\right) = 3.25$$

Step 2

$$p_1 = \gamma L_1 K_a = (15.9)(2)(0.307) = 9.763 \text{ kN/m}^2$$
$$p_2 = (\gamma L_1 + \gamma' L_2)K_a = [(15.9)(2) + (19.33 - 9.81)3]0.307$$
$$= 18.53 \text{ kN/m}^2$$

Step 3

$$L_3 = \frac{p_2}{\gamma'(K_p - K_a)} = \frac{18.53}{(19.33 - 9.81)(3.25 - 0.307)} = 0.66 \text{ m}$$

Step 4

$$P = \tfrac{1}{2}p_1 L_1 + p_1 L_2 + \tfrac{1}{2}(p_2 - p_1)L_2 + \tfrac{1}{2}p_2 L_3$$
$$= \tfrac{1}{2}(9.763)(2) + (9.763)(3) + \tfrac{1}{2}(18.53 - 9.763)3 + \tfrac{1}{2}(18.53)(0.66)$$
$$= 9.763 + 29.289 + 13.151 + 6.115 = 58.32 \text{ kN/m}$$

Step 5. Taking the moment about E

$$\bar{z} = \frac{1}{58.32}\left[9.763\left(0.66 + 3 + \frac{2}{3}\right) + 29.289\left(0.66 + \frac{3}{2}\right) + 13.151\left(0.66 + \frac{3}{3}\right) + 6.115\left(0.66 \times \frac{2}{3}\right)\right] = 2.23 \text{ m}$$

7/11

Step 6

$$\begin{aligned} p_5 &= (\gamma L_1 + \gamma' L_2)K_p + \gamma' L_3(K_p - K_a) \\ &= [(15.9)(2) + (19.33 - 9.81)3]3.25 + (19.33 - 9.81)(0.66)(3.25 - 0.307) \\ &= 196.17 + 18.49 = 214.66 \text{ kN/m}^2 \end{aligned}$$

Step 7

$$A_1 = \frac{p_5}{\gamma'(K_p - K_a)} = \frac{214.66}{(9.52)(2.943)} = 7.66$$

$$A_2 = \frac{8P}{\gamma'(K_p - K_a)} = \frac{(8)(58.32)}{(9.52)(2.943)} = 16.65$$

$$A_3 = \frac{6P[2\bar{z}\gamma'(K_p - K_a) + p_5]}{\gamma'^2(K_p - K_a)^2}$$

$$= \frac{(6)(58.32)[(2)(2.23)(9.52)(2.943) + 214.66]}{(9.52)^2(2.943)^2} = 151.93$$

$$A_4 = \frac{P(6\bar{z}p_5 + 4P)}{\gamma'^2(K_p - K_a)^2}$$

$$= \frac{58.32[(6)(2.23)(214.66) + (4)(58.32)]}{(9.52)^2(2.943)^2} = 230.72$$

Step 8. From Eq. (6.16)

$$L_4^4 + 7.66L_4^3 - 16.65L_4^2 - 151.39L_4 - 230.72 = 0$$

The following table shows the solution of the preceding equation by trial and error.

Assumed L_4 (m)	Left side of Eq. (6.16)
4	−356.44
5	+178.58
4.8	+36.96

So, $L_4 \approx 4.8$ m

Step 9

$$\begin{aligned} p_4 &= p_5 + \gamma' L_4(K_p - K_a) \\ &= 214.66 + (9.52)(4.8)(2.943) = 349.14 \text{ kN/m}^2 \end{aligned}$$

Step 10

$$p_3 = \gamma'(K_p - K_a)L_4 = (9.52)(2.943)(4.8) = 134.48 \text{ kN/m}^2$$

Step 11

$$L_5 = \frac{p_3 L_4 - 2P}{p_3 + p_4} = \frac{(134.48)(4.8) - 2(58.32)}{134.48 + 349.14} = 1.09 \text{ m}$$

Step 12. The net pressure distribution diagram can now be drawn, as shown in Figure 6.7a.

Step 13. The actual depth of penetration $= 1.3(L_3 + L_4) = 1.3(0.66 + 4.8) = 7.1$ m. The theoretical depth of penetration $= 0.66 + 4.8 = 5.46$ m.

9/11

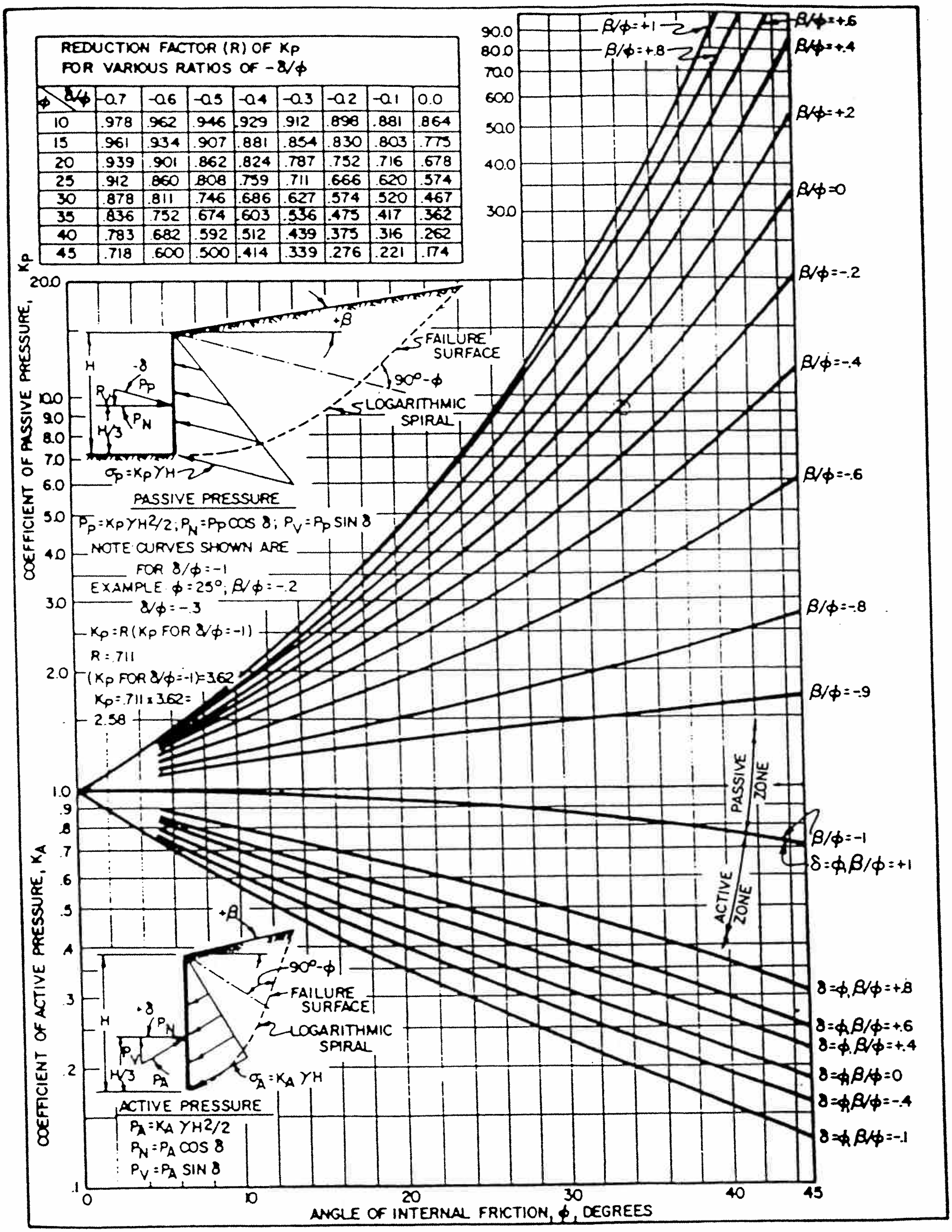
TABLE 1

Ultimate Friction Factors and Adhesion for Dissimilar Materials

Interface Materials	Friction factor, $\tan \delta$	Friction angle, δ degrees
Mass concrete on the following foundation materials:		
Clean sound rock................................	0.70	35
Clean gravel, gravel-sand mixtures, coarse sand...	0.55 to 0.60	29 to 31
Clean fine to medium sand, silty medium to coarse sand, silty or clayey gravel..................	0.45 to 0.55	24 to 29
Clean fine sand, silty or clayey fine to medium sand..	0.35 to 0.45	19 to 24
Fine sandy silt, nonplastic silt.................	0.30 to 0.35	17 to 19
Very stiff and hard residual or preconsolidated clay..	0.40 to 0.50	22 to 26
Medium stiff and stiff clay and silty clay........	0.30 to 0.35	17 to 19
(Masonry on foundation materials has same friction factors.)		
Steel sheet piles against the following soils:		
Clean gravel, gravel-sand mixtures, well-graded rock fill with spalls.........................	0.40	22
Clean sand, silty sand-gravel mixture, single size hard rock fill................................	0.30	17
Silty sand, gravel or sand mixed with silt or clay	0.25	14
Fine sandy silt, nonplastic silt.................	0.20	11
Formed concrete or concrete sheet piling against the following soils:		
Clean gravel, gravel-sand mixture, well-graded rock fill with spalls.........................	0.40 to 0.50	22 to 26
Clean sand, silty sand-gravel mixture, single size hard rock fill................................	0.30 to 0.40	17 to 22
Silty sand, gravel or sand mixed with silt or clay	0.30	17
Fine sandy silt, nonplastic silt.................	0.25	14
Various structural materials:		
Masonry on masonry, igneous and metamorphic rocks:		
Dressed soft rock on dressed soft rock..........	0.70	35
Dressed hard rock on dressed soft rock..........	0.65	33
Dressed hard rock on dressed hard rock..........	0.55	29
Masonry on wood (cross grain).....................	0.50	26
Steel on steel at sheet pile interlocks...........	0.30	17

Interface Materials (Cohesion)	Adhesion C_a (psf)
Very soft cohesive soil (0 - 250 psf)	0 - 250
Soft cohesive soil (250 - 500 psf)	250 - 500
Medium stiff cohesive soil (500 - 1000 psf)	500 - 750
Stiff cohesive soil (1000 - 2000 psf)	750 - 950
Very stiff cohesive soil (2000 - 4000 psf)	950 - 1,300

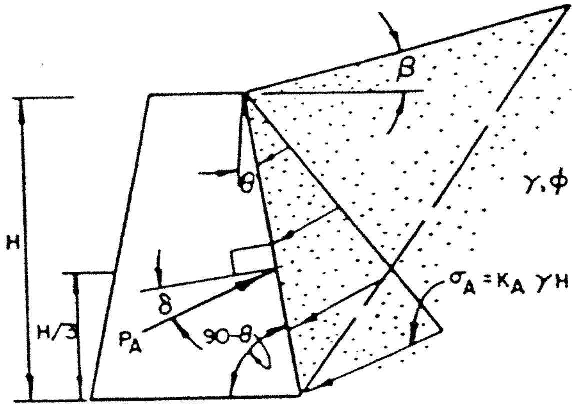
10/11



REDUCTION FACTOR (R) OF Kp FOR VARIOUS RATIOS OF -δ/φ

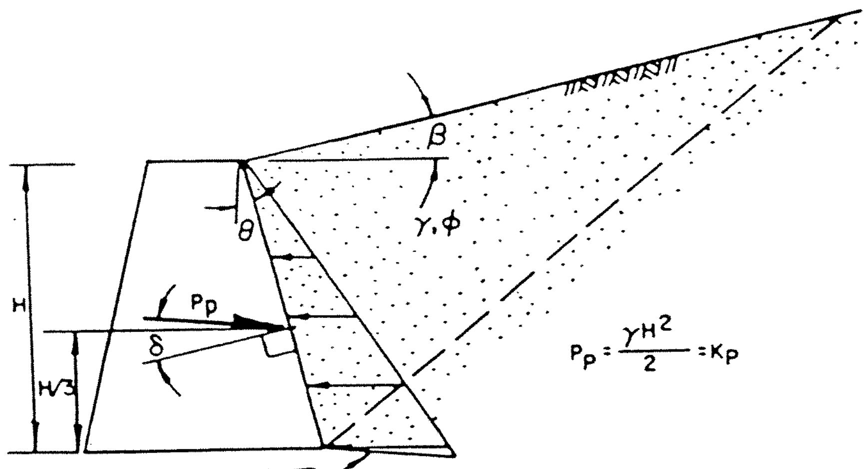
φ \ δ/φ	-0.7	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	0.0
10	.978	.962	.946	.929	.912	.898	.881	.864
15	.961	.934	.907	.881	.854	.830	.803	.775
20	.939	.901	.862	.824	.787	.752	.716	.678
25	.912	.860	.808	.759	.711	.666	.620	.574
30	.878	.811	.746	.686	.627	.574	.520	.467
35	.836	.752	.674	.603	.536	.475	.417	.362
40	.783	.682	.592	.512	.439	.375	.316	.262
45	.718	.600	.500	.414	.339	.276	.221	.174

FIGURE 6
Active and Passive Coefficients with Wall Friction
(Sloping Backfill)



$$P_A = \frac{\gamma H^2}{2} K_A$$

$$K_A = \frac{\cos^2(\phi-\theta)}{\cos^2\theta \cos(\theta+\delta)\left[1+\sqrt{\frac{\sin(\phi+\delta)\sin(\phi-\beta)}{\cos(\theta+\delta)\cos(\theta-\beta)}}\right]^2}$$



$$P_p = \frac{\gamma H^2}{2} = K_P$$

$$K_p = \frac{\cos^2(\theta+\phi)}{\cos^2\theta \cos(\theta-\delta)\left[1-\sqrt{\frac{\sin(\phi+\delta)\sin(\phi+\beta)}{\cos(\theta-\delta)\cos(\theta-\beta)}}\right]^2}$$

K_p VALUES ARE SATISFACTORY FOR $\delta \leq \phi/3$ BUT ARE UNCONSERVATIVE FOR $\delta > \phi/3$ AND THEREFORE SHOULD NOT BE USED.

FIGURE 8
Coefficients K_A and K_p for Walls with Sloping Wall and Friction, and Sloping Backfill

Attachment C

BLASLAND, BOUCK & LEE, INC.

engineers & scientists

Summary of Groundwater Modeling

GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS
CELL G3 AREA SOURCE CONTROL

SUMMARY OF GROUNDWATER MODELING

Introduction

Groundwater flow modeling was utilized to evaluate the potential of water table mounding associated with a proposed sheet pile containment wall just east of Building 68 (in the Cell G3 area of the ½-Mile Reach Removal Action). The same groundwater model utilized for the Building 64W Area and the Cell G2 source control sheet pile containment assessments was used for this effort with some minor modifications, which are described below.

The publicly available and well-documented Visual MODFLOW™ program was used for the groundwater modeling effort (Waterloo Hydrogeologic, Inc., 1996). Visual MODFLOW™ is a proprietary pre- and post-processing program formulated to allow quick and efficient model setup and graphical presentation of model results for the MODFLOW, MODPATH, and MT3D groundwater programs. MODFLOW is a three-dimensional groundwater flow model developed by the USGS to simulate groundwater movement (McDonald, M. G. and A.W. Harbaugh, 1988). MODPATH is a three-dimensional advective particle tracking program designed for use with MODFLOW steady-state flow simulations. MODPATH was also developed by the USGS (Pollack, D. W., 1989). MT3D is a three-dimensional solute transport program developed by S. S. Papadopolus & Associates, Inc. (Zheng, C., 1992) for use with programs such as MODFLOW that accounts for advection, dispersion, and chemical reactions. For this model application, only MODFLOW and MODPATH were applied.

Model Setup

Just as in the Building 64 Area and Cell G2 source control modeling, the area subject to modeling extends in a north-south direction from East Street to the Housatonic River. In the east-west direction, the model extends from, and includes, the East Street Area 2 - South recharge pond westward to just east of the Buildings 63/65. Portions of the model grid (Figure 1) that extend beyond these model boundaries (i.e., south of the Housatonic River) are set as inactive and are not incorporated in the model calculations. The model grid is designed with 188 rows and 268 columns. The Building 64W model was comprised of three layers, which was expanded to five layers for the Cell G2 model. The five layer model was utilized for this Cell G3 area assessment, which facilitated simulating a hanging sheet pile wall and to account for the greater depth to till in this area.

Horizontally, the grid spacing is a uniform 5 feet in the X and Y directions. Vertically (Z direction) Model Layer 1 is 13 feet thick, Model Layer 2 is 10 feet thick, Model Layer 3 is 5 feet thick, Model Layer 4 is 4 feet thick, and Model Layer 5 ranges from 7 to 26 feet thick (Figure 2). There is no differentiation between the different geologic deposits encountered above the till. Since the till has a substantially lower hydraulic conductivity than the overlying fill and alluvium, the top of till surface has been modeled as the impermeable base of the model. For much of the model domain, this impermeable surface is the base of Model Layer 4, which was set at an elevation of 956 feet (in the Cell G2 model the bottom elevation of this layer was 955 feet). In the vicinity of the Cell G3, the base of the model is the bottom of Model Layer 5, which was set at an elevation of 930 feet. In the northern and central portion of the model domain (where the top of till is observed at higher elevations), this impermeable till surface is the base of Model Layer 2, which was set at an elevation of 965 feet.

The input data required for the model includes stratigraphic, groundwater elevations, and hydraulic properties for each layer, estimates regarding the amount of water entering and leaving the hydrogeologic system, and the description of the model boundary conditions. Except for the model layering, the input data remained identical to that used in the Building 64W source control model. Much of this input was duplicated from the East Street Area 2 - South model and the Lyman Street Area model, and supplemented with data from borings and monitoring wells within the modeled area.

Based on the East Street Area 2 - South model, and site geologic logs, the top of till is a sloping surface (from north to south), with till elevations range from 930.0 feet amsl along the Housatonic River to 970 feet amsl closer to East Street. A sloping till surface was not used in this model due to the lack of sensitivity to a sloping till surface that was demonstrated in the East Street Area 2 - South model. However, as indicated above, a portion of Model Layer 3, 4, and 5 were inactivated (made impermeable) in those areas where the observed till elevation was greater than the elevation of the top of the applicable model layer, and the base of Model Layer 5 was reduced from 948 feet to 930 feet in a small area between Buildings 60 A and 68.

The horizontal hydraulic conductivity for all the saturated overburden materials above the till was set to 2×10^{-2} cm/sec (56.7 feet/day) and the vertical hydraulic conductivity was set 10 times less. This approach and hydraulic conductivity values were the same as used in the East Street Area 2 - South model. The model boundary conditions include precipitation recharge, the Housatonic River, the groundwater recharge pond, the till confining layer, and regional groundwater flow lines.

Recharge due to precipitation was set to 10 inches per year based on the previous modeling efforts. The eastern and western model boundaries were impermeable or 'no flow' boundaries presumed to correspond with groundwater flow lines. The till also was modeled as a no flow boundary on the bottom and northern side wall of model. Constant heads were used to represent the Housatonic River with the river stage held constant at 971.6 feet amsl all along the southern edge of the model, which was the high stage value used in the Lyman Street model prepared by HSI GeoTrans (1999). Constant heads were also set along the northern model boundary in Layer 1 to allow upgradient inflow of groundwater. This line of constant heads was set at 979.5 feet amsl, generally parallel to the 980.0 foot contour shown on the April 1998 groundwater elevation contour map. The recharge pond was simulated with a higher permeability pond bottom. The elevation of the recharge pond was set to 983.0 feet amsl and the bottom of recharge pond (set as 3 feet thick) was assigned conductance value of 225 $feet^2$/day. This conductance value is reflective of a vertical hydraulic conductivity of approximately 28.35 feet/day (1×10^{-2} cm/sec) applied across the area of each grid block.

Additional boundary features incorporated into the model include the existing recovery wells and the proposed sheetpile wall. The wall was set at the location shown on the site map. The wells included in the model and the pumping rates used for each well are as follows:

Well ID	Pumping Rate
64S	25 gpm
RW-1(S)	20 gpm
RW-1(X), RW-2(X), 64X(W) combined	20 gpm

The actual pumping rates for RW-1(X), RW-2(X), 64X(W) were combined and then half that amount was input into the model (assuming symmetry) as a single well since these recovery wells are all along the models eastern boundary. Standard vertical tubular well designs were used for all the pumping wells.

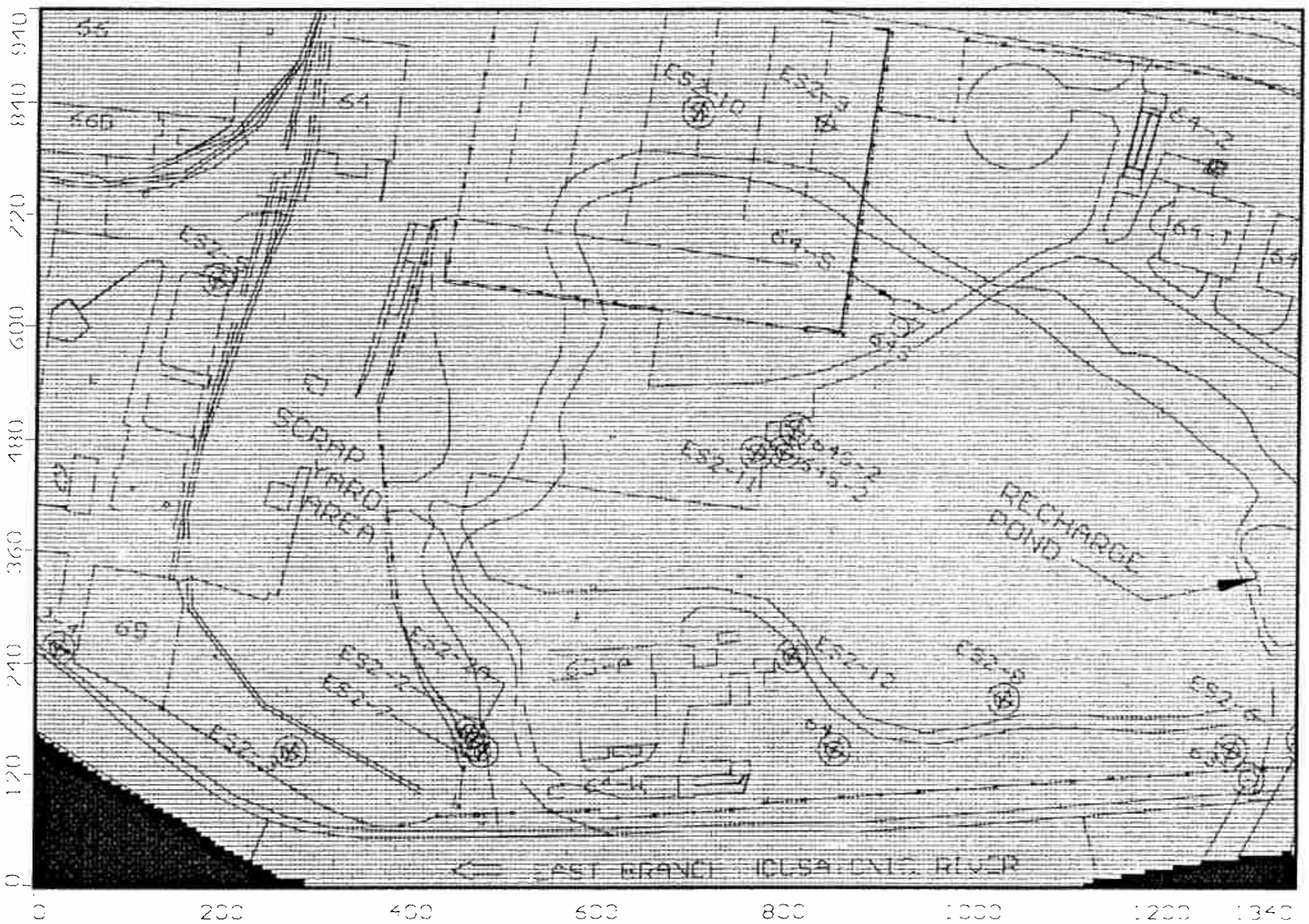
The proposed sheetpile wall was incorporated with the MODFLOW wall option. The sheetpile wall was placed across Model Layers 1 through 4, and wing walls were incorporated (Figure 3). The width of the sheetpile wall was 0.021 feet (0.25 inches) and the hydraulic conductivity was set at 1×10^{-9} cm/sec (0.00000284 feet/day).

Calibration of the model was previously performed in association with the Building 64W modeling effort. Additional calibration was not considered necessary for this application due to the previous calibration efforts, and the similar model results. Additional simulations were performed, however, to assess the effect of potentially lower hydraulic conductivity values for the soil materials in the Cell G3 area, as reported for a few monitoring wells in the general vicinity of Cell G3.

Analysis of the mounding potential following sheetpile emplacement indicates that the groundwater mounding north of the sheet pile wall would be minor (mounding by approximately 0.2 feet within 20 feet of the wall) (Figure 4). The pre-sheetpile wall groundwater ("calibrated") contours elevations are shown on Figure 5. The post-sheetpile wall groundwater elevation contours are shown on Figure 6. The slight increase in the groundwater elevation (mounding) due to emplacement of the sheetpile wall is shown on Figure 4.

As indicated above, additional simulations were performed as a sensitivity analysis to assess how lowering the hydraulic conductivity values could potentially affect the degree of mounding. This was done by establishing a zone that encompassed the Cell G3 area containment wall (Figure 7), then setting the hydraulic conductivity in this zone. Three hydraulic conductivity values were assessed; 4, 10, and 30 feet/day. The resulting simulated mounding for the different hydraulic conductivities are shown in Figures 8 through 10. As shown, the maximum mounding of 0.5 feet occurs with the lowest hydraulic conductivity settings. Based on this modeling, the maximum projection of mounding is expected to be less than 0.5 feet upgradient of the containment wall and is considered to be minor.

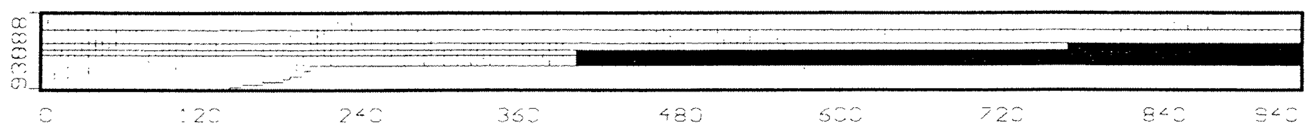
FIGURE 1 – FINITE DIFFERENCE GRID



Blasland, Bouck & Lee, Inc.
Project: 1/2–Mile – Cell G3
Description: Grid
22 Dec 00

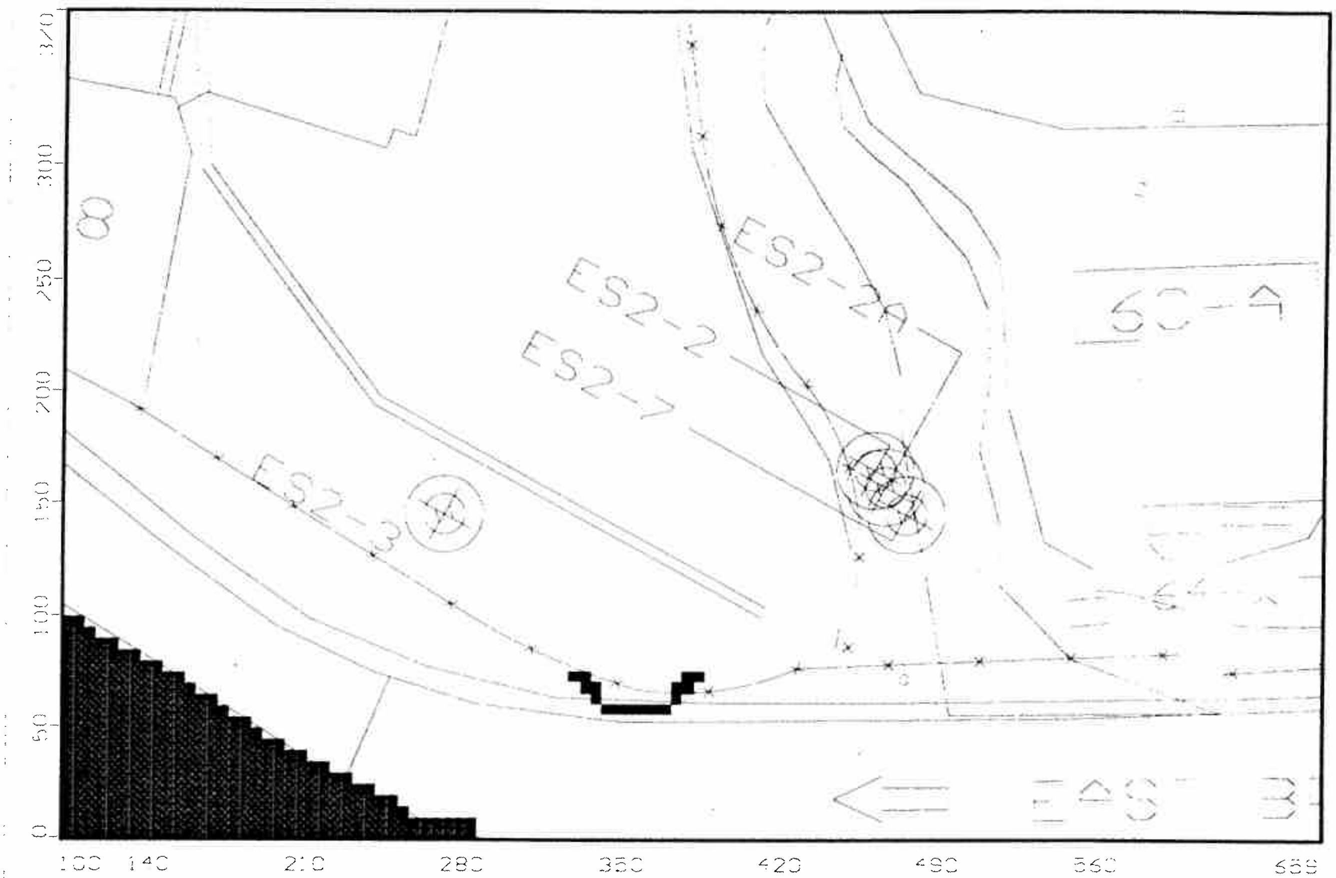
Visual MODFLOW v.2.8.2, (C) 1995–1999
Waterloo hydrogeologic, Inc.
NC: 268 NR: 188 NL: 5
Current Layer: 2

FIGURE 2 - CROSS-SECTION OF FINITE DIFFERENCE GRID



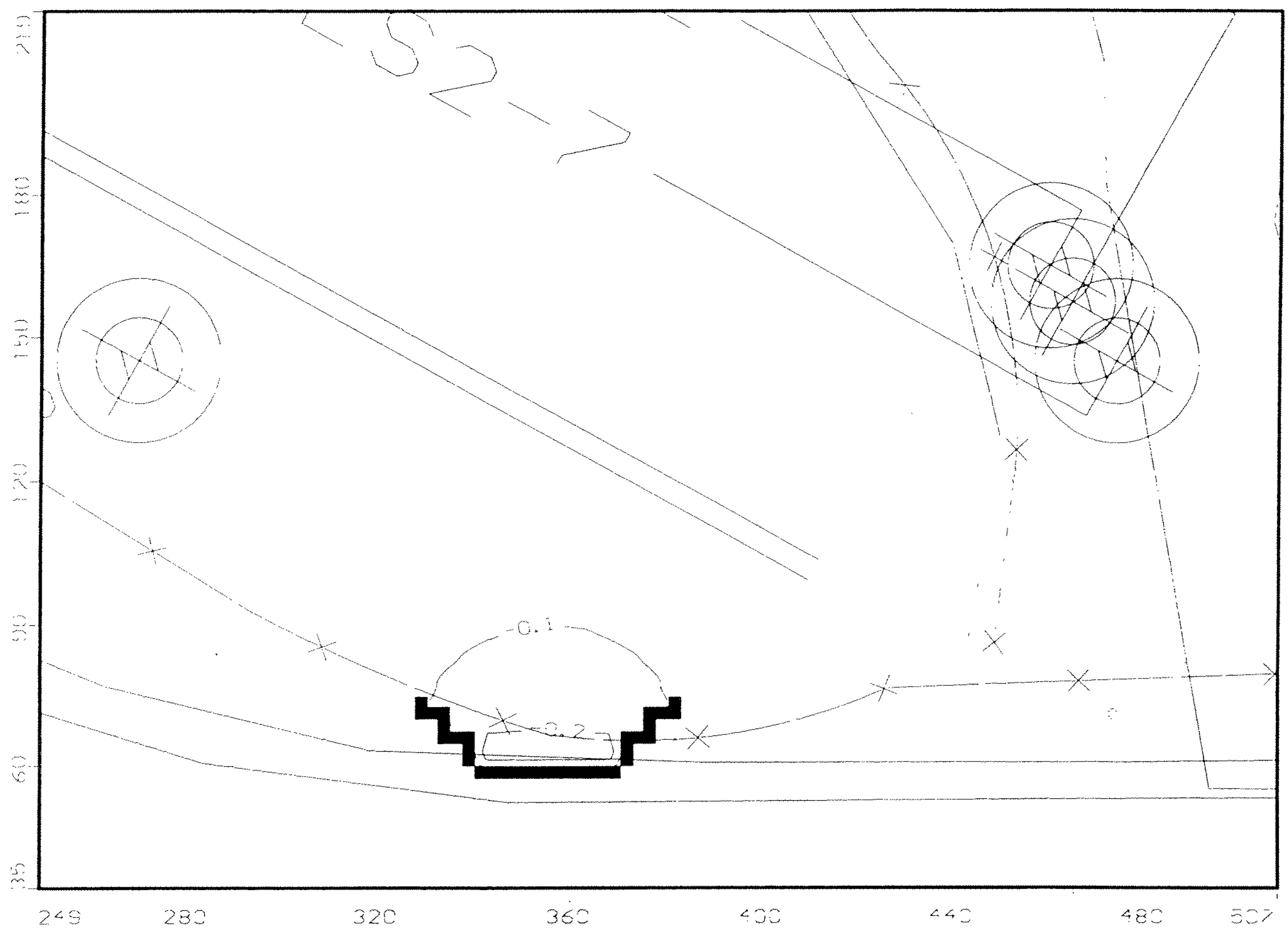
Blasland, Bouck & Lee, Inc. Project: 1/2-Mile - Cell G3 Description: Grid Cross-Section 22 Dec 00	Visual MODFLOW v.2.8.2, (C) 1995-1999 Waterloo Hydrogeologic, Inc. NC: 268 NR: 188 NL: 5 Current Column: 70

FIGURE 3 – SIMULATED SHEETPILE LOCATION



Blasland, Bouck & Lee, Inc.	Visual MODFLOW v.2.8.2, (C) 1995–1999
Project: 1/2–Mile – Cell G3	Waterloo Hydrogeologic, Inc.
Description: Simulated Wall	NC: 268 NR: 188 NL: 5
22 Dec 00	Current Layer: 2

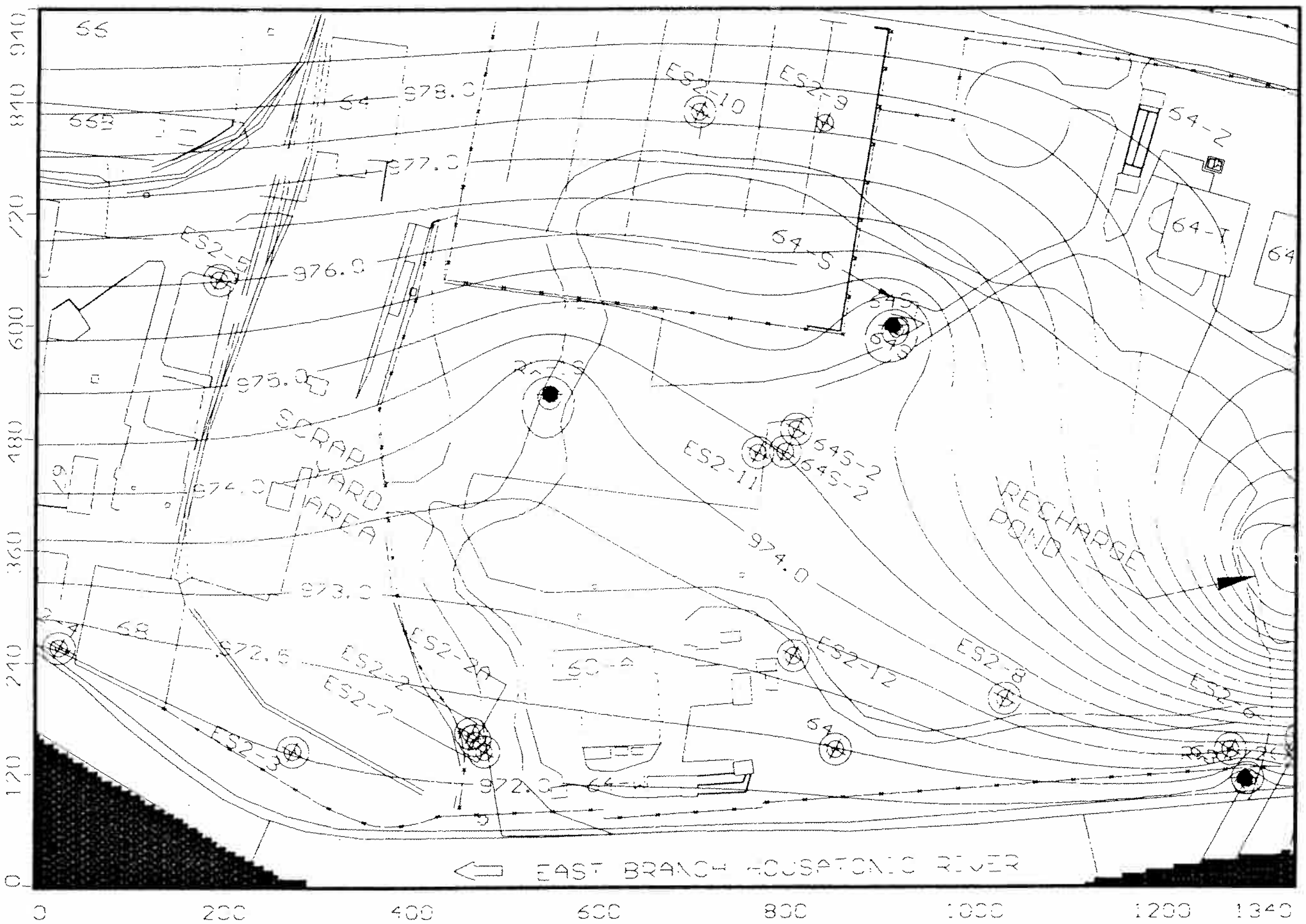
FIGURE 4 – SIMULATED MOUNDING WITH K = 56.7 ft/day



Blasland, Bouck & Lee, Inc.
Project: 1/2-Mile – CellG3_6
Description: Mounding
22 Dec 00

Visual MODFLOW v.2.8.2, (C) 1995–1999
Waterloo Hydrogeologic, Inc.
NC: 268 NR: 188 NL: 5
Current Layer: 2

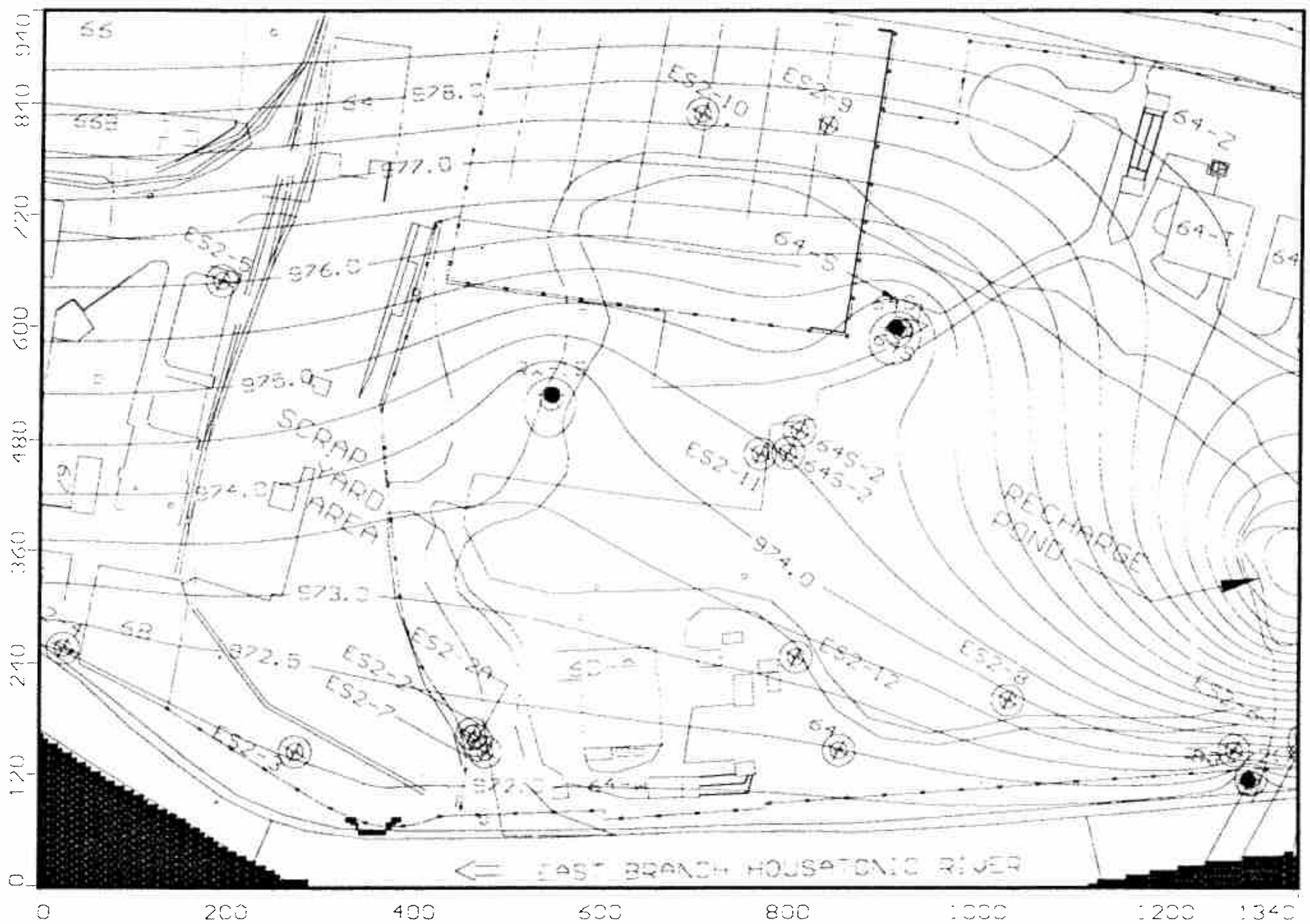
FIGURE 5 - PRE-WALL GROUNDWATER ELEVATION CONTOURS (K = 56.7 ft/day)



Blasland, Bouck & Lee, Inc.
Project: 1/2-Mile - Cell G3_3
Description: Pre-Wall GW Elevations
22 Dec 00

Visual MODFLOW v.2.8.2, (C) 1995-1999
Waterloo Hydrogeologic, Inc.
NC: 268 NR: 188 NL: 5
Current Layer: 2

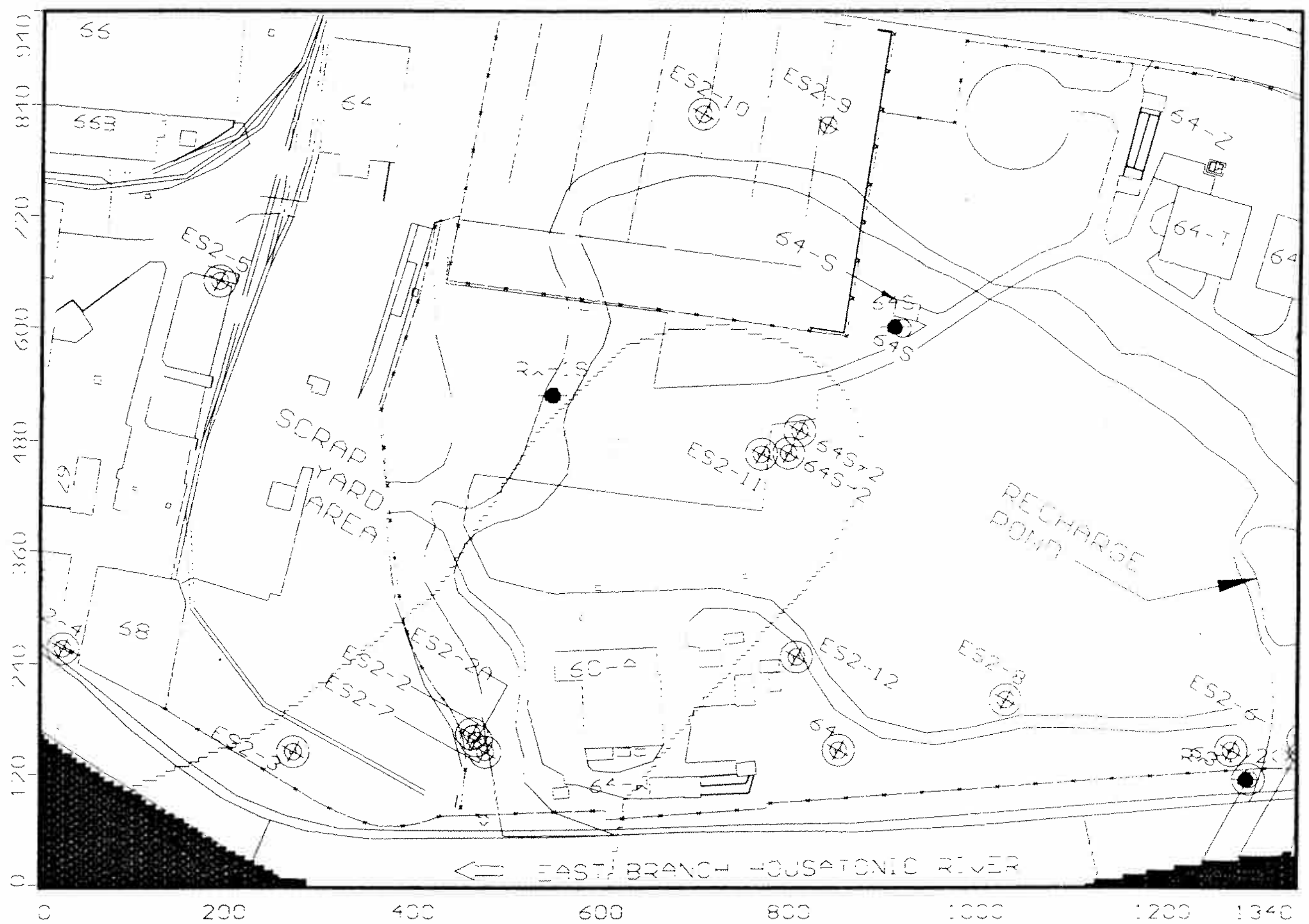
FIGURE 6 - POST-WALL GROUNDWATER ELEVATION CONTOURS



Blasland, Bouck & Lee, Inc.
Project: 1/2-Mile – Cell G3_6
Description: Post-Wall GW Elevations
22 Dec 00

Visual MODFLOW v.2.8.2, (C) 1995-1999
Waterloo Hydrogeologic, Inc.
NC: 268 NR: 188 NL: 5
Current Layer: 2

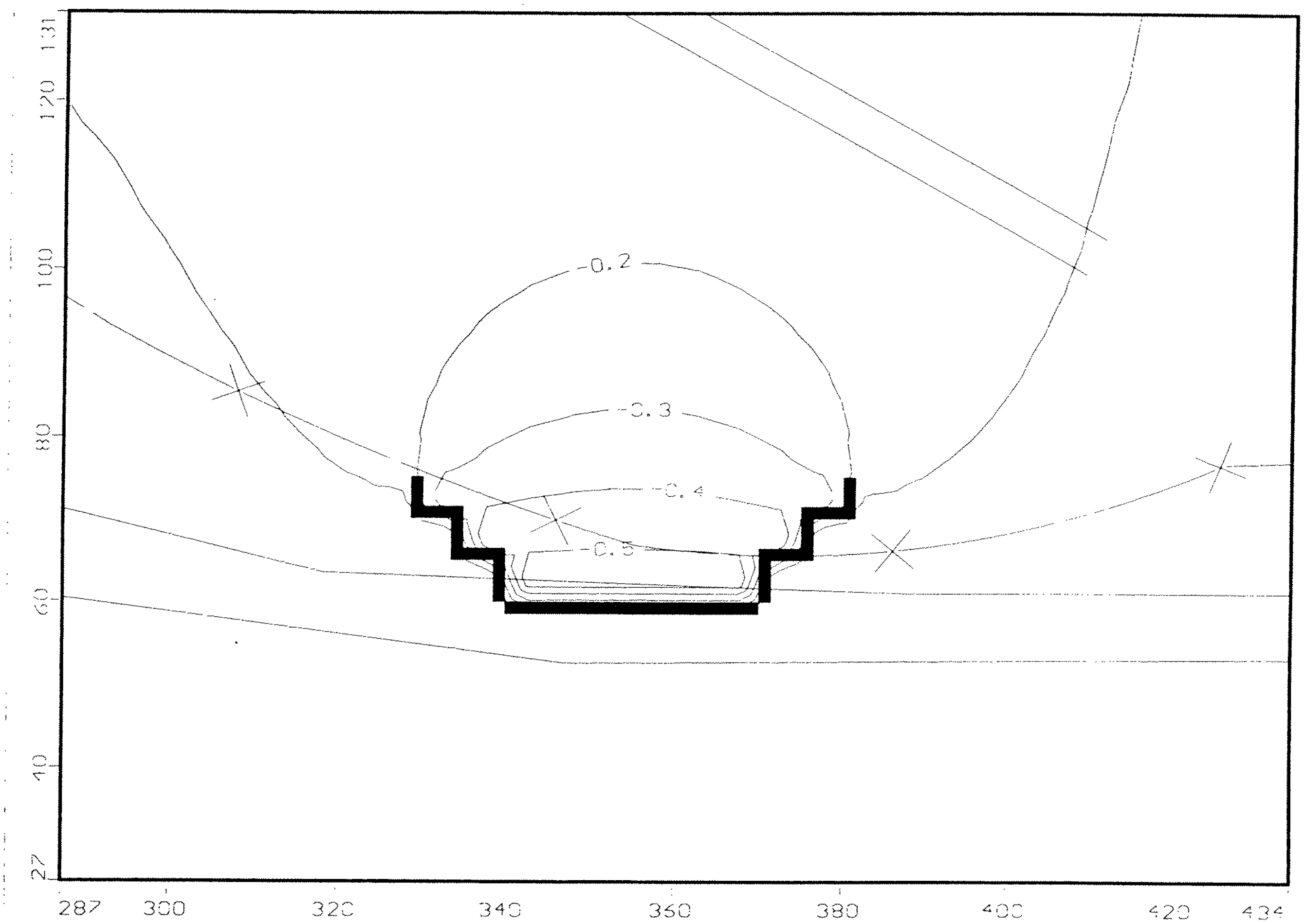
FIGURE 7 – ZONE WHERE HYDRAULIC CONDUCTIVITY WAS LOWERED FOR SENSITIVITY ASSESSMENT



Blasland, Bouck & Lee, Inc.
Project: 1/2-Mile – Cell G3_8
Description: Area Where K Was Varied
22 Dec 00

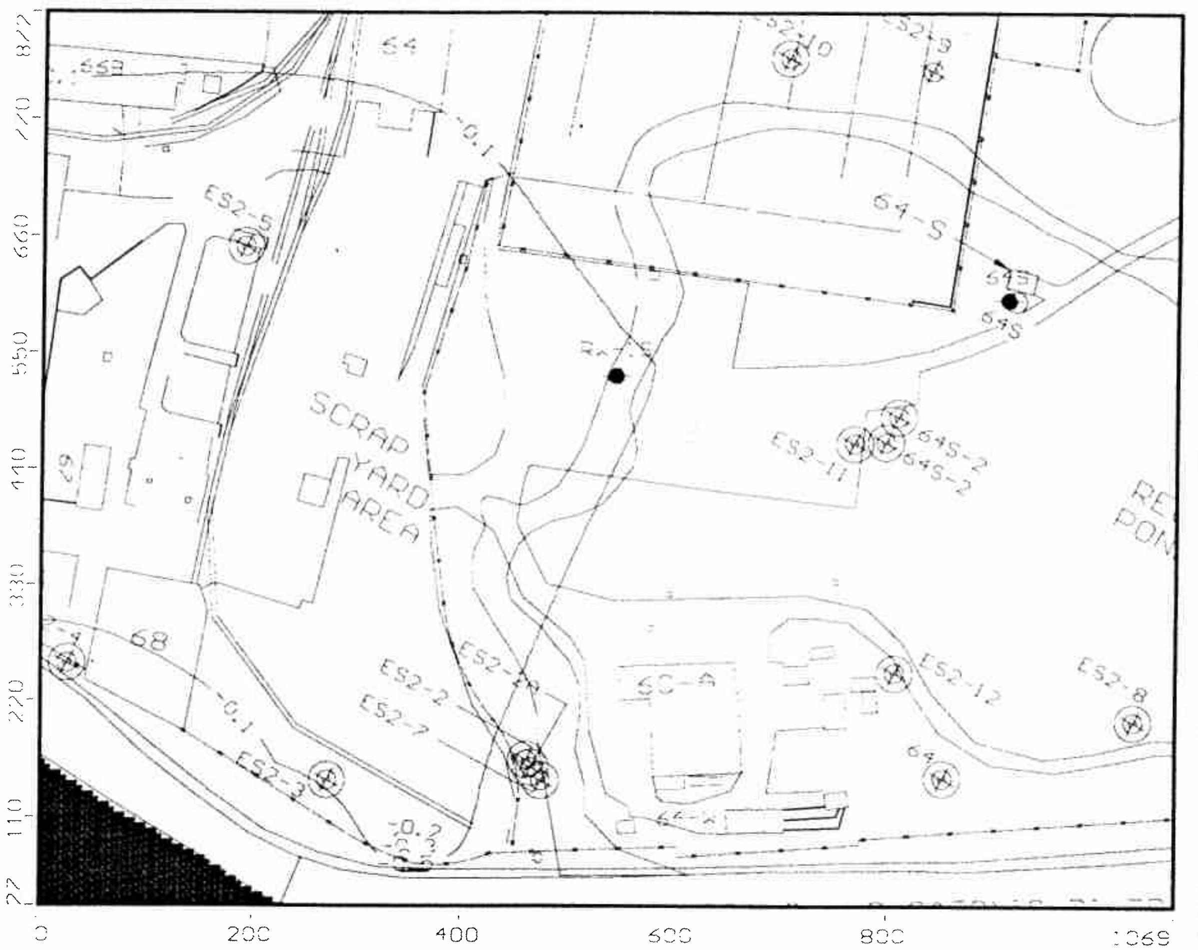
Visual MODFLOW v.2.8.2, (C) 1995–1999
Waterloo Hydrogeologic, Inc.
NC: 268 NR: 188 NL: 5
Current Layer: 1

FIGURE 8 – MOUNDING WHEN K = 4 ft/day



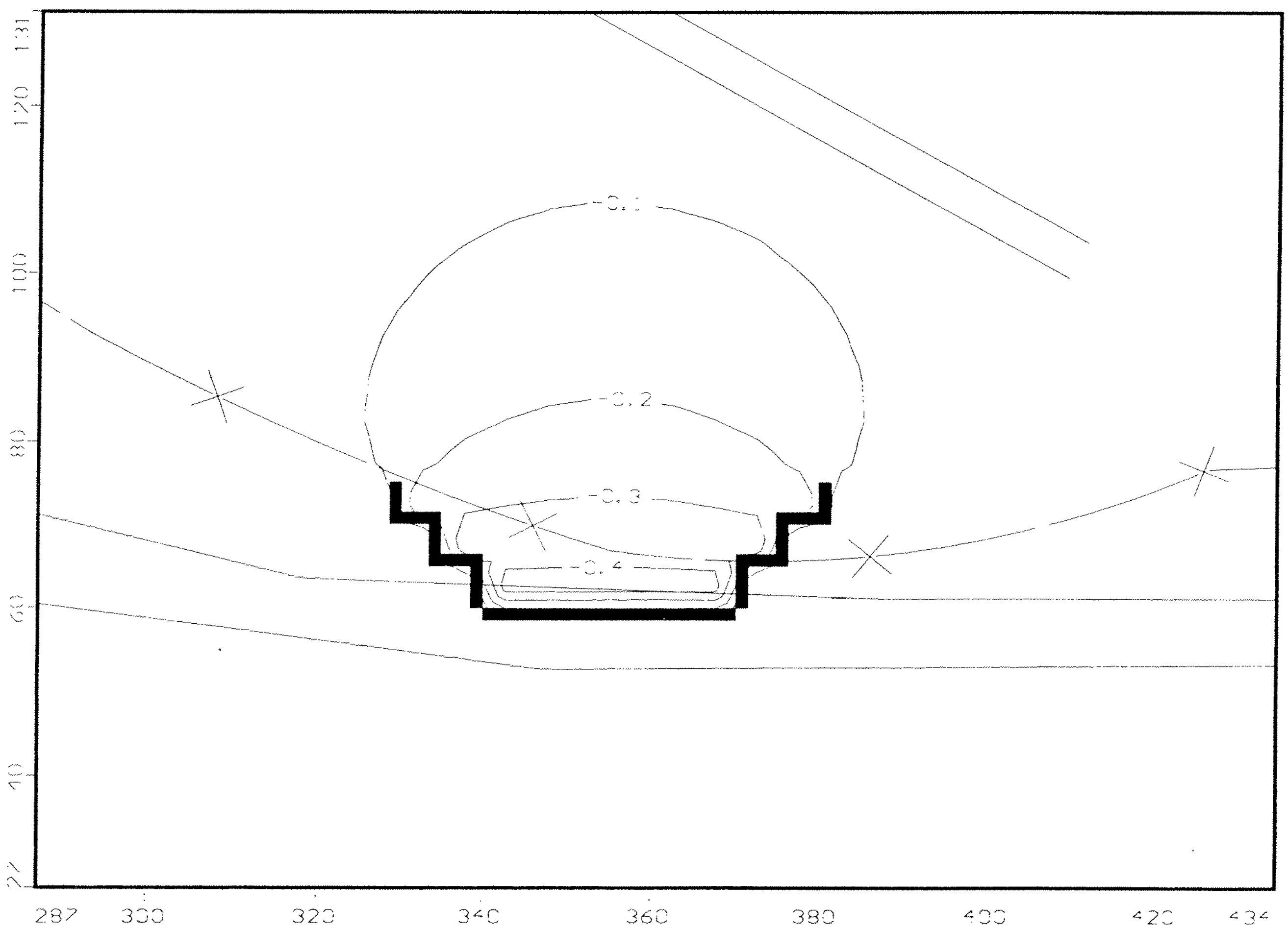
Blasland, Bouck & Lee, Inc. Project: 1/2-Mile – Cell G3_8 Description: Mounding w/ K=4 ft/d 22 Dec 00	Visual MODFLOW v.2.8.2, (C) 1995-1999 Waterloo Hydrogeologic, Inc. NC: 268 NR: 188 NL: 5 Current Layer: 2

FIGURE 8a – MOUNDING WHEN K = 4 ft/day



Blasland, Bouck & Lee, Inc.	Visual MODFLOW v.2.8.2, (C) 1995–1999
Project: 1/2–Mile – Cell G3_8	Waterloo Hydrogeologic, Inc.
Description: Mounding w/ K=4 ft/d	NC: 268 NR: 188 NL: 5
22 Dec 00	Current Layer: 2

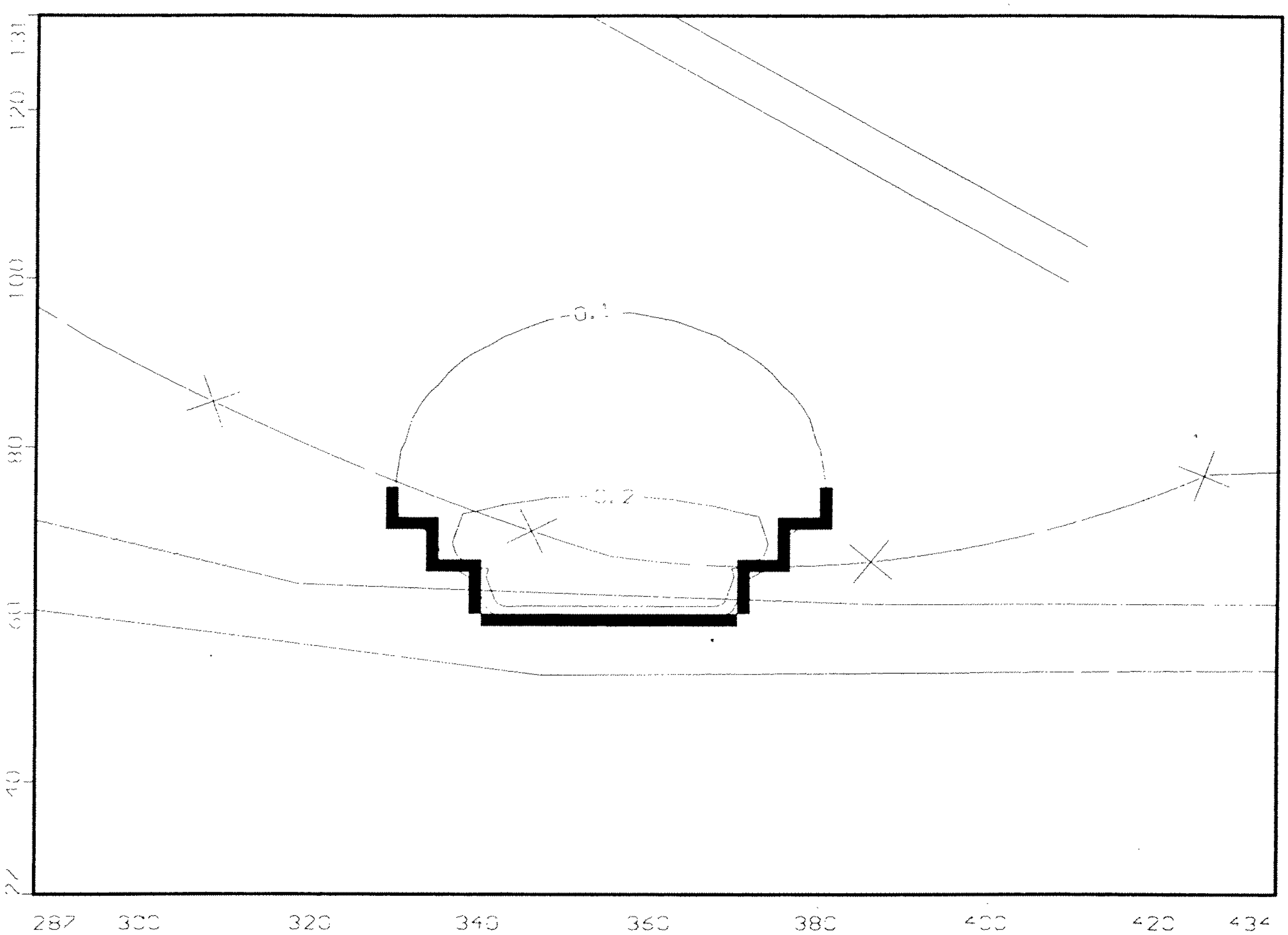
FIGURE 9 – MOUNDING WHEN K = 10 ft/day



Blasland, Bouck & Lee, Inc.
Project: 1/2-Mile – Cell G3_10
Description: Mounding w/ K=10 ft/d
22 Dec 00

Visual MODFLOW v.2.8.2, (C) 1995–1999
Waterloo Hydrogeologic, Inc.
NC: 268 NR: 188 NL: 5
Current Layer: 2

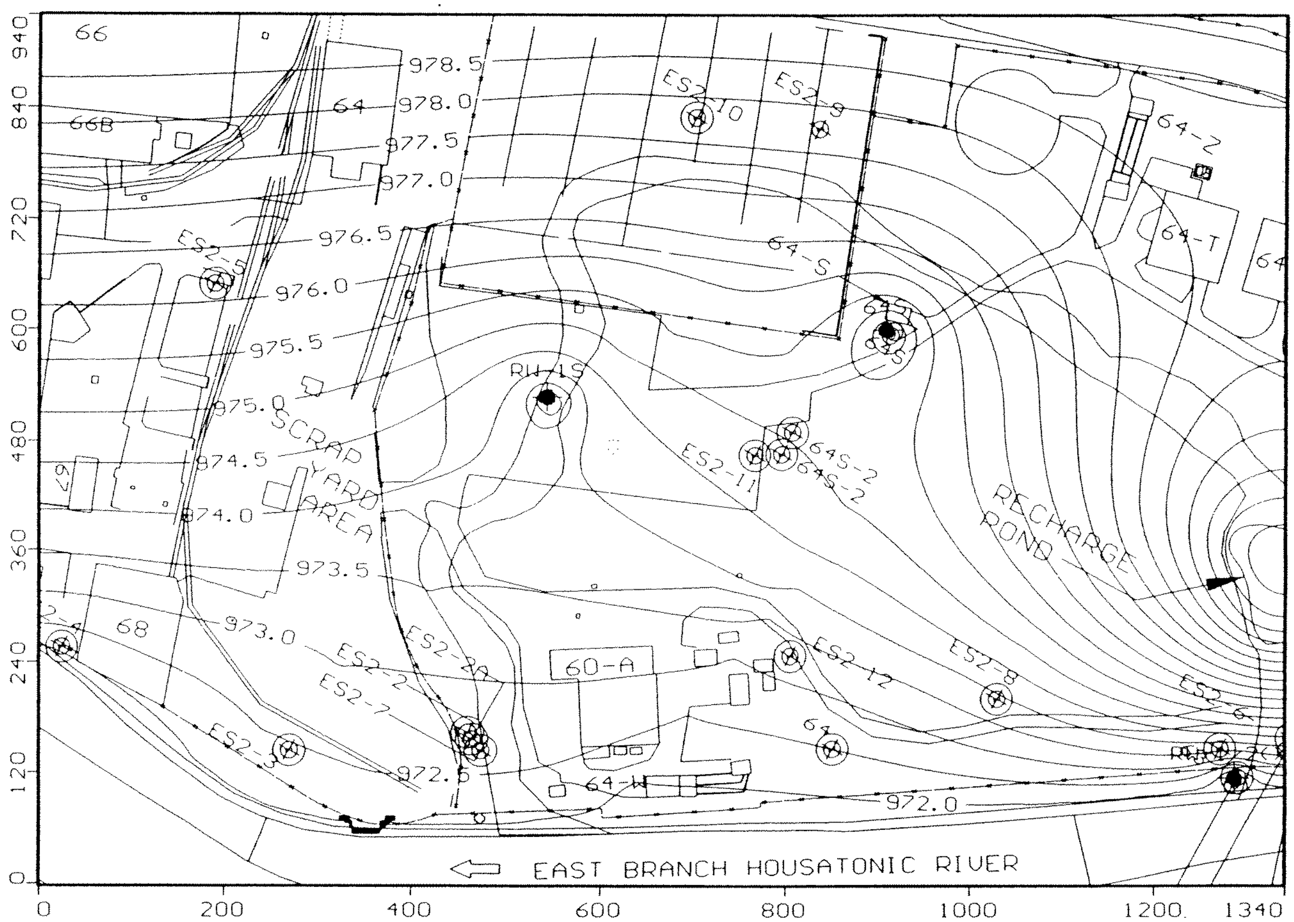
FIGURE 10 - MOUNDING WHEN K = 30 ft/day



Blasland, Bouck & Lee, Inc.
Project: 1/2-Mile - Cell G3_12
Description: Mounding w/ K=30 ft/d
22 Dec 00

Visual MODFLOW v.2.8.2, (C) 1995-1999
Waterloo Hydrogeologic, Inc.
NC: 268 NR: 188 NL: 5
Current Layer: 2

FIGURE 11 – GROUNDWATER ELEVATION CONTOURS WHEN K = 4 ft/day



Blasland, Bouck & Lee, Inc. Project: 1/2-Mile – Cell G3_8 Description: Equipos w/ K=4 ft/d 3 Jan 01	Visual MODFLOW v.2.8.2, (C) 1995-1999 Waterloo Hydrogeologic, Inc. NC: 268 NR: 188 NL: 5 Current Layer: 2