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# FINAL
# FEASIBILITY STUDY REPORT

## SACO MUNICIPAL LANDFILL
## SACO, MAINE

**July 2000**

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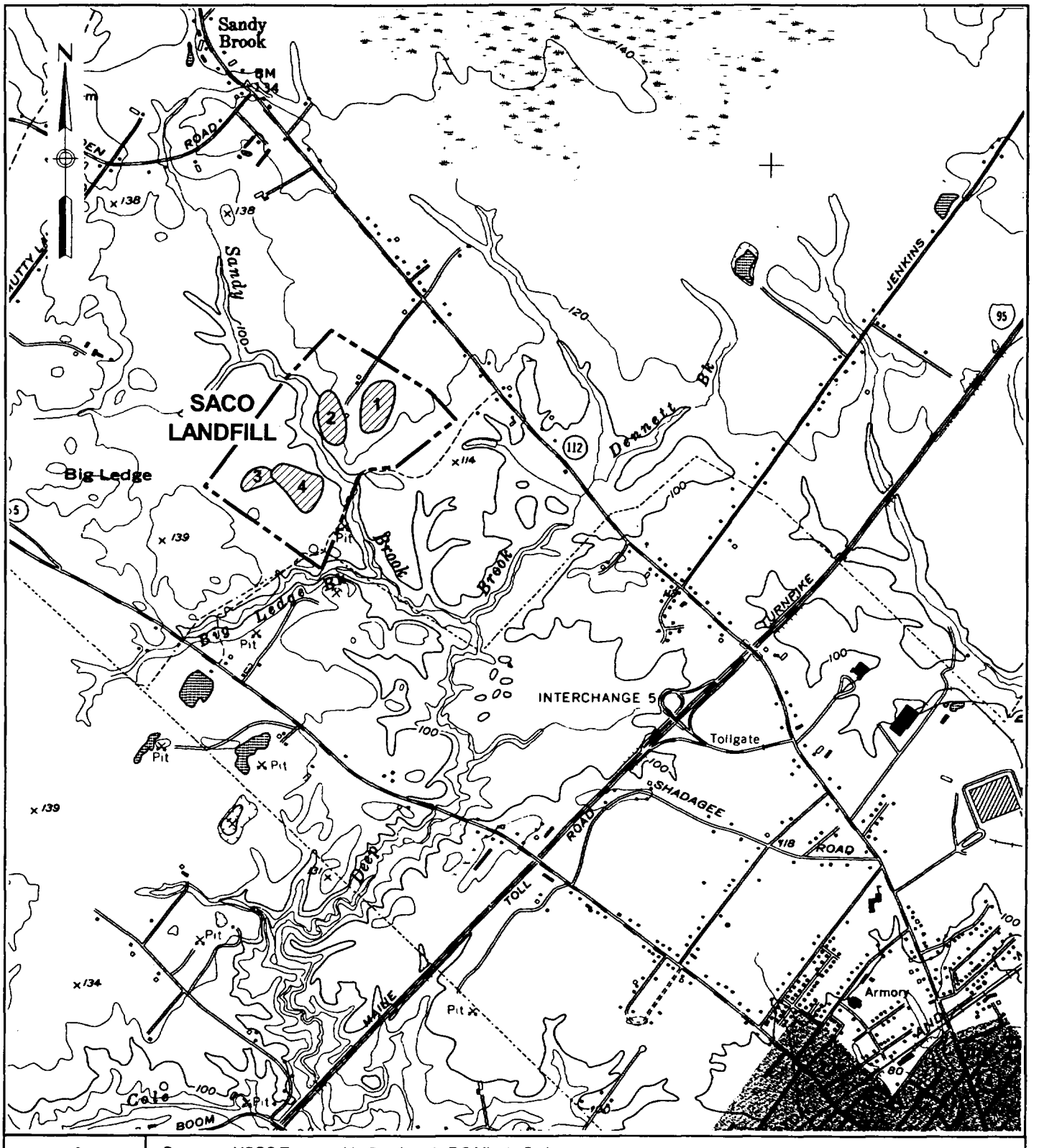
# 1.0 INTRODUCTION

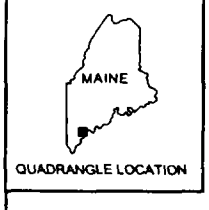
This Feasibility Study (FS) was prepared by Woodard & Curran (W&C) in accordance with the Administrative Order by Consent (USEPA CERCLA Docket No. I-CERCLA-95-1069) (Order), between the City of Saco, Maine; the U.S. Environmental Protection Agency (USEPA); and the Maine Department of Environmental Protection (MEDEP). This FS addresses the management of groundwater migration and was developed based on the findings of the Remedial Investigation (RI) report, Baseline Human Health and Ecological Risk Assessments, Groundwater Modeling results, and U.S. Geological Survey (USGS) studies. This report reflects current site conditions including the Non-Time Critical Removal Action (NTCRA) conducted at the landfill during 1997-98. The NTCRA addressed source control at this site through the placement of a Resource Conservation and Recovery Act (RCRA) Subtitle C Landfill Cover system over Landfill Areas 3 and 4 and focused on "hot spot" sediment removal at two seep areas adjacent to Sandy Brook.

A detailed discussion of site investigations, site characteristics, and the NTCRA is presented in the Final Phase IA RI and Engineering Evaluation/Cost Analysis (EE/CA) reports (W&C, 1998a and 1996) and is not repeated here. Results of studies conducted at the site between December 1997 and October 1998 (e.g., December 1997, and June 1998 Pre-ROD groundwater data; USGS investigations; groundwater modeling and pumping test results and sediment and surface water sampling results) are summarized along with a refined site conceptual model in the text of this report and presented as appendices.

## 1.1 PURPOSE

The purpose of this FS is to develop potential remedial alternatives for the management of migration of groundwater associated with Landfill Areas 3 and 4, such that an appropriate remedy can be selected for the site. Based on results of the human health and ecological risk assessments, groundwater is the only medium associated with Landfill Areas 3 and 4 (Figure 1-1) that poses a potential risk to human health (W&C, 1998a; Exponent, 1999). It should be noted that the concentrations of certain constituents exceed state or federal drinking water standards, or statewide water quality criteria. However, currently no one is being exposed to groundwater or to surface water in Sandy Brook as a drinking water source. Institutional controls implemented as part of the NTCRA will restrict future exposure to these media.. As supported by the Human Health and Ecological Risk Assessment Reports, the NTCRA has resolved all necessary source control actions at the site.




**Source:** USGS Topographic Quadrangle 7.5-Minute Series, Old Orchard Beach, Maine, 1956 (Photorevised 1970; Photoinspected 1975).

Scale in Feet

0 2000 4000

Figure 1-1
Site Location Map
Feasibility Study Report
Saco Municipal Landfill
Saco, Maine

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Long-term monitoring of the source control measures will be undertaken by the City of Saco to ensure continued protection of human health and the environment.

Landfill Areas 1 and 2 did not present a risk to either human health or the environment and, as such, are not considered in this FS. However, as part of the NTCRA, deed restrictions have been placed on both these areas.

## 1.2 ORGANIZATION

This FS was conducted in accordance with National Contingency Plan (NCP) (USEPA, 1990) and guidance described in: "*Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*" (USEPA, 1988), "*Presumptive Remedy for CERCLA Municipal Landfill Sites*" (USEPA, 1993), and "*Conducting Remedial Investigations and Feasibility Studies for CERCLA Municipal Landfill Sites*" (USEPA, 1992) and is in accordance with the Order (USEPA, 1988, 1990, 1992, and 1993). The FS process for Municipal Landfill sites is presented in Figure 1-2.

Section 2.0 presents the results of groundwater, surface water, and sediment investigations conducted between July 1997 and October 1998, and provides a summary of the groundwater model and USGS investigations. This information supports the previous site understanding and is the basis of the site conceptual model. Additional surface water, sediment, and groundwater samples were collected throughout 1999. In general, these data are not included in the summary tables presented in this text. However, the 1999 data are included as Appendix F for completeness. Although this data were not included specifically within this text, they were reviewed and compared to previous results. The 1999 data are similar to the previous sampling results, and therefore, do not change the findings of this FS.

The remainder of this FS is organized to address each of the steps identified in Figure 1-2 as follows:

- Section 3.0 establishes the remedial objectives to mitigate the potential future risks to human health from groundwater exposure and identifies potential action-specific Applicable or Relevant and Appropriate Requirements (ARARs) for the site.

**Remedial Objectives**

- Develop Remedial Response Objectives
- Develop Remedial Action Objectives
- Develop General Response Actions
- Identify ARARs

**Technology Selection and Remedial Alternatives Development**

- Identify Potential Technologies Based on Site-specific Conditions and Vendor Information
- Screen Technologies
- Assemble Alternatives
- Screen Alternatives

**Detailed Analysis of Remedial Alternatives**

- Analyze Alternative Using NCP Evaluation Criteria:
  - Overall Protection of Human Health and the Environment
  - Compliance with ARARs
  - Long-Term Effectiveness and Permanence
  - Reduction of Mobility, Toxicity, or Volume through Treatment
  - Short-Term Effectiveness
  - Implementability
  - Cost
  - State Acceptance
  - Community Acceptance
- Compare Alternatives

**NOTE:**
ARARs = Applicable or Relevant and Appropriate Requirements

Figure 1-2
Feasibility Study Process
Feasibility Study Report
Saco Municipal Landfill
Saco, Maine

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95093.06\fsprocess

- Section 4.0 identifies and screens technologies that may achieve the remedial objectives. The demonstrated performance and applicability of each technology is considered with respect to the site and contaminant characteristics.

- Section 5.0 develops remedial alternatives by combining the technologies retained through the previous screening process.

- Section 6.0 screens these remedial alternatives against the three criteria identified in the NCP: effectiveness, implementability, and cost.

- Section 7.0 presents a detailed analysis of the alternatives retained in Section 6.0 and screens these alternatives against the nine evaluation criteria identified in the NCP.

- Section 8.0 is the comparative analysis of the retained remedial alternatives and compares the advantages and disadvantages of each of the alternatives relative to one another and with respect to the NCP criteria.

# 2.0 SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT

This section presents an evaluation of the data collected at the SML between July 1997 and October 1998 and supplements information presented in the Final Phase IA RI Report (W&C, 1998a). Since 1997, various media have been re-sampled to further define the nature and distribution of contamination and new studies (particularly by the USGS) have been completed and allowed for refinement of the site conceptual model. Additional data have been collected and will continue to be collected as part of the Pre-ROD Sampling. Of these data, the June 1999 surface water program data have been included in this section because they provide the most recent record of conditions in Sandy Brook. A summary of the surface water, sediment, and groundwater data collected between December 1998 and November 1999 is provided in Appendix F. These data are consistent with previous sampling results and has been provided for completeness.

## 2.1 U.S. GEOLOGICAL SURVEY DATA COLLECTION

The USGS collected geologic and hydrologic data in 1997 and 1998 to supplement the information provided in the Final Phase IA RI Report (W&C, 1998a). The USGS data collection efforts were focused primarily on the distribution of contaminants southeast of Landfill Areas 3 and 4. The two main components of the USGS work were installation of several monitoring wells in this portion of the site and detailed analyses of whole-rock samples to assess the primary chemical and physical processes influencing the distribution of arsenic within the aquifer. An additional goal of the USGS study was to characterize the flow path from the landfill to the stream to enable geochemical modeling of the arsenic distribution in this system.

### 2.1.1 Monitoring Well Installation

Nine monitoring wells were installed by the USGS during August and September 1997. These wells are identified with "MW-97" followed by a well number unique to the series and are shown on Figure 2-1. Eight of the nine wells were installed directly southeast of the landfill, both upgradient (north) and downgradient (south) of the sediment retention basin. One well (MW-97-17R) was installed adjacent to the southwest edge of the landfill. Wells MW-97-13R and MW-97-17R were installed in bedrock; the remainder were installed in the unconsolidated sand and gravel unit.

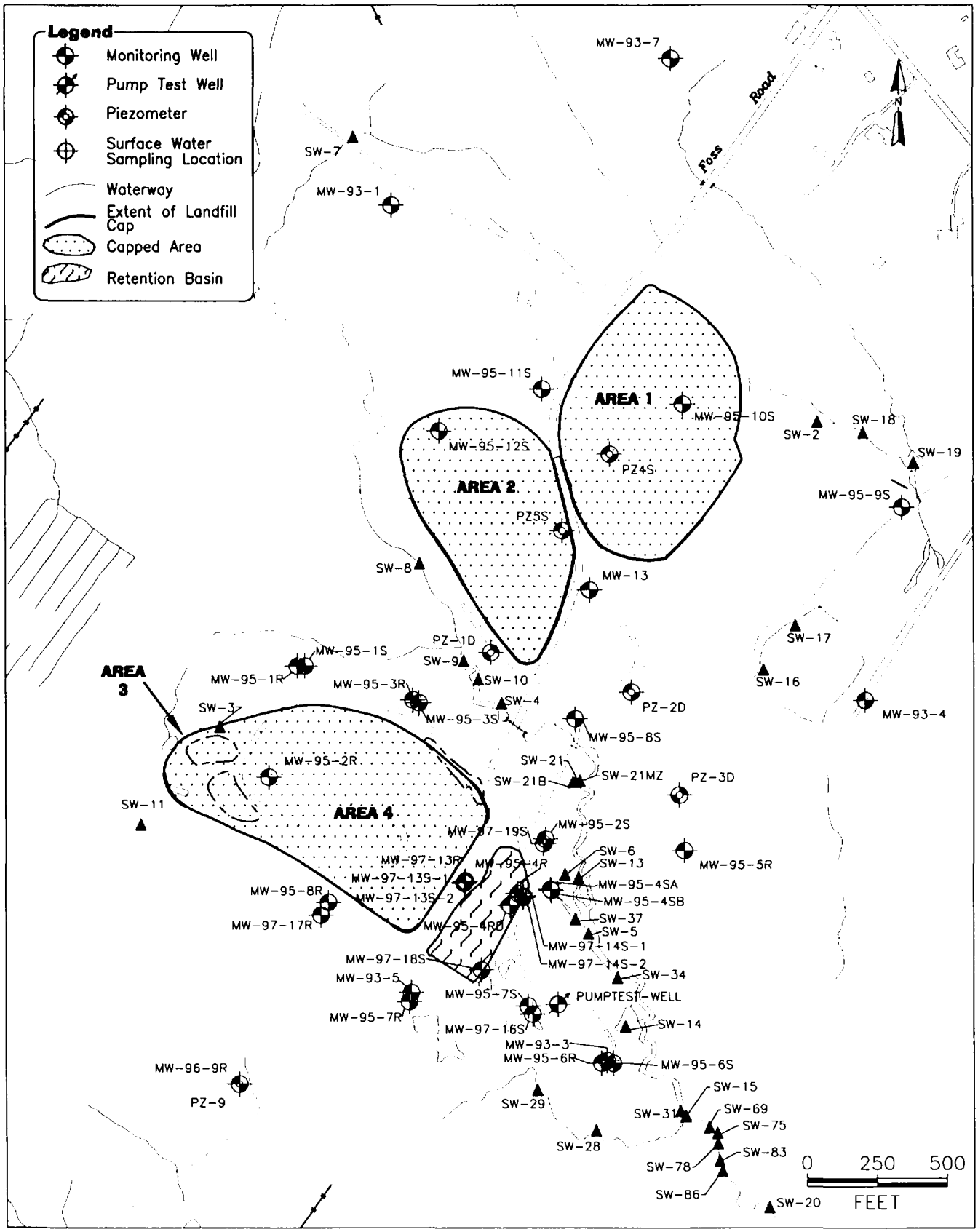


**Figure 2-1**
**Monitoring Well Locations**
**Feasibility Study Report**
**Saco Municipal Landfill**
**Saco, Maine**

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2-1.dwg/95093/pff

Placement of the wells was designed to provide information about the distribution of inorganic parameters, primarily arsenic, downgradient of Landfill Areas 3 and 4. All the wells in unconsolidated materials, with the exception of MW-97-13S1, were screened in the coarse grained glaciomarine deposits. MW-97-13S1 was screened 30 to 35 feet below ground surface (bgs) in a silt-clay layer. Two bedrock wells were installed to verify and support findings of the Phase IA RI Report. Table 2-1 lists pertinent monitoring well construction information for these wells.

Monitoring wells in the unconsolidated materials were installed using hollow-stem augers and were constructed of 2-inch inside diameter PVC materials with 5-foot well screens. Bedrock wells were drilled using a 2.5-inch coring bit and clear water as a drilling fluid, and consist of open boreholes below the top of rock. The bedrock wells have 20 to 30 feet of open borehole.

The USGS wells were sampled in December 1997 and June 1998 along with selected existing wells. The samples were analyzed for inorganic parameters as part of the Pre-ROD groundwater sampling program. Appendix F includes results of the December 1998, June 1999, and November 1999 sampling programs.

### 2.1.2 Soil and Bedrock Descriptions

Geologic logs prepared by the USGS during monitoring well installation are provided in Appendix A. Descriptions of subsurface geology made by the USGS are consistent with data collected during Phase IA investigations for this area and indicate the presence of clay layers (e.g., MW-97-13S1) in a predominantly gravel formation and the presence of numerous fractures in the upper portions of the bedrock. Table 2-2 summarizes the hydrogeologic unit in which each well is screened. Figure 2-2 is a geologic cross-section that and includes geologic detail provided by the USGS monitoring wells.

### 2.1.3 Core Studies

Fourteen soil and rock cores from the contaminated portion of the aquifer downgradient of Landfill Areas 3 and 4 were collected by the USGS and subjected to laboratory tests to mimic the leaching of inorganics from the native rock. The objective of these ongoing USGS studies is to characterize the chemical mechanisms occurring in the aquifer by which arsenic is leached from the rock to provide a basis for estimating the time that may be required to improve groundwater quality beneath and

## TABLE 2-1
## USGS MONITORING WELL CONSTRUCTION SUMMARY

## FEASIBILITY STUDY REPORT
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Well ID | Date Installed | Ground Elevation (ft. msl) | Bottom of Boring (ft. bgs.) | Top of Rock (ft. bgs.) | Screen Interval (ft. bgs.) | Stratigraphic Unit Screened |
|---|---|---|---|---|---|---|
| MW-97-13R | 09/04/97 | 107.60 | 83 | 48 | 53-83** | br |
| MW-97-13S-1 | 08/21/97 | 106.60 | 35 | ne | 30-35 | fm |
| MW-97-13S-2 | 08/25/97 | 106.50 | 48 | 48* | 43-48 | sf/gd |
| MW-97-14S-1 | 08/20/97 | 87.20 | 17.5 | 17.5* | 12.5-17.5 | sf/gd |
| MW-97-14S-2 | 08/20/97 | 87.30 | 14.6 | ne | 5-10 | sf/gd |
| MW-97-16S | 08/18/97 | 86.10 | 25 | ne | 20-25 | sf/gd |
| MW-97-17R | 09/03/97 | 122.50 | 49 | 17 | 19.5-49** | br |
| MW-97-18S | 08/28/97 | 87.10 | 18 | 18* | 13-18 | sf/gd |
| MW-97-19S | 08/18/97 | 89.3 | 26.5 | 26.5* | 21.5-26.5 | sf/gd |

Notes:

ft mgs = feet relative to mean sea level
ft bgs = feet below ground surface
ne = not encountered
* = refusal
** = open boreholes

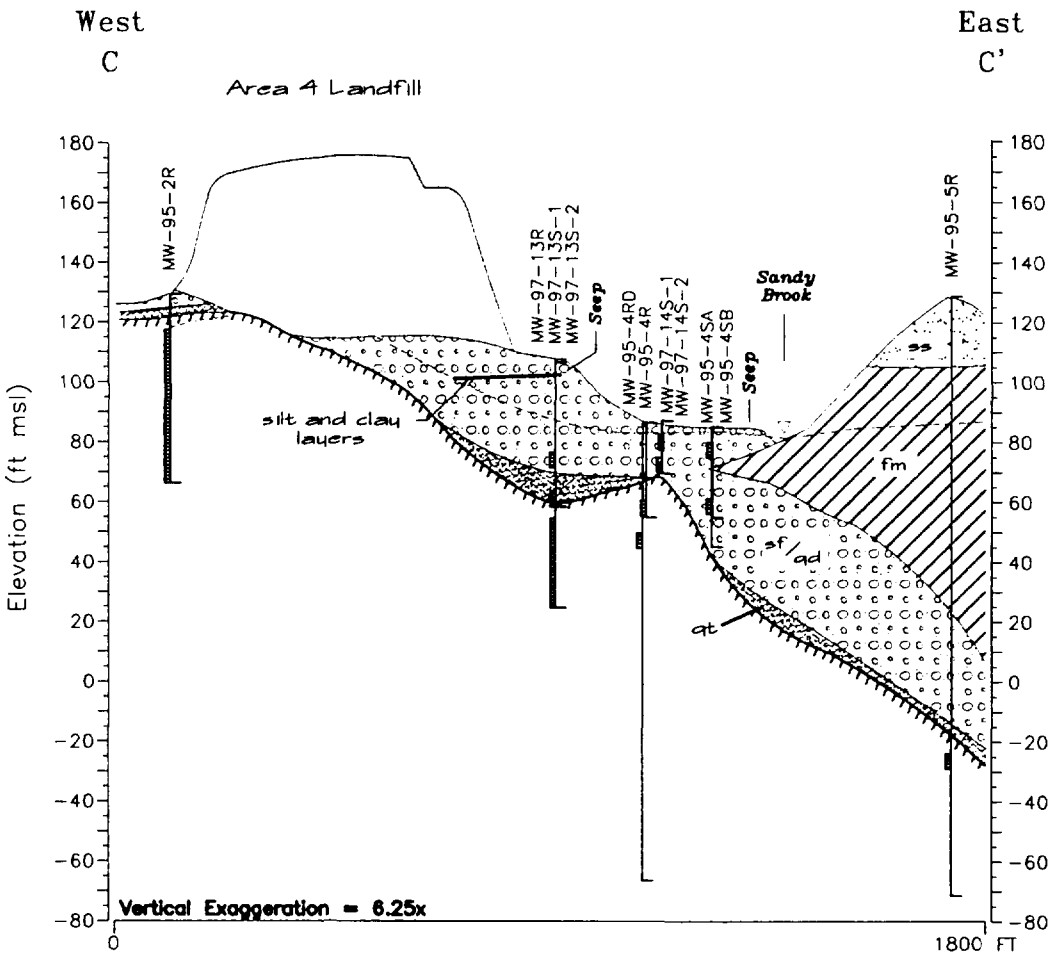
Stratigraphic Units:
ss = sand facies of glaciomarine deposits
fm = silt-clay facies of glaciomarine deposits
sf = sand facies of glaciomarine distal-fan deposits
gd = gravel and diamict facies of glaciomarine proximal-fan deposits
gt = glacial till
br = bedrock

## TABLE 2-2
## MONITORING WELL DESIGNATIONS BY HYDROGEOLOGIC UNIT

### FEASIBILITY STUDY REPORT
### SACO MUNICIPAL LANDFILL
### SACO, MAINE

| AREAS 1 and 2 | | | AREAS 3 and 4 | | |
|---|---|---|---|---|---|
| Upper Sand Facies | Lower Aquifer | Bedrock | Lower Aquifer | | Bedrock |
| | | | Shallow | Deep | |
| MW-93-7 | MW-93-1 | MW-95-5R | MW-95-1S | MW-93-3 | MW-95-1R |
| MW-95-10S* | MW-93-4 | | MW-95-2S | | MW-95-3R |
| MW-95-11S | PZ-1D | | MW-95-3S | | MW-95-4R |
| MW-95-12S* | PZ-2D | | MW-95-4SA | | MW-95-4RD |
| MW-95-9S | PZ-3D | | MW-95-4SB | | MW-95-6R |
| MW-95-8S | | | MW-95-6S | | MW-95-7R |
| MW-13 | | | MW-95-7S | | MW-95-8R |
| PZ-4S* | | | MW-93-5 | | MW-96-9R |
| PZ-5S* | | | MW-97-13S1 | | MW-97-17R |
| | | | MW-97-13S2 | | MW-97-13R |
| | | | MW-97-14S1 | | |
| | | | MW-97-14S2 | | |
| | | | MW-97-16S | | |
| | | | MW-97-18S | | |
| | | | MW-97-19S | | |

MW = monitoring well
PZ = piezometer
S = screen set in overburden materials
R = screen set in bedrock
* = indicates monitoring well/piezometer is in the landfill




| | | |
|---|---|---|
| | | Fill |
| | ss | Marine sand facies |
| | fm | Silt-clay facies |
| | sf/gd | Coarse-grained glaciomarine deposits |
| | gt | Glacial till |
| | | Bedrock |
| | | Water table (January 1996) |
| | | Monitoring well or piezometer |

Figure 2-2
Geologic Cross Section C-C'
Feasibility Study Report
Saco Municipal Landfill
Saco, Maine

Note: See Phase IA RI report, Figure 3-1 for cross section location.

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Engineering Science Operations

downgradient of the landfill. The data collected from these analyses form much of the basis for the chemical conceptual model discussed in Subsection 2.5 (a more detailed presentation of this model is provided in Appendix B).

These data have not been published; however, they were presented by the USGS at American Geophysical Union Meetings held in San Francisco, California in December 1998 and in Boston, Massachusetts in June 1999 (Colman and Lyford, 1999, Stollenwerk and Colman, 1998; Stollenwerk and Colman, 1999).

## 2.2 POST JULY 1997 SAMPLING EVENTS

The Phase IA RI Report was based on site information and analytical data collected through July 1997. Woodard & Curran conducted additional sampling of groundwater, surface water, and sediment in 1997, 1998, and 1999. This section provides a summary of the analytical data collected during the RI and Pre-ROD sampling events. Tables 2-3, 2-4, and 2-5 present a summary of surface water, sediment, and groundwater sampling events, respectively. These tables provide a summary of sampling locations and the analyses conducted during each sampling event. This report is based on the RI completed in January 1998. Since that time four additional sampling events have occurred. This section provides a summary of the analytical results through 1998. Appendix F presents the analytical results collected in 1999.

### 2.2.1 Surface Water Sampling

Three surface-water sampling events were conducted from July 1997 through June 1999. Surface water samples were collected from eight locations in Sandy Brook in June 1998 and were analyzed for total arsenic and iron. Surface water from six of these locations had been sampled during previous investigations and two locations (SW-34 and SW-69) had only been sampled previously for sediments. Surface water samples were collected from seven locations in Sandy and Big Ledge brooks in October 1998 and analyzed for total and dissolved arsenic, chromium, lead, and manganese. Table 2-3 summarizes surface water sampling locations and analyses through October 1998. Surface water samples were collected from 14 locations in Sandy Brook during June and November 1999 and analyzed for arsenic, iron, and manganese. Figure 2-3 shows the surface water sampling locations.

TABLE 2-3
SUMMARY OF SURFACE WATER SAMPLES AND ANALYSIS

FEASIBILITY STUDY REPORT
SACO MUNICIPAL LANDFILL
SACO, MAINE

| | Fall 1995/Winter 1996 | | | | Spring 1996 | | | | Fall 1996 | Summer 1997 | Summer 1998 | Fall 1998 | June 1999 | Nov 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SML Sampling Location | VOCs | SVOCs | Inorganics | Pesticides, PCBs | Dissolved Aluminum | Inorganics* | Pesticides/ PCBs | Mercury | Inorganics | As, Fe | As, Fe | As,Cr, Pb, Mn | As,Fe, Mn | As,Fe, Mn |
| SW-2 | √ | √ | √ | √ | | √ | | | √ | | | | | |
| SW-2 DUP | √ | √ | √ | √ | | | | | | | | | | |
| SW-3 | | √ | √ | √ | | | | | | | | | | |
| SW-4 | | √ | √ | √ | | | | | | √ | √ | | | |
| SW-4 DUP | | | | | | | | | | √ | | | | |
| SW-5 | | √ | √ | √ | | | | | | | | | | |
| SW-6 | √ | √ | √ | √ | | √ | | √ | √ | | √ | | | |
| SW-6A | | | | | | | | | | | √ | √ | | |
| SW-7 | √ | √ | √ | √ | | | | | √ | | √ | | | |
| SW-7D | | | | | √ | | | | | | | √ | | |
| SW-7T | | | | | | √ | | | | | | √ | √ | √ |
| SW-8 | √ | √ | √ | √ | | | | | | √ | √ | | | |
| SW-9 | √ | √ | √ | √ | | | | √ | √ | √ | √ | | | |
| SW-9 DUP | √ | √ | √ | √ | | | | √ | √ | | | | | |
| SW-9D | | | | | √ | | | | | | | | | |
| SW-9T | | | | | | √ | | | | | | | √ | √ |
| SW-10 | | √ | √ | √ | | | | | | | | | | |
| SW-11 | | √ | √ | √ | | | | | | | | | | |
| SW-13 | | √ | √ | √ | | | | | √ | | √ | | | |
| SW-13D | | | | | | | | | | | | √ | | |
| SW-13T | | | | | | | | | | | | √ | √ | √ |
| SW-14 | | √ | √ | √ | | | | | √ | | | | | |
| SW-15 | | √ | √ | √ | | | | | √ | | | | | |
| SW-15D | | | | | | | | | | | | √ | | |
| SW-15T | | | | | | | | | | | | √ | √ | √ |
| SW-16 | √ | √ | √ | √ | | | | | | | | | | |
| SW-17 | √ | √ | √ | √ | | | | | | | | | | |
| SW-18 | √ | √ | √ | √ | | | | | | | | | | |
| SW-20 | | √ | √ | √ | | | | | | | | | | |
| SW-21 | | | | | | √ | | | √ | | | | | |
| SW-21 DUP | | | | | | √ | | | | | | | | |
| SW-21D | | | | | | | | | | | | √ | | |
| SW-21T | | | | | | | | | | | | √ | √ | √ |
| SW-28D | | | | | √ | | | | | | | | | |
| SW-28T | | | | | | √ | √ | | | | | | | |

**TABLE 2-3**
**SUMMARY OF SURFACE WATER SAMPLES AND ANALYSIS**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| | Fall 1995/Winter 1996 | | | | Spring 1996 | | | | Fall 1996 | Summer 1997 | Summar 1998 | Fall 1998 | June 1999 | Nov 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SML Sampling Location** | VOCs | SVOCs | Inorganics | Pesticides, PCBs | Dissolved Aluminum | Inorganics* | Pesticides/ PCBs | Mercury | Inorganics | As, Fe | As, Fe | As,Cr, Pb, Mn | As,Fe, Mn | As,Fe, Mn |
| SW-29 | | | | | | √ | √ | | | | | | | |
| SW-29D | | | | | | | | | | | | √ | | |
| SW-29T | | | | | | | | | | | | √ | | |
| SW-31 | | | | | | | | | | | | | √ | √ |
| SW-34 | | | | | | | | | | | √ | | | |
| SW-34 DUP | | | | | | | | | | | √ | | | |
| SW-34 D | | | | | | | | | | | | √ | | |
| SW-34T | | | | | | | | | | | | √ | √ | √ |
| SW-37 | | | | | | | | | | | | | √ | √ |
| SW-52 | | | | | | | | | | | | | | √ |
| SW-69 | | | | | | | | | | | | | | |
| SW-69D | | | | | | | | | | | | √ | | |
| SW-69T | | | | | | | | | | | | √ | √ | √ |
| SW-73 | | | | | | | | | | | | | √ | |
| SW-75 | | | | | | | | | | | | | √ | |
| SW-78 | | | | | | | | | | | | | √ | |
| SW-83 | | | | | | | | | | | | | √ | |
| SW-84 | | | | | | | | | | | | | | √ |
| SW-86 | | | | | | | | | | | | | √ | |
| SW-93 | | | | | | | | | | | | | | √ |
| SW-98 | | | | | | | | | | | | | | √ |
| SW-103 | | | | | | | | | | | | | | √ |

Notes:
T = Total, D = Dissolved, DUP = duplicate
* Inorganics include Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Hg, Ni, K, Se, Ag, Na, Tl, V, Zn

**TABLE 2-4**
**SUMMARY OF SEDIMENT SAMPLES AND ANALYSES**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| | Fall 1995 | | | | Spring 1996 | | | | Summer 1996 (July & Aug) | Fall 1996 | April 1997 | July 1997 | June 1998 | June 1999 | Nov. 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SML Sampling Location** | **VOC** | **SVOCs** | **Inorganics** | **Pesticide/ PCBs** | SVOCs | Inorganics | Pesticides/ PCBs | Arsenic, Iron | Arsenic, Iron | Arsenic, Iron, Manganese | Arsenic, Iron | Arsenic, Iron | Arsenic, Iron | Arsenic, Iron, Manganese | Arsenic, Iron, Manganese |
| SD-2 | | √ | √ | √ | √ | √ | √ | | | √ | | | | | |
| SD-2 DUP | | √ | √ | √ | | | | | | | | | | | |
| SD-3 | | √ | √ | √ | | | | | | | | | | | |
| SD-4 | | √ | √ | √ | | √ | | | | | | | √ | | |
| SD-5 | | √ | √ | √ | | | | | | | | | | | |
| SD-6 | √ | √ | √ | √ | √ | √ | √ | | | √ | | | √ | | |
| SD-7 | | | √ | √ | √ | √ | √ | | | √ | | | √ | √ | √ |
| SD-8 | √ | √ | √ | √ | | | | | | | | | √ | | |
| SD-9 | √ | √ | √ | √ | √ | √ | √ | | | √ | | | √ | √ | √ |
| SD-9 DUP | √ | √ | √ | √ | √ | √ | √ | | | | | | | | |
| SD-10 | | √ | √ | √ | | | √ | | | | | | | | |
| SD-11 | | √ | √ | √ | | | | | | | | | | | |
| SD-12 | √ | √ | √ | √ | | | | | | | | | | | |
| SD-13 | | √ | √ | √ | | √ | | | | √ | | | √ | √ | √ |
| SD-14 | | √ | √ | √ | | | | √ | | √ | | | | | |
| SD-15 | | √ | √ | √ | | | | √ | | √ | | | | √ | √ |
| SD-16 | | √ | √ | √ | | | | | | | | | | | |
| SD-17 | | √ | √ | √ | | | | | | | | | | | |
| SD-18 | | √ | √ | √ | | | | √ | | | | | | | |
| SD-19 | | √ | √ | √ | | | | √ | | | | | | | |
| SD-20 | | √ | √ | √ | | | | | | | | | | | |
| SD-21 | | | | | | √ | | | | √ | | | √ | √ | √ |
| SD-22 | | | | | | | | √ | | | | | | | |
| SD-22A | | | | | | | | √ | | | | | | | |
| SD-23 | | | | | | | | √ | | | | | | | |
| SD-23A | | | | | | | | √ | | | | | | | |
| SD-24 | | | | | | | | √ | | √ | | | | | |
| SD24A | | | | | | | | √ | | | | | | | |

**TABLE 2-4**
**SUMMARY OF SEDIMENT SAMPLES AND ANALYSES**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| | Fall 1995 | | | | Spring 1996 | | | | Summer 1996 (July & Aug) | Fall 1996 | April 1997 | July 1997 | June 1998 | June 1999 | Nov. 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SML Sampling Location | VOC | SVOCs | Inorganics | Pesticide PCBs | SVOCs | Inorganics | Pesticides/ PCBs | Arsenic, Iron | Arsenic, Iron | Arsenic Iron, Manganese | Arsenic, Iron | Arsenic, Iron | Arsenic, Iron | Arsenic Iron, Manganese | Arsenic Iron, Manganese |
| SD-25 | | | | | | | | √ | | | | | | | |
| SD-26 | | | | | | | | √ | | | | | | | |
| SD-27 | | | | | | | | √ | | | | | √ | | |
| SD-28 | | | | | | √ | √ | | | | | | | | |
| SD-29 | | | | | | √ | √ | | | √ | | | | | |
| SD-30 | | | | | | | | | √ | | | | | | |
| SD-31 | | | | | | | | | √ | | | | | √ | √ |
| SD-32 | | | | | | | | | √ | | | | | | |
| SD-33 | | | | | | | | | √ | | | | | | |
| SD-34 | | | | | | | | | √ | | | | √ | √ | √ |
| SD-34 DUP | | | | | | | | | √ | | | | √ | | |
| SD-35 | | | | | | | | | √ | | | | | | |
| SD-36 | | | | | | | | | √ | | | | | | |
| SD-37 | | | | | | | | | √ | | | | | √ | √ |
| SD-38 | | | | | | | | | √ | | | | | | |
| SD-39 | | | | | | | | | √ | | | | | | |
| SD-40 | | | | | | | | | √ | | | | | | |
| SD-41 | | | | | | | | | √ | | | | | | |
| SD-42 | | | | | | | | | √ | | | | | | |
| SD-43 | | | | | | | | | √ | | | | | | |
| SD-43 DUP | | | | | | | | | √ | | | | | | |
| SD-44 | | | | | | | | | √ | | | | | | |
| SD-45 | | | | | | | | | √ | | | | | | |
| SD-46 | | | | | | | | | √ | | | | | | |
| SD-47 | | | | | | | | | √ | | | | | | |
| SD-48 | | | | | | | | | √ | | | | | | |
| SD-49 | | | | | | | | | √ | | | | | | |

**TABLE 2-4**
**SUMMARY OF SEDIMENT SAMPLES AND ANALYSES**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| | Fall 1995 | | | | Spring 1996 | | | | Summer 1996 (July & Aug.) | Fall 1996 | April 1997 | July 1997 | June 1998 | June 1999 | Nov. 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SML Sampling Location** | VOC | SVOCs | Inorganics | Pesticide /PCBs | SVOCs | Inorganics | Pesticides /PCBs | Arsenic, Iron | Arsenic, Iron | Arsenic, Iron, Manganese | Arsenic, Iron | Arsenic, Iron | Arsenic, Iron | Arsenic Iron, Manganese | Arsenic Iron, Manganese |
| SD-50 | | | | | | | | | √ | | | | | | |
| SD-51 | | | | | | | | | √ | | | | | | |
| SD51DUP | | | | | | | | | √ | | | | | | |
| SD-52 | | | | | | | | | √ | | | | | √ | √ |
| SD-53 | | | | | | | | | √ | | | | | | |
| SD-54 | | | | | | | | | √ | | | | | | |
| SD-55 | | | | | | | | | √ | | | | | | |
| SD-56 | | | | | | | | | √ | | | | | | |
| SD-60 | | | | | | | | | √ | | | | | | |
| SD-61 | | | | | | | | | √ | | | | | | |
| SD-62 | | | | | | | | | √ | | | | | | |
| SD-63 | | | | | | | | | √ | | | | | | |
| SD-64 | | | | | | | | | | | √ | | | | |
| SD-65 | | | | | | | | | | | √ | | | | |
| SD-66 | | | | | | | | | | | √ | | | | |
| SD-67 | | | | | | | | | | | √ | | | | |
| SD-68 | | | | | | | | | | | √ | | | | |
| SD-69 | | | | | | | | | | | √ | | √ | √ | √ |
| SD-70 | | | | | | | | | | | | √ | | | |
| SD70DUP | | | | | | | | | | | | √ | | | |
| SD-71 | | | | | | | | | | | | √ | | | |
| SD-72 | | | | | | | | | | | | √ | | | |
| SD-73 | | | | | | | | | | | | | | √ | √ |
| SD-74 | | | | | | | | | | | | | | √ | |
| SD-75 | | | | | | | | | | | | | | √ | |
| SD-76 | | | | | | | | | | | | | | √ | |
| SD-77 | | | | | | | | | | | | | | √ | |
| SD-78 | | | | | | | | | | | | | | √ | |
| SD-79 | | | | | | | | | | | | | | √ | |
| SD-80 | | | | | | | | | | | | | | √ | |
| SD-81 | | | | | | | | | | | | | | √ | |

**TABLE 2-4**
**SUMMARY OF SEDIMENT SAMPLES AND ANALYSES**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| | Fall 1995 | | | | Spring 1996 | | | | Summer 1996 (July & Aug.) | Fall 1996 | April 1997 | July 1997 | June 1998 | June 1999 | Nov. 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SML Sampling Location** | **VOC** | **SVOCs** | **Inorganics** | **Pesticide /PCBs** | SVOCs | Inorganics | Pesticides/PCBs | Arsenic, Iron | Arsenic, Iron | Arsenic, Iron, Manganese | Arsenic, Iron | Arsenic, Iron | Arsenic, Iron | Arsenic Iron, Manganese | Arsenic Iron, Manganese |
| SD-82 | | | | | | | | | | | | | | √ | |
| SD-83 | | | | | | | | | | | | | | √ | |
| SD-84 | | | | | | | | | | | | | | √ | √ |
| SD-85 | | | | | | | | | | | | | | √ | |
| SD-86 | | | | | | | | | | | | | | √ | |
| SD-87 | | | | | | | | | | | | | | √ | |
| SD-88 | | | | | | | | | | | | | | √ | |
| SD-93 | | | | | | | | | | | | | | | √ |
| SD-98 | | | | | | | | | | | | | | | √ |
| SD-103 | | | | | | | | | | | | | | | √ |

Notes:

1) SD-22 collected at depth of 0.2 ft. to 0.4 ft.; SD-22A collected at depth of 0.4 ft. to 0.6 ft.
2) SD-23 collected at depth of 0.3 ft. to 0.5 ft.; SD-23A collected at depth of 0.5 ft. to 0.8 ft.
3) SD-24 collected at depth of 0 ft. to 0.5 ft.; SD-24A collected at depth of 0.5 ft. to 1.0 ft.

**TABLE 2-5**
**SUMMARY OF GROUNDWATER SAMPLES AND ANALYSES**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| | Fall 1995/Winter 1996 | | | Spring 1996 | | | Fall 1996 | | | July 1997 | | December 1997 | | June 1998 | | December 1998 | | June 1999 | | November 1999 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SML Sampling Location | VOCs | SVOCs | Inorganics | VOCs | SVOCs | Inorganics | VOCs | SVOCs | Inorganics | VOCs | Inorganics | VOCs | Inorganics | VOCs | Inorganics | VOCs | As,Fe Mn | VOCs | As,Fe Mn, | VOCs | As,Fe Mn |
| MW-93-1 | √ | √ | √ | | | √ | | | | | | | | | | | | | | | |
| MW-93-3 | √ | √ | √ | √ | | √ | √ | | √ | | √ | | √ | | | | √ | | √ | | √ |
| MW-93-4 | √ | √ | √ | | | √ | | | | | | | | | | | | | | | |
| MW-93-5 | √ | √ | √ | √ | | √ | √ | | √ | √ | √ | | √ | √ | | | √ | | √ | | √ |
| MW-93-7 | √ | √ | √ | | | √ | | | | | | | | | | | | | | | |
| MW-95-1R | √ | √ | √ | √ | | √ | √ | | √ | √ | √ | | √ | | | | √ | | √ | | √ |
| MW-95-1S | √ | √ | √ | √ | | √ | √ | | √ | √ | √ | √ | √ | √ | | √ | √ | √ | √ | √ | √ |
| MW-95-2S | √ | √ | √ | √ | | √ | | | | | | | √ | | | | | | | | |
| MW-95-3R | | | | √ | √ | √ | √ | | √ | √ | √ | | √ | | | √ | √ | | √ | | √ |
| MW-95-3S | √ | √ | √ | √ | √ | √ | √ | | √ | √ | √ | | | | | | | | | | |
| MW-95-4R | √ | √ | √ | √ | √ | √ | √ | | √ | | | | √ | | | | √ | | √ | | √ |
| MW-95-4RD | √ | √ | √ | √ | √ | √ | √ | | √ | √ | √ | √ | √ | √ | | √ | √ | √ | √ | √ | √ |
| MW-95-4SA | √ | √ | √ | √ | √ | √ | √ | | √ | √ | √ | | √ | | | | | | √ | | √ |
| MW-95-4SB | √ | √ | √ | √ | √ | √ | √ | | √ | √ | √ | | √ | | | | | | √ | | √ |
| MW-95-5R | √ | √ | √ | √ | | √ | √ | | √ | | √ | | √ | | | | | | √ | | √ |
| MW-95-6R | √ | √ | √ | √ | | √ | √ | | √ | | √ | | √ | | | | √ | | √ | | √ |
| MW-95-6S | √ | √ | √ | √ | | √ | √ | | √ | | √ | | √ | | | | √ | | √ | | √ |
| MW-95-7R | √ | √ | √ | √ | √ | √ | √ | | √ | √ | √ | | √ | | | | √ | | √ | | √ |
| MW-95-7S | √ | √ | √ | √ | | √ | √ | | √ | √ | √ | | √ | | | | √ | | √ | | √ |
| MW-95-8R | √ | √ | √ | √ | | √ | √ | | √ | √ | √ | | | | | | √ | | √ | | √ |
| MW-95-8S | √ | √ | √ | √ | √ | √ | √ | | √ | | | | √ | | | | √ | | √ | | √ |
| MW-95-9S | √ | √ | √ | √ | √ | √ | √ | | √ | | √ | | √ | | | | √ | | √ | | √ |
| MW-95-10S | √ | √ | √ | | | | | | | | | | | | | | | | | | |
| MW-95-11S | √ | √ | √ | √ | | √ | | | | | | √ | √ | √ | | | √ | | √ | | √ |
| MW-95-12S | √ | √ | √ | | | | | | | | | | | | | | | | | | |
| MW-96-9R | | | | | | | √ | √ | √ | √ | √ | | | | | | √ | | √ | | √ |
| MW-13 | | | | √ | | √ | √ | | √ | √ | | √ | √ | √ | | √ | √ | √ | √ | √ | √ |
| PZ-1D | √ | √ | √ | | | | | | | | | | | | | | | | | | |
| PZ-2D | √ | √ | √ | | | | | | | | | | | | | | | | | | |
| PZ-3D | √ | √ | √ | | | | | | | | | | | | | | | | | | |
| PZ-4S | | | | √ | √ | √ | | | | | | | | | | | | | | | |
| PZ-5S | | | | √ | √ | √ | | | | | | | | | | | | | | | |
| PZ-9 | | | | | | | | | √ | | | | | | | | | | | | |
| City 18 | | | | | | | √ | √ | √ | | | | | | | | | | | | |
| MW-97-13 R | | | | | | | | | | | | | √ | | √ | | | | √ | | √ |
| MW-97-13 S-1 | | | | | | | | | | | | | √ | | √ | | | | √ | | √ |
| MW-97-13 S-2 | | | | | | | | | | | | | √ | | √ | | | | √ | | √ |
| MW-97-14 S-1 | | | | | | | | | | | | | √ | | √ | | √ | | √ | | √ |
| MW-97-14 S-2 | | | | | | | | | | | | | √ | | √ | | √ | | √ | | √ |

**TABLE 2-5**
**SUMMARY OF GROUNDWATER SAMPLES AND ANALYSES**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| | Fall 1995/Winter 1996 | | | Spring 1996 | | | Fall 1996 | | | July 1997 | | December 1997 | | June 1998 | | December 1998 | | June 1999 | | November 1999 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SML Sampling Location | VOCs | SVOCs | Inorganics | VOCs | SVOCs | Inorganics | VOCs | SVOCs | Inorganics | VOCs | Inorganics | VOCs | Inorganics | VOCs | Inorganics | VOCs | As,Fe Mn | VOCs | As,Fe Mn, | VOCs | As,Fe Mn |
| MW-97-16S | | | | | | | | | | | | | √ | | √ | | √ | | √ | | √ |
| MW-97-17R | | | | | | | | | | | | | √ | | √ | | √ | | √ | | √ |
| MW-97-18S | | | | | | | | | | | | | √ | | √ | | √ | | √ | | √ |
| MW-97-19S | | | | | | | | | | | | | √ | | √ | | | | √ | | √ |

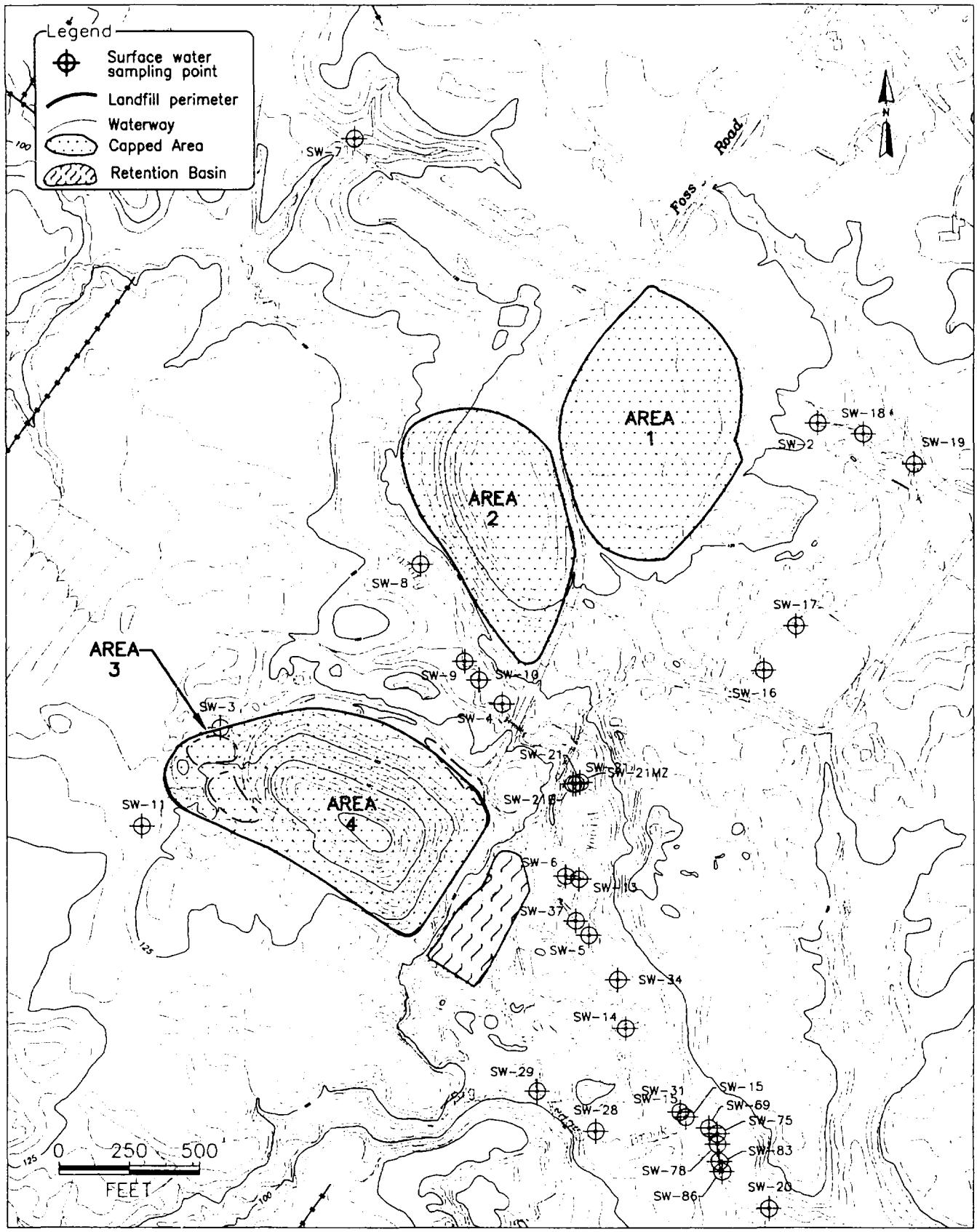


**Figure 2-3**
**Surface Water Sampling Locations**
**Feasibility Study Report**
**Saco Municipal Landfill**
**Saco, Maine**

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9909001.dwg/95093/lgt

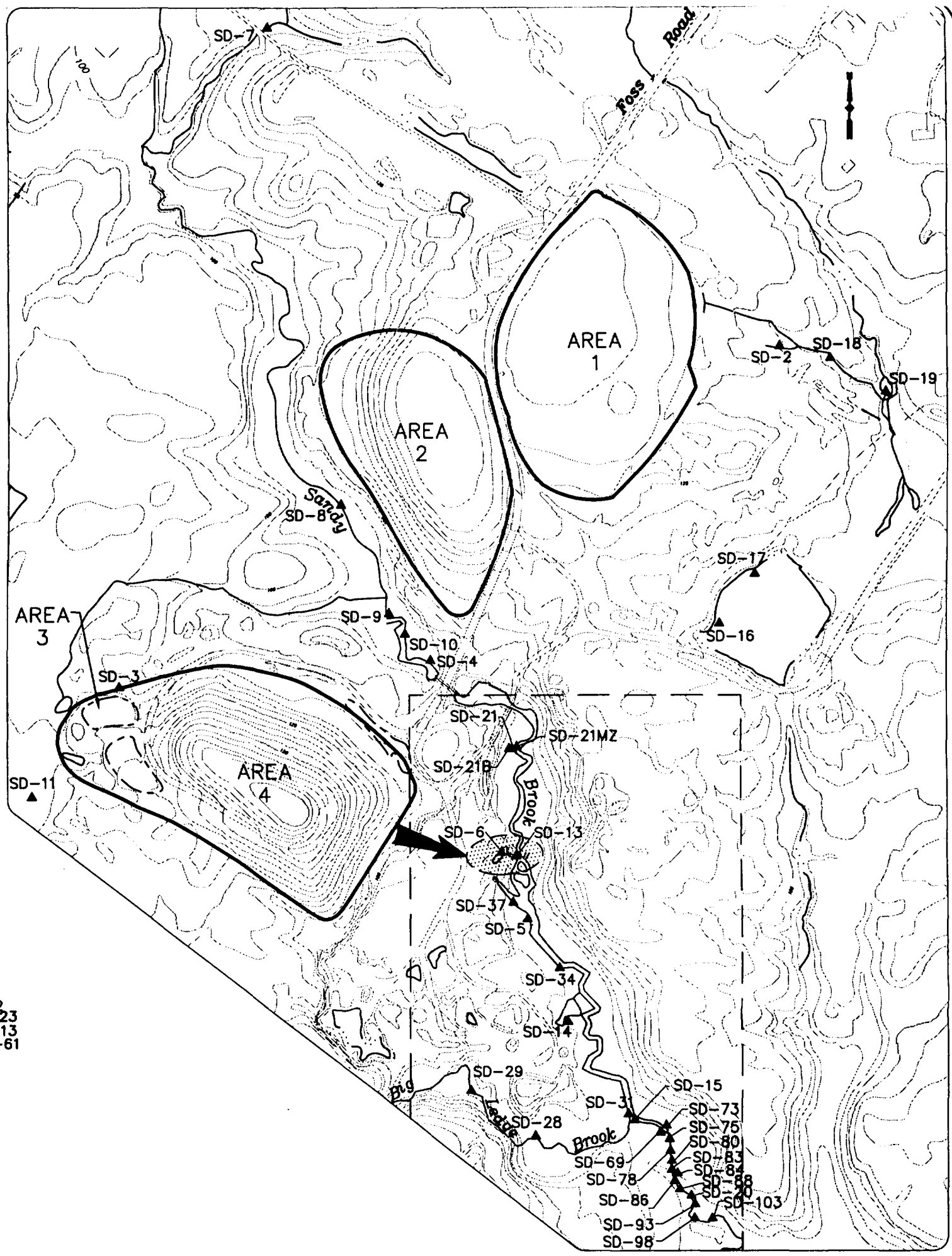
### 2.2.2 Sediment Sampling

Sediment samples were collected in June 1998 from 10 locations in Sandy Brook and analyzed for arsenic and iron. Four samples were collected upstream and adjacent to Area 2; three samples were collected in the groundwater discharge area upstream and adjacent to the primary seep area southeast of Areas 3 and 4; and three samples were collected in the groundwater discharge area downstream of the primary seep. Table 2-4 summarizes sediment sampling locations and analyses and Figure 2-4 shows sediment sample locations.

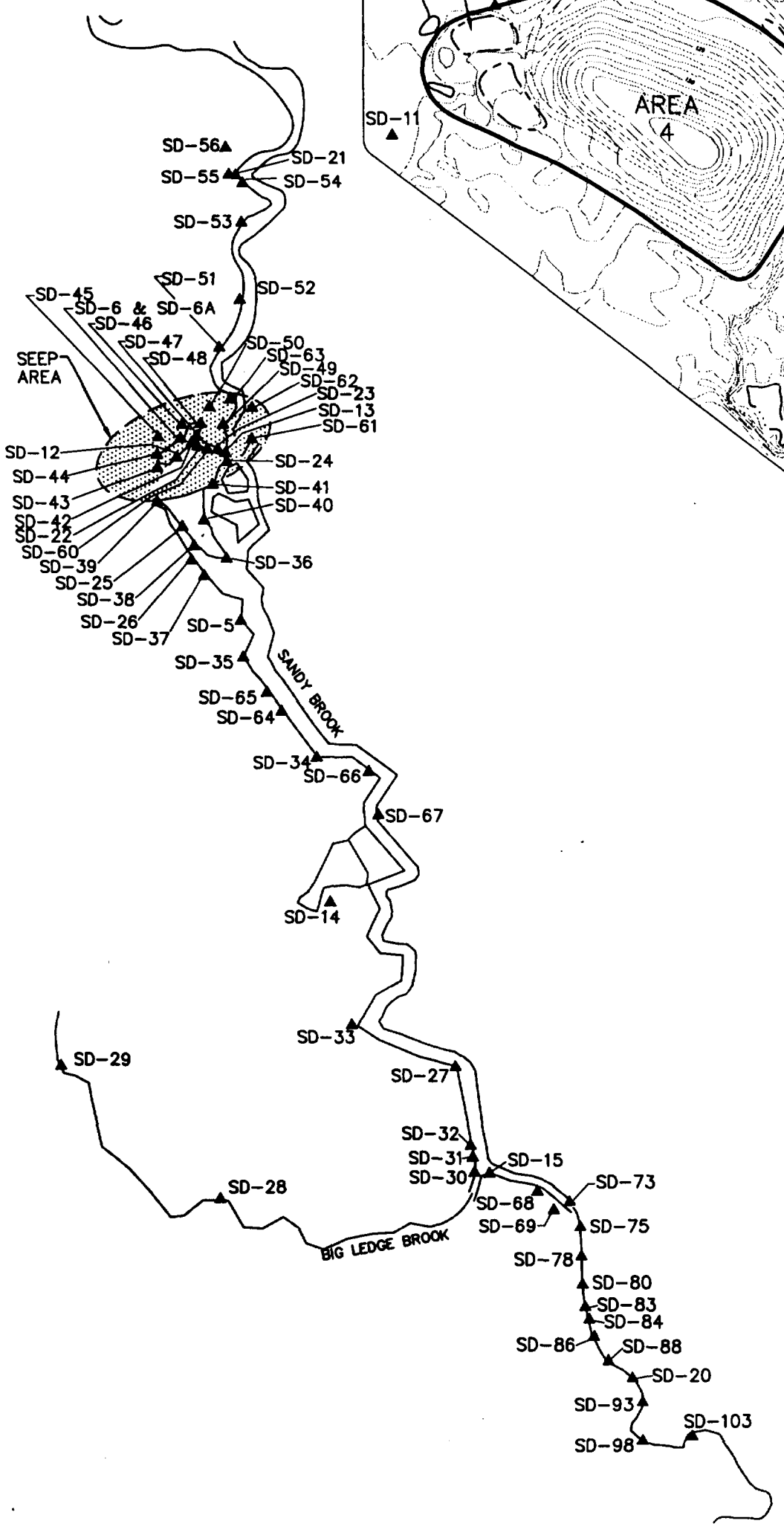
Two additional sediment sampling events were conducted during 1998. The April 1998 event was conducted to provide samples for site-specific toxicity testing and the October 1998 event was conducted to characterize the distribution of arsenic in sediments along Sandy Brook. The data from these events are presented and discussed in more detail in the *Whole Sediment Toxicity Program* (W&C, 1998b) and *Ecological Risk Assessment Reports* (W&C, 2000). The nature and distribution of contaminants are also summarized in Section 2.3 of this report.

### 2.2.3 Groundwater Sampling

Groundwater sampling events were conducted at SML in December 1997 and June 1998. During the December 1997 event, 28 wells were sampled for inorganic parameters, and four were also sampled for VOCs. During the June 1998 sampling event, 29 samples (including two duplicates) were collected from 27 locations. Of the 28 monitoring wells sampled, 26 wells, including the nine USGS wells, were sampled during both events. Monitoring wells MW-95-5R and MW-95-2S were sampled only during the December 1997 event, and wells MW-95-8R and MW-96-9R were sampled only during the June 1998 event. Table 2-5 summarizes the wells sampled and parameters analyzed through June 1998, and Figure 2-1 shows the monitoring well locations. December 1998, June 1999, and November 1999 groundwater sampling results have been reported in Pre-ROD Sampling Program reports. Results for these events are provided in Appendix F.




BASE MAP
SEE DETAIL AREA TO THE LEFT




NOTE:
FOR CLARITY OF PRESENTATION NOT ALL SAMPLING LOCATIONS ARE SHOWN. LOCATIONS IN THE SERIES SD-73 TO SD-103 ARE AT 12.5 FOOT INTERVALS.

LEGEND

- SD-17 SEDIMENT SAMPLING LOCATION
- LANDFILL PERIMETER
- SEEP AREA
- GROUNDWATER FLOW TO SEEP AREA

| DES.BY: TE | DR.BY: PFF | CK.BY: TE |
|---|---|---|

SACO MUNICIPAL LANDFILL
SACO, MAINE

FEASIBILITY STUDY REPORT
FIGURE 2-4

SEDIMENT SAMPLING LOCATIONS

| SCALE: N.T.S. | JOB NO.: 95093.06 |
|---|---|
| DATE: OCTOBER, 1999 | SHEET: FS-SD99 |

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## 2.3 NATURE AND DISTRIBUTION OF CONTAMINANTS

Nature and distribution of contaminants are summarized in the following sections.

### 2.3.1 Surface Water Analytical Data

Surface water samples were collected during June/October 1998, and June/November 1999. Sampling locations for these sampling events are shown in Figure 2-3. The June 1998 event includes one background location (SW-7), three locations adjacent to Area 2 (SW-4, SW-8 and SW-9), and four locations downstream of Landfill Areas 3 and 4 (SW-6A, SW-13, SW-34 and SW-69). These samples were analyzed for arsenic and iron. Sampling locations for the October 1998 sampling event include one background location (SW-7), five locations downstream of Landfill Areas 3 and 4 (SW-21, SW-13, SW-34, SW-15 and SW-69), and one location in Big Ledge Brook (SW-29). These samples were analyzed for total and dissolved arsenic, chromium, lead, and manganese. The analytical data from the June and October 1998 samples are included in Table 2-6 with historical sampling data, and discussed below. The June 1999 event includes one background location (SW-7), one location adjacent to Area 2 (SW-9), and seven locations downstream of Landfill Areas 3 and 4 to the confluence with Big Ledge Brook (SW-21, SW-13, SW-37, SW-34, SW-31, SW-15, and SW-69), and four locations downstream from the confluence (SW-75, SW-78, SW-83, and SW-86). These samples were analyzed for arsenic, iron, and manganese. A summary of the arsenic, iron, and manganese surface water data for samples collected in Sandy and Big Ledge brooks through November 1999 is presented in Table 2-7.

**June 1998** - The three surface water samples collected adjacent to Area 2 (SW-4, SW-8, and SW-9) did not contain detectable concentrations of arsenic. Iron concentrations in these samples were variable. The chronic Ambient Water Quality Criteria (AWQC; EPA, 1992) for iron of 1,000 micrograms/liter (μg/L) was exceeded only at the background location SW-7 (1,880 μg/L). During three prior sampling events, iron was detected at concentrations below the AWQC at SW-7.

TABLE 2-6
SURFACE WATER ANAYTICAL DATA

FEASIBILITY STUDY REPORT
SACO MUNICIPAL LANDFILL
SACO MAINE

| | | | LANDFILL AREA 1[1] | | | | | | | | | | LANDFILL AREA 2[1] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Tributary to Deep Brook | | | | | | Dubois Pond | | | | | | | | | | | | |
| Parameter | AWQC (ug/L) | | SW2 | SW2D | SW2 | SW2 | SW18 | | SW16 | SW17 | | SW4 | SW-4 | SW-4 DUP | SW-4 | SW7 | SW7T | SW7 | SW7 | SW-7D |
| All units in ug/L | Chronic | Acute | 11/17/95 | 11/17/95 | 5/16/96 | 11/19/96 | 11/17/95 | | 11/17/95 | 11/17/95 | | 11/17/95 | 7/17/97 | 7/17/97 | 6/24/98 | 11/17/95 | 5/16/96 | 11/19/96 | 6/24/98 | 10/98 |
| **Pesticides/PCBs** | | | | | | | | | | | | | | | | | | | | |
| Dieldrin | 0.0019 | 2.5 | ND | ND | NA | NA | ND | | ND | ND | | ND | NA | NA | NA | ND | NA | NA | NA | NA |
| Endosulfan II | 0.056 | 0.22 | ND | ND | NA | NA | ND | | 0.0014 | ND | | ND | NA | NA | NA | ND | NA | NA | NA | NA |
| **SVOCs** | | | | | | | | | | | | | | | | | | | | |
| 1,4-Dichlorobenzene | - | - | 3 | 3 | NA | NA | ND | | ND | ND | | ND | NA | NA | NA | ND | NA | NA | NA | NA |
| 4-Chloro-3-methylphenol | - | - | 3 | 3 | NA | NA | 2 | | ND | ND | | ND | NA | NA | NA | ND | NA | NA | NA | NA |
| Bis(2-ethylhexyl)phthalate | 560 | 400 | ND | ND | NA | NA | ND | | 2 | ND | | 2 | NA | NA | NA | ND | NA | NA | NA | NA |
| Di-n-butylphthalate | 3 | 940 | ND | ND | NA | NA | ND | | ND | ND | | ND | NA | NA | NA | ND | NA | NA | NA | NA |
| **VOCs** | | | | | | | | | | | | | | | | | | | | |
| 1,1-Dichloroethene | - | - | ND | ND | NA | NA | ND | | ND | ND | | NA | NA | NA | NA | ND | NA | NA | NA | NA |
| 1,2,4-Trimethylbenzene | - | - | 1 | 1 | NA | NA | 1J | | ND | ND | | NA | NA | NA | NA | ND | NA | NA | NA | NA |
| 1,2-Dichlorobenzene | 783 | 1120 | 1 | ND | NA | NA | ND | | ND | ND | | NA | NA | NA | NA | ND | NA | NA | NA | NA |
| 1,3-Dichlorobenzene | - | - | 1 | ND | NA | NA | ND | | ND | ND | | NA | NA | NA | NA | ND | NA | NA | NA | NA |
| 1,4-Dichlorobenzene | 783 | 1120 | 2 | 2 | NA | NA | ND | | ND | ND | | NA | NA | NA | NA | ND | NA | NA | NA | NA |
| Acetone | - | - | ND | 4 | NA | NA | ND | | ND | 3J | | NA | NA | NA | NA | ND | NA | NA | NA | NA |
| Benzene | - | 6300 | 2 | 2 | NA | NA | ND | | ND | ND | | NA | NA | NA | NA | ND | NA | NA | NA | NA |
| cis-1,2-Dichloroethene | - | 11,600 | 1 | ND | NA | NA | ND | | ND | ND | | NA | NA | NA | NA | ND | NA | NA | NA | NA |
| Chlorobenzene | 50 | 250 | 3 | 3 | NA | NA | 2 | | ND | ND | | NA | NA | NA | NA | ND | NA | NA | NA | NA |
| Ethylbenzene | - | 32,000 | 11 | 10 | NA | NA | ND | | ND | ND | | NA | NA | NA | NA | ND | NA | NA | NA | NA |
| m,p-Xylene | - | - | 16 | 14 | NA | NA | 9 | | ND | ND | | NA | NA | NA | NA | ND | NA | NA | NA | NA |
| Naphthalene | 2300 | 620 | 1 | 1 | NA | NA | ND | | ND | ND | | NA | NA | NA | NA | ND | NA | NA | NA | NA |
| Tetrahydrofuran | - | - | 10 | 13 | NA | NA | ND | | ND | ND | | NA | NA | NA | NA | ND | NA | NA | NA | NA |
| Toluene | - | 17,500 | ND | ND | NA | NA | ND | | 93 | ND | | NA | NA | NA | NA | ND | NA | NA | NA | NA |
| **Inorganics** | | | | | | | | | | | | | | | | | | | | |
| Aluminum | - | - | 201.00 | 113.00 | ND | 1970 | 133.00 | | 1540.00 | 1330.00 | | 444.00 | NA | NA | NA | 533 | 362 | 226 | NA | NA |
| Antimony | 30 | 88 | ND | ND | ND | ND | ND | | ND | ND | | ND | 1 | 1 | NA | ND | ND | ND | NA | NA |
| Arsenic | 150 | 340 | 7.40 | 7.00 | ND | 14.1 | 8.40 | | ND | ND | | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Barium | - | - | 54.10 | 55.10 | 39.40 | 96.3 | 50.60 | | 9.30 | 8.30 | | 14.10 | NA | NA | NA | ND | 4.10 | 4.7 | NA | NA |
| Beryllium | 5.3 | 180 | ND | ND | ND | ND | ND | | ND | ND | | ND | NA | NA | NA | ND | ND | ND | NA | NA |
| Cadmium | 1.1 | 3.9 | ND | ND | ND | ND | ND | | ND | ND | | ND | NA | NA | NA | ND | ND | ND | NA | NA |
| Calcium | - | - | 33500.00 | 34500.00 | 34000.00 | 35500 | 28800.00 | | 9860.00 | 9380.00 | | 8030.00 | NA | NA | NA | 6590 | 2280 | 2070 | NA | NA |
| Chromium | 11 | 18 | 1.60 | 1.10 | 0.88 | ND | 1.60 | | 1.90 | 1.40 | | 0.58 | NA | NA | NA | 0.62 | ND | ND | NA | ND |
| Cobalt | - | - | 1.20 | 1.20 | ND | ND | 1.30 | | ND | ND | | ND | NA | NA | NA | ND | ND | ND | NA | NA |
| Copper | 12 | 18 | ND | ND | ND | ND | ND | | 1.20 | 1.30 | | ND | NA | NA | NA | ND | ND | ND | NA | NA |
| Iron | 1000 | - | 12400.00 | 12500.00 | 2490.00 | 35900 | 14500.00 | | 1950.00 | 1630.00 | | 575.00 | 2020 | 2650 | 839 | 596 | 239 | 315 | 1880 | NA |
| Lead | 3.2 | 83 | 1.60 | ND | ND | 4.9 | ND | | ND | ND | | ND | NA | NA | NA | 1.80 | ND | ND | NA | ND |
| Magnesium | - | - | 10900.00 | 11200.00 | 9820.00 | 9140 | 9330.00 | | 5150.00 | 4830.00 | | 1990.00 | NA | NA | NA | ND | 1090 | 1020 | NA | NA |
| Manganese | - | - | 1040.00 | 1070.00 | 457.00 | 1000 | 981.00 | | 123.00 | 114.00 | | 80.40 | NA | NA | NA | 93.4 | 32.9 | 21.9 | NA | 3050 |
| Mercury | 0.012 | 2.4 | ND | ND | ND | ND | ND | | ND | ND | | 0.13 | NA | NA | NA | ND | ND | ND | NA | NA |
| Nickel | 160 | 1400 | 1.70 | 1.30 | ND | ND | 1.30 | | 1.40 | 1.10 | | ND | NA | NA | NA | ND | ND | ND | NA | NA |
| Potassium | - | - | 7400.00 | 7760.00 | 8010.00 | 9610 | 6250.00 | | 3500.00 | 3830.00 | | ND | NA | NA | NA | 2160 | 893 | 1010 | NA | NA |
| Selenium | 5 | 20 | ND | ND | ND | ND | ND | | ND | ND | | ND | NA | NA | NA | ND | ND | ND | NA | NA |
| Silver | 0.12 | 4.1 | ND | ND | ND | ND | ND | | ND | ND | | ND | NA | NA | NA | ND | ND | ND | NA | NA |
| Sodium | - | - | 55500.00 | 57900.00 | 32800.00 | 32200 | 47700.00 | | 16700.00 | 16000.00 | | 9600.00 | NA | NA | NA | 8110 | 3840 | 3600 | NA | NA |
| Thallium | 40 | 1400 | ND | ND | ND | ND | ND | | ND | 7.00 | | ND | NA | NA | NA | ND | ND | ND | NA | NA |
| Vanadium | - | - | ND | ND | ND | ND | ND | | ND | ND | | ND | NA | NA | NA | ND | ND | ND | NA | NA |
| Zinc | 110 | 120 | ND | ND | ND | ND | ND | | ND | ND | | ND | NA | NA | NA | ND | ND | ND | NA | NA |

U = Undetected. J = Estimated. ND = Not detected NA = Not analyzed.

[1] 1999 results have not been included in this table. See Appendix F for a complete set of results.

TABLE 2-6
SURFACE WATER ANAYTICAL DATA

FEASIBILITY STUDY REPORT
SACO MUNICIPAL LANDFILL
SACO MAINE

| | | | LANDFILL AREA 2[1] | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | AWQC (ug/L) | | SW-7T | SW8 | | SW-8 | SW8 | SW9 | | SW9D | | SW9T | | SW9 | SW9D | SW9 | SW9(DUP | SW-9 | SW-9 | SW10 | |
| All units in ug/L | Chronic | Acute | 10/98 | 11/17/95 | | 7/17/97 | 6/24/98 | 11/17/95 | | 11/17/95 | | 5/16/96 | | 5/16/96 | 5/16/96 | 11/19/96 | 11/19/96 | 7/17/97 | 6/24/98 | 11/17/95 | |
| **Pesticides/PCBs** | | | | | | | | | | | | | | | | | | | | | |
| Dieldrin | 0.0019 | 2.5 | NA | 0.0011 | J | NA | NA | ND | | ND | | NA | | NA | NA | NA | NA | NA | NA | ND | |
| Endosulfan II | 0.056 | 0.22 | NA | 0.0034 | J | NA | NA | ND | | ND | | NA | | NA | NA | NA | NA | NA | NA | ND | |
| **SVOCs** | | | | | | | | | | | | | | | | | | | | | |
| 1,4-Dichlorobenzene | - | - | NA | ND | | NA | NA | ND | | ND | | NA | | NA | NA | NA | NA | NA | NA | ND | |
| 4-Chloro-3-methylphenol | - | - | NA | ND | | NA | NA | ND | | ND | | NA | | NA | NA | NA | NA | NA | NA | ND | |
| Bis(2-ethylhexyl)phthalate | 560 | 400 | NA | ND | | NA | NA | ND | | ND | | NA | | NA | NA | NA | NA | NA | NA | 5 | J |
| Di-n-butylphthalate | 3 | 940 | NA | ND | | NA | NA | ND | | ND | | NA | | NA | NA | NA | NA | NA | NA | ND | |
| **VOCs** | | | | | | | | | | | | | | | | | | | | | |
| 1,1-Dichloroethene | - | - | NA | ND | | NA | NA | 1 | J | ND | | NA | | NA | NA | NA | NA | NA | NA | NA | |
| 1,2,4-Trimethylbenzene | - | - | NA | ND | | NA | NA | ND | | ND | | NA | | NA | NA | NA | NA | NA | NA | NA | |
| 1,2-Dichlorobenzene | 783 | 1120 | NA | ND | | NA | NA | ND | | ND | | NA | | NA | NA | NA | NA | NA | NA | NA | |
| 1,3-Dichlorobenzene | - | - | NA | 1 | | NA | NA | ND | | ND | | NA | | NA | NA | NA | NA | NA | NA | NA | |
| 1,4-Dichlorobenzene | 783 | 1120 | NA | ND | | NA | NA | ND | | ND | | NA | | NA | NA | NA | NA | NA | NA | NA | |
| Acetone | - | - | NA | ND | | NA | NA | ND | | ND | | NA | | NA | NA | NA | NA | NA | NA | NA | |
| Benzene | - | 6300 | NA | ND | | NA | NA | ND | | ND | | NA | | NA | NA | NA | NA | NA | NA | NA | |
| cis-1,2-Dichloroethene | - | 11,600 | NA | ND | | NA | NA | ND | | ND | | NA | | NA | NA | NA | NA | NA | NA | NA | |
| Chlorobenzene | 50 | 250 | NA | ND | | NA | NA | ND | | ND | | NA | | NA | NA | NA | NA | NA | NA | NA | |
| Ethylbenzene | - | 32,000 | NA | ND | | NA | NA | ND | | ND | | NA | | NA | NA | NA | NA | NA | NA | NA | |
| m,p-Xylene | - | - | NA | ND | | NA | NA | ND | | ND | | NA | | NA | NA | NA | NA | NA | NA | NA | |
| Naphthalene | 2300 | 620 | NA | ND | | NA | NA | ND | | ND | | NA | | NA | NA | NA | NA | NA | NA | NA | |
| Tetrahydrofuran | - | - | NA | ND | | NA | NA | ND | | ND | | NA | | NA | NA | NA | NA | NA | NA | NA | |
| Toluene | - | 17,500 | NA | ND | | NA | NA | ND | | ND | | NA | | NA | NA | NA | NA | NA | NA | NA | |
| **Inorganics** | | | | | | | | | | | | | | | | | | | | | |
| Aluminum | - | - | NA | 574.00 | | NA | NA | 485.00 | | 503.00 | | 544.00 | | NA | 224.00 | 281 | ND | NA | NA | 461.00 | |
| Antimony | 30 | 88 | NA | ND | | 1 | NA | ND | | ND | | ND | | NA | NA | ND | ND | 1 | NA | ND | |
| Arsenic | 150 | 340 | ND | ND | | ND | ND | ND | | ND | | ND | | NA | NA | ND | ND | ND | ND | ND | |
| Barium | - | - | NA | 11.50 | J | NA | NA | 16.40 | J | 17.70 | J | 13.60 | | NA | NA | 12.5 | 12.5 | NA | NA | 16.70 | J |
| Beryllium | 5.3 | 180 | NA | ND | | NA | NA | ND | | ND | | ND | | NA | NA | ND | ND | NA | NA | ND | |
| Cadmium | 1.1 | 3.9 | NA | ND | | NA | NA | ND | | ND | | ND | | NA | NA | ND | ND | NA | NA | ND | |
| Calcium | - | - | NA | 6720.00 | | NA | NA | 8660.00 | | 9290.00 | | 8330.00 | J | NA | NA | 8570 | 8720 | NA | NA | 8760.00 | |
| Chromium | 11 | 18 | ND | ND | | NA | NA | 1.10 | J | 0.79 | J | 0.84 | J | NA | NA | ND | ND | NA | NA | 0.71 | J |
| Cobalt | - | - | NA | ND | | NA | NA | ND | | ND | | ND | | NA | NA | ND | ND | NA | NA | ND | |
| Copper | 12 | 18 | NA | ND | | NA | NA | 1.40 | J | ND | | ND | | NA | NA | ND | ND | NA | NA | ND | |
| Iron | 1000 | - | NA | 582.00 | | 3620 | 665 | 611.00 | | 632.00 | | 805.00 | | NA | NA | 548 | 557 | 2680 | 792 | 619.00 | |
| Lead | 3.2 | 83 | ND | ND | | NA | NA | ND | | ND | | 3.00 | J | NA | NA | ND | ND | NA | NA | ND | |
| Magnesium | - | - | NA | 1620.00 | J | NA | NA | 2200.00 | J | 2390.00 | J | 1740.00 | | NA | NA | 1820 | 1850 | NA | NA | 2250.00 | J |
| Manganese | - | - | 3050 | 77.90 | | NA | NA | 95.60 | | 102.00 | | 86.80 | | NA | NA | 65.6 | 67.6 | NA | NA | 97.20 | |
| Mercury | 0.012 | 2.4 | NA | ND | | NA | NA | 0.10 | J | ND | | ND | | 0.0037 | 0.00351 | ND | ND | NA | NA | 0.12 | J |
| Nickel | 160 | 1400 | NA | ND | | NA | NA | ND | | ND | | 1.30 | J | NA | NA | ND | ND | NA | NA | 1.30 | J |
| Potassium | - | - | NA | ND | | NA | NA | ND | | ND | | 1990.00 | | NA | NA | 2370 | 2000 | NA | NA | ND | |
| Selenium | 5 | 20 | NA | ND | | NA | NA | ND | | ND | | ND | | NA | NA | ND | ND | NA | NA | ND | |
| Silver | 0.12 | 4.1 | NA | ND | | NA | NA | ND | | ND | | ND | | NA | NA | ND | ND | NA | NA | ND | |
| Sodium | - | - | NA | 8140.00 | | NA | NA | 10700.00 | | 11800.00 | | 12700.00 | | NA | NA | 12700 | 12700 | NA | NA | 11100.00 | |
| Thallium | 40 | 1400 | NA | ND | | NA | NA | ND | | ND | | ND | | NA | NA | ND | ND | NA | NA | ND | |
| Vanadium | - | - | NA | ND | | NA | NA | ND | | ND | | ND | | NA | NA | ND | ND | NA | NA | ND | |
| Zinc | 110 | 120 | NA | ND | | NA | NA | ND | | ND | | ND | | NA | NA | ND | ND | NA | NA | ND | |

U = Undetected. J = Estimated. ND = Not detected NA = Not analyzed.

[1] 1999 results have not been included in this table. See Appendix F for a complete set of results.

TABLE 2-6
SURFACE WATER ANAYTICAL DATA

FEASIBILITY STUDY REPORT
SACO MUNICIPAL LANDFILL
SACO MAINE

| | | | LANDFILL AREAS 3 & 4[1] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Stream/Pool North | | | | Pool South | | | | Seep South | | | | | | | | | | | | | | | | | | | | | |
| Parameter | AWQC (ug/L) | | SW3 | | SW11 | | SW14 | | SW14 | | SW6 | | | | | | | | SW13 | | | | | | | | SW-13D | | SW-13T | |
| All units in ug/L | Chronic | Acute | 11/17/95 | | 11/17/95 | | 11/17/95 | | 11/19/96 | | 11/17/95 | | 5/16/96 | | 11/19/96 | | 6/24/98 | | 11/17/95 | | 11/19/96 | | 6/24/98 | | 10/98 | | 10/98 | |
| **Pesticides/PCBs** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Dieldrin | 0.0019 | 2.5 | ND | | ND | | ND | | NA | | ND | | NA | | NA | | NA | | ND | | NA | | NA | | NA | | NA | | NA | | NA | |
| Endosulfan II | 0.056 | 0.22 | ND | | ND | | ND | | NA | | ND | | NA | | NA | | NA | | ND | | NA | | NA | | NA | | NA | | NA | | NA | |
| **SVOCs** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1,4-Dichlorobenzene | - | - | ND | | ND | | ND | | NA | | ND | | NA | | NA | | NA | | ND | | NA | | NA | | NA | | NA | | NA | | NA | |
| 4-Chloro-3-methylphenol | - | - | ND | | ND | | ND | | NA | | 2 | J | NA | | NA | | NA | | ND | | NA | | NA | | NA | | NA | | NA | | NA | |
| Bis(2-ethylhexyl)phthalate | 560 | 400 | ND | | ND | | 1 | J | NA | | 2 | J | NA | | NA | | NA | | ND | | NA | | NA | | NA | | NA | | NA | | NA | |
| Di-n-butylphthalate | 3 | 940 | ND | | ND | | 2 | J | NA | | ND | | NA | | NA | | NA | | ND | | NA | | NA | | NA | | NA | | NA | | NA | |
| **VOCs** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1,1-Dichloroethene | - | - | NA | | NA | | NA | | NA | | ND | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | |
| 1,2,4-Trimethylbenzene | - | - | NA | | NA | | NA | | NA | | ND | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | |
| 1,2-Dichlorobenzene | 783 | 1120 | NA | | NA | | NA | | NA | | 1 | J | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | |
| 1,3-Dichlorobenzene | - | - | NA | | NA | | NA | | NA | | ND | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | |
| 1,4-Dichlorobenzene | 783 | 1120 | NA | | NA | | NA | | NA | | 1 | J | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | |
| Acetone | - | - | NA | | NA | | NA | | NA | | ND | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | |
| Benzene | - | 6300 | NA | | NA | | NA | | NA | | 1 | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | |
| cis-1,2-Dichloroethene | - | 11,600 | NA | | NA | | NA | | NA | | ND | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | |
| Chlorobenzene | 50 | 250 | NA | | NA | | NA | | NA | | ND | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | |
| Ethylbenzene | - | 32,000 | NA | | NA | | NA | | NA | | ND | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | |
| m,p-Xylene | - | - | NA | | NA | | NA | | NA | | ND | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | |
| Naphthalene | 2300 | 620 | NA | | NA | | NA | | NA | | ND | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | |
| Tetrahydrofuran | - | - | NA | | NA | | NA | | NA | | 3 | J | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | |
| Toluene | - | 17,500 | NA | | NA | | NA | | NA | | ND | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | | NA | |
| **Inorganics** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Aluminum | - | - | 116.00 | J | 87.80 | J | 776.00 | | ND | | 18 | J | ND | | 71800 | | NA | | 472 | | ND | | NA | | NA | | NA | | NA | | NA | |
| Antimony | 30 | 88 | ND | | ND | | ND | | ND | | ND | | ND | | ND | | NA | | ND | | ND | | NA | | NA | | NA | | NA | | NA | |
| Arsenic | 150 | 340 | 3.70 | J | 3.10 | J | 3.10 | J | 18.6 | | 128 | | 106 | | 7850 | | 12 | | 8.7 | J | 108 | | 14 | | 16 | | 14 | | NA | | NA | |
| Barium | - | - | 7.40 | J | 2.70 | J | 14.70 | J | 30.5 | | 72.3 | J | 81 | | 1870 | | NA | | 20.5 | J | 63 | | NA | | NA | | NA | | NA | | NA | |
| Beryllium | 5.3 | 180 | ND | | ND | | ND | | ND | | ND | | ND | | 4.2 | | NA | | ND | | ND | | NA | | NA | | NA | | NA | | NA | |
| Cadmium | 1.1 | 3.9 | ND | | ND | | ND | | ND | | ND | | ND | | 5.8 | | NA | | ND | | ND | | NA | | NA | | NA | | NA | | NA | |
| Calcium | - | - | 18900.00 | | 5220.00 | | 8800.00 | | 16600 | | 51400 | | 41000 | J | 104000 | | NA | | 11890 | | 37700 | | NA | | NA | | NA | | NA | | NA | |
| Chromium | 11 | 18 | 10.20 | | ND | | 1.20 | J | ND | | 0.87 | J | 5.1 | J | 196 | | NA | | 88 | J | ND | | NA | | ND | | ND | | NA | | NA | |
| Cobalt | - | - | ND | | ND | | ND | | ND | | 2.1 | J | 11.5 | J | 78.7 | | NA | | ND | | ND | | NA | | NA | | NA | | NA | | NA | |
| Copper | 12 | 18 | ND | | ND | | ND | | ND | | ND | | ND | | 93 | | NA | | ND | | ND | | NA | | NA | | NA | | NA | | NA | |
| Iron | 1000 | - | ND | | ND | | 1150.00 | | 2270 | | 18000 | | 27300 | | 3120000 | | 2130 | | 1570 | | 12000 | | 2370 | | NA | | NA | | NA | | NA | |
| Lead | 3.2 | 83 | ND | | ND | | ND | | ND | | ND | | 2.1 | J | 66.7 | | NA | | 1.9 | J | ND | | NA | | ND | | ND | | NA | | NA | |
| Magnesium | - | - | 1990.00 | J | 694.00 | J | 2220.00 | J | 3570 | | 13300 | | 15800 | | 26500 | | NA | | 2850 | J | 8750 | | NA | | NA | | NA | | NA | | NA | |
| Manganese | - | - | ND | | ND | | 118.00 | | 617 | | 3720 | | 7390 | | 52200 | | NA | | 342 | | 2950 | | NA | | 2080 | | 1940 | | NA | | NA | |
| Mercury | 0.012 | 2.4 | ND | | ND | | 0.12 | J | ND | | 0.28 | | 0.00073 | | 0.31 | | NA | | ND | | ND | | NA | | NA | | NA | | NA | | NA | |
| Nickel | 160 | 1400 | ND | | ND | | 1.10 | J | 5.1 | | 5.4 | J | 47.5 | | 151 | | NA | | 1.5 | J | ND | | NA | | NA | | NA | | NA | | NA | |
| Potassium | - | - | 643.00 | J | ND | | 2810.00 | J | 2840 | | 5730 | | 7760 | | 12600 | | NA | | 2270 | J | 4540 | | NA | | NA | | NA | | NA | | NA | |
| Selenium | 5 | 20 | ND | | ND | | ND | | ND | | ND | | ND | | ND | | NA | | ND | | ND | | NA | | NA | | NA | | NA | | NA | |
| Silver | 0.12 | 4.1 | 0.71 | J | ND | | ND | | ND | | ND | | ND | | 48 | | NA | | ND | | ND | | NA | | NA | | NA | | NA | | NA | |
| Sodium | - | - | 3800.00 | J | 2730.00 | J | 9680.00 | | 21400 | | 74700 | | 71200 | | 29000 | | NA | | 13800 | | 47400 | | NA | | NA | | NA | | NA | | NA | |
| Thallium | 40 | 1400 | ND | | ND | | ND | | ND | | 5.9 | J | ND | | ND | | NA | | ND | | ND | | NA | | NA | | NA | | NA | | NA | |
| Vanadium | - | - | ND | | ND | | ND | | ND | | ND | | ND | | 160 | | NA | | ND | | ND | | NA | | NA | | NA | | NA | | NA | |
| Zinc | 110 | 120 | ND | | ND | | ND | | ND | | ND | | ND | | 103 | | NA | | ND | | ND | | NA | | NA | | NA | | NA | | NA | |

U = Undetected. J = Estimated. ND = Not detected NA = Not analyzed.

[1] 1999 results have not been included in this table. See Appendix F for a complete set of results.

TABLE 2-6
SURFACE WATER ANAYTICAL DATA

*FEASIBILITY STUDY REPORT*
SACO MUNICIPAL LANDFILL
SACO MAINE

| | | | LANDFILL AREAS 3 [1] | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Big Ledge Brook | | | | | | | | | | Sandy Brook South Area 4 | | | | | | | | | | | |
| Parameter | AWQC (ug/L) | | SW28T | | SW28D | | SW29 | SW-29D | SW-29T | | SW5 | | SW15 | | | SW-15D | SW-15T | | SW20 | | SW21 | | | |
| All units in ug/L | Chronic | Acute | 5/16/96 | | 5/16/96 | | 5/16/96 | 10/98 | 10/98 | | 11/17/95 | | 11/17/95 | | 11/19/96 | 10/98 | 10/98 | | 11/17/95 | | 5/16/96 | | 11/19/96 | |
| **Pesticides/PCBs** | | | | | | | | | | | | | | | | | | | | | | | | |
| Dieldrin | 0.0019 | 2.5 | NA | | NA | | NA | NA | NA | | ND | | ND | | NA | NA | NA | | ND | | NA | | NA | |
| Endosulfan II | 0.056 | 0.22 | NA | | NA | | NA | NA | NA | | 0.0019 | J | ND | | NA | NA | NA | | ND | | NA | | NA | |
| **SVOCs** | | | | | | | | | | | | | | | | | | | | | | | | |
| 1,4-Dichlorobenzene | - | - | NA | | NA | | NA | NA | NA | | ND | | ND | | NA | NA | NA | | ND | | NA | | NA | |
| 4-Chloro-3-methylphenol | - | - | NA | | NA | | NA | NA | NA | | ND | | ND | | NA | NA | NA | | ND | | NA | | NA | |
| Bis(2-ethylhexyl)phthalate | 560 | 400 | NA | | NA | | NA | NA | NA | | 2 | J | ND | | NA | NA | NA | | ND | | NA | | NA | |
| Di-n-butylphthalate | 3 | 940 | NA | | NA | | NA | NA | NA | | ND | | ND | | NA | NA | NA | | ND | | NA | | NA | |
| **VOCs** | | | | | | | | | | | | | | | | | | | | | | | | |
| 1,1-Dichloroethene | - | - | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | |
| 1,2,4-Trimethylbenzene | - | - | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | |
| 1,2-Dichlorobenzene | 783 | 1120 | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | |
| 1,3-Dichlorobenzene | - | - | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | |
| 1,4-Dichlorobenzene | 783 | 1120 | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | |
| Acetone | - | - | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | |
| Benzene | - | 6300 | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | |
| cis-1,2-Dichloroethene | - | 11,600 | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | |
| Chlorobenzene | 50 | 250 | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | |
| Ethylbenzene | - | 32,000 | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | |
| m,p-Xylene | - | - | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | |
| Naphthalene | 2300 | 620 | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | |
| Tetrahydrofuran | - | - | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | |
| Toluene | - | 17,500 | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | NA | NA | | NA | | NA | | NA | |
| **Inorganics** | | | | | | | | | | | | | | | | | | | | | | | | |
| Aluminum | - | - | ND | | 83.10 | U | ND | NA | NA | | 555.00 | | 440.00 | | ND | NA | NA | | 485 | | ND | | 488 | |
| Antimony | 30 | 88 | ND | | NA | | 4.10 | NA | NA | | ND | | ND | | ND | NA | NA | | ND | | ND | | ND | |
| Arsenic | 150 | 340 | ND | | NA | | ND | ND | ND | | 10.90 | | 4.20 | J | 12.2 | ND | ND | | ND | | 138 | | ND | |
| Barium | - | - | 5.20 | | NA | | 5.10 | NA | NA | | 20.10 | J | 14.90 | J | 22.2 | NA | NA | | 11.4 | J | 160 | | 14 | |
| Beryllium | 5.3 | 180 | ND | | NA | | ND | NA | NA | | ND | | ND | | ND | NA | NA | | ND | | ND | | ND | |
| Cadmium | 1.1 | 3.9 | ND | | NA | | ND | NA | NA | | ND | | ND | | ND | NA | NA | | ND | | ND | | ND | |
| Calcium | - | - | 11900.00 | J | NA | | 9520.00 | NA | NA | | 10900.00 | | 10600.00 | | 21500 | NA | NA | | 5520 | | 58700 | J | 8750 | |
| Chromium | 11 | 18 | ND | | NA | | 12.10 | ND | ND | J | 1.10 | J | 1.10 | J | ND | ND | ND | | 0.59 | J | 1.1 | J | ND | |
| Cobalt | - | - | ND | | NA | | 0.81 | NA | NA | | ND | | ND | | ND | NA | NA | | ND | | 2.8 | J | ND | |
| Copper | 12 | 18 | ND | | NA | | 1.40 | NA | NA | | ND | | ND | | ND | NA | NA | | ND | | ND | | ND | |
| Iron | 1000 | - | ND | | NA | | 528.00 | NA | NA | | 1750.00 | | 863.00 | | 1260 | NA | NA | | 677 | | 15500 | | 772 | |
| Lead | 3.2 | 83 | 1.00 | J | NA | | 34.50 | ND | ND | | ND | | ND | | ND | ND | ND | | ND | | ND | | ND | |
| Magnesium | - | - | 1620.00 | | NA | | 1140.00 | NA | NA | | 2640.00 | J | 2420.00 | J | 4390 | NA | NA | | 1530 | J | 12800 | | 1880 | |
| Manganese | - | - | 17.20 | | NA | | 22.40 | 9.2 | 10.4 | | 239.00 | | 151.00 | | 381 | 18.4 | 29.9 | | 89 | | 3530 | | 83.5 | |
| Mercury | 0.012 | 2.4 | ND | | NA | | ND | NA | NA | | 0.12 | J | ND | | ND | NA | NA | | ND | | ND | | ND | |
| Nickel | 160 | 1400 | ND | | NA | | 99.60 | NA | NA | | 1.90 | J | 1.10 | J | ND | NA | NA | | ND | | 9.2 | J | ND | |
| Potassium | - | - | ND | | NA | | 749.00 | NA | NA | J | 2720.00 | J | 2030.00 | J | 2640 | NA | NA | | 1320 | J | 6500 | | 2180 | |
| Selenium | 5 | 20 | 4.60 | J | NA | | ND | NA | NA | | ND | | ND | | ND | NA | NA | | ND | | 3.9 | J | ND | |
| Silver | 0.12 | 4.1 | ND | | NA | | ND | NA | NA | | ND | | ND | | ND | NA | NA | | ND | | ND | | ND | |
| Sodium | - | - | 8940.00 | | NA | | 8450.00 | NA | NA | | 12700.00 | | 11400.00 | | 17200 | NA | NA | | 7960 | | 55600 | | 12700 | |
| Thallium | 40 | 1400 | ND | | NA | | ND | NA | NA | | ND | | ND | | ND | NA | NA | | ND | | ND | | ND | |
| Vanadium | - | - | ND | | NA | | ND | NA | NA | | ND | | ND | | ND | NA | NA | | ND | | ND | | ND | |
| Zinc | 110 | 120 | ND | | NA | | ND | NA | NA | | ND | | ND | | ND | NA | NA | | ND | | ND | | ND | |

U = Undetected. J = Estimated. ND = Not detected NA = Not analyzed.

[1] 1999 results have not been included in this table. See Appendix F for a complete set of results.

**TABLE 2-6**
**SURFACE WATER ANAYTICAL DATA**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO MAINE**

| | | | LANDFILL AREAS 3 & 4 [1] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sandy Brook South Area 4 | | | | | | | | |
| Parameter | AWQC (ug/L) | | SW-21D | SW-21T | SW-34 | SW-34 DUP | SW-34D | SW-34T | SW-69 | SW-69D | SW-69T |
| All units in ug/L | Chronic | Acute | 10/98 | 10/98 | 6/24/98 | 6/24/98 | 10/98 | 10/98 | 6/24/98 | 10/98 | 10/98 |
| **Pesticides/PCBs** | | | | | | | | | | | |
| Dieldrin | 0.0019 | 2.5 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Endosulfan II | 0.056 | 0.22 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **SVOCs** | | | | | | | | | | | |
| 1,4-Dichlorobenzene | - | - | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 4-Chloro-3-methylphenol | - | - | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Bis(2-ethylhexyl)phthalate | 560 | 400 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Di-n-butylphthalate | 3 | 940 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **VOCs** | | | | | | | | | | | |
| 1,1-Dichloroethene | - | - | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,2,4-Trimethylbenzene | - | - | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,2-Dichlorobenzene | 783 | 1120 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,3-Dichlorobenzene | - | - | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,4-Dichlorobenzene | 783 | 1120 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Acetone | - | - | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Benzene | - | 6300 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| cis-1,2-Dichloroethene | - | 11,600 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Chlorobenzene | 50 | 250 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ethylbenzene | - | 32,000 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| m,p-Xylene | - | - | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Naphthalene | 2300 | 620 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Tetrahydrofuran | - | - | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Toluene | - | 17,500 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Inorganics** | | | | | | | | | | | |
| Aluminum | - | - | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Antimony | 30 | 88 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Arsenic | 150 | 340 | ND | ND | 10 | 12 | 7 | 10 | 11 | 6 | 8 |
| Barium | - | - | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Beryllium | 5.3 | 180 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Cadmium | 1.1 | 3.9 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Calcium | - | - | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Chromium | 11 | 18 | ND | ND | NA | NA | ND | ND | NA | ND | ND |
| Cobalt | - | - | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Copper | 12 | 18 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Iron | 1000 | - | NA | NA | 1760 | 1720 | NA | NA | 1480 | NA | NA |
| Lead | 3.2 | 83 | ND | ND | NA | NA | ND | ND | NA | ND | ND |
| Magnesium | - | - | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manganese | - | - | 38.4 | 43 | NA | NA | 423 | 448 | NA | 243 | 244 |
| Mercury | 0.012 | 2.4 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Nickel | 160 | 1400 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Potassium | - | - | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Selenium | 5 | 20 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Silver | 0.12 | 4.1 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Sodium | - | - | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Thallium | 40 | 1400 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Vanadium | - | - | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Zinc | 110 | 120 | NA | NA | NA | NA | NA | NA | NA | NA | NA |

U = Undetected. J = Estimated. ND = Not detected NA = Not analyzed.

[1] 1999 results have not been included in this table. See Appendix F for a complete set of results.

**Table 2-7**
**Surface Water and Sediment Analytical Data for Total Arsenic, Manganese, and Iron**
**Saco Municipal Landfill**
**Saco, Maine**

| LOCATION | DATE | RESULT TYPE | Arsenic (ug/L) | Manganese (ug/L) | Iron (ug/L) |
|---|---|---|---|---|---|
| | | | | | |
| **Area 2** | | | | | |
| | | | | | |
| SW-7 | 11/17/95 | Primary | 2.8 U | 93.4 | 596 |
| SW-7 | 5/16/96 | Primary | 3 U | 32.9 | 239 |
| SW-7 | 11/19/96 | Primary | 3 U | 21.9 | 315 |
| SW-7 | 6/24/98 | Primary | 8 U | | 1880 |
| SW-7(t) | 10/1/98 | Primary | ND | 3050 | |
| SW-7 | 6/10/99 | Primary < | 5 | 1620 | 1320 |
| SW-7 | 11/19/99 | Primary < | 5 | 708 | 366 |
| SW-8 | 11/17/95 | Primary | 2.8 U | 77.9 | 582 |
| SW-8 | 7/17/97 | Primary | 6.7 U | | 3620 |
| SW-8 | 6/24/98 | Primary | 8 U | | 665 |
| SW-9 | 11/17/95 | Primary | 2.8 U | 95.6 | 611 |
| SW-9 | 11/17/95 | Duplicate 1 | 2.8 U | 102 | 632 |
| SW-9 | 5/16/96 | Primary | 3 U | 86.8 | 805 |
| SW-9 | 11/19/96 | Primary | 2.1 U | 65.6 | 548 |
| SW-9 | 11/19/96 | Duplicate 1 | 2.1 U | 67.6 | 557 |
| SW-9 | 7/17/97 | Primary | 6 U | | 2680 |
| SW-9 | 6/24/98 | Primary | 8 U | | 792 |
| SW-9 | 6/10/99 | Primary < | 5 | 73 | 790 |
| SW-9 | 11/19/99 | Primary < | 5 | 37.4 | 392 |
| SW-10 | 11/17/95 | Primary | 2.8 U | 97.2 | 619 |
| SW-4 | 11/17/95 | Primary | 2.8 U | 80.4 | 575 |
| SW-4 | 7/17/97 | Primary | 4.6 U | | 2020 |
| SW-4 | 7/17/97 | Duplicate 1 | 6.9 U | | 2650 |
| SW-4 | 6/24/98 | Primary | 8 U | | 839 |
| | | | | | |
| **Areas 3 and 4** | | | | | |
| | | | | | |
| SW-21 | 5/16/96 | Primary | 138 | 3530 | 15500 |
| SW-21 | 5/16/96 | Duplicate 1 | 136 | 3500 | 15400 |
| SW-21 | 11/19/96 | Primary | 2.1 U | 83.5 | 772 |
| SW-21(t) | 10/1/98 | Primary | ND | 43 | |
| SW-21 | 6/10/99 | Primary < | 5 | 88 | 806 |
| SW-21 | 6/10/99 | Primary | 34 | 875 | 4110 |
| SW-21 | 11/19/99 | Primary < | 5 | 33.8 | 388 |
| SW-52 | 11/19/99 | Primary | 16 | 515 | 1900 |
| SW-6A | 6/24/98 | Primary | 12 | | 2130 |
| SW-13 | 11/17/95 | Primary | 8.7 J | 342 | 1570 |
| SW-13 | 11/19/96 | Primary | 108 | 2950 | 12000 |
| SW-13 | 6/24/98 | Primary | 14 | | 2370 |

**Table 2-7**
**Surface Water and Sediment Analytical Data for Total Arsenic, Manganese, and Iron**
**Saco Municipal Landfill**
**Saco, Maine**

| LOCATION | DATE | RESULT TYPE | Arsenic (ug/L) | Manganese (ug/L) | Iron (ug/L) |
|---|---|---|---|---|---|
| | | | | | |
| SW-13 (t) | 10/1/98 | Primary | 14 | 1940 | |
| SW-13 | 6/10/99 | Primary | 36 | 1300 | 3980 |
| SW-13 | 6/10/99 | Duplicate 1 | 34 | 1280 | 3850 |
| SW-13 | 11/19/99 | Primary | 17 | 668 | 2010 |
| SW-13 | 11/19/99 | Duplicate 1 | 17 | 671 | 2010 |
| SW-37 | 6/10/99 | Primary | 39 | 1350 | 4990 |
| SW-37 | 11/19/99 | Primary | 15 | 704 | 1890 |
| SW-5 | 11/17/95 | Primary | 10.9 | 239 | 1750 |
| SW-34 | 6/24/98 | Primary | 10 | | 1760 |
| SW-34 | 6/24/98 | Duplicate 1 | 12 | | 1720 |
| SW-34 (t) | 10/1/98 | Primary | 10 | 448 | |
| SW-34 | 6/10/99 | Primary | 22 | 1150 | 2450 |
| SW-34 | 11/19/99 | Primary | 14 | 634 | 1760 |
| SW-31 | 6/10/99 | Primary | 14 | 816 | 1350 |
| SW-31 | 11/19/99 | Primary | 8 | 427 | 827 |
| SW-15 | 11/17/95 | Primary | 4.2 J | 151 | 863 |
| SW-15 | 11/19/96 | Primary | 12.2 | 381 | 1260 |
| SW-15 (t) | 10/1/98 | Primary | ND | 29.9 | |
| SW-15 | 6/10/99 | Primary | 13 | 769 | 1260 |
| SW-15 | 11/19/99 | Primary | 5 J | 274 | 601 |
| SW-69 | 6/24/98 | Primary | 11 | | 1480 |
| SW-69 (t) | 10/1/98 | Primary | 8 | 244 | |
| SW-69 | 6/10/99 | Primary | 12 | 762 | 1100 |
| SW-69 | 11/19/99 | Primary | 6 J | 352 | 684 |
| SW-73 | 11/19/99 | Primary | 6 J | 367 | 652 |
| SW-75 | 6/10/99 | Primary | 12 | 772 | 1150 |
| SW-78 | 6/10/99 | Primary | 11 | 778 | 1050 |
| SW-78 | 6/10/99 | Duplicate 1 | 12 | 756 | 1020 |
| SW-83 | 6/10/99 | Primary | 11 | 787 | 1020 |
| SW-84 | 11/19/99 | Primary < | 5 | 387 | 669 |
| SW-86 | 6/10/99 | Primary | 11 | 794 | 1020 |
| SW-20 | 11/17/95 | Primary | 2.8 U | 89 | 677 |
| SW-93 | 11/19/99 | Primary < | 5 | 374 | 621 |
| SW-98 | 11/19/99 | Primary | 6 J | 288 | 658 |
| SW-103 | 11/19/99 | Primary < | 5 | 359 | 599 |
| SW-103 | 11/19/99 | Duplicate 1 < | 5 | 375 | 630 |
| | | | | | |
| **Big Ledge Brook** | | | | | |
| | | | | | |
| SW-28 | 5/16/96 | Primary | 3 U | 17.2 | 138 U |
| SW-29 | 5/16/96 | Primary | 3 U | 22.4 | 528 |

**Table 2-7**
**Surface Water and Sediment Analytical Data for Total Arsenic, Manganese, and Iron**
**Saco Municipal Landfill**
**Saco, Maine**

| LOCATION | DATE | RESULT TYPE | Arsenic (ug/L) | Manganese (ug/L) | Iron (ug/L) |
|---|---|---|---|---|---|
| | | | | | |
| SW-29 (t) | 10/1/98 | Primary | ND | 10.4 | |
| | | **SEDIMENTS** | | | |
| **Area 2** | | | | | |
| SD-7 | 11/95 | Primary | 6.5 J | 329 J | 10500 J |
| SD-7 | 5/96 | Primary | 2.1 | 137 | 9420 |
| SD-7 | 11/96 | Primary | 4.5 J | 139 | 9410 |
| SD-7 | 6/98 | Primary | 2.1 | NA | 10,100 B |
| SD-7 | 11/99 | Primary | 1.5 | 255 | 5,760 |
| SD-9 | 11/95 | Primary | 2.2 J | 76.3 J | 4700 J |
| SD-9 | 11/95 | Duplicate 1 | 2.2 J | 91.8 J | 5160 |
| SD-9 | 5/96 | Primary | 3.5 | 230 | 8740 |
| SD9D | 5/96 | Duplicate 1 | 4.7 | 305 | 10,900 |
| SD-9 | 11/96 | Primary | 3.4 | 221 | 9080 |
| SD-9 | 6/98 | Primary | 4.5 | NA | 10,300 B |
| SD9D | 5/96 | Duplicate 1 | 4.7 | 305 | 10,900 |
| SD9 | 11/99 | Primary* | 3.5 | 202 | 7,950 |
| **Areas 3 and 4** | | | | | |
| SD-21 | 5/96 | Primary | 29.2 | 102 | 8090 |
| SD-21 | 11/96 | Primary | 9.88 | 214 | 11500 |
| SD-21 | 6/98 | Primary | < 8.6 | NA | 10,000 B |
| SD-21 | 11/99 | Primary | 6.8 | 162 | 10,300 |
| SD-52 | 7/96 | Primary | 12.6 | NA | 9410 |
| SD-52 | 11/99 | Primary | 29.8 | 85.1 | 10,400 |
| SD-13 | 11/95 | Primary | 2250 J | 1660 J | 318,000 J |
| SD-13 | 5/96 | Primary | 41.3 | 184 | 22,400 |
| SD-13 | 1/96 | Primary | 8.7 | 92 | 9,350 |
| SD-13 | 6/98 | Primary | 71 | NA | 15,700 B |
| SD-13 | 11/99 | Primary | 98.5 | 508 | 36,200 |
| SD-13D | 11/99 | Primary | 105 | 551 | 39,000 |
| SD-37 | 11/99 | Primary | 57.9 | 242 | 12,200 |
| SD-34 | 7/96 | Primary | 19.6 | NA | 21,500 |
| SD-34 | 6/98 | Primary | 140 | NA | 30,000 B |
| SD-34 | 6/98 | Duplicate 1 | 120 | NA | 27,500 D |
| SD-34 | 11/99 | Primary | 60.4 | 109 | 9,920 |
| SD-31 | 7/96 | Primary | 81.5 | NA | 13,700 |
| SD-31 | 11/99 | Primary | 175 | 1420 | 30,900 |
| SD-15 | 11/95 | Primary | 42.2 J | 464J | 16,000 J |
| SD-15 | 5/96 | Primary | 84 | NA | 29,000 |
| SD-15 | 11/96 | Primary | 26.1 | 305 | 17,200 |
| SD-15 | 11/99 | Primary | 14.2 | 122 | 7,340 |

**Table 2-7**
**Surface Water and Sediment Analytical Data for Total Arsenic, Manganese, and Iron**
**Saco Municipal Landfill**
**Saco, Maine**

| LOCATION | DATE | RESULT TYPE | Arsenic (ug/L) | Manganese (ug/L) | Iron (ug/L) |
|---|---|---|---|---|---|
| | | | | | |
| **Areas 3 and 4 (continued)** | | | | | |
| SD-69 | 11/99 | Primary | 18.3 | 338 | 6,380 |
| SD-73 | 11/99 | Primary | 17.3 | 77 | 8,130 |
| SD-84 | 11/99 | Primary | 16.8 | 405 | 5,650 |
| SD-93 | 11/99 | Primary | 14.4 | 270 | 5,080 |
| SD-98 | 11/99 | Primary | 12.4 | 262 | 5,360 |
| SD-103 | 11/99 | Primary | 11 | 576 | 14,400 |
| SD-103D | 11/99 | Duplicate | 10 | 557 | 17,800 |
| **Big Ledge Brook** | | | | | |
| SD-28 | 5/96 | Primary | 5.2 | 89.8 | 5610 |
| SD-29 | 5/96 | Primary | 4.4 | 63 | 4570 |

Notes:
Sampling locations are presented in upstream to downstream order (see Figure 2-3)
SW-6A - new location across from SW-13
J = estimated
U = not detected at indicated reporting limit
t = total arsenic analysis
< = element was detected, but at a concentration less than the indicated value
NA = not analyzed

Surface water samples collected adjacent to and downstream of the primary seep area include SW-6A (a new location across from SW-13 in the vicinity of the excavated seep), SW-13, SW-34, and SW-69 (see Figure 2-3). This stretch of Sandy Brook is the primary discharge zone for groundwater impacted by Landfill Areas 3 and 4. Sample SW-6A contained 12 μg/L arsenic, and sample SW-13 contained 14 μg/L arsenic. Surface water samples downstream of the seep, SW-34 and SW-69, contained 10 and 11 μg/L of arsenic, respectively. The chronic SWQC for arsenic developed for the protection of aquatic organisms is 150 μg/L and was not exceeded in these surface water samples. Iron concentrations in these samples exceeded the chronic AWQC of 1,000 μg/L and ranged from 1,480 to 12,000 μg/L.

**October 1998** - Samples collected during the October 1998 sampling event were analyzed for both total and dissolved arsenic, chromium, lead, and manganese. Samples were collected in Sandy Brook both upstream and downstream of the groundwater discharge from Landfill Areas 3 and 4, and in Big Ledge Brook. Chromium and lead were not detected in any of the surface water samples.

Neither total nor dissolved arsenic was detected in the background sample (SW-7), the Big Ledge Brook sample (SW-29), or upstream of the seep area in Sandy Brook (SW-21). Total and dissolved arsenic were detected in the samples adjacent to and downstream of the primary seep areas. The arsenic concentration in SW-13 was 14 μg/L (total) and 16 μg/L (dissolved), and in SW-34 was 10 μg/L (total) and 7 μg/L (dissolved). These concentrations are similar to those reported for total arsenic in June 1998. Arsenic was below the detection limit at the confluence of Big Ledge and Sandy brooks (SW-15), but was detected downstream of the confluence at 8 μg/L (total) and 6 μg/L (dissolved) (SW-69). These data indicate that the arsenic is present in surface water in the dissolved phase. All detected concentrations were well below the chronic arsenic SWQC of 150 μg/L.

Manganese was detected in all surface water samples in both the total and dissolved phases. The highest concentration of manganese was detected in the background sample SW-7 at 3,050 μg/L (total) and 2,930 μg/L (dissolved). Manganese was detected at SW-13, adjacent to the seep area at 1,940 μg/L (total) and 2,080 μg/L (dissolved). The concentration of total manganese in the downstream samples (SW-34, SW-15, and SW-69), ranged from 29 μg/L (SW-15) to 450 μg/L (SW-34). Manganese was detected in the sample collected from Big Ledge Brook at 10 μg/L (total) and 9 μg/L (dissolved). There is no AWQC for manganese.

**June 1999** - Thirteen surface water locations were sampled during June 1999 along Sandy Brook and analyzed for total arsenic, iron, and manganese. The locations included nine locations from the background location (SW-7) to downstream of the confluence of Big Ledge and Sandy brooks (SW-69), and four new locations further downstream of the confluence. (Note: Surface water sampling locations are the same as sediment sampling locations [see Figure 2-4].) Arsenic was detected at all locations at concentrations from <5 μg/L (SW-7 and SW-9) to 39 μg/L (SW-37). The state of Maine has set the State Water Quality Criteria (SWQC) at 150 μg/L for acute exposure to arsenic. EPA has set the AWQC for arsenic at 190 μg/L. The state has reduced the SWQC based on an assumed hardness value of 20 ml/L compared with a hardness value of 100 mg/L assumed by EPA. All concentrations were below both the chronic arsenic SWQC of 150 μg/L and the MCL of 50 μg/L.

Manganese was detected in all surface water samples. The highest concentration of manganese was detected in the background sample SW-7 at 1,620 μg/L, as during the October 1998 event. Manganese was detected at 1,300 μg/L at SW-13, adjacent to the seep area. The concentration of total manganese in the downstream samples ranged from 756 μg/L (SW-78 Duplicate) to 1,350 μg/L (SW-37). There is no AWQC for manganese.

The AWQC for iron of 1,000 (μg/L) was exceeded at the background location SW-7 (1,320 μg/L) and at all other locations except SW-9 and SW-21. During the previous sampling event, iron was detected at a concentration above the AWQC at SW-7 and several other downstream locations.

**November 1999** - W&C collected surface water samples from 15 locations on November 19, 1999. All samples were analyzed for total arsenic, iron, and manganese. Results are presented in Table 2-7 along with results from previous sampling events. The arsenic concentration adjacent to the remediated seep (SW-13) was reported at 17 μg/L. The concentrations of arsenic, manganese, and iron in surface water samples collected 300 to 500 feet downstream from the confluence of Sandy and Big Ledge brooks (SW-93, SW-98, SW-103) are at concentrations similar to background prior to leaving the City of Saco property.

### 2.3.2 Sediment Analytical Data

In June, 1998, ten sediment samples were collected from Sandy Brook, including sediment sample SD-6A collected at a new location across from SD-13. Figure 2-4 shows sediment sample locations and

Table 2-8 presents the sediment analytical data. Table 2-7 provides a summary of the iron, manganese, and arsenic in sediments.

Data from background sediment samples SD-7 and SD-9, upgradient and adjacent to Landfill Area 2, are consistent with previous sampling results. Arsenic was detected below the arsenic benchmark concentrations identified in the Ecological Risk Assessment of 6 milligrams/kilogram (mg/kg) in these samples.

Concentrations of total arsenic detected in SD-6A, SD-13, SD-27, and SD-34 exceeded the benchmark concentration for arsenic (see Table 2-7). Because of the elevated concentrations of arsenic detected in these and other samples, sediment toxicity testing with *Hyalella azteca* for acute and chronic toxicity (e.g., growth and reproductive effects) was conducted to evaluate the potential ecological risks at this Site.

As reported in the Ecological risk assessment (W&C, 2000), the potential ecological risks to environmental receptors at the SML were systematically reviewed and evaluated. Previous sampling at the Site identified Sandy Brook as the only completed pathway to site contaminants. A habitat and chemical stressor evaluation identified sediment as the exposure medium. Arsenic, iron, and manganese are present in sediments above benchmark values, and arsenic, because it is the most toxic of the three, was selected as the contaminant of potential concern for quantitative evaluation. Benthic macroinverebrates were selected as the assessment endpoint, because they have the highest potential exposure to stream sediments. Potential effects on benthic macroinvertebrates were evaluated by a benthic survey and toxicity tests, while the range of exposure of benthic macroinvertebrates to arsenic in Sandy Brook was determined by comprehensive sediment sampling. The findings of these three evaluations are summarized below.

Benthic Survey:

- Results showed slight impairment of community structure at most locations, and moderate impairment at a location immediately south of the remediated seep.
- A sample location upstream of the Area 4 discharge area also showed slight impairment.
- No severe impairment of community structure was detected at any location.
- Sampling reflects the effects of all possible surface water and sediment contaminants.

TABLE 2-8
SEDIMENT ANALYTICAL DATA
FEASIBILITY STUDY REPORT
SACO MUNICIPAL LANDFILL, SACO, MAINE

| COMPOUND | Sediment Quality Criterion or Guidance | Reference | LANDFILL AREA 1 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Tributary to Deep Brook | | | | | | | | Dubois Pond | |
| | | | SD002 Nov-95 | SD002D Nov-95 | SD002 May-96 | SD002 Nov-96 | SD018 Nov-95 | SD018 May-96 | SD019 Nov-95 | SD019 May-96 | SD016 Nov-95 | SD017 Nov-95 |
| ***Pesticides/PCBs, ug/kg*** | | | | | | | | | | | | |
| 4,4-DDD | 8 | OMOE 1992 | ND | ND | | NA | ND | NA | ND | NA | ND | ND |
| 4,4-DDE | 5 | OMOE 1992 | ND | ND | | NA | ND | NA | ND | NA | 0.29J | ND |
| PCB-1260 | 5 | OMOE 1992 | ND | ND | | NA | ND | NA | ND | NA | ND | ND |
| **SVOCs, ug/kg** | | | | | | | | | | | | |
| 1,2-Dichlorobenzene | 340 | U.S. EPA 1996 | 32J | ND | | NA | ND | NA | ND | NA | ND | ND |
| 1,4-Dichlorobenzene | 350 | U.S. EPA 1996 | 110J | 56J | | NA | ND | NA | ND | NA | ND | ND |
| 4-Chloro-3-methylphenol | NA | -- | 50J | 40J | | NA | ND | NA | ND | NA | ND | ND |
| Benzo(a)pyrene | 430 | Long et al. 1995 | ND | ND | | NA | ND | NA | 180J | NA | ND | ND |
| Benzo(b)fluoranthene | 2,300 | Ingersoll et al. 1992 | ND | ND | | NA | ND | NA | ND | NA | ND | ND |
| Bis(2-ethylhexyl)phthalate | 1,200 | Newell 1989 | ND | ND | | NA | ND | NA | 630 | NA | ND | ND |
| Di-n-butylphthalate | 11,000 | U.S. EPA 1996 | ND | ND | | NA | ND | NA | ND | NA | ND | ND |
| Diethylphthalate | 630 | U.S. EPA 1996 | 140J | ND | | NA | ND | NA | 69J | NA | ND | ND |
| Fluoranthene | 600 | Long et al. 1995 | ND | ND | | NA | ND | NA | ND | NA | ND | ND |
| Phenanthrene | 240 | Long et al. 1995 | ND | ND | | NA | ND | NA | ND | NA | ND | ND |
| Pyrene | 665 | Long et al. 1995 | ND | ND | | NA | ND | NA | ND | NA | ND | ND |
| **VOCs, ug/kg** | | | | | | | | | | | | |
| 1,2,3-Trichlorobenzene | 9,200 a | U.S. EPA 1996 | ND | ND | NA | NA | ND | NA | NA | NA | NA | NA |
| 1,2,4-Trichlorobenzene | 9,200 | U.S. EPA 1996 | ND | ND | NA | NA | ND | NA | NA | NA | NA | NA |
| 1,2,4-Trimethylbenzene | NA | -- | ND | ND | NA | NA | ND | NA | NA | NA | NA | NA |
| 1,3,5-Trimethylbenzene | NA | -- | ND | ND | NA | NA | ND | NA | NA | NA | NA | NA |
| 2-Butanone | NA | -- | ND | ND | NA | NA | ND | NA | NA | NA | NA | NA |
| Acetone | 57 | -- | ND | ND | NA | NA | ND | NA | NA | NA | NA | NA |
| Benzene | 820 | U.S. EPA 1996 | ND | ND | NA | NA | ND | NA | NA | NA | NA | NA |
| Chlorobenzene | NA | U.S. EPA 1996 | ND | ND | NA | NA | ND | NA | NA | NA | NA | NA |
| Chloroform | NA | -- | ND | ND | NA | NA | ND | NA | NA | NA | NA | NA |
| Tetrahydrofuran | | -- | ND | ND | NA | NA | ND | NA | NA | NA | NA | NA |
| **Metals, mg/kg** | | | | | | | | | | | | |
| Aluminum | NA | -- | 3880J | 2860J | | NA | 4440J | | 2650J | NA | 10700J | 12300J |
| Arsenic | 6 | OMOE 1992 | 18.3J | 44.4J | 5.1 | 7.9 | 105J | 22 | 3.1J | ND | 4.3J | 4.1J |
| Barium | 20,000 | U.S. EPA 1977 | 30.6J | 38.9J | | NA | 141J | | 22.5J | NA | 45.2J | 49.5J |
| Beryllium | NA | -- | 0.51J | 0.38J | | NA | ND | | 0.4J | NA | 1.1 | 1.4 |
| Cadmium | 0.6 | OMOE 1992 | ND | ND | | NA | ND | | 0.09J | NA | ND | ND |
| Calcium | | | 966 | 1140 | | NA | 3650 | | ND | NA | 1980 | 2380 |
| Chromium | 26 | OMOE 1992 | 7J | 6.8J | | NA | 7.6J | | 4.9J | NA | 16.7J | 17J |
| Cobalt | 50,000 | Fitchko 1989 | 3.3J | 3.1J | | NA | 5.2J | | 1.4J | NA | 8.1J | 9J |
| Copper | 16 | OMOE 1992 | 2.7J | 2.9J | | NA | 3.5J | | 1.2J | NA | 10.1 | 11.4 |
| Iron | 21,200 | BCMOE 1994 | 20500J | 45400J | 2440 | 31600 | 151000J | 29000 | 4610J | 1400 | 17700J | 19600J |
| Lead | 31 | OMOE 1992 | 5.9 | 6.6 | | NA | 9.9 | | 6.6 | NA | 11.1 | 12.9 |
| Magnesium | | | 1000J | 809J | | NA | 1240J | | 452J | NA | 4920J | 6100J |
| Manganese | 460 | OMOE 1992 | 109J | 201J | 1020 | 538 | 517J | | 183J | | 544J | 507J |
| Nickel | 16 | OMOE 1992 | 4.2J | 3.4J | | NA | 5J | | 2.2J | NA | 11.4J | 11.6J |
| Potassium | | | 933J | ND | | NA | ND | | ND | NA | 4800 | 6780 |
| Selenium | 5 | BCMOE 1994 | 0.5J | 0.64J | | NA | 1.9J | | 0.6J | NA | ND | ND |
| Thallium | NA | -- | ND | ND | | NA | ND | | ND | NA | 0.9J | 0.79J |
| Vanadium | NA | -- | 8.2J | 6.8J | | NA | 10.6J | | 4.8J | NA | 25.6J | 29.5J |
| Zinc | 120 | OMOE 1992 | ND | ND | | NA | ND | | ND | NA | 54.8J | 61.9J |

**Note:** -- not applicable
a Surrogate value for 1,2,4-trichlorobenzene

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SVOC - semivolatile organic compound
VOC - volatile organic compound

TABLE 2-8
SEDIMENT ANALYTICAL DATA
FEASIBILITY STUDY REPORT
SACO MUNICIPAL LANDFILL, SACO, MAINE

| COMPOUND | Sediment Quality Criterion or Guidance | Reference | LANDFILL AREA 2 | | | | | | | | | LANDFILL AREAS 3 & 4 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Stream/Pool North | | Pool South | | | Big Ledge Brook | | |
| | | | SD004 Nov-95 | SD004 May-96 | SD008 Nov-95 | SD009 Nov-95 | SD009D Nov-95 | SD009 May-96 | SD009D May-96 | SD009 Nov-96 | SD010 Nov-95 | SD003 Nov-95 | SD011 Nov-95 | SD014 Nov-95 | SD014 May-96 | SD014 Nov-96 | SD028 May-96 | SD029 May-96 | SD029 Nov-96 |
| **Pesticides/PCBs, ug/kg** | | | | | | | | | | | | | | | | | | | |
| 4,4-DDD | 8 | OMOE 1992 | 5.8J | NA | ND | ND | ND | | | NA | ND | ND | 1.6J | ND | NA | NA | ND | ND | NA |
| 4,4-DDE | 5 | OMOE 1992 | 2.3J | NA | ND | ND | ND | | | NA | ND | ND | 1J | ND | NA | NA | ND | ND | NA |
| PCB-1260 | 5 | OMOE 1992 | ND | NA | ND | 150 | ND | | | NA | 61 | ND | ND | ND | NA | NA | ND | ND | NA |
| **SVOCs, ug/kg** | | | | | | | | | | | | | | | | | | | |
| 1,2-Dichlorobenzene | 340 | U.S. EPA 1996 | ND | NA | ND | 36J | ND | | | NA | ND | ND | ND | ND | NA | NA | NA | NA | NA |
| 1,4-Dichlorobenzene | 350 | U.S. EPA 1996 | ND | NA | ND | ND | ND | | | NA | ND | ND | ND | ND | NA | NA | NA | NA | NA |
| 4-Chloro-3-methylphenol | NA | -- | ND | NA | ND | ND | ND | | | NA | ND | ND | ND | ND | NA | NA | NA | NA | NA |
| Benzo(a)pyrene | 430 | Long et al. 1995 | ND | NA | ND | ND | ND | | | NA | ND | ND | 140J | ND | NA | NA | NA | NA | NA |
| Benzo(b)fluoranthene | 2,300 | Ingersoll et al. 1992 | ND | NA | ND | ND | ND | | | NA | ND | ND | ND | ND | NA | NA | NA | NA | NA |
| Bis(2-ethylhexyl)phthalate | 1,200 | Newell 1989 | ND | NA | ND | ND | ND | | | NA | ND | ND | ND | ND | NA | NA | NA | NA | NA |
| Di-n-butylphthalate | 11,000 | U.S. EPA 1996 | ND | NA | ND | ND | ND | | | NA | ND | ND | ND | ND | NA | NA | NA | NA | NA |
| Diethylphthalate | 630 | U.S. EPA 1996 | ND | NA | ND | ND | ND | | | NA | ND | 100J | ND | ND | NA | NA | NA | NA | NA |
| Fluoranthene | 600 | Long et al. 1995 | ND | NA | ND | ND | ND | | | NA | 54J | ND | ND | ND | NA | NA | NA | NA | NA |
| Phenanthrene | 240 | Long et al. 1995 | 63J | NA | ND | ND | ND | | | NA | ND | ND | ND | ND | NA | NA | NA | NA | NA |
| Pyrene | 665 | Long et al. 1995 | 140J | NA | 63J | 41J | ND | | | NA | 44J | ND | ND | ND | NA | NA | NA | NA | NA |
| **VOCs, ug/kg** | | | | | | | | | | | | | | | | | | | |
| 1,2,3-Trichlorobenzene | 9,200 a | U.S. EPA 1996 | NA | NA | ND | 1J | ND | | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,2,4-Trichlorobenzene | 9,200 | U.S. EPA 1996 | NA | NA | ND | ND | 1J | | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,2,4-Trimethylbenzene | NA | -- | NA | NA | ND | 1J | ND | | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,3,5-Trimethylbenzene | NA | -- | NA | NA | ND | 1J | ND | | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2-Butanone | NA | -- | NA | NA | 25J | ND | 4J | | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Acetone | 57 | -- | NA | NA | 72J | ND | ND | | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Benzene | 820 | U.S. EPA 1996 | NA | NA | ND | 1J | ND | | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Chlorobenzene | NA | U.S. EPA 1996 | NA | NA | ND | 1J | ND | | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Chloroform | NA | -- | NA | NA | ND | 1J | ND | | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Tetrahydrofuran | | -- | NA | NA | 31J | ND | ND | | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Metals, mg/kg** | | | | | | | | | | | | | | | | | | | |
| Aluminum | NA | -- | 29000J | | 8370J | 5080J | 6460J | | | NA | 8760J | 18200J | 16200J | 20300J | | NA | | NA | NA |
| Arsenic | 6 | OMOE 1992 | 20.1J | 6.7 | 4J | 2.2J | 2.2J | 3.5 | 4.7 | 3.4 | 4.9J | 15.9J | 7.9J | 10.6J | 9.8 | 10.7 | 3.3 | 5.2 | 4.4 |
| Barium | 20,000 | U.S. EPA 1977 | 144J | | 45.9J | 19.3J | 23.8J | | | NA | 46.6J | 87.5J | 60.7J | 84.3J | | NA | | NA | NA |
| Beryllium | NA | -- | 1.9 | | 0.79J | 0.47J | 0.51J | | | NA | 0.83J | 1.3 | 0.97J | 1 | | NA | | NA | NA |
| Cadmium | 0.6 | OMOE 1992 | ND | | ND | ND | ND | | | NA | ND | ND | ND | ND | | NA | | NA | NA |
| Calcium | | | 5640 | | 2230 | 936 | 1070 | | | NA | 1660 | 2300 | 2360 | 2980 | | NA | | NA | NA |
| Chromium | 26 | OMOE 1992 | 85J | | 11.7J | 6.9J | 8.8J | | | NA | 26.2J | 25.8J | 20.6J | 41.4J | | NA | | NA | NA |
| Cobalt | 50,000 | Fitchko 1989 | 17.3J | | 4.6J | 2.5J | 2.7J | | | NA | 5.5J | 23.6J | 6.9J | 15.4J | | NA | | NA | NA |
| Copper | 16 | OMOE 1992 | 24.7 | | 4.3 | 1.1J | 0.9J | | | NA | 4.4 | 6.7 | 8.5 | 16.9 | | NA | | NA | NA |
| Iron | 21,200 | BCMOE 1994 | 31000J | 16300 | 9550J | 4700J | 5160 | 8740 | 10900 | 9080 | 11800J | 24500J | 11000J | 41100J | 38000 | 42100 | 4440 | 5610 | 4570 |
| Lead | 31 | OMOE 1992 | 27.8 | | 11.1 | 6.6 | 5.1 | | | NA | 12.2 | 22.6 | 16.6 | 9.2 | | NA | | NA | NA |
| Magnesium | | | 8610J | | 2250J | 1250J | 1640J | | | NA | 2100J | 3240J | 2420J | 10400J | | NA | | NA | NA |
| Manganese | 460 | OMOE 1992 | 605J | 358 | 175J | 76.3J | 91.8J | 230 | 305 | 221 | 478J | 6780J | 148J | 686J | | 739 | 53.7 | 89.8 | 63 |
| Nickel | 16 | OMOE 1992 | 34J | | 6.5J | 3.7J | 4.4J | | | NA | 6.9J | 16.9J | 16.8J | 28.8J | | NA | | NA | NA |
| Potassium | | | 6640 | | 1530 | ND | 954 | | | NA | 1560 | 1690 | ND | 10100 | | NA | | NA | NA |
| Selenium | 5 | BCMOE 1994 | ND | | ND | ND | ND | | | NA | ND | 3.4J | 0.82J | ND | | NA | | NA | NA |
| Thallium | NA | -- | 1.6J | | ND | ND | ND | | | NA | ND | 6.7 | ND | ND | | NA | | NA | NA |
| Vanadium | NA | -- | 50.2J | | 14.1J | 7.9J | 9.4J | | | NA | 15.3J | 41.2J | 21.6J | 51.5J | | NA | | NA | NA |
| Zinc | 120 | OMOE 1992 | 126J | | 59.1J | 20.5J | 20.9J | | | NA | 60.1J | 78.1J | ND | 67.2J | | NA | | NA | NA |

**Note:** -- not applicable
a Surrogate value for 1,2,4-trichlorobenzene.

**References:**

British Columbia Ministry of Environment (BCMOE). 1994. Approved and working criteria for water quality — 1994. Water Quality Branch. Environmental Protection Department. ISBN 0-7726-2061-X. Victoria, British Columbia. 45 pp.
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Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environ. Manage. 19(1):81–97.
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U.S. EPA. 1996. Ecotox Thresholds. EPA/540/F-95/038. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.


SVOC - semivolatile organic compound
VOC - volatile organic compound

TABLE 2-8
SEDIMENT ANALYTICAL DATA
FEASIBILITY STUDY REPORT
SACO MUNICIPAL LANDFILL, SACO, MAINE

| COMPOUND | Sediment Quality Criterion or Guidance | Reference | LANDFILL AREAS 3 & 4 (cont'd) Sandy Brook South of Area 4 | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SD005 Nov-95 | SD015 Nov-95 | SD015 May-96 | SD015 Nov-96 | SD024 May-96 | SD024A May-96 | SD0024 Nov-96 | SD025 May-96 | SD027 May-96 | SD030 Jul-96 | SD031 Jul-96 | SD032 Jul-96 | SD033 Jul-96 | SD034 Jul-96 | SD035 Jul-96 | SD040 Jul-96 | SD041 Jul-96 | SD047 Jul-96 |
| **Pesticides/PCBs, ug/kg** | | | | | | | | | | | | | | | | | | | | |
| 4,4-DDD | 8 | OMOE 1992 | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 4,4-DDE | 5 | OMOE 1992 | 0.76J | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| PCB-1260 | 5 | OMOE 1992 | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **SVOCs, ug/kg** | | | | | | | | | | | | | | | | | | | | |
| 1,2-Dichlorobenzene | 340 | U.S. EPA 1996 | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,4-Dichlorobenzene | 350 | U.S. EPA 1996 | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 4-Chloro-3-methylphenol | NA | -- | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Benzo(a)pyrene | 430 | Long et al. 1995 | ND | 47J | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Benzo(b)fluoranthene | 2,300 | Ingersoll et al. 1992 | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Bis(2-ethylhexyl)phthalate | 1,200 | Newell 1989 | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Di-n-butylphthalate | 11,000 | U.S. EPA 1996 | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Diethylphthalate | 630 | U.S. EPA 1996 | ND | 76J | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Fluoranthene | 600 | Long et al. 1995 | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Phenanthrene | 240 | Long et al. 1995 | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Pyrene | 665 | Long et al. 1995 | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **VOCs, ug/kg** | | | | | | | | | | | | | | | | | | | | |
| 1,2,3-Trichlorobenzene | 9,200 a | U.S. EPA 1996 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,2,4-Trichlorobenzene | 9,200 | U.S. EPA 1996 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,2,4-Trimethylbenzene | NA | -- | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,3,5-Trimethylbenzene | NA | -- | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2-Butanone | NA | -- | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Acetone | 57 | -- | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Benzene | 820 | U.S. EPA 1996 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Chlorobenzene | NA | U.S. EPA 1996 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Chloroform | NA | -- | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Tetrahydrofuran | | -- | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Metals, mg/kg** | | | | | | | | | | | | | | | | | | | | |
| Aluminum | NA | -- | 4010J | 6330J | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Arsenic | 6 | OMOE 1992 | 11.9J | 42.2J | 84 | 26.1 | 1.3 | 1.7 | 21.5 | 89 | 36 | 3.1 | 81.5 | 185 | 54.9 | 19.6 | 6.9 | 8.9 | 81.3 | 37.8 |
| Barium | 20,000 | U.S. EPA 1977 | 15.6J | 44.7J | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Beryllium | NA | -- | ND | 0.48J | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Cadmium | 0.6 | OMOE 1992 | ND | ND | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Calcium | | | 511 | 1150 | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Chromium | 26 | OMOE 1992 | 9.5J | 14J | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Cobalt | 50,000 | Fitchko 1989 | 2.7J | 5.1J | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Copper | 16 | OMOE 1992 | 1.5J | 5.4 | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Iron | 21,200 | BCMOE 1994 | 5390J | 16000J | 29000 | 17200 | 1700 | 2000 | 8600 | 11000 | 8300 | 3280 | 13700 | 33500 | 24700 | 21500 | 5300 | 9260 | 15500 | ND |
| Lead | 31 | OMOE 1992 | 4.4 | 6.9 | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Magnesium | | | 1420J | 2200J | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manganese | 460 | OMOE 1992 | 72.7J | 464J | | 305 | | | 155 | | | | | | | | | | | |
| Nickel | 16 | OMOE 1992 | 4.8J | 10.8J | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Potassium | | | ND | ND | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Selenium | 5 | BCMOE 1994 | ND | 0.72J | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Thallium | NA | -- | ND | ND | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Vanadium | NA | -- | 6.6J | 14.6J | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Zinc | 120 | OMOE 1992 | 21.7J | ND | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

**Note:** -- not applicable
a Surrogate value for 1,2,4-trichlorobenzene

**References:**

British Columbia Ministry of Environment (BCMOE). 1994. Approved and working criteria for water quality — 1994. Water Quality Branch. Environmental Protection Department. ISBN 0-7726-2061-X. Victoria, British Columbia. 45 pp
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U.S. EPA. 1996. Ecotox Thresholds. EPA/540/F-95/038. U.S. Environmental Protection Agency. Office of Solid Waste and Emergency Response. Washington, DC


SVOC - semivolatile organic compound
VOC - volatile organic compound

TABLE 2-8
SEDIMENT ANALYTICAL DATA
FEASIBILITY STUDY REPORT
SACO MUNICIPAL LANDFILL, SACO, MAINE

| COMPOUND | Sediment Quality Criterion or Guidance | Reference | LANDFILL AREAS 3 & 4 (cont'd) Sandy Brook South of Area 4 | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SD049 Jul-96 | SD-50 Jul-96 | SD051 Jul-96 | SD051D Jul-96 | SD052 Jul-96 | SD053 Jul-96 | SD060 Jul-96 | SD061 Jul-96 | SD062 Jul-96 | SD063 Jul-96 | SD064 Apr-97 | SD065 Apr-97 | SD066 Apr-97 | SD067 Apr-97 | SD068 Apr-97 | SD069 Apr-97 |
| **Pesticides/PCBs, ug/kg** | | | | | | | | | | | | | | | | | | |
| 4,4-DDD | 8 | OMOE 1992 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 4,4-DDE | 5 | OMOE 1992 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| PCB-1260 | 5 | OMOE 1992 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **SVOCs, ug/kg** | | | | | | | | | | | | | | | | | | |
| 1,2-Dichlorobenzene | 340 | U.S. EPA 1996 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,4-Dichlorobenzene | 350 | U.S. EPA 1996 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 4-Chloro-3-methylphenol | NA | -- | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Benzo(a)pyrene | 430 | Long et al. 1995 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Benzo(b)fluoranthene | 2,300 | Ingersoll et al. 1992 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Bis(2-ethylhexyl)phthalate | 1,200 | Newell 1989 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Di-n-butylphthalate | 11,000 | U.S. EPA 1996 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Diethylphthalate | 630 | U.S. EPA 1996 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Fluoranthene | 600 | Long et al. 1995 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Phenanthrene | 240 | Long et al. 1995 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Pyrene | 665 | Long et al. 1995 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **VOCs, ug/kg** | | | | | | | | | | | | | | | | | | |
| 1,2,3-Trichlorobenzene | 9,200 a | U.S. EPA 1996 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,2,4-Trichlorobenzene | 9,200 | U.S. EPA 1996 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,2,4-Trimethylbenzene | NA | -- | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,3,5-Trimethylbenzene | NA | -- | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2-Butanone | NA | -- | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Acetone | 57 | -- | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Benzene | 820 | U.S. EPA 1996 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Chlorobenzene | NA | U.S. EPA 1996 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Chloroform | NA | -- | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Tetrahydrofuran | | -- | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Metals, mg/kg** | | | | | | | | | | | | | | | | | | |
| Aluminum | NA | -- | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Arsenic | 6 | OMOE 1992 | 43.9 | 13.4 | 114 | 113 | 12.6 | 7.1 | 5.9 | 6.7 | 18.3 | 6 | 33.2 | 42 | 48.3 | 45.9 | 7.7 | 7 |
| Barium | 20,000 | U.S. EPA 1977 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Beryllium | NA | -- | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Cadmium | 0.6 | OMOE 1992 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Calcium | | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Chromium | 26 | OMOE 1992 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Cobalt | 50,000 | Fitchko 1989 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Copper | 16 | OMOE 1992 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Iron | 21,200 | BCMOE 1994 | 27300 | 20900 | 18400 | 22600 | 9410 | 8350 | 4090 | 6490 | 7550 | 6350 | 21000 | 20900 | 15000 | 14000 | 5210 | 6640 |
| Lead | 31 | OMOE 1992 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Magnesium | | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manganese | 460 | OMOE 1992 | | | | | | | | | | | | | | | | |
| Nickel | 16 | OMOE 1992 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Potassium | | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Selenium | 5 | BCMOE 1994 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Thallium | NA | -- | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Vanadium | NA | -- | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Zinc | 120 | OMOE 1992 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

**Note:** -- not applicable
a Surrogate value for 1,2,4-trichlorobenzene.

**References:**

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U.S. EPA. 1977. Guidelines for the pollution classification of Great Lakes Harbor sediments. U.S. Environmental Protection Agency. Region V. Great Lakes Surveillance Branch. Chicago, Illinois.
U.S. EPA. 1996. Ecotox Thresholds. EPA/540/F-95/038. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.


SVOC - semivolatile organic compound
VOC - volatile organic compound

- Results do not reflect potential improvements in community structure following the additional removal of contaminated sediment in November 1998.

Toxicity Tests:

- Tests evaluated survival, growth, and reproduction under acute and chronic conditions
- Survival in all tests was comparable to reference samples
- Slight reductions in growth occurred for all concentrations under the prolonged exposure of a 42-day test.
- Moderate reduction in reproduction was associated with higher arsenic concentrations
- These results suggest that organisms in affected portions of the stream would be able to complete their life cycles in the sediment, but may be slightly smaller than those in unaffected sediments.
- Line-of-evidence evaluation of toxicity data suggests that moderate reduction in growth and reproduction may be associated with samples with sediment arsenic concentrations higher than 106 mg/kg.

Comprehensive Sediment Sampling:

- Results suggest that 14% of the stream area, or approximately 280 ft. of the 2,000 foot study area, potentially contains sediment with arsenic concentrations above 106 mg/kg and thus the potential to affect growth and reproduction in highly sensitive members of the benthic community. This estimate does not reflect probable improvements in sediment quality following the November 1998 sediment remediation.
- Mapping of data indicates that these 280 ft. are not contiguous, but are scattered along the length of the brook, with affected areas separated by 25-75 ft. of stream with lower arsenic levels.
- The separation of potentially affected areas would serve to reduce exposure and effect, since benthic organisms are able to move in and out of affected areas.

Taken together, these test data suggest that:

1. Discharge of groundwater from Area 4 has had a measurable impact on the benthic macroinvertebrate community of Sandy Brook.

2. Although post-remediation concentrations of site-related contaminants are lower than they were before remedial activities, they may still present risks of minor adverse effects among sensitive members of the benthic community.
3. The potential for impacts from current levels of site-related contaminants are limited to a small portion of the brook downstream of the remediated seep.
4. Observed effects do not constitute a significant impact on the ecology of Sandy Brook and do not warrant additional remediation of Area 4 or the sediments of Sandy Brook.

In addition, because the impact on the macrobenthic community of Sandy Brook is minor and restricted in area, it is likely to have little or no effect on downstream reaches, where arsenic levels are significantly lower. However, because elevated concentrations of arsenic, iron, and manganese are still present around the landfill, periodic monitoring of stream sediments is recommended to detect any changes in metal concentrations over time.

### 2.3.3 Groundwater Analytical Data

Groundwater samples were collected from 28 monitoring wells in December 1997, and from 27 wells in June 1998. All samples were analyzed for inorganic parameters. Four of the wells, (MW-13, MW-95-11S, MW-95-1S, and MW-95-4RD) were also analyzed for VOCs during both events. The monitoring wells sampled and parameters analyzed are presented in Table 2-5; the analytical data are presented in Table 2-9; and monitoring well locations are presented in Figure 2-1. The chemical distribution in the overburden and bedrock aquifers generally has remained consistent between the 1997-1998 sampling events and prior events; 1998 data are consistent with the site model. A summary of the analytical data is presented below for VOCs and inorganic parameters.

**2.3.3.1 VOCs** - There were no significant changes in VOC concentrations detected in any of the four monitoring wells between the 1997-98 sampling events and prior events. MW-13 and MW-95-4RD had trace to very low concentrations of up to 25 VOCs. Similar to two prior sampling events, MW-95-11S had no detectable levels of VOCs and MW-95-1S had trace levels of just three VOCs.

**2.3.3.2 Inorganic Parameters** - The inorganic analytical data are discussed separately for the existing RI/FS monitoring wells (e.g., MW-95 series) and the USGS monitoring wells (e.g., MW-97 series).

TABLE 2-9
GROUNDWATER ANALYTICAL DATA - South of Areas 3 4

FEASIBILITY STUDY REPORT
SACO MUNICIPAL LANDFILL
SACO, MAINE

| | | | | SOUTH OF LANDFILL AREAS 3 & 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MW-93-3 | | | | | | MW-93-5 | | | | | | MW-95-2S | | | | MW-95-4R | | | | | | | MW-95-4RD | | | | | | |
| Parameter | MCL | RBC | MEGs | 1/9/96 | 5/15/96 | 11/19/96 | 7/15/97 | 12/11/97 | 6/23/98 | 1/10/96 | 5/21/96 | 11/5/96 | 7/14/97 | 12/12/97 | 6/16/98 | 1/15/96 | 1/15/96 DUP | 5/14/96 | 12/15/97 | 12/19/95 | 12/19/95 D | 5/22/96 | 11/5/96 | 7/16/97 | 12/12/97 | 6/18/98 | 1/10/96 | 5/22/96 | 11/5/96 | 11/5/96 DUP | 7/16/97 | 12/12/97 | 6/18/98 |
| **VOCs μg/L** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1,1-Dichloroethane | - | 810 | 5 | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | 1 | 1 | 1 | ND | ND | NA | NA | 1 | 1 J | ND | 1 J | ND | 1 | 0.7 J |
| 1,1-Dichloropropene | - | - | - | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA |
| 1,1,2,2-Tetrachloroethane | - | 0.052 | - | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA |
| 1,2,3-Trichlorobenzene | - | - | - | ND | ND | ND | NA | NA | NA | 1 J | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | 1 J | ND | ND | ND | ND | 0.7 J | NA |
| 1,2,3-Trichloropropane | - | 0.0015 | 40 | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA |
| 1,2,4-Trichlorobenzene | 70 | 190 | 70 | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | 2.4 J | NA |
| 1,2,4-Trimethylbenzene | - | 300 | - | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | 6 | 6 | 6 | 5 J | 8 | NA | NA | 9 | 6 | 2 J | 2 J | 8 | 9 | 4 J |
| 1,2-Dibromo-3-chloropropane | - | 0.048 | - | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA |
| 1,2-Dichlorobenzene | 600 | 270 | - | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | 4 | 4 | 4 | 4 J | 5 | NA | NA | 5 | 4 | 4 J | 4 J | 5 | 6 | 4 |
| 1,2-Dichloroethane | 5 | 0.12 | 5 | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | 1 | 1 | ND | ND | NA | NA | ND | 1 | 1 J | 1 J | 1 | NA | 0.6 J |
| 1,2-Dichloropropane | 5 | 0.16 | 5 | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA |
| 1,3-Dichlorobenzene | 600 | 540 | - | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | 1 J | 1 J | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | 0.6 J | NA |
| 1,3,5-Trimethylbenzene | - | 300 | - | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | 3 | 3 | 4 | 4 J | 4 | NA | NA | 5 | 4 | 2 J | 3 J | 5 | 4 | 2 |
| 1,4-Dichlorobenzene | 75 | 0.44 | - | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | 6 | 6 | 5 | 5 J | 6 | NA | NA | 7 | 5 | 5 J | 5 J | 7 | 9 | 5 |
| 2-Butanone | - | 1900 | 170 | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | 15 | 17 | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | 3 J | |
| 2-Chlorotoluene | - | 120 | - | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | 1 J | ND | ND | ND | NA | NA | 1 | ND | ND | ND | ND | NA | |
| 2-Hexanone | - | - | - | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | |
| 2,2-Dichloropropane | - | - | - | ND | ND | ND | NA | NA | NA | ND | 0.2 J | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | 0.4 J | ND | ND | NA | NA | ND | 0.4 J | ND | ND | ND | NA | |
| 4-Isopropyltoluene | - | - | - | ND | ND | ND | NA | NA | NA | ND | ND | 2 J | ND | NA | NA | ND | ND | ND | NA | 1 J | 1 J | ND | 0.8 J | ND | NA | NA | 1 | ND | ND | 0.9 J | 2 | NA J | 0.6 J |
| 4-Methyl-2-pentanone | - | - | - | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | |
| Acetone | - | 3700 | - | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | 6 J | 16 J |
| Benzene | 5 | 0.36 | 5 | ND | ND | ND | NA | NA | NA | ND | 0.3 J | ND | ND | NA | NA | ND | ND | ND | NA | 13 | 12 | 11 | 11 J | 12 | NA | NA | 13 | 11 | 9 J | 10 J | 12 | 15 | 10 |
| Bromobenzene | - | - | - | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA |
| Chlorobenzene | 100 | 39 | - | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | 3 | 3 | 3 | 3 J | 4 | NA | NA | 4 | 3 | 3 J | 3 J | 5 | NA | NA |
| Chloroethane | - | 8600 | - | ND | ND | ND | NA | NA | NA | 1 J | 0.7 J | ND | ND | NA | NA | 1 J | 1 J | ND | NA | 89 | 93 | 65 | 38 J | 39 | NA | NA | 82 | 62 | 30 J | 32 J | 48 | NA | NA |
| Chloroform | | | | | | | | | | | | | | | | | | | NA | | | | | | NA | NA | | | | | | NA | NA |
| Chloromethane | - | 1.4 | 3 | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA |
| cis-1,2-DCE | - | 61 | 70 | ND | ND | 1 | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | 1 J | 1 | 0.6 J | ND | ND | NA | NA | ND | 0.6 J | ND | ND | ND | NA | NA |
| Dichlorodifluoromethane | - | 390 | 1050 | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | <2 R | NA | NA | ND | ND | ND | ND | <2 R | NA | NA |
| Ethylbenzene | 700 | 1300 | 700 | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | 30 | 29 | 26 | 21 J | 25 | NA | NA | 34 | 27 | 16 J | 17 J | 29 | 31 | 14 |
| Hexachlorobutadiene | - | 0.14 | 1 | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA |
| Isopropylbenzene | - | - | - | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | 3 | 3 | 4 | 3 J | 4 | NA | NA | 6 | 4 | 2 J | 3 J | 4 | 4 | 3 |
| Isopropyltoluene | - | - | - | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA |
| Methylene Chloride | - | 4.1 | - | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA |
| Naphthalene | - | 1500 | 25 | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | 8 | 9 | 5 J | 6 J | 11 | NA | NA | 13 | 5 J | 4 J | 5 J | 12 | 14 | 6 |
| Styrene | 100 | 1600 | 5 | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | 1 J | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA |
| Tetrachloroethene | 5 | 1.1 | 3 | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA |
| Tetrahydrofuran | - | - | - | ND | ND | ND | NA | NA | NA | 21 J | ND | ND | <50 R | NA | NA | ND | ND | ND | NA | 160 | 170 | 110 J | 97 J | 140 | NA | NA | 160 | 110 J | 71 J | 74 J | 130 | 140 | NA |
| Toluene | 1000 | 750 | 1400 | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | 2 | 2 | 1 | 0.9 J | 1 | NA | NA | 3 | 1 | 0.8 J | 0.6 J | 1 | 2 | 1 |
| trans-1,2-DCE | 100 | 120 | 70 | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | 1 J | 1 J | 0.6 J | ND | ND | NA | NA | 1 J | 0.6 J | ND | ND | ND | 0.7 J | NA |
| Trichloroethene | 5 | 1.6 | 5 | ND | ND | 2 | NA | NA | NA | ND | 0.3 J | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA |
| Trichlorofluoromethane | - | 1300 | 2300 | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA |
| Vinyl Chloride | 2 | 0.019 | 0.15 | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA |
| m-Xylene/p-Xylene | 10000 | 1400/520 | 600 | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | 22 | 22 | 21 J | 8 J | 20 | NA | NA | 32 | 21 J | 3 J | 4 J | 25 | 41 | 6 J |
| n-Butylbenzene | - | - | - | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | 1 J | 1 J | ND | 0.9 J | ND | NA | NA | 2 | ND | 0.8 J | 1 J | 2 | 1 J | 0.6 J |
| n-Propylbenzene | - | - | - | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | 1 J | 1 J | ND | 1 J | 2 | NA | NA | ND | ND | 0.7 J | 0.9 J | 2 | 1 | 1 |
| o-Xylene | 10000 | 1400 | 600 | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | 9 | 9 | 6 | 4 J | 8 | NA | NA | 14 | 8 | 2 J | 2 J | 8 | 13 | 3 |
| sec-Butylbenzene | - | 61 | - | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | 1 J | 1 J | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | 0.6 J | NA |
| MTBE | | | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | | | | | | NA | 1 J |
| **SVOCs μg/L** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2-Methylnaphthalene | - | - | - | ND | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | 5 J | ND | NA | NA | NA | NA | NA |
| 2,4-Dimethylphenol | - | 730 | - | ND | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | ND | ND | NA | NA | 1 J | ND | 5 J | NA | NA | NA | NA | ND | 5 J | NA | NA | NA | NA | NA |
| 4-Chloro-3-methylphenol | - | - | - | ND | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | ND | ND | NA | NA | 23 | 24 | 19 J | NA' | NA | NA | NA | 29 | 16 | NA | NA | NA | NA | NA |
| 4-Methylphenol | - | 180 | - | ND | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | NA |
| Acenaphthylene | - | - | 0.03 | ND | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | NA |
| Benzo(a)pyrene | - | 0.0092 | 0.03 | ND | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | NA |
| Benzo(g,h,i)perylene | - | - | 0.03 | ND | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | NA |
| Benzo(k)fluoranthene | - | 0.92 | 0.03 | ND | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | NA |
| Bis(2-ethylhexyl)phthalate | - | 4.8 | - | ND | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | 45 J | ND | NA | NA | 11 | 1 J | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | NA |
| Dibenzo(a,h)anthracene | - | 0.0092 | 0.03 | ND | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | NA |
| Diethylphthalate | - | 29000 | - | ND | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | ND | ND | NA | NA | 6 J | 3 J | ND | NA | NA | NA | NA | 10 J | ND | NA | NA | NA | NA | NA |
| Di-n-butylphthalate | - | - | 220 | ND | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | NA |
| Indeno(1,2,3-cd)pyrene | - | 0.092 | - | ND | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | NA |
| Phenol | - | 22000 | - | ND | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | NA |
| **Metals μg/L** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Aluminum | 50-200(s) | 37000 | 1430 | ND | ND | ND | ND | ND | 160 J | ND | ND | ND | ND | ND | 100 U | ND | ND | ND | 320 | ND | ND | ND | ND | ND | ND | ND | ND | ND | NA | NA | NA | ND | ND |
| Antimony | 6 | 15 | - | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | ND | NA | NA | NA | NA | NA |
| Arsenic | 50 | 11 (0.045) | - | ND | ND | ND | ND | ND | ND | 82.1 | 85.4 J | 95.9 | 91.3 | 100 | 75 | ND | ND | ND | ND | 504 | 566 | 479 J | 416 | 394 | 438 | 354 | 556 | 533 J | 511 | 461 | 491 | 578 | 461 |
| Barium | 2000 | 2600 | 1500 | ND | 9.3 | 9.7 | 9.6 | ND | 10.1 | ND | ND | 19.4 | 15.1 | ND | 21.7 | ND | ND | 6.2 | ND | 329 | 372 | 295 | 272 | 372 | 156 | 269 | 463 | 312 | 196 | 189 | 319 | 358 | 251 |
| Beryllium | 4 | 0.016 | - | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA |
| Cadmium | 5 | 18 | 5 | 0.25 J | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA |
| Calcium | - | - | - | 59000 | 51900 J | 57600 | 60100 | NA | NA | ND | 29700 | 28900 | 21400 | NA | NA | ND | ND | 10500 J | NA | 111000 | 125000 | 128000 | 104000 | 118000 | NA | NA | 148000 | 137000 | 118000 | 109000 | 130000 | NA | NA |
| Chromium | 100 | 180 (37000 | 100 | ND | ND | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | ND | ND | ND | ND | 7.2 J | 8.4 J | 6.2 J | 5.9 | 7.8 J | 15 | NA | 10.4 | 7.7 J | 5.8 | ND | 9.3 J | ND | NA |
| Cobalt | - | 2200 | - | ND | ND | ND | ND | ND | ND | 22.8 J | 22.1 J | 19.5 | 13.2 | ND | 30 U | 2.1 J | 2.1 J | ND | ND | 41.1 J | ND | 10.3 J | 9.4 | 11.4 | ND | ND | 12.5 J | 11 J | 8.4 | 8.2 | 11.8 | ND | ND |
| Copper | 1300 | 1500 | - | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | 25 U | ND | ND | ND | ND | ND | 1.4 J | 1.2 J | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Cyanide | 200 | 730 | 154 | NA | NA | NA | ND | NA | NA | NA | NA | NA | NA | NA | NA | ND | ND | NA | NA | ND | 1.5 J | NA | NA | NA | NA | NA | ND | ND | ND | ND | ND | NA | NA |
| Iron | 300 (s) | 11000 | - | ND | ND | ND | ND | ND | 302 J | 40000 | 36900 J | 42400 | 27900 J | 40700 | 42800 | ND | ND | ND | 600 | 39800 | 44400 | 45500 J | 40700 | 46200 | 46000 | 44700 | 41300 | 42400 J | 42700 | 38800 | 48000 J | 44,800 | 46,100 |
| Lead | 15 | - | 20 | 1.8 J | ND | ND | ND | NA | NA | 6.2 J | 12.5 | 8.1 | 10.8 | NA | NA | ND | ND | ND | NA | ND | ND | ND | 1.5 | ND | NA | NA | ND | 1.4 J | ND | ND | ND | NA | NA |
| Magnesium | - | - | - | 11500 | 11700 J | 11300 | 12400 | NA | NA | 5640 | 4750 J | 4740 J | 3430 | NA | NA | ND | ND | 1770 J | NA | 50500 J | 52100 J | 48100 J | 39300 J | 52700 | NA | NA | 61500 | 50900 J | 37300 J | 35100 J | 528000 | NA | NA |
| Manganese | 50 (s) | 840 | 200 | ND | ND | ND | ND | ND | ND | 13200 | 11600 | 9950 J | 6990 J | 8270 | 10500 | 3320 | 3230 | 831 J | 3370 | 2180 J | 2200 J | 2420 | 2220 J | 2300 J | 2050 | 2660 | 2530 | 2680 | 2740 J | 2560 J | 2550 J | 1,960 | 2,760 |
| Mercury | 2 | 11 | 2 | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | <0.01 R | NA | NA | ND | ND | ND | ND | <0.01 R | NA | NA |
| Nickel | 100 | 730 | 150 | ND | ND | ND | ND | NA | NA | ND | 6.2 J | 5.4 | 8.8 | NA | NA | ND | ND | ND | NA | 89.2 | 100 | 45.6 | 34.9 | 42.2 | NA | NA | 59.1 | 47.8 | 29 | 28.4 | 45.3 | NA | NA |
| Potassium | - | - | - | 4970 J | 4070 | 4100 | 4930 | NA | NA | ND | 2130 J | 2200 | ND | NA | NA | ND | ND | 2080 | NA | 34200 | 37800 | 31400 J | 27900 | 40300 | NA | NA | 41600 | 34200 J | 22400 | 21500 | 39700 | NA | NA |
| Selenium | 50 | 180 | 10 | 3.8 J | ND | ND | ND | NA | NA | 4.6 J | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA |
| Silver | 100 (s) | 180 | 50 | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | 1.4 J | ND | ND | ND | NA | NA |
| Sodium | - | - | - | 12100 | 12100 | 11500 | 13500 | NA | NA | ND | 6790 | 6850 | 6190 | NA | NA | ND | ND | 4360 | NA | 304000 | 344000 | 297000 | 256000 | 287000 | NA | NA | 363000 | 328000 | 258000 | 247000 | 288000 | NA | NA |
| Thallium | 2 | - | 0.4 | ND | ND | ND | ND | NA | NA | 7.1 J | ND | ND | ND | NA | NA | ND | ND | ND | NA | 6.8 J | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA |
| Vanadium | - | 260 | - | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | 0.71 J | ND | NA | ND | ND | 2.3 J | ND | ND | NA | NA | ND | 2.2 J | ND | ND | ND | NA | NA |
| Zinc | 5000 (s) | 11000 | - | 27.9 | ND | ND | ND | NA | NA | 31.6 | 7.6 J | ND | ND | NA | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA |

NA = Not analyzed. MCL = Federal Maximum Contaminant Level
ND = Not detected. RBC = USEPA Risk-Based Concentration, 10/95
J=Estimated Value. MEG= Maine Maximum Exposure Guidelines, 10/92.
(S)=Secondary MCL.

TABLE 2-8
GROUNDWATER ANALYTICAL DATA - South of Areas 3 4

FEASIBILITY STUDY REPORT
SACO MUNICIPAL LANDFILL
SACO, MAINE

| | | | | SOUTH OF LANDFILL AREAS 3 & 4 | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MW-95-4SA | | | | | | | MW-95-4SB | | | | | | MW-95-6R | | | | | | | | MW-95-6S | | | | | |
| Parameter | MCL | RBC | MEGs | 1/10/96 | 5/21/96 | 5/22/96 | 11/6/96 | 7/15/97 | 12/15/97 | 6/17/98 | 1/11/96 | 5/21/96 | 11/6/96 | 7/14/97 | 12/15/97 | 6/17/98 | 1/9/96 | 5/15/96 | 11/20/96 | 7/14/97 | 7/14/97 DUP | 12/11/97 | 6/23/98 | 6/23/98 DUP | 1/12/96 | 5/15/96 | 11/20/96 | 7/14/97 | 12/11/97 | 6/23/98 |
| **VOCs µg/L** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1,1-Dichloroethane | - | 810 | 5 | 1 J | NA | 0.6 J | ND | ND | NA | NA | ND | 0.2 J | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| 1,1-Dichloropropene | - | - | - | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| 1,1,2,2-Tetrachloroethane | - | 0.052 | - | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| 1,2,3-Trichlorobenzene | - | - | - | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| 1,2,3-Trichloropropane | - | 0.0015 | 40 | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| 1,2,4-Trichlorobenzene | 70 | 190 | 70 | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| 1,2,4-Trimethylbenzene | - | 300 | - | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| 1,2-Dibromo-3-chloropropane | - | 0.048 | - | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| 1,2-Dichlorobenzene | 600 | 270 | - | 2 | NA | ND | 2 | 2 | NA | NA | 1 J | ND | 0.9 J | 0.8 J | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| 1,2-Dichloroethane | 5 | 0.12 | 5 | 2 | NA | 0.5 J | ND | ND | NA | NA | 1 J | 0.3 J | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| 1,2-Dichloropropane | 5 | 0.16 | 5 | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| 1,3-Dichlorobenzene | 600 | 540 | - | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| 1,3,5-Trimethylbenzene | - | 300 | - | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| 1,4-Dichlorobenzene | 75 | 0.44 | - | 2 | NA | ND | 2 | 2 | NA | NA | 1 J | ND | 1 | 1 | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| 2-Butanone | - | 1900 | 170 | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| 2-Chlorotoluene | - | 120 | - | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| 2-Hexanone | - | - | - | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| 2,2-Dichloropropane | - | - | - | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | 0.2 J | ND | NA | NA | NA |
| 4-Isopropytoluene | - | - | - | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | 1 J | ND | ND | NA | NA | NA |
| 4-Methyl-2-pentanone | - | - | - | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| Acetone | - | 3700 | - | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| Benzene | 5 | 0.36 | 5 | 4 | NA | 3 | 1 | 2 | NA | NA | 1 | 2 | 1 | 1 | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| Bromobenzene | - | - | - | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| Chlorobenzene | 100 | 39 | - | 1 | NA | 1 | 0.9 J | 1 | NA | NA | ND | 0.4 J | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| Chloroethane | - | 8600 | - | 22 | NA | 12 | 6 | 5 | NA | NA | 5 | 7 | 3 | 4 | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| Chloroform | | | | | | | | | | | | | | | NA | NA | | | | | | | | | | | | | | |
| Chloromethane | - | 1.4 | 3 | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| cis-1,2-DCE | - | 61 | 70 | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | 0.6 J | NA | NA | NA |
| Dichlorodifluoromethane | - | 390 | 1050 | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| Ethylbenzene | 700 | 1300 | 700 | 1 | NA | ND | ND | ND | NA | NA | ND | 0.3 J | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | 0.7 J | NA | NA | NA |
| Hexachlorobutadiene | - | 0.14 | 1 | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| Isopropylbenzene | - | - | - | 1 J | NA | ND | ND | ND | NA | NA | ND | 0.3 J | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| Isopropyltoluene | - | - | - | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| Methylene Chloride | - | 4.1 | - | ND | NA | ND | ND | ND | NA | NA | ND | 1 | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| Naphthalene | - | 1500 | 25 | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| Styrene | 100 | 1600 | 5 | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| Tetrachloroethene | 5 | 1.1 | 3 | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| Tetrahydrofuran | - | - | - | 14 J | NA | ND | ND | ND | NA | NA | 3 J | ND | ND | ND | NA | NA | 5 J | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| Toluene | 1000 | 750 | 1400 | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| trans-1,2-DCE | 100 | 120 | 70 | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| Trichloroethene | 5 | 1.6 | 5 | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | 0.7 J | NA | NA | NA |
| Trichlorofluoromethane | - | 1300 | 2300 | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| Vinyl Chloride | 2 | 0.019 | 0.15 | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| m-Xylene/p-Xylene | 10000 | 1400/520 | 600 | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | 0.8 J | NA | NA | NA | NA | NA | ND | ND | 3 | NA | NA | NA |
| n-Butylbenzene | - | - | - | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| n-Propylbenzene | - | - | - | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| o-Xylene | 10000 | 1400 | 600 | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| sec-Butylbenzene | - | 61 | - | ND | NA | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA |
| MTBE | | | | | | | | | NA | NA | | | | | | | | | | | | | | | | | | | | |
| **SVOCs µg/L** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2-Methylnaphthalene | - | - | - | ND | NA | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA |
| 2,4-Dimethylphenol | - | 730 | - | ND | NA | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA |
| 4-Chloro-3-methylphenol | - | - | - | ND | NA | ND | NA | NA | NA | NA | 1 J | ND | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA |
| 4-Methylphenol | - | 180 | - | ND | NA | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA |
| Acenaphthylene | - | - | 0.03 | ND | NA | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA |
| Benzo(a)pyrene | - | 0.0092 | 0.03 | ND | NA | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA |
| Benzo(g,h,i)perylene | - | - | 0.03 | ND | NA | ND | NA | NA | NA | NA | 3 J | ND | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA |
| Benzo(k)fluoranthene | - | 0.92 | 0.03 | ND | NA | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA |
| Bis(2-ethylhexyl)phthalate | - | 4.8 | - | ND | NA | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA |
| Dibenzo(a,h)anthracene | - | 0.0092 | 0.03 | ND | NA | ND | NA | NA | NA | NA | 2 J | ND | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA |
| Diethylphthalate | - | 29000 | - | 1 J | NA | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA |
| Di-n-butylphthalate | - | - | 220 | ND | NA | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA |
| Indeno(1,2,3-cd)pyrene | - | 0.092 | - | ND | NA | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA |
| Phenol | - | 22000 | - | ND | NA | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA |
| **Metals µg/L** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Aluminum | 50-200(s) | 37000 | 1430 | ND | ND | NA | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | 120 J | ND | ND | ND | 165 | ND | ND | ND |
| Antimony | 6 | 15 | - | ND | ND | NA | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA |
| Arsenic | 50 | 11 (0.045) | - | 202 | 234 J | NA | 217 | 187 | 221 | 130 | 29.7 | 73 | 81 | 95.4 | 8.2 | 72 | ND | ND | ND | ND | ND | ND | ND | ND | ND | 6.5 J | 12.2 | ND | ND | 10 |
| Barium | 2000 | 2600 | 1500 | 209 | 142 | NA | 97.9 | 109 | 130 | 216 | 51.3 J | 66.1 | 47.6 | 58.7 | 47.5 | 120 | ND | 12.3 | 15.4 | 13.5 | 14.2 | ND | NA | NA | ND | 8.1 | 11.9 | 12.4 | ND | 10.5 |
| Beryllium | 4 | 0.016 | - | ND | ND | NA | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA |
| Cadmium | 5 | 18 | 5 | ND | ND | NA | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA |
| Calcium | - | - | - | 109000 | 95600 | NA | 78500 | 73400 | NA | NA | ND | 49900 J | 41400 | 46900 | NA | NA | ND | 50500 J | 54200 | 58000 | 60700 | NA | NA | NA | ND | 23800 J | 30600 | 32800 | NA | NA |
| Chromium | 100 | 180 (37000 | 100 | ND | 8.7 J | NA | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | NA |
| Cobalt | - | 2200 | - | 16.2 J | 16 J | NA | 12.8 | 15 | ND | 30 | 5.4 J | ND | 9.3 | 10.5 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Copper | 1300 | 1500 | - | ND | ND | NA | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | ND |
| Cyanide | 200 | 730 | 154 | ND | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA | ND | NA | NA | ND | ND | NA | NA | NA | ND | NA | NA | ND | NA | NA |
| Iron | 300 (s) | 11000 | - | 31300 | 31600 J | NA | 27200 | 30300 J | 39,000 | 60,400 | ND | 23100 J | 17500 | 22100 J | 16,000 | 43,800 | ND | ND | 834 | 227 J | ND | 160 | 189 J | 133 J | ND | 5550 J | 6040 | 6410 J | 3,700 | 6,510 J |
| Lead | 15 | - | 20 | 2 J | ND | NA | ND | ND | NA | NA | ND | ND | ND | 5.6 | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA |
| Magnesium | - | - | - | 22300 | 19000 J | NA | 15000 J | 14800 | 6010 | 9620 | 8760 | 10100 J | 7660 J | 9540 | NA | NA | 11200 | 12300 J | 12000 | 13000 | 13600 | NA | NA | NA | 5470 | 5050 J | 5980 | 7210 | NA | NA |
| Manganese | 50 (s) | 840 | 200 | 5300 | 5120 | NA | 4310 J | 4290 J | NA | NA | 6450 | 6600 J | 5190 J | 6640 J | 6,280 | 16,500 | ND | ND | ND | ND | ND | ND | ND | ND | 705 | 213 J | 239 | 229 J | 234 | 218 |
| Mercury | 2 | 11 | 2 | ND | ND | NA | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | <0.01 R | <0.01 R | NA | NA | NA | ND | ND | ND | ND | NA | NA |
| Nickel | 100 | 730 | 150 | 16.7 | 18 J | NA | 10.7 | 11.6 | NA | NA | ND | ND | 8.1 | 11.3 | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA |
| Potassium | - | - | - | 6630 | 5610 J | NA | 3910 | 5520 | NA | NA | 4230 J | 3970 | 3690 | 4570 | NA | NA | ND | 3500 | 3780 | 3940 | 4340 | NA | NA | NA | ND | 1340 | 222 | ND | NA | NA |
| Selenium | 50 | 180 | 10 | ND | ND | NA | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | 4.3 J | ND | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA |
| Silver | 100 (s) | 180 | 50 | ND | ND | NA | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA |
| Sodium | - | - | - | 134000 | 103000 | NA | 63400 | 71600 | NA | NA | 34400 | 37800 | 31100 | 37500 | NA | NA | 17900 | 13500 | 13600 | 14800 | 15400 | NA | NA | NA | ND | 5330 | 5850 | 6520 | NA | NA |
| Thallium | 2 | - | 0.4 | ND | ND | NA | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA |
| Vanadium | - | 260 | - | 1.2 J | 0.68 J | NA | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA |
| Zinc | 5000 (s) | 11000 | - | ND | ND | NA | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | ND | ND | ND | ND | NA | NA |

NA = Not analyzed. MCL = Federal Maximum Contaminant Level
ND = Not detected. RBC = USEPA Risk-Based Concentration, 10/95
J=Estimated Value. MEG= Maine Maximum Exposure Guidelines, 10/92.
(S)=Secondary MCL.

**TABLE 2-9**
**GROUNDWATER ANALYTICAL DATA - South of Areas 3 4**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| | | | | SOUTH OF LANDFILL AREAS 3 & 4 | | | | | | | | | | | | | | | | | | | | | | | | UPGRADIENT LOCATION | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MW-95-7R | | | | | | MW-95-7S | | | | | | MW-95-8R | | | | | | MW-97-13R | | MW-97-13S1 | | MW-97-17R | MW-97-18S | MW-93-1 | | MW-93-7 | |
| Parameter | MCL | RBC | MEGs | 12/19/95 | 5/22/96 | 11/5/96 | 7/14/97 | 12/12/97 | 6/16/98 | 1/9/96 | 5/15/96 | 11/19/96 | 7/15/97 | 12/11/97 | 6/23/98 | 12/21/95 | 5/13/96 D | 5/13/96 T | 11/20/96 | 7/16/97 | 6/16/98 | 12/16/97 | 6/23/98 | 12/13/97 | 6/19/98 | 6/16/98 | 6/16/98 | 1/15/96 | 5/17/96 | 1/17/96 | 5/20/96 |
| **VOCs µg/L** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1,1-Dichloroethane | - | 810 | 5 | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| 1,1-Dichloropropene | - | - | - | 1 J | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| 1,1,2,2-Tetrachloroethane | - | 0.052 | - | 1 J | ND | ND | 1 J | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| 1,2,3-Trichlorobenzene | - | - | - | 1 J | ND | 0.8 J | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| 1,2,3-Trichloropropane | - | 0.0015 | 40 | 1 J | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| 1,2,4-Trichlorobenzene | 70 | 190 | 70 | 1 J | ND | 0.6 J | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| 1,2,4-Trimethylbenzene | - | 300 | - | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| 1,2-Dibromo-3-chloropropane | - | 0.048 | - | 1 | ND | ND | 1 J | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| 1,2-Dichlorobenzene | 600 | 270 | - | 1 J | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| 1,2-Dichloroethane | 5 | 0.12 | 5 | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| 1,2-Dichloropropane | 5 | 0.16 | 5 | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| 1,3-Dichlorobenzene | 600 | 540 | - | 1 J | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| 1,3,5-Trimethylbenzene | - | 300 | - | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| 1,4-Dichlorobenzene | 75 | 0.44 | - | 1 J | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | 1 J | ND | ND | 0.7 J | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| 2-Butanone | - | 1900 | 170 | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| 2-Chlorotoluene | - | 120 | - | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| 2-Hexanone | - | - | - | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| 2,2-Dichloropropane | - | - | - | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| 4-Isopropytoluene | - | - | - | ND | ND | 4 J | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| 4-Methyl-2-pentanone | - | - | - | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| Acetone | - | 3700 | - | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| Benzene | 5 | 0.36 | 5 | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | 1 | ND | 0.3 J | 0.7 J | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| Bromobenzene | - | - | - | 1 J | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| Chlorobenzene | 100 | 39 | - | 1 J | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | 1 J | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| Chloroethane | - | 8600 | - | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | 2 J | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| Chloroform | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Chloromethane | - | 1.4 | 3 | ND | ND | 2 J | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| cis-1,2-DCE | - | 61 | 70 | ND | ND | ND | ND | NA | NA | ND | ND | 5 | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| Dichlorodifluoromethane | - | 390 | 1050 | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | 1 J | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| Ethylbenzene | 700 | 1300 | 700 | 1 J | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | 1 J | ND | 0.2 J | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| Hexachlorobutadiene | - | 0.14 | 1 | 1 J | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| Isopropylbenzene | - | - | - | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| Isopropyltoluene | - | - | - | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| Methylene Chloride | - | 4.1 | - | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| Naphthalene | - | 1500 | 25 | 1 J | ND | 0.8 J | 1 J | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | 1 J | NA | NA | NA |
| Styrene | 100 | 1600 | 5 | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| Tetrachloroethene | 5 | 1.1 | 3 | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| Tetrahydrofuran | - | - | - | 3 J | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| Toluene | 1000 | 750 | 1400 | 1 J | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | 1 J | ND | 0.5 J | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| trans-1,2-DCE | 100 | 120 | 70 | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| Trichloroethene | 5 | 1.6 | 5 | ND | ND | 2 J | ND | NA | NA | ND | ND | 7 | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| Trichlorofluoromethane | - | 1300 | 2300 | 1 J | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| Vinyl Chloride | 2 | 0.019 | 0.15 | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| m-Xylene/p-Xylene | 10000 | 1400/520 | 600 | 1 J | ND | 0.5 J | ND | NA | NA | ND | ND | ND | ND | NA | NA | 1 J | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| n-Butylbenzene | - | - | - | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| n-Propylbenzene | - | - | - | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| o-Xylene | 10000 | 1400 | 600 | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| sec-Butylbenzene | - | 61 | - | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | NA | NA | NA |
| MTBE | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **SVOCs µg/L** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2-Methylnaphthalene | - | - | - | ND | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | ND | NA | ND | NA |
| 2,4-Dimethylphenol | - | 730 | - | ND | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | ND | NA | ND | NA |
| 4-Chloro-3-methylphenol | - | - | - | ND | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | 1 J | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | ND | NA | ND | NA |
| 4-Methylphenol | - | 180 | - | ND | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | ND | NA | ND | NA |
| Acenaphthylene | - | - | 0.03 | ND | ND | NA | NA | NA | NA | 1 J | ND | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | ND | NA | ND | NA |
| Benzo(a)pyrene | - | 0.0092 | 0.03 | ND | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | ND | NA | ND | NA |
| Benzo(g,h,i)perylene | - | - | 0.03 | ND | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | ND | NA | ND | NA |
| Benzo(k)fluoranthene | - | 0.92 | 0.03 | ND | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | ND | NA | ND | NA |
| Bis(2-ethylhexyl)phthalate | - | 4.8 | - | 12 | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | ND | NA | ND | NA |
| Dibenzo(a,h)anthracene | - | 0.0092 | 0.03 | ND | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | ND | NA | ND | NA |
| Diethylphthalate | - | 29000 | - | ND | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | ND | NA | ND | NA |
| Di-n-butylphthalate | - | - | 220 | ND | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | ND | NA | ND | NA |
| Indeno(1,2,3-cd)pyrene | - | 0.092 | - | ND | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | ND | NA | ND | NA |
| Phenol | - | 22000 | - | ND | ND | NA | NA | NA | NA | ND | ND | NA | NA | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | 1 J | NA | ND | NA |
| **Metals µg/L** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Aluminum | 50-200(s) | 37000 | 1430 | 430 J | 400 | ND | ND | 338 | 200 | ND | ND | ND | ND | ND | ND | 891 J | ND | 5690 J | ND | ND | 100 U | 3910 | 970 | NA | NA | 100 U | 100 | ND | 694 J | ND | ND |
| Antimony | 6 | 15 | - | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | ND | ND | ND |
| Arsenic | 50 | 11 (0.045) | - | 21.1 | ND | 2.5 | ND | ND | 8 U | ND | ND | ND | ND | ND | ND | 164 | 79.6 | 81.7 | 121 | 96.5 | 64 | 179 | 40 | NA | NA | 8 U | 8 U | 24.7 | 28.2 | ND | ND |
| Barium | 2000 | 2600 | 1500 | 13.3 J | ND | 6.6 | 4.5 | ND | 13 | ND | 13.1 | 13.2 | 9.8 | ND | 8.4 | 57.5 J | 24.4 | 43.6 | 41.4 | 37.7 | 109 | 12 | 19.6 | NA | NA | 8.6 | 10 | ND | 7.2 | ND | 13.9 |
| Beryllium | 4 | 0.016 | - | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | ND | ND | ND |
| Cadmium | 5 | 18 | 5 | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | ND | ND | ND |
| Calcium | - | - | - | 14700 | 13400 | 14400 | 11600 | NA | NA | ND | 26700 J | 27600 | 27600 | NA | NA | 41700 | 21700 J | 26100 J | 36800 | 41000 | NA | NA | NA | NA | NA | NA | NA | ND | 20200 J | ND | 13200 J |
| Chromium | 100 | 180 (37000 | 100 | 1.7 J | ND | ND | ND | ND | NA | ND | ND | ND | ND | ND | NA | 1.3 J | ND | ND | ND | ND | NA | ND | NA | NA | NA | NA | NA | ND | ND | ND | ND |
| Cobalt | - | 2200 | - | 5.3 J | 1.5 J | ND | ND | ND | 30 U | 1.2 J | 6 J | ND | ND | ND | ND | 74.6 | 38.6 | 41.6 | 60.6 | 59.6 | 117 | ND | ND | NA | NA | 30 U | 30 U | 0.88 J | ND | ND | ND |
| Copper | 1300 | 1500 | - | ND | ND | ND | ND | ND | 25 U | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | 25 U | ND | ND | NA | NA | 25 U | 25 U | ND | ND | ND | ND |
| Cyanide | 200 | 730 | 154 | ND | NA | NA | ND | NA | NA | ND | NA | NA | ND | NA | NA | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | NA | NA | ND | NA | ND | NA |
| Iron | 300 (s) | 11000 | - | 4250 | 412 J | ND | ND | 830 | 1800 | ND | ND | 543 | 286 J | 130 | 117 J | 35000 | 16800 J | 20400 J | 26600 | 23900 J | 65100 | 40700 | 600 | NA | NA | 1240 | 148 | ND | 763 J | ND | ND |
| Lead | 15 | - | 20 | ND | ND | ND | 5 | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | 65.1 | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | ND | ND | ND |
| Magnesium | - | - | - | 2640 J | 2150 J | 2250 J | 1900 | NA | NA | ND | 4990 J | 5500 | 4840 | NA | NA | 6310 J | 3040 J | 4620 J | 4460 | 4800 | NA | NA | NA | NA | NA | NA | NA | 5340 | 5320 J | 6590 | 6010 J |
| Manganese | 50 (s) | 840 | 200 | 584 J | 192 | 156 J | 25.9 J | 30.9 | 1070 | 246 | 1040 J | 570 | 2945 | 148 | 172 | 8800 J | 7300 J | 7780 J | 8690 | 9910 J | 16400 | 8270 | 3370 | NA | NA | 19.6 | 120 | ND | 75.9 J | ND | 11.6 J |
| Mercury | 2 | 11 | 2 | ND | ND | ND | <0.01 R | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | <0.01 R | NA | NA | NA | NA | NA | NA | NA | ND | ND | ND | ND |
| Nickel | 100 | 730 | 150 | 11.4 J | 5.4 J | 7 | ND | NA | NA | ND | ND | ND | ND | NA | NA | 95.4 | 47.6 | 56.1 | 67.3 | 95 | NA | NA | NA | NA | NA | NA | NA | ND | ND | ND | ND |
| Potassium | - | - | - | ND | 1090 J | 696 | ND | NA | NA | ND | 2760 | 3140 | 2480 | NA | NA | 4470 J | 2500 | 2530 | 3470 | 3110 | NA | NA | NA | NA | NA | NA | NA | ND | 3320 | ND | 2990 |
| Selenium | 50 | 180 | 10 | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | 6.9 J | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | ND | ND | ND |
| Silver | 100 (s) | 180 | 50 | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | 1.5 | ND | NA | NA | NA | NA | NA | NA | NA | ND | ND | ND | ND |
| Sodium | - | - | - | 13300 | 5530 | 5130 | 4360 | NA | NA | 34000 | 13400 | 11900 | 7920 | NA | NA | 15600 | 6160 | 8220 | 7570 | 7350 | NA | NA | NA | NA | NA | NA | NA | 27100 | 28900 | 61700 | 53300 |
| Thallium | 2 | - | 0.4 | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | 11 J | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | ND | ND | ND |
| Vanadium | - | 260 | - | ND | ND | ND | ND | NA | NA | 0.6 J | ND | ND | ND | NA | NA | 0.95 J | ND | 2 J | ND | ND | NA | NA | NA | NA | NA | NA | NA | 2.3 J | 1.6 J | ND | 0.88 J |
| Zinc | 5000 (s) | 11000 | - | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | NA | NA | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | NA | NA | ND | ND | ND | ND |

NA = Not analyzed. MCL = Federal Maximum Contaminant Level
ND = Not detected. RBC = USEPA Risk-Based Concentration, 10/95
J=Estimated Value. MEG= Maine Maximum Exposure Guidelines, 10/92.

RI/FS Monitoring Wells - Nineteen of the 28 wells sampled in December 1997 and 27 wells sampled in June 1998 had been sampled at least twice previously. No significant changes in either detected analytes or concentrations were noted in the following 13 monitoring wells:

| | |
|---|---|
| • MW-95-4R, MW-95-4SA, MW-95-4SB, MW-95-4RD, | Area 4 |
| • MW-95-6S, | Area 4 |
| • MW-95-7S, MW-95-7R, | Area 4 |
| • MW-95-9S, | Area 2 |
| • MW-95-3R, | Area 4 |
| • MW-95-5R, | Areas 1 and 2 |
| • MW-95-8R, | Area 2 |
| • MW-93-5, | Area 4 |
| • MW-96-9R. | Area 4 |

However, differences in inorganic analyte concentrations from previous results were noted for some monitoring wells and are discussed below for Landfill Area 2 and Landfill Areas 3 and 4. These differences likely reflect the inherent variability in environmental sampling.

**Area 2 Wells**

The most notable difference between the 1997-98 data and previous data collected at Area 2 was the detection of aluminum in two wells where this metal had previously not been detected. Aluminum was detected at 430 μg/L in MW-13 during the December 1997 event but was below detection levels in two prior events and during the June 1998 event. Aluminum was detected at 420 and 170 μg/L in MW-95-11S during the December 1997 and June 1998 events, respectively, and was below detection levels during two prior events. There is no Maximum Contaminant Level (MCL) for aluminum; however, these reported concentrations are all below the Maximum Exposure Guideline (MEG) for aluminum of 1,430 μg/L developed by the Maine Department of Human Services (MEDHS). Iron concentrations in MW-95-8S have increased from below detection levels in the first two sampling events (1995-96), to 380, 560, and 1,920 μg/L in the last three sampling events, including 1997-98. There is no primary MCL or MEG for iron. While this apparent increase in iron concentrations is not currently understood, MW-

95-8S will continue to be sampled during Post-ROD long-term monitoring. Evaluation of this data may reveal a trend.

**Areas 3 and 4 Wells**

Notable differences between the analytical data for 1997-98 and previous sampling events were observed in seven wells. As with Area 2, aluminum was detected in four monitoring wells (i.e., MW-95-8S, MW-95-2S, MW-95-6R and MW-93-3) during the 1997-98 sampling at locations where it had previously not been detected. Concentrations of aluminum in these wells ranged from 120 μg/L (MW-95-6R) to 1,080 μg/L (MW-95-8S), all below the MEG of 1,430 μg/L.

Other differences observed at Areas 3 and 4 include changes in arsenic and iron concentrations at MW-95-1S and MW-95-1R located north of the landfill. Arsenic was detected for the first time in MW-95-1S at 13 μg/L during the June 1998 event. Iron concentrations have also increased over the five sampling events from below detection levels to 11,600 μg/L in June 1998. Concentrations of arsenic, iron, and manganese have increased two- to three-fold in MW-95-1R between the 1997-98 events and four prior sampling events.

Concentrations of barium, cobalt, iron, and manganese in MW-95-8R located to the west of the landfill in June 1998 were approximately twice the reported concentrations during four prior events. However, the arsenic concentration in this well in June 1998 (64 μg/L) was the lowest reported concentration for this well.

Although changes were noted between the 1997-98 sampling results and previous data, it is unlikely they reflect a significant change in environmental conditions at this site. These changes likely reflect the inherent variability in environmental media and sampling. Overall, these data are consistent with previously collected data and support the site conceptual model for this site.

<u>USGS Monitoring Wells</u> - The nine USGS monitoring wells installed around Landfill Areas 3 and 4 were sampled both in December 1997 and June 1998. Data from these wells provide additional information on the distribution of groundwater contaminants in the aquifer between the toe of the landfill and Sandy Brook. Eight of the nine wells are located southeast and downgradient of Landfill Areas 3 and 4; one well (i.e., MW-97-17R) is located southwest of the landfill.

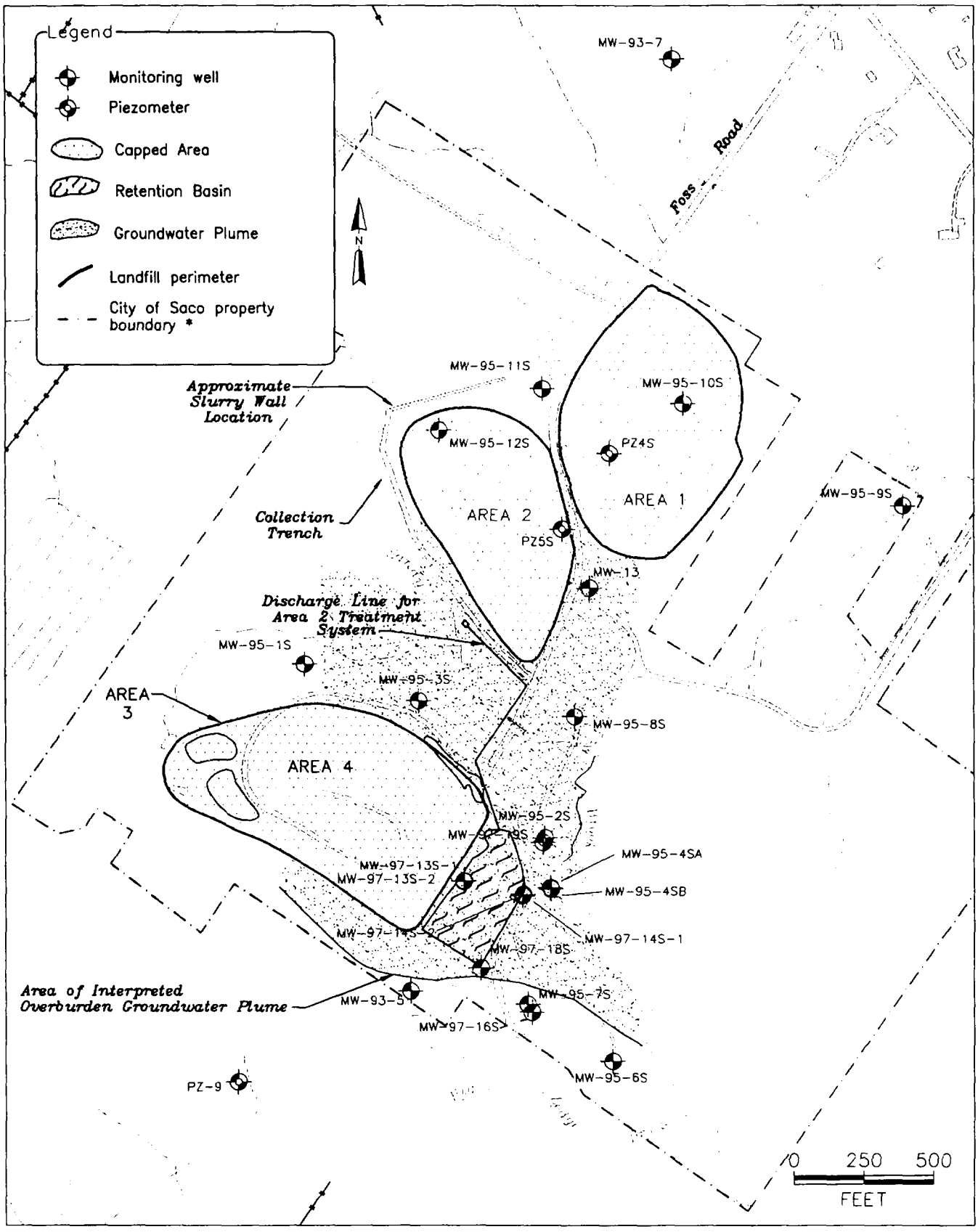
Monitoring well series MW-97-13 includes three wells: two in the unconsolidated gravel and clay deposit (S1 and S2), and one in shallow bedrock (R). All three monitoring wells are located between the toe of the landfill and the sediment retention basin, and contained elevated concentrations of arsenic. The overburden wells contained the highest arsenic concentrations reported at the site, ranging from 700 to 800 μg/L. The bedrock well contained arsenic at concentrations ranging from 40 to 179 μg/L. Manganese and iron were also detected at elevated concentrations, with concentrations highest in the shallowest well (S1) and decreasing with depth.

Monitoring well series MW-97-14, located downgradient of the MW-97-13 series wells, includes two wells in the unconsolidated material: S1 and S2. Arsenic was detected at concentrations of 149 to 232 μg/L in S1 and at concentrations of 115 to 119 μg/L in S2. Iron and manganese were also detected at elevated concentrations. Arsenic was also detected in monitoring well MW-97-19S, located east of Landfill Area 4, at concentrations of 150 to 190 μg/L.

Arsenic was not detected in monitoring wells MW-16S, MW-17R, and MW-18S, the southernmost of the USGS wells.

**2.3.3.3 Chemical Plume Maps** – An interpretive plume map presented as Figure 2-5 illustrates the distribution of arsenic, iron, and manganese in the overburden aquifer based on the June 1998 data. Figure 2-6 shows the isopleths for arsenic in the bedrock aquifer based on the June 1998 data.

Figure 2-7 shows a cross-section of the gravel pit, from the toe of the landfill to Sandy Brook. This figure shows the distribution of arsenic in both the overburden and bedrock aquifers based on June 1998 data from both RI/FS and USGS monitoring wells. Arsenic concentrations in the overburden aquifer are greatest in the MW-97-13 series wells and decreased by almost an order of magnitude to the MW-97-14 series wells located approximately 400 feet downgradient of the landfill. The observed decrease in concentration is attributed primarily to dilution through precipitation recharge to the aquifer. Groundwater bedrock contamination appears limited to the upper fractured portion of the rock. The strong upward gradients observed in these wells indicate groundwater flow from the rock to the overburden aquifer with ultimate discharge to Sandy Brook.




* Source: City of Saco Property Maps 88 and 97

Figure 2-5
Interpretive Plume Map for June 1998,
Overburden Groundwater
Feasibility Study Report
Saco Municipal Landfill
Saco, Maine

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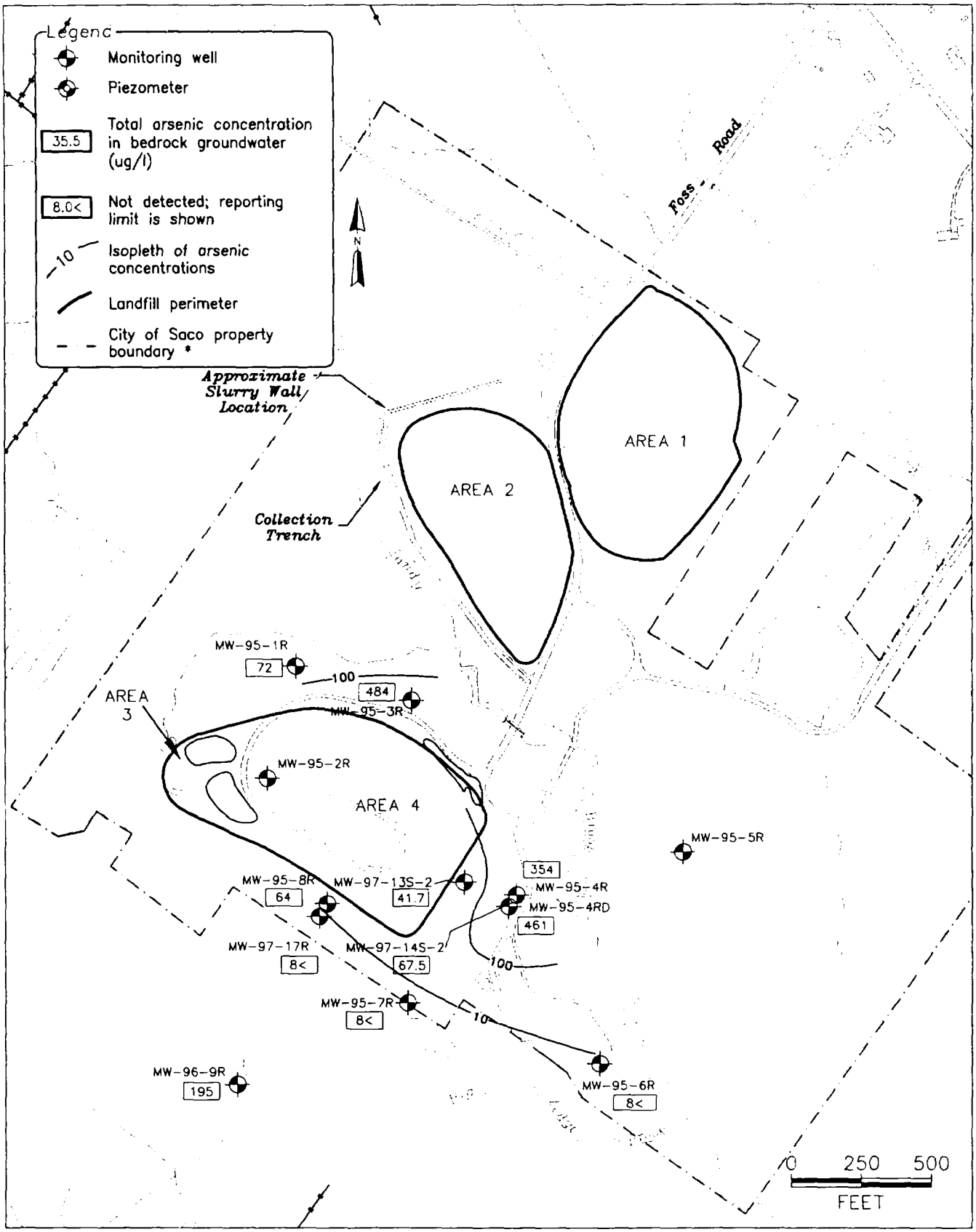


* Source: City of Saco Property Maps 88 and 97

Figure 2-6
Interpretive Total Arsenic Isopleth Map for June 1998
Bedrock Groundwater
Feasibility Study Report
Saco Municipal Landfill
Saco, Maine

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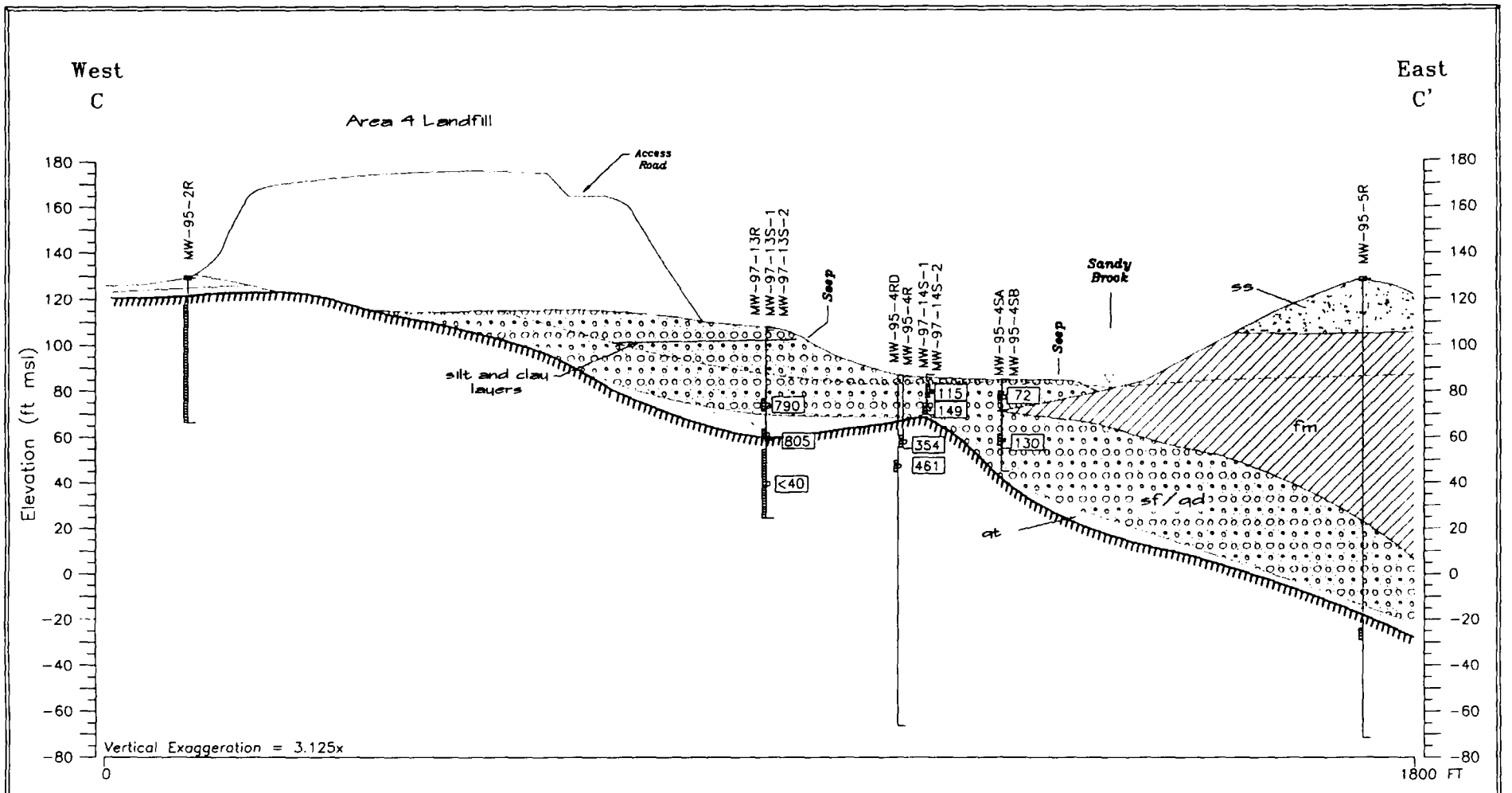
9810030.dwa/95093/lat




| | | | |
|---|---|---|---|
| | Fill | | Bedrock |
| ss | Marine sand facies | | Water table (January 1996) |
| fm | Silt-clay facies | | Monitoring well or piezometer |
| sf/gd | Coarse-grained glaciomarine deposits | | |
| gt | Glacial till | 461 | Arsenic concentration (ug/l) (June 1998) |

Note: See Phase IA RI report, Figure 3-1 for cross section location.

Figure 2-7
Arsenic Distribution Downgradient of Landfill in Cross Section
Feasibility Study Report
Saco Municipal Landfill
Saco, Maine

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fig2-7/95093/pff

Overall, the chemical distribution in the overburden and bedrock aquifers has remained consistent over past sampling events (e.g., 1997, 1998, and 1999). This distribution appears to be controlled by the groundwater flow paths and geology at this site, as is described in the following two sections.

## 2.4 PUMPING TEST AND GROUNDWATER MODELING

The hydrogeological investigation and modeling efforts at the SML site were completed to further the understanding of site conditions. The construction of the groundwater model has led to a better understanding of the site conditions, particularly the water balance and groundwater within the flow system. This improved understanding has allowed for the evaluation of various remedial activities. The Hydrogeological Investigation Report and supporting materials are presented in Appendix B-1 and B-2, respectively. Calculations related to mixing of contaminants in surface water are presented in Appendix B-3.

The following findings were identified from the hydrogeological investigation and modeling:

- While there are no wells installed through the Area 4 landfill cap, the model predicted the greatest degree of change in modeled groundwater elevations beneath the landfill, subsequent to capping, would occur during the first two years (approximately 10 ft.);
- Groundwater elevations downgradient from the capped area are not significantly affected by the cap because of their location;
- Volume of groundwater moving through bedrock and till beneath the landfill is estimated at less than 5% of the total groundwater flow. The volume of groundwater moving through the sand and gravel deposits is estimated at greater than 95% of the total groundwater flow;
- Radial flow from the landfill causes groundwater in the northern portion of the landfill to flow under Sandy Brook then flow southwest again eventually discharging within the same area in Sandy Brook; and
- Approximately one pore volume will be flushed from between the toe of the landfill and Sandy Brook within 2 years.

The overall understanding of the flow system indicates that groundwater flow is controlled by the bedrock and surface topography of the site. Groundwater flow is directed radially away from a bedrock high located just to the west of Landfill Areas 3 and 4. The groundwater flowing from the northern boundary of the landfill gradually turns to the east and then turns again to the south-southwest, paralleling the flow of Sandy Brook. The groundwater at the southeast toe of the landfill flows generally southeast toward, and discharges to, Sandy Brook (see plume distribution Figure 2-5).

Groundwater and surface water interactions at the site are governed by the discontinuous nature of the silt and clay deposits of the Presumpscot Formation (Fm.) and their relationship to the sand and gravel deposits of the lower aquifer (W&C, 1998a). The Presumpscot Fm. is present below the portion of the stream between Areas 3 and 4 and Areas 1 and 2. The presence of this clay and silt layer limits the discharge of groundwater to the stream between Areas 1 and 2 and Areas 3 and 4. The Presumpscot Fm. is absent beneath the stream directly downgradient of Areas 3 and 4 allowing for greater discharge to the stream via the higher conductivity sand and gravel deposits.

## 2.5 CONCEPTUAL MODEL

Based on work completed during the RI phase of the investigation and subsequent investigations completed by the USGS, a conceptual model for the occurrence of arsenic in groundwater has been developed for this site. The studies focused on the aqueous geochemistry of the system as a whole in an effort to understand the mechanisms that allow for the release of arsenic from naturally-deposited and landfilled materials.

Analyses of samples of the bedrock and overburden were conducted by the USGS to determine the chemical composition of the native materials at the site. The whole rock analyses results and references to the laboratory column tests completed by the USGS are provided in Appendix C. In general, whole rock analyses indicate that the concentrations of arsenic on the west side of the stream range from 3 to 15 mg/kg in the bedrock and from 1 to 3 mg/kg in the overburden materials. The concentration of arsenic from whole rock digestion for the sand on the east side of Sandy Brook was below approximately 1 mg/kg.

### 2.5.1 Occurrence of Arsenic in Groundwater

Two distinct, yet dependent, processes govern the occurrence of arsenic in groundwater at the SML site; the first is a biological process, and the second is a physical process (Colman and Lyford, 1999, Stollenwerk and Colman, 1998; Stollenwerk and Colman, 1999). The biological process is the consumption of oxygen by microbial organisms as they feed on the dissolved organic carbon (DOC) present in the system. The physical process is the reductive dissolution of arsenic and iron contained both within the aquifer materials and in the bedrock caused by the reducing conditions created by depletion of oxygen below the landfill.

Infiltration of rainwater through landfill wastes generates leachate. As waste materials in the form of DOC are degraded by microorganisms, oxygen is consumed and the supply of dissolved oxygen in the leachate is depleted creating reducing conditions within the leachate. The reducing conditions of the leachate cause the reductive dissolution of arsenic and other metals (i.e. iron and manganese) from the natural overburden and bedrock materials beneath the landfill. As arsenic- and iron-rich leachate mixes with more oxygenated water downgradient of the landfill, arsenic co-precipitates with iron, coating the overburden aquifer materials, and in effect "staining" the aquifer materials.

Arsenic is present, primarily in its As(III) form, along with high concentrations of iron and manganese as coatings on the grains of the overburden materials. The USGS studies indicate that mobile arsenic (i.e., As(III)) is present in groundwater only when oxygen is absent. In addition, speciation modeling conducted by the USGS indicated that arsenic minerals are not formed. The USGS study also showed that dissolved As(III) is in equilibrium with substantial amounts of As(III) adsorbed on the solid phase. A reductive dissolution model for arsenic dissolved from iron hydroxide coatings adequately explains observed arsenic to iron ratios in source materials and leachate plume water in areas where overburden was isolated from the bedrock by the presence of the Presumpscot Fm. (i.e., east of Sandy Brook). In areas where overburden and bedrock are not separated by the Presumpscot Fm. (i.e., west side of Sandy Brook), sources within both the bedrock and overburden are necessary to explain the observed arsenic to iron ratios in the leachate. For either situation, natural arsenic in native materials accounts for elevated concentrations of arsenic in groundwater and sediment.

The USGS studies further indicate that large quantities of DOC may be adsorbed to the grains of the aquifer materials downgradient of the landfill between Area 4 and Sandy Brook. Adsorption of DOC onto aquifer materials in significant quantities suggests that DOC may provide a long-term source of nutrients for the microbial population within this area. The long-term source of nutrients means that the microbial population will consume oxygen until the DOC or oxygen supply is exhausted. Once the DOC in the system has been consumed, the demand for oxygen by the microbes will begin to decrease. The purpose of the landfill cap is to cut-off infiltration of rainfall thereby preventing the formation of DOC-rich leachate. As the availability of DOC decreases, the ability of reducing conditions to be substained will become less pronounced causing a corresponding decrease in the reductive dissolution of arsenic and iron from the coatings of the overburden aquifer materials and from the bedrock. Significant amounts of recharge to the groundwater system now occur only in areas not covered by the cap. The Design Report (W&C, 1997) estimated that the cap would allow less than 0.006 percent of precipitation to pass through it. The recharge entering the flow system above the landfill outside of the capped area will eventually introduce more oxygen-rich waters to the area beneath the landfill. Concentrations of iron, manganese, and arsenic in groundwater will decrease over time as fresh oxygenated water flushes through the system diluting the existing groundwater and pushing the equilibrium of the reductive dissolution/precipitation reaction toward the precipitation side of the equation. Eventually, oxygen-rich waters will serve to immobilize the arsenic by precipitating first iron, then manganese, and finally arsenic beneath the landfill.

The time frame for the stabilization of arsenic is uncertain and governed to a large extent by the DOC available to microorganisms. Laboratory core leaching studies and modeling projections by the USGS indicate that arsenic concentrations in groundwater will stabilize at or below concentrations of 50 μg/L after 30 to 50 pore volumes have been flushed through the system. Based on modeled travel time of approximately two years for groundwater from the toe of Landfill Area 4 to reach the stream, arsenic concentrations will stabilize after approximately 50 to 100 years.

### 2.5.2 Mixing of Groundwater with Surface Water

Mixing of groundwater discharging from Landfill Area 4 with streamflow in Sandy Brook will result in lower chemical concentrations in surface water than in the discharging groundwater. The resulting concentrations will be a function of the concentrations in influent groundwater, the quantity of influent groundwater, the concentrations in influent surface water, and the quantity of surface water at the point

of groundwater discharge. Calculations using stream discharges measured by the USGS indicate that groundwater discharge from the plume represents about five percent of total streamflow at high flow and about 39 percent of total streamflow at low flow (Appendix B-3). Consequently, at high flow, concentrations of inorganic chemicals in surface water downstream of the plume discharge should be about five percent of the concentrations in the discharging groundwater, assuming that influent surface water has a unit concentration. Details regarding the low-flow and high-flow scenarios and sensitivity of the scenarios is included in Appendix B.

Mixing calculations for Sandy Brook indicate that present arsenic concentrations should range from 11 to 82 μg/L and manganese concentrations should range from 151 to 1108 μg/L. Analytical results from recent sampling events are generally consistent with this calculated range. These calculations are based on area-weighted average concentrations for arsenic and manganese at the toe of Landfill Area 4 calculated from the December 1998 Pre-ROD sampling and upstream groundwater concentrations. When arsenic concentrations at the core of the plume have been reduced to 50 μg/L and the weighted-average groundwater concentration reduced to about 15 μg/L, arsenic concentrations in the stream are estimated to be at or below the practical quantitation limit (PQL) for arsenic of 3 μg/L at harmonic mean flow.

### 2.5.3 Model for Reduction of Arsenic Concentrations in Groundwater and Surface Water

Appendix B-4 provides a detailed discussion of the analytical model developed by W&C, based on the leaching studies conducted by the USGS to explore the relationship between the groundwater plume and Sandy Brook surface water concentrations. The goal of the model is to predict arsenic concentrations in groundwater and surface water during implementation of a natural attenuation remedy (SML-3) at the site. Using information provided by the USGS and the existing groundwater surface water data, the following approach was followed in developing this model:

1. Estimate timeframe of initial aquifer flushing;
2. Estimate rate of groundwater plume contaminant reduction;
3. Estimate average arsenic concentration in plume over time;
4. Estimate flow characteristics of Sandy Brook;
5. Estimate the relationship between surface water flow and groundwater flux;

6. Estimate the variation of arsenic concentration in surface water down stream of groundwater flux; and
7. Predict arsenic concentrations in Sandy Brook overtime.

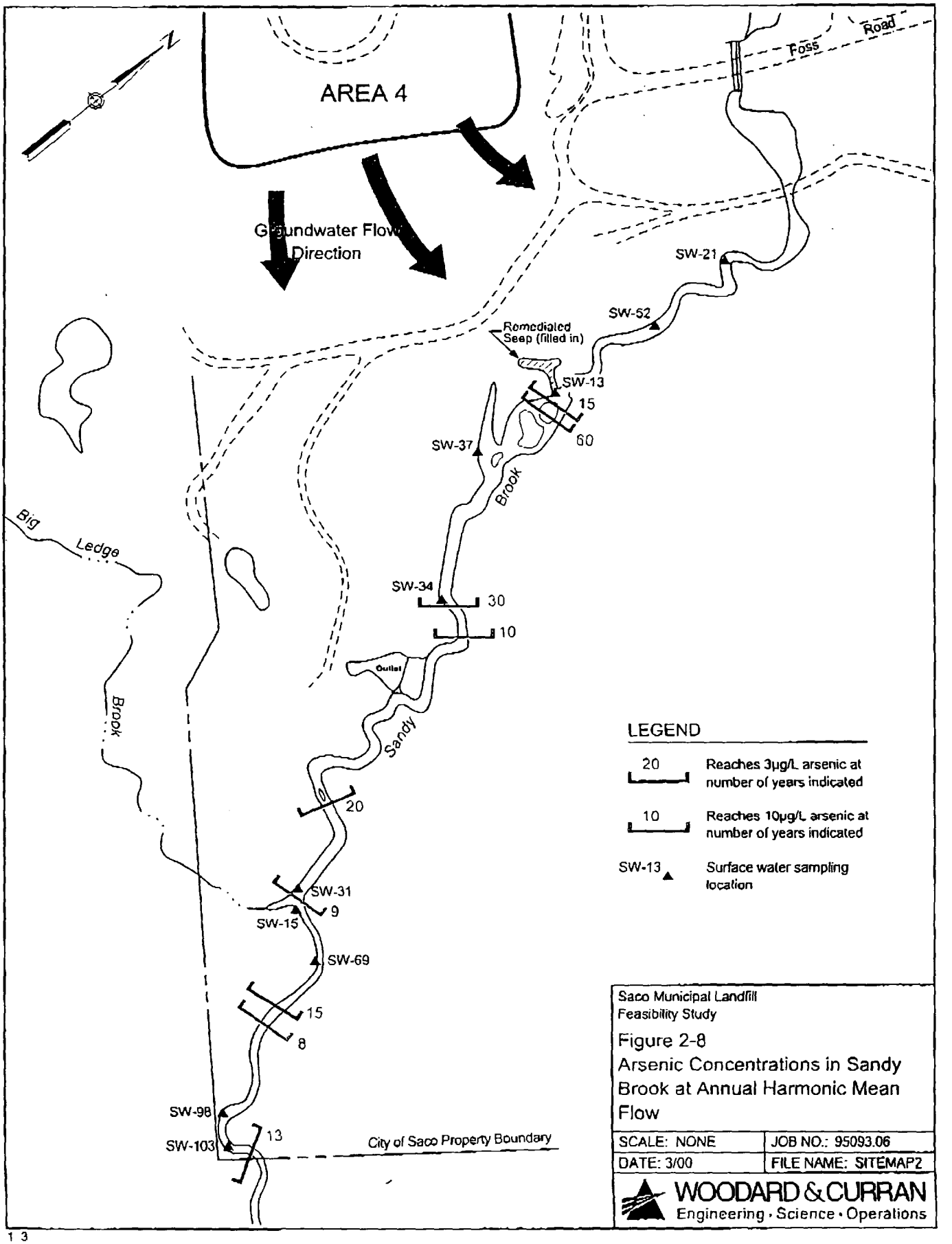
The analytical model developed by W&C was calibrated using the existing groundwater and surface water chemical concentrations, USGS flow measurements, and USGS column leaching studies (Stollenwerk and Colman, 1999). As required by the EPA and the MEDEP, the model results are presented using the harmonic mean flow to provide a conservative estimate of flow volume and therefore a conservative estimate of the arsenic concentrations in surface water. Table 2-10 provides a summary of predicted arsenic concentrations at several sampling locations along Sandy Brook. Figure 2-8 provides a graphic representation of the same data. The model results predicted that within 15 years arsenic concentrations in Sandy Brook, exceeding the site-specific performance standard (3 μg/L) at the harmonic mean flow conditions, will be limited to a very small area directly adjacent to the remediated seep. Based on this same model, it is expected that the entire length of Sandy Brook will be at or below the PQL of 3 μg/L (i.e., background concentrations) between 50 and 100 years from the present time (see Table 2-10).

There are inherent limitations in the ability of this model to accurately predict arsenic concentrations within Sandy Brook 5, 10, and 50 years from the present. However, based on the available flow data, USGS column studies, and the conservative nature of many of the assumptions used in developing this groundwater flux and surface water transport model (see Appendix B-4), we believe the arsenic concentrations predicted for Sandy Brook are conservative and are within the inherent limitations imposed by the existing data set. Because the arsenic concentrations in Sandy Brook are most sensitive to the volume of flow within the brook, actual arsenic concentrations measured at any given time may vary depending on actual flow volume. Based on the USGS flow information, predictions at the harmonic mean (estimate of the average flow), 0.35 cfs is an appropriate estimate for projecting average exposure point concentrations for arsenic in surface water. It is expected that this model will continue to be updated and evaluated during each 5-year site review conducted by EPA. Pending those future evaluations, this model provides a reasonable estimate of arsenic concentrations in Sandy Brook surface water over time.

**Table 2-10**
**Estimated Arsenic Concentrations in Sandy Brook**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| Arsenic at Surface Water Stations (ug/l) at Harmonic Mean Flow | | | | | | |
|---|---|---|---|---|---|---|
| Years After Cap | Surface Water Sampling Location | | | | | |
| | SW-13 | SW-34 | SW-31 | SW-15 | SW-69 | SW-103 |
| 0-8 | 35.0 | 22.0 | 14.0 | 12.9 | 11.8 | 8.0 |
| 9 | 25.7 | 16.1 | 10.3 | 9.5 | 8.7 | 5.9 |
| 10 | 17.4 | 10.9 | 7.0 | 6.4 | 5.9 | 4.0 |
| 15 | 9.3 | 5.8 | 3.7 | 3.4 | 3.1 | 2.1 |
| 20 | 6.9 | 4.3 | 2.8 | 2.5 | 2.3 | 1.6 |
| 30 | 4.8 | 3.0 | 1.9 | 1.8 | 1.6 | 1.1 |
| 40 | 3.8 | 2.4 | 1.5 | 1.4 | 1.3 | 0.9 |
| 50 | 3.2 | 2.0 | 1.3 | 1.2 | 1.1 | 0.7 |
| 100 | 2.0 | 1.3 | 0.8 | 0.7 | 0.7 | 0.5 |
| 150 | 1.5 | 0.9 | 0.6 | 0.6 | 0.5 | 0.3 |
| 200 | 1.2 | 0.8 | 0.5 | 0.4 | 0.4 | 0.3 |


AREA 4
Groundwater Flow Direction
Foss Road
SW-21
SW-52
Remediated Seep (filled in)
SW-13
15
60
SW-37
Brook
Big Ledge Brook
SW-34
30
10
Outlet
Sandy
20
SW-31
9
SW-15
SW-69
15
8
SW-98
SW-103
13
City of Saco Property Boundary
LEGEND
20 Reaches 3µg/L arsenic at number of years indicated
10 Reaches 10µg/L arsenic at number of years indicated
SW-13 Surface water sampling location
Saco Municipal Landfill
Feasibility Study
Figure 2-8
Arsenic Concentrations in Sandy Brook at Annual Harmonic Mean Flow
SCALE: NONE
JOB NO.: 95093.06
DATE: 3/00
FILE NAME: SITEMAP2
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# 3.0 BASIS FOR SITE REMEDIATION

This section presents a summary of the remedial objectives and regulatory requirements for developing remedial alternatives for Landfill Areas 3 and 4. These remedial actions address the final response actions identified during the NTCRA to minimize and mitigate impacts of the Landfill on all environmental media. This section also provides a review of the response actions taken as part of the NTCRA which support the basis for the remedial actions proposed in this report. The remainder of the section presents the ARARs identified for this site and the remedial objectives including the preliminary remedial goals (PRGs).

## 3.1 PREVIOUS RESPONSE ACTIONS

In June 1996, the USEPA authorized the preparation of an EE/CA for a NTCRA at the SML site. This was based on the results of the Phase IA RI and investigations conducted at the site by the City of Saco and the USGS. Field investigations detected elevated concentrations of chromium in the surface soils of Area 3; arsenic, barium, manganese and iron in sediments of a groundwater seep adjacent to Sandy Brook; arsenic and iron in the surface water of Sandy Brook; and arsenic, manganese, benzene and other VOCs in both shallow and bedrock groundwater downgradient of the landfill. These conditions demonstrated a continuing release and migration of hazardous substances from the landfill to groundwater, surface soils, sediments, and surface water of Sandy Brook. Estimated human health risks associated with exposure to these media exceeded the USEPA target risk range (e.g., $10^{-4}$ to $10^{-6}$ for cancer risk and Hazard Index (HI) of 1.0 for noncancer risk). The potential for adverse ecological impacts to Sandy Brook was identified. In addition, compounds were detected in groundwater above state and federal drinking water standards.

The action objectives for the removal action, as presented in the Approval Memorandum (USEPA, 1996), were:

- Prevent, to the extent practicable, direct contact with and ingestion of soil/debris within the landfill and beneath the landfill;

- Prevent, to the extent practicable, the potential for water to infiltrate through the landfill debris mass;

- Control landfill gas so that methane does not present a fire or explosion hazard;

- Prevent, to the extent practicable, the release of landfill gas containing hazardous substances, pollutants or contaminants at levels that would represent an unacceptable human health exposure to a site worker or trespasser;

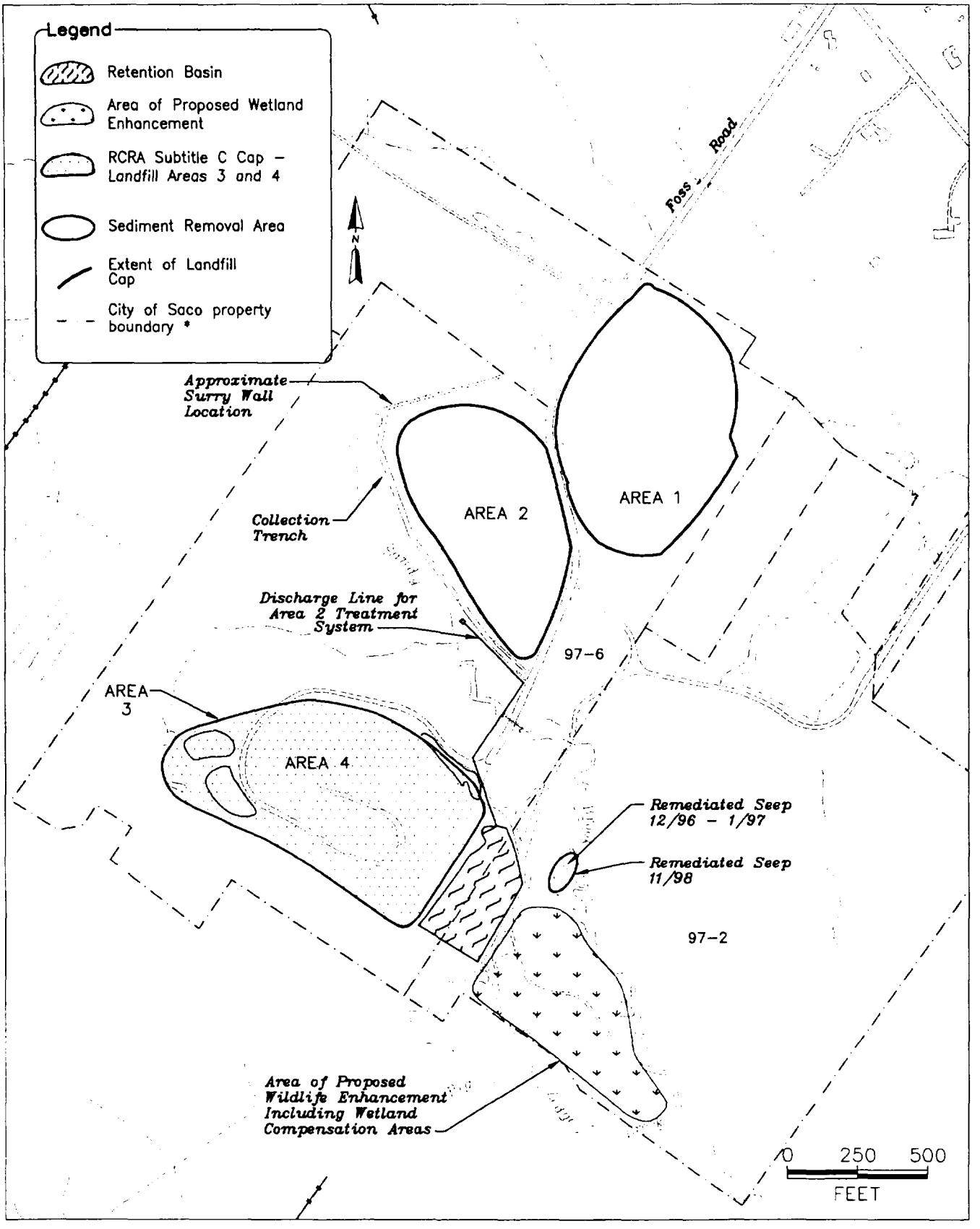
- Remove sediments and soils at levels that would result in an unacceptable ecological impact;

- Prevent, to the extent practicable, the migration of groundwater with contaminant concentrations above state or federal drinking water standards, or in their absence a level equal to a hazard quotient of 1 or excess carcinogenic risk of $1 \times 10^{-6}$ beyond the edge of the landfill;

- Prevent, to the extent practicable, continued ecological impacts to Sandy Brook or Big Ledge Brook; and

- Prevent, to the extent practicable, the migration of landfill-impacted groundwater into Sandy Brook.

Between 1997-98, the City of Saco implemented the NTCRA pursuant to Administrative Order USEPA CERCLA Docket No. 1-CERCLA-95-1069. The NTCRA included construction of a RCRA Subtitle C landfill cover system over Landfill Areas 3 and 4, focused "hot spot" sediment removal at two seep locations adjacent to Sandy Brook (Figure 3-1), and implementation of institutional controls (Figure 3-2). Actions conducted to date by the City of Saco fully address all but the last three response objectives of the removal action. Although, the landfill cover system has reduced the amount of water infiltrating through the waste material, there is currently a localized plume of inorganic-contaminated groundwater downgradient of the landfill that continues to discharge to Sandy Brook. This FS is being conducted specifically to address the last three response objectives as described in the following sections.




* Source: City of Saco Property Maps 88 and 97

Figure 3-1
Non-Time – Critical Removal Action (NTCRA) Components
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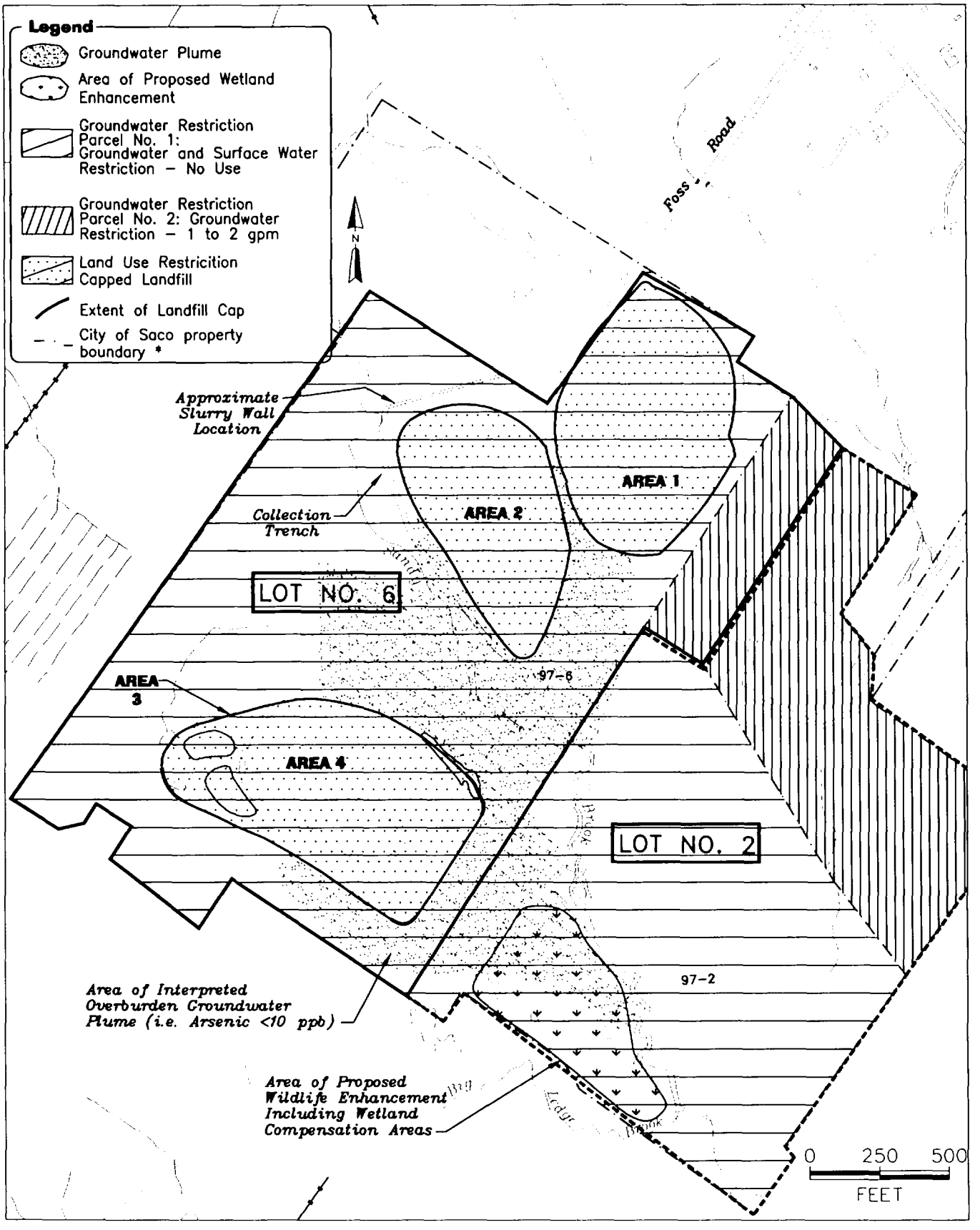


**Figure 3-2**
**Institutional Controls**
**Feasibility Study Report**
**Saco Municipal Landfill**
**Saco, Maine**

* Source: City of Saco Property Maps 88 and 97

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## 3.2 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This section provides a summary of the regulatory requirements to be used in the FS for the SML Site. Subsection 3.2.1 discusses the definition of ARARs; Subsection 3.2.2 identifies the categories of ARARs; Subsection 3.2.3 identifies chemical-specific ARARs; Subsection 3.2.4 identifies location-specific ARARs; Subsection 3.2.5 identifies potential action-specific ARARs for the Removal Action at SML Site Areas 3 and 4; and Subsection 3.2.6 identifies potential action-specific ARARs for management of migration at the SML site.

### 3.2.1 Definition of ARARs

The CERCLA of 1980, as amended by the 1986 Superfund Amendments and Reauthorization Act (SARA), and the NCP require that potential ARARs be identified during the RI/FS process. ARARs are federal and state human health and environmental requirements and guidelines that will be used to (1) evaluate the appropriate extent of site cleanup; (2) define and formulate remedial action alternatives; and (3) govern implementation and operation of the selected action.

To properly consider ARARs and to clarify their function in the RI/FS and remedial response processes, the NCP defines three ARAR components: (1) applicable requirements; (2) relevant and appropriate requirements and, (3) other requirements to be considered (TBCs). These definitions are discussed in the following paragraphs.

**Applicable requirements** are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a site. These include federal requirements that are directly applicable, as well as those incorporated by a federally authorized state program. Only those state standards identified by the state in a timely manner that are more stringent than federal requirements may be applicable. Examples of applicable requirements are the MCL drinking standards for a site where groundwater contamination has affected a public water supply.

**Relevant and appropriate requirements** are those cleanup standards, standards of control, or other substantive environmental protection requirements criteria, or limitations promulgated under federal or state law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a site, address problems or situations sufficiently similar to those encountered at the site that their use is well-suited to the particular site. There is more discretion in this determination in that it is possible for only part of a requirement to be considered relevant and appropriate, the rest being dismissed if judged not to be relevant and appropriate in a given case. Only those state standards identified by the state in a timely manner that are more stringent than the applicable federal standard may be relevant and appropriate. Examples of relevant and appropriate requirements for the SML include the MCLs that are appropriate for the groundwater aquifer at the site that, although is not a public water supply, is designated as a potential drinking water source.

**Other requirements to be considered (TBC)** are non-promulgated advisories or guidance issued by the federal or state government that are not legally binding, and do not have the status of potential ARARs. However, if there are no specific ARARs for a chemical or site condition, or if existing ARARs are not deemed sufficiently protective, then guidance or advisory criteria should be identified and used to confirm protection of human health and the environment. Examples of a TBC are the reference concentrations used in the risk assessment calculations.

Development of a comprehensive inventory of ARARs involves a two-tiered analysis: establishing the applicability of an environmental regulation; and evaluating relevancy and appropriateness if the regulation is not applicable. A requirement may be either "applicable" or "relevant and appropriate," but not both.

### 3.2.2 Identification of ARARs

Because of their site-specific nature, identification of ARARs requires evaluation of the body of federal, state, and local environmental and health regulations with respect to chemicals of concern, site characteristics, and proposed remedial alternatives. Requirements that pertain to the remedial response at a CERCLA site can be categorized into three distinct areas:

- **Chemical-specific** requirements generally involve health- or risk-based numerical values or methodologies that establish site-specific acceptable chemical concentrations or amounts of a chemical that may be found in, or discharged to, the environment.

- **Location-specific** requirements involve restrictions established for specific substances or activities based on their location.

- **Action-specific** requirements involve performance, design, or other action-specific requirements and are generally technology- or activity-based.

### 3.2.3 Identification of Chemical-Specific ARARs

Chemical-specific ARARs are numerical values or procedures that, when applied to a specific site, establish numerical limits for individual chemicals or groups of chemicals. These ARARs are generally health- or risk-based standards limiting the concentration of a chemical found in or discharged to the environment. They govern the extent of site remediation by providing either actual cleanup levels, or the basis for calculating such levels. Table 3-1 summarizes potential chemical-specific ARARs listed by media to which they may apply. Media applicable to Areas 3 and 4 include groundwater, surface water and sediment. A summary of key chemical-specific ARAR issues by environmental media is provided below.

Groundwater

Chemical-specific ARARs for groundwater include regulations and criteria promulgated under the Safe Drinking Water Act (SDWA), Clean Water Act (CWA), and Maine Drinking Water Rules. The federal National Drinking Water Regulations consist of contaminant-specific standards known as MCLs and Maximum Contaminant Level Goals (MCLGs). MCLs are enforceable standards for a limited number of organic and inorganic compounds that are the maximum permissible level for specific contaminants in public water supplies. MCLGs are non-enforceable health-based goals that establish levels at which no known or anticipated adverse health effects occur. For parameters with no MCLs, MCLGs, or Maine MEGs promulgated in 1992 (Maximum Exposure Guidelines for Drinking Water) the January 3, 2000 Draft interim MEGs (Bureau of Health, Maine Department of Human Services; Draft, January 3, 2000) were reviewed and considered TBCs.

## TABLE 3-1
## CHEMICAL-SPECIFIC ARARs and TBCs

## GROUNDWATER FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Consideration in the FS |
|---|---|---|---|
| | | **Groundwater/Surface Water** | |
| **Federal Regulatory Requirements** | | | |
| SDWA-MCLs (40 CFR 141.11-141.16) | Relevant and Appropriate | MCLs have been promulgated for several common organic and inorganic contaminants. These levels regulate the concentration of contaminants in public drinking water supplies, but may also be considered relevant and appropriate for groundwater aquifers potentially used for drinking water. | To assess the potential risks to human health due to consumption of groundwater, contaminant concentrations were compared to their MCLs. MCLs were also used to develop groundwater and surface water cleanup criteria. |
| SDWA-MCLGs (40 CFR 141.50-141.51) | Relevant and Appropriate | MCLGs are health-based criteria. As promulgated under SARA, MCLGs are to be considered for drinking water sources. Non-zero MCLGs are available for several organic and inorganic contaminants. | The 1990 NCP states that non-zero MCLGs are to be used as goals. Contaminant concentrations in groundwater were compared to their MCLGs. |
| Federal AWQC | Relevant and Appropriate | Federal AWQC include (1) health-based criteria developed for 95 carcinogenic and noncarcinogenic compounds and (2) water quality parameters. AWQC for the protection of human health provide levels for exposure from drinking water and consuming aquatic organisms, and from consuming fish alone. Remedial actions involving contaminated surface water or groundwater must consider the uses of the water and the circumstances of the release or threatened release; this determines whether AWQC are relevant and appropriate. | This requirement will be used, if appropriate, when determining clean-up levels or potential discharge limits for treated groundwater. |

**TABLE 3-1**
**CHEMICAL-SPECIFIC ARARs and TBCs**

**GROUNDWATER FEASIBILITY STUDY**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| Requirement | Status | Summary of Requirement | Consideration in the FS |
|---|---|---|---|
| | | **Groundwater/Surface Water (continued)** | |
| **Federal Regulatory Requirements** | | | |
| USEPA RfDs | To be considered | Guidance values used to evaluate the potential non-carcinogenic hazard caused by exposure to contaminants. | USEPA RfDs were used in the HHRA to characterize risks due to noncarcinogens in various media. |
| USEPA Carcinogen Assessment Group CSFs | To be considered | Guidance values used to evaluate the potential carcinogenic risk caused by exposure to contaminants. | USEPA CFS were used in the HHRA to compute the individual incremental cancer risk resulting from exposure to carcinogenic compounds. |
| USEPA Proposed Rule for Primary Drinking Water Regulations; Arsenic MCL. (Federal Register 6/22/2000, Vol. 65, No. 121, pages 38887-38983) | To be considered | Promulgated MCLs regulate the concentration of contaminants in public drinking water supplies, and are considered relevant and appropriate for groundwater aquifers potentially used for drinking water. The proposed value should be considered a guidance value until it is adopted. | This proposed MCL was considered in developing groundwater and surface water cleanup criteria. |
| **State Regulatory Requirements** | | | |
| Department of Human Services (10-144 CMR Chapters 231-233) | Relevant and Appropriate | Maine's Primary Drinking Water Standards are equivalent to federal MCLs. When state levels are more stringent than federal levels, the state levels may be used. | Primary drinking water standards may be used to set clean-up levels. |

**TABLE 3-1**
**CHEMICAL-SPECIFIC ARARs and TBCs**

**GROUNDWATER FEASIBILITY STUDY**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| Requirement | Status | Summary of Requirement | Consideration in the FS |
|---|---|---|---|
| **Groundwater/Surface Water (continued)** | | | |
| **Federal Regulatory Requirements** | | | |
| Maine Regulations Relating to Surface Water Toxic Control Program (38 M.R.S.A. Section 420, Chapter 530.5) | Applicable | This rule limits the concentrations of certain materials allowed in Maine waters to prevent the occurrence of pollutants in toxic amounts as required by state and federal law. Except if naturally occurring, ambient levels of toxic pollutants shall not exceed the Clean Water Act AWQC. Where AWQC do not exist, the Board of Environmental Protection shall adopt site-specific numerical criteria. | These standards may be used when determining clean-up levels or potential discharge limits. |
| **Sediments** | | | |
| **Federal Regulatory Requirements** | | | |
| USEPA Risk Reference Doses (RfDs) | To be considered | Guidance values used to evaluate the potential non-carcinogenic hazard caused by exposure to contaminants. | RfDs were used in the HHRA to evaluate potential risk from contaminant exposure. |
| **Federal Regulatory Requirements** | | | |
| USEPA Carcinogen Assessment Group CSFs | To be considered | Guidance values used to evaluate the potential carcinogenic risk caused by exposure to contaminants. | CSFs were used in the HHRA to estimate potential incremental cancer risk resulting from contaminant exposure. |
| National Oceanic and Atmospheric Administration Effects Range-Low Concentrations for Sediments | To be considered | National Oceanic and Atmospheric Administration Effects Range-Low concentrations for sediments identify contaminant concentrations that have the potential for environmental impact. | These concentration ranges were used to screen for CPCs in Sandy Brook sediments. |

**TABLE 3-1**
**CHEMICAL-SPECIFIC ARARs and TBCs**

**GROUNDWATER FEASIBILITY STUDY**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| Requirement | Status | Summary of Requirement | Consideration in the FS |
|---|---|---|---|
| | | **Sediments (continued)** | |
| **Federal Regulatory Requirements** | | | |
| Ontario Canada Ministry of Environmental Sediment Concentrations | To be considered | Ontario, Canada Ministry of Environment Sediment Concentrations identify concentrations of contaminants that protect ecological habitat. | These concentration ranges were used to screen for CPCs in Sandy Brook sediments. |
| USEPA Sediment Quality Criteria | To be considered | These sediment criteria are developed for non-ionic compounds based on equilibrium partitioning and identify contaminant concentrations that have the potential for environmental impact. | These concentrations were used to screen for CPCs in Sandy Brook sediments. |

NOTES:

ARAR=Applicable or Relevant and Appropriate Reqmts
AWQC=Ambient Water Quality Criteria
CAGCarcinogen Assessment Group
CMR=Code of Maine Regulations
CPC=contaminants of potential concern
CSF=Cancer Slope Factor
HHRA = Human Health Risk Assessment
MCL = Maximum Contaminant Level
MCLG = Maximum Contaminant Level Goal
MEDEP = Maine Department of Environmental Protection
MEG = Maximum Exposure Guideline
M.R.S.A. = Maine Revised Statutes Annotated
mg/kg = milligrams per kilograms
NAAQS = National Ambient Air Quality Standards
NCP = National Contingency Plan
RfD = Reference dose mg/kg - milligrams per kilograms
SDWA= Safe Drinking Water Act
TBC=To be considered
USEPA=U.S. Environmental Protection Agency

Surface Water

Federal AWQC have been developed for 157 chemicals under the CWA. The AWQC are health- and ecological-based criteria developed for carcinogenic and non-carcinogenic compounds and water quality parameters. There are four components to the AWQC:

(1) protection of aquatic life from acute effects,
(2) protection of aquatic life from chronic effects,
(3) protection of human health from the consumption of organisms, and,
(4) protection of human health from the consumption of water and organisms.

In 1990, the MEDEP adopted the Federal AWQC as part of Maine's Surface Water Quality Standards. These Statewide Water Quality Criteria (SWQC) are the maximum allowable amounts of contaminants allowed instream to protect the designated use of the stream. In addition, State regulations provide a mechanism for development of site-specific water quality criteria where such criteria would be more appropriate as an alternative to the SWQC. For example, site-specific criteria are appropriate where they reflect circumstances different from the SWQC, such as in exposure scenarios, and meet the requirements of Chapter 530.5 including protection of designated uses.

Based on actual exposure to surface water contaminants at this site, the first two components of the SWQC (i.e., protection of aquatic life from acute effects [340 μg/L for arsenic, no criterion for manganese] and protection of aquatic life from chronic effects [150 μg/L for arsenic, no criterion for manganese]) are considered to be relevant and appropriate to this site.

Exposure of humans to contaminants through the ingestion of organisms (e.g. fish) obtained from Sandy Brook is considered to be an incomplete exposure pathway as explained below and was not considered in the baseline risk assessment. The arsenic SWQC for protection of human health from water and fish consumption is 0.018 μg/L. Neither of these exposure pathways is considered complete. A site-specific performance standard of 3μg/L is proposed, which represents the arsenic PQL. The exposure assumptions on which the SWQC is based assume a daily ingestion rate of 6.5 grams of fish obtained from the brook per day. Stream survey data obtained from the Maine Department of Inland Fisheries identified the presence of only small (e.g., less than 4 inches in length) fish in Sandy Brook. Electroshocking of the stream yielded 12 golden shiners between 1 ½ to 3 ½ inches long and one sunfish

1 inch long. These species of fish are generally not considered to be the highly desirable edible fish; however, even if consumed, these populations of fish represent an insufficient biomass to support the assumed exposure conditions of 6.5 grams fish per day. No sport fisheries (e.g., trout) were identified in the stream. Discussions with the Maine Department of Inland Fisheries biologist indicate that sport fish would not be expected to be in the upper portions of the brook (i.e., upstream of the confluence of Sandy Brook with Deep Brook) because the natural fluctuation in temperature and dissolved oxygen content of the surface water is not conducive to cold water or sports fish. It is possible that trout could be in the lower portions of Sandy Brook (i.e., near the confluence of Deep Brook) during the spring months as the temperature during this time of year is colder. However, these trout are not expected to migrate upstream towards the landfill portion of the brook and neither Sandy Brook nor Big Ledge has ever been stocked with sport fish.

Exposure to contaminants through the ingestion of surface water is also considered to be an incomplete exposure pathway and was not evaluated in the baseline Human Health Risk Assessment. Although it is possible that trespassers or site visitors could drink from Sandy Brook, currently no one is being exposed to groundwater or surface water in Sandy Brook as a drinking water source. The trespasser and recreational user scenario evaluated in the risk assessment included incidental ingestion of surface water. The risk assessment concluded that there was no unacceptable risk to human health based on this scenario. Institutional controls mandated as part of the NTCRA will restrict future use of on-site surface water and groundwater for potable or other domestic purposes. Therefore, SWQC based on the protection of human health from the ingestion of water and organisms is not considered to be relevant or appropriate at this site.

Of the four components of the SWQC, two components (e.g., the protection of aquatic organisms from acute exposure and the protection of aquatic organisms from chronic exposure), are considered to be appropriate and relevant to this site and will be used in this FS.

In summary, the protection of surface water quality at this site falls in to three categories:

1. Protection of aquatic organisms from acute and chronic exposure,
2. Protection of human health from the long-term use of surface water as a drinking water source, and
3. Non-degradation requirements for a Class B stream.

Protection Of Aquatic Organisms – The federal AWQC for protection of aquatic organisms from acute exposure to arsenic is 360 μg/L with the chronic exposure set at 190 μg/L. The state has set the SWQC (see letter from MEDEP dated January 14, 2000) for protection of aquatic organisms from acute exposure to arsenic at 340 μg/L and from chronic exposure at 150 μg/L (based on a hardness value of 20). There is no AWQC or SWQC for manganese; however, the benchmark value used as a screening criterion in the Ecological Risk Assessment (W&C, 2000) is the British Columbia Ministry of the Environment range of 100 μg/L to 1,000 μg/L for chronic effects (BCMOE, 1994).

Protection of Human Health - The exposure pathway for human ingestion (i.e., long-term drinking water source) currently is not considered a complete exposure pathway, because no one currently is using the surface water of Sandy Brook as a drinking water source. Nonetheless, compliance with appropriate drinking water criteria is a long-term goal for the site. The federal MCL for arsenic is 50 μg/L. The state has proposed a new MEG of 10 μg/L for arsenic; this standard has not been promulgated and is therefore considered a TBC. EPA has not established a MCL for manganese. The state has a MEG for manganese of 200 μg/L.

Non-Degradation Requirement – The state of Maine has designated Sandy Brook as a Class B stream. As such, Sandy Brook should be suitable as a drinking water supply after treatment, for general recreation, and industrial use. Currently, the background sampling location SW-7 has reported arsenic concentrations at or below the PQL. For discussion purposes in this FS, background concentrations of arsenic will be set at the PQL for arsenic of 3 μg/L. Developing a background concentration for arsenic will be one of the goals for long-term monitoring of surface water. Manganese was reported at concentrations greater than 1,000 μg/L at this background location, indicating that elevated manganese concentrations within Sandy Brook are not caused by the landfill.

The criteria used to evaluate the protectiveness of the proposed remedy for Sandy Brook shall be the most protective for current or possible long-term use. In the case of Sandy Brook, the ecological criterion is less restrictive than the human health criterion. Therefore, the human health criterion shall be used. As discussed previously, Sandy Brook is not currently being used as a drinking water source, nor is it likely to be used in the future because of institutional controls restricting its use. The following criteria will be used to evaluate surface water quality:

- **Arsenic** – the site-specific performance standard for arsenic will be set at 3 μg/L (i.e., PQL) or background if upstream monitoring establishes a background concentration higher than 3 μg/L.
- **Manganese** - the criterion for manganese will be set at 200 μg/L (i.e. MEG), or background if upstream monitoring establishes a background concentration greater than 200 μg/L.

Sediment

No federal or state regulations have been promulgated for concentration limits for contaminants in sediment. For this reason, site-specific sediment toxicity testing was performed on sediment from Sandy Brook to evaluate baseline risks and determine an acceptable sediment concentration for arsenic. Whole sediment toxicity testing demonstrated that exposure of benthic organisms to concentrations of arsenic as high as 189 mg/kg in sediments did not result in significant risk (e.g., acute effects). This site-specific toxicity information will be used to evaluate the need for sediment remediation and develop sediment remediation goals, if necessary.

### 3.2.4 Identification of Location-Specific ARARs

Location-specific ARARs represent restrictions placed on the concentration of hazardous substances or the conduct of activities relative to natural site features (e.g., wetlands, floodplains, sensitive ecosystems) and manmade features (e.g., existing landfills and disposal areas). Table 3-2 presents site-specific federal and state requirements identified for the SML Site.

The SML site is located adjacent to and upgradient of Sandy Brook and the associated riparian wetlands, and is within a 100-year floodplain. The presence and proximity of these features may trigger the location-specific ARARs shown in Table 3-2. The implementation of remedial activities such as installing a fence for institutional controls or constructing an on-site groundwater treatment facility could involve a certain amount of soil excavation and placement. In addition, potential discharge of treated groundwater may trigger state location-specific ARARs that regulate streams and wetlands. These natural features are regulated under the Maine Natural Resources Protection Act (38 M.R.S.A. 480A-S). Specific standards affecting activities that take place in, or adjacent to, wetlands or water bodies are set forth in the Permit by Rule Standards (MEDEP Regulations, Chapter 305). The design of remedial alternatives conducted within 100 feet of the high-water mark of a wetland, or other water body, would address the requirements of these rules.

## TABLE 3-2
## LOCATION-SPECIFIC ARARs AND TBCs

## GROUNDWATER FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Consideration in the FS |
|---|---|---|---|
| | | **Wetlands/Floodplains** | |
| **Federal Regulatory Requirements** | | | |
| National Environmental Policy Act Wetland Executive Order (EO11990), 40 CFR 6.302(a) and 40 CFR Part 6, Appendix A | Applicable | The Wetlands Executive Order requires federal agencies to minimize the destruction, loss, or degradation of wetlands, and preserve and enhance natural and beneficial values of wetlands. | Wetland areas adjacent to Areas 3 and 4 have been identified. Wetlands destroyed as part of remedial action have been documented and compensatory wetlands are currently being constructed. |
| National Environmental Policy Act Floodplains Executive Order (EO11988), 40 CFR Part 6, Appendix A | Applicable | The Floodplains Executive Order requires federal agencies to reduce the risk of flood loss, to minimize the impact of floods, and to restore and preserve the natural and beneficial values of Floodplains. | All construction activities will be conducted in a manner that minimizes impacts to the flood plain. |
| Clean Water Act Section 404 Requirements for discharge of dredged and fill materials (33 USC 1344, 40 CFR 230) | Applicable | Section 404 of the CWA regulates the discharge of dredged fill material into U.S. waters, including wetlands. The purpose of Section 404 is to ensure that proposed discharges are evaluated with respect to impact on the aquatic ecosystem. The guidelines prohibit the discharge of dredge or fill material is a practicable alternative with less impact to the aquatic system. Discharge is also prohibited unless steps are taken to minimize potential adverse impacts, or if it will cause or contribute to significant degradation of U.S. waters. | Sediment excavation/dredging of Sandy Brook is not anticipated. However, any sediment excavation will be conducted in accordance with this regulation. |

## TABLE 3-2
## LOCATION-SPECIFIC ARARs AND TBCs

## GROUNDWATER FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Consideration in the FS |
|---|---|---|---|
| **Federal Regulatory Requirements** | | | |
| Section 10 of the Rivers and Harbors Act (33 USC 403, 33 CFR, 320-323) | Relevant and Appropriate | These requirements include criteria for obtaining authorization to excavate sediments from waters of the United States. | Sediment excavation from Sandy Brook is not anticipated. |
| Fish and Wildlife Coordination Act (16 U.S.C. 661); 40 CFR 6.302 | Applicable | This act requires that any federal agency proposing to modify a body of water must consult with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and other related State agencies. | No stream modification is necessary or will result from remedial actions. |
| RCRA Location Standards (40 CFR 264.18) | Relevant and Appropriate | A facility located in 100-year Floodplain must be designed, constructed, operated, and maintained to prevent washout of any hazardous wastes by a 100-year flood. | The landfill cap was designed to meet RCRA requirements, including to prevent washout of hazardous substances during a 100-year flood. |
| **State Regulatory Requirements** | | | |
| Maine Wetlands Protection Rule (06-096 CMR Chapter 310, Section 1) | Applicable | This act outlines requirements and performance standards for certain activities adjacent to any freshwater wetland greater than 10 acres or with an associated stream, pond, or brook. The activities must not unreasonably interfere with certain natural features, such as natural flow or quality of any waters, nor harm significant aquatic habitat, freshwater fisheries, or other aquatic life. | Stormwater and erosion controls will be incorporated into any remedial design to minimize the impacts of construction on the natural resources of Sandy Brook. |

## TABLE 3-2
## LOCATION-SPECIFIC ARARs AND TBCs

## GROUNDWATER FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Consideration in the FS |
|---|---|---|---|
| **State Regulatory Requirements** | | | |
| Maine Natural Resource Protection Act, Permit by Rule Standards (06-096 CMR, Chapter 305) | Applicable | This rule outlines prescribed standards for specific activities that may take place in or adjacent to wetlands and water bodies. The standards are designed to ensure that disturbed soil material is stablized to prevent erosion and filtration of water. | Stormwater and erosion controls will be incorporated into any remedial design to minimize the impacts of construction on the natural resources of Sandy Brook. |
| Maine Natural Resources Protection Act (38 M.R.S.A.; Section 480-A through S) | Applicable | A permit application must be submitted and approved by the Maine Bureau of Land Quality Control and Section 480-D performance standards met when conducting activities adjacent to any freshwater wetland greater than 10 acres or with an associated stream, brook, or pond. | Remedial activities regulated under this act must meet activity standards developed by the Maine Bureau of Land Quality Control. |
| Maine Standards for Classification of Major River Basins and Minor Drainages (38 M.R.S.A., Chapter 3, Sections 465, 467, and 468) | Applicable | Sandy Brook is classified as a Class B water under the state water quality standards. Class B waters are defined as suitable for drinking water (after treatment), fishing, recreation in and on the water, and as a habitat for fish and other aquatic life. | Remedial actions should not result in the degradation of surface water quality classification. |

**TABLE 3-2**
**LOCATION-SPECIFIC ARARs AND TBCs**

**GROUNDWATER FEASIBILITY STUDY**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| Requirement | Status | Summary of Requirement | Consideration in the FS |
|---|---|---|---|
| | | **Other Natural Resources** | |
| **Federal Regulatory Requirements** | | | |
| Endangered Species Act (16 USC 1531 et seq.; 40 CFR 6.302(h) | Relevant and Appropriate | This statute requires that federal agencies avoid activities that jeopardize threatened or endangered species or adversely modify habitats essential to their survival. Mitigation measures should be considered if a listed species or habitat may be jeopardized. | No endangered or threatened species have been documented in the site area. |
| **State Regulatory Requirements** | | | |
| Maine Site Location and Development Law and Regulations (38 M.R.S.A. Sections 481 through 490; MEDEP Regs. Chapters 371-377) | Relevant and Appropriate | This act and regulations govern new development, including those that handle hazardous wastes and oil. Activities cannot adversely affect existing uses, scenic character, or natural resources in the municipality or neighboring municipality. | Remedial alternatives will consider these regulations. |
| Maine Standards for Classification of Groundwater (38 M.R.S.A., Sections 465-C and 470) | Applicable | This law requires the classification of the state's groundwater to protect, conserve, and maintain groundwater resources in the interest of the health, safety, and general welfare of the people of the state. | Under the Maine standards, groundwater is classified as GW-A. Class GW-A is the highest groundwater classification and is designated as a potential public water supply. |

## TABLE 3-2
## LOCATION-SPECIFIC ARARs AND TBCs

## GROUNDWATER FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Consideration in the FS |
|---|---|---|---|
| **State Regulatory Requirements** | | | |
| Maine Endangered Species Act and Regulations (12 MRSA Section 7751-7756;09-137 CMR 008) | Applicable | The State of Maine has authority to research, list, and protect any species deemed endangered or threatened as listed in the state regulations. The Maine Department of Inland Fisheries and Wildlife has also developed the following administrative categories for species not considered endangered or threatened but considered important for research and further evaluation: Maine Watch List, Special Concern List, and Indeterminate Category. The Department determines appropriate use(s) of various habitats on a case-by-case- basis. The Maine lists may differ from the federal lists of endangered species. | No endangered or threatened species have been identified in the site area. |
| Town Shoreland Zoning Ordinances and State Minimum Guidelines | To be considered | These minimum guidelines and town ordinances apply to activities proposed within 200 feet of a high-water mark of a stream or other body of water. | These guidelines will be considered in the siting of treatment facilities during the development and evaluation of remedial alternatives. |
| Maine Critical Areas Program and Maine Natural Heritage Program | To be considered | These state programs issue policies and regulations governing special habitats or communities. | Where such special areas exist, these state programs will become involved in the project and/or permit review process. |

## TABLE 3-2
## LOCATION-SPECIFIC ARARs AND TBCs

## GROUNDWATER FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Consideration in the FS |
|---|---|---|---|
| **State Regulatory Requirements** | | | |
| Maine Critical Areas Act (5 M.R.S.A. 3310 through 3316) | To be considered | This nonregulatory legislation allows Maine agencies such as the Critical Areas Program and the Natural Heritage Areas Program to identify, research, and protect critical areas and endangered or threatened plants. | Where such special areas exist, these state programs will become involved in the project and/or permit review process. |

Notes:
ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
CMR = Code of Maine Regulations
CWA = Clean Water Act
MEDEP = Maine Department of Environmental Protection
M.R.S.A. = Maine Revised Statues Annotated
RCRA = Resource Conservation and Recovery Act
TBC = To be considered
USC = U.S. Code
mg/kg = milligram per kilogram

Construction within wetlands and floodplains is regulated under the Federal National Environmental Protection Act (NEPA) and the Wetlands and Floodplain Executive Orders (EO 11990 and EO 11988) and the CWA. NEPA requires that federal agencies include, in their decision-making processes, appropriate and careful consideration of the environmental effects of proposed actions, avoid or minimize adverse effects of the proposed actions, and restore and enhance environmental quality as much as possible.

Additional location-specific requirements include the Fish and Wildlife Coordination Act. This law requires that before issuing a federal permit or undertaking an action that causes impoundment, diversion, or other control or modification of a water body, the applicable federal agency must consult with (1) the appropriate state agency exercising jurisdiction over wildlife resources, (2) the U.S. Fish and Wildlife Service, and (3) the National Marine Fisheries Service.

### 3.2.5 Identification of Potential Action-Specific ARARs for the SML Areas 3 & 4 Removal Action

ARARs previously identified as part of the NTCRA for this site were limited to the scope of the removal action, which included the capping of Landfill Areas 3 and 4. The action-specific ARARs for the removal action are presented in the EE/CA as Table 3-3 (W&C, 1996). Summaries of specific removal action ARARs are presented in Section 3.4 of the EE/CA.

### 3.2.6 Identification of Potential Action-Specific ARARs for the SML Site Management of Migration

Action-specific ARARs, unlike chemical-specific and location-specific ARARs, are technology- or activity-based requirements that direct how remedial actions are conducted and are, therefore, addressed as part of this FS. The applicability of this set of requirements is directly related to the particular remedial activities proposed for the Site. Table 3-3 identifies those requirements that may pertain to components of each of the remedial alternatives developed as part of this FS. The applicability of the action-specific ARARs pertinent to each specific remedial alternative is discussed in Section 7.0, Detailed Analysis of Remedial Action Alternatives. In addition, because identification of ARARs is an iterative process to be conducted throughout the remedial response, the list of requirements and their

## TABLE 3-3
## POTENTIAL ACTION-SPECIFIC ARARs, AND TBCs

## GROUNDWATER FEASIBILITY STUDY REPORT
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Requirement Synopsis | Consideration in the Feasibility Study |
|---|---|---|
| **Federal Regulatory Requirements** | | |
| CWA NPDES (40 CFR Parts 122, 125) | This requirement implements the NPDES program that specifies the applicable effluent standards, monitoring requirements, and standards and special conditions for direct discharge to surface water bodies. | Direct discharges to surface waters from CERCLA sites are required to meet the substantive CWA NPDES requirements, including discharge limitations, monitoring requirements, and best management practices. |
| Underground Injection Control Regulations (40 CFR Parts 144,145,146, and 147) | These regulations provide regulatory compliance standards for treatment facilities that inject wastes underground. The use at wells to dispose of hazardous waste is prohibited. | Extracted groundwater would be treated to meet discharge limits prior to meet discharge limits prior to subsurface discharge through the infiltration basin. |
| CWA - Regulations on Disposal Site Determinations Under the CWA (40 CFR 231) | These regulations apply to all existing, proposed, or potential disposal sites for discharges of dredged or fill material into U.S. waters, which include wetlands. | The dredged or fill material should not be discharged unless it can be demonstrated that such a discharge will not have an unacceptable impact on Sandy Brook or the adjacent wetlands. |
| U.S. Army Corps of Engineers Permit Program Regulations (33 CRF 320-330) | These regulations prescribed the statutory authorities, and general and special policies and procedures applicable to the review of applications for permits for controlling certain activities in U.S. waters; this includes discharge of dredged or fill material. | Dredging and filling of Sandy Brook or the adjacent wetlands must be shown to cause minimal adverse impacts, if a less environmentally damaging alternative does not exist, and the project is in the overall public interest, the permit process must be followed. |

## TABLE 3-3
## POTENTIAL ACTION-SPECIFIC ARARs, AND TBCs

## GROUNDWATER FEASIBILITY STUDY REPORT
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Requirement Synopsis | Consideration in the Feasibility Study |
|---|---|---|
| **Federal Regulatory Requirements** | | |
| CWA - Permits for Dredged and Fill Material (Section 404) | This regulation outlines requirements for discharges of dredged or fill material. Under this requirement, no activity that impacts the adjacent wetland shall be permitted if a practicable alternative with less impact on the adjacent wetland is available. If there is no other practicable alternative, impacts must be mitigated. | During the identification, screening, and evaluation of alternatives, the effects on the adjacent wetlands will be evaluated. |
| Clean Air Act-National Primary and Secondary Ambient Air Quality Standards | Primary ambient air quality standards define levels of air quality to protect human health. Secondary ambient air quality standards protect public welfare from known or anticipated adverse effects from pollutants. | The National Ambient Air Quality Standard for particulate matter less than 10 microns is 150 $\mu g/m^3$ 24-hour average concentation. This standard would apply to any invasive or construction activities with the potential of generating significant dust. |
| **State Regulatory Requirements** | | |
| Maine Rules to Control the Subsurface Discharge of Pollutants by Well Injection (06-096 CMR, Chapter 543) | This regulation prohibits the injection of hazardous waste into or above water-bearing formations via a new Class IV well. The subsurface discharge into or through a Class IV well that would cause or allow the movement of fluid into an underground source of drinking water that may result in a violation of any Maine Primary Drinking Water Standard, or which may otherwise adversely affect public health, is prohibited. | Groundwater must be treated to a target clean-up level less than or equal to the Maine MEGs to be recharged to the aquifer. |
| MEDEP, Bureau of Water Quality Control, Policy Number 10 "The Discharge of Hazardous Substances to Groundwaters of the State" | The Board will deny applications for waste discharge licenses for the discharge to groundwaters of substances designated by the Board to be hazardous when such substances are present in concentrations exceeding groundwater levels which occur naturally in the area. Exemption may be granted if the groundwater is treated to reduce the concentrations of pollutants discharged to below the level considered safe for drinking water. | At least the minimum level of groundwater treatment would be required to provide adequate protection or if no other means of disposal is feasible. |

## TABLE 3-3
## POTENTIAL ACTION-SPECIFIC ARARs, AND TBCs

## GROUNDWATER FEASIBILITY STUDY REPORT
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Requirement Synopsis | Consideration in the Feasibility Study |
|---|---|---|
| **State Regulatory Requirements** | | |
| Maine Hazardous Waste, Septage, and Solid Waste Management Act Title 38, Chapter 13 and 06-096 CMR, Chapters 800-802, 850, 851, 853-857) | The rules provide a comprehensive program for handling, storage, and recordkeeping at hazardous waste facilities. They supplement the RCRA regulations.<br><br>A hazardous waste miscellaneous unit must be closed in a manner that will ensure that no hazardous waste shall appear in ground or surface waters above MEGs or standards for aquatic toxicity (Chapter 854, Section 15, A(1)(a). | Because these requirements supplement RCRA hazardous waste regulations, they would also be considered.<br><br>Implementation of remedial alternatives would result in eventual attainment of this ARAR. |
| Classification of Maine Waters 38 M.R.S.A. Section 464 - 470. | This rule prohibits the new discharge to water bodies with a drainage area of less than 10 square miles. | Because Sandy Brook has a drainage area less than 10 square miles, no discharge to this water body will be allowed. |
| Erosion and Sedimentation Control (38 M.R.S.A., Chapter 3 Subsec. 420-C), Chapter 500, Stormwater Management Rules | Erosion control measures must be in place before activities, such as filling, displacing, or exposing soil or other earthen materials occur. Prior MEDEP approval is needed if the disturbed area is in the direct watershed of a body of water most at risk. | The appropriate controls will be implemented to address erosion, sedimentation, or stormwater. Applicable plans will be coordinated with the MEDEP prior to implementation. |
| Maine Ambient Air Quality Standards (MEDEP Regulations, Chapter 110) | This regulation establishes ambient air quality standards that are maximum levels for a particulate matter permitted in the ambient air. | During excavation and construction activities, the 24-hour maximum particulate concentration must be maintained below 150 ug/m$^3$ and the annual geometric mean of the 24-hour concentrations should not exceed 60 ug/m$^3$. Dust suppressants may be necessary. |

**TABLE 3-3**
**POTENTIAL ACTION-SPECIFIC ARARs, AND TBCs**

**GROUNDWATER FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| Requirement | Requirement Synopsis | Consideration in the Feasibility Study |
|---|---|---|
| **State Regulatory Requirements** | | |
| Maine Water Pollution Control Law: Conditions of Licenses (38 M.R.S.A., Chapter 3, Article 2, Section 414-A) | Regulates the discharge of any pollutants. Specifies that the discharge, either by itself or in combination with other discharges, will not lower the quality of any classified body of water below such classification. The discharge will be subject to effluent limitations that require application of the best practicable treatment. | The effluent water from any proposed on-site activities would receive the best practicable treatment before discharge. |
| Maine Water Pollution Control Law: Certain Deposits and Discharges Prohibited (38 M.R.S.A., Chapter 3, Article 2, Section 420). | No person, firm, corporation, or other legal entity shall place, deposit, discharge, or spill mercury or toxic or hazardous substances, either directly or indirectly, into the inland ground or surface waters, tidal waters, on the ice, or on the banks thereof, so that the same may flow or be washed into such waters, or in such manner that the drainage therefrom may flow into such waters. | Best Management Practices will be used when handling wastes. |

NOTES:

ARAR = Applicable or Relevant and Appropriate Requirement
CAA = Clean Air Act
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
CFR = Code of Federal Regulations
CWA = Clean Water Act
DA = Department of the Army
DOT = Department of Transportation (U.S.)
lbs/day = pounds per day
LDRs = Land Disposal Restrictions
MCL = Maximum Contaminant Level
MEDEP = Maine Department of Environmental Protection
MEG = Maine Exposure Guidelines
OSHA = Occupational Safety and Health Administration
NPDES = National Pollution Discharge Elimination System
POTW = Publicly Owned Treatment Works
RCRA = Resource Conservation and Recovery Act
$ug/m^3$ = microgram per cubic meter
M.R.S.A.= Maine Revised Statues Annotated

relevance may change as more information is obtained, as the preferred alternative is chosen, and as the design and approach to remediation becomes more refined. A brief summary of primary action-specific ARARs that may apply to the remedial alternatives developed as part of the FS follows.

Discharge to Surface Water. The regulations outlining criteria for the direct discharge of treated groundwater to surface waters are set forth under the federal CWA and the Maine Department of Environmental Protection Surface Water Toxics Control Program (Chapter 530.5 of the Wastewater Discharge Law, Title 38, Chapter 3, Section 413). Discharge of treated groundwater from on-site treatment operations would be required to meet the substantive National Pollution Discharge Elimination System (NPDES) requirements under these rules, including discharge limitations, monitoring requirements, and best management practices. The discharge of treated groundwater to a Publicly Owned Treatment Works (POTW) is also regulated under the CWA. The treated water must also meet all discharge limitations/rules imposed by the specific POTW.

Discharge to Groundwater. The Maine Department of Environmental Protection Rules to Control the Subsurface Discharges of Pollutants by Well Injection (Chapter 543 of the Wastewater Discharge Law, Title 38, Chapter 3, Section 413) provides procedures and protocols that pertain to discharges of treated groundwater to subsurface groundwater. Compliance with the substantive requirements of this rule would be required if remedial actions include reinjection of treated groundwater and/or in situ remedial actions that require injection of nutrients, chemicals, etc. (e.g., in situ bioremediation).

Discharge to Air. Under the Clean Air Act, USEPA promulgated primary and secondary national ambient air quality standards for six pollutants (particulate matter, sulfur dioxide, carbon monoxide, ozone, nitrogen dioxide, and lead). Primary standards are set at levels to protect public health and secondary standards at levels to protect public welfare (i.e., wildlife, climate, recreation, transportation, and economic values). If remedial activities require invasive or construction activities with potential of generating significant dust, the standard for particulate matter promulgated under the Clean Air Act would apply and measures would be taken to ensure compliance.

Remedial actions involving on-site treatment operations with air emissions (e.g., air strippers) must comply with the substantive requirements of Maine Title 38, Chapter 4 (Protection and Improvement of Air). These regulations include standards that outline permitting requirements and specific emission

standards that pertain to various air containment source categories and processes (Maine Ambient Air Quality Standards and Growth Offset Regulations, MEDEP Chapters 110 and 113).

Management/Transportation of Hazardous Waste. If remedial actions require off-site transportation of hazardous waste, activities would be conducted in accordance with federal Department of Transportation regulations and Maine Hazardous Waste Management Rules (MEDEP Regulations, Chapters 853 and 857).

Site Worker Health and Safety. Per the NCP, federal Occupational Safety and Health Administration (OSHA) (29 CFR 1904, 1910, and 1926) standards are not ARARs because: (1) certain OSHA standards apply directly to all CERCLA response actions; and (2) USEPA views OSHA as an "employee" protection law rather than an "environmental" law (USEPA, 1990). Federal worker health and safety regulations would, however, need to be complied with by on-site workers during remedial construction activities.

## 3.3 REMEDIAL OBJECTIVES

The remedial objectives for groundwater at this site are based on the results of the RI and baseline risk assessments and form the basis for identifying technologies and developing and screening remedial alternatives. They are derived following a series of steps that direct the focus of remedial actions to specific media and contaminants of concern. These steps include developing remedial response objectives, preliminary remediation goals, remedial action objectives and general response actions, and are discussed in the following sections.

### 3.3.1 Remedial Response Objectives

Remedial response objectives are site-specific, qualitative, initial cleanup objectives established on the basis of the nature and distribution of contamination, the resource currently or potentially threatened, and the potential for human and environmental exposure. These response objectives are used to develop remedial action objectives and appropriate remedial alternatives.

The baseline Human Health Risk Assessment (Woodard & Curran, 1998) evaluated potential risks associated with exposure to site-related contaminants through incidental ingestion of soil and sediment; direct contact with soil, sediment, and surface water; and ingestion of groundwater. These routes of exposure were considered to represent realistic and likely exposures by both resident and trespasser populations. Remedial actions taken under the NTCRA (e.g., landfill cover system and sediment removal action) effectively eliminated direct contact exposure to surface soils and highly contaminated seep sediments. Currently, arsenic, iron, and manganese contaminant concentrations in stream sediments are below concentrations considered to present a human health risk. Although arsenic is present in surface water at concentrations in excess of the SWQC established to be protective of human health, there is no unacceptable risk for the realistic and likely exposures evaluated in the HHRA. The results of the risk assessment indicate the need for remedial action at the site to address groundwater contamination. Although there is currently no exposure to site groundwater, potential future exposure to this medium poses an unacceptable risk to human health. Response objectives are being proposed to restore the aquifer to its beneficial use within a reasonable time frame.

Neither ingestion of fish nor use of surface water for domestic purposes was considered to be a complete exposure pathway and neither pathway was evaluated in the baseline Human Health Risk Assessment. Ingestion of fish is not considered to be a viable exposure pathway because of the absence of sport fish and the low biomass of fish species in Sandy Brook (*Department of Inland Fisheries, 1986*). Currently no one is exposed to site contaminants via ingestion of surface water, and institutional controls mandated as part of the NTCRA will prevent future use of on-site surface water for potable or other domestic purposes. According to the Bureau of Land and Water Quality, as a tributary to the Saco River, Sandy Brook is classified as Class B under Maine Surface Water Quality Standards. Class B waters are, among other uses, suitable for drinking water supplies after treatment. Although there is no current or expected future exposure to site surface water as drinking water, a response objective is being proposed to reduce concentrations in the brook within a reasonable time frame (see Section 7.0) and enhance its potential use. Arsenic is currently below its chronic and acute SWQC derived to be protective of aquatic organisms. A site-specific performance criterion of 3 μg/L, based on the PQL, or background if upstream monitoring establishes a background concentration greater than 3 μg/L, is proposed for arsenic in surface water and is consistent with classification of Sandy Brook as a Class B stream.

The baseline Ecological Risk Assessment evaluated contaminant concentrations in surface water and sediment. A screening level evaluation of surface water concentrations to benchmark concentrations shows that most contaminants in surface water, notably arsenic, are either non-detect or below their respective benchmarks derived to be protective of aquatic organisms. Iron and manganese exceed their respective benchmarks. Because the absence of sport fish and the low biomass of fish species in Sandy Brook make it unlikely that humans would be able to catch enough fish to consume, the SWQC derived to be protective of ingestion of organisms was not considered to be a complete exposure pathway and therefore was not used in the screening evaluation.

A macrobenthic survey and site-specific sediment toxicity testing were conducted to evaluate the potential impacts of sediment contamination on benthic organisms. Discharge of groundwater from Area 4 has had a measurable impact on the benthic macroinvertebrate community of Sandy Brook. Although post-remediation concentrations of site-related contaminants are lower than they were before remedial activities, they may still present risks of minor adverse effects among sensitive members of the benthic community. The potential for impacts from current levels of site related contaminants are limited to a small portion of the brook downstream of the remediated seep. Observed effects do not constitute a significant impact on the ecology of Sandy Brook and do not warrant additional remediation of Area 4 or the sediments of Sandy Brook. However, response objectives specific to ecological receptors will be to continue to monitor the quality of the surface water and sediments to confirm that contaminant concentrations do not significantly increase over time.

Based on the information contained in the Phase IA RI, baseline risk assessments and EE/CA reports, and consideration of the Sandy Brook classification and ARARs, response objectives were developed for groundwater and surface water. The response objectives for potential future use of groundwater and surface water at the site are:

- Prevent exposure to or reduce chemical concentration in groundwater to levels considered protective of human health.
- Reduce chemical concentrations in surface water to levels consistent with potential use as drinking water.
- Monitor the quality of surface water and sediments to confirm that contaminant concentrations do not significantly increase over time.

The remedial action objectives aimed at addressing these remedial response objectives are discussed in Subsection 3.2.4.

### 3.3.2 Preliminary Remediation Goals

This section presents the PRGs established for groundwater and surface water associated with Landfill Areas 3 and 4. These PRGs are combined with the remedial response objectives listed above to develop the chemical-specific remedial action objectives for the site and are used in the FS to direct the development and evaluation of remedial alternatives.

Groundwater

The PRGs for groundwater at this site were selected based on the results of the baseline human health risk assessment and set at the more stringent federal or state promulgated drinking water standard (i.e., MCLs and promulgated MEGs), or derived as a health-based criterion where no MCL is available. This approach is consistent with the NCP Section 300.430 which states that "remediation goals establish acceptable exposure levels that are protective of human health and the environment and shall be developed considering ARARs". This section of the NCP goes on to define acceptable exposure for noncarcinogens as an HI of 1.0 and carcinogenic risk between $10^{-4}$ to $10^{-6}$.

The results of the baseline risk assessment indicate that potential future exposure to groundwater presents an "unacceptable" risk to human health. Compounds are present in the groundwater at concentrations associated with noncarcinogenic risks greater than an HI of 1 and/or carcinogenic risks greater than $10^{-6}$. The baseline risk assessment is presented as Appendix F to the Phase IA RI and summarized in Section 6.0 of that report.

A total of 69 compounds were detected at least once in the groundwater downgradient of Landfill Areas 3 and 4 and are listed in Table 3-4. Of these, 52 were selected as compounds of potential concern (CPC) and quantitatively evaluated in the baseline risk assessment. Most of these CPC's were detected infrequently and at relatively low (e.g., estimated) concentrations. The results of the quantitative risk assessment indicate that only two inorganic metals are present at concentrations associated with elevated risk levels. These metals are arsenic and manganese. Exposure to arsenic accounts for 99.8 percent of

the baseline carcinogenic risk and exposure to arsenic and manganese account for 50.9 and 48.5 percent of the baseline noncarcinogenic risk, respectively, for a total of 99.4 percent of the total noncarcinogenic risk (see Table B-19 of the Baseline Human Health Risk Assessment - Appendix F to the Final Phase IA RI report).

Table 3-5 lists the maximum detected concentration, federal MCL and MEG for each compound detected in groundwater at Landfill Areas 3 and 4. Two organic compounds (benzene and trichloroethylene) and four inorganics (arsenic, lead, manganese and thallium) are present in the groundwater at concentrations in excess of either their respective state or federal primary drinking water standards.
Of the two organic compounds, benzene was detected in excess of its MCL at sampling locations MW-95-4R and MW-95-4RD at concentrations ranging from 9 to 13 µg/L. This sampling location is immediately downgradient of Landfill Areas 3 and 4 and historically has been the most contaminated area in the groundwater plume with arsenic concentrations reported as high as 566 µg/L. Based on its continued presence at concentrations in excess of its MCL, benzene was retained as a contaminant of concern (COC) in the FS. Trichloroethylene (TCE) was detected in five out of 12 sampling rounds in MW-95-7S. The average TCE concentration from MW-95-7S for all 12 events is less than MCL. Therefore, TCE is not considered a COC in the FS.

Arsenic was the only inorganic consistently detected in excess of its respective primary drinking water standard (i.e., MCL of 50 µg/L, proposed MEG of 10 µg/L). Elevated concentrations, as high as 805 µg/L (MW-97-13S1 and MW-97-13S2) were reported in the groundwater downgradient of Landfill Areas 3 and 4. Although a federal primary drinking water standard does not exist for manganese, this compound was detected frequently and in excess of the MEG of 200 µg/L developed by the MEDHS. Manganese was detected as high as 13,200 µg/L in groundwater downgradient of the landfill (MW-93-5). Both arsenic and manganese were retained as COCs in this FS.

The other two inorganics, lead and thallium, were detected sporadically and infrequently above their respective standards. Lead was detected only twice and thallium only three times in excess of its standard. Because these groundwater samples were unfiltered, turbidity readings were reviewed. In general, elevated concentrations of these inorganic compounds coincided with the high turbidity readings, suggesting that the elevated concentrations are the result of suspended solids and not dissolved concentrations. Based on their limited distribution, low frequency, and association with turbidity, lead and thallium were excluded as COCs in the FS.

TABLE 3-4
SUMMARY OF GROUNDWATER ANALYTICAL DATA

FEASIBILITY STUDY REPORT
SACO MUNICIPAL LANDFILL
SACO, MAINE

| GROUNDWATER DOWNGRADIENT OF LANDFILL AREAS 3 AND 4 | | | |
|---|---|---|---|
| **Parameter** | **Frequency of Detection** | **Range of Concentrations** | **Retained as CPC in Risk Assessment** |
| **VOCs, ug/l** | | | |
| 1,1-Dichloroethane | 4/12 | 0.2J-1 | Yes |
| 1,1-Dichloropropene | 1/12 | 1J | No |
| 1,1,2,2-Tetrachloroethane | 1/12 | 1J | No |
| 1,2,3-Trichlorobenzene | 1/12 | 0.8J-1J | Yes |
| 1,2,3-Trichloropropane | 1/12 | 1J | No |
| 1,2,4-Trichlorobenzene | 2/12 | 0.6J-1J | Yes |
| 1,2,4-Trimethylbenzene | 2/12 | 2J-9 | Yes |
| 1,2-Dibromo-3-chloropropane | 1/12 | 1 | No |
| 1,2-Dichlorobenzene | 5/12 | 0.8J-5 | Yes |
| 1,2-Dichloroethane | 4/12 | 0.3J-1 | Yes |
| 1,3-Dichlorobenzene | 2/12 | 1J-1J | No |
| 1,3,5-Trimethylbenzene | 2/12 | 2J-5 | Yes |
| 1,4-Dichlorobenzene | 6/12 | 0.7J-7 | Yes |
| 2-Butanone | 1.12 | 15-17 | No |
| 2-Chlorotoluene | 1/12 | 1J | No |
| 2,2-Dichloropropane | 4/12 | 0.2J-0.4J | Yes |
| 4-Isopropytoluene | 5/12 | 0.8J-4J | Yes |
| Benzene | 6/12 | 0.3J-13 | Yes |
| Bromobenzene | 1/12 | 1J | No |
| Chlorobenzene | 6/12 | 0.4J-5 | Yes |
| Chloroethane | 7/12 | 0.7J-93 | Yes |
| Chloromethane | 1/12 | 2J | Yes |
| cis-1,2-DCE | 4/12 | 0.6J-5 | Yes |
| Dichlorodifluoromethane | 1/12 | 1J | Yes |
| Ethylbenzene | 7/12 | 0.2J-34 | Yes |
| Hexachlorobutadiene | 1/12 | 1J | No |
| Isopropylbenzene | 4/12 | 0.3J-6 | Yes |
| Methylene Chloride | 1/11 | 1 | Yes |
| Naphthalene | 3/12 | 0.8J-13 | Yes |
| Styrene | 1/11 | 1J | No |
| Tetrahydrofuran | 7/12 | 3J-170 | Yes |
| Toluene | 5/12 | 0.5J-3 | Yes |
| trans-1,2-DCE | 5/12 | 0.6J-1J | Yes |
| Trichloroethene | 5/12 | 0.7J-7 | Yes |
| Trichlorofluoromethane | 1/12 | 1J | No |
| m-Xylene/p-Xylene | 5/12 | 0.5J-32 | Yes |
| n-Butylbenzene | 3/12 | 0.8J-2 | Yes |
| n-Propylbenzene | 2/12 | 0.7J-2 | Yes |
| o-Xylene | 2/12 | 2J-14 | Yes |
| sec-Butylbenzene | 1/12 | 1J-1J | No |

TABLE 3-4
SUMMARY OF GROUNDWATER ANALYTICAL DATA

FEASIBILITY STUDY REPORT
SACO MUNICIPAL LANDFILL
SACO, MAINE

| GROUNDWATER DOWNGRADIENT OF LANDFILL AREAS 3 AND 4 | | | |
|---|---|---|---|
| **Parameter** | **Frequency of Detection** | **Range of Concentrations** | **Retained as CPC in Risk Assessment** |
| **SVOCs, ug/l** | | | |
| 2-Methynaphthalene | 1/12 | 5J | Yes |
| 2,4-Dimethylphenol | 2/12 | 1J-5J | Yes |
| 4-Chloro-3-methylphenol | 4/12 | 1J-29 | Yes |
| Acenaphthylene | 1/12 | 1J | No |
| Benzo(g,h,I)perylene | 1/12 | 3J | No |
| Bis (2-ethylhexyl)phthalate | 3/12 | 1J-45J | No |
| Dibenzo(a,h)anthracene | 1/12 | 2J | No |
| Diethylphthalate | 1/12 | 1J-10J | No |
| **Metals, ug/l** | | | |
| Aluminum | 3/12 | 165-5690 | Yes |
| Arsenic | 9/13 | 2-566 | Yes |
| Barium | 12/12 | 4.5-463 | Yes |
| Cadmium | 1/12 | 0.25J | Yes |
| Calcium | 12/12 | 10500J-148000 | Yes |
| Chromium | 8/12 | 1.3J-10.4 | Yes |
| Cobalt | 9/12 | 1.2J-74.6 | Yes |
| Copper | 1/12 | 1.2J-1.4J | Yes |
| Cyanide | 1/17 | 1.5J | Yes |
| Iron | 12/13 | 227J-48000 | Yes |
| Lead | 8/12 | 1.8J-65.1 | Yes |
| Magnesium | 12/12 | 1770J-61500 | Yes |
| Manganese | 11/13 | 25.9J-13200 | Yes |
| Nickel | 7/12 | 5.4J-100 | Yes |
| Potassium | 12/12 | 222-41,600 | Yes |
| Selenium | 6/12 | 3.8J-6.9J | Yes |
| Silver | 2/12 | 1.4J-1.5 | Yes |
| Sodium | 12/12 | 4360-363000 | Yes |
| Thallium | 3/12 | 6.8J-11J | Yes |
| Vanadium | 6/12 | 0.6J-2.3J | Yes |
| Zinc | 2/12 | 7.6J-31.6 | Yes |

**NOTES:**

Source: Baseline Human Health Risk Assessment

EPC = Exposure Point Concentrations for CPCs

CPC = Contaminant of Potential Concern

NA = Not Analyzed

ND = Not Detected

J = Estimated Concentration

**TABLE 3-5**
**COMPARISON OF GROUNDWATER CONCENTRATIONS**
**TO DRINKING WATER STANDARDS**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| | | | DRINKING WATER STANDARDS | | |
|---|---|---|---|---|---|
| **Parameter** | **Frequency of Detection** | **Maximum Detected Concentration** | **Federal MCLs** | **State MEGs[1]** | **Retained as COC** |
| **VOCs, ug/l** | | | | | |
| 1,1-Dichloroethane | 4/12 | 1 | NA | 70 | No |
| 1,2,3-Trichlorobenzene | 1/12 | 1 | NA | NA | No |
| 1,2,4-Trichlorobenzene | 2/12 | 1 | 70 | 70 | No |
| 1,2,4-Trimethylbenzene | 2/12 | 9 | NA | 70 | No |
| 1,2-Dichlorobenzene | 5/12 | 5 | 600 | 63 | No |
| 1,2-Dichloroethane | 4/12 | 1 | 5 | 4 | No |
| 1,3,5-Trimethylbenzene | 2/12 | 5 | NA | NA | No |
| 1,4-Dichlorobenzene | 6/12 | 7 | 75 | 21 | No |
| 2,2-Dichloropropane | 4/12 | 0.4 | NA | NA | No |
| 4-Isopropytoluene | 5/12 | 4 | NA | NA | No |
| **Benzene** | **6/12** | **13** | **5** | **12** | **Yes** |
| Chlorobenzene | 6/12 | 5 | NA | 47 | No |
| Chloroethane | 7/12 | 93 | NA | NA | No |
| Chloromethane | 1/12 | 2 | NA | 3 | No |
| cis-1,2-DCE | 4/12 | 5 | 70 | 70 | No |
| Dichlorodifluoromethane | 1/12 | 1 | 1400 | NA | No |
| Ethylbenzene | 7/12 | 34 | 700 | 700 | No |
| Isopropylbenzene | 4/12 | 6 | NA | NA | No |
| Methylene Chloride | 1/11 | 1 | NA | 48 | No |
| Naphthalene | 3/12 | 13 | NA | 14 | No |
| Tetrahydrofuran | 7/12 | 170 | NA | 70 | No |
| Toluene | 5/12 | 3 | 1,000 | 1,400 | No |
| trans-1,2-DCE | 5/12 | 1 | 100 | 140 | No |
| Trichloroethene | 5/12 | 7 | 5 | 32 | No |
| m-Xylene/p-Xylene | 5/12 | 32 | 10,000 | 14,000 | No |
| n-Butylbenzene | 3/12 | 2 | NA | NA | No |
| n-Propylbenzene | 2/12 | 2 | NA | NA | No |
| o-Xylene | 2/12 | 14 | 10,000 | 14,000 | No |
| **SVOCs, ug/l** | | | | | |
| 2-Methynaphthalene | 1/12 | 5 | NA | NA | No |
| 2,4-Dimethylphenol | 2/12 | 5 | NA | NA | No |
| 4-Chloro-3-methylphenol | 4/12 | 29 | NA | NA | No |

**TABLE 3-5**
**COMPARISON OF GROUNDWATER CONCENTRATIONS**
**TO DRINKING WATER STANDARDS**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| | | | DRINKING WATER STANDARDS | | |
|---|---|---|---|---|---|
| **Parameter** | **Frequency of Detection** | **Maximum Detected Concentration** | **Federal MCLs** | **State MEGs[1]** | **Retained as COC** |
| **Metals, ug/l** | | | | | |
| Aluminum | 3/12 | 5,690 | NA | 1,430 | No |
| **Arsenic** | **9/13** | **566** | **50** | **10** | **Yes** |
| Barium | 12/12 | 463 | 2,000 | 2,000 | No |
| Cadmium | 1/12 | 0.25 | 5 | 3.5 | No |
| Calcium | 12/12 | 148,000 | NA | NA | No |
| Chromium | 8/12 | 10.4 | 100 | 40 | No |
| Cobalt | 9/12 | 74.6 | NA | NA | No |
| Copper | 1/12 | 1.4 | NA | NA | No |
| Cyanide | 1/17 | 1.5 | 200 | 140 | No |
| Iron | 12/13 | 48,000 | NA | NA | No |
| Lead | 8/12 | **65.1** | 15 | 20 | No |
| Magnesium | 12/12 | 61,500 | NA | NA | No |
| **Manganese** | **11/13** | **13,200** | **NA** | **500** | **Yes** |
| Nickel | 7/12 | 100 | 100 | 140 | No |
| Potassium | 12/12 | 41,600 | NA | NA | No |
| Selenium | 6/12 | 6.9 | 50 | 35 | No |
| Silver | 2/12 | 1.5 | NA | 35 | No |
| Sodium | 12/12 | 363,000 | NA | 20,000 | No |
| Thallium | 3/12 | **11** | 2 | 0.5 | No |
| Vanadium | 6/12 | 2.3 | NA | NA | No |
| Zinc | 2/12 | 31.6 | NA | 2,000 | No |

**NOTES:**

MCLs = Federal Maximum Contaminant Levels, February 1996
MEGs = State of Maine Maximum Exposure Guidelines, September 1992
NA = Not Available
Bold = Maximum exceeded MCLs or MEGs
Shaded = Retained as COC
COC = Contaminant of Concern
[1]State of Maine Maximum Exposure Guidelines, proposed January 2000, notes these values have not beem promulgated but have been included for comparison purposes only.

Based on results of the Baseline Human Health Risk Assessment and comparison to standards and/or TBCs, three compounds were retained as COCs: benzene, arsenic, and manganese. Of these three COCs, arsenic and manganese were detected most frequently and at elevated concentrations throughout the aquifer downgradient of Landfill Areas 3 and 4. The PRGs for arsenic and benzene are set at their federal MCLs of 50 µg/L and 5 µg/L, respectively, and the PRG for manganese is set at the MEG of 200 µg/L. Table 3-6 provides preliminary remediation goals for groundwater.

**TABLE 3-6**
**PRELIMINARY REMEDIATION GOALS FOR GROUNDWATER**

| GROUNDWATER | PRG | BASIS |
|---|---|---|
| Arsenic | 50 µg/L | MCL |
| Manganese | 200 µg/L | MEG [1] |
| Benzene | 5 µg/L | MCL |

Note: [1] No MCL for Manganese, the 1992 Maine Maximum Exposure guideline (MEG) is used.

Surface Water

PRGs were not established for surface water at this site because there is not an unacceptable risk to human health and the environment. As described in Section 3.2.3, neither ingestion of fish nor ingestion of surface water was considered to be a complete exposure pathway and therefore neither pathway was evaluated in the baseline Human Health Risk Assessment. As a result, the Statewide Water Quality Criteria for the protection of human health from the consumption of organisms is not appropriate criteria for establishing remediation goals. Although there is no current or expected future exposure to the surface water as drinking water, the classification of Sandy Brook as a Class B stream means that it is suitable for drinking water supplies after treatment, among other uses. Because the source of surface water contamination is groundwater discharge to Sandy Brook, remedial action objectives are being set for groundwater at a concentration that will result in reductions in surface that will result in compliance with SWQC. This is appropriate because there is no ecological risk and only hypothetical future risk to human health from surface water contamination. This approach will ensure that the beneficial use of Sandy Brook is maintained or enhanced.

Results of sampling and analysis have identified concentrations of arsenic in surface water at concentrations above the federal MCL (50 μg/L) and the proposed state MEG (10 μg/L), and manganese above the state MEG (200 μg/L). Table 3-7 provides a summary of surface water data. Arsenic was detected in Sandy Brook in excess of its MCL of 50 μg/L at only two locations, 138 μg/L at SW-21 and 108 μg/L at SW-13. Each of these concentrations were detected during one sampling event in 1996. Subsequent sampling at these locations has not detected arsenic in excess of the MCL and may indicate that the seep removal is already reducing concentrations of contaminants in Sandy Brook. A federal drinking water standard does not exist for manganese; however, detected concentrations of manganese exceed the TBC (MEG of 500 μg/L) developed by the MEDEP. Manganese concentrations in Sandy Brook surface water in excess of the MEG have been detected at the background location (SW-7) and four other locations (SW-21, SW-13, SW-37, and SW-34) as recently as 1999.

Calculations in Section 2.5.2 indicate that mixing of groundwater discharging from the toe of the Landfill Area 4 slope with streamflow in Sandy Brook will result in lower chemical concentrations in surface water than in the discharging groundwater. This approach can be used to calculate the arsenic and manganese concentrations in groundwater at Landfill 4 Area that will result in surface water concentrations at or below the MEGs of 10 μg/L for arsenic and 200 μg/L for manganese.

In the preceding section, the groundwater PRG is identified at 50 μg/L for arsenic and 200 μg/L for manganese. Calculations of groundwater and surface water mixing in Section 2.5.2 indicated that when groundwater arsenic concentrations in the plume core were reduced to 50 μg/L, arsenic concentrations in Sandy Brook at the harmonic mean annual flow would be reduced to the MEG of 10 μg/L.

### 3.3.3 Residual Risk Evaluation

The risks associated with future exposure to groundwater and surface water were estimated assuming remediation of groundwater to PRG concentrations (i.e., 50 μg/L arsenic, 200 μg/L manganese and 5 μg/L benzene). Carcinogenic and noncarcinogenic residual risks were estimated for these COCs assuming the same future residential exposure scenario as presented in the baseline human health risk assessment. This scenario assumes the groundwater is used for potable purposes. The residual carcinogenic risk from this hypothetical exposure to arsenic and benzene is $8.8 \times 10^{-4}$ with over 99 Table percent of the risk from exposure to arsenic. The residual noncarcinogenic risk from this hypothetical

## TABLE 3-7
## SUMMARY OF SURFACE WATER ANALYTICAL DATA
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Compounds | N | Frequency of Detection | Min | Max | Chronic | Retained as COC |
|---|---|---|---|---|---|---|
| **Pesticides/PCBs (ug/L)** | | | | | | |
| Dieldrin | 15 | 1/15 | 0.0011 | 0.0011 | 0.0019 | No |
| Endosulfan II | 15 | 3/15 | 0.0014 | 0.0034 | 0.056 | No |
| **SVOCs (ug/L)** | | | | | | |
| 1,4-Dichlorobenzene | 15 | 2/15 | 1.0 | 3.0 | 5.0 | No |
| 4-Chloro-3-methylphenol | 15 | 3/15 | 1.0 | 3.0 | 2000 | No |
| Bis(2-ethylhexyl)phthalate | 15 | 5/15 | 1.0 | 5.0 | 560 | No |
| Di-n-butylphthalate | 15 | 1/15 | 1.0 | 2.0 | 3.0 | No |
| **VOCs (ug/L)** | | | | | | |
| 1,1-Dichloroethene | 8 | 1/8 | 1.0 | 1.0 | 200 | No |
| 1,2,4-Trimethylbenzene | 8 | 2/8 | 1.0 | 1.0 | NA | No |
| 1,2-Dichlorobenzene | 8 | 1/8 | 1.0 | 1.0 | 5.0 | No |
| 1,3-Dichlorobenzene | 8 | 2/8 | 1.0 | 1.0 | 5.0 | No |
| 1,4-Dichlorobenzene | 8 | 2/8 | 1.0 | 2.0 | 5.0 | No |
| Benzene | 8 | 2/8 | 1.0 | 2.0 | 100 | No |
| *cis-1,2-Dichloroethene* | 8 | 1/8 | 1.0 | 1.0 | 200 | No |
| Chlorobenzene | 8 | 3/8 | 1.0 | 3.0 | 50 | No |
| Ethylbenzene | 8 | 2/8 | 1.0 | 11.0 | 30 | No |
| *m,p-Xylene* | 8 | 3/8 | 1.0 | 16.0 | 40 | No |
| Naphthalene | 8 | 2/8 | 1.0 | 1.0 | 2300 | No |
| Tetrahydrofuran | 8 | 2/8 | 10 | 50.0 | NA | No |
| **Inorganics (ug/L)** | | | | | | |
| Aluminum | 26 | 19/26 | 14.3 | 1,970 | NA | Yes |
| Arsenic | 25 | 12/25 | 1.8 | 18.6 | 190.0 | Yes |
| Barium | 24 | 24/24 | 2.7 | 96.3 | 50,000 | No |
| Chromium | 24 | 16/24 | 0.53 | 12.1 | 11 | No |
| Cobalt | 24 | 4/24 | 0.51 | 1.3 | 5.0 | No |
| Copper | 24 | 4/24 | 0.74 | 1.4 | 12.0 | No |
| Iron | 24 | 21/24 | 20 | 35,900 | 1,000 | Yes |
| Lead | 24 | 5/24 | 1.0 | 34.5 | 3.2 | No |
| Manganese | 24 | 22/24 | 0.1 | 1,070 | 100-1000 | Yes |
| Mercury | 26 | 7/26 | 0.0035 | 0.13 | -- | No |
| Nickel | 24 | 12/24 | 0.72 | 99.6 | 160 | No |

Note: NA - not applicable
[1]Samples collected on Nov. 17, 1995, May 16, 1996, and Nov. 19. 1996, prior to sediment remediation.
Sample results are presented in Appendix B.
[2] = Number of samples detected / Total number of samples
UCL - upper confidence limit
VOC - volatile organic compound

exposure to arsenic, benzene and manganese is the arsenic HI of 4.6 which represents over 80 percent of the noncancer risk. These calculations are presented in Table 3-8.

These residual risk estimates exceed the USEPA target risk range of $10^{-4}$ to $10^{-6}$ for cancer risk and HI of 1.0 for non-cancer risk as well as the MEDEP target risk level of $10^{-5}$ for cancer risk with the majority of both cancer risk and non-cancer risk attributable to arsenic. USEPA guidance provides two interpretations of the target risk range: (1) that "the upper boundary of the risk range is not a discrete line at $1 \times 10^{-4}$. A specific risk estimate around $10^{-4}$ may be considered acceptable" and (2) "That compliance with a chemical specific ARAR [e.g., MCLs] generally will be considered protective, even if it is outside the risk range" (OSWER Directive 9355.0.03). Therefore, because the residual risk estimates were calculated based on the PRGs set at the federal MCL for arsenic, it is considered acceptable for this site and therefore, protective of human health.

Residual risks associated with future exposure to surface water as a drinking water supply will be acceptable when surface water concentrations meet appropriate drinking standards for arsenic and manganese. Arsenic and manganese groundwater concentrations that result in surface water concentrations at drinking water standards calculated as part of Section 3.3.2 are significantly higher than the arsenic MCL and manganese MEG. Although there is no current or foreseen future domestic use of groundwater or surface water at the site, the City of Saco agrees that the arsenic MCL and manganese MEG are appropriate groundwater PRGs. The site-specific surface water performance criterion for arsenic of 3 µg/L (MEDEP, 2000) will be relevant criterion for surface water of Sandy Brook.

### 3.3.4 Remedial Action Objectives

Remedial action objectives are site-specific quantitative goals defining the extent of cleanup required to achieve response objectives developed during the FS process and are used as the framework for developing detailed remedial alternatives. The objectives are formulated to achieve the overall goal of protecting human health and the environment and specify: (1) the contaminant of concern; (2) exposure route(s) and receptor(s); and (3) an acceptable concentration or range of concentrations for each exposure route.

TABLE 3-8
RESIDUAL RISK ESTIMATES FROM GROUNDWATER EXPOSURE TO THE PROPOSED PRGs.

FEASIBILITY STUDY REPORT
SACO MUNICIPAL LANDFILL
SACO, MAINE

EXPOSURE PARAMETERS

| PARAMETER | SYMBOL | VALUE | UNITS |
|---|---|---|---|
| CONCENTRATION WATER | CW | Maximum | mg/l |
| INGESTION RATE | IR | 2 | liters/day |
| INHALATION RATE | IH | 15 | m3/day |
| BODY WEIGHT | BW | 70 | kg |
| SURFACE AREA EXPOSED | SA | 19400 | cmšu2› |
| PERMEABILITY CONSTANT | PC | chemical specific | cm/hour |
| VOLATILIZATION CONSTANT | K | 0.5 | l/mšu3› |
| CONVERSION FACTOR | CFšd1› | 0.001 | l/cmšu3› |
| CONVERSION FACTOR | CFšd2› | 24 | hours/day |
| EXPOSURE FREQUENCY | EF | 350 | days/year |
| SHOWERING FREQUENCY | EFšds› | 2.9 | days/year |
| EXPOSURE DURATION | ED | 30 | years |
| AVERAGING TIME | | | |
| CANCER | AT | 70 | years |
| NONCANCER | AT | 30 | years |

Note: NA = Value not applicable by this route
For noncarcinogenic effects: AT ND = Not determined NG= Negligible

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)šu-1›

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

INTAKE-INGESTION = $\frac{CW \times IR \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$

INTAKE-INHALATION = OF VOLATILES $\frac{CW \times K \times IH \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$

INTAKE-DERMAL = $\frac{CW \times SA \times PC \times CFšd1› \times CFšd2› \times EFšds› \times ED}{BW \times AT \times 365 \text{ days/yr}}$

CARCINOGENIC EFFECTS

| COMPOUND | WATER CONCENTRATION (mg/l) | PC (cm/hr) | ORAL SLOPE FACTOR (mg/kg-day)šu-1› | INHALATION SLOPE FACTOR* (mg/kg-day)šu-1› | CANCER RISK INGESTION | CANCER RISK INHALATION | CANCER RISK DERMAL | TOTAL CANCER RISK | PER CENT OF TOTAL CANCER RISK |
|---|---|---|---|---|---|---|---|---|---|
| Benzene | 0.005 | 2.10E-02 | 2.9E-02 | 0.0E+00 | 1.7E-06 | | 6.9E-08 | 1.8E-06 | 0.20% |
| Arsenic | 0.05 | NG | 1.5E+00 | NA | 8.8E-04 | | | 8.8E-04 | 99.80% |
| SUMMARY CANCER RISK | | | | | 8.8E-04 | 0.0E+00 | 6.9E-08 | 8.8E-04 | |

NONCARCINOGENIC EFFECTS

| COMPOUND | WATER CONCENTRATION (mg/l) | PC (cm/hr) | ORAL REFERENCE DOSE (mg/kg-day) | INHALATION REFERENCE DOSE* (mg/kg-day) | HAZARD QUOTIENT INGESTION | HAZARD QUOTIENT INHALATION | HAZARD QUOTIENT DERMAL | TOTAL HAZARD QUOTIENT | PER CENT OF TOTAL HAZARD QUOTIENT |
|---|---|---|---|---|---|---|---|---|---|
| Benzene | 0.005 | NG | 3.0E-03 | ND | 4.6E-02 | | | 4.6E-02 | 1.00% |
| Arsenic | 0.05 | NG | 3.0E-04 | ND | 4.6E+00 | | | 4.6E+00 | 100.00% |
| Manganese | 0.5 | NG | 2.4E-02 | ND | 5.7E-01 | | | 5.7E-01 | 12.50% |
| SUMMARY HAZARD INDEX | | | | | 5.2E+00 | 0.0E+00 | 0.0E+00 | 4.6E+00 | |

Based on this discussion the remedial action objectives for groundwater, surface water, and sediment associated with Landfill Areas 3 and 4 are to:

- Prevent the ingestion of groundwater with constituents that exceed federal MCLs, promulgated state MEGs (1992), or in their absence, constituents with concentrations above levels that would represent a $10^{-4}$ to $10^{-6}$ excess cancer risk range or hazard quotient of 1;
- Restore groundwater to levels that do not exceed federal MCLs, state MEGs, or in their absence, constituents with concentrations above levels that would represent a $10^{-4}$ to $10^{-6}$ excess cancer risk range or hazard quotient of 1;
- Monitor the sediments of Sandy Brook to demonstrate that arsenic, iron, and manganese concentrations to not increase significantly over time; and
- Restore surface water quality of Sandy Brook to the site-specific performance standard for arsenic of 3 µg/L (i.e., PQL), or background if upstream monitoring establishes a background concentration greater than 3 µg/L.

Achieving these objectives will restore groundwater beneath the landfill to its beneficial use and reduce the potential for degradation of surface water downgradient from the landfill and will allow continued use of surface water in Sandy Brook in conformance with its Class B classification, specifically as a potential drinking water supply.

### 3.3.5 General Response Actions

General response actions describe general categories of remedial technologies that may be employed to address remedial action objectives, and lay the groundwork for identifying specific technologies in Section 4.0. The general response actions for groundwater at this site include one or a combination of the following:

- no further action;
- institutional controls;
- containment;
- collection;
- treatment; and
- disposal.

General response actions for surface water have not been established. Surface water remedial action objectives will be attained through the selected response action or actions for groundwater.

No remedial activities would be implemented under the No Further Action alternative; however, per the NCP and RI/FS guidance, it is considered throughout the FS process as a baseline against which other alternatives can be compared.

# 4.0 IDENTIFICATION AND SCREENING OF APPLICABLE TECHNOLOGIES

This section identifies and screens applicable technologies for remediation of groundwater associated with Landfill Areas 3 and 4 at the SML. As explained in Section 3.3, the surface water remedial action objective is to restore surface water quality to meet the site-specific performance standard for arsenic of 3 µg/L, or background if upstream monitoring establishes a background concentration greater than 3 µg/L. This remedial action objective will be attained through the selected response actions for groundwater. Source control measures have already been implemented at this site. Between 1997 and 1998, as part of the NTCRA, a low permeability cover system was installed at Landfill Area 4 (see Figure 3-1) to minimize infiltration of precipitation through the landfill into groundwater. An Operations and Maintenance (O&M) plan was developed and is currently being implemented to ensure the continued integrity of the cover system. In 2000, institutional controls (Appendix G) will be implemented on selected properties adjacent to the Site as part of the NTCRA (see Figure 3-2). Based on the results of the pumping test and MODFLOWn modeling, Woodard& Curran determined that pumping groundwater at 1 to 2 gallons per minute in Groundwater Restriction Parcel No. 2 should not affect the groundwater plume distribution. In addition, removal actions were previously conducted at two seep locations adjacent to Sandy Brook. The process of identifying and screening technologies suitable for groundwater remediation will address the remaining response objectives stated in the NTCRA (see Section 3) and ensure long-term protection to human health and the environment. This process was completed in accordance with USEPA guidance (USEPA, 1988, 1990, 1992, and 1993), and included identifying those technologies that both attain the remedial action objectives and fit the categories of general response actions as presented in Subsection 3.2. The result of this screening is a list of potential remedial technologies that can be combined to form a range of remedial alternatives.

The demonstrated performance and applicability of each technology is established by considering site and waste characteristics. Site characteristics include site geology, hydrogeology, and terrain, availability of space and resources necessary to implement the technology. Waste characteristics include contaminated media, types and concentrations of waste constituents, and physical and chemical properties of the waste (e.g., oxidation/reduction state, solubility, and mobility).

As discussed in Section 2.0, arsenic, benzene, and manganese were identified as CPCs in the baseline risk assessment and retained as COCs in this FS based on exceedence of MCLs or MEGs. Of these COCs, arsenic and manganese were detected most frequently at concentrations in excess of state and/or federal standards throughout the aquifer downgradient of Landfill Areas 3 and 4. Benzene was detected at only one location (MW-4R series) at concentrations in excess of its respective MCL. However, all three COCs were considered in identifying and screening technologies to contain, collect, treat in situ and ex situ, and discharge groundwater at this site.

The technology screening process reduces the number of potentially applicable technologies by evaluating each technology as to:

- its effectiveness in providing protection to human health and the environment and to the reduction in toxicity, mobility, or volume of the waste;
- its implementability, as a measure of both the technical and administrative feasibility of constructing, operating, maintaining a remedial technology; and
- its cost, as compared among technologies.

Technically feasible technologies passing this initial screening process are grouped into potential remedial alternatives in Section 5.0.

Table 4-1 identifies general response actions and potential remedial technologies for Landfill Areas 3 and 4 groundwater at the SML. Technology screening is presented in Table 4-2. Technologies judged not effective or implementable were eliminated from further consideration.

**TABLE 4-1**
**GENERAL RESPONSE ACTIONS AND IDENTIFICATION OF POTENTIAL TECHNOLOGIES FOR GROUNDWATER REMEDIATION**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| GENERAL RESPONSE ACTION/TECHNOLOGY | DESCRIPTION OF TECHNOLOGY |
|---|---|
| **No Further Action** | |
| None | No action taken to further reduce risk. |
| **Institutional Actions** | |
| Institutional Controls | Implements zoning and/or other deed restrictions prohibiting the use of or access to groundwater or surface water as a drinking water source within and around the site. |
| Environmental Monitoring | Evaluates the migration and distribution of groundwater, surface water and sediment contamination over time. |
| **Containment** | |
| Physical Barrier | Use of slurry wall/sheet piling to contain groundwater flow downgradient of Landfill Areas 3 and 4. |
| Hydraulic Containment | Use of strategically located extraction wells to contain groundwater flow downgradient of Landfill Areas 3 and 4. |
| **Collection** | |
| Trenches | Use of trenches, drains, and piping to passively collect (by gravity flow) contaminated groundwater. |
| Extraction Wells | Installation of strategically located pumping wells to collect contaminated groundwater. |
| Funnel Gate System | Use of an innovative technology that includes subsurface cut-off walls with gaps that may or may not contain in situ reactors. If reactors are in place, such as reactive porous media that remove contaminants, treatment is also provided. If reactors are not in place, the funnel gate is used to channel groundwater flow to specific extraction well locations. |

**TABLE 4-1 (cont.)**
**GENERAL RESPONSE ACTIONS AND IDENTIFICATION OF POTENTIAL TECHNOLOGIES FOR GROUNDWATER REMEDIATION**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| GENERAL RESPONSE ACTION/TECHNOLOGY | DESCRIPTION OF TECHNOLOGY |
|---|---|
| **Ex Situ Treatment** | |
| Oxidation | Use of chemicals to oxidize As (III) to As (V) prior to any groundwater treatment. As(V) is more effectively removed from groundwater by most treatment technologies than the more soluble As(III). |
| Precipitation/Coagulation/Flocculation | This combination of technologies removes dissolved metals from aqueous wastes by chemically converting the metals to an insoluble form. The process produces a metal sludge that may need to be managed. |
| Filtration | This technology removes solid particles from groundwater by passing through a porous medium (e.g., sand). |
| Ion Exchange | This technology removes ions from aqueous wastes by exchange with cations or anions between the contaminants and the exchange medium. |
| Adsorption w/Activated Alumina | This technology utilizes adsorption whereby As (V) is exchanged for surface hydroxides on packed beds of activated alumina. |
| Granular Activated Carbon | This technology is a physical removal process in which organic and inorganic materials are removed from wastewater by sorption (i.e., the attraction and accumulation) onto granular activated carbon sites. With this technology, groundwater is pumped through canisters containing activated carbon, and dissolved contaminants will be adsorbed onto the carbon and removed from groundwater. |
| **In Situ Treatment** | |
| Natural Attenuation | Natural process where inorganic metal concentrations in groundwater are reduced by sorption or oxidation/reduction reactions. |
| Aeration/Oxidation | Injection of air, or chemicals to increase oxygen content of groundwater sufficient to oxidize the arsenic to immobile As (V). |
| Passive Treatment Walls | This technology involves installation of a permeable reaction wall across the flow path of a contaminant plume. Contaminants will either be degraded or retained in a precipitated/concentrated form by the reaction wall materials, as the groundwater passes through. |

**TABLE 4-1 (cont.)**
**GENERAL RESPONSE ACTIONS AND IDENTIFICATION OF POTENTIAL TECHNOLOGIES FOR GROUNDWATER REMEDIATION**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| GENERAL RESPONSE ACTION/TECHNOLOGY | DESCRIPTION OF TECHNOLOGY |
|---|---|
| **In Situ Treatment (continued)** | |
| Contructed Wetlands | The use of constructed wetlands to enhance natural geochemical and biological processes inherent in a wetland ecosystem to accumulate and remove metals and other contaminants from influent waters. |
| Phytoremediation | Use of plants to clean contamination in groundwater and surface water. |
| **Disposal** | |
| Groundwater Discharge | Discharge of treated groundwater to on-site location for passive infiltration to the aquifer. |
| Saco WWTP | Discharge pre-treated or untreated groundwater to the Saco WWTP for treatment and disposal. |
| Surface Water Discharge | Discharge of treated groundwater to a surface water body. |

**NOTES:**

As = Arsenic
WWTP = waste water treatment plant

TABLE 4-2
GROUNDWATER REMEDIAL TECHNOLOGY SCREENING

FEASIBILITY STUDY REPORT
SACO MUNICIPAL LANDFILL
SACO, MAINE

| GENERAL RESPONSE ACTION/TECHNOLOGY | SCREENING STATUS | | POTENTIAL APPLICATIONS/COMMENTS |
|---|---|---|---|
| | RETAINED | ELIMINATED | |
| **No Further Action** | X | | Required by the NCP as a baseline for comparison to other alternatives. |
| **Institutional Actions** | | | |
| Institutional Controls | X | | Institutional controls have been implemented as part of the NTCRA and limit the future land and groundwater use at this site. No additional land-use restrictions/controls are considered necessary to protect human health or the environment. |
| Environmental Monitoring | X | | Groundwater monitoring wells currently exist on site that can be used in a groundwater monitoring program. Surface water and sediment in Sandy Brook can also be monitored. |
| **Containment** | | | |
| Physical Barrier | | X | Due to the fractures in the bedrock at the SML, it would be difficult to achieve an effective seal for the slurry wall/sheet piling. In addition, the radial flow of groundwater from the landfill would require the construction of a long physical barrier downgradient of the landfill to contain groundwater. Extraction wells would also be required within the barrier wall to remove the contained groundwater. |
| Hydraulic Containment | X | | Extraction wells would effectively contain groundwater, thereby minimizing the volume of contaminated groundwater discharging to Sandy Brook. Extracted groundwater may require treatment before discharge. |

TABLE 4-2 (cont.)
GROUNDWATER REMEDIAL TECHNOLOGY SCREENING

FEASIBILITY STUDY REPORT
SACO MUNICIPAL LANDFILL
SACO, MAINE

| GENERAL RESPONSE ACTION/TECHNOLOGY | SCREENING STATUS | | POTENTIAL APPLICATIONS/COMMENTS |
|---|---|---|---|
| | RETAINED | ELIMINATED | |
| **Collection** | | | |
| Trenches | | X | A trench approximately 400 feet long and approximately 15 feet deep would be required on each side of Sandy Brook to collect the contaminated groundwater. |
| Extraction Wells | X | | Extraction wells would effectively contain and remove contaminated groundwater from the overburden aquifer. |
| Funnel Gate System | | X | A significant length of slurry wall/sheet pile would be required downgradient of the landfill to channel groundwater flow through a gate of porous media designed for metals treatment. However, the fractured bedrock would make it difficult to achieve an effective seal for the slurry wall/sheet pile. |
| **Ex Situ Treatment** | | | |
| Oxidation | X | | As (V) is more effectively removed from groundwater than the more soluble As (III). The use of an oxidant, such as chlorine can create an environment conducive to the formation of As (V). Lab and pilot studies conducted at other sites indicate that chlorine and potassium permanganate are both effective in oxidizing As (III) to As (V), but aeration was not effective. |

TABLE 4-2 (cont.)
GROUNDWATER REMEDIAL TECHNOLOGY SCREENING

FEASIBILITY STUDY REPORT
SACO MUNICIPAL LANDFILL
SACO, MAINE

| GENERAL RESPONSE ACTION/TECHNOLOGY | SCREENING STATUS | | POTENTIAL APPLICATIONS/COMMENTS |
|---|---|---|---|
| | RETAINED | ELIMINATED | |
| **Ex Situ Treatment (cont.)** | | | |
| Precipitation/Coagulation/Flocculation | X | | Coprecipitation with iron and filtration is an effective method of removing As (III) in groundwater under reducing conditions. Coagulation with Fe or aluminum salts is also effective at removing As (V), but less effective at removing As (III). Arsenic and other materials are removed in a clarifier as a sludge, which would require off-site disposal. |
| Filtration | X | | Filtration could be used alone to remove As (V), or as a step prior to ion exchange or activated alumina treatment to remove precipitated iron from the groundwater. |
| Ion Exchange | X | | The high concentrations of Fe and organics present in the landfill leachate may foul the resin. However, ion exchange could be used as a polishing step to reduce arsenic concentrations. |
| Adsorption w/Activated Alumina | X | | High concentrations of Fe and organics present in the landfill leachate may foul the activated alumina. It could be used as a polishing step if treatment by precipitation does not achieve groundwater MCLs. |
| Granular Activated Carbon (GAC) | X | | GAC could be used as a polishing step to reduce dissolved contaminant concentrations. |

TABLE 4-2 (cont.)
GROUNDWATER REMEDIAL TECHNOLOGY SCREENING

FEASIBILITY STUDY REPORT
SACO MUNICIPAL LANDFILL
SACO, MAINE

| GENERAL RESPONSE ACTION/TECHNOLOGY | SCREENING STATUS | | POTENTIAL APPLICATIONS/COMMENTS |
|---|---|---|---|
| | RETAINED | ELIMINATED | |
| **In Situ Treatment** | | | |
| Natural Attenuation | X | | USGS research shows highly reduced groundwater beneath the landfill containing high concentrations of DOC. The DOC is acting as a food source for naturally occurring bacteria and indirectly controlling the level of DO in the groundwater. The research suggests that over time as the DOC is depleted; the level of DO will increase. As the aquifer becomes more oxidized a hierarchy of chemical reactions will occur whereby the concentrations of dissolved Fe will decrease, then Mn and As. Over time, the DO level will increase sufficiently to keep the aquifer in an oxidized state and As in the insoluble As (V) form. |
| Chemical Oxidation | X | | Chemical oxidants would be added to decrease the DOC content of groundwater will allow the oxidation of dissolved As (III) to As (V) which would then precipitate out of solution. |
| Passive Treatment Walls | | X | This technology has not been proven effective for the treatment of As. With the radial flow of groundwater from the landfill, a very long treatment wall would be required. |
| Constructed Wetlands | | X | This technology has not been proven effective for removal of As. |
| Phytoremediation | | X | This technology has not been proven effective full scale for removal of As. |

TABLE 4-2 (cont.)
GROUNDWATER REMEDIAL TECHNOLOGY SCREENING

FEASIBILITY STUDY REPORT
SACO MUNICIPAL LANDFILL
SACO, MAINE

| GENERAL RESPONSE ACTION/TECHNOLOGY | SCREENING STATUS | | POTENTIAL APPLICATIONS/COMMENTS |
|---|---|---|---|
| | RETAINED | ELIMINATED | |
| **Disposal** | | | |
| Groundwater Discharge | X | | Groundwater treated to MCLs can be allowed to passively recharge to the aquifer. |
| Saco WWTP | X | | Pre-treated or untreated groundwater can be discharged to WWTP. |
| Surface Water Discharge | | X | Because Sandy Brook has a drainage area less than 10 $mi^2$, treated groundwater cannot be discharged to Sandy Brook. |

**NOTES:**

As = Arsenic
DOC = dissolved organic carbon
DO = dissolved oxygen
Fe = Iron
MCL = Maximum Contaminant Level
mi = miles
NCP = National Contingency Plan
NTCRA = Non-Time Critical Removal Action
SML = Saco Municipal Landfill
USGS = United States Geological Survey
WWTP = waste water treatment plant

# 5.0 DEVELOPMENT OF REMEDIAL ALTERNATIVES

Technologies identified in Section 4.0 as being technically feasible to address the groundwater contamination associated with Landfill Areas 3 and 4 are grouped into a range of potential remedial alternatives that address the remedial action objectives identified in Section 3.0. The range of alternatives include no further action, containment, monitored natural attenuation, and in situ and ex situ treatment of contaminated groundwater. A total of five alternatives was developed, and each alternative has been assigned a number for identification purposes. The major technical components of the alternatives are summarized in Table 5-1, illustrated in a flow chart in Figure 5-1, and described below.

**SML-1: No Further Action.** In accordance with the USEPA guidance (USEPA, 1988, 1990, 1992 and 1993), the No Further Action alternative was developed for consideration throughout the FS process as a baseline for comparison to other alternatives. The alternative consists of no remedial activities additional to the institutional controls implemented on-site, and the RCRA Subtitle C cover system placed over the landfill as a source control measure as part of the NTCRA. This alternative represents the minimum proposed remedial action for groundwater.

**SML-2: Hydraulic Containment and Discharge With or Without Treatment.** This alternative was developed to contain groundwater to minimize the volume of contaminated groundwater discharging to Sandy Brook. A pumping rate of approximately 60 gallons per minute (gpm) is the minimum rate necessary to achieve significant containment. Extracted groundwater would either be discharged to the Saco Waste Water Treatment Plant (WWTP) untreated or treated on-site and discharged to an on-site infiltration basin and allowed to passively infiltrate to the aquifer.

Off-site discharge to the Saco WWTP would require construction of a piping system to the North Street sewer, and capacity evaluation and possible upgrades to the North Street sewer and pump stations. If treatment is necessary, extracted groundwater would be treated using precipitation, coagulation, and flocculation to reduce metals to concentrations that meet discharge requirements (e.g., MCLs). This treatment process would involve the construction of an on-site treatment plant that would require long-term operation and maintenance and construction of an infiltration basin for on-site discharge of treated groundwater. Sludges generated during groundwater treatment would require off-site disposal.

**TABLE 5-1**
**COMPONENTS OF THE REMEDIAL ALTERNATIVES**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| ALTERNATIVE | KEY COMPONENTS |
|---|---|
| SML-1: NO FURTHER ACTION | • None |
| SML-2: HYDRAULIC CONTAINMENT, AND DISCHARGE WITH OR WITHOUT TREATMENT | • Environmental monitoring<br>• Site preparation<br>• Installation of two groundwater extraction wells<br>• Discharge of extracted untreated groundwater to Saco WWTP<br>• Treatment of groundwater on-site using precipitation/flocculation/coagulation<br>• Discharge of treated groundwater to on-site infiltration basin<br>• Off-site disposal of treatment sludges<br>• Five-year site reviews |
| SML-3: MONITORED NATURAL ATTENUATION | • Environmental monitoring<br>• Natural attenuation of dissolved metals<br>• Five-year site reviews |
| SML-4: CHEMICAL OXIDATION & WITH HYDRAULIC CONTAINMENT | • Environmental monitoring<br>• Site preparation<br>• Installation of chemical oxidant injection wells<br>• Installation of groundwater extraction system<br>• Discharge of extracted untreated groundwater to Saco WWTP<br>• Treatment of groundwater using precipitation/flocculation/coagulation<br>• Discharge of treated groundwater to on-site infiltration basin<br>• Off-site disposal of treatment sludges<br>• Five-year site reviews |
| SML-5: GROUNDWATER EXTRACTION AND DISCHARGE, WITH OR WITHOUT TREATMENT AND DISCHARGE | • Environmental monitoring<br>• Site preparation<br>• Installation of groundwater extraction<br>• Discharge of extracted untreated groundwater to Saco WWTP<br>• Treatment of groundwater using precipitation/flocculation/coagulation<br>• Discharge of treated groundwater to on-site infiltration basin<br>• Off-site disposal of treatment sludges<br>• Five-year site reviews |

**NOTES:**

WWTP = waster water treatment plant

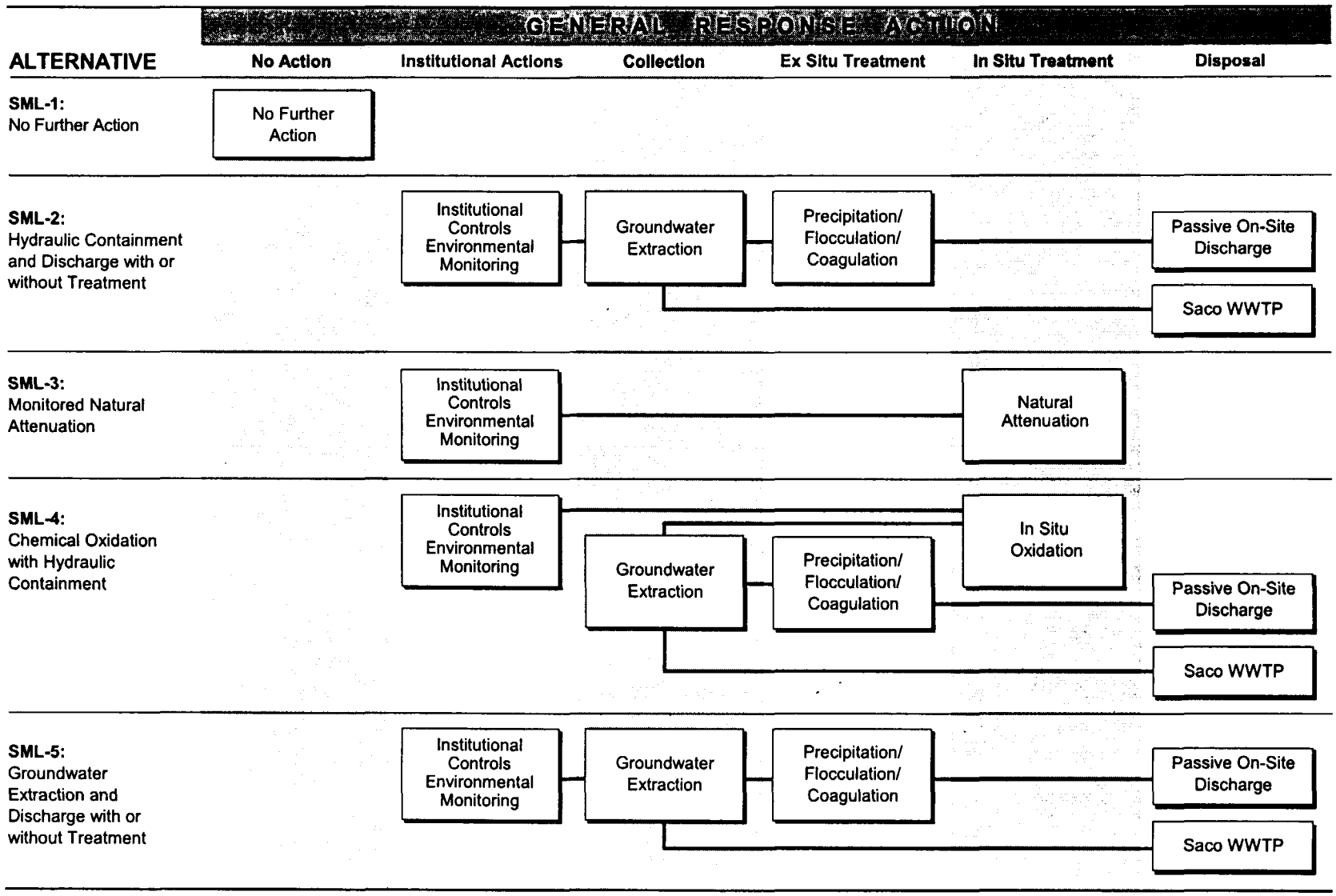


Figure 5-1
Development of Remedial Alternatives
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An environmental monitoring plan would be developed to evaluate the continued effectiveness of this alternative. Five-year site reviews would be conducted to assess the continued protection of human health and the environment as a part of this alternative. Institutional controls have been implemented as part of the NTCRA to restrict future land and groundwater use at the site. No institutional controls beyond those implemented pursuant to the NTCRA are anticipated at this time. However, EPA will evaluate the need for further institutional controls as part of each five-year review.

**SML-3: Monitored Natural Attenuation.** This alternative consists of natural attenuation of dissolved arsenic and manganese in groundwater through changes in groundwater chemistry (e.g., oxidation/reduction potential). Per the NCP (USEPA, 1990) and the Final OSWER Monitored Natural Attenuation Policy (USEPA, 1999b), under certain conditions, natural attenuation is considered an appropriate remedial alternative for the treatment of groundwater.

The RCRA Subtitle C cover system installed on Landfill Areas 3 and 4 is minimizing the infiltration of precipitation through the landfill and, over time, will reduce leachate generation. As discussed in Section 2.0, the groundwater beneath and downgradient of the landfill is highly reduced and contains elevated concentrations of DOC.

The DOC, acting as a nutrient source for naturally occurring bacteria, indirectly controls the level of DO in the groundwater. USGS research suggests that over time the level of DO in the groundwater will increase and the aquifer will become more oxidized. With increased oxidation, a hierarchy of chemical reactions will occur whereby the concentrations of dissolved iron will decrease, followed by decreases in manganese and then arsenic. Over time, the level of DO will increase sufficiently to keep the aquifer in an oxidized state and arsenic in the insoluble As(V) form.

An environmental monitoring plan would be developed to evaluate the continued effectiveness of the natural attenuation processes. Five-year site reviews would be conducted to ensure the continued protection of human health and the environment. Institutional controls have been implemented as part of the NTCRA to restrict future land and groundwater use at the site. No institutional controls beyond those

implemented pursuant to the NTCRA are anticipated at this time. However, EPA will evaluate the need for further institutional controls as part of each five-year review.

**SML-4: Chemical Oxidation with Hydraulic Containment.** This treatment alternative was developed to reduce the time to meet remedial action objectives by injecting a chemical oxidant into the sand and gravel aquifer to reduce the concentration of DOC. Under this treatment alternative, the concentration of DOC in the groundwater would be decreased by adding chemical oxidants to the aquifer. The chemicals could be introduced to the aquifer through a series of injection wells. By changing the groundwater chemistry, the capacity of the groundwater to leach inorganics from soil and bedrock will be reduced. Hydraulic containment has been included in this alternative to manage the distribution of chemicals added to the contaminated plume. Groundwater extraction would be used to capture the chemical oxidant to prevent the chemical from reaching Sandy Brook and/or spreading to portions of the non-contaminated aquifer. Over time, the concentration of arsenic in the groundwater will decrease. Environmental monitoring and five-year site reviews would also be components of this alternative. Institutional controls have been implemented as part of the NTCRA to restrict future land and groundwater use at the site. No institutional controls beyond those implemented pursuant to the NTCRA are anticipated at this time. However, EPA may evaluate the need for further institutional controls as part of each five-year review.

**SML-5: Groundwater Extraction and Discharge With or Without Treatment.** This alternative consists of groundwater extraction from the area downgradient of the capped landfill. This alternative was developed to reduce the time to meet remedial action objectives by pumping groundwater to "flush" the aquifer. It has been assumed that extracted groundwater would be replaced by more oxygenated groundwater facilitating the change in groundwater chemistry necessary to reduce the leaching of arsenic from soil and bedrock. Reductions in surface water concentration of arsenic and manganese would be accomplished by capturing the groundwater plume.

Extracted groundwater would be either discharged directly to the Saco WWTP or treated on-site using precipitation, coagulation, and flocculation to reduce metals to concentrations that meet discharge requirements. Treatment would require the construction of an on-site plant, long-term operation and maintenance, and construction of an infiltration basin for on-site discharge. Sludges generated during the

groundwater treatment process would require off-site disposal. Discharge to the Saco WWTP would require construction of a piping system to the North Street sewer and possible upgrades to the North Street sewer and pump stations.

Environmental monitoring and five-year site reviews would also be components of this alternative. Institutional controls have been implemented as part of the NTCRA to restrict future land and groundwater use at the site. No institutional controls beyond those implemented pursuant to the NTCRA are anticipated at this time. However, EPA may evaluate the need for further institutional controls as part of each five-year review.

# 6.0 INITIAL SCREENING OF REMEDIAL ALTERNATIVES

In accordance with the NCP (USEPA, 1990 and 1993) and USEPA guidance (USEPA, 1988 and 1992), the remedial alternatives developed in Section 5.0 are screened against effectiveness, implementability, and cost based on the criteria presented in Table 6-1. The objective of this screening is to eliminate from further consideration alternatives that have undesirable results, while still preserving a range of options that will undergo a more thorough and extensive analysis in the Detailed Analysis of Remedial Action Alternatives in Section 7.0.

A matrix was developed in this section highlighting the advantages and disadvantages of each alternative developed in Section 5.0 with respect to effectiveness, implementability, and cost. This matrix presents clear, concise information necessary to screen and either retain or eliminate potential remedial alternatives from further consideration. The initial screening of the groundwater remedial alternatives is presented in Section 6.1 and summarized in Section 6.2.

## 6.1 INITIAL SCREENING

Five remedial alternatives were developed in Section 5.0:

- SML-1: No Further Action;
- SML-2: Hydraulic Containment and Discharge With or Without Treatment;
- SML-3: Monitored Natural Attenuation;
- SML-4: Chemical Oxidation with Hydraulic Containment;
- SML-5 Groundwater Extraction, With or Without Treatment and Discharge.

These alternatives provide a combination of technologies that range from no further action to aggressive treatment of groundwater to meet the remedial action objectives established for groundwater at the SML. As explained in Section 3.3, surface water remedial action objectives will be attained through the selection response action or actions for groundwater. Tables 6-2 through 6-6 present the matrices that highlight the screening of each alternative for effectiveness, implementability, and cost. Each table includes a recommendation whether or not to retain the alternative for detailed analysis.

## TABLE 6-1
## CRITERIA FOR INITIAL SCREENING OF ALTERNATIVES

## FEASIBILITY STUDY REPORT
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| • Compliance with ARARs | • Technical Feasibility | • Equipment/Construction |
| • Reduction of Mobility, Toxicity, or Volume of Contaminants | • Demonstrated Performance | • Operation and Maintenance |
| • Protection of Human Health and the Environment | • Availability of Equipment, Space, and Services | |
| • Adverse Short- and Long-term Effects Caused by Implementation | • Administrative Feasibility | |

ARAR = Applicable or Relevant and Appropriate Requirement

## TABLE 6-2
## SCREENING OF REMEDIAL ALTERNATIVES

## FEASIBILITY STUDY REPORT
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

### SML-1: NO FURTHER ACTION

**Synopsis:** Source control measures (e.g., low permeability cover system) and institutional controls have been implemented at the site as part of the NTCRA. No additional remedial activities would be implemented under this alternative.

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| **Advantages** | **Advantages** | **Advantages** |
| • The contaminated groundwater is currently not being used as a drinking water supply; therefore, there is no current threat to public health. Institutional control will be used to mitigate the potential for future exposure.<br>• Source control measures and institutional controls have been implemented as a part of the NTCRA and restrict future land and groundwater use, thereby minimizing potential future risk to human health. | • Most easily implemented because no remedial actions are required. | • No capital costs would be required.<br>• No O&M costs would be required. |
| **Disadvantages** | **Disadvantages** | **Disadvantages** |
| • The site would not be monitored for contaminant migration.<br>• May require 50 to 100 years to achieve remedial action objectives.<br>• No mechanism, either monitoring or five-year reviews, to track the progress of natural attenuation process; implies that current concentrations in environmental media are acceptable. | • May require future remedial actions. | • Potential for increased costs if remedial actions are required in the future. |

**Conclusion:** The No Further Action Alternative is retained as a baseline for comparison to the remaining alternatives.

NTCRA = Non-Time Critical Removal Action

# TABLE 6-3
# SCREENING OF REMEDIAL ALTERNATIVES

## SACO MUNICIPAL LANDFILL
## SACO, MAINE

### SML-2: HYDRAULIC CONTAINMENT AND DISCHARGE WITH OR WITHOUT TREATMENT

**Synopsis:** This alternative includes extraction of groundwater from the area downgradient of Landfill Areas 3 and 4 to contain contaminated groundwater and minimize its discharge to Sandy Brook. Extracted groundwater would either be discharged to the Saco WWTP or treated on site and discharged to an on-site groundwater infiltration basin. Environmental monitoring would be included in this alternative. Source control measures and institutional controls have been implemented at this site as part of the NTCRA.

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| **Advantages** | **Advantages** | **Advantages** |
| • This alternative would manage migration of the plume and reduce the flux of contaminants discharging to Sandy Brook.<br>• The proposed groundwater extraction rate will not adversely affect surface water flow in Sandy Brook.<br>• Source control measures and institutional controls have been implemented as a part of the NTCRA and restrict future land and groundwater use, thereby minimizing potential future risk to human health. | • Services and materials are readily available.<br>• Installation of extraction wells is technically feasible and easily implementable.<br>• Precipitation/flocculation/coagulation is a proven technology for treatment of dissolved arsenic and manganese in groundwater. | • Potentially lower capital costs compared to other extraction alternative and in-situ oxidation alternative because a smaller volume of groundwater would be extracted/treated/discharged. |
| **Disadvantages** | **Disadvantages** | **Disadvantages** |
| • Treatability studies would be required to determine the requirements for treatment of groundwater using precipitation, flocculation, and coagulation.<br>• A pumping rate of 60 gpm is sufficient to contain the plume, but is not considered sufficient to enhance flushing of oxygenated groundwater through the aquifer, and will therefore, not reduce the time to meet remedial action objectives over natural attenuation. USGS research indicates that 50 to 100 years would be required to meet these groundwater objectives. | • Long-term maintenance of extraction wells would be required to prevent fouling caused by high concentrations of iron and other metals in groundwater.<br>• If groundwater treatment is required, an on-site treatment plant must be constructed that would require long-term O&M.<br>• An infiltration study would be required to determine the location and dimensions for an infiltration basin.<br>• Sludge generated during groundwater treatment would require off-site disposal.<br>• If groundwater is discharged to the Saco WWTP, upgrades to the North Street sewer and pump stations would be required.<br>• Long-term environmental monitoring would be required. | • Overall high cost for minimal risk reduction.<br>• Extensive long-term environmental monitoring and maintenance costs.<br>• Capital cost for construction of pipeline to sewer and upgrade of pumphouse or construction of on-site treatment plant.<br>• Long-term O&M costs for treatment system, maintenance of extraction wells and replacement of pumps.<br>• Disposal cost for small quantities of sludge. |

**Conclusion:** This alternative would manage migration of the plume without adversely affecting surface water flow in Sandy Brook, but would not enhance the flushing of oxidized groundwater through the aquifer. Therefore, this alternative would not reduce the time to meet groundwater remedial action objectives over the No Further Action or Natural Attenuation alternatives. Containment of the groundwater plume would reduce concentrations in surface water downstream from the groundwater discharge area within a few years. Although management of migration of the plume is a goal of remediation, currently groundwater downgradient of Landfill Areas 3 and 4 discharging to Sandy Brook is not causing an adverse ecological effect or creating a human health risk. Therefore, a separate alternative providing only hydraulic containment is not necessary as containment is also a component of Alternative SML-5. This alternative is **NOT** retained for detailed analysis.

MCL = Maximum Contaminant Level
O&M = Operations and Maintenance
USGS = U.S. Geological Survey
WWTP = waste water treatment plant

## TABLE 6-4
## SCREENING OF REMEDIAL ALTERNATIVES

## FEASIBILITY STUDY REPORT
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

### SML-3: MONITORED NATURAL ATTENUATION

**Synopsis:** This alternative consists of natural attenuation of dissolved arsenic and manganese in groundwater. Environmental monitoring would be included in this alternative. Source control measures and institutional controls have been implemented as a part of the NTCRA.

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| **Advantages** | **Advantages** | **Advantages** |
| • The contaminated groundwater is currently not being used as a drinking water supply, therefore, there is no current threat to public health. Institutional controls implemented as part of the NTCRA will restrict the potential for future exposure to groundwater and surface water as a drinking water supply.<br>• Over time, as the concentration of dissolved oxygen increases sufficiently to keep the aquifer in an oxidized state, arsenic and manganese will be either chemically stabilized through oxidation reactions to their less soluble and less mobile form (e.g., As(V)), and/or sorbed to aquifer material rendering them immobile.<br>• Environmental monitoring would be conducted to demonstrate effectiveness of natural attenuation processes.<br>• Source control measures and institutional controls have been implemented as a part of the NTCRA and restrict future land and groundwater use, thereby minimizing potential exposure to contaminated groundwater. | • No active remedial actions are required<br>• Services and/or materials to implement an environmental monitoring program are readily available.<br>• Additional remedial actions would be easy to implement if necessary | • Minimal capital and O&M costs. |
| **Disadvantages** | **Disadvantages** | **Disadvantages** |
| • USGS research indicates that 50 to 100 years would be required to meet remedial action objectives. | • May require future remedial actions.<br>• Long-term environmental monitoring would be required. | • Long-term environmental monitoring costs.<br>• Potential future costs if monitoring indicates natural attenuation processes are no longer effective. |

**Conclusion:** Natural attenuation will chemically stabilize dissolved arsenic and manganese by oxidation reactions and sorption as the concentration of dissolved oxygen in the aquifer increases naturally over time. The site currently poses no risks to human health or the environment and institutional controls implemented as part of the NTCRA will prevent future exposure. Therefore, this alternative is retained for detailed analysis.

As = arsenic
USGS = U.S. Geological Survey
O&M = Operations and Maintenance

# TABLE 6-5
# SCREENING OF REMEDIAL ALTERNATIVES

## FEASIBILITY STUDY REPORT
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

### SML-4: CHEMICAL OXIDATION WITH HYDRAULIC CONTAINMENT

**Synopsis:** This alternative consists of chemical oxidation to enhance natural attenuation of dissolved arsenic and manganese in the groundwater. Hydraulic containment of the polume in the area downgradient Landfill Areas 3 and 4 to enhance the movement of oxygenated groundwater through the aquifer. Extracted groundwater either would be discharged to the Saco WWTP or treated on-site using precipitation, coagulation, and flocculation and discharged to an on-site groundwater infiltration basin. Environmental monitoring would be included in this alternative. Source control measures and institutional controls have been implemented as a part of the NTCRA.

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| **Advantages** | **Advantages** | **Advantages** |
| • In situ aeration/oxidation may enhance natural attenuation processes by increasing the concentration of DO in the groundwater and reduce the time to achieve PRGs compared to natural processes.<br>• This alternative would manage the migration of the plume.<br>• Source control measures and institutional controls have been implemented as a part of the NTCRA and restrict future land and groundwater use, thereby minimizing potential future risk to human health. | • Services and materials are readily available.<br>• Installation of remedial systems is technically feasible.<br>• Precipitation, coagulation and flocculation is a proven technology for treatment of dissolved arsenic in groundwater to 50 ug/L. | • Lower capital costs for installation of injection wells in comparison to ex situ treatment alternatives. |
| **Disadvantages** | **Disadvantages** | **Disadvantages** |
| • Long-term effectiveness of in-situ aeration/oxidation is not demonstrated.<br>• Injection of oxygen into the aquifer would eventually clog the aquifer with precipitated iron, manganese and arsenic, minimizing additional dispersion of oxygen in the aquifer. Therefore, many injection points would be required to oxidize the plume.<br>• Continued active injection of air or oxidant would be required until DOC has been degraded. Therefore, time to achieve remedial action objectives is unknown.<br>• Precipitated metals could be redissolved as they come into contact with reduced groundwater around the periphery of the zone of influence of air sparge or oxidation injection wells.<br>• Precipitated iron, manganese, and arsenic could clog the aquifer and change the flow path of the plume.<br>• Backwashing of air sparge or oxidation injection wells with an anti-fouling compound (i.e., acid) would lower the pH potentially causing precipitated metals to redissolve.<br>• Treatability studies would be required to determine the requirements for treatment of groundwater using precipitation, flocculation, and coagulation. | • Would be very difficult to implement an injection system that could effectively deliver oxygen to ensure a completely mixed system.<br>• Quantity of oxygen required to change the groundwater chemistry to an oxidized state is unknown and difficult to predict, because the mass of dissolved organic carbon in the system is unknown.<br>• Long-term maintenance of injection wells would be required to prevent fouling caused by high concentrations of iron and other metals in groundwater in contact with injected air/oxygen.<br>• Time frame to meet remedial action objectives with air/oxygen injection is unknown.<br>• Long-term maintenance of extraction wells would be required to prevent fouling caused by high concentrations of Fe and other metals in groundwater. | • High O&M costs to provide a continued supply of air or chemicals to oxygenate the groundwater, and to maintain/replace injection systems that will frequently foul due to precipitating iron.<br>• Long-term monitoring and maintenance costs.<br>• Additional monitoring costs over other alternatives would be required to monitor the oxygen content throughout the system to ensure effectiveness.<br>• High capital costs to install extraction wells, extensive piping system for extraction and discharge, and construction of a groundwater treatment system or pumphouse upgrades. |

## TABLE 6-5 (continued)
## SCREENING OF REMEDIAL ALTERNATIVES

## FEASIBILITY STUDY REPORT
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

### SML-4: CHEMICAL OXIDATION WITH HYDRAULIC CONTAINMENT

**Synopsis:** This alternative consists of chemical oxidation to enhance natural attenuation of dissolved arsenic and manganese in the groundwater. Hydraulic containment of the polume in the area downgradient Landfill Areas 3 and 4 to enhance the movement of oxygenated groundwater through the aquifer. Extracted groundwater either would be discharged to the Saco WWTP or treated on-site using precipitation, coagulation, and flocculation and discharged to an on-site groundwater infiltration basin. Environmental monitoring would be included in this alternative. Source control measures and institutional controls have been implemented as a part of the NTCRA.

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| **Disadvantages** | **Disadvantages** | **Disadvantages** |
| | • If groundwater treatment is required, a large on-site treatment plant must be constructed, that would require long-term O&M.<br>• Sludge generated during groundwater treatment would require off-site disposal.<br>• An infiltration study would be required to determine the on-site location and dimensions for an infiltration basin.<br>• If groundwater is discharged to Saco WWTP, upgrades to the North Street sewer and pump stations would be required.<br>• Long-term environmental monitoring would be required | • Long-term O&M costs, to clean and/or replace pumps that have fouled due to high iron content.<br>• Cost for disposal of sludge generated from groundwater treatment |

**Conclusion:** Chemical/oxidation with hydraulic containment is expected to have limited effectiveness due to the difficulty of delivering and maintaining oxygen in the aquifer, because of the significant potential for the injection points to clog with precipitate. In addition, the reducing conditions in the aquifer create the potential for stabilized contaminants to be redissolved. Although this alternative would incur high capital and O&M costs for hydraulic containment, discharge and potential treatment, it has the potential to reduce the time to achieve groundwater remedial action objectives. Therefore, this alternative is retained for detailed analysis.

DO = dissolved oxygen
DOC = dissolved organic carbon
PRG = Preliminary Remediation Goal

# TABLE 6-6
# SCREENING OF REMEDIAL ALTERNATIVES

## FEASIBILITY STUDY REPORT
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

### SML-5: GROUNDWATER EXTRACTION, AND DISCHARGE WITH OR WITHOUT TREATMENT

**Synopsis:** This alternative includes extraction of groundwater from the area downgradient Landfill Areas 3 and 4 to enhance the movement of oxygenated groundwater through the aquifer. Extracted groundwater either would be discharged to the Saco WWTP or treated on-site using precipitation, coagulation, and flocculation and discharged to an on-site groundwater infiltration basin. Environmental monitoring would be included in this alternative. Source control measures and institutional controls have been implemented at this site as a part of the NTCRA.

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| **Advantages** | **Advantages** | **Advantages** |
| • This alternative would manage the migration of the plume and may enhance the flushing of oxygenated groundwater through the aquifer.<br>• This alternative may reduce the time to achieve PRGs compared to natural processes by enhancing the movement of oxygenated groundwater through the aquifer.<br>• Source control measures and institutional controls have been implemented as a part of the NTCRA and restrict future land and groundwater use, thereby minimizing potential future risk to human health. | • Services and materials are readily available.<br>• Installation of extraction wells is technically feasible and easily implementable.<br>• Precipitation, coagulation and flocculation is a proven technology for treatment of dissolved arsenic in groundwater to 50 ug/L. | • None |
| **Disadvantages** | **Disadvantages** | **Disadvantages** |
| • Treatability studies would be required to determine the requirements for treatment of groundwater using precipitation, flocculation, and coagulation.<br>• Pumping tests would be required to determine the pumping rate necessary to enhance the "flushing" of oxygenated groundwater through the aquifer.<br>• The pumping rate required to enhance the "flushing" of oxygenated groundwater through the aquifer may adversely impact the surface water flow in Sandy Brook. | • Long-term maintenance of extraction wells would be required to prevent fouling caused by high concentrations of Fe and other metals in groundwater.<br>• If groundwater treatment is required, a large on-site treatment plant must be constructed, that would require long-term O&M.<br>• Sludge generated during groundwater treatment would require off-site disposal.<br>• An infiltration study would be required to determine the on-site location and dimensions for an infiltration basin.<br>• If groundwater is discharged to Saco WWTP, upgrades to the North Street sewer and pump stations would be required.<br>• Long-term environmental monitoring would be required. | • Overall highest cost alternative for minimal risk reduction.<br>• High capital costs to install extraction wells, extensive piping system for extraction and discharge, and construction of a groundwater treatment system or pumphouse upgrades.<br>• Long-term monitoring costs.<br>• Long-term O&M costs, to clean and/or replace pumps that have fouled due to high iron content.<br>• Cost for disposal of sludge generated from groundwater treatment. |

**Conclusion:** Although this alternative would incur high capital and O&M costs for groundwater extraction, discharge, and potential treatment, this alternative provides the only remedial action that has the potential to enhance the movement of oxygenated groundwater through the aquifer and therefore, potentially reduce the time to achieve groundwater remedial action objectives. This alternative is retained for detailed analysis.

O&M = Operations and Maintenance WWTP = Waste water treatment plant

## 6.2 SUMMARY

Based on the initial screening of alternatives, three remedial alternatives were retained for further evaluation in the detailed analysis of remedial action alternatives (Section 7.0). Figure 6-1 and Table 6-7 summarize the alternatives retained for detailed analysis for groundwater associated with Landfill Areas 3 and 4 at the SML.

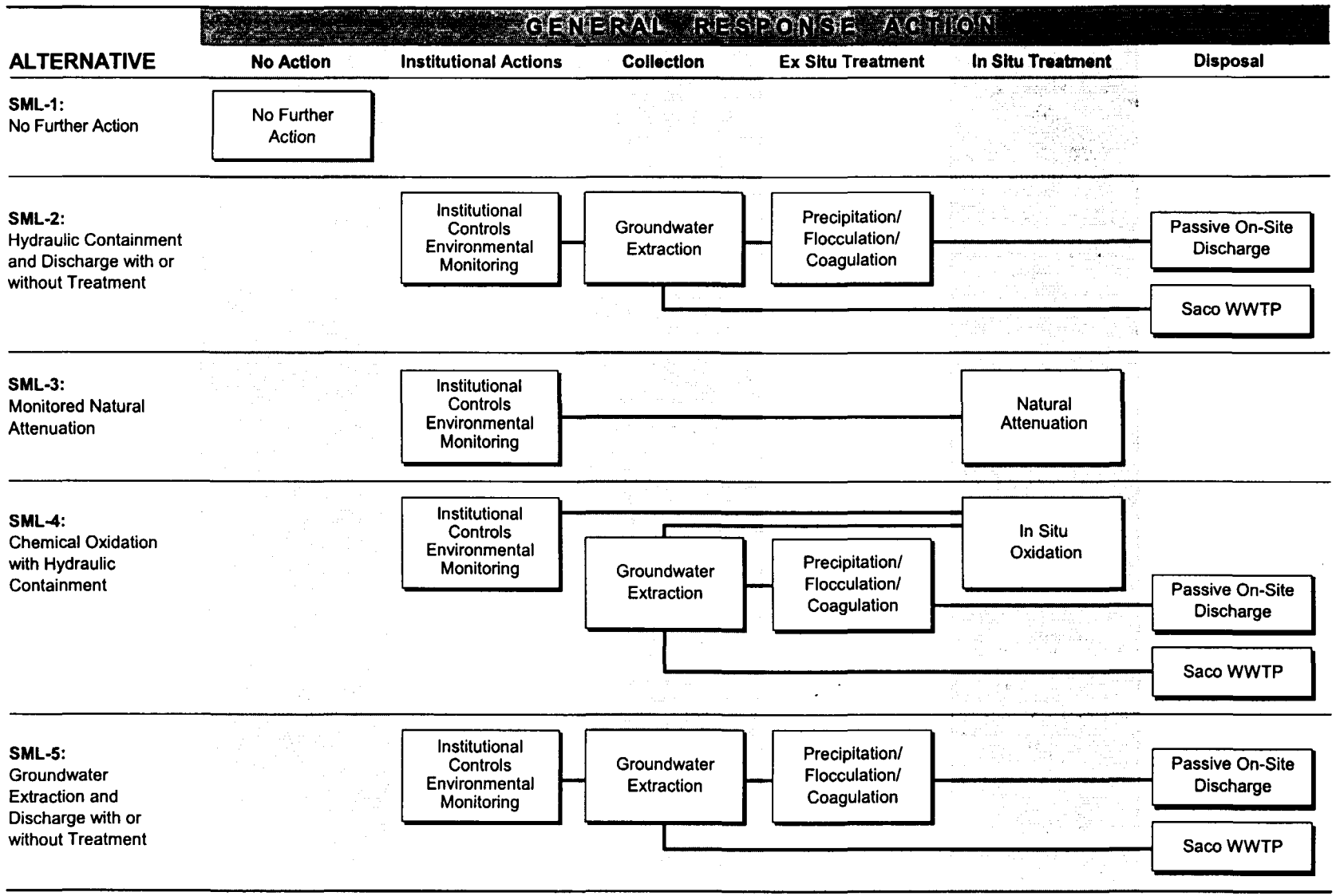


Figure 6-1
Development of Remedial Alternatives
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**TABLE 6-7**
**REMEDIAL ALTERNATIVES RETAINED FOR DETAILED ANALYSIS**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| ALTERNATIVE NO. | DESCRIPTION | RETAINED | ELIMINATED |
|---|---|---|---|
| SML-1 | No Action | X | |
| SML-2 | Hydraulic Containment and Discharge | | X |
| SML-3 | Monitored Natural Attenuation | X | |
| SML-4 | In Situ Oxidation with Hydraulic Containment | X | |
| SML-5 | Groundwater Extraction, Treatment and Discharge | X | |

# 7.0 DETAILED ANALYSIS OF ALTERNATIVES

This section presents the detailed analysis of remedial action alternatives that were retained from the initial screening in Section 6.0. Section 7.1 discusses the approach to the detailed analysis, and Section 7.2 presents the detailed analysis for alternatives retained for groundwater remediation.

## 7.1 GENERAL APPROACH TO THE DETAILED ANALYSIS

The detailed analysis is intended to provide decision-makers with sufficient information to select the appropriate remedial alternative for management of groundwater at the SML site that best meets the following CERCLA requirements:

- Is protective of public health and the environment;
- Restores the groundwater and the surface water of Sandy Brook to their beneficial use in a reasonable time frame;
- Attains ARARs (or provides grounds for invoking a waiver);
- Is cost-effective;
- Is a permanent solution using alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and
- Provides preference for treatment that reduces toxicity, mobility, or volume as a principal element.

The detailed analysis performed as part of this FS has been conducted in accordance with CERCLA Section 121, the NCP (USEPA, 1990), and USEPA RI/FS guidance (USEPA, 1988), and includes a detailed description of each remedial alternative emphasizing the application of various technologies as components of the alternative; and a detailed evaluation of each alternative against the nine evaluation criteria described in the NCP (USEPA, 1990).

The detailed description of the technologies or processes for each alternative includes, where appropriate, preliminary site layouts, process flow diagrams, and a discussion of the limitations, assumptions, and uncertainties for each component. These descriptions are intended to provide the conceptual design of each alternative and are used for cost purposes only. Costs presented in this

analysis are based on existing data and knowledge of the site and will be reevaluated at the time of remedial design of the selected alternative(s). Per the RI/FS guidance (USEPA, 1988), the costs are intended to be within the target accuracy range of -30 to +50 percent of the actual cost.

The remedial alternatives are evaluated according to seven of the nine criteria listed in Table 7-1. State and community acceptance (i.e., the eighth and ninth criteria) will be addressed when state and public comments on this FS report and the subsequent Proposed Plan have been received. Both the state and public had an opportunity to comment on the source control measures implemented at the SML under the NTCRA.

## 7.2 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

Based on the initial screening, three remedial alternatives were retained for further evaluation in the detailed analysis of alternatives for remediation of groundwater associated with Landfill Areas 3 and 4 at the SML:

- SML-1: No Further Action;
- SML-3: Monitored Natural Attenuation;
- SML-4: Chemical Oxidation with Hydraulic Containment; and
- SML-5: Groundwater Extraction and Discharge with or without Treatment.

The detailed analysis for each of these alternatives is presented in the following subsections.

**TABLE 7-1**
**CRITERIA FOR DETAILED ANALYSIS OF ALTERNATIVES**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| CRITERIA | DESCRIPTION |
|---|---|
| Overall protection of human health and the environment | Describes how each alternative, as a whole, protects and maintains human health and the environment. |
| Compliance with ARARs | Describes how the alternative complies with ARARs or if a waiver is required and how it is justified. |
| Long-term effectiveness and permanence | Evaluates the effectiveness of alternatives in protecting human health and the environment after response objectives have been met. |
| Reduction of mobility, toxicity, or volume through treatment. | Evaluates the anticipated performance of the specific treatment technologies. |
| Short-term effectiveness | Examines the effectiveness of alternatives in protecting human health and the environment during the construction and implementation period until the response objectives are met. |
| Implementability | Assesses the technical and administrative feasibility of alternatives and the availability of required resources. |
| Cost | Evaluates the capital and operation and maintenance costs of each alternative. |
| State Acceptance* | Evaluates the technical and administrative issues and concerns the state may have. |
| Community Acceptance* | Evaluates the issues and concerns the public may have. |

**NOTES:**
*This criterion will be addressed once state and public comments on the feasibility study and proposed plan have been received.

ARARs = Applicable and Relevant and Appropriate Requirements.

### 7.2.1 SML-1: No Further Action

This subsection presents the detailed analysis for Alternative SML-1.

#### 7.2.1.1 Description

In accordance with the NCP (USEPA, 1990) and RI/FS Guidance (USEPA, 1988), the No Further Action Alternative was developed as a baseline with which to compare other remedial alternatives. This alternative represents the minimal effort that would be taken at this site. A RCRA Subtitle C cover system has been placed over Landfill Areas 3 and 4 as a source control measure (Figure 3-1), and institutional controls, including restrictions on future land and groundwater use, have been implemented at the site as a part of the NTCRA (Figure 3-2). No additional remedial actions are included in this alternative. In addition, based on current Site conditions, the remedial time frame for the No Further Action Alternative has been estimated and is described below.

**Institutional Controls.** As part of the NTCRA, the City of Saco agreed to implement institutional controls, including deed restrictions and/or other controls to prohibit specific future use of the site. The terms of these controls are presented in the Grant of Environmental Restrictions and Right of Access (Environmental Restrictions), agreed to by the City of Saco, USEPA, and the MEDEP. The Environmental Restrictions were considered necessary to ensure the long-term protection of public health.

Included in the Environmental Restrictions are the *Restricted Uses and Activities* for the site that include the following:

- No use shall be made which disturbs the integrity of any layers of the cap, or any other structures for maintaining the effectiveness of the Removal Action, whether in place now or put in place in the future.

- Groundwater shall not be used in any manner, including, but not limited to, use as a drinking water supply. No groundwater wells shall be installed within the Groundwater Restriction Parcel except for purposes of groundwater monitoring pursuant to a plan approved by the City of Saco and USEPA.

- There shall be no residential development, and no activity or use shall be conducted which adversely impacts the Removal Action, whether now or in the future, including, without limitation: (1) systems and areas to collect and/or contain groundwater, surface water runoff, or leachate; (2) systems or containment areas to excavate, dewater, store, treat, and/or dispose of soils and sediments; and (3) systems and studies to provide long-term environmental monitoring of groundwater, surface waters, and to ensure the long-term effectiveness of the Removal Action and its protectiveness of human health and the environment.

The Environmental Restrictions were written to run with the property, and the City of Saco has agreed to incorporate the Grant into all deeds, easements, mortgages, leases, licenses or other instruments of transfer. These restrictions can only be modified by written approval from the Maine Commissioner of Environmental Protection and USEPA's Director, Site Restoration and Remediation Division.

**Remedial Time Frame.** As part of the detailed analysis of alternatives, the time required to meet remedial action objectives (i.e., achieve PRGs) in groundwater throughout the entire aquifer was qualitatively evaluated.

Redox reactions and sorption are the dominant mechanisms responsible for the chemical stabilization (i.e., reduction of mobility and toxicity) of arsenic and manganese. As described in Section 2.5 of this report, the time frame for stabilization of arsenic and manganese is uncertain and governed by the dissolved oxygen (DO) content of the groundwater beneath and downgradient of Landfill Areas 3 and 4. The concentration of DO is expected to increase over time with the concurrent reduction in leachate generation and continuing flow of oxygenated groundwater from upgradient recharge areas to areas beneath and downgradient of Landfill Areas 3 and 4. As the aquifer becomes more oxygenated, a hierarchy of chemical reactions will occur whereby the concentrations of dissolved iron, manganese, and then arsenic will decrease. Over time, the concentration of DO will increase sufficiently to keep the aquifer in an oxidized state and arsenic in the insoluble As (V) form. Laboratory core studies and modeling projections by the USGS indicate that arsenic concentrations will stabilize at or below its MCL of 50 μg/L after approximately 50 to 100 years.

Concentrations in surface water are dependent upon the concentrations in groundwater because surface water chemical concentrations are the result of mixing of groundwater and surface water. Any reduction in groundwater chemical concentrations will result in a reduction in surface water chemical concentrations. Because of the mixing of surface water and groundwater, surface water and arsenic concentrations will be less than 50 μg/L and manganese concentrations will be less than 500 μg/L before the same groundwater PRGs are met. Arsenic concentrations during the June 1999 sampling event were below the PRG. Some surface water manganese concentrations during the June 1999 sampling event exceeded 500 μg/L; however, the concentration at the background location was the highest concentration recorded during the event.

#### 7.2.1.2 Alternative Evaluation

Table 7-2 presents the detailed analysis for Alternative SML-1 against the seven NCP evaluation criteria.

#### 7.2.1.3 Cost

No cost is included for this alternative.

### 7.2.2 SML-3: Monitored Natural Attenuation

This subsection presents the detailed analysis for Alternative SML-3.

#### 7.2.2.1 Description

Alternative SML-3 is based on natural attenuation of the contamination in the groundwater. Based on studies conducted by the USGS, natural attenuation over time will reduce concentrations of manganese and arsenic in groundwater downgradient of Landfill Areas 3 and 4 to their respective PRGs within 50 to 100 years. Mixing of groundwater and surface water will reduce concentrations of arsenic and manganese in surface water downstream from the groundwater discharge.

**TABLE 7-2**
**DETAILED ANALYSIS: ALTERNATIVE SML-1**
**NO FURTHER ACTION**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-1: NO FURTHER ACTION |
|---|---|
| **OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT** | |
| Human Health Protection | The results of the baseline risk assessment indicate no current risk to human health and moderate impacts to the environment from groundwater or surface water. Potential future risks are associated with future domestic use of groundwater. However, this scenario is extremely unlikely as the area is currently supplied by public water and institutional controls restricting future land and groundwater use have been implemented as a part of the NTCRA.<br><br>No remedial actions would be conducted to reduce concentrations of arsenic, manganese and benzene in groundwater to PRGs. However, USGS research suggests that arsenic concentrations will stabilize at or below the PRG of 50 µg/L over a 50 to 100 year period via natural attenuation processes. Reduced arsenic concentrations in groundwater will result in reduced arsenic concentrations in surface water downgradient from Landfill Area 4. |
| Ecological Protection | The results of the baseline ecological risk assessment indicate no significant risks to aquatic receptors in Sandy Brook. |
| **COMPLIANCE WITH ARARS** | |
| Chemical-Specific | Under baseline conditions, concentrations of benzene and arsenic in groundwater exceed chemical-specific ARARs (i.e., MCLs).<br><br>At present, concentrations of arsenic in surface water exceed the chemical-specific ARAR (site-specific performance standard for arsenic is 3 µg/L). The expected decrease in arsenic concentration in groundwater will result in further reductions in arsenic concentrations in surface water. Concentrations of manganese exceed the chemical-specific ARAR. However, the highest concentration is at the background location. |

**TABLE 7-2**
**DETAILED ANALYSIS: ALTERNATIVE SML-1**
**NO FURTHER ACTION**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-1: NO FURTHER ACTION |
|---|---|
| Location-Specific | Location-specific ARARs would not apply because there are no remedial activities associated with this alternative (i.e., construction, excavation, etc.) that would cause an adverse impact to natural resources. |
| Action-Specific | Action-specific ARARs would not apply because there are no remedial activities associated with this alternative. |
| **LONG-TERM EFFECTIVENESS AND PERFORMANCE** | |
| Magnitude of Residual Risk | The residual risks associated with the remedial objectives are within the USEPA target range and are considered to be acceptable for this site. Institutional controls implemented as a part of the NTCRA restrict future use of groundwater while contaminant concentrations are reduced over time by natural attenuation processes, effectively eliminating this pathway as a source of contaminant exposure. |
| Adequacy and Reliability of Controls | Placement of the cover system over Landfill Areas 3 and 4 is providing source control by controlling the generation of DOC rich leachate from the landfill. Over time, the reduction of DOC together with more oxygen rich waters flushing the aquifer will change the redox potential, and iron, manganese and arsenic will be precipitated to their less soluble forms. Institutional controls implemented as a part of the NTCRA restrict future land groundwater use at the site. |
| **REDUCTION OF TOXICITY, MOBILITY, AND VOLUME THROUGH TREATMENT** | |
| Treatment Process Used and Materials Treated | No active treatment is proposed for this alternative. |
| Amount Destroyed or Treated | No active treatment is proposed for this alternative. |

**TABLE 7-2**
**DETAILED ANALYSIS: ALTERNATIVE SML-1**
**NO FURTHER ACTION**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-1: NO FURTHER ACTION |
|---|---|
| Degree of Expected Reductions of Toxicity, Mobility, or Volume Through Treatment | None through active treatment. |
| Degree to Which Treatment is Irreversible | No applicable. |
| Type and Quantity of Residuals Remaining After Treatment | Not applicable. |
| **SHORT-TERM EFFECTIVENESS** | |
| Protection of Community During Remedial Action | Not applicable because no remedial actions are included in this alternative. |
| Protection of Workers During Remedial Action | Not applicable because no remedial actions are included in this alternative. |

**TABLE 7-2**
**DETAILED ANALYSIS: ALTERNATIVE SML-1**
**NO FURTHER ACTION**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-1: NO FURTHER ACTION |
|---|---|
| Environmental Impacts | Not applicable because no remedial actions are included in this alternative. |
| Time Until Remedial Action Objectives Are Achieved | Based on USGS modeling results, natural attenuation processes are estimated to reduce concentrations of arsenic in groundwater to its PRG within 50 to 100 years. |
| **IMPLEMENTABILITY** | |
| Ability to Construct and Operate the Technology | Not applicable because no construction is necessary. |
| Reliability of the Technology | Once the level of DO increases in the groundwater beneath and downgradient of Landfill Areas 3 and 4, it is expected to remain relatively constant over time. Natural attenuation is therefore reliable because the higher DO content in groundwater will chemically stabilize the dissolved metals via redox reactions and sorption. |
| Ease of Undertaking Additional Remedial Actions, If Necessary | This alternative would not limit or interfere with the ability to implement or perform future remedial actions. |
| Ability to Monitor Effectiveness of Remedy | There will be no basis to monitor the effectiveness of the remedy. |
| Ability to Obtain Approvals and Coordinate with Other Agencies | Institutional controls have been implemented under NTCRA. |
| Availability of Off-site Treatment, Storage, and Disposal Services and Capacity | Not required under this alternative. |

**TABLE 7-2**
**DETAILED ANALYSIS: ALTERNATIVE SML-1**
**NO FURTHER ACTION**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-1: NO FURTHER ACTION |
|---|---|
| Availability of Necessary Equipment and Specialists | No equipment, materials, or services required. |
| Availability of Technology | Not applicable. No remedial technologies would be used. |
| COSTS | |
| Capital Cost | $ 0 |
| Net Present Worth Cost (Five-year reviews for 30 yrs.) | $ 0 |

Alternative SML-3 is more comprehensive than SML-1 in that it acknowledges that the concentrations of contaminants in the groundwater and surface water are above ARARs and that groundwater is not suitable for human consumption. Institutional controls have been implemented as a part of the NTCRA for the site. No additional institutional controls are anticipated at this time. Alternative SML-3 includes environmental monitoring and five-year site reviews, as described below. Figure 7-1 presents a schematic diagram of Alternative SML-3.

**Monitored Natural Attenuation**. As discussed in Section 2.5, USGS research shows that over time the concentration of DO in groundwater beneath and downgradient of the landfill will change the geochemical conditions in the aquifer from a reduced to an oxidized state. In this more oxygenated environment, the dissolved arsenic (As(III)) will precipitate as the more insoluble As(V) form, and/or co-precipitate with iron and manganese. Laboratory core studies and modeling projections completed by the USGS indicate that arsenic concentrations will stabilize at or below its MCL of 50 µg/L after approximately 50 to 100 years. SWQCs for arsenic and manganese in Sandy brook are currently not being met within a limited area (see Appendix B-4). Reductions in concentrations in groundwater by natural attenuation will further reduce concentrations in Sandy Brook.

Environmental monitoring of on-site groundwater and Sandy Brook surface water and sediment would be conducted as a part of this alternative. The primary objective of this monitoring is to ensure the remedy continues to be protective of human health and the environment. Long-term monitoring would also verify that natural attenuation processes are occurring and specifically that arsenic and manganese concentrations are decreasing to their respective PRGs in groundwater.

The groundwater monitoring program would be developed to:

- Detect changes in the environmental conditions (e.g., hydrogeologic, geochemical, microbial or other changes) that may reduce the ability of natural attenuation processes to meet the remedial action objective;

- Verify management of migration (e.g., that the plume boundaries are not expanding);

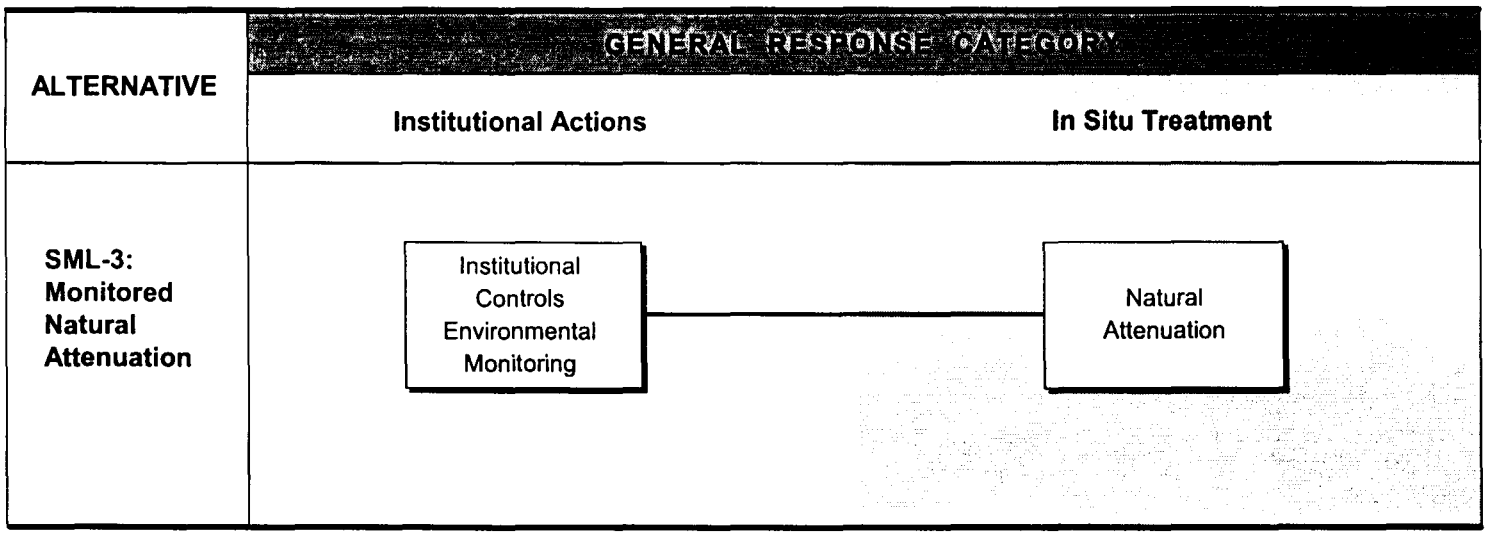


Figure 7-1
Schematic of Alternative SML-3:
Monitored Natural Attenuation
Feasibility Study Report
Saco Municipal Landfill
Saco, Maine

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- Detect new releases of contaminants to the environment that could impact the effect of the natural attenuation processes;

Environmental monitoring would consist of semi-annual sampling of groundwater monitoring wells, and surface water and sediment sampling in Sandy Brook. A re-assessment of the protectiveness of the remedy will be conducted every five years. Major re-evaluation each 10 years will be conducted involving statistical evaluation of data and trends to demonstrate decline in concentrations. Model results predict that within 60 years, arsenic concentrations in surface water exceeding the site-specific performance standard (3 μg/L) at the harmonic mean flow conditions will be limited to a small area directly adjacent to the remediated seep. Based upon the most recent research, the geochemical model and groundwater flow model will be re-evaluated.

#### 7.2.2.2 Alternative Evaluation

Table 7-3 presents the detailed analysis of Alternative SML-3 against the seven NCP evaluation criteria.

#### 7.2.2.3 Cost

A cost estimate was prepared for Alternative SML-3 to help select a remedial alternative. In general, cost estimates contain the following principal elements:

- Capital costs; and
- Operation and maintenance costs.

Capital costs consist of direct and indirect costs that typically include those expenditures initially incurred to develop, construct, and implement the remedial alternative. Operation and maintenance (O&M) costs typically include post-construction costs necessary to ensure the continued effectiveness of the remedial action. The cost estimate for Alternative SML-3 includes long-term environmental monitoring and five-year site reviews. While it is recognized that SML-3 will require 50 to 100 years to meet PRGs, costs are estimated for 30 years only. This is to provide a consistent basis of comparing alternatives and is consistent with EPA requirements for conducting an FS (EPA, 1992). The total estimated present worth (i.e., 7 percent for 30 years) of Alternative SML-3 is $1,680,000. The present

**TABLE 7-3**
**DETAILED ANALYSIS: ALTERNATIVE SML-3**
**MONITORED NATURAL ATTENUATION**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-3: MONITORED NATURAL ATTENUATION |
|---|---|
| **OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT** | |
| Human Health Protection | There are currently no risks to human health and moderate impacts to the environment. Potential future risks are associated with future domestic use of groundwater. However, this scenario is extremely unlikely, as the area is currently supplied by public water and institutional controls restricting future land and groundwater use have been implemented as a part of the NTCRA.<br><br>USGS research suggests that arsenic concentrations in groundwater will stabilize at or below 50 µg/L over a 50 to 100 year period via natural attenuation processes. Reduced arsenic concentrations in groundwater will result in reduced arsenic concentrations in surface water downgradient from Landfill Area 4. |
| Ecological Protection | The results of the baseline ecological risk assessment indicate no significant risks to aquatic receptors in Sandy Brook |
| **COMPLIANCE WITH ARARS** | |
| Chemical-Specific | Concentrations of benzene and arsenic in groundwater currently exceed chemical-specific ARARs (i.e., MCLs). However, USGS modeling indicates that concentrations of arsenic and other metals in groundwater will decrease over a 50 to 100 year time frame.<br><br>Concentrations of arsenic and manganese in surface water are lower than concentrations in groundwater. At present, however, concentrations of arsenic and manganese in surface water exceed the chemical-specific ARAR. The highest manganese concentration is at the background location. The modeled reduction of arsenic and manganese concentrations in groundwater will result in reductions in surface water. |

**TABLE 7-3**
**DETAILED ANALYSIS: ALTERNATIVE SML-3**
**MONITORED NATURAL ATTENUATION**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-3: MONITORED NATURAL ATTENUATION |
|---|---|
| Location-Specific | Location-specific ARARs would not apply because there are no active remedial activities associated with this alternative (i.e., construction, excavation, etc.) that would cause an adverse impact to natural resources. |
| Action-Specific | Action-specific ARARs would not apply, as the only actions associated with this alternative include sampling of groundwater monitoring wells and surface water/sediment locations in Sandy Brook. These activities would be conducted according to OSHA regulations. |
| **LONG-TERM EFFECTIVENESS AND PERFORMANCE** | |
| Magnitude of Residual Risk | The residual risks associated with the remedial objectives are within the USEPA target range and are considered to be acceptable for this site. Institutional controls implemented as a part of the NTCRA restrict future use of groundwater while contaminant concentrations are reduced over time by natural attenuation processes, effectively eliminating this pathway as a source of contaminant exposure. In addition, five-year site reviews will be conducted to ensure the continued protection of human health and the environment. |
| Adequacy and Reliability of Controls | Placement of the cover system over Landfill Areas 3 and 4 is providing source control by controlling the generation of DOC rich leachate from the landfill. Over time, the reduction of DOC together with more oxygen rich waters flushing the aquifer will change the redox potential, and iron, manganese and arsenic will be precipitated to their less soluble forms. Institutional controls implemented as a part of the NTCRA restrict future land and groundwater use at the site. |
| **REDUCTION OF TOXICITY, MOBILITY, AND VOLUME THROUGH TREATMENT** | |
| Treatment Process Used and Materials Treated | No active treatment is proposed for this alternative. |

**TABLE 7-3**
**DETAILED ANALYSIS: ALTERNATIVE SML-3**
**MONITORED NATURAL ATTENUATION**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-3: MONITORED NATURAL ATTENUATION |
|---|---|
| Amount Destroyed or Treated | No active treatment is proposed for this alternative. |
| Degree of Expected Reductions of Toxicity, Mobility, or Volume Through Treatment | None through active treatment. |
| Degree to Which Treatment is Irreversible | Not applicable. |
| Type and Quantity of Residuals Remaining After Treatment | Not applicable. |
| **SHORT-TERM EFFECTIVENESS** | |
| Protection of Community During Remedial Action | Not applicable because no active treatment is included in this alternative. |
| Protection of Workers During Remedial Action | Individuals accessing the Site for groundwater, surface water and sediment sampling activities would be required to be trained in health and safety procedures for work at hazardous waste sites. To minimize the possibility of exposure to contamination, a site-specific health and safety plan would be followed and appropriate personal protective equipment would be used. |

**TABLE 7-3**
**DETAILED ANALYSIS: ALTERNATIVE SML-3**
**MONITORED NATURAL ATTENUATION**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-3: MONITORED NATURAL ATTENUATION |
|---|---|
| Environmental Impacts | Not applicable because no remedial actions are included in this alternative. |
| Time Until Remedial Action Objectives Are Achieved | Based on USGS modeling results, natural attenuation processes are estimated to reduce concentrations of arsenic in groundwater to the PRG (MCL of 50 µg/L) within 50 to 100 years.<br><br>At present, the arsenic concentrations in Sandy Brook exceed the chemical-specific ARARs within a limited area of Sandy Brook. Over time, the area of Sandy Brook exceeding PRGs is expected to decrease as arsenic and manganese concentrations in groundwater decrease. |
| **IMPLEMENTABILITY** | |
| Ability to Construct and Operate the Technology | Not applicable because no construction is necessary. |
| Reliability of the Technology | Once the level of DO increases in the groundwater beneath and downgradient of Landfill Areas 3 and 4, it is expected to remain relatively constant over time. Natural attenuation is therefore reliable because the higher DO content in groundwater will chemically stabilize the dissolved metals via redox reactions and sorption. |
| Ease of Undertaking Additional Remedial Actions, If Necessary | This alternative would not limit or interfere with the ability to implement or perform future remedial actions. |
| Ability to Monitor Effectiveness of Remedy | The long-term environmental monitoring program would demonstrate the effectiveness of natural attenuation processes by verifying the increase in DO concentration in groundwater and the reduction in concentrations of arsenic and manganese in groundwater and surface water over time. |
| Ability to Obtain Approvals and Coordinate with Other Agencies | Institutional controls have been implemented under NTCRA. A detailed long-term environmental monitoring plan and the five-year site reviews would be subject to regulatory review. |

**TABLE 7-3**
**DETAILED ANALYSIS: ALTERNATIVE SML-3**
**MONITORED NATURAL ATTENUATION**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-3: MONITORED NATURAL ATTENUATION |
|---|---|
| Availability of Off-site Treatment, Storage, and Disposal Services and Capacity | Not required under this alternative. |
| Availability of Necessary Equipment and Specialists | Equipment, materials, and services for groundwater, surface water and sediment sampling and off-site laboratory analyses are readily available. |
| Availability of Technology | Not applicable. No remedial technologies would be used. |
| **COSTS** | |
| Capital Cost | $ 0 |
| Net Present Worth Cost of Environmental Monitoring | $ 1,551,000 |
| Net Present Worth Cost of Five-Year Reviews | $ 129,000 |
| Total Net Present Worth Cost | $ 1,680,000 |

**TABLE 7-4**
**COST ESTIMATE: ALTERNATIVE SML-3**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| | |
|---|---|
| **DIRECT COSTS** | |
| TOTAL DIRECT COSTS | $0 |
| **INDIRECT COSTS** | |
| TOTAL INDIRECT COSTS | $0 |
| **TOTAL CAPITAL COSTS (DIRECT AND INDIRECT)** | **$0** |
| **ENVIRONMENTAL MONITORING AND REVIEW COSTS** | |
| Annual Monitoring Groundwater/Surface Water and Sediment (Includes 20% contingency) | $125,000 |
| **TOTAL PRESENT WORTH ANNUAL ENVIRONMENTAL MONITORING COSTS (7%, 30 YEARS)** | **$1,551,000** |
| Five Year Site Reviews (includes 20% Contingency) | $60,000 |
| **TOTAL PRESENT WORTH OF FIVE YEAR SITE REVIEWS (7%, 30 YEARS)** | **$129,000** |
| **TOTAL PRESENT WORTH (30 YEARS) - ALTERNATIVE SML-3** | **$1,680,000** |

worth of environmental monitoring costs was estimated at $1,551,000 and the present worth of five-year site reviews was estimated at $129,000. Table 7-4 summarizes the costs estimated for Alternative SML-3. Cost back-up information for the components summarized in Table 7-4 is presented in Appendix D. To develop these costs, the following assumptions were made with respect to Alternative SML-3:

- Natural attenuation processes in the groundwater beneath and downgradient of the landfill will result in a decrease in dissolved arsenic and manganese concentrations in groundwater to meet PRGs, and ultimately in Sandy Brook surface water;

- Environmental monitoring (surface water, sediment and groundwater) will occur semi-annually for 30 years; and

- All data associated with the site will be presented, reviewed and evaluated every five years. Every 10 years a more comprehensive review will be conducted for a period of 30 years.

### 7.2.3 SML-4: Chemical Oxidation with Hydraulic Containment

This subsection presents the detailed analysis for Alternative SML-4

#### 7.2.3.1 Description

Alternative SML-4 includes in situ chemical oxidation and hydraulic containment of groundwater downgradient of Landfill Areas 3 and 4. Two discharge options are included in this alternative and treatment may or may not be required. This alternative is proposed as a potential way to restore the aquifer to beneficial use more quickly than through natural attenuation (SML-3). Alternative SML-4 is designed to chemically oxidize the DOC and inorganics in the groundwater and create a closed system, using groundwater containment, to minimize impacts of the oxidizing chemicals on the unaffected aquifer and surface water of Sandy Brook. Injection of chemical oxidants will reduce the concentrations of DOC, which will change the redox potential of the groundwater and allow the groundwater to become more aerobic resulting in less iron, arsenic, and manganese leaching from the natural site soils and bedrock. Injection of chemical oxidants into groundwater will cause dissolved iron, arsenic, and manganese to precipitate, reducing dissolved concentrations of these natural elements. Hydraulic containment of groundwater is included in this alternative to prevent chemical oxidants (Fenton's

reagents or potassium permanganate ($KMnO_4$)) that are injected into the groundwater from becoming distributed in the aquifer and surface water.

As stated in Alternative SML-1, institutional controls have been implemented as a part of the NTCRA for the Site (see Figure 3-2).

Alternative SML-4 includes the following major components:

1. Installation and Operation of Chemical Oxidation System
2. Installation of Groundwater Extraction System
3. Discharge of Groundwater
4. Installation and Operation of Groundwater Treatment System
5. Environmental Monitoring
6. Five-Year Site Reviews

Figure 7-2 presents a schematic diagram of Alternative SML-4.

**Installation of In Situ Chemical Oxidation System.**

The in situ chemical oxidation system was designed to oxidize the DOC, iron, manganese, and arsenic in groundwater downgradient of Landfill Areas 3 and 4. The oxidation of DOC will change the redox potential of the aquifer. Increasing the redox potential in groundwater should decrease the capacity of the groundwater to leach inorganics from the native soil and bedrock, and should cause iron, manganese, and arsenic to be precipitated as less soluble forms. Therefore, over time the concentration of dissolved manganese and arsenic in the groundwater should decrease. The chemical oxidants applied in this process are typically Fenton's Reagent or $KMnO_4$.

Based on an estimated radius of influence of between 20 and 40 feet for these chemical oxidants in this sand and gravel aquifer, this alternative includes the installation of 17 chemical oxidant injection wells, as shown in Figure 7-3. These wells will be installed in the shallow overburden and bedrock aquifers, to depths of approximately 25 feet bgs. It is estimated that chemical oxidants would be injected into the wells on a semi-annual basis for five years. If this alternative were implemented, pilot scale field studies

would have to be completed prior to implementation of this alternative to determine the appropriate application rate of chemical oxidant.

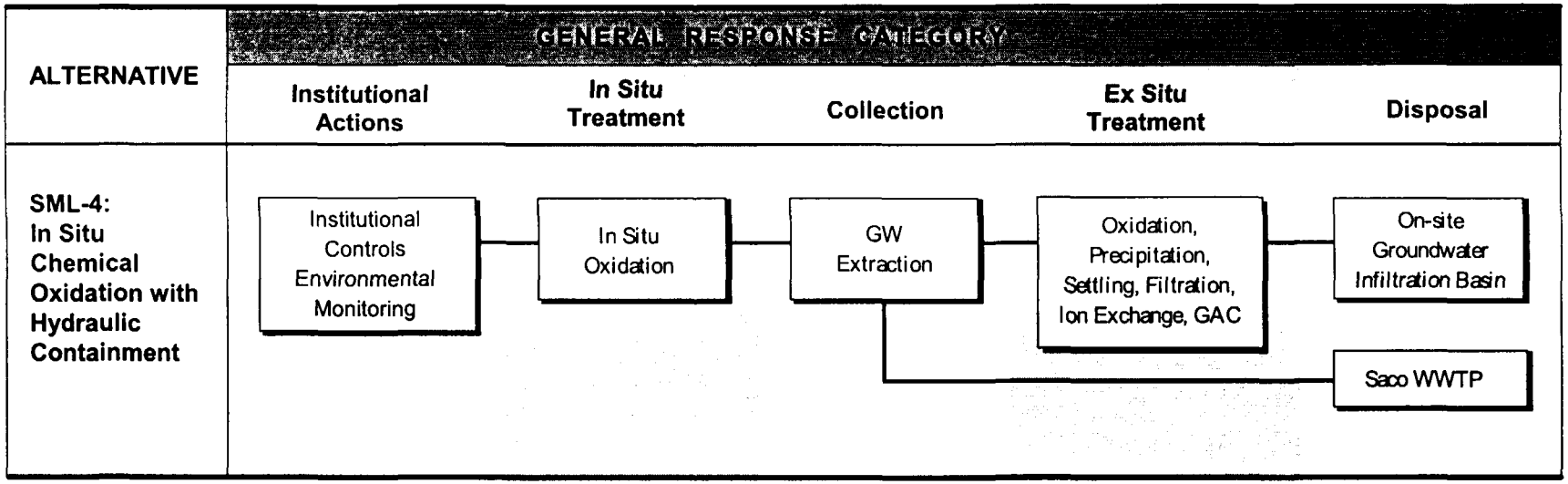


Figure 7-2
Schematic of Alternative SML-4:
Chemical Oxidation with Hydraulic Containment
Feasibility Study Report
Saco Municipal Landfill
Saco, Maine

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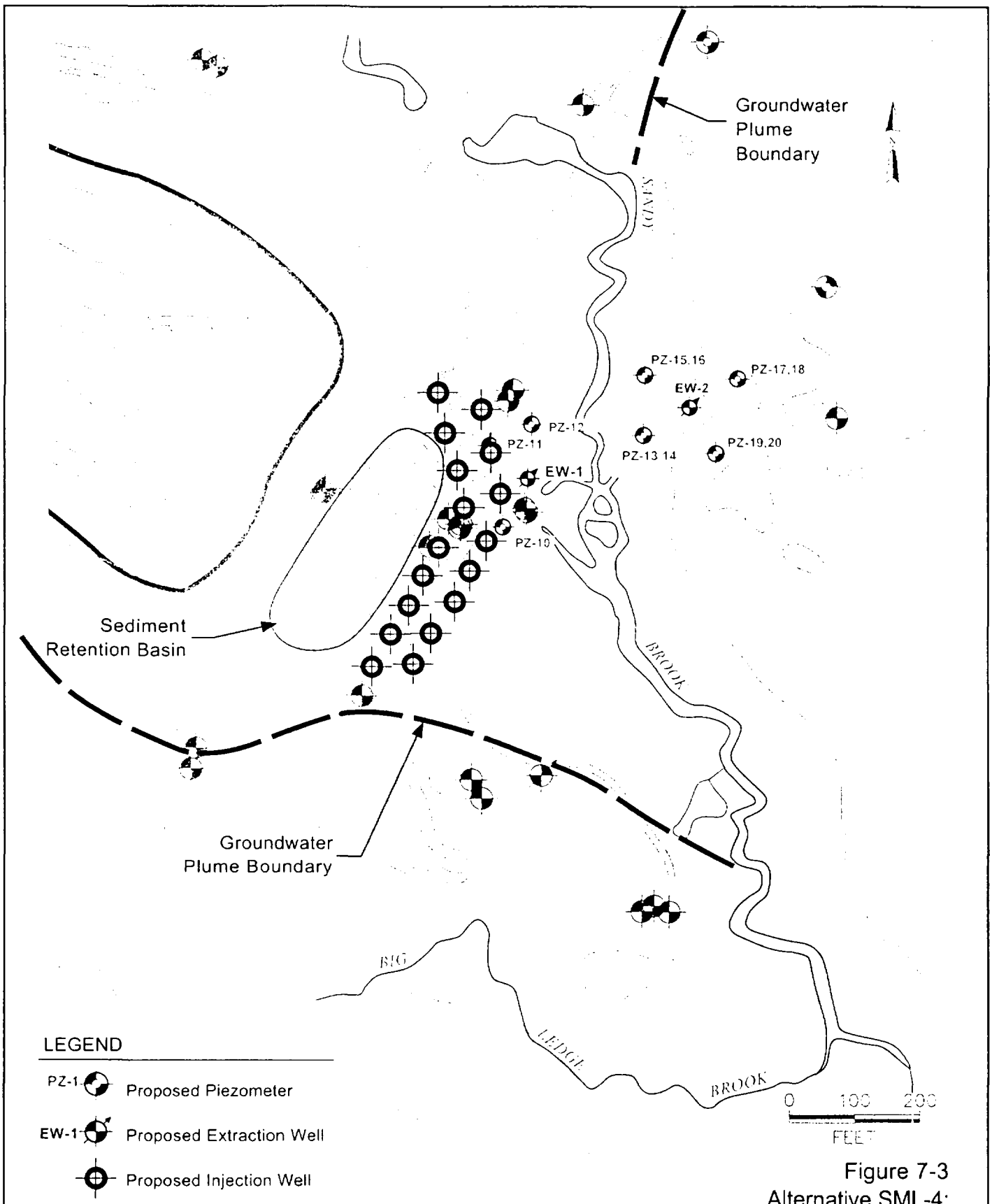


Figure 7-3
Alternative SML-4:
Location of Injection Wells
Saco Municipal Landfill
Saco, Maine

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**Installation of Hydraulic Containment System.** The hydraulic containment system was developed to achieve four objectives; (1) to minimize the impact the chemical oxidant will have on the larger aquifer and adjacent surface water of Sandy Brook, (2) to manage the migration of the existing iron, manganese and arsenic plume, (3) to minimize the impact of groundwater extraction on the surface water flow of Sandy Brook and (4) to enhance the movement of oxygenated water through the aquifer. Various extraction well locations, depths, and pumping rates were evaluated to determine the optimal configuration and parameters for the extraction system. Hydraulic containment is affected by extracting groundwater downgradient from chemical injection wells.

As discussed in Section 2.0 and shown on Figure 2-2, the groundwater impacted by Landfill Areas 3 and 4 flows beneath and downgradient of the landfill in three distinct layers: bedrock, till, and the sand and gravel overburden. The volume of water flowing through the bedrock and the glacial till is considerably less than the volume of water moving through the shallow sand and gravel aquifer (approximately 5% of total flow) due to the lower conductivity observed in the bedrock and till layers. The large volume of groundwater moving through the overburden suggested that pumping efforts be focused on this aquifer. In addition, pumping well simulations in bedrock indicated that pumping influence within the bedrock was limited and much of the water extracted from the rock is supplied by the overlying sand and gravel aquifer. Therefore, placement of groundwater extraction wells within the sand and gravel aquifer was evaluated to determine the conditions that best meet the three pumping objectives.

The groundwater model indicates that a minimum of two extraction wells placed near the downgradient edges of the plume on the western and eastern sides of Sandy Brook are necessary to manage the migration of the majority of the plume. Other well configurations were evaluated; however, all required a greater combined pumping rate to capture the groundwater flow. The model was also used to evaluate the effects of various pumping rates at these wells on both the travel time of groundwater flow between the toe of the landfill and Sandy Brook and the groundwater discharge and subsequent surface water flow in the brook. These pumping rates and subsequent changes in travel time and surface water flow are shown in Table 7-5.

**TABLE 7-5**
**ALTERNATIVE SML-4**
**MODELED GROUNDWATER EXTRACTION RATES, TRAVEL TIMES, AND DISCHARGES TO SANDY BROOK**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| PUMP RATE (gpm) | TRAVEL TIME (years) | GROUNDWATER DISCHARGE [1] $ft^3$/day |
|---|---|---|
| 0 | 2 | -19, 889 |
| 60 | 1.78 | -17,419 |
| 200 | 1.56 | -4,899 |
| 500 | 1.37 | +21,675 |

Notes:

[1] Groundwater discharge through sand and gravel aquifer to Sandy Brook directly downgradient from landfill.

- values indicate groundwater discharge to brook
+ values indicate brook discharge to groundwater

The results of the model show that as the pumping rate is increased from 0 gpm to 500 gpm the groundwater travel time between the landfill and Sandy Brook is decreased from 2 to 1.4 years. This decrease in travel time suggests enhanced groundwater flow through the aquifer. However, a pumping rate of 500 gpm causes a significant impact to Sandy Brook to the point where surface water will be "pulled" by pumping into the subsurface (groundwater). Model results show that under pumping conditions of greater than 250 gpm, Sandy Brook becomes a losing stream. During drought periods, this high pumping rate may potentially eliminate surface water flow in the brook altogether.

Based on our flow model, a pumping rate of 60 gpm should capture the majority of the plume; however, during low flow periods in the summer and fall, the flow could be reduced within Sandy Brook by up to 40%. The model results presented in Table 7-5 show that at a pumping rate of 60 gpm the travel time of groundwater flow from the toe of the landfill to Sandy Brook is reduced only from 2 to approximately 1.8 years. Nevertheless, the model illustrates that the rate of travel time reduction per pumping rate is greater for 60 gpm than for higher pumping rates.

Based on the data presented in Table 7-5, a combined pumping rate of 60 gpm for two extraction wells placed in the sand and gravel aquifer was selected for this alternative because it meets three of the three objectives. This alternative will contain the majority of the existing iron, manganese and arsenic plume, and minimize the impact the chemical oxidant will have on the larger aquifer and adjacent surface water of Sandy Brook, while impacting the surface water flow of Sandy Brook, to a lesser degree than other pumping rates. The proposed extraction system for Alternative SML-4 consists of two wells, EW-1 located on the western side of Sandy Brook pumped at 40 gpm to contain the majority of the plume and EW-2 located on the eastern side of Sandy Brook pumped at 20 gpm to contain the northern portion of the plume that travels beneath the brook and surfaces on the eastern side. The extraction wells would be eight-inch diameter stainless steel and screened in the sand and gravel aquifer. The western well would be installed to a depth of 46 feet bgs. with the well screen extending from 18 feet to 46 feet bgs. The eastern well would be installed to a depth of 76 feet bgs, with a well screen extending from 44 feet to 76 feet bgs. The location of the extraction wells is shown on Figure 7-4.

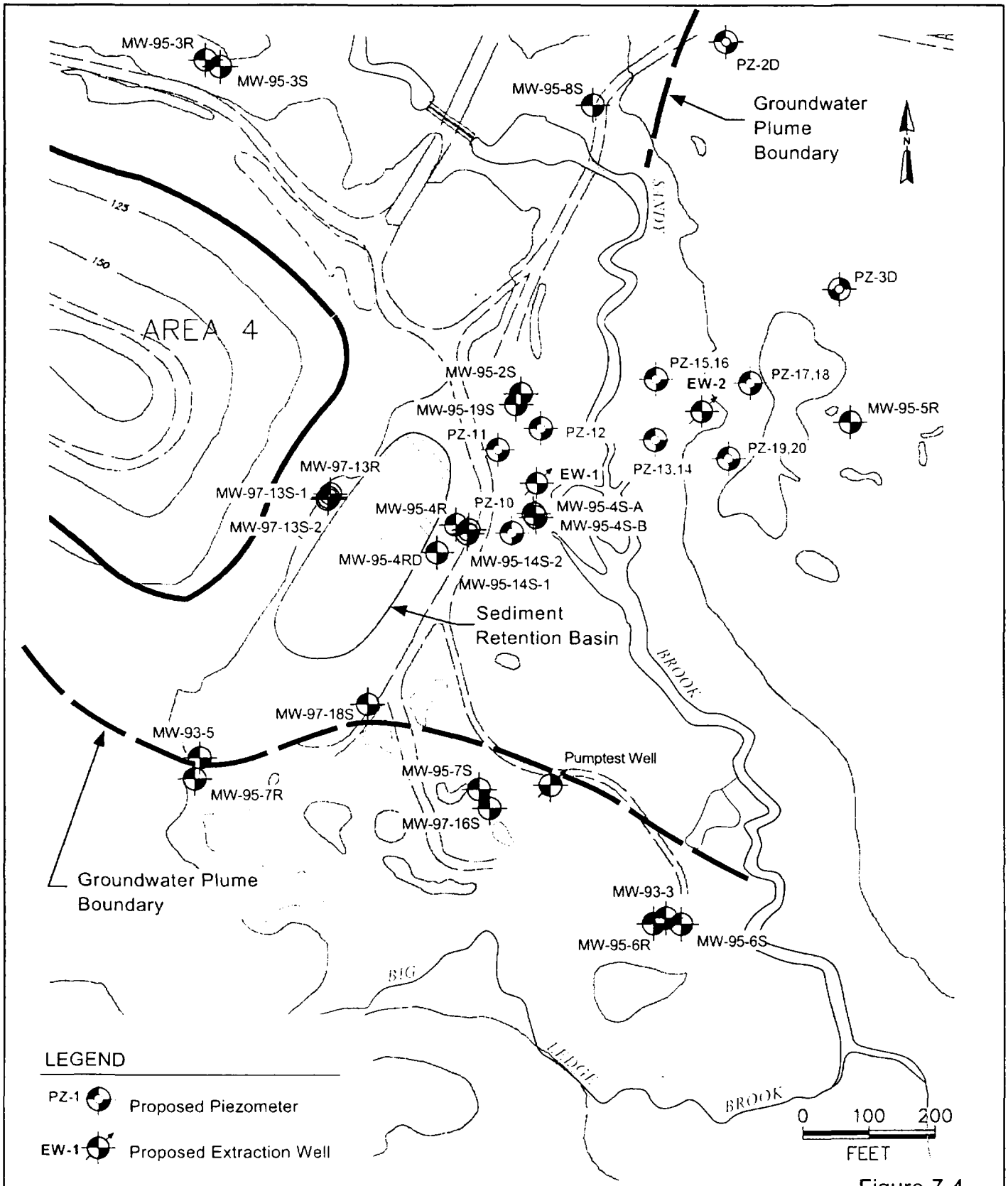


Figure 7-4
Alternative SML-4:
Proposed Extraction Well and Piezometer Locations
Saco Municipal Landfill
Saco, Maine

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In addition, eleven piezometers (Figure 7-4) would be installed in the vicinity of the extraction wells to evaluate hydraulic capture of the plume over time. The proposed one-inch diameter piezometers would be constructed of polyvinyl chloride (PVC). Three piezometers (screened 15 to 25 feet bgs) would be installed in the vicinity of the extraction well on the western side of Sandy Brook. Existing shallow monitoring wells in the vicinity of this extraction well would also be used to evaluate hydraulic capture of the plume. Because there are no existing monitoring wells in the vicinity of the extraction well on the eastern side of Sandy Brook, eight piezometers (one screened at 25-35 feet bgs, four screened at 35 to 45 feet bgs, and three screened at 65 to 75 feet bgs) would be installed to evaluate hydraulic capture of the plume. Water levels would be measured in each piezometer on a semi-annual basis.

Until a pilot scale field study is completed, the effectiveness of chemical oxidation to oxidize the DOC and precipitate dissolved iron, manganese and arsenic permanently at this site is unknown. It is anticipated that in situ chemical oxidation will reduce the concentrations of benzene, manganese, and arsenic to meet PRGs in a shorter time frame than the 50 to 100 years estimated for natural attenuation. A time frame to meet PRGs would be estimated based on the pilot scale field study but is assumed to be less than 30 years if proven to be effective.

At present, in Sandy Brook the State SWQC of 10 μg/L for arsenic and manganese (500 ppb) are substantially being met except for a limited area directly downgradient of the groundwater plume (see Appendix B-4). For arsenic, pumping of the plume would reduce groundwater plume inflow into Sandy Brook and result in lower arsenic concentrations in Sandy Brook even prior to complete chemical oxidation of the plume. For manganese, the concentration at the background location on Sandy Brook exceeds the State SWQC. Therefore, reductions of manganese concentration would not be expected from reducing flow of the plume into Sandy Brook.

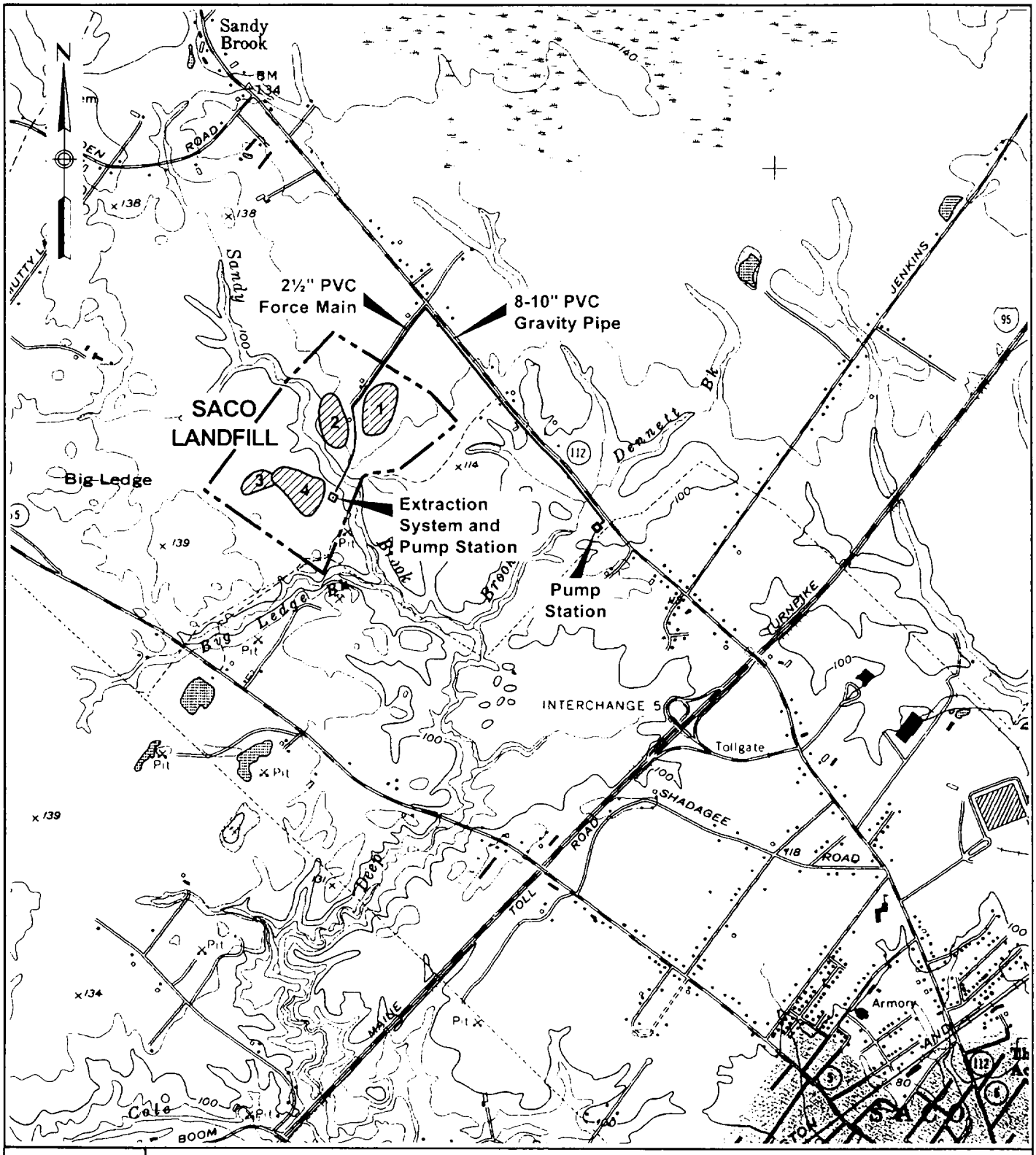
**Discharge of Groundwater.** Two options exist for the discharge of extracted groundwater: (1) discharge untreated to the Saco WWTP; or (2) discharge on-site after treatment. Both discharge options are described below. The technical and administrative issues associated with each option would, however, require a detailed evaluation during the final design.

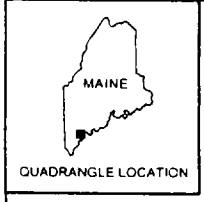
Discharge to Waste Water Treatment Plant (WWTP): The first option would involve discharging untreated groundwater to the Saco WWTP. A pump station would be constructed in the vicinity of the extraction wells, and extracted groundwater would be pumped to and through a 2½-inch PVC force main installed along Foss Road to an 8 to 10 inch gravity line installed along Route 112 to the pump station. Upgrades to the pump station may be required, and would be evaluated as a part of the final design. A conceptual layout of this discharge option is shown on Figure 7-5.

Discharge On-Site: The second option would include the on-site treatment of groundwater to remove arsenic, manganese and benzene to their PRGs prior to on-site discharge of the treated groundwater. The potential impacts to the plume resulting from the discharge of treated groundwater to the existing stormwater retention basin were evaluated using the groundwater model. Based on the model, the boundaries of the plume in the vicinity of the retention basin would expand with the placement of 60 gpm pumping system such that the extraction wells would no longer capture the entire plume. Therefore, to allow on-site discharge, the location of the infiltration basin would be outside the plume boundary as shown on Figure 7-6. To contain the treated groundwater, the proposed infiltration basin would be constructed with an area of approximately 23,000 square feet and a depth of five feet. An infiltration study would be required during final design to determine the exact location based on the groundwater level and actual infiltration rate.

**Installation of Groundwater Treatment System.** To meet ARARs for proposed groundwater infiltration, the proposed groundwater treatment system was designed to remove arsenic, manganese and benzene to their respective PRGs. The groundwater treatment system would consist of the following major unit processes:

- oxidation of metals in groundwater;
- precipitation and settling;
- filtration;
- ion exchange;




**Source:** USGS Topographic Quadrangle 7.5-Minute Series, Old Orchard Beach, Maine, 1956 (Photorevised 1970; Photoinspected 1975).

Scale in Feet

0 2000 4000

Figure 7-5
Alternative SML-4
Groundwater Discharge to Saco WWTP
Saco Municipal Landfill
Saco, Maine

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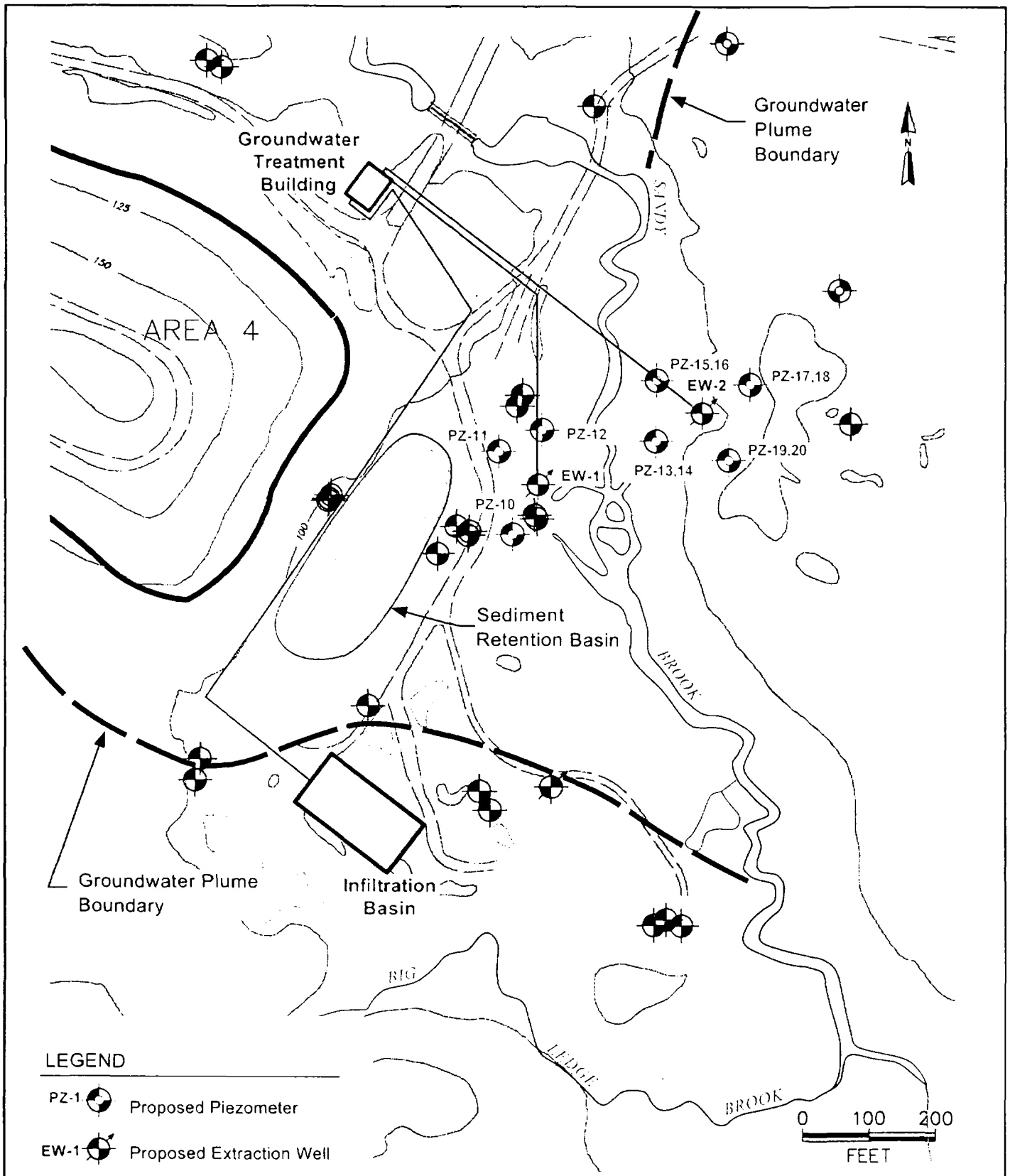


Figure 7-6
Alternative SML-4:
Conceptual Site Layout
Saco Municipal Landfill
Saco, Maine

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- granulated activated carbon;
- treated water disposal;
- sludge thickening;
- sludge dewatering; and
- sludge disposal.

The treatment system would be housed in a treatment building located northeast of Landfill Area 3 and 4. A preliminary layout of the groundwater treatment building is shown on Figure 7-7, and a process flow diagram of the proposed treatment system is presented in Figure 7-8. Actual design of the treatment system would include bench and/or pilot studies to determine operating parameters.

The assumed influent concentrations used to size the treatment system were determined by estimating the average concentrations of contaminants and other groundwater parameters measured at monitoring wells MW-95-4SA, MW-95-4SB, MW-97-14S-1 and MW-97-14S-2. These wells are in the vicinity of the proposed extraction wells. Data from the March 1998 RI and most recent groundwater sampling rounds (June 1998, December 1998, and June 1999) were used to calculate influent concentrations to the treatment system. These influent concentrations are summarized in Table 7-6.

The extraction system would consist of two groundwater extraction wells and associated piping. Each well would have its own submersible pump controlled by a variable frequency drive linked to a flow meter to maintain constant flow during operation of the treatment system.

Groundwater from the two extraction wells would be conveyed through separate 2-inch pipes to the treatment building, where both pipes would empty into a single, well-mixed tank, to which $KMnO_4$ and caustic (NaOH) would be added. The purpose of permanganate is to convert reduced iron, manganese, and arsenic into their less soluble oxidized forms so that they can be removed in subsequent settling and ion exchange phases of treatment. The function of caustic addition is to adjust the pH to a value of approximately 8.0 to optimize metals precipitation.

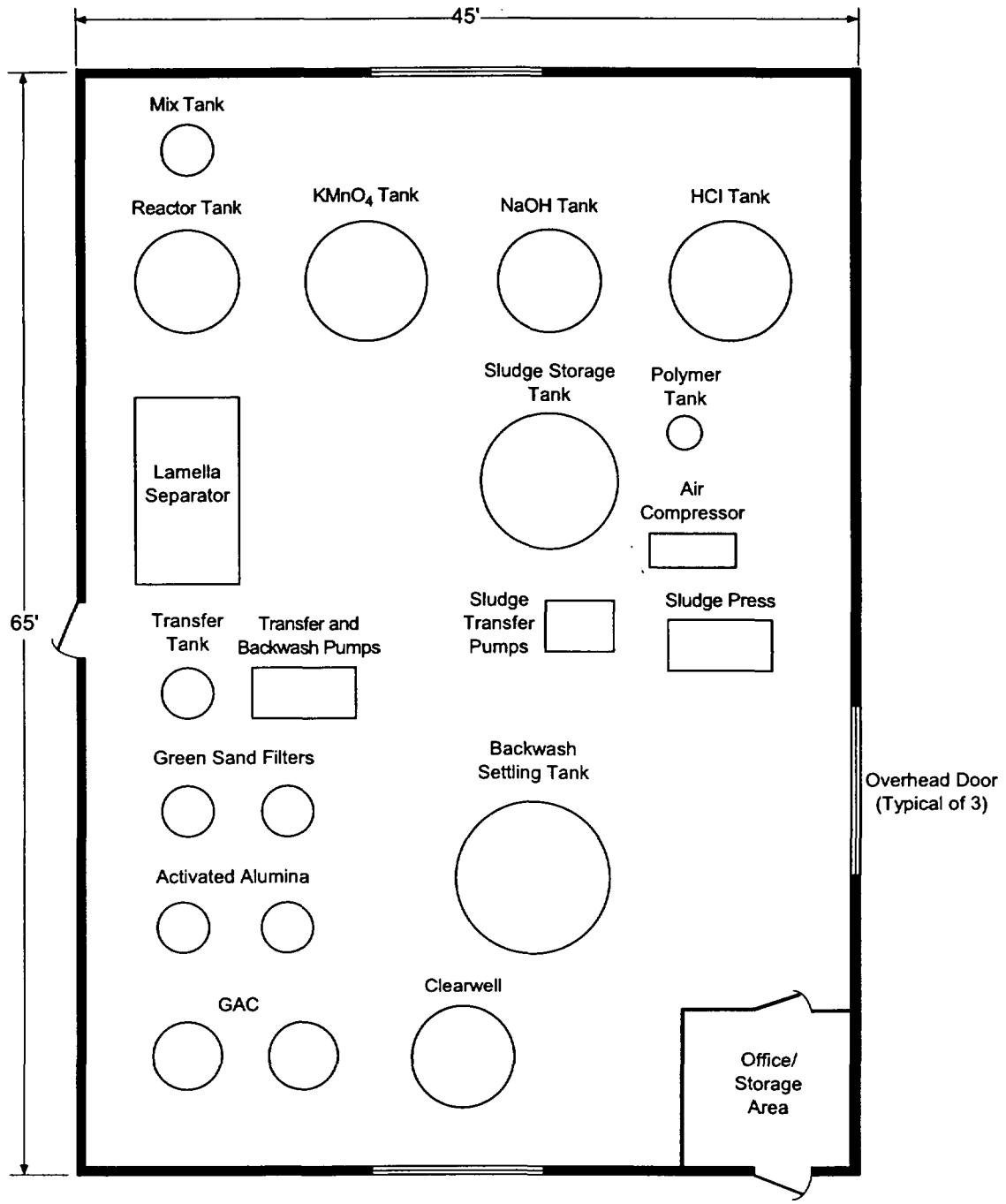


Figure 7-7
Alternative SML-4:
Preliminary Layout of Groundwater Treatment Building
Feasibility Study Report
Saco Municipal Landfill
Saco, Maine

Scale in Feet
0 10 20

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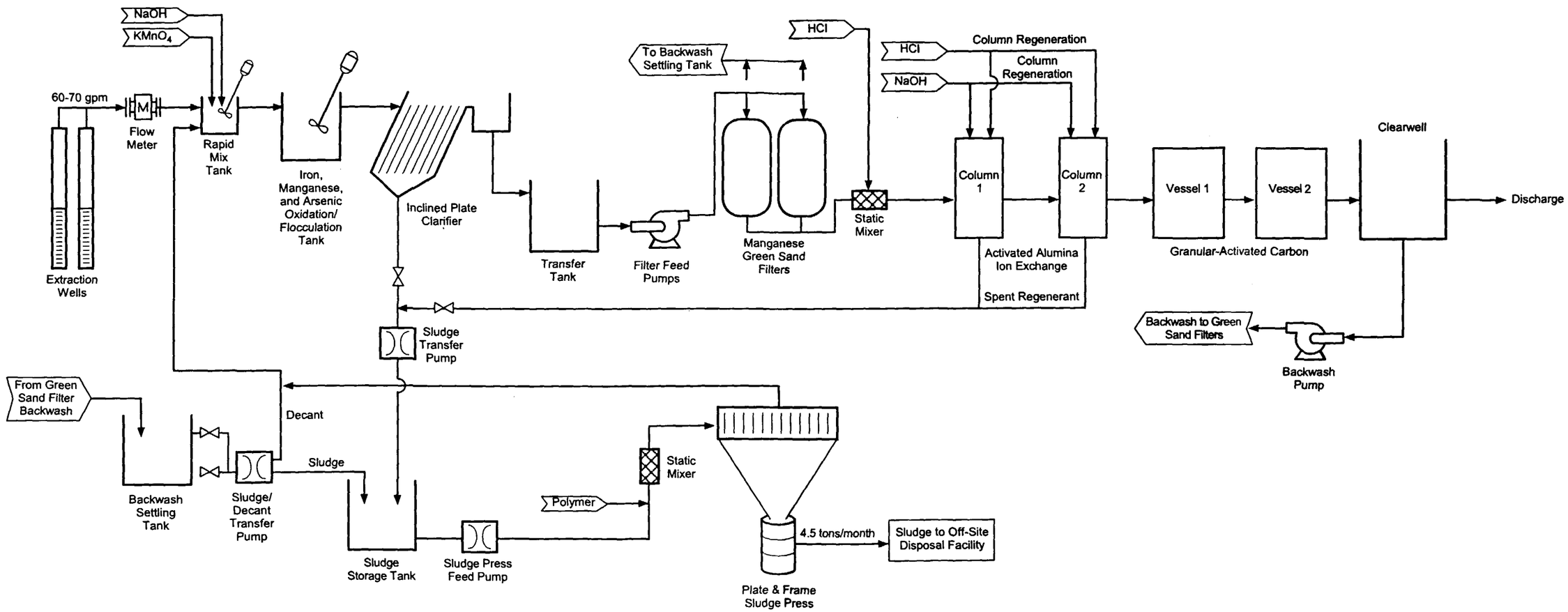


Figure 7-8
Alternative SML-4:
Treatment Process Flow Diagram
Feasibility Study Report
Saco Municipal Landfill
Saco, Maine

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**TABLE 7-6**
**ALTERNATIVE SML-4**
**ESTIMATED INFLUENT CONTAMINANT CONCENTRATIONS**
**AND PRELIMINARY REMEDIATION GOALS**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| PARAMETER | UNITS | ESTIMATED INFLUENT CONCENTRATION | PRG |
|---|---|---|---|
| Arsenic | µg/L | 140 | 50 |
| Manganese | µg/L | 7700 | 500 |
| Iron | mg/L | 45 | NA |
| Benzene | µg/L | 3 (1) | 5 |
| pH | standard unit | 6.7 | NA |
| Alkalinity | ppm as $CaCO_3$ | 400 | NA |

NOTES:

(1) Although the average benzene concentation was calculated as 3 µg/L, benzene is a contaminant of concern because a concentration of 13 µg/L was detected at MW-95-4R.

NA = Not Applicable
PRG = Preliminary Remediation Goal

After the groundwater has been mixed with permanganate and caustic, it flows by gravity to a well-mixed oxidation tank, where the permanganate is allowed to react for approximately 25 minutes, in order to fully oxidize the metals in solution. From the oxidation tank, groundwater flows to an inclined plate separator, where an estimated 70 to 90 percent of the precipitated iron and manganese will be removed by settling, and some of the arsenic is expected to be removed as well, as a co-precipitate. Sludge from the separator would be pumped to a sludge holding tank as necessary.

Water from the inclined plate separator flows to a transfer tank, where the system shifts from gravity to pressure operation. Two pumps linked to level sensors in the transfer tank would pump groundwater continuously to two manganese greensand filters arranged in parallel. Manganese greensand filters are special sand filters that are extremely efficient at removing iron and manganese, and may remove a substantial amount of arsenic as well. The effluent from the greensand filters is expected to contain less than 0.3 mg/L of iron and manganese, well below the 0.84 mg/L PRG for manganese. Greensand filtration is commonly used in the water treatment industry to reduce iron and manganese concentrations below the secondary drinking water standards of 0.3 mg/L iron, and 0.05 mg/L manganese.

Greensand is a natural zeolite that requires potassium permanganate to function effectively, and would be continuously "recharged" by the addition of permanganate at the head end of the treatment system. Two filters would be provided in parallel. Under normal operating conditions, flow would alternate from one filter to the other to accommodate periodic filter backwashing. Since there will not be a potable water supply to the plant, the filters will be backwashed with final effluent pumped from the clear well. Backwash waters would discharge to a backwash holding tank, where settled solids would be discharged to the sludge holding tank, and supernatant liquids would be returned to the head of the treatment plant. The purpose of the backwash holding tank is to minimize the volume of wet sludge that needs to be processed.

Discharge from the greensand filters would flow under pressure to a small, well-mixed tank where hydrochloric acid would be added to the groundwater to adjust the pH back down to a value of 6.0. Next, groundwater flows through a pair of ion exchange columns containing activated alumina. The activated alumina media ion is very selective for arsenic, but is only effective in a narrow pH range around 6.0. Discharge from the activated alumina is expected to contain less than 10 μg/L of arsenic. The columns would operate in series, and would be piped and valved such that either column could be first in series, and either vessel could be isolated for regeneration, as necessary. Discharge from both columns would

be monitored monthly for arsenic, and the lead column in series would be isolated and regenerated by treatment with hydrochloric acid and sodium hydroxide when breakthrough occurred. The freshly regenerated column would then be returned to service as the second column in series. Regenerate liquids containing precipitated arsenic would be discharged to the backwash holding tank, where settled solids would be pumped to the sludge storage tank, and supernatant liquids returned to the head of the plant.

Finally, two granular activated carbon (GAC) vessels would be placed downstream of the ion exchange columns. GAC would reduce the concentration of benzene in the groundwater to less than 5 μg/L. Like the ion exchange columns, the GAC vessels would operate in series, and would be piped and valved such that either vessel could be first in series, and either vessel could be isolated for regeneration, as necessary. Discharge from both vessels would be monitored monthly for VOCs, and the lead column in series would be isolated, emptied, and refilled with virgin carbon when breakthrough occurred. The freshly regenerated column would then be returned to service as the second column in series. Although preliminary calculations of benzene concentration in the extracted groundwater indicate that it would be less than 5 μg/L initially, the GAC vessels are included in this alternative as a necessary contingency in the event the benzene concentrations were higher than anticipated.

Discharge from the GAC vessels would flow to a clear well, which would provide a supply of clean process water for filter backwashing and similar operations. From the clear well, groundwater would flow by gravity through a 3-inch discharge pipe to a newly constructed infiltration basin located outside of the plume boundary.

Solids produced during the inorganics treatment would be concentrated and dewatered in a plate and frame filter press prior to disposal. Based on the existing concentrations of arsenic in groundwater, the resulting sludge may be hazardous, and would be disposed off-site at a licensed hazardous waste facility.

Performance of the groundwater treatment system would be monitored periodically. It was assumed that effluent samples would be collected on a monthly basis to determine that applicable discharge criteria are being achieved. In addition, groundwater samples from each extraction well would be collected quarterly to evaluate mass removal rates for arsenic, manganese, benzene, and DOC, as well as changes in water quality parameters.

**Environmental Monitoring.** The long-term environmental monitoring program proposed for Alternative SML-4 would similar to Alternative SML-3. Additional monitoring would be required for O&M for the groundwater treatment system and groundwater monitoring to determine the distribution and effectiveness of the chemical oxidant added to the plume. The objective of environmental monitoring would be to ensure protection of human health and the environment by monitoring changes in chemical concentrations in groundwater, surface water, and sediment over time and to determine the effectiveness of this alternative to reduce the concentrations of arsenic, manganese, and benzene to their respective PRGs in groundwater.

Environmental monitoring as well as five and ten-year site reviews will be conducted according to guidelines covered in Subsection 7.2.2.1.

#### 7.2.3.2 Alternative Evaluation

Table 7-7 presents the detailed analysis of Alternative SML-4 against the seven NCP evaluation criteria.

#### 7.2.3.3 Cost

A cost estimate was prepared for Alternative SML-4 to help in selection of a remedial alternative. In general, cost estimates contain the following principal elements:

- capital costs; and
- operation and maintenance costs.

Capital costs consist of direct and indirect costs that typically include those expenditures initially incurred to develop, construct, and implement the remedial alternative. Operation and maintenance (O&M) costs typically include post-construction costs necessary to ensure the continued effectiveness of the remedial action. The cost estimate for Alternative SML-4 includes long-term environmental monitoring and five-year site reviews. While it is recognized that SML-4 will require 50 to 100 years to meet PRGs, costs are estimated for 30 years only. This is to provide a consistent basis of comparing alternatives and is consistent with EPA requirements for conducting an FS (EPA, 1992).

**TABLE 7-7**
**DETAILED ANALYSIS: ALTERNATIVE SML-4**
**CHEMICAL OXIDATION WITH GROUNDWATER CONTAINMENT**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-4: CHEMICAL OXIDATION WITH GROUNDWATER CONTAINMENT |
|---|---|
| **OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT** | |
| Human Health Protection | The results of the baseline risk assessment indicate no potential risks to human health, with the exception of potential future risks if groundwater were to be used for drinking water purposes. This scenario is, however, extremely unlikely as the area is currently supplied by public water and institutional controls restricting land and groundwater use have been implemented as a part of the NTCRA.<br><br>USGS research suggests that arsenic concentrations in groundwater will reach background over a 50 to 100 year period via natural attenuation processes. Reduced arsenic concentrations in groundwater will result in reduced arsenic concentrations in surface water downgradient from Landfill Areas 3 and 4. Because in situ chemical oxidation will increase the concentration of DO in the groundwater, this alternative may shorten the time to induce chemical changes over natural conditions. |
| Ecological Protection | The results of the baseline risk assessment indicate moderate risks to the environment. This alternative would provide an increased level of protection over the no action alternative because it would capture the plume and prevent potentially contaminated groundwater from entering Sandy Brook. This advantage could be offset by a decrease in surface water flow (through groundwater extraction) having a potentially significant negative impact on ecological habitat. |
| **COMPLIANCE WITH ARARS** | |
| Chemical-Specific | Under baseline conditions, concentrations of arsenic and benzene in groundwater exceed chemical-specific ARARs (i.e., MCLs and MEGs). Changes in groundwater geochemistry are necessary for arsenic concentrations to decrease; USGS research suggests that these changes would occur over a 50 to 100 year time frame. Concentrations of arsenic and manganese in surface water are lower than concentrations in groundwater. At present, concentrations of arsenic in surface water exceed the chemical-specific ARAR (i.e. SWQC) within a control area of Sandy Brook. Concentrations of manganese exceed the chemical-specific ARAR in Sandy Brook at present; however, the highest manganese concentration is at the background location. It is unknown whether the addition of oxidants to groundwater would reduce the concentrations of arsenic and manganese more quickly than natural processes. Containment of the plume would reduce groundwater plume inflow into Sandy Brook and would result in lower arsenic concentrations in Sandy Brook.<br><br>Required approvals would be obtained prior to on-site discharge of treated groundwater or off-site discharge of untreated groundwater. |

**TABLE 7-7**
**DETAILED ANALYSIS: ALTERNATIVE SML-4**
**CHEMICAL OXIDATION WITH GROUNDWATER CONTAINMENT**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-4: GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT |
|---|---|
| Location-Specific | Location-specific ARARs identified for Alternative SML-4 are presented in Appendix E. This alternative would be designed to comply with pertinent location-specific ARARs. |
| Action-Specific | Action-specific ARARs identified for Alternative SML-4 are presented in Appendix E. This alternative would be designed to comply with pertinent action-specific ARARs. |
| **LONG-TERM EFFECTIVENESS AND PERFORMANCE** | |
| Magnitude of Residual Risk | Semi-annual injection of chemical oxidants into groundwater is expected to oxidize the DOC and precipitate iron, manganese, and arsenic reducing the dissolved concentrations of these natural elements. Groundwater extraction will then be used to hydraulically contain the majority of the plume, minimizing the impact of the chemical oxidants on the aquifer and the surface water of Sandy Brook. Therefore, this alternative may reduce the magnitude of residual risk.<br><br>As stated previously, the residual risks associated with the remedial objectives are within the USEPA target range and are considered to be acceptable for this site. Institutional controls, implemented as a part of the NTCRA restrict future land and groundwater use at the site. Therefore, future potential exposure to contaminants in groundwater would be prevented, effectively eliminating this exposure pathway. In addition, five-year site reviews will be conducted to ensure the continued protection of human health and the environment. |
| Adequacy and Reliability of Controls | *In situ* chemical oxidation has the potential to reduce the concentrations of DOC, and dissolved iron, manganese and arsenic in the groundwater. The adequacy and reliability of chemical oxidation to permanently reduce the concentrations of these metals is unknown. In addition, clogging of the aquifer with metal precipitates could minimize additional dispersion of oxidant in the aquifer, and could cause the groundwater flow paths to change.<br><br>The proposed hydraulic containment system would manage the migration of remaining dissolved iron, manganese and arsenic into Sandy Brook, and would minimize the potential impact of chemical oxidants on the brook.<br><br>A long-term monitoring program would, however, be implemented to monitor groundwater concentrations throughout the plume to evaluate the effectiveness of this alternative.<br><br>With the exception of pumps, which may need to be replaced frequently, the estimated service life of the treatment system components will exceed the injection and extraction periods anticipated for this project. |

**TABLE 7-7**
**DETAILED ANALYSIS: ALTERNATIVE SML-4**
**CHEMICAL OXIDATION WITH GROUNDWATER CONTAINMENT**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-4: GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT |
|---|---|
| | Placement of the cover system over Landfill Areas 3 and 4 is providing source control by controlling the generation of DOC-rich leachate from the landfill. Institutional controls implemented as a part of the NTCRA will adequately control the future land and groundwater use at the site. |
| **REDUCTION OF TOXICITY, MOBILITY, AND VOLUME THROUGH TREATMENT** | |
| Treatment Process Used and Materials Treated | Fenton's reagents or $KMnO_4$ would be injected into the groundwater to oxidize the DOC, which would increase the redox potential of the groundwater and decrease the concentrations of dissolved iron, arsenic, and manganese in groundwater.<br><br>Extracted groundwater containing concentrations of arsenic, manganese, and benzene exceeding PRGs would be discharged to the Saco WWTP for treatment, or would be treated on site via precipitation, filtration, ion exchange and activated carbon to meet PRGs. Groundwater treated on site would then be discharged to a newly constructed infiltration basin. |
| Amount Destroyed or Treated | Based on average dissolved influent concentrations estimated to design the groundwater treatment system, approximately 3.5 lbs/month of arsenic, 1135 lbs/month of iron and 697 lbs/month of manganese would be removed. |
| Degree of Expected Reductions of Toxicity, Mobility, or Volume Through Treatment | The proposed in situ chemical oxidation treatment system would change the redox potential of the groundwater, thereby decreasing the reductive dissolution of arsenic, iron and manganese from overburden and bedrock, causing these metals to precipitate to their less soluble forms.<br><br>The groundwater containment system would manage the migration of the plume, and would minimize the loading of metals and chemical oxidant to the surface water and sediment in Sandy Brook. The groundwater treatment system would increase the volume of contaminants through the generation of sludge. |

**TABLE 7-7**
**DETAILED ANALYSIS: ALTERNATIVE SML-4**
**CHEMICAL OXIDATION WITH GROUNDWATER CONTAINMENT**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-4: GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT |
|---|---|
| Degree to Which Treatment is Irreversible | It is uncertain if the reduction in mobility of iron, arsenic, and manganese through precipitation would be permanent, or if groundwater geochemistry could cause precipitated metals to be re-dissolved. In addition, if precipitated metals clogged the injection wells, backwashing with an anti-fouling compound could re-dissolve metals. |
| Type and Quantity of Residuals Remaining After Treatment | Approximately four tons of sludge (including precipitated arsenic, iron, manganese and other inorganics) would be generated per month from the groundwater treatment process. Based on the elevated concentrations of arsenic and manganese in the groundwater, the resulting sludge may be hazardous, requiring stabilization and disposal at a hazardous waste facility.<br><br>Additional treatment residuals (e.g., activated carbon) that may be generated that would require off-site disposal at a permitted facility. |
| **SHORT-TERM EFFECTIVENESS** | |
| Protection of Community During Remedial Action | Installation of chemical oxidation injection wells, and operation of the on-site chemical oxidation system and on-site groundwater treatment facility and infiltration basin would not have significant short-term impacts on the local community. The treatment facility and infiltration basin would be constructed on site, with the nearest local resident located approximately 0.4 miles from the proposed treatment system location. Residents are not expected to be exposed to any site-related hazards.<br><br>Implementation of the off-site discharge option would impact the local community with the installation of new pipes along Foss Road and Route 112, and pump station upgrades. Residents are not expected to be exposed to any site related contaminants during construction of implementation of this alternative. |
| Protection of Workers During Remedial Action | Workers would be required to be trained in health and safety procedures for work at hazardous waste sites. Appropriate site-specific health and safety plan(s) would also be followed and appropriate personal protective equipment would be used to minimize risks to workers during well installation, construction activities, sampling, and treatment plant operation. Hazards associated with chemicals and heavy equipment during construction would be mitigated through safe work practices. |

**TABLE 7-7**
**DETAILED ANALYSIS: ALTERNATIVE SML-4**
**CHEMICAL OXIDATION WITH GROUNDWATER CONTAINMENT**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-4: GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT |
|---|---|
| Environmental Impacts | Implementation of this alternative may include installation of wells and piping, subsurface injection of chemical oxidants, excavation of an infiltration basin and construction of a treatment facility. These activities have the potential to impact the environment, and all remedial activities would be conducted in accordance with pertinent ARARs.<br><br>Subsurface injection of chemical oxidants could have a major impact on biota at the site. Hydraulic containment of the majority of the plume and oxidant should minimize impacts to the aquifer outside the treatment area and to the surface water of Sandy Brook.<br><br>The proposed groundwater extraction rate of 60 gpm is not expected to significantly reduce the surface water flow within the brook. This pumping rate has a lesser impact on the brook than higher pumping rates, while still containing the majority of the plume. |
| Time Until Remedial Action Objectives Are Achieved | Until a pilot scale field study is conducted, it is not known to what degree in situ chemical oxidation may reduce the remediation time frame.<br><br>At present, arsenic concentrations in Sandy Brook are above the PRG. Background concentrations are below the PRG of manganese in surface water are above the PRG. For arsenic, pumping of the plume will reduce groundwater plume inflow into Sandy Brook and result in lower concentrations in Sandy Brook within 10 to 20 years. Reduced concentrations of arsenic and manganese in groundwater will further reduce concentrations in surface water; however, manganese concentrations may never reach the PRG. |
| **IMPLEMENTABILITY** | |
| Ability to Construct and Operate the Technology | The installation of wells, underground piping, and an infiltration basin involves common construction techniques and would be easy to implement. Several vendors are available to design, install, and operate the treatment system. Prior to implementation, treatability tests to determine optimum operating parameters and to evaluate the effectiveness of the system at reducing contaminant concentrations to meet applicable discharge criteria would be performed.<br><br>The estimated time to design and construct the extraction, treatment, and on-site discharge system is estimated to be approximately ten months. The time to design and construct the off-site piping and upgrade pump stations would also be approximately ten months. |

**TABLE 7-7**
**DETAILED ANALYSIS: ALTERNATIVE SML-4**
**CHEMICAL OXIDATION WITH GROUNDWATER CONTAINMENT**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-4: GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT |
|---|---|
| Reliability of Technology | The high dissolved iron, arsenic, and manganese concentrations in groundwater downgradient of Landfill Areas 3 and 4 would cause clogging of the chemical oxidation injection wells with metal precipitates. Both injection and groundwater extraction wells would require annual cleaning with an anti-fouling compound (e.g., hydrochloric acid, sulfamanic acid, or hydroxyacetic acid). Based on experience at similar sites, it is assumed that pumps would have to be cleaned every 6 to 10 weeks and would potentially need to be replaced every 3 years.<br><br>Discharge of treated groundwater to an on-site infiltration basin or to the Saco WWTP are considered reliable means of disposal.<br><br>The technologies proposed for groundwater treatment (oxidation, precipitation, settling, filtration, ion exchange and GAC) are proven technologies for treatment of the contaminants of concern. |
| Ease of Undertaking Additional Remedial Actions, If Necessary | This alternative would not limit or interfere with the ability to implement or perform future remediation actions. |
| Ability to Monitor Effectiveness of Remedy | The long-term environmental monitoring program would be easily implemented and would monitor the effectiveness of this alternative and contaminant migration throughout the plume.<br><br>Treatment system effluent would be monitored on a routine basis to evaluate the effectiveness of the treatment system and ensure that discharge criteria are achieved. Monitoring/analysis of samples collected from the treatment system would be easily implemented using an off-site laboratory. |
| Ability to Obtain Approvals and Coordinate with Other Agencies | Administratively, groundwater extraction and/or treatment and discharge would be easy to implement.<br><br>Substantive requirements of permits to DOT, local utilities and the City of would be met.<br><br>A detailed long-term groundwater monitoring program and the five year site review would be subject to regulatory review and approval. |

**TABLE 7-7**
**DETAILED ANALYSIS: ALTERNATIVE SML-4**
**CHEMICAL OXIDATION WITH GROUNDWATER CONTAINMENT**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-4: GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT |
|---|---|
| Availability of Off-site Treatment, Storage, and Disposal Services and Capacity. | Pump stations may not have sufficient capacity to receive an additional 60 to 70 gpm of groundwater from the site. Upgrades to these pump station would be required for this option to be viable.<br><br>Implementation of this alternative would require off-site disposal of waste solids generated from the treatment system that may be potentially hazardous. Both non-hazardous and hazardous waste services and off-site disposal facilities are currently available. |
| Availability of Necessary Equipment and Specialists | Equipment, materials, and services for construction of the chemical oxidation treatment system and the groundwater extraction, treatment, and discharge systems would be readily available. |
| Availability of Technology | Several qualified vendors would be available to design, construct, and operate the chemical oxidation treatment system and the groundwater extraction and treatment system. |
| **COSTS** | |
| **GROUNDWATER EXTRACTION WITH OFF-SITE DISCHARGE TO SACO WWTP** | |
| Capital Cost | $ 1,355,000 |
| Net Present Worth Cost of Operations and Maintenance of In-Situ Chemical Oxidation Treatment | $ 2,190,000 |
| Net Present Worth Cost of Operations and Maintenance of Extraction and Discharge System | $ 509,000 |
| Net present Worth of Environmental Monitoring | $ 1,551,000 |
| Net Present Worth Cost of Five-Year Site Reviews | $ 129,000 |
| Total Net Present Cost Worth | $ 5,734,000 |

**TABLE 7-7**
**DETAILED ANALYSIS: ALTERNATIVE SML-4**
**GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-4: GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT |
|---|---|
| **GROUNDWATER EXTRACTION WITH ON-SITE TREATMENT AND DISCHARGE** | |
| Capital Cost | $ 2,312,000 |
| Net Present Worth Cost of Operations and Maintenance of In-Situ Chemical Oxidation Treatment | $ 2,190,000 |
| Net Present Worth Cost of Operations and Maintenance of Extraction, Treatment and Discharge System | $3,177,000 |
| Net Present Worth Cost of Environmental Monitoring | $ 1,551,000 |
| Net Present Worth Cost of Five-Year Site Reviews | $ 129,000 |
| Total Net Present Cost Worth | $ 9,359,000 |

Two cost estimates were prepared for Alternative SML-4. The first estimate presented in Table 7-8 was prepared assuming that groundwater would be extracted and discharged untreated to the Saco WWTP. The second estimate presented in Table 7-9 was prepared assuming that groundwater would be extracted, treated, and discharged on-site.

**Off-Site Discharge:** The estimated total present worth (i.e., 7 percent for 30 years) of Alternative SML-4 with off-site discharge is $5,734,000. The estimated capital costs (i.e., construction, engineering, and administrative) are $1,355,000. The present worth of operations and maintenance costs for in situ chemical oxidation was estimated at $2,190,000 and the present worth costs for operations and maintenance for the extraction and discharge system was estimated to be $509,000. The present worth of environmental monitoring was estimated at $1,551,000 and the present worth of five-year site reviews was estimated at $129,000. Table 7-8 summarizes the costs estimated for Alternative SML-4 with off-site discharge at the Saco WWTP. Cost backup information for the components summarized in Table 7-8 is presented in Appendix D.

To develop these costs, the following assumptions were made:

- Environmental monitoring (surface water, sediment, and groundwater sampling and analysis) will occur for 30 years;
- A chemical oxidation system consisting of 17 injection wells will be installed downgradient of Landfill Areas 3 and 4.
- Chemical oxidants will be injected semi-annually for five years.
- Extraction and discharge systems will operate continuously for 30 years at a 60 gpm extraction rate;
- An extraction system consisting of two extraction wells and associated piping will be installed for the collection of groundwater associated with Landfill Areas 3 and 4;
- Groundwater will be pumped to an on-site pump station, and transported via a newly constructed 2½-inch force main to the North Street sewer, and then to an 8 to 10-inch gravity line transporting groundwater to the pump station on Route 112.
- Site data will be reviewed every five years for a period of 30 years.

**TABLE 7-8**
**COST ESTIMATE: ALTERNATIVE SML-4A**
**(DISCHARGE TO SACO WWTP)**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| DIRECT COSTS | |
|---|---|
| Pilot Scale Field Study | $75,000 |
| Installation of 17 Injection wells | $85,000 |
| Groundwater Extraction System | $92,000 |
| Discharge to Saco WWTP (1) | $453,000 |
| Installation of Groundwater Extraction/Discharge System | $164,000 |
| SUBTOTAL | $869,000 |
| 20% Contingency on Direct Costs | $174,000 |
| TOTAL DIRECT COSTS | $1,043,000 |

| INDIRECT COSTS | |
|---|---|
| Health and Safety @ 5% | $52,000 |
| Legal, Administrative and Permitting @ 5% | $52,000 |
| Engineering Design @ 10% | $104,000 |
| Services during Construction @10 % | $104,000 |
| TOTAL INDIRECT COSTS | $312,000 |
| **TOTAL CAPITAL COSTS (DIRECT AND INDIRECT)** | **$1,355,000** |

| ANNUAL OPERATION AND MAINTENANCE COSTS | |
|---|---|
| In Situ Chemical Oxidation injection | $391,000 |
| Injection Well Maintenance | $20,000 |
| SUBTOTAL | $411,000 |
| Engineering @ 10% | $41,000 |
| 20 % Contingency on O&M Costs | $82,000 |
| TOTAL O&M COSTS | $534,000 |
| **TOTAL PRESENT WORTH ANNUAL O&M COSTS (7%, 5 YEARS)** | **$2,190,000** |

**TABLE 7-8**
**COST ESTIMATE: ALTERNATIVE SML-4A**
**(DISCHARGE TO SACO WWTP)**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| | |
|---|---|
| Monitoring 2 Extraction Wells (Quarterly) | $5,000 |
| Maintenance (Annual) | $27,000 |
| SUBTOTAL | $32,000 |
| Engineering @ 10% | $3,000 |
| 20 % Contingency on O&M Costs | $6,000 |
| TOTAL O&M COSTS | $41,000 |
| **TOTAL PRESENT WORTH ANNUAL O&M COSTS (7%, 30 YEARS)** | **$509,000** |
| Monitoring Groundwater/Surface Water and Sediment (annually) | $125,000 |
| **TOTAL PRESENT WORTH ANNUAL ENVIRONMENTAL MONITORING COSTS (7%, 30 YEARS)** | **$1,551,000** |
| Five Year Site Reviews (includes 20% Contingency) | $60,000 |
| **TOTAL PRESENT WORTH OF FIVE YEAR SITE REVIEWS (7%,30 YEARS)** | **$129,000** |
| **TOTAL PRESENT WORTH (30 YEARS) - ALTERNATIVE SML-4A** | **$5,734,000** |

(1) Costs for upgrades to pump station on Route 112 not included.

**TABLE 7-9**
**COST ESTIMATE: ALTERNATIVE SML-4B**
**(TREATMENT/ON-SITE DISCHARGE)**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| DIRECT COSTS | |
|---|---|
| Pilot Scale Field Study | $75,000 |
| Installation of 17 Injection wells | $85,000 |
| Groundwater Extraction System | $92,000 |
| Treatability Study for Groundwater Treatment System | $100,000 |
| Groundwater Treatment System | $443,000 |
| Treated Groundwater Discharge System | $11,000 |
| Installation of Groundwater Extraction/Treatment/Discharge System | $676,000 |
| SUBTOTAL | $1,482,000 |
| 20% Contingency on Direct Costs | $296,000 |
| TOTAL DIRECT COSTS | $1,778,000 |

| INDIRECT COSTS | |
|---|---|
| Health and Safety @ 5% | $89,000 |
| Legal, Administrative and Permitting @ 5% | $89,000 |
| Engineering Design @ 10% | $178,000 |
| Services during Construction @10 % | $178,000 |
| TOTAL INDIRECT COSTS | $534,000 |
| **TOTAL CAPITAL COSTS (DIRECT AND INDIRECT)** | **$2,312,000** |

| ANNUAL OPERATION AND MAINTENANCE COSTS | |
|---|---|
| In Situ Chemical Oxidation injection | $391,000 |
| Injection Well Maintenance | $20,000 |
| SUBTOTAL | $411,000 |
| Engineering @ 10% | $41,000 |
| 20 % Contingency on O&M Costs | $82,000 |
| TOTAL O&M COSTS | $534,000 |
| **TOTAL PRESENT WORTH ANNUAL O&M COSTS (7%, 5 YEARS)** | **$2,190,000** |

**TABLE 7-9**
**COST ESTIMATE: ALTERNATIVE SML-4B**
**(TREATMENT/ON-SITE DISCHARGE)**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| | |
|---|---|
| Treatment System (Labor, Power, Chemicals, Maintenance, etc...) | $166,000 |
| Monitoring 2 Extraction Wells (Quarterly) | $5,000 |
| Treatment System Monitoring (Monthly) | $12,000 |
| Tretment Sludge Disposal | $14,000 |
| SUBTOTAL | $197,000 |
| Engineering @ 10% | $20,000 |
| 20 % Contingency on O&M Costs | $39,000 |
| TOTAL O&M COSTS | $256,000 |
| **TOTAL PRESENT WORTH ANNUAL O&M COSTS (7%, 30 YEARS)** | **$3,177,000** |
| Monitoring Groundwater/Surface Water and Sediment (annually) (includes 20% Contingency) | $125,000 |
| **TOTAL PRESENT WORTH ANNUAL ENVIRONMENTAL MONITORING COSTS (7%, 30 YEARS)** | **$1,551,000** |
| Five Year Site Reviews (includes 20% Contingency) | $60,000 |
| **TOTAL PRESENT WORTH OF FIVE YEAR SITE REVIEWS (7%,30 YEARS)** | **$129,000** |
| **TOTAL PRESENT WORTH (30 YEARS) - ALTERNATIVE SML-4B** | **$9,359,000** |

**On-Site Treatment and Discharge:** The estimated total present worth (i.e., 7 percent for 30 years) of Alternative SML-4 with on-site treatment and discharge is $9,359,000. The estimated capital costs (i.e., construction, engineering, and administrative) are $2,312,000. The present worth of operations and maintenance costs for in situ chemical oxidation was estimated at $2,190,000 and the present worth costs for operations and maintenance for the extraction, treatment and discharge system was estimated to be $3,177,000. The present worth of environmental monitoring was estimated at $1,551,000 and the present worth of five-year site reviews was estimated at $129,000. Table 7-9 summarizes the costs estimated for Alternative SML-4 with on-site treatment and discharge. Cost backup information for the components summarized in Table 7-9 is presented in Appendix D.

This second cost estimate includes many of the same assumptions as the first estimate, except that instead of discharging groundwater off-site, it would be treated on-site via precipitation, filtration, ion exchange and activated carbon, and then discharged on-site to a newly excavated infiltration basin. An additional assumption is that treated effluent will be monitored monthly for arsenic, iron, manganese, and DOC.

### 7.2.4 SML-5: Groundwater Extraction and Discharge with or without Treatment

This subsection presents the detailed analysis for Alternative SML-5.

#### 7.2.4.1 Description

Alternative SML-5 includes extraction and discharge of groundwater downgradient of Landfill Areas 3 and 4. Several discharge options are included in this alternative and treatment may or may not be required. This alternative is proposed as a way to potentially restore the aquifer to beneficial use more quickly than natural attenuation. Alternative SML-5 is designed to enhance the movement of oxygenated groundwater through the aquifer. It is hypothesized that the extracted groundwater would be replaced by oxygen-rich recharge. As discussed in Section 2.5, USGS research shows that concentrations of dissolved arsenic in groundwater will be reduced as the DO concentration increases. Concentrations of arsenic and manganese in Sandy Brook will also be reduced as concentrations in groundwater decrease. As stated in Alternative SML-1, institutional controls have been implemented as a part of the NTCRA for the Site.

Alternative SML-5 includes the following major components:

1. Installation of Groundwater Extraction System
2. Discharge of Groundwater
3. Installation and Operation of Groundwater Treatment System
4. Environmental Monitoring
5. Five-Year Site Reviews

Figure 7-9 presents a schematic diagram of Alternative SML-5.

**Installation of Groundwater Extraction System.** The groundwater extraction system was developed to achieve three objectives; (1) to manage the migration of the plume (2) to enhance the movement of oxygenated water through the aquifer and (3) to minimize the impact of groundwater extraction on the surface water flow in Sandy Brook. Various extraction well locations, depths, and pumping rates were evaluated to determine the optimal configuration and parameters for the extraction system.

As discussed in Section 2.0 and shown on Figure 2-2, the groundwater impacted by Landfill Areas 3 and 4 flows beneath and downgradient of the landfill in three distinct layers: bedrock, till, and the sand and gravel overburden. The volume of water flowing through the bedrock and the glacial till is considerably less (approximately 5% of total flow) than the volume of water moving through the sand and gravel aquifer due to the lower conductivity reported in the bedrock and till layers. The large volume of groundwater moving through the overburden suggested that pumping efforts be focused on this aquifer. In addition, pumping well simulations in bedrock indicated that pumping influence within the bedrock was limited and much of the water extracted from the rock is supplied by the overlying sand and gravel aquifer. Therefore, placement of groundwater extraction wells within the sand and gravel aquifer was evaluated to determine the conditions that best meet the three pumping objectives.

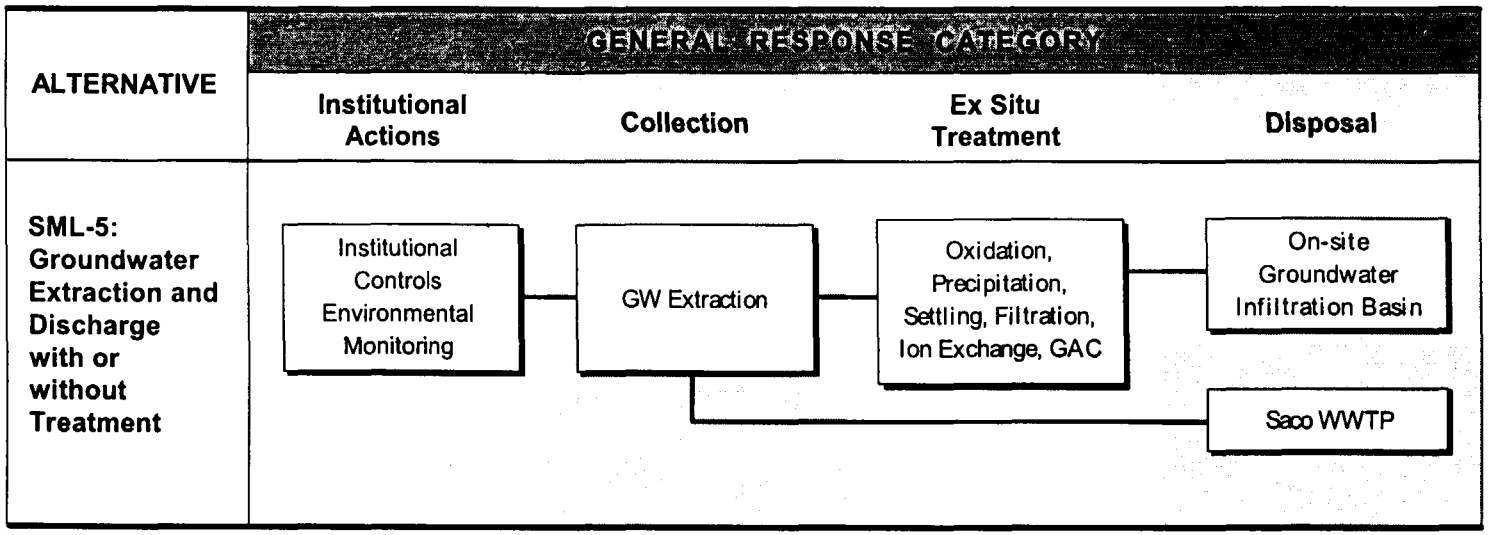


Figure 7-9
Schematic of Alternative SML-5:
Groundwater Extraction and Discharge with or without Treatment
Feasibility Study Report
Saco Municipal Landfill
Saco, Maine

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The groundwater model indicates that a minimum of two extraction wells placed near the downgradient edges of the plume on the western and eastern sides of Sandy Brook are necessary to manage the migration of the majority of the plume. Other well configurations were evaluated; however, all required a greater combined pumping rate to capture the groundwater flow. The model was also used to evaluate the effects of various pumping rates at these wells on both the travel time of groundwater flow between the toe of the landfill and Sandy Brook and the groundwater discharge and subsequent surface water flow in the brook. These pumping rates and subsequent changes in travel time and surface water flow are shown in Table 7-10.

The results of the model show that as the pumping rate is increased from 0 gpm to 500 gpm the groundwater travel time between the landfill and Sandy Brook is decreased from 2 to 1.4 years. This decrease in travel time suggests enhanced groundwater flow through the aquifer. However, a pumping rate of 500 gpm causes a significant impact to Sandy Brook. Model results show that under pumping conditions of greater than 250 gpm, Sandy Brook becomes a losing stream. During drought periods, this high pumping rate may potentially eliminate all surface water flow in the brook. The data presented in Table 7-10 show that a pumping rate of 60 gpm captures the majority of the plume without causing a significant decrease in groundwater discharge to the brook. A pumping rate of 60 gpm with two extraction wells appears to be the appropriate balance between capturing the plume and retaining sufficient recharge to the brook. Under this scenario, the southern fringe of the plume is not captured and allowed to discharge to the brook maintaining surface water flow. At a pumping rate of 60 gpm the travel time of groundwater flow from the toe of the landfill to Sandy Brook is reduced only from 2 to approximately 1.8 years. Nevertheless, the rate of travel time reduction per pumping rate is greater for 60 gpm than for higher pumping rates.

The effect of groundwater extraction on enhancing the movement of oxygen-rich water through the aquifer and subsequent time to achieve response objectives is difficult to quantitatively evaluate. Clean recharge to this aquifer appears limited to the amount of precipitation falling over the footprint of the plume and actually infiltrating to the overburden aquifer, because the only source of "clean" upgradient groundwater comes from the limited recharge area above the bedrock high that is not covered by the landfill cap. The average annual infiltration at this site (outside the capped landfill areas) is estimated to be 17 inches per year. Assuming a surface area of approximately 17.6 acres (13-acre landfill and 4.6 acres in the gravel pit)

**TABLE 7-10**
**ALTERNATIVE SML-5**
**MODELED GROUNDWATER EXTRACTION RATES, TRAVEL TIMES, AND DISCHARGES TO SANDY BROOK**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| PUMP RATE (gpm) | TRAVEL TIME (years) | GROUNDWATER DISCHARGE [1] $ft^3$/day |
|---|---|---|
| 0 | 2 | -19, 889 |
| 60 | 1.78 | -17,419 |
| 200 | 1.56 | -4,899 |
| 500 | 1.37 | +21,675 |

Notes:

[1] Groundwater discharge through sand and gravel aquifer to Sandy Brook directly downgradient from landfill.

- values indicate groundwater discharge to brook
+ values indicate brook discharge to groundwater

on average 16 gallons/minute of clean oxygenated water would recharge this plume. This recharge is approximately one-quarter of the volume of water being pumped, suggesting that most of the water extracted is from the overburden and not clean recharge being pulled through the aquifer.

Enhancing or pulling clean groundwater from the sides of the plume would require multiple wells at high pumping rates. The groundwater flow paths for this portion of the aquifer (see Appendix B-1) would have to be redirected through pumping to pull clean groundwater from unimpacted areas outside the plume boundaries through the aquifer. Groundwater modeling results indicate that the pumping rate necessary to move a large enough volume of water through the plume would be quite high and would adversely affect groundwater discharge to Sandy Brook. Although it is likely that pumping contaminated water from the plume may enhance groundwater flow, given the small change in travel time that can be achieved through pumping and the amount of recharge available to this system, pumping the plume is not expected to significantly shorten the time to restoration over natural conditions.

Based on the data presented in Table 7-10, a combined pumping rate of 60 gpm for two extraction wells placed in the sand and gravel aquifer was selected for this alternative because it meets two of the pumping objectives; it will contain the plume and it will not significantly impact groundwater discharge to Sandy Brook. The proposed extraction system for Alternative SML-5 consists of two wells, EW-1 located on the western side of Sandy Brook pumped at 40 gpm to contain the majority of the plume and EW-2 located on the eastern side of Sandy Brook pumped at 20 gpm to contain the northern portion of the plume that travels beneath the brook and surfaces on the eastern side. The extraction wells would be eight-inch diameter stainless-steel and screened in the sand and gravel aquifer. The western well would be installed to a depth of 46 feet bgs. with the well screen extending from 18 feet to 46 feet bgs. The eastern well would be installed to a depth of 76 feet bgs, with a well screen extending from 44 feet to 76 feet bgs. The location of the extraction wells is shown on Figure 7-10.

In addition, eleven piezometers would be installed in the vicinity of the extraction wells to evaluate hydraulic capture of the plume over time (Figure 7-10). The proposed one-inch diameter piezometers would be constructed of polyvinyl chloride (PVC). Three piezometers (screened 15 to 25 feet bgs) would be installed in the vicinity of the extraction well on the western side of Sandy Brook. Existing shallow monitoring wells in the vicinity of this extraction well would also be used to evaluate hydraulic capture of the plume. Because there are no existing monitoring wells in the vicinity of the extraction well on the

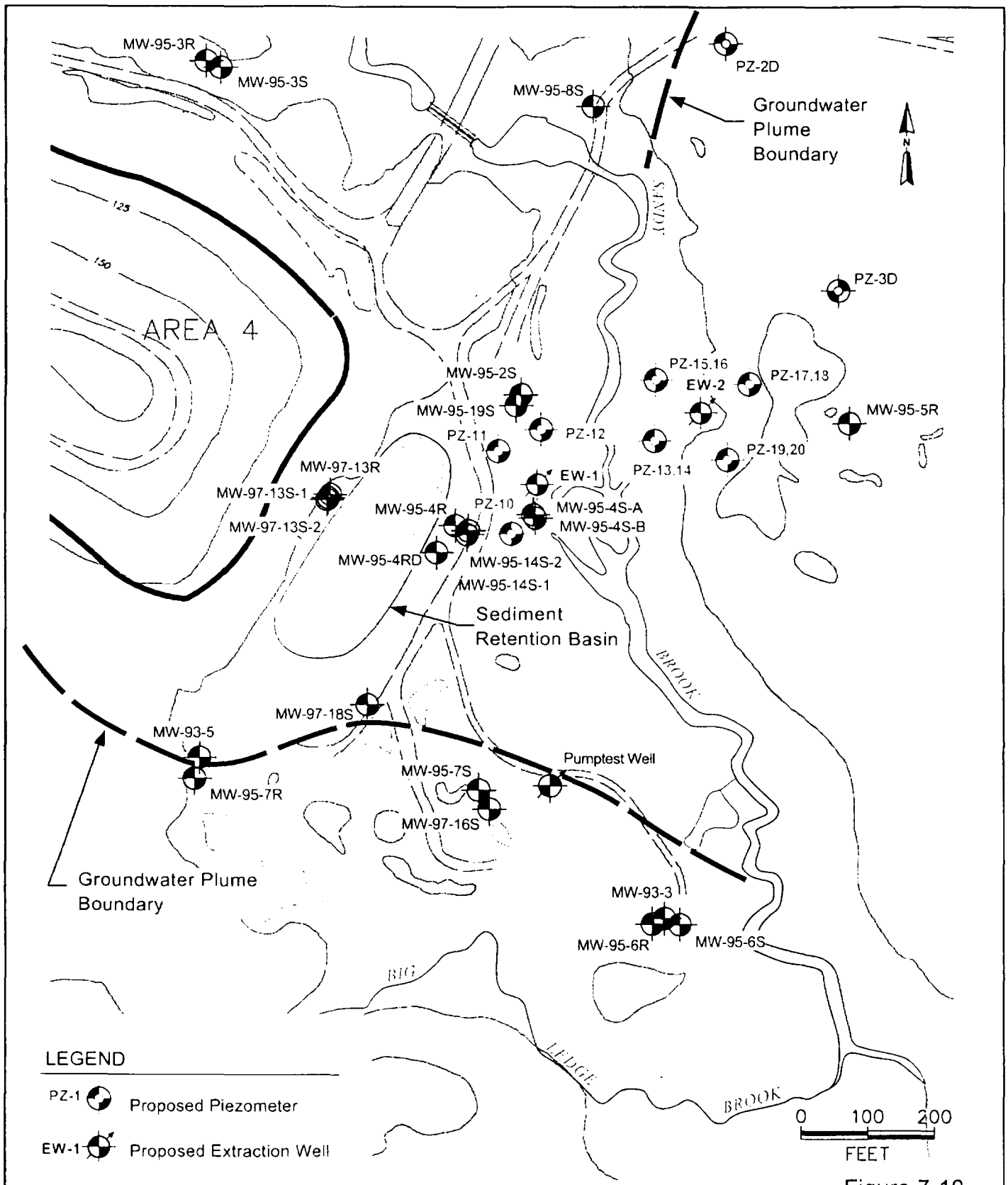


Figure 7-10
Alternative SML-5:
Proposed Extraction Well and Piezometer Locations
Saco Municipal Landfill
Saco, Maine

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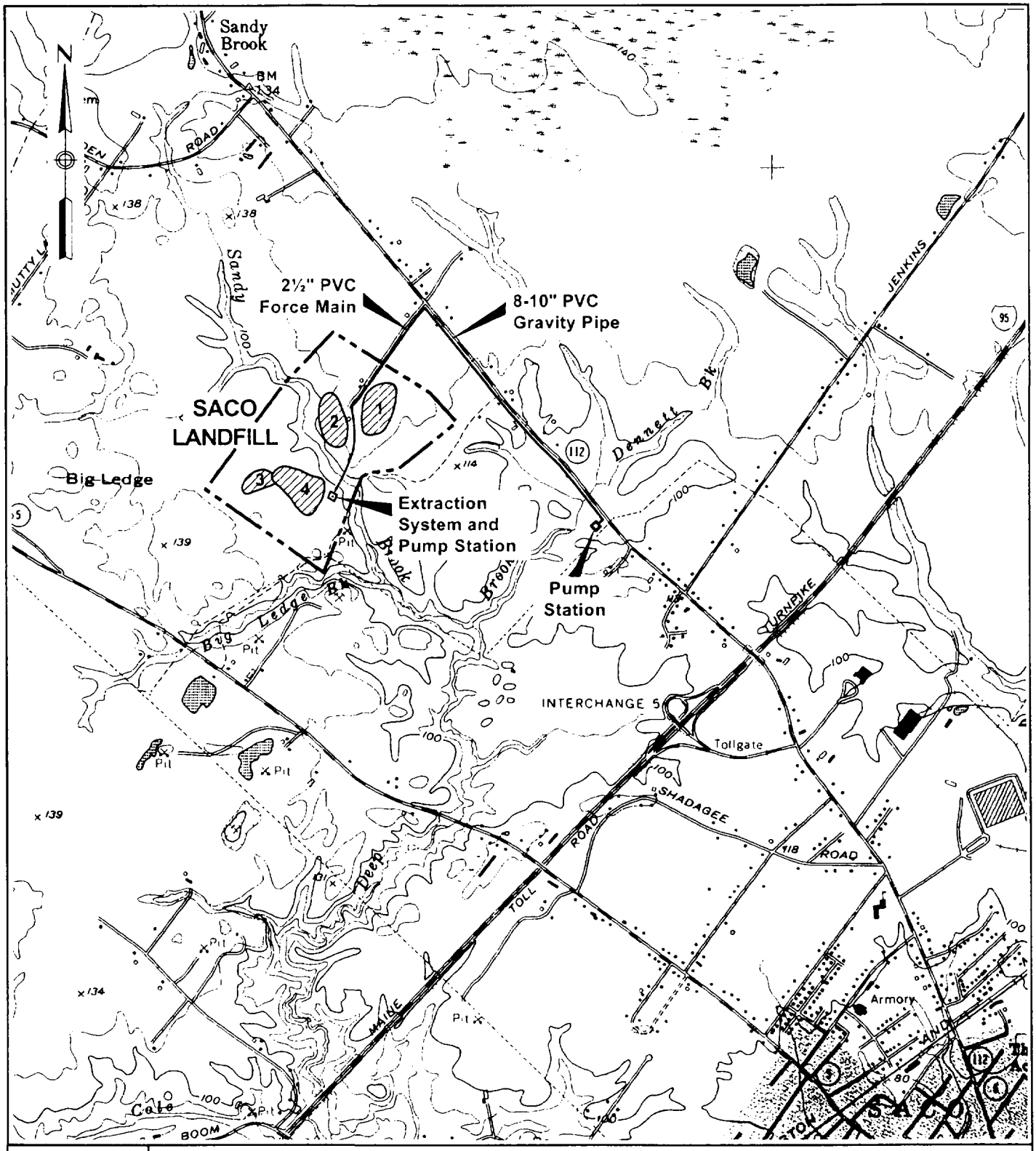
eastern side of Sandy Brook, eight piezometers (one screened at 25-35 feet bgs, four screened at 35 to 45 feet bgs, and three screened at 65 to 75 feet bgs) would be installed to evaluate hydraulic capture of the plume. Water levels would be measured in each piezometer on a semi-annual basis.

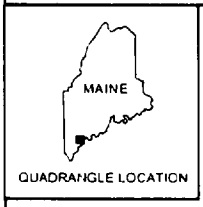
At pumping rates that do not significantly decrease groundwater discharges to Sandy Brook, most of the extracted groundwater is not clean recharge. Because of this, the pumping system is not expected to increase the concentration of DO in the groundwater beneath and downgradient of Landfill Areas 3 and 4 significantly faster than natural attenuation processes. As a result, the time frame estimated to meet PRGs for arsenic, manganese, and benzene for this alternative is approximately the same as the time frame estimated for Alternative SML-3, Monitored Natural Attenuation, of approximately 50 to 100 years.

Although Alternative SML-5 would contain the plume, it is not expected to have significant impact on attainment of surface water standards (e.g. SWQC of 10 ug/L for arsenic). At present, in Sandy Brook the surface water criteria for arsenic and manganese are substantially being met for a majority of Sandy Brook except for an area directly downgradient of the plume (see Appendix B-4). For arsenic, pumping of the plume would reduce groundwater plume inflow into Sandy Brook and result in somewhat lower arsenic concentrations in Sandy Brook without complete capture of the plume. For manganese, the concentration at the background location on Sandy Brook exceeds the State SWQC of 500. Therefore, reductions of manganese concentration would not be expected from reducing flow of the plume into Sandy Brook.

**Discharge of Groundwater.** Two options exist for the discharge of extracted groundwater: (1) discharge untreated to the Saco WWTP; or (2) discharge on-site after treatment. Both discharge options are described below. The technical and administrative issues associated with each option would, however, require a detailed evaluation during the final design.

Untreated Groundwater: The first option would involve discharging untreated groundwater to the Saco WWTP. A pump station would be constructed in the vicinity of the extraction wells, and extracted groundwater would be pumped to and through a 2 ½ inch PVC force main installed along Foss Road to an 8 to 10 inch gravity line installed along Route 112 to the pump station. Upgrades to the pump station may be required, and would be evaluated as a part of the final design. A conceptual layout of this discharge option is shown on Figure 7-11.




**Source:** USGS Topographic Quadrangle 7.5-Minute Series, Old Orchard Beach, Maine, 1956 (Photorevised 1970; Photoinspected 1975).

Scale in Feet

0 2000 4000

Figure 7-11
Alternative SML-5
Groundwater Discharge to Saco WWTP
Saco Municipal Landfill
Saco, Maine

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Treated Groundwater: The second option would include the on-site treatment of groundwater to remove arsenic, manganese and benzene to their PRGs prior to on-site discharge of the treated groundwater. The potential impacts to the plume resulting from the discharge of treated groundwater to the existing stormwater retention basin was evaluated using the groundwater model. Based on the model, the boundaries of the plume in the vicinity of the retention basin would expand with the placement of 60 gpm pumping system such that the extraction wells would no longer capture the plume. Therefore, to allow on-site discharge, the location of the infiltration basin would be outside the plume boundary as shown on Figure 7-12. To contain the treated groundwater, the proposed infiltration basin would be constructed with an area of approximately 23,000 square feet and a depth of five feet. An infiltration study would be required during final design to determine the exact location based on the groundwater level and actual infiltration rate.

**Installation of Groundwater Treatment System.** To meet ARARs for proposed groundwater infiltration, the proposed groundwater treatment system was designed to remove arsenic, manganese and benzene to their respective PRGs. The groundwater treatment system would consist of the following major unit processes:

- oxidation of metals in groundwater;
- precipitation and settling;
- filtration;
- ion exchange;
- granulated activated carbon;
- treated water disposal;
- sludge thickening;
- sludge dewatering; and
- sludge disposal.

The treatment system would be housed in a treatment building located northeast of Landfill Area 3 and 4. A conceptual site layout of the proposed extraction, treatment and discharge system is shown on Figure 7-12. A preliminary layout of the groundwater treatment building is shown on Figure 7-13, and a process flow diagram of the proposed treatment system is presented in Figure 7-14. Actual design of the treatment system would include bench and/or pilot studies to determine operating parameters.

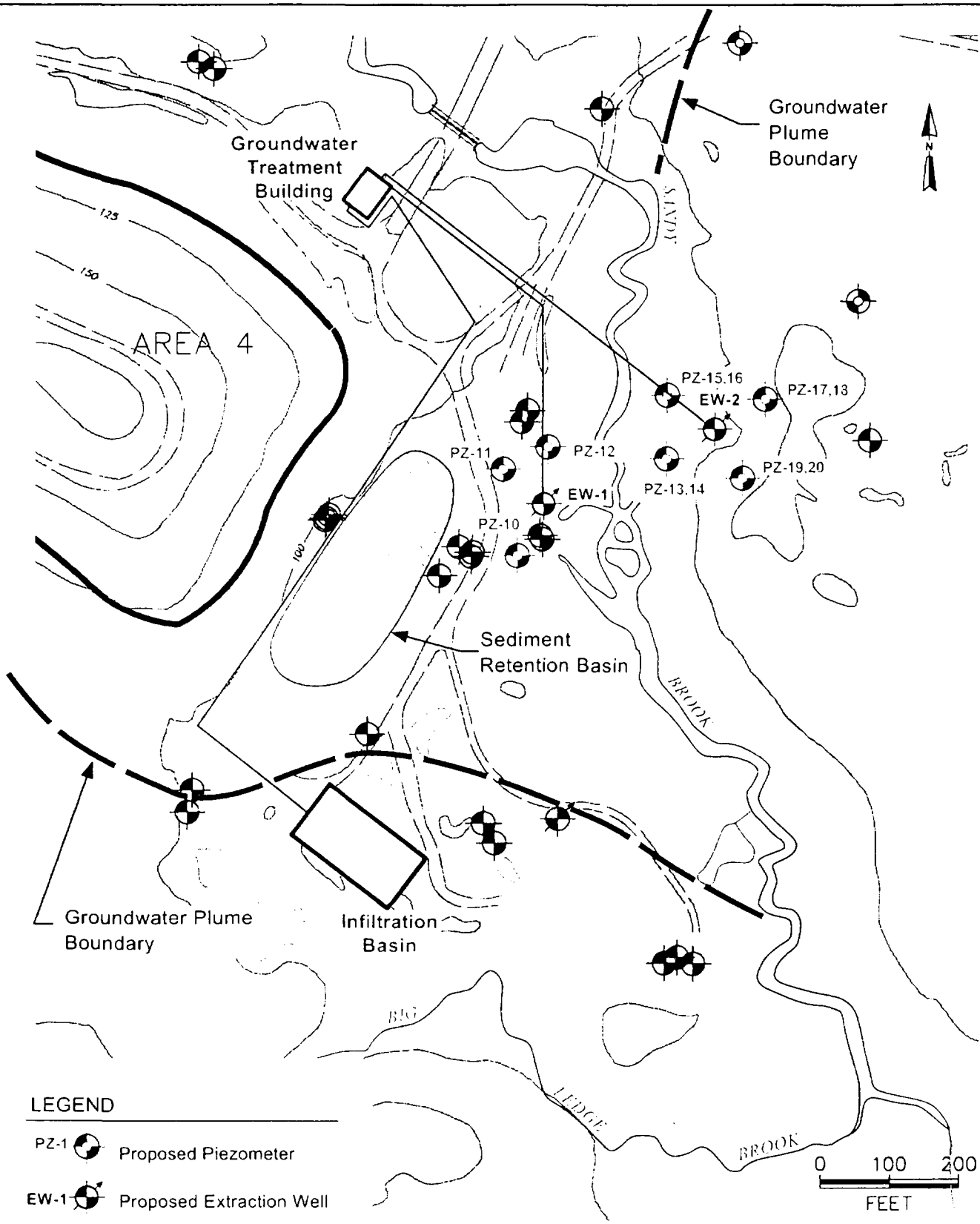


Figure 7-12
Alternative SML-5:
Conceptual Site Layout
Saco Municipal Landfill
Saco, Maine

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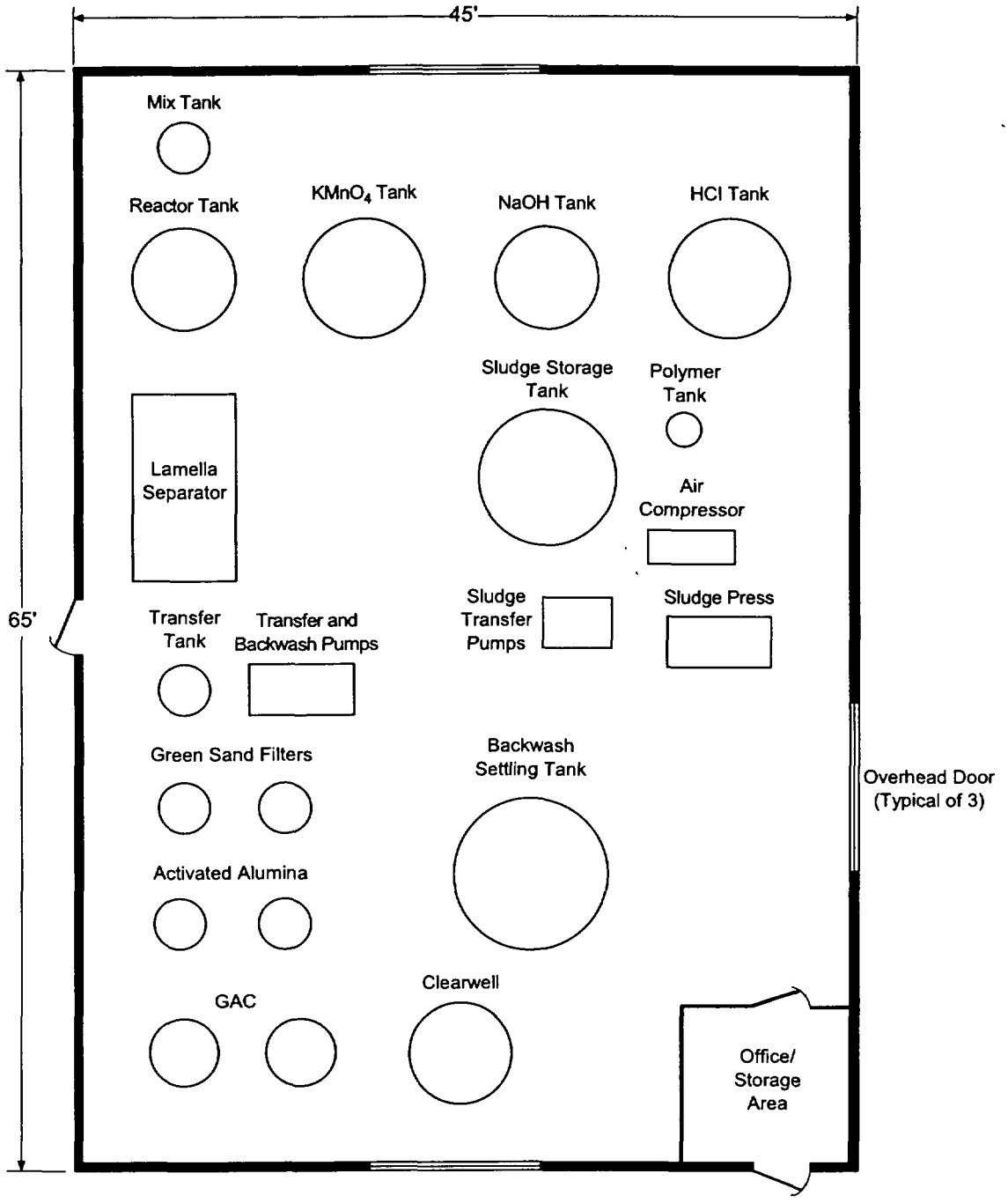


Figure 7-13
Alternative SML-5:
Preliminary Layout of Groundwater Treatment Building
Feasibility Study Report
Saco Municipal Landfill
Saco, Maine

Scale in Feet
0 10 20

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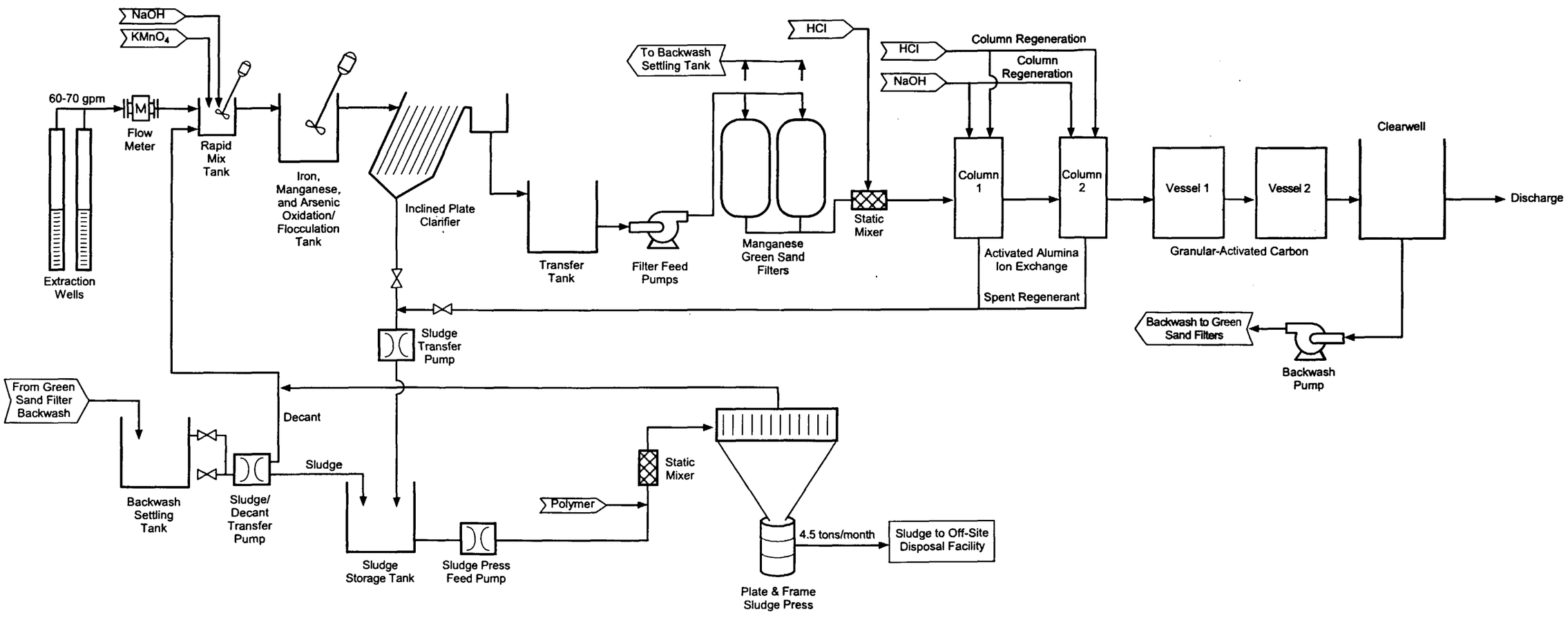


Figure 7-14
Alternative SML-5:
Treatment Process Flow Diagram
Feasibility Study Report
Saco Municipal Landfill
Saco, Maine

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The assumed influent concentrations used to size the treatment system were determined by estimating the average concentrations of contaminants and other groundwater parameters measured at monitoring wells MW-95-4SA, MW-95-4SB, MW-97-14S-1 and MW-97-14S-2. These wells are in the vicinity of the proposed extraction wells. Data from the March 1998 RI and most recent groundwater sampling rounds (June 1998, December 1998, and June 1999) were used to calculate influent concentrations to the treatment system. These influent concentrations are summarized in Table 7-11.

The extraction system would consist of two groundwater extraction wells and associated piping. Each well would have its own submersible pump controlled by a variable frequency drive linked to a flow meter to maintain constant flow during operation of the treatment system.

Groundwater from the two extraction wells would be conveyed through separate 2-inch pipes to the treatment building, where both pipes would empty into a single, well-mixed tank, to which potassium permanganate ($KMnO_4$) and caustic (NaOH) would be added. The purpose of permanganate is to convert reduced iron, manganese, and arsenic into their less soluble oxidized forms so that they can be removed in subsequent settling and ion exchange phases of treatment. The function of caustic addition is to adjust the pH to a value of approximately 8.0 to optimize metals precipitation.

After the groundwater has been mixed with permanganate and caustic, it flows by gravity to a well-mixed oxidation tank, where the permanganate is allowed to react for approximately 25 minutes, in order to fully oxidize the metals in solution. From the oxidation tank, groundwater flows to an inclined plate separator, where an estimated 70 to 90 percent of the precipitated iron and manganese will be removed by settling, and some of the arsenic is expected to be removed as well, as a co-precipitate. Sludge from the separator would be pumped to a sludge holding tank as necessary.

The inclined plate separator flows to a transfer tank, where the system shifts from gravity to pressure operation. Two pumps linked to level sensors in the transfer tank would pump groundwater continuously to two manganese greensand filters arranged in parallel. Manganese greensand filters are special sand filters that are extremely efficient at removing iron and manganese, and may remove a substantial amount of arsenic as well. The effluent from the greensand filters is expected to contain less than 0.3 mg/L of iron

**TABLE 7-11**
**ALTERNATIVE SML-5**
**ESTIMATED INFLUENT CONTAMINANT CONCENTRATIONS**
**AND PRELIMINARY REMEDIATION GOALS**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| PARAMETER | UNITS | ESTIMATED INFLUENT CONCENTRATION | PRG |
|---|---|---|---|
| Arsenic | µg/L | 140 | 50 |
| Manganese | µg/L | 7700 | 840 |
| Iron | mg/L | 45 | NA |
| Benzene | µg/L | 3 (1) | 5 |
| pH | standard unit | 6.7 | NA |
| Alkalinity | ppm as $CaCO_3$ | 400 | NA |

NOTES:

(1) Although the average benzene concentation was calculated as 3 µg/L, benzene is a contaminant of concern because a concentration of 13 µg/L was detected at MW-95-4R.

NA = Not Applicable
PRG = Preliminary Remediation Goal

and manganese, well below the 0.84 mg/L PRG for manganese. Greensand filtration is commonly used in the water treatment industry to reduce iron and manganese concentrations below the secondary drinking water standards of 0.3 mg/L iron, and 0.05 mg/L manganese.

Greensand is a natural zeolite that requires potassium permanganate to function effectively, and would be continuously "recharged" by the addition of permanganate at the head end of the treatment system.

Two filters would be provided in parallel. Under normal operating conditions, flow would alternate from one filter to the other to accommodate periodic filter backwashing. Since there will not be a potable water supply to the plant, the filters will be backwashed with final effluent pumped from the clearwell. Backwash waters would discharge to a backwash holding tank, where settled solids would be discharged to the sludge holding tank, and supernatant liquids would be returned to the head of the treatment plant. The purpose of the backwash holding tank is to minimize the volume of wet sludge that needs to be processed.

Discharge from the greensand filters would flow under pressure to a small, well-mixed tank where hydrochloric acid would be added to the groundwater to adjust the pH back down to a value of 6.0. Next, groundwater flows through a pair of ion exchange columns containing activated alumina. Activated alumina media is very selective for arsenic, but is only effective in a narrow pH range around 6.0. Discharge from the activated alumina is expected to contain less than 10 μg/L of arsenic, based on case studies reported in the literature. The columns would operate in series, and would be piped and valved such that either column could be first in series, and either vessel could be isolated for regeneration, as necessary. Discharge from both columns would be periodically monitored monthly for arsenic, and the lead column in series would be isolated and regenerated by treatment with hydrochloric acid and sodium hydroxide when breakthrough occurred. The freshly regenerated column would then be returned to service as the second column in series. Regenerate liquids containing precipitated arsenic would be discharged to the backwash holding tank, where settled solids would be pumped to the sludge storage tank, and supernatant liquids returned to the head of the plant.

Finally, two granular activated carbon (GAC) vessels would be placed downstream of the ion exchange columns. GAC would reduce the concentration of benzene in the groundwater to less than 5 μg/L. Like the ion exchange columns, the GAC vessels would operate in series, and would be piped and valved such that either vessel could be first in series, and either vessel could be isolated for regeneration, as

necessary. Discharge from both vessels would be monitored monthly for VOCs, and the lead column in series would be isolated, emptied, and refilled with virgin carbon when breakthrough occurred. The freshly regenerated column would then be returned to service as the second column in series. Although preliminary calculations of benzene concentration in the extracted groundwater indicate that it would be less than 5 μg/L initially, the GAC vessels are included in this alternative as a necessary contingency in the event the benzene concentrations were higher than anticipated.

Discharge from the GAC vessels would flow to a clearwell, which would provide a supply of clean process water for filter backwashing and similar operations. From the clearwell, groundwater would flow by gravity through a 3-inch discharge pipe to a newly constructed infiltration basin located outside of the plume boundary.

Solids produced during the inorganics treatment would be concentrated and dewatered in a plate and frame filter press prior to disposal. Based on the existing concentrations of arsenic in groundwater, the resulting sludge may be hazardous, and would be disposed off-site at a licensed hazardous waste facility.

Performance of the groundwater extraction, treatment and discharge system would be monitored periodically. It was assumed that effluent samples would be collected on a monthly basis to determine that applicable discharge criteria are being achieved. In addition, groundwater samples from each extraction well would be collected quarterly to evaluate mass removal rates for arsenic, manganese, benzene, and DOC, as well as changes in water quality parameters.

**Environmental Monitoring.** The long-term environmental monitoring program proposed for Alternative SML-5 would be the same as for Alternative SML-3. The objective of environmental monitoring would be to ensure protection of human health and the environment by monitoring changes in chemical concentrations in groundwater, surface water, and sediment over time and to determine the effectiveness of this alternative to reduce the concentrations of arsenic, manganese, and benzene to their respective PRGs within the aquifer.

Environmental monitoring as well as five and ten-year site reviews will be conducted according to guidelines discussed in Section 7.2.2.1.

#### 7.2.4.2 Alternative Evaluation

Table 7-12 presents the detailed analysis of Alternative SML-5 against the seven NCP evaluation criteria.

A cost estimate was prepared for Alternative SML-5 to help in selection of a remedial alternative. In general, cost estimates contain the following principal elements:

- capital costs; and
- operation and maintenance costs.

Capital costs consist of direct and indirect costs that typically include those expenditures initially incurred to develop, construct, and implement the remedial alternative. However, because the No Further Action Alternative consists of no active remedial activities, no capital costs (either direct or indirect) would be incurred.

Operation and maintenance (O&M) costs typically include post-construction costs necessary to ensure the continued effectiveness of the remedial action. The only costs included in Alternative SML-1 are those costs required to conduct five-year site reviews over a period of 30 years. Because ongoing environmental monitoring is not included in this alternative, one round of groundwater and surface water/sediment sampling will be conducted immediately prior to each review, and the cost to conduct this round of environmental sampling and analysis is included in the five-year review costs. The cost estimate for Alternative SML-3 includes long-term environmental monitoring and five-year site reviews.

#### 7.2.4.3 Cost

Two cost estimates were prepared for Alternative SML-5. The first estimate (Table 7-13) was prepared assuming that groundwater would be extracted and discharged untreated to the Saco WWTP. The second estimate (Table 7-14) was prepared assuming that groundwater would be extracted, treated, and discharged on-site.

**TABLE 7-12**
**DETAILED ANALYSIS: ALTERNATIVE SML-5**
**GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-5: GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT |
|---|---|
| **OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT** | |
| Human Health Protection | The results of the baseline risk assessment indicate no potential risks to human health, with the exception of potential future risks if groundwater were to be used for drinking water purposes. This scenario is, however, extremely unlikely as the area is currently supplied by public water and institutional controls restricting land and groundwater use have been implemented as a part of the NTCRA.<br><br>USGS research suggests that arsenic concentrations in groundwater will stabilize at or below 50 µg/L over a 50 to 100 year period via natural attenuation processes. Reduced arsenic concentrations in groundwater will result in reduced arsenic concentrations in surface water downgradient from Landfill Areas 3 and 4. Groundwater extraction is not expected to significantly shorten the time to induce chemical changes over natural conditions. |
| Ecological Protection | Although the results of the baseline risk assessment indicate no current risks to the environment, this alternative would provide an increased level of protection over other alternatives, because it would capture the plume and prevent contaminated groundwater from entering Sandy Brook. |
| **COMPLIANCE WITH ARARS** | |
| Chemical-Specific | Under baseline conditions, concentrations of arsenic and benzene in groundwater exceed chemical-specific ARARs (i.e., MCLs). Changes in groundwater geochemistry are necessary for arsenic concentrations to decrease; USGS research suggests that these changes would occur over a 50 to 100 year time frame. Concentrations of arsenic and manganese in surface water are lower than concentrations in groundwater. At present, concentrations of arsenic in surface water are below the chemical-specific ARAR. Concentrations of manganese exceed the chemical-specific ARAR in Sandy Brook at present; however, the highest manganese concentration is at the background location. The time frame of the modeled reduction of arsenic and manganese concentrations in groundwater would not be reduced by groundwater extraction. Pumping of the plume would reduce groundwater plume inflow into Sandy Brook and result in lower arsenic concentrations in Sandy Brook even prior to complete capture of the plume.<br><br>Required approvals would be obtained prior to on-site discharge of treated groundwater or off-site discharge of untreated groundwater. |

## TABLE 7-12
## DETAILED ANALYSIS: ALTERNATIVE SML-5
## GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT

## FEASIBILITY STUDY REPORT
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| EVALUATION CRITERIA | ALTERNATIVE SML-5: GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT |
|---|---|
| Location-Specific | Location-specific ARARs identified for Alternative SML-5 are presented in Appendix E. This alternative would be designed to comply with pertinent location-specific ARARs. |
| Action-Specific | Action-specific ARARs identified for Alternative SML-5 are presented in Appendix E. This alternative would be designed to comply with pertinent action-specific ARARs. |
| **LONG-TERM EFFECTIVENESS AND PERFORMANCE** | |
| Magnitude of Residual Risk | An extraction rate of 60 gpm is proposed for Alternative SML-5 to manage the migration of the plume without reducing groundwater discharge to, and adversely impacting surface water flow in Sandy Brook. Due to the geology and hydrogeology of the site, groundwater extraction at this rate would not enhance the movement of groundwater through the aquifer, and therefore would not increase the concentration of DO in the aquifer.<br><br>Because, Alternative SML-5 would not increase the concentration of DO in the aquifer anymore quickly than would occur naturally, this alternative is not expected to reduce concentrations of contaminants in groundwater beneath or downgradient of the landfill, and is therefore, not expected to reduce the magnitude of residual risk.<br><br>As stated previously, the residual risks associated with the remedial objectives are within the USEPA target range and are considered to be acceptable for this site. Institutional controls, implemented as a part of the NTCRA restrict future land and groundwater use at the site. Therefore, future potential exposure to contaminants in groundwater would be prevented, effectively eliminating this exposure pathway. In addition, five-year site reviews will be conducted to ensure the continued protection of human health and the environment. |
| Adequacy and Reliability of Controls | The proposed groundwater extraction system would adequately manage the migration of the plume and minimize the volume of contaminated groundwater entering Sandy Brook.<br><br>Groundwater extraction and discharge is not expected to adequately or reliably reduce concentrations of arsenic, manganese and benzene in groundwater beneath or downgradient of the landfill. A long-term monitoring program would, however, be implemented to monitor groundwater concentrations throughout the plume to evaluate the effectiveness of this alternative.<br><br>With the exception of pumps, which may need to be replaced frequently, the estimated service life of the treatment system components is expected to be at least 30 years. |

**TABLE 7-12**
**DETAILED ANALYSIS: ALTERNATIVE SML-5**
**GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-5: GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT |
|---|---|
| | Placement of the cover system over Landfill Areas 3 and 4 is providing source control by controlling the generation of DOC-rich leachate from the landfill. Over time, the reduction of DOC together with more oxygen rich waters flushing the aquifer will change the redox potential, such that dissolved iron, manganese and arsenic will be precipitated to their less soluble forms. Institutional controls implemented as a part of the NTCRA will adequately control the future land and groundwater use at the site. |
| **REDUCTION OF TOXICITY, MOBILITY, AND VOLUME THROUGH TREATMENT** | |
| Treatment Process Used and Materials Treated | Extracted groundwater containing concentrations of arsenic, manganese, and benzene exceeding PRGs would be discharged to the Saco WWTP for treatment, or would be treated on site via precipitation, filtration, ion exchange and activated carbon to meet PRGs. Groundwater treated on site would then be discharged to a newly constructed infiltration basin. |
| Amount Destroyed or Treated | Based on average dissolved influent concentrations estimated to design the groundwater treatment system, approximately 3.5 lbs/month of arsenic, 1135 lbs/month of iron and 697 lbs/month of manganese would be removed. |
| Degree of Expected Reductions of Toxicity, Mobility, or Volume Through Treatment | The proposed groundwater treatment system would reduce the mobility of dissolved arsenic and manganese and would increase the volume of contaminants through the generation of sludge.<br><br>The groundwater extraction system would manage the migration of the plume, and would minimize the loading of arsenic to the surface water and sediment in Sandy Brook.<br><br>The mobility of arsenic in the groundwater beneath and downgradient of the landfill would be reduced by natural attenuation processes. It is expected that DO concentrations will increase over time in the aquifer as DOC concentrations decrease and as oxygen-rich groundwater continues to flow beneath the landfill. The oxidizing conditions will decrease the reductive dissolution of arsenic from overburden and bedrock, and will cause dissolved As(III) to precipitate to As(V), reducing its mobility. |

**TABLE 7-12**
**DETAILED ANALYSIS: ALTERNATIVE SML-5**
**GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-5: GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT |
|---|---|
| Degree to Which Treatment is Irreversible | Groundwater extraction with off-site discharge or on-site treatment, would permanently remove dissolved arsenic and manganese from the plume, but it would not prevent the dissolution of arsenic that will continue to occur as long as the aquifer is in a reduced state.<br><br>However, regardless of the extraction and or treatment systems installed, natural attenuation processes will occur over time creating a more oxidized aquifer that will stabilize the contaminants. |
| Type and Quantity of Residuals Remaining After Treatment | Approximately four tons of sludge (including precipitated arsenic, iron, manganese and other inorganics) would be generated per month from the groundwater treatment process. Based on the elevated concentrations of arsenic and manganese in the groundwater, the resulting sludge may be hazardous, requiring stabilization and disposal at a hazardous waste facility.<br><br>Additional treatment residuals (e.g., activated carbon) that may be generated that would require off-site disposal at a permitted facility. |
| **SHORT-TERM EFFECTIVENESS** | |
| Protection of Community During Remedial Action | Implementation of the off-site discharge option would impact the local community with the installation of new pipes along Foss Road and Route 112, and pump station upgrades. Residents are not expected to be exposed to any site related contaminants during construction of implementation of this alternative.<br><br>Construction and operation of an on-site groundwater treatment facility and infiltration basin would not have significant short-term impacts on the local community. The treatment facility and infiltration basin would be constructed on site, with the nearest local resident located approximately 0.4 miles from the proposed treatment system location. Residents are not expected to be exposed to any site-related hazards. |
| Protection of Workers During Remedial Action | Workers would be required to be trained in health and safety procedures for work at hazardous waste sites. Appropriate site-specific health and safety plan(s) would also be followed and appropriate personal protective equipment would be used to minimize risks to workers during well installation, construction activities, sampling, and treatment plant operation. Hazards associated with heavy equipment during construction would be mitigated through safe work practices. |

**TABLE 7-12**
**DETAILED ANALYSIS: ALTERNATIVE SML-5**
**GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-5: GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT |
|---|---|
| Environmental Impacts | Implementation of this alternative may include installation of wells and piping, excavation of an infiltration basin and construction of a treatment facility. These activities have the potential to impact the environment, and all remedial activities would be conducted in accordance with pertinent ARARs.<br><br>The proposed groundwater extraction rate of 60 gpm is not expected to reduce significantly the groundwater recharge to Sandy Brook, and therefore, would not impact surface water flow. |
| Time Until Remedial Action Objectives Are Achieved | Based on USGS modeling results, natural attenuation processes are estimated to reduce concentrations of arsenic in groundwater to the PRG within 50 to 100 years. Groundwater modeling shows that extracting groundwater at a rate of 60 gpm will not enhance the movement of groundwater through the plume, and would therefore, not increase the concentration of DO in the aquifer anymore quickly than natural attenuation processes. Therefore, this alternative would not increase the rate at which the concentrations of arsenic and manganese in groundwater are reduced. The estimated time to achieve PRGs is the same as the time frame estimated for natural attenuation, approximately 50 to 100 years.<br><br>At present, arsenic concentrations in Sandy Brook is below PRG. Background concentrations are below the PRG of manganese in surface water are above the PRG. For arsenic, pumping of the plume will reduce groundwater plume inflow into Sandy Brook and result in lower concentrations in Sand Brook within 10 to 20 years. Reduced concentrations of arsenic and manganese in groundwater will further reduce concentrations in surface water; however, manganese concentrations may never reach the PRG. |
| **IMPLEMENTABILITY** | |
| Ability to Construct and Operate the Technology | The installation of wells, underground piping, and an infiltration basin involves common construction techniques and would be easy to implement. Several vendors are available to design, install, and operate the treatment system. Prior to implementation, treatability tests to determine optimum operating parameters and to evaluate the effectiveness of the system at reducing contaminant concentrations to meet applicable discharge criteria would be performed.<br><br>The estimated time to design and construct the extraction, treatment, and on-site discharge system is estimated to be approximately ten months. The time to design and construct the off-site piping and upgrade pump stations would also be approximately ten months. |

**TABLE 7-12**
**DETAILED ANALYSIS: ALTERNATIVE SML-5**
**GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-5: GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT |
|---|---|
| Reliability of Technology | Extraction wells are a reliable means of collecting groundwater; however, high concentrations of iron and other metals in the groundwater downgradient of Landfill Areas 3 and 4 would cause fouling of extraction wells. Well screens would require annual cleaning with an anti-fouling compound (i.e., hydrochloric acid, sulfamanic acid or hydroxyacetic acid). Based on experience at a similar site, it is assumed that pumps would have to be cleaned every 6 to 10 weeks and would potentially need to be replaced every 3 years.<br><br>Discharge of treated groundwater to an on-site infiltration basin or to the Saco WWTP are considered reliable means of disposal.<br><br>The technologies proposed for groundwater treatment (oxidation, precipitation, settling, filtration, ion exchange and GAC) are proven technologies for treatment of the contaminants of concern. |
| Ease of Undertaking Additional Remedial Actions, If Necessary | This alternative would not limit or interfere with the ability to implement or perform future remediation actions. |
| Ability to Monitor Effectiveness of Remedy | Treatment system effluent would be monitored on a routine basis to evaluate the effectiveness of the treatment system and ensure that discharge criteria are achieved. Monitoring/analysis of samples collected from the treatment system would be easily implemented using an off-site laboratory.<br><br>The long-term environmental monitoring program would be easily implemented and would monitor the effectiveness of this alternative and contaminant migration throughout the plume. |
| Ability to Obtain Approvals and Coordinate with Other Agencies | Administratively, groundwater extraction and/or treatment and discharge would be easy to implement.<br><br>Substantive requirements of permits to DOT, local utilities and the City of would be met.<br><br>A detailed long-term groundwater monitoring program and the five year site review would be subject to regulatory review and approval. |

**TABLE 7-12**
**DETAILED ANALYSIS: ALTERNATIVE SML-5**
**GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-5: GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT |
|---|---|
| Availability of Off-site Treatment, Storage, and Disposal Services and Capacity. | Pump stations may not have sufficient capacity to receive an additional 60 to 70 gpm of groundwater from the site. Upgrades to these pump station would be required for this option to be viable.<br><br>Implementation of this alternative would require off-site disposal of waste solids generated from the treatment system and may be potentially hazardous. Both non-hazardous and hazardous waste services and off-site disposal facilities are currently available. |
| Availability of Necessary Equipment and Specialists | Equipment, materials, and services for construction of the extraction, treatment, and discharge systems would be readily available. |
| Availability of Technology | Several qualified vendors would be available to design, construct, and operate the groundwater extraction and treatment system |
| **COSTS** | |
| **GROUNDWATER EXTRACTION WITH OFF-SITE DISCHARGE TO SACO WWTP** | |
| Capital Cost | $ 1,107,000 |
| Net Present Worth Cost of Operations and Maintenance (includes Environmental Monitoring) | $ 1,154,000 |
| Net Present Worth Cost of Five-Year Site Reviews | $ 129,000 |
| Total Net Present Cost Worth | $ 2,390,000 |

**TABLE 7-12**
**DETAILED ANALYSIS: ALTERNATIVE SML-5**
**GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| EVALUATION CRITERIA | ALTERNATIVE SML-5: GROUNDWATER EXTRACTION AND DISCHARGE WITH OR WITHOUT TREATMENT |
|---|---|
| **GROUNDWATER EXTRACTION WITH ON-SITE TREATMENT AND DISCHARGE** | |
| Capital Cost | $ 2,062,000 |
| Net Present Worth Cost of Operations and Maintenance (includes Environmental Monitoring) | $ 3,822,000 |
| Net Present Worth Cost of Five-Year Site Reviews | $ 129,000 |
| Total Net Present Cost Worth | $ 6,013,000 |

**TABLE 7-13**
**COST ESTIMATE: ALTERNATIVE SML-5A**
**(DISCHARGE TO SACO WWTP)**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| | |
|---|---|
| **DIRECT COSTS** | |
| Groundwater Extraction System | $92,000 |
| Discharge to Saco WWTP (1) | $453,000 |
| Installation of Groundwater Extraction/ Discharge System | $164,000 |
| SUBTOTAL | $709,000 |
| 20% Contingency on Direct Costs | $142,000 |
| TOTAL DIRECT COSTS | $851,000 |
| **INDIRECT COSTS** | |
| Health and Safety @ 5% | $43,000 |
| Legal, Administrative and Permitting @ 5% | $43,000 |
| Engineering Design @ 10% | $85,000 |
| Services during Construction @10 % | $85,000 |
| TOTAL INDIRECT COSTS | $256,000 |
| **TOTAL CAPITAL COSTS (DIRECT AND INDIRECT)** | **$1,107,000** |
| **ANNUAL OPERATION AND MAINTENANCE COSTS** | |
| Monitoring 2 Extraction Wells (Quarterly) | $5,000 |
| Monitoring Groundwater/Surface Water and Sediment (Annually) (2) | $40,000 |
| Maintenance (Annual) | $27,000 |
| SUBTOTAL | $72,000 |
| Engineering @ 10% | $7,000 |
| 20% Contingency on Annual O&M | $14,000 |
| TOTAL O&M COSTS | $93,000 |
| **TOTAL PRESENT WORTH ANNUAL O&M COSTS (7%, 30 YEARS)** | **$509,000** |
| Monitoring Groundwater/Surface Water and Sediment (annually) (includes 20% Contingency) | $125,000 |
| **TOTAL PRESENT WORTH ANNUAL ENVIRONMENTAL MONITORING COSTS (7%, 30 YEARS)** | **$1,551,000** |
| Five Year Site Reviews (includes 20% Contingency) | $60,000 |
| **TOTAL PRESENT WORTH OF FIVE YEAR SITE REVIEWS (7%, 30 YEARS)** | **$129,000** |
| **TOTAL PRESENT WORTH (30 YEARS) - ALTERNATIVE SML-5A** | **$3,296,000** |

(1) Costs for upgrades to pump station on Route 112 not included.

**TABLE 7-14**
**COST ESTIMATE: ALTERNATIVE SML-5B**
**(TREATMENT/ON-SITE DISCHARGE)**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| DIRECT COSTS | |
|---|---|
| Groundwater Extraction System | $92,000 |
| Treatability Study for Groundwater Treatment System | $100,000 |
| Groundwater Treatment System | $443,000 |
| Treated Groundwater Discharge System | $11,000 |
| Installation of Groundwater Extraction /Treatment/ Discharge Systems | $676,000 |
| SUBTOTAL | $1,322,000 |
| 20% Contingency on Direct Costs | $264,000 |
| TOTAL DIRECT COSTS | $1,586,000 |

| INDIRECT COSTS | |
|---|---|
| Health and Safety @ 5% | $79,000 |
| Legal, Administrative and Permitting @ 5% | $79,000 |
| Engineering Design @ 10% | $159,000 |
| Services during Construction @10 % | $159,000 |
| TOTAL INDIRECT COSTS | $476,000 |
| **TOTAL CAPITAL COSTS (DIRECT AND INDIRECT)** | **$2,062,000** |

| ANNUAL OPERATION AND MAINTENANCE COSTS | |
|---|---|
| Treatment System (Labor, Power, Chemicals, Maintenance, etc...) | $166,000 |
| Monitoring 2 Extraction Wells (Quarterly) | $5,000 |
| Treatment System Monitoring (Monthly) | $12,000 |
| Treatment Sludge Disposal | $14,000 |
| SUBTOTAL | $197,000 |
| Engineering @ 10% | $20,000 |
| 20% Contingency on Annual O&M | $39,000 |
| TOTAL O&M COSTS | $256,000 |
| **TOTAL PRESENT WORTH ANNUAL O&M COSTS (7%, 30 YEARS)** | **$3,177,000** |
| Monitoring Groundwater/Surface Water and Sediment (annually) (includes 20% Contingency) | $125,000 |
| **TOTAL PRESENT WORTH ANNUAL ENVIRONMENTAL MONITORING COSTS (7%, 30 YEARS)** | **$1,551,000** |
| Five Year Site Reviews (includes 20% Contingency) | $60,000 |
| **TOTAL PRESENT WORTH OF FIVE YEAR SITE REVIEWS (7%, 30 YEARS)** | **$129,000** |
| **TOTAL PRESENT WORTH (30 YEARS) - ALTERNATIVE SML-5B** | **$6,919,000** |

**Off-Site Discharge:** The estimated total present worth (i.e., 7 percent for 30 years) of Alternative SML-5 with off-site discharge is $3,296,000. The estimated capital costs (i.e., construction, engineering, and administrative) are $1,107,000. The present worth of operation and maintenance costs was estimated at $509,000. The present worth of environmental monitoring was estimated at $1,551,000, and the present worth of five-year site reviews was estimated at $129,000. Table 7-14 summarizes the costs estimated for Alternative SML-5 with off-site discharge at the Saco WWTP. Cost backup information for the components summarized in Table 7-14 is presented in Appendix D.

To develop these costs, the following assumptions were made:

- Environmental monitoring (surface water, sediment, and groundwater sampling and analysis) will occur annually for 30 years;
- Extraction and discharge systems will operate continuously for 30 years at a 60 gpm extraction rate;
- An extraction system consisting of two extraction wells and associated piping will be installed for the collection of groundwater associated with Landfill Areas 3 and 4;
- Eleven piezometers will be installed and water levels measured semi-annually to evaluate hydraulic capture of the Plume;
- Groundwater will be pumped to an on-site pump station, and transported via a newly constructed 2½-inch force main to the North Street sewer, and then to an 8 to 10-inch gravity line transporting groundwater to the pump station on Route 112.
- Site data will be reviewed every five years for a period of 30 years.

**On-Site Treatment and Discharge:** The estimated total present worth (i.e., 7 percent for 30 years) of Alternative SML-5 with on-site treatment and discharge is $ 6,919,000. The estimated capital costs (i.e., construction, engineering, and administrative) are $ 2,062,000. The present worth of operation and maintenance costs was estimated at $ 3,177,000. The present worth of environmental monitoring was estimated at $1,551,000, and the present worth of five-year site reviews was estimated at $ 129,000. Table 7-14 summarizes the costs estimated for Alternative SML-5 with on-site treatment and discharge. Cost backup information for the components summarized in Table 7-14 is presented in Appendix D.

This second cost estimate includes many of the same assumptions as the first estimate, except that instead of discharging groundwater off-site, it would be treated on-site via precipitation, filtration, ion

exchange and activated carbon, and then discharged on-site to a newly excavated infiltration basin. An additional assumption is that treated effluent will be monitored monthly for arsenic, iron, manganese, and DOC.

# 8.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

The comparative analysis presented in this section compares the remedial action alternatives evaluated in Section 7.0 relative to the evaluation criteria used during the detailed analysis of alternatives. The purpose of the comparative analysis is to identify the advantages and disadvantages of the alternatives relative to one another and to aid in the selection of a remedial alternative for groundwater associated with Landfill Areas 3 and 4 at the SML. Subsection 8.1 presents the approach of the comparative analysis based on the NCP, and Subsection 8.2 presents the comparison of the alternatives.

## 8.1 APPROACH TO THE COMPARATIVE ANALYSIS

Specific CERCLA requirements are considered when comparing alternatives for selection of a preferred site remedy. To the extent practicable, the selected alternative should:

- be protective of human health and the environment;
- comply with ARARs (or provide grounds for invoking a waiver);
- use permanent solutions and alternative treatment technologies to the maximum extent practicable;
- satisfy the preference for treatment that reduces toxicity, mobility, or volume as a principal element; if this preference is not satisfied, the ROD must explain why; and
- be cost-effective.

Per the approach outlined in the NCP for performing the comparative analysis of site alternatives, the remedy selected for the Site must reflect the scope and purpose of the actions being undertaken and how these actions relate to other remedial actions and the long-term response at the Site. The identification of the preferred alternative and the final remedy selection are based on an evaluation of the major trade-offs among the alternatives in terms of the nine evaluation criteria. USEPA has categorized the evaluation criteria into three groups: threshold, balancing, and modifying. A discussion of each criteria group is provided below.

### 8.1.1 Threshold Criteria

Because the selected remedy must be protective of human health and the environment and comply with ARARs, USEPA has designated (1) overall protection of human health and the environment, and (2) compliance with ARARs, as the two threshold criteria. An alternative must meet both criteria to be eligible for selection as the Site remedy.

### 8.1.2 Primary Balancing Criteria

The five primary balancing criteria are:

- long-term effectiveness and permanence;
- reduction of toxicity, mobility, or volume through treatment;
- short-term effectiveness;
- implementability; and
- cost.

This balancing provides a preliminary assessment of the maximum extent to which permanent solutions and treatment can be used practicably in a cost-effective manner.

The alternative that is protective of human health and the environment, is ARAR-compliant, and affords the best combination of attributes is identified as the preferred alternative. The balancing criteria emphasize long-term effectiveness and reduction of toxicity, mobility, or volume through treatment.

### 8.1.3 Modifying Criteria

State and community acceptance are factored into a final balancing that determines the remedy and the extent of permanent solutions and treatment practicable for the Site. As stated in Subsection 7.1, State and community acceptance will be addressed when State and public comments on this FS report and the subsequent Proposed Plan have been received. Both the State and public had an opportunity to comment on the source control measures implemented at the SML under the NTCRA.

## 8.2 COMPARATIVE ANALYSIS OF ALTERNATIVES

Table 8-1 presents the comparative analysis for the three remedial alternatives evaluated in Subsection 7.2 for groundwater associated with Landfill Areas 3 and 4 at the SML. The comparative analysis highlights the results of the detailed analysis.

### 8.2.1 Comparison of Threshold Criteria

The alternatives were first compared relative to the two threshold criteria, overall protection of human health and the environment, and compliance with ARARs.

Results of the baseline risk assessment indicate that there is currently no risk to human health and no significant risk to the environment from contaminants in groundwater associated with Landfill Areas 3 and 4. Source control measures and institutional controls (restricting future land and groundwater use) have been implemented as part of the NTCRA at the site and effectively minimize future potential risks to human health and the environment. No additional institutional controls are anticipated at this time. The need for additional institutional controls to protect public health or the environment would be evaluated during 5-year reviews. As SM-1 does not include 5-year reviews, this alternative would be less protective than SML-3, SML-4, and SML-5, which include 5-year reviews. SML-1 also does not identify the groundwater as being unacceptable for consumption and does not include cleanup levels as a benchmark for the evaluation of the success of the cleanup. SML-3, SML-4, and SML-5 are based upon the unacceptable future risk resulting from consumption of groundwater and include cleanup levels to measure success. However, because Alternatives SML-4 and SML-5 would provide containment of a majority of the plume, this may reduce the contaminant loading to Sandy Brook more quickly than Alternatives SML-1 or SML-3, providing some level of risk reduction to aquatic receptors in Sandy Brook, although there is at present no significant risk.

## TABLE 8-1
## COMPARATIVE ANALYSIS OF ALTERNATIVES

## FEASIBILITY STUDY REPORT
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| ALTERNATIVE | THRESHOLD CRITERIA | | BALANCING CRITERIA | | | | |
|---|---|---|---|---|---|---|---|
| | OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT | COMPLIANCE WITH ARARs | LONG-TERM EFFECTIVENESS AND PERMANENCE | REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT | SHORT-TERM EFFECTIVENESS | IMPLEMENTABILITY | COST |
| **Alternative SML-1** No Further Action | Site conditions currently pose no risks to human health and moderate risks to the environment. Source control measures and institutional controls (restricting future groundwater use) implemented as a part of the NTCRA effectively minimize future risks to human health and the environment. | Would, over time, achieve chemical-specific ARARs. Location- and action-specific ARARs would not apply because no active remedial activities would be conducted. | Over time, natural attenuation would provide effective and permanent reduction of concentrations of dissolved arsenic and manganese.<br><br>Source control measures and institutional controls (restricting future groundwater use) implemented as a part of the NTCRA would minimize future risks to human health and the environment. | None through active treatment. | No remedial actions would be implemented under this alternative; therefore, there would be no adverse effects on the local community or environment.<br><br>Between approximately 50 to 100 years to achieve remedial action objectives for groundwater. | No remedial activities would require implementation under this alternative. | Least costly of the alternatives.<br><br>NPW = $0 |

## TABLE 8-1
## COMPARATIVE ANALYSIS OF ALTERNATIVES

## FEASIBILITY STUDY REPORT
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| ALTERNATIVE | THRESHOLD CRITERIA | | BALANCING CRITERIA | | | | |
|---|---|---|---|---|---|---|---|
| | OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT | COMPLIANCE WITH ARARs | LONG-TERM EFFECTIVENESS AND PERMANENCE | REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT | SHORT-TERM EFFECTIVENESS | IMPLEMENTABILITY | COST |
| **Alternative SML-3** Monitored Natural Attenuation | Site conditions pose no current risk to human health and moderate impacts to the environment. Over time, natural attenuation processes would reduce concentrations of dissolved arsenic and manganese in groundwater downgradient of Landfill Area 3 and 4.<br><br>Source control measures and institutional controls (restricting future groundwater use) implemented as a part of the NTCRA effectively minimize future risks to human health and the environment.<br><br>Environmental monitoring would ensure continued protection of human health and the environment. | Would, over time, achieve chemical-specific ARARs. Location- and action-specific ARARs would not apply because no active remedial activities would be conducted.<br><br>The only actions associated with this alternative include annual environmental sampling. | Over time, natural attenuation would provide effective and permanent reduction of concentrations of dissolved arsenic and manganese to PRGs.<br><br>Source control measures and institutional controls (restricting future groundwater use) implemented as a part of the NTCRA would minimize future risks to human health and the environment. | None through active treatment. | Impacts to community and site worker health and safety during environmental monitoring would be unlikely. No adverse impacts to the environment would be expected.<br><br>Between approximately 50 to 100 years to achieve remedial action objectives for groundwater.<br><br>Reductions in surface water concentrations will result as groundwater remedial action objectives are approached. | Environmental monitoring would be easily implementable. | Relatively low cost treatment alternative.<br><br>NPW = $1.7M |

## TABLE 8-1
## COMPARATIVE ANALYSIS OF ALTERNATIVES

### FEASIBILITY STUDY REPORT
### SACO MUNICIPAL LANDFILL
### SACO, MAINE

| ALTERNATIVE | THRESHOLD CRITERIA | | BALANCING CRITERIA | | | | |
|---|---|---|---|---|---|---|---|
| | OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT | COMPLIANCE WITH ARARs | LONG-TERM EFFECTIVENESS AND PERMANENCE | REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT | SHORT-TERM EFFECTIVENESS | IMPLEMENTABILITY | COST |
| **Alternative SML-4** Chemical Oxidation with Hydraulic Containment | Chemical oxidants would be added to the groundwater to reduce the leaching capacity. Extraction and treating groundwater would be required to manage the potential migration of added chemicals.<br><br>If proven effective could reduce time frame to meet groundwater PRG but would not reduce the time frame to meet surface water criteria. Chemical treatment of the plume would minimize the volume of contaminated groundwater discharging into Sandy Brook, and therefore providing added protection to ecological receptors..<br><br>Environmental monitoring would ensure continued protection of human health and the environment. | Would be designed to comply with location and action-specific ARARs.<br><br>Would, over time, achieve chemical-specific ARARs in groundwater. At present, concentrations of arsenic in surface water are above the chemical-specific ARAR. Background concentrations of manganese in surface water exceed the ARAR. | Chemical oxidation would reduce leaching potential in the aquifer could provide to be effective by permanently reducing of contaminant concentrations over time.<br><br>Treatability studies would be required to evaluate the effectiveness of chemical oxidants.<br><br>Source control measures and institutional controls (restricting future groundwater use) implemented as a part of the NTCRA would minimize future risks to human health and the environment. | Chemical oxidation would reduce the dissolved arsenic, iron, manganese in groundwater.<br><br>But, groundwater extraction would be needed to control the potential migration for oxidizing chemicals to Sandy Brook. | Chemical oxidation would reduce leaching potential in the aquifer could provide to be effective by permanently reducing of contaminant concentrations over time It is expected that groundwater PRG would be meet within 30 years.<br><br>Treatability studies would be required to evaluate the effectiveness of chemical oxidants.<br><br>Groundwater extraction would not significantly impact surface water flow in Sandy Brook. | Well-developed technologies. Would require standard construction techniques. Wells would require significant and frequent maintenance of extraction wells due to fouling from the high concentrations of dissolved iron and other metals present in the plume.<br><br>Implementation time estimated to be approximately 10 months. | Most costly of the alternatives.<br><br>NPW = $5.7M (off-site discharge to Saco WWTP) to $9.4M (on-site treatment and discharge) |

## TABLE 8-1
## COMPARATIVE ANALYSIS OF ALTERNATIVES

### FEASIBILITY STUDY REPORT
### SACO MUNICIPAL LANDFILL
### SACO, MAINE

| ALTERNATIVE | THRESHOLD CRITERIA | | BALANCING CRITERIA | | | | |
|---|---|---|---|---|---|---|---|
| | OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT | COMPLIANCE WITH ARARs | LONG-TERM EFFECTIVENESS AND PERMANENCE | REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT | SHORT-TERM EFFECTIVENESS | IMPLEMENTABILITY | COST |
| **Alternative SML-4 (continued)** Chemical Oxidation with Hydraulic Containment | | | | | Between approximately 50 to 100 years to achieve remedial action objectives in groundwater.<br><br>Surface water remedial action objectives are substantially met at present. Further reductions in surface water concentrations will result as groundwater remedial action objectives are approached.<br><br>Containment of plume by extraction system will accelerate reduction of surface water concentrations. | | |

**Notes:**
ARARs = Applicable or Relevant and Appropriate Requirement
NPW = Net Present Worth
NTCRA = Non-Time Critical Removal Action
OSHA = Occupational Safety and Health Administration
PRGs = preliminary remediation goals

## TABLE 8-1
## COMPARATIVE ANALYSIS OF ALTERNATIVES

### FEASIBILITY STUDY REPORT
### SACO MUNICIPAL LANDFILL
### SACO, MAINE

| ALTERNATIVE | THRESHOLD CRITERIA | | BALANCING CRITERIA | | | | |
|---|---|---|---|---|---|---|---|
| | OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT | COMPLIANCE WITH ARARs | LONG-TERM EFFECTIVENESS AND PERMANENCE | REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT | SHORT-TERM EFFECTIVENESS | IMPLEMENTABILITY | COST |
| **Alternative SML-5** Groundwater Extraction and Discharge with or without Treatment | Extracting and treating groundwater from the area downgradient of Landfill Areas 3 and 4, would not reduce the time frame required to meet remedial action objectives, and would therefore not provide an increased level of protection over other alternatives.<br><br>Groundwater extraction would manage the migration of the plume, minimizing the volume of contaminated groundwater discharging into Sandy Brook, and therefore providing added protection to ecological receptors. But, the proposed extraction rate would not impact the surface water flow in Sandy Brook.<br><br>Environmental monitoring would ensure continued protection of human health and the environment. | Would be designed to comply with location and action-specific ARARs.<br><br>Would, over time, achieve chemical-specific ARARs in groundwater. At present, concentrations of arsenic in surface water are below the chemical-specific ARAR. Background concentrations of manganese in surface water exceed the ARAR. | Groundwater extraction would not enhance the movement of oxygenated water through the aquifer, and therefore, would not have any advantageous effect on the natural attenuation processes that would provide effective and permanent reduction of contaminant concentrations over time.<br><br>Source control measures and institutional controls (restricting future groundwater use) implemented as a part of the NTCRA would minimize future risks to human health and the environment. | Groundwater treatment would remove dissolved arsenic, iron, manganese and other inorganics in groundwater in the vicinity of the extraction wells, generating approximately 4 tons/month of potentially hazardous sludge.<br><br>But, because groundwater extraction would not enhance the movement of oxygenated water through the aquifer beneath and downgradient of Landfill Areas 3 and 4, it would not reduce the mobility of dissolved arsenic and manganese in the plume any faster than natural attenuation processes. | Construction of discharge piping to the Saco WWTP, would impact the local community. Residents are not expected to be exposed to any site-related contaminants during construction or implementation. Construction and operation of an on-site treatment system is not expected to impact local residents. Impacts to site worker health and safety during implementation would be unlikely, and would be minimized by the implementation of health and safety training and safe work practices.<br><br>Groundwater extraction would not significantly impact surface water flow in Sandy Brook. | Well-developed technologies. Would require standard construction techniques. Would require significant and frequent maintenance of extraction wells due to fouling from the high concentrations of dissolved iron and other metals present in the plume.<br><br>Implementation time estimated to be approximately 10 months. | Most costly of the alternatives.<br><br>NPW = $3.3M (off-site discharge to Saco WWTP) to 6.9M (on-site treatment and discharge) |

TABLE 8-1
COMPARATIVE ANALYSIS OF ALTERNATIVES

FEASIBILITY STUDY REPORT
SACO MUNICIPAL LANDFILL
SACO, MAINE

| ALTERNATIVE | THRESHOLD CRITERIA | | BALANCING CRITERIA | | | | |
|---|---|---|---|---|---|---|---|
| | OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT | COMPLIANCE WITH ARARs | LONG-TERM EFFECTIVENESS AND PERMANENCE | REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT | SHORT-TERM EFFECTIVENESS | IMPLEMENTABILITY | COST |
| **Alternative SML-5 (continued)** Groundwater Extraction and Discharge with or without Treatment | | | | | Between approximately 50 to 100 years to achieve remedial action objectives in groundwater.<br><br>Surface water remedial action objectives are substantially met at present. Further reductions in surface water concentrations will result as groundwater remedial action objectives are approached.<br><br>Containment of plume by extraction system will accelerate reduction of surface water concentrations. | | |

**Notes:**
ARARs = Applicable or Relevant and Appropriate Requirement
NPW = Net Present Worth
NTCRA = Non-Time Critical Removal Action
OSHA = Occupational Safety and Health Administration
PRGs = preliminary remediation goals

Currently, arsenic and benzene exceed chemical-specific ARARS (i.e., MCLs) in groundwater. Arsenic and manganese exceed the State surface water criteria (i.e., SWQC). However, manganese, a natural element in New England surface water, was reported at its highest concentration in the background surface water samples. Concentrations of arsenic, manganese, and benzene in groundwater are expected to be reduced to their respective PRGs within the same time frame for SML-1, SML-3, and SML-5. If proven effective, SML-4 (chemical oxidation with hydraulic containment) may reach PRGs in groundwater faster than the other alternatives.

Groundwater modeling indicates that pumping groundwater at 60 gpm with ex situ treatment (Alternative SML-5) would not significantly enhance the movement of groundwater through the aquifer. Therefore, the concentrations of DO in the aquifer will not increase more quickly than natural attenuation processes would allow. Thus, Alternative SML-5 would not reduce contaminant concentrations in groundwater to their respective PRGs more quickly than Alternatives SML-1, SML-3, or SML-4. It is anticipated that pumping (SML-4 and SML-5) would reduce arsenic in Sandy Brook to the SWQC of 10 ug/L in 10 to 20 years. At a pumping rate of 60 gal/min, the entire plume is not captured. It is likely that the time required to meet the PQL for arsenic (3 ug/L) will not be significantly reduced over SML-3. Reduction of arsenic concentrations in Sandy Brook to the PQL is expected in 50 to 100 years when groundwater PRGs are attained at the toe of Landfill Area through SML-3, Monitored Natural Attenuation.

Neither location-specific nor action-specific ARARs apply to Alternative SML-1 or SML-3, because no active remedial activities would be conducted. Alternatives SML-4 and SML-5 would be designed to meet both location-specific and action-specific ARARs.

### 8.2.2 Comparison of Primary Balancing Criteria

As discussed previously, the primary balancing criteria emphasize long-term effectiveness and permanence, and reduction in toxicity, mobility, or volume through treatment.

As stated above, remedial action objectives would be met over time due to the natural attenuation processes that are expected to occur in the groundwater beneath and downgradient of Landfill Areas 3 and 4. Alternatives SML-4 and SML-5, in regards to surface water quality, would not improve the long-term effectiveness over that provided by SML-3, because extraction of groundwater would not capture

the entire plume, thereby allowing some arsenic contaminated groundwater to continue to enter Sandy Brook. Alternatives SML-4 and SML-5 would, therefore, not significantly reduce the time to achieve State SWQCs over Alternatives SML-1 or SML-3. SML-3, SML-4, and SML-5 include monitoring and five-year reviews and would be more effective than SML-1 because they provide a mechanism for evaluating future protectiveness of the alternative.

The mobility of dissolved iron, manganese, and arsenic is expected to be reduced over time by natural attenuation processes as these contaminants are precipitated out of solution. Neither natural attenuation processes nor groundwater extraction and treatment will reduce the toxicity of contaminants in groundwater. The volume of contaminants would be increased with the on-site treatment option for Alternatives SML-4 and SML-5. It is estimated that approximately four tons per month of potentially hazardous sludge would be generated, requiring off-site disposal.

In conclusion, although Alternatives SML-4 and SML-5 provide groundwater extraction and discharge with or without treatment, those alternatives would not provide risk reduction, improved long-term effectiveness, or significantly reduce the time required to meet both groundwater remedial action objectives and surface water criteria over Alternative SML-1 or Alternative SML-3. Furthermore, costs to implement Alternative SML-4 would be $5.7M to $9.4M and costs to implement Alternative SML-5 would be $3.3M to $6.9M compared to $0 for Alternative SML-1 or $1.7M for Alternative SML-3. Alternatives SML-4 and SML-5 would manage the migration of a majority of the plume, improving surface water quality into Sandy Brook and therefore provide added protection to ecological receptors, although at present there is no significant risk. Implementation of Alternatives SML-4 or SML-5 would increase the volume of contaminants by generating four tons per month of potentially hazardous sludge requiring off-site disposal. These alternatives would not in all likelihood meet arsenic background levels (or PQLs) in surface water significantly faster than Alternative SML-3. Therefore, it is recommended that Alternative SML-3 be proposed as the preferred remedy for this Site.

# ACRONYMS

## LIST OF ACRONYMS

| | |
|---|---|
| AET | Apparent Effects Threshold |
| ARAR | Applicable or Relevant and Appropriate Requirement |
| As | Arsenic |
| AWQC | ambient water quality criterion |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| COC | contaminant of concern |
| CPC | compound of potential concern |
| CWA | Clean Water Act |
| DO | dissolved oxygen |
| DOC | dissolved organic compound |
| EE/CA | Engineering Evaluation/Cost Analysis |
| ER-l | Effective Range-Low |
| FS | Feasibility Study |
| GAC | granular activated carbon |
| gpm | gallons per minute |
| HI | Hazard Index |
| $KMn0_4$ | potassium permanganate |
| LOEL | Lowest Observed Effect Level |
| MCL | maximum contaminant level. |
| MCLG | Maximum Contaminant Level Goal |
| mg/kg | milligrams per kilogram |
| MEDEP | Maine Department of Environmental Protection |
| MEDHS | Maine Department of Human Services |
| MEG | Maine maximum exposure guidelines |
| NaOH | sodium hydroxide (caustic) |
| NCP | National Contingency Plan |
| NEPA | National Environmental Protection Act |
| NOAA | National Oceanic and Atmospheric Administration |
| NPDES | National Pollution Discharge Elimination System |
| NTCRA | Non-Time Critical Removal Action |
| OSHA | Occupational Safety and Health Administration |
| O&M | Operations and Maintenance |

## LIST OF ACRONYMS (continued)

| | |
|---|---|
| POTW | Publicly Owned Treatment Works |
| PRG | preliminary remediation goal |
| PVC | polyvinyl chloride |
| RBC | risk based concentration |
| RCRA | Resource Conservation and Recovery Act |
| RI | Remedial Investigation |
| SARA | Superfund Amendments and Reauthorization Act |
| SDWA | Safe Drinking Water Act |
| SML | Saco Municipal Landfill |
| SWQC | statewide water quality criteria |
| SVOC | semivolatile organic compound |
| TBC | to be considered |
| µg/L | micrograms per liter |
| µg/g | micrograms per gram |
| USEPA | United States Environmental Protection Agency |
| USGS | United States Geological Survey |
| VOC | volatile organic compound |
| W&C | Woodard & Curran Inc. |
| WQS | water quality standard |
| WQC | water quality criteria |
| WWTP | Waste Water Treatment Plant |

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# APPENDIX A

# USGS GEOLOGIC LOGS

**Table 1.** Lithologic logs and coring record for wells, test borings, and surface sampling, August - September 1997,Saco Landfill , Saco, Maine [ft, feet]

| Well, boring, or sample number | Description | Depth below land surface (ft) |
|---|---|---|
| MW97-13S1 | | |
| | Waterloo core collected in aluminum tube. Recovered 3 ft. | 15-20 |
| | Waterloo core collected in aluminum tube. Recovered 3.5 ft. | 20-25 |
| | Waterloo core attempted but no recovery in clay sediments. | 25-30 |
| | Waterloo core attempted but no recovery in clay sediments. | 30-35 |
| MW97-13S2 | | |
| | Waterloo core attempted but no recovery in clay sediments. | 25-30 |
| | Waterloo core collected in aluminum tube. Recovered 3 ft. | 30-35 |
| | Refusal | 48 |
| MW97-13R | | |
| | No description. See MW97-13S1 and MW97-13S2.. | 0-48 |
| | Bedrock (probably hornfels), very hard to drill, numerous fractures from 53 to 63 feet. Iron staining observed in fractures at 75 ft. Rock core collected. | 48-83 |
| MW97-14S1 | | |
| | Split-spoon sample. Recovered 0.8 ft of Gravel, granule and pebble, bluish gray. | 5-7 |
| | Split-spoon sample. Recovered 1.2 ft of Sand, blue-gray. | 8-10 |
| | Waterloo core collected in aluminum tube. Recovered 1.6 ft. | 10-15 |
| | Waterloo core attempted but no recovery | 15-17.5 |
| | Refusal | 17.5 |
| MW97-14S2 | | |
| | Waterloo core collected in aluminum tube. Recovered 1.6 ft. | 13-17 |
| | Bottom of well. | 10 |
| MW97-16S | | |
| | Gravel, granule and pebble. Sand layers, fine- to medium. | 0-5 |
| | Waterloo core collected in aluminum tube. Many pebbles. Recovered 1.4 ft of core. | 5-10 |

**Table 1.** Lithologic logs and coring record for wells, test borings, and surface sampling, August - September 1997,Saco Landfill , Saco, Maine [ft, feet]

| Well, boring, or sample number | Description | Depth below land surface (ft) |
|---|---|---|
| | Split-spoon sample. Recovered 0.8 ft of Gravel, granule and pebble, reddish; Sand fine to coarse, silty, light brown. | 10-12 |
| | Split-spoon sample. Recovered 0.25 ft of Gravel and Sand similar to 10-12 ft. | 13-15 |
| | Waterloo core collected in tube. Recovered 1.7 ft. | 15-20 |
| | Split-spoon sample. Recovered 1.35 ft of Sand, fine to medium, moderate brown, minor gravel. | 20-22 |
| | Split-spoon sample. Recovered 1 ft of Gravel, granule and pebble; Sand, fine to coarse, moderate brown. | 23-25 |
| MW97-17R | | |
| | Clay. | 0-2 |
| | Split-spoon sample. Recovered 1.4 ft. of Sand, medium, gravelly and clay lenses. | 5-7 |
| | Split-spoon sample. Recovered 2 ft of Sand, medium, tan. | 10-12 |
| | Split-spoon sample. Recovered 1 ft of Sand, medium, tan and rock fragments at bottom.. | 15-16 |
| | Bedrock (probably hornfels), numerous fractures, iron staining in fractures. Rock core collected. | 17-49 |
| MW97-18S | | |
| | No samples. Mainly sand and gravel. | 0-18 |
| | Refusal. | 18 |
| MW97-19S | | |
| | No samples. Mainly sand and gravel. | 0-26.5 |
| | Refusal | 26.5 |
| TB97-1 | (Unable to complete bedrock well - planned MW97-15R at this location) | |
| | Split-spoon sample, Recovered 0.4 ft of Gravel, granule and pebble, silty, some iron staining | 5-7 |
| | Split-spoon sample. Recovered 1.2 ft of Sand, fine to coarse, encountered boulder at depth of 9.5 ft. | 8-10 |
| | Split-spoon sample. Recovered 1.8 ft of Sand, medium to coarse. | 10-12 |
| | Waterloo core collected in aluminum tube. Recovered 2.5 ft. | 12-17 |

**Table 1.** Lithologic logs and coring record for wells, test borings, and surface sampling, August - September 1997,Saco Landfill , Saco, Maine [ft, feet]

| Well, boring, or sample number | Description | Depth below land surface (ft) |
|---|---|---|
| | Split-spoon sample. Recovered 2 ft of Sand, medium to coarse. | 15-17 |
| | Split-spoon sample. Recovered 0.6 ft of Sand, medium to coarse, blue-gray, some globs of sand, lightly cemented and red. | 18-20 |
| | Split-spoon sample. Recovered 1.7 ft of Gravel, granule and bebble; Sand, light brown to light gray. | 20-22 |
| | Split-spoon sample. Recovered 2 ft of Sand, medium, blue-gray. Gravel, pebbles. | 23-25 |
| | Waterloo core collected in aluminum tube. Recovered 2.2 ft. | 25-29.5 |
| | Bedrock (bedrock at 32 ft on second try near this location). | 29.5 |
| TB97-2 | | |
| | Split-spoon sample. Recovered 2 ft of Sand, fine, silty, tan. | 0-2 |
| | Split-spoon sample. Recovered 1.3 ft of Sand, fine, silty, tan. | 4-6 |
| | Split-spoon sample. Recovered 2 ft of Sand, fine, silty, tan. | 9-11 |
| | Split-spoon sample. Recovered 1.5 ft of Sand that heaved into auger and Clay, silty, light gray. | 12-14 |
| SS-1 | Weathered gravel from quarry | surface sample |
| SS-2 | Sand from quarry | surface sample |
| SS-3 | Weathered hornfels bedrock outcrop | surface sample |
| SS-4 | Weathered hornfels bedrock outcrop | surface sample |
| SS-5 | Red glacial till | surface sample |
| SS-6 | Saco pluton rock | surface sample |
| SS-7 | Saco pluton outcrop at road cut | surface sample |

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# APPENDIX B-1

# HYDROGEOLOGICAL INVESTIGATION REPORT

# HYDROGEOLOGICAL INVESTIGATION REPORT


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- 1.1 Background
- 1.2 Purpose

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6.0 SUMMARY

# 1.0 INTRODUCTION

The groundwater modeling effort at Saco Municipal Landfill (SML) was undertaken to evaluate remedial alternatives for the Feasibility Study (FS). The main objectives of the modeling effort were to:

- evaluate remedial alternatives,
- understand the distribution of arsenic within the flow system and its impact on Sandy Brook and,
- determine flushing rate and travel times of groundwater through different parts of the flow system.

To meet these objectives:

- a pumping test was completed,
- hydrogeologic parameters were determined,
- a numerical groundwater flow model was constructed based on the conceptual hydrogeologic model,
- the model was calibrated and verified, and
- analysis of the flow system was completed.

## 1.1 BACKGROUND

The Remedial Investigation (RI) completed in March of 1998 identified an arsenic groundwater plume traveling with groundwater and discharging to Sandy Brook. This plume was considered to be the last significant remaining potential risk for the site (W&C, 1998). To evaluate the potential risk and cleanup times of remedial measures, a groundwater model was developed. A pumping test was completed to understand the hydraulic properties of the aquifer and supply data for the modeling effort. An eight inch pumping well was installed in the gravel pit area and a pumping test completed in December of 1997. The pumping test data were analyzed and used as a basis for hydraulic parameters used in the groundwater model of the site. The site as a whole was modeled to determine flow paths and travel times for contaminants discharging to Sandy Brook.

Data from the RI completed by W&C, a USGS study completed in 1995, and the supplemental remedial investigation were integrated to develop a more complete understanding of the site. These data were further utilized to develop a conceptual model of groundwater flow at the site. A numerical groundwater flow model was constructed based on the conceptual model and verified by transient simulation.

## 1.2 PURPOSE

The purpose of this report is to present the analysis of the pumping test data, discuss the construction of the groundwater model, and present the findings of the groundwater modeling effort undertaken in support of the FS. This report presents the results of modeling the SML hydrogeology.

# 2.0 SITE CHARACTERIZATION

## 2.1 SITE LOCATION AND DESCRIPTION

The Saco Municipal Landfill site is located on Foss Road in the northern part of Saco, Maine (see Figure 2-1). The site lies in the coastal lowlands of southern Maine. Topography at the SML site is low and gently undulating. The topographical character of the site is due to recent long periods of glacial deposition and erosion. The landfill is located at an elevation of 120 to 130 feet with topography sloping down to the east in the direction of Sandy Brook, a small perennial tributary to the Saco River. Big Ledge Brook, another small stream located in the study area, joins Sandy Brook to the south of the Landfill.

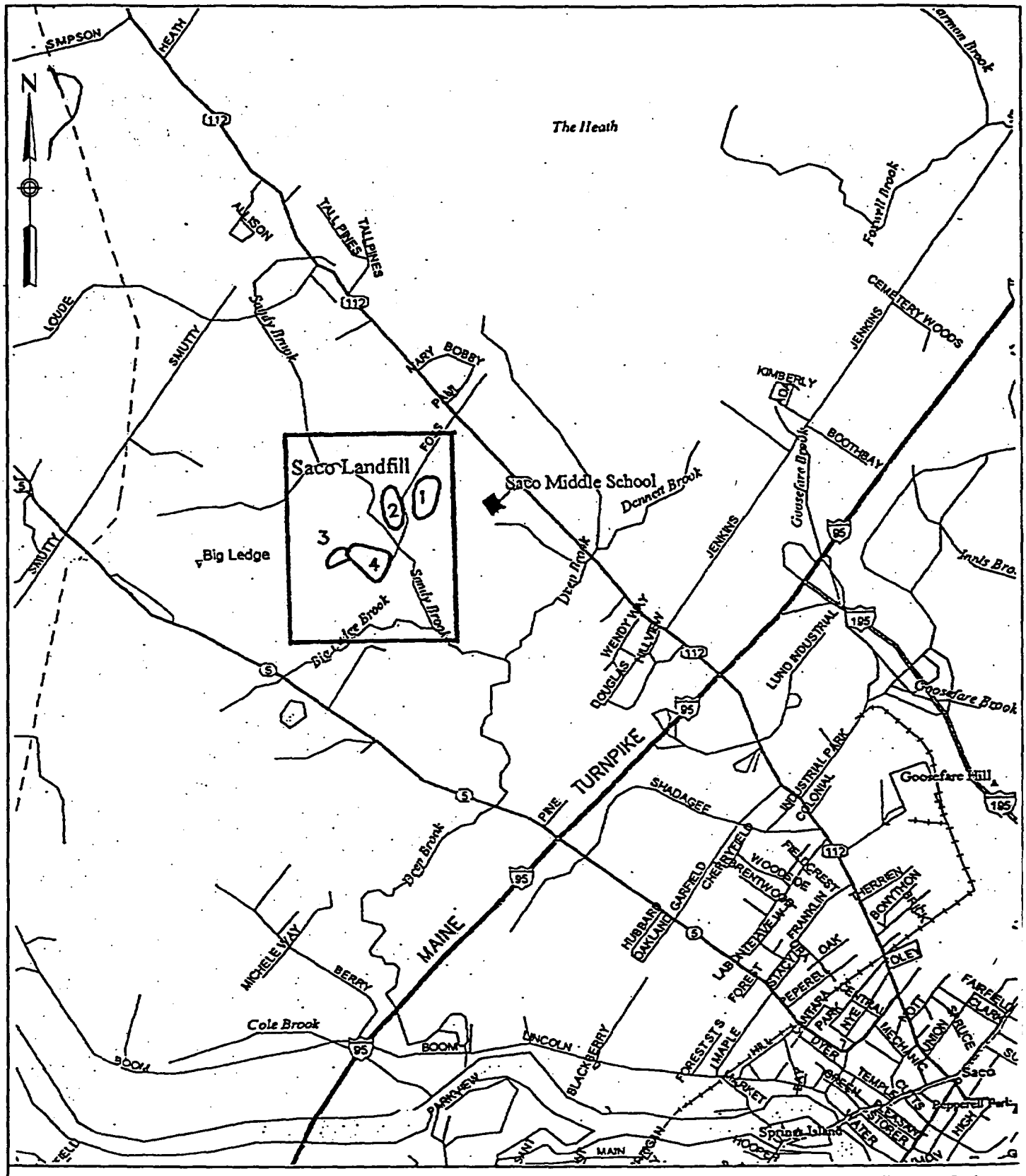
## 2.2 HYDROGEOLOGY

The geology and hydrogeology of the Saco Landfill site have been studied and evaluated over the past 20 years. A comprehensive study conducted by the USGS was completed in 1995. Numerous other studies conducted by W&C as part of the Remedial Investigation have been completed since 1995. All the investigations conducted since 1995 support the work completed by the USGS in 1995 and further the conceptual understanding. Key geologic, hydrogeologic, and hydrologic factors reported by the USGS in 1995 and deemed influential in controlling contaminant distribution, fate, and transport at the site are presented below.

Geology at the SML site consists of unconsolidated glacial deposits overlying bedrock. Generally, the unconsolidated deposits are saturated and each unit is an integral part of the overall hydrogeologic system at the site (W&C, 1997). A summary of the stratigraphy, bedrock conditions, groundwater flow, and groundwater interaction with surface water is given in the following sections.

### 2.2.1 Stratigraphy

The stratigraphy of the SML site consists of four unconsolidated overburden deposits overlying bedrock. A stylized cross section presenting the stratigraphy of the site is shown in Figure 2-2.




Source: Delorme, 1995.

Figure 2-1
Site Location Map
Hydrogeological Study
Saco Municipal landfill
Saco, Maine

Not to Scale

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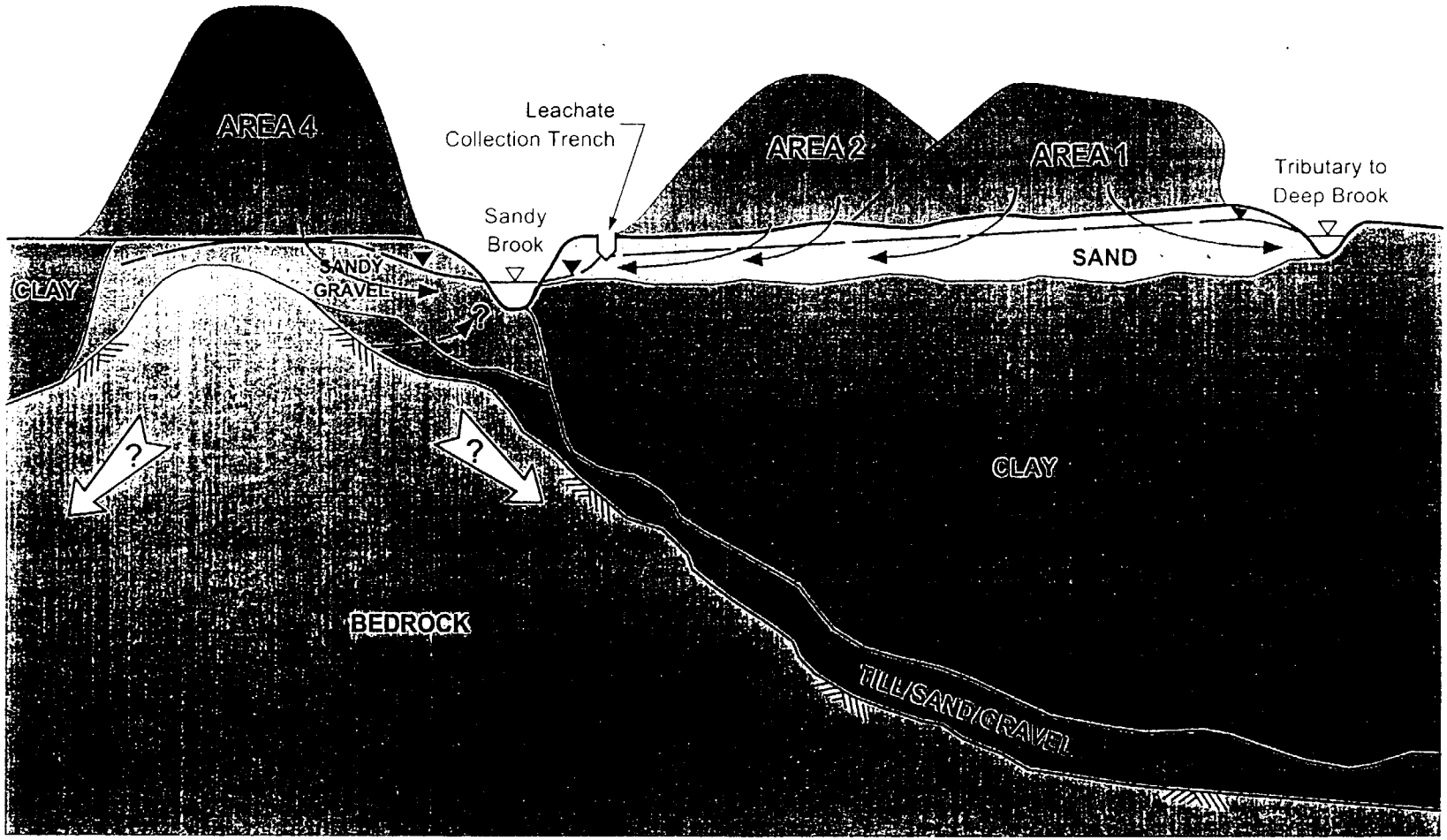
The unconsolidated overburden deposits include, from bottom to top, a glacial till, a coarse-grained glaciofluvial (sand and gravel) deposits, a thick fine-grained glaciomarine silt and clay, and a fine-grained sand unit (see Figure 2-2). The upper two units are facies within the Presumpscot Formation.

**Glacial Till:** The glacial till observed at the site is comprised of a brown to olive unsorted mixture of clay, silt, gravel, cobbles and frequent boulders. This unit is discontinuous and ranges in thickness from less than a foot to over ten feet. The till in general occurs below the water table. The abundance of fine-grained matrix prevents this unit from being considered a productive aquifer.

**Coarse-Grained Glaciofluvial Deposits:** The coarse-grained glaciofluvial deposits consist of well-sorted sand, gravel, and cobbles with minor amounts of silt. The coarse-grained glaciofluvial deposits are divided into two facies an upper fine-grained facies corresponding to distal fan deposits, and a lower, coarse-grained facies corresponding to proximal fan deposits (USGS, 1995). Occasional silt lenses are associated with the upper fine-grained deposit and cause groundwater seeps where the silt lenses become exposed at the ground surface.

**Fine-Grained Glaciomarine:** There are two facies of the fine-grained unit present at the site. The lower facies consists of silty clay and the upper facies consists of reworked fine sand. The lower silty clay is characterized as massive- to thinly-laminated silty clay with minor amounts of fine sand. The thickness of this unit ranges from approximately 35 to 145 feet. The hydraulic conductivity of this unit is between $1 \times 10^{-5}$ and $1 \times 10^{-3}$ (USGS, 1995). The upper fine sand unit is not considered an aquifer due to its thin saturated thickness.

**Bedrock:** The bedrock at the site is classified by Hussey (USGS, 1995) as a metasedimentary hornfels of the Cape Elizabeth Formation. The majority of the bedrock fractures are present in the upper 20 feet of bedrock and produce the largest quantities of groundwater under both static and pumping conditions (W&C, 1998). The flow between fractures is upward toward the overburden, indicating an upward movement of groundwater in the bedrock (W&C, 1998).




LEGEND

Shallow Overburden Groundwater Flow

Deep Overburden Groundwater Flow

Bedrock Groundwater Flow

**NOTE:**
All depths and distances are for illustrative purposes only.

**Original includes color coding.**

Saco Municipal Landfill
Feasibility Study

Figure 2-2
Site Conceptual Model

| | |
|---|---|
| SCALE: NONE | JOB NO.: 95093.05 |
| DATE: 1/00 | FILE NAME: MODEL-XS |

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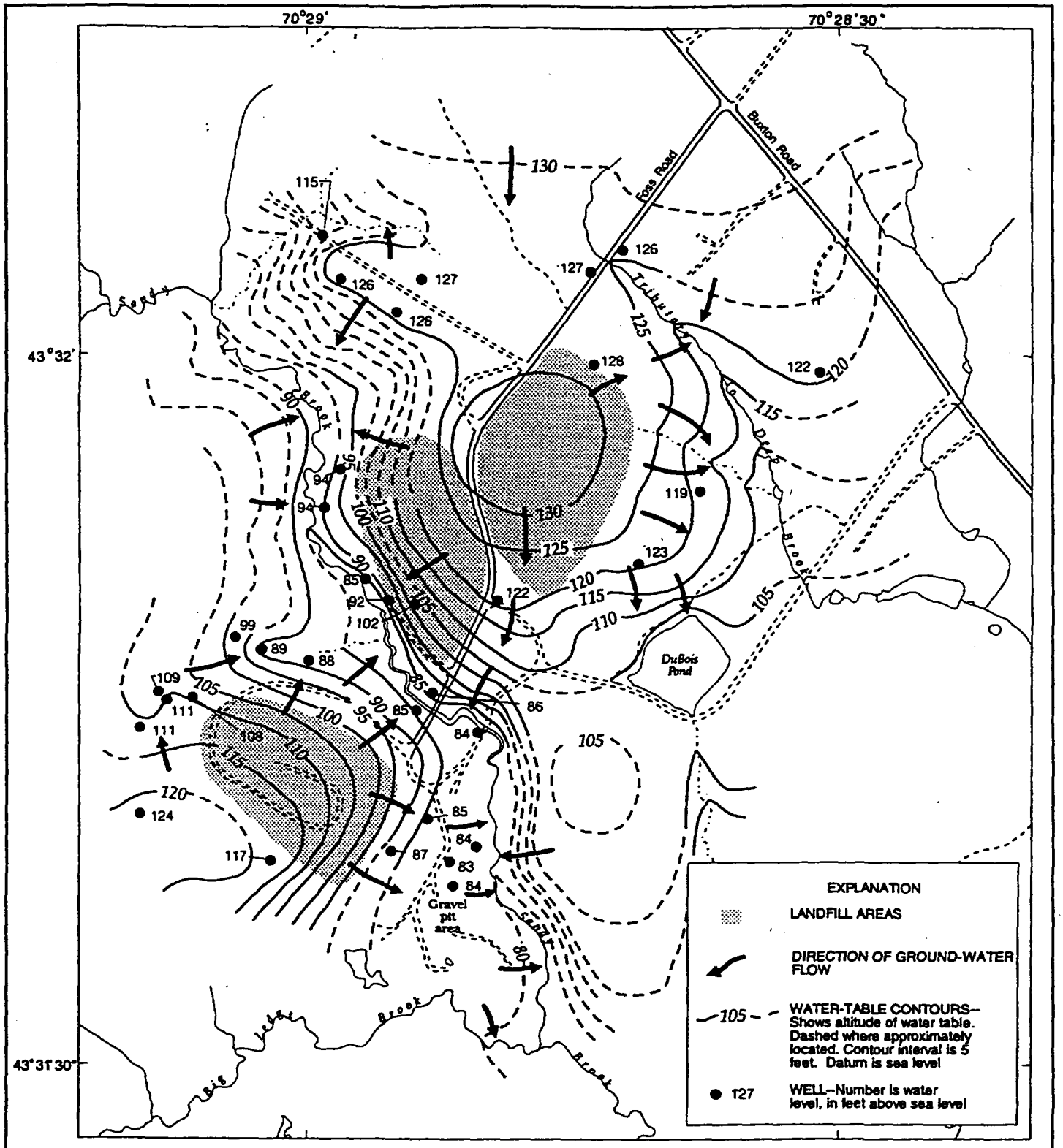
### 2.2.3 Groundwater Flow

Groundwater flow at the site is controlled by three primary factors: (1) the sloping irregular surface of the bedrock, (2) the presence of the thick sequence of clay east of Sandy Brook and its absence west of the brook, and (3) the degree of fracturing in shallow versus deep bedrock of the Cape Elizabeth metasediments. In areas where the depth to bedrock is shallow, the bedrock exerts control on the flow of groundwater in the overlying unconsolidated water-bearing soils. Fracture distribution in the bedrock is important to the flow of groundwater in the bedrock. Flow is contained in the upper portions of the bedrock; the lack of fractures at depth effectively restricts groundwater flow. The clay deposit is important because its thickness east of Sandy Brook provides a barrier to the vertical flow of groundwater and contaminant migration to deeper water-bearing units.

A groundwater contour map presented in the 1995 USGS report is included as Figure 2-3. In general, groundwater flows radially away from the topographic high located in the vicinity of Landfill Areas 3 and 4. The groundwater north of Landfill Areas 3 and 4 flows toward a small intermittent stream that flows east and joins Sandy Brook. The groundwater parallels this stream and then turns south to follow Sandy Brook as it flows toward its confluence with Big Ledge Brook. Groundwater flowing off the south side of the landfill flows beneath the gravel pit area and parallels flow of Sandy Brook. Groundwater ultimately discharges to the brook.

The thick deposits of sand and gravel within the sand pit exhibit flat gradients that change little during the seasons. These thick deposits of sand and gravel with large storage of groundwater maintain the level of groundwater within the lower aquifer at an elevation of between 83 and 85 ft above MSL. The water table at higher elevations within and immediately surrounding Areas 3 and 4 is subject to much more rapidly changing heads, due primarily to the thinness of the deposits, the nature of the deposits (lower conductivity), and the low storage capacity of the deposits at higher elevations. These deposits at higher elevations are subject to seasonal changes in heads to a greater degree than the lower sand and gravel deposits.




Base from U.S. Army Corps of Engineers Saco Municipal Landfill 1:2,400, 1988

0 200 400 FEET
0 50 100 METERS

Figure 2-3
USGS Water Table Elevation Contours
Hydrogeological Investigation Report
Saco Municipal Landfill
Saco, Maine
WOODARD&CURRAN

Source: USGS Water-Resources Investigations Report 95-4027,1995.

95093.06\contours

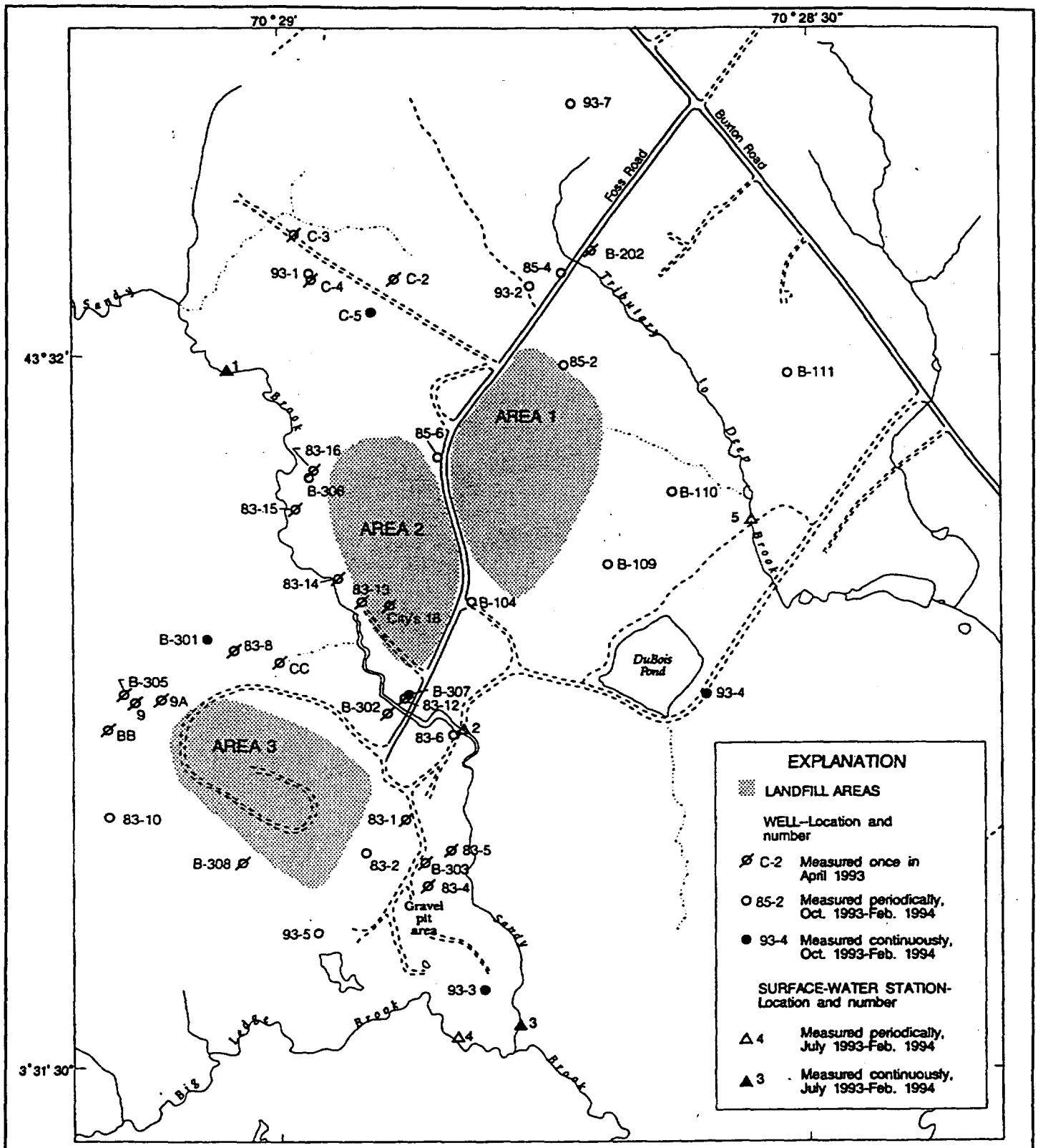
Groundwater flow east of Sandy Brook is divided into two regimes, upper and lower, due primarily to the presence of the silt and clay of the Presumpscot Formation The upper regime exhibits radial flow away from Landfill Area 1 (W&C, 1998) in the upper sandy member of the Presumpscot Formation East of Sandy Brook the lower aquifer is confined by the presence of overlying silts and clays of the Presumpscot Formation The lower aquifer exhibits flow from north-northeast to south-southwest (W&C, 1998).

### 2.2.4 Groundwater Interaction with Surface Water

The surface water bodies in the study area consist of two perennial streams and one intermittent stream. The two perennial streams are Big Ledge Brook and Sandy Brook (see Figure 2-4). Big Ledge Brook flows eastward along the southern side of the study area. Sandy Brook flows southwards through the middle of the study area between Landfill Areas 1and 2 and Landfill Areas 3 and 4. Sandy Brook and Big Ledge Brook join south of the landfill areas and continue to flow south, joining Deep Brook with ultimate drainage to the Saco River.

A study conducted by the USGS (1995) indicates that Sandy Brook is a gaining stream over its length within the landfill study area. Big Ledge Brook is also a gaining stream within the confines of the study area. The intermittent stream located north of the landfill was not included in the USGS report (1995) and appears to be a losing stream at higher elevations, based on groundwater levels in adjacent well MW-1S being lower than the stream surface, but becomes a gaining stream at lower elevation as it flows toward Sandy Brook. The majority of the groundwater gained by Sandy Brook occurs from the course-grained deposits located in the lower portion of the study area in the vicinity of the gravel pit.

Three stream gauging stations are located along Sandy Brook (labeled as surface water stations on Figure 2-4). Station 1 is located upstream from Landfill Areas 3 and 4; gauging station 2 is located east of Landfill Area 3 where Sandy Brook flows under the road; and gauging station 3 is located south of Landfill Areas 3 and 4 upstream from the confluence of Sandy Brook and Big Ledge Brook. Calculations based on stream gauging performed by the USGS (1995) indicates that Sandy Brook gains approximately 5,184 $ft^3$/day from groundwater




Base from U.S. Army Corps of Engineers Saco Municipal Landfill 1:2,400, 1988.

Figure 2-4
Location of USGS Stream Gauging Stations
Hydrogeological Investigation Report
Saco Municipal Landfill
Saco, Maine
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Source: USGS Water-Resources Investigations Report 95-4027,1995.

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between stations 1 and 2, and gains approximately 21,600 $ft^3$/day from groundwater between stations 2 and 3.

The difference in stream discharge between the northern and southern portions of Sandy Brook is due primarily to the difference in the deposits underlying the stream. North of Station 2 the stream is underlain primarily by clay deposits of the Presumpscot Formation. The clay impedes the upward flow of groundwater restricting groundwater discharge to the brook. The fine-grained deposits of the Presumpscot Formation. intermittently cross the stream south of Station 2. This leaves windows of course grained deposits through which groundwater can more easily discharge, accounting for the disparity in groundwater discharges north and south of Station 2.

## 3.0 DESCRIPTION OF PUMPING TEST

A pumping test of the lower aquifer (sand and gravel deposits) was conducted from December 16, 1997 through December 19,1997. An 8-inch pumping well was installed in the gravel pit area (see Figure 3-1) between December 8, 1997 and December 12, 1997. Observation wells for the pumping test included wells installed by W&C during the Remedial Investigation (RI) and wells installed by the USGS during various phases of their studies.

### 3.1 INSTALLATION OF PUMPING WELL

An eight inch well was installed in the sand and gravel deposits of the lower aquifer beginning on December 8, 1997 with completion on December 12, 1997. The eight-inch pumping well was installed using standard drive and wash techniques by R.E. Chapman Co. of Oakdale, Massachusetts. The total well depth was 50 feet. Based on the driller's log, the stratigraphy at the location of the pumping well consisted of stratified gray silts and clay from 0 to 35 feet and very coarse brown sand and very coarse gravel from 35 to 50 feet. A 0.120 slotted screen was placed from 44 to 50 feet below the ground surface. The well was developed by pumping at 322 gallons per minute (gpm) for 12 hours.

Prior to operation of the pumping well, approximately 700 feet of hose was laid out from the pumping well to the borrow area located east of the landfill see (Figure 3-1). The water pumped from the pumping well was piped to the borrow area for infiltration outside the influence of the pumping test. An orifice and pitot tube were installed on the piping discharge to monitor the flow rate from the extraction well.

Observation wells consisted of groundwater monitoring wells previously installed by W&C and other wells installed by the USGS. The observation wells monitored during the course of the pumping test are shown on Figure 3-1. The observation well identification, unit screened, and screened interval for each well is presented in Table 1.

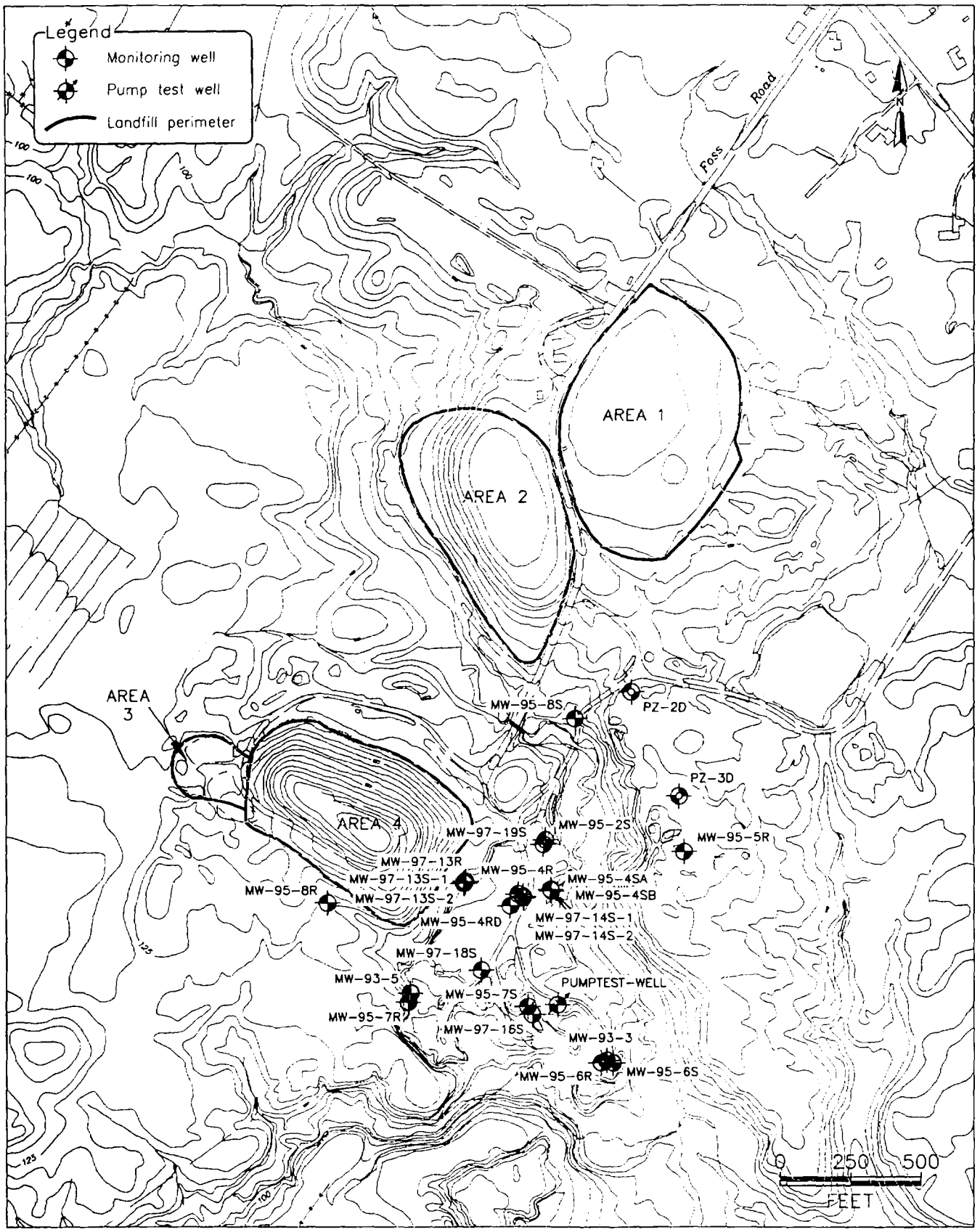


Figure 3-1
Pumping Test Well Locations
Hydrogeological Investigation Report
Saco Municipal Landfill
Saco, Maine

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Table 1: Observation Well Summary for Pumping Test
Saco Municipal Landfill
Saco, Maine

| Well ID | Ground Surface Elevation | Screen Interval (ft bgs) | Stratigraphic Unit Screened |
|---|---|---|---|
| MW-93-3 | 87.1 | 68-70 | sf/gd |
| MW-93-5 | 90.17 | 27-29 | sf/gd |
| MW-95-2S | 87.11 | 5-15 | sf/gd |
| MW-95-4R | 91.93 | 31.5-36.5 | br |
| MW-95-4RD | 93.26 | 43.6-48.6 | br |
| MW-95-4SA | 85.2 | 24-29 | sf/gd |
| MW-95-4SB | 84.97 | 5-10 | sf/gd |
| MW-95-5R | 122.95 | 152.5-157.5 | bf |
| MW-95-6R | 85.73 | 111-116 | bf |
| MW-95-6S | 87.69 | 4-14 | sf/gd |
| MW-95-7R | 89.3 | 58-63 | br |
| MW-95-7S | 86.78 | 4-14 | sf/gd |
| MW-95-8R | 122.17 | 15-20 | br |
| MW-95-8S | 93 | 7-17 | sf/gd |
| MW97-13R | 106.4 | 53-83 | br |
| MW97-13S-1 | 106.4 | 30-35 | sf/gd |
| MW97-13S-2 | 106.2 | 43-48 | sf/gd |
| MW97-14S-1 | 87.2 | 12.5-17.5 | sf/gd |
| MW97-14S-2 | 87.3 | 5-10 | sf/gd |
| MW97-16S | 86.1 | 20-25 | sf/gd |
| MW97-18S | 87.1 | 13-18 | sf/gd |
| MW97-19S | 89.3 | 21.5-26.5 | sf/gd |
| PZ-2D | 118 | 95-100 | sf/gd |
| PZ-3D | 114.89 | 90-95 | sf/gd |
| Pumping Well | 89.54 | 44-50 | sf/gd |

ft msl = feet relative to mean sea level
ft bgs = feet below ground surface

Stratigraphic Units:
sf = sand facies of glaciomarine distal fan deposits
gd = gravel and diamict facies of glaciomarine proximal fan deposits
br = bedrock

## 3.2 ANTECEDENT TRENDS

Historical water level measurement data have been collected in wells at the SML site. The water levels were collected prior to sampling rounds in the wells to be sampled and in other wells at various times. Historical measurements in three wells utilized as observation wells during the pumping test were evaluated to determine the antecedent trends. The wells were MW-93-5, MW-95-7S, and PZ-2D. Wells MW-93-5 and MW-95-7S are located in the gravel pit area west of Sandy Brook and south of Landfill Areas 3 and 4. Piezometer PZ-2D is located east of Sandy Brook.

Figure 3-2 shows historical measurements of groundwater elevation in three wells utilized as observation wells for the pumping test. The graphs in Figure 3-2 exhibit the same basic characteristics. The curves are relatively flat with minor perturbations until a significant recharge event took place in early 1998. This recharge event took place well after the pumping test was completed.

## 3.3 PUMPING TEST

The pumping test of the 8-inch well was initiated to test the aquifer characteristics for the feasibility study. The drawdown measurements for the pumping test and the various observation wells were analyzed for transmissivity and storage values for use in the groundwater modeling effort for the feasibility study.

The pumping test was initiated on December 16, 1997 at 12:47 p.m. Static water levels in the observation wells were gathered on the morning of December 16 prior to initiation of the pumping test. The discharge system had been filled prior to starting the test to provide for uniform early discharge. The pumping test was run at a constant discharge rate of 209 gpm. The pumping test was terminated on December 19, 1997 at 9:00 a.m.

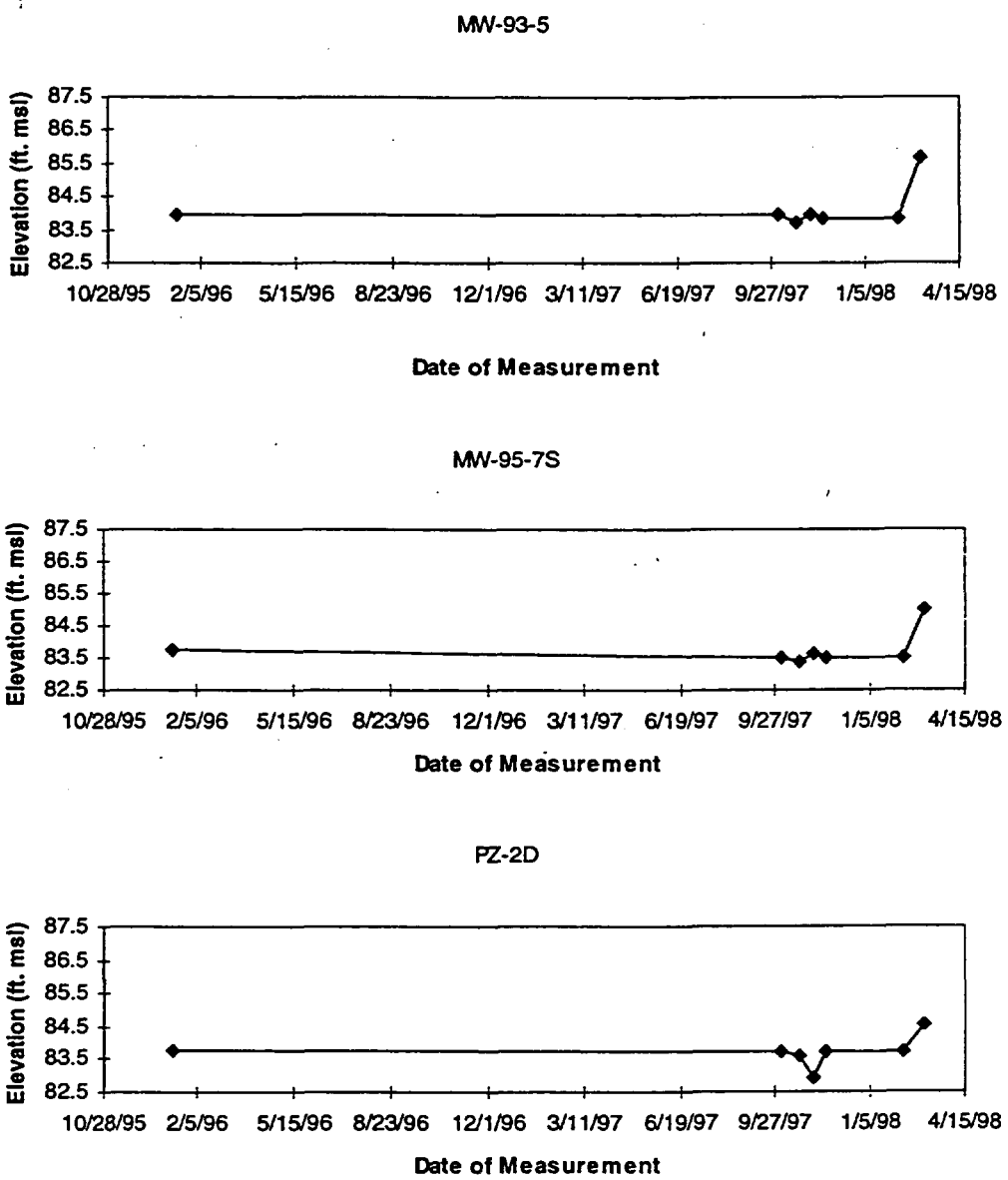


**Figure 3-2: Groundwater elevation measurements at three selected wells.**

Water level measurements were made according to the following time schedule:

| Time | Frequency of Measurement |
|---|---|
| 0-2 minutes | every 30 seconds |
| 5-10 minutes | every minute |
| 10-15 minutes | every 5 minutes |
| 30 minutes-2 hours | every 1/2 hour |
| 2 hours - 4 hours | hourly |
| 4 hours - 20 hours | every 4 hours |
| 20 hours - end of test | every 6 hours |

The pumping test ran for approximately 2 days and 20 hours (4092 minutes). Stabilization of drawdown was not achieved during the pumping test. The pumping test had to be terminated because the retention pond containing the extracted groundwater reached capacity prior to stabilization of drawdown. The pumping test ran for sufficient time to generate adequate data to determine aquifer transmissivity.

## 3.5 GROUNDWATER/SURFACE WATER MONITORING

Groundwater was monitored for total arsenic during the pumping test. Samples were collected at the well head and sent to Katahdin Analytical Labs for total arsenic analysis. A total of six samples were collected and analyzed during the course of the pumping test.

The first sample was collected approximately one hour into the pumping test. A second sample was collected on December 16, 1997 approximately 8 hours after initiation of the pumping test. Two samples were collected on December 17, 1997, and one sample was collected per day on the 18$^{th}$ and 19$^{th}$ of December.

The analysis of the groundwater was below the practical quantitation level of the laboratory for each of the samples collected. Significant levels of arsenic were not detected in the groundwater extracted during the pumping test. Full laboratory results are presented in Appendix C-2. Surface water was not analyzed during the course of the pumping test.

## 4.0 EVALUATION OF AQUIFER CHARACTERISTICS

This section presents an evaluation of the data collected during the pumping test. The evaluation includes discussion of water level corrections, evaluation of drawdown and recovery data, aquifer parameters, aquifer boundaries, groundwater flow, groundwater quality, and groundwater/surface water interactions. The objective of the pumping test was to obtain the data necessary to determine the aquifer properties for the modeling effort undertaken in support of remedial alternatives in the feasibility study.

### 4.1 WATER LEVEL CORRECTIONS

Ambient water levels were not measured during the course of the pumping test. No recharge events took place during the course of the pumping test. An ambient correction was not applied to the data from this pumping test. The average daily barometric pressure as measured at the Portland International Jetport varied between 29.7 and 29.9 inches of mercury over the period of the pumping test. Assuming a barometric efficiency of 50% the resulting fluctuation in measured heads would amount to 0.00113 feet Therefore, corrections to the pumping test drawdown data for changes in barometric changes were not necessary.

### 4.2 EVALUATION OF DRAWDOWN DATA

The time drawdown data were entered into an aquifer analysis computer program, Aquifer$^{win32}$ version1.0. This aquifer analysis program produces log-log and semi-log plots. The plotted data curves are then matched visually to type curves, or straight line matching techniques are used from which the program computes the aquifer parameters.

Data curves were plotted and analyzed using two or more analytical methods in Aquifer$^{win32}$. The boring logs from the pumping well and observation wells were used in conjunction with the curve or straight line matches to determine aquifer characteristics. Numerous methods are available to determine aquifer parameters (transmissivity and storativity) from pumping well tests. The selection of appropriate analytical pumping test solutions rests on satisfaction of assumptions upon which the solution is based. Common assumptions for aquifer test analyses are as follows:

- The aquifer is homogeneous, isotropic, and of uniform thickness over the area influenced by the test.
- The aquifer is pumped at a constant discharge rate
- The pumping well penetrates the entire thickness of the aquifer and receives water by horizontal flow.
- Prior to pumping, the potentiometric surface of the confined aquifer and the water table in the unconfined aquifer are nearly horizontal over the area influenced by pumping.
- The aquifer is either confined, leaky, or unconfined and seemingly infinite in areal extent. The flow in the aquitard is vertical.
- The water removed from storage in the aquifer and the water supplied by leakage from the aquitard is discharged instantaneously with decline in head.

Plotting the elapsed time (t) versus the corrected drawdown (y) on semi-log graphs and on log-log graphs permits the recognition of aquifer types and boundaries. Unconfined aquifers can be distinguished from confined aquifers by the depression in the time-drawdown curve caused by delayed gravity drainage of the water in the unconfined aquifer. Specific boundary conditions may effect the time-drawdown data. Specific boundary conditions are partial penetration of the well, well bore storage, recharge boundaries, or impermeable boundaries. The effect of pumping from a partially penetrating well is vertical flow components in the vicinity of the well accompanied by additional head losses. Well bore storage affects the early time-drawdown data during which time storage in the well is being discharged. Recharge boundaries are discerned by a downward inflection in the drawdown curve. In contrast, impermeable boundaries cause a steepening of the drawdown with time.

## 4.3 AQUIFER PARAMETERS

Aquifer parameters were determined from the time-drawdown data generated during the pumping test. The time-drawdown graphs are presented in Appendix C-2. The methods used to

determine the values for transmissivity were generally the Cooper-Jacob method or the Neuman method.

Transmissivity values were determined for each observation well where drawdown was observed during the pumping test. Transmissivity values were observed in a range from 9,000 $ft^2$/day to 31,000 $ft^2$/day. Transmissivity values are presented in Table 2.

Hydraulic conductivities were computed from the transmissivity values by dividing by the normalized aquifer thickness. The normalized aquifer thickness was computed by averaging the values for the aquifer thickness at the observation well and the aquifer thickness at the pumping well. The average hydraulic conductivity for the lower course grained sand and gravel aquifer is 310 ft/day. The hydraulic conductivity values are presented in Table 2 along with the corresponding transmissivities.

## 4.4 AQUIFER BOUNDARIES

For the duration of this pumping test, there are no discernible boundaries encountered by the drawdown cone induced by the pumping well. The basal boundary is the bedrock and till underlying the site. The sand and gravel deposits are unconfined west of Sandy Brook. East of Sandy Brook the sand and gravel aquifer is confined on the top by the fine silts and clays of the Presumpscot Formation Boundaries were not readily discernible from the time drawdown graphs.

## 4.5 GROUNDWATER FLOW

The stresses induced by the pumping well cause a significant interruption of the natural groundwater flow field. In general, the normal flow field toward the south is maintained along the river. In the immediate vicinity of the pumping well, however, there is a gradient reversal and groundwater appears to flow toward the pumping well. Also, during the pumping test deep groundwater wells on the east side of the stream experienced significant drawdown indicating that groundwater east of the stream responded to the prolonged pumping at the extraction well.

TABLE 2
HYDRAULIC CONDUCTIVITY AND CALCULATED TRANSMISSIVITY VALUES

SACO MUNICIPAL LANDFILL
SACO, MAINE

| Well ID | GS Elevation | MP Elevation | Depth to Static GW | Bedrock Elevation | Well Screen Elevation | Overburden Thickness | Aquifer Thickness | Normalized Aquifer Thickness | Calculated Transmissivity (sq. ft./day) | Hydraulic Conductivity (cm/sec) |
|---|---|---|---|---|---|---|---|---|---|---|
| MW-95-6R | 85.73 | 89.49 | 6.08 | -23.27 | -25.27 | 109.00 | 102.92 | 76.81 | 23487 | 0.1079 |
| MW-95-5R | 122.95 | 125.95 | 42.49 | -14.5 | -24 | 137.45 | 94.96 | 72.83 | 13347 | 0.0647 |
| MW-93-3 | 87.1 | 89.89 | 6.49 | -11.90 | 19.10 | 99.00 | 92.51 | 71.61 | 21844 | 0.1076 |
| PZ-2D | 118 | 121.72 | 38.59 | -20 | 26.71 | 138.00 | 99.41 | 75.06 | 30577 | 0.1437 |
| MW-95-7R | 89.3 | 91.22 | 7.3 | 35.8 | 31.3 | 53.50 | 46.20 | 48.45 | 9819 | 0.0715 |
| PZ-3D | 114.89 | 117.07 | 33.98 | 22.97 | 32.97 | 91.92 | 57.94 | 54.32 | 16889 | 0.1097 |
| Pumping Well | 89.54 | 89.54 | 8.84 | 30 | 45.54 | 59.54 | 50.70 | NA | | |
| MW-95-4RD | 93.26 | 95.26 | 11.72 | 68.18 | 49.68 | 25.08 | 13.36 | 32.03 | 12707 | 0.1400 |
| MW97-13R | 106.4 | 106.4 | 25.01 | 58.4 | 53.4 | 48.00 | 22.99 | 36.85 | 29201 | 0.2796 |
| MW-95-4R | 91.93 | 93.93 | 10.42 | 68.44 | 60.44 | 23.49 | 13.07 | 31.89 | 11483 | 0.1270 |
| MW-95-4SA | 85.2 | 88.24 | 4.86 | 65 | 61.2 | 20.20 | 15.34 | 33.02 | 14139 | 0.1511 |
| MW-93-5 | 90.17 | 92.89 | 9.09 | 41.17 | 63.17 | 49.00 | 39.91 | 45.31 | 9168 | 0.0714 |
| MW97-13S-2 | 106.2 | 106.2 | 23.95 | 58.2 | 63.2 | 48.00 | 24.05 | 37.38 | 9449 | 0.0892 |
| MW97-16S | 86.1 | 88.9 | 5.39 | 26 | 66.1 | 60.10 | 54.71 | 52.71 | 9894 | 0.0662 |
| MW97-19S | 89.3 | 92.5 | 8.2 | 62.8 | 67.8 | 26.50 | 18.30 | 34.50 | 11378 | 0.1163 |
| MW97-18S | 87.1 | 89.1 | 5.69 | 69.1 | 74.1 | 18.00 | 12.31 | 31.51 | 10219 | 0.1144 |
| MW97-14S-1 | 87.2 | 89.8 | 6.27 | 69.7 | 74.7 | 17.50 | 11.23 | 30.97 | 13177 | 0.1501 |

**TABLE 2**
**HYDRAULIC CONDUCTIVITY AND CALCULATED TRANSMISSIVITY VALUES**

**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| Well ID | GS Elevation | MP Elevation | Depth to Static GW | Bedrock Elevation | Well Screen Elevation | Overburden Thickness | Aquifer Thickness | Normalized Aquifer Thickness | Calculated Transmissivity (sq. ft./day) | Hydraulic Conductivity (cm/sec) |
|---|---|---|---|---|---|---|---|---|---|---|
| MW97-13S-1 | 106.4 | 108.4 | 24.65 | 58 | 76.4 | 48.40 | 23.75 | 37.23 | 11413 | 0.1082 |
| MW-95-4SB | 84.97 | 88.16 | 4.83 | 65 | 79.97 | 19.97 | 15.14 | 32.92 | 11204 | 0.1201 |
| MW-95-2S | 87.11 | 90.04 | 6.77 | 63 | 82.1 | 24.11 | 17.34 | 34.02 | 10125 | 0.1050 |
| MW97-14S-2 | 87.3 | 89.9 | 6.27 | 70 | 82.3 | 17.30 | 11.03 | 30.87 | 10845 | 0.1240 |
| MW-95-7S | 86.78 | 89.16 | 5.9 | 40 | 82.78 | 46.78 | 40.88 | 45.79 | 9493 | 0.0731 |
| MW-95-6S | 87.69 | 90.52 | 7.19 | -23 | 83.69 | 110.69 | 103.50 | 77.10 | 20325 | 0.0930 |
| MW-95-8S<br>MW-95-8R | 93<br>122.17 | 94.84<br>124.14 | 11.97<br>15.07 | 25<br>112.17 | 87.84<br>107.17 | 68.00<br>10.00 | 56.03<br>10.00 | 53.37<br>30.35 | 25668 | 0.1697 |

$\Sigma$ : 2.7015

n = 23

$\bar{x}$ = 0.1175 cm/sec

= 333 ft/day

The drawdown induced in wells east of the stream is likely due to the depth of completion of the pumping wells and observation wells east of the stream coupled with the stratigraphy of the site. The pumping well was completed in the course-grained sand and gravel deposits of the lower aquifer. The observation wells completed on the east side of Sandy Brook were also completed in the lower course-grained sand and gravel aquifer. As mentioned portions of the brook are underlain by the silt and clay deposits of the Presumpscot Formation In addition, some finer-grained distal fan deposits are superimposed on the proximal fan deposits corresponding to the lower aquifer. The combination of these stratigraphic conditions and the depth of completion of the pumping and observation wells allow pumping on the west side of the stream to induce drawdown in observation wells on the east side of the stream.

## 4.6 GROUNDWATER QUALITY

Groundwater was tested for total arsenic content during the pumping test. The test results were less than the practical quantitation level of the laboratory (0.008 mg/l). Testing indicates that arsenic was not present in quantities above the PQL in the water discharged during the pumping test.

## 4.7 GROUNDWATER/SURFACE WATER INTERACTIONS

The interaction between groundwater and surface water has been characterized by the USGS (1995). Stream gauging of Sandy Brook indicates that the brook is a gaining stream as it flows through the landfill study area. Based on the stream gauging conducted by the USGS (1995), the majority of the baseflow received by the stream occurs in the lower portion of the stream in the vicinity of the gravel pit south of the landfill.

Three gauging stations were used to compute the average amount of groundwater discharging to the stream between gauging stations (see Figure 2-4). Measurements were made at these gauging stations between July 1993 and January 1994 The average amount of groundwater discharging to the stream between Station 1 and Station 2 is 5,184 $ft^3$/day. The average amount of groundwater discharging to the stream between Station 2 and Station 3 is 21,600 $ft^3$/day. These averages were computed by averaging the stream gauging values for the driest months of

the measuring period (July-August) and computing the differences between the averages for each station. The driest months were chosen because changes in stream flow between stations would more accurately reflect the groundwater/surface water interaction rather than the effect of precipitation, overland flow, or interflow to the stream. Therefore, the groundwater discharging to the stream would be due primarily to infiltration recharging the water table and flowing through the groundwater system to ultimately discharge within Sandy Brook.

The fact that there is more baseflow to the lower reach of the stream than to the upper reach within the study area is due primarily to the type of deposits underlying the stream in the two respective areas. In the upper portion of the stream above the Station 2, the stream is underlain by the fine-grained deposits of the Presumpscot Formation In the lower portion of the stream below Station 2, the stream is underlain by the coarser sand and gravel deposits of the lower aquifer.

The upper portion of the stream is almost entirely underlain by fine-grained Presumpscot deposits until approximately Station 2. The bottom deposits of the stream change just downstream from the culvert underlying the access road to a gravel bottom. An associated drop in stream elevation occurs in this same location. The drop in stream elevation coupled with the sudden change in bottom type creates a preferential window for groundwater discharge to the stream. This window extends to the vicinity of the seep area located downgradient from the landfill. The bottom material of the stream then changes again to a more silty, fine-grained sediment type. Several changes in bottom type similar to those mentioned above occur along the lower reach of Sandy Brook below Station 2. These "windows" provide opportunities for greater discharge to Sandy Brook by groundwater.

The mixing of groundwater from the toe of Landfill Areas 3 and 4 with streamflow in Sandy Brook results in lower chemical concentrations in the surface water than in the discharging groundwater. The concentration of a contaminant in surface water will be a function of the concentration of the contaminant in the influent groundwater, the quantity of influent groundwater, the influent concentration of the contaminant in the surface water, and the surface water discharge at the point of groundwater discharge. Calculations using stream discharges measured by the USGS indicate that groundwater discharge from the plume represents about five percent of total streamflow at high flow conditions and about 39 percent of total streamflow

at low flow conditions (see Appendix B-3). Consequently, at high flow, concentrations of inorganic chemicals in surface water downstream of the plume discharge should be about five percent of the concentrations in the discharging groundwater, assuming that influent surface water has a unit concentration.

Calculations were made to evaluate the effect of various influent groundwater and surface water concentrations (Appendix B-3). These calculations show that with unit arsenic and manganese concentrations in influent surface water, when groundwater concentrations are reduced to a maximum of 50 μg/L for arsenic (average plume concentration 14.6 μg/L) and 2,875 μg/L for manganese (average plume concentration 196 μg/L), concentrations in surface water at the groundwater discharge area are expected to be below the PQL of 8 μg/L for arsenic and to be 76 μg/L or less for manganese. Using background concentrations for arsenic and manganese as influent surface water concentrations, surface water concentrations downstream of the groundwater discharge area are calculated to be at the PQL of 8 μg/L for arsenic and to be 1545 μg/L or less for manganese.

# 5.0 GROUNDWATER MODEL

The objective of the groundwater model is to evaluate remedial alternatives for the feasibility study, to understand the distribution of arsenic within the flow system and its impact on Sandy Brook, and to determine the flushing rate and travel times of groundwater through different parts of the flow system. The groundwater model development included the following:

- Development of a conceptual model of the aquifer conditions including simplifying assumptions necessary to construct the model,
- Selection of a numerical model.
- Model design and development including: grid, flow parameters, initial conditions, boundary conditions, and hydrologic stresses.
- Calibration, verification, and sensitivity analysis of the model by approximating field measured heads and stream discharge.
- Analysis of flow system.

## 5.1 CONCEPTUAL MODEL OF FLOW SYSTEM

The conceptual model of the flow system is generally characterized based on the geology, groundwater flow, aquifer parameters (hydraulic conductivity, storage, thickness, etc.), the interaction of groundwater with surface water, and the boundaries of the flow domain.

### 5.1.1 Geology

The geology, stratigraphy, and depositional environment at the Saco Municipal Landfill is based on work completed by the USGS (1995) and W&C (1998). Stratified glacial deposits consisting of glacial till, coarse-grained glaciomarine deposits, and fine-grained glaciomarine deposits are positioned over bedrock at the SML site. The geology is typical of glaciomarine depositional environments. Glaciomarine sediments were deposited along glacial margins where glaciers were in contact with marine waters.

The upper portion of the sediments is generally the fine-grained silts and clays of the Presumpscot Formation The fine-grained silts and clays are present east of Sandy Brook and are generally absent west of Sandy Brook. The Presumpscot Formation is the upper most sequence of sediments modeled at the SML. The upper fine sand facies of the Presumpscot Formation was not modeled because the layer is thin, isolated from the lower aquifer by the less-permeable silt and clay facies, and does not produce useable quantities of water. The Presumpscot Formation underlies Sandy Brook above USGS stream gauging Station 2. Below this station, the Presumpscot Formation is intermittently present. The Presumpscot Formation has been eroded in some locations exposing windows to the lower coarser-grained sand and gravel of the underlying layer.

The course-grained glaciofluvial sediments are referred to as the "lower aquifer" because they are stratigraphically below the fine-grained sediments of the Presumpscot Formation The term "lower aquifer" is still used for the course-grained unit over the entire study area despite the general absence of the Presumpscot Formation west of Sandy Brook. These deposits are the most significant water bearing zone at SML. These deposits are interpreted to have an upper and lower member corresponding to distal and proximal fan deposits respectively. The upper member of this unit consists of finer sands and little gravel while the lower member consists of coarse sands and gravel. Locally present within the sand and gravel aquifer are clay lenses. Seeps are present where the clay lenses become exposed at the surface.

Beneath the "lower aquifer", a till layer mantles the bedrock surface. The glacial till deposits consist of an unsorted mixture of clay, silt, gravel, cobbles, and frequent boulders. The abundance of fine-grained matrix material within this unit prevents the till from transmitting water in useable quantities.

Bedrock underlies the unconsolidated deposits at the site. The bedrock geology of the Saco Landfill region has been mapped by Hussey (USGS, 1995). The primary bedrock type is described as a metasedimentary hornfels belonging to the Cape Elizabeth Formation (USGS, 1995). The majority of fractures within the bedrock occur in the upper 20 feet of the rock and produce the greatest quantities of water (W&C, 1998). Additionally, flow measured in bedrock

boreholes was upward indicating upward movement of groundwater in the bedrock (W&C, 1998).

A site plan showing the locations of cross-sections A-A' and B-B' is given in Figure 5-1. Cross-section A-A' shows the stratigraphy from Area 4 across Sandy Brook and into Areas 1 and 2. Cross-section B-B' depicts the stratigraphy from Area 4 east across Sandy Brook to just south of the borrow area.

The cross-section A-A'( Figure 5-2) shows the thick silt and clay deposits as a wedge of sediment that is thin beneath Sandy Brook and thickens to the northeast. This facies is absent west of the brook. The silts and clays are underlain by the coarse-grained glaciomarine deposits of the lower aquifer. Glacial till underlies the lower aquifer; it pinches out to the west atop the bedrock high upon which the Area 4 is situated and thickens to the east.

Cross-section B-B'(Figure 5-3) depicts the stratigraphy from Area 4 across Sandy Brook to south of the borrow area. The stratigraphy is the same as that depicted in cross-section A-A'. The glacial till underlying the lower aquifer is present as a thin mantle overlying the bedrock. The glacial till is interpreted to be locally absent beneath the landfill. The coarse-grained deposits of the lower aquifer are interpreted to pinch out locally beneath the Area 4, thicken to the east after passing beneath Sandy Brook and then thin again beneath the silt and clay deposits to the east. The silt and clay is present as a wedge beneath Sandy Brook that thickens to the east.

The base of the lower aquifer is defined by the contoured top of till and bedrock. The top of till and bedrock are based on drilling results (W&C, 1998, and USGS, 1995) and seismic refraction experiments completed by the USGS (1995). The top of the lower aquifer east of Sandy Brook is defined by the base of the silts and clays of the Presumpscot Formation based on drilling results by the USGS (1995) and W&C (1998). West of Sandy Brook the top of the lower aquifer is either the ground surface or the interpreted base of the landfill.

### 5.1.2 Groundwater Flow

The non-stressed regional potentiometric surface map presented as Figure 2-3 is representative of the long-term average.. The potentiometric contours, all relative to sea-level,

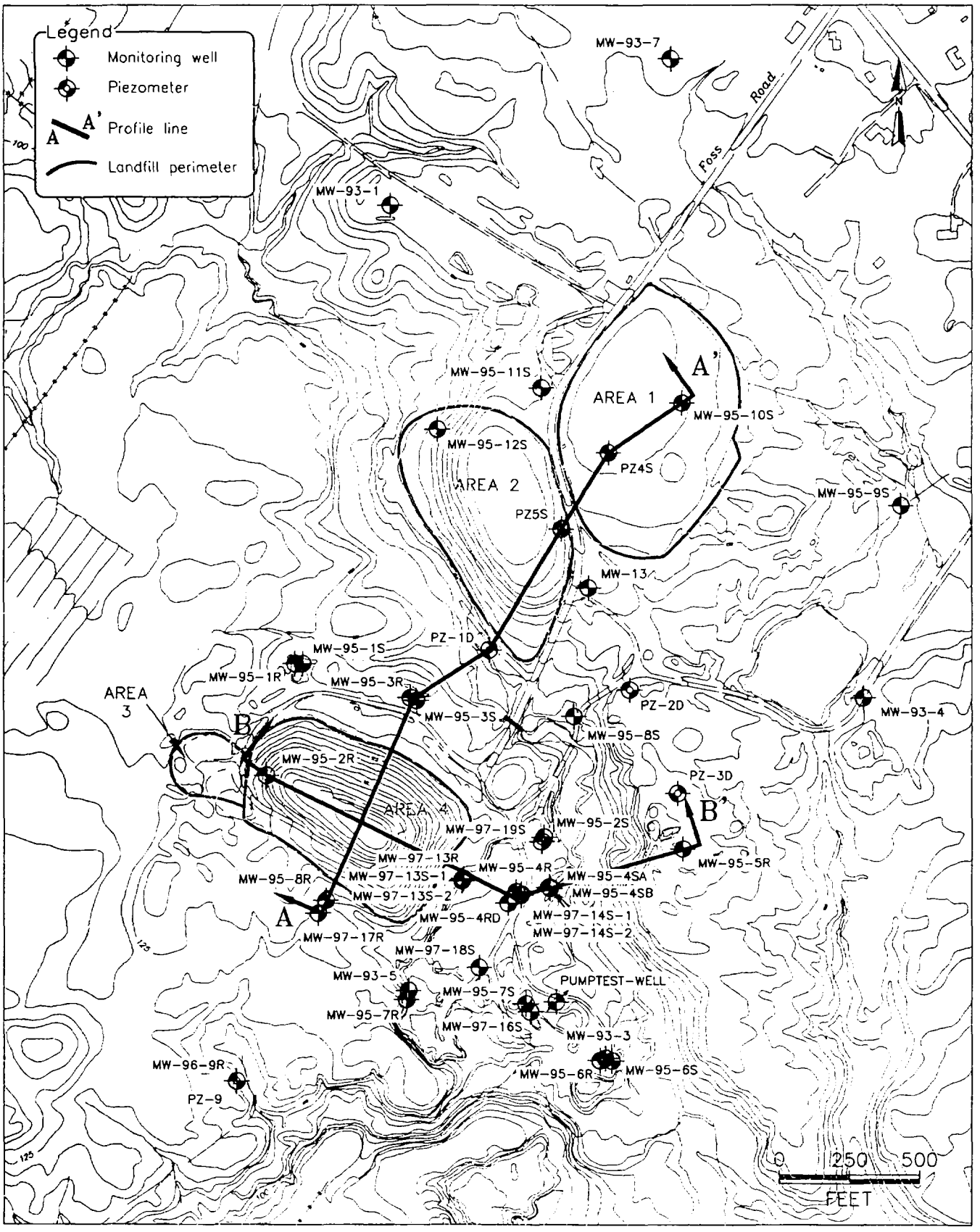


Figure 5-1
Location of Geologic Profiles
Hydrogeological Investigation Report
Saco Municipal Landfill
Saco, Maine

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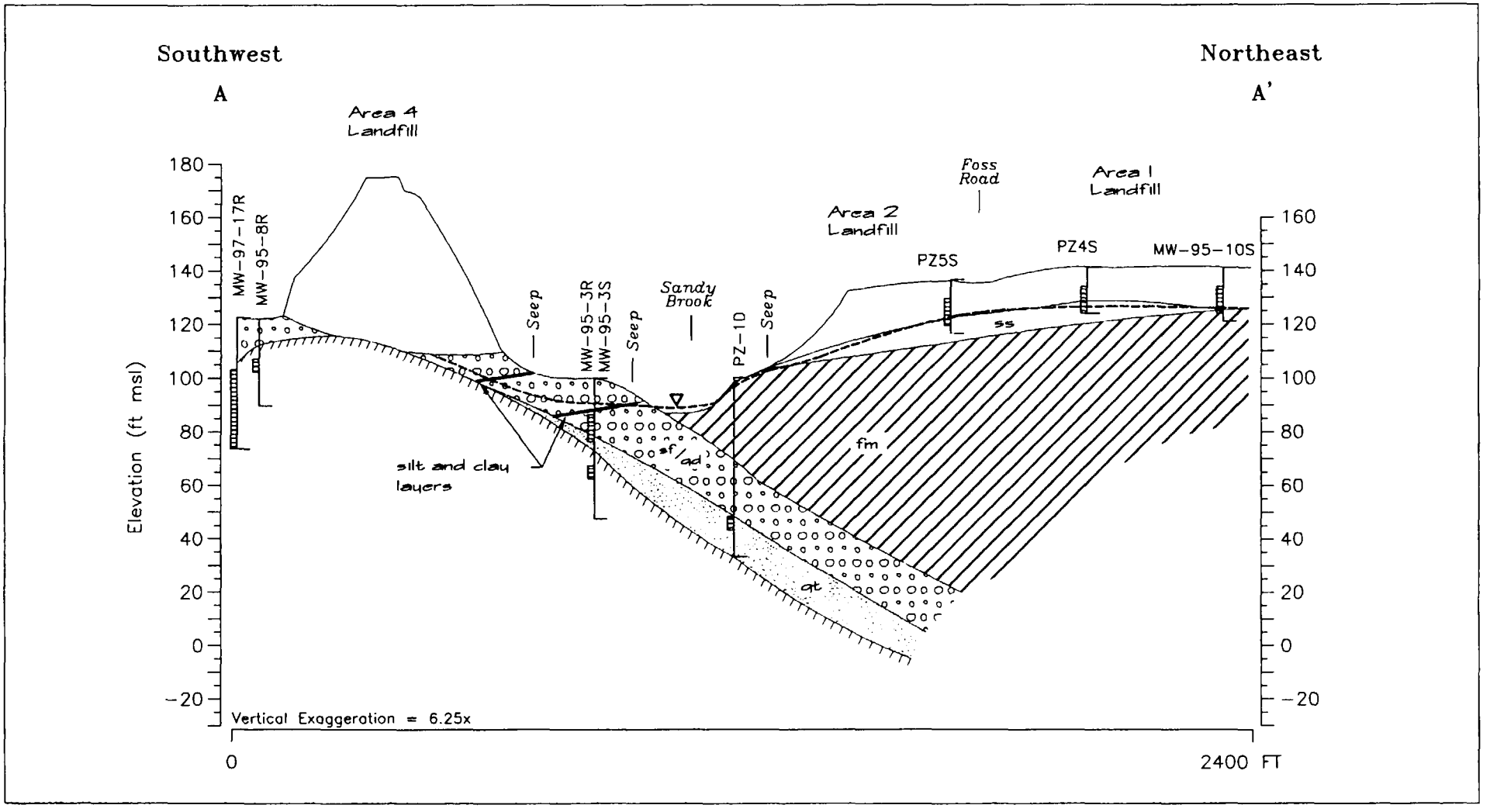


| | | | |
|---|---|---|---|
| | Fill | | Bedrock |
| ss | Marine sand facies | | Water table (January 1996) |
| fm | Silt-clay facies | | Monitoring well or piezometer |
| sf/gd | Coarse-grained glacio-marine deposits | | |
| gt | Glacial till | | |

**Figure 5-2**
**Geologic Cross Section A-A'**
**Hydrogeological Investigation Report**
**Saco Municipal Landfill**
**Saco, Maine**

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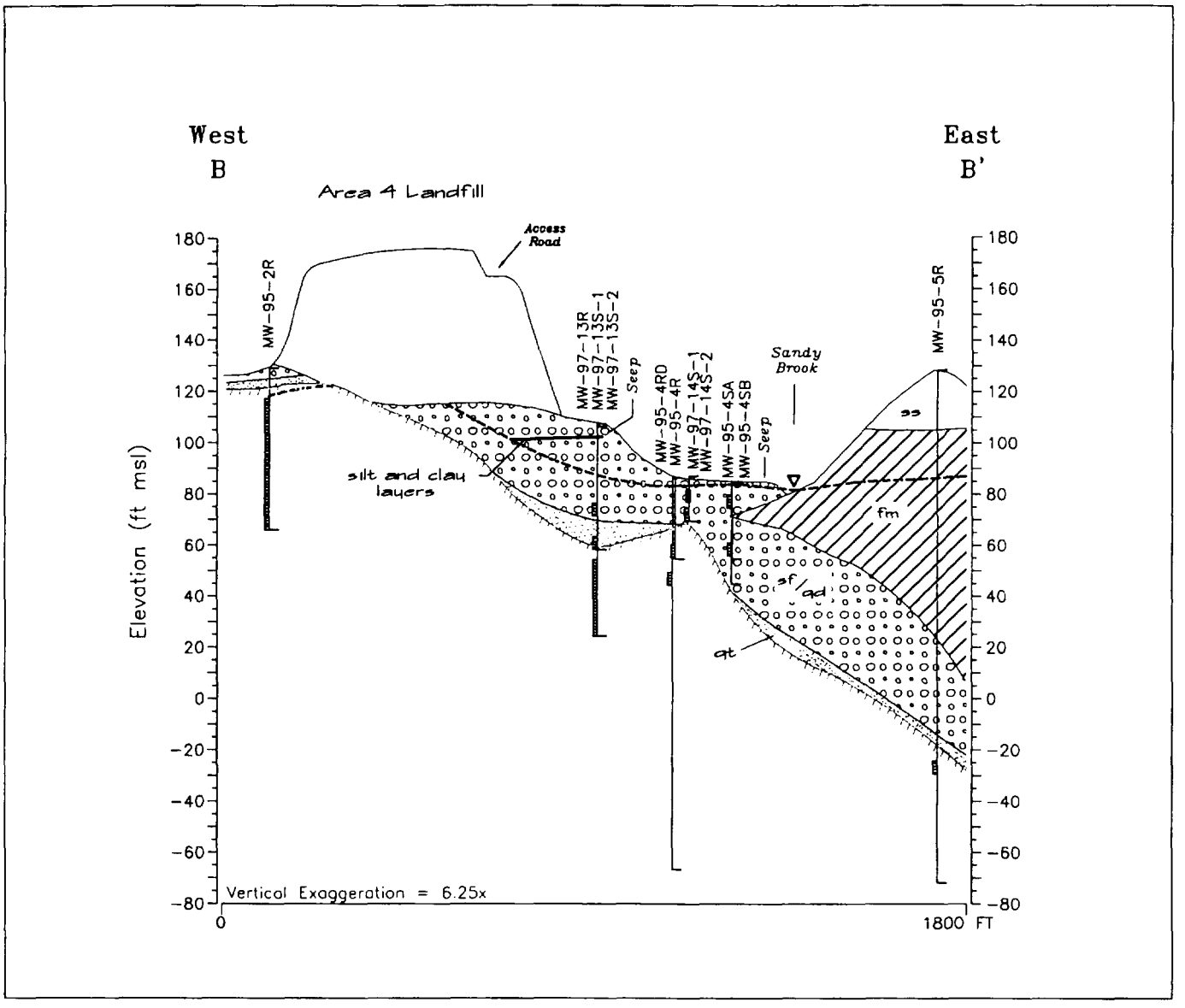


| | | |
|---|---|---|
| | | Fill |
| | ss | Marine sand facies |
| | fm | Silt-clay facies |
| | sf/gd | Coarse-grained glaciomarine deposits |
| | gt | Glacial till |
| | | Bedrock |
| | | Water table (January 1996) |
| | | Monitoring well or piezometer |

Figure 5-3
Geologic Cross Section B-B'
Hydrogeological Investigation Report
Saco Municipal Landfill
Saco, Maine

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9810028.dwg/95093/lgt

represent static water level elevations in wells and at points where topographic contours cross swamps and streams.

The configuration of the potentiometric surface indicates that Sandy Brook is a gaining stream, a conclusion that is supported by stream discharge measurements by the USGS (1995). The primary source of recharge to the aquifer is the portion of recharge that reaches the water table of the aquifer, i.e., the portion not removed by evapotranspiration, specific retention, or surface water runoff. A secondary source of recharge after large storm events is the sedimentation basin located at the toe of the landfill, into which runoff from rain events is directed.

The direction of groundwater flow, perpendicular to inferred groundwater contours, is from areas of recharge to areas of discharge. In general, the groundwater contours indicate flow is radially away from Area 4 and then is diverted toward Sandy Brook. West of Sandy Brook the contours trend east and then south following the general direction of the stream. East of Sandy Brook flow is southwest towards the brook and then south following the direction of the stream.

### 5.1.3 Aquifer Characteristics

Aquifer characteristics are based upon analysis of pumping test data. The pumping test data were analyzed using a variety of curve-matching techniques. Similar results were provided by many of the techniques including the Cooper-Jacob straight line fitting technique and the Neuman curve matching technique. For the most part, the Cooper-Jacob method appeared to give the best estimate of the average aquifer properties. The average value for transmissivity and hydraulic conductivity are 14,390 sq. ft./day and 310 ft./day respectively.

## 5.2 NUMERICAL MODEL SELECTION

MODFLOW was selected for aquifer simulation. Documentation of MODFLOW is described by McDonald and Harbaugh (1988).

The code, or computer program, solves a set of algebraic equations generated by approximating the partial differential equations (governing equation, boundary conditions, and initial

conditions) that form the mathematical model. The finite difference technique transforms the mathematical model into a matrix equation that can be solved efficiently by a computer. The strongly implicit procedure (SIP) was selected to solve the matrix equation in MODFLOW. Finite difference methods compute the potentiometric head at the center of each grid block (node). The location of each node is identified in MODFLOW with i,j,k notation, where i represents the column, j the row, and k, the layer. The equation for the head at node i,j,k includes the head at the node itself as well as the heads at the six surrounding nodes.

The modeling approach was to develop the model to be a reasonable representation of the major physical and hydraulic features of the flow system based on existing hydrogeologic data from reports and field measurements.

## 5.3 MODEL DESIGN AND DEVELOPMENT

The conceptual model was developed and incorporated into a numerical model of groundwater flow at the site. The development of the numerical model included the design of the following: the model grid and layer construction, boundary conditions, model parameter assignment, recharge, river nodes, and storage coefficients.

### 5.3.1 Model Grid and Layer Construction

The grid in the model is defined by a set of 105 rows in the y direction (following the Cartesian coordinate system), 108 columns in the x direction, and 4 layers in the z direction. Figure 5-4 shows the model grid and boundaries superimposed on a map of the site. The area between adjacent rows and columns is defined as a cell. Each cell has uniform dimensions of 25 feet between rows and 25 feet between columns. The uniform spacing of 25 feet was adequate to represent the changes in each of the layers while maintaining model stability. Nodes where potentiometric head is to be calculated, are centered in each cell (the block centered formulation of the finite difference equation was used in MODFLOW). The grid was rotated 45 degrees east of

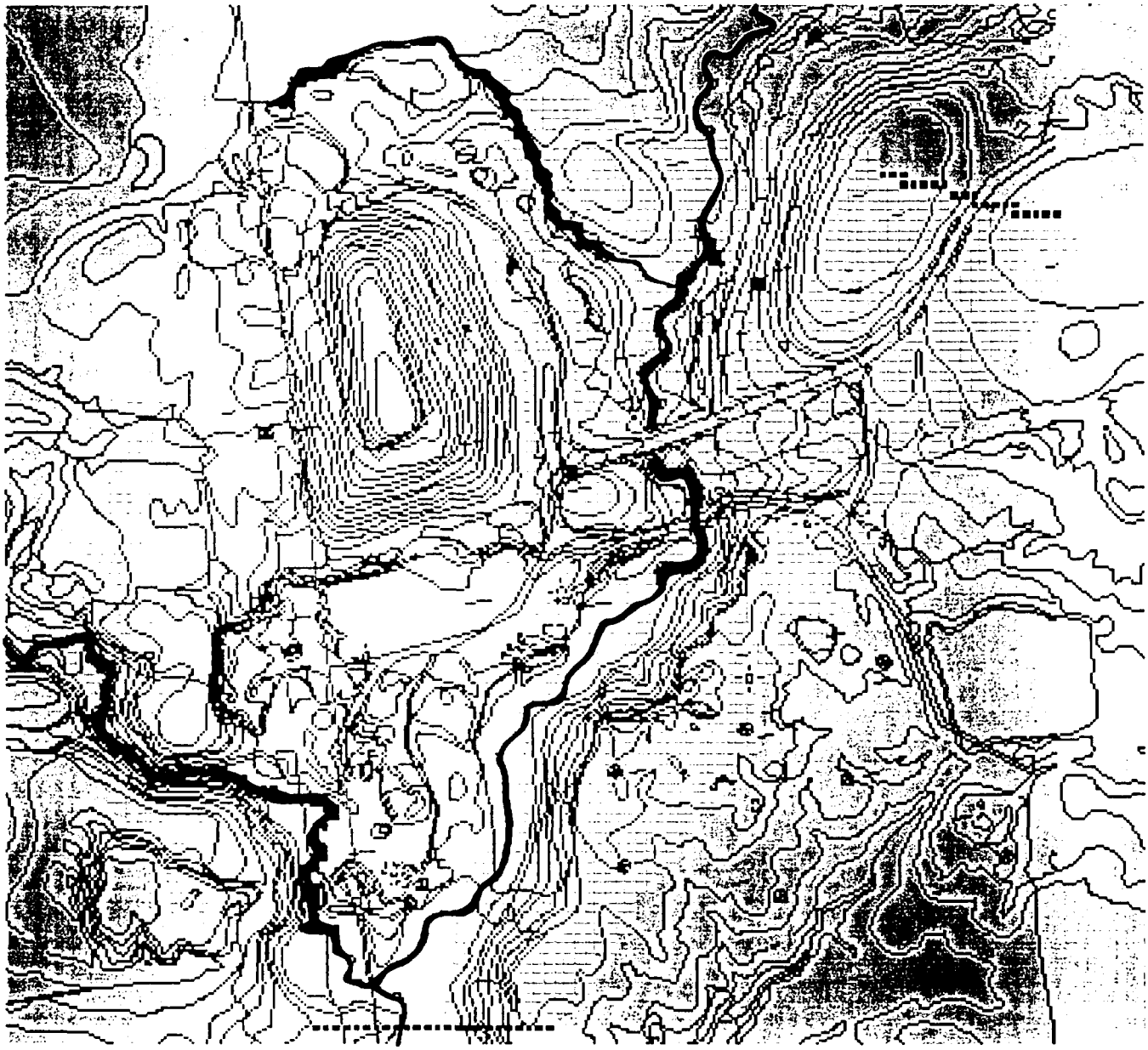

Figure 5-4
Groundwater Model Grid and Boundary Conditions
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Saco, Maine

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95093.06\gwgrid

north and aligned to the extent possible with Sandy Brook. The grid was extended to aquifer boundaries to the east and west. The northern portion of the grid was placed such that it encompassed all of Areas 3 and 4 and the southern half of Areas 1 and 2. The southern boundary of the grid was placed just below the confluence of Sandy Brook and Big Ledge Brook.

Four layers were necessary to simulate the hydrostratigraphic units present in the study area. The upper layer (Layer 1), the fine silts and clays of the Presumpscot Formation, is present east of Sandy Brook and acts as a confining layer where present. The next layer (Layer 2) is representative of the glaciomarine proximal fan deposits making up the major aquifer in the study area. The third layer included in the model was the basal till draping the bedrock surface. The top 20 feet of bedrock was modeled as the fourth layer.

Layers were designed based on boring data from the site. Elevations of the respective hydrostratigraphic layers from the boreholes were submitted to a geostatistical analysis using kriging to produce a surface for each layer. The surfaces for each layer were imported into the model domain and thicknesses were verified against borehole data.

### 5.3.2 Boundary Conditions

The boundary conditions for the model were based on landfill conditions prior to capping. No-flow boundaries, river boundaries, and constant head boundaries were included in this model. A discussion of the individual boundaries is presented below.

The no-flow boundaries selected for the site are shown on Figure 5-4. No-flow boundaries correspond to areas parallel to flow lines. Constant head boundaries were utilized in this model to represent areas where groundwater either enters or is released from the model. Constant head boundaries were placed in active nodes in the northeast corner of the grid to represent groundwater flow under a regional gradient from the northeast and to allow water to enter the model. A second constant head boundary was placed in active nodes along the southern model boundary to remove water from the model. The boundary conditions were selected based on groundwater flow conditions prior to capping the landfill.

The river boundaries simulate the action of rivers or streams and their interactions with the groundwater flow system.

Figure 5-4 shows the types, numbers, and locations of boundary conditions made use of in the SML groundwater model. Constant head boundaries are shown in the northeastern and southern portion of the model. Groundwater is allowed to flow into the model in the northeast and is released from the model in the south. Sandy Brook, Big Ledge Brook and a small intermittent stream north of Areas 3 and 4 have been modeled as river boundary conditions. The no-flow boundary conditions are located on the eastern, western, and northwestern borders of the modeled area (see Figure 5-4). These boundaries are no-flow boundaries because groundwater flow appears to be parallel to these boundaries such that there is no flow of water into or out of the model in relation to these boundaries.

### 5.3.3 Model Parameters

Hydraulic conductivities were assigned as five major zones. Horizontal hydraulic conductivity ($K_h$) and vertical hydraulic conductivity ($K_v$) were assigned with differing values to represent formation anisotropy. The hydraulic conductivity in the model was equal in both the x and y directions.

**Zone 1** (high K) was assigned a K value of 300 ft/day determined from the pumping test. The assigned hydraulic conductivity was conservative given the range of hydraulic conductivities from 183 to 481 ft./day. Zone 1 corresponds to portions of the lower sand and gravel deposits (i.e. proximal fan deposits).

**Zone 2** (low K) was assigned a K value of 0.283 ft/day was assigned to the till deposits. Zone 2 corresponds to the till deposits. The value of 0.283 ft/day for the till falls at the upper limit of the range of values for hydraulic conductivity of till (Freeze and Cherry, 1979).

**Zone 3** (low K) corresponds to the upper 20 feet of bedrock. Zone 3 was assigned a K value of 0.4 ft/day, within the measured range of 2.83 $x10^{-3}$ to 2.83 ft./day. The 0.4 ft./day value assigned is slightly higher than that calculated by the USGS. The sensitivity analysis showed that the model is not that sensitive to the value of hydraulic conductivity assigned to the bedrock.

**Zone 4** (intermediate K) was assigned a value of 36 ft/day for $K_h$ and 20 ft/day for $K_v$. These values for Zone 4 were assigned to represent a finer grained member of the lower aquifer. The finer grained member of the coarse-grained glaciomarine sediments is present around the periphery of the landfill. The finer grained sediments correspond to the sand facies of glaciomarine distal fan deposits (USGS, 1995).

**Zone 5** (low K) was assigned a value of 1.5 ft./day for $K_h$ and 20 ft./day for $K_v$. The values for Zone 5 were assigned to represent trash materials within the landfill. Hydraulic conductivities within trash materials are expected to be highly variable depending upon nature of materials, degree of compaction, and percentage of interconnected void spaces.

### 5.3.4 Recharge

The MODFLOW recharge package was used to simulate aerial recharge from precipitation to all active nodes in the highest active layer. Estimates of annual recharge to aquifers for this region are approximately 18 to 20 in./yr. (USGS, 1995). An annual recharge rate of 18 in./yr. was used in this model.

### 5.3.5 River Nodes

Sandy Brook, Big Ledge Brook, and the small intermittent stream were modeled using the MODFLOW river package. The river package requires the input of the stage, vertical hydraulic conductivity of the river bed, and the elevation of the river bed for each cell of the model occupied by the river. The stage elevation was assigned based on a survey of Sandy Brook tied to known elevations at the site. During the course of this survey, bottom type was also noted for later incorporation into the model.

The base of Sandy Brook was assumed to be 4 feet below the stage which accounted for variability in stage and stream bed thickness. Sandy Brook was assigned a width of 25 feet, a vertical hydraulic conductivity ranging from 2.83 to 30 ft/day, and a bed thickness of 3 feet The range in conductivities assigned to the stream was based on visual observations of the stream

bottom (refer to Section 4.7) and using published values for earth materials (Freeze and Cherry, 1979).

The base of Big Ledge Brook was assumed to be 4feet below the stage which accounted for variability in stage and stream bed thickness. Big Ledge Brook was assigned a width of 25 feet, a vertical hydraulic conductivity of 3 ft/day, and a bed thickness of 3 feet

The base of the small, intermittent stream was assumed to be 1 feet below the stage which accounted for variability in stage and stream bed thickness. This small stream was assigned a width of 10 feet, a vertical hydraulic conductivity of 1 ft/day, and a bed thickness of 1 feet

### 5.3.6 Storage Coefficients

The transient portion of the model required the assignment of storativity or specific yield to the layers within the model. These values were assigned based on pumping test analyses and published values for these parameters (Freeze and Cherry, 1979). Sands and clays were assigned a value of 0.03 for storativity, 0.15 for specific yield, and 0.30 for porosity. Till was assigned a value of 0.01 for storativity, 0.01 for specific yield, and 0.25 for porosity. Bedrock was assigned values of 0.001, 0.001, and 0.001 respectively for storativity, specific yield, and porosity.

## 5.4 MODEL CALIBRATION AND VERIFICATION

The steady-state groundwater flow model was considered calibrated based on the following criteria:

- the potentiometric surface simulated by the steady state model approximated the non-stressed potentiometric surface map as determined by the computation of calibration statistics that indicated that all modeled head values were sufficiently close to measured head values and ,
- the flow of groundwater leaving the model via the river was reasonable based on stream discharge records.

Calibration targets were imported into *Groundwater Vistas* (a graphical user interface for MODFLOW) for computation of calibration statistics based on field-measured potentiometric heads. The calibration targets consisted of head measurements in 21 wells widely-spaced throughout the model domain. Water levels in selected wells at Saco Landfill fluctuated as much as 6.15 feet based on historical head measurements.

*GroundwaterVistas* was used to compute the calibration statistics for the model. The calibration statistics consisted of the residual, which is the difference between the target head and the model head; the residual mean; residual standard deviation; residual sum of squares; the absolute residual mean; the minimum and maximum residual; the observed range in head; and the residual standard deviation divided by the range. In a good calibration, the residual mean should be close to zero indicating that the model is not overly biased in either the positive or negative direction. The residual standard deviation provides an indication of the spread of the residuals and should be as low as possible. For a good calibration, the residual standard deviation should vary much less than the total change in head across the model, perhaps 10 to 15 percent. The absolute residual mean (ARM) is calculated by averaging the absolute value of the residuals, with the objective in calibration to minimize this value. Groundwater Vistas also posts residuals on the head contour map for evaluation of the spatial bias in the residuals. A calibration was considered acceptable when the calibration statistics indicated that:

- Spatial bias was minimized;
- Absolute residual mean was minimized;
- Residual standard deviation was within the standard deviation of 5.80 feet of the calibration target heads;
- Residual mean was close to zero; and,
- Residual standard deviation divided by the range was less than 15 percent of the total head change across the model.

To calibrate the model, four stress periods equal to 3 months each in 1993 were set up with 50 % of the actual precipitation allowed to recharge the flow system. Calibration of the model was

done by adjusting the input parameters (recharge, hydraulic conductivity), one at a time, within reasonable ranges based on site-specific and textbook values. The steady-state groundwater flow model was considered calibrated when the potentiometric surface simulated by MODFLOW was a reasonable, close approximation of the non-stressed regional potentiometric surface; when the calibration statistics indicated a good calibration; and when the volume of water leaving the model through Sandy Brook compared favorably to stream discharge measurements at the three gauging stations on Sandy Brook. The period chosen for calibration was the three-month period ending in the end of August. This was chosen because precipitation data suggested that all flow in Sandy Brook was base flow derived from groundwater flow discharging to Sandy Brook.

The model was verified by transient simulation. The transient simulation consisted of two stress periods. The first stress period was for 10,000 days with the pumping well inactive. The second stress period was 3 days of pumping the pumping well at 209 gpm. The stress periods selected simulate the conditions before and during the pumping test conducted at Saco Landfill. The model was considered verified when predicted hydraulic head values at selected well locations simulated the non-stressed and stressed hydraulic head values as observed in the field. The statistics are presented in Table 3.

## 5.5 ANALYSIS OF SYSTEM

After model calibration and verification, the groundwater model was developed as a transient model with four different stress periods. The first stress period was 10,000 days long and was utilized to simulate steady state conditions prior to capping the landfill. The average recharge used for this simulation was 18 inches/year (USGS, 1995). The second stress period was 365 days long and was used to simulate one year of capped landfill conditions. The recharge that fell on the landfill area was removed and redirected downgradient of the landfill to the gravel pit area to simulate the capped conditions. The third stress period was also 365 days long and simulated the groundwater conditions after 2 years of the cap being in place. The recharge conditions were the same as the second stress period. The final stress period was 2,920 days long and simulated the groundwater conditions 10 years after the completion of the cap.

Each stress period that was modeled produced a contour map of groundwater conditions at the end of the stress period. The contour maps were compared to determine the effect of the cap on

Table 3: Observed vs. Modeled Heads for SML Model

| Name | Time | Layer | Observed | Computed | Residual |
|---|---|---|---|---|---|
| MW-93-3 | 10000 | 2 | 83.4 | 83.16 | 0.24 |
| MW-93-3 | 10003 | 2 | 82.96 | 82.81 | 0.15 |
| MW-93-5 | 10000 | 2 | 83.8 | 83.65 | 0.15 |
| MW-93-5 | 10003 | 2 | 82.98 | 83.09 | -0.11 |
| MW-95-4R | 10000 | 4 | 83.51 | 83.92 | -0.41 |
| MW-95-4R | 10003 | 4 | 82.85 | 83.68 | -0.83 |
| MW-95-4RD | 10000 | 4 | 83.54 | 83.88 | -0.34 |
| MW-95-4RD | 10003 | 4 | 82.81 | 83.65 | -0.84 |
| MW-95-4SA | 10000 | 2 | 83.38 | 83.80 | -0.42 |
| MW-95-4SA | 10003 | 2 | 82.68 | 83.32 | -0.64 |
| MW-95-4SB | 10000 | 2 | 83.33 | 83.77 | -0.44 |
| MW-95-4SB | 10003 | 2 | 82.66 | 83.28 | -0.62 |
| MW-95-5R | 10000 | 4 | 83.46 | 83.97 | -0.51 |
| MW-95-5R | 10003 | 4 | 82.97 | 83.88 | -0.91 |
| MW-95-6R | 10000 | 4 | 83.41 | 83.37 | 0.04 |
| MW-95-6R | 10003 | 4 | 82.97 | 83.29 | -0.32 |
| MW-95-6S | 10000 | 2 | 83.33 | 83.15 | 0.18 |
| MW-95-6S | 10003 | 2 | 82.9 | 82.82 | 0.08 |
| MW-95-7R | 10000 | 4 | 83.92 | 85.04 | -1.12 |
| MW-95-7R | 10003 | 4 | 83.41 | 84.95 | -1.54 |
| MW-95-7S | 10000 | 2 | 83.26 | 83.39 | -0.13 |
| MW-95-7S | 10003 | 2 | 81.53 | 82.56 | -1.03 |
| MW-95-8R | 10000 | 4 | 110.66 | 112.55 | -1.89 |
| MW-95-8R | 10003 | 4 | 109.08 | 112.50 | -3.42 |
| MW-95-8S | 10000 | 2 | 82.87 | 85.46 | -2.59 |
| MW-95-8S | 10003 | 2 | 82.6 | 85.32 | -2.72 |
| PZ-2D | 10000 | 2 | 83.13 | 85.68 | -2.55 |
| PZ-2D | 10003 | 2 | 82.8 | 85.55 | -2.75 |
| PZ-3D | 10000 | 2 | 83.09 | 84.66 | -1.57 |
| PZ-3D | 10003 | 2 | 82.87 | 84.48 | -1.61 |
| MW-97-13S-1 | 10000 | 3 | 83.75 | 85.26 | -1.51 |
| MW-97-13S-1 | 10003 | 3 | 83.03 | 85.06 | -2.03 |
| MW-97-14S-1 | 10000 | 2 | 83.53 | 83.75 | -0.22 |
| MW-97-14S-1 | 10003 | 2 | 82.75 | 83.18 | -0.43 |
| MW-97-14S-2 | 10000 | 2 | 83.63 | 83.77 | -0.14 |
| MW-97-14S-2 | 10003 | 2 | 82.79 | 83.20 | -0.41 |
| MW-97-16S | 10000 | 2 | 83.51 | 83.36 | 0.15 |
| MW-97-16S | 10003 | 2 | 81.02 | 82.58 | -1.56 |
| MW-97-18S | 10000 | 2 | 83.41 | 83.50 | -0.09 |
| MW-97-18S | 10003 | 2 | 82.35 | 82.76 | -0.41 |
| MW-97-19S | 10000 | 2 | 84.3 | 84.27 | 0.03 |
| MW-97-19S | 10003 | 2 | 82.84 | 83.94 | -1.10 |
| | | | Residual Mean | | -0.86 |
| | | | Standard Deviation | | 5.80 |
| | | | Res. Std. Dev. | | 0.94 |
| | | | Sum of Squares | | 68.05 |
| | | | Abs. Res. Mean | | 0.91 |
| | | | Min. Residual | | -3.42 |
| | | | Max. Residual | | 0.24 |
| | | | Head Range | | 29.64 |
| | | | Head Range/Std | | 0.03 |

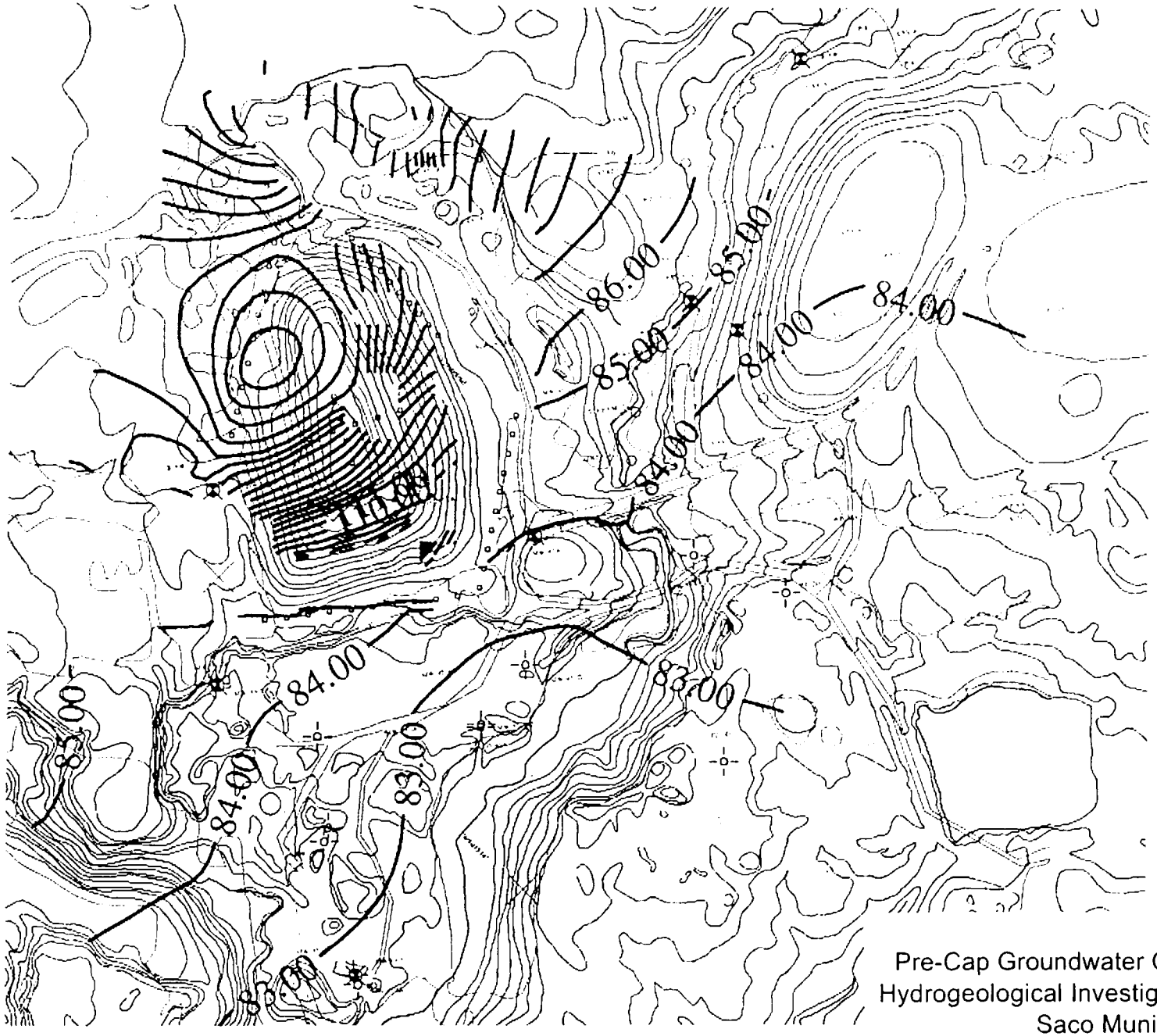


Figure 5-5
Pre-Cap Groundwater Contour Map
Hydrogeological Investigation Report
Saco Municipal Landfill
Saco, Maine

WOODARD&CURRAN

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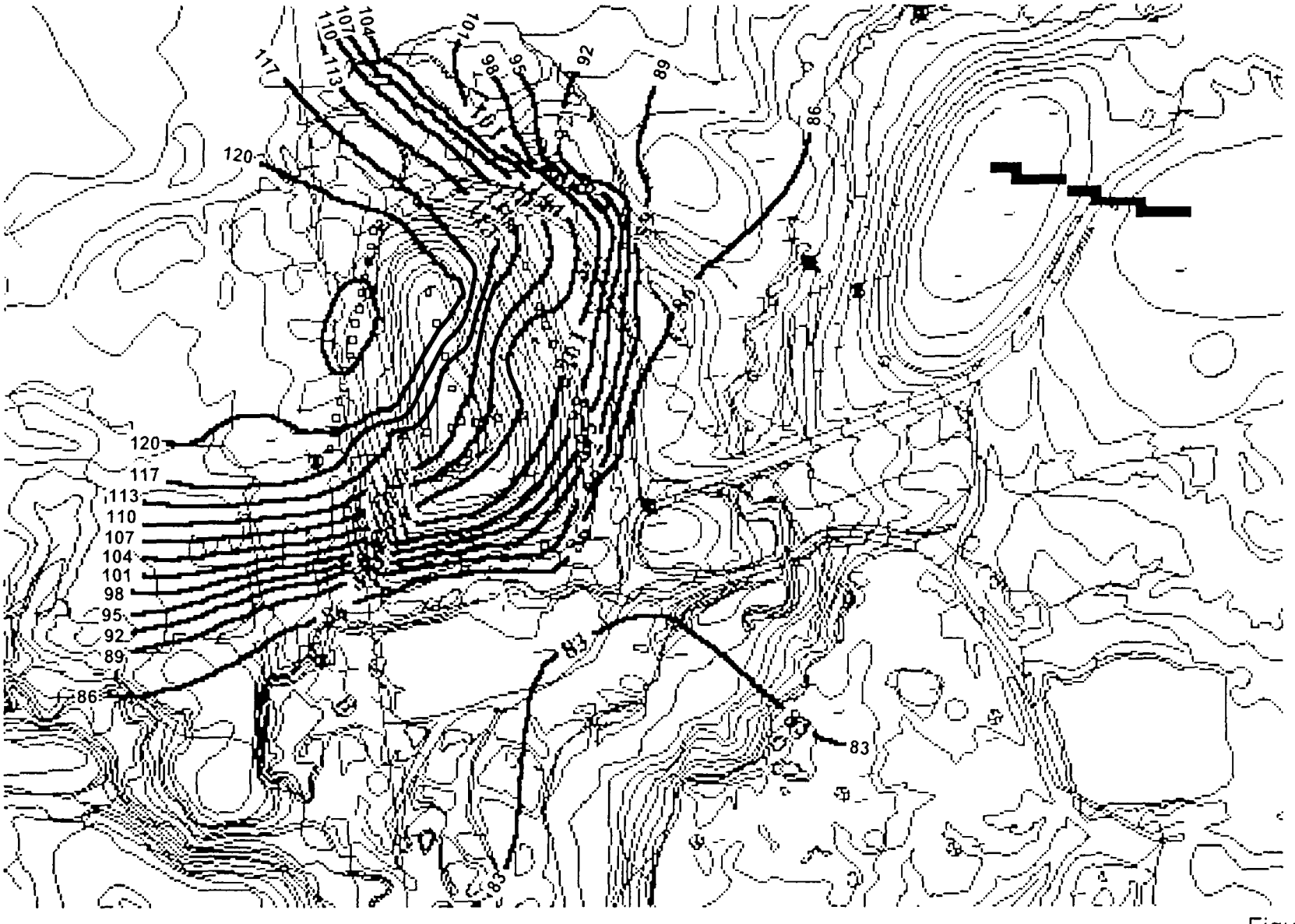


Figure 5-6
Groundwater Contour Map 1 Year Post Cap
Hydrogeological Investigation Report
Saco Municipal Landfill
Saco, Maine

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groundwater levels beneath and adjacent to the landfill. In addition to the groundwater contour maps, particle tracking was performed to determine the migration pathways for contaminants from beneath the landfill and travel times associated with those particles.

The groundwater conditions prior to capping of the landfill indicate that groundwater is at a maximum elevation beneath the landfill of 127 feet ( Figure 5-5). The potentiometric contours show a fairly rapid change beneath the landfill after the cap has been installed. Figure 5-6 demonstrates the modeled groundwater conditions at the site following one year of the cap being in place. The groundwater level beneath the landfill has fallen to approximately 122 feet

Although a rapid change in head is observed under the landfill, the head in the deeper sand and gravel deposit remain relatively unchanged. This is reasonable because the upland areas adjacent to and under the landfill have very little water in storage. Head fluctuations are relatively dramatic season to season. However, within the sand and gravel deposit huge quantities of water are in storage, buffering any change in head (the head within the sand and gravel remains relatively unchanged at approximately 83 feet above MSL). In addition, the water table is relatively flat creating a shallow, even gradient in this area.

The groundwater conditions two years after installation of the cap again shows declining groundwater levels beneath the landfill (Figure 5-7). The groundwater level is approximately 118 feet after two years of capped conditions. Once again the groundwater elevation in the gravel pit area is approximately 83 feet above MSL, indicating that the cap has little effect on groundwater conditions downgradient of the landfill.

Figure 5-8 shows the model results following ten years of capped conditions at the landfill. The groundwater level has dropped to approximately 117 feet beneath the landfill. The groundwater elevation in the sand pit remains at approximately 83 feet.

The response of water table elevations at various locations within the aquifer at SML is shown in Figure 5-9. The greatest response to capping the landfill is, as expected, seen beneath the landfill itself. The greatest decrease in groundwater elevation takes place during the first two years. There are no wells present within the landfill to confirm these modeling results. The response of the water table at the toe of the landfill shows only minor perturbations in water level, but

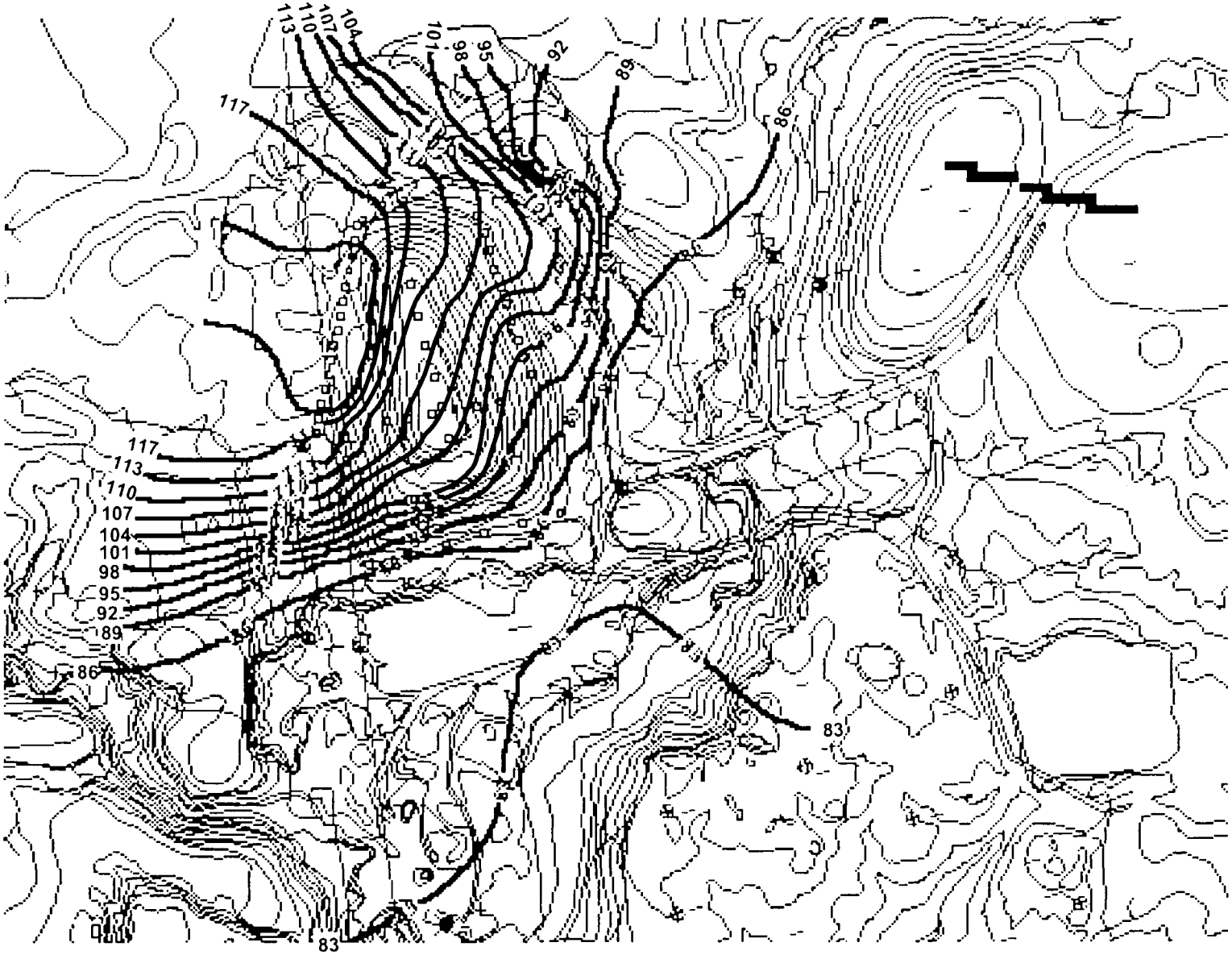


Figure 5-7
Groundwater Contour Map 2 Years Post Cap
Hydrogeological Investigation Report
Saco Municipal Landfill
Saco, Maine

WOODARD&CURRAN

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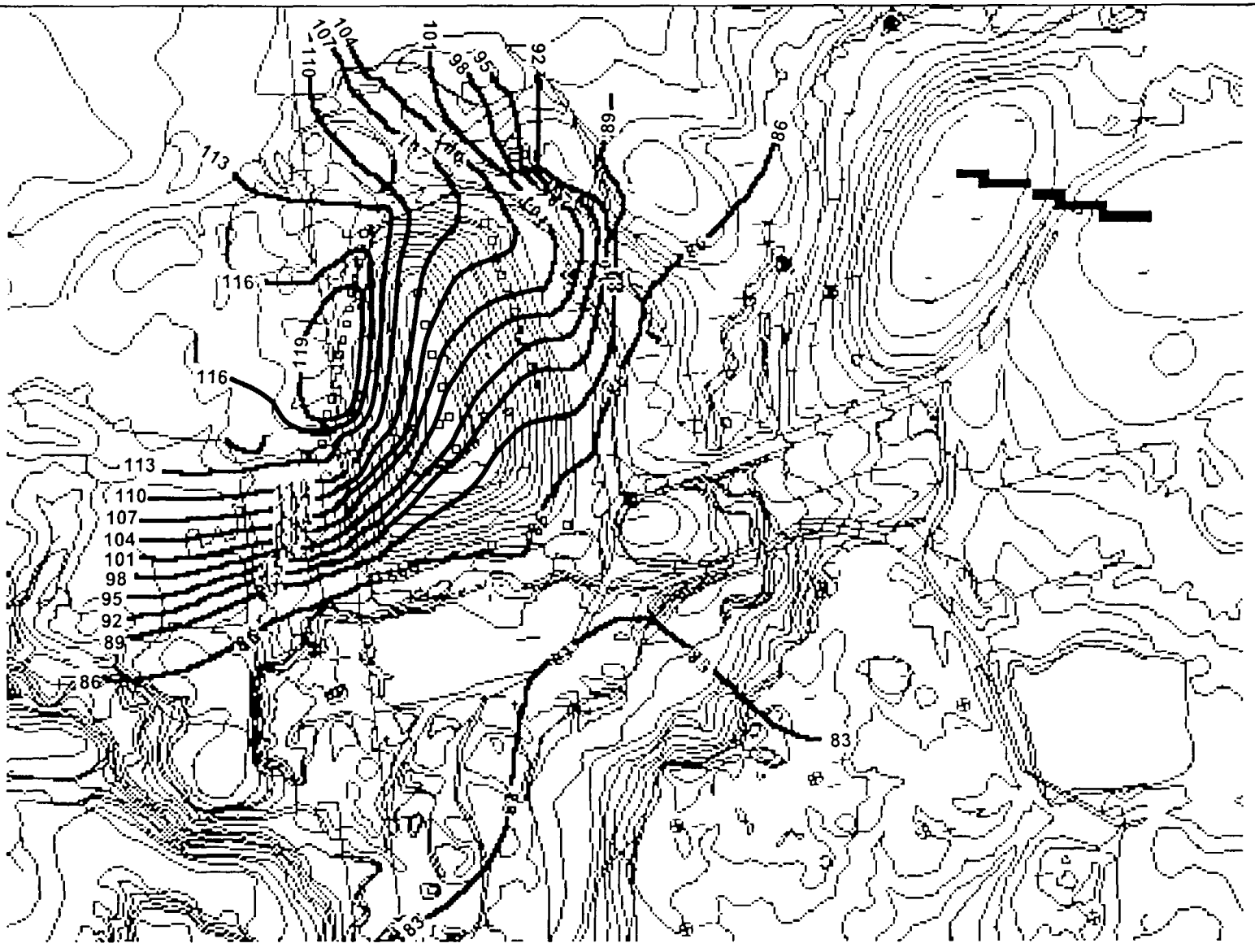


Figure 5-8
Groundwater Contour Map 10 Years Post Cap
Hydrogeological Investigation Report
Saco Municipal Landfill
Saco, Maine

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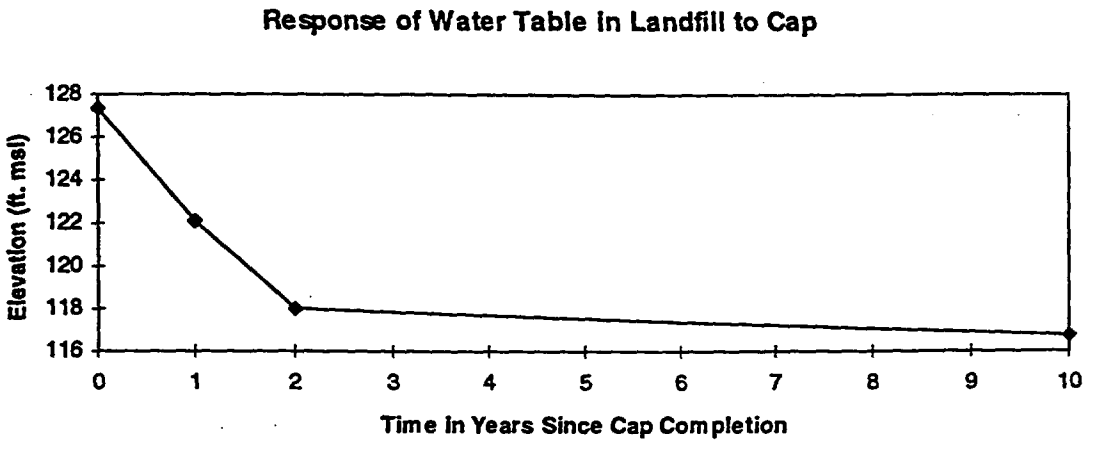


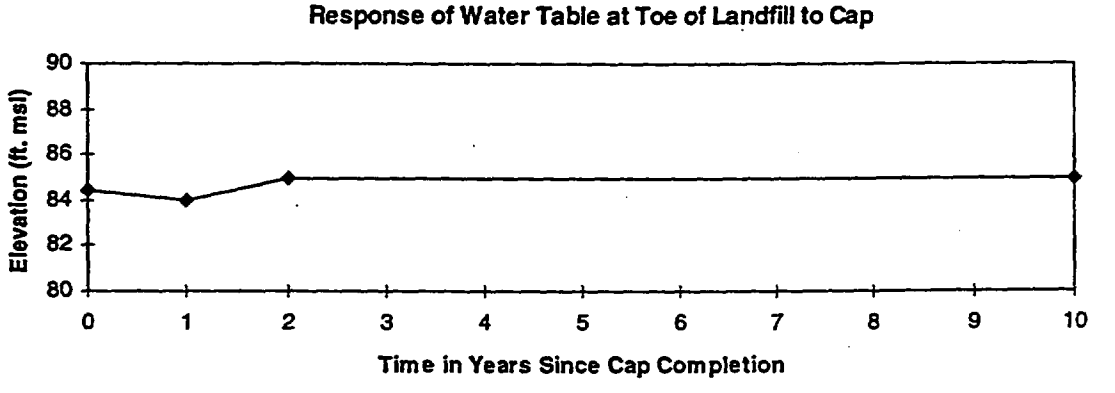


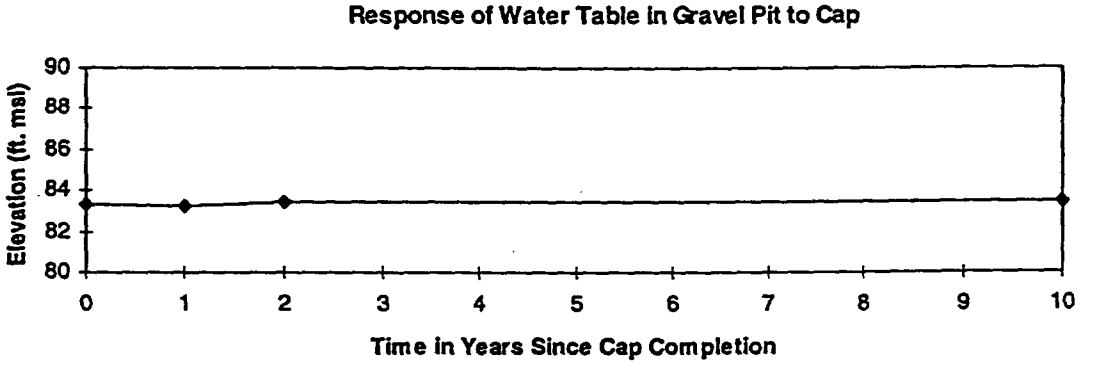


**Figure 5-9: Response of water table at various locations within aquifer to capping of landfill.**

eventually reaches equilibrium. The response of the water table in the gravel pit to the capped landfill condition is negligible.

The flux of groundwater through the toe of the landfill is shown on Figure 5-10. The graph depicts the groundwater discharge for various time periods related to landfill capping. The groundwater discharge was approximately 950 cu. feet/day prior to capping. The groundwater discharge through the toe of the landfill decreases to approximately 590 cu. feet/day after the landfill is capped for 1 year. After 2 years the groundwater through the toe has only decreased to approximately 510 cu.

feet/day. The flux through the toe after ten years is approximately 500 cu. ft./day. The greatest decrease in groundwater flux takes place within the first year, and after two years the groundwater under the landfill is almost entirely within the bedrock, discharging to the sand and gravel only at the toe of the landfill and immediately downgradient.

Particle tracking was performed to determine the pathways for contaminant migration. The particle tracking results presented in Figures 5-11 through 5-13 indicate two significant facts. First, the majority of groundwater flow from the landfill is being discharged to a relatively small window within Sandy Brook. Second, particles leaving the landfill on the most direct path toward the stream reach the stream within two years. Figure 5-11 shows particle traces after one year of capping the landfill. Figure 5-12 shows the particle tracks after two years discharging to Sandy Brook. Particle traces after 10 years are shown in Figure 5-13. Several particles originating at the northern edge of the landfill can be seen flowing radially away toward the north, then being swept east beneath Sandy Brook. These particles are not discharged to the brook within the modeled ten-year period.

Modeling results indicate that stream discharge is not greatly effected by capping of the landfill. Figure 5-14 is a graph of discharge to the stream in the window that is effected by the landfill for four scenarios: pre-cap, one year post-cap, two year post-cap, and ten year post-cap. The overall discharge does not change significantly. The values vary from 16,100 to approximately 15,600 cu. ft./day. The overall fluctuation of 500 cu ft/day that amounts to approximately 2.6 gpm.

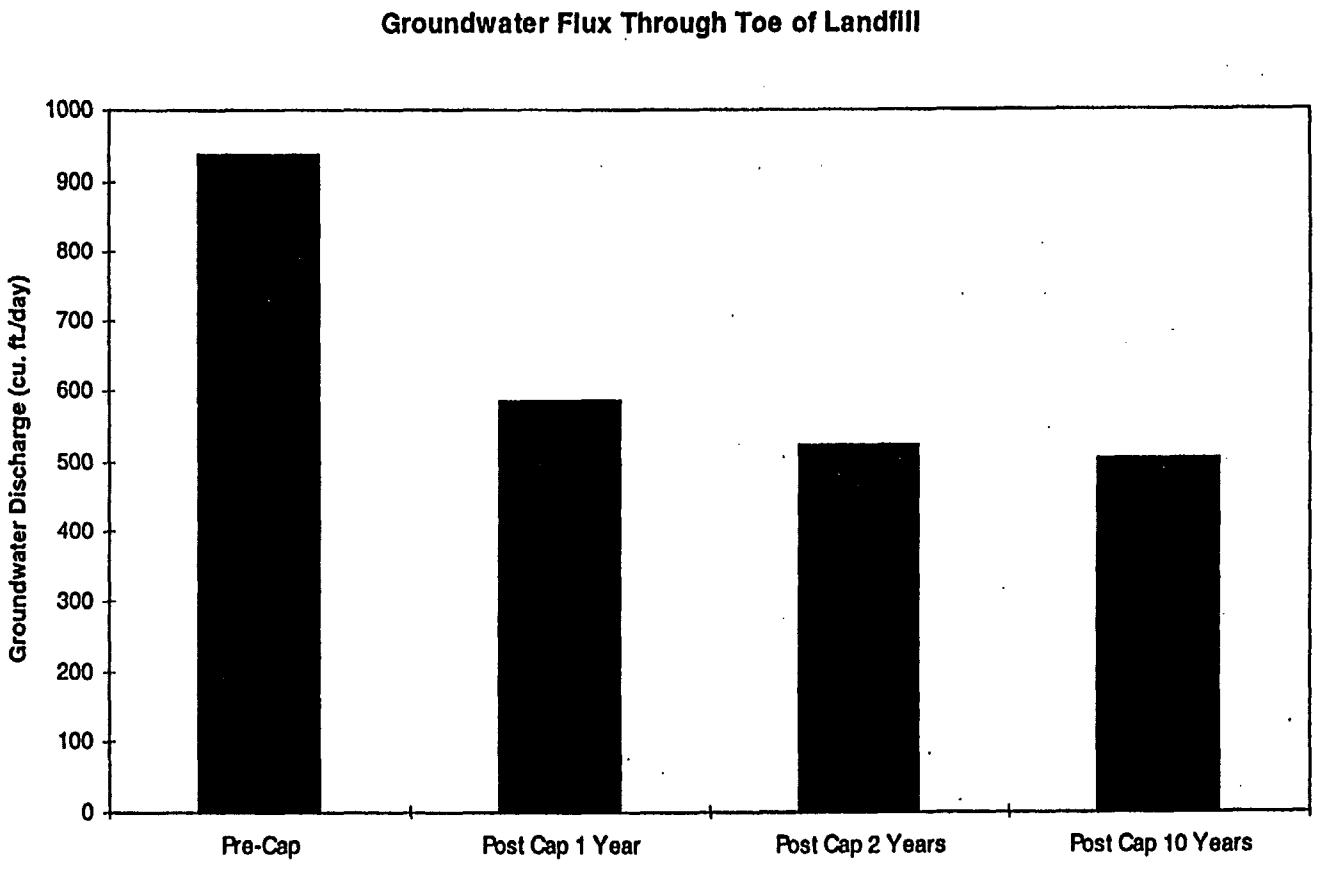


**Figure 5-10: Groundwater flux through toe of landfill.**

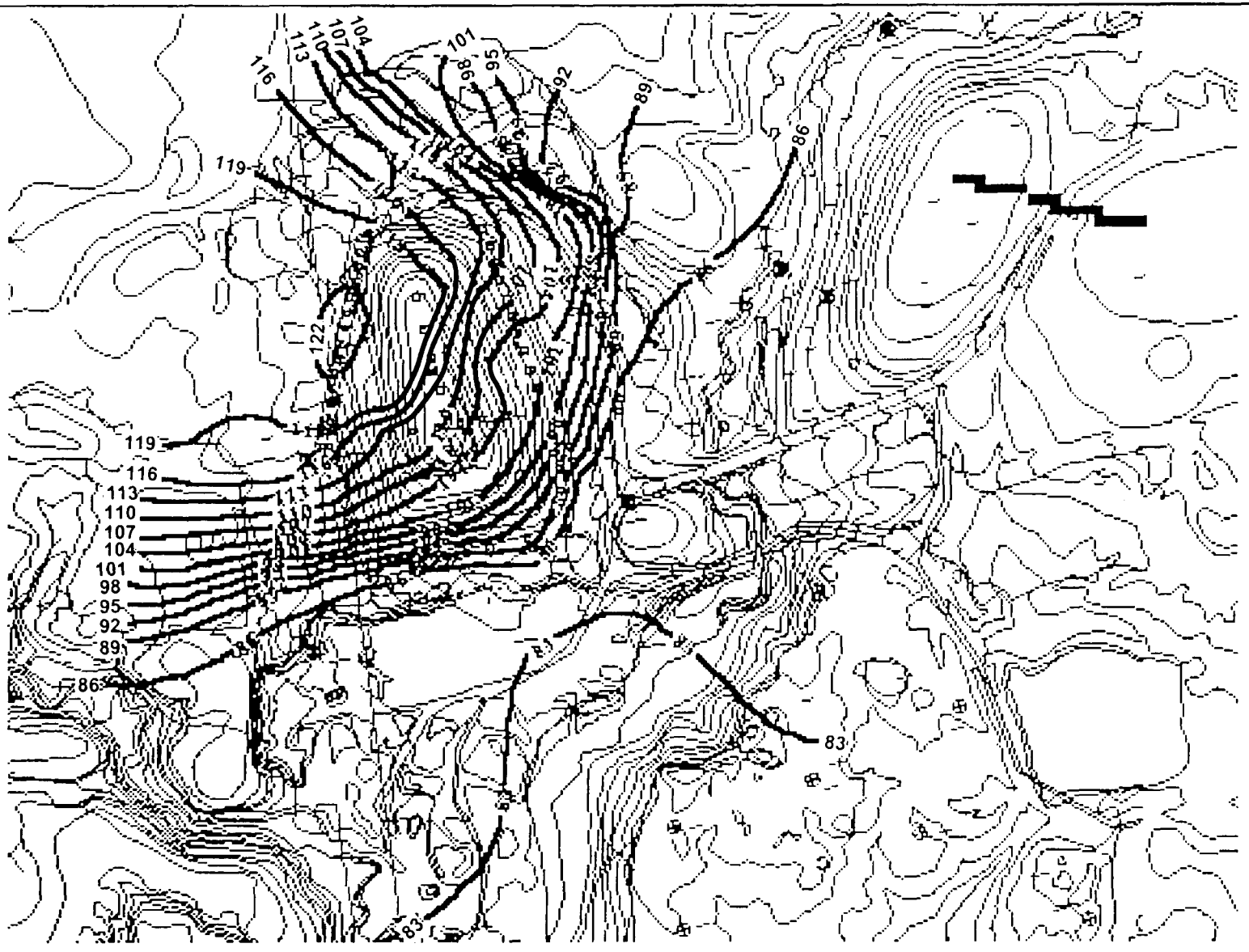


Figure 5-11
Particle Tracks One Year Post Cap
Hydrogeological Investigation Report
Saco Municipal Landfill
Saco, Maine

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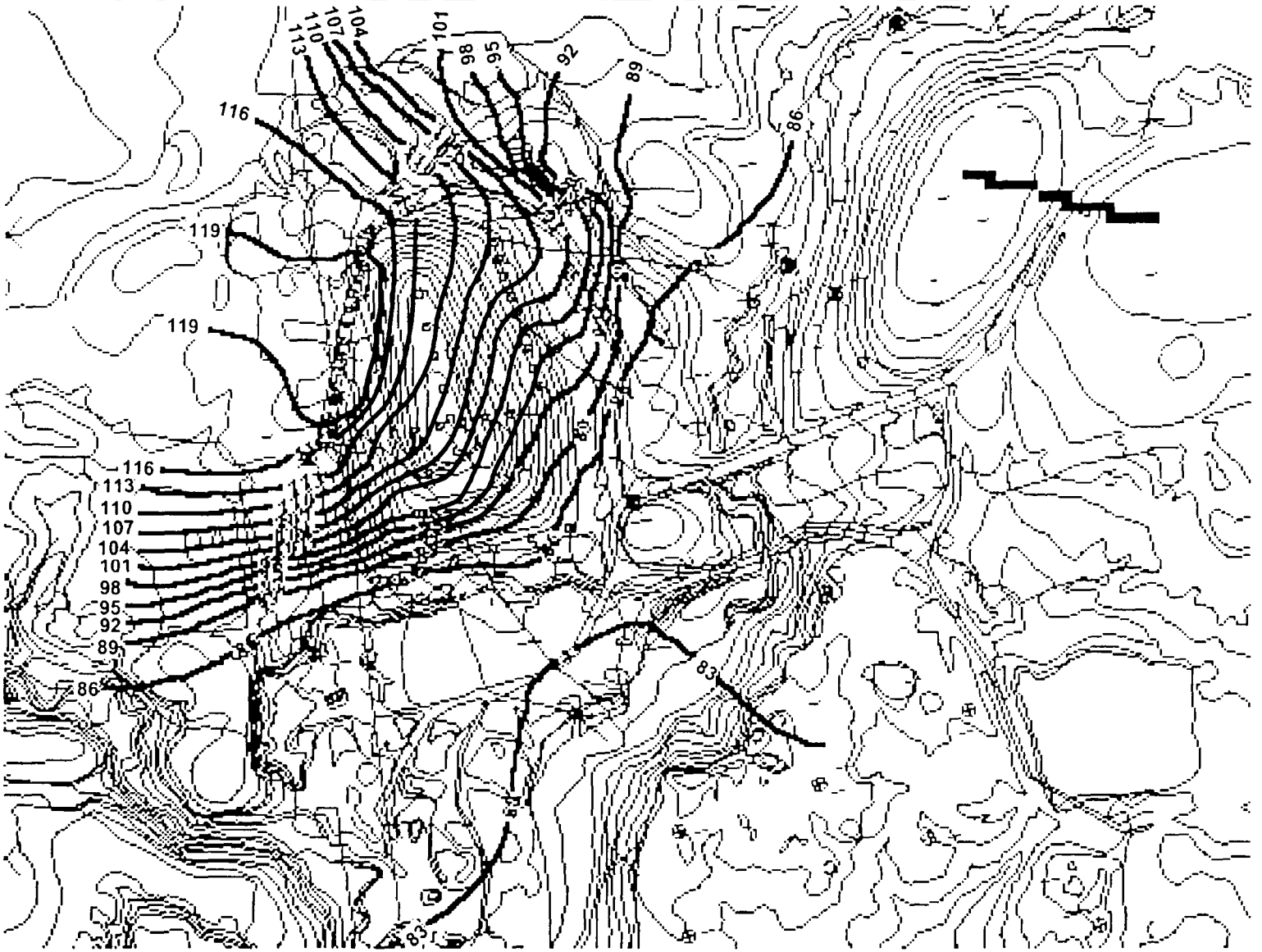


Figure 5-12
Particle Tracks Two Years Post Cap
Hydrogeological Investigation Report
Saco Municipal Landfill
Saco, Maine

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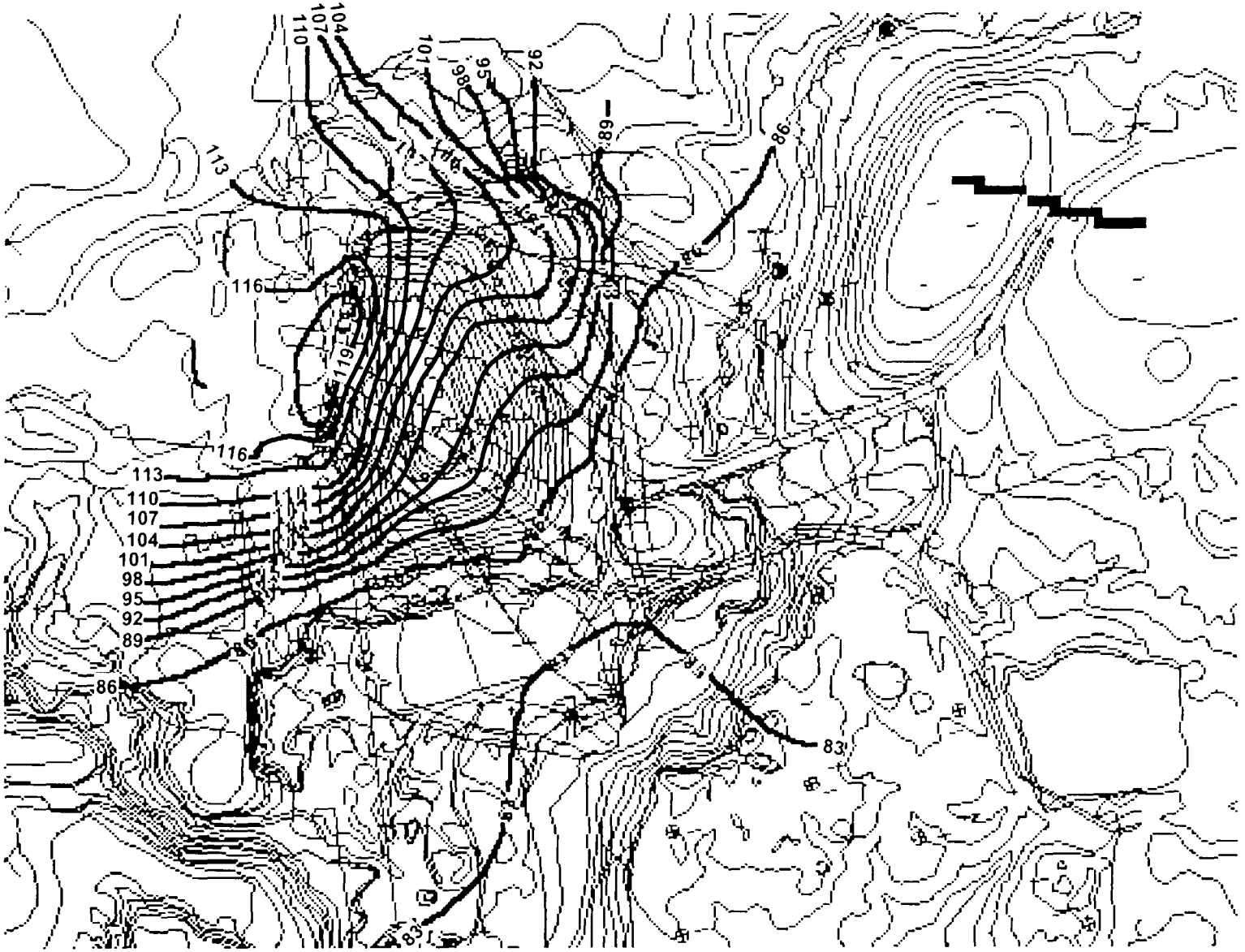


Figure 5-13
Particle Tracks Ten Years Post Cap
Hydrogeological Investigation Report
Saco Municipal Landfill
Saco, Maine

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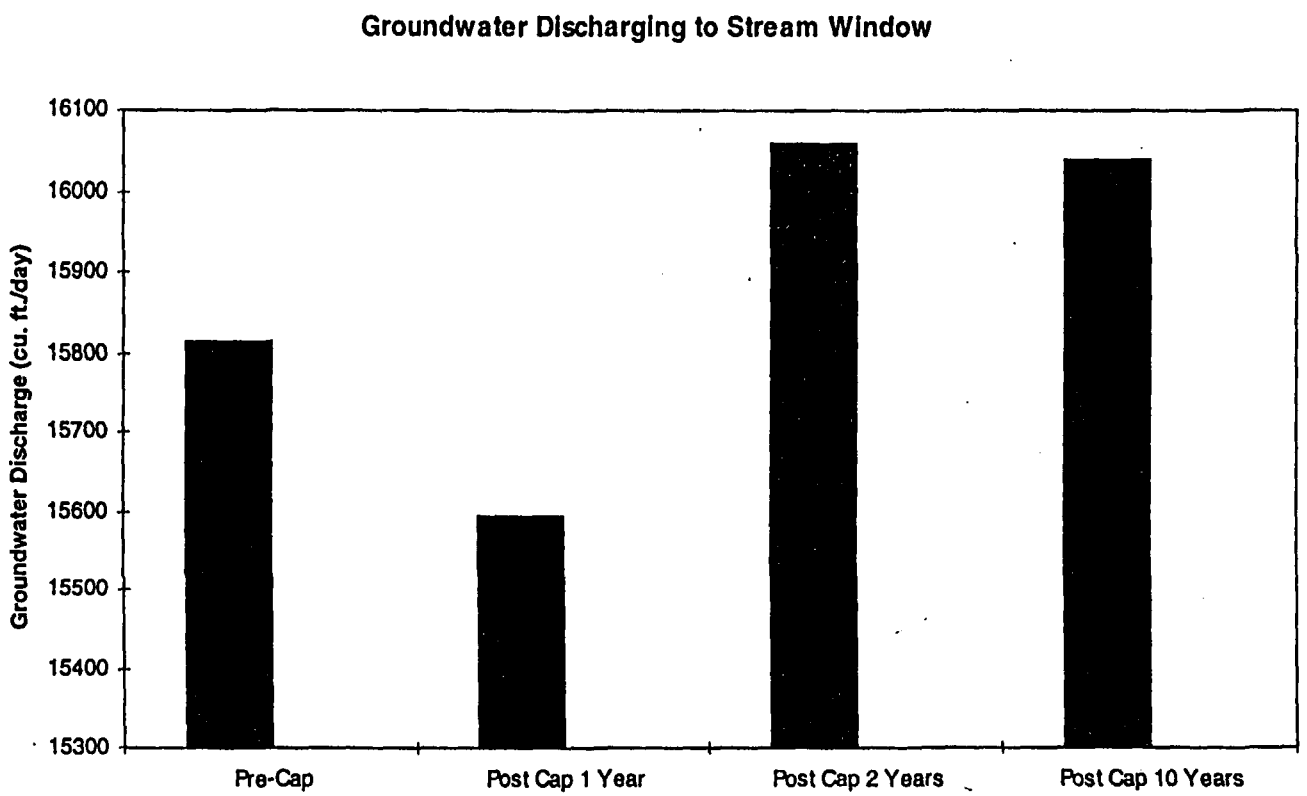


**Figure 5-14: Groundwater discharging to stream window.**

## 6.0 SUMMARY

The hydrogeological investigation and modeling efforts at the SML site were completed to further the understanding of site conditions. The pumping test and subsequent groundwater modeling efforts have confirmed the site conceptual model. The construction of the groundwater model has led to a better understanding of the site conditions relevant to the water balance within the flow system, the movement of groundwater within the flow system, and the impacts of various remedial activities.

The following findings were made as a result of the hydrogeological investigation:

- modeled groundwater elevation changes beneath the landfill subsequent to capping exhibited the greatest degree of change in the first two years (approximately 10 feet),
- groundwater elevations downgradient from the capped area are not significantly effected by the cap,
- groundwater flowing from the landfill is discharged to a relatively small window in Sandy Brook downgradient from the landfill,
- approximately one pore volume flush between the toe of the landfill and Sandy Brook will occur within 2 years, and
- radial flow from the landfill causes groundwater in the northern portion of the landfill to flow under Sandy Brook then flow southwest again eventually discharging within the same window in Sandy Brook.

The overall understanding of the flow system indicates that groundwater flow is controlled by the bedrock and surface topography of the site. Groundwater flow is directed radially away from a bedrock high located just to the west of the Landfill Area 4. The groundwater flowing from the northern boundary of the landfill gradually turns to the east and then turns again to the south-southwest, paralleling the flow of Sandy Brook. The groundwater at the toe of the landfill flows more or less directly southeast toward Sandy Brook where the groundwater is discharged to the brook.

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# APPENDIX B-2

# HYDROGEOLOGICAL INVESTIGATION SUPPORTING MATERIALS

Katahdin
ANALYTICAL SERVICES

December 29, 1997

Mr. Eric Carlson
Woodard & Curran
41 Hutchins Dr.
Portland, ME 04102

RE: Katahdin Lab Number: WN3494
Project ID: Saco Landfill
Project Manager: Ms. Andrea Colby
Sample Receipt Date: December 16, 1997

Dear Mr. Carlson:

Please find enclosed the following information:

* Report of Analysis
* Confirmation
* Chain of Custody

Should you have any questions or comments concerning this Report of Analysis, please do not hesitate to contact the project manager listed above. This cover letter is an integral part of the ROA.

We appreciate your continued use of our laboratory and look forward to working with you in the future. The following signature indicates technical review and acceptance of the data.

Sincerely,

KATAHDIN ANALYTICAL SERVICES

María Crouch
Authorized Signature

12/29/97
Date

0000001

340 County Road No. 5
P.O. Box 720, Westbrook, ME 04098
Tel: (207) 874-2400 Fax: (207) 775-4029

210 West Road No. 5, Portsmouth, NH 03801
Tel: (603) 431-5777 Fax: (603) 436-3356

Katahdin
ANALYTICAL SERVICES

CLIENT: ERIC CARLSON
Woodard & Curran
41 Hutchins Dr.
Portland, ME 04102

Lab Number : WN-3494-1
Report Date: 12/29/97
PO No. : 12.16.97
Project : SACO LANDFILL

REPORT OF ANALYTICAL RESULTS



| SAMPLE DESCRIPTION | MATRIX | SAMPLED BY | SAMPLED DATE | RECEIVED |
|---|---|---|---|---|
| WS-1 | Aqueous | CLIENT | 12/16/97 | 12/16/97 |

| PARAMETER | RESULT | UNITS | DF | *PQL | METHOD | ANALYZED | BY | NOTES |
|---|---|---|---|---|---|---|---|---|
| Arsenic, Total | <0.008 | mg/L | 1.0 | 0.008 | 6010/200.7 | 12/16/97 | EM | 1 |

* PQL (Practical Quantitation Level) represents laboratory reporting limits and may not reflect sample-specific reporting limits. Sample-specific limits are indicated by results annotated with '<' values.
(1) Sample Preparation on 12/16/97 by PLC using 3010

12/29/97

LJO/ejnajc(dw)
NL16ICW2

0000002

340 County Road No. 5
P.O. Box 720, Westbrook, ME 04098
Tel: (207) 874-2400 Fax: (207) 775-4029

210 West Road No. 5, Portsmouth, NH 03801
Tel: (603) 431-5777 Fax: (603) 436-3556

Katahdin
ANALYTICAL SERVICES

CLIENT: ERIC CARLSON
Woodard & Curran
41 Hutchins Dr.
Portland, ME 04102

Lab Number : WN-3494-2
Report Date: 12/29/97
PO No. : 12.16.97
Project : SACO LANDFILL

REPORT OF ANALYTICAL RESULTS



| SAMPLE DESCRIPTION | MATRIX | SAMPLED BY | SAMPLED DATE | RECEIVED |
|---|---|---|---|---|
| WS-2 | Aqueous | CLIENT | 12/16/97 | 12/16/97 |

| PARAMETER | RESULT | UNITS | DF | *PQL | METHOD | ANALYZED | BY | NOTES |
|---|---|---|---|---|---|---|---|---|
| Arsenic, Total | <0.008 | mg/L | 1.0 | 0.008 | 6010/200.7 | 12/16/97 | EM | 1 |

* PQL (Practical Quantitation Level) represents laboratory reporting limits and may not reflect sample-specific reporting limits. Sample-specific limits are indicated by results annotated with '<' values.
(1) Sample Preparation on 12/16/97 by PLC using 3010

12/29/97

LJO/ejnajc(dw)
NL16ICW2

0000003

340 County Road No. 5
P.O. Box 720, Westbrook, ME 04098
Tel: (207) 874-2400 Fax: (207) 775-4029

210 West Road No. 5, Portsmouth, NH 03801
Tel: (603) 431-5777 Fax: (603) 436-3356

**KATAHDIN ANALYTICAL SERVICES, INCORPORATED**
**New England-ME Laboratory (207) 874-2400**
**CONFIRMATION**



ORDER NO WN-3494

Project Manager: Andrea J. Colby
ORDER DATE: 12/16/97
PHONE: 207/774-2112
FAX: 207/774-6635
DUE: 17 DEC

REPORT TO: ERIC CARLSON
Woodard & Curran
41 Hutchins Dr.
Portland, ME 04102

INVOICE: Tanya Talbot
Woodard & Curran
41 Hutchins Dr.
Portland, ME 04102

PHONE: 207/774-2112
PO: 12.16.97

PROJECT: SACO LANDFILL

SAMPLED BY: CLIENT DELIVERED BY: KATAHDIN DISPOSE: AFTER 15 JAN

| ITEM | LOG NUMBER | SAMPLE DESCRIPTION | SAMPLED DATE/TIME | RECEIVED | MATRIX |
|---|---|---|---|---|---|
| 1 | WN3494-1 | WS-1 | 16 DEC 1305 | 16 DEC | AQ |
| | WN3494-2 | WS-2 | 16 DEC 1500 | | |

| DETERMINATION | METHOD | QTY | PRICE | AMOUNT |
|---|---|---|---|---|
| Arsenic, Total | 200.7/6010 | 2 | 40.00 | 80.00 |

ORDER NOTE: QC-I
SACO LANDFILL
RUSH

INVOICE: With Report

TOTAL ORDER AMOUNT $80.00
This is NOT an Invoic

AJC/KAS
12-17Please contact KATAHDIN ANALYTICAL SERVICES promptly if you have any ques

0000004

Katahdin
ANALYTICAL SERVICES
340 County Road No. 5
P.O. Box 720
Westbrook, ME 04098
Tel: (207) 874-2400
Fax: (207) 775-4029

# CHAIN of CUSTODY

PLEASE PRINT IN PEN

Page ____ of ____

Client: WHC

Contact:

Phone #: ( )

Fax #: ( )

Address:

City:

State:

Zip Code:

Purchase Order #:

Proj. Name / No.: SACO LAND FILL

Katahdin Quote #:

Bill (if different than above):

Address:

Sampler (Print / Sign): ERIC CARLSON

Copies To:

LAB USE ONLY

WORK ORDER #: 3494

KATAHDIN PROJECT MANAGER:

REMARKS:

SHIPPING INFO: ☐ FED EX ☐ UPS ☐ CLIENT

AIRBILL NO:

TEMP°C: ☐ TEMP BLANK ☐ INTACT ☐ NOT INTACT

ANALYSIS AND CONTAINER TYPE PRESERVATIVES

| * | Sample Description | Date / Time coll'd | Matrix | No. of Cntrs. | 5 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | F ☐Y |
| | WS-1 | 12/16/ 105 | AQ | 1 | X | | | | | | | | | |
| | WS-2 | 12/16/ 3pm | AQ | 1 | X | | | | | | | | | |
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COMMENTS

| Relinquished By: (Signature) | Date / Time | Received By: (Signature) | Relinquished By: (Signature) | Date / Time | Received By: (Signa |
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| Relinquished By: (Signature) | Date / Time | Received By: (Signature) | Relinquished By: (Signature) | Date / Time | Received By: (Signa |
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**KATAHDIN ANALYTICAL SERVICES, INC.**
**SAMPLE RECEIPT CONDITION REPORT**
Tel. (207) 874-2400
Fax (207) 775-4029

LAB (WORK ORDER) # WN3494

PAGE: 1 OF 1

COOLER: 1 OF 1

CLIENT: W+C

PROJECT: SACO LANDFILL

COC# –
SDG# –
DATE / TIME RECEIVED: 12/16/97 1325
DELIVERED BY: KATAHDIN
RECEIVED BY: PS
LIMS ENTRY BY: PS
LIMS REVIEW BY / PM: AJC

| | YES | NO | EXCEPTIONS | COMMENTS | RESOLUTION |
|---|---|---|---|---|---|
| 1. CUSTODY SEALS PRESENT / INTACT? | ☐ | ☒ | ☐ | | |
| 2. CHAIN OF CUSTODY PRESENT IN THIS COOLER? | ☒ | ☒ AK (6/17/97) | ☐ | | |
| 3. CHAIN OF CUSTODY SIGNED BY CLIENT? | ☐ | ☒ | ☐ | | |
| 4. CHAIN OF CUSTODY MATCHES SAMPLES? | ☒ | ☐ | ☐ | | |
| 5. TEMPERATURE BLANKS PRESENT? | ☒ | ☐ | ☐ | TEMP BLANK TEMP (°C)= 9.1 | |
| 6. SAMPLES RECEIVED AT 4°C +/- 2? ICE / ICE PACKS PRESENT Y or (N?) | ☐ | ☒ | ☐ | COOLER TEMP (°C )= NA (RECORD COOLER TEMP ONLY IF TEMP BLANK IS NOT PRESENT) | |
| 7. VOLATILES FREE OF HEADSPACE? | ☐ | ☐ | ☒ | NA | |
| 8. TRIP BLANK PRESENT IN THIS COOLER | ☐ | ☒ | ☐ | | |
| 9. PROPER SAMPLE CONTAINERS AND VOLUME? | ☒ | ☐ | ☐ | | |
| 10. SAMPLES WITHIN HOLD TIME UPON RECEIPT? | ☒ | ☐ | ☐ | | |
| 11. SAMPLES PROPERLY PRESERVED[1]? | ☒ | ☐ | ☐ | | |
| 12. CORRECTIVE ACTION REPORT FILED? | ☐ | ☒ | N/A | | |

13. ANALYTICAL PROGRAMS (CIRCLE ONE) COMMERCIAL CLP HAZWRAP NFESC ACOE AFCEE OTHER (STATE OF ORIGIN):

LOG-IN NOTES[1]:

[1] Use this space (and additional sheets if necessary) to document samples that are received broken or compromised, C-O-C discrepancies, radiation checks, residual chlorine check, results of pH check if required. If samples required pH adjustment, record volume and type of preservative added.

000006

Katahdin
ANALYTICAL SERVICES

December 29, 1997

Mr. Eric Carlson
Woodard & Curran
41 Hutchins Dr.
Portland, ME 04102

RE: Katahdin Lab Number: WN3504
Project ID: Saco Landfill
Project Manager: Ms. Andrea Colby
Sample Receipt Date: December 17, 1997

Dear Mr. Carlson:

Please find enclosed the following information:

* Report of Analysis
* Confirmation
* Chain of Custody

Should you have any questions or comments concerning this Report of Analysis, please do not hesitate to contact the project manager listed above. This cover letter is an integral part of the ROA.

We appreciate your continued use of our laboratory and look forward to working with you in the future. The following signature indicates technical review and acceptance of the data.

Sincerely,

KATAHDIN ANALYTICAL SERVICES

Maria Crouch
Authorized Signature

12/29/97
Date

0000001

340 County Road No. 5
P.O. Box 720, Westbrook, ME 04098

210 West Road No. 5, Portsmouth, NH 03801
Tel: (603) 431-5777 Fax: (603) 436-3356

Katahdin
ANALYTICAL SERVICES

CLIENT: ERIC CARLSON
Woodard & Curran
41 Hutchins Dr.
Portland, ME 04102

Lab Number : WN-3504-1
Report Date: 12/29/97
PO No. : 12.17.97
Project : SACO LANDFILL

REPORT OF ANALYTICAL RESULTS



| SAMPLE DESCRIPTION | MATRIX | SAMPLED BY | SAMPLED DATE | RECEIVED |
|---|---|---|---|---|
| WS-3 | Aqueous | WARREN | 12/17/97 | 12/17/97 |

| PARAMETER | RESULT | UNITS | DF | *PQL | METHOD | ANALYZED | BY | NOTES |
|---|---|---|---|---|---|---|---|---|
| Arsenic, Total | <0.008 | mg/L | 1.0 | 0.008 | 6010/200.7 | 12/18/97 | EM | 1 |

* PQL (Practical Quantitation Level) represents laboratory reporting limits and may not reflect sample-specific reporting limits. Sample-specific limits are indicated by results annotated with '<' values.
(1) Sample Preparation on 12/17/97 by DPD using 3010

12/29/97

LJO/ejnajc(dw)
NL17ICW2

0000002

340 County Road No. 5
P.O. Box 720, Westbrook, ME 04098
Tel: (207) 874-2400 Fax: (207) 775-4029

210 West Road No. 5, Portsmouth, NH 03801
Tel: (603) 431-5777 Fax: (603) 436-3356

**KATAHDIN ANALYTICAL SERVICES, INCORPORATED**
**New England-ME Laboratory (207) 874-2400**
**CONFIRMATION**



ORDER NO WN-3504

Project Manager: Andrea J. Colby
ORDER DATE: 12/17/97
PHONE: 207/774-2112
FAX: 207/774-6635
DUE: 18 DEC

REPORT TO: ERIC CARLSON
Woodard & Curran
41 Hutchins Dr.
Portland, ME 04102

INVOICE: Tanya Talbot
Woodard & Curran
41 Hutchins Dr.
Portland, ME 04102

PHONE: 207/774-2112
PO: 12.17.97

PROJECT: SACO LANDFILL

SAMPLED BY: WARREN DELIVERED BY: KATAHDIN DISPOSE: AFTER 16 JAN

| ITEM | LOG NUMBER | SAMPLE DESCRIPTION | SAMPLED DATE/TIME | RECEIVED | MATRIX |
|---|---|---|---|---|---|
| 1 | WN3504-1 | WS-3 | 17 DEC 0840 | 17 DEC | AQ |

| DETERMINATION | METHOD | QTY | PRICE | AMOUNT |
|---|---|---|---|---|
| Arsenic, Total | 200.7/6010 | 1 | 40.00 | 40.00 |

ORDER NOTE: QC-I
RUSH
SACO LANDFILL

INVOICE: With Report

TOTAL ORDER AMOUNT $40.00
This is NOT an Invoice

AJC/KAS

0000003

12-17Please contact KATAHDIN ANALYTICAL SERVICES promptly if you have any ques

Katahdin ANALYTICAL SERVICES
340 County Road No. 5
P.O. Box 720
Westbrook, ME 04098
Tel: (207) 874-2400
Fax: (207) 775-4029

# CHAIN of CUSTODY

PLEASE PRINT IN PEN



Client: WOODARD & CURRAN
Contact: ERIC CARLSON
Phone #: ( )
Fax #: ( )
Address: 41 HUTCHINS DR
City: PORTLAND
State: ME
Zip Code:
Purchase Order #:
Proj. Name / No.:
Katahdin Quote #:
Bill (if different than above):
Address:
Sampler (Print / Sign): W. WARREN
Copies To:

LAB USE ONLY
WORK ORDER #: 3504
KATAHDIN PROJECT MANAGER:

REMARKS:

SHIPPING INFO: ☐ FED EX ☐ UPS ☐ CLIENT
AIRBILL NO:
TEMP°C: ☐ TEMP BLANK ☐ INTACT ☐ NOT INTACT

ANALYSIS AND CONTAINER TYPE PRESERVATIVES

| * | Sample Description | Date / Time coll'd | Matrix | No. of Cntrs. | Filt. ☐Y☐N TOTAL ARSENIC | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | WS-3 | 12-17/8:40 | AQ | 1 | X | | | | | | | | |
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COMMENTS

| Relinquished By: (Signature) | Date / Time | Received By: (Signature) | Relinquished By: (Signature) | Date / Time | Received By: (Signature) |
|---|---|---|---|---|---|
| [illegible] | 12-17-13 8:40 | [illegible] 12/17/13 | | | |
| Relinquished By: (Signature) | Date / Time | Received By: (Signature) | Relinquished By: (Signature) | Date / Time | Received By: (Signature) |
| | | | | | |

**KATAHDIN ANALYTICAL SERVICES, INC.**
**SAMPLE RECEIPT CONDITION REPORT**
Tel. (207) 874-2400
Fax (207) 775-4029

LAB (WORK ORDER) # WN3504

PAGE: 1 OF 1

COOLER: 1 OF 1

CLIENT: W+C

COC# –
SDG# –
DATE / TIME RECEIVED: 12/17 913
DELIVERED BY: KATAHDIN
RECEIVED BY: PS
LIMS ENTRY BY: PS
LIMS REVIEW BY / PM: AJC

PROJECT: Sara Landfill

| | YES | NO | EXCEPTIONS | COMMENTS | RESOLUTION |
|---|---|---|---|---|---|
| 1. CUSTODY SEALS PRESENT / INTACT? | ☐ | ☒ | ☐ | | |
| 2.CHAIN OF CUSTODY PRESENT IN THIS COOLER? | ☐ | ☒ | ☐ | | |
| 3. CHAIN OF CUSTODY SIGNED BY CLIENT? | ☒ | ☐ | ☐ | | |
| 4. CHAIN OF CUSTODY MATCHES SAMPLES? | ☒ | ☐ | ☐ | | |
| 5. TEMPERATURE BLANKS PRESENT? | ☐ | ☒ | ☐ | TEMP BLANK TEMP (°C)= | |
| 6. SAMPLES RECEIVED AT 4°C +/- 2? ICE / ICE PACKS PRESENT Y or (N?) | ☐ | ☒ | ☐ | COOLER TEMP (°C )= NA (RECORD COOLER TEMP ONLY IF TEMP BLANK IS NOT PRESENT) | |
| 7. VOLATILES FREE OF HEADSPACE? | ☐ | ☐ | ☒ | | |
| 8. TRIP BLANK PRESENT IN THIS COOLER | ☐ | ☒ | ☐ | | |
| 9. PROPER SAMPLE CONTAINERS AND VOLUME? | ☒ | ☐ | ☐ | | |
| 10. SAMPLES WITHIN HOLD TIME UPON RECEIPT? | ☒ | ☐ | ☐ | | |
| 11. SAMPLES PROPERLY PRESERVED[1]? | ☒ | ☐ | ☐ | | |
| 12. CORRECTIVE ACTION REPORT FILED? | ☐ | ☒ | N/A | | |

13. ANALYTICAL PROGRAMS (CIRCLE ONE) COMMERCIAL CLP HAZWRAP NFESC ACOE AFCEE OTHER (STATE OF ORIGIN):

LOG-IN NOTES[1]: HAND OFF - NO COOLER

(1) Use this space (and additional sheets if necessary) to document samples that are received broken or compromised, C-O-C discrepancies, radiation checks, residual chlorine check, results of pH check if required. If samples required pH adjustment, record volume and type of preservative added.

Katahdin
ANALYTICAL SERVICES

January 5, 1998

Mr. Eric Carlson
Woodard & Curran
41 Hutchins Drive
Portland, ME 04102

RE: Katahdin Lab Number: WN3534
Project ID: Saco Landfill
Project Manager: Ms. Andrea Colby
Sample Receipt Date: December 18, 1997

Dear Mr. Carlson:

Please find enclosed the following information:

* Report of Analysis
* Confirmation
* Chain of Custody

Should you have any questions or comments concerning this Report of Analysis, please do not hesitate to contact the project manager listed above. This cover letter is an integral part of the ROA.

We appreciate your continued use of our laboratory and look forward to working with you in the future. The following signature indicates technical review and acceptance of the data.

Sincerely,

KATAHDIN ANALYTICAL SERVICES

Deborah J. Nadeau
Authorized Signature

1.5.98
Date

000001

340 County Road No. 5
P.O. Box 720, Westbrook, ME 04098
Tel: (207) 874-2400 Fax: (207) 775-4029

210 West Road No. 5, Portsmouth, NH 03801
Tel: (603) 431-5777 Fax: (603) 436-3356

Katahdin
ANALYTICAL SERVICES

CLIENT: ERIC CARLSON
Woodard & Curran
41 Hutchins Dr.
Portland, ME 04102

Lab Number : WN-3534-1
Report Date: 01/05/98
PO No. : 12.18.97
Project : SACO LANDFILL

REPORT OF ANALYTICAL RESULTS



| SAMPLE DESCRIPTION | MATRIX | SAMPLED BY | SAMPLED DATE | RECEIVED |
|---|---|---|---|---|
| WS-4 | Aqueous | E.CARLSON | 12/17/97 | 12/18/97 |

| PARAMETER | RESULT | UNITS | DF | *PQL | METHOD | ANALYZED | BY | NOTES |
|---|---|---|---|---|---|---|---|---|
| Arsenic, Total | <0.008 | mg/L | 1.0 | 0.008 | 6010/200.7 | 12/23/97 | EM | 1 |

* PQL (Practical Quantitation Level) represents laboratory reporting limits and may not reflect sample-specific reporting limits. Sample-specific limits are indicated by results annotated with '<' values.
(1) Sample Preparation on 12/18/97 by DPD using 3010

01/05/98

LJO/ejnajc(dw)
NL18ICW1



340 County Road No. 5
P.O. Box 720, Westbrook, ME 04098
Tel: (207) 874-2400 Fax: (207) 775-4029

210 West Road No. 5, Portsmouth, NH 03801
Tel: (603) 431-5777 Fax: (603) 436-3356

**KATAHDIN ANALYTICAL SERVICES, INCORPORATED**
**New England-ME Laboratory (207) 874-2400**
**CONFIRMATION**



ORDER NO WN-3534

Project Manager: Andrea J. Colby
ORDER DATE: 12/18/97
PHONE: 207/774-2112
FAX: 207/774-6635
DUE: 19 DEC

REPORT TO: ERIC CARLSON
Woodard & Curran
41 Hutchins Dr.
Portland, ME 04102

INVOICE: Tanya Talbot
Woodard & Curran
41 Hutchins Dr.
Portland, ME 04102

PHONE: 207/774-2112
PO: 12.18.97

PROJECT: SACO LANDFILL

SAMPLED BY: E.CARLSON DELIVERED BY: CLIENT DISPOSE: AFTER 17 JAN

| ITEM | LOG NUMBER | SAMPLE DESCRIPTION | SAMPLED DATE/TIME | RECEIVED | MATRIX |
|---|---|---|---|---|---|
| 1 | WN3534-1 | WS-4 | 17 DEC 1630 | 18 DEC | AQ |

| DETERMINATION | METHOD | QTY | PRICE | AMOUNT |
|---|---|---|---|---|
| Arsenic, Total | 200.7/6010 | 1 | 40.00 | 40.00 |

ORDER NOTE: QC-I
SACO LANDFILL
RUSH
Prices include RUSH surcharges

INVOICE: With Report

TOTAL ORDER AMOUNT $40.00
This is NOT an Invoice

AJC/KAS
12-18Please contact KATAHDIN ANALYTICAL SERVICES promptly if you have any ques

Katahdin ANALYTICAL SERVICES
340 County Road No. 5
P.O. Box 720
Westbrook, ME 04098
Tel: (207) 874-2400
Fax: (207) 775-4029

# CHAIN of CUSTODY

PLEASE PRINT IN PEN

Page ____ of ____

lient: Woodard & Curran

Contact: Eric Carlson

Phone #: ( )

Fax #: ( )

ddress

City

State

Zip Code

urchase Order #

Proj. Name / No.: Sara Landfill

Katahdin Quote #

ill (if different than above)

Address

ampler (Print / Sign): Eric Carlson

Copies To:

AB USE ONLY

WORK ORDER #: W3534

KATAHDIN PROJECT MANAGER

EMARKS:

HIPPING INFO: ☐ FED EX ☐ UPS ☐ CLIENT

IRBILL NO:

EMP°C ____ ☐ TEMP BLANK ☐ INTACT ☐ NOT INTACT

ANALYSIS AND CONTAINER TYPE PRESERVATIVES

| Sample Description | Date / Time coll'd | Matrix | No. of Cntrs. | Filt. ☐Y☑N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N |
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| WS-4 | 12/17/97 16:30 | AQ | 1 | ✓ | | | | | | | | | |
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OMMENTS

| Relinquished By: (Signature) | Date / Time | Received By: (Signature) | Relinquished By: (Signature) | Date / Time | Received By: (Signature) |
|---|---|---|---|---|---|
| Eric Carlson | 12/18/97 1330 | Andrea Cox | | | |
| Relinquished By: (Signature) | Date / Time | Received By: (Signature) | Relinquished By: (Signature) | Date / Time | Received By: (Signature) |
| | | | | | 000004 |

Katahdin
ANALYTICAL SERVICES

January 5, 1998

Mr. Eric Carlson
Woodard & Curran
41 Hutchins Drive
Portland, ME 04102

RE: Katahdin Lab Number: WN3524
Project ID: Saco Landfill
Project Manager: Ms. Andrea Colby
Sample Receipt Date: December 18, 1997

Dear Mr. Carlson:

Please find enclosed the following information:

* Report of Analysis
* Confirmation
* Chain of Custody

Should you have any questions or comments concerning this Report of Analysis, please do not hesitate to contact the project manager listed above. This cover letter is an integral part of the ROA.

We appreciate your continued use of our laboratory and look forward to working with you in the future. The following signature indicates technical review and acceptance of the data.

Sincerely,

KATAHDIN ANALYTICAL SERVICES

Deborah J. Nadeau
Authorized Signature

1·5·98
Date

0000001

340 County Road No. 5
P.O. Box 720, Westbrook, ME 04098
Tel: (207) 874-2400 Fax: (207) 775-4029

210 West Road No. 5, Portsmouth, NH 03801
Tel: (603) 431-5777 Fax: (603) 436-3356

Katahdin
ANALYTICAL SERVICES

CLIENT: ERIC CARLSON
Woodard & Curran
41 Hutchins Dr.
Portland, ME 04102

Lab Number : WN-3524-1
Report Date: 01/05/98
PO No. : 12.18.97
Project : SACO LANDFILL

REPORT OF ANALYTICAL RESULTS



| SAMPLE DESCRIPTION | MATRIX | SAMPLED BY | SAMPLED DATE | RECEIVED |
|---|---|---|---|---|
| WS-5 | Aqueous | W.WARREN | 12/18/97 | 12/18/97 |

| PARAMETER | RESULT | UNITS | DF | *PQL | METHOD | ANALYZED | BY | NOTES |
|---|---|---|---|---|---|---|---|---|
| Arsenic, Total | <0.008 | mg/L | 1.0 | 0.008 | 6010/200.7 | 12/23/97 | EM | 1 |

* PQL (Practical Quantitation Level) represents laboratory reporting limits and may not reflect sample-specific reporting limits. Sample-specific limits are indicated by results annotated with '<' values.
(1) Sample Preparation on 12/18/97 by DPD using 3010

01/05/98

LJO/ejnajc(dw)
NL18ICW1

0000002

340 County Road No. 5
P.O. Box 720, Westbrook, ME 04098
Tel: (207) 874-2400 Fax: (207) 775-4029

210 West Road No. 5, Portsmouth, NH 03801
Tel: (603) 431-5777 Fax: (603) 436-3356

**KATAHDIN ANALYTICAL SERVICES, INCORPORATED**
**New England-ME Laboratory (207) 874-2400**
**CONFIRMATION**



ORDER NO WN-3524

Project Manager: Andrea J. Colby
ORDER DATE: 12/18/97
PHONE: 207/774-2112
FAX: 207/774-6635
DUE: 19 DEC

REPORT TO: ERIC CARLSON
Woodard & Curran
41 Hutchins Dr.
Portland, ME 04102

INVOICE: Tanya Talbot
Woodard & Curran
41 Hutchins Dr.
Portland, ME 04102

PHONE: 207/774-2112
PO: 12.18.97

PROJECT: SACO LANDFILL

SAMPLED BY: W.WARREN DELIVERED BY: KATAHDIN DISPOSE: AFTER 17 JAN

| ITEM | LOG NUMBER | SAMPLE DESCRIPTION | SAMPLED DATE/TIME | RECEIVED | MATRIX |
|---|---|---|---|---|---|
| 1 | WN3524-1 | WS-5 | 18 DEC 0840 | 18 DEC | AQ |

| DETERMINATION | METHOD | QTY | PRICE | AMOUNT |
|---|---|---|---|---|
| Arsenic, Total | 200.7/6010 | 1 | 40.00 | 40.00 |

ORDER NOTE: QC-I
SACO LANDFILL
RUSH
Prices include RUSH surcharges

INVOICE: With Report

TOTAL ORDER AMOUNT $40.00
This is NOT an Invoice

AJC/KAS
12-18Please contact KATAHDIN ANALYTICAL SERVICES promptly if you have any questi

000003

Katahdin
ANALYTICAL SERVICES
340 County Road No. 5
P.O. Box 720
Westbrook, ME 04098
Tel: (207) 874-2400
Fax: (207) 775-4029

# CHAIN of CUSTODY

PLEASE PRINT IN PEN

Page ____ of ____

Client: WOODARD & CURRAN

Contact: ERIC CARLSON

Phone #: ( )

Fax #: ( )

Address: 41 HUTCHINS DR

City: PORTLAND

State: ME

Zip Code:

Purchase Order #:

Proj. Name / No.:

Katahdin Quote #:

Bill (if different than above):

Address:

Sampler (Print / Sign): W WARREN / [signature]

Copies To:

LAB USE ONLY

WORK ORDER #: W1-3524

KATAHDIN PROJECT MANAGER

REMARKS:

SHIPPING INFO: ☐ FED EX ☐ UPS ☐ CLIENT

AIRBILL NO:

TEMP°C ____ ☐ TEMP BLANK ☐ INTACT ☐ NOT INTACT

ANALYSIS AND CONTAINER TYPE PRESERVATIVES

| * | Sample Description | Date / Time coll'd | Matrix | No. of Cntrs. | Filt. O Y O N: GAL ARSENIC | Filt. O Y O N | Filt. O Y O N | Filt. O Y O N | Filt. O Y O N | Filt. O Y O N | Filt. O Y O N | Filt. O Y O N | Filt. O Y O N | Filt. O Y O N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | WS-5 | 12/18/8:40 | AQ | 1 | ✓ | | | | | | | | | |
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COMMENTS

| Relinquished By: (Signature) | Date / Time | Received By: (Signature) | Relinquished By: (Signature) | Date / Time | Received By: (Signature) |
|---|---|---|---|---|---|
| [signature] | 12/18/97 8:40 | | | | |
| Relinquished By: (Signature) | Date / Time | Received By: (Signature) | Relinquished By: (Signature) | Date / Time | Received By: (Signature) |
| | | | | | 0000004 |

**KATAHDIN ANALYTICAL SERVICES, INC.**
**SAMPLE RECEIPT CONDITION REPORT**
Tel. (207) 874-2400
Fax (207) 775-4029

LAB (WORK ORDER) # WM 3524

PAGE: 1 OF 1

COOLER: 1 OF 1

CLIENT: WK

COC# —
SDG# —
DATE / TIME RECEIVED: 12/18/97 0840
DELIVERED BY: KATAHDIN
RECEIVED BY: KAS
LIMS ENTRY BY: KAS
LIMS REVIEW BY / PM: AJC

PROJECT: Saco Landfill

| | YES | NO | EXCEPTIONS | COMMENTS | RESOLUTION |
|---|---|---|---|---|---|
| 1. CUSTODY SEALS PRESENT / INTACT? | ☐ | ☒ | ☐ | | |
| 2. CHAIN OF CUSTODY PRESENT IN THIS COOLER? | ☐ | ☒ | ☐ | | |
| 3. CHAIN OF CUSTODY SIGNED BY CLIENT? | ☒ | ☐ | ☐ | | |
| 4. CHAIN OF CUSTODY MATCHES SAMPLES? | ☒ | ☐ | ☐ | | |
| 5. TEMPERATURE BLANKS PRESENT? | ☐ | ☒ | ☐ | TEMP BLANK TEMP (°C)= — | |
| 6. SAMPLES RECEIVED AT 4°C +/- 2? ICE / ICE PACKS PRESENT Y or (N)? | ☐ | ☒ | ☐ | COOLER TEMP (°C )= — NA (RECORD COOLER TEMP ONLY IF TEMP BLANK IS NOT PRESENT) | |
| 7. VOLATILES FREE OF HEADSPACE? | ☐ | ☐ | ☒ | | |
| 8. TRIP BLANK PRESENT IN THIS COOLER | ☐ | ☒ | ☐ | | |
| 9. PROPER SAMPLE CONTAINERS AND VOLUME? | ☒ | ☐ | ☐ | | |
| 10. SAMPLES WITHIN HOLD TIME UPON RECEIPT? | ☒ | ☐ | ☐ | | |
| 11. SAMPLES PROPERLY PRESERVED[1]? | ☒ | ☐ | ☐ | | |
| 12. CORRECTIVE ACTION REPORT FILED? | ☐ | ☒ | N/A | | |

13. ANALYTICAL PROGRAMS (CIRCLE ONE) COMMERCIAL CLP HAZWRAP NFESC ACOE AFCEE OTHER (STATE OF ORIGIN):

LOG-IN NOTES[1]:

(1) Use this space (and additional sheets if necessary) to document samples that are received broken or compromised, C-O-C discrepancies, radiation checks, residual chlorine check, results of pH check if required. If samples required pH adjustment, record volume and type of preservative added.

Katahdin
ANALYTICAL SERVICES

January 5, 1998

Mr. Eric Carlson
Woodard & Curran
41 Hutchins Drive
Portland, ME 04102

RE: Katahdin Lab Number: WN3542
Project ID: Saco Landfill
Project Manager: Ms. Andrea Colby
Sample Receipt Date: December 19, 1997

Dear Mr. Carlson:

Please find enclosed the following information:

* Report of Analysis
* Confirmation
* Chain of Custody

Should you have any questions or comments concerning this Report of Analysis, please do not hesitate to contact the project manager listed above. This cover letter is an integral part of the ROA.

We appreciate your continued use of our laboratory and look forward to working with you in the future. The following signature indicates technical review and acceptance of the data.

Sincerely,

KATAHDIN ANALYTICAL SERVICES

Deborah J. Nadeau
Authorized Signature

1·5·98
Date

000001

340 County Road No. 5
P.O. Box 720, Westbrook, ME 04098
Tel: (207) 874-2400 Fax: (207) 775-4029

210 West Road No. 5, Portsmouth, NH 03801
Tel: (603) 431-5777 Fax: (603) 436-3356

Katahdin
ANALYTICAL SERVICES

CLIENT: ERIC CARLSON
Woodard & Curran
41 Hutchins Dr.
Portland, ME 04102

Lab Number : WN-3542-1
Report Date: 01/05/98
PO No. : 12.19.97

REPORT OF ANALYTICAL RESULTS



| SAMPLE DESCRIPTION | MATRIX | SAMPLED BY | SAMPLED DATE | RECEIVED |
|---|---|---|---|---|
| WS-6 | Aqueous | WARREN | 12/19/97 | 12/19/97 |

| PARAMETER | RESULT | UNITS | DF | *PQL | METHOD | ANALYZED | BY | NOTES |
|---|---|---|---|---|---|---|---|---|
| Arsenic, Total | <0.008 | mg/L | 1.0 | 0.008 | 6010/200.7 | 12/23/97 | EM | 1 |

* PQL (Practical Quantitation Level) represents laboratory reporting limits and may not reflect sample-specific reporting limits. Sample-specific limits are indicated by results annotated with '<' values.
(1) Sample Preparation on 12/19/97 by DPD using 3010

01/05/98

LJO/ejnajc(dw)
NL19ICW2

340 County Road No. 5
P.O. Box 720, Westbrook, ME 04098
Tel: (207) 874-2400 Fax: (207) 775-4029

210 West Road No. 5, Portsmouth, NH 03801
Tel: (603) 431-5777 Fax: (603) 436-3356

**KATAHDIN ANALYTICAL SERVICES, INCORPORATED**
**New England-ME Laboratory (207) 874-2400**
**CONFIRMATION**



ORDER NO WN-3542

Project Manager: Andrea J. Colby
ORDER DATE: 12/19/97
PHONE: 207/774-2112
FAX: 207/774-6635
DUE: 22 DEC

REPORT TO: ERIC CARLSON
Woodard & Curran
41 Hutchins Dr.
Portland, ME 04102

INVOICE: Tanya Talbot
Woodard & Curran
41 Hutchins Dr.
Portland, ME 04102

PHONE: 207/774-2112
PO: 12.19.97

SAMPLED BY: WARREN DELIVERED BY: KATAHDIN DISPOSE: AFTER 18 JAN

| ITEM | LOG NUMBER | SAMPLE DESCRIPTION | SAMPLED DATE/TIME | RECEIVED | MATRIX |
|---|---|---|---|---|---|
| 1 | WN3542-1 | WS-6 | 19 DEC 0840 | 19 DEC | AQ |

| DETERMINATION | METHOD | QTY | PRICE | AMOUNT |
|---|---|---|---|---|
| Arsenic, Total | 200.7/6010 | 1 | 40.00 | 40.00 |

ORDER NOTE: QC-I
SACO LANDFILL

INVOICE: With Report

TOTAL ORDER AMOUNT $40.00
This is NOT an Invoice

AJC/PRS
12-19Please contact KATAHDIN ANALYTICAL SERVICES promptly if you have any questi

Katahdin
ANALYTICAL SERVICES
340 County Road No. 5
P.O. Box 720
Westbrook, ME 04098
Tel: (207) 874-2400
Fax: (207) 775-4029

# CHAIN of CUSTODY

PLEASE PRINT IN PEN

Page ____ of ____

Client: WOODARD & CURRAN

Contact: ERIC CARLSON

Phone #: ( )

Fax #: ( )

Address: 41 HUTCHINS DR

City: PORTLAND

State: ME

Zip Code:

Purchase Order #:

Proj. Name / No.:

Katahdin Quote #:

Bill (if different than above):

Address:

Sampler (Print / Sign): W WARREN / WCW

Copies To:

LAB USE ONLY

WORK ORDER #: 3542

KATAHDIN PROJECT MANAGER: ASC

REMARKS:

SHIPPING INFO: ☐ FED EX ☐ UPS ☐ CLIENT

AIRBILL NO:

TEMP°C ____ ☐ TEMP BLANK ☐ INTACT ☐ NOT INTACT

ANALYSIS AND CONTAINER TYPE PRESERVATIVES

| * | Sample Description | Date / Time coll'd | Matrix | No. of Cntrs. | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N | Filt. ☐Y☐N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | J A K F | J A K F | J A K F | J A K F | J A K F | J A K F | J A K F | J A K F | J A K F | J A K F |
| | WS - 6 | 12-19 / 8:40 | AQ | 1 | X | | | | | | | | | |
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OMMENTS

| Relinquished By: (Signature) | Date / Time | Received By: (Signature) | Relinquished By: (Signature) | Date / Time | Received By: (Signature) |
|---|---|---|---|---|---|
| WCW | 12-19 / 8:40 | [illegible] 12/19 910 | | | |
| Relinquished By: (Signature) | Date / Time | Received By: (Signature) | Relinquished By: (Signature) | Date / Time | Received By: (Signature) |
| | | | | | 000004 |

**KATAHDIN ANALYTICAL SERVICES, INC.**
**SAMPLE RECEIPT CONDITION REPORT**
Tel. (207) 874-2400
Fax (207) 775-4029

LAB (WORK ORDER) #: 3542

PAGE: 1 OF 1

COOLER: 1 OF 1

CLIENT: W+C

COC#: –
SDG#: –
DATE / TIME RECEIVED: 12/19 0910
DELIVERED BY: KATAHDIN
RECEIVED BY: PS
LIMS ENTRY BY: PS
LIMS REVIEW BY / PM: AJC

PROJECT: Sara Landfill

| | YES | NO | EXCEPTIONS | COMMENTS | RESOLUTION |
|---|---|---|---|---|---|
| 1. CUSTODY SEALS PRESENT / INTACT? | ☐ | ☒ | ☐ | | |
| 2. CHAIN OF CUSTODY PRESENT IN THIS COOLER? | ☐ | ☒ | ☐ | | |
| 3. CHAIN OF CUSTODY SIGNED BY CLIENT? | ☒ | ☐ | ☐ | | |
| 4. CHAIN OF CUSTODY MATCHES SAMPLES? | ☒ | ☐ | ☐ | | |
| 5. TEMPERATURE BLANKS PRESENT? | ☐ | ☒ | ☐ | TEMP BLANK TEMP (°C)= | |
| 6. SAMPLES RECEIVED AT 4°C +/- 2? ICE / ICE PACKS PRESENT Y or (N?) | ☐ | ☒ | ☐ | COOLER TEMP (°C )= NA (RECORD COOLER TEMP ONLY IF TEMP BLANK IS NOT PRESENT) | |
| 7. VOLATILES FREE OF HEADSPACE? | ☐ | ☐ | ☒ | | |
| 8. TRIP BLANK PRESENT IN THIS COOLER | ☐ | ☒ | ☐ | | |
| 9. PROPER SAMPLE CONTAINERS AND VOLUME? | ☒ | ☐ | ☐ | | |
| 10. SAMPLES WITHIN HOLD TIME UPON RECEIPT? | ☒ | ☐ | ☐ | | |
| 11. SAMPLES PROPERLY PRESERVED(1)? | ☒ | ☐ | ☐ | | |
| 12. CORRECTIVE ACTION REPORT FILED? | ☐ | ☒ | N/A | | |

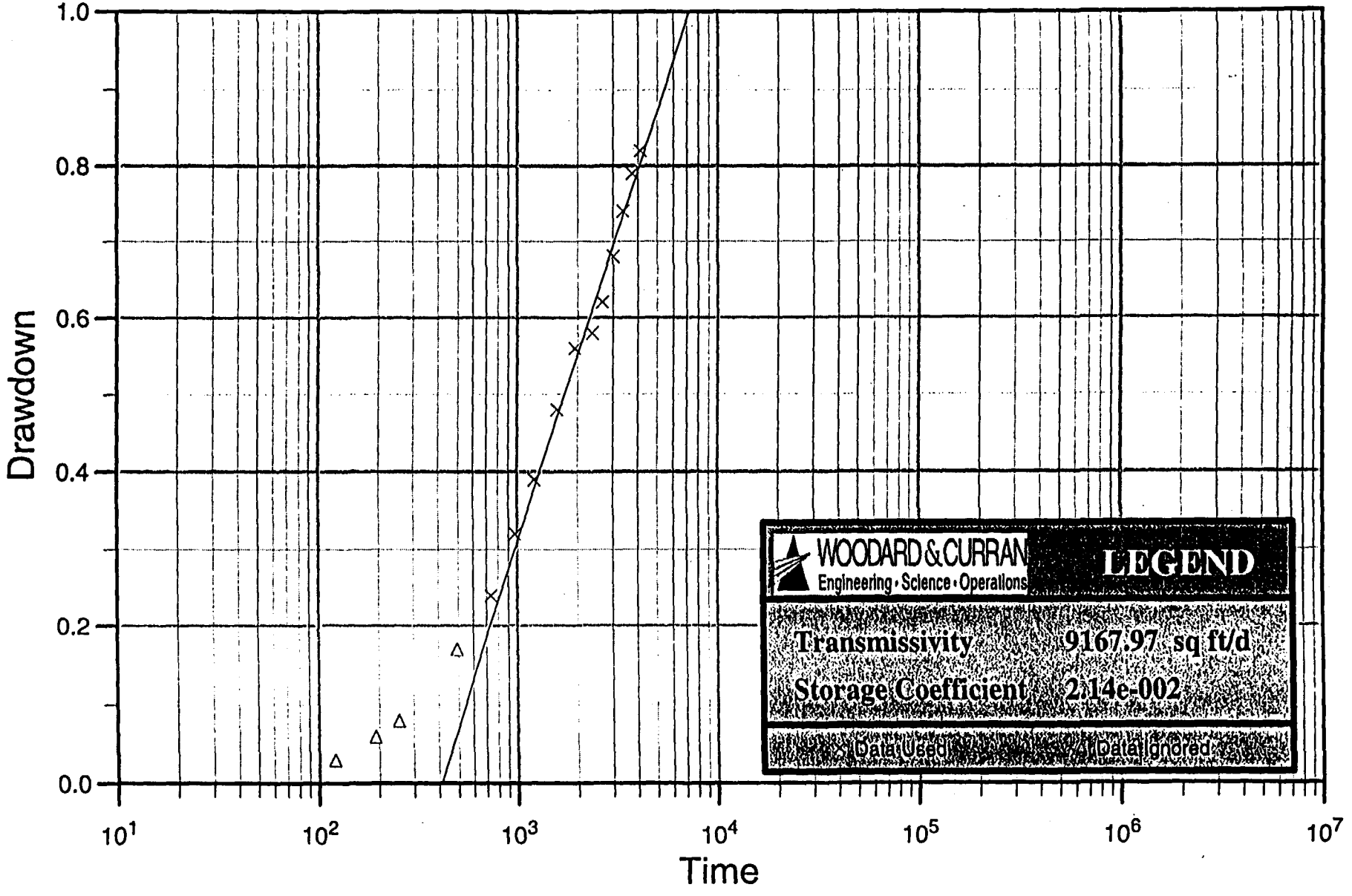
13. ANALYTICAL PROGRAMS (CIRCLE ONE) COMMERCIAL CLP HAZWRAP NFESC ACOE AFCEE OTHER (STATE OF ORIGIN):

LOG-IN NOTES(1):

(1) Use this space (and additional sheets if necessary) to document samples that are received broken or compromised, C-O-C discrepancies, radiation checks, residual chlorine check, results of pH check if required. If samples required pH adjustment, record volume and type of preservative added.

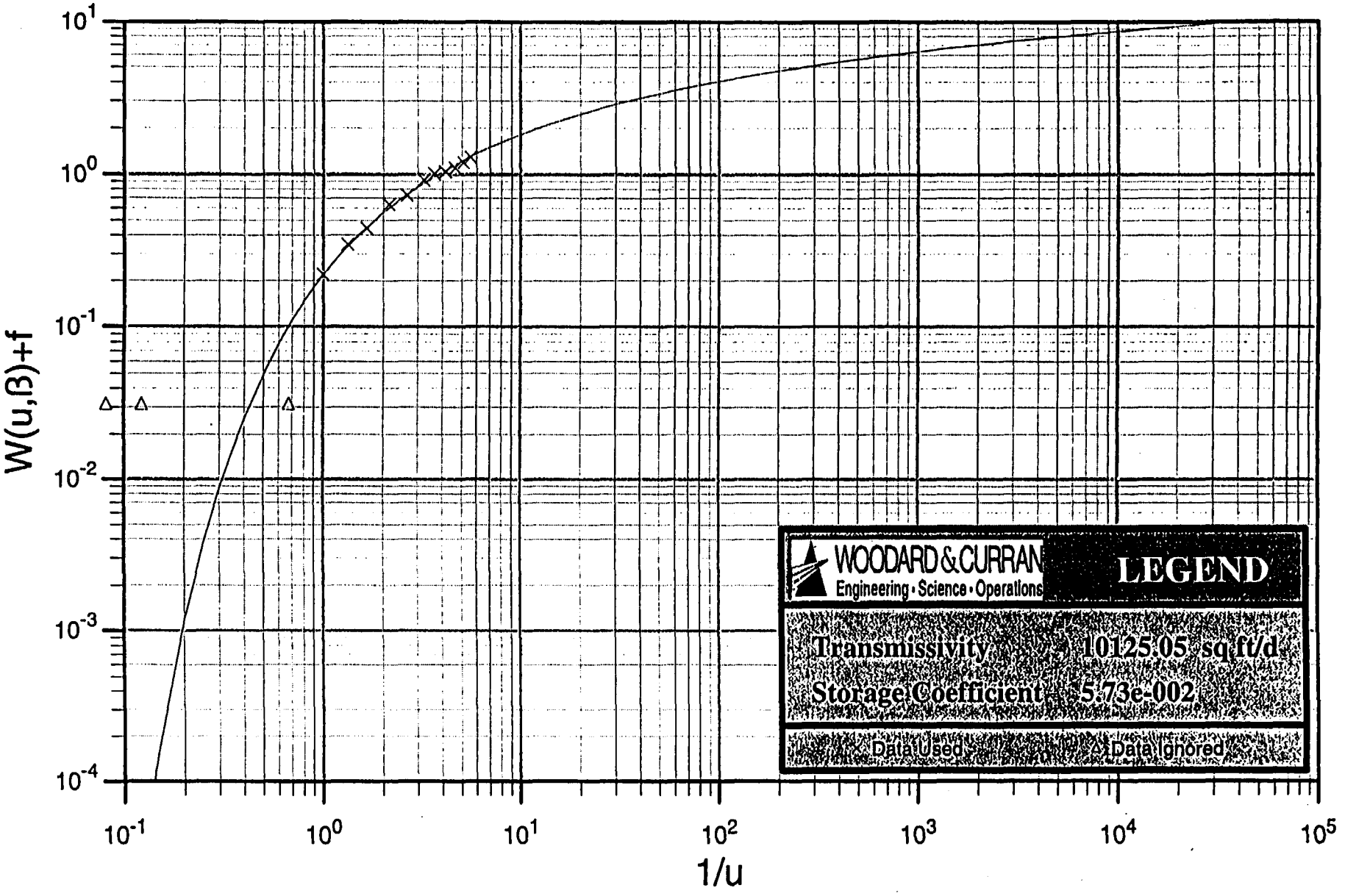
WELL 93-5

# Cooper and Jacob



WELL 95-2S

# Hantush



# Cooper and Jacob

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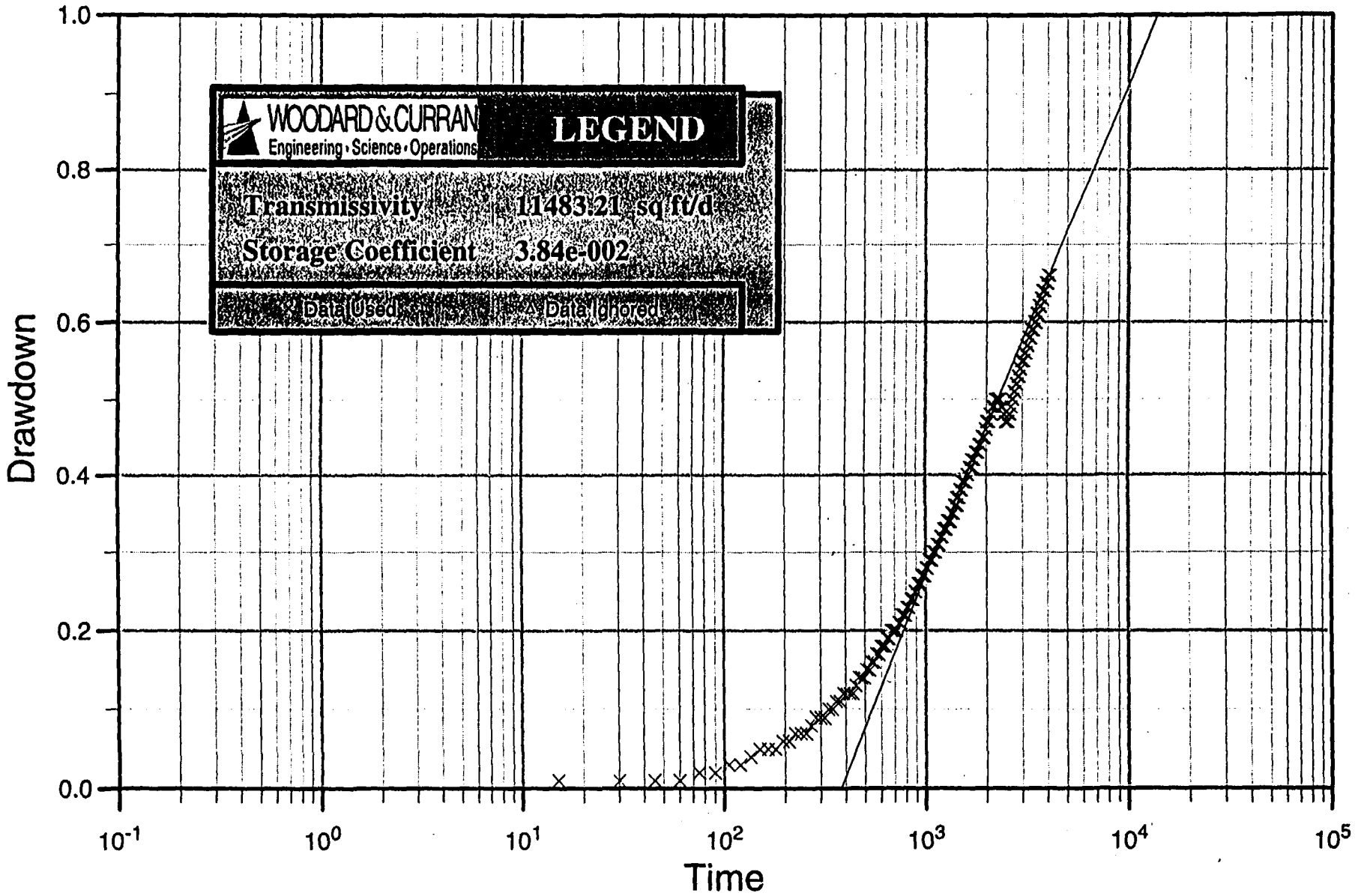

# Cooper and Jacob

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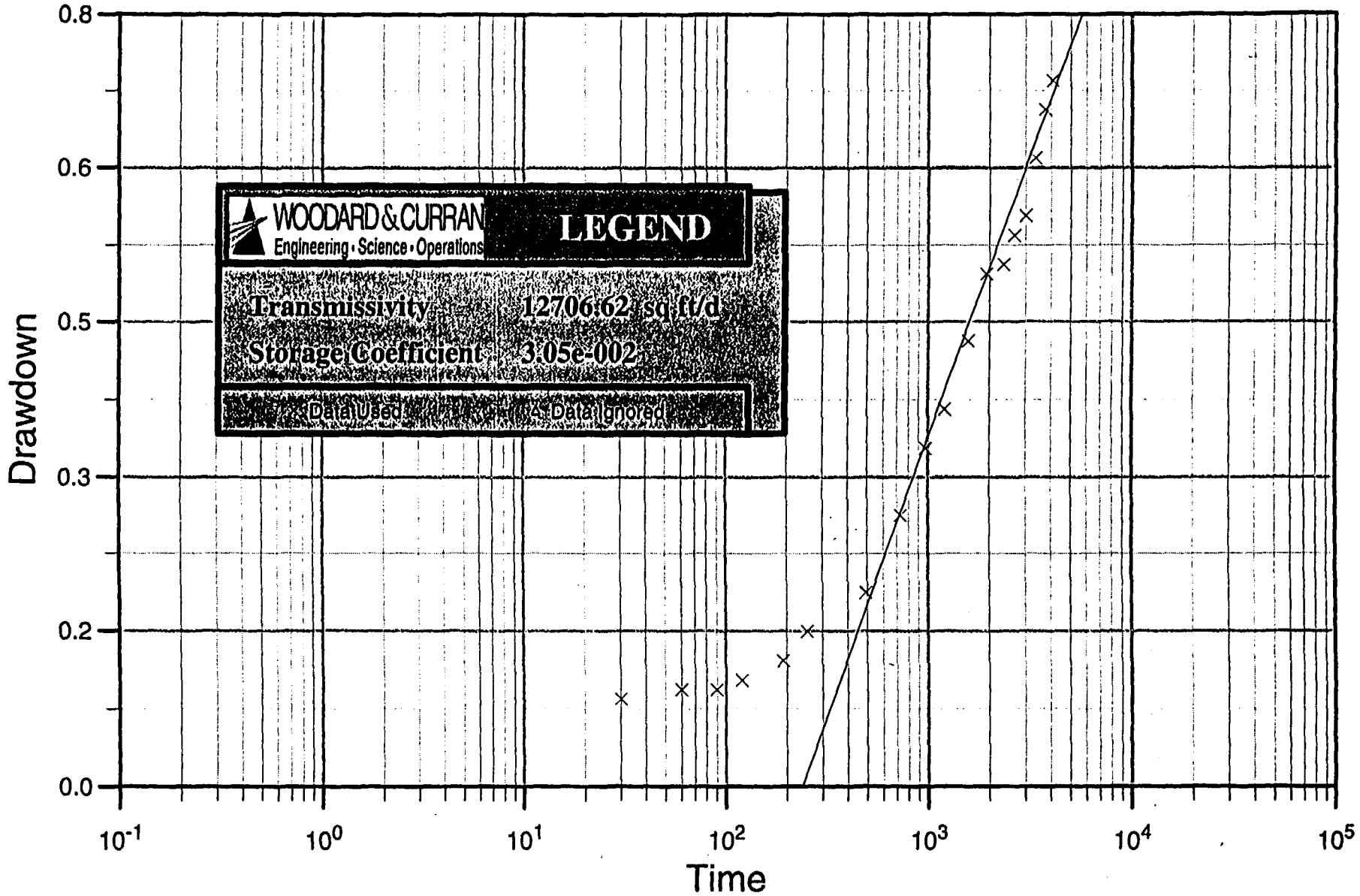

# Cooper and Jacob

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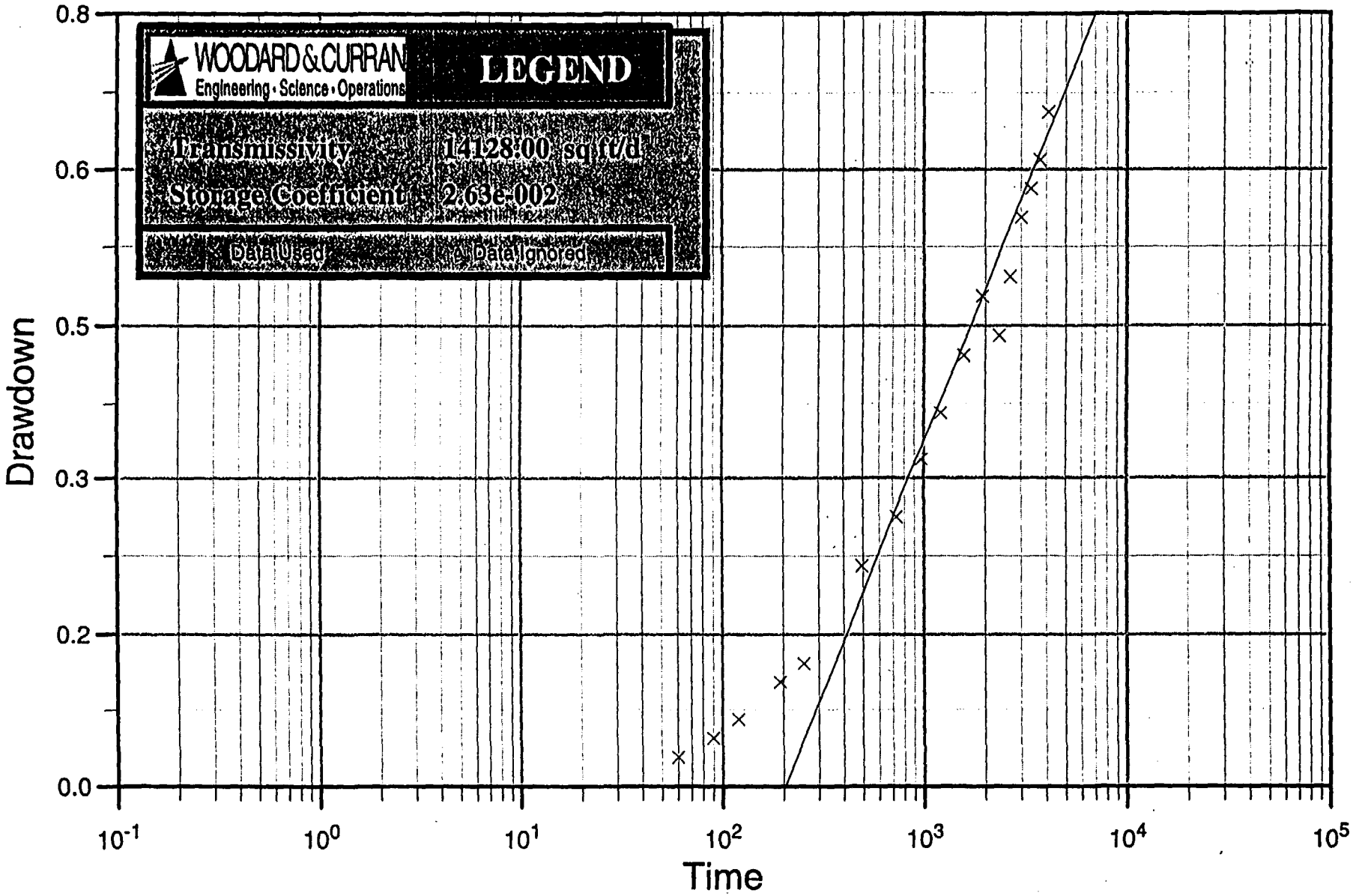

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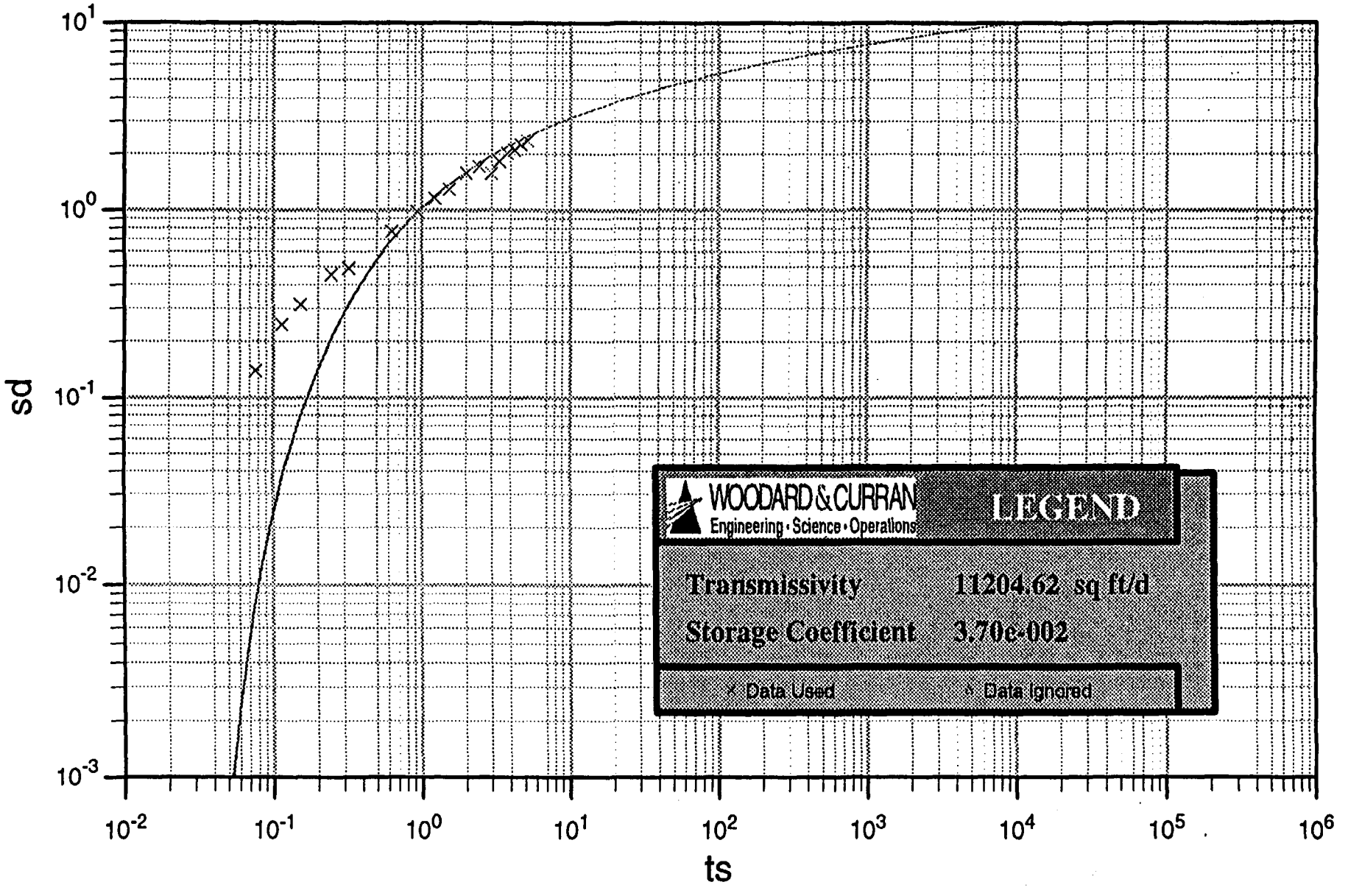
WELL 95-4SB
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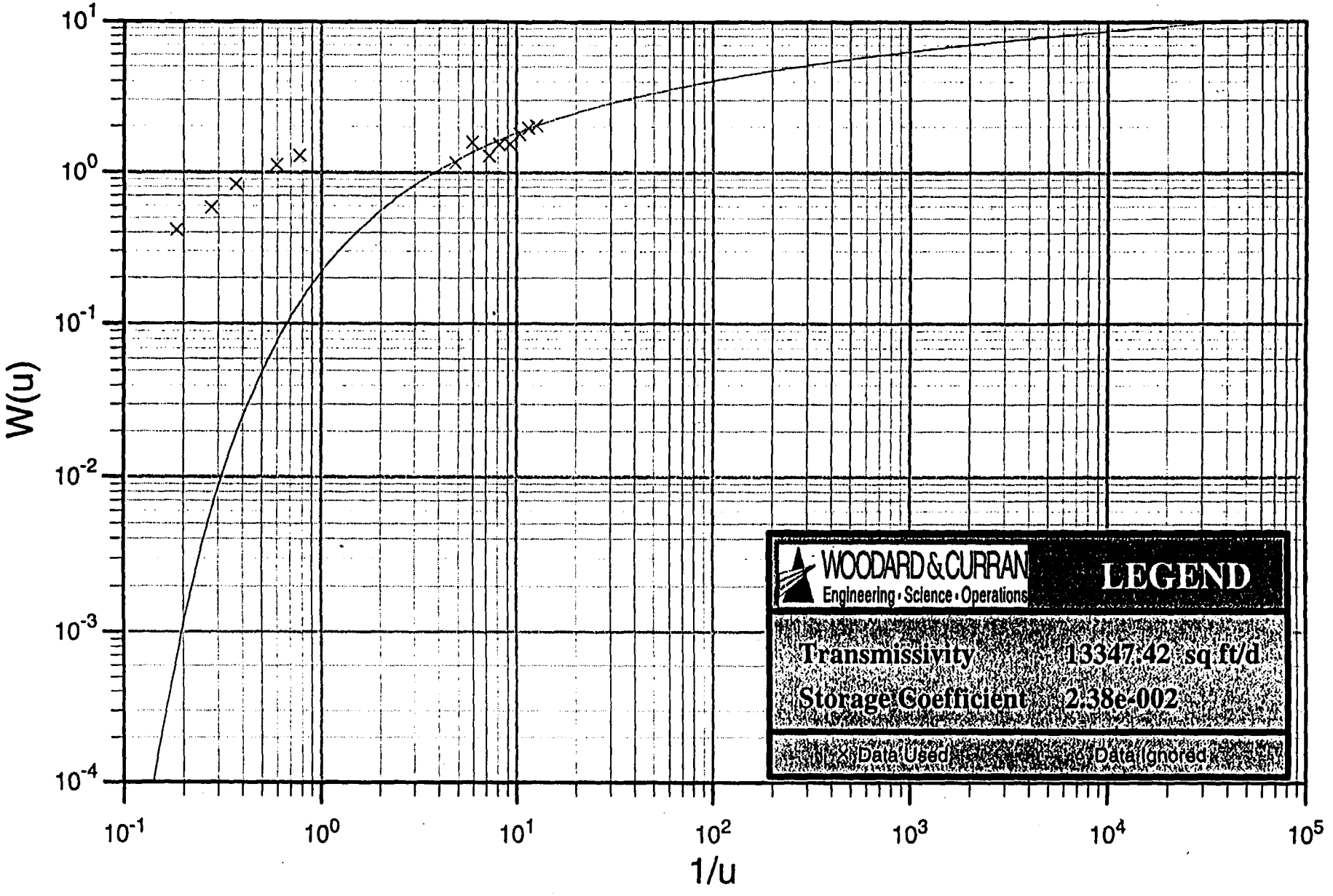
$10^{1}$
$10^{0}$
$10^{-1}$
$10^{-2}$
$10^{-3}$
$10^{-2}$
$10^{-1}$
$10^{0}$
$10^{1}$
$10^{2}$
$10^{3}$
$10^{4}$
$10^{5}$
$10^{6}$
WOODARD & CURRAN
Engineering • Science • Operations
LEGEND
Transmissivity 11204.62 sq ft/d
Storage Coefficient 3.70e-002
× Data Used
○ Data Ignored

WELL 95-5R

# Theis



# Cooper and Jacob

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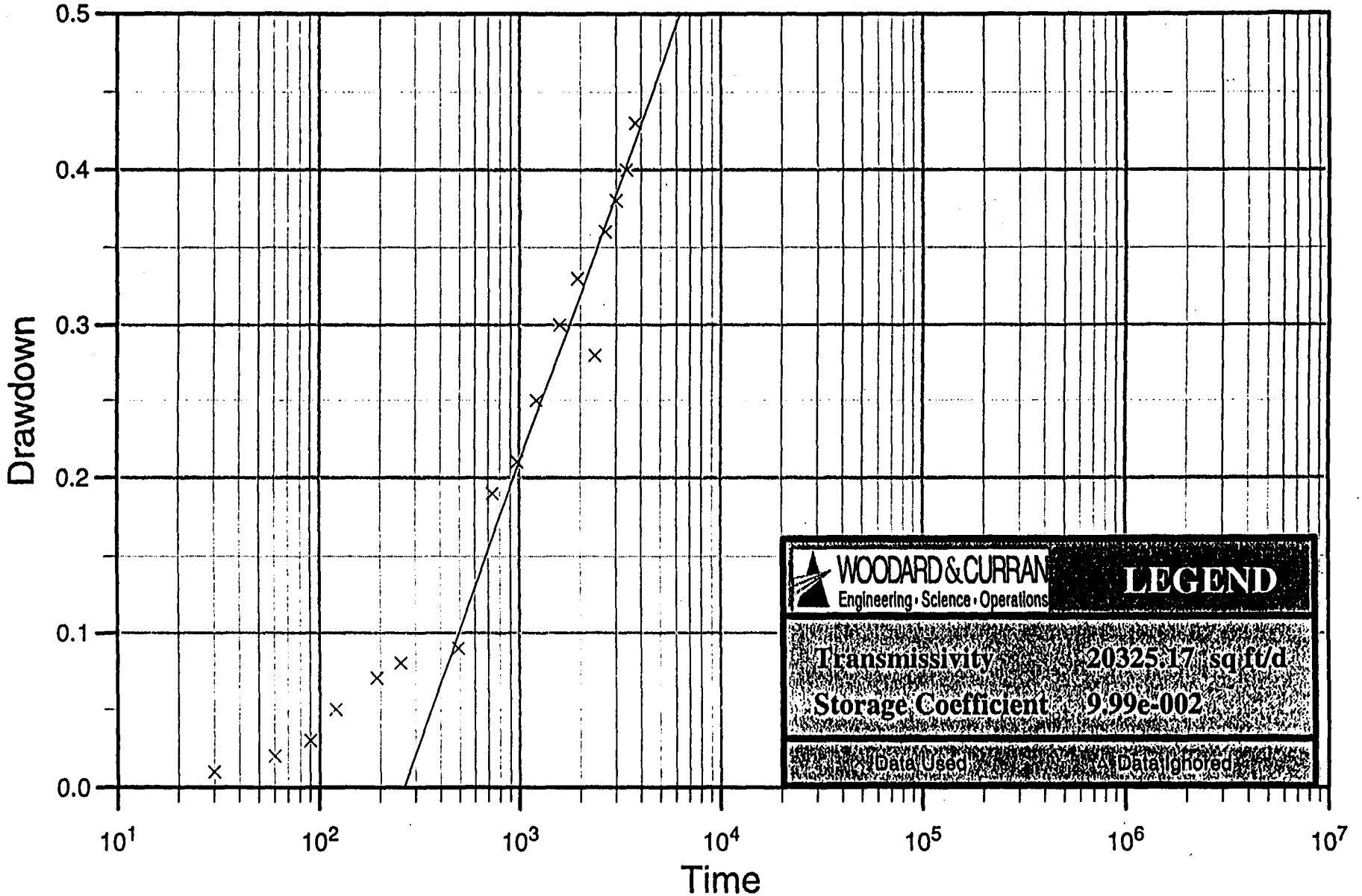
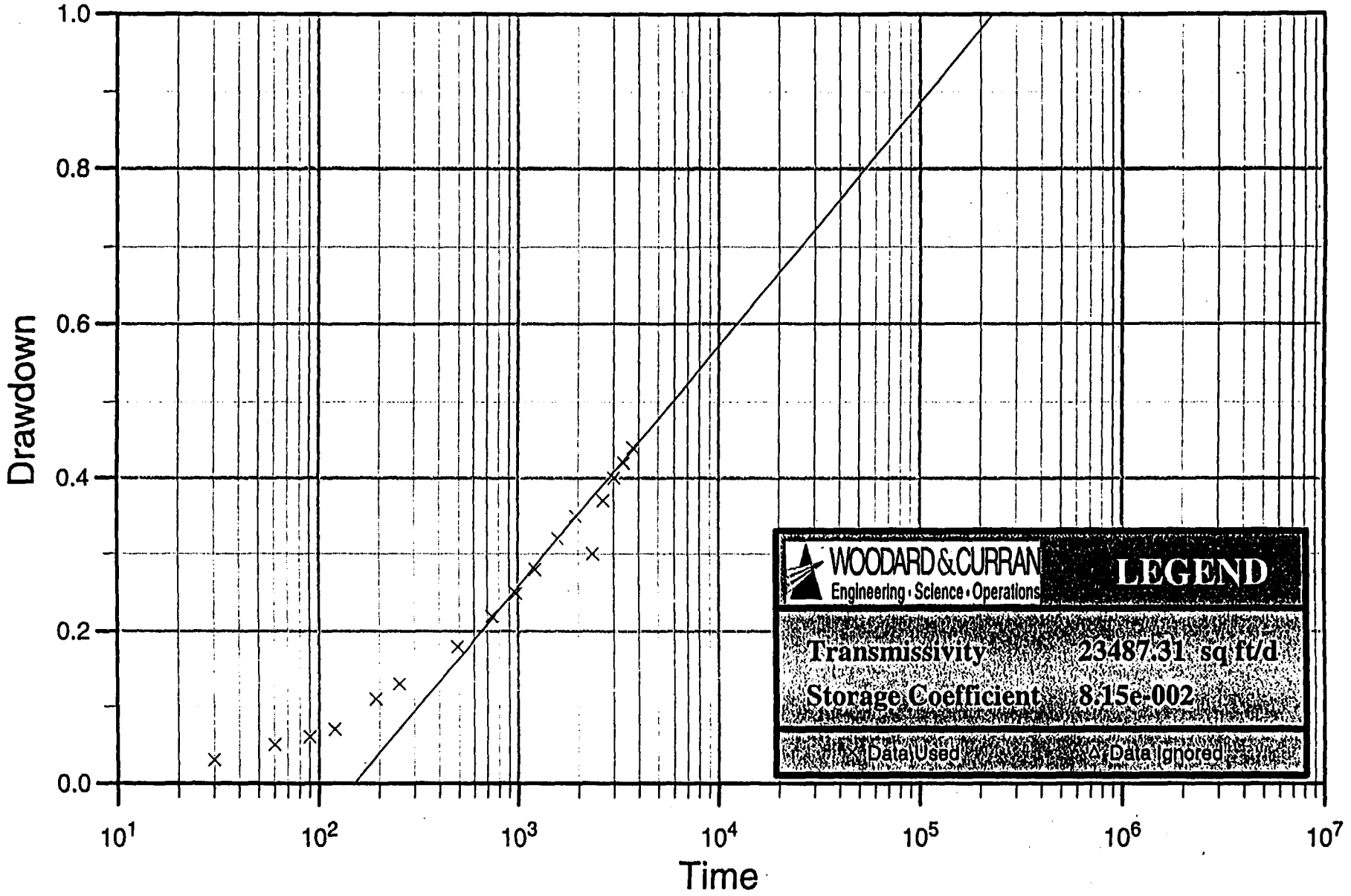


WELL 95-6R

# Cooper and Jacob



# Neuman

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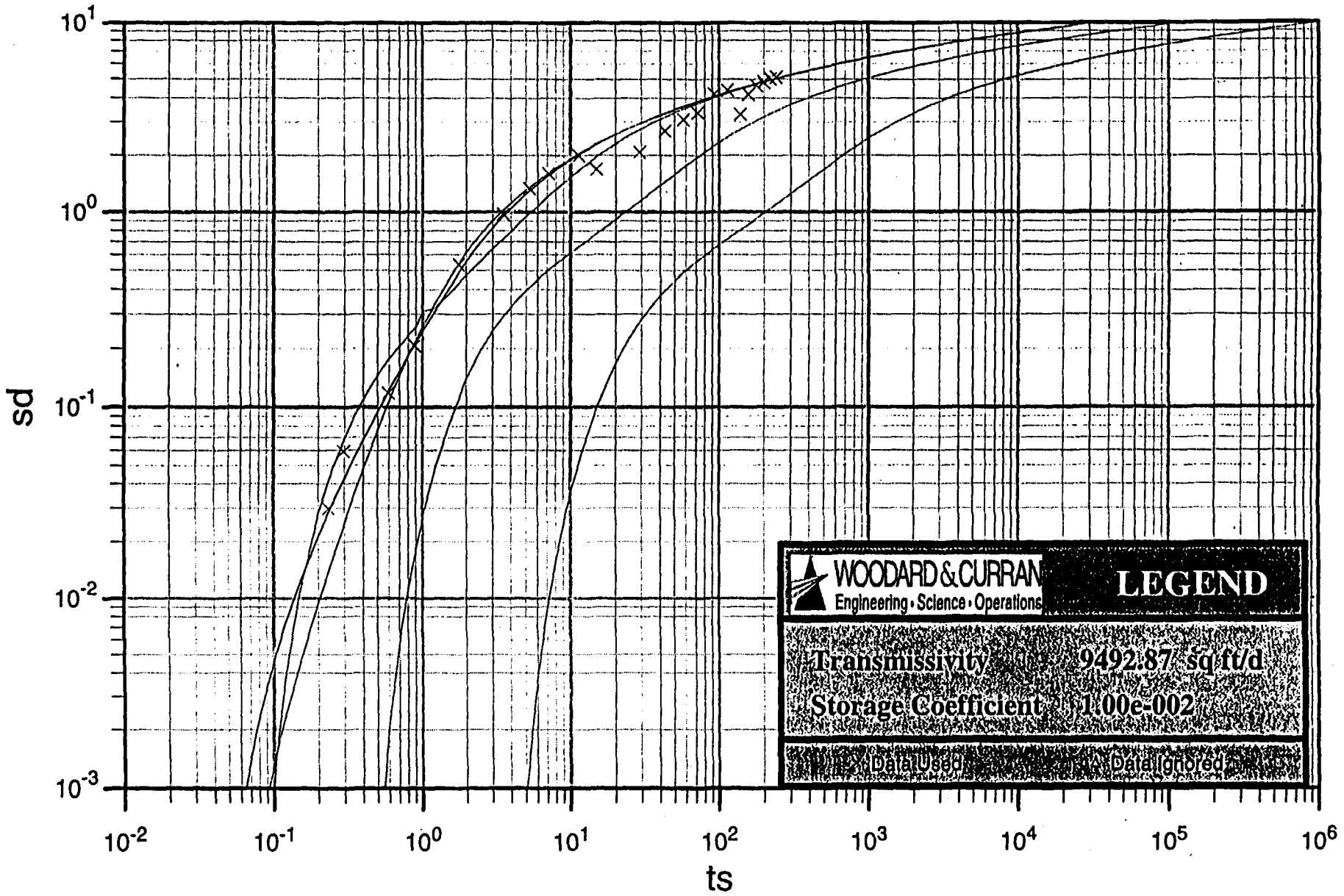

# Cooper and Jacob

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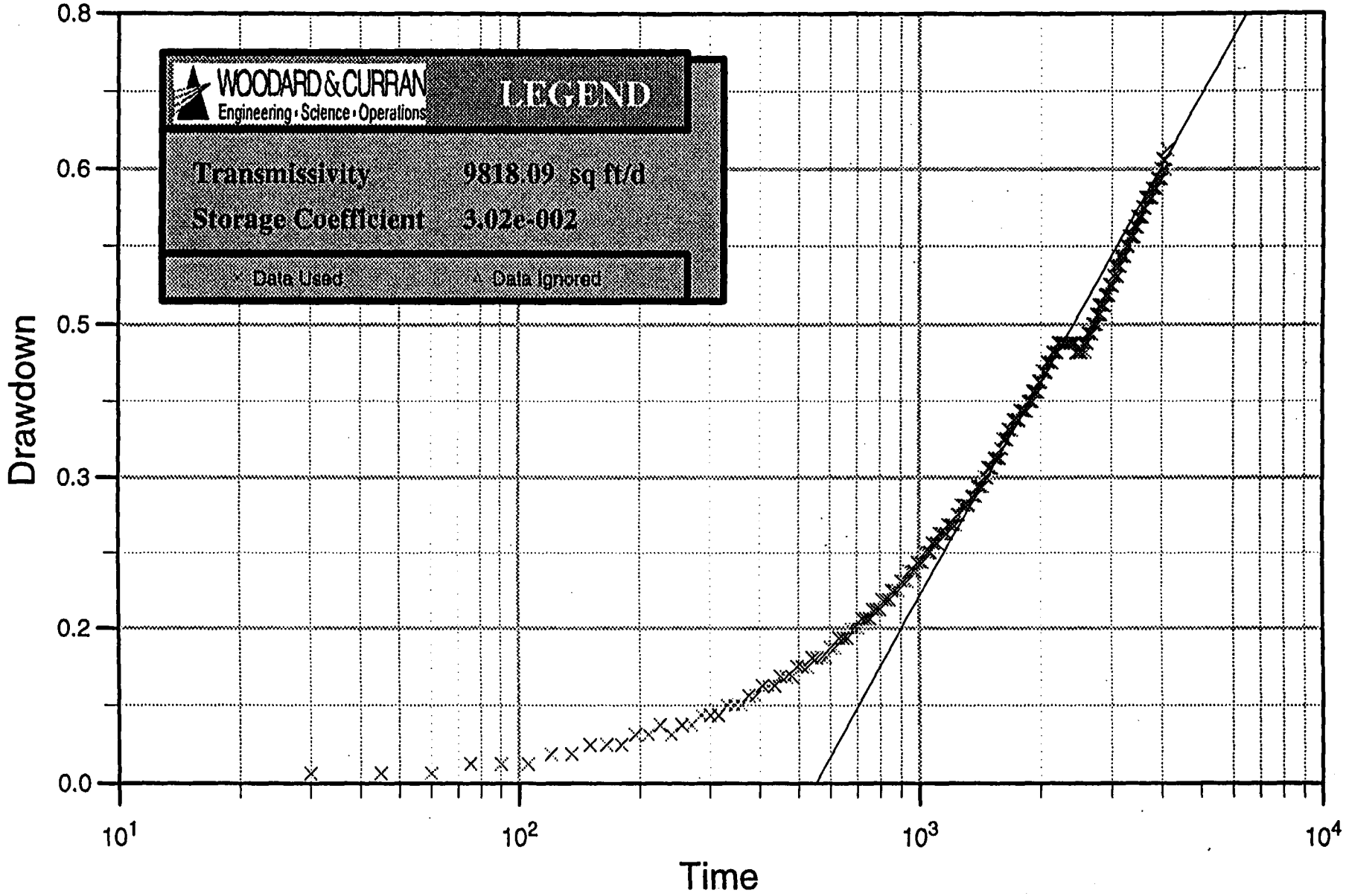

WELL 95-8S

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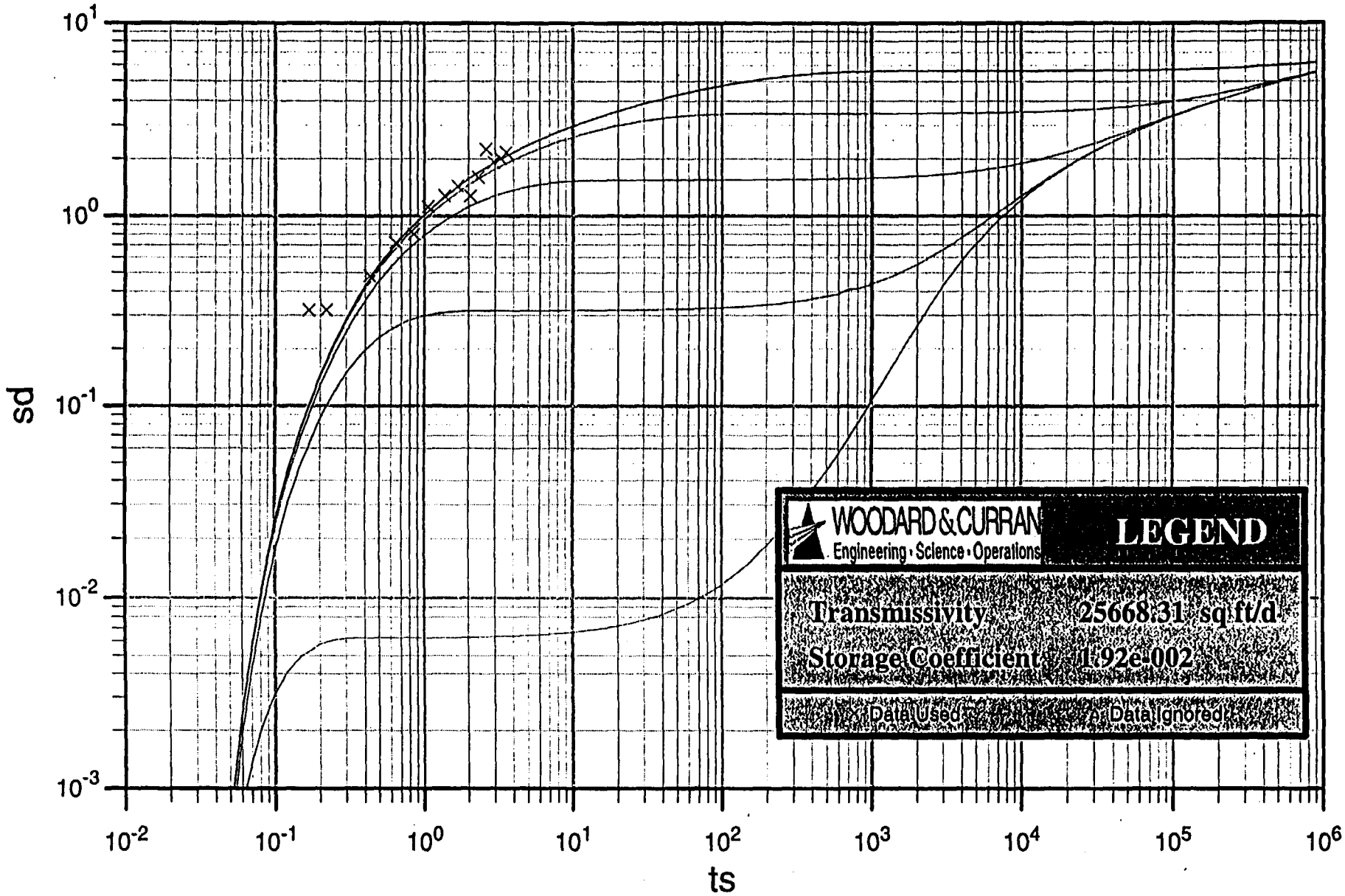

WELL 97-13S-1

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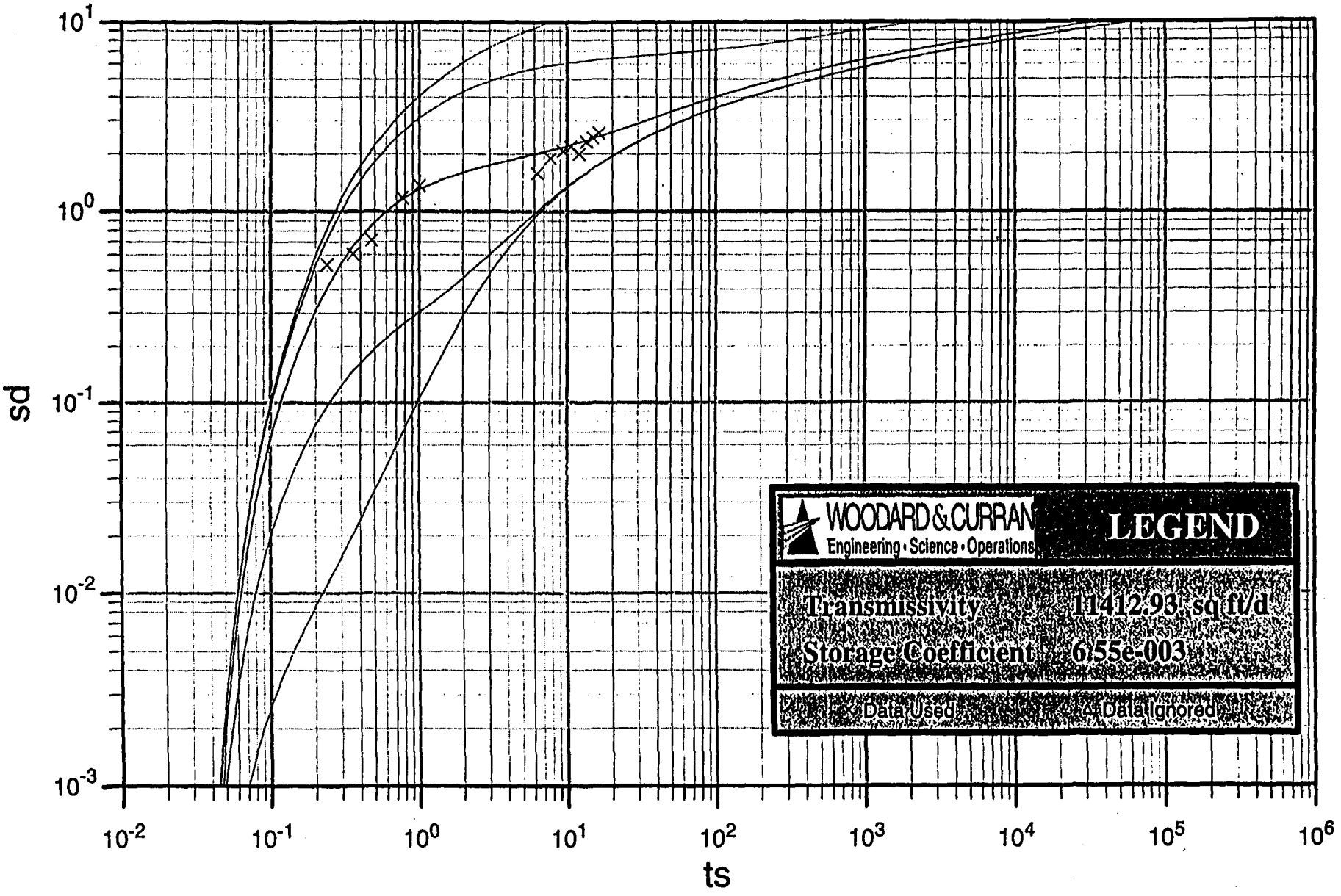
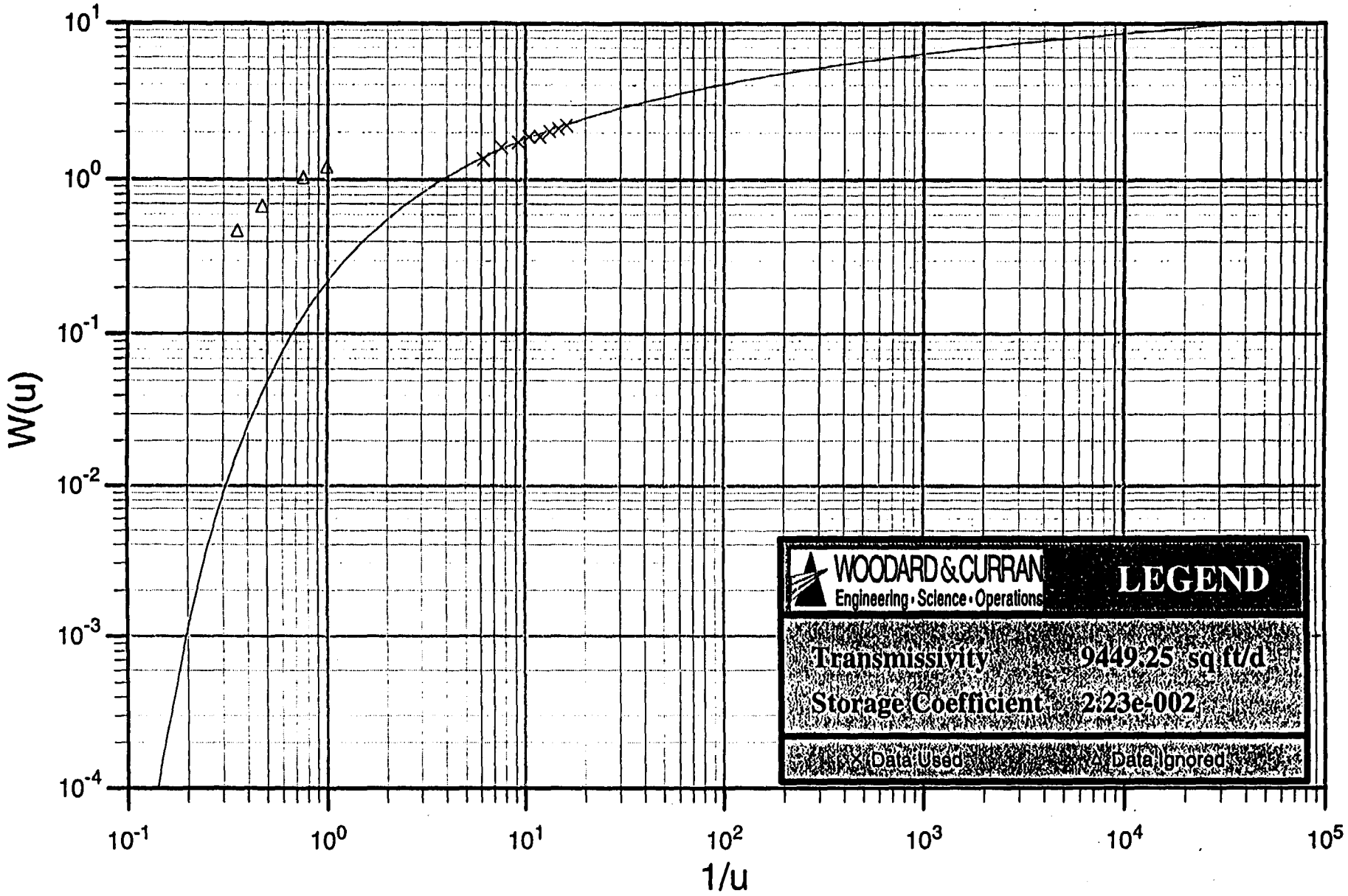


WELL 97-13S-2

# Theis



WELL 97-14S-1

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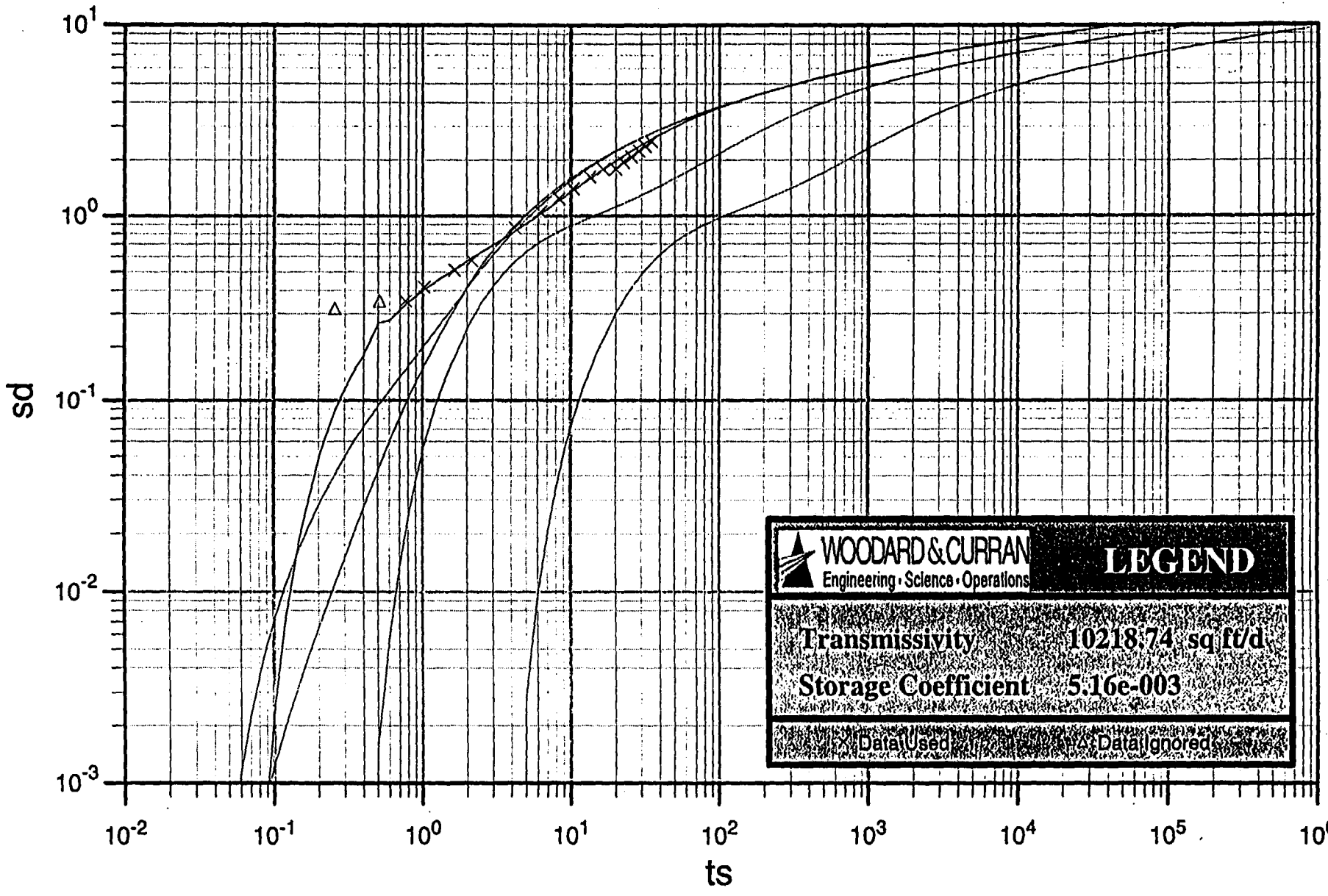
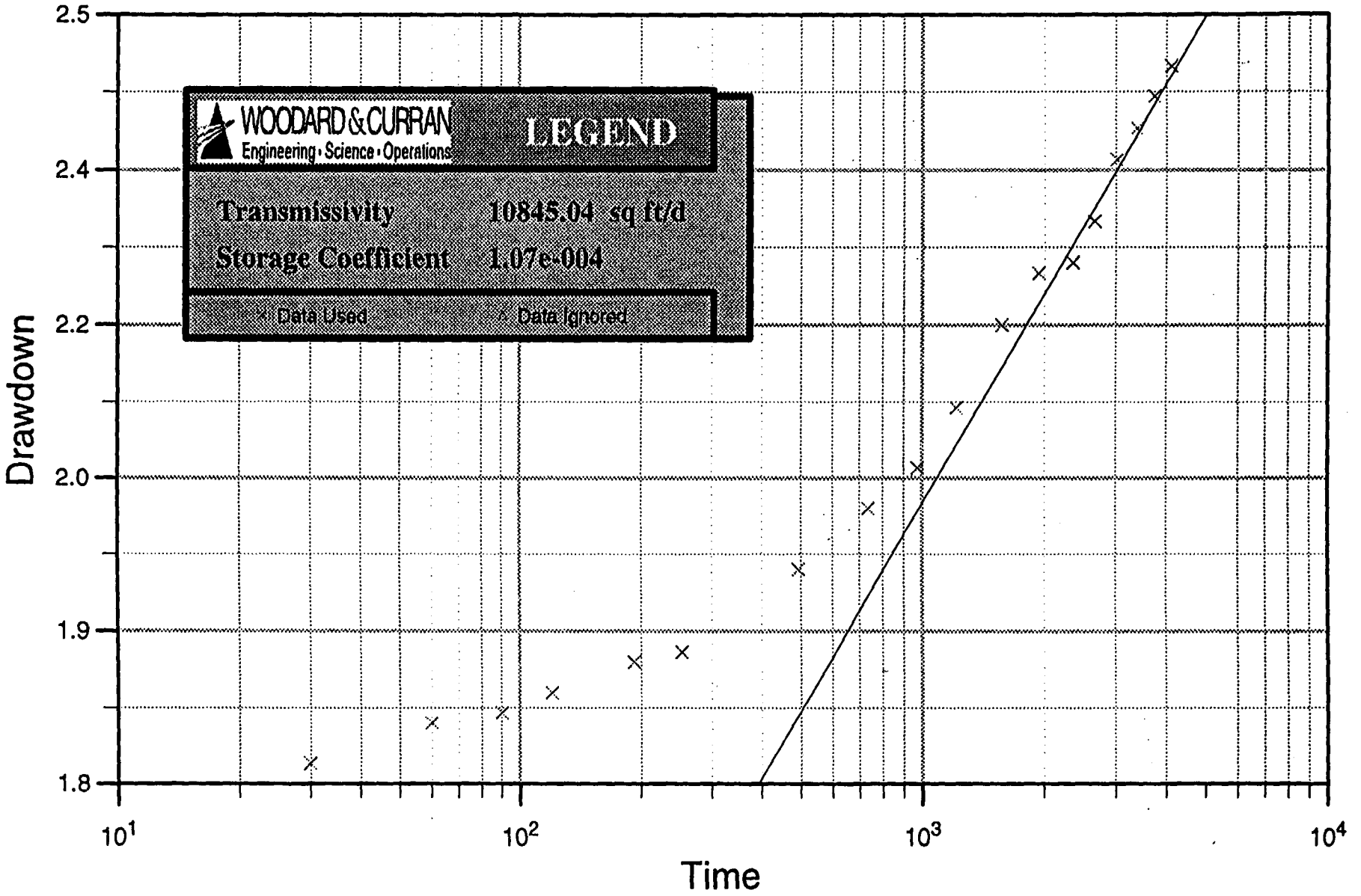


# Cooper and Jacob

**MW-97-14S-2**



# Cooper and Jacob

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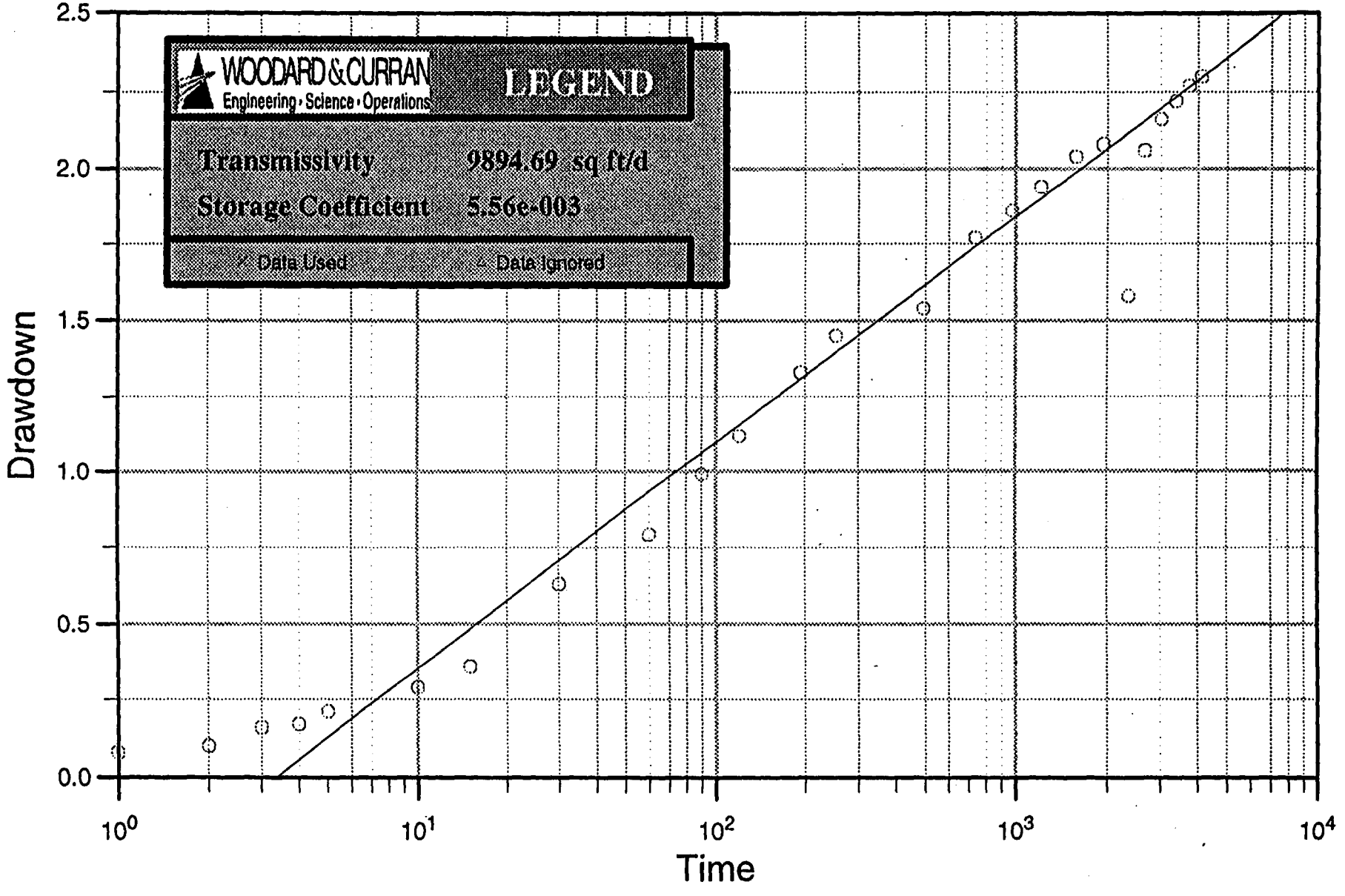

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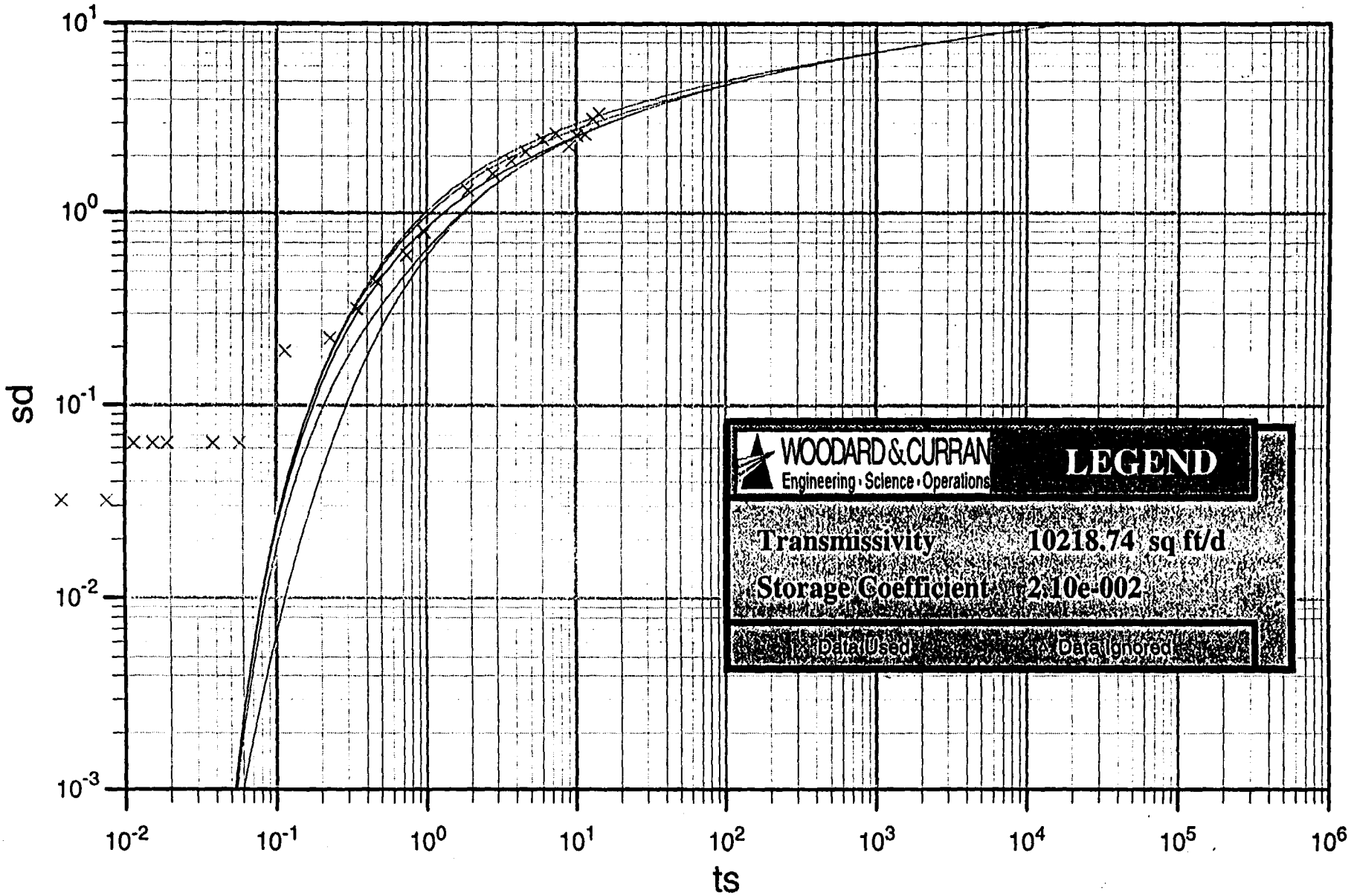
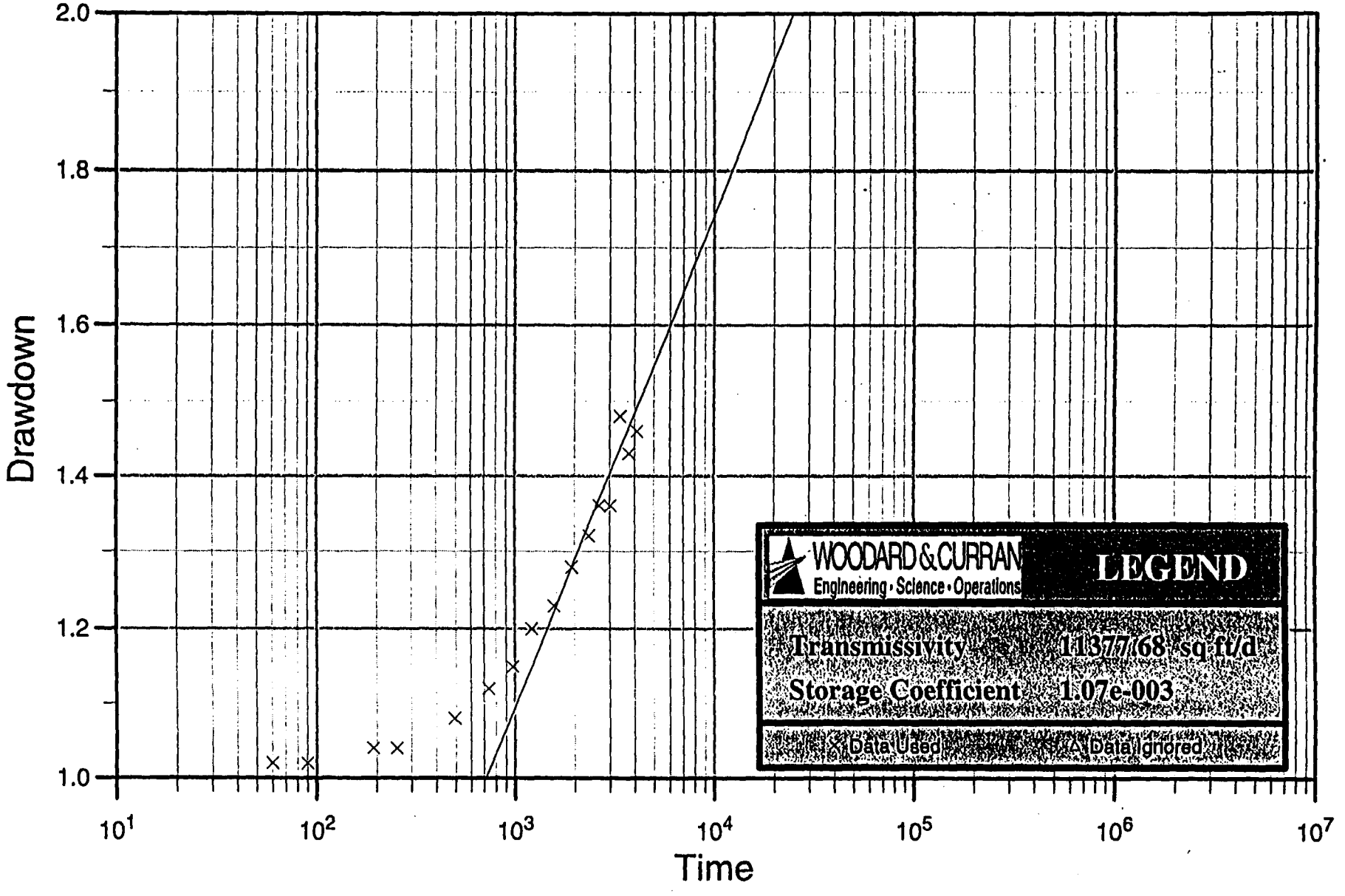


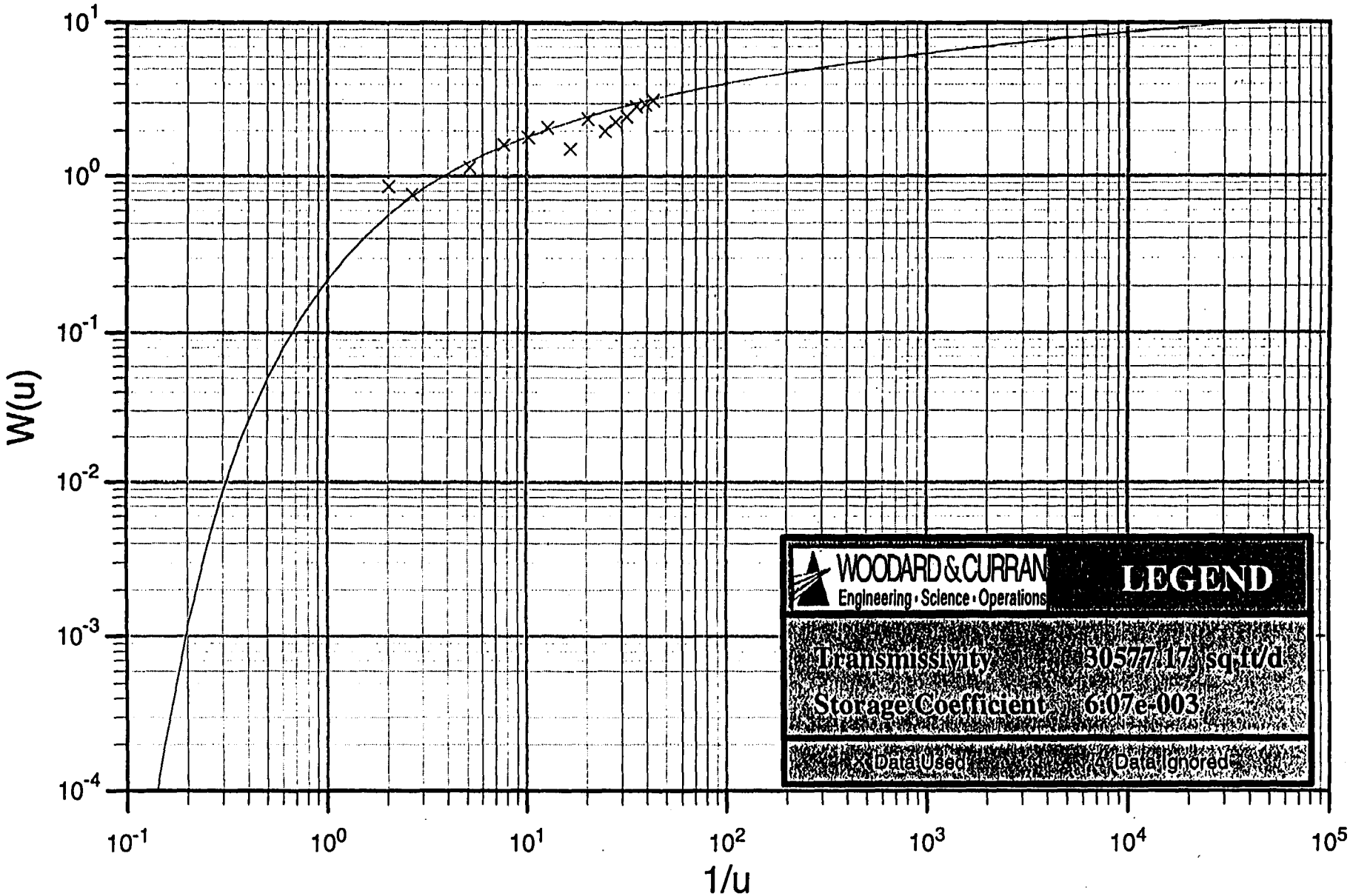
WELL 97-19S

# Cooper and Jacob



WELL PZ-2D

# Theis



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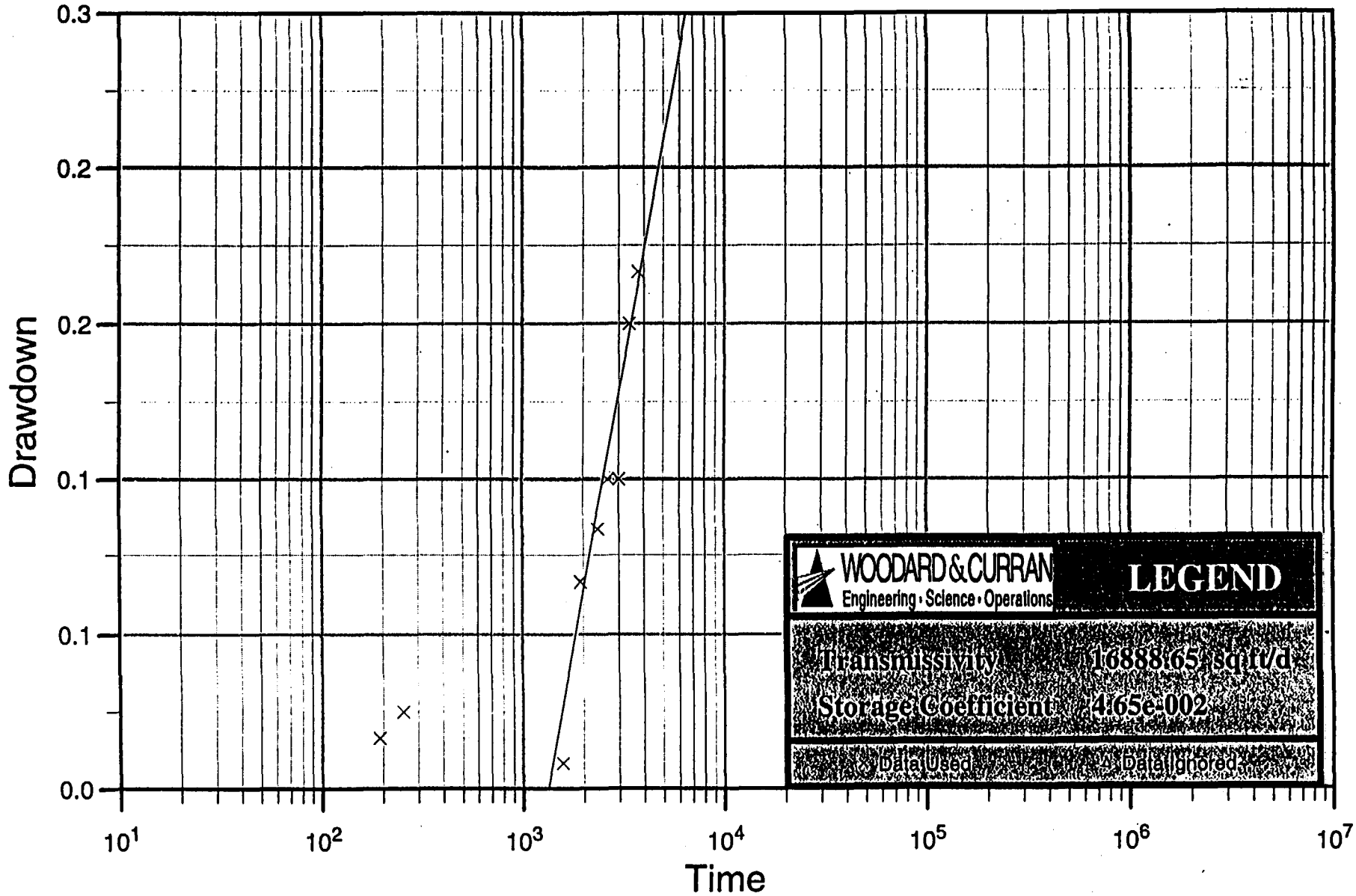

SACO MUNILF
4.6
6867

# APPENDIX B-3

# SURFACE WATER MIXING CALCULATIONS

Saco Municipal Landfill Hydrogeological Investigation

**Stream and Groundwater Discharges from Model Results and Stream Guaging**

| Flow Contributions | High Q, Ave GW flow (cu. ft./day) | Harmonic Mean Q (cu. ft. /day) | Low Q, Post Drought Condition (cu. ft./day) |
|---|---|---|---|
| Stream flow in at station 2 | 250,560 | 30,240 | 11,232 |
| GW contribution to stream N. of plume | 1,776 | 1,599 | 1,599 |
| GW into stream W. side (arsenic cont.) | 14,319 | 12,562 | 12,562 |
| GW into stream E. side ("clean") | 6,165 | 7,218 | 7,218 |
| Total flow in stream at downstream plume edge | 272,820 | 51,619 | 32,611 |

**Concentration of Arsenic and Manganese Discharge to Stream and Corresponding Calculated Concentrations of Arsenic and Manganese in Stream**

| | Concentration in GW (ug/L) ** | Concentration in Stream (ug/L) High Flow | Concentration in Stream (ug/L) Harmonic Mean Flow | Concentration in Stream (ug/L) Low Flow |
|---|---|---|---|---|
| Present Arsenic Concentration | 214 | 11.2 | 52.1 | 82.4 |
| Concentration of Arsenic after 30-50 pore volumes* | 14.6 | 0.8 | 3.6 | 5.6 |
| Present Manganese Concentration | 2,875 | 151 | 700 | 1107.5 |
| Concentration of Manganese after 30-50 pore volumes* | 196 | 10.3 | 47.7 | 75.5 |

* Pore volumes based on USGS arsenic modeling. Each pore volume represents two years based on W&C groundwater flow modeling.

** Calculated weighted average concentration in plume. Concentration after 30 - 50 pore volumes assumes arsenic concentration of 50 ug/L at core of plume.

Saco Municipal Landfill Hydrogeological Investigation

**Calculations assuming various surface water influent concentrations**

| | | | |
|---|---|---|---|
| Influent groundwater arsenic concentration | 214 | | |
| Assuming 1 ppb As in influent stream (background) | | 12.2 | 83.0 |
| Assuming 3 ppb As in influent stream (background) | | 14.1 | 84.3 |
| Assuming 10 ppb As in influent stream | | 20.7 | 88.6 |
| Assuming 15 ppb As in influent stream | | 25.4 | 91.7 |
| Influent groundwater manganese concentration | 2,875 | | |
| Assuming 100 ppb Mn in influent stream | | 246 | 1169 |
| Assuming 1620 ppb Mn in influent stream | | 1686 | 2103 |
| Influent groundwater arsenic concentration | 128 | | |
| Assuming 1 ppb As in influent stream (background) | | 7.7 | 49.9 |
| Assuming 3 ppb As in influent stream (background) | | 9.6 | 51.2 |
| Assuming 10 ppb As in influent stream | | 16.2 | |
| Assuming 15 ppb As in influent stream | | | 58.5 |
| Influent groundwater manganese concentration | 500 | | |
| Assuming 100 ppb Mn in influent stream | | 121 | 254 |
| Assuming 1620 ppb Mn in influent stream | | 1561 | 1189 |
| Influent groundwater arsenic concentration | 14.6 | | |
| Assuming 1 ppb As in influent stream (background) | | 1.7 | 6.2 |
| Assuming 3 ppb As in influent stream (background) | | 3.6 | 7.5 |
| Assuming 10 ppb As in influent stream | | 10.2 | 11.8 |
| Assuming 15 ppb As in influent stream | | 15.0 | 14.8 |
| Influent groundwater manganese concentration | 196 | | |
| Assuming 100 ppb Mn in influent stream | | 105 | 137 |
| Assuming 1620 ppb Mn in influent stream | | 1545 | 1071 |

Calculation:

$$\frac{(Qgw \times Cgw)}{Qsw} + \frac{(Qsw - Qgw) \times Csw}{Qsw}$$

Where: Qgw = groundwater discharge
Cgw = concentration in groundwater
Qsw = surface water discharge downstream
Csw = concentration in influent surface water

Back calculations of concentrations in groundwater assuming ARARs met in surface water

Method: divide surface water ARAR by percentage of flow represented by groundwater

| Surface water concentration (ppb) | Groundwater fraction of surface water flow: Low-flow | Groundwater fraction of surface water flow: High-flow | Groundwater Concentration |
|---|---|---|---|
| 50 | 0.052 | | 962 |
| | | 0.385 | 130 |
| 500 | 0.052 | | 9615 |
| | | 0.385 | 1299 |

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# APPENDIX B-4

# MODEL FOR REDUCTION OF ARSENIC CONCENTRATIONS IN GROUNDWATER AND SURFACE WATER

## SACO MUNICIPAL LANDFILL FINAL FEASIBILITY STUDY

## APPENDIX B-4
## Model for Reduction of Arsenic Concentrations in Groundwater and Surface Water

This appendix describes the analytical model used to predict arsenic concentrations in groundwater downgradient from the Saco Municipal Landfill and resulting surface water concentrations in Sandy Brook. The monitored natural attenuation process is described in Alternative SML-3.

Approach

The following steps were used to predict the timeframe for contaminant reduction:

1. Estimate the timeframe for initiation of contaminant concentration reduction in the aquifer,
2. Estimate the rate of reduction of concentration in the plume,
3. Estimate the average concentration of arsenic in the plume and estimate its variation over time,
4. Estimate an appropriate flow characteristic to evaluate contaminant concentrations in Sandy Brook,
5. Estimate the relationship between flow and contaminant concentration in Sandy Brook at the point of groundwater discharge,
6. Estimate the variation in concentration with distance downstream from the discharge location,
7. Predict the variation in concentration in Sandy Brook over time.

Each of these steps is described in more detail below.

**Step 1 - Timeframe for Initiation of Contaminant Reduction**

Studies by the U.S. Geological Survey (USGS) indicate that large quantities of dissolved organic carbon (DOC) may be adsorbed to the grains of aquifer materials downgradient of the landfill between Area 4 and Sandy Brook. This DOC may provide a long-term source of nutrients for the microbial population in the aquifer, allowing that population to consume oxygen and maintain the reducing conditions responsible for the reductive dissolution. As a result, even after the landfill is capped DOC beneath the landfill would prevent arsenic concentrations in groundwater from decreasing for some indeterminate time, potentially decades. Reactive solute modeling conducted by the USGS indicated that arsenic concentrations downgradient from the landfill could be substantially higher than present concentrations in the short-term (0 to 10 years), before beginning a long-term reduction (Stollenwerk and Colman, 1999).

On the basis of the USGS estimates of the DOC reservoir and the potential for short-term increases in contaminant concentrations, Woodard & Curran assumed that reductions in groundwater contaminant concentrations would not start before five to 10 years from the present. Eight (8) years was selected as the time that reductions would start, and further assumed that concentrations would show neither an increasing nor decreasing trend during the first eight years.

**Step 2 - Rate of Concentration Reduction in the Plume**

The USGS collected cores from the contaminated portion of the aquifer and leached them with uncontaminated groundwater in column experiments to estimate the time required for natural attenuation of the aquifer. Woodard & Curran developed an equation relating the concentration in the core effluent to the number of pore volumes that had been flushed through the core. To predict the arsenic concentrations with time in those cores locations, Woodard & Curran used the relationship of two years travel time per aquifer volume previously developed as part of the groundwater modeling (see Section 2.1). The predicted core leaching effluent concentrations are shown in Figure B-4-1.

**Step 3 – Average Concentration of Arsenic in the Plume and its Variation over Time**

Woodard & Curran compared the core leaching data from the first pore volume to measured arsenic concentrations in groundwater at the same locations the cores were collected and determined that the leaching data are representative of conditions at present. We used these data with measured arsenic concentrations to develop a plot of groundwater arsenic concentration across the plume (perpendicular to flow) for present conditions (0 –8 years), represented as the top curve on Figure B-4-2. Using the relationship between arsenic concentrations and time shown in Figure B-4-1 and the plume cross section shown as the top curve on Figure B-4-2, Woodard & Curran estimated the distribution of arsenic in the plume over time (Table B-4-1 and Figure B-4-2). We then estimated an average plume concentration for each of the specified times. The variation in average plume concentration with time is represented on Figure B-4-3.

**Step 4 - Flow Characteristic to Evaluate Contaminant Concentrations in Sandy Brook**

As directed by USEPA and MEDEP, arsenic concentrations in Sandy Brook were evaluated at annual harmonic mean flow. The harmonic mean of *n* numbers is *n* divided by the sum of the reciprocals of the variables, or

$$\text{Harmonic Mean} = \frac{n}{\Sigma(f/x)}$$

This statistic is always less than the geometric mean, which is in turn always less than the arithmetic mean.

One year of continuous streamflow data was collected at two locations on Sandy Brook from July 17, 1993 through July 16, 1994. The harmonic mean calculated for the location upstream from the landfill (USGS Station 01067853) is 0.35 cubic feet per second (cfs).

In order to determine whether the record obtained from Sandy Brook is representative of seasonality of small watersheds in Maine, the Sandy Brook data were compared to an average calculated from 10 years of data from Collyer Brook near Grey, Maine. The Collyer Brook drainage area is approximately 10 times larger than the Sandy Brook drainage area; however, it is of a generally similar size. No other drainage area of similar size was available in Cumberland or York counties. Comparison of the discharges from Sandy Brook and Collyer Brook shows that they have a similar seasonality (Figure B-4-

4). Therefore, it appears reasonable to assume that the one-year of record from Sandy Brook is representative of stream flow in small drainage basins in southern Maine and does not represent unusual flow conditions.

Woodard & Curran then used the record from Sandy Brook to estimate the ratio between annual harmonic mean flow and measured flows in June (ratio of 1.0) and measured flows in November (ratio of 0.55), as well as estimated low flow (month of August, ratio of 2.7) and high flow (month of March, ratio of 0.19). These ratios were subsequently used in calculations of surface water concentrations.

**Step 5 - Relationship Between Flow and Contaminant Concentration in Sandy Brook at the Point of Groundwater Discharge**

Woodard & Curran calculated the harmonic mean flow in Sandy Brook to be 0.35 cfs. The measured flows at the gauging station in Sandy Brook ranged from a low of 0.1 cfs, recorded in July and August, to a high of 45 cfs, recorded in March. The harmonic mean is 270 percent of the measured daily low flow, and less than one percent of the measured daily high flow. The harmonic mean is, therefore, a conservative estimate of average flow conditions. Woodard & Curran measured arsenic concentrations in Sandy Brook in June and November of 1999. The harmonic mean flow rate for the month of June was the same as the annual harmonic mean, so the June arsenic concentration in surface water is assumed to be representative of the concentration at harmonic mean flow.

**Step 6 - Variation in Concentration with Distance Downstream from the Groundwater Discharge Location**

The ratios calculated for measured arsenic concentration at the groundwater discharge (SW-13) to downstream locations in June 1999 (also representative of harmonic mean) were used to estimate downstream concentrations in future years based on the estimated concentration in groundwater discharging to Sandy Brook.

**Step 7 - Variation in Concentration in Sandy Brook over Time**

Concentrations in Sandy Brook over time were estimated using the estimated concentration at the point of groundwater discharge, the ratio between the point of discharge and downstream locations, and the ratios between harmonic mean and high and low flows. These calculations are presented in Table B-4-2. The areas of Sandy Brook estimated to be above 10 μg/L of arsenic and 3 μg/L or arsenic are shown on Figure B-4-5 for harmonic mean flow at current conditions and in the future.

**Uncertainty Assessment**

The uncertainty assessment associated with this model is based on the uncertainties associated with each component of the model. The key uncertainties associated with these components are highlighted below.

USGS Column Studies – The limitations of the USGS studies include: (1) columns are flushed at a faster rate than groundwater moves through the aquifer, (2) column studies were conducted ex situ and may not accurately reflect in situ conditions, (3) the soil cores used in the ex situ column studies were collected from the center (e.g., most highly contaminated area) of the plume and clearly over estimate DOC concentrations across the vast majority of the plume.

Groundwater and Surface Water Data – The limitations associated with the existing groundwater and surface water data set include: (1) groundwater data is limited to approximately eight sampling rounds (4 years); the inherent variability of the natural groundwater system and the impact this may have on geochemical reactions is not well understood at this time, and (2) surface water data for the entire brook is limited to the past 4 years, during which time there was both a 100-year storm event and a 100-drought event. These events may have biased results. For example, the June 1999 surface water data, collected during 100-year drought conditions, is a very conservative estimate of the worst-case arsenic concentrations within Sandy Brook.

The long-term interaction between the groundwater flux and the surface water arsenic concentrations is represented by four years of data. Long-term predictions are dependent on how representative current conditions are of the future. The model used conservative assumptions regarding the size and average concentration of the plume, thereby overestimating the net flux to the stream. The result should be a conservative estimate of surface water arsenic concentrations.

Groundwater Flux and Surface Water Flow - Groundwater flux to Sandy Brook is based on the W&C MODFLOW model developed during the RI/FS to evaluate pumping strategies. While we believe this model provides a consistent view of groundwater flow in the vicinity of Area 4 and Sandy Brook, it is not a unique solution. Actual flow paths and flow rates may vary.

Surface Water Flow in Sandy Brook is based on a one-year study completed by the USGS in 1994. For the purpose of this model, that record was compared to a different drainage basin within Cumberland County that has a much longer period of record to verify that the seasonality of the Sandy Brook record was representative of the longer record.

Conclusion – Based on the conservative nature of many of the assumptions used in developing the groundwater flux and surface water transport model (see discussion above), we believe the arsenic concentrations predicted for Sandy Brook are conservative and are within the inherent limitations imposed by the existing data set. Because the arsenic concentrations in Sandy Brook are most sensitive to the volume of flow within the brook, actual arsenic concentrations measured at any given time may vary depending on actual flow volume (see peak flow compared to low flows). Based on the USGS flow information, the harmonic mean of 0.35 cfs (i.e., approximately 1% of high flow conditions) is an appropriate estimate for predicting the average exposure point concentrations for arsenic in surface water. It is expected that this model will continue to be updated and evaluated during each 5-year site review conducted by EPA. Until these future evaluations can be completed, this model is provided as a reasonable estimate of arsenic concentrations in Sandy Brook surface water over time (see Table B-4-2 and Figure B-4-5).

**Figure B-4-1**
**Arsenic Concentrations in Water Flushed From Cores**

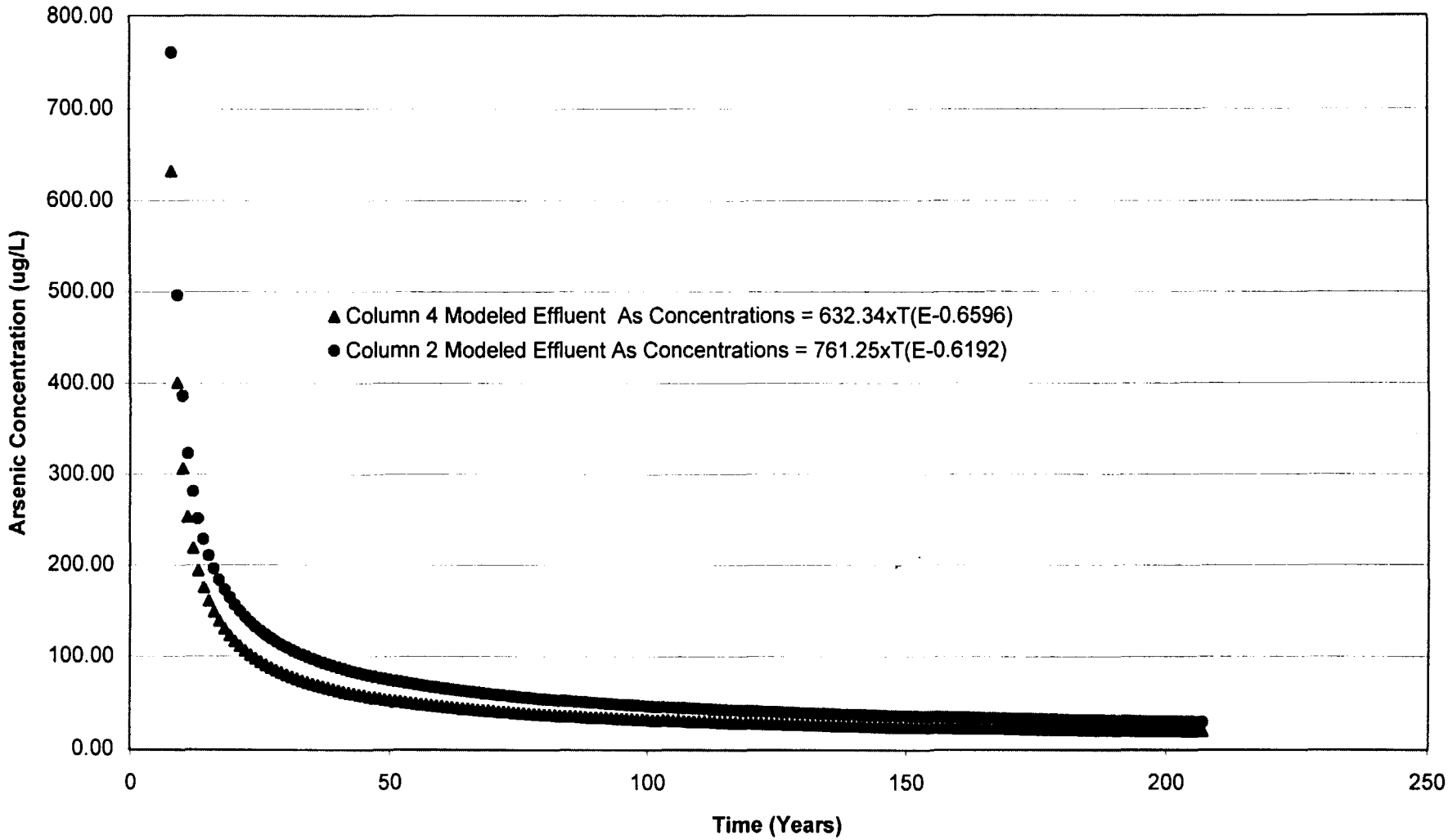


**Figure B-4-2**
**Arsenic Concentrations in Groundwater Plume**

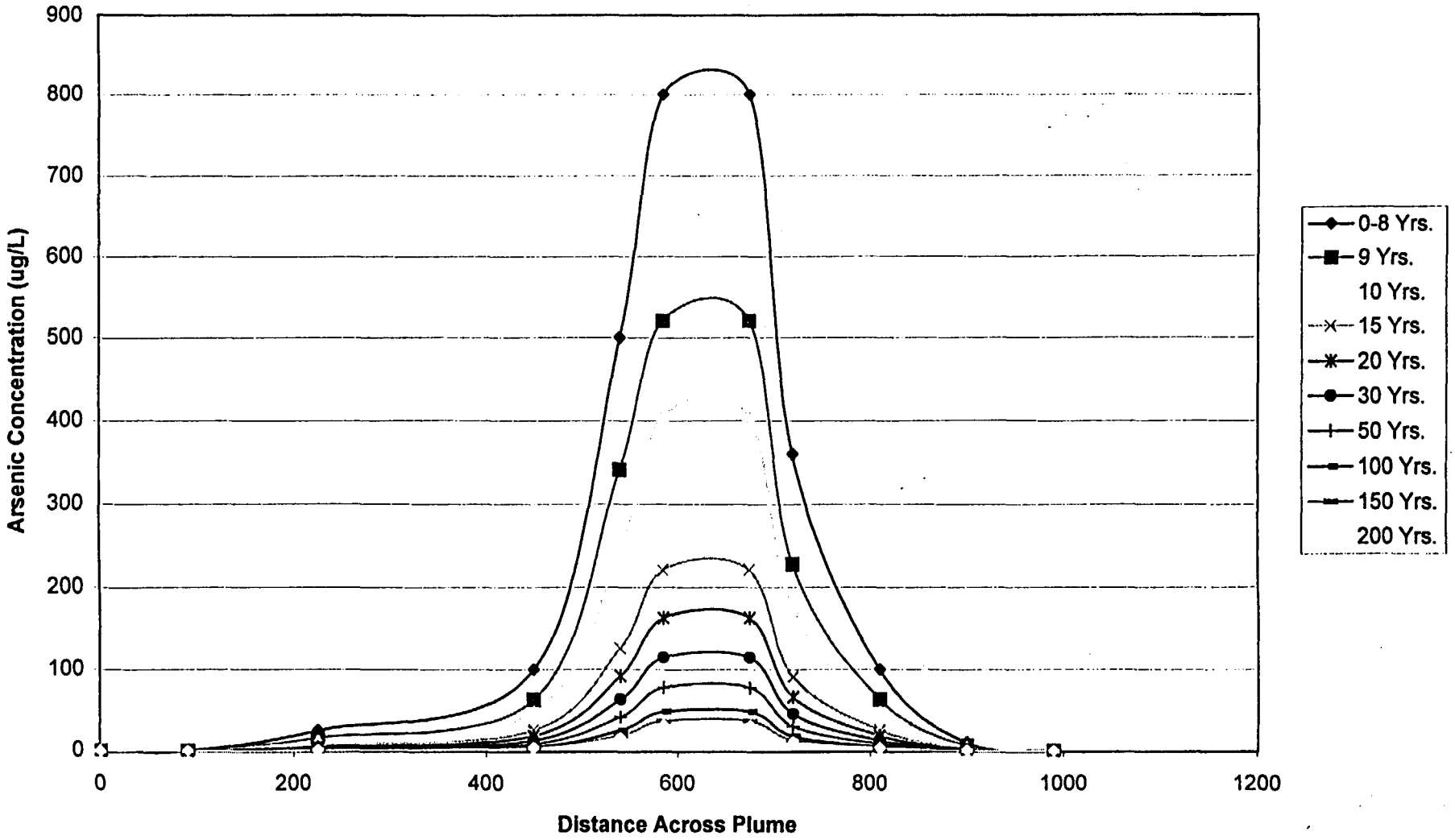


**Figure B-4-3**
**Variation in Average Arsenic Concentration in Plume with Time**

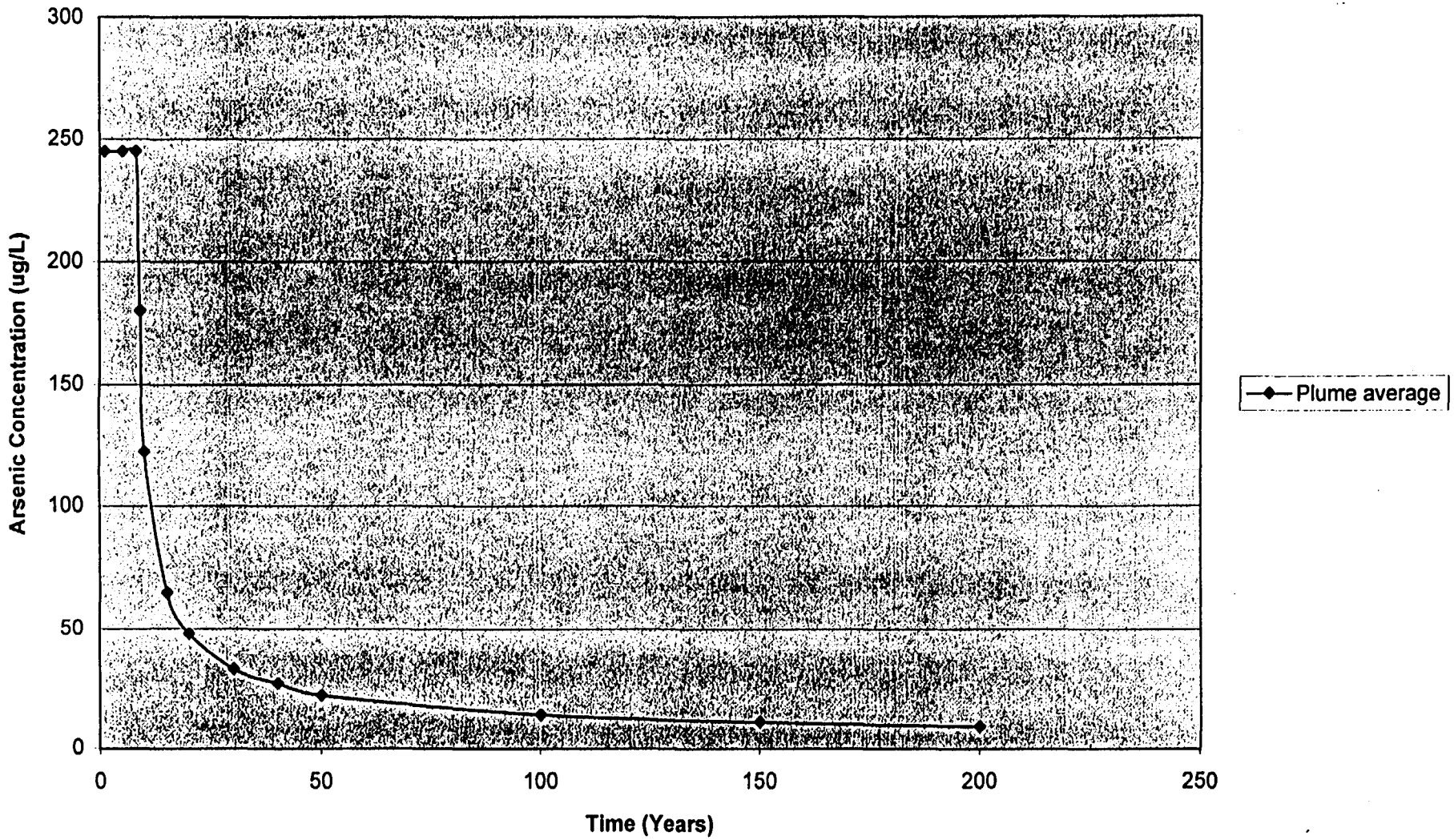
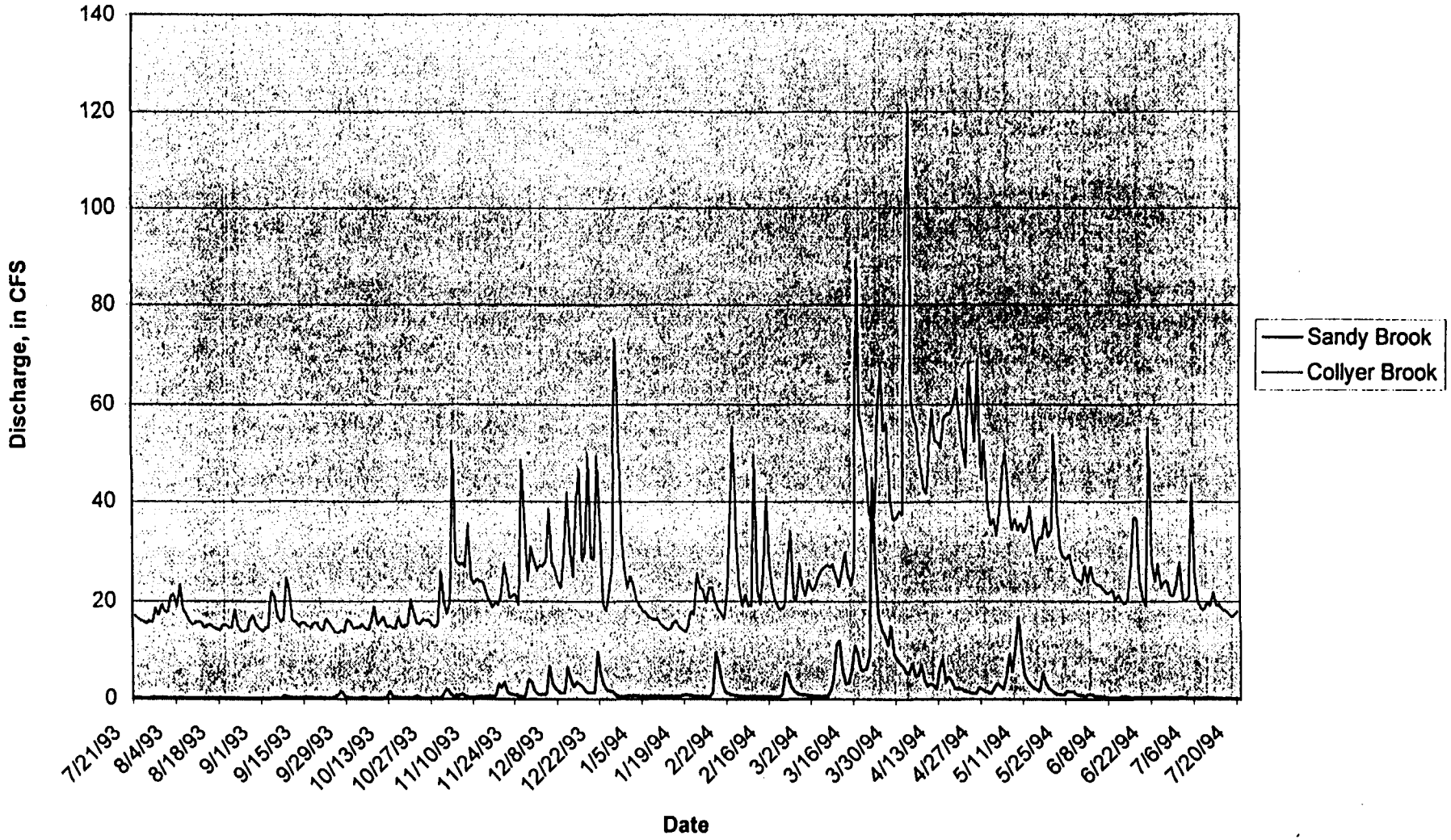


**Table B-4-1**

**Saco Municipal Landfill**
**Expected Arsenic Concentrations in Groundwater Plume Downgradient from Landfill 4**

| Distance From Edge of Plume | Arsenic Concentration at Specified Distance After Indicated Number of Years | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0 - 8 years | 9 year | 10 year | 15 year | 20 year | 30 year | 50 year | 100 year | 150 year | 200 year |
| 0 | 0.001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 90 | 0.001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 225 | 25 | 16 | 12 | 6 | 5 | 3 | 2 | 1 | 1 | 1 |
| 450 | 100 | 63 | 48 | 25 | 18 | 13 | 8 | 5 | 4 | 3 |
| 540 | 500 | 342 | 242 | 127 | 92 | 63 | 42 | 25 | 19 | 16 |
| 585 | 800 | 521 | 405 | 221 | 163 | 115 | 78 | 48 | 37 | 31 |
| 675 | 800 | 521 | 405 | 221 | 163 | 115 | 78 | 48 | 37 | 31 |
| 720 | 360 | 228 | 174 | 91 | 66 | 46 | 30 | 18 | 14 | 11 |
| 810 | 100 | 63 | 48 | 25 | 18 | 13 | 8 | 5 | 4 | 3 |
| 900 | 10 | 6 | 5 | 3 | 2 | 1 | 1 | 1 | 0 | 0 |
| 990 | 0.001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Average Concentration | 245 | 160 | 122 | 65 | 48 | 33 | 22 | 14 | 11 | 9 |

**Figure B-4-4**
**Discharge - Sandy Brook and Collyer Brook**




collyer at grey/collyer,sandy plot

**Table B-4-2**
**Estimated Arsenic Concentrations in Sandy Brook Over Time**

| Arsenic at Surface Water Stations (ug/l) at Harmonic Mean Flow | | | | | | |
|---|---|---|---|---|---|---|
| | Surface Water Sampling Location | | | | | |
| Years After Cap | SW-13 | SW-34 | SW-31 | SW-15 | SW-69 | SW-103 |
| 0-8 | 35.0 | 22.0 | 14.0 | 12.9 | 11.8 | 8.0 |
| 9 | 25.7 | 16.1 | 10.3 | 9.5 | 8.7 | 5.9 |
| 10 | 17.4 | 10.9 | 7.0 | 6.4 | 5.9 | 4.0 |
| 15 | 9.3 | 5.8 | 3.7 | 3.4 | 3.1 | 2.1 |
| 20 | 6.9 | 4.3 | 2.8 | 2.5 | 2.3 | 1.6 |
| 30 | 4.8 | 3.0 | 1.9 | 1.8 | 1.6 | 1.1 |
| 40 | 3.8 | 2.4 | 1.5 | 1.4 | 1.3 | 0.9 |
| 50 | 3.2 | 2.0 | 1.3 | 1.2 | 1.1 | 0.7 |
| 100 | 2.0 | 1.3 | 0.8 | 0.7 | 0.7 | 0.5 |
| 150 | 1.5 | 0.9 | 0.6 | 0.6 | 0.5 | 0.3 |
| 200 | 1.2 | 0.8 | 0.5 | 0.4 | 0.4 | 0.3 |

Arsenic concentrations calculated as:

$$C_{As\ at\ harmonic\ mean} = Q_{GW/QT} \times C_{As(GW)} \times C_m/C_e \times C_{sp}/C_d$$

Where:

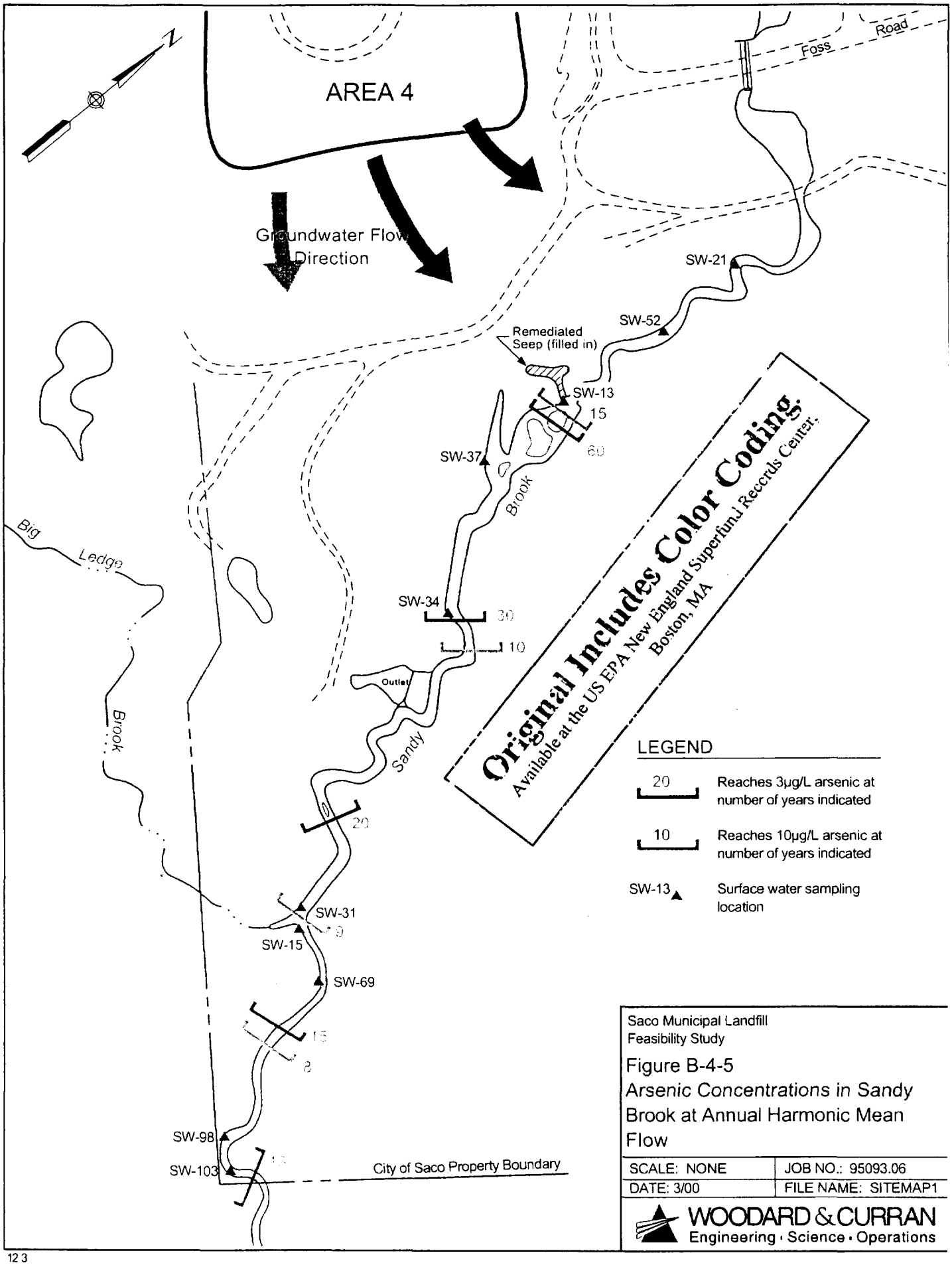
$C_{As\ at\ harmonic\ mean}$ = concentration of arsenic in Sandy Brook

$Q_{GW/QT}$ = ratio of discharge of arsenic-contminated groundwater into Sandy Brook to total flow in Sandy Brook at downstream end of plume (see Appendix B-3)

Cas(GW) = average concentration of arsenic in groundwater plume discharging into Sandy Brook (see Table B-4-1)

$C_m/C_e$ = ratio of measured concentration in Sandy Brook to estimated concentration at sampling point

$C_{sp}/C_d$ = ratio of concentration at sampling point to concentration in Sandy Brook at discharge point




Original Includes Color Coding.
Available at the US EPA New England Superfund Records Center, Boston, MA

Saco Municipal Landfill
Feasibility Study

Figure B-4-5
Arsenic Concentrations in Sandy Brook at Annual Harmonic Mean Flow

| | |
|---|---|
| SCALE: NONE | JOB NO.: 95093.06 |
| DATE: 3/00 | FILE NAME: SITEMAP1 |

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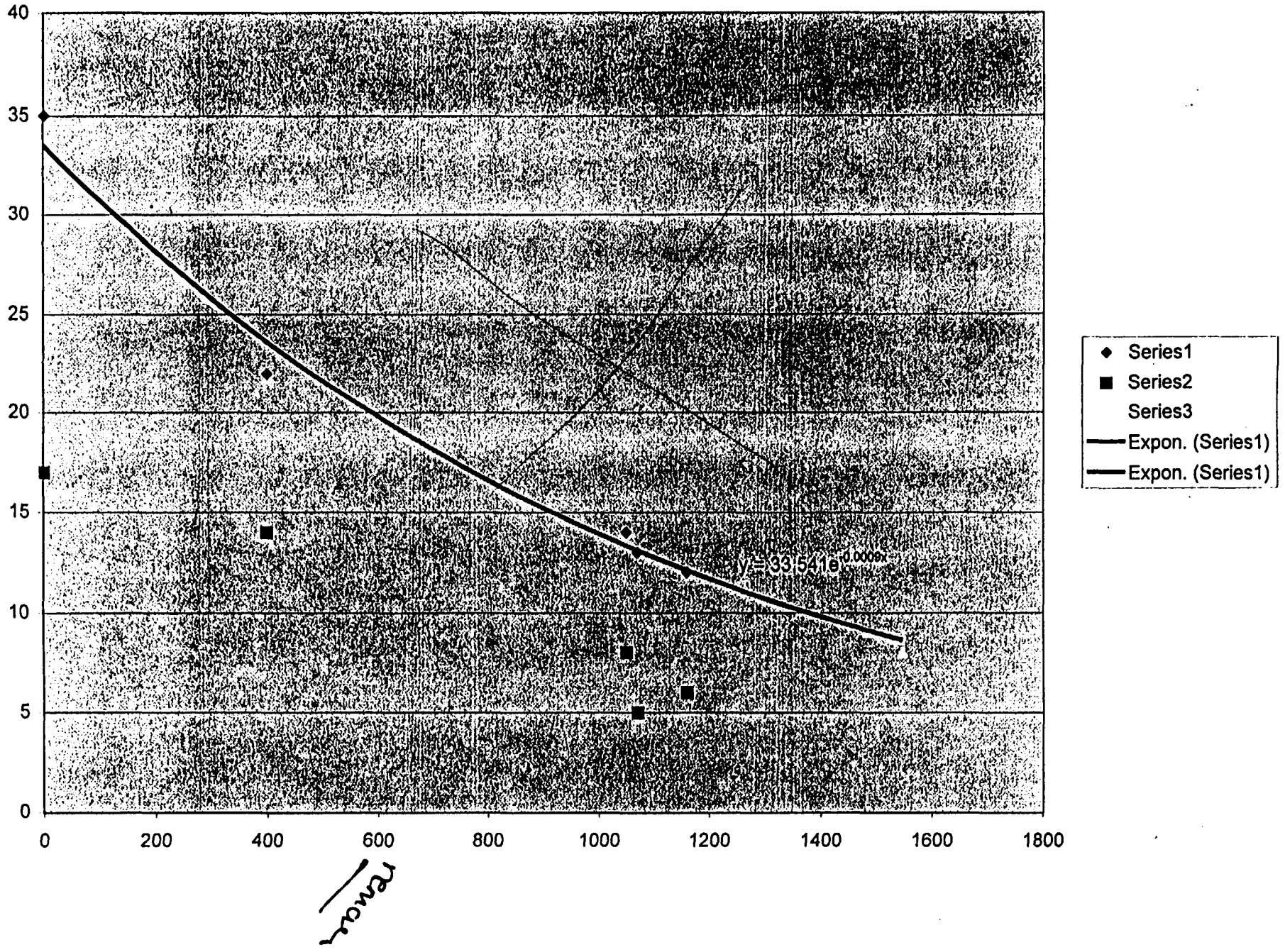
40
35
30
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200
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y = 33.541e^-0.0009x
Series1
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Series3
Expon. (Series1)
Expon. (Series1)

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# APPENDIX C

# USGS WHOLE-ROCK ANALYSES

The USGS has requested that this draft data not be copied or cited.

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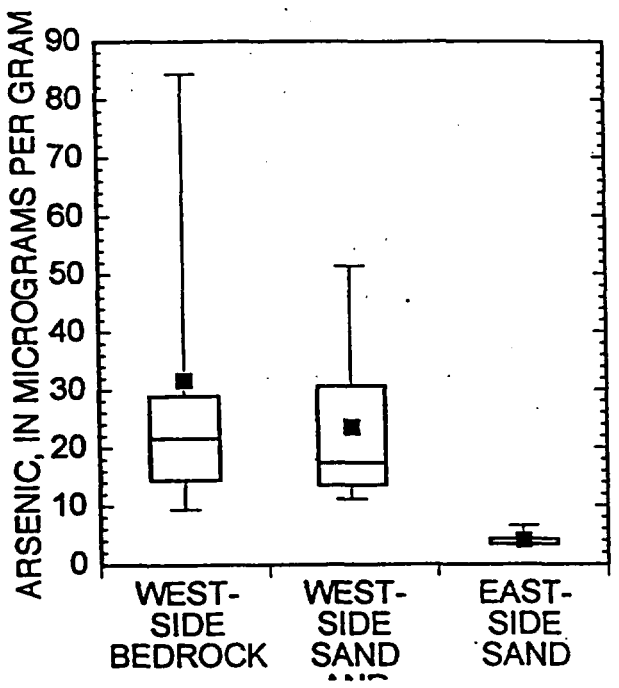
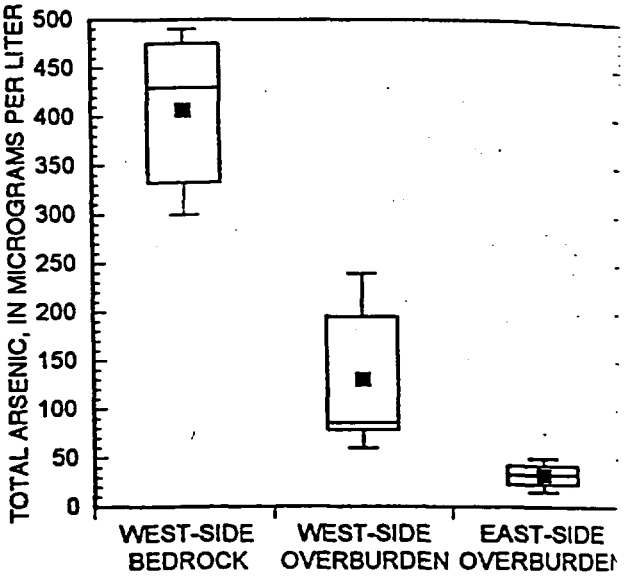
TABLE 4. Constituent concentrations in aquifer and bedrock materials, Saco landfill, ME, August -October, 1997

| Sample location, and depth below surface or below bedrock surface | *** whole rock *** As µg/g | Fe µg/g | Mn µg/g | ***leachable *** As µg/g | Fe µg/g | Mn µg/g | whole rock As:Fe % | leachable As:Fe % |
|---|---|---|---|---|---|---|---|---|
| UNCONSOLIDATED MATERIAL--EAST SIDE OF SANDY BROOK | | | | | | | | |
| TB97-2 hill cut | 3.0 | 7,800 | 359 | 0.2 | 694 | 132 | 0.0385 | 0.0288 |
| TB97-2 0' | 3.4 | 7,300 | 347 | | | | 0.0466 | |
| TB97-2 0-2' | 4.3 | 9,300 | 418 | 0.4 | 1,670 | 78 | 0.0462 | 0.0239 |
| TB97-2 4-6' | 3.4 | 10,000 | 329 | 0.3 | 1,740 | 46 | 0.0340 | 0.0172 |
| TB97-2 9-11' | 3.4 | 6,600 | 262 | 0.3 | 1,060 | 42 | 0.0515 | 0.0284 |
| TB97-2 12-14' | 6.8 | 35,500 | 703 | 0.2 | 6,190 | 258 | 0.0192 | 0.0032 |
| UNCONSOLIDATED MATERIAL--WEST SIDE OF SANDY BROOK | | | | | | | | |
| TB97-1 5-7' | 28.1 | 36,600 | 582 | 2.0 | 4,010 | 173 | 0.0768 | 0.0498 |
| TB97-1 8-10' | 20.4 | 27,900 | 580 | 3.0 | 4,060 | 200 | 0.0731 | 0.0739 |
| TB97-1 10-12' | 13.6 | 14,000 | 383 | 2.4 | 3,350 | 120 | 0.0971 | 0.0716 |
| TB97-1 15-17' | 9.4 | 11,400 | 399 | 1.4 | 2,150 | 47 | 0.0825 | 0.0652 |
| TB97-1 18-20' | 6.8 | 8,400 | 325 | 1.5 | 1,840 | 55 | 0.0810 | 0.0813 |
| TB97-1 20-22' | 11.9 | 14,600 | 360 | 2.3 | 3,520 | 89 | 0.0815 | 0.0653 |
| TB97-1 23-25' | 11.9 | 14,800 | 413 | 3.5 | 3,060 | 60 | 0.0804 | 0.1144 |
| MW97-15B 10' | 14.5 | 16,500 | 346 | 2.2 | 2,680 | 86 | 0.0879 | 0.0822 |
| MW97-16S 10-12' | 32.3 | 36,400 | 777 | 2.5 | 5,100 | 354 | 0.0887 | 0.0490 |
| MW97-16S 13-13.25' | 36.6 | 35,100 | 764 | 2.5 | 3,590 | 293 | 0.1043 | 0.0696 |
| MW97-16S 20-21.3' | 30.6 | 33,000 | 668 | 1.4 | 4,700 | 432 | 0.0927 | 0.0298 |
| MW97-16S 23-24' | 22.1 | 32,900 | 812 | 1.2 | 5,200 | 487 | 0.0672 | 0.0231 |
| MW97-17R 5-6.4' | 17.0 | 11,700 | 338 | 2.4 | 3,300 | 186 | 0.1453 | 0.0726 |
| MW97-17R 10-12' | 15.3 | 8,200 | 314 | 4.2 | 1,930 | 51 | 0.1866 | 0.2172 |
| MW97-17R 15-16' | 17.9 | 14,500 | 518 | 5.5 | 2,130 | 219 | 0.1234 | 0.2579 |
| SS-1 Gravel quarry rock | 51.0 | 33,200 | 1120 | 0.7 | 8,790 | 992 | 0.1536 | 0.0080 |
| SS-2 Gravel quarry sand | 13.6 | 10,600 | 400 | 2.4 | 830 | 50 | 0.1283 | 0.2896 |
| SS-5 Glacial till | 17.9 | 30,300 | 524 | 2.1 | 2,660 | 79 | 0.0591 | 0.0789 |
| BEDROCK--WEST SIDE OF SANDY BROOK | | | | | | | | |
| MW97-13R 1.5' | 16.2 | 31,500 | 621 | | | | 0.0514 | |
| MW97-13R 29' | 28.9 | 35,600 | 369 | | | | 0.0812 | |
| MW97-13R 29' | 27.2 | 35,800 | 394 | | | | 0.0760 | |
| MW97-17R 2' | 10.2 | 29,000 | 422 | 1.8 | 1,900 | 1248 | 0.0352 | 0.0946 |
| MW97-17R 8' | 8.5 | 28,600 | 573 | 4.1 | 670 | 61 | 0.0297 | 0.6088 |
| MW97-17R 28' | 14.5 | 39,600 | 577 | | | | 0.0366 | |
| MW96-9R 0' | 27.2 | 42,000 | 465 | 13.2 | 1,320 | 169 | 0.0648 | 1.0021 |
| MW96-9R 145' | 122. | 48,800 | 1160 | 15.5 | 710 | 588 | 0.2500 | 2.1907 |
| SS-3 Bedrock outcrop surface | 16.2 | 41,600 | 672 | 3.0 | 4,670 | 423 | 0.0389 | 0.0642 |
| SS-4 Bedrock outcrop surface | 46.8 | 50,900 | 343 | 0.2 | 4550 | 120 | 0.0919 | 0.0044 |
| SS-6 Saco pluton rock | 12.8 | 45,100 | 846 | | | | 0.0284 | |
| SS-7 Saco pluton outcrop surface at road cut | 13.6 | 64,100 | 1000 | 2.5 | 1,330 | 61 | 0.0212 | 0.1881 |

ARSENIC IN WHOLE-ROCK ANALYSIS




ARSENIC IN GROUND WATER

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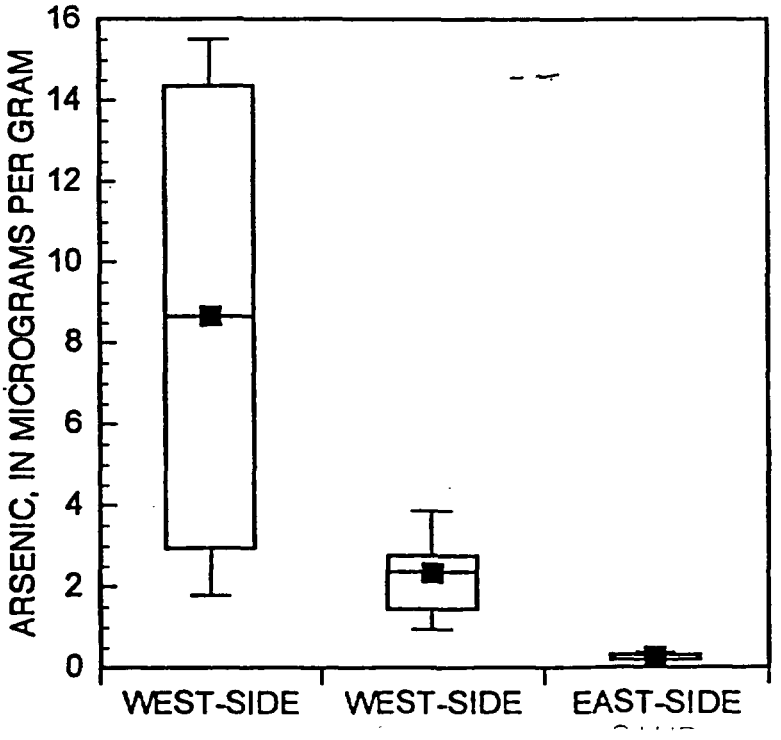
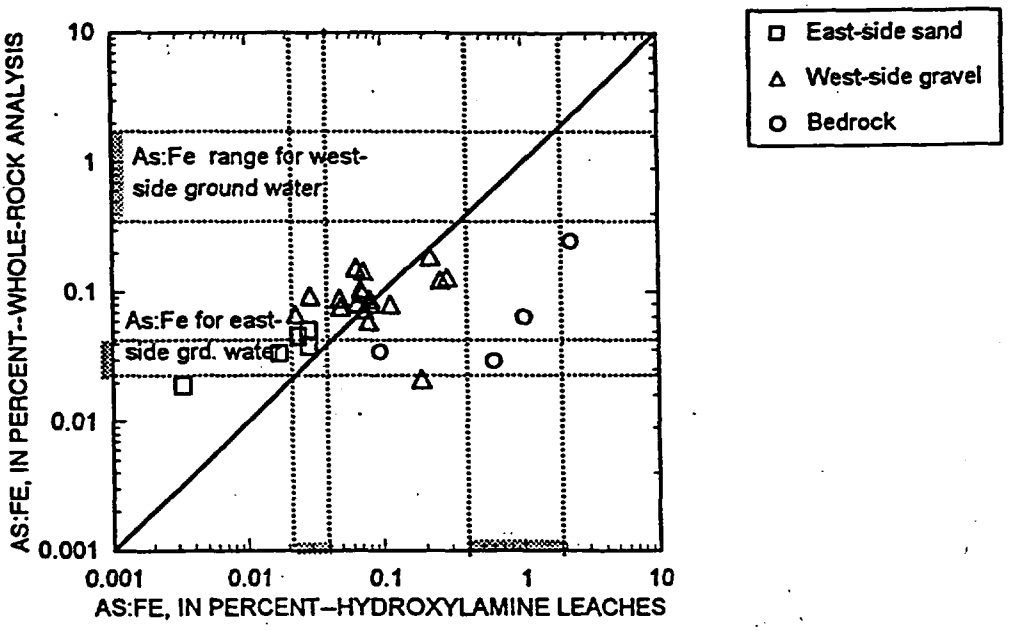
ITS/JACOLMAN/ARSENIC

ARSENIC IN HYDROXYLAMINE LEACHES



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# APPENDIX D

# COST BACK-UP INFORMATION

**TABLE 7-4**
**COST ESTIMATE: ALTERNATIVE SML-3**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| | |
|---|---|
| **DIRECT COSTS** | |
| TOTAL DIRECT COSTS | $0 |
| **INDIRECT COSTS** | |
| TOTAL INDIRECT COSTS | $0 |
| **TOTAL CAPITAL COSTS (DIRECT AND INDIRECT)** | **$0** |
| **ENVIRONMENTAL MONITORING AND REVIEW COSTS** | |
| Annual Monitoring Groundwater/Surface Water and Sediment (Includes 20% contingency) | $125,000 |
| **TOTAL PRESENT WORTH ANNUAL ENVIRONMENTAL MONITORING COSTS (7%, 30 YEARS)** | **$1,551,000** |
| Five Year Site Reviews (includes 20% Contingency) | $60,000 |
| **TOTAL PRESENT WORTH OF FIVE YEAR SITE REVIEWS (7%, 30 YEARS)** | **$129,000** |
| **TOTAL PRESENT WORTH (30 YEARS) - ALTERNATIVE SML-3** | **$1,680,000** |

| | | | |
|---|---|---|---|
| ALTERNATIVE SML-3 (cost back-up for Environmental Monitoring and five-year reviews) | | | |
| | | | |
| | | | |
| FIVE YEAR SITE REVIEWS ($50,000 + a 20 % contingency ($10,000) = $60,000 every five | | | |
| years at an interest rate of 7% is an annual cost of $10,434 for 30 years) (A/F factor used was 0.1739) | | $10,434 | |
| | | 7% | |
| | | 30 | years |
| TOTAL PRESENT WORTH FIVE YEAR SITE REVIEWS (P/A factor used was 12.4090) | | $129,000 | |
| | | | |
| | | | |
| Monitoring Groundwater/Surface Water and Sediment (Annually) | | $125,000 | |
| | | 7% | |
| | | 30 | |
| PRESENT WORTH ANNUAL ENV. MONITORING AND MAINTENANCE (7% FOR 30 YEARS) | | $1,551,000 | |

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CLIENT City of Saco
PROJECT Saco Municipal Landfill -FS
DESIGNED BY L. Truesdale DATE 9/8/99
CHECKED BY GW DATE 9/9/99
PROJECT NO. 95093 SHEET NO. 1 OF 1

Alternative SML-3 and SML-5

Five Year Site Reviews $50,000
+ 20% Contingency $10,000
$60,000

Annualize $60,000 spent every 5 years

60,000 (A/F, 7%, 5) = 60,000 (0.1739) = $10,434

Then present worth of $10,434/yr for 30 yrs

$10,434 (P/A, 7%, 30) = $10,434 (12.4090)

NPW = $129,475

**TABLE 7-8**
**COST ESTIMATE: ALTERNATIVE SML-4A**
**(DISCHARGE TO SACO WWTP)**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| DIRECT COSTS | |
|---|---|
| Pilot Scale Field Study | $75,000 |
| Installation of 17 Injection wells | $85,000 |
| Groundwater Extraction System | $92,000 |
| Discharge to Saco WWTP (1) | $453,000 |
| Installation of Groundwater Extraction/Discharge System | $164,000 |
| SUBTOTAL | $869,000 |
| 20% Contingency on Direct Costs | $174,000 |
| TOTAL DIRECT COSTS | $1,043,000 |

| INDIRECT COSTS | |
|---|---|
| Health and Safety @ 5% | $52,000 |
| Legal, Administrative and Permitting @ 5% | $52,000 |
| Engineering Design @ 10% | $104,000 |
| Services during Construction @10 % | $104,000 |
| TOTAL INDIRECT COSTS | $312,000 |
| **TOTAL CAPITAL COSTS (DIRECT AND INDIRECT)** | **$1,355,000** |

| ANNUAL OPERATION AND MAINTENANCE COSTS | |
|---|---|
| In Situ Chemical Oxidation injection | $391,000 |
| Injection Well Maintenance | $20,000 |
| SUBTOTAL | $411,000 |
| Engineering @ 10% | $41,000 |
| 20 % Contingency on O&M Costs | $82,000 |
| TOTAL O&M COSTS | $534,000 |
| **TOTAL PRESENT WORTH ANNUAL O&M COSTS (7%, 5 YEARS)** | **$2,190,000** |

**TABLE 7-8**
**COST ESTIMATE: ALTERNATIVE SML-4A**
**(DISCHARGE TO SACO WWTP)**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| | |
|---|---|
| Monitoring 2 Extraction Wells (Quarterly) | $5,000 |
| Maintenance (Annual) | $27,000 |
| SUBTOTAL | $32,000 |
| Engineering @ 10% | $3,000 |
| 20 % Contingency on O&M Costs | $6,000 |
| TOTAL O&M COSTS | $41,000 |
| **TOTAL PRESENT WORTH ANNUAL O&M COSTS (7%, 30 YEARS)** | **$509,000** |
| Monitoring Groundwater/Surface Water and Sediment (annually) | $125,000 |
| **TOTAL PRESENT WORTH ANNUAL ENVIRONMENTAL MONITORING COSTS (7%, 30 YEARS)** | **$1,551,000** |
| Five Year Site Reviews (includes 20% Contingency) | $60,000 |
| **TOTAL PRESENT WORTH OF FIVE YEAR SITE REVIEWS (7%,30 YEARS)** | **$129,000** |
| **TOTAL PRESENT WORTH (30 YEARS) - ALTERNATIVE SML-4A** | **$5,734,000** |

(1) Costs for upgrades to pump station on Route 112 not included.

| | | | |
|---|---|---|---|
| ALTERNATIVE SML-4A (O&M cost back-up) | | | |
| SAMPLING AND ANALYSIS (extraction system) | | | |
| (assumes quarterly monitoring of 2 extraction well- VOCs, metals) | | | |
| | | | |
| | | | |
| DESCRIPTION | | COST | |
| | | | |
| Monitoring 2 Extraction Wells (Quarterly) | | $5,000 | yr |
| Maintenance (5% of equipment subtotal) | | $27,000 | yr |
| | | | |
| Subtotal annual costs | | $32,000 | |
| | | | |
| Engineering @ 10% | | $3,000 | |
| 20% Contingency on Annual O&M | | $6,000 | |
| | | $41,000 | |
| | | 7% | |
| | | 30 | years |
| PRESENT WORTH ANNUAL MONITORING AND MAINTENANCE (7% FOR 30 YEARS) | | $509,000 | |
| (P/A factor used was 12.4090) | | | |
| | | | |
| Monitoring Groundwater/Surface Water and Sediment (Annually) | | $125,000 | yr |
| | | 7% | |
| | | 30 | |
| PRESENT WORTH ANNUAL ENV. MONITORING AND MAINTENANCE (7% FOR 30 YEARS) | | $1,551,000 | |
| | | | |
| | | | |
| FIVE YEAR SITE REVIEWS ($50,000 + a 20 % contingency ($10,000) = $60,000 every five | | | |
| years at an interest rate of 7% is an annual cost of $10,434 for 30 years) (A/F factor used was 0.1739) | | $10,434 | |
| | | 7% | |
| | | 30 | years |
| TOTAL PRESENT WORTH FIVE YEAR SITE REVIEWS (P/A factor used was 12.4090) | | $129,000 | |

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41 HUTCHINS DRIVE
PORTLAND, MAINE 04102
TEL. (207)774-2112

CLIENT Saco Municipal Landfill
PROJECT Feasibility Study
DESIGNED BY L. Tweedale DATE 7/27/99
CHECKED BY [illegible] DATE 9/9/99
PROJECT NO. 95093.06 SHEET NO. 1 OF 2

Discharge of Untreated Extracted Groundwater to Saco WWTP

(Design and cost based on assumptions in internal memo from Bob Severence to Guy Vaillancourt and Bill Fisher 9/25/98 Regarding Leachate Transportation: Landfill No. 2)

- Pump station wetwell and slab (includes min. 8-ft diameter manhole, telemetry, utilities, excavation, start-up, etc...) $100,000

- 3200 feet 2 1/2 inch PVC force main @ 30 - 35$/foot
  transport untreated groundwater from holding tank at Landfill Area 4 along Foss Rd to intersection of Route 112

  $96,000 - $112,000 + $4000 for air relief manhole $104,000

- 3550 feet of 8" and 10" diameter gravity sewer along the shoulder of Rt 112
  $60 - $80 / foot ($213,000 to $284,000) $249,000

Total $453,000

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CLIENT Saco Municipal Landfill
PROJECT Feasibility Study
DESIGNED BY L. Tolesdale DATE 9/10/99
CHECKED BY GW DATE 9/9/99
PROJECT NO. 95093.06 SHEET NO. 2 OF 2

Alternative SML-4A

Equipment Costs

| | |
|---|---|
| Groundwater Extraction System | $92,000 |
| Discharge to Saco WWTP | $453,000 |
| Subtotal | $545,000 |

Installation Costs

| | |
|---|---|
| Instrumentation (15% of equipment subtotal) | = $81,750 |
| Electrical (15% of equipment subtotal) | = $81,750 |
| Installation Subtotal | = 163,500 |
| Total | $708,500 |

**TABLE 7-9**
**COST ESTIMATE: ALTERNATIVE SML-4B**
**(TREATMENT/ON-SITE DISCHARGE)**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| DIRECT COSTS | |
|---|---|
| Pilot Scale Field Study | $75,000 |
| Installation of 17 Injection wells | $85,000 |
| Groundwater Extraction System | $92,000 |
| Treatability Study for Groundwater Treatment System | $100,000 |
| Groundwater Treatment System | $443,000 |
| Treated Groundwater Discharge System | $11,000 |
| Installation of Groundwater Extraction/Treatment/Discharge System | $676,000 |
| SUBTOTAL | $1,482,000 |
| 20% Contingency on Direct Costs | $296,000 |
| TOTAL DIRECT COSTS | $1,778,000 |

| INDIRECT COSTS | |
|---|---|
| Health and Safety @ 5% | $89,000 |
| Legal, Administrative and Permitting @ 5% | $89,000 |
| Engineering Design @ 10% | $178,000 |
| Services during Construction @10 % | $178,000 |
| TOTAL INDIRECT COSTS | $534,000 |
| **TOTAL CAPITAL COSTS (DIRECT AND INDIRECT)** | **$2,312,000** |

| ANNUAL OPERATION AND MAINTENANCE COSTS | |
|---|---|
| In Situ Chemical Oxidation injection | $391,000 |
| Injection Well Maintenance | $20,000 |
| SUBTOTAL | $411,000 |
| Engineering @ 10% | $41,000 |
| 20 % Contingency on O&M Costs | $82,000 |
| TOTAL O&M COSTS | $534,000 |
| **TOTAL PRESENT WORTH ANNUAL O&M COSTS (7%, 5 YEARS)** | **$2,190,000** |

**TABLE 7-9**
**COST ESTIMATE: ALTERNATIVE SML-4B**
**(TREATMENT/ON-SITE DISCHARGE)**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| | |
|---|---|
| Treatment System (Labor, Power, Chemicals, Maintenance, etc...) | $166,000 |
| Monitoring 2 Extraction Wells (Quarterly) | $5,000 |
| Treatment System Monitoring (Monthly) | $12,000 |
| Tretment Sludge Disposal | $14,000 |
| SUBTOTAL | $197,000 |
| Engineering @ 10% | $20,000 |
| 20 % Contingency on O&M Costs | $39,000 |
| TOTAL O&M COSTS | $256,000 |
| **TOTAL PRESENT WORTH ANNUAL O&M COSTS (7%, 30 YEARS)** | **$3,177,000** |
| Monitoring Groundwater/Surface Water and Sediment (annually) (includes 20% Contingency) | $125,000 |
| **TOTAL PRESENT WORTH ANNUAL ENVIRONMENTAL MONITORING COSTS (7%, 30 YEARS)** | **$1,551,000** |
| Five Year Site Reviews (includes 20% Contingency) | $60,000 |
| **TOTAL PRESENT WORTH OF FIVE YEAR SITE REVIEWS (7%,30 YEARS)** | **$129,000** |
| **TOTAL PRESENT WORTH (30 YEARS) - ALTERNATIVE SML-4B** | **$9,359,000** |

| | | | | |
|---|---|---|---|---|
| ALTERNATIVE SML-4B - IN SITU CHEMICAL OXIDATION (PRELIMINARY DIRECT COST BACKUP) | | | | |
| INSTALLATION OF CHEMICAL INJECTION WELLS (17) | | | | |
| (Assumed 17 wells, depth = 45 feet, 13 days to install) | | | | |
| | | | | |
| | | | | |
| DESCRIPTION | QUANTITY | UNIT | UNIT COST | TOTAL |
| | | | | |
| Drilling Estimate (Sterns Drilling 7/16/96) | | | | |
| Equipment Mobilization/ Demobilization | 1 | EA | 500 | $ 500 |
| Advance 4.25-inch augers in overburden soils w/ 5-foot soil samples | 765 | LF | 16 | $ 12,240 |
| Pure bentonite grout, 30% solids by weight | 765 | LF | 7 | $ 5,355 |
| Install 2-inch SCH 40 No. 7 slot CPVC screen | 170 | LF | 20 | $ 3,400 |
| Sand pack, Morie No.00 | 240 | LF | 20 | $ 4,800 |
| Install 2-inch SCH 40 CPVC riser | 720 | LF | 13 | $ 9,360 |
| Well development | 40 | HR | 110 | $ 4,400 |
| Steam cleaning | 15 | EA | 300 | $ 4,500 |
| Build Decontamination Pad | 1 | EA | 400 | $ 400 |
| Containerization and stage of soils 55-gallon DOT drums | 40 | DRUMS | 50 | $ 2,000 |
| Containerization and stage of water 55-gallon DOT drums | 15 | DRUMS | 50 | $ 750 |
| Tractor loader move drums and tools to decon area | 13 | DAY | 100 | $ 1,300 |
| Per Diem for each drilling crew | 13 | DAY | 150 | $ 1,950 |
| 4-inch protective casing with keyed alike locks | 17 | EA | 120 | $ 2,040 |
| Analysis of soil cuttings and well development water | 2 | SAMPLE | 500 | $ 1,000 |
| Transportation of soil and water drums | 53 | DRUMS | 83 | $ 4,399 |
| Disposal of soil cuttings | 40 | DRUMS | 75 | $ 3,000 |
| Disposal of well development water | 15 | DRUMS | 350 | $ 5,250 |
| | | | | |
| SUBTOTAL | | | | $ 66,644 |
| | | | | |
| Woodard & Curran Oversight | | | | |
| Labor (assumes 1 person x 32 days x 12 hours) | 156 | HR | 75 | $ 11,700 |
| Hotel | | NIGHT | 60 | $ - |
| Meals | 13 | DAY | 7 | $ 91 |
| Flight | | EA | 1000 | $ - |
| Car | 2 | WEEK | 200 | $ 400 |
| Equipment (assumes PID, draegger, cell phone, water level meter and miscellaneous expendables) | | | | $ 3,000 |
| Analysis (TOC only for soil, 2 per boring) | 38 | SAMPLE | 77 | $ 2,926 |
| Shipping | 2 | COOLER | 75 | $ 150 |
| | | | | |
| SUBTOTAL | | | | $ 18,267 |
| | | | | |
| TOTAL | | | | $ 85,000 |

| | | | | |
|---|---|---|---|---|
| ALTERNATIVE SML-4B - Insitu Chemical Oxidation (PRELIMINARY O&M cost back-up) | | | | |
| CHEMICAL INJECTION | | | | |
| (assumes 17 injection wells, dosed twice per year) | | | | |
| | | | | |
| DESCRIPTION | QUANTITY | UNIT | UNIT COST | TOTAL |
| | | | | |
| Chemical injection | | | | |
| addition activities per well (includes labor, chemical, equip, etc.) | 34 | well | 10000 | $340,000.00 |
| travel costs | 2 | event | 500 | $1,000.00 |
| oversight labor/reporting costs | 1 | year | 50000 | $50,000.00 |
| TOTAL ANNUAL CHEMICAL INJECTION | | | | $391,000.00 |
| INJECTION WELL MAINTENANCE | | | | $20,000.00 |
| | | | | |
| | | | | |
| | | | | |
| SUBTOTAL | | | | $411,000.00 |
| 10 % Engineering | | | | $41,000.00 |
| 20% Contingency | | | | $82,000.00 |
| | | | | $534,000.00 |
| | | | | |
| | | | | |
| | | | | 7% |
| | | | | 5 |
| PRESENT WORTH FOR ANNUAL OPERATIONS AND MAINTENANCE (7% FOR 5 YEARS) | | | | $2,190,000.00 |
| | | | | |
| FIVE YEAR SITE REVIEWS ($50,000 + a 20 % contingency (10,000) = 60,000 every five | | | | |
| years at an interest rate of 7% is an annual cost of 10,434 for 30 years) | | | | $10,434.00 |
| | | | | 7% |
| | | | | 30 |
| TOTAL PRESENT WORTH FIVE YEAR SITE REVIEWS | | | | $129,000.00 |

**Saco Municipal Landfill Feasibility Study**
**Saco, Maine**
**Alternative SML-5 (60-70 gpm Pump and Treat)**
**Capital Costs**

| 1 EQUIPMENT COSTS | | | | |
|---|---|---|---|---|
| **Item** | **Quantity** | **Unit** | **Unit Cost** | **Total Cost** |
| **(a) Extraction System** | | | | |
| Extraction Wells with Development (Level D) | 2 | ea | $15,000 | $30,000 |
| Pumps with VFDs and Controls | 2 | ea | $3,300 | $6,600 |
| Flow meters (2" magmeters) | 2 | ea | $2,300 | $4,600 |
| Piezometers (Level D) | 11 | ea | $3,000 | $33,000 |
| Piping (HDPE) | | | | |
| 2 inch | 1,160 | LF | $8 | $9,280 |
| Subtotal | | | | $83,480 |
| Contractor's Profit (@ 10% of equipment cost) | | | | $8,350 |
| **Extraction System Subtotal** | | | | **$91,830** |
| **(b) Treatment System** | | | | |
| Flow meter (2" magmeter) | 1 | ea | $2,300 | $2,300 |
| Mix tank (400 gal.) | 1 | ea | $770 | $770 |
| Mixer (1 HP) | 1 | ea | $1,500 | $1,500 |
| KMnO4 storage tank (3800 gal. w/ sec. cont.) | 1 | ea | $10,120 | $10,120 |
| Mixer (3 HP) | 1 | ea | $2,300 | $2,300 |
| Chemical feed pump (120 gpd) | 1 | ea | $850 | $850 |
| NaOH storage tank (1800 gal. w/ sec. cont.) | 1 | ea | $6,160 | $6,160 |
| Chemical feed pump (70 gpd) | 1 | ea | $790 | $790 |
| Spare portable mixer (1.5 HP) | 1 | ea | $1,800 | $1,800 |
| Oxidation tank (2000 gal.) | 1 | ea | $2,800 | $2,800 |
| Mixer (2 HP) | 1 | ea | $2,200 | $2,200 |
| Lamella separator (240 sq. ft.) | 1 | ea | $45,000 | $45,000 |
| Transfer tank (400 gal.) | 1 | ea | $770 | $770 |
| Transfer and backwash pumps (2 HP) | 3 | ea | $3,000 | $9,000 |
| Greensand Filters (3 ft. diam.) | 2 | ea | $8,000 | $16,000 |
| HCl storage tank (2500 gal. w/ sec. cont.) | 1 | ea | $9,900 | $9,900 |
| Chemical feed pump (80 gpd) | 1 | ea | $790 | $790 |
| Activated alumina colums (5 ft. diam., 120 cu. ft.) | 2 | ea | $26,800 | $53,600 |
| GAC vessels (4' daim., 1800 lb. GAC) | 2 | ea | $10,296 | $20,592 |
| Backwash holding tank (7,500 gal) | 1 | ea | $7,600 | $7,600 |
| Clearwell (2,000 gal.) | 1 | ea | $2,800 | $2,800 |
| Sludge holding tank (5500 gal.) | 1 | ea | $6,300 | $6,300 |
| Air Diaphragm Pumps - Press feed and sludge trans. | 2 | ea | $1,000 | $2,000 |

**Saco Municipal Landfill Feasibility Study**
**Saco, Maine**
**Alternative SML-5 (60-70 gpm Pump and Treat)**
**Capital Costs**

| | | | | |
|---|---|---|---|---|
| Air Compressor (3 HP) | 1 | ea | $1,700 | $1,700 |
| Polymer mixing tank (50 gal.) | 1 | ea | $330 | $330 |
| Mixer (0.5 HP) | 1 | ea | $1,300 | $1,300 |
| Chemical feed pump - polymer (120 gpd) | 1 | ea | $850 | $850 |
| Static mixers - in-line, 3" | 2 | ea | $600 | $1,200 |
| Sludge press (4 cu. ft) | 1 | ea | $24,000 | $24,000 |
| Fork lift (for sludge bin and chemical handling) | 1 | ea | $23,000 | $23,000 |
| Building Costs (65'L x 45'W x 16'H) | 2925 | SF | $50 | $146,250 |
| Subtotal | | | | $402,272 |
| Contractor's Profit (@ 10% of equipment cost) | | | | $40,230 |
| **Treatment System Subtotal** | | | | **$442,502** |
| **(c) Surface Water Discharge System** | | | | |
| 3" HDPE Pipe | 1070 | LF | $9 | $9,630 |
| Infiltration Basin (150' x 150' x 5') | 4167 | CY | $10 | $41,667 |
| Fence | 600 | LF | $15 | $9,000 |
| Swing Gate | 1 | Ea | $400 | $400 |
| Subtotal | | | | $9,630 |
| Sales Tax (@ 6% of equipment cost) | | | | $580 |
| Contractor's Profit (@ 10% of equipment cost) | | | | $960 |
| **Discharge System Subtotal** | | | | **$11,170** |
| **EQUIPMENT SUBTOTAL** | | | | **$545,502** |
| **2 INSTALLATION COSTS** | | | | |
| Instrumentation (15% of Equipment Subtotal) | | | | $81,825 |
| Electrical (15% of Equipment Subtotal) | | | | $81,825 |
| Process Piping (30% of Equipment Subtotal) | | | | $163,651 |
| HVAC System (7% of Equipment Subtotal) | | | | $38,185 |
| Labor (30% of Equipment Subtotal) | | | | $163,651 |
| Field Indirect (90% of Labor Cost) | | | | $147,286 |
| **INSTALLATION SUBTOTAL** | | | | **$676,422** |
| **TOTAL CAPITAL COSTS** | | | | **$1,222,000** |

Note: Capital Costs are rounded to the nearest thousand

| O&M COST ESTIMATES- Saco Groundwater P&T | |
|---|---|
| *Saco, Maine* | |
| *Alternative SML-5 (60-70 gpm)* | |
| **COST CATEGORIES** | **ANNUAL COSTS** |
| Labor (1 full-time operator) | $73,000 |
| Electricity | $9,000 |
| Other utilities (oil, phone) | $5,000 |
| Chemicals | $47,000 |
| Maintenance @ 5% of capital | $27,300 |
| Sludge disposal | $13,700 |
| Monitoring | $17,080 |
| Office/Supplies/Misc.disposable items | $5,000 |
| **TOTAL COST** | **$197,000** |

**Saco Landfill Groundwater Pump & Treat System**
**ALTERNATIVE SML-5 (60-70 GPM)**

| *POWER ESTIMATE* | HP | KW | HOURS/ DAY | KWH/ DAY |
|---|---|---|---|---|
| 2 Extraction pumps | 2.80 | 2.09 | 24 | 50 |
| 2 Continuous mixers | 3.00 | 2.24 | 24 | 54 |
| 4 Chemical Feed Pumps | 1.00 | 0.75 | 24 | 18 |
| 1 Transfer Pump | 2.00 | 1.49 | 24 | 36 |
| 1 Air Compressor | 3.00 | 2.24 | 6 | 13 |
| HVAC/Lights | 3.00 | 2.24 | 18 | 40 |
| Miscellaneous | 2.00 | 1.49 | 24 | 36 |

| *ELECTRIC POWER SUMMARY* | HP | KW | KWH/ DAY | KWH/ YEAR |
|---|---|---|---|---|
| TOTAL | 16.80 | 12.53 | 247 | 90,182 |

| | |
|---|---|
| **UNIT POWER COST** | $0.100 |
| **TOTAL ANNUAL POWER COST** | $9,000 |

**Saco Landfill Groundwater Pump & Treat System**
**ALTERNATIVE SML-5 (60-70 GPM)**
**Chemical Costs**

| CHEMICAL | QUANTITY/ YEAR | UNITS | UNIT COST | ANNUAL COST |
|---|---|---|---|---|
| Sodium Hydroxide (25%) | 30,130 | Gal. | $0.40 | $12,100 |
| Hydrochloric Acid (30%) | 34,488 | Gal. | $0.60 | $20,693 |
| Potassium Permanganate, pure solid | 6,117 | Lbs. | $1.60 | $9,800 |
| Polymer | 22 | Lbs. | $2.50 | $100 |
| GAC | 1,104 | Lbs. | $3.00 | $3,300 |
| Subtotal | | | | $42,693 |
| Freight (10%) | | | | $4,269 |
| **SUBTOTAL CHEMICALS** | | | | $46,962 |

**Sludge Costs**

| ITEM | |
|---|---|
| Wet Tons/yr | 55 |
| Unit Hauling and Tipping cost ($/WT) | $250 |
| **Sludge Disposal Cost ($/yr)** | $13,695 |

Assuming Sludge is disposed of as hazardous waste.

**Saco Landfill Groundwater Pump & Treat System**
**ALTERNATIVE SML-5 (60-70 GPM)**
**Monitoring Costs**

**1. Extraction Wells (Monitored Quarterly)**

| | | |
|---|---|---|
| No. of Samples = | 2 | |
| Trip Blanks = | 1 | |
| Duplicates = | 1 | |
| MS/MSD = | 0 | |
| Eq. Blanks = | 0 | |
| Total = | 4 | |
| Cost for VOC Analysis = | $147 | (for VOC Method 8260) |
| Cost for Metals Analysis = | $181 | (for TAL Metals Method SW-846) |
| Monitoring Frequency = | 4 | times per year |
| **Cost Subtotal =** | **$5,200** | **per year** |

**2. Treatment System Sampling (Monthly)**

| | | |
|---|---|---|
| No. of Samples = | 3 | |
| QA/QC = | 0 | |
| Total = | 3 | |
| Cost for VOC Analysis = | $150 | (for VOC Method 8260) |
| Cost for Metals Analysis = | $180 | (for TAL Metals Method SW-846) |
| Monitoring Frequency = | 12 | times per year |
| **Cost Subtotal =** | **$11,880** | **per year** |
| **Total Cost =** | **$17,080** | **per year** |

**Saco Landfill Groundwater Pump & Treat System**
**Conceptual Design**

| **Influent Criteria:** | | | Source: |
|---|---|---|---|
| Flow | 70 gpm | 0.101 MGD | Modflow modelling by JRH w/ 15% safety factor |
| Mn | 7.7 mg/L | | Average of wells 95-4SA,B and 97-14S-1 and 2 |
| As | 0.14 mg/L | | Average of wells 95-4SA,B and 97-14S-1 and 2 |
| Fe | 45 mg/L | | Average of wells 95-4SA,B and 97-14S-1 and 2 |
| pH | 6.7 units | | Average of wells 95-4SA,B |
| Alkalinity | 390 mg/L as CaCO3 | | Average of wells 95-4SA,B and 97-14S-1 and 2 |
| Benzene | 2 ug/L | | Average of wells 95-4SA,B |

| **Effluent Criteria:** | | Source: |
|---|---|---|
| Mn | 0.84 mg/L | EPA |
| As | 0.05 mg/L | EPA |
| Benzene | 5 ug/L | EPA |

**Assumptions**

All metals in reduced state

Linear titration curve between pH 4.5 and 10.5

| **Unit Processes:** | Function: |
|---|---|
| Wells, pumps, and piping | Deliver groundwater to treatment |
| $KMnO_4$ and NaOH rapid mix addition | Oxidize Fe, Mn, As, pH adjust to 8.0 |
| Oxidation tank w/ mixer | Oxidize Fe, Mn, As, pH adjust to 8.0 |
| Lamella inclined plate separator | Remove majority of Fe, some Mn and As |
| Transfer tank and pumps | Shift from gravity to pressure operation |
| Manganese greensand filters | Remove Fe, Mn to less than 0.5 ppm |
| HCl addition | Adjust pH to 6.0 |
| Activated alumina ion exchange | Remove As to less than 30 ppb |
| Granular activated carbon vessels | Remove VOCs |
| Backwash tank | Collect and settle backwash water to minimize volume |
| Sludge thickening tank | Mix sludge with polymer for enhanced dewatering |
| Polymer mixing tank | Prepare polymer for mixing with sludge |
| Sludge press | Press sludge for disposal |
| Discharge piping | Convey clean water to discharge point |

| **Wells, pumps, and piping** | | Notes: |
|---|---|---|
| Desired flow velocity in piping | 4 ft/sec | |
| East well flow | 23 gpm | |
| East well line diameter | 2 inches | |

**Saco Landfill Groundwater Pump & Treat System**
**Conceptual Design**

| | | |
|---|---|---|
| Line length | 580 feet | |
| Depth to screen midpoint | 60 feet | 44' to 76' bgs |
| Additional head required | 50 feet | 25 feet elevation difference + 10 psi excess |
| Total head required | 110 feet | |
| Pump size required | 1.1 hp | |
| West well flow | 47 gpm | |
| West well line diameter | 2 inches | |
| Line length | 580 feet | |
| Depth to screen midpoint | 32 feet | 18' to 46' bgs |
| Additional head required | 50 feet | |
| Total head required | 82 feet | |
| Pump size required | 1.7 hp | |

| **$KMnO_4$ and NaOH and caustic addition** | | Notes: |
|---|---|---|
| Mix tank residence time | 5 min. | Reasonable time for stable pH control |
| Mix tank volume | 350 gallons | |
| Tank diameter | 3 feet | |
| Tank height | 7.6 feet | Includes 1 ft. freeboard |
| Actual tank volume w/ freeboard | 400 gallons | |
| Dose $KMnO_4$ required | 57 mg/L | Dose 0.94 lb/lb Fe, 1.92 lb/lb Mn, 2 lb/lb As |
| $KMnO_4$ solution strength | 50,000 mg/L | |
| $KMnO_4$ addition rate | 0.08 gpm | 116 gpd 17 lb Mn/day |
| Desired storage time | 30 days | |
| $KMnO_4$ storage volume reqd. | 3500 gallons | |
| $KMnO_4$ Tank diameter | 7 feet | |
| $KMnO_4$ tank height | 13.1 feet | Includes 1 ft. freeboard |
| Actual tank volume w/ freeboard | 3790 gallons | |
| Desired pH | 8.0 units | |
| Alk. per pH unit (as $CaCO_3$) | 177 mg/L | 3.5 meq |
| Alkalinity lost in oxidation | 1.5 meq | 1.49 lb as CaCO3/lb Fe, 1.21 lb/lb Mn, 2 lb/lb As |
| Total alkalinity required | 6.1 meq | |
| NaOH solution strength | 7.5 N | 25% (w/w) NaOH approx. = 7.5N |
| NaOH addition rate | 0.06 gpm | 83 gpd |
| Desired storage time | 30 days | |
| NaOH storage volume reqd. | 2500 gallons | |
| NaOH tank diameter | 7 feet | |
| NaOH tank height | 9.7 feet | Includes 1 ft. freeboard |
| Actual tank volume w/ freeboard | 2790 gallons | |

**Saco Landfill Groundwater Pump & Treat System**
**Conceptual Design**

| | | |
|---|---|---|
| **Oxidation tank** | | Notes: |
| Oxidation tank residence time | 25 min. | Reaction time of 5 to 30 minutes suggested in AWWA |
| Oxidation tank volume | 1800 gallons | |
| Tank diameter | 6 feet | |
| Tank height | 9.5 feet | Includes 1 ft. freeboard |
| Actual tank volume w/ freeboard | 2010 gallons | |
| **Lamella inclined plate separator** | | |
| Surface loading rate | 0.4 gpm/ft$^2$ | 0.4 to 0.6 gpm/sq. ft recommended by Parkson |
| Required surface area | 175 ft$^2$ | |
| Unit size | 240 ft$^2$ | Unit sizes of 240, 480, 740, and 1150 sq. ft available |
| Number of units | 1 unit | |
| Approx. height | 13 feet | Dimensions from Parkson |
| Approx. length | 11 feet | |
| Approx. width | 6 feet | |
| **Transfer tank and pumps** | | Notes: |
| Transfer tank residence time | 5 min. | Reasonable time for stable pump control |
| Transfer tank volume | 350 gallons | |
| Tank diameter | 3 feet | |
| Tank height | 7.6 feet | Includes 1 ft. freeboard |
| Actual tank volume w/ freeboard | 400 gallons | |
| Pump capacity | 70 ft head | 30 psi |
| Pump flow | 70 gpm | |
| Pump horsepower | 2.1 HP | |
| **Manganese greensand filters** | | Notes: |
| Surface loading rate | 3 gpm/ft$^2$ | 3 to 5 gpm per sq. ft. recommended in AWWA |
| Required surface area | 23 ft$^2$ | |
| Required diameter | 2.7 ft | |
| Unit size provided | 28 ft$^2$ | |
| Diameter provided | 3.0 ft | |
| Number of units | 2 units | Plan to alternate units, can also run in series or parallel |
| **Activated alumina ion exchange** | | Notes: |
| Desired pH for act. alumina | 6.0 units | |
| HCl required to offset NaOH | 6.1 meq | |

**Saco Landfill Groundwater Pump & Treat System**
**Conceptual Design**

| | | |
|---|---|---|
| HCl required to achieve setpoint | 2.5 meq | |
| Total acidity required | 8.6 meq | |
| HCl solution strength | 9 N | 20 deg. Be = 30% soln. = 9.2 N |
| HCl addition rate | 0.07 gpm | 94 gpd |
| Desired storage time | 30 days | |
| HCl storage volume reqd. | 2900 gallons | |
| HCl tank diameter | 7 feet | |
| HCl tank height | 11.1 feet | Includes 1 ft. freeboard |
| Actual tank volume w/ freeboard | 3190 gallons | |
| Act. alum. surface loading rate | 1 gpm/ft$^2$ | 1 to 5 gpm per sq. ft. recommended in AWWA |
| Required surface area | 70 ft$^2$ | |
| Required diameter | 4.7 ft | |
| Unit size provided | 79 ft$^2$ | |
| Diameter provided | 5.0 ft | |
| EBCT required | 5.0 min. | |
| Volume to satisfy EBCT | 47 cu. ft. | |
| Bed volumes to breakthrough | 10000 volumes | From AWWA p. 615 |
| Desired time to breakthrough | 90 days | Regenerate once per quarter. Complicated task. |
| Bed vol. reqd. for breakthrough | 121 cu. ft. | |
| Controlling bed volume | 121 cu. ft. | |
| Number of units | 2 units | Plan to alternate units, can also run in series or parallel |

| **Granular Activated Carbon** | | Notes: |
|---|---|---|
| Carbon vessels required | 2 units | Plan to run in series |
| Flow rate | 70.0 gpm | |
| Min. vessel diameter | 48 inches | |
| Mass of carbon in vessel | 1700 lbs. | |
| Mass of carbon used per day | 3 lbs. | Based on use rate of 0.03 lb/1000 gal. from Calgon |
| Life of vessel | 1.5 years | |

| **Clearwell and backwash settling tanks** | | Notes: |
|---|---|---|
| Filter backwash rate | 175 gpm | Assume 250% of forward flow rate |
| Backwash cycles per day | 2 cycles | |
| Backwash duration | 10 minutes | |
| Settling tank hold time | 2 days | |
| Settling tank volume required | 7000 gallons | |
| Settling tank diameter | 9 feet | |
| Settling tank height | 15.7 feet | Includes 1 ft. freeboard |
| Actual tank volume w/ freeboard | 7480 gallons | |

**Saco Landfill Groundwater Pump & Treat System**
**Conceptual Design**

| | | |
|---|---|---|
| Clearwell volume required | 1750 gallons | |
| Clearwell tank diameter | 6 feet | |
| Clearwell tank height | 9.3 feet | Includes 1 ft. freeboard |
| Actual tank volume w/ freeboard | 1960 gallons | |

| **Sludge storage/thickening tank** | | Notes: |
|---|---|---|
| Mass of Fe removed | 38 lb/day | as Fe |
| | 72 lb/day | as $Fe(OH)_3$ |
| Mass of Mn removed | 23 lb/day | as Mn, includes Mn added with $KMnO_4$ |
| | 37 lb/day | as $MnO_2$ |
| Mass of As removed | 0.1 lb/day | as As |
| | 0.2 lb/day | as $As(OH)_2$ |
| Misc. other metals removed | 11 lb/day | assumes 10% of Fe, Mn total |
| Total metals removed | 120 lb/day | |
| Conc. of As in dry sludge | 980 mg/kg | |
| Hazardous waste? | Yes | Hazardous waste threshhold is 100 mg/kg. |
| Settled sludge concentration | 20000 mg/L | 2 % |
| Sludge specific gravity | 1.01 | |
| Settled sludge volume | 714 gal/day | |
| Sludge holding between presses | 7 days maximum | |
| Necessary tank volume | 5100 gallons | |
| Tank diameter | 8 feet | |
| Tank height | 14.5 feet | Includes 1 ft. freeboard |
| Actual tank volume w/ freeboard | 5480 gallons | |

| **Polymer day tank** | | Notes: |
|---|---|---|
| Necessary tank volume | 30 gallons | Polymer diluted in day tank, dosed in-line w/ static mixer |
| Tank diameter | 2 feet | |
| Tank height | 2.3 feet | Includes 1 ft. freeboard |
| Actual tank volume w/ freeboard | 50 gallons | |
| Polymer dose | 10 mg/L | |
| Polymer use | 22 lb/year | |

| **Sludge press** | | Notes: |
|---|---|---|
| Pressed sludge concentration | 400000 mg/L | |
| Sludge specific gravity | 1.40 | |
| Pressed sludge volume | 26 gal/day | 3 $ft^3$/day |
| Pressed sludge mass | 300 lb/day | 4.5 ton/month |

**Saco Landfill Groundwater Pump & Treat System**
**Conceptual Design**

| | | |
|---|---|---|
| Required press volume | 4 $ft^3$ | Assumes more than one press cycle per day as reqd. |
| Length | 6.2 ft | Based on JWI catalog cuts |
| Width | 3 ft | Based on JWI catalog cuts |
| Height | 4.1 ft | Based on JWI catalog cuts |
| Initial press fill time | 5 min. | Based on JWI recommendation |
| AOD pump flow rate | 6 gpm | at peak 100 psi discharge |
| Compressed air flow rate | 12 scfm | (incorporates 2x correction for high viscosity) |
| HP required | 3 hp | Assumes 4 cfm/hp |
| | | |
| **Discharge piping** | | Notes: |
| Flow rate | 70 gpm | |
| Desired flow velocity in piping | 4 ft/sec | |
| East well line diameter | 3 inches | |
| Line length | 1070 feet | |

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TEL. (207)774-2112

CLIENT Saco Municipal Landfill
PROJECT FS
DESIGNED BY L. Tivesdale DATE 8/10/99
CHECKED BY GW DATE 9/9/99
PROJECT NO. 95093.06 SHEET NO. _____ OF _____

## Installation of Piezometers around extraction wells

11 proposed piezometers to be installed around 2 extraction wells as shown on Figure 7-3 in Feasibility Study Report

3 piezometers to be installed to 25 ft bgs with 10ft screens from 15-25 ft bgs
1 piezometer screened from 25-35 ft bgs
4 piezometers screened from 35-45 ft bgs
3 piezometers to be installed to 75 ft bgs with 10 ft screens from 65-75 ft bgs

Assume installation of 1 piezometer per day and 15$/ft for piezometer construction

(11 days) (1000$/day drilling) = 11,000

(3 piez)(25 ft)(15$/ft) + (1 piez)(35 ft)(15$/ft) + (4 piez)(45 ft)(15$/ft) + (3 piez)(75 ft)(15$/ft) = 7,725

Inspection (per diem, travel, mileage)
(11 days)(12 hrs/day)(85$/hr) = 11,220

Equipment / Health and Safety = 4,000

= $33,945

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# MEMORANDUM TO FILE

Project: Saco Municipal Landfill Saco, ME
Project No.: 95093 Date: 8/9/99

PHONE CALL FROM Lori Trivesdale PHONE NO. 774-2112 x334
PHONE CALL TO Dick Grims @ Clean Harbors PHONE NO. 799-8112

SUBJECT Disposal of sludge from Groundwater treatment system. We estimated system would generate approximately 4 tons/month or ~ 3 cy month
we estimated that dry sludge would contain ~ 1,000 mg/kg arsenic (based on a flowrate of 60 gpm)

I spoke with Dick Grims @ Clean Harbors
Dick confirmed that at 1,000 ppm the sludge would be RCRA regulated and would need to be removed from the site every 90 days

Dick quoted $250/ton for stabilization and landfill disposal @ either Model City, NY or Stabilex, Canada

SIGNED

Form C-10

**TABLE 7-13**
**COST ESTIMATE: ALTERNATIVE SML-5A**
**(DISCHARGE TO SACO WWTP)**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| DIRECT COSTS | |
|---|---|
| Groundwater Extraction System | $92,000 |
| Discharge to Saco WWTP (1) | $453,000 |
| Installation of Groundwater Extraction/ Discharge System | $164,000 |
| SUBTOTAL | $709,000 |
| 20% Contingency on Direct Costs | $142,000 |
| TOTAL DIRECT COSTS | $851,000 |

| INDIRECT COSTS | |
|---|---|
| Health and Safety @ 5% | $43,000 |
| Legal, Administrative and Permitting @ 5% | $43,000 |
| Engineering Design @ 10% | $85,000 |
| Services during Construction @10 % | $85,000 |
| TOTAL INDIRECT COSTS | $256,000 |
| **TOTAL CAPITAL COSTS (DIRECT AND INDIRECT)** | **$1,107,000** |

| ANNUAL OPERATION AND MAINTENANCE COSTS | |
|---|---|
| Monitoring 2 Extraction Wells (Quarterly) | $5,000 |
| Monitoring Groundwater/Surface Water and Sediment (Annually) (2) | $40,000 |
| Maintenance (Annual) | $27,000 |
| SUBTOTAL | $72,000 |
| Engineering @ 10% | $7,000 |
| 20% Contingency on Annual O&M | $14,000 |
| TOTAL O&M COSTS | $93,000 |
| **TOTAL PRESENT WORTH ANNUAL O&M COSTS (7%, 30 YEARS)** | **$509,000** |
| Monitoring Groundwater/Surface Water and Sediment (annually) (includes 20% Contingency) | $125,000 |
| **TOTAL PRESENT WORTH ANNUAL ENVIRONMENTAL MONITORING COSTS (7%, 30 YEARS)** | **$1,551,000** |
| Five Year Site Reviews (includes 20% Contingency) | $60,000 |
| **TOTAL PRESENT WORTH OF FIVE YEAR SITE REVIEWS (7%, 30 YEARS)** | **$129,000** |
| **TOTAL PRESENT WORTH (30 YEARS) - ALTERNATIVE SML-5A** | **$3,296,000** |

(1) Costs for upgrades to pump station on Route 112 not included.

| | | | |
|---|---|---|---|
| ALTERNATIVE SML-5A (O&M cost back-up) | | | |
| SAMPLING AND ANALYSIS (extraction system) | | | |
| (assumes quarterly monitoring of 2 extraction well- VOCs, metals) | | | |
| | | | |
| | | | |
| DESCRIPTION | | COST | |
| | | | |
| Monitoring 2 Extraction Wells (Quarterly) | | $5,000 | yr |
| Maintenance (5% of equipment subtotal) | | $27,000 | yr |
| | | | |
| Subtotal annual costs | | $32,000 | |
| | | | |
| Engineering @ 10% | | $3,000 | |
| 20% Contingency on Annual O&M | | $6,000 | |
| | | $41,000 | |
| | | 7% | |
| | | 30 | years |
| PRESENT WORTH ANNUAL MONITORING AND MAINTENANCE (7% FOR 30 YEARS) | | $509,000 | |
| (P/A factor used was 12.4090) | | | |
| | | | |
| Monitoring Groundwater/Surface Water and Sediment (Annually) | | $125,000 | yr |
| | | 7% | |
| | | 30 | |
| PRESENT WORTH ANNUAL ENV. MONITORING AND MAINTENANCE (7% FOR 30 YEARS) | | $1,551,000 | |
| | | | |
| | | | |
| FIVE YEAR SITE REVIEWS ($50,000 + a 20 % contingency ($10,000) = $60,000 every five | | | |
| years at an interest rate of 7% is an annual cost of $10,434 for 30 years) (A/F factor used was 0.1739) | | $10,434 | |
| | | 7% | |
| | | 30 | years |
| TOTAL PRESENT WORTH FIVE YEAR SITE REVIEWS (P/A factor used was 12.4090) | | $129,000 | |

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TEL. (207)774-2112

CLIENT Saco Municipal Landfill
PROJECT Feasibility Study
DESIGNED BY L. Tyerdale DATE 7/27/99
CHECKED BY [illegible] DATE 9/9/99
PROJECT NO. 95093.06 SHEET NO. 1 OF 2

Discharge of Untreated Extracted Groundwater to Saco WWTP

(Design and cost based on assumptions in internal memo from Bob Severence to Guy Vaillancourt and Bill Fisher 9/25/98 Regarding Leachate Transportation: Landfill No. 2)

- Pump station wetwell and slab (includes min. 8 ft diameter manhole, telemetry, utilities, excavation, start-up, etc...) $100,000

- 3200 feet 2 1/2 inch PVC force main @ 30 - 35$/foot
  transport untreated groundwater from holding tank at Landfill Area 4 along Foss Rd to intersection of Route 112

  $96,000 - $112,000 + $4000 for air relief manhole $104,000

- 3550 feet of 8" and 10" diameter gravity sewer along the shoulder of Rt 112
  $60 - $80 / foot ($213,000 to $284,000) $249,000

Total $453,000

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TEL. (207)774-2112

CLIENT Saco Municipal Landfill
PROJECT Feasibility Study
DESIGNED BY L. Jaresdale DATE 9/10/99
CHECKED BY JW DATE 9/9/99
PROJECT NO. 95093.06 SHEET NO. 2 OF 2

Alternative SML-5A

Equipment Costs

| | |
|---|---|
| Groundwater Extraction System | $92,000 |
| Discharge to Saco WWTP | $453,000 |
| Subtotal | $545,000 |

Installation Costs

| | |
|---|---|
| Instrumentation (15% of equipment subtotal) | = $81,750 |
| Electrical (15% of equipment subtotal) | = $81,750 |
| Installation Subtotal | = 163,500 |
| Total | $708,500 |

**TABLE 7-14**
**COST ESTIMATE: ALTERNATIVE SML-5B**
**(TREATMENT/ON-SITE DISCHARGE)**

**FEASIBILITY STUDY REPORT**
**SACO MUNICIPAL LANDFILL**
**SACO, MAINE**

| DIRECT COSTS | |
|---|---|
| Groundwater Extraction System | $92,000 |
| Treatability Study for Groundwater Treatment System | $100,000 |
| Groundwater Treatment System | $443,000 |
| Treated Groundwater Discharge System | $11,000 |
| Installation of Groundwater Extraction /Treatment/ Discharge Systems | $676,000 |
| SUBTOTAL | $1,322,000 |
| 20% Contingency on Direct Costs | $264,000 |
| TOTAL DIRECT COSTS | $1,586,000 |

| INDIRECT COSTS | |
|---|---|
| Health and Safety @ 5% | $79,000 |
| Legal, Administrative and Permitting @ 5% | $79,000 |
| Engineering Design @ 10% | $159,000 |
| Services during Construction @10 % | $159,000 |
| TOTAL INDIRECT COSTS | $476,000 |
| **TOTAL CAPITAL COSTS (DIRECT AND INDIRECT)** | **$2,062,000** |

| ANNUAL OPERATION AND MAINTENANCE COSTS | |
|---|---|
| Treatment System (Labor, Power, Chemicals, Maintenance, etc...) | $166,000 |
| Monitoring 2 Extraction Wells (Quarterly) | $5,000 |
| Treatment System Monitoring (Monthly) | $12,000 |
| Treatment Sludge Disposal | $14,000 |
| SUBTOTAL | $197,000 |
| Engineering @ 10% | $20,000 |
| 20% Contingency on Annual O&M | $39,000 |
| TOTAL O&M COSTS | $256,000 |
| **TOTAL PRESENT WORTH ANNUAL O&M COSTS (7%, 30 YEARS)** | **$3,177,000** |
| Monitoring Groundwater/Surface Water and Sediment (annually) (includes 20% Contingency) | $125,000 |
| **TOTAL PRESENT WORTH ANNUAL ENVIRONMENTAL MONITORING COSTS (7%, 30 YEARS)** | **$1,551,000** |
| Five Year Site Reviews (includes 20% Contingency) | $60,000 |
| **TOTAL PRESENT WORTH OF FIVE YEAR SITE REVIEWS (7%, 30 YEARS)** | **$129,000** |
| **TOTAL PRESENT WORTH (30 YEARS) - ALTERNATIVE SML-5B** | **$6,919,000** |

| | | | |
|---|---|---|---|
| ALTERNATIVE SML-5B (O&M cost back-up) | | | |
| SAMPLING AND ANALYSIS (extraction and treatment systems) | | | |
| (assumes quarterly monitoring of 2 extraction well- VOCs, metals) | | | |
| (assumes monthly monitoring of treatment system - VOCs, metals) | | | |
| | | | |
| | | | |
| DESCRIPTION | | COST | |
| | | | |
| Treatment System (Labor, Power, Chemicals, Maintenance, etc...) | | $166,000 | |
| Monitoring 2 Extraction Wells (Quarterly) | | $5,000 | |
| Treatment System Monitoring (Monthly) | | $12,000 | |
| Treatment Sludge Disposal | | $14,000 | |
| | | | |
| | | | |
| Subtotal annual costs | | $197,000 | |
| | | | |
| Engineering @ 10% | | $20,000 | |
| 20% Contingency on Annual O&M | | $39,000 | |
| | | $256,000 | |
| | | 7% | |
| | | 30 | years |
| PRESENT WORTH ANNUAL MONITORING AND MAINTENANCE (7% FOR 30 YEARS) | | $3,177,000 | |
| (P/A factor used was 12.4090) | | | |
| | | | |
| Monitoring Groundwater/Surface Water and Sediment (Annually) | | $125,000 | |
| | | 7% | |
| | | 30 | |
| PRESENT WORTH ANNUAL ENV. MONITORING AND MAINTENANCE (7% FOR 30 YEARS) | | $1,551,000 | |
| | | | |
| FIVE YEAR SITE REVIEWS ($50,000 + a 20 % contingency ($10,000) = $60,000 every five | | | |
| years at an interest rate of 7% is an annual cost of $10,434 for 30 years) (A/F factor used was 0.1739) | | $10,434 | |
| | | 7% | |
| | | 30 | years |
| TOTAL PRESENT WORTH FIVE YEAR SITE REVIEWS (P/A factor used was 12.4090) | | $129,000 | |

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# APPENDIX E

## CHEMICAL-SPECIFIC, LOCATION-SPECIFIC, AND ACTION-SPECIFIC ARARs BY ALTERNATIVE

# TABLE E-1A
# ALTERNATIVE SML-1: NO-ACTION
# CHEMICAL-SPECIFIC ARARs and TBCs

## FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Actions to be Taken to Attain Requirement |
|---|---|---|---|
| | | **Groundwater/Surface Water** | |
| **Federal Regulatory Requirements** | | | |
| SDWA-MCLs (40 CFR 141.11-141.16) | Relevant and Appropriate | MCLs were used as cleanup levels for several common organic and inorganic contaminants. These levels regulate the concentration of contaminants in public drinking water supplies and are considered relevant and appropriate because the aquifer beneath the site could be a potential future drinking water source. | SML-1 does not comply with ARARs. |
| SDWA-MCLGs (40 CFR 141.50-141.51) | Relevant and Appropriate | Non-zero MCLGs are health-based criteria. As promulgated under SARA, MCLGs are to be considered for drinking water sources. Non-zero MCLGs are available for several organic and inorganic contaminants. | SML-1 does not comply with ARARs |

# TABLE E-1A
# ALTERNATIVE SML-1: NO-ACTION
# CHEMICAL-SPECIFIC ARARs and TBCs

## FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Actions to be Taken to Attain Requirement |
|---|---|---|---|
| | | Groundwater/Surface Water (continued) | |
| **Federal Regulatory Requirements** | | | |
| USEPA RfDs | To be considered | Guidance values used to evaluate the potential non-carcinogenic hazard caused by exposure to contaminants. | USEPA RfDs were used in the HHRA to characterize risks due to noncarcinogens in various media. |
| USEPA Carcinogen Assessment Group CSFs | To be considered | Guidance values used to evaluate the potential carcinogenic risk caused by exposure to contaminants. | USEPA CFS were used in the HHRA to compute the individual incremental cancer risk resulting from exposure to carcinogenic compounds. |
| **State Regulatory Requirements** | | | |
| Department of Human Services (10-144 CMR Chapters 231-233) | Relevant and Appropriate | Maine's Primary Drinking Water Standards are equivalent to federal MCLs. When state levels are more stringent than federal levels, the state levels will be used. | SML-1 does not comply with ARARs |

# TABLE E-1A
# ALTERNATIVE SML-1: NO-ACTION
# CHEMICAL-SPECIFIC ARARs and TBCs

## FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Actions to be Taken to Attain Requirement |
|---|---|---|---|
| | | **Groundwater/Surface Water (continued)** | |
| **State Regulatory Requirements** | | | |
| Maine Regulations Relating to Surface Water Toxic Control Program (38 M.R.S.A. Section 420, Chapter 530.5) | Applicable | This rule limits the concentrations of certain materials allowed in Maine waters to prevent the occurrence of pollutants in toxic amounts as required by state and federal law. Except if naturally occurring, ambient levels of toxic pollutants shall not exceed the Clean Water Act AWQC. | SML-1 does not comply with all State water quality criteria. |
| Maine Standards for Hazardous Waste Facilities, Misc. Units (06-096 CMR Chapter 854, Section 8) | Relevant and Appropriate | A hazardous waste landfill unit must be closed in a manner that provides protection to groundwater or surface water from hazardous waste above Maximum Exposure Guidelines (MEGs). | SML-1 does not comply with ARARs |

NOTES:
ARAR=Applicable or Relevant and Appropriate Requirements
AWQC=Ambient Water Quality Criteria
CMR=Code of Maine Regulations
CSF=Cancer Slope Factor
HHRA = Human Health Risk Assessment
MCL = Maximum Contaminant Level
MCLG = Maximum Contaminant Level Goal
MEDEP = Maine Department of Environmental Protection
MEG = Maximum Exposure Guideline
M.R.S.A. = Maine Revised Statutes Annotated
RfD = Reference dose mg/kg - milligrams per kilograms
SDWA= Safe Drinking Water Act
TBC=To be considered
USEPA=U.S. Environmental Protection Agency

# TABLE E-2A
# ALTERNATIVE SML-3: MONITORED NATURAL ATTENUATION
# CHEMICAL-SPECIFIC ARARs AND TBCs

## FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| | | **Groundwater/Surface Water** | |
| **Federal Regulatory Requirements** | | | |
| SDWA-MCLs (40 CFR 141.11-141.16) | Relevant and Appropriate | MCLs were used as cleanup levels for several common organic and inorganic contaminants. These levels regulate the concentration of contaminants in public drinking water supplies and are considered relevant and appropriate because the aquifer beneath the site could be a potential future drinking water source. | SML-3 would not comply in the short term. In the long term, once aquifer quality is restored through natural attenuation, SML-3 would comply. |
| SDWA-MCLGs (40 CFR 141.50-141.51) | Relevant and Appropriate | Non-zero MCLGs are health-based criteria. As promulgated under SARA, MCLGs are to be considered for drinking water sources. Non-zero MCLGs are available for several organic and inorganic contaminants. | SML-3 would not comply in the short term. In the long term, once aquifer quality is restored through natural attenuation, SML-3 would comply. |

# TABLE E-2A
## ALTERNATIVE SML-3: MONITORED NATURAL ATTENUATION
## CHEMICAL-SPECIFIC ARARs AND TBCs

## GROUNDWATER FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| | | **Groundwater/Surface Water (continued)** | |
| **Federal Regulatory Requirements** | | | |
| USEPA RfDs | To be considered | Guidance values used to evaluate the potential non-carcinogenic hazard caused by exposure to contaminants. | USEPA RfDs were used in the HHRA to characterize risks due to noncarcinogens in various media. |
| USEPA Carcinogen Assessment Group CSFs | To be considered | Guidance values used to evaluate the potential carcinogenic risk caused by exposure to contaminants. | USEPA CFS were used in the HHRA to compute the individual incremental cancer risk resulting from exposure to carcinogenic compounds. |
| **State Regulatory Requirements** | | | |
| Department of Human Services (10-144 CMR Chapters 231-233) | Relevant and Appropriate | Maine's Primary Drinking Water Standards are equivalent to federal MCLs. When state levels are more stringent than federal levels, the state levels will be used. | SML-3 would not comply in the short term. In the long term, once aquifer quality is restored through natural attenuation, SML-3 would comply. |
| Department of Human Services (10-144 CMR Chapters 231-233) | Relevant and Appropriate | Maine's Primary Drinking Water Standards are equivalent to federal MCLs. When state levels are more stringent than federal levels, the state levels will be used. | SML-1 does not comply with ARARs |

# TABLE E-2A
# ALTERNATIVE SML-3: MONITORED NATURAL ATTENUATION
# CHEMICAL-SPECIFIC ARARs AND TBCs

## GROUNDWATER FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| | | **Groundwater/Surface Water (continued)** | |
| **State Regulatory Requirements** | | | |
| Maine Regulations Relating to Surface Water Toxic Control Program (38 M.R.S.A. Section 420, Chapter 530.5) | Applicable | This rule limits the concentrations of certain materials allowed in Maine waters to prevent the occurrence of pollutants in toxic amounts as required by state and federal law. Except if naturally occurring, ambient levels of toxic pollutants shall not exceed the Clean Water Act AWQC. | SML-3 may not comply with all AWQC criteria at all locations along Sandy Brook in the short-term. In the long-term, once aquifer quality is restored through natural attenuation, SML-3 would comply. |
| RCRA Subtitle C – Releases from Solid Waste Management Units (40 CFR, Subpart F – 264.95 and 264.96(a) and (c) (Incorporated by reference into MEDEP Regulations, Chapter 800) | Relevant and Appropriate | These regulations identify specific monitoring requirements applicable to hazardous waste facilities. | The long-term monitoring program conducted in association with this action will meet the substantive requirements of this ARAR. |

NOTES:

ARAR=Applicable or Relevant and Appropriate Requirement
AWQC=Ambient Water Quality Criteria
CAG = Carcinogen Assessment Group
CMR=Code of Maine Regulations
CPC=contaminants of potential concern
CSF=Cancer Slope Factor
HHRA = Human Health Risk Assessment
MCL = Maximum Contaminant Level
MCLG = Maximum Contaminant Level Goal
MEDEP = Maine Department of Environmental Protection
MEG = Maximum Exposure Guideline
M.R.S.A. = Maine Revised Statutes Annotated
mg/kg = milligrams per kilograms
NAAQS = National Ambient Air Quality Standards
NCP = National Contingency Plan
RfD = Reference dose mg/kg - milligrams per kilograms
SDWA= Safe Drinking Water Act
TBC=To be considered
USEPA=U.S. Environmental Protection Agency

# TABLE E-3A
## ALTERNATIVE SML-4: IN-SITU CHEMICAL OXIDATION WITH HYDRAULIC CONTAINMENT
## CHEMICAL-SPECIFIC ARARs and TBCs

## FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Action to be Taken to Attain Requirements |
|---|---|---|---|
| | | **Groundwater/Surface Water** | |
| **Federal Regulatory Requirements** | | | |
| SDWA-MCLs (40 CFR 141.11-141.16) | Relevant and Appropriate | MCLs have been promulgated for several common organic and inorganic contaminants. These levels regulate the concentration of contaminants in public drinking water supplies, but may also be considered relevant and appropriate for groundwater aquifers used for drinking water. | SML-5 would not comply in the short term. In the long term, once aquifer quality is restored through groundwater extraction and treatment, SML-5 would comply. |
| SDWA-MCLGs (40 CFR 141.50-141.51) | Relevant and Appropriate | MCLGs are health-based criteria. As promulgated under SARA, MCLGs are to be considered for drinking water sources. MCLGs are available for several organic and inorganic contaminants. | SML-5 would not comply in the short term. In the long term, once aquifer quality is restored through groundwater extraction and treatment, SML-5 would comply. |

# TABLE E-3A
## ALTERNATIVE SML-4: IN-SITU CHEMICAL OXIDATION WITH HYDRAULIC CONTAINMENT
## CHEMICAL-SPECIFIC ARARs and TBCs

## FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Action to be Taken to Attain Requirements |
|---|---|---|---|
| | | **Groundwater/Surface Water (continued)** | |
| **Federal Regulatory Requirements** | | | |
| USEPA RfDs | To be considered | Guidance values used to evaluate the potential non-carcinogenic hazard caused by exposure to contaminants. | USEPA RfDs were used in the HHRA to characterize risks due to noncarcinogens in various media. |
| USEPA Carcinogen Assessment Group CSFs | To be considered | Guidance values used to evaluate the potential carcinogenic risk caused by exposure to contaminants. | USEPA CFS were used in the HHRA to compute the individual incremental cancer risk resulting from exposure to carcinogenic compounds. |
| **State Regulatory Requirements** | | | |
| Maine Standards for Hazardous Waste Facilities, Misc. Units (06-096 CMR Chapter 854, Section 8) | Relevant and Appropriate | A hazardous waste landfill unit must be closed in a manner that provides protection to groundwater or surface water from hazardous waste above Maximum Exposure Guidelines (MEGs). | SML-1 does not comply with ARARs |
| Department of Human Services (10-144 CMR Chapters 231-233) | Relevant and Appropriate | Maine's Primary Drinking Water Standards are equivalent to federal MCLs. When state levels are more stringent than federal levels, the state levels will be used. | SML-1 does not comply with ARARs |

# TABLE E-3A
## ALTERNATIVE SML-4: IN-SITU CHEMICAL OXIDATION WITH HYDRAULIC CONTAINMENT
## CHEMICAL-SPECIFIC ARARs and TBCs

## FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Action to be Taken to Attain Requirements |
|---|---|---|---|
| | | **Groundwater/Surface Water (continued)** | |
| **State Regulatory Requirements** | | | |
| Maine Regulations Relating to Surface Water Toxic Control Program (38 M.R.S.A. Section 420, Chapter 530.5) | Applicable | This rule limits the concentrations of certain materials allowed in Maine waters to prevent the occurrence of pollutants in toxic amounts as required by state and federal law. Except if naturally occurring, ambient levels of toxic pollutants shall not exceed the Clean Water Act AWQC. Where AWQC do not exist, the Board of Environmental Protection shall adopt site-specific numerical criteria. | SML-5 may not comply with all AWQC criteria at all locations along Sandy Brook in the short-term. In the long-term, once aquifer quality is restored through natural attenuation, SML-5 would comply. |

NOTES:

ARAR=Applicable or Relevant and Appropriate Reqmts
AWQC=Ambient Water Quality Criteria
CAGCarcinogen Assessment Group
CMR=Code of Maine Regulations
CPC=contaminants of potential concern
CSF=Cancer Slope Factor
HHRA = Human Health Risk Assessment
MCL = Maximum Contaminant Level
MCLG = Maximum Contaminant Level Goal
MEDEP = Maine Department of Environmental Protection
MEG = Maximum Exposure Guideline
M.R.S.A. = Maine Revised Statutes Annotated
mg/kg = milligrams per kilograms
NAAQS = National Ambient Air Quality Standards
NCP = National Contingency Plan
RfD = Reference dose mg/kg - milligrams per kilograms
SDWA= Safe Drinking Water Act
TBC=To be considered
USEPA=U.S. Environmental Protection Agency

# TABLE E-3B
## ALTERNATIVE SML-4: IN-SITU CHEMICAL OXIDATION WITH HYDRAULIC CONTAINMENT
## LOCATION-SPECIFIC ARARs AND TBCs

## FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| | | **Wetlands/Floodplains** | |
| **Federal Regulatory Requirements** | | | |
| National Environmental Policy Act Wetland Executive Order (EO11990), 40 CFR 6.302(a) and 40 CFR Part 6, Appendix A | Applicable | The Wetlands Executive Order requires federal agencies to minimize the destruction, loss, or degradation of wetlands, and preserve and enhance natural and beneficial values of wetlands. | Measures will be taken under SML-5 to avoid disturbing the onsite wetlands. However, wetlands may be unavoidably affected. This requirement will nonetheless be attained because there is no practicable alternative with less adverse impact and all practicable measures will be taken to minimize and mitigate adverse impacts. |
| National Environmental Policy Act Floodplains Executive Order (EO11988), 40 CFR Part 6, Appendix A | Applicable | The Floodplains Executive Order requires federal agencies to reduce the risk of flood loss, to minimize the impact of floods, and to restore and preserve the natural and beneficial values of Floodplains. | Measures will be taken under SML-5 to avoid construction activities within the flood plan. However, flood plan disturbance may be unavoidably affected. This requirement will nonetheless be attained because there is no practicable alternative with less adverse impact and all practicable measures will be taken to minimize and mitigate adverse impacts. |
| Clean Water Act Section 404 Requirements for discharge of dredged and fill materials (33 USC 1344, 40 CFR 230) | Applicable | Section 404 of the CWA regulates the discharge of dredged fill material into U.S. waters, including wetlands. The purpose of Section 404 is to ensure that proposed discharges are evaluated with respect to impact on the aquatic ecosystem. The guidelines prohibit the discharge of dredge or fill material is a practicable alternative with less impact to the aquatic system. Discharge is also prohibited unless steps are | Measures will be taken under SML-5 to avoid excavation or dredging of Sandy Brook. However, these activities may be unavoidably affected. This requirement will nonetheless be attained because there is no practicable alternative with less adverse impact and all practicable measures will be taken to minimize and mitigate adverse impacts. |

# TABLE E-3B
# ALTERNATIVE SML-4: IN-SITU CHEMICAL OXIDATION WITH HYDRAULIC CONTAINMENT
# LOCATION-SPECIFIC ARARs AND TBCs

## FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| **Federal Regulatory Requirements** | | | |
| Fish and Wildlife Coordination Act (16 U.S.C. 661); 40 CFR 6.302 | Applicable | This act requires that any federal agency proposing to modify a body of water must consult with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and other related State agencies. | Wetland disturbance under SML –5 will be avoided; however, if required, wetlands may be disturbed with the concurrence of the U.S. Fish and Wildlife Service and appropriate State agencies. |
| RCRA Location Standards (40 CFR 264.18) | Relevant and Appropriate | A facility located in 100-year Floodplain must be designed, constructed, operated, and maintained to prevent washout of any hazardous wastes by a 100-year flood. | The landfill cap was designed to meet RCRA requirements, including to prevent washout of hazardous substances during a 100-year flood. |
| **State Regulatory Requirements** | | | |
| Maine Wetlands Protection Rule (06-096 CMR Chapter 310, Section 1) | Applicable | This act outlines requirements and performance standards for certain activities adjacent to any freshwater wetland greater than 10 acres or with an associated stream, pond, or brook. The activities must not unreasonably interfere with certain natural features, such as natural flow or quality of any waters, nor harm significant aquatic habitat, freshwater fisheries, or other aquatic life. | Stormwater and erosion controls will be incorporated into any remedial design to minimize the impacts of construction on the natural resources of Sandy Brook. |

# TABLE E-3B
## ALTERNATIVE SML-4: IN-SITU CHEMICAL OXIDATION WITH HYDRAULIC CONTAINMENT
## LOCATION-SPECIFIC ARARs AND TBCs

## FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| **State Regulatory Requirements** | | | |
| Maine Natural Resource Protection Act, Permit by Rule Standards (06-096 CMR, Chapter 305) | Applicable | This rule outlines prescribed standards for specific activities that may take place in or adjacent to wetlands and water bodies. The standards are designed to ensure that disturbed soil material is stablized to prevent erosion and filtration of water. | Stormwater and erosion controls will be incorporated into any remedial design to minimize the impacts of construction on the natural resources of Sandy Brook. |
| Maine Natural Resources Protection Act (38 M.R.S.A.; Section 480-A through S) | Applicable | A permit application must be submitted and approved by the Maine Bureau of Land Quality Control and Section 480-D performance standards met when conducting activities adjacent to any freshwater wetland greater than 10 acres or with an associated stream, brook, or pond. | Measures will be taken under SML-5 to avoid excavation or dredging of Sandy Brook; however, these activities may be unavoidable. This requirement will nonetheless be attained because there is no practicable alternative with less adverse impact and all practicable measures will be taken to minimize and mitigate adverse impacts as required by this standard. |
| Maine Standards for Classification of Major River Basins and Minor Drainages (38 M.R.S.A., Chapter 3, Sections 465, 467, and 468) | Applicable | Sandy Brook is classified as a Class B water under the state water quality standards. Class B waters are defined as suitable for drinking water (after treatment), fishing, recreation in and on the water, and as a habitat for fish and other aquatic life. | Measures will be taken under SML-5 to avoid excavation or dredging of Sandy Brook; however, these activities may be unavoidable. This requirement will nonetheless be attained because there is no practicable alternative with less adverse impact and all practicable measures will be taken to minimize and mitigate adverse impacts as required by this standard. |

# TABLE E-3B
## ALTERNATIVE SML-4: IN-SITU CHEMICAL OXIDATION WITH HYDRAULIC CONTAINMENT
## LOCATION-SPECIFIC ARARs AND TBCs

## FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| | | **Other Natural Resources** | |
| **Federal Regulatory Requirements** | | | |
| Endangered Species Act (16 USC 1531 et seq.; 40 CFR 6.302(h) | Relevant and Appropriate | This statute requires that federal agencies avoid activities that jeopardize threatened or endangered species or adversely modify habitats essential to their survival. Mitigation measures should be considered if a listed species or habitat may be jeopardized. | No endangered or threatened species have been documented in the site area. |
| **State Regulatory Requirements** | | | |
| Maine Site Location and Development Law and Regulations (38 M.R.S.A. Sections 481 through 490; MEDEP Regs. Chapters 371-377) | Relevant and Appropriate | This act and regulations govern new development, including those that handle hazardous wastes and oil. Activities cannot adversely affect existing uses, scenic character, or natural resources in the municipality or neighboring municipality. | Measures will be taken under SML-5 to avoid excavation or dredging of Sandy Brook. However, these activities may be unavoidably affected. This requirement will nonetheless be attained because there is no practicable alternative with less adverse impact and all practicable measures will be taken to minimize and mitigate adverse impacts as required by this standard. |
| Maine Standards for Classification of Groundwater (38 M.R.S.A., Sections 465-C and 470) | Applicable | This law requires the classification of the state's groundwater to protect, conserve, and maintain groundwater resources in the interest of the health, safety, and general welfare of the people of the state. | SML-5 would not comply in the short term. In the long term, once aquifer quality is restored through natural attenuation, SML-5 would comply. |

# TABLE E-3B
# ALTERNATIVE SML-4: IN-SITU CHEMICAL OXIDATION WITH HYDRAULIC CONTAINMENT
# LOCATION-SPECIFIC ARARs AND TBCs

## FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| **State Regulatory Requirements** | | | |
| Maine Endangered Species Act and Regulations (12 MRSA Section 7751-7756;09-137 CMR 008) | Applicable | The State of Maine has authority to research, list, and protect any species deemed endangered or threatened as listed in the state regulations. The Maine Department of Inland Fisheries and Wildlife has also developed the following administrative categories for species not considered endangered or threatened but considered important for research and further evaluation: Maine Watch List, Special Concern List, and Indeterminate Category. The Department determines appropriate use(s) of various habitats on a case-by-case- basis. The Maine lists may differ from the federal lists of endangered species. | No endangered or threatened species have been identified in the site area. |
| Town Shoreland Zoning Ordinances and State Minimum Guidelines | To be considered | These minimum guidelines and town ordinances apply to activities proposed within 200 feet of a high-water mark of a stream or other body of water. | These guidelines will be considered in the siting of treatment facilities during the development and evaluation of remedial alternatives. |
| Maine Critical Areas Program and Maine Natural Heritage Program | To be considered | These state programs issue policies and regulations governing special habitats or communities. | Where such special areas exist, these state programs will become involved in the project and/or permit review process. |

# TABLE E-3B
# ALTERNATIVE SML-4: IN-SITU CHEMICAL OXIDATION WITH HYDRAULIC CONTAINMENT
# LOCATION-SPECIFIC ARARs AND TBCs

## FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| **State Regulatory Requirements** | | | |
| Maine Critical Areas Act (5 M.R.S.A. 3310 through 3316) | To be considered | This nonregulatory legislation allows Maine agencies such as the Critical Areas Program and the Natural Heritage Areas Program to identify, research, and protect critical areas and endangered or threatened plants. | Where such special areas exist, these state programs will become involved in the project and/or permit review process. |

Notes:
ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
CMR = Code of Maine Regulations
CWA = Clean Water Act
MEDEP = Maine Department of Environmental Protection
M.R.S.A. = Maine Revised Statues Annotated
RCRA = Resource Conservation and Recovery Act
TBC = To be considered
USC = U.S. Code
mg/kg = milligram per kilogram

# TABLE E-3C
## ALTERNATIVE SML-4: IN-SITU CHEMICAL OXIDATION WITH HYDRAULIC CONTAINMENT POTENTIAL ACTION-SPECIFIC ARARs, AND TBCs

## GROUNDWATER FEASIBILITY STUDY REPORT
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Requirement Synopsis | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| **Federal Regulatory Requirements** | | | |
| CWA NPDES (40 CFR Parts 122, 125) | Relevant and Appropriate | This requirement implements the NPDES program that specifies the applicable effluent standards, monitoring requirements, and standards and special conditions for direct discharge to surface water bodies. | Measures will be taken under SML-5 to meet the direct discharge to surface water requirements as required by CWA NPDES including limitations, monitoring requirements, and best management practices. |
| Clean Air Act - National Primary and Secondary Ambient Air Quality Standards | Relevant and Appropriate | Primary ambient air quality standards define levels of air quality to protect human health. Secondary ambient air quality standards protect public welfare from known or anticipated adverse effects from pollutants. | Measures will be taken under SML-5 to meet the National Ambient Air Quality Standards for invasive or construction activities with the potential of generating significant dust. |
| RCRA Subtitle C – Releases from Solid Waste Management Units (40 CFR, Subpart F – 264.95 and 264.96(a) and (c) (Incorporated by reference into MEDEP Regulations, Chapter 800) | Relevant and Appropriate | These regulations identify specific monitoring requirements applicable to hazardous waste facilities. | The long-term monitoring program conducted in association with this action will meet the substantive requirements of this ARAR. |
| Underground Injection Control Regulations (40 CFR Parts 144,145,146, and 147) | Relevant and Appropriate | These regulations provide regulatory compliance standards for treatment facilities that inject wastes underground. The use of wells to dispose of hazardous waste is prohibited. | Measures will be taken under SML-5 to meet the direct discharge to the subsurface as required by Underground Injection Control Regulations. |

# TABLE E-3C
## ALTERNATIVE SML-4: IN-SITU CHEMICAL OXIDATION WITH HYDRAULIC CONTAINMENT POTENTIAL ACTION-SPECIFIC ARARs, AND TBCs

## GROUNDWATER FEASIBILITY STUDY REPORT
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Requirement Synopsis | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| **Federal Regulatory Requirements** | | | |
| CWA - Regulations on Disposal Site Determinations Under the CWA (40 CFR 231) | Relevant and Appropriate | These regulations apply to all existing, proposed, or potential disposal sites for discharges of dredged or fill material into U.S. waters, which include wetlands. | Measures will be taken under SML-5 to avoid impact to Sandy Brook or onsite wetlands by onsite disposal of dredged or fill material. |
| U.S. Army Corps of Engineers Permit Program Regulations (33 CRF 320-330) | Relevant and Appropriate | These regulations prescribed the statutory authorities, and general and special policies and procedures applicable to the review of applications for permits for controlling certain activities in U.S. waters; this includes discharge of dredged or fill material. | Measures will be taken under SML-5 to avoid disturbing the onsite wetlands. However, wetlands may be unavoidably affected. This requirement will nonetheless be attained because there is no practicable alternative with less adverse impact and all practicable measures will be taken to minimize and mitigate adverse impacts. |
| CWA - Permits for Dredged and Fill Material (Section 404) | Relevant and Appropriate | This regulation outlines requirements for discharges of dredged or fill material. Under this requirement, no activity that impacts the adjacent wetland shall be permitted if a practicable alternative with less impact on the adjacent wetland is available. If there is no other practicable alternative, impacts must be mitigated. | Measures will be taken under SML-5 to avoid disturbing the onsite wetlands. However, wetlands may be unavoidably affected. This requirement will nonetheless be attained because there is no practicable alternative with less adverse impact and all practicable measures will be taken to minimize and mitigate adverse impacts. |

# TABLE E-3C
## ALTERNATIVE SML-4: IN-SITU CHEMICAL OXIDATION WITH HYDRAULIC CONTAINMENT POTENTIAL ACTION-SPECIFIC ARARs, AND TBCs

## GROUNDWATER FEASIBILITY STUDY REPORT
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Requirement Synopsis | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| **Federal Regulatory Requirements** | | | |
| Maine Rules to Control the Subsurface Discharge of Pollutants by Well Injection (06-096 CMR, Chapter 543) | Relevant and Appropriate | This regulation prohibits the injection of hazardous waste into or above water-bearing formations via a new Class IV well. The subsurface discharge into or through a Class IV well that would cause or allow the movement of fluid into an underground source of drinking water that may result in a violation of any Maine Primary Drinking Water Standard, or which may otherwise adversely affect public health, is prohibited. | Measures will be taken under SML-5 to meet the direct discharge to the subsurface as required by the Maine Rules to Control the Subsurface Discharge of Pollutants by Well Injection. |
| MEDEP, Bureau of Water Quality Control, Policy Number 10 "The Discharge of Hazardous Substances to Groundwaters of the State" | Relevant and Appropriate | The Board will deny applications for waste discharge licenses for the discharge to groundwaters of substances designated by the Board to be hazardous when such substances are present in concentrations exceeding groundwater levels which occur naturally in the area. Exemption may be granted if the groundwater is treated to reduce the concentrations of pollutants discharged to below the level considered safe for drinking water. | At least the minimum level of groundwater treatment would be required to provide adequate protection or if no other means of disposal is feasible. |
| Classification of Maine Waters 38 M.R.S.A. Section 464 - 470. | Relevant and Appropriate | This rule prohibits the new discharge to water bodies with a drainage area of less than 10 square miles. | Because Sandy Brook has a drainage area less than 10 square miles, no discharge to this water body will be allowed. |

# TABLE E-3C
## ALTERNATIVE SML-4: IN-SITU CHEMICAL OXIDATION WITH HYDRAULIC CONTAINMENT POTENTIAL ACTION-SPECIFIC ARARs, AND TBCs

## GROUNDWATER FEASIBILITY STUDY REPORT
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Requirement Synopsis | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| **Federal Regulatory Requirements** | | | |
| Erosion and Sedimentation Control (38 M.R.S.A., Chapter 3 Subsec. 420-C), Chapter 500, Stormwater Management Rules | Applicable | Erosion control measures must be in place before activities, such as filling, displacing, or exposing soil or other earthen materials occur. Prior MEDEP approval is needed if the disturbed area is in the direct watershed of a body of water most at risk. | Measures will be taken under SML-5 to control erosion, sedimentation, or stormwater. Applicable plans will be coordinated with the MEDEP prior to implementation. |
| Maine Ambient Air Quality Standards (MEDEP Regulations, Chapter 110) | Relevant and Appropriate | This regulation establishes ambient air quality standards that are maximum levels for a particulate matter permitted in the ambient air. | Measures will be taken under SML-5 to meet the Maine Ambient Air Quality Standards for invasive or construction activities with the potential of generating significant dust. |
| Maine Water Pollution Control Law: Conditions of Licenses (38 M.R.S.A., Chapter 3, Article 2, Section 414-A) | Relevant and Appropriate | Regulates the discharge of any pollutants. Specifies that the discharge, either by itself or in combination with other discharges, will not lower the quality of any classified body of water below such classification. The discharge will be subject to effluent limitations that require application of the best practicable treatment. | Measures will be taken under SML-5 to meet the direct discharge to surface water requirements as required by the Maine Water Pollution Control Law including limitations, monitoring requirements and best management practices. |

# TABLE E-3C
## ALTERNATIVE SML-4: IN-SITU CHEMICAL OXIDATION WITH HYDRAULIC CONTAINMENT POTENTIAL ACTION-SPECIFIC ARARs, AND TBCs

## GROUNDWATER FEASIBILITY STUDY REPORT
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Requirement Synopsis | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| **Federal Regulatory Requirements** | | | |
| Maine Water Pollution Control Law: Certain Deposits and Discharges Prohibited (38 M.R.S.A., Chapter 3, Article 2, Section 420). | Relevant and Appropriate | No person, firm, corporation, or other legal entity shall place, deposit, discharge, or spill mercury or toxic or hazardous substances, either directly or indirectly, into the inland ground or surface waters, tidal waters, on the ice, or on the banks thereof, so that the same may flow or be washed into such waters, or in such manner that the drainage there from may flow into such waters. | Measures will be taken under SML-5 to prevent discharge of toxic or hazardous substances into groundwater or surface water. |

NOTES:

ARAR = Applicable or Relevant and Appropriate Requirement
CAA = Clean Air Act
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
CFR = Code of Federal Regulations
CWA = Clean Water Act
DA = Department of the Army
DOT = Department of Transportation (U.S.)
lbs/day = pounds per day
LDRs = Land Disposal Restrictions
MCL = Maximum Contaminant Level
MEDEP = Maine Department of Environmental Protection
MEG = Maine Exposure Guidelines
OSHA = Occupational Safety and Health Administration
NPDES = National Pollution Discharge Elimination System
POTW = Publicly Owned Treatment Works
RCRA = Resource Conservation and Recovery Act
$ug/m^3$ = microgram per cubic meter
M.R.S.A.= Maine Revised Statues Annotated

# TABLE E-4A
## ALTERNATIVE SML-5: GROUNDWATER EXTRACTION AND TREATMENT
## CHEMICAL-SPECIFIC ARARs and TBCs

## FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Action to be Taken to Attain Requirements |
|---|---|---|---|
| | | **Groundwater/Surface Water** | |
| **Federal Regulatory Requirements** | | | |
| SDWA-MCLs (40 CFR 141.11-141.16) | Relevant and Appropriate | MCLs have been promulgated for several common organic and inorganic contaminants. These levels regulate the concentration of contaminants in public drinking water supplies, but may also be considered relevant and appropriate for groundwater aquifers used for drinking water. | SML-5 would not comply in the short term. In the long term, once aquifer quality is restored through groundwater extraction and treatment, SML-5 would comply. |
| SDWA-MCLGs (40 CFR 141.50-141.51) | Relevant and Appropriate | MCLGs are health-based criteria. As promulgated under SARA, MCLGs are to be considered for drinking water sources. MCLGs are available for several organic and inorganic contaminants. | SML-5 would not comply in the short term. In the long term, once aquifer quality is restored through groundwater extraction and treatment, SML-5 would comply. |

# TABLE E-4A
# ALTERNATIVE SML-5: GROUNDWATER EXTRACTION AND TREATMENT
# CHEMICAL-SPECIFIC ARARs and TBCs

## FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Action to be Taken to Attain Requirements |
|---|---|---|---|
| | | **Groundwater/Surface Water (continued)** | |
| **Federal Regulatory Requirements** | | | |
| USEPA RfDs | To be considered | Guidance values used to evaluate the potential non-carcinogenic hazard caused by exposure to contaminants. | USEPA RfDs were used in the HHRA to characterize risks due to noncarcinogens in various media. |
| USEPA Carcinogen Assessment Group CSFs | To be considered | Guidance values used to evaluate the potential carcinogenic risk caused by exposure to contaminants. | USEPA CFS were used in the HHRA to compute the individual incremental cancer risk resulting from exposure to carcinogenic compounds. |
| **State Regulatory Requirements** | | | |
| Maine Standards for Hazardous Waste Facilities, Misc. Units (06-096 CMR Chapter 854, Section 8) | Relevant and Appropriate | A hazardous waste landfill unit must be closed in a manner that provides protection to groundwater or surface water from hazardous waste above Maximum Exposure Guidelines (MEGs). | SML-1 does not comply with ARARs |
| Department of Human Services (10-144 CMR Chapters 231-233) | Relevant and Appropriate | Maine's Primary Drinking Water Standards are equivalent to federal MCLs. When state levels are more stringent than federal levels, the state levels will be used. | SML-1 does not comply with ARARs |

# TABLE E-4A
## ALTERNATIVE SML-5: GROUNDWATER EXTRACTION AND TREATMENT
## CHEMICAL-SPECIFIC ARARs and TBCs

## FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Action to be Taken to Attain Requirements |
|---|---|---|---|
| | | **Groundwater/Surface Water (continued)** | |
| **State Regulatory Requirements** | | | |
| Maine Regulations Relating to Surface Water Toxic Control Program (38 M.R.S.A. Section 420, Chapter 530.5) | Applicable | This rule limits the concentrations of certain materials allowed in Maine waters to prevent the occurrence of pollutants in toxic amounts as required by state and federal law. Except if naturally occurring, ambient levels of toxic pollutants shall not exceed the Clean Water Act AWQC. Where AWQC do not exist, the Board of Environmental Protection shall adopt site-specific numerical criteria. | SML-5 may not comply with all AWQC criteria at all locations along Sandy Brook in the short-term. In the long-term, once aquifer quality is restored through natural attenuation, SML-5 would comply. |

NOTES:
ARAR=Applicable or Relevant and Appropriate Reqmts
AWQC=Ambient Water Quality Criteria
CAGCarcinogen Assessment Group
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NAAQS = National Ambient Air Quality Standards
NCP = National Contingency Plan
RfD = Reference dose mg/kg - milligrams per kilograms
SDWA= Safe Drinking Water Act
TBC=To be considered
USEPA=U.S. Environmental Protection Agency

# TABLE E-4B
## ALTERNATIVE SML-5: GROUNDWATER EXTRACTION AND TREATMENT
## LOCATION-SPECIFIC ARARs and TBCs

## FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| | | **Wetlands/Floodplains** | |
| **Federal Regulatory Requirements** | | | |
| National Environmental Policy Act Wetland Executive Order (EO11990), 40 CFR 6.302(a) and 40 CFR Part 6, Appendix A | Applicable | The Wetlands Executive Order requires federal agencies to minimize the destruction, loss, or degradation of wetlands, and preserve and enhance natural and beneficial values of wetlands. | Measures will be taken under SML-5 to avoid disturbing the onsite wetlands. However, wetlands may be unavoidably affected. This requirement will nonetheless be attained because there is no practicable alternative with less adverse impact and all practicable measures will be taken to minimize and mitigate adverse impacts. |
| National Environmental Policy Act Floodplains Executive Order (EO11988), 40 CFR Part 6, Appendix A | Applicable | The Floodplains Executive Order requires federal agencies to reduce the risk of flood loss, to minimize the impact of floods, and to restore and preserve the natural and beneficial values of Floodplains. | Measures will be taken under SML-5 to avoid construction activities within the flood plan. However, flood plan disturbance may be unavoidably affected. This requirement will nonetheless be attained because there is no practicable alternative with less adverse impact and all practicable measures will be taken to minimize and mitigate adverse impacts. |
| Clean Water Act Section 404 Requirements for discharge of dredged and fill materials (33 USC 1344, 40 CFR 230) | Applicable | Section 404 of the CWA regulates the discharge of dredged fill material into U.S. waters, including wetlands. The purpose of Section 404 is to ensure that proposed discharges are evaluated with respect to impact on the aquatic ecosystem. The guidelines prohibit the discharge of dredge or fill material is a practicable alternative with less impact to the aquatic system. Discharge is also prohibited unless steps are | Measures will be taken under SML-5 to avoid excavation or dredging of Sandy Brook. However, these activities may be unavoidably affected. This requirement will nonetheless be attained because there is no practicable alternative with less adverse impact and all practicable measures will be taken to minimize and mitigate adverse impacts. |

# TABLE E-4B
## ALTERNATIVE SML-5: GROUNDWATER EXTRACTION AND TREATMENT
## LOCATION-SPECIFIC ARARs and TBCs

## FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| **Federal Regulatory Requirements** | | | |
| Fish and Wildlife Coordination Act (16 U.S.C. 661); 40 CFR 6.302 | Applicable | This act requires that any federal agency proposing to modify a body of water must consult with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and other related State agencies. | Wetland disturbance under SML –5 will be avoided; however, if required, wetlands may be disturbed with the concurrence of the U.S. Fish and Wildlife Service and appropriate State agencies. |
| RCRA Location Standards (40 CFR 264.18) | Relevant and Appropriate | A facility located in 100-year Floodplain must be designed, constructed, operated, and maintained to prevent washout of any hazardous wastes by a 100-year flood. | The landfill cap was designed to meet RCRA requirements, including to prevent washout of hazardous substances during a 100-year flood. |
| **State Regulatory Requirements** | | | |
| Maine Wetlands Protection Rule (06-096 CMR Chapter 310, Section 1) | Applicable | This act outlines requirements and performance standards for certain activities adjacent to any freshwater wetland greater than 10 acres or with an associated stream, pond, or brook. The activities must not unreasonably interfere with certain natural features, such as natural flow or quality of any waters, nor harm significant aquatic habitat, freshwater fisheries, or other aquatic life. | Stormwater and erosion controls will be incorporated into any remedial design to minimize the impacts of construction on the natural resources of Sandy Brook. |

# TABLE E-4B
## ALTERNATIVE SML-5: GROUNDWATER EXTRACTION AND TREATMENT
## LOCATION-SPECIFIC ARARs and TBCs

## FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| **State Regulatory Requirements** | | | |
| Maine Natural Resource Protection Act, Permit by Rule Standards (06-096 CMR, Chapter 305) | Applicable | This rule outlines prescribed standards for specific activities that may take place in or adjacent to wetlands and water bodies. The standards are designed to ensure that disturbed soil material is stablized to prevent erosion and filtration of water. | Stormwater and erosion controls will be incorporated into any remedial design to minimize the impacts of construction on the natural resources of Sandy Brook. |
| Maine Natural Resources Protection Act (38 M.R.S.A.; Section 480-A through S) | Applicable | A permit application must be submitted and approved by the Maine Bureau of Land Quality Control and Section 480-D performance standards met when conducting activities adjacent to any freshwater wetland greater than 10 acres or with an associated stream, brook, or pond. | Measures will be taken under SML-5 to avoid excavation or dredging of Sandy Brook; however, these activities may be unavoidable. This requirement will nonetheless be attained because there is no practicable alternative with less adverse impact and all practicable measures will be taken to minimize and mitigate adverse impacts as required by this standard. |
| Maine Standards for Classification of Major River Basins and Minor Drainages (38 M.R.S.A., Chapter 3, Sections 465, 467, and 468) | Applicable | Sandy Brook is classified as a Class B water under the state water quality standards. Class B waters are defined as suitable for drinking water (after treatment), fishing, recreation in and on the water, and as a habitat for fish and other aquatic life. | Measures will be taken under SML-5 to avoid excavation or dredging of Sandy Brook; however, these activities may be unavoidable. This requirement will nonetheless be attained because there is no practicable alternative with less adverse impact and all practicable measures will be taken to minimize and mitigate adverse impacts as required by this standard. |

# TABLE E-4B
# ALTERNATIVE SML-5: GROUNDWATER EXTRACTION AND TREATMENT
# LOCATION-SPECIFIC ARARs and TBCs

## FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| | | **Other Natural Resources** | |
| **Federal Regulatory Requirements** | | | |
| Endangered Species Act (16 USC 1531 et seq.; 40 CFR 6.302(h) | Relevant and Appropriate | This statute requires that federal agencies avoid activities that jeopardize threatened or endangered species or adversely modify habitats essential to their survival. Mitigation measures should be considered if a listed species or habitat may be jeopardized. | No endangered or threatened species have been documented in the site area. |
| **State Regulatory Requirements** | | | |
| Maine Site Location and Development Law and Regulations (38 M.R.S.A. Sections 481 through 490; MEDEP Regs. Chapters 371-377) | Relevant and Appropriate | This act and regulations govern new development, including those that handle hazardous wastes and oil. Activities cannot adversely affect existing uses, scenic character, or natural resources in the municipality or neighboring municipality. | Measures will be taken under SML-5 to avoid excavation or dredging of Sandy Brook. However, these activities may be unavoidably affected. This requirement will nonetheless be attained because there is no practicable alternative with less adverse impact and all practicable measures will be taken to minimize and mitigate adverse impacts as required by this standard. |
| Maine Standards for Classification of Groundwater (38 M.R.S.A., Sections 465-C and 470) | Applicable | This law requires the classification of the state's groundwater to protect, conserve, and maintain groundwater resources in the interest of the health, safety, and general welfare of the people of the state. | SML-5 would not comply in the short term. In the long term, once aquifer quality is restored through natural attenuation, SML-5 would comply. |

# TABLE E-4B
## ALTERNATIVE SML-5: GROUNDWATER EXTRACTION AND TREATMENT
## LOCATION-SPECIFIC ARARs and TBCs

## FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| **State Regulatory Requirements** | | | |
| Maine Endangered Species Act and Regulations (12 MRSA Section 7751-7756;09-137 CMR 008) | Applicable | The State of Maine has authority to research, list, and protect any species deemed endangered or threatened as listed in the state regulations. The Maine Department of Inland Fisheries and Wildlife has also developed the following administrative categories for species not considered endangered or threatened but considered important for research and further evaluation: Maine Watch List, Special Concern List, and Indeterminate Category. The Department determines appropriate use(s) of various habitats on a case-by-case- basis. The Maine lists may differ from the federal lists of endangered species. | No endangered or threatened species have been identified in the site area. |
| Town Shoreland Zoning Ordinances and State Minimum Guidelines | To be considered | These minimum guidelines and town ordinances apply to activities proposed within 200 feet of a high-water mark of a stream or other body of water. | These guidelines will be considered in the siting of treatment facilities during the development and evaluation of remedial alternatives. |
| Maine Critical Areas Program and Maine Natural Heritage Program | To be considered | These state programs issue policies and regulations governing special habitats or communities. | Where such special areas exist, these state programs will become involved in the project and/or permit review process. |

# TABLE E-4B
## ALTERNATIVE SML-5: GROUNDWATER EXTRACTION AND TREATMENT
## LOCATION-SPECIFIC ARARs and TBCs

## FEASIBILITY STUDY
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Summary of Requirement | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| **State Regulatory Requirements** | | | |
| Maine Critical Areas Act (5 M.R.S.A. 3310 through 3316) | To be considered | This nonregulatory legislation allows Maine agencies such as the Critical Areas Program and the Natural Heritage Areas Program to identify, research, and protect critical areas and endangered or threatened plants. | Where such special areas exist, these state programs will become involved in the project and/or permit review process. |

Notes:
ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
CMR = Code of Maine Regulations
CWA = Clean Water Act
MEDEP = Maine Department of Environmental Protection
M.R.S.A. = Maine Revised Statues Annotated
RCRA = Resource Conservation and Recovery Act
TBC = To be considered
USC = U.S. Code
mg/kg = milligram per kilogram

# TABLE E-4C
## ALTERNATIVE SML-5: GROUNDWATER EXTRACTION AND TREATMENT POTENTIAL ACTION-SPECIFIC ARARs, AND TBCs

## GROUNDWATER FEASIBILITY STUDY REPORT
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Requirement Synopsis | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| **Federal Regulatory Requirements** | | | |
| CWA NPDES (40 CFR Parts 122, 125) | Relevant and Appropriate | This requirement implements the NPDES program that specifies the applicable effluent standards, monitoring requirements, and standards and special conditions for direct discharge to surface water bodies. | Measures will be taken under SML-5 to meet the direct discharge to surface water requirements as required by CWA NPDES including limitations, monitoring requirements, and best management practices. |
| Clean Air Act - National Primary and Secondary Ambient Air Quality Standards | Relevant and Appropriate | Primary ambient air quality standards define levels of air quality to protect human health. Secondary ambient air quality standards protect public welfare from known or anticipated adverse effects from pollutants. | Measures will be taken under SML-5 to meet the National Ambient Air Quality Standards for invasive or construction activities with the potential of generating significant dust. |
| RCRA Subtitle C – Releases from Solid Waste Management Units (40 CFR, Subpart F – 264.95 and 264.96(a) and (c) (Incorporated by reference into MEDEP Regulations, Chapter 800) | Relevant and Appropriate | These regulations identify specific monitoring requirements applicable to hazardous waste facilities. | The long-term monitoring program conducted in association with this action will meet the substantive requirements of this ARAR. |
| Underground Injection Control Regulations (40 CFR Parts 144,145,146, and 147) | Relevant and Appropriate | These regulations provide regulatory compliance standards for treatment facilities that inject wastes underground. The use of wells to dispose of hazardous waste is prohibited. | Measures will be taken under SML-5 to meet the direct discharge to the subsurface as required by Underground Injection Control Regulations. |

# TABLE E-4C
# ALTERNATIVE SML-5: GROUNDWATER EXTRACTION AND TREATMENT
# POTENTIAL ACTION-SPECIFIC ARARs, AND TBCs

## GROUNDWATER FEASIBILITY STUDY REPORT
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Requirement Synopsis | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| **Federal Regulatory Requirements** | | | |
| CWA - Regulations on Disposal Site Determinations Under the CWA (40 CFR 231) | Relevant and Appropriate | These regulations apply to all existing, proposed, or potential disposal sites for discharges of dredged or fill material into U.S. waters, which include wetlands. | Measures will be taken under SML-5 to avoid impact to Sandy Brook or onsite wetlands by onsite disposal of dredged or fill material. |
| U.S. Army Corps of Engineers Permit Program Regulations (33 CRF 320-330) | Relevant and Appropriate | These regulations prescribed the statutory authorities, and general and special policies and procedures applicable to the review of applications for permits for controlling certain activities in U.S. waters; this includes discharge of dredged or fill material. | Measures will be taken under SML-5 to avoid disturbing the onsite wetlands. However, wetlands may be unavoidably affected. This requirement will nonetheless be attained because there is no practicable alternative with less adverse impact and all practicable measures will be taken to minimize and mitigate adverse impacts. |
| CWA - Permits for Dredged and Fill Material (Section 404) | Relevant and Appropriate | This regulation outlines requirements for discharges of dredged or fill material. Under this requirement, no activity that impacts the adjacent wetland shall be permitted if a practicable alternative with less impact on the adjacent wetland is available. If there is no other practicable alternative, impacts must be mitigated. | Measures will be taken under SML-5 to avoid disturbing the onsite wetlands. However, wetlands may be unavoidably affected. This requirement will nonetheless be attained because there is no practicable alternative with less adverse impact and all practicable measures will be taken to minimize and mitigate adverse impacts. |

# TABLE E-4C
# ALTERNATIVE SML-5: GROUNDWATER EXTRACTION AND TREATMENT
# POTENTIAL ACTION-SPECIFIC ARARs, AND TBCs

## GROUNDWATER FEASIBILITY STUDY REPORT
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Requirement Synopsis | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| **Federal Regulatory Requirements** | | | |
| Maine Rules to Control the Subsurface Discharge of Pollutants by Well Injection (06-096 CMR, Chapter 543) | Relevant and Appropriate | This regulation prohibits the injection of hazardous waste into or above water-bearing formations via a new Class IV well. The subsurface discharge into or through a Class IV well that would cause or allow the movement of fluid into an underground source of drinking water that may result in a violation of any Maine Primary Drinking Water Standard, or which may otherwise adversely affect public health, is prohibited. | Measures will be taken under SML-5 to meet the direct discharge to the subsurface as required by the Maine Rules to Control the Subsurface Discharge of Pollutants by Well Injection. |
| MEDEP, Bureau of Water Quality Control, Policy Number 10 "The Discharge of Hazardous Substances to Groundwaters of the State" | Relevant and Appropriate | The Board will deny applications for waste discharge licenses for the discharge to groundwaters of substances designated by the Board to be hazardous when such substances are present in concentrations exceeding groundwater levels which occur naturally in the area. Exemption may be granted if the groundwater is treated to reduce the concentrations of pollutants discharged to below the level considered safe for drinking water. | At least the minimum level of groundwater treatment would be required to provide adequate protection or if no other means of disposal is feasible. |
| Classification of Maine Waters 38 M.R.S.A. Section 464 - 470. | Relevant and Appropriate | This rule prohibits the new discharge to water bodies with a drainage area of less than 10 square miles. | Because Sandy Brook has a drainage area less than 10 square miles, no discharge to this water body will be allowed. |

# TABLE E-4C
## ALTERNATIVE SML-5: GROUNDWATER EXTRACTION AND TREATMENT POTENTIAL ACTION-SPECIFIC ARARs, AND TBCs

## GROUNDWATER FEASIBILITY STUDY REPORT
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Requirement Synopsis | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| **Federal Regulatory Requirements** | | | |
| Erosion and Sedimentation Control (38 M.R.S.A., Chapter 3 Subsec. 420-C), Chapter 500, Stormwater Management Rules | Applicable | Erosion control measures must be in place before activities, such as filling, displacing, or exposing soil or other earthen materials occur. Prior MEDEP approval is needed if the disturbed area is in the direct watershed of a body of water most at risk. | Measures will be taken under SML-5 to control erosion, sedimentation, or stormwater. Applicable plans will be coordinated with the MEDEP prior to implementation. |
| Maine Ambient Air Quality Standards (MEDEP Regulations, Chapter 110) | Relevant and Appropriate | This regulation establishes ambient air quality standards that are maximum levels for a particulate matter permitted in the ambient air. | Measures will be taken under SML-5 to meet the Maine Ambient Air Quality Standards for invasive or construction activities with the potential of generating significant dust. |
| Maine Water Pollution Control Law: Conditions of Licenses (38 M.R.S.A., Chapter 3, Article 2, Section 414-A) | Relevant and Appropriate | Regulates the discharge of any pollutants. Specifies that the discharge, either by itself or in combination with other discharges, will not lower the quality of any classified body of water below such classification. The discharge will be subject to effluent limitations that require application of the best practicable treatment. | Measures will be taken under SML-5 to meet the direct discharge to surface water requirements as required by the Maine Water Pollution Control Law including limitations, monitoring requirements and best management practices. |

# TABLE E-4C
## ALTERNATIVE SML-5: GROUNDWATER EXTRACTION AND TREATMENT POTENTIAL ACTION-SPECIFIC ARARs, AND TBCs

## GROUNDWATER FEASIBILITY STUDY REPORT
## SACO MUNICIPAL LANDFILL
## SACO, MAINE

| Requirement | Status | Requirement Synopsis | Actions to be Taken to Attain Requirements |
|---|---|---|---|
| **Federal Regulatory Requirements** | | | |
| Maine Water Pollution Control Law: Certain Deposits and Discharges Prohibited (38 M.R.S.A., Chapter 3, Article 2, Section 420). | Relevant and Appropriate | No person, firm, corporation, or other legal entity shall place, deposit, discharge, or spill mercury or toxic or hazardous substances, either directly or indirectly, into the inland ground or surface waters, tidal waters, on the ice, or on the banks thereof, so that the same may flow or be washed into such waters, or in such manner that the drainage there from may flow into such waters. | Measures will be taken under SML-5 to prevent discharge of toxic or hazardous substances into groundwater or surface water. |

NOTES:

ARAR = Applicable or Relevant and Appropriate Requirement
CAA = Clean Air Act
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
CFR = Code of Federal Regulations
CWA = Clean Water Act
DA = Department of the Army
DOT = Department of Transportation (U.S.)
lbs/day = pounds per day
LDRs = Land Disposal Restrictions
MCL = Maximum Contaminant Level
MEDEP = Maine Department of Environmental Protection
MEG = Maine Exposure Guidelines
OSHA = Occupational Safety and Health Administration
NPDES = National Pollution Discharge Elimination System
POTW = Publicly Owned Treatment Works
RCRA = Resource Conservation and Recovery Act
ug/m$^3$ = microgram per cubic meter
M.R.S.A.= Maine Revised Statues Annotated

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# APPENDIX F-1

# POST-RI GROUNDWATER SAMPLING RESULTS

Volatile Organic Compounds
Groundwater Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 12/01/1998 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE<br>DATE<br>RESULT TYPE | MW-13<br>12/03/1998<br>Primary | MW-13<br>06/11/1999<br>Primary | MW-13<br>11/15/1999<br>Primary | MW-13<br>11/15/1999<br>Duplicate 1 |
|---|---|---|---|---|---|
| Dichlorodifluoromethane | (ug/L) | <2 | <2 | <2 | <2 |
| Chloromethane | (ug/L) | <2 | <2 | <2 | <2 |
| Vinyl chloride | (ug/L) | <2 | <2 | <2 | <2 |
| Bromomethane | (ug/L) | <2 | <2 | <2 | <2 |
| Chloroethane | (ug/L) | 7 | 7 | 8 | 8 |
| Trichlorofluoromethane | (ug/L) | <2 | <2 | <2 | <2 |
| 1,1-Dichloroethene | (ug/L) | <1 | <1 | <1 | <1 |
| Methylene chloride | (ug/L) | 2B | 9B | 1JB | <1 |
| trans-1,2-Dichloroethene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,1-Dichloroethane | (ug/L) | 26 | 29 | 31 | 32 |
| cis-1,2-Dichloroethene | (ug/L) | <1 | <1 | <1 | <1 |
| 2,2-Dichloropropane | (ug/L) | <1 | <1 | <1 | <1 |
| Bromochloromethane | (ug/L) | <1 | <1 | <1 | <1 |
| Chloroform | (ug/L) | <1 | <1 | <1 | <1 |
| 1,1,1-Trichloroethane | (ug/L) | <1 | <1 | <1 | <1 |
| 1,2-Dichloroethane | (ug/L) | <1 | <1 | <1 | <1 |
| 1,1-Dichloropropene | (ug/L) | <1 | <1 | <1 | <1 |
| Carbon tetrachloride | (ug/L) | <1 | <1 | <1 | <1 |
| Benzene | (ug/L) | 1J | 1 | 1 | 1 |
| 1,2-Dichloropropane | (ug/L) | <1 | <1 | <1 | <1 |
| Trichloroethene | (ug/L) | <1 | <1 | <1 | <1 |
| cis-1,3-Dichloropropene | (ug/L) | <1 | <1 | <1 | <1 |
| Dibromomethane | (ug/L) | <1 | <1 | <1 | <1 |
| Bromodichloromethane | (ug/L) | <1 | <1 | <1 | <1 |
| Toluene | (ug/L) | 1J | 3 | 1 | 1 |
| trans-1,3-Dichloropropene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,1,2-Trichloroethane | (ug/L) | <1 | <1 | <1 | <1 |
| 1,3-Dichloropropane | (ug/L) | <1 | <1 | <1 | <1 |
| Dibromochloromethane | (ug/L) | <1 | <1 | <1 | <1 |
| Tetrachloroethene | (ug/L) | <1 | <1 | <1 | <1 |

J= Estimated B= Detected in laboratory method blank(s) —=Not analyzed
<= Not detected at indicated reporting limit

Volatile Organic Compounds
Groundwater Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 12/01/1998 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE<br>DATE<br>RESULT TYPE | MW-13<br>12/03/1998<br>Primary | MW-13<br>06/11/1999<br>Primary | MW-13<br>11/15/1999<br>Primary | MW-13<br>11/15/1999<br>Duplicate 1 |
|---|---|---|---|---|---|
| 1,2-Dibromoethane | (ug/L) | <1 | <1 | <1 | <1 |
| Chlorobenzene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,1,1,2-Tetrachloroethane | (ug/L) | <1 | <1 | <1 | <1 |
| Ethylbenzene | (ug/L) | <1 | 1J | 1J | 1J |
| m/p-Xylenes | (ug/L) | 2 | 3 | 3 | 3 |
| Bromoform | (ug/L) | <1 | <1 | <1 | <1 |
| o-Xylene | (ug/L) | 2 | 3 | 2 | 2 |
| Styrene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,1,2,2-Tetrachloroethane | (ug/L) | <1 | <1 | <1 | <1 |
| 1,2,3-Trichloropropane | (ug/L) | <1 | <1 | <1 | <1 |
| Isopropylbenzene | (ug/L) | <1 | 1J | 1J | 1J |
| Bromobenzene | (ug/L) | <1 | <1 | <1 | <1 |
| 2-Chlorotoluene | (ug/L) | <1 | <1 | <1 | <1 |
| n-Propylbenzene | (ug/L) | 1J | 1 | 2 | 1 |
| 4-Chlorotoluene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,3,5-Trimethylbenzene | (ug/L) | 4 | 5 | 6 | 6 |
| tert-Butylbenzene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,2,4-Trimethylbenzene | (ug/L) | 12 | 16 | 17 | 17 |
| sec-Butylbenzene | (ug/L) | <1 | 1J | 1J | 1J |
| 1,3-Dichlorobenzene | (ug/L) | <1 | <1 | <1 | <1 |
| 4-Isopropyltoluene | (ug/L) | <1 | 2 | 1J | 1J |
| 1,4-Dichlorobenzene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,2-Dichlorobenzene | (ug/L) | <1 | <1 | <1 | <1 |
| n-Butylbenzene | (ug/L) | 1J | 1J | 1 | 1 |
| 1,2-Dibromo-3-chloropropane | (ug/L) | <1 | <1 | <1 | <1 |
| 1,2,4-Trichlorobenzene | (ug/L) | <1 | <1 | 1 | <1 |
| Naphthalene | (ug/L) | 6 | 8 | 8 | 7 |
| Hexachlorobutadiene | (ug/L) | <1 | <1 | 1J | <1 |
| 1,2,3-Trichlorobenzene | (ug/L) | <1 | <1 | 1 | <1 |

J= Estimated B= Detected in laboratory method blank(s) —=Not analyzed
<= Not detected at indicated reporting limit

Volatile Organic Compounds
Groundwater Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 12/01/1998 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE<br>DATE<br>RESULT TYPE | MW-95-1S<br>12/03/1998<br>Primary | MW-95-1S<br>12/03/1998<br>Duplicate 1 | MW-95-1S<br>06/11/1999<br>Primary | MW-95-1S<br>11/15/1999<br>Primary |
|---|---|---|---|---|---|
| Dichlorodifluoromethane | (ug/L) | <2 | <2 | <2 | <2 |
| Chloromethane | (ug/L) | <2 | <2 | <2 | <2 |
| Vinyl chloride | (ug/L) | <2 | <2 | <2 | <2 |
| Bromomethane | (ug/L) | <2 | <2 | <2 | <2 |
| Chloroethane | (ug/L) | <2 | <2 | <2 | <2 |
| Trichlorofluoromethane | (ug/L) | <2 | <2 | <2 | <2 |
| 1,1-Dichloroethene | (ug/L) | <1 | <1 | <1 | <1 |
| Methylene chloride | (ug/L) | 3B | 3B | 5B | <1 |
| trans-1,2-Dichloroethene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,1-Dichloroethane | (ug/L) | <1 | <1 | <1 | <1 |
| cis-1,2-Dichloroethene | (ug/L) | <1 | <1 | <1 | <1 |
| 2,2-Dichloropropane | (ug/L) | <1 | <1 | <1 | <1 |
| Bromochloromethane | (ug/L) | <1 | <1 | <1 | <1 |
| Chloroform | (ug/L) | <1 | <1 | <1 | <1 |
| 1,1,1-Trichloroethane | (ug/L) | <1 | <1 | <1 | <1 |
| 1,2-Dichloroethane | (ug/L) | <1 | <1 | <1 | <1 |
| 1,1-Dichloropropene | (ug/L) | <1 | <1 | <1 | <1 |
| Carbon tetrachloride | (ug/L) | <1 | <1 | <1 | <1 |
| Benzene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,2-Dichloropropane | (ug/L) | <1 | <1 | <1 | <1 |
| Trichloroethene | (ug/L) | <1 | <1 | <1 | <1 |
| cis-1,3-Dichloropropene | (ug/L) | <1 | <1 | <1 | <1 |
| Dibromomethane | (ug/L) | <1 | <1 | <1 | <1 |
| Bromodichloromethane | (ug/L) | <1 | <1 | <1 | <1 |
| Toluene | (ug/L) | <1 | <1 | <1 | <1 |
| trans-1,3-Dichloropropene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,1,2-Trichloroethane | (ug/L) | <1 | <1 | <1 | <1 |
| 1,3-Dichloropropane | (ug/L) | <1 | <1 | <1 | <1 |
| Dibromochloromethane | (ug/L) | <1 | <1 | <1 | <1 |
| Tetrachloroethene | (ug/L) | <1 | <1 | <1 | <1 |

J= Estimated B= Detected in laboratory method blank(s) —=Not analyzed
<= Not detected at indicated reporting limit

Volatile Organic Compounds
Groundwater Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 12/01/1998 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE<br>DATE<br>RESULT TYPE | MW-95-1S<br>12/03/1998<br>Primary | MW-95-1S<br>12/03/1998<br>Duplicate 1 | MW-95-1S<br>06/11/1999<br>Primary | MW-95-1S<br>11/15/1999<br>Primary |
|---|---|---|---|---|---|
| 1,2-Dibromoethane | (ug/L) | <1 | <1 | <1 | <1 |
| Chlorobenzene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,1,1,2-Tetrachloroethane | (ug/L) | <1 | <1 | <1 | <1 |
| Ethylbenzene | (ug/L) | <1 | <1 | <1 | <1 |
| m/p-Xylenes | (ug/L) | <1 | <1 | <1 | <1 |
| Bromoform | (ug/L) | <1 | <1 | <1 | <1 |
| o-Xylene | (ug/L) | <1 | <1 | <1 | <1 |
| Styrene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,1,2,2-Tetrachloroethane | (ug/L) | <1 | <1 | <1 | <1 |
| 1,2,3-Trichloropropane | (ug/L) | <1 | <1 | <1 | <1 |
| Isopropylbenzene | (ug/L) | <1 | <1 | <1 | <1 |
| Bromobenzene | (ug/L) | <1 | <1 | <1 | <1 |
| 2-Chlorotoluene | (ug/L) | <1 | <1 | <1 | <1 |
| n-Propylbenzene | (ug/L) | <1 | <1 | <1 | <1 |
| 4-Chlorotoluene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,3,5-Trimethylbenzene | (ug/L) | <1 | <1 | <1 | <1 |
| tert-Butylbenzene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,2,4-Trimethylbenzene | (ug/L) | <1 | <1 | <1 | <1 |
| sec-Butylbenzene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,3-Dichlorobenzene | (ug/L) | <1 | <1 | <1 | <1 |
| 4-Isopropyltoluene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,4-Dichlorobenzene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,2-Dichlorobenzene | (ug/L) | <1 | <1 | <1 | <1 |
| n-Butylbenzene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,2-Dibromo-3-chloropropane | (ug/L) | <1 | <1 | <1 | <1 |
| 1,2,4-Trichlorobenzene | (ug/L) | <1 | <1 | <1 | <1 |
| Naphthalene | (ug/L) | <1 | <1 | <1 | <1 |
| Hexachlorobutadiene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,2,3-Trichlorobenzene | (ug/L) | <1 | <1 | <1 | <1 |

J= Estimated B= Detected in laboratory method blank(s) —=Not analyzed
<= Not detected at indicated reporting limit

Volatile Organic Compounds
Groundwater Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 12/01/1998 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE<br>DATE<br>RESULT TYPE | MW-95-4RD<br>12/03/1998<br>Primary | MW-95-4RD<br>06/11/1999<br>Primary | MW-95-4RD<br>06/11/1999<br>Duplicate 1 | MW-95-4RD<br>11/15/1999<br>Primary |
|---|---|---|---|---|---|
| Dichlorodifluoromethane | (ug/L) | <2 | <2 | <2 | <2 |
| Chloromethane | (ug/L) | <2 | <2 | <2 | <2 |
| Vinyl chloride | (ug/L) | <2 | <2 | <2 | <2 |
| Bromomethane | (ug/L) | <2 | <2 | <2 | <2 |
| Chloroethane | (ug/L) | 35 | 34 | 31 | 54 |
| Trichlorofluoromethane | (ug/L) | <2 | <2 | <2 | <2 |
| 1,1-Dichloroethene | (ug/L) | <1 | <1 | <1 | <1 |
| Methylene chloride | (ug/L) | 1B | 7B | 6B | 2B |
| trans-1,2-Dichloroethene | (ug/L) | <1 | <1 | <1 | 1J |
| 1,1-Dichloroethane | (ug/L) | 1J | <1 | <1 | 1J |
| cis-1,2-Dichloroethene | (ug/L) | 1J | <1 | <1 | 1J |
| 2,2-Dichloropropane | (ug/L) | <1 | <1 | <1 | <1 |
| Bromochloromethane | (ug/L) | <1 | <1 | <1 | <1 |
| Chloroform | (ug/L) | <1 | <1 | <1 | <1 |
| 1,1,1-Trichloroethane | (ug/L) | <1 | <1 | <1 | <1 |
| 1,2-Dichloroethane | (ug/L) | <1 | <1 | <1 | 1J |
| 1,1-Dichloropropene | (ug/L) | <1 | <1 | <1 | <1 |
| Carbon tetrachloride | (ug/L) | <1 | <1 | <1 | <1 |
| Benzene | (ug/L) | 12 | 14 | 13 | 15 |
| 1,2-Dichloropropane | (ug/L) | <1 | <1 | <1 | <1 |
| Trichloroethene | (ug/L) | <1 | <1 | <1 | <1 |
| cis-1,3-Dichloropropene | (ug/L) | <1 | <1 | <1 | <1 |
| Dibromomethane | (ug/L) | <1 | <1 | <1 | <1 |
| Bromodichloromethane | (ug/L) | <1 | <1 | <1 | <1 |
| Toluene | (ug/L) | 1J | 1J | 2 | 2 |
| trans-1,3-Dichloropropene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,1,2-Trichloroethane | (ug/L) | <1 | <1 | <1 | <1 |
| 1,3-Dichloropropane | (ug/L) | <1 | <1 | <1 | <1 |
| Dibromochloromethane | (ug/L) | <1 | <1 | <1 | <1 |
| Tetrachloroethene | (ug/L) | <1 | <1 | <1 | <1 |

J= Estimated B= Detected in laboratory method blank(s) —=Not analyzed
<= Not detected at indicated reporting limit

Volatile Organic Compounds
Groundwater Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 12/01/1998 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE<br>DATE<br>RESULT TYPE | MW-95-4RD<br>12/03/1998<br>Primary | MW-95-4RD<br>06/11/1999<br>Primary | MW-95-4RD<br>06/11/1999<br>Duplicate 1 | MW-95-4RD<br>11/15/1999<br>Primary |
|---|---|---|---|---|---|
| 1,2-Dibromoethane | (ug/L) | <1 | <1 | <1 | <1 |
| Chlorobenzene | (ug/L) | 7 | 9 | 9 | 9 |
| 1,1,1,2-Tetrachloroethane | (ug/L) | <1 | <1 | <1 | <1 |
| Ethylbenzene | (ug/L) | 20 | 23 | 23 | 29 |
| m/p-Xylenes | (ug/L) | 11 | 16 | 14 | 18 |
| Bromoform | (ug/L) | <1 | <1 | <1 | <1 |
| o-Xylene | (ug/L) | 4 | 5 | 5 | 11 |
| Styrene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,1,2,2-Tetrachloroethane | (ug/L) | <1 | <1 | <1 | <1 |
| 1,2,3-Trichloropropane | (ug/L) | <1 | <1 | <1 | <1 |
| Isopropylbenzene | (ug/L) | 3 | 4 | 4 | 6 |
| Bromobenzene | (ug/L) | <1 | <1 | <1 | <1 |
| 2-Chlorotoluene | (ug/L) | <1 | <1 | <1 | 1 |
| n-Propylbenzene | (ug/L) | 1 | 2 | 2 | 2 |
| 4-Chlorotoluene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,3,5-Trimethylbenzene | (ug/L) | 3 | 3 | 3 | 5 |
| tert-Butylbenzene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,2,4-Trimethylbenzene | (ug/L) | 6 | 8 | 8 | 15 |
| sec-Butylbenzene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,3-Dichlorobenzene | (ug/L) | <1 | <1 | <1 | <1 |
| 4-Isopropyltoluene | (ug/L) | 1J | 1J | 1 | 1 |
| 1,4-Dichlorobenzene | (ug/L) | 6 | <1 | <1 | 7 |
| 1,2-Dichlorobenzene | (ug/L) | 5 | 5 | 6 | 6 |
| n-Butylbenzene | (ug/L) | 1J | 1J | <1 | 1 |
| 1,2-Dibromo-3-chloropropane | (ug/L) | <1 | <1 | <1 | <1 |
| 1,2,4-Trichlorobenzene | (ug/L) | <1 | <1 | <1 | <1 |
| Naphthalene | (ug/L) | 12 | 14 | 14 | 24 |
| Hexachlorobutadiene | (ug/L) | <1 | <1 | <1 | <1 |
| 1,2,3-Trichlorobenzene | (ug/L) | <1 | <1 | <1 | <1 |

J= Estimated B= Detected in laboratory method blank(s) —=Not analyzed
<= Not detected at indicated reporting limit

Inorganic Analytes (Total)
Groundwater Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE<br>DATE<br>RESULT TYPE | MW-13<br>06/11/1999<br>Primary | MW-13<br>11/15/1999<br>Primary | MW-13<br>11/15/1999<br>Duplicate 1 | MW-93-3<br>06/08/1999<br>Primary | MW-93-3<br>11/16/1999<br>Primary | MW-93-5<br>06/08/1999<br>Primary |
|---|---|---|---|---|---|---|---|
| Arsenic | (mg/l) | 0.038 | 0.038 | 0.039 | <0.008 | <0.005 | 0.103 |
| Iron | (mg/l) | 113. | 92.6 | 94.1 | 0.02 | 0.02 | 42.6 |
| Manganese | (mg/l) | 5.33 | 4.25 | 4.32 | <0.0050 | <0.005 | 7.24 |

J= Estimated
<= Not detected at indicated reporting limit

---=Not analyzed

Inorganic Analytes (Total)
Groundwater Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE<br>DATE<br>RESULT TYPE | MW-93-5<br>11/16/1999<br>Primary | MW-95-11S<br>06/12/1999<br>Primary | MW-95-11S<br>11/18/1999<br>Primary | MW-95-1R<br>06/11/1999<br>Primary | MW-95-1R<br>11/15/1999<br>Primary | MW-95-1S<br>06/11/1999<br>Primary |
|---|---|---|---|---|---|---|---|
| Arsenic | (mg/l) | 0.099 | <0.008 | <0.005 | 0.112 | 0.125 | 0.097 |
| Iron | (mg/l) | 43.4 | 0.54 | 0.79 | 25.7 | 27.9 | 43.3 |
| Manganese | (mg/l) | 6.82 | 0.0165 | 0.0201 | 28.0 | 34.6 | 8.30 |

J= Estimated
<= Not detected at indicated reporting limit

---=Not analyzed

Inorganic Analytes (Total)
Groundwater Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE<br>DATE<br>RESULT TYPE | MW-95-1S<br>11/15/1999<br>Primary | MW-95-3R<br>06/11/1999<br>Primary | MW-95-3R<br>11/15/1999<br>Primary | MW-95-4R<br>06/11/1999<br>Primary | MW-95-4R<br>11/15/1999<br>Primary | MW-95-4RD<br>06/11/1999<br>Primary |
|---|---|---|---|---|---|---|---|
| Arsenic | (mg/l) | 0.078 | 0.571 | 0.6 | 0.413 | 0.427 | 0.470 |
| Iron | (mg/l) | 110 | 89.1 | 88.3 | 39.2 | 33.4 | 39.1 |
| Manganese | (mg/l) | 14.4 | 2.48 | 2.51 | 2.14 | 1.53 | 2.13 |

J= Estimated
<= Not detected at indicated reporting limit

---=Not analyzed

Inorganic Analytes (Total)
Groundwater Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE<br>DATE<br>RESULT TYPE | MW-95-4RD<br>06/11/1999<br>Duplicate 1 | MW-95-4RD<br>11/15/1999<br>Primary | MW-95-4SA<br>06/09/1999<br>Primary | MW-95-4SA<br>11/17/1999<br>Primary | MW-95-4SB<br>06/09/1999<br>Primary | MW-95-4SB<br>11/17/1999<br>Primary |
|---|---|---|---|---|---|---|---|
| Arsenic | (mg/l) | 0.428 | 0.448 | 0.182 | 0.201 | 0.091 | 0.098 |
| Iron | (mg/l) | 35.8 | 34.8 | 52.7 | 58.6 | 25.8 | 23.1 |
| Manganese | (mg/l) | 1.95 | 1.71 | 8.72 | 9.94 | 9.45 | 11.1 |

J= Estimated
<= Not detected at indicated reporting limit

---=Not analyzed

Inorganic Analytes (Total)
Groundwater Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE<br>DATE<br>RESULT TYPE | MW-95-5R<br>06/09/1999<br>Primary | MW-95-5R<br>11/17/1999<br>Primary | MW-95-5R<br>11/17/1999<br>Duplicate 1 | MW-95-6R<br>06/08/1999<br>Primary | MW-95-6R<br>11/16/1999<br>Primary | MW-95-6S<br>06/08/1999<br>Primary |
|---|---|---|---|---|---|---|---|
| Arsenic | (mg/l) | 0.022 | 0.018 | 0.018 | <0.008 | <0.005 | 0.012 |
| Iron | (mg/l) | 0.11 | 0.051 | 0.032 | 0.19 | 0.03 | 4.38 |
| Manganese | (mg/l) | 0.0416 | <0.005 | <0.005 | <0.0050 | <0.005 | 0.188 |

J= Estimated
<= Not detected at indicated reporting limit
---=Not analyzed

Inorganic Analytes (Total)
Groundwater Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE<br>DATE<br>RESULT TYPE | MW-95-6S<br>11/16/1999<br>Primary | MW-95-7R<br>11/16/1999<br>Primary | MW-95-7S<br>06/09/1999<br>Primary | MW-95-7S<br>06/09/1999<br>Duplicate 1 | MW-95-7S<br>11/16/1999<br>Primary | MW-95-7S<br>11/16/1999<br>Duplicate 1 |
|---|---|---|---|---|---|---|---|
| Arsenic | (mg/l) | 0.007J | <0.005 | <0.008 | <0.008 | <0.005 | <0.005 |
| Iron | (mg/l) | 4.51 | 1.75 | 0.05 | 0.05 | 0.1 | 0.1 |
| Manganese | (mg/l) | 0.229 | 0.252 | 0.379 | 0.403 | 0.585 | 0.618 |

J= Estimated
<= Not detected at indicated reporting limit

---=Not analyzed

Inorganic Analytes (Total)
Groundwater Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE | MW-95-8R | MW-95-8R | MW-95-8S | MW-95-8S | MW-95-9S | MW-95-9S |
|---|---|---|---|---|---|---|---|
| | DATE | 06/12/1999 | 11/18/1999 | 06/08/1999 | 11/17/1999 | 06/11/1999 | 11/18/1999 |
| | RESULT TYPE | Primary | Primary | Primary | Primary | Primary | Primary |
| Arsenic | (mg/l) | 0.110 | 0.137 | <0.008 | <0.005 | <0.008 | <0.005 |
| Iron | (mg/l) | 31.8 | 40.6 | 0.12 | 0.558 | 2.82 | 0.64 |
| Manganese | (mg/l) | 13.4 | 12.2 | 0.0063 | 0.0122 | 0.826 | 1.16 |

J= Estimated
<= Not detected at indicated reporting limit
---=Not analyzed

Inorganic Analytes (Total)
Groundwater Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE | MW-96-9R | MW-96-9R | MW-96-9R | MW-97-13R | MW-97-13R | MW-97-13S-1 |
|---|---|---|---|---|---|---|---|
| | DATE | 06/09/1999 | 06/09/1999 | 11/16/1999 | 06/12/1999 | 11/18/1999 | 06/12/1999 |
| | RESULT TYPE | Primary | Duplicate 1 | Primary | Primary | Primary | Primary |
| Arsenic | (mg/l) | 0.209 | 0.207 | 0.2 | 0.021 | 0.03 | 0.959 |
| Iron | (mg/l) | 0.04 | 0.04 | 0.04 | 5.34 | 36 | 82.0 |
| Manganese | (mg/l) | 0.134 | 0.135 | 0.129 | 0.0692 | 1.25 | 1.35 |

J= Estimated
<= Not detected at indicated reporting limit

---=Not analyzed

Inorganic Analytes (Total)
Groundwater Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE<br>DATE<br>RESULT TYPE | MW-97-13S-1<br>11/18/1999<br>Primary | MW-97-13S-2<br>06/12/1999<br>Primary | MW-97-13S-2<br>11/18/1999<br>Primary | MW-97-14S-1<br>06/11/1999<br>Primary | MW-97-14S-1<br>11/17/1999<br>Primary | MW-97-14S-2<br>06/11/1999<br>Primary |
|---|---|---|---|---|---|---|---|
| Arsenic | (mg/l) | 0.907 | 0.850 | 0.666 | 0.163 | 0.242 | 0.122 |
| Iron | (mg/l) | 78.2 | 40.2 | 35.9 | 21.5 | 18.8 | 23.0 |
| Manganese | (mg/l) | 1.17 | 0.463 | 0.422 | 1.30 | 1.73 | 4.07 |

J= Estimated
<= Not detected at indicated reporting limit

---=Not analyzed

Inorganic Analytes (Total)
Groundwater Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE | MW-97-14S-2 | MW-97-16S | MW-97-16S | MW-97-17R | MW-97-17R | MW-97-18S |
|---|---|---|---|---|---|---|---|
| | DATE | 11/17/1999 | 06/09/1999 | 11/16/1999 | 06/12/1999 | 11/18/1999 | 06/09/1999 |
| | RESULT TYPE | Primary | Primary | Primary | Primary | Primary | Primary |
| Arsenic | (mg/l) | 0.186 | <0.008 | <0.005 | <0.008 | <0.005 | <0.008 |
| Iron | (mg/l) | 24.5 | 0.06 | 0.04 | 2.91 | 2.29 | 0.05 |
| Manganese | (mg/l) | 3.26 | 0.0098 | 0.705 | 0.0530 | 0.0285 | 0.0183 |

J= Estimated
<= Not detected at indicated reporting limit

---=Not analyzed

Inorganic Analytes (Total)
Groundwater Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE<br>DATE<br>RESULT TYPE | MW-97-18S<br>11/17/1999<br>Primary | MW-97-19S<br>06/09/1999<br>Primary | MW-97-19S<br>11/17/1999<br>Primary |
|---|---|---|---|---|
| Arsenic | (mg/l) | <0.005 | 0.130 | 0.144 |
| Iron | (mg/l) | <0.025 | 28.7 | 27.2 |
| Manganese | (mg/l) | 0.075 | 9.65 | 8.47 |

J= Estimated
<= Not detected at indicated reporting limit
---=Not analyzed

Inorganic Analytes (Dissolved)
Groundwater Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE<br>DATE | MW-95-7R<br>06/08/1999 |
|---|---|---|
| Arsenic (Dissolved) | (mg/l) | <0.008 |
| Iron (Dissolved) | (mg/l) | 2.69 |
| Manganese (Dissolved) | (mg/l) | 0.158 |

<= Not detected at indicated reporting limit

---=Not analyzed

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# APPENDIX F-2

# POST-RI SURFACE WATER SAMPLING RESULTS

Inorganic Analytes (Total)
Surface Water Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE<br>DATE<br>RESULT TYPE | SW-103<br>11/19/1999<br>Primary | SW-103<br>11/19/1999<br>Duplicate 1 | SW-13<br>06/10/1999<br>Primary | SW-13<br>06/10/1999<br>Duplicate 1 | SW-13<br>11/19/1999<br>Primary | SW-13<br>11/19/1999<br>Duplicate 1 |
|---|---|---|---|---|---|---|---|
| Arsenic | (mg/L) | <0.005 | <0.005 | 0.036 | 0.034 | 0.017 | 0.017 |
| Iron | (mg/L) | 0.599 | 0.630 | 3.98 | 3.85 | 2.01 | 2.01 |
| Manganese | (mg/L) | 0.359 | 0.375 | 1.3 | 1.28 | 0.668 | 0.671 |

J= Estimated
<= Not detected at indicated reporting limit

---=Not analyzed

Inorganic Analytes (Total)
Surface Water Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE<br>DATE<br>RESULT TYPE | SW-15<br>06/10/1999<br>Primary | SW-15<br>11/19/1999<br>Primary | SW-21<br>06/10/1999<br>Primary | SW-21<br>11/19/1999<br>Primary | SW-21B<br>06/10/1999<br>Primary | SW-21MZ<br>06/10/1999<br>Primary |
|---|---|---|---|---|---|---|---|
| Arsenic | (mg/L) | 0.013 | 0.005J | <0.005 | <0.005 | 0.097 | 0.034 |
| Iron | (mg/L) | 1.26 | 0.601 | 0.806 | 0.388 | 10.8 | 4.11 |
| Manganese | (mg/L) | 0.769 | 0.274 | 0.088 | 0.0338 | 2.16 | 0.875 |

J= Estimated
<= Not detected at indicated reporting limit

---=Not analyzed

Inorganic Analytes (Total)
Surface Water Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE | SW-31 | SW-31 | SW-34 | SW-34 | SW-37 | SW-37 |
|---|---|---|---|---|---|---|---|
| | DATE | 06/10/1999 | 11/19/1999 | 06/10/1999 | 11/19/1999 | 06/10/1999 | 11/19/1999 |
| | RESULT TYPE | Primary | Primary | Primary | Primary | Primary | Primary |
| Arsenic | (mg/L) | 0.014 | 0.008 | 0.022 | 0.014 | 0.039 | 0.015 |
| Iron | (mg/L) | 1.35 | 0.827 | 2.45 | 1.76 | 4.99 | 1.89 |
| Manganese | (mg/L) | 0.816 | 0.427 | 1.15 | 0.634 | 1.35 | 0.704 |

J= Estimated
<= Not detected at indicated reporting limit
---=Not analyzed

Inorganic Analytes (Total)
Surface Water Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE | SW-52 | SW-69 | SW-69 | SW-7 | SW-7 | SW-73 |
|---|---|---|---|---|---|---|---|
| | DATE | 11/19/1999 | 06/10/1999 | 11/19/1999 | 06/10/1999 | 11/19/1999 | 11/19/1999 |
| | RESULT TYPE | Primary | Primary | Primary | Primary | Primary | Primary |
| Arsenic | (mg/L) | 0.016 | 0.012 | 0.006J | <0.005 | <0.005 | 0.006J |
| Iron | (mg/L) | 1.90 | 1.1 | 0.684 | 1.32 | 0.366 | 0.652 |
| Manganese | (mg/L) | 0.515 | 0.762 | 0.352 | 1.62 | 0.708 | 0.367 |

J= Estimated
<= Not detected at indicated reporting limit

---=Not analyzed

Inorganic Analytes (Total)
Surface Water Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE | SW-75 | SW-78 | SW-78 | SW-83 | SW-84 | SW-86 |
|---|---|---|---|---|---|---|---|
| | DATE | 06/10/1999 | 06/10/1999 | 06/10/1999 | 06/10/1999 | 11/19/1999 | 06/10/1999 |
| | RESULT TYPE | Primary | Primary | Duplicate 1 | Primary | Primary | Primary |
| Arsenic | (mg/L) | 0.012 | 0.011 | 0.012 | 0.011 | <0.005 | 0.011 |
| Iron | (mg/L) | 1.15 | 1.05 | 1.02 | 1.02 | 0.669 | 1.02 |
| Manganese | (mg/L) | 0.772 | 0.778 | 0.756 | 0.787 | 0.387 | 0.794 |

J= Estimated
<= Not detected at indicated reporting limit

---=Not analyzed

Inorganic Analytes (Total)
Surface Water Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Water

| CONSTITUENT | SITE | SW-9 | SW-9 | SW-93 | SW-98 |
|---|---|---|---|---|---|
| | DATE | 06/10/1999 | 11/19/1999 | 11/19/1999 | 11/19/1999 |
| | RESULT TYPE | Primary | Primary | Primary | Primary |
| Arsenic | (mg/L) | <0.005 | <0.005 | <0.005 | 0.006J |
| Iron | (mg/L) | 0.79 | 0.392 | 0.621 | 0.658 |
| Manganese | (mg/L) | 0.073 | 0.0374 | 0.374 | 0.388 |

J= Estimated
<= Not detected at indicated reporting limit

---=Not analyzed

SUPERFUND RECORDS CTR
SITE: SACOMUNI LF
BREAK: 4.6
OTHER: 6876

# APPENDIX F-3

# POST-RI SEDIMENT SAMPLING RESULTS

Inorganic Analytes
Sediment Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Soil

| CONSTITUENT | SITE | SD-103 | SD-103 | SD-13 | SD-13 | SD-13 | SD-13 |
|---|---|---|---|---|---|---|---|
| | SAMPLE ID | SD-103 | SD-103(DUP) | SD-13 | SD-13 (DUP) | SD-13 | SD-13(DUP) |
| | DATE | 11/19/1999 | 11/19/1999 | 06/10/1999 | 06/10/1999 | 11/19/1999 | 11/19/1999 |
| | DEPTH (ft) | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| | RESULT TYPE | Primary | Duplicate 1 | Primary | Duplicate 1 | Primary | Duplicate 1 |
| Arsenic | (mg/Kg) | 11. | 10. | 38 | 30 | 98.5 | 105. |
| Iron | (mg/Kg) | 14400. | 17800. | 9710 | 10900 | 36200. | 39000. |
| Manganese | (mg/Kg) | 576. | 557. | 122 | 137 | 508. | 551. |

---=Not analyzed

Inorganic Analytes
Sediment Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Soil

| CONSTITUENT | SITE | SD-15 | SD-15 | SD-21 | SD-21 | SD-31 | SD-31 |
|---|---|---|---|---|---|---|---|
| | SAMPLE ID | SD-15 | SD-15 | SD-21 | SD-21 | SD-31 | SD-31 |
| | DATE | 06/10/1999 | 11/19/1999 | 06/10/1999 | 11/19/1999 | 06/10/1999 | 11/19/1999 |
| | DEPTH (ft) | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| | RESULT TYPE | Primary | Primary | Primary | Primary | Primary | Primary |
| Arsenic | (mg/Kg) | 8 | 14.2 | 8 | 6.8 | 78 | 175. |
| Iron | (mg/Kg) | 10400 | 7340. | 9170 | 10300. | 14700 | 30900. |
| Manganese | (mg/Kg) | 163 | 122. | 221 | 162. | 973 | 1420. |

---=Not analyzed

Inorganic Analytes
Sediment Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Soil

| CONSTITUENT | SITE | SD-34 | SD-34 | SD-37 | SD-37 | SD-52 | SD-52 |
|---|---|---|---|---|---|---|---|
| | SAMPLE ID | SD-34 | SD-34 | SD-37 | SD-37 | SD-52 | SD-52 |
| | DATE | 06/10/1999 | 11/19/1999 | 06/10/1999 | 11/19/1999 | 06/10/1999 | 11/19/1999 |
| | DEPTH (ft) | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| | RESULT TYPE | Primary | Primary | Primary | Primary | Primary | Primary |
| Arsenic | (mg/Kg) | 82 | 60.4 | 108 | 57.9 | 56 | 29.8 |
| Iron | (mg/Kg) | 25400 | 9920. | 22400 | 12200. | 16300 | 10400. |
| Manganese | (mg/Kg) | 324 | 109. | 734 | 242. | 417 | 85.1 |

---=Not analyzed

Inorganic Analytes
Sediment Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Soil

| CONSTITUENT | SITE | SD-69 | SD-69 | SD-7 | SD-7 | SD-73 | SD-73 |
|---|---|---|---|---|---|---|---|
| | SAMPLE ID | SD-69 | SD-69 | SD-7 | SD-7 | SD-73 | SD-73 |
| | DATE | 06/10/1999 | 11/19/1999 | 06/10/1999 | 11/19/1999 | 06/10/1999 | 11/19/1999 |
| | DEPTH (ft) | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| | RESULT TYPE | Primary | Primary | Primary | Primary | Primary | Primary |
| Arsenic | (mg/Kg) | 18 | 18.3 | 5 | 1.5 | 19 | 17.3 |
| Iron | (mg/Kg) | 7020 | 6380. | 21600 | 5760. | 9730 | 8130. |
| Manganese | (mg/Kg) | 255 | 338. | 1500 | 255. | 308 | 464. |

---=Not analyzed

Inorganic Analytes
Sediment Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Soil

| CONSTITUENT | SITE | SD-74 | SD-74 | SD-75 | SD-76 | SD-77 | SD-78 |
|---|---|---|---|---|---|---|---|
| | SAMPLE ID | SD-74 | SD-74 (DUP) | SD-75 | SD-76 | SD-77 | SD-78 |
| | DATE | 06/10/1999 | 06/10/1999 | 06/10/1999 | 06/10/1999 | 06/10/1999 | 06/10/1999 |
| | DEPTH (ft) | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| | RESULT TYPE | Primary | Duplicate 1 | Primary | Primary | Primary | Primary |
| Arsenic | (mg/Kg) | 15 | 15 | 10 | 6 | 9 | 22 |
| Iron | (mg/Kg) | 7010 | 6510 | 8790 | 5510 | 6830 | 6400 |
| Manganese | (mg/Kg) | 346 | 327 | 673 | 160 | 502 | 429 |

---=Not analyzed

Inorganic Analytes
Sediment Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Soil

| CONSTITUENT | SITE | SD-79 | SD-80 | SD-81 | SD-82 | SD-83 | SD-84 |
|---|---|---|---|---|---|---|---|
| | SAMPLE ID | SD-79 | SD-80 | SD-81 | SD-82 | SD-83 | SD-84 |
| | DATE | 06/10/1999 | 06/10/1999 | 06/10/1999 | 06/10/1999 | 06/10/1999 | 06/10/1999 |
| | DEPTH (ft) | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| | RESULT TYPE | Primary | Primary | Primary | Primary | Primary | Primary |
| Arsenic | (mg/Kg) | 22 | 12 | 16 | 20 | 19 | 28 |
| Iron | (mg/Kg) | 7080 | 6260 | 5830 | 7240 | 8150 | 7690 |
| Manganese | (mg/Kg) | 412 | 203 | 240 | 528 | 567 | 579 |

---=Not analyzed

Inorganic Analytes
Sediment Samples
Saco Municipal Landfill
Saco, Maine

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: Soil

| CONSTITUENT | SITE | SD-84 | SD-85 | SD-85 | SD-86 | SD-87 | SD-88 |
|---|---|---|---|---|---|---|---|
| | SAMPLE ID | SD-84 | SD-85 | SD-85 | SD-86 | SD-87 | SD-88 |
| | DATE | 11/19/1999 | 06/10/1999 | 06/10/1999 | 06/10/1999 | 06/10/1999 | 06/10/1999 |
| | DEPTH (ft) | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| | RESULT TYPE | Primary | Primary | Duplicate 1 | Primary | Primary | Primary |
| Arsenic | (mg/Kg) | 16.8 | 18 | 17 | 20 | 25 | 23 |
| Iron | (mg/Kg) | 5650. | 5440 | 7690 | 6830 | 6140 | 6860 |
| Manganese | (mg/Kg) | 405. | 287 | 352 | 230 | 652 | 425 |

---=Not analyzed

Inorganic Analytes
Sediment Samples
Saco Municipal Landfill
*Saco, Maine*

PERIOD: From 06/08/1999 thru 11/19/1999 - Selected
SAMPLE TYPE: *Soil*

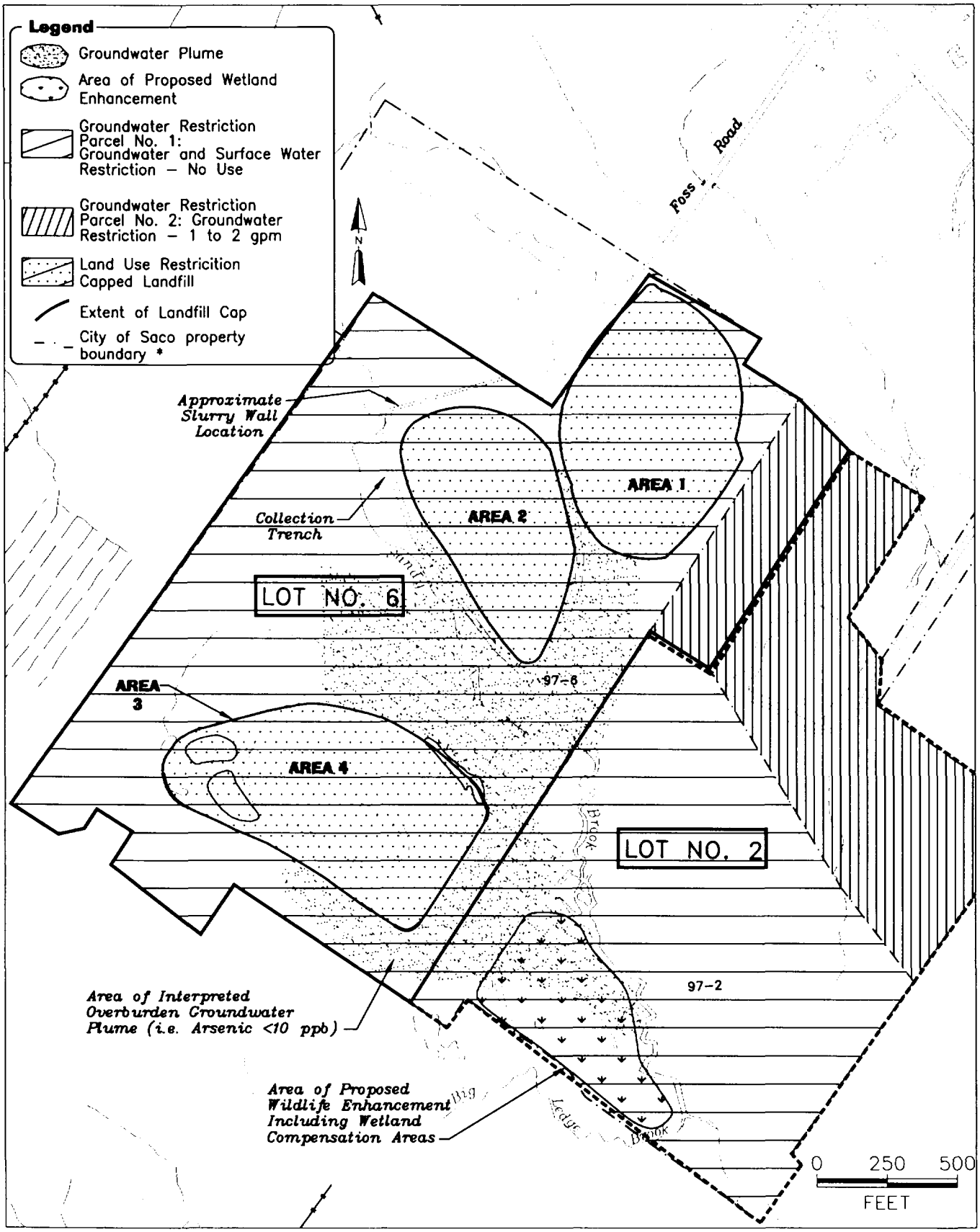
| CONSTITUENT | SITE | SD-9 | SD-9 | SD-93 | SD-98 |
|---|---|---|---|---|---|
| | SAMPLE ID | SD-9 | SD-9 | SD-93 | SD-98 |
| | DATE | 06/10/1999 | 11/19/1999 | 11/19/1999 | 11/19/1999 |
| | DEPTH (ft) | 0.25 | 0.25 | 0.25 | 0.25 |
| | RESULT TYPE | Primary | Primary | Primary | Primary |
| Arsenic | (mg/Kg) | 3 | 3.5 | 14.4 | 12.4 |
| Iron | (mg/Kg) | 6040 | 7950. | 5080. | 5360. |
| Manganese | (mg/Kg) | 277 | 202. | 270. | 262. |

---=Not analyzed

SACOMUNI LF
46
6873

# APPENDIX G

# DESCRIPTION OF INSTITUTIONAL CONTROLS




* Source: City of Saco Property Maps 88 and 97

**Institutional Controls**
**Feasibility Study Report**
**Saco Municipal Landfill**
**Saco, Maine**

WOODARD & CURRAN
Engineering · Science · Operations

3-2.dwg/95093/pff

# PRETI, FLAHERTY, BELIVEAU, PACHIOS & HALEY, LLC

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July 6, 2000


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*Leave of absence
**Admitted to practice law only in the District of Columbia

JOHN J. FLAHERTY
(1929 – 1995)

MEMBER
TERRALEX


**BY COURIER**

Timothy S. Murphy, Esq.
Prescott, LeMoine, Jamieson & Nelson
37 Beach Street
P. O. Box 1190
Saco, ME 04072

**Re: City of Saco – Grant of Environmental Restrictions**

Dear Mr. Murphy:

Enclosed is one (1) execution original of the Grant of Environmental Restrictions and Right of Access to be recorded by you at the request of Rich Roedner. It is my understanding that Rich has already spoken to you regarding this matter.

The covered parcels are contained on page one of the Grant. All are owned by the City of Saco. Should you have any further questions, please do not hesitate to call me at 791-3241. My e-mail address, should you need it, is snewman@preti.com.

After you have recorded the Grant, please forward me a copy of the recorded document with time and date stamp or other evidence of recording, for my records.

Very truly yours,

Sharon G. Newman

Sharon G. Newman

cc: Richard Roedner (with enclosure)

sgn H:\Saco Landfill\Murphy07062000.doc


45 MEMORIAL CIRCLE – P.O. BOX 1058
AUGUSTA, MAINE 04332-1058
TELEPHONE: (207) 623-5300 – TELEFAX: (207) 623-2914

THIRTY FRONT STREET, P.O. BOX 665
BATH, MAINE 04530-0665
TELEPHONE: (207) 443-5576 – TELEFAX: (207) 443-6665

## GRANT OF ENVIRONMENTAL RESTRICTIONS AND RIGHT OF ACCESS

THIS AGREEMENT is made this 21ST day of JUNE 2000 by THE CITY OF SACO, a Maine municipal corporation, in the County of York and the State of Maine (hereinafter referred to as "Grantor") and the Maine Department of Environmental Protection (hereinafter referred to as the "Grantee");

WITNESSETH THAT:

WHEREAS, Grantor is the legal title holder in fee simple of certain real property parcels situated in Saco, County of York, State of Maine, more particularly depicted in Exhibit A and described as follows:

The parcels of land consist of approximately one hundred twenty (120) acres, more or less, on a portion of which the former City of Saco Landfill (the "Landfill") is located, adjacent to Foss Road in Saco, Maine. These parcels are identified on Tax Map 97, lot 6 ("Lot 6"), and Tax Map 97, Lot 2 ("Lot 2") and are depicted on Attachment A hereto. Lots 2 and 6 are hereinafter referred to collectively as the "Property." The capped areas on Lot 6 shall be referred to herein as the "Land Use Restriction Parcel." A portion of Lot 6 and a portion of Lot 2 shall be referred to as "Groundwater Restriction Parcel No. 1." The remainder of Lot 2 and the remainder of Lot 6 shall be referred to as "Groundwater Restriction Parcel No. 2." Groundwater Restriction Parcel No. 1 and Groundwater Restriction Parcel No. 2 shall be collectively referred to as the "Groundwater Restriction Parcels."

Lots 2 and 6 are described in the deeds to the City as follows:

a. Lot 2: The City acquired Lot 2 through an automatic tax lien foreclosure against Claude P. Dubois and Claire M. Dubois in May, 1993. Title was conveyed to Claude P. Dubois and Claire M. Dubois in a quitclaim deed, with covenant, from Donald R. Abbott and Irene Y. Abbott, dated May 11, 1985, and recorded in the York County Registry of Deeds at Book 3510, Page 182.

b. Lot 6: The City acquired Lot 6 from Clayton P. King, Sr. and Pearl D. King, in a warranty deed dated May 18, 1963 and recorded in the York County Registry of Deeds at Book 1521, Page 77; from Carol and Lawrence Patterson in a warranty deed dated February 24, 1998, and recorded in the York County Registry of Deeds at Book 8686, Page 324; and from Catherine R. Cousens and Maynard J. Cousens, in a warranty deed, dated March 9, 2000 and recorded in the York County Registry of Deeds at Book 9929, Page 168.

WHEREAS, the Land Use Restrictions Parcel and the Groundwater Restriction Parcels include the Saco Municipal Landfill Superfund Site (the "Site"). The Site consists of a solid

waste landfill and the surrounding areas impacted or potentially impacted by the release of hazardous substances, pollutants or contaminants from the Landfill. The Site is the subject of a response action by the United States Environmental Protection Agency ("EPA"), a duly constituted agency organized under the laws of the United States of America, pursuant to the Comprehensive Environmental Response, Compensation and Liability Act ("CERCLA"), as amended, 42 U. S.C. § 9601 et seq. and the National Contingency Plan ("NCP"), 40 C.F.R. 300.400 et seq. and the Maine Department of Environmental Protection, a duly constituted agency organized under the laws of the State of Maine.

WHEREAS, pursuant to Section 105 of CERCLA, 42 U.S.C. § 9605, EPA placed the Site on the National Priorities List, set forth at 40 C.F.R. Part 300, on February 21, 1990 (55 Fed. Reg. 6154).

WHEREAS, in an Action Memorandum dated September 23, 1996, the EPA Regional Administrator selected a non-time critical removal action (the "NTCRA" or "Removal Action") for the Site.

WHEREAS, under the terms of an Administrative Order by Consent for Removal Action, U.S. EPA Region I CERCLA Docket No. CERCLA-I-97-1009 (the "Removal Action AOC"), the Grantor and the other PRPs have agreed to fund and/or perform the Removal Action identified in the Action Memorandum in order to protect the public health and welfare and the environment from the actual or threatened release of hazardous wastes or hazardous substances at or from the Site. Under the terms of the Removal Action AOC, Grantor, and the other PRPs have agreed to fund, design, construct and/or perform, among other obligations, the following:

a. the design and construction of a multi-layer, low hydraulic conductivity, cap over Areas 3 and 4 of the landfill and maintenance of the existing cap on Areas 1 and 2 of the landfill;

b. the excavation of contaminated soils and sediments having an arsenic concentration above 19 mg/kg from a groundwater seep at the Site;

c. long-term monitoring of the groundwater, surface water, and sediments;

d. Post-Removal Site Control;

e. implementation of institutional controls, including deed restrictions and/or other controls to prohibit the future use of the Site in any manner that would compromise the integrity of the cap and its related systems.

A copy of the Removal Action AOC is available from:

Office of Environmental Stewardship
United States Environmental Protection Agency
1 Congress Street, Suite 1100
Boston, MA 02114-2003
Attention: Diane Boudrot (SES)
or
United States Environmental Protection Agency
Waste Management Division Records Center
JFK Federal Building
Boston, MA 02203

WHEREAS, the United States has determined that certain easements, rights, obligations, covenants and restrictions, as more particularly set forth below, are necessary at certain portions of the Site to conduct and maintain the integrity and effectiveness of the Removal Action; and

WHEREAS, the Grantor agrees to grant the aforesaid easements, rights, obligations, covenants, and restrictions, as more particularly set forth below, to the Grantee pursuant to the Removal Action AOC;

NOW, THEREFORE, in consideration of the agreements reached in the Removal Action AOC, Grantor covenants with the Grantee and its assigns, including the EPA, that it has the right to convey the easements, rights, obligations, covenants, and restrictions (hereinafter, collectively referred to as the "Environmental Restrictions) set forth herein; Grantor covenants with the Grantee and its assigns, including the EPA, that Grantor, its executors, administrators, heirs, successors and assigns will warrant and defend the same to the said Grantee and assigns forever against the lawful claims and demands of all persons; and Grantor grants the Environmental Restrictions to Grantee and its assigns, including the EPA, the terms and conditions of which are as follows:

1. Right of Access.

a. In establishing the within Environmental Restrictions, Grantor hereby grants to the Grantee and its assigns, including EPA, a perpetual right of access (i) in, on, upon, through, over and under the Land Use Restriction Parcel described above and (ii) to pass and repass over the Site, on the Land Use Restriction Parcel described above, for the following purposes:

i. Monitoring the Removal Action, including Operation and Maintenance of the Removal Action and any future response action;

ii. Verifying any data or information submitted to the United States and the State;

iii. Conducting investigations relating to the contamination at or near the Site;

iv. Obtaining samples;

v. Monitoring the groundwater, surface water or air;

vi. Assessing the need for, planning, or implementing additional response actions at or near the Site;

vii Inspecting and copying records, operating logs, contracts, or other documents maintained or generated by PRPs or their agents, consistent with Section XVIII of the Removal Action AOC;

viii. Assessing PRPs' compliance with the Removal Action AOC; and

ix. Conducting other investigations and response actions consistent with CERCLA, the NCP, and/or other applicable State or Federal environmental regulations, including, but not limited to, the performance of the Removal Action by the State and/or EPA pursuant to the Removal Action AOC.

b. With respect to the Groundwater Restriction Parcels described above, Grantor hereby grants to the Grantee and its assigns, including EPA, a right of access (i) in, on, upon, through, over and under the Groundwater Restriction Parcels, and (ii) to pass and repass over the Groundwater Restriction Parcels for the following purposes:

i. Monitoring the Removal Action, including Operation and Maintenance of the Removal Action and any future response action;

ii. Verifying any data or information submitted to the United States and the State;

iii. Conducting investigations relating to contamination at or near the Site;

iv. Obtaining samples;

v. Monitoring the groundwater, surface water or air;

vi. Assessing the need for, planning, or implementing additional response actions at or near the Site;

vii. Inspecting and copying records, operating logs, contracts, or other documents maintained or generated by PRPs or their agents, consistent with Section XVIII of the Removal Action AOC;

viii. Assessing PRPs' compliance with the Removal Action AOC; and

ix. Conducting other investigations and response actions consistent with CERCLA, the NCP, and/or other applicable State or Federal environmental regulations, including, but not limited to, the performance of the Removal Action by the State and/or EPA pursuant to the Removal Action AOC.

Grantee's right of access under this Subparagraph, 1.b. shall expire 100 years from EPA approval of the Completion of Removal Action Report under paragraph VII of the Removal Action AOC, or sooner, provided that Grantor has petitioned the Grantee for amendment, modification, or release of this Grant, and such petition is approved by the Grantee, pursuant to Paragraph 13 below. Grantee may require Grantor to substantiate that such amendment, modification, or release is appropriate.

2. Designation of Restricted Areas. The Environmental Restrictions shall apply, as set forth below in Paragraph 3, to:

a. the "Land Use Restriction Parcel," e.g., that section of the land herein restricted which constitutes the capped areas on Lot 6, as identified in Exhibit A, attached hereto; and

b. "Groundwater Restriction Parcel No. 1," e.g., that section of the land, as identified in Exhibit A, comprised of approximately 86 acres of Lot 6 and approximately 48 acres of Lot 2, and separated from Groundwater Restriction Parcel No. 2 by a line defined in Exhibit B, attached hereto.

c. "Groundwater Restriction Parcel No. 2," e.g., that section of the land, as identified in Exhibit A, comprised of those sections of Lot 2 (23 acres) and Lot 6 (5 acres) not included in Groundwater Restriction Parcel No. 1, totaling approximately 28

acres, and separated from Groundwater Restriction Parcel No. 1 by a line defined in Exhibit B, attached hereto.

3. Restricted Uses and Activities. Grantor shall neither perform, nor suffer, allow or cause any other person to perform, any of the following activities or uses in, on upon, through, over or under those portions of the above-listed lots.

a. The Land Use Restriction Parcel. Except pursuant to a plan approved by the Grantee (and by EPA pursuant to the Removal Action AOC), and in accordance with the procedures set forth in subsection 3.d. below, no use shall be made which disturbs the integrity of any of the layers of the cap, or any other structures for maintaining the effectiveness of the Removal Action, whether in place now or put in place in the future. Nor shall any use be made which disturbs or interferes with the function of any necessary system for monitoring these structures. This restriction shall apply, without limitation, to all aspects of the cap and related structures identified in Exhibit A.

b. Groundwater Restriction Parcel No. 1. Except pursuant to a plan approved by the Grantee (and by EPA pursuant to the Removal Action AOC), and in accordance with the procedures set forth in subsection 3.d. below, groundwater and surface water within Groundwater Restriction Parcel No. 1 shall not be used in any manner, including, but not limited to, use as a drinking water supply. No groundwater wells shall be installed within the Groundwater Restriction Parcel except for purposes of groundwater monitoring pursuant to a plan approved by the Grantee and EPA. The restrictions set forth in this Subparagraph 3.b. may be modified pursuant to Paragraph 13 below.

c. Groundwater Restriction Parcel No. 2. Except pursuant to a plan approved by the Grantee (and by EPA pursuant to the Removal Action AOC), and in accordance with the procedures set forth in subsection 3.d. below, groundwater within Groundwater Restriction Parcel No. 2 shall be used at a rate no greater than 1 to 2 gallons per minute. No groundwater wells shall be installed within the Groundwater Restriction Parcel No. 2 except for purposes of groundwater monitoring pursuant to a plan approved by the Grantee and EPA or as provided in the preceding sentence. The restrictions set forth in this Subparagraph 3.c. may be modified pursuant to Paragraph 13 below.

d. The Land Use Restriction Parcel and the Groundwater Restriction Parcels. Except pursuant to a plan approved by the Grantee (and by EPA pursuant to the Removal Action AOC), and in accordance with the procedures set forth in subsection 3.e. below, there shall be no residential development, and no activity or use shall be

conducted which adversely impacts the Removal Action, or any aspect thereof, whether now or in the future, including, without limitation: (1) systems and areas to collect and/or contain groundwater, surface water runoff, or leachate; (2) systems or containment areas to excavate, dewater, store, treat, and/or dispose of soils and sediments; and (3) systems and studies to provide long-term environmental monitoring of on-site groundwater, surface waters, and to ensure the long-term effectiveness of the Removal Action and its protectiveness of human health and the environment. The restrictions set forth in this Subparagraph 3.d. may be modified pursuant to Paragraph 13 below.

e. The restrictions in 3.a. through 3.d. above shall not apply if and only if, for the specific activity planned, Grantor first obtains from the Grantee (and by EPA pursuant to the Removal Action AOC) a written approval to a demonstration by Grantor, that the proposed disturbance: (a) will not increase the potential hazard to public health, safety, or welfare or the environment; or (b) is necessary to reduce a threat to public health, safety or welfare or the environment. The Maine Commissioner of Environmental Protection and EPA's Director, Site Restoration and Remediation Division, shall sign such written approval. This approval shall be recorded by Grantor in the York County Registry of Deeds within twenty-one (21) days of receipt. A certified copy of the same shall be filed with MEDEP and EPA within twenty-one (21) days of the date of its recordation.

4. Reserved Rights of Grantor. Grantor hereby reserves unto itself, its successors, and assigns, all rights and privileges in and to the use of the Land Use Restriction Parcel and the Groundwater Restriction Parcels which are not incompatible with the restrictions, rights and easements granted herein. Any and all non-residential activities, including, without limitation, recreational fields, accessory buildings, and parking areas, not otherwise prohibited by applicable law or this Grant may be conducted upon the Land Use Restriction Parcel and the Groundwater Restriction Parcels without the consent of or notification to Grantee or EPA.

5. Applicability. The Environmental Restrictions established herein shall not apply to any and all activities or uses in, on, upon, through, over or under those portions of the Land Use Restriction Parcel and the Groundwater Restriction Parcels situated within the Site, or any portion thereof, duly authorized or approved by the Grantee pursuant to the Maine Uncontrolled Hazardous Substance Site law, 38 M.R.S.A.§ 1361 et seq. and the Removal Action AOC, and EPA pursuant to CERCLA and the Removal Action AOC, including, without limitation, all response actions authorized or approved by the State and/or EPA for the Site.

6. Emergency Excavation. In the event it becomes necessary to excavate a portion of the Land Use Restriction Parcel or the Groundwater Restriction Parcels as part of a response to emergency conditions, the activity and use restriction provisions of Paragraph 3 above, which would otherwise restrict such excavation, shall be suspended with respect to such excavation for the duration of such response, provided that Grantor:

   a. orally notifies the MEDEP's Site Manager and EPA's Project Coordinator or, in his or her absence, EPA's Alternate Project Coordinator, or in the event of both of EPA's designated representatives are unavailable, the Director of the Office of Site Remediation and Restoration, EPA Region I, of such emergency as soon as possible but no more than twenty-four (24) hours after having learned thereof, and follows up with a written notice to MEDEP and EPA; and

   b. limits the actual disturbance involved in such excavation to the minimum reasonably necessary to adequately respond to the emergency.

   This provision shall not waive liability for releases of hazardous substances, nor shall this provision excuse compliance with CERCLA or any other applicable federal or state laws and regulations.

7. Severability. If any court or other tribunal determines that any provision of this Grant is invalid or unenforceable, such provision shall be deemed to have been modified automatically to conform to the requirements for validity and enforceability as determined by such court or tribunal. In the event the provision invalidated is of such a nature that it cannot be so modified, the provision shall be deemed deleted from this Grant as though it had never been included herein. In either case, the remaining provisions of this Grant shall remain in full force and effect; provided, however, that the Grantee retains its right to modify this Grant pursuant to Paragraph 13 below.

8. Enforcement. Grantor expressly acknowledges that a violation of the terms of this Grant could result in the following:

   a. Upon a determination by a court of competent jurisdiction, in the issuance of criminal and civil penalties, and/or equitable remedies, including, but not limited to, injunctive relief; such injunctive relief could include, without limitation, the issuance of an order to modify or remove any improvements constructed upon those portions of the Property, situated within the Site in violation of the terms of the within Environmental Restrictions;

   b. In the assessment of penalties and enforcement action by the Grantee or EPA to enforce the terms of the within Environmental Restrictions pursuant to CERCLA

and the NCP, separate from, or in addition to, any penalties applicable by virtue of non-compliance with the Removal Action AOC; and

c. In the assessment by Grantee of all costs and expenses incurred by the State or EPA, in the event of either 6.a. or 6.b. above, including, without limitation, attorneys' fees.

Any action taken by the Grantee, or EPA pursuant to this Section shall be in addition to, but not in lieu of, such rights as EPA and/or the State possess to enforce the terms and conditions of the Administrative Order and the Removal Action AOC, which enforcement rights the State and EPA fully reserve.

9. Provisions to Run With the Land. These Environmental Restrictions set forth rights, liabilities, agreements and obligations upon and subject to which the Property, or any portion thereof, shall be improved, held, used, occupied, leased, sold, hypothecated, encumbered, or conveyed. The rights, liabilities, agreements and obligations herein set forth shall run with the Property, as applicable thereto, and any portion thereof, and shall inure to the benefit of the Grantee and EPA, and their successors and be binding upon Grantor and all parties claiming by, through or under Grantor. The rights hereby granted to the Grantee, and their successors and assigns, include the right of Grantee and EPA, as its agent, to enforce these Environmental Restrictions. Grantor hereby covenants for itself and its executors, administrators, heirs, successors and assigns, to stand seized and hold title to the Property, or any portion thereof, subject to these Environmental Restrictions, provided, however, that a violation of these Environmental Restrictions shall not result in a forfeiture or reversion of Grantor's title to the Property.

10. Grantor Concurrence. Grantor and all parties claiming by, through or under Grantor covenant and agree with the provisions herein set forth and agree for and among themselves and any party claiming by, through or under them, and their respective agents, contractors, sub-contractors and employees, that the Environmental Restrictions herein established shall be adhered to and not violated and that their respective interests in the Property shall be subject to the provisions herein set forth.

11. Incorporation into Deeds, Mortgages, Leases and Instruments of Transfer. Grantor hereby agrees to incorporate this Grant, in full or by reference, into all deeds, easements, mortgages, leases, licenses, occupancy agreements or any other instrument of transfer by which an interest in and/or a right to use the Property, or any portion thereof, is conveyed. Any transfer of the Property, or any portion thereof, shall take place only if the Grantee agrees, as a part of the agreement to purchase or otherwise obtain an interest in the Property, that it will comply with the obligations of the Grantor to provide access and/or

Institutional Controls, as set forth in the Removal Action AOC and this Grant, with respect to such Property.

12. Recordation. Grantor shall record this Grant with the York County Registry of Deeds within ten (10) days of having received the Grantee's written approval of this Grant. The Grantor, within thirty (30) days of the date of recordation, shall mail a certified Registry copy of this Grant to EPA Project Manager and Maine DEP Project Manager.

Grantor shall record any amendment to or release of this Grant, made pursuant to Paragraph 13 below, with the York County Registry of Deeds within thirty (30) days of having received from the Grantee said amendment or release, as agreed to and accepted by, or granted by, the Grantee and mailed to Grantor by certified mail, return receipt requested. Grantor shall file with the Maine DEP's Project Manager and EPA's Project Manager a certified Registry copy of any such amendment or release as recorded within thirty (30) days of its date of recordation.

This Grant shall become effective upon its recordation with the York County Registry of Deeds.

13. Amendment, Modification and Release. This Grant may be amended, modified, or released only by the Grantee, after a reasonable opportunity for review and comment by EPA, in accordance with CERCLA and the NCP, to the extent applicable. Grantor may submit to EPA and the MEDEP Site Manager a proposal for modifying or withdrawing the Environmental Restrictions or a portion thereof. Said proposal shall demonstrate that the Environmental Restrictions contained herein may be modified or withdrawn in whole or in part consistent with the public interest and the public purposes of protecting human health and the environment. The Grantee shall issue a written decision with an explanation of the reasons for the approval, modification, or denial of such petition.

Grantor shall pay any and all recording fees, land transfer taxes and other such transactional costs associated with any such amendment, modification, or release.

14. No Dedication Intended. Nothing herein set forth shall be construed to be a gift or dedication of the Land Use Restriction Parcel or the Groundwater Restriction Parcels to the Grantee, or to the general public for any purpose whatsoever.

15. Rights Reserved. It is expressly agreed that acceptance of this Grant by the Grantee shall not operate to bar, diminish, or in any way affect any legal or equitable right of the State and/or EPA to issue any future order or take response action with respect to the Site or in any way affect any other claim, action, suit, cause of action, or demand which the State and/or EPA may otherwise possess with respect thereto.

16. Filing with Grantee. All copies of instruments and documents to be filed with the MEDEP's and EPA's Project Managers, as required hereunder, shall be delivered to the MEDEP and EPA by any of the following methods: (i) hand delivery; (ii) delivery by overnight mail; or (iii) delivery by certified mail, return receipt requested.

17. Governing Law. It is expressly agreed that the law of the State of Maine is the law governing this Grant and any disputes regarding its contents and interpretation.

18. Dispute Resolution. The dispute resolution procedures of this Paragraph shall be the exclusive mechanism to resolve disputes between the Grantor and Grantee or EPA regarding petitions for amendment, modification and release under Paragraph 13 of this Grant.

    a. Informal Negotiations - Any dispute under this Subparagraph shall in the first instance be the subject of informal negotiations between the parties to the dispute. The period for informal negotiations shall not exceed 30 days from the time the dispute arises, unless it is modified by written agreement of the parties. The dispute shall be considered to have arisen three (3) days from the date of mailing by certified, registered, or express mail by one party to the other parties of a written Notice of Dispute.

    b. Formal Dispute Resolution - In the event that the parties cannot resolve a dispute by informal negotiations under Subparagraph a, above, then the position advanced by the Grantee, after a reasonable opportunity for review and comment by EPA, shall be considered binding unless, within twenty-one (21) days after the conclusion of the informal negotiation period, Grantor invokes the formal dispute resolution procedures by serving on the Grantee, with a copy to EPA, a written Statement of Position on the matter in dispute, including, but not limited to, any factual data, analysis or opinion supporting that position and any supporting documentation relied upon by the Grantor. Within twenty-one (21) days after receipt of Grantor's Statement of Position, the Grantee, after a reasonable opportunity for review and comment by EPA, will serve on Grantor its Statement of Position, including, but not limited to, any factual date, analysis, or opinion supporting that position and supporting documentation relied upon by the Grantee. Formal dispute resolution shall provide for review on the administrative record under applicable principles of administrative law. An administrative record of the dispute shall be maintained by the State and shall contain all Statements of Position, including supporting documentation, submitted pursuant to this Subparagraph. Where appropriate, the State may allow submission of supplemental Statements of Position by themselves or the Grantor. The MEDEP Sites Management Section will issue, after a reasonable opportunity for review

and comment by EPA's Director of the Office of Site Remediation and Restoration, New England Region, a final administrative decision resolving the dispute based on the administrative record. This decision shall be binding upon the Grantor, subject only to the right to seek judicial review pursuant to Subparagraph 18.c. below.

c. Judicial Appeal - Any decision rendered pursuant to Subparagraph 18.b. above and any administrative decision made by the Grantee pursuant to Subparagraph 8.b. shall be reviewable by a Court of competent jurisdiction, provided that a notice of judicial appeal is served by the Grantor on the Grantee, with a copy to the Environmental Protection Agency, and within 10 days of receipt of the final administrative decision of the Grantee. The notice of judicial appeal shall include a description of the matter in dispute, the efforts made by the parties to resolve it, and the relief requested. The Grantee may file within 30 days a response to Grantor's notice of judicial appeal. In proceedings on any dispute governed by this Subparagraph, Grantor shall have the burden of demonstrating that the decision of the MEDEP Director of Sites Management Section is arbitrary and capricious or otherwise not in accordance with law. Judicial review of the decision by the Grantee shall be on the administrative record compiled pursuant to Subparagraph 18.b. above and shall be governed by the Maine Administrative Procedure Act, 5 MRSA Section 8001 et seq.

IN WITNESS WHEREOF, City OF SACO as record title-holder of the above described lands and premises, hereby submits this GRANT OF ENVIRONMENTAL RESTRICTIONS AND RIGHT OF ACCESS, which said Grant shall be recorded in the York County Registry of Deeds.

Dated this 21ST day of JUNE, 2000.

Witness:

Lisa Smith

City of Saco

By: Richard Michaud
Name
Its Duly Authorized Agent

State of
Maine
County of York

On this 21st day of JUNE, 2000 personally appeared RICHARD MICHAUD signer and sealer of the foregoing written conveyance, and acknowledged the same to be his own free act and deed and the free act and deed of the City of Saco.

Before me, Lisa Smith
Notary Public
My Commission Expires: 6/26/02

The Grantee accepts the conveyance of the Environmental Restrictions and Right of Access contained herein.

By:

Martha Kirkpatrick, Commissioner
Department of Environmental Protection

State of Maine
Maine
County of Kennebec

On this 28 day of June, 2000 personally appeared Martha Kirkpatrick signer and sealer of the foregoing written acceptance, and acknowledged the same to be her own free act and deed and the free act and deed of the Maine Department of Environmental Protection.

Before me, Lynn Bangs
Notary Public Lynn Bangs
My Commission Expires: 4/10/04

EXHIBIT A

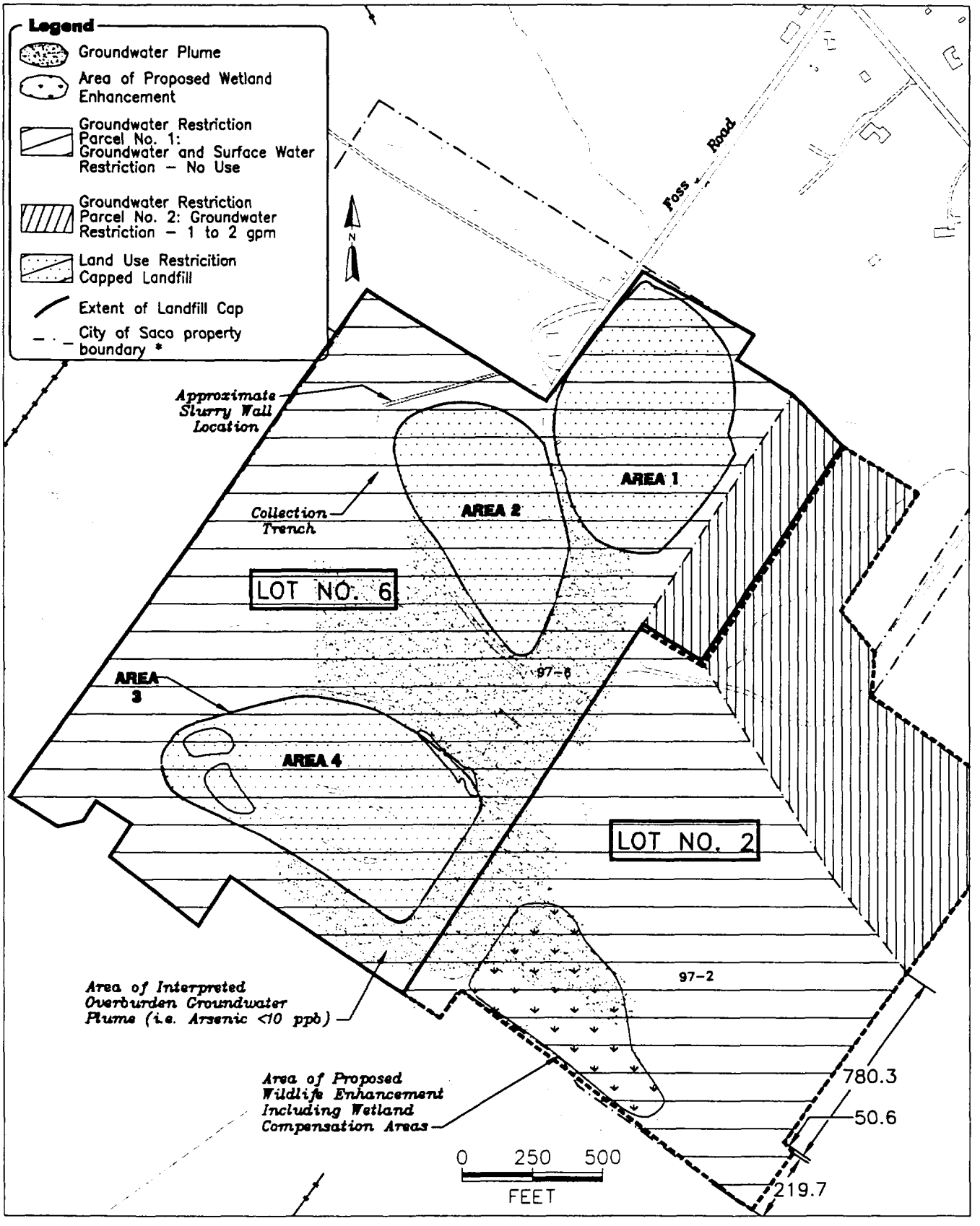


**Figure 3-2**
**Institutional Controls**
**Feasibility Study Report**
**Saco Municipal Landfill**
**Saco, Maine**

* Source: City of Saco Property Maps 88 and 97

WOODARD & CURRAN

3-2.dwg/95083/prf

EXHIBIT B

**Dow & Coulombe, Inc.**
SINCE 1864
LAND SURVEYORS
LAND USE AND PLANNING CONSULTANTS
13 PARK STREET
SACO, MAINE 04072
(207) 284-4521
FAX (207) 284-4522
EMAIL dowcoul@cybertours.com

May 24, 2000

PROPOSED DESCRIPTION OF THE DIVIDING LINE OF THE GROUNDWATER RESTRICTION AREA FOR THE CITY OF SACO
(written without survey from the plans and deeds referenced herein)

Beginning at an old barbed wire fence marking the northwesterly line of land described in a deed from Saco & Biddeford Savings Institution to Laurel Hill Cemetery Association dated April 24, 1950 and recorded in York County Registry of Deeds in Book 1142, Page 475.

Said point of beginning is located as follows:

Beginning at a 16 inch hemlock tree with old wire imbedded at the corner of old barbed wire fences near the southwesterly side of Sandy Brook; said tree and old fences marking the northwesterly side of the third parcel of land described in a deed from Leon E. Fenderson to Leon E. Fenderson et als dated February 26, 1973 and recorded in said Registry in Book 1983, Page 176; said tree also marking the easterly corner of the first parcel of land described in a deed from Leslie D. Patterson to Leslie D. Patterson et als dated March 11, 1977 and recorded in said Registry in Book 2172, Page 147;

Thence, North 52°-44' East, by said Fenderson land and said old fence 219.70 feet to an iron pipe found driven into the ground at another old fence corner;

Thence by said Laurel Hill Cemetery Association land and said old fence by the following six (6) lines;

North 27°-52'West, a distance of 50.6 feet to an iron pipe found driven into the ground at still another old fence corner; (said line is described as North 27°-30'West,-50.7 feet in said association deed);

Thence, North 55°-43'-45" East, a distance of 138.52 feet to a 32 inch pine tree with old fence imbedded;

Thence, North 51°-32'-45" East, a distance of 147.75 feet;

Continued

Thence, North 45°-50'-30" East, a distance of 186.67 feet;

Thence, North 60°-19'-00" East, a distance of 211.89 feet;

Thence, North 53°-40'-45" East, a distance of 95.47 feet to the point of beginning of the dividing line (the course of the last five lines is given as North 53°-35' East, in said association of deed).

Thence, from said point of beginning, North 20°-12'-30" West, across land described in a deed from Maggie May Limited Liability Company to the City of Saco, dated January 31, 2000 and recorded in said Registry in Book 9882, Page 267, a distance of 1394.83 feet to a tall iron pipe found driven into the ground at the southwesterly end of still another old barbed wire fence;

Thence, by land described in a deed from Catherine R. and Maynard J.Cousens to the City of Saco, dated March 9, 2000 and recorded in said Registry in Book 9929, Page 168, by the following seven (7) lines;

North 37°-38'-00" West, a distance of 207.68 feet to a 20" oak tree with old barbed wire fence imbedded;

Thence by land described in a deed from Clayton P. Sr. and Pearl D. King to the City of Saco dated May 18, 1963 and recorded in said Registry in Book 1521, Page 77, and by another old barbed wire fence, by the following six (6) lines;

North 52°-54'-40" East, a distance of 264.89 feet;

Thence, North 51°-57'-30" East, a distance of 130.45 feet;

Thence, North 54°-27'-35" East, a distance of 165.76 feet;

Thence, North 52°-36'-30" East, a distance of 78.01 feet;

Thence, North 52°-06'-10" East, a distance of 206.70 feet;

Thence, North 50°-56'-40" East, a distance of 122.71 feet to the easterly corner of land described in the deed from Clayton P. Sr. and Pearl D. King to the City of Saco,

Continued

dated May 18, 1963 and recorded at said Registry in Book 1521, Page 77, as shown on a "Plan of Property In Saco Maine Made For Saco Solid Waste Disposal Site", dated 1982, made by H.I. & E.C. Jordan.

There were steel spring bars found driven into the ground at the northeasterly ends of the last five above described lines;

The above bearings refer to the 1976 magnetic meridian.

Reference is made to the following named plans on file at Saco Municipal Offices;

1- "Plan of Property in Saco, Maine Made for Saco Solid Waste Disposal Site", by H.I. & E.C. Jordan, dated 1982.

2- "Plan Showing a Standard Boundary Survey Made for Claude P. DuBois", by Dow & Coulombe, Inc., dated February 25, 1985.

Alfred J Coulombe