REMEDIAL INVESTIGATION
APPENDIX F

HUMAN HEALTH RISK ASSESSMENT

SACO MUNICIPAL LANDFILL
SUPERFUND SITE, SACO, MAINE

March 1998

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ATTACHMENTS

Attachment A Analytical Data
Attachment B Risk Calculations
Attachment C Toxicity Profiles

1.0 INTRODUCTION

The Saco Municipal Landfill (SML) Superfund Site is located on Foss Road, York County, Maine (see Figure 1-1). The site is owned by the City of Saco and is approximately 90 acres, of which the four separate landfill areas (Areas 1, 2, 3, and 4) comprise approximately 26 acres of the site. Various portions of the site were operated as a landfill from approximately 1963 until 1988. In 1990, the U.S. Environmental Protection Agency (USEPA) placed the SML on the National Priorities List (NPL). In November of 1995, the City of Saco entered into an Administrative Consent Order with the USEPA and the Maine Department of Environmental Protection (MEDEP) to conduct a Remedial Investigation (RI) for the site. Woodard & Curran (W&C) completed an Engineering Evaluation/Cost Analysis (EE/CA) for Landfill Areas 3 & 4 of the SML in July 1996, and a Technical Memorandum for Area 2 in February 1997.

This Human Health Risk Assessment was conducted as part of the RI to evaluate potential human health risks associated with exposure to residual contamination at the SML. The results of this assessment will be combined with the results of the hydrologic investigation to determine the need for and extent of further remedial actions. This report focuses on the Human Health Evaluation, while the Ecological Evaluation is presented in a separate document.

This human health risk assessment was conducted in accordance with MEDEP and USEPA methodology and guidance, including: "Guidance Manual for Human Health Risk Assessment at Hazardous Waste Sites" (MEDEP, 1994), "Risk Assessment Guidance for Superfund: Volume I Human Health Evaluation" (EPA, 1989a), the "Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors" (USEPA, 1991), and USEPA Region I Waste Management Division Risk Updates. Additional guidance documents cited in the Attachment A Statement of Work to the Order were also used as appropriate. These guidance documents provide the procedures, assumptions, methods and format for conducting risk assessments.

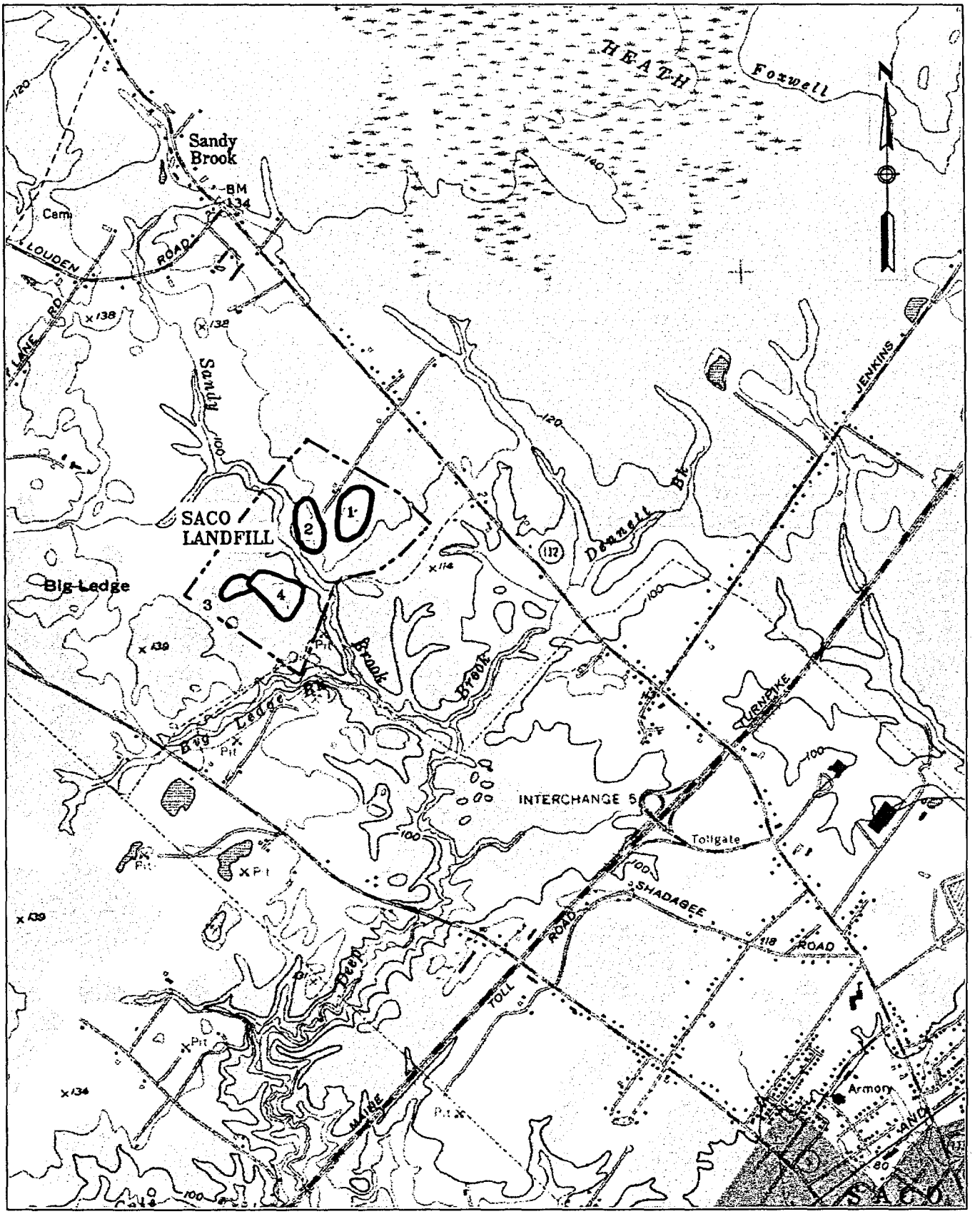

Figure 1–1
Site Location Map
Remedial Investigation Report
Saco Municipal Landfill
Saco, Maine

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fig1-1/95093/ntd

1.1 OBJECTIVES

The objectives of this human health risk assessment are to provide:

- an evaluation of potential human health risks and a basis for determining the need, if any, for remedial action at the SML;

- a basis for determining the appropriate remedial target cleanup levels for contaminants in soils, groundwater, sediments, and/or surface water, as necessary; and

- a basis for comparing the health impacts of various proposed remedial alternatives.

1.2 REPORT ORGANIZATION

This human health risk assessment was based on analytical data collected as part of the ongoing RI at the SML and developed to assist the City of Saco, USEPA and MEDEP in determining what actions, if any, are necessary to reduce risks at this landfill. The risk assessment was not intended to fully characterize site risks or eliminate all uncertainty from the risk analysis process (USEPA, 1989a). A qualitative uncertainty analysis, however, is presented at the end of this report. All analytical data and quantitative risk estimates are presented in attachments at the end of this report. This Risk Assessment is organized as follows:

Section 2.0 Site Characterization (provides a summary of the site background, conceptual model, and areas of concern);

Section 3.0 Hazard Assessment (presents the data, compounds of concern, and exposure point concentrations for each area of concern by medium);

Section 4.0 Exposure Assessment (identifies potential receptors, exposure pathways, and other exposure parameters for each medium);

Section 5.0 Toxicity Assessment (identifies carcinogenic and non-carcinogenic toxicological dose-response values for the compounds of concern);

Section 6.0 Risk Characterization (presents quantitative and qualitative risk estimates for each exposure scenario for each area of concern);

Section 7.0 Uncertainties and Limitations; and

Section 8.0 Summary and Conclusions.

2.0 SITE CHARACTERIZATION

The 90-acre SML Superfund Site is owned by the City of Saco and is located on Foss Road in the northern part of Saco, Maine. The site consists of four distinct waste disposal areas, Areas 1, 2, 3, and 4 (as presented in Figure 2-1), and is bordered by wooded areas in all directions except for an open sand and gravel pit to the southwest. The City currently operates a transfer station and compost area on the northern portion of the site. Private residences are located to the north and east of the site.

The regional groundwater flow direction is from the Heath (located to the northeast of the SML) towards the Saco River (located approximately 2.3 miles to the west and south of the SML). Locally, groundwater flow is generally towards Sandy Brook, which flows from the north to south through the site. Landfill Areas 1 and 2 are located to the east of the brook, while Landfill Areas 3 and 4 are located to the west of the brook.

This risk assessment evaluates potential risks separately for Landfill Area 1, Landfill Area 2, and Landfill Areas 3 & 4 at the SML. Presented below is a brief description of each landfill area, including the background and site conceptual model based on previous investigations, and the areas of concern evaluated in this risk assessment.

2.1 LANDFILL AREA 1

Landfill Area 1 is located to the south of Foss Road and is approximately 10 acres in size. It was the original municipal landfill operating as an open dump beginning in the early 1960s. This area was closed in 1974, regraded, and covered with a clay cap in 1976. An additional 18 inches of compacted clay and six inches of seeded topsoil were placed on the landfill in 1985.

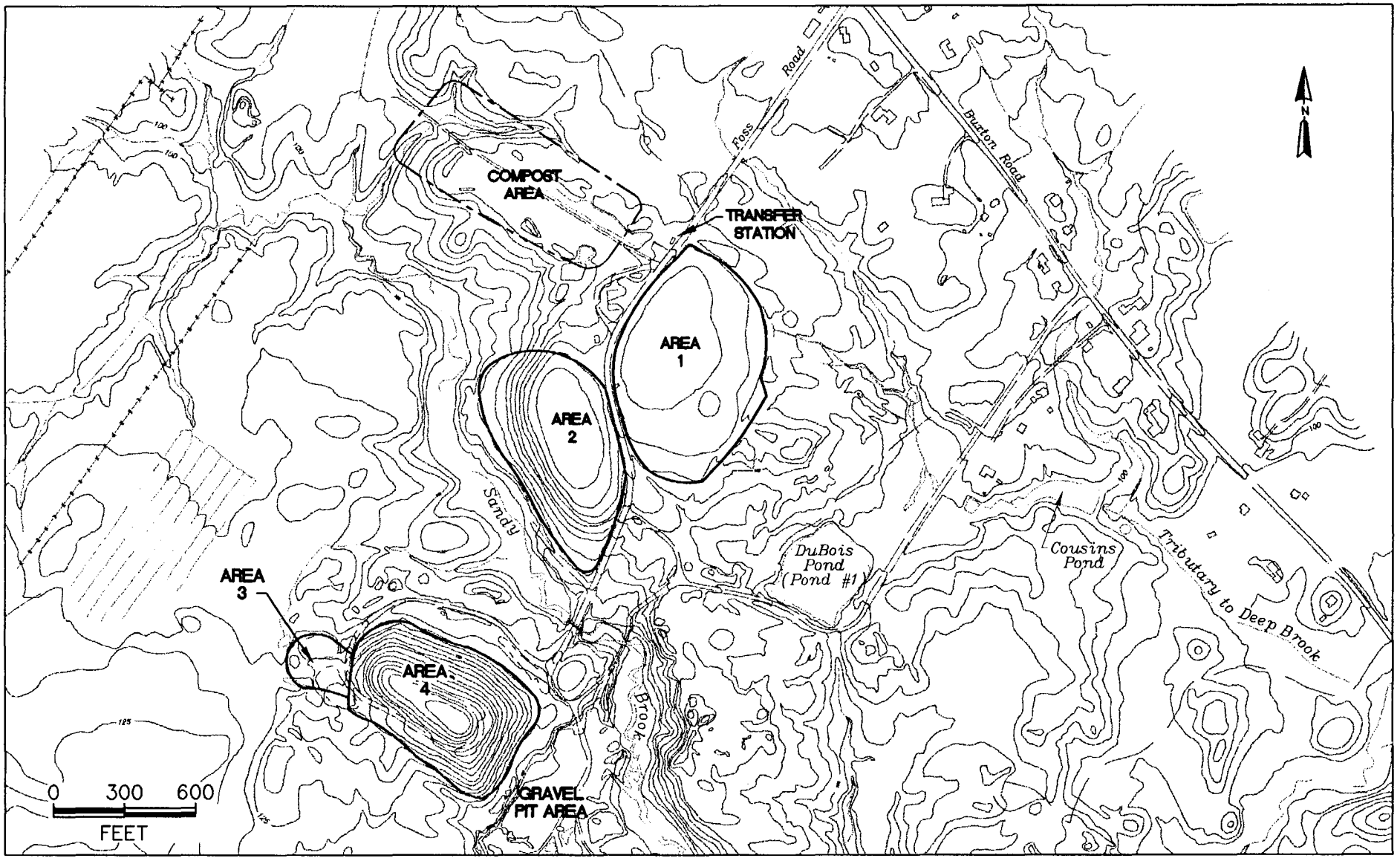

Figure 2-1
Location of Key Site Features
Risk Assessment
Saco Municipal Landfill
Saco, Maine

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A conceptual model for Areas 1 and 2 was developed by W&C based on the culmination of investigations conducted at this site, as referenced in the RI. Portions of Areas 1 and 2 are underlain by a fine sand, which in turn lies over a marine clay. This fine sand, which is several feet thick, represents the water bearing zone for a perched groundwater system. This saturated unit contains so little water that it is not considered an aquifer. Because of its greater permeability relative to the underlying clay (which is greater than 70 feet thick), this uninterrupted, permeable sand layer appears to serve as a conduit through which shallow groundwater flows from potential recharge areas around Area 1 to the interior of Area 2. The direction of groundwater flow from Area 1 is primarily west towards Area 2 and Sandy Brook. A smaller portion of groundwater flow is towards Sandy Brook, and a smaller portion of groundwater flows east and south towards Dubois Pond and Cousins Pond. Deep groundwater below the clay flows from the northeast to southwest.

The three sub-areas of concern associated with Landfill Area 1 include the landfill itself and additional natural features in its vicinity, as presented in Figure 2-2. A brief description of these sub-areas and the media of concern for each is provided below.

1. Landfill Area 1: The landfill itself is capped and exists as an artificial open meadow. Media of concern include surface soils covering the landfill and deep groundwater located downgradient and to the south-southwest of the landfill. Groundwater within the landfill is not a viable drinking water source, because the landfill was closed under the Maine Solid Waste Program. Shallow groundwater is perched in a thin sand layer above the clay, and is not a likely source of drinking water. Groundwater is not a current drinking water source, and the City of Saco is implementing institutional controls to prohibit the future use of groundwater at the entire SML property. However, for conservative purposes of this risk assessment, the deep groundwater downgradient of Areas 1 and 2 was evaluated as a potential drinking water source.

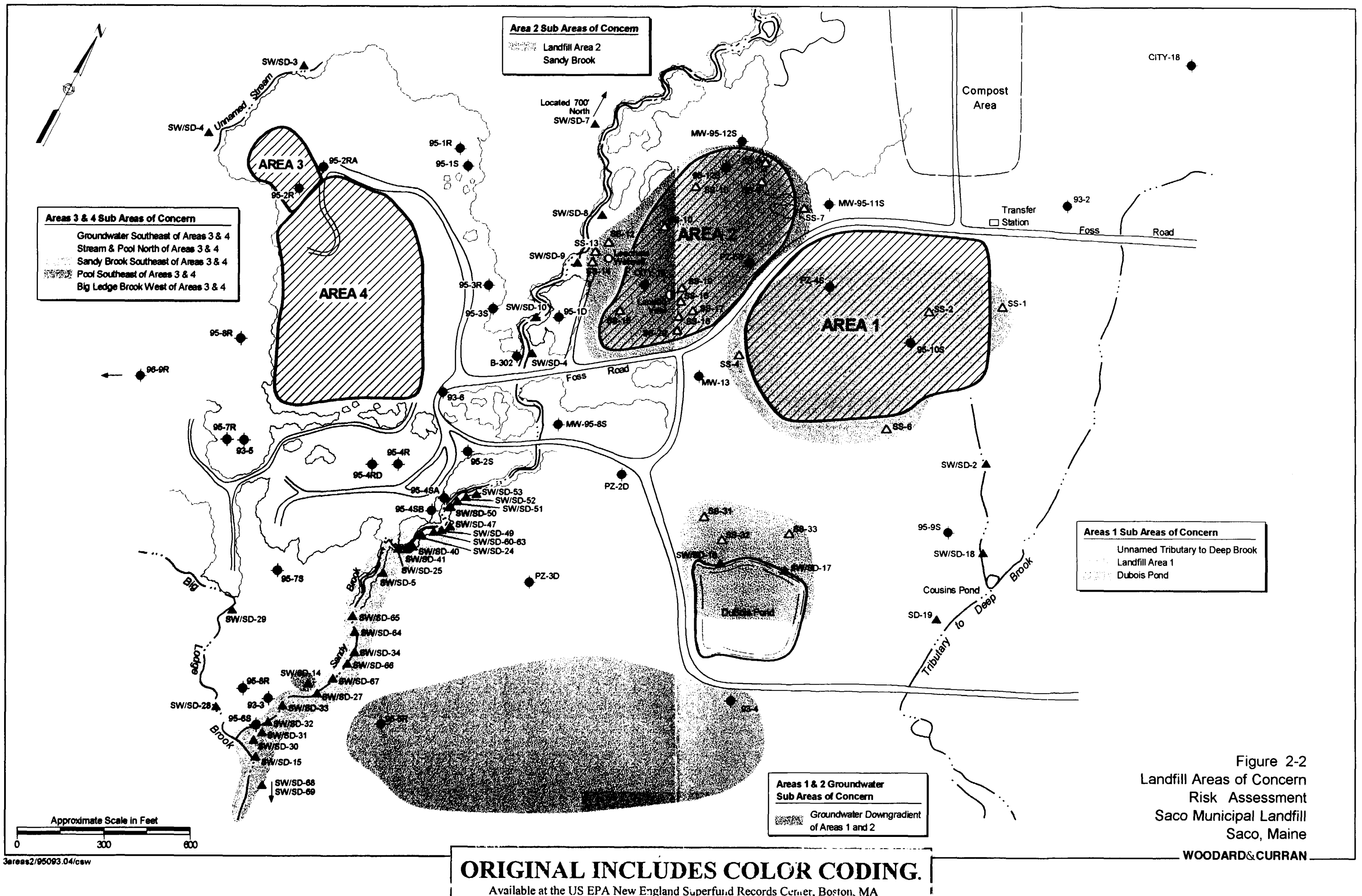

Figure 2-2
Landfill Areas of Concern
Risk Assessment
Saco Municipal Landfill
Saco, Maine

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3areas2/95093.04/csw

ORIGINAL INCLUDES COLOR CODING.
Available at the US EPA New England Superfund Records Center, Boston, MA

2. Unnamed tributary to Deep Brook: An unnamed tributary to Deep Brook is located in a wooded area to the southeast of Area 1. Media of concern include surface water and sediments in this tributary.

3. Dubois Pond: Dubois Pond is located in an open area to the south of Landfill Area 1. Media of concern include surface soils to the north of the pond, and surface water and sediments associated with the pond.

2.2 LANDFILL AREA 2

Landfill Area 2 is approximately 6 acres in size. This landfill area began operation in 1974, accepting industrial waste, brush, and construction demolition debris. This area was closed in 1985 in conformance with the Maine Solid Waste Management Regulations, including the construction of an 18 to 20 inch clay cover with four inches of topsoil, a clay slurry wall along the northern edge of the landfill, and a leachate collection and recirculation system. The slurry wall was constructed on the north side of the landfill based on the belief that shallow groundwater was approaching the landfill from the north. However, rather than being a barrier to groundwater flow, the slurry wall appears to be situated parallel to the groundwater flow direction, where it would have little isolating effect on the landfill interior. Consequently, problems with the leachate collection and recirculation system were encountered during the first year, resulting in leachate reaching Sandy Brook. The leachate is currently being pumped from the wetwell located west of Area 2 and is being discharged to the Saco Wastewater Treatment Plant.

A conceptual model was developed by W&C based on the culmination of investigations conducted at this site, as referenced in the RI. Deep groundwater flows from northeast to southwest. However, shallow groundwater flows from the east (from Area 1) to west (towards Sandy Brook). Groundwater flows in the fine sand layer from Area 1 to the interior of Area 2, passing underneath the eastern edge of the clay cap of Area 2. Within Area 2, this sand layer

disappears along the western slope, exposing the marine clay which serves as the base of the landfill towards the western edge. Once groundwater enters the landfill, it flows down the relatively steep slope of the landfill towards the leachate collection system. The location of the collection trench below the clay base of landfill results in the collection of nearly all the water that reaches it. Because a portion of the trench is located outside the clay cap at the lowest point in the system, groundwater outbreaks historically occurred in this section. Recommendations provided in the W&C Technical Memorandum for Area 2 include modifications to the existing collection and distribution system by pumping the collected groundwater from the wet well system into an iron removal treatment system prior to piping the water to the Area 3 & 4 sedimentation basin. This will prevent the iron-rich water from entering Sandy Brook directly and will enable this groundwater to be reintroduced to the groundwater system after the majority of the iron has oxidized.

Based on the site conceptual model, there are two sub-areas of concern associated with Landfill Area 2, as presented in Figure 2-2. A brief description of these sub-areas and the media of concern for each is provided below.

1. Landfill Area 2: The landfill itself is capped and exists as an artificial open meadow. Media of concern include surface soils covering the landfill and deep groundwater located downgradient and south of the landfill. Groundwater within the landfill is not a viable drinking water source, because the landfill was closed under the Maine Solid Waste Program. Shallow groundwater is perched in a thin sand layer above the clay, and is not a likely source of drinking water. Groundwater is not a current drinking water source, and the City of Saco is implementing institutional controls to prohibit the future use of groundwater at the entire SML property. However, for conservative purposes of this risk assessment, the deep groundwater downgradient of Areas 1 and 2 was evaluated as a potential drinking water source.

2. Sandy Brook: Sandy Brook is located to the west of Area 2 and serves as a discharge point for groundwater and leachate from this area. Media of concern include surface water and sediments in Sandy Brook downgradient of Area 2.

2.3 LANDFILL AREAS 3 & 4

Landfill Areas 3 & 4 are contiguous and total approximately 14 acres, and are located to the west of Sandy Brook.

Landfill Area 3 is located adjacent to the northwestern edge of Area 4. Area 3 was developed in 1985 as a temporary industrial waste area. Removal and offsite disposal of a majority of this material was completed in December 1992 with the approval of MEDEP.

Landfill Area 4 was operated between 1974 and 1989, accepting primarily municipal waste. Waste in this area is currently covered with a layer of soil to promote vegetation; however, the landfill has been closed under CERCLA.

An open sand and gravel pit is located to the south of Area 4. Sandy Brook is located to the east of Areas 3 & 4, while Big Ledge Brook is located to the southwest of Areas 3 & 4. Big Ledge Brook converges with Sandy Brook to the south of the sand and gravel pit. Sandy Brook flows to Deep Brook, which is a tributary to the Saco River (see Figure 1-2).

Based on the site conceptual model developed by W&C (see Section 5.2 of the RI report), the groundwater flow pattern is radially out from Area 4, with minimal flow to the north and with the majority of the groundwater flow to the south-southeast. The groundwater high is at the northwest edge of Area 4, likely caused by a bedrock knob occurring below this area. Precipitation infiltrating through Areas 3 & 4 travels along the interface of the waste and the bedrock. Groundwater flow appears to be within the fractured bedrock surface under Area 4. The bedrock surface drops off steeply to the east-southeast of Area 4, and sand overlies the

bedrock in this area. The groundwater flow direction is primarily to the southeast of Area 4, discharging to seeps and Sandy Brook due to upward flow gradients in this area.

As described in Section 5.2 of the RI, water passing through the waste material results in highly reduced water leaving the bottom of the landfill. The reducing conditions result in the mobilization of naturally occurring metals from the soil and rock underneath the waste. Therefore, leachate and naturally occurring metals that have been mobilized in the subsurface, including arsenic, iron, and manganese, are traveling with groundwater flow downgradient of Area 4 and discharging to sediments and surface water along Sandy Brook. In January 1997, sediments were removed from locations along Sandy Brook with the highest arsenic concentrations. These sediments were placed on Landfill Areas 3 & 4 under the cover system, which was constructed in the summer-fall of 1997. The purpose of the cover system was to cover contaminated surface soils (and excavated sediments) and minimize the migration of contaminants from the landfills to the groundwater by reducing the amount of infiltration.

As a result of Landfill Areas 3 & 4 being closed under CERCLA, there are no media of concern within the footprint of the landfill. Surface soils are isolated under the cover system. Likewise, groundwater is not accessible and is not a future drinking water source due to the presence of the landfill. Groundwater flow to the north of Areas 3 & 4 is minimal, and groundwater to the west of Areas 3 & 4 is not believed to be hydrologically connected to the landfill, as discussed in the RI. The City of Saco is implementing institutional controls to prohibit the future use of groundwater at the SML. Therefore, soils under the cover system and groundwater underneath the landfill and to the north-northeast and west of the landfill were not evaluated in this risk assessment.

Therefore, based on the site conceptual model and for purposes of this risk assessment, there are five sub-areas of concern associated with Landfill Areas 3 & 4, as presented in Figure 2-2. A brief description of these sub-areas and the media of concern for each is provided below.

1. Groundwater South of Areas 3 & 4: Groundwater downgradient and to the south-southeast of Landfill Areas 3 & 4 is not directly accessible. Furthermore, there are no likely future exposures due to the location near the landfill and proposed institutional controls prohibiting future use of groundwater. However, groundwater in this area was evaluated as a potential future drinking water source for conservative purposes of this risk assessment.

2. Stream and pool North of Areas 3 & 4: A stream and pool are located to the north of Areas 3 & 4. Media of concern include surface water and sediments in these locations.

3. Sandy Brook Southeast of Areas 3 & 4: Groundwater from Areas 3 & 4 is discharging to Sandy Brook southeast of the landfill. Media of concern include surface water and sediments in Sandy Brook remaining after the sediment removal action that took place in the winter of 1997.

4. Pool Southeast of Areas 3 & 4: A pool is located to the south of Areas 3 & 4, west of Sandy Brook. Media of concern include surface water and sediments in this location.

5. Big Ledge Brook West of Areas 3 & 4: Big Ledge Brook is located to the southwest of Areas 3 & 4. Media of concern include surface water and sediments in Big Ledge Brook.

3.0 HAZARD ASSESSMENT

The objective of the hazard assessment is to present the analytical data for each area of concern by medium to identify data sets suitable for use in a quantitative risk assessment, and identify contaminants of concern (COCs). The COCs are generally a subset of all contaminants detected in each media, and are selected to focus the risk assessment on those compounds that present the greatest health concern.

The analytical data and COCs are summarized below by medium. All sampling and analysis was conducted in accordance with the Field Sampling Plan and Amendments and the Quality Assurance Project Plan (W&C, 1995). The analytical data for the SML is presented in greater detail in the RI Report, and is summarized in tables A-1 through A-4 provided in Attachment A of this Risk Assessment.

3.1 METHODOLOGY FOR SELECTION OF COCs and EPCs

COCs are generally a subset of all contaminants detected in each medium and are selected based on concentration and frequency of detection, historical use, and comparison of detected concentrations to appropriate health/risk-based federal and state criteria. For conservative purposes, however, all compounds detected at least once at a concentration greater than the instrument detection limit (IDL) or method detection limit (MDL) were retained as COCs, except where noted for groundwater.

Exposure point concentrations (EPCs) were calculated as the maximum detected concentrations for each medium and area of concern for conservative purposes of this risk assessment. To provide a more realistic EPC for soils in Area 2, however, the 95% upper confidence limit of the arithmetic mean was calculated as the EPC for arsenic. A summary of the laboratory analytical data used to select the COCs and EPCs is provided in Tables A-1 through A-4 in Attachment A.

The laboratory data includes flagged results and duplicate sample results. The use of the laboratory data to determine COCs and EPCs is discussed below.

- Laboratory data flagged with "J" indicate that the reported concentrations are estimated values. Most often these flags indicate that the reported result was estimated between the IDL and practical quantitation limit (PQL), but other inconsistencies in sample management and analysis may result in flagged sample results as well. The "J" flagged data were used in the risk assessment at the estimated concentrations.

- Laboratory data flagged with "U" indicate that the contaminant was undetected. The "U" flagged data was considered as "non-detects" in this report.

- Duplicate samples of soil, sediment, surface water, and groundwater were collected to evaluate inherent variability of contaminant distribution and the sampling procedures. Both the sample and duplicate results were considered when identifying the maximum detected concentrations. A chemical was counted as "detected" at a sampling location if it was detected at least once among the sample or duplicate results, or at least once among samples collected over time. The maximum concentrations detected, regardless of whether they represented the sample or duplicate results, were used as the EPCs.

- Some of the compounds detected at the site are common laboratory contaminants and are probably not site-related. These compounds include methylene chloride, acetone, bis(2-ethylhexyl)phthalate, and 2-butanone (methyl ethyl ketone). EPA guidance states that sample results should be considered positive results only if the concentrations in the sample exceed ten times the maximum amount detected in any blank (EPA 1989a). However, although these compounds are probably not site-related, they were not eliminated as COCs for conservative purposes of this risk assessment.

Further consideration was given to the metals data in the selection of the COCs, as described below.

- Metals are naturally occurring chemicals that are usually present at background concentrations. EPA guidance states that inorganic chemicals present at a site at naturally occurring levels may be eliminated from the quantitative risk assessment (EPA 1989a). For conservative purposes of this risk assessment, the inorganic compounds were not eliminated as COCs based on a comparison to background. However, it should be noted that the key chemicals resulting in remedial actions at this site (arsenic, iron, and manganese), are naturally occurring inorganic chemicals. Arsenic, in particular, is naturally occurring in the bedrock at the SML and is believed to be mobilized due to the presence of landfill leachate (see Section 5.0 of the RI report).

- The metals detected at the SML include several chemicals that are essential human nutrients. These chemicals include iron, magnesium, calcium, potassium, and sodium (EPA, 1989a). According to EPA guidance (EPA 1989a), these chemicals may be eliminated from consideration in the quantitative risk assessment if they are present at low concentrations (i.e. only slightly above naturally occurring levels) and if they are toxic at only very high doses. The determination of acceptable dietary levels for essential nutrients is often very difficult. For conservative purposes of this risk assessment, essential nutrients are not eliminated as COCs, but their status as essential human nutrients is noted.

The data, COCs, and EPCs are presented by medium, below.

3.2 SOILS

Surface soils at the SML were considered to be a potential exposure point for site-related contaminants. The COCs in site soils were selected based on the analytical data for samples collected in November 1995.

The soil data is summarized in Table A-1 of Attachment A. The frequency of detection, concentration range, and maximum concentrations of the chemicals detected are presented in Table 1. Each chemical detected at least once was retained as a COC, for conservative purposes. A review of the data and selected COCs for each area of concern is presented below.

3.2.1 Landfill Area 1

Surface soils are a potential exposure point at two areas of concern at Landfill Area 1 (see Figure 2-2).

3.2.1.1 Area 1

Four surface soil samples (soil samples SS-1, SS-2, SS-4, and SS-6) were collected from Landfill Area 1. These samples were analyzed for pesticides/polychlorinated biphenyls (PCBs), semi-volatile organic compounds (SVOCs), volatile organic compounds (VOCs), and metals.

The COCs (all detected chemicals) include three pesticides (maximum concentrations totaling 0.47 ug/kg), eight SVOCs (maximum concentrations totaling 636 ug/kg), 20 VOCs (maximum concentrations totaling 20 ug/kg), and 18 metals, as presented in Table 1.

3.2.1.2 Dubois Pond

Three surface soil samples (soil samples SS-31, SS-32, and SS-33) were collected from the area just north of Dubois Pond. These samples were analyzed for pesticides/PCBs and metals.

The COCs (all detected chemicals) include 17 metals, as presented in Table 1.

TABLE 1
SOIL DATA AND COMPOUNDS OF CONCERN
REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

	LANDFILL AREA 1			DUBOIS POND			LANDFILL AREA 2			LANDFILL AREAS 3 & 4		
COMPOUND	Frequency of Detection	Range	MAX	Frequency of Detection	Range	MAX	Frequency of Detection	Range	MAX	Frequency of Detection	Range	MAX
Pesticides/PCBs, ug/kg												
4,4-DDT	0/4	ND	ND	0/3	ND	ND	1/14	94	**94**	3/10	5.8 - 32	32
4,4-DDD	0/4	ND	ND	0/3	ND	ND	3/14	1 - 24	**24**	4/10	0.13 - 8.6	8.6
4,4-DDE	0/4	ND	ND	0/3	ND	ND	3/14	0.52 - 37	**37**	3/10	1 - 7.8	7.8
Alpha-chlordane	1/4	0.2	**0.2**	0/3	ND	ND	1/14	0.35	**0.35**	3/10	0.25 - 1.5	1.5
Dieldrin	1/4	0.19	**0.19**	0/3	ND	ND	1/14	0.69 - 1.2	**1.2**	1/10	0.16	0.16
Endosulfan II	0/4	ND	ND	0/3	ND	ND	2/14	0.33 - 0.55	**0.55**	0/10	ND	ND
Endrin ketone	0/4	ND	ND	0/3	ND	ND	1/14	0.25	**0.25**	1/10	0.85	0.85
gamma-Chlordane	0/4	ND	ND	0/3	ND	ND	1/14	0.41	**0.41**	3/10	0.25 - 1.3	1.3
Heptachlor epoxide	1/4	0.08	**0.08**	0/3	ND	ND	1/14	0.11	**0.11**	1/10	0.84	0.84
Total Maximum Conc.			*0.47*			*ND*			*157.87*			*53.05*
SVOCs, ug/kg												
2-Methylnaphthalene	0/4	ND	ND	NA	NA	NA	0/14	ND	ND	2/10	26 - 2000	2,000
Acenaphthene	0/4	ND	ND	NA	NA	NA	0/14	ND	ND	2/10	66 - 310	310
Acenaphthylene	0/4	ND	ND	NA	NA	NA	0/14	ND	ND	1/10	26	26
Anthracene	0/4	ND	ND	NA	NA	NA	0/14	ND	ND	4/10	93 - 390	390
Benzo(a)anthracene	0/4	ND	ND	NA	NA	NA	1/14	130	**130**	4/10	430 - 2000	2,000
Benzo(a)pyrene	2/4	28 - 81	**81**	NA	NA	NA	1/14	96	**96**	6/10	45 - 2400	2,400
Benzo(b)fluoranthene	2/4	39 - 110	**110**	NA	NA	NA	1/14	160	**160**	7/10	79 - 2600	2,600
Benzo(k)fluoranthene	1/4	17	**17**	NA	NA	NA	1/14	56	**56**	4/10	32 - 3200	3,200
Benzo(g,h,i)perylene	2/4	19 - 59	**59**	NA	NA	NA	1/14	66	**66**	5/10	40 - 1300	1,300
Bis(2-ethylhexyl)phthalate	0/4	ND	ND	NA	NA	NA	2/14	1500 - 6800	**6800**	2/10	84 - 93	93
Carbazole	0/4	ND	ND	NA	NA	NA	0/14	ND	ND	1/10	73	73
Chrysene	0/4	ND	ND	NA	NA	NA	1/14	140	**140**	5/10	61 - 2300	2,300
Dibenzo(a,h)anthracene	0/4	ND	ND	NA	NA	NA	0/14	ND	ND	4/10	81 - 480	480
Dibenzofuran	0/4	ND	ND	NA	NA	NA	0/14	ND	ND	2/10	44 - 300	300
Di-n-butylphthalate	0/4	ND	ND	NA	NA	NA	0/14	ND	ND	2/10	430 - 430	430
Di-n-octylphthalate	0/4	ND	ND	NA	NA	NA	1/14	82	**82**	0/10	ND	ND
Fluoranthene	1/4	120	**120**	NA	NA	NA	1/14	310	**310**	5/10	98 - 2400	2,400
Fluorene	0/4	ND	ND	NA	NA	NA	0/14	ND	ND	3/10	84 - 690	690
Hexachlorobutadiene	0/4	ND	ND	NA	NA	NA	1/14	1.94	**1.94**	0/10	ND	ND
Indeno(1,2,3-cd)pyrene	1/4	48	**48**	NA	NA	NA	1/14	57	**57**	6/10	33 - 1200	1,200
Naphthalene	0/4	ND	ND	NA	NA	NA	0/14	ND	ND	2/10	49 - 590	590
n-Nitrosodiphenylamine	0/4	ND	ND	NA	NA	NA	0/14	ND	ND	1/10	720	720
Phenanthrene	1/4	61	**61**	NA	NA	NA	1/14	180	**180**	5/10	68 - 1600	1,600
Pyrene	1/4	140	**140**	NA	NA	NA	1/14	250	**250**	5/10	73 - 2800	2,800
Total Maximum Conc.			*636*			*NA*			*8328.94*			*25176*

Bold = Compounds of Concern and Exposure Point Concentrations for each Area of Concern
NA = Not Analyzed ND = Not Detected

TABLE 1
SOIL DATA AND COMPOUNDS OF CONCERN
REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

	LANDFILL AREA 1			DUBOIS POND			LANDFILL AREA 2			LANDFILL AREAS 3 & 4		
COMPOUND	Frequency of Detection	Range	MAX	Frequency of Detection	Range	MAX	Frequency of Detection	Range	MAX	Frequency of Detection	Range	MAX
VOCs, ug/kg												
1,1,1,2-Tetrachloroethane	1/4	1	1	NA	NA	NA	0/14	ND	ND	0/10	ND	ND
1,1,1-Trichloroethane	1/4	1	1	NA	NA	NA	1/14	0.19	**0.19**	1/10	1	1
1,1,2,2-Tetrachloroethane	0/4	ND	ND	NA	NA	NA	2/14	0.56 - 0.6	**0.6**	0/10	ND	ND
1,1-Dichloropropene	1/4	1	1	NA	NA	NA	4/14	0.27 - 1	**1**	0/10	ND	ND
1,2,3-Trichlorobenzene	0/4	ND	ND	NA	NA	NA	3/14	0.44 - 1.51	**1.51**	0/10	ND	ND
1,2,3-Trichloropropane	1/4	1	1	NA	NA	NA	1/14	0.6	**0.6**	0/10	ND	ND
1,2,4-Trichlorobenzene	0/4	ND	ND	NA	NA	NA	3/14	0.36 - 1.29	**1.29**	0/10	ND	ND
1,2,4-Trimethylbenzene	2/4	1 - 1	1	NA	NA	NA	4/14	0.54 - 0.99	**0.99**	0/10	ND	ND
1,2-Dibromomethane	1/4	1	1	NA	NA	NA	0/14	ND	ND	0/10	ND	ND
1,2-Dichlorobenzene	2/4	1 -1	1	NA	NA	NA	3/14	0.34 - 1.29	**1.29**	0/10	ND	ND
1,3,5-Trimethylbenzene	1/4	1	1	NA	NA	NA	5/14	0.26 - 0.97	**0.97**	0/10	ND	ND
1,3-Dichlorobenzene	1/4	1	1	NA	NA	NA	2/14	0.4 - 1.43	**1.43**	0/10	ND	ND
1,4-Dichorobenzene	3/4	1 - 1	1	NA	NA	NA	4/14	0.57 - 76	**76**	2/10	1 - 1	1
2-Butanone	0/4	ND	ND	NA	NA	NA	1/14	8.79	**8.79**	0/10	ND	ND
2-Chlorotoluene	0/4	ND	ND	NA	NA	NA	1/14	1.14	**1.14**	0/10	ND	ND
4-Chlorotoluene	0/4	ND	ND	NA	NA	NA	1/14	1.09	**1.09**	2/10	1 - 1	1
4-Isopropyltoluene	1/4	1	1	NA	NA	NA	3/14	0.73 - 1.15	**1.15**	0/10	ND	ND
Acetone	0/4	ND	ND	NA	NA	NA	0/14	ND	ND	1/10	4	4
Bromodichloromethane	1/4	1	1	NA	NA	NA	0/14	ND	ND	0/10	ND	ND
Benzene	1/4	1	1	NA	NA	NA	4/14	0.26 - 0.93	**0.93**	1/10	1	1
Bromobenzene	1/4	1	1	NA	NA	NA	1/14	0.88	**0.88**	0/10	ND	ND
Bromomethane	0/4	ND	ND	NA	NA	NA	1/14	2.56	**2.56**	0/10	ND	ND
Chlorobenzene	1/4	1	1	NA	NA	NA	2/14	0.38 - 1.05	**1.05**	0/10	ND	ND
Chloroform	0/4	ND	ND	NA	NA	NA	0/14	ND	ND	1/10	1	1
cis-1,2-Dichloroethene	0/4	ND	ND	NA	NA	NA	1/14	1.92	**1.92**	1/10	2	2
Dibromomethane	1/4	1	1	NA	NA	NA	0/14	ND	ND	0/10	ND	ND
Ethylbenzene	2/4	1 - 1	1	NA	NA	NA	3/14	0.26 - 0.87	**0.87**	1/10	1	1
Hexachlorobutadiene	1/4	1	1	NA	NA	NA	0/14	ND	ND	1/10	1	1
Isopropylbenzene	0/4	ND	ND	NA	NA	NA	1/14	0.98	**0.98**	0/10	ND	ND
n-Butylbenzene	0/4	ND	ND	NA	NA	NA	2/14	0.92 - 1.33	**1.33**	0/10	ND	ND
n-Propylbenzene	0/4	ND	ND	NA	NA	NA	2/14	0.29 - 1.03	**1.03**	0/10	ND	ND
Naphthalene	1/4	1	1	NA	NA	NA	1/14	1.41	**1.14**	0/10	ND	ND
o-Xylene	0/4	ND	ND	NA	NA	NA	1/14	0.57	**0.57**	1/10	1	1

Bold = Compounds of Concern and Exposure Point Concentrations for each Area of Concern
NA = Not Analyzed ND = Not Detected

TABLE 1
SOIL DATA AND COMPOUNDS OF CONCERN
REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

	LANDFILL AREA 1			DUBOIS POND			LANDFILL AREA 2			LANDFILL AREAS 3 & 4		
COMPOUND	Frequency of Detection	Range	MAX	Frequency of Detection	Range	MAX	Frequency of Detection	Range	MAX	Frequency of Detection	Range	MAX
sec-Butylbenzene	0/4	ND	ND	NA	NA	NA	3/14	0.44 - 1.22	**1.22**	0/10	ND	ND
Styrene	0/4	ND	ND	NA	NA	NA	0/14	ND	ND	1/10	1	1
tert-Butylbenzene	0/4	ND	ND	NA	NA	NA	3/14	0.43 - 0.9	**0.9**	0/10	ND	ND
Tetrahydrofuran	0/4	ND	ND	NA	NA	NA	1/14	3.37	**3.37**	0/10	ND	ND
Toluene	0/4	ND	ND	NA	NA	NA	1/14	0.66	**0.66**	2/10	1 - 1	1
Trichlorofluoromethane	3/4	1 - 1	**1**	NA	NA	NA	6/14	0.56 - 1.15	**1.15**	4/10	1 - 2	2
Total Maximum Conc.			*20*			*NA*			*118.6*			*18*
Metals, mg/kg												
Aluminum	4/4	10500 - 13300	**13,330**	3/3	9140 - 9680	**9,680**	14/14	198 - 17300	**17,300**	10/10	5140 - 18800	18800
Antimony	0/4	ND	ND	0/3	ND	ND	2/14	1.3 - 2.4	**2.4**	3/10	1.1 - 74	74
Arsenic	4/4	2.8 - 5.5	**5.5**	3/3	2.1 - 3	**3**	14/14	1.5 - 88	**37 ***	9/10	1.9 - 13.5	13.5
Barium	4/4	41.3 - 58	**58**	3/3	32.5 - 38.1	**38.1**	14/14	19.2 - 2490	**2490**	10/10	20.3 - 323	323
Beryllium	4/4	0.8 - 1.3	**1.3**	3/3	0.86 - 1.1	**1.1**	12/14	0.46 - 1.7	**1.7**	10/10	0.44 - 0.93	0.93
Cadmium	0/4	ND	ND	0/3	ND	ND	1/14	0.06 - 1.9	**1.9**	0/10	ND	ND
Calcium	4/4	1360 - 1750	**1,750**	3/3	754 - 1300	**1,300**	14/14	603 - 42800	**42,800**	10/10	204 - 6170	6,170
Chromium	4/4	14.5 - 36.4	**36.4**	3/3	12.6 - 14.8	**14.8**	14/14	5.5 - 70.2	**70.2**	10/10	14 - 32200	32,200
Cobalt	4/4	5.7 - 9.3	**9.3**	3/3	5.2 - 5.7	**5.7**	14/14	1 - 11.3	**11.3**	9/10	3.1 - 8.1	8.1
Copper	4/4	5.6 - 11.6	**11.6**	3/3	7.5 - 9.4	**9.4**	14/14	1.2 - 17.6	**17.6**	10/10	3.2 - 39.2	39.2
Iron	4/4	12500 - 17700	**17,700**	3/3	12000 - 13500	**13,500**	14/14	6640 - 473000	**473,000**	10/10	6410 - 37600	37,600
Lead	4/4	11.6 - 18.4	**18.4**	3/3	6.6 - 8.6	**8.6**	14/14	2.3 - 37.6	**37.6**	10/10	4.8 - 1360	1,360
Magnesium	4/4	2490 - 3550	**3,550**	3/3	2460 - 2920	**2,920**	14/14	407 - 4970	**4,970**	10/10	1350 - 8150	8,150
Manganese	4/4	240 - 399	**399**	3/3	172 - 294	**294**	14/14	130 - 1700	**1700**	10/10	84.6 - 509	509
Mercury	2/4	0.06 - 0.07	**0.07**	0/3	ND	ND	4/14	0.08 - 0.16	**0.16**	1/10	0.57	0.57
Nickel	4/4	8.4 - 13	**13**	3/3	7.2 - 9.4	**9.4**	14/14	2 - 18.5	**18.5**	10/10	4.9 - 26.5	26.5
Potassium	4/4	1990 - 5170	**5,170**	3/3	3570 - 5530	**5,530**	13/14	1330 - 6550	**6,550**	9/10	914 - 10100	10,100
Selenium	3/4	0.46 - 0.6	**0.6**	0/3	ND	ND	7/14	0.63 - 5.2	**5.2**	3/10	0.36 - 0.8	0.8
Thallium	0/4	ND	ND	1/3	0.67	**0.67**	2/14	1.9 - 13.4	**13.4**	4/10	0.5 - 13.4	13.4
Vanadium	4/4	21 - 27.9	**27.9**	3/3	19.7 - 21.8	**21.8**	14/14	7.7 - 36.9	**36.9**	10/10	9.1 - 44.8	44.8
Zinc	4/4	41.4 - 61.9	**61.9**	3/3	36.9 - 52.3	**52.3**	14/14	23.1 - 346	**346**	10/10	23.4 - 409	409

* The EPC for arsenic was calculated as the 95% upper confidence limit, 37 mg/kg, instead of the maximum detected concentration, 88 mg/kg.

Bold = Compounds of Concern and Exposure Point Concentrations for each Area of Concern
NA = Not Analyzed ND = Not Detected

3.2.2 Landfill Area 2

Fourteen surface soil samples (soil samples SS-7 through SS-20) were collected from Landfill Area 2 (see Figure 2-2). These samples were analyzed for pesticides/ PCBs, SVOCs, VOCs, and metals.

The COCs (all detected chemicals) include nine pesticides (maximum concentrations totaling 158 ug/kg), 13 SVOCs (maximum concentrations totaling 8,329 ug/kg), 31 VOCs (maximum concentrations totaling 119 ug/kg), and 21 metals, as presented in Table 1. The 95% upper confidence level of the arithmetic mean was used as the EPC for arsenic; the EPCs for the other COCs were based on the maximum detected concentration.

3.2.3 Landfill Areas 3 & 4

Ten surface soil samples (soil samples SS-21 through SS-30) were collected from Landfill Areas 3 & 4. These samples were analyzed for pesticides/ PCBs, SVOCs, VOCs, and metals.

The chemicals detected include eight pesticides (maximum concentrations totaling 53 ug/kg), 22 SVOCs (maximum concentrations totaling 25,176 ug/kg), 13 VOCs (maximum concentrations totaling 18 ug/kg), and 20 metals, as presented in Table 1.

The EE/CA evaluated a potential child recreational/trespasser exposure to chromium in surface soils via incidental ingestion. The results indicated that a hazard index of 1 was exceeded for children exposed to the maximum detected chromium concentration, but was not exceeded for children exposed to the average detected chromium concentration.

Per the recommendations of the EE/CA, a cover system was designed for Areas 3 & 4, and was constructed during the summer-fall of 1997. The soils are now located under the completed cover system for Areas 3 & 4, and therefore, are no longer a potential exposure point. As a

result, none of the chemicals detected in surface soils at Areas 3 & 4 were retained as COCs for purposes of this risk assessment.

3.3 SEDIMENTS

Sediments at the SML were considered to be a potential exposure point for site-related contaminants. The COCs in sediments were selected based on the analytical results for samples collected during the Fall 1995, Spring 1996, July 1996, Aug. 1996, Fall 1996, and July 1997 sampling events.

A summary of the sediment data is presented in Table A-2 of Attachment A. The frequency of detection, concentration range, and maximum concentrations of the chemicals are presented for each area of concern in Table 2. Each chemical detected at least once was retained as a COC, for conservative purposes. A review of the data and selected COCs for each area of concern is presented below.

3.3.1 Landfill Area 1

Sediments are a potential exposure point at two sub-areas of concern at Landfill Area 1 (see Figure 2-2).

3.3.1.1 Unnamed tributary to Deep Brook

Three sediment samples (SD-2, SD-18, SD-19) were collected from the unnamed tributary to Deep Brook, located southeast of Landfill Area 1. These samples were analyzed for pesticides/PCBs, SVOCs, VOCs, and metals in November 1995, and metals (SD-2) and iron, arsenic, and manganese (SD-18 and SD-19) in May 1996. Sample SD-2 was also sampled for iron, arsenic, and manganese in November 1996. The COCs (all detected chemicals) include six SVOCs (maximum concentrations totaling 1,142 ug/kg) and 20 metals, as presented in Table 2.

TABLE 2
SEDIMENT DATA AND COMPOUNDS OF CONCERN
REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

CHEMICAL	LANDFILL AREA 1						LANDFILL AREA 2		
	Unnamed Tributary to Deep Brook			Dubois Pond			Landfill Area 2		
	Freq. of Detect.	Range	Max.	Freq. of Detect.	Range	Max.	Freq. of Detect.	Range	Max.
Pesticides/PCBs, ug/kg									
4,4-DDD	0/3	ND	ND	0/2	ND	ND	2/5	0.46J - 5.8J	**5.8**
4,4-DDE	0/3	ND	ND	1/2	0.29J	**0.29**	3/5	0.52J - 2.3J	**2.3**
PCB-1260	0/3	ND	ND	0/2	ND	ND	2/5	61 - 150	**150**
Total			*0*			*0.29*			*158.1*
SVOCs, ug/kg									
1,2-Dichlorobenzene	1/3	32J	**32**	0/2	ND	ND	1/5	36J	**36**
1,4-Dichlorobenzene	1/3	56J - 110J	**110**	0/2	ND	ND	0/5	ND	ND
4-Chloro-3-methylphenol	1/3	40J - 50J	**50**	0/2	ND	ND	0/5	ND	ND
Benzo(a)pyrene	1/3	180J	**180**	0/2	ND	ND	0/5	ND	ND
Benzo(b)fluoranthene	0/3	ND	ND	0/2	ND	ND	0/5	ND	ND
Bis(2-ethylhexyl)phthalate	1/3	630	**630**	0/2	ND	ND	0/5	ND	ND
Di-n-butylphthalate	0/3	ND	ND	0/2	ND	ND	0/5	ND	ND
Diethylphthalate	2/3	69J - 140J	**140**	0/2	ND	ND	0/5	ND	ND
Fluoranthene	0/3	ND	ND	0/2	ND	ND	1/5	54J	**54**
Phenanthrene	0/3	ND	ND	0/2	ND	ND	1/5	63J	**63**
Pyrene	0/3	ND	ND	0/2	ND	ND	4/5	41J - 140J	**140**
Total			*1142*			*0*			*293*
VOCs, ug/kg									
1,2,3-Trichlorobenzene	0/2	ND	ND	0/0	NA	NA	1/2	1J	**1**
1,2,4-Trichlorobenzene	0/2	ND	ND	0/0	NA	NA	1/2	1J	**1**
1,2,4-Trimethylbenzene	0/2	ND	ND	0/0	NA	NA	1/2	1J	**1**
1,3,5-Trimethylbenzene	0/2	ND	ND	0/0	NA	NA	1/2	1J	**1**
2-Butanone	0/2	ND	ND	0/0	NA	NA	2/2	4J - 25J	**25**
Acetone	0/2	ND	ND	0/0	NA	NA	1/2	72J	**72**
Benzene	0/2	ND	ND	0/0	NA	NA	1/2	1J	**1**
Chlorobenzene	0/2	ND	ND	0/0	NA	NA	1/2	1J	**1**
Chloroform	0/2	ND	ND	0/0	NA	NA	1/2	1J	**1**
Tetrahydrofuran	0/2	ND	ND	0/0	NA	NA	1/2	31J	**31**
Total			*0*			*0*			*135*
Metals, mg/kg									
Aluminum	3/3	2650J - 7650	**7650**	2/2	10700J - 12300J	**12300**	5/5	6000J - 29000J	**29000**
Arsenic	3/3	3.1J - 105J	**105**	2/2	4.1J - 4.3J	**4.3**	5/5	2.1J - 20.1J	**20.1**
Barium	3/3	22.5J - 141J	**141**	2/2	45.2J - 49.5J	**49.5**	5/5	19.3J - 144J	**144**
Beryllium	3/3	0.4J - 0.66J	**0.66**	2/2	1.1 - 1.4	**1.4**	5/5	0.47J - 1.9	**1.9**
Cadmium	1/3	0.09J	**0.09**	0/2	ND	ND	1/5	0.66J	**0.66**
Calcium	3/3	966 - 3650	**3650**	2/2	1980 - 2380	**2380**	5/5	727 - 5640	**5640**
Chromium	3/3	4.9J - 10.5	**10.5**	2/2	16.7J - 17J	**17**	5/5	6.9J - 85J	**85**
Cobalt	3/3	1.4J - 7	**7**	2/2	8.1J - 9J	**9**	5/5	2.5J - 17.7J	**17.3**
Copper	3/3	1.2J - 7	**7**	2/2	10.1 - 11.4	**11.4**	5/5	0.9J - 24.7	**24.7**
Iron	3/3	1400 - 151000	**151000**	2/2	17700J - 19600J	**19600**	5/5	4700J - 31000J	**31000**
Lead	3/3	5.9 - 27.5J	**27.5**	2/2	11.1 - 12.9	**12.9**	5/5	5.1 - 34J	**34**
Magnesium	3/3	452J - 2020	**2020**	2/2	4920J - 6100J	**6100**	5/5	1190J - 8610J	**8610**
Manganese	3/3	109J - 1020	**1020**	2/2	507J - 544J	**544**	5/5	76.3J - 605J	**605**
Mercury	1/3	0.9J	**0.9**	0/3	ND	ND	1/5	0.1J	**0.1**
Nickel	3/3	2.2J - 7.8	**7.8**	2/2	11.4J - 11.6J	**11.6**	5/5	3.7J - 34J	**34**
Potassium	2/3	933J - 1730	**1730**	2/2	4800 - 6780	**6780**	5/5	954 - 6640	**6640**
Selenium	3/3	0.5J - 1.9J	**1.9**	0/2	ND	ND	1/5	0.63J	**0.63**
Sodium	1/3	169	**169**	0/3	ND	ND	3/5	91.2 - 237	**237**
Thallium	0/3	ND	ND	2/2	0.79J - 0.9J	**0.9**	1/5	1.6J	**1.6**
Vanadium	3/3	4.8J - 16.5	**16.5**	2/2	25.6J - 29.5J	**29.5**	5/5	7.9J - 50.2J	**50.2**
Zinc	1/3	48	**48**	2/2	54.8J - 61.9J	**61.9**	5/5	20.5J - 126J	**126**

Bold = Compounds of Concern and Exposure Point Concentrations
for each Area of Concern
ND = Not Detected
NA = Not Analyzed
J = Estimated Concentration

TABLE 2
SEDIMENT DATA AND COMPOUNDS OF CONCERN
REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

CHEMICAL	LANDFILL AREAS 3 & 4					
	Stream/Pool North			Pool South		
	Freq. of Detect.	Range	Max.	Freq. of Detect.	Range	Max.
Pesticides/PCBs, ug/kg						
4,4-DDD	1/2	1.6J	**1.6**	0/1	ND	ND
4,4-DDE	1/2	1J	**1**	0/1	ND	ND
PCB-1260	0/2	ND	ND	0/1	ND	ND
Total			*2.6*			*0*
SVOCs, ug/kg						
1,2-Dichlorobenzene	0/2	ND	ND	0/1	ND	ND
1,4-Dichlorobenzene	0/2	ND	ND	0/1	ND	ND
4-Chloro-3-methylphenol	0/2	ND	ND	0/1	ND	ND
Benzo(a)pyrene	1/2	140J	**140**	0/1	ND	ND
Benzo(b)fluoranthene	0/2	ND	ND	0/1	ND	ND
Bis(2-ethylhexyl)phthalate	0/2	ND	ND	0/1	ND	ND
Di-n-butylphthalate	0/2	ND	ND	0/1	ND	ND
Diethylphthalate	1/2	100J	**100**	0/1	ND	ND
Fluoranthene	0/2	ND	ND	0/1	ND	ND
Phenanthrene	0/2	ND	ND	0/1	ND	ND
Pyrene	0/2	ND	ND	0/1	ND	ND
Total			*240*			*0*
VOCs, ug/kg						
1,2,3-Trichlorobenzene	0/0	NA	NA	0/0	NA	NA
1,2,4-Trichlorobenzene	0/0	NA	NA	0/0	NA	NA
1,2,4-Trimethylbenzene	0/0	NA	NA	0/0	NA	NA
1,3,5-Trimethylbenzene	0/0	NA	NA	0/0	NA	NA
2-Butanone	0/0	NA	NA	0/0	NA	NA
Acetone	0/0	NA	NA	0/0	NA	NA
Benzene	0/0	NA	NA	0/0	NA	NA
Chlorobenzene	0/0	NA	NA	0/0	NA	NA
Chloroform	0/0	NA	NA	0/0	NA	NA
Tetrahydrofuran	0/0	NA	NA	0/0	NA	NA
Total			*0*			*0*
Metals, mg/kg						
Aluminum	2/2	16200J - 18200J	**18200**	1/1	20300J	**20300**
Arsenic	2/2	7.9J - 15.9J	**15.9**	1/1	9.8 - 10.7	**10.7**
Barium	2/2	87.5J - 60.7J	**60.7**	1/1	84.3J	**84.3**
Beryllium	2/2	0.97J - 1.3	**1.3**	1/1	1	**1**
Cadmium	0/2	ND	ND	0/1	ND	ND
Calcium	2/2	2300 - 2360	**2360**	1/1	2980	**2980**
Chromium	2/2	20.6J - 25.8J	**25.8**	1/1	41.4J	**41.4**
Cobalt	2/2	6.9J - 23.6J	**23.6**	1/1	15.4J	**15.4**
Copper	2/2	6.7 - 8.5	**8.5**	1/1	16.9	**16.9**
Iron	2/2	11000J - 24500J	**24500**	1/1	38000 - 42100	**42100**
Lead	2/2	16.6 - 22.6	**22.6**	1/1	9.2	**9.2**
Magnesium	2/2	2420J - 3240J	**3240**	1/1	10400J	**10400**
Manganese	2/2	148J - 6780J	**6780**	1/1	686J - 739	**739**
Mercury	0/2	ND	ND	0/1	ND	ND
Nickel	2/2	16.8J - 16.9J	**16.9**	1/1	28.8J	**28.8**
Potassium	1/2	1690	**1690**	1/1	10100	**10100**
Selenium	2/2	0.82J - 3.4J	**3.4**	0/1	ND	ND
Sodium	0/2	ND	ND	0/1	ND	ND
Thallium	1/2	6.7	**6.7**	0/1	ND	ND
Vanadium	2/2	21.6J - 41.2J	**41.2**	1/1	51.5J	**51.5**
Zinc	1/2	78.1J	**78.1**	1/1	67.2J	**67.2**

Bold = Compounds of Concern and Exposure Point Concentrations
for each Area of Concern
ND = Not Detected
NA = Not Analyzed
J = Estimated Concentration

TABLE 2
SEDIMENT DATA AND COMPOUNDS OF CONCERN
REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

CHEMICAL	LANDFILL AREAS 3 & 4 (cont'd)					
	Big Ledge Brook			Sandy Brook South Area 4		
	Freq. of Detect.	Range	Max.	Freq. of Detect.	Range	Max.
Pesticides/PCBs, ug/kg						
4,4-DDD	0/2	ND	ND	0/2	ND	ND
4,4-DDE	0/2	ND	ND	1/2	0.76J	**0.76**
PCB-1260	0/2	ND	ND	0/2	ND	ND
Total			*0*			*0.76*
SVOCs, ug/kg						
1,2-Dichlorobenzene	0/0	NA	NA	0/2	ND	ND
1,4-Dichlorobenzene	0/0	NA	NA	0/2	ND	ND
4-Chloro-3-methylphenol	0/0	NA	NA	0/2	ND	ND
Benzo(a)pyrene	0/0	NA	NA	1/2	47J	**47**
Benzo(b)fluoranthene	0/0	NA	NA	0/2	ND	ND
Bis(2-ethylhexyl)phthalate	0/0	NA	NA	0/2	ND	ND
Di-n-butylphthalate	0/0	NA	NA	0/2	ND	ND
Diethylphthalate	0/0	NA	NA	1/2	76J	**76**
Fluoranthene	0/0	NA	NA	0/2	ND	ND
Phenanthrene	0/0	NA	NA	0/2	ND	ND
Pyrene	0/0	NA	NA	0/2	ND	ND
Total			*0*			*123*
VOCs, ug/kg						
1,2,3-Trichlorobenzene	0/0	NA	NA	0/0	NA	NA
1,2,4-Trichlorobenzene	0/0	NA	NA	0/0	NA	NA
1,2,4-Trimethylbenzene	0/0	NA	NA	0/0	NA	NA
1,3,5-Trimethylbenzene	0/0	NA	NA	0/0	NA	NA
2-Butanone	0/0	NA	NA	0/0	NA	NA
Acetone	0/0	NA	NA	0/0	NA	NA
Benzene	0/0	NA	NA	0/0	NA	NA
Chlorobenzene	0/0	NA	NA	0/0	NA	NA
Chloroform	0/0	NA	NA	0/0	NA	NA
Tetrahydrofuran	0/0	NA	NA	0/0	NA	NA
Total			*0*			*0*
Metals, mg/kg						
Aluminum	2/2	2640 - 3970	**3970**	2/2	4010J - 6330J	**6330**
Arsenic	2/2	3.3 - 5.2	**5.2**	32/32	1.3 - 185	**185**
Barium	2/2	8.2 - 12.1	**12.1**	2/2	15.6J - 44.7J	**44.7**
Beryllium	0/2	ND	ND	1/2	0.48J	**0.48**
Cadmium	0/2	ND	ND	0/2	ND	ND
Calcium	2/2	470J - 657J	**657**	2/2	511 - 1150	**1150**
Chromium	2/2	6.4 - 9.2	**9.2**	2/2	9.5J - 14J	**14**
Cobalt	2/2	1.8J - 2.7J	**2.7**	2/2	2.7J - 5.1J	**5.1**
Copper	2/2	1.8J - 2.6J	**2.6**	2/2	1.5J - 5.4	**5.4**
Iron	2/2	4440 - 5610	**5610**	31/32	1700 - 48200	**48200**
Lead	2/2	1.8J - 3J	**3**	2/2	4.4 - 6.9	**6.9**
Magnesium	2/2	1450 - 1690	**1690**	2/2	1420J - 2200J	**2200**
Manganese	2/2	53.7 - 89.8	**89.8**	3/3	72.7J - 464J	**464**
Mercury	0/2	ND	ND	0/2	ND	ND
Nickel	2/2	7 - 9.6	**9.6**	2/2	4.8J - 10.8J	**10.8**
Potassium	2/2	307 - 479	**479**	0/2	ND	ND
Selenium	0/2	ND	ND	1/2	0.72J	**0.72**
Sodium	2/2	35.3 - 45.2	**45.2**	0/2	ND	ND
Thallium	0/2	ND	ND	0/2	ND	ND
Vanadium	2/2	6 - 8.8	**8.8**	2/2	6.6J- 14.6J	**14.6**
Zinc	2/2	10.6 - 18.4	**18.4**	1/2	21.7J	**21.7**

Bold = Compounds of Concern and Exposure Point Concentrations
for each Area of Concern
ND = Not Detected
NA = Not Analyzed
J = Estimated Concentration

3.3.1.2 Dubois Pond

Two sediment samples (SD-16 and SD-17) were collected from Dubois Pond, located south of Landfill Area 1. These samples were analyzed for pesticides/PCBs, SVOCs, and metals in November 1995.

The COCs (all detected chemicals) include one pesticide (4,4-DDE at 0.29 ug/kg), and 17 metals, as presented in Table 2.

3.3.2 Landfill Area 2

Five sediment samples (SD-4, SD-7, SD-8, SD-9, and SD-10) were collected from Sandy Brook located to the west of Landfill Area 2 (see Figure 2-2). These samples were analyzed for pesticides/PCBs, SVOCs, and metals in November 1995; samples SD-8 and SD-9 were sampled for VOCs in November 1995; sample SD-7 was sampled for pesticides/PCBs, SVOCs, and metals in May 1996; samples SD-4 and SD-9 were sampled for metals in May 1996; and SD-7 and SD-9 were sampled for arsenic, iron, and manganese in November 1996.

The COCs (all detected chemicals) include two pesticides and one PCB (arochlor 1260) (maximum concentrations totaling 158 ug/kg), four SVOCs (maximum concentrations totaling 293 ug/kg), 10 VOCs (maximum concentrations totaling 135 ug/kg), and 21 metals, as presented in Table 2.

3.3.3 Landfill Areas 3 & 4

Sediments are a potential exposure point at four areas of concern at Landfill Areas 3 & 4 (see Figure 2-2).

3.3.3.1 Stream and Pool North of Landfill Area 3

Two sediment samples (SD-3 and SD-11) were collected from a stream and pool to the north of Landfill Area 3. These samples were analyzed for pesticides/PCBs, SVOCs, and metals in November 1995.

The COCs (all detected chemicals) include two pesticides (maximum concentrations totaling 2.6 ug/kg), two SVOCs (maximum concentrations totaling 240 ug/kg), and 18 metals, as presented in Table 2.

3.3.3.2 Sandy Brook Southeast of Landfill Area 4

Thirty-two sediment samples (SD-5, SD-15, SD-24, SD-25, SD-27, SD-30, SD-31, SD-32, SD-33, SD-34, SD-35, SD-40, SD-41, SD-47, SD-49, SD-50, SD-51, SD-52, SD-53, SD-60, SD-61, SD-62, SD-63, SD-64, SD-65, SD-66, SD-67, SD-68, SD-69, SD-70, SD-71, and SD-72) were collected from Sandy Brook to the south-southeast of Landfill Area 4. Samples SD-5 and SD-15 were analyzed for pesticides/PCBs, SVOCs, and metals in November 1995, and the remainder of the samples were analyzed for arsenic, iron, and manganese in May 1996, July 1996, November 1996, April 1997 and/or July 1997.

The COCs (all detected chemicals) include one pesticides (4,4-DDE, detected at 0.76 ug/kg), two SVOCs (maximum concentrations totaling 123 ug/kg), and 16 metals, as presented in Table 2.

3.3.3.3 Pool South of Landfill Area 4

Sediment samples were collected from one location (SD-14) in a pool to the south of Landfill Area 4. Samples were analyzed for pesticides/PCBs, SVOCs, and metals in November 1995, and arsenic, iron, and manganese in May 1996 and November 1996.

The COCs (all detected chemicals) include 16 metals, as presented in Table 2.

3.3.3.4 Big Ledge Brook

Two sediment samples (SD-28 and SD-29) were collected from Big Ledge Brook to the southwest of Landfill Areas 3 and 4. These samples were analyzed for pesticides/PCBs and metals in May 1996, and SD-29 was analyzed for arsenic, iron, and manganese in November 1996.

The COCs (all detected chemicals) include 16 metals, as presented in Table 2.

3.4 SURFACE WATER

Surface water at the SML was considered to be a potential exposure point for site-related contaminants. The COCs in surface water were selected based on the analytical results for samples collected during the Fall 1995, Spring 1996, Summer 1996, Fall 1996, and Summer 1997 sampling events.

A summary of the data is presented in Table A-3 of Attachment A. The frequency of detection, concentration range, and maximum concentrations of the chemicals are presented for each area of concern in Table 3. Each chemical detected at least once was retained as a COC, for conservative purposes. A review of the data and selected COCs for each area of concern is presented below.

3.4.1 Landfill Area 1

Surface waters are a potential exposure point at two areas of concern at Landfill Area 1 (see Figure 2-2).

TABLE 3
SURFACE WATER DATA AND COMPOUNDS OF CONCERN
REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

Parameter All units in ug/L	LANDFILL AREA 1						LANDFILL AREA 2		
	Tributary to Deep Brook			Dubois Pond			Landfill Area 2		
	Freq. Detect.	Range	Max.	Freq. Detect.	Range	Max.	Freq. Detect.	Range	Max.
Pesticides/PCBs									
Dieldrin	0/2	ND	ND	0/2	ND	ND	1/5	0.0011J	**0.0011**
Endosulfan II	0/2	ND	ND	1/2	0.0014J	**0.0014**	1/5	0.0034J	**0.0034**
Total			*0*			*0.0014*			*0.0045*
SVOCs									
1,4-Dichlorobenzene	2/2	3J - 3J	**3**	0/2	ND	ND	0/5	ND	ND
4-Chloro-3-methylphenol	2/2	2J - 3J	**3**	0/2	ND	ND	0/5	ND	ND
Bis(2-ethylhexyl)phthalate	0/2	ND	ND	1/2	2J	**2**	2/5	2J - 5J	**5**
Di-n-butylphthalate	0/2	ND	ND	0/2	ND	ND	0/5	ND	ND
Total			*6*			*2*			*5*
VOCs									
1,1-Dichloroethene	0/2	ND	ND	0/2	ND	ND	1/2	1J	**1**
1,2,4-Trimethylbenzene	2/2	1J - 1J	**1**	0/2	ND	ND	0/2	ND	ND
1,2-Dichlorobenzene	1/2	1J	**1**	0/2	ND	ND	0/2	ND	ND
1,3-Dichlorobenzene	1/2	1J	**1**	0/2	ND	ND	1/2	1	**1**
1,4-Dichlorobenzene	2/2	2 - 2	**2**	0/2	ND	ND	0/2	ND	ND
Acetone	1/2	4J	**4**	1/2	3J	**3**	0/2	ND	ND
Benzene	1/2	2 - 2	**2**	0/2	ND	ND	0/2	ND	ND
cis-1,2-Dichloroethene	1/2	1J	**1**	0/2	ND	ND	0/2	ND	ND
Chlorobenzene	2/2	2 - 3	**3**	0/2	ND	ND	0/2	ND	ND
Ethylbenzene	1/2	10 - 11	**11**	0/2	ND	ND	0/2	ND	ND
m,p-Xylene	2/2	9 - 16	**16**	0/2	ND	ND	0/2	ND	ND
Naphthalene	2/2	1J - 1J	**1**	0/2	ND	ND	0/2	ND	ND
Tetrahydrofuran	1/2	10J - 13J	**13**	0/2	ND	ND	0/2	ND	ND
Toluene	0/2	ND	ND	1/2	93	**93**	0/2	ND	ND
Total			*56*			*96*			*2*
Inorganics									
Aluminum	2/2	113J - 1970	**1970**	2/2	1330 - 1540	**1540**	5/5	224 - 574	**574**
Antimony	0/1	ND	**ND**	0/2	ND	ND	0/5	ND	ND
Arsenic	2/2	7J - 14.1	**14.1**	0/2	ND	ND	0/5	ND	ND
Barium	2/2	39.4 - 96.3	**96.3**	2/2	8.3J - 9.3J	**9.3**	5/5	11.5J - 17.7J	**17.7**
Beryllium	0/2	ND	ND	0/2	ND	ND	0/5	ND	ND
Cadmium	0/2	ND	ND	0/2	ND	ND	0/5	ND	ND
Calcium	2/2	28800 - 35500	**35500**	2/2	9380 - 9860	**9860**	5/5	6720 - 9290	**9290**
Chromium	2/2	0.88J - 1.6J	**1.6**	2/2	1.4J - 1.9J	**1.9**	3/5	0.58J - 1.1J	**1.1**
Cobalt	2/2	1.2J - 1.3J	**1.3**	0/2	ND	ND	0/5	ND	ND
Copper	0/2	ND	ND	2/2	1.2J - 1.3J	**1.3**	1/5	1.4J	**1.4**
Iron	2/2	2490 - 14500	**14500**	2/2	1630 - 1950	**1950**	5/5	548 - 3620	**3620**
Lead	2/2	1.6J - 4.9	**4.9**	0/2	ND	ND	1/5	3J	**3**
Magnesium	2/2	9140 - 11200	**11200**	2/2	4830J - 5150	**5150**	5/5	1620J - 2390J	**2390**
Manganese	2/2	457 - 1070	**1070**	2/2	114 - 123	**123**	5/5	65.6 - 102	**102**
Mercury	0/2	ND	ND	0/2	ND	ND	3/5	0.0037 - 0.12	**0.12**
Nickel	2/2	1.3J - 1.7J	**1.7**	2/2	1.1J - 1.4J	**1.4**	2/5	1.3J - 1.3J	**1.3**
Potassium	2/2	7400 - 9610	**9610**	2/2	3500J - 3830J	**3830**	3/5	1990 - 2370	**2370**
Selenium	0/2	ND	ND	0/2	ND	ND	0/5	ND	ND
Silver	0/2	ND	ND	0/2	ND	ND	0/5	ND	ND
Sodium	2/2	32,800 - 57,900	**57900**	2/2	16000 - 1670	**16700**	5/5	8140 - 12700	**12700**
Thallium	0/2	ND	ND	1/2	7J	**7**	0/5	ND	ND
Vanadium	0/2	ND	ND	0/2	ND	ND	0/5	ND	ND
Zinc	0/2	ND	ND	0/2	ND	ND	0/5	ND	ND

Bold = Compounds of Concern and Exposure Point Concentrations
for each Area of Concern
ND = Not detected
NA = Not analyzed.
J = Estimated Concentration.

TABLE 3
SURFACE WATER DATA AND COMPOUNDS OF CONCERN
REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

Parameter All units in ug/L	LANDFILL AREAS 3 & 4					
	Stream/Pool North			Pool South		
	Freq. Detect.	Range	Max.	Freq. Detect.	Range	Max.
Pesticides/PCBs						
Dieldrin	0/2	ND	ND	0/1	ND	ND
Endosulfan II	0/2	ND	ND	0/1	ND	ND
Total			*0*			*0*
SVOCs						
1,4-Dichlorobenzene	0/2	ND	ND	0/1	ND	ND
4-Chloro-3-methylphenol	0/2	ND	ND	0/1	ND	ND
Bis(2-ethylhexyl)phthalate	0/2	ND	ND	1/1	1J	**1**
Di-n-butylphthalate	0/2	ND	ND	1/1	2J	**2**
Total			*0*			*3*
VOCs						
1,1-Dichloroethene	0/0	NA	NA	0/0	NA	NA
1,2,4-Trimethylbenzene	0/0	NA	NA	0/0	NA	NA
1,2-Dichlorobenzene	0/0	NA	NA	0/0	NA	NA
1,3-Dichlorobenzene	0/0	NA	NA	0/0	NA	NA
1,4-Dichlorobenzene	0/0	NA	NA	0/0	NA	NA
Acetone	0/0	NA	NA	0/0	NA	NA
Benzene	0/0	NA	NA	0/0	NA	NA
cis-1,2-Dichloroethene	0/0	NA	NA	0/0	NA	NA
Chlorobenzene	0/0	NA	NA	0/0	NA	NA
Ethylbenzene	0/0	NA	NA	0/0	NA	NA
m,p-Xylene	0/0	NA	NA	0/0	NA	NA
Naphthalene	0/0	NA	NA	0/0	NA	NA
Tetrahydrofuran	0/0	NA	NA	0/0	NA	NA
Toluene	0/0	NA	NA	0/0	NA	NA
Total			*0*			*0*
Inorganics						
Aluminum	2/2	87.8J - 116J	**116**	1/1	776	**776**
Antimony	0/2	ND	ND	0/1	ND	ND
Arsenic	2/2	3.1J - 3.7J	**3.7**	1/1	3.1J - 18.6	**18.6**
Barium	2/2	2.7J - 7.4J	**7.4**	1/1	14.7J - 30.5	**30.5**
Beryllium	0/2	ND	ND	0/1	ND	ND
Cadmium	0/2	ND	ND	0/1	ND	ND
Calcium	2/2	5220 - 18900	**18900**	1/1	8800 - 16600	**16600**
Chromium	1/2	10.2	**10.2**	1/1	1.2J	**1.2**
Cobalt	0/2	ND	ND	0/1	ND	ND
Copper	0/2	ND	ND	0/1	ND	ND
Iron	0/2	ND	ND	1/1	1150 - 2270	**2270**
Lead	0/2	ND	ND	0/1	ND	ND
Magnesium	2/2	694J - 1990J	**1990**	1/1	2200 - 3570	**3570**
Manganese	0/2	ND	ND	1/1	118 - 617	**617**
Mercury	0/2	ND	ND	1/1	0.12J	**0.12**
Nickel	0/2	ND	ND	1/1	1.1J - 5.1	**5.1**
Potassium	1/2	643J	**643**	1/1	2810 - 2840	**2840**
Selenium	0/2	ND	ND	0/1	ND	ND
Silver	1/2	0.71J	**0.71**	0/1	ND	ND
Sodium	2/2	2730J - 3800J	**3800**	1/1	9680 - 21400	**21400**
Thallium	0/2	ND	ND	0/1	ND	ND
Vanadium	0/2	ND	ND	0/1	ND	ND
Zinc	0/2	ND	ND	0/1	ND	ND

Bold = Compounds of Concern and Exposure Point Concentrations
for each Area of Concern
ND = Not detected
NA = Not analyzed.
J = Estimated Concentration.

TABLE 3
SURFACE WATER DATA AND COMPOUNDS OF CONCERN
REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

Parameter All units in ug/L	LANDFILL AREAS 3 & 4 (cont'd)					
	Big Ledge Brook			Sandy Brook		
	Freq. Detect.	Range	Max.	Freq. Detect.	Range	Max.
Pesticides/PCBs						
Dieldrin	0/0	NA	NA	0/2	ND	ND
Endosulfan II	0/0	NA	NA	1/2	0.0019J	**0.0019**
Total			*0*			*0.0019*
SVOCs						
1,4-Dichlorobenzene	0/0	NA	NA	0/2	ND	ND
4-Chloro-3-methylphenol	0/0	NA	NA	0/2	ND	ND
Bis(2-ethylhexyl)phthalate	0/0	NA	NA	1/2	2J	**2**
Di-n-butylphthalate	0/0	NA	NA	0/2	ND	ND
Total			*0*			*2*
VOCs						
1,1-Dichloroethene	0/0	NA	NA	0/0	NA	NA
1,2,4-Trimethylbenzene	0/0	NA	NA	0/0	NA	NA
1,2-Dichlorobenzene	0/0	NA	NA	0/0	NA	NA
1,3-Dichlorobenzene	0/0	NA	NA	0/0	NA	NA
1,4-Dichlorobenzene	0/0	NA	NA	0/0	NA	NA
Acetone	0/0	NA	NA	0/0	NA	NA
Benzene	0/0	NA	NA	0/0	NA	NA
cis-1,2-Dichloroethene	0/0	NA	NA	0/0	NA	NA
Chlorobenzene	0/0	NA	NA	0/0	NA	NA
Ethylbenzene	0/0	NA	NA	0/0	NA	NA
m,p-Xylene	0/0	NA	NA	0/0	NA	NA
Naphthalene	0/0	NA	NA	0/0	NA	NA
Tetrahydrofuran	0/0	NA	NA	0/0	NA	NA
Toluene	0/0	NA	NA	0/0	NA	NA
Total			*0*			*0*
Inorganics						
Aluminum	0/2	ND	ND	2/2	440 - 555	**555**
Antimony	1/2	4.1J	**4.1**	0/2	ND	ND
Arsenic	0/2	ND	**ND**	2/2	4.2J - 12.2	**12.2**
Barium	2/2	5.1 - 5.2	**5.2**	2/2	14.9J - 22.2	**22.2**
Beryllium	0/2	ND	ND	0/2	ND	ND
Cadmium	0/2	ND	ND	0/2	ND	ND
Calcium	2/2	9520J - 11900J	**11900**	2/2	10600 - 21500	**21500**
Chromium	1/2	12.1J	**12.1**	2/2	1.1J - 1.1J	**1.1**
Cobalt	1/2	0.81J	**0.81**	0/2	ND	ND
Copper	1/2	1.4J	**1.4**	0/2	ND	ND
Iron	1/2	528	**528**	2/2	863 - 1750	**1750**
Lead	2/2	1J - 34.5	**34.5**	0/2	ND	ND
Magnesium	2/2	1140 - 1620	**1620**	2/2	2420 - 4390	**4390**
Manganese	2/2	17.2 - 22.4	**22.4**	2/2	151 - 381	**381**
Mercury	0/2	ND	ND	1/2	0.12J	**0.12**
Nickel	1/2	99.6	**99.6**	2/2	1.1J - 1.9J	**1.9**
Potassium	1/2	749J	**749**	2/2	2030 - 2720	**2720**
Selenium	1/2	4.6J	**4.6**	0/2	ND	ND
Silver	0/2	ND	ND	0/2	ND	ND
Sodium	2/2	8450 - 8940	**8940**	2/2	11400 - 17200	**17200**
Thallium	0/2	ND	ND	0/2	ND	ND
Vanadium	0/2	ND	ND	0/2	ND	ND
Zinc	0/2	ND	ND	0/2	ND	ND

Bold = Compounds of Concern and Exposure Point Concentrations
for each Area of Concern
ND = Not detected
NA = Not analyzed.
J = Estimated Concentration.

3.4.1.1 Unnamed tributary to Deep Brook

Two surface water samples (SW-2 and SW-18) were collected from the unnamed tributary to Deep Brook, located southeast of Landfill Area 1. These samples were analyzed for pesticides/PCBs, SVOCs, VOCs, and metals in November 1995, and sample SW-2 was analyzed for metals in May 1996 and November 1996.

The COCs (all detected chemicals) include two SVOCs (maximum concentrations totaling 6 ug/l), 12 VOCs (maximum concentrations totaling 56 ug/l), and 13 metals, as presented in Table 3.

3.4.1.2 Dubois Pond

Two surface water samples (SW-16 and SW-17) were collected from Dubois Pond, located south of Landfill Area 1. These samples were analyzed for pesticides/PCBs, SVOCs, VOCs, and metals in November 1995.

The COCs (all detected chemicals) include one pesticide (endosulfan II at 0.0014 ug/l), one SVOC (bis-2-ethylhexylphthalate at 2 ug/l), two VOCs (maximum concentrations totaling 96 ug/l), and 12 metals, as presented in Table 3.

3.4.2 Landfill Area 2

Four surface water samples (SW-4, SW-8, SW-9, and SW-10) were collected from Sandy Brook located to the west of Landfill Area 2 (see Figure 2-2). These samples were analyzed for pesticides/PCBs, SVOCs, and metals in November 1995; samples SW-8 and SW-9 were analyzed for VOCs in November 1995; sample SW-9 was analyzed for metals in May 1996 and November 1996, and for aluminum and mercury in May 1996; and samples SW-4, SW-8, and SW-9 were analyzed for arsenic and iron in July 1997.

The COCs (all detected chemicals) include two pesticides (maximum concentrations totaling 0.0045 ug/l), one SVOC (bis-2-ethylhexylphthalate at 5 ug/l), two VOCs (maximum concentrations totaling 2 ug/l), and 13 metals, as presented in Table 3.

3.4.3 Landfill Areas 3 & 4

Surface waters are a potential exposure point at four areas of concern at Landfill Areas 3 & 4 (see Figure 2-2).

3.4.3.1 Stream and pool north of Landfill Area 3

Two surface water samples (SW-3 and SW-11) were collected from a stream and pool to the north of Landfill Area 3. These samples were analyzed for pesticides/PCBs, SVOCs, and metals in November 1995.

The COCs (all detected chemicals) include nine metals, as presented in Table 3.

3.4.3.2 Sandy Brook Southeast of Landfill Area 4

Two surface water samples (SW-5 and SW-15) were collected from Sandy Brook to the south-southeast of Landfill Area 4. These samples were analyzed for pesticides/PCBs, SVOCs, and metals in November 1995, and SD-15 was analyzed for metals in November 1996.

The COCs (all detected chemicals) include one pesticide (endosulfan II, detected at 0.0019 ug/l), one SVOC (bis-2-ethylhexylphthalate at 2 ug/l), and 12 metals, as presented in Table 3.

3.4.3.3 Pool South of Landfill Area 4

Surface water samples were collected from one location (SW-14) in a pool to the south of Landfill Area 4. Samples were analyzed for pesticides/PCBs, SVOCs, and metals in November 1995, and for metals in November 1996.

The COCs (all detected chemicals) include two SVOCs (maximum concentrations totaling 3 ug/l) and 12 metals, as presented in Table 3.

3.4.3.4 Big Ledge Brook

Two surface water samples (SW-28 and SW-29) were collected from Big Ledge Brook to the southwest of Landfill Areas 3 and 4. These samples were analyzed for metals in May 1996.

The COCs (all detected chemicals) include 14 metals, as presented in Table 3.

3.5 GROUNDWATER

There is no current groundwater exposure at the SML. The City of Saco is in the process of implementing institutional controls on the SML property to prohibit the future use of groundwater as a drinking water source. Area residents along Route 112, Louden Road, Route 5, and Fire Lane 10 are connected to the City water supply. However, for conservative purposes of this risk assessment, deep groundwater downgradient of Areas 1 & 2 and groundwater downgradient and to the southeast of Areas 3 & 4 were evaluated as potential future residential drinking water sources.

The COCs in site groundwater were selected based on the analytical results for samples collected from 15 wells in the November 1995, May 1996, Fall 1996, and/or July 1997 sampling events.

For each well, the specific sampling dates, analytical parameters, and analytical results are presented in Table A-4 in Appendix A.

The frequency of detection, concentration range, and maximum concentrations of the detected chemicals are summarized for each area of concern in Table 4. Those VOCs and SVOCs detected during the December 1995/January 1996 sampling event and not detected during subsequent sampling events are believed to be artifacts of that sampling effort and were eliminated as COCs. All other chemicals detected at least once were retained as COCs, for conservative purposes. A review of the data and selected COCs for each area of concern is presented below.

3.5.1 Landfill Areas 1 & 2

Deep groundwater downgradient of Landfill Areas 1 & 2 is represented by groundwater monitoring wells 93-4 and MW-95-5R (see Figure 2-2). Groundwater samples were analyzed for VOCs, SVOCs, metals, and cyanide.

The groundwater COCs (all detected chemicals) include one VOC (acetone at 3 ug/l), one SVOC (di-n-butylphthalate at 1 ug/l), and 13 metals and cyanide, as presented in Table 4.

3.5.2 Landfill Areas 3 & 4

For purposes of this risk assessment, the potential groundwater exposure points for Landfill Areas 3 & 4 are considered to be groundwater located downgradient and to the south-southeast of Landfill Areas 3 & 4, as discussed in the RI report and as presented in Figure 2-2. Groundwater flow to the north-northeast is to wetland areas and is believed to be minimal, and the groundwater to the west of the landfill is not hydrologically connected to the groundwater at Areas 3 & 4; therefore, these areas were not evaluated in this risk assessment.

TABLE 4
GROUNDWATER ANALYTICAL DATA AND COMPOUNDS OF CONCERN
REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

	DEEP GROUNDWATER DOWNGRADIENT OF AREAS 1 & 2				GROUNDWATER SOUTH-SOUTHEAST OF LANDFILL AREAS 3 & 4			
Parameter	Freq. of Detect.	Range	Max.	Retained as COC	Freq. of Detect.	Range	Max.	Retained as COC
VOCs, ug/l								
1,1-Dichloroethane	0/1	ND	ND	No	4/12	0.2J - 1	**1**	Yes
1,1-Dichloropropene	0/1	ND	ND	No	1/12	1J	1	No
1,1,2,2-Tetrachloroethane	0/1	ND	ND	No	1/12	1J	1	No
1,2,3-Trichlorobenzene	0/1	ND	ND	No	1/12	0.8J - 1J	**1**	Yes
1,2,3-Trichloropropane	0/1	ND	ND	No	1/12	1J	1	No
1,2,4-Trichlorobenzene	0/1	ND	ND	No	2/12	0.6J - 1J	**1**	Yes
1,2,4-Trimethylbenzene	0/1	ND	ND	No	2/12	2J - 9	**9**	Yes
1,2-Dibromo-3-chloropropan	0/1	ND	ND	No	1/12	1	1	No
1,2-Dichlorobenzene	0/1	ND	ND	No	5/12	0.8J - 5	**5**	Yes
1,2-Dichloroethane	0/1	ND	ND	No	4/12	0.3J - 1	**1**	Yes
1,3-Dichlorobenzene	0/1	ND	ND	No	2/12	1J - 1J	1	No
1,3,5-Trimethylbenzene	0/1	ND	ND	No	2/12	2J - 5	**5**	Yes
1,4-Dichlorobenzene	0/1	ND	ND	No	6/12	0.7J - 7	**7**	Yes
2-Butanone	0/1	ND	ND	No	1/12	15 - 17	17	No
2-Chlorotoluene	0/1	ND	ND	No	1/12	1J	1	No
2,2-Dichloropropane	0/1	ND	ND	No	4/12	0.2J - 0.4J	**0.4**	Yes
4-Isopropytoluene	0/1	ND	ND	No	5/12	0.8J - 4J	**4**	Yes
Acetone	1/1	3J	**3**	Yes	0/12	ND	ND	No
Benzene	0/1	ND	ND	No	6/12	0.3J - 13	**13**	Yes
Bromobenzene	0/1	ND	ND	No	1/12	1J	1	No
Chlorobenzene	0/1	ND	ND	No	6/12	0.4J - 5	**5**	Yes
Chloroethane	0/1	ND	ND	No	7/12	0.7J - 93	**93**	Yes
Chloromethane	0/1	ND	ND	No	1/12	2J	**2**	Yes
cis-1,2-DCE	0/1	ND	ND	No	4/12	0.6J - 5	**5**	Yes
Dichlorodifluoromethane	0/1	ND	ND	No	1/12	1J	**1**	Yes
Ethylbenzene	0/1	ND	ND	No	7/12	0.2J - 34	**34**	Yes
Hexachlorobutadiene	0/1	ND	ND	No	1/12	1J	1	No
Isopropylbenzene	0/1	ND	ND	No	4/12	0.3J - 6	**6**	Yes
Methylene Chloride	0/1	ND	ND	No	1/11	1	**1**	Yes
Naphthalene	0/1	ND	ND	No	3/12	0.8J - 13	**13**	Yes
Styrene	0/1	ND	ND	No	1/11	1J	1	No
Tetrachloroethene	0/1	ND	ND	No	0/12	ND	ND	No
Tetrahydrofuran	0/1	ND	ND	No	7/12	3J - 170	**170**	Yes
Toluene	0/1	ND	ND	No	5/12	0.5J - 3	**3**	Yes
trans-1,2-DCE	0/1	ND	ND	No	5/12	0.6J - 1J	**1**	Yes
Trichloroethene	0/1	ND	ND	No	5/12	0.7J - 7	**7**	Yes
Trichlorofluoromethane	0/1	ND	ND	No	1/12	1J	1	No
m-Xylene/p-Xylene	0/1	ND	ND	No	5/12	0.5J - 32	**32**	Yes
n-Butylbenzene	0/1	ND	ND	No	3/12	0.8J - 2	**2**	Yes
n-Propylbenzene	0/1	ND	ND	No	2/12	0.7J - 2	**2**	Yes
o-Xylene	0/1	ND	ND	No	2/12	2J - 14	**14**	Yes
sec-Butylbenzene	0/1	ND	ND	No	1/12	1J - 1J	1	No
Total COCs			*3*				*438*	

Bold = Exposure Point Concentrations for COCs for each Area of Concern.
COCs = Compounds of Concern
NA = Not analyzed.
ND = Not detected.
J = Estimated Concentration.

TABLE 4
GROUNDWATER ANALYTICAL DATA AND COMPOUNDS OF CONCERN
REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

	DEEP GROUNDWATER DOWNGRADIENT OF AREAS 1 & 2				GROUNDWATER SOUTH-SOUTHEAST OF LANDFILL AREAS 3 & 4			
Parameter	Freq. of Detect.	Range	Max.	Retained as COC	Freq. of Detect.	Range	Max.	Retained as COC
SVOCs, ug/l								
2-Methylnaphthalene	0/1	ND	ND	No	1/12	5J	**5**	Yes
2,4-Dimethylphenol	0/1	ND	ND	No	2/12	1J - 5J	**5**	Yes
4-Chloro-3-methylphenol	0/1	ND	ND	No	4/12	1J - 29	**29**	Yes
Acenaphthylene	0/1	ND	ND	No	1/12	1J	1	No
Benzo(g,h,i)perylene	0/1	ND	ND	No	1/12	3J	3	No
Bis(2-ethylhexyl)phthalate	0/1	ND	ND	No	3/12	1J - 45J	45	No
Dibenzo(a,h)anthracene	0/1	ND	ND	No	1/12	2J	2	No
Diethylphthalate	0/1	ND	ND	No	1/12	1J - 10J	10	No
Di-n-butylphthalate	1/1	1	**1**	Yes	0/12	ND	ND	No
Total COCs			*1*				*39*	
Metals, ug/l								
Aluminum	1/2	682	**682**	Yes	3/12	165 - 5690	**5,690**	Yes
Arsenic	2/2	8.9 - 16.3	**16.3**	Yes	9/13	2 - 566	**566**	Yes
Barium	2/2	4.2J - 52.8	**52.8**	Yes	12/12	4.5 - 463	**463**	Yes
Cadmium	0/2	ND	ND	No	1/12	0.25J	**0.25**	Yes
Calcium	2/2	13600 - 18400	**18,400**	Yes	12/12	10500J - 148000	**148,000**	Yes
Chromium	0/2	ND	ND	No	8/12	1.3J - 10.4	**10.4**	Yes
Cobalt	0/2	ND	ND	No	9/12	1.2J - 74.6	**74.6**	Yes
Copper	0/2	ND	ND	No	1/12	1.2J - 1.4J	**1.4**	Yes
Cyanide	1/2	15J	**15**	Yes	1/17	1.5J	**1.5**	Yes
Iron	1/2	287 - 969	**969**	Yes	12/13	227J - 48000	**48,000**	Yes
Lead	0/2	ND	ND	No	8/12	1.8J - 65.1	**65.1**	Yes
Magnesium	2/2	4530J - 14600	**14,600**	Yes	12/12	1770J - 61500	**61,500**	Yes
Manganese	2/2	44J - 87	**87**	Yes	11/13	25.9J - 432000	**43,200**	Yes
Mercury	1/2	0.1	**0.1**	Yes	0/12	ND	ND	No
Nickel	1/2	5.2	**5.2**	Yes	7/12	5.4J - 100	**100**	Yes
Potassium	2/2	3020 - 7190	**7,190**	Yes	12/12	222 - 41,600	**41,600**	Yes
Selenium	1/2	4.3J	**4.3**	Yes	6/12	3.8J - 6.9J	**6.9**	Yes
Silver	0/2	ND	ND	No	2/12	1.4J - 1.5	**1.5**	Yes
Sodium	2/2	48700 - 300000	**300,000**	Yes	12/12	4360 - 363000	**363,000**	Yes
Thallium	0/2	ND	ND	No	3/12	6.8J - 11J	**11**	Yes
Vanadium	1/2	0.69J	**0.69**	Yes	6/12	0.6J - 2.3J	**2.3**	Yes
Zinc	0/2	ND	ND	No	2/12	7.6J - 31.6	**31.6**	Yes

Bold = Exposure Point Concentrations for COCs for each Area of Concern.
COCs = Compounds of Concern
NA = Not analyzed.
ND = Not detected.
J = Estimated Concentration.

Groundwater to the southeast of Landfill Areas 3 & 4 is represented by 13 shallow and deep groundwater monitoring wells MW-95-2S, MW-95-4R, MW-95-4RD, MW-95-6R, MW-95-7R, MW-4SA, MW-95-6S, MW-95-7S, MW-93-3, MW-93-5, MW-95-4SB, MW-95-8R, and USGS well 17-R. Groundwater samples were analyzed for VOCs, SVOCs, metals, and cyanide.

The groundwater COCs include 28 VOCs (maximum concentrations totaling 438 ug/l), three SVOCs (maximum concentrations totaling 39 ug/l), and 20 metals and cyanide, as presented in Table 4. Twelve VOCs and five SVOCs were eliminated as COCs because they were detected at low concentrations and during only one sampling event. Based on the validation process, these compounds are believed to be artifacts of the December 1995/January 1996 sampling effort because they were not detected during subsequent sampling events.

4.0 EXPOSURE ASSESSMENT

The purpose of the Exposure Assessment is to estimate the type and magnitude of potential exposure to site-related chemicals at or migrating from the site. The exposure estimates are compared to or combined with chemical-specific dose-response information to characterize potential risk to human receptors.

This assessment is conducted in accordance with USEPA and MEDEP methodology and guidance for conducting exposure assessments (USEPA, 1989a and 1991, and MEDEP 1994). These documents provide standard exposure scenarios and default values for many exposure parameters and were used, as appropriate, in this exposure assessment. These parameters were used to calculate an exposure dose for each scenario. Values for site-specific exposure parameters were chosen, as necessary, using best professional judgment and knowledge of expected current and future land use at the SML.

4.1 LAND USE

The site is approximately 90 acres, of which the four landfill areas comprise approximately 26 acres of the site. The site is bordered by wooded areas in all directions with the exception of a sand and gravel quarry southeast and adjacent to Area 4. The surrounding area is semi-rural, with residences located along Route 112, Louden Road and Route 5. These residents are provided with City water. Land use in the surrounding area is mixed, and includes primarily low-density residential, agricultural, light commercial and forested areas. Trespassers, accessing the site for recreational activities such as horseback riding, walking, snowmobiling etc. are considered to represent the maximally potentially exposed population. While there is some maintenance activity (e.g., mowing the landfill), these types of exposure are significantly less than possible trespasser exposure. In addition, it is highly unlikely that this site will ever be developed for residential purposes, due to the presence of the landfills and wetlands. The City of

Saco is currently placing institutional controls on the property to prohibit the future use of groundwater as a drinking water source. As such, future exposure at this site is expected to remain the same as current exposure.

Exposure by a trespasser to residual contamination at the SML is possible through several pathways. The exposure pathways evaluated under current and assumed future land uses are presented in Table 5. The standard equations and exposure parameters used to estimate exposure at this site are presented in Table 6. To provide a conservative estimate of potential exposure and risk, the maximum detected concentration of each COC was used as the EPC. To provide a more realistic EPC for arsenic in soils at Area 2, the 95% upper confidence limit of the arithmetic mean was used as the EPC. The exposure scenarios for each medium of concern are described below.

4.2 SOILS

Surface soils are potential exposure points for Landfill Areas 1 and 2. Landfill Areas 3 & 4 have been covered under CERCLA, and therefore, those soils are no longer considered to be an exposure point. Access to the SML is unrestricted and trespassers have been observed at the site. In addition, it is likely that neighborhood children may trespass onto the site and inadvertently come in contact with and ingest soil. Areas 1 & 2 are vegetated and, therefore, the inhalation of dust is an insignificant route of exposure compared to soil ingestion. Although some maintenance of the landfill is expected, a child trespasser is considered to be the maximally exposed receptor for purposes of this evaluation. Based on this information, the most likely current and future exposure scenario for this area includes:

- Children trespassers/recreational users (ages 6 - 18 years) exposed to soils through direct contact and incidental ingestion at Areas 1 and 2. The frequency of contact is assumed to be 112 days per year (best professional judgment) for a 12 year exposure duration (MEDEP 1994). It is assumed that the child ingests 100 mg soil, contacts 1,000 mg soil per event

TABLE 5
POTENTIAL EXPOSURE PATHWAYS

REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

POTENTIALLY EXPOSED POPULATION	EXPOSURE, ROUTE, MEDIUM & EXPOSURE POINT	PATHWAY SELECTED FOR EVALUATION	REASON FOR SELECTION OR EXCLUSION
Trespasser/Recreational User	Direct contact with and incidental ingestion of chemicals in surface soil.	Yes	Children living in the area could potentially be exposed to chemicals in surface soil if they trespass onto the site.
Trespasser/Recreational User	Direct contact with and incidental ingestion of surface water and sediment.	Yes	Children could potentially be exposed to chemicals in surface water and sediments if they trespass onto this area of the site.
Residents	Direct contact with surface water/sediments.	No	The site is not currently supporting residential development and through use of deed restrictions, these areas of the site will not be developed for residential uses in the future.
Residents	Direct contact with and incidental ingestion of chemicals in surface soil.	No	The landfill areas are not currently supporting residential development and will be prohibited from doing so in the future.
Residents	Ingestion of groundwater.	Yes	The site is not currently supporting residential development, and most of the site will be prohibited from doing so in the future. However, a future hypothetical residential scenario was evaluated.
Workers	Direct contact with and incidental ingestion of chemicals in surface soil.	No	Low frequency of exposure and low concentrations of chemicals detected in surface soils.

TABLE 6
EXPOSURE EQUATIONS AND PARAMETERS
REMDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

DIRECT CONTACT WITH SOILS/SEDIMENTS

Equation *Exposure Dose (mg/kg-day) =* $\frac{CS * CF * SA * AF * DAF * EF * ED}{BW * AT}$

Variables			Values		References
			Child Trespasser Exposed to Soils	Child Trespasser Exposed to Sediments	
CS	=	Chemical Conc. in soil (mg/kg)	See Table 1	See Table 2	
CF	=	Conversion Factor	10E-6 kg/mg	10E-6 kg/mg	
SA	=	Skin Surface Area	1,000 cm2/day	1,000 cm2/day	MEDEP 1994, EPA 1989
AF	=	Adherence Factor	1 mg/cm2	1 mg/cm2	MEDEP 1994
DAF	=	Dermal Absorption Factor	chem. specific	chem. specific	EPA, 1992
EF	=	Exposure Frequency	112 days/year	20 days/year	BPJ
ED	=	Exposure Duration	12 years	12 years	MEDEP 1994
BW	=	Body Weight	42 kg	42 kg	MEDEP 1994
AT	=	Averaging Time	70 years	70 years	EPA 1991

INGESTION OF SOILS/SEDIMENTS

Equation *Exposure Dose (mg/kg-day) =* $\frac{CS * CF * IR * RAF * EF * ED}{}$

Variables			Values		References
			Child Trespasser Exposed to Soils	Child Trespasser Exposed to Sediments	
CS	=	Chemical Conc. in soil (mg/kg)	See Table 1	See Table 2	
CF	=	Conversion Factor	10E-6 kg/mg	10E-6 kg/mg	
IR	=	Ingestion Rate	100 mg/day	100 mg/day	EPA 1991
RAF	=	Relative Absorption Factor	chem. specific	chem. specific	EPA, 1992
EF	=	Exposure Frequency	112 days/year	20 days/year	BPJ
ED	=	Exposure Duration	12 years	12 years	MEDEP 1994
BW	=	Body Weight	42 kg	42 kg	MEDEP 1994
AT	=	Averaging Time	70 years	70 years	EPA 1991

TABLE 6
EXPOSURE EQUATIONS AND PARAMETERS
REMDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

INGESTION OF GROUNDWATER

Equation *Exposure Dose (mg/kg-day) =* $\frac{CW * IR * RAF * EF * ED}{BW * AT}$

Variables			Values Residential Drinking Water Scenario	References
CW	=	Chemical Conc. in water (mg/l)	See Table 4	
IR	=	Ingestion Rate	2 liters /day	EPA 1991
RAF	=	Relative Absorption Factor	Chemical Specific	EPA, 1992
EF	=	Exposure Frequency	350 days/year	EPA 1991
ED	=	Exposure Duration	30 years	EPA 1991
BW	=	Body Weight	70 kg	EPA 1991
AT	=	Averaging Time	70 years	USEPA 1991

DIRECT CONTACT WITH GROUNDWATER

Equation *Exposure Dose (mg/kg-day) =* $\frac{CW * SA * PC * ET * EF * ED * CF * CF2}{BW * AT}$

Variables			Values Child Trespasser Exposed to Surface Water	References
CW	=	Chemical Conc. in water (mg/l)	See Table 4	
SA	=	Surface Area available for contact	19,400 cm2	MEDEP 1994
PC	=	Permeability Constant (cm/hr)	Chemical Specific	EPA, 1992
ET	=	Exposure Time	2.6 hours/day	EPA 1988, MEDEP 1994
EF	=	Exposure Frequency	2.9 days/year	BPJ
ED	=	Exposure Duration	30 years	MEDEP 1994
CF	=	Conversion Factor	1 liter/1000 cm3	
CF2	=	Conversion Factor 2	24 hours/day	
BW	=	Body Weight	42 kg	MEDEP 1994
AT	=	Averaging Time	70 years	EPA 1991

TABLE 6
EXPOSURE EQUATIONS AND PARAMETERS
REMDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

DIRECT CONTACT WITH SURFACE WATER

Equation *Exposure Dose (mg/kg-day) =* $\frac{CW * SA * PC * ET * EF * ED * CF}{BW * AT}$

Variables			Values Child Trespasser Exposed to Surface Water	References
CW	=	Chemical Conc. in water (mg/l)	See Table 3	
SA	=	Surface Area available for contact	5,240 cm2	MEDEP 1994
PC	=	Permeability Constant (cm/hr)	Chemical Specific	EPA, 1992
ET	=	Exposure Time	2.6 hours/day	EPA 1988, MEDEP 1994
EF	=	Exposure Frequency	20 days/year	BPJ
ED	=	Exposure Duration	12 years	MEDEP 1994
CF	=	Conversion Factor	1 liter/1000 cm3	
BW	=	Body Weight	42 kg	MEDEP 1994
AT	=	Averaging Time	70 years	EPA 1991

INGESTION OF SURFACE WATER

Equation *Exposure Dose (mg/kg-day) =* $\frac{CW * IR * RAF * ET * EF * ED}{BW * AT}$

Variables			Values Child Trespasser Exposed to Surface Water	References
CW	=	Chemical Conc. in water (mg/l)	See Table 3	
IR	=	Ingestion Rate	0.05 liters/hour	EPA 1988, MEDEP 1994
RAF	=	Relative Absorption Factor	Chemical Specific	EPA, 1992
ET	=	Exposure Time	2.6 hours/day	EPA, 1988, MEDEP 1994
EF	=	Exposure Frequency	20 days/year	BPJ
ED	=	Exposure Duration	12 years	MEDEP 1994
BW	=	Body Weight	42 kg	MEDEP 1994
AT	=	Averaging Time	70 years	EPA, 1991

TABLE 6
EXPOSURE EQUATIONS AND PARAMETERS
REMDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

SOURCES:

EPA, "Superfund Exposure Assessment Manual", April 1988.

EPA, "Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual (Part A) Interim Final", December 1989.

EPA, "Supplemental Risk Assessment Guidance for Superfund, Draft Final", June 1989.

EPA, "Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors, Interim Final", March 25, 1991.

MEDEP, "Guidance Manual for Human Health Risk Assessments at Hazardous Substance Sites", State of Maine Department of Environmental Protection and Department of Human Services, June 1994.

BPJ = Best Professional Judgement.

(MEDEP 1994 and EPA 1989), and weighs 42 kg (MEDEP 1994). Each exposure is assumed to be to the maximum detected concentration of each COC (with the exception of the 95th UCL for arsenic at Area 2). The exposure parameters used to quantify this route of exposure are presented in Table 6. Based on these assumptions, it is recognized that this scenario is an overly conservative estimate of potential exposure. However, it is included to demonstrate that even under unrealistic exposure assumptions, residual contamination at Areas 1 and 2 does not pose a significant risk.

4.3 SURFACE WATER AND SEDIMENTS

The potential for exposure to surface water and sediments is considered to be by primarily children trespassers/recreational users. Surface water bodies include the unnamed tributary to Deep Brook and Dubois Pond at Area 1; Sandy Brook to the west of Area 2; Sandy Brook to the southeast of Area 4; a pool and stream to the north of Area 3; a pool to the south of Area 4, and Big Ledge Brook to the south-southwest of Area 4. These areas may be attractive places to wade. Swimming is not considered to be a potential route of exposure due to the relatively narrow and/or shallow features of these waterways. Exposure to surface water and sediments is assumed to occur in the following way:

- Child trespassers/recreational users (ages 6-18 with an average weight of 42 kg) exposed to surface water and sediments through direct contact and incidental ingestion. The frequency of contact is assumed to be 20 days per year (twice per week for the 10 weeks of summer, best professional judgment) for a 12 year exposure duration. It is assumed that the child ingests 50 milliliters (mls) of surface water and 100 mg sediment per exposure (MEDEP 1994, EPA 1991). It is further assumed that the child is in contact with 1,000 mg sediment per event (MEDEP 1994, EPA 1989), and that the surface area exposed to the water is one-half the total body surface area, or 5,240 cm^2 (MEDEP 1994). Each exposure is assumed to be to the maximum detected concentration of each COC. The exposure parameters used to quantify this route of exposure are presented in Table 6.

4.4 GROUNDWATER

There is no current or likely future exposure to the groundwater beneath Landfill Areas 1, 2, 3, & 4. Most of the area surrounding the landfill is not a sustainable aquifer due to the presence of the landfills and the subsurface geology. Future residential development in this area is also unlikely due to the setback requirements required for the landfill and the surrounding waterways. The implementation of institutional controls is being conducted to restrict the use of the groundwater as a potential drinking water resource. However, for conservative purposes of this risk assessment, a potential future residential drinking water scenario was quantitatively and qualitatively evaluated, as follows.

- Residents (adults weighing 70 kg) exposed to groundwater through ingestion, dermal contact, and inhalation of volatiles. Residents are assumed to ingest 2 liters of water per day, 350 days per year, for a 30 year exposure duration (EPA 1991). For VOCs, inhalation and dermal exposures were evaluated by doubling the risk attributed to the ingestion pathway (EPA 1991). Exposure via dermal contact (19,400 cm^2 skin surface area) to non-VOCs is assumed to occur 2.9 days per year, for a 30 year exposure duration (EPA 1991, 1992). Each exposure is assumed to be to the maximum detected concentration of each COC. The exposure parameters used to quantify this route of exposure are presented in Table 6.

5.0 TOXICITY ASSESSMENT

The toxicity assessment provides information regarding the potential for a specific COC to cause adverse effects in humans, and characterizes the relationship between the dose of a chemical and the incidence of adverse health effects in the exposed population. The purpose of this assessment was to identify dose-response values that can be used to quantitatively evaluate potential health risks as a function of chemical exposure. The toxicity assessments were conducted separately for carcinogenic and noncarcinogenic effects.

5.1 CARCINOGENS

The USEPA is currently in the process of revising the guidelines for evaluating carcinogenic effects. The proposed guidelines, published in April 1996 (61FR32799) will result in changes such as: how the USEPA evaluates the mode of action of suspected carcinogens, the descriptors for classifying carcinogenic potential, and the subsequent hazard and risk characterization. However, until these guidelines are final, USEPA continues to rely on existing assessments. As such, it should be noted that the information in this section may need to be updated at a later date.

Currently carcinogens are categorized according to the weight of scientific evidence, both from animal and human studies, that indicates carcinogenicity; these categories include:

- **Group A - Human Carcinogen** - This category indicates that there is sufficient evidence from epidemiological studies to support a causal association between an agent and cancer in humans.

- **Group B - Probable Human Carcinogen** - This category generally indicates that there is at least limited evidence from epidemiological studies of carcinogenicity to

humans (Group B1) or that, in the absence of positive data on humans, there is sufficient evidence of carcinogenicity in animals (Group B2).

- **Group C - Possible Human Carcinogen** - This category indicates that there is limited evidence of carcinogenicity in animals, in the absence of positive human data.

- **Group D - Not Classified** - This category indicates that there was no data to evaluate or that the evidence for carcinogenicity in humans and in animals was inadequate.

- **Group E - No Evidence of Carcinogenicity to Humans** - This category indicates that there is no evidence for carcinogenicity in at least two adequate animal tests in different species or in both epidemiological and animal studies.

Carcinogenicity is further quantified by the cancer slope factor (CSF). The CSF is EPA's upper-bound lifetime probability of an individual developing cancer as a result of a lifetime exposure to a carcinogen. CSFs are determined by EPA and published in integrated risk information system (IRIS, 1996), an on-line database for toxicity data, and health effects assessment summary tables (HEAST, 1995). A summary of the oral dose-response information for carcinogenic effects, including the CSFs, for each COC is provided in Table 7.

5.2 NON-CARCINOGENS

Non-carcinogens are compounds that cause an effect other than carcinogenicity (e.g., liver damage, birth defects). Carcinogens may also have non-carcinogenic effects; these effects are considered and included with the effects of non-carcinogenic compounds. In addition, non-carcinogenic compounds differ from carcinogens in that they are believed to have threshold dosage levels below which adverse effects are not expected.

TABLE 7
ORAL DOSE-RESPONSE INFORMATION FOR CARCINOGENIC AND NON-CARCINOGENIC EFFECTS

REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

Compound	Weight of Evidence	Oral Slope Factor 1/(mg/kg-day)	Inhalation Slope Factor 1/(mg/kg-day)	Oral Reference Dose (mg/kg-day)	Inhalation Reference Dose (mg/kg-day)	Source	Permeability Constant
VOCs							
1,1-Dichloroethane	C			1.00E-01	1.43E-01	HEAST	8.90E-03
1,1-Dichlorothene	C	6.00E-01	1.75E-01	9.00E-03		IRIS	1.60E-02
1,1,1,2-Tetrachloroethane		2.60E-02	2.59E-02	3.00E-02		IRIS	
1,1,1-Trichloroethane	D			3.50E-02	2.86E-01	ECAO	1.70E-02
1,1,2,2-Tetrachloroethane	C	2.00E-01	2.03E-01			IRIS	9.00E-03
1,1-Dichloropropene							
1,2,3-Trichlorobenzene							
1,2,3-Trichloropropane	B2	7.00E+00		6.00E-03		IRIS	
1,2,4-Trichlorobenzene	D			1.00E-02	5.71E-02	IRIS/HEAST	
1,2,4-Trimethylbenzene				5.00E-02		ECAO	1.00E-01
1,2-Dibromomethane							
1,2-Dichlorobenzene	D			9.00E-02	4.00E-02	IRIS	6.10E-02
1,2-Dichloroethane	B2	9.10E-02	9.10E-02		2.86E-03	IRIS	5.00E-03
1,3,5-Trimethylbenzene				5.00E-02		ECAO	
1,3-Dichlorobenzene	D			8.90E-02		IRIS	8.70E-02
1,4-Dichlorobenzene		2.40E-02			2.29E-01	IRIS/HEAST	6.20E-02
2,2-Dichloropropane							
2-Butanone (MEK)	D			6.00E-01	2.86E-01	IRIS	5.00E-03
2-Chlorotoluene				2.00E-02		IRIS	
2-Hexanone							
4-Chloro-3-methylphenol							
4-Chlorotoluene							
4-Isopropyltoluene							
Acetone	D			1.00E-01		IRIS	
Benzene	A	2.90E-02	2.90E-02		1.71E-03	IRIS	1.10E-01
Bromobenzene							
Bromodichloromethane	B2	6.20E-02		2.00E-02		IRIS	5.80E-03
Bromomethane	D			1.40E-03	1.40E-03	IRIS	3.50E-03
Chlorobenzene	D			2.00E-02	5.71E-03	IRIS	4.10E-02
Chloroethane	ND			4.00E-01	2.86E+00	IRIS	8.00E-03
Chloroform	B2	6.10E-03	8.05E-02	1.00E-02		IRIS	8.90E-03
Chloromethane	C	1.30E-02	6.30E-03			HEAST	4.20E-03
cis-1,2-Dichloroethene	D			1.00E-02		IRIS	
Dibromomethane							
Dichlorodifluoromethane	ND			2.00E-01	5.71E-02	IRIS	1.20E-02
Ethylbenzene	D			1.00E-01	2.86E-01	IRIS	1.00E+00
Hexachlorobutadiene	C	7.80E-02	7.70E-02	2.00E-04		IRIS/HEAST	
Isopropylbenzene							
Isopropyltoluene							
Methylene Chloride	C	7.50E-03	1.64E-03	6.00E-02	8.57E-01	IRIS	4.50E-03
m,p-Xylene	D			2.00E+00	8.57E-02	HEAST	8.00E-02
n-Butylbenzne							

TABLE 7
ORAL DOSE-RESPONSE INFORMATION FOR CARCINOGENIC AND NON-CARCINOGENIC EFFECTS

REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

Compound	Weight of Evidence	Oral Slope Factor 1/(mg/kg-day)	Inhalation Slope Factor 1/(mg/kg-day)	Oral Reference Dose (mg/kg-day)	Inhalation Reference Dose (mg/kg-day)	Source	Permeability Constant
n-Propylbenzene							
Naphthalene	D			4.00E-02		W	6.90E-02
o-Xylene	D			2.00E+00	2.00E-01	HEAST	
sec-Butylbenzene				1.00E-02		ECAO	
tert-Butylbenzene				1.00E-02		ECAO	
Tetrachloroethene	B2	5.20E-02	2.03E-03	1.00E-02		IRIS/ECAO	3.70E-01
Tetrahydrofuran	ND						
Toluene	D			2.00E-01	1.14E-01	IRIS	1.00E+00
trans-1,2-Dichloroethene				1.00E-02		HEAST	1.00E-02
Trichloroethene	B2	1.10E-02	6.00E-03	6.00E-03		ECAO	2.30E-01
Trichlorofluoromethane	ND			3.00E-01	2.00E-01	IRIS	1.70E-02
SVOCs							
2-Methylnaphthalene							
2,4-Dimethylphenol				2.00E-02		IRIS	1.10E-01
Benzo(a)anthracene	B2	7.30E-01	6.10E-01			ECAO	8.10E-01
Benzo(a)pyrene	B2	7.30E+00	6.10E+00			IRIS	1.20E+00
Benzo(b)fluoranthene	B2	7.30E-01	6.10E-01			ECAO	1.20E+00
Benzo(k)fluoranthene	B2	7.30E-02	6.10E-02			ECAO	
Benzo(g,h,i)perylene							
Bis(2-ethylhexyl)phthalate	B2	1.40E-02		2.00E-02		IRIS	
Chyrsene	B2	7.30E-03	6.10E-03			ECAO	8.10E-01
Diethylphthalate	D			8.00E-01		IRIS	4.80E-03
Di-n-buylphthalate	D					IRIS	
Di-n-octylphthalate	ND			2.00E-02		HEAST	
Fluoranthene	D			4.00E-02		IRIS	3.60E-01
Hexachlorobutadiene	C	7.80E-02	7.70E-02	2.00E-04		HEAST	1.20E-01
Indeno(1,2,3-cd)pyrene	B2	7.30E-01	6.10E-01			ECAO	1.90E+00
Phenanthrene	D					IRIS	2.30E-01
Pyrene	D			3.00E-02		IRIS	
Pesticides/PCBs							
4,4-DDT	B2	3.40E-01	3.40E-01	5.00E-04		IRIS	4.30E-01
4,4-DDD	B2			2.40E-01		IRIS	2.80E-01
4,4-DDE	B2			3.40E-01		IRIS	2.40E-01
Alpha-Chlordane		1.30E+00	1.29E+00	6.00E-05		IRIS	5.20E-02
Dieldrin	B2	1.60E+01	1.61E+00	5.00E-05		IRIS	1.60E-02
Endosulfan II	NA			6.00E-03		IRIS	
Endrin ketone	D			3.00E-04		IRIS	1.60E-02
gamma-Chlordane	B2	1.30E+00	1.29E+00	6.00E-05		IRIS	5.20E-02
Heptachlor epoxide	B2	9.10E+00	9.10E+00	1.30E-05		IRIS	1.10E-02
PCB-1260	B2	2.00E+00	4.00E-01	2.00E-05		IRIS	

TABLE 7
ORAL DOSE-RESPONSE INFORMATION FOR CARCINOGENIC AND NON-CARCINOGENIC EFFECTS

REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

Compound	Weight of Evidence	Oral Slope Factor 1/(mg/kg-day)	Inhalation Slope Factor 1/(mg/kg-day)	Oral Reference Dose (mg/kg-day)	Inhalation Reference Dose (mg/kg-day)	Source	Permeability Constant
Metals							
Aluminum	ND						
Antimony	ND			4.00E-04		IRIS	
Arsenic	A	1.50E+00	1.51E+00	3.00E-04		IRIS	
Barium	ND			7.00E-02	1.43E-04	IRIS	
Beryllium	B2	4.30E+00	8.40E+00	5.00E-03		IRIS	
Cadmium	B1		6.30E+00	5.00E-04	5.71E-05	IRIS	
Calcium							
Chromium VI	A		4.20E+01	5.00E-03		IRIS	
Cobalt	ND						
Copper	D						
Iron	ND						
Lead	B2	ND				IRIS	
Magnesium	ND					IRIS/EPA	
Manganese	D			2.40E-02	1.53E-05	IRIS	
Mercury	D			3.00E-04	8.57E-05	HEAST	
Nickel	ND			2.00E-02		IRIS	
Potassium							
Selenium	D			5.00E-03		IRIS	
Silver	D			5.00E-03		IRIS	
Sodium							
Thallium	ND					IRIS	
Vanadium	ND			7.00E-03		HEAST	
Zinc	D			3.00E-01		IRIS	
Cyanide	D			2.00E-02		IRIS	

NA - Not Applicable (not carcinogenic by oral route)
ND - Not Determined
W - Withdrawn from IRIS
mg - milligram kg - kilogram
IRIS - Integrated Risk Information System
HEAST - Health Effects Assessment Summary Tables
ECAO - Environmental Criteria and Assessment Office

IRIS as of 12/96
HEAST, May 1995
ECAO, 1992

Weight of Evidence: A - Human carcinogen
B - Probable human carcinogen (B1 - limited evidence of cancer in humans; B2 - sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans)
C - Possible human carcinogen
D - Not classifiable as to human carcinogenicity
E - Evidence of lack of carcinogenicity to humans

EPA's preferred criterion for quantifying non-carcinogenic risk is the reference dose (RfD), which corresponds to EPA's identification of the threshold effects level with an added margin of safety. The IRIS database maintains a current listing of all the verified RfDs, which are reported in units of mg/kg-day. By definition, the RfD is an estimate of an average daily exposure level below which significant, adverse non-carcinogenic health effects are not expected.

Table 7 presents the chronic RfDs and oral dose-response information for non-carcinogenic effects for each COC at SML. Toxicity profiles for selected site contaminants (arsenic, manganese, benzene, TCE, lead, nickel, and thallium) are provided in Attachment C. Toxicity profiles for other COCs are available from the IRIS database.

5.3 OTHER ISSUES

There is little biokinetic or toxicological information available to quantitatively estimate dermal absorption of contaminants in soil or sediments (EPA, 1992). EPA guidance has provided estimates of the dermal absorption of only three contaminants: dioxin, cadmium, and tetrachlorobiphenyl. Of these, cadmium and PCBs have been detected at the SML and therefore, are quantitatively evaluated in this risk assessment. Dermal exposure to other contaminants are only qualitatively evaluated and discussed in the uncertainty section.

Toxicity data is not currently available for lead. According to IRIS, a great deal of information on the health effects of lead has been obtained through decades of medical observation and scientific research. However, EPA has considered it inappropriate to develop an RfD for inorganic lead. Furthermore, lead is classified as a B2 carcinogen. However, due to uncertainties in quantifying the carcinogenic risk (some of which may be unique to lead), EPA recommends that a numerical estimate not be used (IRIS, 1996). As a result, quantitative estimates of risk could not be calculated for lead. Lead was evaluated by qualitatively comparing the exposure point concentration to applicable EPA and MEDEP criteria.

RfDs for aluminum, cobalt, copper, and iron are not available through IRIS or HEAST. Provisional RfDs are available through the EPA Environmental Criteria and Assessment Office; however, these provisional RfDs are not routinely acknowledged by EPA Region 1. Therefore, these metals were not quantitatively evaluated in this Risk Assessment, but were included in the qualitative evaluation.

The inhalation pathway is considered for VOCs when evaluating the hypothetical drinking water scenario. However, EPA does not advocate the quantitative assessment of the inhalation of VOCs from household water uses. Instead, the risk attributed to the ingestion of groundwater was doubled to account for this exposure pathway.

6.0 RISK CHARACTERIZATION

This section presents the quantitative risk estimates developed for the exposure pathways described in Section 4.0 and a qualitative evaluation of potential risk where applicable. The risk estimates were generated by combining the numerical exposure dose estimates with the quantitative dose-response data. It should be emphasized that the risk estimates are based on numerous conservative exposure assumptions including exposure to maximum detected site concentrations. The results are presented in this section for each Landfill Area.

Both carcinogenic and noncarcinogenic risks estimates were derived, as described below. The non-carcinogenic risk estimates include non-carcinogenic effects from exposure to carcinogens.

Carcinogenic Effects

Carcinogenic risks were evaluated by multiplying the estimated exposure dose by the CSF to obtain an estimate of incremental risk, as follows:

$$\text{Carcinogenic Risk} = \text{Exposure Dose (mg/kg-day)} \times \text{CSF (mg/kg-day)}^{-1}$$

The CSF converts the estimated daily intake of a chemical averaged over a lifetime of exposure to an incremental risk of an individual developing cancer. The CSF used in these calculations is often the upper 95^{th} percentile confidence limit of the probability of a response based on experimental data. As such, the carcinogenic risk estimates presented in this assessment are considered to be an upper-bound estimate of risk. The "true risk" to an individual is likely to be much less than predicted in this assessment (USEPA, 1989a).

The cancer risks of each compound are summed within each exposure scenario. USEPA's guidelines state that the total incremental carcinogenic risk for an individual resulting from

exposure at a hazardous waste site should not exceed a target risk range of $1x10^{-6}$ to $1x10^{-4}$ (USEPA, 1990). In this risk assessment, the estimated carcinogenic risk for each exposure scenario was compared to these USEPA values.

MEDEP has set $1x10^{-5}$ as the upper bound for an acceptable incremental lifetime cancer risk (MEDEP 1994). It is noted in any case where the estimated carcinogenic risk exceeds the MEDEP upperbound target risk of $1x10^{-5}$, but is within the USEPA target risk range of $1x10^{-6}$ to $1x10^{-4}$.

Non-carcinogenic Effects

Non-carcinogenic effects were quantified in terms of a Hazard Index (HI), which was calculated by dividing the exposure dose by the RfD:

Hazard Index (HI) = Exposure Dose (mg/kg-day) / RfD (mg/kg-day)

Non-carcinogenic risks were evaluated by dividing the exposure dose of each compound by its respective RfD, and summing the resulting hazard index for each compound within each exposure scenario. The resulting cumulative non-carcinogenic risk for each exposure scenario was compared to the USEPA target HI of 1. If the HI is less than or equal to 1, no adverse health effects are anticipated from the predicted exposure dose level. If the HI is greater than 1, the predicted exposure dose level could potentially cause adverse effects (USEPA 1989a).

All quantitative risk estimates are presented in Attachment B and summarized in Table 8. The quantitative and qualitative risk characterization results for each exposure scenario are presented by Landfill Area, as summarized below.

6.1 LANDFILL AREA 1

Two exposure scenarios were evaluated for Landfill Area 1. The first scenario evaluated children trespassers/recreational users potentially exposed to surface soils, sediments, and/or surface water. The second scenario evaluated hypothetical future residents potentially exposed to deep groundwater downgradient of Areas 1 & 2 as drinking water (discussed in Section 6.2). The quantitative and qualitative risk assessment results are presented for each scenario, below.

6.1.1 Children Trespasser/Recreational Scenario

The children trespasser/recreational scenario evaluated potential exposure to surface soils, sediments, and/or surface waters at three sub-areas of concern. These sub-areas are Landfill Area 1, the Unnamed Tributary to Deep Brook, and Dubois Pond.

- Landfill Area 1: Children trespassers/recreational users are potentially exposed to surface soils at Landfill Area 1. The carcinogenic risk was estimated to be $1.8x10^{-6}$ and the HI was estimated to be $3.5x10^{-2}$. These potential risks are below the USEPA and MEDEP upperbound limits of acceptable risk. Lead was detected in surface soils at a maximum concentration of 18.4 mg/kg, well below the USEPA screening concentration of 400 mg/kg (USEPA, 1994) and the MEDEP draft soil guidelines of 375 mg/kg (MEDEP 1994).

- Unnamed Tributary to Deep Brook: Children trespassers/recreational users are potentially exposed to sediments and surface waters in the unnamed tributary to Deep Brook, located to the southeast of Landfill Area 1. The associated carcinogenic risk was estimated to be $3.6x10^{-6}$ and the HI was estimated to be $3.0x10^{-2}$. These potential risks are below the USEPA and MEDEP upperbound limits of acceptable risk.

TABLE 8
SUMMARY OF SITE RISK
REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

SCENARIOS		Carcinogenic Risk	Hazard Index
LANDFILL AREA 1			
Trespasser Scenario by Sub Area of Concern			
Area 1	Soils, *Total*	*1.8E-6*	*3.5E-2*
Unnamed Tributary	Sediments	3.6E-6	1.2E-2
	Surface Water	3.7E-8	1.8E-2
	Total	*3.6E-6*	*3.0E-2*
Dubois Pond	Soils	1.2E-6	2.2E-2
	Sediments	2.8E-7	4.4E-3
	Surface Water	8.1E-10	9.3E-3
	Total	*1.5E-6*	*3.6E-2*
LANDFILL AREA 2			
Trespasser Scenario by Sub Area of Concern			
Area 2	Soils, *Total*	*8.0E-6*	*1.9E-1*
Sandy Brook	Sediments	8.7E-7	8.2E-3
	Surface Water	5.0E-8	9.9E-4
	Total	*9.2E-7*	*9.2E-3*
LANDFILL AREAS 1 &2			
Residential Drinking Water Scenario			
Areas 1 & 2	Deep Groundwater, *Total*	***2.8E-4***	***1.6E+0***
LANDFILL AREAS 3 & 4			
Trespasser Scenario by Sub Area of Concern			
Stream/Pool North	Sediments	6.8E-7	3.9E-2
	Surface Water	1.6E-7	2.5E-3
	Total	*8.4E-7*	*4.2E-2*
Sandy Brook	Sediments	6.3E-6	1.1E-2
	Surface Water	5.3E-7	9.8E-3
	Total	*6.8E-6*	*2.1E-2*
Pool South	Sediments	4.6E-7	6.9E-3
	Surface Water	8.1E-7	1.5E-2
	Total	*1.3E-6*	*2.2E-2*
Big Ledge Brook	Sediments	1.7E-7	3.7E-3
	Surface Water	0.0E+0	3.2E-3
	Total	*1.7E-7*	*6.9E-3*
LANDFILL AREAS 3 & 4			
Residential Drinking Water Scenario			
Wells South	Groundwater, *Total*	***1.0E-2***	***1.0E+2***

Bold indicates Carcinogenic Risk exceeds 1E-4 or HI exceeds 1.

- Dubois Pond: Children trespassers/recreational users are potentially exposed to sediments and surface waters in Dubois Pond and surface soils around Dubois Pond, located to the south of the Landfill Area 1. The associated carcinogenic risk was estimated to be $1.5x10^{-6}$ and the HI was estimated to be $3.6x10^{-2}$. These potential risks are below the USEPA and MEDEP upperbound limits of acceptable risk. Lead was detected in surface soils at a maximum concentration of 8.6 mg/kg, well below the USEPA screening concentration of 400 mg/kg and the MEDEP draft soil guidelines of 375 mg/kg.

6.2 LANDFILL AREA 2

Two exposure scenarios were evaluated for Landfill Area 2. The first scenario evaluated children trespassers/recreational users potentially exposed to surface soils, sediments, and/or surface water. The second scenario evaluated hypothetical future residents potentially exposed to deep groundwater downgradient of Areas 1 & 2 as drinking water. The quantitative and qualitative risk assessment results are presented for each scenario, below.

6.2.1 Children Trespasser/Recreational Scenario

The children trespasser/recreational scenario evaluated potential exposure to surface soils, sediments, and/or surface waters at two sub-areas of concern. These sub-areas are Landfill Area 2 and Sandy Brook.

- Landfill Area 2: Children trespassers/recreational users are potentially exposed to surface soils at Landfill Area 2. The carcinogenic risk was estimated to be $8.0x10^{-6}$, which is within the USEPA target risk range and below the MEDEP target cancer risk. The HI was estimated to be 0.19, less than the target HI of 1.0.

Lead was detected in surface soils at a maximum concentration of 37.6 mg/kg, well below the USEPA screening concentration of 400 mg/kg (USEPA, 1994) and the MEDEP draft soil guidelines of 375 mg/kg (MEDEP 1994).

- Sandy Brook: Children trespassers/recreational users are potentially exposed to sediments and surface waters in Sandy Brook, located to the west of Landfill Area 2. The associated carcinogenic risk was estimated to be $9.2x10^{-7}$ and the HI was estimated to be $9.2x10^{-3}$. These potential risks are below the USEPA target risk range and MEDEP upperbound limits of acceptable risk.

6.2.2 Residential Drinking Water Scenario

Although the groundwater downgradient of Landfill Areas 1 & 2 is not currently and will not foreseeably be used for drinking water purposes, a residential drinking water scenario was evaluated for conservative purposes. The quantitative and qualitative results of the risk characterization for this scenario are presented below.

- Landfill Areas 1 & 2: Future residents are assumed to be potentially exposed to groundwater via a drinking water scenario. The carcinogenic risk was estimated to be $2.8x10^{-4}$ and the HI was estimated to be 1.6. These potential risks just exceed the USEPA and MEDEP upperbound limits of acceptable risk. Arsenic contributes most significantly to both carcinogenic risk (100%) and non-carcinogenic risk (98%) (see Table B-18 in Attachment B). Arsenic was detected at a high of 16 ug/l at well 93-4, but does not exceed federal maximum contaminant levels (MCLs) or state maximum exposure guidelines (MEGs) as discussed below.

  Groundwater was also qualitatively evaluated by comparing EPCs to federal MCLs and state MEGs, as shown in Table 9. None of the EPCs, including arsenic, exceed available federal MCLs or state MEGs.

TABLE 9
COMPARISON OF GROUNDWATER EPCs TO DRINKING WATER STANDARDS
REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

PARAMETER	LANDFILL AREAS 1 & 2 Downgradient EPC	LANDFILL AREAS 3 & 4 South EPC	DRINKING WATER STANDARDS	
			Federal MCLs	State MEGs
VOCs, ug/l				
1,1-Dichloroethane	Not CPC	1	NA	5
1,2,3-Trichlorobenzene	Not CPC	1	NA	NA
1,2,4-Trichlorobenzene	Not CPC	1	70	70
1,2,4-Trimethylbenzene	Not CPC	9	NA	NA
1,2-Dichlorobenzene	Not CPC	5	600	85
1,2-Dichloroethane	Not CPC	1	5	5
1,3,5-Trimethylbenzene	Not CPC	5	NA	NA
1,4-Dichlorobenzene	Not CPC	7	75	27
2,2-Dichloropropane	Not CPC	0.4	NA	NA
4-Isopropytoluene	Not CPC	4	NA	NA
Acetone	3	Not CPC	NA	NA
Benzene	Not CPC	**13**	5	5
Chlorobenzene	Not CPC	5	NA	47
Chloroethane	Not CPC	93	NA	NA
Chloromethane	Not CPC	2	NA	3
cis-1,2-DCE	Not CPC	5	70	70
Dichlorodifluoromethane	Not CPC	1	NA	NA
Ethylbenzene	Not CPC	34	700	700
Isopropylbenzene	Not CPC	6	NA	NA
Isopropyltoluene	Not CPC	Not CPC	NA	NA
Methylene Chloride	Not CPC	1	NA	48
Naphthalene	Not CPC	13	NA	25
Tetrachloroethene	Not CPC	Not CPC	5	3
Tetrahydrofuran	Not CPC	170	NA	NA
Toluene	Not CPC	3	1,000	1,400
trans-1,2-DCE	Not CPC	1	100	70
Trichloroethene	Not CPC	**7**	5	5
m-Xylene/p-Xylene	Not CPC	32	10,000	600
n-Butylbenzene	Not CPC	2	NA	NA
n-Propylbenzene	Not CPC	2	NA	NA
o-Xylene	Not CPC	14	10,000	600
SVOCs, ug/l				
2-Methylnaphthalene	Not CPC	5	NA	NA
2,4-Dimethylphenol	Not CPC	5	NA	NA
4-Chloro-3-methylphenol	Not CPC	29	NA	NA
Bis(2-ethylhexyl)phthalate	Not CPC	Not CPC	NA	25
Di-n-butylphthalate	1	Not CPC	NA	220

TABLE 9
COMPARISON OF GROUNDWATER EPCs TO DRINKING WATER STANDARDS
REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

PARAMETER	LANDFILL AREAS 1 & 2 Downgradient EPC	LANDFILL AREAS 3 & 4 South EPC	DRINKING WATER STANDARDS Federal MCLs	DRINKING WATER STANDARDS State MEGs
Metals, ug/l				
Aluminum	682	**5,690**	NA	1,430
Arsenic	16.3	**566**	50	NA
Barium	52.8	463	2,000	1,500
Cadmium	Not CPC	0.25	5	5
Calcium	18,400	148,000	NA	NA
Chromium	Not CPC	10.4	100	100
Cobalt	Not CPC	74.6	NA	NA
Copper	Not CPC	1.4	NA	NA
Cyanide	15	1.5	200	154
Iron	969	48,000	NA	NA
Lead	Not CPC	**65.1**	NA	20
Magnesium	14,600	61,500	NA	NA
Manganese	87	**43,200**	NA	200
Mercury	0.1	ND	2	2
Nickel	5.2	**100**	100	150
Potassium	7,190	41,600	NA	NA
Selenium	4.3	6.9	50	10
Silver	Not CPC	1.5	NA	50
Sodium	300,000	363,000	NA	NA
Thallium	Not CPC	**11**	2	0.4
Vanadium	0.69	2.3	NA	NA
Zinc	Not CPC	31.6	NA	NA

NOTES:
EPC = Exposure Point Concentration.
MCLs = Federal Maximum Contaminant Levels, Februrary 1996.
MEGs = State of Maine Maximum Exposure Guidelines, September 1992.
Not CPC = Not Compound of Concern.
NA = Not Available.
Bold = EPCs exceed MCLs or MEGs.

6.3 LANDFILL AREAS 3 AND 4

Two exposure scenarios were evaluated for Landfill Areas 3 and 4. The first scenario evaluated children trespassers/recreational users potentially exposed to surface soils, sediments, and/or surface water. The second scenario evaluated hypothetical future residents potentially exposed to groundwater as drinking water. The quantitative and qualitative risk assessment results are presented for each scenario, below.

6.3.1 Children Trespasser/Recreational Scenario

The children trespasser/recreational scenario evaluated potential exposure to sediments and/or surface waters at four sub-areas of concern. These sub-areas are the stream/pool north of Landfill Areas 3 & 4, Sandy Brook to the southeast of Landfill Areas 3 & 4, the pool to the southeast of Landfill Areas 3 & 4, and Big Ledge Brook to the southwest of Landfill Areas 3 & 4.

- Stream/Pool North of Landfill Areas 3 & 4: Children trespassers/recreational users are potentially exposed to sediments and surface water at the stream and pool to the north of Landfill Areas 3 & 4. The carcinogenic risk was estimated to be $8.4x10^{-7}$ and the HI was estimated to be $4.2x10^{-2}$. These potential risks are below the USEPA target risk range and MEDEP upperbound limits of acceptable risk.

- Sandy Brook: Children trespassers/recreational users are potentially exposed to sediments and surface waters in Sandy Brook, located to the southeast of Landfill Areas 3 & 4. The associated carcinogenic risk was estimated to be $6.8x10^{-6}$ and the HI was estimated to be 2.110^{-2}. These potential risks are below the USEPA and MEDEP upperbound limits of acceptable risk.

- Pool South of Landfill Areas 3 & 4: Children trespassers/recreational users are potentially exposed to sediments and surface waters in the pool to the south of the Landfill Areas 3 & 4. The associated carcinogenic risk was estimated to be $1.3x10^{-6}$ and the HI was estimated to be $2.2x10^{-2}$. These potential risks are below the USEPA and MEDEP upperbound limits of acceptable risk.

- Big Ledge Brook: Children trespassers/recreational users are potentially exposed to sediments and surface waters in Big Ledge Brook to the southwest of the Landfill Areas 3 & 4. The associated carcinogenic risk was estimated to be $1.7x10^{-7}$ and the HI was estimated to be $6.9x10^{-3}$. These potential risks are below the USEPA target risk range and MEDEP upperbound limits of acceptable risk.

6.3.2 Residential Drinking Water Scenario

Although the groundwater around Landfill Areas 3 & 4 is not currently and will not likely be used for future drinking water purposes, a residential drinking water scenario was evaluated for conservative purposes for groundwater downgradient and to the south-southeast of Areas 3 & 4, as presented below.

- Wells to the Southeast of Landfill Areas 3 & 4: Future residents are assumed to be potentially exposed to groundwater via a drinking water scenario. The carcinogenic risk was estimated to be $1.0x10^{-2}$ and the HI was estimated to be $1.0x10^{+2}$. These potential risks exceed the USEPA and MEDEP upperbound limits of acceptable risk. The compound contributing most significantly to carcinogenic risk (see Table B-19 in Attachment B) was arsenic (detected at 566 ug/l and contributing 99.8% of the risk). The compounds contributing most significantly to non-carcinogenic risk were arsenic (detected 566 ug/l and contributing 50.8% of the risk) and manganese (detected at 43,200 ug/l and contributing 48.6% of the risk).

Groundwater was also qualitatively evaluated by comparing EPCs to federal MCLs and state MEGs, as shown in Table 9. The maximum concentrations of eight chemicals detected in wells southeast of Landfill Areas 3 & 4 met or exceeded the MCLs and/or the MEGs: benzene, trichloroethene, aluminum, arsenic, lead, manganese, nickel, and thallium. Available toxicity profiles for these compounds are provided in Attachment C.

7.0 UNCERTAINTIES AND LIMITATIONS

The quantitative estimates of risk are based on a considerable number of assumptions. These assumptions and associated uncertainties are generally associated with the following aspects of the project: sampling and analysis, exposure point concentration estimation, exposure parameter estimation, and toxicity assessment. As outlined in Table 10, each uncertainty may result in an underestimate or overestimate of risk. Overall, however, assumptions were made in this risk assessment to render the final risk estimates as conservative.

The parameters used to estimate exposure doses were considered to be conservative. For example, the sampling data was biased high because it was collected to identify potential hot spots of contamination. The EPCs were extremely conservative, because they were based on the maximum detected concentrations (except for arsenic in soils at Area 2 where a more realistic approach was taken by using the 95th percent upper confidence limit of the arithmetic mean). The intake rates and exposure frequency, duration, and intensity for potential children receptors were based on conservative assumptions.

Uncertainties in the toxicity data may over or underestimate the risk. The available toxicity data is typically based on conservative assumptions. However, toxicity data is not available for all site-related chemicals, i.e. iron, aluminum, lead, cobalt, and copper. Due to the lack of toxicity data, these compounds were not quantitatively evaluated in the risk assessment. However, these compounds were qualitatively evaluated when possible, based on a comparison to available federal or state standards or screening levels.

TABLE 10
POTENTIAL SOURCES OF UNCERTAINTY

REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

POTENTIAL SOURCE	DIRECTION OF EFFECT	JUSTIFICATION
Site-Specific Factors		
Location and adequacy of sampling	Overestimate	Sampling program was designed to identify areas of contamination and potential hot spots. Analytical data is biased high.
Exposure assumptions (frequency, duration, and intensity)	Overestimate	Parameters selected are conservative estimates of potential exposure. Exposure point concentrations (e.g., maximum concentrations) are biased high.
Limited dermal absorption information	May underestimate	Quantitative information currently exists for only three compounds (see text).
Toxicity-Related Factors:		
Extrapolation of animal toxicity data to humans	Unknown, probably overestimate	Animals and human differ with respect to absorption, distribution, metabolism, and excretion of chemicals. The magnitude and direction of the difference will vary with each chemical. Animal studies typically involve high-dose exposures, whereas humans are exposed to low doses in the environment.
Use of linearized, multi-stage model to derive cancer slope factors	Overestimate	Model results in a 95 percent upper confidence limit of the cancer risk. The true risk is unlikely to be higher and may be as low as zero.
Available Toxicity Data	Unknown, possibly underestimate	There are no EPA Region I acknowledged CSFs or RfDs for several COCs, including aluminum, cobalt, copper, and iron.

8.0 SUMMARY AND CONCLUSIONS

This Human Health Risk Assessment was completed in support of the RI conducted for the SML Superfund Site in Saco, Maine. The Human Health Risk Assessment was conducted in accordance with MEDEP and USEPA methodology and guidance, including: "Guidance Manual for Human Health Risk Assessment at Hazardous Waste Sites" (MEDEP, 1994), "Risk Assessment Guidance for Superfund: Volume I Human Health Evaluation" (EPA, 1989a), the "Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors" (USEPA, 1991), USEPA Region I Waste Management Division Risk Updates, and additional guidance as appropriate.

The objectives of this Human Health Risk Assessment, as required by CERCLA, are to provide:

- an evaluation of potential human health risks and a basis for determining the need, if any, for remedial action at the SML;

- a basis for determining the appropriate remedial target cleanup levels for contaminants in soils, groundwater, sediments, and/or surface water, as necessary; and

- a basis for comparing the potential health impacts of various proposed remedial alternatives.

The Human Health Risk Assessment consisted of the following components:

The Site Characterization provided in the RI and summarized in this Risk Assessment presented the site background and conceptual model. Based on the site characterization, this Risk Assessment evaluated potential risks separately for Landfill Area 1, Landfill Area 2, and Landfill Areas 3 and 4. For each of these areas of concern, sub-areas of concern were identified.

The Hazard Assessment presented the site data, the COCs, and the EPCs for each area of concern by medium. The data was presented for the following media of concern: soils, sediments, surface water, and groundwater. The selected COCs included pesticides/PCBs, VOCs, SVOCs, and/or metals, and consisted of all the chemicals detected at least once at a concentration greater than the instrument detection limit for each medium and area of concern. EPA guidance (EPA 1989a) allows for the elimination of chemicals as COCs based on frequency of detection, detection in laboratory blanks, naturally occurring chemicals present at background concentrations, or chemicals considered to be essential human nutrients. However, for conservative purposes, the only compounds that were eliminated as COCs in this risk assessment were chemicals in groundwater that were determined through the validation process to be artifacts of the sampling effort. The EPCs were assumed to be the maximum detected concentration of each COC for each medium and area of concern, for conservative purposes. To account for a more realistic exposure to soils at Area 2, the 95% upper confidence limit of the arithmetic mean was used as the EPC for arsenic.

The Exposure Assessment estimated the type and magnitude of potential exposure to site-related chemicals at or migrating from the site. Children trespassers/recreational users potentially exposed to surface soils, sediments, and surface waters at the SML were considered to be the most sensitive site receptors. Future use of groundwater as drinking water is not foreseeable due to most of the SML being an unsustainable aquifer (see Section 3.7 of the RI report); most of the SML being unsuitable for residential development due to the presence of the landfill and surrounding waterways; and due to institutional controls which are being implemented to prevent the use of groundwater as drinking water at the SML. While groundwater is not currently nor is likely to be used in the future as a drinking water resource, a future potential residential drinking water scenario was evaluated for conservative purposes of this risk assessment. Therefore, exposure doses were estimated for both child trespasser/recreational and residential drinking water scenarios based on USEPA and MEDEP guidance.

The Toxicity Assessment identified carcinogenic and non-carcinogenic toxicological dose-response values for each of the COCs. This information was combined with the exposure doses to quantitatively evaluate potential carcinogenic and non-carcinogenic risks.

The Risk Characterization presented the quantitative and qualitative risk estimates for each exposure scenario for each sub-area of concern within each Landfill Area. Carcinogenic risks were compared to the USEPA target risk range of $1x10^{-6}$ to $1x10^{-4}$, and the MEDEP upperbound limit of acceptable risk of $1x10^{-5}$. Non-carcinogenic HIs were compared to the USEPA and MEDEP target risk of 1.0. Groundwater was qualitatively evaluated by comparison to federal MCLs and state MEGs. These results are presented in greater detail, below.

The Uncertainties and Limitations section of the report identified the uncertainties inherent in risk assessment, including the uncertainties in sampling and analysis, exposure parameter estimation, and toxicity assessment. Each uncertainty may result in an underestimate or overestimate of risk. Overall, however, the assumptions made in this risk assessment render the final risk estimates to be overly conservative.

A summary of the results and conclusions of the Human Health Risk Assessment is presented in Table 11, and is also described by landfill area of concern, below.

8.1 LANDFILL AREA 1

Landfill Area 1 consists of approximately 10 acres of open meadow, and is covered with a clay cap and seeded topsoil. Surface soils are a medium of concern at the landfill itself. Sediments and surface water are associated with an unnamed tributary to Deep Brook, located southeast of Landfill Area 1, and Dubois Pond, located south of Landfill Area 1. Groundwater is present in a thin sand lens beneath the landfill. This saturated unit contains so little available water that it is

TABLE 11
SUMMARY OF RISK ASSESSMENT RESULTS
REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

AREAS OF CONCERN	EXPOSURE SCENARIOS	RESULTS	COMMENTS
LANDFILL AREA 1			
Area 1	Child Trespasser/ Recreational User Potentially Exposed to Surface Soils	Carcinogenic Risk = $1.8x10^{-6}$ Non-Carcinogenic HI = $3.5x10^{-2}$	Estimated risks below EPA/DEP upperbound limits of acceptable risk.
Unnamed Tributary to Deep Brook Southeast of Area 1	Child Trespasser/ Recreational User Potentially Exposed to Sediments and Surface Water	Carcinogenic Risk = $3.6x10^{-6}$ Non-Carcinogenic HI = $3.0x10^{-2}$	Estimated risks below EPA/DEP upperbound limits of acceptable risk.
Dubois Pond South of Area 1	Child Trespasser/ Recreational User Potentially Exposed to Surface Soils, Sediments and Surface Water	Carcinogenic Risk = $1.5x10^{-6}$ Non-Carcinogenic HI = $3.6x10^{-2}$	Estimated risks below EPA/DEP upperbound limits of acceptable risk.
LANDFILL AREA 2			
Area 2	Child Trespasser/ Recreational User Potentially Exposed to Surface Soils	Carcinogenic Risk = $8.0x10^{-6}$ Non-Carcinogenic HI = $1.9x10^{-1}$	Estimated risks below EPA/DEP upperbound limits of acceptable risk.
Sandy Brook West of Area 2	Child Trespasser/ Recreational User Potentially Exposed to Sediments and Surface Water	Carcinogenic Risk = $9.2x10^{-7}$ Non-Carcinogenic HI = $9.2x10^{-3}$	Estimated risks below EPA target risk range and DEP upperbound limits of acceptable risk.
LANDFILL AREAS 1 & 2			
Downgradient of Landfill Areas 1 & 2	Future Residents Exposed to Groundwater via Drinking Water Scenario	Carcinogenic Risk = $2.8x10^{-4}$ Non-Carcinogenic HI = $1.6x10^{+0}$ No Chemicals exceed MCLs/MEGs	Estimated risks just exceed EPA/DEP upperbound limits of acceptable risk due to arsenic. Arsenic does not exceed MCLs/MEGs.

EPA = US Environmental Protection Agency
DEP = Maine Department of Environmental Protection
MCLs = Federal Maximum Contaminant Levels
MEGs = Maine Maximum Exposure Guidelines

TABLE 11
SUMMARY OF RISK ASSESSMENT RESULTS
REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

AREAS OF CONCERN	EXPOSURE SCENARIOS	RESULTS	CONCLUSIONS
LANDFILL AREAS 3 & 4			
Stream/Pool North of Areas 3 & 4	Child Trespasser/ Recreational User Potentially Exposed to Sediments and Surface Water	Carcinogenic Risk = $8.4x10^{-7}$ Non-Carcinogenic HI = $4.2x10^{-2}$	Estimated risks below EPA target risk range and DEP upperbound limits of acceptable risk.
Sandy Brook Southeast of Areas 3 & 4	Child Trespasser/ Recreational User Potentially Exposed to Sediments and Surface Water	Carcinogenic Risk = $6.8x10^{-6}$ Non-Carcinogenic HI = $2.1x10^{-2}$	Estimated risks below EPA/DEP upperbound limits of acceptable risk..
Pool South of Areas 3 & 4	Child Trespasser/ Recreational User Potentially Exposed to Sediments and Surface Water	Carcinogenic Risk = $1.3x10^{-6}$ Non-Carcinogenic HI = $2.2x10^{-2}$	Estimated risks below EPA/DEP upperbound limits of acceptable risk.
Big Ledge Brook Southwest of Areas 3 & 4	Child Trespasser/ Recreational User Potentially Exposed to Sediments and Surface Water	Carcinogenic Risk = $1.7x10^{-7}$ Non-Carcinogenic HI = $6.9x10^{-3}$	Estimated risks below EPA target risk range and DEP upperbound limits of acceptable risk.
Wells Southeast of Areas 3 & 4	Future Residents Exposed to Groundwater via Drinking Water Scenario	Carcinogenic Risk = $1.0x10^{-2}$ Non-Carcinogenic HI = $1.0x10^{+2}$ 8 Chemicals exceed MCLs/MEGs	Estimated risks exceed EPA/DEP upperbound limits of acceptable risk.

EPA = US Environmental Protection Agency
DEP = Maine Department of Environmental Protection
MCLs = Federal Maximum Contaminant Levels
MEGs = Maine Maximum Exposure Guidelines

not considered an aquifer. The direction of shallow groundwater flow from Landfill Area 1 is primarily west towards Landfill Area 2. Deep groundwater is present under a clay layer (greater than 70 feet thick) and flows from the northeast to the southwest.

The children trespasser/recreational scenario evaluated potential exposure to soils, sediments, and/or surface waters at three sub-areas of concern. These sub-areas are Landfill Area 1, the Unnamed Tributary to Deep Brook, and Dubois Pond. The estimated carcinogenic risk and non-carcinogenic HIs were below the USEPA and MEDEP upperbound limits of acceptable risk, thereby indicating that exposure to these media do not result in an unacceptable risk.

Lead concentrations in soil at Area 1 and north of Dubois Pond were below the USEPA screening concentration and MEDEP draft soil guidelines, and therefore do not pose an unacceptable risk.

Deep groundwater downgradient of Landfill Areas 1 & 2 is not currently nor is likely to be used as a drinking water supply. However, potential exposure to this groundwater as drinking water was evaluated for conservative purposes. The results are discussed in Section 8.2.

8.2 LANDFILL AREA 2

Landfill Area 2 consists of approximately 6 acres of open meadow, and is capped with clay and topsoil. Surface soils are a media of concern at the landfill itself. Sediments and surface waters associated with Sandy Brook are media of concern and are located to the west of Landfill Area 2. Groundwater is present in a thin sand layer underneath the landfill, and is not considered an aquifer. The direction of shallow groundwater flow is east from Landfill Area 1 to west towards Sandy Brook. Problems with the leachate collection and recirculation system have resulted in leachate outbreaks historically reaching Sandy Brook. Deep groundwater flows from northeast to the southwest.

The children trespasser/recreational scenario evaluated potential exposure to surface soils, sediments, and/or surface waters at two sub-areas of concern. These sub-areas are Landfill Area 2 and Sandy Brook. The estimated carcinogenic risks and non-carcinogenic HIs at Landfill Area 2 were within the USEPA target risk range and below the MEDEP upperbound limits of acceptable risk. Lead concentrations in surface soil at Area 2 were below the USEPA screening concentration and MEDEP draft soil guidelines. The estimated carcinogenic risk and non-carcinogenic HI at Sandy Brook were below the USEPA target risk range and MEDEP upperbound limits of acceptable risk. Therefore, potential exposure to these media do not pose an unacceptable risk.

Although deep groundwater downgradient of Landfill Areas 1 & 2 is not currently and will not foreseeably be used for drinking water, a residential drinking water scenario was evaluated for conservative purposes. The estimated carcinogenic risk and non-carcinogenic HI just exceed the USEPA and MEDEP upperbound limits of acceptable risk. Arsenic (detected at 16.3 ug/l) contributed 100% of the carcinogenic risk and 98% of the non-carcinogenic risk, but does not exceed federal MCLs or state MEGs. Groundwater was also qualitatively evaluated by comparing EPCs to federal MCLs and state MEGs. None of the EPCs, including arsenic, exceeded the MCLs or MEGs. The results indicate that even if this water were to be used as a drinking water source, however unlikely due to the implementation of institutional controls, federal and state drinking water standards are not exceeded.

8.3 LANDFILL AREAS 3 & 4

Landfill Areas 3 and 4 are contiguous with a total acreage of approximately 14 acres, and are located to the west of Sandy Brook. As a result of the EE/CA completed in July 1996, a cover system was designed and constructed for Areas 3 & 4 in the Summer-Fall of 1997. Because the landfill cap is now covering surface soils, they are no longer considered as a medium of concern at Areas 3 & 4. Sediments and surface water are associated with a stream and pool to the north of Landfill Areas 3 & 4, a pool south of Areas 3 & 4, Sandy Brook to the southeast of Areas 3 &

4, and Big Ledge Brook to the southwest of Areas 3 & 4. The groundwater flow direction is predominantly to the southeast towards Sandy Brook.

The children trespasser/recreational scenario evaluated potential exposure to sediments and surface waters at four sub-areas of concern:

- the stream and pool to the north of Landfill Areas 3 & 4,
- the pool south of Areas 3 & 4,
- Sandy Brook to the southeast of Areas 3 & 4, and
- Big Ledge Brook to the southwest of Areas 3 & 4.

The estimated carcinogenic risks and non-carcinogenic HIs were below the USEPA and MEDEP upperbound limits of acceptable risk for each subarea of concern for a child trespasser scenario. Therefore, potential exposure to these media do not pose an unacceptable risk.

A residential drinking water scenario was evaluated for conservative purposes, although the groundwater around Landfill Areas 3 & 4 is not currently and will not likely foreseeably be used for drinking water purposes. The residential drinking water scenario was quantitatively evaluated for wells to the south-southeast of Landfill Areas 3 & 4.

For groundwater to the south-southeast of Landfill Areas 3 & 4, the estimated carcinogenic risk and non-carcinogenic HI exceed the USEPA and MEDEP upperbound limits of acceptable risk. The compound contributing most significantly to carcinogenic risk was arsenic (detected at 566 ug/l and contributing 99.8% of the risk). The compounds contributing most significantly to the non-carcinogenic HI were arsenic (detected 566 ug/l and contributing 50.8% of the risk) and manganese (detected at 43,200 ug/l and contributing 48.5% of the risk). The maximum concentrations of eight chemicals detected in wells southeast of Landfill Areas 3 & 4 met or exceeded the MCLs and/or the MEGs: benzene, trichloroethene, aluminum, arsenic, lead, manganese, nickel, and thallium. Based on this assessment, groundwater in this area is not

suitable as a drinking water source. The City of Saco is currently implementing institutional controls to prohibit the future use of groundwater as a drinking water source at the SML.

In conclusion, based on the results of the risk assessment, chemicals present in surface soils, sediments and surface waters at the SML do not present risks to human health based on EPA and DEP criteria.

While groundwater is not currently a drinking water source and will not be used as a future drinking water source due to institutional controls, a residential drinking water scenario was evaluated for conservative purposes. For deep groundwater downgradient of Areas 1 and 2, the potential risks associated with exposure to the maximum arsenic concentration slightly exceeds the EPA target risk levels. However, the maximum arsenic concentration (16.3 ug/l) does not exceed federal MCLs or state MEGs (50 ug/l), and is considered to be consistent with background levels for the SML area. The results indicate that even if this water were to be used as a drinking water source, however unlikely due to the implementation of institutional controls, federal and state drinking water standards are not exceeded.

The risk assessment results indicate EPA target risk levels are exceeded for a hypothetical residential drinking water scenario for groundwater to the south-southeast of Landfill Areas 3 & 4. Chemicals exceeding target risk levels and/or federal MCLs/MEGs consist of benzene, trichloroethene, aluminum, arsenic, lead, manganese, nickel, and thallium. The potential risks associated with a residential drinking water scenario for groundwater downgradient of Areas 3 & 4 will be addressed in the feasibility study for the SML.

REFERENCES

1. USEPA, "Risk Assessment Guidance for Superfund: Volume I Human Health Evaluation", 1989 (USEPA 1989a).

2. USEPA, "Dermal Exposure Assessment: Principles and Applications", January 1992 (USEPA, 1992).

3. USEPA, "Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors", March 25, 1991 (USEPA, 1991).

4. USEPA, "Integrated Risk Information System (IRIS)", December 1, 1996.

5. USEPA, "Health Effects Assessment Summary Tables (HEAST)", May 1995.

6. USEPA, "Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities", July 1994 (USEPA, 1994).

7. USEPA Region III, "Updated Risk Based Concentration Table", March 17, 1997.

8. USEPA, "Drinking Water Regulations and Health Advisories", October 1996 (EPA 1996).

9. USEPA, "National Oil and Hazardous Substances Pollution Contingency Plan: Final Rule", 55FR8666, March 8, 1990 (USEPA 1990b).

10. USEPA, "Superfund Exposure Assessment Manual", April 1988.

11. USEPA, Region 1 Waste Management Division Risk Updates, August 1994, August 1995, and November 1996.

12. USEPA, "Region 1 Supplemental Risk Assessment Guidance for the Superfund Program, Part 1", 1989 (EPA 1989b).

13. MEDEP, "Guidance Manual for Human Health Risk Assessments at Hazardous Substance Sites", State of Maine Department of Environmental Protection and Department of Human Services, June 1994, (MEDEP, 1994).

14. Woodard & Curran "Phase 1A Remedial Investigation Work Plan for Saco Municipal Landfill, Saco, Maine", Portland, Maine, December 1995 (W&C 1995).

15. Chas. T. Main, Inc. "City of Saco, Maine Saco Municipal Landfill Demolition Debris Site Leachate Management System", Boston, MA, January 1987.

16. USGS, "Geohydrology Water quality, and Conceptual Model of the Hydrologic System, Saco Landfill Area, Saco, Maine", Water Resource Investigations Report 95-4027, Augusta, Maine, 1995 (USGS 1995).

17. HNUS, "Final Site Summary Report Saco Municipal Landfill, Saco, Maine", USEPA Work Assignment No. 36-1122, USEPA Contract No. 68-W8-0117, April 1994 (HNUS, 1994).

18. W&C, "Engineering Evaluation/Cost Analysis, Areas 3 & 4, Saco Municipal Landfill", July 1996.

19. W&C, "Draft Technical Memorandum for Landfill Area 2, Saco Municipal Landfill", February 1997.

LIST OF ACRONYMS

COCs	Compounds of Concern
CSF	Cancer Slope Factor
EE/CA	Engineering Evaluation/Cost Analysis
EPCs	Exposure Point Concentrations
HEAST	Health Effects Assessment Summary Tables
HI	Hazard Index
IDL	Instrument Detection Limit
IRIS	Integrated Risk Information System
MCLs	Maximum Contaminant Levels
MEDEP	Maine Department of Environmental Protection
MEGs	Maximum Exposure Guidelines
MDL	Method Detection Limit
NPL	National Priorities List
PCBs	Polychlorinated Biphenyls
PQL	Practical Quantitation Limit
RfD	Reference Dose
RI	Remedial Investigation
SML	Saco Municipal Landfill
SVOCs	Semi-volatile Organic Compounds
USEPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds

ATTACHMENT A
ANALYTICAL DATA

TABLE A-1
SOIL ANALYTICAL DATA
SACO MUNCIPAL LANDFILL

	LANDFILL AREA 1				DUBOIS POND		
COMPOUND	**SS001**	**SS002**	**SS004**	**SS006**	**SS031**	**SS032**	**SS033**
Pesticides/PCBs, ug/kg							
4,4-DDT	ND	ND	ND	ND	ND	ND	ND
4,4-DDD	ND	ND	ND	ND	ND	ND	ND
4,4,-DDE	ND	ND	ND	ND	ND	ND	ND
Alpha-chlordane	ND	0.2	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	0.19	ND	ND	ND
Endosulfan II	ND	ND	ND	ND	ND	ND	ND
Endrin ketone	ND	ND	ND	ND	ND	ND	ND
gamma-Chlordane	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	0.08	ND	ND	ND
SVOCs, ug/kg							
2-Methylnaphthalene	ND	ND	ND	ND	NA	NA	NA
Acenaphthene	ND	ND	ND	ND	NA	NA	NA
Acenaphthylene	ND	ND	ND	ND	NA	NA	NA
Anthracene	ND	ND	ND	ND	NA	NA	NA
Benzo(a)anthracene	ND	ND	ND	ND	NA	NA	NA
Benzo(a)pyrene	ND	28	81	ND	NA	NA	NA
Benzo(b)fluoranthene	ND	39	110	ND	NA	NA	NA
Benzo(k)fluoranthene	ND	17	ND	ND	NA	NA	NA
Benzo(g,h,i)perylene	ND	19	59	ND	NA	NA	NA
Bis(2-ethylhexyl)phthalat	ND	ND	ND	ND	NA	NA	NA
Carbazole	ND	ND	ND	ND	NA	NA	NA
Chrysene	ND	ND	ND	ND	NA	NA	NA
Dibenzo(a,h)anthracene	ND	ND	ND	ND	NA	NA	NA
Dibenzofuran	ND	ND	ND	ND	NA	NA	NA
Di-n-butylphthalate	ND	ND	ND	ND	NA	NA	NA
Di-n-octylphthalate	ND	ND	ND	ND	NA	NA	NA
Fluoranthene	ND	ND	120	ND	NA	NA	NA
Fluorene	ND	ND	ND	ND	NA	NA	NA
Hexachlorobutadiene	ND	ND	ND	ND	NA	NA	NA
Indeno(1,2,3-cd)pyrene	ND	ND	48	ND	NA	NA	NA
Naphthalene	ND	ND	ND	ND	NA	NA	NA
n-Nitrosodiphenylamine	ND	ND	ND	ND	NA	NA	NA
Phenanthrene	ND	ND	61	ND	NA	NA	NA
Pyrene	ND	ND	140	ND	NA	NA	NA

ND = Not detected.
NA = Not analyzed.

TABLE A-1
SOIL ANALYTICAL DATA
SACO MUNCIPAL LANDFILL

COMPOUND	LANDFILL AREA 1				DUBOIS POND		
	SS001	SS002	SS004	SS006	SS031	SS032	SS033
VOCs, ug/kg							
1,1,1,2-Tetrachloroethan	1	ND	ND	ND	NA	NA	NA
1,1,1-Trichloroethane	1	ND	ND	ND	NA	NA	NA
1,1,2,2-Tetrachloroethan	ND	ND	ND	ND	NA	NA	NA
1,1-Dichloropropene	1	ND	ND	ND	NA	NA	NA
1,2,3-Trichlorobenzene	ND	ND	ND	ND	NA	NA	NA
1,2,3-Trichloropropane	1	ND	ND	ND	NA	NA	NA
1,2,4-Trichlorobenzene	ND	ND	ND	ND	NA	NA	NA
1,2,4-Trimethylbenzene	1	1	ND	ND	NA	NA	NA
1,2-Dibromomethane	1	ND	ND	ND	NA	NA	NA
1,2-Dichlorobenzene	1	1	ND	ND	NA	NA	NA
1,3,5-Trimethylbenzene	ND	1	ND	ND	NA	NA	NA
1,3-dichlorobenzene	1	ND	ND	ND	NA	NA	NA
1,4-Dichorobenzene	1	ND	1	1	NA	NA	NA
2-Butanone	ND	ND	ND	ND	NA	NA	NA
2-Chlorotoluene	ND	ND	ND	ND	NA	NA	NA
4-Chlorotoluene	ND	ND	ND	ND	NA	NA	NA
4-Isopropyltoluene	ND	ND	ND	1	NA	NA	NA
Acetone	ND	ND	ND	ND	NA	NA	NA
Bromodichloromethane	1	ND	ND	ND	NA	NA	NA
Benzene	1	ND	ND	ND	NA	NA	NA
Bromobenzene	1	ND	ND	ND	NA	NA	NA
Bromomethane	ND	ND	ND	ND	NA	NA	NA
Chlorobenzene	1	ND	ND	ND	NA	NA	NA
Chloroform	ND	ND	ND	ND	NA	NA	NA
cis-1,2-Dichloroethene	ND	ND	ND	ND	NA	NA	NA
Dibromomethane	1	ND	ND	ND	NA	NA	NA
Ethylbenzene	1	1	ND	ND	NA	NA	NA
Hexachlorobutadiene	1	ND	ND	ND	NA	NA	NA
Isopropylbenzene	ND	ND	ND	ND	NA	NA	NA
n-Butylbenzene	ND	ND	ND	ND	NA	NA	NA
n-Propylbenzene	ND	ND	ND	ND	NA	NA	NA
Naphthalene	ND	1	ND	ND	NA	NA	NA
o-Xylene	ND	ND	ND	ND	NA	NA	NA
sec-Butylbenzene	ND	ND	ND	ND	NA	NA	NA
Styrene	ND	ND	ND	ND	NA	NA	NA
tert-Butylbenzene	ND	ND	ND	ND	NA	NA	NA
Tetrahydrofuran	ND	ND	ND	ND	NA	NA	NA
Toluene	ND	ND	ND	ND	NA	NA	NA
Trichlorofluoromethane	1	1	1	1	NA	NA	NA

ND = Not detected.
NA = Not analyzed.

TABLE A-1
SOIL ANALYTICAL DATA
SACO MUNCIPAL LANDFILL

COMPOUND	LANDFILL AREA 1				DUBOIS POND		
	SS001	SS002	SS004	SS006	SS031	SS032	SS033
Metals, mg/kg							
Aluminum	11400	13300	12500	10500	9140	9300	9680
Antimony	ND	ND	ND	ND	ND	ND	ND
Arsenic	3.6	4	5.5	2.8	3	2.1	2.4
Barium	42.6	58	42.9	41.3	38.1	32.5	35.5
Beryllium	1.1	1.3	1	0.8	0.86	0.92	1.1
Cadmium	ND	ND	ND	ND	ND	ND	ND
Calcium	1750	1660	1470	1360	1300	754	913
Chromium	15.2	24.9	36.4	14.5	14.8	12.6	13.9
Cobalt	6.7	9.3	7.7	5.7	5.7	5.2	5.5
Copper	10	11.6	11.3	5.6	7.5	8.3	9.4
Iron	16600	17700	17100	12500	12000	12700	13500
Lead	11.6	18.4	17.5	12.9	8.6	6.6	8.6
Magnesium	3250	3480	3550	2490	2730	2460	2920
Manganese	375	399	326	240	188	294	172
Mercury	ND	0.07	ND	0.06	ND	ND	ND
Nickel	9.5	11.2	13	8.4	9.4	7.2	8.9
Potassium	5080	5170	3270	1990	3570	4100	5530
Selenium	ND	0.6	0.46	0.49	ND	ND	ND
Thallium	ND	ND	ND	ND	ND	ND	0.67
Vanadium	25.4	27.9	25.6	21	19.7	21.1	21.8
Zinc	54.8	57.5	61.9	41.4	44.6	36.9	52.3

ND = Not detected.
NA = Not analyzed.

TABLE A-1
SOIL ANALYTICAL DATA
SACO MUNCIPAL LANDFILL

COMPOUND	LANDFILL AREA 2															
	SS-7	SS-8	SS-9	SS-10	SS-11	SS-12	SS-12D	SS-13	SS-14	SS-15	SS-16	SS-17	SS-18	SS18D	SS-19	SS-20
Pesticides/PCBs, ug/kg																
4,4-DDT	ND	ND	ND	ND	ND	ND	ND	ND	ND	94	ND	ND	ND	ND	ND	ND
4,4-DDD	ND	ND	ND	ND	ND	1.2	ND	ND	1	24	ND	ND	ND	ND	ND	ND
4,4,-DDE	ND	ND	ND	ND	ND	0.9	ND	ND	ND	37	ND	ND	ND	0.52	0.52	ND
Alpha-chlordane	ND	ND	ND	ND	ND	ND	ND	ND	0.35	ND	ND	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.69	1.2	ND	ND
Endosulfan II	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.33	0.55	ND	ND
Endrin ketone	ND	ND	ND	ND	ND	ND	ND	ND	0.25	ND	ND	ND	ND	ND	ND	ND
gamma-Chlordane	ND	ND	ND	ND	ND	ND	ND	ND	0.41	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	0.11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SVOCs, ug/kg																
2-Methylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	130	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	96	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	160	ND	ND	ND	ND	ND	ND
Benzo(k)fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	56	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	66	ND	ND	ND	ND	ND	ND
Bis(2-ethylhexyl)phthalat	ND	1500	ND	ND	ND	ND	ND	ND	ND	6800	ND	ND	ND	ND	ND	ND
Carbazole	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	ND	ND	ND	ND	ND	ND	ND	ND	ND	140	ND	ND	ND	ND	ND	ND
Dibenzo(a,h)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzofuran	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Di-n-butylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Di-n-octylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	82	ND	ND	ND	ND	ND	ND
Fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	310	ND	ND	ND	ND	ND	ND
Fluorene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobutadiene	ND	ND	ND	ND	ND	1.94	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	57	ND	ND	ND	ND	ND	ND
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Nitrosodiphenylamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	180	ND	ND	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	250	ND	ND	ND	ND	ND	ND

ND = Not detected.
NA = Not analyzed.

TABLE A-1
SOIL ANALYTICAL DATA
SACO MUNCIPAL LANDFILL

COMPOUND	LANDFILL AREA 2															
	SS-7	SS-8	SS-9	SS-10	SS-11	SS-12	SS-12D	SS-13	SS-14	SS-15	SS-16	SS-17	SS-18	SS18D	SS-19	SS-20
VOCs, ug/kg																
1,1,1,2-Tetrachloroethan	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	0.19	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethan	ND	ND	ND	0.56	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropene	ND	ND	ND	ND	1	0.99	ND	0.27	ND	0.44	ND	ND	ND	ND	ND	ND
1,2,3-Trichlorobenzene	ND	ND	ND	0.44	0.99	1.51	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichloropropane	ND	ND	ND	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	ND	ND	ND	0.36	1.16	1.29	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzene	ND	0.54	ND	ND	0.86	0.99	ND	0.65	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	ND	ND	ND	ND	ND	1.29	ND	0.34	ND	ND	ND	ND	ND	0.77	ND	ND
1,3,5-Trimethylbenzene	ND	0.26	ND	0.4	0.97	0.9	ND	0.35	ND	ND	ND	ND	ND	ND	ND	ND
1,3-dichlorobenzene	ND	ND	ND	ND	ND	1.43	ND	0.4	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichorobenzene	ND	ND	ND	76	ND	2.13	ND	0.93	ND	ND	ND	ND	ND	ND	ND	0.57
2-Butanone	ND	ND	ND	ND	ND	ND	ND	8.79	ND	ND	ND	ND	ND	ND	ND	ND
2-Chlorotoluene	ND	ND	ND	ND	ND	1.14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Chlorotoluene	ND	ND	ND	ND	ND	1.09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Isopropyltoluene	ND	ND	ND	ND	1.15	0.73	ND	1.13	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	0.37	0.93	0.58	ND	ND	ND	0.26	ND	ND	ND	ND	ND	ND
Bromobenzene	ND	ND	ND	ND	ND	0.88	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	ND	ND	ND	ND	ND	ND	ND	2.56	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	ND	ND	ND	1.05	ND	0.38	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.92	ND	ND
Dibromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	0.26	ND	ND	ND	ND	0.87	ND	0.39	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobutadiene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Isopropylbenzene	ND	ND	ND	ND	ND	0.98	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Butylbenzene	ND	ND	ND	ND	1.33	0.92	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	ND	0.29	ND	ND	ND	1.03	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	ND	ND	ND	ND	ND	1.41	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	ND	ND	ND	ND	ND	0.57	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
sec-Butylbenzene	ND	ND	ND	0.44	1.22	0.88	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
tert-Butylbenzene	ND	ND	ND	0.43	0.9	0.72	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrahydrofuran	ND	ND	ND	ND	ND	ND	ND	3.37	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.66
Trichlorofluoromethane	ND	ND	ND	0.56	0.88	0.71	0.98	ND	ND	0.88	1.15	0.62	ND	ND	ND	ND

ND = Not detected.
NA = Not analyzed.

TABLE A-1
SOIL ANALYTICAL DATA
SACO MUNCIPAL LANDFILL

COMPOUND	LANDFILL AREA 2															
	SS-7	SS-8	SS-9	SS-10	SS-11	SS-12	SS-12D	SS-13	SS-14	SS-15	SS-16	SS-17	SS-18	SS18D	SS-19	SS-20
Metals, mg/kg																
Aluminum	9840	5660	9850	10300	17300	1270	1400	17000	198	12700	6590	8020	7910	5970	560	6230
Antimony	ND	ND	ND	ND	ND	2.4	1.3	ND	1.5	ND	ND	ND	ND	ND	ND	ND
Arsenic	3.6	1.5	3.2	11	6.3	17.1	13	8.2	83.5	5.5	5.2	4.6	3.1	2	88	1.7
Barium	38.6	19.2	52.4	327	167	2080	1130	108	2490	75.9	276	336	218	109	601	54.2
Beryllium	0.81	0.46	0.89	1	1.7	ND	ND	1.2	ND	1.1	0.58	0.65	0.64	0.53	ND	0.56
Cadmium	ND	ND	ND	ND	ND	1.9	0.06	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	1280	603	7410	11200	11200	15400	9790	3250	29900	4760	11700	18600	42800	25800	6170	6710
Chromium	14.9	5.5	45.3	27.7	38.1	16.2	12.1	30.1	19.7	28.9	58.1	40.1	70.2	55.9	26.7	49.7
Cobalt	5.5	2.9	4.3	5.8	10.5	0.34	0.74	11.3	1	6.7	3.5	4.8	5	3.4	3.5	3
Copper	8.5	3.2	8.7	13.1	17.6	7	5.6	15.6	3.6	14.8	6.2	7	7.2	5.6	1.2	6.7
Iron	11700	6680	9200	77900	28400	467000	269000	24300	413000	15100	45400	40700	20200	10600	473000	6640
Lead	8.7	5.3	6.6	15.7	13.8	6.2	6	18.9	2.3	37.6	5.5	5.6	6.3	5.3	2.6	4.9
Magnesium	2690	1190	1820	2920	4630	888	706	4970	795	2580	1800	1930	2440	1690	407	1430
Manganese	211	130	197	422	906	427	215	518	1080	479	426	1700	1620	674	1130	244
Mercury	ND	ND	ND	0.15	ND	0.16	ND	0.08	ND	0.09	ND	ND	ND	ND	ND	ND
Nickel	8.8	3.4	7.8	10.4	15.4	4	3	18.5	2	11.7	7	7.2	8.4	6.5	3	5.9
Potassium	3190	1330	2310	3760	6550	ND	ND	5740	ND	2930	1630	2060	2290	1480	ND	1490
Selenium	ND	ND	ND	0.76	1.1	3.7	3.1	0.63	5.2	ND	ND	0.65	1.1	ND	ND	ND
Thallium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.9	ND	ND	13.4	ND
Vanadium	19.9	10.8	17.8	24.1	36.9	5.2	5.6	36.3	7.7	24.7	14.8	14.6	17	10.5	10.9	12.1
Zinc	37.8	23.1	48.8	73.1	87.4	141	113	82.8	346	220	45.9	51.8	57.9	44.1	117	37.3

ND = Not detected.
NA = Not analyzed.

TABLE A-1
SOIL ANALYTICAL DATA
SACO MUNCIPAL LANDFILL

COMPOUND	LANDFILL AREAS 3 & 4											
	SS-21	SS-22	SS-23	SS-24	SS-24D	SS-25	SS-26	SS-27	SS-28	SS-29	SS-30	SS-30D
Pesticides/PCBs, ug/kg												
4,4-DDT	ND	ND	32	ND	ND	ND	ND	ND	5.8	8	ND	ND
4,4-DDD	8.6	ND	ND	ND	ND	ND	ND	0.13	2.5	4.7	ND	ND
4,4,-DDE	ND	ND	7.8	ND	2.3	ND	ND	ND	ND	ND	ND	ND
Alpha-chlordane	ND	ND	ND	1.5	ND	ND	ND	0.25	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND	ND	0.16	ND	ND	ND	ND
Endosulfan II	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endrin ketone	ND	ND	ND	0.85	ND	ND	ND	ND	ND	ND	ND	ND
gamma-Chlordane	ND	ND	ND	1.3	ND	ND	ND	0.25	0.47	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	0.84	ND	ND	ND	ND	ND	ND	ND	ND
SVOCs, ug/kg												
2-Methylnaphthalene	ND	ND	2000	ND	ND	ND	ND	ND	ND	26	ND	ND
Acenaphthene	ND	ND	310	ND	ND	ND	ND	ND	ND	66	ND	ND
Acenaphthylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	26	ND	ND
Anthracene	93	360	390	ND	ND	ND	ND	ND	ND	190	ND	ND
Benzo(a)anthracene	430	2000	1000	ND	ND	ND	ND	ND	ND	740	ND	ND
Benzo(a)pyrene	410	2400	720	ND	ND	ND	ND	45	57	600	ND	ND
Benzo(b)fluoranthene	810	2600	930	ND	110	ND	ND	79	82	870	ND	ND
Benzo(k)fluoranthene	ND	1100	320	ND	ND	ND	ND	ND	32	270	ND	ND
Benzo(g,h,i)perylene	270	1300	470	ND	ND	ND	ND	ND	40	440	ND	ND
Bis(2-ethylhexyl)phthalat	ND	ND	ND	ND	ND	ND	ND	ND	93	84	ND	ND
Carbazole	ND	ND	ND	ND	ND	ND	ND	ND	ND	73	ND	ND
Chrysene	440	2300	1100	ND	ND	ND	ND	ND	61	760	ND	ND
Dibenzo(a,h)anthracene	81	480	140	ND	ND	ND	ND	ND	ND	110	ND	ND
Dibenzofuran	ND	ND	300	ND	ND	ND	ND	ND	ND	44	ND	ND
Di-n-butylphthalate	ND	430	ND	ND	ND	ND	ND	ND	ND	430	ND	ND
Di-n-octylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND
Fluoranthene	840	2400	2200	ND	ND	ND	ND	98	ND	1400	ND	ND
Fluorene	ND	ND	690	ND	ND	ND	ND	ND	120	84	ND	ND
Hexachlorobutadiene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	240	1200	470	130	ND	ND	ND	ND	33	530	ND	ND
Naphthalene	ND	ND	590	ND	ND	ND	ND	ND	ND	49	ND	ND
n-Nitrosodiphenylamine	ND	ND	720	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	460	1200	1600	ND	ND	ND	ND	ND	68	820	ND	ND
Pyrene	660	2800	1300	ND	ND	ND	ND	ND	73	1100	ND	ND

ND = Not detected.
NA = Not analyzed.

TABLE A-1
SOIL ANALYTICAL DATA
SACO MUNCIPAL LANDFILL

COMPOUND	LANDFILL AREAS 3 & 4											
	SS-21	SS-22	SS-23	SS-24	SS-24D	SS-25	SS-26	SS-27	SS-28	SS-29	SS-30	SS-30D
VOCs, ug/kg												
1,1,1,2-Tetrachloroethan	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	ND	ND
1,1,2,2-Tetrachloroethan	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	ND	ND	ND	ND	ND	1	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
2-Butanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Chlorotoluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Chlorotoluene	1	ND	ND	ND	ND	1	ND	ND	ND	ND	ND	ND
4-Isopropyltoluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	1	ND	ND	ND	ND	ND	ND	ND	ND
Bromobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	ND	ND	ND	ND	1	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	1	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobutadiene	ND	ND	ND	ND	ND	ND	1	ND	ND	ND	ND	ND
Isopropylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Butylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	ND	ND	ND	1	ND	ND	ND	ND	ND	ND	ND	ND
sec-Butylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Styrene	ND	ND	ND	1	ND	ND	ND	ND	ND	ND	ND	ND
tert-Butylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrahydrofuran	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	1	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	ND	ND	ND	ND	2	ND	ND	1	ND	ND	ND	ND

ND = Not detected.
NA = Not analyzed.

TABLE A-1
SOIL ANALYTICAL DATA
SACO MUNCIPAL LANDFILL

COMPOUND	LANDFILL AREAS 3 & 4											
	SS-21	SS-22	SS-23	SS-24	SS-24D	SS-25	SS-26	SS-27	SS-28	SS-29	SS-30	SS-30D
Metals, mg/kg												
Aluminum	5520	5430	10700	13600	12100	18800	12700	11600	9670	5140	5380	5420
Antimony	ND	ND	ND	50.6	74	ND	ND	1.1	ND	9	ND	ND
Arsenic	4.2	6.7	13.5	ND	ND	10.4	5.3	9.2	12.9	5.8	2	1.9
Barium	28	24.3	55.8	222	323	79.6	36.6	46	38.6	20.3	19.4	19.3
Beryllium	0.63	ND	0.63	0.49	0.44	0.93	0.77	0.55	0.55	0.55	0.51	0.51
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	1210	1250	1770	3450	4620	2890	943	3400	775	854	226	204
Chromium	17.7	14.8	25.7	22000	32200	39.4	16.4	789	55.5	14.3	14	16.7
Cobalt	3.6	5.4	8	8.1	ND	12.8	5.6	5.3	ND	4.8	3.1	3.1
Copper	8.4	7.8	18	39.2	ND	16.3	7.5	8.1	8.4	6.9	3.2	3.3
Iron	7850	10600	20100	21100	34500	37600	12800	13000	12400	9190	6410	6860
Lead	35.6	11.9	84.9	912	1360	7.3	9	85.7	85.6	17.7	4.8	4.8
Magnesium	2290	3170	4360	2830	2210	8150	2420	2580	3050	2350	1350	1400
Manganese	84.6	346	395	241	311	509	206	182	192	150	143	149
Mercury	ND	ND	ND	0.57	0.92	ND	ND	ND	ND	ND	ND	ND
Nickel	7.8	14.5	21.1	18.1	14.8	26.5	11.9	11.6	13.8	9.4	4.9	5.1
Potassium	1470	1290	2780	ND	ND	10100	1290	914	1630	1480	1130	1180
Selenium	ND	ND	ND	ND	ND	ND	0.53	0.84	ND	0.36	ND	ND
Thallium	ND	0.63	ND	12.2	12.5	ND	ND	ND	ND	ND	ND	0.5
Vanadium	17	14.9	25.9	27.3	30.9	44.8	20	23.2	17.9	13.1	9.1	9.1
Zinc	41.3	61.1	107	336	409	65.6	31.4	62.5	314	39.8	23.4	24

ND = Not detected.
NA = Not analyzed.

TABLE A-2
SEDIMENT ANALYTICAL DATA
SACO MUNICIPAL LANDFILL, SACO, MAINE

	LANDFILL AREA 1									
	Tributary to Deep Brook								Dubois Pond	
COMPOUND	SD002	SD002D	SD002	SD002	SD018	SD018	SD019	SD019	SD016	SD017
	Nov-95	Nov-95	May-96	Nov-96	Nov-95	May-96	Nov-95	May-96	Nov-95	Nov-95
Pesticides/PCBs, ug/kg										
4,4-DDD	ND	ND	NA	NA	ND	NA	ND	NA	ND	ND
4,4-DDE	ND	ND	NA	NA	ND	NA	ND	NA	0.29J	ND
PCB-1260	ND	ND	NA	NA	ND	NA	ND	NA	ND	ND
SVOCs, ug/kg										
1,2-Dichlorobenzene	32J	ND	NA	NA	ND	NA	ND	NA	ND	ND
1,4-Dichlorobenzene	110J	56J	NA	NA	ND	NA	ND	NA	ND	ND
4-Chloro-3-methylphenol	50J	40J	NA	NA	ND	NA	ND	NA	ND	ND
Benzo(a)pyrene	ND	ND	NA	NA	ND	NA	180J	NA	ND	ND
Benzo(b)fluoranthene	ND	ND	NA	NA	ND	NA	ND	NA	ND	ND
Bis(2-ethylhexyl)phthalate	ND	ND	NA	NA	ND	NA	630	NA	ND	ND
Di-n-butylphthalate	ND	ND	NA	NA	ND	NA	ND	NA	ND	ND
Diethylphthalate	140J	ND	NA	NA	ND	NA	69J	NA	ND	ND
Fluoranthene	ND	ND	NA	NA	ND	NA	ND	NA	ND	ND
Phenanthrene	ND	ND	NA	NA	ND	NA	ND	NA	ND	ND
Pyrene	ND	ND	NA	NA	ND	NA	ND	NA	ND	ND
VOCs, ug/kg										
1,2,3-Trichlorobenzene	ND	ND	NA	NA	ND	NA	NA	NA	NA	NA
1,2,4-Trichlorobenzene	ND	ND	NA	NA	ND	NA	NA	NA	NA	NA
1,2,4-Trimethylbenzene	ND	ND	NA	NA	ND	NA	NA	NA	NA	NA
1,3,5-Trimethylbenzene	ND	ND	NA	NA	ND	NA	NA	NA	NA	NA
2-Butanone	ND	ND	NA	NA	ND	NA	NA	NA	NA	NA
Acetone	ND	ND	NA	NA	ND	NA	NA	NA	NA	NA
Benzene	ND	ND	NA	NA	ND	NA	NA	NA	NA	NA
Chlorobenzene	ND	ND	NA	NA	ND	NA	NA	NA	NA	NA
Chloroform	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	3880J	2860J	7650	NA	4440J	NA	2650J	NA	10700J	12300J
Arsenic	18.3J	44.4J	5.1	7.9	105J	22	3.1J	ND	4.3J	4.1J
Barium	30.6J	38.9J	59.3	NA	141J	NA	22.5J	NA	45.2J	49.5J
Beryllium	0.51J	0.38J	.66J	NA	ND	NA	0.4J	NA	1.1	1.4
Cadmium	ND	ND	ND	NA	ND	NA	0.09J	NA	ND	ND
Calcium	966	1140	3240J	NA	3650	NA	ND	NA	1980	2380
Chromium	7J	6.8J	10.5	NA	7.6J	NA	4.9J	NA	16.7J	17J
Cobalt	3.3J	3.1J	7	NA	5.2J	NA	1.4J	NA	8.1J	9J
Copper	2.7J	2.9J	7	NA	3.5J	NA	1.2J	NA	10.1	11.4
Iron	20500J	45400J	2440	31600	151000J	29000	4610J	1400	17700J	19600J
Lead	5.9	6.6	27.5J	NA	9.9	NA	6.6	NA	11.1	12.9
Magnesium	1000J	809J	2020	NA	1240J	NA	452J	NA	4920J	6100J
Manganese	109J	201J	1020	538	517J	NA	183J	ND	544J	507J
Mercury	ND	ND	0.09J	NA	ND	NA	ND	NA	ND	ND
Nickel	4.2J	3.4J	7.8	NA	5J	NA	2.2J	NA	11.4J	11.6J
Potassium	933J	ND	1730	NA	ND	NA	ND	NA	4800	6780
Selenium	0.5J	0.64J	ND	NA	1.9J	NA	0.6J	NA	ND	ND
Sodium	ND	ND	169	NA	ND	NA	ND	NA	ND	ND
Thallium	ND	ND	ND	NA	ND	NA	ND	NA	0.9J	0.79J
Vanadium	8.2J	6.8J	16.5	NA	10.6J	NA	4.8J	NA	25.6J	29.5J
Zinc	ND	ND	48	NA	ND	NA	ND	NA	54.8J	61.9J

NA = Not analyzed.
ND = Not detected.
J = Estimated value.

TABLE A-2
SEDIMENT ANALYTICAL DATA
SACO MUNICIPAL LANDFILL, SACO, MAINE

	LANDFILL AREA 2												LANDFILL AREAS 3 & 4							
													Stream/Pool North		Pool South			Big Ledge Brook		
COMPOUND	SD004	SD004	SD007	SD007	SD007	SD008	SD009	SD009D	SD009	SD009D	SD009	SD010	SD003	SD011	SD014	SD014	SD014	SD028	SD029	SD029
	Nov-95	May-96	Nov-95	May-96	Nov-96	Nov-95	Nov-95	Nov-95	May-96	May-96	Nov-96	Nov-95	Nov-95	Nov-95	Nov-95	May-96	Nov-96	May-96	May-96	Nov-96
Pesticides/PCBs, ug/kg																				
4,4-DDD	5.8J	NA	ND	ND	NA	ND	ND	ND	0.46J	ND	NA	ND	ND	1.6J	ND	NA	NA	ND	ND	NA
4,4-DDE	2.3J	NA	ND	1.5J	NA	ND	ND	ND	0.59J	0.52J	NA	ND	ND	1J	ND	NA	NA	ND	ND	NA
PCB-1260	ND	NA	ND	ND	NA	ND	150	ND	ND	ND	NA	61	ND	ND	ND	NA	NA	ND	ND	NA
SVOCs, ug/kg																				
1,2-Dichlorobenzene	ND	NA	NA	ND	NA	ND	36J	ND	ND	ND	NA	ND	ND	ND	ND	NA	NA	NA	NA	NA
1,4-Dichlorobenzene	ND	NA	NA	ND	NA	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND	NA	NA	NA	NA	NA
4-Chloro-3-methylphenol	ND	NA	NA	ND	NA	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND	NA	NA	NA	NA	NA
Benzo(a)pyrene	ND	NA	NA	ND	NA	ND	ND	ND	ND	ND	NA	ND	ND	140J	ND	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	ND	NA	NA	ND	NA	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND	NA	NA	NA	NA	NA
Bis(2-ethylhexyl)phthalate	ND	NA	NA	ND	NA	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND	NA	NA	NA	NA	NA
Di-n-butylphthalate	ND	NA	NA	ND	NA	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND	NA	NA	NA	NA	NA
Diethylphthalate	ND	NA	NA	ND	NA	ND	ND	ND	ND	ND	NA	ND	100J	ND	ND	NA	NA	NA	NA	NA
Fluoranthene	ND	NA	NA	ND	NA	ND	ND	ND	ND	ND	NA	54J	ND	ND	ND	NA	NA	NA	NA	NA
Phenanthrene	63J	NA	NA	ND	NA	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND	NA	NA	NA	NA	NA
Pyrene	140J	NA	NA	ND	NA	63J	41J	ND	ND	ND	NA	44J	ND	ND	ND	NA	NA	NA	NA	NA
VOCs, ug/kg																				
1,2,3-Trichlorobenzene	NA	NA	NA	NA	NA	ND	1J	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trichlorobenzene	NA	NA	NA	NA	NA	ND	ND	1J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trimethylbenzene	NA	NA	NA	NA	NA	ND	1J	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3,5-Trimethylbenzene	NA	NA	NA	NA	NA	ND	1J	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-Butanone	NA	NA	NA	NA	NA	25J	ND	4J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acetone	NA	NA	NA	NA	NA	72J	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	NA	NA	NA	NA	NA	ND	1J	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chlorobenzene	NA	NA	NA	NA	NA	ND	1J	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chloroform	NA	NA	NA	NA	NA	ND	1J	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tetrahydrofuran	NA	NA	NA	NA	NA	31J	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Metals, mg/kg																				
Aluminum	29000J	13500	6000J	10100	NA	8370J	5080J	6460J	7500	8850	NA	8760J	18200J	16200J	20300J	NA	NA	2640	3970	NA
Arsenic	20.1J	6.7	6.5J	2.1	4.5	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	144J	78.8	27.8J	38.4	NA	45.9J	19.3J	23.8J	45.8	51.8	NA	46.6J	87.5J	60.7J	84.3J	NA	NA	8.2	12.1	NA
Beryllium	1.9	0.95	0.76	0.99	NA	0.79J	0.47J	0.51J	.59J	.64J	NA	0.83J	1.3	0.97J	1	NA	NA	ND	ND	NA
Cadmium	ND	.66J	ND	ND	NA	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND	NA	NA	ND	ND	NA
Calcium	5640	1790	727	847J	NA	2230	936	1070	1410J	1610J	NA	1660	2300	2360	2980	NA	NA	470J	657J	NA
Chromium	85J	32.2	7J	11.4	NA	11.7J	6.9J	8.8J	9.9	12.1	NA	26.2J	25.8J	20.6J	41.4J	NA	NA	6.4	9.2	NA
Cobalt	17.3J	6.8	4.2J	3J	NA	4.6J	2.5J	2.7J	3.5J	3.8J	NA	5.5J	23.6J	6.9J	15.4J	NA	NA	1.8J	2.7J	NA
Copper	24.7	15.4	2.4J	4.1J	NA	4.3	1.1J	0.9J	4.4	4.9	NA	4.4	6.7	8.5	16.9	NA	NA	1.8J	2.6J	NA
Iron	31000J	16300	10500J	9420	9410	9550J	4700J	5160	8740	10900	9080	11800J	24500J	11000J	41100J	38000	42100	4440	5610	4570
Lead	27.8	34J	11	14.7J	NA	11.1	6.6	5.1	10.1J	11.2J	NA	12.2	22.6	16.6	9.2	NA	NA	1.8J	3J	NA
Magnesium	8610J	3180	1190J	1800	NA	2250J	1250J	1640J	1630	1990	NA	2100J	3240J	2420J	10400J	NA	NA	1450	1690	NA
Manganese	605J	358	329J	137	139	175J	76.3J	91.8J	230	305	221	478J	6780J	148J	686J	NA	739	53.7	89.8	63
Mercury	ND	ND	ND	ND	NA	ND	ND	ND	ND	0.1J	NA	ND	ND	ND	ND	NA	NA	ND	ND	NA
Nickel	34J	15.2	4.9J	6.9	NA	6.5J	3.7J	4.4J	6.6	7.7	NA	6.9J	16.9J	16.8J	28.8J	NA	NA	7	9.6	NA
Potassium	6640	2230	1070	1310	NA	1530	ND	954	1110	1350	NA	1560	1690	ND	10100	NA	NA	307	479	NA
Selenium	ND	ND	0.63J	ND	NA	ND	ND	ND	ND	ND	NA	ND	3.4J	0.82J	ND	NA	NA	ND	ND	NA
Sodium	ND	195	ND	91.2	NA	ND	ND	ND	215	237	NA	ND	ND	ND	ND	NA	NA	35.3	45.2	NA
Thallium	1.6J	ND	ND	ND	NA	ND	ND	ND	ND	ND	NA	ND	6.7	ND	ND	NA	NA	ND	ND	NA
Vanadium	50.2J	24.3	13.9J	16.3	NA	14.1J	7.9J	9.4J	12.6	15.4	NA	15.3J	41.2J	21.6J	51.5J	NA	NA	6	8.8	NA
Zinc	126J	107	46.3J	43	NA	59.1J	20.5J	20.9J	47.9	54.8	NA	60.1J	78.1J	ND	67.2J	NA	NA	10.6	18.4	NA

NA = Not analyzed.
ND = Not detected.
J = Estimated value.

TABLE A-2
SEDIMENT ANALYTICAL DATA
SACO MUNICIPAL LANDFILL, SACO, MAINE

	LANDFILL AREAS 3 & 4 (cont'd)																	
	Sandy Brook South of Area 4																	
COMPOUND	SD005	SD015	SD015	SD015	SD024	SD024A	SD0024	SD025	SD027	SD030	SD031	SD032	SD033	SD034	SD035	SD040	SD041	SD047
	Nov-95	Nov-95	May-96	Nov-96	May-96	May-96	Nov-96	May-96	May-96	Jul-96	Jul-96	Jul-96	Jul-96	Jul-96	Jul-96	Jul-96	Jul-96	Jul-96
Pesticides/PCBs, ug/kg																		
4,4-DDD	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4,4-DDE	0.76J	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PCB-1260	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SVOCs, ug/kg																		
1,2-Dichlorobenzene	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,4-Dichlorobenzene	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4-Chloro-3-methylphenol	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	ND	47J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bis(2-ethylhexyl)phthalate	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Di-n-butylphthalate	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Diethylphthalate	ND	76J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	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	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trichlorobenzene	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
1,3,5-Trimethylbenzene	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
Acetone	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chlorobenzene	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
Tetrahydrofuran	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Metals, mg/kg																		
Aluminum	4010J	6330J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	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	15.6J	44.7J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	ND	0.48J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	ND	ND	NA	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	NA
Chromium	9.5J	14J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	2.7J	5.1J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	1.5J	5.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iron	5390J	16000J	29000	17200	1700	2000	8600	11000	8300	3280	13700	33500	24700	21500	5300	9260	15500	ND
Lead	4.4	6.9	NA	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	NA
Manganese	72.7J	464J	NA	305	NA	NA	155	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	4.8J	10.8J	NA	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	NA
Selenium	ND	0.72J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	6.6J	14.6J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	21.7J	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA = Not analyzed.
ND = Not detected.
J = Estimated value.

TABLE A-2
SEDIMENT ANALYTICAL DATA
SACO MUNICIPAL LANDFILL, SACO, MAINE

	LANDFILL AREAS 3 & 4 (cont'd)																			
	Sandy Brook South of Area 4																			
COMPOUND	SD049	SD-50	SD051	SD051D	SD052	SD053	SD060	SD061	SD062	SD063	SD064	SD065	SD066	SD067	SD068	SD069	SD70	SD70DU	SD71	SD72
	Jul-96	Jul-96	Jul-96	Jul-96	Jul-96	Jul-96	Jul-96	Jul-96	Jul-96	Jul-96	Apr-97	Apr-97	Apr-97	Apr-97	Apr-97	Apr-97	Jul-97	Jul-97	Jul-97	Jul-97
Pesticides/PCBs, ug/kg																				
4,4-DDD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4,4-DDE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PCB-1260	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SVOCs, ug/kg																				
1,2-Dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,4-Dichlorobenzene	NA	NA	NA	NA	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	NA	NA	NA
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bis(2-ethylhexyl)phthalate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Di-n-butylphthalate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Diethylphthalate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
VOCs, ug/kg																				
1,2,3-Trichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trichlorobenzene	NA	NA	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	NA
1,3,5-Trimethylbenzene	NA	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	NA
Acetone	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chlorobenzene	NA	NA	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	NA
Tetrahydrofuran	NA	NA	NA	NA	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	NA	NA	NA
Arsenic	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	22.7	19.3	19	11.5
Barium	NA	NA	NA	NA	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	NA	NA	NA
Cadmium	NA	NA	NA	NA	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	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iron	27300	20900	18400	22600	9410	8350	4090	6490	7550	6350	21000	20900	15000	14000	5210	6640	33000	35100	29700	48200
Lead	NA	NA	NA	NA	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	NA	NA	NA	NA
Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	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	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	NA	NA	NA	NA	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	NA	NA	NA
Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA = Not analyzed.
ND = Not detected.
J = Estimated value.

TABLE A-3
SURFACE WATER ANAYTICAL DATA
SACO MUNICIPAL LANDFILL, SACO MAINE

	LANDFILL AREA 1															
	Tributary to Deep Brook												Dubois Pond			
Parameter	SW2		SW2D		SW2		SW-02		SW18		SW16		SW17	
All units in ug/L	(11/17/95)		(11/17/95)		(5/16/96)		11/19/96		(11/17/95)		(11/17/95)		(11/17/95)	
Pesticides/PCBs														
Dieldrin	ND		ND		NA		NA		ND		ND		ND	
Endosulfan II	ND		ND		NA		NA		ND		0.0014	J	ND	
SVOCs														
1,4-Dichlorobenzene	3	J	3	J	NA		NA		ND		ND		ND	
4-Chloro-3-methylphenol	3	J	3	J	NA		NA		2	J	ND		ND	
Bis(2-ethylhexyl)phthalate	ND		ND		NA		NA		ND		2	J	ND	
Di-n-butylphthalate	ND		ND		NA		NA		ND		ND		ND	
VOCs														
1,1-Dichloroethene	ND		ND		NA		NA		ND		ND		ND	
1,2,4-Trimethylbenzene	1	J	1	J	NA		NA		1J		ND		ND	
1,2-Dichlorobenzene	1	J	ND		NA		NA		ND		ND		ND	
1,3-Dichlorobenzene	1	J	ND		NA		NA		ND		ND		ND	
1,4-Dichlorobenzene	2		2		NA		NA		ND		ND		ND	
Acetone	ND		4	J	NA		NA		ND		ND		3J	
Benzene	2		2		NA		NA		ND		ND		ND	
cis-1,2-Dichloroethene	1	J	ND		NA		NA		ND		ND		ND	
Chlorobenzene	3		3		NA		NA		2		ND		ND	
Ethylbenzene	11		10		NA		NA		ND		ND		ND	
m,p-Xylene	16		14		NA		NA		9		ND		ND	
Naphthalene	1	J	1	J	NA		NA		ND		ND		ND	
Tetrahydrofuran	10	J	13	J	NA		NA		ND		ND		ND	
Inorganics														
Aluminum	201.00		113.00	J	108.00	U	1970		133.00	J	1540.00		1330.00	
Antimony	2.60	U	2.60	U	3.60	U	2.1	U	2.60	U	2.60	U	2.60	U
Arsenic	7.40	J	7.00	J	3.00	U	14.1		8.40	J	2.80	U	2.80	U
Barium	54.10	J	55.10	J	39.40		96.3		50.60	J	9.30	J	8.30	J
Beryllium	0.12	U	0.12	U	0.20	U	0.32	U	0.12	U	0.21	U	0.22	U
Cadmium	0.24	U	0.24	U	0.30	U	0.39	U	0.24	U	0.24	U	0.24	U
Calcium	33500.00		34500.00		34000.00	J	35500		28800.00		9860.00		9380.00	
Chromium	1.60	J	1.10	J	0.88	J	5	U	1.60	J	1.90	J	1.40	J
Cobalt	1.20	J	1.20	J	0.70	U	3.2	U	1.30	J	0.61	U	0.61	U
Copper	1.10	U	1.10	U	0.70	U	2.8	U	1.10	U	1.20	J	1.30	J
Iron	12400.00		12500.00		2490.00		35900		14500.00		1950.00		1630.00	
Lead	1.60	J	1.60	UJ	1.00	U	4.9		1.60	UJ	1.80	U	2.20	UJ
Magnesium	10900.00		11200.00		9820.00		9140		9330.00		5150.00		4830.00	J
Manganese	1040.00		1070.00		457.00		1000		981.00		123.00		114.00	
Mercury	0.10	U	0.10	U	0.13	U	0.10	U	0.10	U	0.10	U	0.10	UJ
Nickel	1.70	J	1.30	J	1.00	U	3.2	U	1.30	J	1.40	J	1.10	J
Potassium	7400.00		7760.00		8010.00		9610		6250.00		3500.00	J	3830.00	J
Selenium	3.70	UJ	3.70	UJ	3.70	U	3.1	U	3.70	UJ	3.70	U	3.70	UJ
Silver	0.67	U	0.67	U	1.00	U	1.2	U	0.67	U	0.67	U	0.67	U
Sodium	55500.00		57900.00		32800.00		32200		47700.00		16700.00		16000.00	
Thallium	5.50	UJ	5.50	UJ	3.90	U	3.7	U	5.50	UJ	5.50	U	7.00	J
Vanadium	1.20	U	1.40	U	1.40	U	3.0	U	1.10	U	3.40	U	2.70	U
Zinc	11.30	U	10.20	U	5.50	U	15.2	U	11.80	U	14.20	U	13.20	U

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

SWDAT.XLS

TABLE A-3
SURFACE WATER ANAYTICAL DATA
SACO MUNICIPAL LANDFILL, SACO MAINE

	LANDFILL AREA 2													
Parameter All units in ug/L	SW4 (11/17/95)	SW4 (7/17/97)	SW4-DUP (7/17/97)	SW8 (11/17/95)	SW8 (7/17/97)	SW9 (11/17/95)	SW9D (11/17/95)	SW9T (5/16/96)	SW9 (5/16/96)	SW9D (5/16/96)	SW-09 11/19/96	SW-09(DUP) 11/19/96	SW-09 (7/17/97)	SW10 (11/17/95)
Pesticides/PCBs														
Dieldrin	ND	NA	NA	0.0011 J	NA	ND	ND	NA	NA	NA	NA	NA	NA	ND
Endosulfan II	ND	NA	NA	0.0034 J	NA	ND	ND	NA	NA	NA	NA	NA	NA	ND
SVOCs														
1,4-Dichlorobenzene	ND	NA	NA	ND	NA	ND	ND	NA	NA	NA	NA	NA	NA	ND
4-Chloro-3-methylphenol	ND	NA	NA	ND	NA	ND	ND	NA	NA	NA	NA	NA	NA	ND
Bis(2-ethylhexyl)phthalate	2 J	NA	NA	ND	NA	ND	ND	NA	NA	NA	NA	NA	NA	5 J
Di-n-butylphthalate	ND	NA	NA	ND	NA	ND	ND	NA	NA	NA	NA	NA	NA	ND
VOCs														
1,1-Dichloroethene	NA	NA	NA	ND	NA	1 J	ND	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trimethylbenzene	NA	NA	NA	ND	NA	ND	ND	NA	NA	NA	NA	NA	NA	NA
1,2-Dichlorobenzene	NA	NA	NA	ND	NA	ND	ND	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	NA	NA	NA	1	NA	ND	ND	NA	NA	NA	NA	NA	NA	NA
1,4-Dichlorobenzene	NA	NA	NA	ND	NA	ND	ND	NA	NA	NA	NA	NA	NA	NA
Acetone	NA	NA	NA	ND	NA	ND	ND	NA	NA	NA	NA	NA	NA	NA
Benzene	NA	NA	NA	ND	NA	ND	ND	NA	NA	NA	NA	NA	NA	NA
cis-1,2-Dichloroethene	NA	NA	NA	ND	NA	ND	ND	NA	NA	NA	NA	NA	NA	NA
Chlorobenzene	NA	NA	NA	ND	NA	ND	ND	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	NA	NA	NA	ND	NA	ND	ND	NA	NA	NA	NA	NA	NA	NA
m,p-Xylene	NA	NA	NA	ND	NA	ND	ND	NA	NA	NA	NA	NA	NA	NA
Naphthalene	NA	NA	NA	ND	NA	ND	ND	NA	NA	NA	NA	NA	NA	NA
Tetrahydrofuran	NA	NA	NA	ND	NA	ND	ND	NA	NA	NA	NA	NA	NA	NA
Inorganics														
Aluminum	444.00	NA	NA	574.00	NA	485.00	503.00	544.00	NA	224.00	281	309 U	NA	461.00
Antimony	2.60 U	NA	NA	2.60 U	NA	2.60 U	2.60 U	3.60 U	NA	NA	2.1 U	2.4 U	NA	2.60 U
Arsenic	2.80 U	4.6 U	6.9 U	2.80 U	7 U	2.80 U	2.80 U	3.00 U	NA	NA	2.1 U	2.1 U	6 U	2.80 U
Barium	14.10 J	NA	NA	11.50 J	NA	16.40 J	17.70 J	13.60	NA	NA	12.5	12.5	NA	16.70 J
Beryllium	0.23 U	NA	NA	0.20 U	NA	0.21 U	0.22 U	0.20 U	NA	NA	0.13 U	0.13 U	NA	0.20 U
Cadmium	0.24 U	NA	NA	0.24 U	NA	0.24 U	0.24 U	0.30 U	NA	NA	0.27 U	0.27 U	NA	0.24 U
Calcium	8030.00	NA	NA	6720.00	NA	8660.00	9290.00	8330.00 J	NA	NA	8570	8720	NA	8760.00
Chromium	0.58 J	NA	NA	0.54 U	NA	1.10 J	0.79 J	0.84 J	NA	NA	0.83 U	0.83 U	NA	0.71 J
Cobalt	0.61 U	NA	NA	0.61 U	NA	0.61 U	0.61 U	0.70 U	NA	NA	0.79 U	0.79 U	NA	0.61 U
Copper	1.10 U	NA	NA	1.10 U	NA	1.40 J	1.10 U	0.70 U	NA	NA	1.4 U	0.98 U	NA	1.10 U
Iron	575.00	2020	2650 U	582.00	3620	611.00	632.00	805.00	NA	NA	548	557	2680	619.00
Lead	2.10 U	NA	NA	2.00 U	NA	1.70 U	1.60 U	3.00 J	NA	NA	1.3 U	1.3 U	NA	1.60 U
Magnesium	1990.00 J	NA	NA	1620.00 J	NA	2200.00 J	2390.00 J	1740.00	NA	NA	1820	1850	NA	2250.00 J
Manganese	80.40	NA	NA	77.90	NA	95.60	102.00	86.80	NA	NA	65.6	67.6	NA	97.20
Mercury	0.13 J	NA	NA	0.10 U	NA	0.10 J	0.10 U	0.13 U	0.0037	0.00351	0.10 U	0.10 U	NA	0.12 J
Nickel	1.00 U	NA	NA	1.00 U	NA	1.00 U	1.00 U	1.30 J	NA	NA	1.1 U	0.86 U	NA	1.30 J
Potassium	1980.00 U	NA	NA	2180.00 U	NA	2630.00 U	2610.00 U	1990.00	NA	NA	2370	2000	NA	2520.00 U
Selenium	3.70 U	NA	NA	3.70 U	NA	3.70 U	3.70 U	3.70 U	NA	NA	3.1 U	3.1 U	NA	3.70 U
Silver	0.67 U	NA	NA	0.67 U	NA	0.67 U	0.67 U	1.00 U	NA	NA	1.2 U	1.2 U	NA	0.67 U
Sodium	9600.00	NA	NA	8140.00	NA	10700.00	11800.00	12700.00	NA	NA	12700	12700	NA	11100.00
Thallium	5.70 U	NA	NA	5.50 U	NA	5.50 U	7.90 U	3.90 U	NA	NA	3.7 U	3.7 U	NA	5.50 U
Vanadium	1.60 U	NA	NA	2.00 U	NA	2.20 U	1.80 U	1.00 U	NA	NA	0.91 U	0.79 U	NA	2.00 U
Zinc	16.30 U	NA	NA	15.40 U	NA	15.70 U	11.70 U	10.00 U	NA	NA	7 U	4.7 U	NA	12.10 U

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

TABLE A-3
SURFACE WATER ANAYTICAL DATA
SACO MUNICIPAL LANDFILL, SACO MAINE

	LANDFILL AREAS 3 & 4																				
	Stream/Pool North				Pool South				Big Ledge Brook								Sandy Brook South Area 4				
Parameter	SW3		SW11		SW14		SW-14		SW28T		SW28D		SW29		SW5		SW15		SW-15		
All units in ug/L	(11/17/95)		(11/17/95)		(11/17/95)		11/19/96		(5/16/96)		(5/16/96)		(5/16/96)		(11/17/95)		(11/17/95)		11/19/96		
Pesticides/PCBs																					
Dieldrin	ND		ND		ND		NA		NA		NA		NA		ND		ND		NA		
Endosulfan II	ND		ND		ND		NA		NA		NA		NA		0.0019	J	ND		NA		
SVOCs																					
1,4-Dichlorobenzene	ND		ND		ND		NA		NA		NA		NA		ND		ND		NA		
4-Chloro-3-methylphenol	ND		ND		ND		NA		NA		NA		NA		ND		ND		NA		
Bis(2-ethylhexyl)phthalate	ND		ND		1	J	NA		NA		NA		NA		2	J	ND		NA		
Di-n-butylphthalate	ND		ND		2	J	NA		NA		NA		NA		ND		ND		NA		
VOCs																					
1,1-Dichloroethene	NA		NA		NA		NA		NA		NA		NA		NA		NA		NA		
1,2,4-Trimethylbenzene	NA		NA		NA		NA		NA		NA		NA		NA		NA		NA		
1,2-Dichlorobenzene	NA		NA		NA		NA		NA		NA		NA		NA		NA		NA		
1,3-Dichlorobenzene	NA		NA		NA		NA		NA		NA		NA		NA		NA		NA		
1,4-Dichlorobenzene	NA		NA		NA		NA		NA		NA		NA		NA		NA		NA		
Acetone	NA		NA		NA		NA		NA		NA		NA		NA		NA		NA		
Benzene	NA		NA		NA		NA		NA		NA		NA		NA		NA		NA		
cis-1,2-Dichloroethene	NA		NA		NA		NA		NA		NA		NA		NA		NA		NA		
Chlorobenzene	NA		NA		NA		NA		NA		NA		NA		NA		NA		NA		
Ethylbenzene	NA		NA		NA		NA		NA		NA		NA		NA		NA		NA		
m,p-Xylene	NA		NA		NA		NA		NA		NA		NA		NA		NA		NA		
Naphthalene	NA		NA		NA		NA		NA		NA		NA		NA		NA		NA		
Tetrahydrofuran	NA		NA		NA		NA		NA		NA		NA		NA		NA		NA		
Inorganics																					
Aluminum	116.00	J	87.80	J	776.00		398	U	143.00	U	83.10	U	170.00	U	555.00		440.00		170	U	
Antimony	2.60	U	2.60	U	2.60	U	2.1	U	3.60	U			4.10	J	2.60	U	2.60	U	2.1	U	
Arsenic	3.70	J	3.10	J	3.10	J	18.6		3.00	U	[These samp		3.00	U	10.90		4.20	J	12.2		
Barium	7.40	J	2.70	J	14.70	J	30.5		5.20				5.10		20.10	J	14.90	J	22.2		
Beryllium	0.12	U	0.27	U	0.23	U	0.13	U	0.20	U			0.20	U	0.22	U	0.19	U	0.13	U	
Cadmium	0.29	U	0.24	U	0.24	U	0.27	U	0.30	U			0.30	U	0.24	U	0.24	U	0.27	U	
Calcium	18900.00		5220.00		8800.00		16600		11900.00	J			9520.00	J	10900.00		10600.00		21500		
Chromium	10.20		0.54	U	1.20	J	1.3	U	0.70	U			12.10	J	1.10	J	1.10	J	0.83	U	
Cobalt	0.61	U	0.61	U	0.61	U	1.1	U	0.70	U			0.81	J	0.61	U	0.61	U	0.79	U	
Copper	1.10	U	1.10	U	1.10	U	2.1	U	0.70	U			1.40	J	1.10	U	1.10	U	1.2	U	
Iron	72.00	U	40.70	U	1150.00		2270		138.00	U			528.00		1750.00		863.00		1260		
Lead	1.60	U	1.60	UJ	1.60	UJ	1.3	U	1.00	J			34.50		1.60	U	1.60	UJ	1.3	U	
Magnesium	1990.00	J	694.00	J	2220.00	J	3570		1620.00				1140.00		2640.00	J	2420.00	J	4390		
Manganese	2.10	U	1.70	U	118.00		617		17.20				22.40		239.00		151.00		381		
Mercury	0.10	U	0.10	U	0.12	J	0.10	U	0.13	U			0.13	U	0.12	J	0.10	U	0.10	U	
Nickel	1.00	U	1.00	U	1.10	J	5.1		1.00	U			99.60		1.90	J	1.10	J	1.9	U	
Potassium	643.00	J	331.00	U	2810.00	J	2840		635.00	U			749.00	J	2720.00	J	2030.00	J	2640		
Selenium	3.70	U	3.70	UJ	3.70	UJ	3.1	U	4.60	J			3.70	U	3.70	UJ	3.70	UJ	3.1	U	
Silver	0.71	J	0.67	U	0.67	U	1.2	U	1.00	U			1.00	U	0.67	U	0.67	U	1.2	U	
Sodium	3800.00	J	2730.00	J	9680.00		21400		8940.00				8450.00		12700.00		11400.00		17200		
Thallium	9.90	U	5.50	UJ	5.50	UJ	3.7	U	5.40	U			3.90	U	5.50	UJ	5.50	UJ	3.7	U	
Vanadium	1.30	U	1.10	U	2.10	U	0.96	U	0.60	U			0.85	U	1.80	U	1.60	U	0.57	U	
Zinc	9.30	U	6.70	U	13.20	U	8.3	U	3.30	U			5.80	U	17.10	U	9.60	U	7.8	U	

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

TABLE A-4
GROUNDWATER ANALYTICAL DATA

	DEEP GROUNDWATER DOWNGRADIENT OF AREAS 1 & 2									
	MW-93-4		MW-95-5R							
Parameter	1/12/96	5/17/96	1/12/96		5/17/96		11/21/96	11/21/96	7/17/97	
VOCs										
1,1-Dichloroethane	NA	NA	ND		ND		ND	ND	NA	
1,1-Dichloropropene	NA	NA	ND		ND		ND	ND	NA	
1,1,2,2-Tetrachloroethane	NA	NA	ND		ND		ND	ND	NA	
1,2,3-Trichlorobenzene	NA	NA	ND		ND		ND	ND	NA	
1,2,3-Trichloropropane	NA	NA	ND		ND		ND	ND	NA	
1,2,4-Trichlorobenzene	NA	NA	ND		ND		ND	ND	NA	
1,2,4-Trimethylbenzene	NA	NA	ND		ND		ND	ND	NA	
1,2-Dibromo-3-chloropropan	NA	NA	ND		ND		ND	ND	NA	
1,2-Dichlorobenzene	NA	NA	ND		ND		ND	ND	NA	
1,2-Dichloroethane	NA	NA	ND		ND		ND	ND	NA	
1,3-Dichlorobenzene	NA	NA	ND		ND		ND	ND	NA	
1,3,5-Trimethylbenzene	NA	NA	ND		ND		ND	ND	NA	
1,4-Dichlorobenzene	NA	NA	ND		ND		ND	ND	NA	
2-Butanone	NA	NA	ND		ND		ND	ND	NA	
2-Chlorotoluene	NA	NA	ND		ND		ND	ND	NA	
2,2-Dichloropropane	NA	NA	ND		ND		ND	ND	NA	
4-Isopropytoluene	NA	NA	ND		ND		ND	ND	NA	
Acetone	NA	NA	3	J	ND		ND	ND	NA	
Benzene	NA	NA	ND		ND		ND	ND	NA	
Bromobenzene	NA	NA	ND		ND		ND	ND	NA	
Chlorobenzene	NA	NA	ND		ND		ND	ND	NA	
Chloroethane	NA	NA	ND		ND		ND	ND	NA	
Chloromethane	NA	NA	ND		ND		ND	ND	NA	
cis-1,2-DCE	NA	NA	ND		ND		ND	ND	NA	
Dichlorodifluoromethane	NA	NA	ND		ND		ND	ND	NA	
Ethylbenzene	NA	NA	ND		ND		ND	ND	NA	
Hexachlorobutadiene	NA	NA	ND		ND		ND	ND	NA	
Isopropylbenzene	NA	NA	ND		ND		ND	ND	NA	
Methylene Chloride	NA	NA	ND		ND		ND	ND	NA	
Naphthalene	NA	NA	ND		ND		ND	ND	NA	
Styrene	NA	NA	ND		ND		ND	ND	NA	
Tetrachloroethene	NA	NA	ND		ND		ND	ND	NA	
Tetrahydrofuran	NA	NA	ND		ND		ND	ND	NA	
Toluene	NA	NA	ND		ND		ND	ND	NA	
trans-1,2-DCE	NA	NA	ND		ND		ND	ND	NA	
Trichloroethene	NA	NA	ND		ND		ND	ND	NA	
Trichlorofluoromethane	NA	NA	ND		ND		ND	ND	NA	
m-Xylene/p-Xylene	NA	NA	ND		ND		ND	ND	NA	
n-Butylbenzene	NA	NA	ND		ND		ND	ND	NA	
n-Propylbenzene	NA	NA	ND		ND		ND	ND	NA	
o-Xylene	NA	NA	ND		ND		ND	ND	NA	
sec-Butylbenzene	NA	NA	ND		ND		ND	ND	NA	

NA = Not analyzed.
ND = Not detected.
J = Estimated Value.

TABLE A-4
GROUNDWATER ANALYTICAL DATA

	DEEP GROUNDWATER DOWNGRADIENT OF AREAS 1 & 2															
	MW-93-4				MW-95-5R											
Parameter	1/12/96		5/17/96		1/12/96		5/17/96		11/21/96		11/21/96		7/17/97			
SVOCs																
2-Methylnaphthalene	NA		NA		ND		NA		NA		NA		NA			
2,4-Dimethylphenol	NA		NA		ND		NA		NA		NA		NA			
4-Chloro-3-methylphenol	NA		NA		ND		NA		NA		NA		NA			
Acenaphthylene	NA		NA		ND		NA		NA		NA		NA			
Benzo(g,h,i)perylene	NA		NA		ND		NA		NA		NA		NA			
Bis(2-ethylhexyl)phthalate	NA		NA		ND		NA		NA		NA		NA			
Dibenzo(a,h)anthracene	NA		NA		ND		NA		NA		NA		NA			
Diethylphthalate	NA		NA		ND		NA		NA		NA		NA			
Di-n-butylphthalate	NA		NA		1	J	NA		NA		NA		NA			
Metals																
Aluminum	ND		ND		ND		ND		ND		ND		682	J		
Antimony	ND		ND		ND		ND		ND		ND		ND			
Arsenic	12.7		16.3		8.9	J	12.1		14.5		13.5		ND			
Barium	ND		4.2	J	52.8	J	37.2		23.8		23		28.9			
Cadmium	ND		ND		ND		ND		ND		ND		ND			
Calcium	ND		17200	J	ND		18400	J	14100		13600		15300			
Chromium	ND		ND		ND		ND		ND		ND		5.3			
Cobalt	ND		ND		ND		ND		ND		ND		ND			
Copper	ND		ND		ND		ND		ND		ND		ND			
Cyanide	15	J	NA		ND		ND		ND		ND		ND			
Iron	ND		ND		ND		ND		306		287		969	J		
Lead	ND		ND		ND		ND		ND		ND		ND			
Magnesium	4530	J	4740	J	14600		12000	J	8420		8160		10000			
Manganese	ND		44	J	ND		83.2	J	62.8		59.1		87	J		
Mercury	ND		ND		ND		ND		0.1		ND		ND			
Nickel	ND		ND		ND		ND		ND		ND		5.2			
Potassium	ND		3020		6960		ND		5830		5600		7190			
Selenium	4.3	J	ND		ND		ND		ND		ND		ND			
Silver	ND		ND		ND		ND		ND		ND		ND			
Sodium	48700		51900		300000		204000		162000		160000		237000			
Thallium	ND		ND		ND		ND		ND		ND		ND			
Vanadium	ND		ND		0.69	J	ND		ND		ND		ND			
Zinc	ND		ND		ND		ND		ND		ND		ND			

NA = Not analyzed.
ND = Not detected.
J = Estimated Value.

TABLE A-4
GROUNDWATER ANALYTICAL DATA

	SOUTH OF LANDFILL AREAS 3 & 4																							
	MW-93-3								MW-93-5								MW-95-2S							
Parameter	1/9/96		5/15/96		11/19/96		7/15/97		1/10/96		5/21/96		11/5/96		7/14/97		1/15/96		1/15/96 DUP		5/14/96			
VOCs																								
1,1-Dichloroethane	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
1,1-Dichloropropene	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
1,1,2,2-Tetrachloroethane	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
1,2,3-Trichlorobenzene	ND		ND		ND		NA		1	J	ND		ND		ND		ND		ND		ND			
1,2,3-Trichloropropane	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
1,2,4-Trichlorobenzene	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
1,2,4-Trimethylbenzene	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
1,2-Dibromo-3-chloropropan	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
1,2-Dichlorobenzene	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
1,2-Dichloroethane	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
1,3-Dichlorobenzene	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
1,3,5-Trimethylbenzene	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
1,4-Dichlorobenzene	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
2-Butanone	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
2-Chlorotoluene	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
2,2-Dichloropropane	ND		ND		ND		NA		ND		0.2	J	ND		ND		ND		ND		ND			
4-Isopropytoluene	ND		ND		ND		NA		ND		ND		2	J	ND		ND		ND		ND			
Acetone	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
Benzene	ND		ND		ND		NA		ND		0.3	J	ND		ND		ND		ND		ND			
Bromobenzene	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
Chlorobenzene	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
Chloroethane	ND		ND		ND		NA		1	J	0.7	J	ND		ND		1	J	1	J	ND			
Chloromethane	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
cis-1,2-DCE	ND		ND		1		NA		ND		ND		ND		ND		ND		ND		ND			
Dichlorodifluoromethane	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
Ethylbenzene	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
Hexachlorobutadiene	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
Isopropylbenzene	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
Methylene Chloride	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
Naphthalene	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
Styrene	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
Tetrachloroethene	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
Tetrahydrofuran	ND		ND		ND		NA		21	J	ND		ND		<50	R	ND		ND		ND			
Toluene	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
trans-1,2-DCE	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
Trichloroethene	ND		ND		2		NA		ND		0.3	J	ND		ND		ND		ND		ND			
Trichlorofluoromethane	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
m-Xylene/p-Xylene	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
n-Butylbenzene	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
n-Propylbenzene	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
o-Xylene	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			
sec-Butylbenzene	ND		ND		ND		NA		ND		ND		ND		ND		ND		ND		ND			

NA = Not analyzed.
ND = Not detected.
J = Estimated Value.

TABLE A-4
GROUNDWATER ANALYTICAL DATA

	SOUTH OF LANDFILL AREAS 3 & 4																							
	MW-93-3								MW-93-5								MW-95-2S							
Parameter	1/9/96		5/15/96		11/19/96		7/15/97		1/10/96		5/21/96		11/5/96		7/14/97		1/15/96		1/15/96 DUP		5/14/96			
SVOCs																								
2-Methylnaphthalene	ND		NA		NA		NA		ND		NA		NA		NA		ND		ND		NA			
2,4-Dimethylphenol	ND		NA		NA		NA		ND		NA		NA		NA		ND		ND		NA			
4-Chloro-3-methylphenol	ND		NA		NA		NA		ND		NA		NA		NA		ND		ND		NA			
Acenaphthylene	ND		NA		NA		NA		ND		NA		NA		NA		ND		ND		NA			
Benzo(g,h,i)perylene	ND		NA		NA		NA		ND		NA		NA		NA		ND		ND		NA			
Bis(2-ethylhexyl)phthalate	ND		NA		NA		NA		ND		NA		NA		NA		45	J	ND		NA			
Dibenzo(a,h)anthracene	ND		NA		NA		NA		ND		NA		NA		NA		ND		ND		NA			
Diethylphthalate	ND		NA		NA		NA		ND		NA		NA		NA		ND		ND		NA			
Di-n-butylphthalate	ND		NA		NA		NA		ND		NA		NA		NA		ND		ND		NA			
Metals																								
Aluminum	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND			
Antimony	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND			
Arsenic	ND		ND		ND		ND		82.1		85.4	J	95.9		91.3		ND		ND		ND			
Barium	ND		9.3		9.7		9.6		ND		ND		19.4		15.1		ND		ND		6.2			
Cadmium	0.25	J	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND			
Calcium	59000		51900	J	57600		60100		ND		29700		28900		21400		ND		ND		10500	J		
Chromium	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND			
Cobalt	ND		ND		ND		ND		22.8	J	22.1	J	19.5		13.2		2.1	J	2.1	J	ND			
Copper	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND			
Cyanide	NA		NA		NA		NA		NA		NA		NA		NA		ND		ND		NA			
Iron	ND		ND		ND		ND		40000		36900	J	42400		27900	J	ND		ND		ND			
Lead	1.8	J	ND		ND		ND		6.2	J	12.5		8.1		10.8		ND		ND		ND			
Magnesium	11500		11700	J	11300		12400		5640		4750	J	4740	J	3430		ND		ND		1770	J		
Manganese	ND		ND		ND		ND		13200		11600		9950	J	6990	J	3320		3230		831	J		
Mercury	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND			
Nickel	ND		ND		ND		ND		ND		6.2	J	5.4		8.8		ND		ND		ND			
Potassium	4970	J	4070		4100		4930		ND		2130	J	2200		ND		ND		ND		2080			
Selenium	3.8	J	ND		ND		ND		4.6	J	ND		ND		ND		ND		ND		ND			
Silver	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND			
Sodium	12100		12100		11500		13500		ND		6790		6850		6190		ND		ND		4360			
Thallium	ND		ND		ND		ND		7.1	J	ND		ND		ND		ND		ND		ND			
Vanadium	ND		ND		ND		ND		ND		ND		ND		ND		ND		0.71	J	ND			
Zinc	27.9		ND		ND		ND		31.6		7.6	J	ND		ND		ND		ND		ND			

NA = Not analyzed.
ND = Not detected.
J = Estimated Value.

TABLE A-4
GROUNDWATER ANALYTICAL DATA

	SOUTH OF LANDFILL AREAS 3 & 4, CONT'D																							
	MW-95-4R												MW-95-4RD											
Parameter	12/19/95		12/19/95 D		5/22/96		11/5/96		7/16/97		1/10/96		5/22/96		11/5/96		11/5/96 DUP		7/16/97					
VOCs																								
1,1-Dichloroethane	1		1		1		ND		ND		1		1	J	ND		1	J	ND					
1,1-Dichloropropene	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND					
1,1,2,2-Tetrachloroethane	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND					
1,2,3-Trichlorobenzene	ND		ND		ND		ND		ND		1	J	ND		ND		ND		ND					
1,2,3-Trichloropropane	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND					
1,2,4-Trichlorobenzene	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND					
1,2,4-Trimethylbenzene	6		6		6		5	J	8		9		6		2	J	2	J	8					
1,2-Dibromo-3-chloropropan	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND					
1,2-Dichlorobenzene	4		4		4		4	J	5		5		4		4	J	4	J	5					
1,2-Dichloroethane	ND		1		1		ND		ND		ND		1		1	J	1	J	1					
1,3-Dichlorobenzene	1	J	1	J	ND		ND		ND		ND		ND		ND		ND		ND					
1,3,5-Trimethylbenzene	3		3		4		4	J	4		5		4		2	J	3	J	5					
1,4-Dichlorobenzene	6		6		5		5	J	6		7		5		5	J	5	J	7					
2-Butanone	15		17		ND		ND		ND		ND		ND		ND		ND		ND					
2-Chlorotoluene	ND		1	J	ND		ND		ND		1		ND		ND		ND		ND					
2,2-Dichloropropane	ND		ND		0.4	J	ND		ND		ND		0.4	J	ND		ND		ND					
4-Isopropytoluene	1	J	1	J	ND		0.8	J	ND		1		ND		ND		0.9	J	2					
Acetone	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND					
Benzene	13		12		11		11	J	12		13		11		9	J	10	J	12					
Bromobenzene	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND					
Chlorobenzene	3		3		3		3	J	4		4		3		3	J	3	J	5					
Chloroethane	89		93		65		38	J	39		82		62		30	J	32	J	48					
Chloromethane	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND					
cis-1,2-DCE	1	J	1		0.6	J	ND		ND		ND		0.6	J	ND		ND		ND					
Dichlorodifluoromethane	ND		ND		ND		ND		<2	R	ND		ND		ND		ND		<2	R				
Ethylbenzene	30		29		26		21	J	25		34		27		16	J	17	J	29					
Hexachlorobutadiene	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND					
Isopropylbenzene	3		3		4		3	J	4		6		4		2	J	3	J	4					
Methylene Chloride	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND					
Naphthalene	8		9		5	J	6	J	11		13		5	J	4	J	5	J	12					
Styrene	1	J	ND		ND		ND		ND		ND		ND		ND		ND		ND					
Tetrachloroethene	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND					
Tetrahydrofuran	160		170		110	J	97	J	140		160		110	J	71	J	74	J	130					
Toluene	2		2		1		0.9	J	1		3		1		0.8	J	0.6	J	1					
trans-1,2-DCE	1	J	1	J	0.6	J	ND		ND		1	J	0.6	J	ND		ND		ND					
Trichloroethene	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND					
Trichlorofluoromethane	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND					
m-Xylene/p-Xylene	22		22		21	J	8	J	20		32		21	J	3	J	4	J	25					
n-Butylbenzene	1	J	1	J	ND		0.9	J	ND		2		ND		0.8	J	1	J	2					
n-Propylbenzene	1	J	1	J	ND		1	J	2		ND		ND		0.7	J	0.9	J	2					
o-Xylene	9		9		6		4	J	8		14		8		2	J	2	J	8					
sec-Butylbenzene	1	J	1	J	ND		ND		ND		ND		ND		ND		ND		ND					

NA = Not analyzed.
ND = Not detected.
J = Estimated Value.

TABLE A-4
GROUNDWATER ANALYTICAL DATA

	SOUTH OF LANDFILL AREAS 3 & 4, CONT'D																					
	MW-95-4R										MW-95-4RD											
Parameter	12/19/95		12/19/95 D		5/22/96		11/5/96		7/16/97		1/10/96		5/22/96		11/5/96		11/5/96 DUP		7/16/97			
SVOCs																						
2-Methylnaphthalene	ND		ND		ND		NA		NA		5	J	ND		NA		NA		NA			
2,4-Dimethylphenol	1	J	ND		5	J	NA		NA		ND		5	J	NA		NA		NA			
4-Chloro-3-methylphenol	23		24		19	J	NA		NA		29		16		NA		NA		NA			
Acenaphthylene	ND		ND		ND		NA		NA		ND		ND		NA		NA		NA			
Benzo(g,h,i)perylene	ND		ND		ND		NA		NA		ND		ND		NA		NA		NA			
Bis(2-ethylhexyl)phthalate	11		1	J	ND		NA		NA		ND		ND		NA		NA		NA			
Dibenzo(a,h)anthracene	ND		ND		ND		NA		NA		ND		ND		NA		NA		NA			
Diethylphthalate	6	J	3	J	ND		NA		NA		10	J	ND		NA		NA		NA			
Di-n-butylphthalate	ND		ND		ND		NA		NA		ND		ND		NA		NA		NA			
Metals																						
Aluminum	ND		ND		ND		ND		ND		ND		ND		NA		NA		NA			
Antimony	ND		ND		ND		ND		ND		ND		ND		NA		NA		NA			
Arsenic	504		566		479	J	416		394		556		533	J	511		461		491			
Barium	329		372		295		272		372		463		312		196		189		319			
Cadmium	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND			
Calcium	111000		125000		128000		104000		118000		148000		137000		116000		109000		130000			
Chromium	7.2	J	8.4	J	6.2	J	5.9		7.8	J	10.4		7.7	J	5.8		ND		9.3	J		
Cobalt	41.1	J	ND		10.3	J	9.4		11.4		12.5	J	11	J	8.4		8.2		11.8			
Copper	ND		1.4	J	1.2	J	ND		ND		ND		ND		ND		ND		ND			
Cyanide	ND		1.5	J	NA		NA		NA		ND		ND		ND		ND		ND			
Iron	39800		44400		45500	J	40700		46200		41300		42400	J	42700		38800		48000	J		
Lead	ND		ND		ND		1.5		ND		ND		1.4	J	ND		ND		ND			
Magnesium	50500	J	52100	J	48100	J	39300	J	52700		61500		50900	J	37300	J	35100	J	528000			
Manganese	2180	J	2200	J	2420		2220	J	2300	J	2530		2680		2740	J	2560	J	2550	J		
Mercury	ND		ND		ND		ND		<0.01	R	ND		ND		ND		ND		<0.01	R		
Nickel	89.2		100		45.6		34.9		42.2		59.1		47.8		29		28.4		45.3			
Potassium	34200		37800		31400	J	27900		40300		41600		34200	J	22400		21500		39700			
Selenium	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND			
Silver	ND		ND		ND		ND		ND		ND		1.4	J	ND		ND		ND			
Sodium	304000		344000		297000		256000		287000		363000		328000		258000		247000		288000			
Thallium	6.8	J	ND		ND		ND		ND		ND		ND		ND		ND		ND			
Vanadium	ND		ND		2.3	J	ND		ND		ND		2.2	J	ND		ND		ND			
Zinc	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND			

NA = Not analyzed.
ND = Not detected.
J = Estimated Value.

TABLE A-4
GROUNDWATER ANALYTICAL DATA

	SOUTH OF LANDFILL AREAS 3 & 4, CONT'D																							
	MW-95-4SA										MW-95-4SB								MW-96-6R					
Parameter	1/10/96		5/21/96		5/22/96		11/6/96		7/15/97		1/11/96		5/21/96		11/6/96		7/14/97		1/9/96		5/15/96		11/20/96		7/14/97	7/14/97 DU
VOCs																										
1,1-Dichloroethane	1	J	NA		0.6	J	ND		ND		ND		0.2	J	ND		ND		ND		ND		ND		NA	NA
1,1-Dichloropropene	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
1,1,2,2-Tetrachloroethane	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
1,2,3-Trichlorobenzene	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
1,2,3-Trichloropropane	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
1,2,4-Trichlorobenzene	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
1,2,4-Trimethylbenzene	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
1,2-Dibromo-3-chloropropan	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
1,2-Dichlorobenzene	2		NA		ND		2		2		1	J	ND		0.9	J	0.8	J	ND		ND		ND		NA	NA
1,2-Dichloroethane	2		NA		0.5	J	ND		ND		1	J	0.3	J	ND		ND		ND		ND		ND		NA	NA
1,3-Dichlorobenzene	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
1,3,5-Trimethylbenzene	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
1,4-Dichlorobenzene	2		NA		ND		2		2		1	J	ND		1		1		ND		ND		ND		NA	NA
2-Butanone	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
2-Chlorotoluene	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
2,2-Dichloropropane	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
4-Isopropytoluene	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
Acetone	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
Benzene	4		NA		3		1		2		1		2		1		1		ND		ND		ND		NA	NA
Bromobenzene	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
Chlorobenzene	1		NA		1		0.9	J	1		ND		0.4	J	ND		ND		ND		ND		ND		NA	NA
Chloroethane	22		NA		12		6		5		5		7		3		4		ND		ND		ND		NA	NA
Chloromethane	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
cis-1,2-DCE	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
Dichlorodifluoromethane	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
Ethylbenzene	1		NA		ND		ND		ND		ND		0.3	J	ND		ND		ND		ND		ND		NA	NA
Hexachlorobutadiene	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
Isopropylbenzene	1	J	NA		ND		ND		ND		ND		0.3	J	ND		ND		ND		ND		ND		NA	NA
Methylene Chloride	ND		NA		ND		ND		ND		ND		1		ND		ND		ND		ND		ND		NA	NA
Naphthalene	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
Styrene	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
Tetrachloroethene	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
Tetrahydrofuran	14	J	NA		ND		ND		ND		3	J	ND		ND		ND		5	J	ND		ND		NA	NA
Toluene	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
trans-1,2-DCE	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
Trichloroethene	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
Trichlorofluoromethane	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
m-Xylene/p-Xylene	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		0.8	J	NA	NA
n-Butylbenzene	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
n-Propylbenzene	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
o-Xylene	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA
sec-Butylbenzene	ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		NA	NA

NA = Not analyzed.
ND = Not detected.
J = Estimated Value.

TABLE A-4
GROUNDWATER ANALYTICAL DATA

	SOUTH OF LANDFILL AREAS 3 & 4, CONT'D																																	
	MW-95-4SA										MW-95-4SB										MW-96-6R													
Parameter	1/10/96		5/21/96		5/22/96		11/6/96		7/15/97		1/11/96		5/21/96		11/6/96		7/14/97		1/9/96		5/15/96		11/20/96		7/14/97		7/14/97 DU							
SVOCs																																		
2-Methylnaphthalene	ND		NA		ND		NA		NA		ND		ND		NA		NA		ND		NA		NA		NA		NA							
2,4-Dimethylphenol	ND		NA		ND		NA		NA		ND		ND		NA		NA		ND		NA		NA		NA		NA							
4-Chloro-3-methylphenol	ND		NA		ND		NA		NA		1	J	ND		NA		NA		ND		NA		NA		NA		NA							
Acenaphthylene	ND		NA		ND		NA		NA		ND		ND		NA		NA		ND		NA		NA		NA		NA							
Benzo(g,h,i)perylene	ND		NA		ND		NA		NA		3	J	ND		NA		NA		ND		NA		NA		NA		NA							
Bis(2-ethylhexyl)phthalate	ND		NA		ND		NA		NA		ND		ND		NA		NA		ND		NA		NA		NA		NA							
Dibenzo(a,h)anthracene	ND		NA		ND		NA		NA		2	J	ND		NA		NA		ND		NA		NA		NA		NA							
Diethylphthalate	1	J	NA		ND		NA		NA		ND		ND		NA		NA		ND		NA		NA		NA		NA							
Di-n-butylphthalate	ND		NA		ND		NA		NA		ND		ND		NA		NA		ND		NA		NA		NA		NA							
Metals																																		
Aluminum	ND		ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND							
Antimony	ND		ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND							
Arsenic	202		234	J	NA		217		187		29.7		73		81		95.4		ND		ND		ND		ND		ND							
Barium	209		142		NA		97.9		109		51.3	J	66.1		47.6		58.7		ND		12.3		15.4		13.5		14.2							
Cadmium	ND		ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND							
Calcium	109000		95600		NA		78500		73400		ND		49900	J	41400		46900		ND		50500	J	54200		58000		60700							
Chromium	ND		8.7	J	NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND							
Cobalt	16.2	J	16	J	NA		12.8		15		5.4	J	ND		9.3		10.5		ND		ND		ND		ND		ND							
Copper	ND		ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND							
Cyanide	ND		NA		NA		NA		NA		ND		NA		NA		NA		ND		NA		NA		NA		NA							
Iron	31300		31600	J	NA		27200		30300	J	ND		23100	J	17500		22100	J	ND		ND		834		227	J	ND							
Lead	2	J	ND		NA		ND		ND		ND		ND		ND		5.6		ND		ND		ND		ND		ND							
Magnesium	22300		19000	J	NA		15000	J	14800		8760		10100	J	7660	J	9540		11200		12300	J	12000		13000		13600							
Manganese	5300		5120		NA		4310	J	4290	J	6450		6600	J	5190	J	6640	J	ND		ND		ND		ND		ND							
Mercury	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		<0.01	R	<0.01	R						
Nickel	16.7		18	J	NA		10.7		11.6		ND		ND		8.1		11.3		ND		ND		ND		ND		ND							
Potassium	6630		5610	J	NA		3910		5520		4230	J	3970		3690		4570		ND		3500		3780		3940		4340							
Selenium	ND		ND		NA		ND		ND		ND		ND		ND		ND		4.3	J	ND		ND		ND		ND							
Silver	ND		ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND							
Sodium	134000		103000		NA		63400		71600		34400		37800		31100		37500		17900		13500		13600		14800		15400							
Thallium	ND		ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND							
Vanadium	1.2	J	0.68	J	NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND							
Zinc	ND		ND		NA		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND							

NA = Not analyzed.
ND = Not detected.
J = Estimated Value.

TABLE A-4
GROUNDWATER ANALYTICAL DATA

	SOUTH OF LANDFILL AREAS 3 & 4, CONT'D															
	MW-95-6S				MW-95-7R				MW-95-7S			
Parameter	1/12/96	5/15/96	11/20/96	7/14/97	12/19/95	5/22/96	11/5/96	7/14/97	1/9/96	5/15/96	11/19/96	7/15/97
VOCs												
1,1-Dichloroethane	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropene	ND	ND	ND	NA	1 J	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND	ND	NA	1 J	ND	ND	1 J	ND	ND	ND	ND
1,2,3-Trichlorobenzene	ND	ND	ND	NA	1 J	ND	0.8 J	ND	ND	ND	ND	ND
1,2,3-Trichloropropane	ND	ND	ND	NA	1 J	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	ND	ND	ND	NA	1 J	ND	0.6 J	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzene	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromo-3-chloropropan	ND	ND	ND	NA	1	ND	ND	1 J	ND	ND	ND	ND
1,2-Dichlorobenzene	ND	ND	ND	NA	1 J	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	ND	ND	ND	NA	1 J	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzene	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	ND	ND	ND	NA	1 J	ND	ND	ND	ND	ND	ND	ND
2-Butanone	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
2-Chlorotoluene	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
2,2-Dichloropropane	ND	0.2 J	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
4-Isopropytoluene	1 J	ND	ND	NA	ND	ND	4 J	ND	ND	ND	ND	ND
Acetone	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
Bromobenzene	ND	ND	ND	NA	1 J	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	ND	NA	1 J	ND	ND	ND	ND	ND	ND	ND
Chloroethane	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
Chloromethane	ND	ND	ND	NA	ND	ND	2 J	ND	ND	ND	ND	ND
cis-1,2-DCE	ND	ND	0.6 J	NA	ND	ND	ND	ND	ND	ND	5	ND
Dichlorodifluoromethane	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	0.7 J	NA	1 J	ND	ND	ND	ND	ND	ND	ND
Hexachlorobutadiene	ND	ND	ND	NA	1 J	ND	ND	ND	ND	ND	ND	ND
Isopropylbenzene	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	ND	ND	ND	NA	1 J	ND	0.8 J	1 J	ND	ND	ND	ND
Styrene	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
Tetrahydrofuran	ND	ND	ND	NA	3 J	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	NA	1 J	ND	ND	ND	ND	ND	ND	ND
trans-1,2-DCE	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	ND	ND	0.7 J	NA	ND	ND	2 J	ND	ND	ND	7	ND
Trichlorofluoromethane	ND	ND	ND	NA	1 J	ND	ND	ND	ND	ND	ND	ND
m-Xylene/p-Xylene	ND	ND	3	NA	1 J	ND	0.5 J	ND	ND	ND	ND	ND
n-Butylbenzene	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
sec-Butylbenzene	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND

NA = Not analyzed.
ND = Not detected.
J = Estimated Value.

TABLE A-4
GROUNDWATER ANALYTICAL DATA

	SOUTH OF LANDFILL AREAS 3 & 4, CONT'D															
	MW-95-6S				MW-95-7R				MW-95-7S			
Parameter	1/12/96	5/15/96	11/20/96	7/14/97	12/19/95	5/22/96	11/5/96	7/14/97	1/9/96	5/15/96	11/19/96	7/15/97
SVOCs												
2-Methylnaphthalene	ND	NA	NA	NA	ND	ND	NA	NA	ND	ND	NA	NA
2,4-Dimethylphenol	ND	NA	NA	NA	ND	ND	NA	NA	ND	ND	NA	NA
4-Chloro-3-methylphenol	ND	NA	NA	NA	ND	ND	NA	NA	ND	ND	NA	NA
Acenaphthylene	ND	NA	NA	NA	ND	ND	NA	NA	1 J	ND	NA	NA
Benzo(g,h,i)perylene	ND	NA	NA	NA	ND	ND	NA	NA	ND	ND	NA	NA
Bis(2-ethylhexyl)phthalate	ND	NA	NA	NA	12	ND	NA	NA	ND	ND	NA	NA
Dibenzo(a,h)anthracene	ND	NA	NA	NA	ND	ND	NA	NA	ND	ND	NA	NA
Diethylphthalate	ND	NA	NA	NA	ND	ND	NA	NA	ND	ND	NA	NA
Di-n-butylphthalate	ND	NA	NA	NA	ND	ND	NA	NA	ND	ND	NA	NA
Metals												
Aluminum	ND	ND	165	ND	430 J	400	ND	ND	ND	ND	ND	ND
Antimony	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	ND	6.5 J	12.2	ND	21.1	ND	2.5	ND	ND	ND	ND	ND
Barium	ND	8.1	11.9	12.4	13.3 J	ND	6.6	4.5	ND	13.1	13.2	9.8
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	ND	23800 J	30600	32800	14700	13400	14400	11600	ND	26700 J	27600	27600
Chromium	ND	ND	ND	ND	1.7 J	ND	ND	ND	ND	ND	ND	ND
Cobalt	ND	ND	ND	ND	5.3 J	1.5 J	ND	ND	1.2 J	6 J	ND	ND
Copper	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cyanide	ND	NA	NA	ND	ND	NA	NA	NA	ND	NA	NA	ND
Iron	ND	5550 J	6040	6410 J	4250	412 J	ND	ND	ND	ND	543	2865
Lead	ND	ND	ND	ND	ND	ND	ND	5	ND	ND	ND	ND
Magnesium	5470	5050 J	5980	7210	2640 J	2150 J	2250 J	1900	ND	4990 J	5500	4840
Manganese	705	213 J	239	229 J	584 J	192	156 J	25.9 J	246	1040 J	570	2945
Mercury	ND	ND	ND	ND	ND	ND	ND	<0.01 R	ND	ND	ND	ND
Nickel	ND	ND	ND	ND	11.4 J	5.4 J	7	ND	ND	ND	ND	ND
Potassium	ND	1340	222	ND	ND	1090 J	696	ND	ND	2760	3140	2480
Selenium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	ND	5330	5850	6520	13300	5530	5130	4360	34000	13400	11900	7920
Thallium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	ND	ND	ND	ND	ND	ND	ND	ND	0.6 J	ND	ND	ND
Zinc	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

NA = Not analyzed.
ND = Not detected.
J = Estimated Value.

TABLE A-4
GROUNDWATER ANALYTICAL DATA

	SOUTH OF LANDFILL AREAS 3 & 4, CONT'D											
	MW-95-8R										MW-97-17R	
Parameter	12/21/95		5/13/96 D		5/13/96 T		11/20/96		7/16/97		10/16/97	
VOCs												
1,1-Dichloroethane	ND		ND		ND		ND		ND		NA	
1,1-Dichloropropene	ND		ND		ND		ND		ND		NA	
1,1,2,2-Tetrachloroethane	ND		ND		ND		ND		ND		NA	
1,2,3-Trichlorobenzene	ND		ND		ND		ND		ND		NA	
1,2,3-Trichloropropane	ND		ND		ND		ND		ND		NA	
1,2,4-Trichlorobenzene	ND		ND		ND		ND		ND		NA	
1,2,4-Trimethylbenzene	ND		ND		ND		ND		ND		NA	
1,2-Dibromo-3-chloropropan	ND		ND		ND		ND		ND		NA	
1,2-Dichlorobenzene	ND		ND		ND		ND		ND		NA	
1,2-Dichloroethane	ND		ND		ND		ND		ND		NA	
1,3-Dichlorobenzene	ND		ND		ND		ND		ND		NA	
1,3,5-Trimethylbenzene	ND		ND		ND		ND		ND		NA	
1,4-Dichlorobenzene	1	J	ND		ND		0.7	J	ND		NA	
2-Butanone	ND		ND		ND		ND		ND		NA	
2-Chlorotoluene	ND		ND		ND		ND		ND		NA	
2,2-Dichloropropane	ND		ND		ND		ND		ND		NA	
4-Isopropytoluene	ND		ND		ND		ND		ND		NA	
Acetone	ND		ND		ND		ND		ND		NA	
Benzene	1		ND		0.3	J	0.7	J	ND		NA	
Bromobenzene	ND		ND		ND		ND		ND		NA	
Chlorobenzene	1	J	ND		ND		ND		ND		NA	
Chloroethane	2	J	ND		ND		ND		ND		NA	
Chloromethane	ND		ND		ND		ND		ND		NA	
cis-1,2-DCE	ND		ND		ND		ND		ND		NA	
Dichlorodifluoromethane	1	J	ND		ND		ND		ND		NA	
Ethylbenzene	1	J	ND		0.2	J	ND		ND		NA	
Hexachlorobutadiene	ND		ND		ND		ND		ND		NA	
Isopropylbenzene	ND		ND		ND		ND		ND		NA	
Methylene Chloride	ND		ND		ND		ND		ND		NA	
Naphthalene	ND		ND		ND		ND		ND		NA	
Styrene	ND		ND		ND		ND		ND		NA	
Tetrachloroethene	ND		ND		ND		ND		ND		NA	
Tetrahydrofuran	ND		ND		ND		ND		ND		NA	
Toluene	1	J	ND		0.5	J	ND		ND		NA	
trans-1,2-DCE	ND		ND		ND		ND		ND		NA	
Trichloroethene	ND		ND		ND		ND		ND		NA	
Trichlorofluoromethane	ND		ND		ND		ND		ND		NA	
m-Xylene/p-Xylene	1	J	ND		ND		ND		ND		NA	
n-Butylbenzene	ND		ND		ND		ND		ND		NA	
n-Propylbenzene	ND		ND		ND		ND		ND		NA	
o-Xylene	ND		ND		ND		ND		ND		NA	
sec-Butylbenzene	ND		ND		ND		ND		ND		NA	

NA = Not analyzed.
ND = Not detected.
J = Estimated Value.

TABLE A-4
GROUNDWATER ANALYTICAL DATA

	SOUTH OF LANDFILL AREAS 3 & 4, CONT'D																					
	MW-95-8R																				MW-97-17R	
Parameter	12/21/95			5/13/96 D			5/13/96 T			11/20/96			7/16/97			10/16/97					
SVOCs																						
2-Methylnaphthalene	ND			ND			ND			NA			NA			NA					
2,4-Dimethylphenol	ND			ND			ND			NA			NA			NA					
4-Chloro-3-methylphenol	1	J		ND			ND			NA			NA			NA					
Acenaphthylene	ND			ND			ND			NA			NA			NA					
Benzo(g,h,i)perylene	ND			ND			ND			NA			NA			NA					
Bis(2-ethylhexyl)phthalate	ND			ND			ND			NA			NA			NA					
Dibenzo(a,h)anthracene	ND			ND			ND			NA			NA			NA					
Diethylphthalate	ND			ND			ND			NA			NA			NA					
Di-n-butylphthalate	ND			ND			ND			NA			NA			NA					
Metals																						
Aluminum	891	J		ND			5690	J		ND			ND			NA					
Antimony	ND			ND			ND			ND			ND			NA					
Arsenic	164			79.6			81.7			121			96.5			2					
Barium	57.5	J		24.4			43.6			41.4			37.7			NA					
Cadmium	ND			ND			ND			ND			ND			NA					
Calcium	41700			21700	J		26100	J		36800			41000			NA					
Chromium	1.3	J		ND			ND			ND			ND			NA					
Cobalt	74.6			38.6			41.6			60.6			59.6			NA					
Copper	ND			ND			ND			ND			ND			NA					
Cyanide	ND			ND			ND			NA			NA			NA					
Iron	35000			16800	J		20400	J		26600			23900	J		270					
Lead	ND			ND			65.1			ND			ND			NA					
Magnesium	6310	J		3040	J		4620	J		4460			4800			NA					
Manganese	8800	J		7300	J		7780	J		8690			9910	J		31					
Mercury	ND			ND			ND			ND			<0.01	R		NA					
Nickel	95.4			47.6			56.1			67.3			95			NA					
Potassium	4470	J		2500			2530			3470			3110			NA					
Selenium	6.9	J		ND			ND			ND			ND			NA					
Silver	ND			ND			ND			1.5			ND			NA					
Sodium	15600			6160			8220			7570			7350			NA					
Thallium	11	J		ND			ND			ND			ND			NA					
Vanadium	0.95	J		ND			2	J		ND			ND			NA					
Zinc	ND			ND			ND			ND			ND			NA					

NA = Not analyzed.
ND = Not detected.
J = Estimated Value.

ATTACHMENT B
RISK CALCULATIONS

TABLE B-1
INCIDENTAL INGESTION AND DIRECT CONTACT WITH SURFACE SOILS- AREA 1

REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL, SACO MAINE

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL/SEDIMENT	CS		mg/kg	
INGESTION RATE	IR	100	mg/day	EPA, 1991
FRACTION INGESTED	FI	100%		
SOIL CONTACT RATE	SCR	5240	mg/day	DEP, 1994
CONVERSION FACTOR	CF	0.000001	kg/mg	
BODY WEIGHT	BW	42	kg	DEP,1994
EXPOSURE FREQUENCY	EF	112	days/year	EPA/BPJ, 1996
EXPOSURE DURATION	ED	12	years	DEP,1994
AVERAGING TIME				
CANCER	AT	70	years	
NONCANCER	AT	12	years	

EQUATIONS

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

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

INTAKE = (INTAKE-INGESTION) + (INTAKE-DERMAL)

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

$$\text{INTAKE-DERMAL} = \frac{CS \times SCR \times RAF \times CF \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Note:
For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Tetrachloroethane(1,1,1,2)	0.001	1	1.3E-10	NA		0.026	3.3E-12	0.0E+00	3.3E-12
Dichlorobenzene (1,4)	0.001	1	1.3E-10	NA		0.024	3.0E-12		3.0E-12
Bromodichloromethane	0.001	1	1.3E-10	NA		0.062	7.8E-12		7.8E-12
Chlordane	0.0002	1	2.5E-11	NA		6.3	1.6E-10		1.6E-10
Benzene	0.001	1	1.3E-10	NA		0.029	3.6E-12		3.6E-12
B(a)P	0.081	1	1.0E-08	NA		7.3	7.4E-08		7.4E-08
Benzo(b)fluoranthene	0.11	1	1.4E-08	NA		0.73	1.0E-08		1.0E-08
Benzo(k)fluoranthene	0.017	1	2.1E-09	NA		0.073	1.6E-10		1.6E-10
Dieldrin	0.00019	1	2.4E-11	NA		16	3.8E-10		3.8E-10
Heptachlor	0.00008	1	1.0E-11	NA		4.5	4.5E-11		4.5E-11
Hexachlorobutadiene	0.001	1	1.3E-10	NA		0.078	9.8E-12		9.8E-12
Indeno(1,2,3-cd)pyrene	0.048	1	6.0E-09	NA		0.7	4.2E-09		4.2E-09
Arsenic	5.5	1	6.9E-07	NA		1.5	1.0E-06		1.0E-06
Beryllium	1.3	1	1.6E-07	NA		4.3	7.0E-07		7.0E-07
					TOTAL CANCER RISK		1.8E-06	0.0E+00	1.8E-06

NONCARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
		1							
Tetrachloroethene (1,1,1,2)	0.001	1	7.3E-10	NA		0.03	2.4E-08		2.4E-08
Bromodichloromethane	0.001	1	7.3E-10	NA		0.02	3.7E-08		3.7E-08
Trimethylbenzene (1,2,4)	0.001	1	7.3E-10	NA		0.05	1.5E-08		1.5E-08
Dichlorobenzene (1,2)	0.001	1	7.3E-10	NA		0.09	8.1E-09		8.1E-09
Trimethylbenzene (1,3,5)	0.001	1	7.3E-10	NA		0.05	1.5E-08		1.5E-08
Dichlorobenzene (1,3)	0.001	1	7.3E-10	NA		0.089	8.2E-09		8.2E-09
Chlorobenzene	0.001	1	7.3E-10	NA		0.02	3.7E-08		3.7E-08
Ethylbenzene	0.001	1	7.3E-10	NA		0.1	7.3E-09		7.3E-09
Fluoranthene	0.12	1	8.8E-08	NA		0.04	2.2E-06		2.2E-06
Napthalene	0.001	1	7.3E-10	NA		0.04	1.8E-08		1.8E-08
Pyrene	0.14	1	1.0E-07	NA		0.03	3.4E-06		3.4E-06
Trichlorofluoromethane	0.001	1	7.3E-10	NA		0.3	2.4E-09		2.4E-09
Arsenic	5.5	1	4.0E-06	NA		0.0003	1.3E-02		1.3E-02
Barium	58	1	4.2E-05	NA		0.07	6.1E-04		6.1E-04
Beryllium	1.3	1	9.5E-07	NA		0.005	1.9E-04		1.9E-04
Chromium (VI)	36.4	1	2.7E-05	NA		0.005	5.3E-03		5.3E-03
Manganese	399	1	2.9E-04	NA		0.024	1.2E-02		1.2E-02
Mercury	0.07	1	5.1E-08	NA		0.0003	1.7E-04		1.7E-04
Nickel	13	1	9.5E-06	NA		0.02	4.7E-04		4.7E-04
Selenium	0.6	1	4.4E-07	NA		0.005	8.8E-05		8.8E-05
Vanadium	27.9	1	2.0E-05	NA		0.007	2.9E-03		2.9E-03
Zinc	61.9	1	4.5E-05	NA		0.3	1.5E-04		1.5E-04
TCA	0.001	1	7.3E-10	NA		0.03	2.4E-08		2.4E-08
Trichloropropane	0.001	1	7.3E-10	NA		0.006	1.2E-07		1.2E-07
Dieldrin	0.00019	1	1.4E-10	NA		0.00005	2.8E-06		2.8E-06
Heptachlor	0.0008	1	5.8E-10	NA		0.0005	1.2E-06		1.2E-06
Hexachlorobutadiene	0.001	1	7.3E-10	NA		0.0002	3.7E-06		3.7E-06
					TOTAL HAZARD INDEX		3.5E-02	0.0E+00	3.5E-02

Note: These tables include only those compounds for which quantitative toxicity information is available.

TABLE B-2
INCIDENTAL INGESTION AND DIRECT CONTACT WITH SURFACE SOILS- DUBOIS POND

REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL, SACO MAINE

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL/SEDIMENT	CS		mg/kg	
INGESTION RATE	IR	100	mg/day .	EPA, 1991
FRACTION INGESTED	FI	100%		
SOIL CONTACT RATE	SCR	5240	mg/day	DEP, 1994
CONVERSION FACTOR	CF	0.000001	kg/mg	
BODY WEIGHT	BW	42	kg	DEP,1994
EXPOSURE FREQUENCY	EF	112	days/year	EPA/BPJ, 1996
EXPOSURE DURATION	ED	12	years	DEP,1994
AVERAGING TIME				
CANCER	AT	70	years	
NONCANCER	AT	12	years	

EQUATIONS

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

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

INTAKE = (INTAKE-INGESTION) + (INTAKE-DERMAL)

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

$$\text{INTAKE-DERMAL} = \frac{CS \times SCR \times RAF \times CF \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Note:
For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	3	1	3.8E-07	NA		1.5	5.6E-07		5.6E-07
Beryllium	1.1	1	1.4E-07	NA		4.3	5.9E-07		5.9E-07
TOTAL CANCER RISK							1.2E-06	0.0E+00	1.2E-06

NONCARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
		1							
Arsenic	3	1	2.2E-06	NA		0.0003	7.3E-03		7.3E-03
Barium	38.1	1	2.8E-05	NA		0.07	4.0E-04		4.0E-04
Beryllium	1.1	1	8.0E-07	NA		0.005	1.6E-04		1.6E-04
Chromium (VI)	14.8	1	1.1E-05	NA		0.005	2.2E-03		2.2E-03
Manganese	294	1	2.1E-04	NA		0.024	8.9E-03		8.9E-03
Nickel	9.4	1	6.9E-06	NA		0.02	3.4E-04		3.4E-04
Vanadium	21.8	1	1.6E-05	NA		0.007	2.3E-03		2.3E-03
Zinc	52.3	1	3.8E-05	NA		0.3	1.3E-04		1.3E-04
TOTAL HAZARD INDEX							2.2E-02	0.0E+00	2.2E-02

Note: These tables include only those compounds for which quantitative toxicity information is available.

TABLE B-3
INCIDENTAL INGESTION AND DIRECT CONTACT WITH SURFACE SOILS- AREA 2

REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL, SACO MAINE

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL/SEDIMENT	CS		mg/kg	
INGESTION RATE	IR	100	mg/day	EPA, 1991
FRACTION INGESTED	FI	100%		
SOIL CONTACT RATE	SCR	5240	mg/day	DEP, 1994
CONVERSION FACTOR	CF	0.000001	kg/mg	
BODY WEIGHT	BW	42	kg	DEP,1994
EXPOSURE FREQUENCY	EF	112	days/year	EPA/BPJ, 1996
EXPOSURE DURATION	ED	12	years	DEP,1994
AVERAGING TIME				
CANCER	AT	70	years	
NONCANCER	AT	12	years	

EQUATIONS

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

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

INTAKE = (INTAKE-INGESTION) + (INTAKE-DERMAL)

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

$$\text{INTAKE-DERMAL} = \frac{CS \times SCR \times RAF \times CF \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Note:
For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Tetrachloroethane(1,1,2,2	0.006	1	7.5E-10	NA		0.2	1.5E-10	0.0E+00	1.5E-10
Trichloropropane	0.006	1	7.5E-10	NA		7	5.3E-09		5.3E-09
Dichlorobenzene	0.076	1	9.5E-09	NA		0.024	2.3E-10		2.3E-10
DDT	0.094	1	1.2E-08	NA		0.34	4.0E-09		4.0E-09
DDD	0.024	1	3.0E-09	NA		0.24	7.2E-10		7.2E-10
DDE	0.037	1	4.6E-09	NA		0.34	1.6E-09		1.6E-09
Chlordane	0.00035	1	4.4E-11	NA		6.3	2.8E-10		2.8E-10
Benzene	0.00093	1	1.2E-10	NA		0.029	3.4E-12		3.4E-12
Benzo(a)anthracene	0.13	1	1.6E-08	NA		0.73	1.2E-08		1.2E-08
B(a)P	0.096	1	1.2E-08	NA		7.3	8.8E-08		8.8E-08
Benzo(b)fluoranthene	0.16	1	2.0E-08	NA		0.73	1.5E-08		1.5E-08
Benzo(k)fluoranthene	0.056	1	7.0E-09	NA		0.073	5.1E-10		5.1E-10
DEHP	6.8	1	8.5E-07	NA		0.014	1.2E-08		1.2E-08
Chrysene	0.14	1	1.8E-08	NA		0.0073	1.3E-10		1.3E-10
Dieldrin	0.0012	1	1.5E-10	NA		16	2.4E-09		2.4E-09
g-Chlordane	0.00041	1	5.1E-11	NA		1.3	6.7E-11		6.7E-11
Heptachlor	0.00011	1	1.4E-11	NA		4.5	6.2E-11		6.2E-11
Hexachlorobutadiene	0.00194	1	2.4E-10	NA		0.078	1.9E-11		1.9E-11
Indeno(1,2,3-cd)pyrene	0.057	1	7.1E-09	NA		0.7	5.0E-09		5.0E-09
Arsenic*	37	1	4.6E-06	NA		1.5	7.0E-06		7.0E-06
Beryllium	1.7	1	2.1E-07	NA		4.3	9.2E-07		9.2E-07
					TOTAL CANCER RISK		8.0E-06	0.0E+00	8.0E-06

* Arsenic EPC is the 95th UCL on the arithmetic mean concentration.

Note: These tables include only those compounds for which quantitative toxicity information is available.

TABLE B-3
INCIDENTAL INGESTION AND DIRECT CONTACT WITH SURFACE SOILS- AREA 2

REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL, SACO MAINE

NONCARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
		1							
Trichloroethane	0.00019	1	1.4E-10	NA		0.035	4.0E-09		4.0E-09
Trichlorobenzene (1,2,4)	0.00129	1	9.4E-10	NA		0.01	9.4E-08		9.4E-08
Trimethylbenzene (1,2,4)	0.00099	1	7.2E-10	NA		0.05	1.4E-08		1.4E-08
Dichlorobenzene (1,2)	0.00129	1	9.4E-10	NA		0.09	1.0E-08		1.0E-08
Trimethylbenzene (1,3,5)	0.00097	1	7.1E-10	NA		0.05	1.4E-08		1.4E-08
Dichlorobenzene (1,3)	0.00143	1	1.0E-09	NA		0.089	1.2E-08		1.2E-08
MEK	0.0087	1	6.4E-09	NA		0.6	1.1E-08		1.1E-08
Chlorotoluene (2)	0.00114	1	8.3E-10	NA		0.02	4.2E-08		4.2E-08
Bromethane	0.00256	1	1.9E-09	NA		0.0014	1.3E-06		1.3E-06
Chlorobenzene	0.00105	1	7.7E-10	NA		0.02	3.8E-08		3.8E-08
cis-Dichloroethene	0.00192	1	1.4E-09	NA		0.01	1.4E-07		1.4E-07
DNOP	0.082	1	6.0E-08	NA		0.02	3.0E-06		3.0E-06
Endosulfan II	0.00055	1	4.0E-10	NA		0.006	6.7E-08		6.7E-08
Endrin Ketone	0.00025	1	1.8E-10	NA		0.0003	6.1E-07		6.1E-07
Ethylbenzene	0.00087	1	6.4E-10	NA		0.1	6.4E-09		6.4E-09
Fluoranthene	0.31	1	2.3E-07	NA		0.04	5.7E-06		5.7E-06
Napthalene	0.00141	1	1.0E-09	NA		0.04	2.6E-08		2.6E-08
xylene	0.00057	1	4.2E-10	NA		2	2.1E-10		2.1E-10
Pyrene	0.25	1	1.8E-07	NA		0.03	6.1E-06		6.1E-06
sec-butylbenzene	0.00122	1	8.9E-10	NA		0.01	8.9E-08		8.9E-08
tert-butylbenzene	0.0009	1	6.6E-10	NA		0.01	6.6E-08		6.6E-08
Toluene	0.00066	1	4.8E-10	NA		0.2	2.4E-09		2.4E-09
Trichlorofluoromethane	0.00115	1	8.4E-10	NA		0.3	2.8E-09		2.8E-09
Antimony	2.4	1	1.8E-06	NA		0.0004	4.4E-03		4.4E-03
Arsenic*	37	1	2.7E-05	NA		0.0003	9.0E-02		9.0E-02
Barium	2490	1	1.8E-03	NA		0.07	2.6E-02		2.6E-02
Beryllium	1.7	1	1.2E-06	NA		0.005	2.5E-04		2.5E-04
Cadmium	1.9	1	1.4E-06	0.01	7.3E-07	0.0005	2.8E-03	1.5E-03	4.2E-03
Chromium (VI)	70.2	1	5.1E-05	NA		0.005	1.0E-02		1.0E-02
Manganese	1700	1	1.2E-03	NA		0.024	5.2E-02		5.2E-02
Mercury	0.16	1	1.2E-07	NA		0.0003	3.9E-04		3.9E-04
Nickel	18.5	1	1.4E-05	NA		0.02	6.8E-04		6.8E-04
Selenium	5.2	1	3.8E-06	NA		0.005	7.6E-04		7.6E-04
Vanadium	36.9	1	2.7E-05	NA		0.007	3.9E-03		3.9E-03
Zinc	346	1	2.5E-04	NA		0.3	8.4E-04		8.4E-04
TCA	0.006	1	4.4E-09	NA		0.03	1.5E-07		1.5E-07
Trichloropropane	0.006	1	4.4E-09	NA		0.006	7.3E-07		7.3E-07
DDT	0.094	1	6.9E-08	NA		0.0005	1.4E-04		1.4E-04
BEHP	6.8	1	5.0E-06	NA		0.02	2.5E-04		2.5E-04
Dieldrin	0.0012	1	8.8E-10	NA		0.00005	1.8E-05		1.8E-05
Heptachlor	0.00011	1	8.0E-11	NA		0.0005	1.6E-07		1.6E-07
Hexachlorobutadiene	0.0019	1	1.4E-09	NA		0.0002	6.9E-06		6.9E-06
g-Chlordane	0.00041	1	3.0E-10	NA		0.00006	5.0E-06		5.0E-06
					TOTAL HAZARD INDEX		1.9E-01	1.5E-03	1.9E-01

*: Arsenic EPC is the 95th UCL on the arithmetic mean concentration.

Note: These tables include only those compounds for which quantitative toxicity information is available.

TABLE B-4
INCIDENTAL INGESTION AND DIRECT CONTACT WITH SEDIMENTS- AREA 1, UNNAMED TRIBUTARY TO DEEP BROOK

REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL,SACO MAINE

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL/S	CS		mg/kg	
INGESTION RATE	IR	100	mg/day	EPA, 1991/DEP,1994
FRACTION INGESTED	FI	100%		
SOIL CONTACT RATE	SCR	1000	mg/day	EPA, 1989
CONVERSION FACTOR	CF	0.000001	kg/mg	
BODY WEIGHT	BW	42	kg	DEP, 1994
EXPOSURE FREQUENCY	EF	20	days/year	EPA/BPJ, 1996
EXPOSURE DURATION	ED	12	years	EPA, 1996/DEP,1994
AVERAGING TIME				
CANCER	AT	70	years	
NONCANCER	AT	12	years	

EQUATIONS

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

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

INTAKE = (INTAKE-INGESTION) + (INTAKE-DERMAL)

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

$$\text{INTAKE-DERMAL} = \frac{CS \times SCR \times RAF \times CF \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Note:
For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	105	1	2.3E-06	NA		1.5	3.5E-06	0.0E+00	3.5E-06
Beryllium	0.51	1	1.1E-08	NA		4.3	4.9E-08		4.9E-08
1,4-Dichlorobenzene	0.11	1	2.5E-09	NA		0.024	5.9E-11		5.9E-11
Benzo(a)pyrene	0.18	1	4.0E-09	NA		7.3	2.9E-08		2.9E-08
DEHP	0.63	1	1.4E-08	0.06	8.5E-09	0.014	2.0E-10	1.2E-10	3.2E-10
TOTAL CANCER RISK							3.6E-06	1.2E-10	3.6E-06

NONCARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	105	1	1.4E-05	NA		0.003	4.6E-03		4.6E-03
Barium	141	1	1.8E-05	NA		0.07	2.6E-04		2.6E-04
Beryllium	0.66	1	8.6E-08	NA		0.005	1.7E-05		1.7E-05
Cadmium	0.09	1	1.2E-08	0.01	1.2E-09	0.0005	2.3E-05	2.3E-06	2.6E-05
Chromium	10.5	1	1.4E-06	NA		0.005	2.7E-04		2.7E-04
Manganese	1020	1	1.3E-04	NA		0.024	5.5E-03		5.5E-03
Nickel	7.8	1	1.0E-06	NA		0.02	5.1E-05		5.1E-05
Selenium	1.9	1	2.5E-07	NA		0.005	5.0E-05		5.0E-05
Vanadium	16.5	1	2.2E-06	NA		0.007	3.1E-04		3.1E-04
DEHP	0.63	1	8.2E-08	NA		0.02	4.1E-06		4.1E-06
Diethylphthalate	0.14	1	1.8E-08	NA		0.8	2.3E-08		2.3E-08
1,2-Dichlorobenzene	0.032	1	4.2E-09	NA		0.09	4.6E-08		4.6E-08
Zinc	48	1	6.3E-06	NA		0.3	2.1E-05		2.1E-05
Mercury	0.9	1	1.2E-07	NA		0.0003	3.9E-04		3.9E-04
TOTAL HAZARD INDEX							1.2E-02	2.3E-06	1.2E-02

Note: These tables include only those compounds for which quantitative toxicity information is available.

TABLE B-5
INCIDENTAL INGESTION AND DIRECT CONTACT WITH SEDIMENTS- AREA 1, DUBOIS POND

REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL,SACO MAINE

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL/SEDIMENT	CS		mg/kg	
INGESTION RATE	IR	100	mg/day	EPA, 1991/DEP,1994
FRACTION INGESTED	FI	100%		
SOIL CONTACT RATE	SCR	1000	mg/day	EPA, 1989
CONVERSION FACTOR	CF	0.000001	kg/mg	
BODY WEIGHT	BW	42	kg	DEP, 1994
EXPOSURE FREQUENCY	EF	20	days/year	EPA/BPJ, 1996
EXPOSURE DURATION	ED	12	years	EPA, 1996/DEP,1994
AVERAGING TIME				
CANCER	AT	70	years	
NONCANCER	AT	12	years	

EQUATIONS

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

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

INTAKE = (INTAKE-INGESTION) + (INTAKE-DERMAL)

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

$$\text{INTAKE-DERMAL} = \frac{CS \times SCR \times RAF \times CF \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Note:
For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	4.3	1	9.6E-08	NA		1.5	1.4E-07	0.0E+00	1.4E-07
Beryllium	1.4	1	3.1E-08	NA		4.3	1.3E-07		1.3E-07
TOTAL CANCER RISK							2.8E-07	0.0E+00	2.8E-07

NONCARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	4.3	1	5.8E-07	NA		0.003	1.9E-04		1.9E-04
Barium	49.5	1	6.5E-06	NA		0.07	9.2E-05		9.2E-05
Beryllium	1.4	1	1.8E-07	NA		0.005	3.7E-05		3.7E-05
Chromium	17	1	2.2E-06	NA		0.005	4.4E-04		4.4E-04
Manganese	544	1	7.1E-05	NA		0.024	3.0E-03		3.0E-03
Nickel	11.6	1	1.5E-06	NA		0.02	7.6E-05		7.6E-05
Vanadium	29.5	1	3.8E-06	NA		0.007	5.5E-04		5.5E-04
DDE	0.00029	1	3.8E-11	NA		0.34	1.1E-10		1.1E-10
Zinc	61.9	1	8.1E-06	NA		0.3	2.7E-05		2.7E-05
TOTAL HAZARD INDEX							4.4E-03	0.0E+00	4.4E-03

Note: These tables include only those compounds for which quantitative toxicity information is available.

TABLE B-6
INCIDENTAL INGESTION AND DIRECT CONTACT WITH SEDIMENTS- AREA 2

REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL,SACO MAINE

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL/SEDIMENT	CS		mg/kg	
INGESTION RATE	IR	100	mg/day	EPA, 1991/DEP,1994
FRACTION INGESTED	FI	100%		
SOIL CONTACT RATE	SCR	1000	mg/day	EPA, 1989
CONVERSION FACTOR	CF	0.000001	kg/mg	
BODY WEIGHT	BW	42	kg	DEP, 1994
EXPOSURE FREQUENCY	EF	20	days/year	EPA/BPJ, 1996
EXPOSURE DURATION	ED	12	years	EPA, 1996/DEP,1994
AVERAGING TIME				
CANCER	AT	70	years	
NONCANCER	AT	12	years	

EQUATIONS

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

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

INTAKE = (INTAKE-INGESTION) + (INTAKE-DERMAL)

INTAKE-INGESTION = $\frac{CS \times IR \times RAF \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/yr}$

INTAKE-DERMAL = $\frac{CS \times SCR \times RAF \times CF \times EF \times ED}{BW \times AT \times 365\ days/yr}$

Note:
For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	20.1	1	4.5E-07	NA		1.5	6.7E-07	0.0E+00	6.7E-07
Beryllium	1.9	1	4.2E-08	NA		4.3	1.8E-07		1.8E-07
DDD	0.0058	1	1.3E-10	NA		0.24	3.1E-11		3.1E-11
DDE	0.0023	1	5.1E-11	NA		0.34	1.7E-11		1.7E-11
PCB-1260	0.15	1	3.4E-09	0.06	2.0E-09	2	6.7E-09	4.0E-09	1.1E-08
Benzene	0.001	1	2.2E-11	NA		0.029	6.5E-13		6.5E-13
Chloroform	0.001	1	2.2E-11	NA		0.0061	1.4E-13		1.4E-13
						TOTAL CANCER RISK	8.6E-07	4.0E-09	8.7E-07

NONCARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	20.1	1	2.6E-06	NA		0.003	8.7E-04		8.7E-04
Barium	144	1	1.9E-05	NA		0.07	2.7E-04		2.7E-04
Beryllium	1.9	1	2.5E-07	NA		0.005	5.0E-05		5.0E-05
Cadmium	0.66	1	8.6E-08	0.01	8.6E-09	0.0005	1.7E-04	1.7E-05	1.9E-04
Chromium	85	1	1.1E-05	NA		0.005	2.2E-03		2.2E-03
Manganese	605	1	7.9E-05	NA		0.024	3.3E-03		3.3E-03
Mercury	0.1	1	1.3E-08	NA		0.0003	4.3E-05		4.3E-05
Nickel	34	1	4.4E-06	NA		0.02	2.2E-04		2.2E-04
Selenium	0.63	1	8.2E-08	NA		0.005	1.6E-05		1.6E-05
Vanadium	50.2	1	6.5E-06	NA		0.007	9.4E-04		9.4E-04
Zinc	126	1	1.6E-05	NA		0.3	5.5E-05		5.5E-05
Fluoranthene	0.054	1	7.0E-09	NA		0.04	1.8E-07		1.8E-07
Pyrene	0.14	1	1.8E-08	NA		0.03	6.1E-07		6.1E-07
Trichlorobenzene (1,2,4)	0.001	1	1.3E-10	NA		0.01	1.3E-08		1.3E-08
Trimethylbenzene(1,2,4)	0.001	1	1.3E-10	NA		0.05	2.6E-09		2.6E-09
Trimethylbenzene (1,3,5)	0.001	1	1.3E-10	NA		0.05	2.6E-09		2.6E-09
Butanone	0.025	1	3.3E-09	NA		0.6	5.4E-09		5.4E-09
Acetone	0.072	1	9.4E-09	NA		0.1	9.4E-08		9.4E-08
Chlorobenzene	0.001	1	1.3E-10	NA		0.02	6.5E-09		6.5E-09
1,2-Dichlorobenzene	0.036	1	4.7E-09	NA		0.09	5.2E-08		5.2E-08
						TOTAL HAZARD INDEX	8.1E-03	1.7E-05	8.2E-03

Note: These tables include only those compounds for which quantitative toxicity information is available.

TABLE B-7
INCIDENTAL INGESTION AND DIRECT CONTACT WITH SEDIMENTS- AREAS 3 & 4, STREAM/POOL NORTH

REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL,SACO MAINE

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL/SEDIMENT	CS		mg/kg	
INGESTION RATE	IR	100	mg/day	EPA, 1991/DEP,1994
FRACTION INGESTED	FI	100%		
SOIL CONTACT RATE	SCR	1000	mg/day	EPA, 1989
CONVERSION FACTOR	CF	0.000001	kg/mg	
BODY WEIGHT	BW	42	kg	DEP, 1994
EXPOSURE FREQUENCY	EF	20	days/year	EPA/BPJ, 1996
EXPOSURE DURATION	ED	12	years	EPA, 1996/DEP,1994
AVERAGING TIME				
CANCER	AT	70	years	
NONCANCER	AT	12	years	

EQUATIONS

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

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

INTAKE = (INTAKE-INGESTION) + (INTAKE-DERMAL)

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

$$\text{INTAKE-DERMAL} = \frac{CS \times SCR \times RAF \times CF \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Note:
For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	15.9	1	3.6E-07	NA		1.5	5.3E-07	0.0E+00	5.3E-07
Beryllium	1.3	1	2.9E-08	NA		4.3	1.3E-07		1.3E-07
Benzo(a)pyrene	0.14	1	3.1E-09	NA		7.3	2.3E-08		2.3E-08
					TOTAL CANCER RISK		6.8E-07	0.0E+00	6.8E-07

NONCARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	15.9	1	2.1E-06	NA		0.003	6.9E-04		6.9E-04
Barium	60.7	1	7.9E-06	NA		0.07	1.1E-04		1.1E-04
Beryllium	1.3	1	1.7E-07	NA		0.005	3.4E-05		3.4E-05
Chromium	25.8	1	3.4E-06	NA		0.005	6.7E-04		6.7E-04
Manganese	6780	1	8.8E-04	NA		0.024	3.7E-02		3.7E-02
Nickel	16.9	1	2.2E-06	NA		0.02	1.1E-04		1.1E-04
Selenium	3.4	1	4.4E-07	NA		0.005	8.9E-05		8.9E-05
Vanadium	41.2	1	5.4E-06	NA		0.007	7.7E-04		7.7E-04
Zinc	78.1	1	1.0E-05	NA		0.3	3.4E-05		3.4E-05
Diethylphthalate	0.1	1	1.3E-08	NA		0.8	1.8E-08		1.8E-08
DDD	0.0016	1	2.1E-10	NA		0.24	8.7E-10		8.7E-10
DDE	0.001	1	1.3E-10	NA		0.34	3.8E-10		3.8E-10
					TOTAL HAZARD INDEX		3.9E-02	0.0E+00	3.9E-02

Note: These tables include only those compounds for which quantitative toxicity information is available.

TABLE B-8
INCIDENTAL INGESTION AND DIRECT CONTACT WITH SEDIMENTS- AREAS 3 & 4, POOL SOUTH

REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL,SACO MAINE

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL/SEDIMENT	CS		mg/kg	
INGESTION RATE	IR	100	mg/day	EPA, 1991/DEP,1994
FRACTION INGESTED	FI	100%		
SOIL CONTACT RATE	SCR	1000	mg/day	EPA, 1989
CONVERSION FACTOR	CF	0.000001	kg/mg	
BODY WEIGHT	BW	42	kg	DEP, 1994
EXPOSURE FREQUENCY	EF	20	days/year	EPA/BPJ, 1996
EXPOSURE DURATION	ED	12	years	EPA, 1996/DEP,1994
AVERAGING TIME				
CANCER	AT	70	years	
NONCANCER	AT	12	years	

EQUATIONS

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

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

INTAKE = (INTAKE-INGESTION) + (INTAKE-DERMAL)

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

$$\text{INTAKE-DERMAL} = \frac{CS \times SCR \times RAF \times CF \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Note:
For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	10.7	1	2.4E-07	NA		1.5	3.6E-07	0.0E+00	3.6E-07
Beryllium	1	1	2.2E-08	NA		4.3	9.6E-08		9.6E-08
					TOTAL CANCER RISK		4.6E-07	0.0E+00	4.6E-07

NONCARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	10.7	1	1.4E-06	NA		0.003	4.7E-04		4.7E-04
Barium	84.3	1	1.1E-05	NA		0.07	1.6E-04		1.6E-04
Beryllium	1	1	1.3E-07	NA		0.005	2.6E-05		2.6E-05
Chromium	41.4	1	5.4E-06	NA		0.005	1.1E-03		1.1E-03
Manganese	739	1	9.6E-05	NA		0.024	4.0E-03		4.0E-03
Nickel	28.8	1	3.8E-06	NA		0.02	1.9E-04		1.9E-04
Vanadium	51.5	1	6.7E-06	NA		0.007	9.6E-04		9.6E-04
Zinc	67.2	1	8.8E-06	NA		0.3	2.9E-05		2.9E-05
					TOTAL HAZARD INDEX		6.9E-03	0.0E+00	6.9E-03

Note: These tables include only those compounds for which quantitative toxicity information is available.

TABLE B-9
INCIDENTAL INGESTION AND DIRECT CONTACT WITH SEDIMENTS- AREAS 3 & 4, BIG LEDGE BROOK

REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL,SACO MAINE

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL/SEDIMENT	CS		mg/kg	
INGESTION RATE	IR	100	mg/day	EPA, 1991/DEP,1994
FRACTION INGESTED	FI	100%		
SOIL CONTACT RATE	SCR	1000	mg/day	EPA, 1989
CONVERSION FACTOR	CF	0.000001	kg/mg	
BODY WEIGHT	BW	42	kg	DEP, 1994
EXPOSURE FREQUENCY	EF	20	days/year	EPA/BPJ, 1996
EXPOSURE DURATION	ED	12	years	EPA, 1996/DEP,1994
AVERAGING TIME				
CANCER	AT	70	years	
NONCANCER	AT	12	years	

EQUATIONS

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

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

INTAKE = (INTAKE-INGESTION) + (INTAKE-DERMAL)

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

$$\text{INTAKE-DERMAL} = \frac{CS \times SCR \times RAF \times CF \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Note:
For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	5.2	1	1.2E-07	NA		1.5	1.7E-07	0.0E+00	1.7E-07
TOTAL CANCER RISK							1.7E-07	0.0E+00	1.7E-07

NONCARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	5.2	1	6.8E-07	NA		0.003	2.3E-04		2.3E-04
Iron	5610	1	7.3E-04	NA		0.3	2.4E-03		2.4E-03
Manganese	89.8	1	1.2E-05	NA		0.024	4.9E-04		4.9E-04
Barium	12.1	1	1.6E-06	NA		0.07	2.3E-05		2.3E-05
Chromium	9.2	1	1.2E-06	NA		0.005	2.4E-04		2.4E-04
Nickel	9.6	1	1.3E-06	NA		0.02	6.3E-05		6.3E-05
Vanadium	8.8	1	1.1E-06	NA		0.007	1.6E-04		1.6E-04
Zinc	18.4	1	2.4E-06	NA		0.3	8.0E-06	0.0E+00	8.0E-06
TOTAL HAZARD INDEX							3.7E-03	0.0E+00	3.7E-03

Note: These tables include only those compounds for which quantitative toxicity information is available.

TABLE B-10
INCIDENTAL INGESTION AND DIRECT CONTACT WITH SEDIMENTS- AREAS 3 & 4, SANDY BROOK

REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL,SACO MAINE

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL/SEDIMENT	CS		mg/kg	
INGESTION RATE	IR	100	mg/day	EPA, 1991/DEP,1994
FRACTION INGESTED	FI	100%		
SOIL CONTACT RATE	SCR	1000	mg/day	EPA, 1989
CONVERSION FACTOR	CF	0.000001	kg/mg	
BODY WEIGHT	BW	42	kg	DEP, 1994
EXPOSURE FREQUENCY	EF	20	days/year	EPA/BPJ, 1996
EXPOSURE DURATION	ED	12	years	EPA, 1996/DEP,1994
AVERAGING TIME				
CANCER	AT	70	years	
NONCANCER	AT	12	years	

EQUATIONS

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

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

INTAKE = (INTAKE-INGESTION) + (INTAKE-DERMAL)

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

$$\text{INTAKE-DERMAL} = \frac{CS \times SCR \times RAF \times CF \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Note:
For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	185	1	4.1E-06	NA		1.5	6.2E-06	0.0E+00	6.2E-06
Beryllium	0.48	1	1.1E-08	NA		4.3	4.6E-08		4.6E-08
Benzo(a)pyrene	0.047	1	1.1E-09	NA		7.3	7.7E-09		7.7E-09
TOTAL CANCER RISK							6.3E-06	0.0E+00	6.3E-06

NONCARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	185	1	2.4E-05	NA		0.003	8.0E-03		8.0E-03
Barium	44.7	1	5.8E-06	NA		0.07	8.3E-05		8.3E-05
Beryllium	0.48	1	6.3E-08	NA		0.005	1.3E-05		1.3E-05
Chromium	14	1	1.8E-06	NA		0.005	3.7E-04		3.7E-04
Manganese	464	1	6.1E-05	NA		0.024	2.5E-03		2.5E-03
Nickel	10.8	1	1.4E-06	NA		0.02	7.0E-05		7.0E-05
Selenium	0.72	1	9.4E-08	NA		0.005	1.9E-05		1.9E-05
Vanadium	14.6	1	1.9E-06	NA		0.007	2.7E-04		2.7E-04
Zinc	21.7	1	2.8E-06	NA		0.3	9.4E-06		9.4E-06
Diethylphthalate	0.076	1	9.9E-09	NA		0.8	1.2E-08		1.2E-08
DDE	0.00076	1	9.9E-11	NA		0.34	2.9E-10		2.9E-10
TOTAL HAZARD INDEX							1.1E-02	0.0E+00	1.1E-02

Note: These tables include only those compounds for which quantitative toxicity information is available.

TABLE B-11
INCIDENTAL INGESTION/DERMAL CONTACT WITH SURFACE WATER - AREA 1, TRIBUTARY TO DEEP BROOK

TECHNICAL MEMORANDUM
SACO MUNICIPAL LANDFILL, SACO MAINE

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW		mg/liter	
INGESTION RATE	IR	0.05	liters/hour	DEP,1994
SURFACE AREA EXPOSED	SA	5,240	cm2	DEP, 1994
BODY WEIGHT	BW	42	kg	DEP,1994
CONVERSION FACTOR	CF	0.001	liter/cm2	
EXPOSURE TIME	ET	2.6	hours/day	EPA, 1988/DEP, 1994
EXPOSURE FREQUENCY	EF	20	days/year	BPJ
EXPOSURE DURATION	ED	12	years	EPA 1991/DEP,1994
AVERAGING TIME				
CANCER	AT	70	years	EPA 1991
NONCANCER	AT	12	years	EPA 1991/DEP,1994

EQUATIONS

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

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

INTAKE = (INTAKE-INGESTION) + (INTAKE-DERMAL)

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

$$\text{INTAKE-DERMAL} = \frac{CW \times SA \times PC \times CF \times ET \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Note:
For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	PERMEABILITY CONSTANT (PC) (cm/hr)	INTAKE DERMAL (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
1,4-Dichlorobenzene	0.003	1	8.7E-08	0.062	5.7E-07	2.40E-02	2.1E-09	1.4E-08	1.6E-08
Benzene	0.002	1	5.8E-08	0.11	6.7E-07	2.90E-02	1.7E-09	1.9E-08	2.1E-08
Arsenic	0.0141	1	4.1E-07	NA		3.00E-04	1.2E-10	0.0E+00	1.2E-10
						SUMMARY CANCER RISK	3.9E-09	3.3E-08	3.7E-08

NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	PERMEABILITY CONSTANT (PC) (cm/hr)	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
1,2,4-Trimethylbenzene	0.001	1	1.7E-07	0.1	1.8E-06	0.05	3.4E-06	3.6E-05	3.9E-05
1,2-Dichlorobenzene	0.001	1	1.7E-07	0.061	1.1E-06	0.09	1.9E-06	1.2E-05	1.4E-05
1,3-Dichlorobenzene	0.001	1	1.7E-07	0.087	1.5E-06	0.089	1.9E-06	1.7E-05	1.9E-05
Acetone	0.004	1	6.8E-07	NA		1.00E-01	6.8E-06	0.0E+00	6.8E-06
cis-1,2-Dichloroethene	0.001	1	1.7E-07	NA		1.00E-02	1.7E-05	0.0E+00	1.7E-05
Chlorobenzene	0.003	1	5.1E-07	0.041	2.2E-06	2.00E-02	2.5E-05	1.1E-04	1.3E-04
Ethylbenzene	0.011	1	1.9E-06	1	2.0E-04	1.00E-01	1.9E-05	2.0E-03	2.0E-03
m,p-Xylene	0.016	1	2.7E-06	0.08	2.3E-05	2.00E+00	1.4E-06	1.1E-05	1.3E-05
Naphthalene	0.001	1	1.7E-07	0.069	1.2E-06	4.00E-02	4.2E-06	3.1E-05	3.5E-05
Arsenic	0.0141	1	2.4E-06	NA		3.00E-04	8.0E-03	0.0E+00	8.0E-03
Barium	0.0963	1	1.6E-05	NA		7.00E-02	2.3E-04	0.0E+00	2.3E-04
Chromium	0.0016	1	2.7E-07	NA		5.00E-03	5.4E-05	0.0E+00	5.4E-05
Manganese	1.07	1	1.8E-04	NA		2.40E-02	7.6E-03	0.0E+00	7.6E-03
Nickel	0.0017	1	2.9E-07	NA		2.00E-02	1.4E-05	0.0E+00	1.4E-05
						SUMMARY HAZARD INDEX	1.6E-02	2.2E-03	1.8E-02

Note: These tables include only those compounds for which quantitative toxicity information is available.

TABLE B-12
INCIDENTAL INGESTION/DERMAL CONTACT WITH SURFACE WATER - AREA 1, DUBOIS POND

TECHNICAL MEMORANDUM
SACO MUNICIPAL LANDFILL, SACO MAINE

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW		mg/liter	
INGESTION RATE	IR	0.05	liters/hour	DEP,1994
SURFACE AREA EXPOSED	SA	5,240	cm2	DEP, 1994
BODY WEIGHT	BW	42	kg	DEP,1994
CONVERSION FACTOR	CF	0.001	liter/cm2	
EXPOSURE TIME	ET	2.6	hours/day	EPA, 1988/DEP, 1994
EXPOSURE FREQUENCY	EF	20	days/year	BPJ
EXPOSURE DURATION	ED	12	years	EPA 1991/DEP,1994
AVERAGING TIME				
CANCER	AT	70	years	EPA 1991
NONCANCER	AT	12	years	EPA 1991/DEP,1994

EQUATIONS

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

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

INTAKE = (INTAKE-INGESTION) + (INTAKE-DERMAL)

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

$$\text{INTAKE-DERMAL} = \frac{CW \times SA \times PC \times CF \times ET \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Note:
For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	PERMEABILITY CONSTANT (PC) (cm/hr)	INTAKE DERMAL (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
BEHP	0.002	1	5.8E-08	NA		1.40E-02	8.1E-10	0.0E+00	8.1E-10
					SUMMARY CANCER RISK		8.1E-10	0.0E+00	**8.1E-10**

NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	PERMEABILITY CONSTANT (PC) (cm/hr)	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
BEHP	0.002	1	3.4E-07	NA		2.00E-02	1.7E-05	0.0E+00	1.7E-05
Endosulfan II	0.0000014	1	2.4E-10	NA		6.00E-03	4.0E-08	0.0E+00	4.0E-08
Barium	0.0093	1	1.6E-06	NA		7.00E-02	2.3E-05	0.0E+00	2.3E-05
Chromium	0.0019	1	3.2E-07	NA		5.00E-03	6.4E-05	0.0E+00	6.4E-05
Manganese	0.123	1	2.1E-05	NA		2.40E-02	8.7E-04	0.0E+00	8.7E-04
Nickel	0.0014	1	2.4E-07	NA		2.00E-02	1.2E-05	0.0E+00	1.2E-05
Acetone	0.003	1	5.1E-07	NA		1.00E-01	5.1E-06	0.0E+00	5.1E-06
Toluene	0.093	1	1.6E-05	1	1.7E-03	2.00E-01	7.9E-05	8.3E-03	8.3E-03
						SUMMARY HAZARD INDEX	1.1E-03	8.3E-03	**9.3E-03**

Note: These tables include only those compounds for which quantitative toxicity information is available.

TABLE B-13
INCIDENTAL INGESTION/DERMAL CONTACT WITH SURFACE WATER - SANDY BROOK - AREA 2

TECHNICAL MEMORANDUM
SACO MUNICIPAL LANDFILL, SACO MAINE

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW		mg/liter	
INGESTION RATE	IR	0.05	liters/hour	DEP,1994
SURFACE AREA EXPOSED	SA	5,240	cm2	DEP, 1994
BODY WEIGHT	BW	42	kg	DEP,1994
CONVERSION FACTOR	CF	0.001	liter/cm2	
EXPOSURE TIME	ET	2.6	hours/day	EPA, 1988/DEP, 1994
EXPOSURE FREQUENCY	EF	20	days/year	BPJ
EXPOSURE DURATION	ED	12	years	EPA 1991/DEP,1994
AVERAGING TIME				
CANCER	AT	70	years	EPA 1991
NONCANCER	AT	12	years	EPA 1991/DEP,1994

EQUATIONS

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

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

INTAKE = (INTAKE-INGESTION) + (INTAKE-DERMAL)

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

$$\text{INTAKE-DERMAL} = \frac{CW \times SA \times PC \times CF \times ET \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

Note:
For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	PERMEABILITY CONSTANT (PC) (cm/hr)	INTAKE DERMAL (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Dieldrin	0.000001	1	2.9E-11	0.016	4.9E-11	1.60E+01	4.7E-10	7.8E-10	1.2E-09
BEHP	0.005	1	1.5E-07	NA		1.40E-02	2.0E-09	0.0E+00	2.0E-09
DCE (1,1)	0.001	1	2.9E-08	0.016	4.9E-08	0.6	1.7E-08	2.9E-08	4.7E-08
					SUMMARY CANCER RISK		2.0E-08	3.0E-08	**5.0E-08**

NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	PERMEABILITY CONSTANT (PC) (cm/hr)	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Dieldrin	0.000001	1	1.7E-10	0.016	2.8E-10	5.00E-05	3.4E-06	5.7E-06	9.1E-06
BEHP	0.005	1	8.5E-07	NA		2.00E-02	4.2E-05	0.0E+00	4.2E-05
DCE (1,1)	0.001	1	1.7E-07	0.016	2.8E-07	9.00E-03	1.9E-05	3.2E-05	5.0E-05
Endosulfan II	0.000003	1	5.1E-10	NA		6.00E-03	8.5E-08	0.0E+00	8.5E-08
Barium	0.0177	1	3.0E-06	NA		7.00E-02	4.3E-05	0.0E+00	4.3E-05
Chromium	0.0011	1	1.9E-07	NA		5.00E-03	3.7E-05	0.0E+00	3.7E-05
Manganese	0.102	1	1.7E-05	NA		2.40E-02	7.2E-04	0.0E+00	7.2E-04
Mercury	0.00013	1	2.2E-08	NA		3.00E-04	7.3E-05	0.0E+00	7.3E-05
Nickel	0.0013	1	2.2E-07	NA		2.00E-02	1.1E-05	0.0E+00	1.1E-05
					SUMMARY HAZARD INDEX		9.5E-04	3.7E-05	**9.9E-04**

Note: These tables include only those compounds for which quantitative toxicity information is available.

TABLE B-14

INCIDENTAL INGESTION/DERMAL CONTACT WITH SURFACE WATER - AREAS 3 & 4, STREAM/POOL NORTH

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW		mg/liter	
INGESTION RATE	IR	0.05	liters/hour	DEP,1994
SURFACE AREA EXPOSED	SA	5,240	cm2	DEP, 1994
BODY WEIGHT	BW	42	kg	DEP,1994
CONVERSION FACTOR	CF	0.001	liter/cm2	
EXPOSURE TIME	ET	2.6	hours/day	EPA, 1988/DEP, 1994
EXPOSURE FREQUENCY	EF	20	days/year	BPJ
EXPOSURE DURATION	ED	12	years	EPA 1991/DEP,1994
AVERAGING TIME				
CANCER	AT	70	years	EPA 1991
NONCANCER	AT	12	years	EPA 1991/DEP,1994

EQUATIONS

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

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

INTAKE = (INTAKE-INGESTION) + (INTAKE-DERMAL)

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

$$\text{INTAKE-DERMAL} = \frac{CW \times SA \times PC \times CF \times ET \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

Note:
For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	PERMEABILITY CONSTANT (PC) (cm/hr)	INTAKE DERMAL (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	0.0037	1	1.1E-07	NA		1.50E+00	1.6E-07	0.0E+00	1.6E-07
					SUMMARY CANCER RISK		1.6E-07	0.0E+00	**1.6E-07**

NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	PERMEABILITY CONSTANT (PC) (cm/hr)	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	0.0037	1	6.3E-07	NA		3.00E-04	2.1E-03	0.0E+00	2.1E-03
Barium	0.0074	1	1.3E-06	NA		7.00E-02	1.8E-05	0.0E+00	1.8E-05
Chromium	0.0102	1	1.7E-06	NA		5.00E-03	3.5E-04	0.0E+00	3.5E-04
Silver	0.00071	1	1.2E-07	NA		5.00E-03	2.4E-05	0.0E+00	2.4E-05
					SUMMARY HAZARD INDEX		2.5E-03	0.0E+00	**2.5E-03**

Note: These tables include only those compounds for which quantitative toxicity information is available.

TABLE B-15
INCIDENTAL INGESTION/DERMAL CONTACT WITH SURFACE WATER - AREAS 3 & 4, POOL SOUTH

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW		mg/liter	
INGESTION RATE	IR	0.05	liters/hour	DEP,1994
SURFACE AREA EXPOSED	SA	5,240	cm2	DEP, 1994
BODY WEIGHT	BW	42	kg	DEP,1994
CONVERSION FACTOR	CF	0.001	liter/cm2	
EXPOSURE TIME	ET	2.6	hours/day	EPA, 1988/DEP, 1994
EXPOSURE FREQUENCY	EF	20	days/year	BPJ
EXPOSURE DURATION	ED	12	years	EPA 1991/DEP,1994
AVERAGING TIME				
CANCER	AT	70	years	EPA 1991
NONCANCER	AT	12	years	EPA 1991/DEP,1994

EQUATIONS

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

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

INTAKE = (INTAKE-INGESTION) + (INTAKE-DERMAL)

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

$$\text{INTAKE-DERMAL} = \frac{CW \times SA \times PC \times CF \times ET \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

Note:
For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	PERMEABILITY CONSTANT (PC) (cm/hr)	INTAKE DERMAL (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	0.0186	1	5.4E-07	NA		1.50E+00	8.1E-07	0.0E+00	8.1E-07
BEHP	0.001	1	2.9E-08	NA		1.40E-02	4.1E-10	0.0E+00	4.1E-10
					SUMMARY CANCER RISK		8.1E-07	0.0E+00	**8.1E-07**

NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	PERMEABILITY CONSTANT (PC) (cm/hr)	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
BEHP	0.001	1	1.7E-07	NA		2.00E-02	8.5E-06	0.0E+00	8.5E-06
Arsenic	0.0186	1	3.2E-06	NA		3.00E-04	1.1E-02	0.0E+00	1.1E-02
Barium	0.0305	1	5.2E-06	NA		7.00E-02	7.4E-05	0.0E+00	7.4E-05
Chromium	0.0012	1	2.0E-07	NA		5.00E-03	4.1E-05	0.0E+00	4.1E-05
Manganese	0.617	1	1.0E-04	NA		2.40E-02	4.4E-03	0.0E+00	4.4E-03
Mercury	0.00012	1	2.0E-08	NA		3.00E-04	6.8E-05	0.0E+00	6.8E-05
Nickel	0.0051	1	8.6E-07	NA		2.00E-02	4.3E-05	0.0E+00	4.3E-05
Silver	NA	1		NA		5.00E-03			
					SUMMARY HAZARD INDEX		1.5E-02	0.0E+00	**1.5E-02**

Note: These tables include only those compounds for which quantitative toxicity information is available.

TABLE B-16
INCIDENTAL INGESTION/DERMAL CONTACT WITH SURFACE WATER - AREAS 3 & 4, BIG LEDGE BROOK

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW		mg/liter	
INGESTION RATE	IR	0.05	liters/hour	DEP,1994
SURFACE AREA EXPOSED	SA	5,240	cm2	DEP, 1994
BODY WEIGHT	BW	42	kg	DEP,1994
CONVERSION FACTOR	CF	0.001	liter/cm2	
EXPOSURE TIME	ET	2.6	hours/day	EPA, 1988/DEP, 1994
EXPOSURE FREQUENCY	EF	20	days/year	BPJ
EXPOSURE DURATION	ED	12	years	EPA 1991/DEP,1994
AVERAGING TIME				
CANCER	AT	70	years	EPA 1991
NONCANCER	AT	12	years	EPA 1991/DEP,1994

EQUATIONS

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

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

INTAKE = (INTAKE-INGESTION) + (INTAKE-DERMAL)

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

$$\text{INTAKE-DERMAL} = \frac{CW \times SA \times PC \times CF \times ET \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

Note:
For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	PERMEABILITY CONSTANT (PC) (cm/hr)	INTAKE DERMAL (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	NA	1		NA		1.50E+00			
					SUMMARY CANCER RISK		0.0E+00	0.0E+00	**0.0E+00**

NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	PERMEABILITY CONSTANT (PC) (cm/hr)	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Antimony	0.0041	1	7.0E-07	NA		4.00E-04	1.7E-03	0.0E+00	1.7E-03
Barium	0.0052	1	8.8E-07	NA		7.00E-02	1.3E-05	0.0E+00	1.3E-05
Chromium	0.0121	1	2.1E-06	NA		5.00E-03	4.1E-04	0.0E+00	4.1E-04
Manganese	0.0024	1	4.1E-07	NA		2.40E-02	1.7E-05	0.0E+00	1.7E-05
Nickel	0.0996	1	1.7E-05	NA		2.00E-02	8.4E-04	0.0E+00	8.4E-04
Selenium	0.0046	1	7.8E-07	NA		0.005	1.6E-04	0.0E+00	1.6E-04
					SUMMARY HAZARD INDEX		3.2E-03	0.0E+00	**3.2E-03**

Note: These tables include only those compounds for which quantitative toxicity information is available.

TABLE B-17
INCIDENTAL INGESTION/DERMAL CONTACT WITH SURFACE WATER - AREAS 3 & 4, SANDY BROOK

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW		mg/liter	
INGESTION RATE	IR	0.05	liters/hour	DEP,1994
SURFACE AREA EXPOSED	SA	5,240	cm2	DEP, 1994
BODY WEIGHT	BW	42	kg	DEP,1994
CONVERSION FACTOR	CF	0.001	liter/cm2	
EXPOSURE TIME	ET	2.6	hours/day	EPA, 1988/DEP, 1994
EXPOSURE FREQUENCY	EF	20	days/year	BPJ
EXPOSURE DURATION	ED	12	years	EPA 1991/DEP,1994
AVERAGING TIME				
CANCER	AT	70	years	EPA 1991
NONCANCER	AT	12	years	EPA 1991/DEP,1994

EQUATIONS

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

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

INTAKE = (INTAKE-INGESTION) + (INTAKE-DERMAL)

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

$$\text{INTAKE-DERMAL} = \frac{CW \times SA \times PC \times CF \times ET \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

Note:
For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	PERMEABILITY CONSTANT (PC) (cm/hr)	INTAKE DERMAL (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	0.0122	1	3.5E-07	NA		1.50E+00	5.3E-07	0.0E+00	5.3E-07
BEHP	0.002	1	5.8E-08	NA		1.40E-02	8.1E-10	0.0E+00	8.1E-10
					SUMMARY CANCER RISK		5.3E-07	0.0E+00	**5.3E-07**

NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	PERMEABILITY CONSTANT (PC) (cm/hr)	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	0.0122	1	2.1E-06	NA		3.00E-04	6.9E-03	0.0E+00	6.9E-03
Barium	0.0222	1	3.8E-06	NA		7.00E-02	5.4E-05	0.0E+00	5.4E-05
Chromium	0.0011	1	1.9E-07	NA		5.00E-03	3.7E-05	0.0E+00	3.7E-05
Manganese	0.381	1	6.5E-05	NA		2.40E-02	2.7E-03	0.0E+00	2.7E-03
Mercury	0.00012	1	2.0E-08	NA		3.00E-04	6.8E-05	0.0E+00	6.8E-05
Nickel	0.0019	1	3.2E-07	NA		2.00E-02	1.6E-05	0.0E+00	1.6E-05
Endosulfan	0.0000019	1	3.2E-10	NA		6.00E-03	5.4E-08	0.0E+00	5.4E-08
BEHP	0.002	1	3.4E-07	NA		0.02	1.7E-05	0.0E+00	1.7E-05
					SUMMARY HAZARD INDEX		9.8E-03	0.0E+00	**9.8E-03**

Note: These tables include only those compounds for which quantitative toxicity information is available.

TABLE B-18
EXPOSURE TO GROUNDWATER AS DRINKING WATER - DOWNGRADIENT OF AREAS 1 AND 2

REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS
CONCENTRATION WATER	CW	Maximum	mg/l
INGESTION RATE	IR	2	liters/day
BODY WEIGHT	BW	70	kg
SKIN SURFACE AREA EXPOSED	SA	19400	cmšu2›
PERMEABILITY CONSTANT	PC	ical specific	cm/hour
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 = Not available.
For noncarcinogenic effects: AT = ED

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

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

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

INTAKE-INHALATION OF VOLATILES: Evaluated by doubling the risk from ingestion, as per EPA, 1991

INTAKE-DERMAL = $\frac{CW \times SA \times PC \times CF_{d1} \times CF_{d2} \times EF_{ds} \times ED}{BW \times AT \times 365\ days/yr}$

CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	PC (cm/hr)	ORAL SLOPE FACTOR (mg/kg-day)šu-1›	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK	PER CENT OF TOTAL CANCER RISK
Arsenic	0.016	NA	1.5E+00	2.82E-04		2.82E-04	100.00%
			SUMMARY CANCER	2.8E-04	0.0E+00	2.8E-04	

NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	PC (cm/hr)	ORAL REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT	PER CENT OF TOTAL HAZARD QUOTIENT
Acetone	0.033	NA	1.0E-01	9.04E-03		1.81E-02	1.16%
Arsenic	0.016	NA	3.0E-04	1.46E+00		1.46E+00	93.70%
Barium	0.0528	NA	7.0E-02	2.07E-02		2.07E-02	1.33%
Manganese	0.087	NA	1.4E-01	1.70E-02		1.70E-02	1.09%
Mercury	0.0001	NA	3.0E-04	9.13E-03		9.13E-03	0.59%
Nickel	0.0052	NA	2.0E-02	7.12E-03		7.12E-03	0.46%
Selenium	0.0043	NA	5.0E-03	2.36E-02		2.36E-02	1.51%
Vanadium	0.00069	NA	7.0E-03	2.70E-03		2.70E-03	0.17%
			SUMMARY HAZAR	1.6E+00	0.0E+00	1.6E+00	

TABLE B-19
EXPOSURE TO GROUNDWATER AS DRINKING WATER - SOUTHEAST OF AREAS 3 AND 4

REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS
CONCENTRATION WATER	CW	Maximum	mg/l
INGESTION RATE	IR	2	liters/day
BODY WEIGHT	BW	70	kg
SKIN SURFACE AREA EXPOSED	SA	19400	cmšu2›
PERMEABILITY CONSTANT	PC	mical specific	cm/hour
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

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-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: Evaluated by doubling the risk from ingestion, as per EPA, 1991

INTAKE-DERMAL = $\frac{CW \times SA \times PC \times CF_{d1} \times CF_{d2} \times EF_{ds} \times ED}{BW \times AT \times 365 \text{ days/yr}}$

Note: NA = Not available.
NR = Not Relevant
For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	PC (cm/hr)	ORAL SLOPE FACTOR (mg/kg-day)šu-1›	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK	PER CENT OF TOTAL CANCER RISK
1,2-Dichloroethane	0.001	NR	9.1E-02	1.07E-06		2.14E-06	0.02%
1,4-Dichlorobenzene	0.007	NR	2.4E-02	1.97E-06		3.95E-06	0.04%
Benzene	0.013	NR	2.9E-02	4.43E-06		8.85E-06	0.09%
Choromethane	0.002	NR	1.3E-02	3.05E-07		6.11E-07	0.01%
Methylene Cloride	0.001	NR	7.5E-03	8.81E-08		1.76E-07	0.00%
Trichloroethylene	0.007	NR	1.1E-02	9.04E-07		1.81E-06	0.02%
Arsenic	0.566	NA	1.5E+00	9.97E-03		9.97E-03	99.82%
			SUMMARY CANCER	1.0E-02	0.0E+00	1.0E-02	

TABLE B-19
EXPOSURE TO GROUNDWATER AS DRINKING WATER - SOUTHEAST OF AREAS 3 AND 4

REMEDIAL INVESTIGATION/RISK ASSESSMENT
SACO MUNICIPAL LANDFILL

NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	PC (cm/hr)	ORAL REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT	PER CENT OF TOTAL HAZARD QUOTIENT
1,1-Dichloroethane	0.001	NR	1.0E-01	2.74E-04		5.48E-04	0.00%
1,2,4-Trichlorobenzene	0.001	NR	1.0E-02	2.74E-03		5.48E-03	0.01%
1,2,4-Trimethylbenzene	0.009	NR	5.0E-02	4.93E-03		9.86E-03	0.01%
1,2-Dichlorobenzene	0.005	NR	9.0E-02	1.52E-03		3.04E-03	0.00%
1,3,5-Trimethylbenzene	0.005	NR	5.0E-02	2.74E-03		5.48E-03	0.01%
Chlorobenzene	0.005	NR	2.0E-02	6.85E-03		1.37E-02	0.01%
Chloroethane	0.093	NR	4.0E-01	6.37E-03		1.27E-02	0.01%
cis-1,2-Dichloroethene	0.005	NR	1.0E-02	1.37E-02		2.74E-02	0.03%
Dichlorofluoromethane	0.001	NR	2.0E-01	1.37E-04		2.74E-04	0.00%
Ethylbenzene	0.034	NR	1.0E-01	9.32E-03		1.86E-02	0.02%
Methylene Chloride	0.001	NR	6.0E-02	4.57E-04		9.13E-04	0.00%
m,p-Xylene	0.032	NR	2.0E+00	4.38E-04		8.77E-04	0.00%
Naphthalene	0.013	NR	4.0E-02	8.90E-03		8.90E-03	0.01%
o-Xylene	0.014	NR	2.0E+00	1.92E-04		1.92E-04	0.00%
Toluene	0.003	NR	2.0E-01	4.11E-04		4.11E-04	0.00%
trans-1,2-Dichloroethene	0.001	NR	1.0E-02	2.74E-03		2.74E-03	0.00%
Trichloroethene	0.007	NR	6.0E-03	3.20E-02		3.20E-02	0.03%
2,4-Dimethylphenol	0.005	1.10E-01	2.0E-02	6.85E-03	1.45E-03	8.30E-03	0.01%
Arsenic	0.566	NA	3.0E-04	5.17E+01		5.17E+01	50.87%
Barium	0.463	NA	7.0E-02	1.81E-01		1.81E-01	0.18%
Cadmium	0.00025	NA	5.0E-04	1.37E-02		1.37E-02	0.01%
Chromium	0.0104	NA	5.0E-03	5.70E-02		5.70E-02	0.06%
Manganese	43.2	NA	2.4E-02	4.93E+01		4.93E+01	48.54%
Nickel	0.1	NA	2.0E-02	1.37E-01		1.37E-01	0.13%
Selenium	0.0069	NA	5.0E-03	3.78E-02		3.78E-02	0.04%
Silver	0.0015	NA	5.0E-03	8.22E-03		8.22E-03	0.01%
Vanadium	0.0023	NA	7.0E-03	9.00E-03		9.00E-03	0.01%
Zinc	0.0316	NA	3.0E-01	2.89E-03		2.89E-03	0.00%
Cyanide	0.0015	NA	2.0E-02	2.05E-03		2.05E-03	0.00%
				1.0E-01	1.5E-03	1.0E+02	

Note: These tables include only those compounds for which quantitative toxicity information is available.

ATTACHMENT C
TOXICITY PROFILES

ARSENIC

GENERAL BACKGROUND INFORMATION

The toxicity of arsenic depends upon its chemical form along with the route, dose, and duration of exposure. In general, arsenites (As^{+3}) are potentially more toxic than arsenates, soluble arsenic compounds are potentially more toxic than insoluble compounds, and inorganic arsenic compounds are potentially more toxic than organic derivatives (U.S. EPA, 1985).

PHARMACOKINETICS

Absorption from the gastrointestinal tract is dependent upon the solubility of the specific arsenic compound and the dose. Absorption from the respiratory tract is also dependent upon the specific arsenic compound, along with particle size (see section on Relative Absorption Factors).

HUMAN TOXICOLOGICAL PROFILE

Depending upon dose and exposure route, arsenic is an irritant of the skin, mucous membranes, and the gastrointestinal tract. Acute toxicity from the ingestion of higher doses of arsenic may result in vomiting, diarrhea, convulsions, a severe drop in blood pressure, and cardiovascular effects. The lethal dose for humans is reported to be 1.0 to 2.6 mg/kg-bw (Vallee et al., 1960). Acute toxicity from inhalation exposure to arsenic adsorbed to particulate matter may result in conjunctivitis and pharyngitis. Subchronic effects included hyperpigmentation (melanosis), multiple arsenical keratoses, sensory-motor polyneuropathy, persistent chronic headache, lethargy, gastroenteritis, and mild iron deficiency anemia. Inhaled arsenic compounds have been reported to be associated with skin lesions, cardiovascular and respiratory effects, and peripheral neuropathy (Stokinger, 1981; IARC, 1980). Chronic oral exposure of humans to inorganic arsenic compounds has been reported to cause skin lesions, peripheral vascular disease, and peripheral neuropathy (Silver and Wainman, 1952). The incidence of blackfoot disease, a peripheral circulatory disease characterized by gangrene of the extremities, has reportedly been related to the presence of arsenic in the drinking water of residents of the southwest of Taiwan (Tseng, 1977). The symptoms of chronic inhalation exposure to arsenic compounds are similar to those associated with chronic oral toxicity.

MAMMALIAN TOXICOLOGICAL PROFILE

Oral LD_{50} values for trivalent arsenic vary from 15 to 293 mg/kg in rats and from 10-150 mg/kg in other test species (U.S. EPA, 1984). Chronic toxicity data from arsenic exposure to rats cannot be extrapolated to man as the rat is able to store this compound bound to hemoglobin in red blood cells (Lanz et al., 1950). This binding results in extremely slow excretion by rats compared to other species (Mealey et al., 1959). For this reason, dogs have been used to obtain experimental toxicity information. Studies of the subchronic oral toxicity of diets containing sodium arsenite or sodium arsenate in dogs report that arsenite is potentially more toxic than arsenate. The NOEL (no observed effect level) was reported to be 50 mg/kg-diet for both substances (Byron et al., 1967). Schroeder and Balassa (1967) studied the chronic oral toxicity of arsenic on growth and survival in mice. Ingestion of water containing As^{+3} at 5 mg/L over two years is reported to have resulted in decreased survival and reduced median life span in male and female mice. No information regarding chronic inhalation exposure of experimental animals to arsenic could be located in the available literature. Animal studies to test the teratogenic potential of arsenic have been performed. Matsumoto et al. (1973) reported decreased fetal weight in oral doses of up to 40 mg-arsenate/kg-bw/day administered to pregnant mice for three consecutive days. Diets containing up to 100 mg-arsenite/kg-diet, however, were reported to have had no effect on offspring (Kojima, 1974). No data regarding the teratogenicity of inhaled arsenic could be found in the literature.

GENOTOXICITY

Nearly all results of gene mutation studies for arsenic (III) and arsenic (V) compounds have been negative. Arsenite and arsenate also have been inactive in gene-specific mutation assays in yeast and in cultured mammalian cells. In contrast, arsenic (III), arsenic (V), arsenite and arsenate have been found to result in chromosome aberrations and sister chromatid exchanges in cultured animal and human cells tested in vitro (ATSDR, 1987). There is limited evidence that occupational exposure to arsenic may cause chromosome changes in humans (Beckman et al., 1977). Beckman et al. (1977) reported an increase in gaps, chromatid aberrations and chromosome aberrations from mine workers at a smelter in northern Sweden.

The majority of tests in which experimental animals were exposed orally to a variety of arsenic compounds produced negative results regarding carcinogenicity (Hueper and Payne, 1962; Byron et al., 1967). A few studies have, however, reported tumorigenic effects of arsenic treatment (Schrauzer et al., 1978). Mixed results were reported in arsenic inhalation studies (Ishinishi et al., 1977; Ivankovic et al., 1979). Epidemiological studies conducted in the U.S. have failed to correlate the incidence of skin cancer with arsenic in drinking water (Morton et al., 1976; Goldsmith et al., 1972). A dose-response relationship between the

occurrence of skin cancer and arsenic consumption in the drinking water of Taiwanese, however, was reported by Tseng et al. (1977). Arsenic exposure at certain doses may produce a pattern of skin disorders, hyperpigmentation, and keratosis that may develop into basal or squamous cell carcinoma (U.S. EPA, 1985). Several epidemiological studies of workers occupationally exposed to arsenic have reported a correlation between this exposure and mortality due to respiratory cancer (Higgins et al., 1982; Enterline and Marsh, 1982; Brown and Chu, 1983). Based upon epidemiological data, the EPA has classified arsenic as Group A -Human Carcinogen.

REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR) (1987) Toxicological profile for arsenic. U.S. Public Health Service.

Beckman, G. et al., (1977) *Chromosome aberrations in workers exposed to arsenic.* **Environ. Health Perspect.** 19:145.

Brown, C.C. and Chu, K.C. (1983). *Implications of the multistage theory of carcinogenesis applied to occupational arsenic exposure.* **J. Natl. Cancer Inst.** 70:455-463.

Byron, W.R., Bierbower, G.W., Brouwer, J.B. and Hansen, W.H. (1967) *Pathological changes in rats and dogs from two-year feeding of sodium arsenite or sodium arsenate.* **Toxicol. Appl. Pharmacol.** 10:132-147.

Enterline, P.E. and Marsh, G.M. (1982) *Mortality among workers exposed to arsenic and other substances in a copper smelter.* **Am. J. Epidemiol.** 116:895-910.

Goldsmith, J.R. et al. (1972) *Evaluation of health implications of elevated arsenic in well water.* **Water Res.** 6:1133-1136.

Higgins, I., Welch, K. and Burchfiel, C. (1982) Mortality of Anaconda smelter workers in relation to arsenic and other exposures. Dept. of Epidemiology, Univ. of Michigan, Ann Arbor, MI.

Hueper, W.C. and Payne, W.W. (1962) *Experimental studies in metal carcinogenesis. Chromium, nickel, iron, arsenic.* **Arch. Environ. Health** 5:445.

IARC (International Agency for Research on Cancer). (1980) Arsenic and arsenic compounds. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Humans. WHO, Lyon, France. 23:39-142.

Ishinishi, N., et al. (1977). *Preliminary experimental study on carcinogenicity of arsenic trioxide in rat lung.* **Environ. Health Perspect.** 19:191-196.

Ivankovic, S., Eisenbrand, G. and Preasman, R. (1979) *Lung carcinoma induction in BD rats after single intratracheal instillation of an arsenic containing pesticide mixture formerly used in vineyards.* **Int. J. Cancer** 24:786-788.

Kojima, H. (1974) *Studies on developmental pharmacology of arsenite. II. Effect of arsenite on pregnancy, nutrition, and hard tissue.* **Fol. Pharmacol. Japon.** 70:149-163.

Lantz, H., Wallace, P.W. and Hamilton, J.G. (1950) *The metabolism of arsenic in laboratory animals using As^{74} as trace.* **Univ. Calif. Pub. Pharmacol.** 2:263-282.

Mealey, J., Bronwell, G.L. and Sweet, W.H. (1959) *Radioarsenic in plasma, urine, normal tissues, and intracranial neoplasms.* **Arch. Neurol. Psychiatry** 81:310-320.

Morton, W., Starr, G., Pohl, D., Stoner, J., Wagner, S. and Weswig, P. (1976) *Skin cancer and water arsenic in Lane County, Oregon.* **Cancer** 37:2523-2532.

Schrauzer, G.N., White, J.E., McGinness, J.E., Schneider, C.J. and Bell, L.J. (1978) *Arsenic and cancer: Effects of joint administration of arsenite and selenite on the genesis of mammary adenocarcinoma in inbred female C3H/ST mice.* **Bioorg. Khim.** 9:245-253.

Schroeder, H.A. and Balassa, J.J. (1967) *Arsenic, germanium, tin, and vanadium in mice: Effects on growth, survival and tissue levels.* **J. Nutr.** 92:245-252.

Silver, A.S. and Wainman, P.L. (1952) *Chronic arsenic poisoning following use of an asthma remedy.* **JAMA** 150:584.

Stokinger, H.E. (1981) The Metals: Arsenic. In: Patty's Industrial Hygiene and Toxicology, Vol. II, 3rd ed., C.D. Clayton and F.E. Clayton, Ed.; John Wiley and Sons, Inc., NY. pp. 1517-1531.

Tseng, W.P. (1977) *Effects and dose-response relationships of skin cancer and Blackfoot Disease with arsenic.* **Environ. Health Perspect.** 19:109-119.

U.S. Environmental Protection Agency (EPA) (1985) Health advisories for 52 chemicals which have been detected in drinking water. Office of Drinking Water. NTIS PB860118338.

U.S. Environmental Protection Agency (EPA) (1984) Health effects assessment for arsenic. ECAO-HO20. Prepared for the Office of Emergency and Remedial Response by the Environmental Criteria and Assessment Office.

Vallee, B.L., Ulmer, D.D. and Wacker, W.E.C. (1960) *Arsenic toxicology and chemistry.* **Arch. Ind. Health** 21:132-151.

0373
Manganese; CASRN 7439-96-5 (07/01/95)

Health risk assessment information on a chemical is included in IRIS only after a comprehensive review of chronic toxicity data by work groups composed of U.S. EPA scientists from several Program Offices. The summaries presented in Sections I and II represent a consensus reached in the review process. The other sections contain U.S. EPA information which is specific to a particular EPA program and has been subject to review procedures prescribed by that Program Office. The regulatory actions in Section IV may not be based on the most current risk assessment, or may be based on a current, but unreviewed, risk assessment, and may take into account factors other than health effects (e.g., treatment technology). When considering the use of regulatory action data for a particular situation, note the date of the regulatory action, the date of the most recent risk assessment relating to that action, and whether technological factors were considered. Background information and explanations of the methods used to derive the values given in IRIS are provided in the five Background Documents in Service Code 5, which correspond to Sections I through V of the chemical files.

STATUS OF DATA FOR Manganese

File On-Line 09/26/88

Category (section)	Status	Last Revised
Oral RfD Assessment (I.A.)	on-line	06/01/95
Inhalation RfC Assessment (I.B.)	on-line	12/01/93
Carcinogenicity Assessment (II.)	on-line	03/01/94
Drinking Water Health Advisories (III.A.)	no data	
U.S. EPA Regulatory Actions (IV.)	on-line	01/01/92

_I. CHRONIC HEALTH HAZARD ASSESSMENTS FOR NONCARCINOGENIC EFFECTS

__I.A. REFERENCE DOSE FOR CHRONIC ORAL EXPOSURE (RfD)

Substance Name -- Manganese
CASRN -- 7439-96-5
Last Revised -- 06/01/95

The Reference Dose (RfD) is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis, but may not exist for other toxic effects such as carcinogenicity. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Please refer to Background Document 1 in Service Code 5 for an elaboration of these concepts. RfDs can also be derived for the noncarcinogenic health effects of compounds which are also carcinogens. Therefore, it is essential to refer to other sources of information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file when a review of that evaluation is completed.

NOTE: The Oral RfD for manganese may change in the near future pending the outcome of a further review now being conducted by the RfD/RfC Work Group.

___I.A.1. ORAL RfD SUMMARY

Critical Effect	Experimental Doses*	UF	MF	RfD
CNS effects Human Chronic Ingestion Data Kondakis et al., 1989	NOAEL (water): 0.005 mg/kg-day LOAEL (water): 0.06 mg/kg-day	1	1	5E-3 mg/kg-day (water)
CNS effects	NOAEL (food): 0.14	1	1	1.4E-1

	mg/kg-day	mg/kg-day
Human Chronic Ingestion Data	LOAEL (food): None	(food)

WHO, 1973; Schroeder et al., 1966; NRC, 1989

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*Conversion Factors and Assumptions: The arithmetic mean of the range of manganese concentrations for the NOAEL and LOAEL are 167 ug/L and 1950 ug/L, respectively. Assuming a water consumption of 2 L/day and a body weight of 70 kg, these are equivalent to 0.005 mg/kg-day and 0.06 mg/kg-day, respectively. The water RfD assumes a separate dietary intake of manganese, as this essential element is found in varying amounts in all diets. The NOAEL of 10 mg/day (0.14 mg/kg-day for 70 kg adult) for chronic human consumption of manganese in the diet is based on a composite of data from all three references. WHO (1973) reported no adverse effects in humans consuming supplements of 8-9 mg Mn/day (0.11-0.13 mg/kg-day). Schroeder et al. (1966) reported a chronic human NOAEL of 11.5 mg Mn/day (0.16 mg/kg-day).

___I.A.2. PRINCIPAL AND SUPPORTING STUDIES (ORAL RfD)

WHO (World Health Organization). 1973. Trace Elements in Human Nutrition: Manganese. Report of a WHO Expert Committee. Technical Report Service, 532, WHO, Geneva, Switzerland. p. 34-36.

Schroeder, H.A., J.J. Balassa and I.H. Tipton. 1966. Essential trace metals in man: Manganese, a study in homeostasis. J. Chron. Dis. 19: 545-571.

NRC (National Research Council). 1989. Recommended Dietary Allowances, 10th ed. Food and Nutrition Board, National Research Council, National Academy Press, Washington, DC. p. 230-235.

Kondakis, X.G., N. Makris, M. Leotsinidis, M. Prinou and T. Papapetropoulos. 1989. Possible health effects of high manganese concentration in drinking water. Arch. Environ. Health. 44: 175-178.

The World Health Organization (WHO) reviewed several investigations of adult diets and reported the average daily consumption of manganese to range from 2.0-8.8 mg Mn/day. Higher manganese intakes are associated with diets high in whole-grain cereals, nuts, green leafy vegetables, and tea. From

manganese balance studies, the WHO concluded that 2-3 mg/day is adequate for adults and 8-9 mg/day is "perfectly safe."

Evaluations of standard diets from the United States, England, and Holland reveal average daily intakes of 2.3-8.8 mg Mn/day. Depending on individual diets, however, a normal intake may be well over 10 mg Mn/day, especially from a vegetarian diet. While the actual intake is higher, the bioavailability of manganese from a vegetarian diet is lower, thereby decreasing the actual absorbed dose. This is discussed in more detail in the Additional Studies / Comments Section.

No signs of toxicity were reported in patients (number not specified) given 30 mg manganese citrate (9 mg Mn/day) for many months. Assuming the patients also consumed 2.5 mg Mn/day in food, the total manganese intake would be approximately 11.5 mg Mn/day.

The Food and Nutrition Board of the National Research Council (NRC, 1989) determined an "adequate and safe" intake of manganese to be 2-5 mg/day for adults. This level was chosen because it includes an "extra margin of safety" from the level of 10 mg/day, which the NRC considered to be safe for an occasional intake.

There is one epidemiologic study of manganese in drinking water performed by Kondakis et al. (1989). Three areas in northwest Greece were chosen for this study, with manganese concentrations in natural well water of 3.6-14.6 ug/L in area A, 81.6-252.6 ug/L in area B, and 1600-2300 ug/L in area C. The total population of the three areas studied ranged from 3200 to 4350 people. The study included only individuals over the age of 50 drawn from a random sample of 10% of all households (n=62, 49, and 77 for areas A, B, and C, respectively). The authors reported that "all areas were similar with respect to social and dietary characteristics," but few details were reported. The three areas are located within a 200-square km region. Although the amount of manganese in the diet was not reported, the authors indicated that most of the food was purchased from markets and is expected to be comparable for all three areas. Chemicals other than manganese in the well water were reported to be within Economic Community (EC) standards, except for hardness (120-130 mg calcium carbonate per liter). The individuals chosen were submitted to a neurologic examination, the score of which represents a composite of the presence and severity of 33 symptoms (e.g., weakness/fatigue, gait disturbances, tremors, dystonia). Whole blood and hair manganese concentrations also were determined. The mean concentration of manganese in hair was 3.51, 4.49, and 10.99 ug/g dry weight for areas A, B, and C, respectively ($p<0.0001$ for area C versus A). The concentration of manganese

in whole blood did not differ between the three areas, but this is not considered to be a reliable indicator of manganese exposure. The mean (x) and range (r) of neurologic scores were as follows: Area A (males: x=2.4, r=0-21; females: x=3.0, r=0-18; both x=2.7, r=0-21); Area B (males x=1.6, r=0-6; females: x=5.7 r=0-43; both: x=3.9, r=0-43); and Area C (males: x=4.9, r=0-29; females: x=5.5, r=0-21; both x=5.2, r=0-29). The authors indicate that the difference in mean scores for area C versus A was significantly increased (Mann-Whitney z=3.16, p=0.002 for both sexes combined). In a subsequent analysis, logistic regression indicated that there is a significant difference between areas A and C even when both age and sex are taken into account (Kondakis, 1990). Therefore, the LOAEL for this study is defined by Area C (1600-2300 ug/L) and NOAEL by Area B (81.6-252.6 ug/L). Using the arithmetic means of the ranges of manganese provided (1950 ug/L for Area C and 167 ug/L for Area B), and assuming a water consumption of 2 L/day and a body weight of 70 kg, the LOAEL is equivalent to 0.06 mg Mn/kg-day and the NOAEL is equivalent to 0.005 mg Mn/kg-day.

The individuals examined in the Greek epidemiologic study also had exposure to manganese in their diet. This was roughly estimated to be 10-15 mg/day because of the high intake of vegetables (Kondakis, 1990). In a subsequent correspondence from the investigator, a lower dietary estimate of 5-6 mg Mn/day was stated (Kondakis, 1993), but data have not been supplied to substantiate either estimate. Because of the uncertainty in the amount of manganese in the diet, it is difficult to estimate a total oral intake. The lack of dietary data is recognized as a source of significant uncertainty in this assessment.

The use of the Kondakis et al. (1989) study in supporting the derivation of a separate "water RfD" assumes that the manganese exposure from drinking water is in addition to that found in the diet. This assumption is made primarily because the differences in the bioavailability of manganese in food as compared with that of manganese in water may be such that it is inappropriate to add these intakes together. Unfortunately, while it is agreed that the bioavailability of manganese may vary substantially, relatively few data are available to quantitate these differences, and the number of variables that may affect the uptake of manganese are such that to determine a single value for the absorption of manganese from any medium is not appropriate. These issues are discussed further in the Additional Studies / Comments Section. If the water RfD is used to support a drinking water standard for manganese, no relative source contribution needs to be applied because dietary intake of manganese is already assumed. An RfD of 0.005 mg/kg-day for manganese in water is equivalent to a drinking water standard of 0.2 mg/L.

A report by Kawamura et al. (1941) is the only epidemiologic study describing toxicologic responses in humans consuming large amounts of manganese dissolved in drinking water. The manganese came from about 400 dry-cell batteries buried near a drinking water well resulting in high levels of both manganese and zinc in the water. Twenty-five cases of manganese poisoning were reported, with symptoms including lethargy, increased muscle tonus, tremor and mental disturbances. The most severe symptoms were seen in elderly people, while children appeared to be unaffected. Three individuals died, one from suicide. The cause of death for the other two was not reported, but the autopsy of one individual revealed manganese concentration in the liver to be 2-3 times higher than in control autopsies. Zinc levels also were increased in the liver. The well water was not analyzed until 1 month after the outbreak, at which time it was found to contain approximately 14 mg Mn/L. When re-analyzed 1 month later, however, the levels were decreased by about half. Therefore, by retrospective extrapolation, the concentration of manganese at the time of exposure may have been as high as 28 mg Mn/L. Consumption of 2 liters of water per day containing 28 mg/L of manganese approximates an intake of 0.8 mg/kg-day for a 70-kg adult. The severe effects seen in this study support the LOAEL estimated from the 1989 Kondakis et al. study of 0.06 mg/kg-day, which was associated with less severe effects.

___I.A.3. UNCERTAINTY AND MODIFYING FACTORS (ORAL RfD)

UF -- The information used to determine the RfD for manganese in food was taken from many large populations consuming normal diets over an extended period of time with no adverse health effects. As long as physiologic systems are not overwhelmed, humans exert an efficient homeostatic control over manganese such that body burdens are kept constant with variations in diet. It is recognized that manganese is an essential element, being required for normal human growth and maintenance of health. It has also been suggested that children are less susceptible to manganese intoxication and may require slightly higher levels of manganese than adults. This is not true for infants, who may represent a more sensitive subpopulation (see discussion in the Additional Studies / Comments Section). The available information providing a chronic NOAEL in many cross-sections of human populations, taken in conjunction with the essentiality of manganese, warrants an uncertainty factor of 1. For the drinking water RfD, the study by Kondakis et al. (1989) describes a population of older adults (over 50 years) who had consumed well water containing various concentrations of manganese for a lifetime. The

study group is considered to represent a sensitive subpopulation, hence an uncertainty factor of 1 is applied.

MF -- The modifying factors are 1 for both the dietary RfD and the drinking water RfD.

___I.A.4. ADDITIONAL STUDIES / COMMENTS (ORAL RfD)

While the Greek epidemiologic study (Kondakis et al., 1989) is considered to be acceptable for deriving a separate water RfD for manganese, it is also recognized as being limited in scope. Arguments for using the Greek study are strengthened when it is reviewed in the context of additional information. In addition to the Greek and Japanese studies of humans ingesting manganese in drinking water, one limited oral study has been performed in a group of four Rhesus monkeys (Gupta et al., 1980). Muscular weakness and rigidity of the lower limbs developed after 18 months of exposure to 6.9 mg Mn/kg-day (as MnC12.4H2O). Histologic analysis showed degenerated neurons in the substantia nigra and scanty neuromelanin granules in some other pigmented cells.

A pattern is seen when the two human studies are viewed in conjunction with the study in Rhesus monkeys. Kondakis et al. (1989) identified a NOAEL for humans ingesting manganese in drinking water of 0.005 mg/kg-day and a LOAEL associated with minor neurologic effects of 0.06 mg/kg-day. Kawamura et al. (1941) reported severe effects in a small group of people ingesting about 0.8 mg/kg-day of manganese in water. Some subpopulations (e.g., children) appeared to be unaffected. Finally, Gupta et al. (1980) reported severe effects confirmed by histopathologic analysis in monkeys receiving 6.9 mg/kg manganese.

A couple of case studies have also pointed to the potential for manganese poisoning by routes other than inhalation. One involved a 59-year-old male who was admitted to the hospital with symptoms of classical manganese poisoning, including dementia and a generalized extrapyramidal syndrome (Banta and Markesbery, 1977). The patient's serum, hair, urine, feces, and brain were found to have manganese "elevated beyond toxic levels," perhaps a result of his consumption of "large doses of vitamins and minerals for 4 to 5 years." Unfortunately, no quantitative data were reported.

Another case study of manganese intoxication involved a 62-year-old male who had been receiving total parenteral nutrition that provided 2.2 mg of manganese (form not stated) daily for 23 months (Ejima et al., 1992). The

patient's whole blood manganese was found to be elevated, and he was diagnosed as having parkinsonism, with dysarthria, mild rigidity, hypokinesia with masked face, a halting gait, and severely impaired postural reflexes. To be able to compare the manganese load in this individual with that corresponding to an oral intake, the difference between the direct intravenous exposure and the relatively low level of absorption of manganese from the gastrointestinal tract must be taken into account. Assuming an average absorption of roughly 5% of an oral dose, the intravenous dose of 2.2 mg Mn/day would be approximately equivalent to an oral intake of 40 mg Mn/day. This is consistent with the severe neurological effects reported in the Japanese drinking water poisoning (Kawamura et al., 1941) in which it is estimated that the individuals were exposed to about 58 mg Mn/day.

Several oral studies have been performed in rodents, also demonstrating biochemical changes in the brain following administration of 1 mg MnC12.4H2O/mL in drinking water (approximately 38.9 mg Mn/kg-day) (Lai et al., 1981, 1982; Leung et al., 1981; Chandra and Shukla, 1981). However, rodents do not exhibit the same neurologic deficits that humans do following exposure to manganese; thus the relevance of these biochemical changes has been challenged. The problem with using rodents is exemplified by the disease of parkinsonism, which is characterized by effects very similar to those seen in manganese poisoning. Marsden and Jenner (1987) hypothesize that the ability of certain drugs to induce parkinsonism in primates but not in rodents is due to the relative lack of neuromelanin in rodents. Because manganese selectively accumulates in pigmented regions of the brain (e.g., the substantia nigra), this species difference is fundamentally important.

It is also important to recognize the substantial difference in species' requirements for manganese. For rats, the estimated requirement is 50 mg Mn/kg diet (Rogers, 1979). Assuming a food consumption equivalent to 5% of body weight, this corresponds to a requirement of about 2.5 mg Mn/kg-day. Although the dietary requirement for manganese has not been determined quantitatively for humans, the "Estimated Safe and Adequate Daily Dietary Intake" is 2-5 mg/day, or about 0.03-0.07 mg Mn/kg-day, assuming a reference body weight of 70 kg. The dietary requirement for manganese in rats then, is about 50-fold higher than the estimated safe and adequate intake for humans, suggesting that data derived from rodent studies may not be appropriate for use in deriving quantitative risk estimates for manganese in humans.

Another issue of great importance to consider in the risk assessment for manganese concerns the bioavailability of different forms of manganese consumed under different exposure conditions. The separate RfDs for food and water indicate a potentially higher bioavailability of manganese from drinking

water. In considering dietary sources, it is also important to recognize that various dietary factors as well as the form of manganese can have a significant bearing on the dose absorbed from the gastrointestinal tract. Many constituents of a vegetarian diet (e.g., tannins, oxalates, phytates, fiber, calcium, and phosphorus) have been found to inhibit manganese absorption presumably by forming insoluble complexes in the gut. Individuals who are deficient in iron demonstrate an increase in manganese absorption. It is also recognized that manganese uptake and elimination are under homeostatic control, generally allowing for a wide range of dietary intakes considered to be safe. These factors and others are described in a review by Kies (1987). In addition to the influence of extrinsic variables, significant interindividual differences in manganese absorption and retention have been reported. In humans administered a dose of radiolabeled manganese in an infant formula, the mean absorption was 5.9 +/- 4.8%, but the range was 0.8-16%, a 20-fold difference (Davidsson et al., 1989). Retention at day 10 was 2.9 +/- 1.8%, but the range was 0.6-9.2%, again indicating substantial differences between individuals.

In a 100-day dietary study in 6-week-old male mice, Komura and Sakamoto (1991) demonstrated significant differences in tissue levels of manganese in mice fed equivalent amounts of manganese as MnCl2.4H2O, Mn(Ac)2.4H2O, MnCO3 and MnO2. Mice receiving the two soluble forms of manganese (the chloride and acetate salts) were found to gain significantly less weight than controls, while mice consuming the insoluble forms of manganese (the carbonate and dioxide salts) appeared to actually gain slightly more weight than controls. However, the acetate and carbonate groups had significantly higher manganese levels in the liver and kidney compared with the chloride and dioxide groups, both of which were elevated above control levels. Reduced locomotor activity in the carbonate and acetate groups was also reported, perhaps related to the higher tissue levels of manganese. This study points out a need for understanding the effects of the various forms of manganese, of which relatively little is known. More information on manganese speciation can be found in the RfC file on IRIS.

It is also recognized that neonates may be at increased risk of toxicity resulting from exposure to manganese because of a higher level of uptake from the gastrointestinal tract. The uptake and retention of manganese have been reviewed by Lonnerdal et al. (1987). In rats, manganese absorption decreased dramatically as the animals matured. While 24-hour retention values are as high as 80% in 14-day-old pups, this value drops to about 30% by day 18. Low levels of manganese absorption (about 3-4%) have also been reported for mature humans, but few data are available for infants.

Collipp et al. (1983) found that hair manganese levels in newborn infants was found to increase significantly from birth (0.19 ug/g) to 6 weeks of age (0.865 ug/g) and 4 months of age (0.685 ug/g) when the infants were given formula, but that the increase was not significant in babies who were breast-fed (0.330 ug/g at 4 months). While human breast milk is relatively low in manganese (7-15 ug/L), levels in infant formulas are 3-100 times higher. It was further reported in this study that the level of manganese in the hair of learning disabled children (0.434 ug/g) was significantly increased in comparison with that of normal children (0.268 ug/g). Other investigators also have reported an association between elevated levels of manganese in hair and learning disabilities in children (Barlow and Kapel, 1979; Pihl and Parkes, 1977). Although no causal relationship has been determined for learning disabilities and manganese intake, further research in this area is warranted. High levels of manganese in infant formulas may be of concern because of the increased absorption and retention of manganese that has been reported in neonatal animals (Lonnerdal et al., 1987). Also, manganese has been shown to cross the blood-brain barrier, with the rate of penetration in animal experiments being 4 times higher in neonates than in adults (Mena, 1974). It was suggested by Dieter et al. (1992) that "if there were a toxicological limit to manganese according to the principles of preventive health care, then it would have to be set at 0.2 mg/L of manganese for infants as a group at risk."

Although conclusive evidence is lacking, some investigators have also linked increased intakes of manganese with violent behavior. Gottschalk et al. (1991) found statistically significantly elevated levels of manganese in the hair of convicted felons (1.62 +/- 0.173 ppm in prisoners compared with 0.35 +/- 0.020 ppm in controls). The authors suggest that "a combination of cofactors, such as the abuse of alcohol or other chemical substances, as well as psychosocial factors, acting in concert with mild manganese toxicity may promote violent behavior." Caution should be exercised to prevent reading too much into these data, but support for this hypothesis is provided by studies of a population of Aborigines in Groote Eylandt. Several clinical symptoms consistent with manganese intoxication are present in about 1% of the inhabitants of this Australian island, and it may not be coincidental that the proportion of arrests in this native population is the highest in Australia (Cawte and Florence, 1989; Kilburn, 1987). The soil in this region is very high in manganese (40,000-50,000 ppm), and the fruits and vegetables grown in the region also are reported to be high in manganese. Quantitative data on oral intakes have not been reported, but elevated concentrations of manganese have been determined in the blood and hair of the Aborigines (Stauber et al., 1987). In addition to the high levels of environmental manganese, other factors common to this population may further increase the propensity for

manganism: high alcohol intake, anemia, and a diet deficient in zinc and several vitamins (Florence and Stauber, 1989).

In addition to the toxicity information available by the oral route, several inhalation toxicity studies on manganese also have been performed in laboratory animals, demonstrating an effect on both the brain and lungs. An in-depth discussion of the psychologic and neurologic effects associated with inhalation of manganese can be found in the RfC file on IRIS.

___I.A.5. CONFIDENCE IN THE ORAL RfD

Study -- Not applicable
Data Base -- Not applicable
RfD -- Not applicable

Many studies have reported similar findings with regard to the normal dietary intake of manganese by humans. These data are considered to be superior to any data obtained from animal toxicity studies, especially as the physiologic requirements for manganese vary quite a bit among different species, with man requiring less than rodents (Schroeder et al., 1966). There is no one study used to derive the dietary RfD for manganese. While several studies have determined average levels of manganese in various diets, no quantitative information is available to indicate toxic levels of manganese in the diet of humans. Because of the homeostatic control humans maintain over manganese, it is generally not considered to be very toxic when ingested with the diet. It is important to recognize that while the RfD process involves the determination of a point estimate of an oral intake, it is also stated that this estimate is associated "with uncertainty spanning perhaps an order of magnitude." Numerous factors, both environmental factors (e.g., the presence or absence of many dietary constituents) and biological or host factors (e.g., age, alcohol consumption, anemia, and general nutritional status) can significantly influence an individual's uptake of manganese from the diet. As discussed in the Additional Studies / Comments Section, there is significant variability in the absorption of manganese by humans. The determination of a single intake of manganese in the diet must be recognized as a process that is limited in its ability to reflect the variable nature of manganese toxicity. Such a determination may both over- and underestimate the risk, depending on the specific combination of environmental and individual circumstances. Confidence in the data base is medium and confidence in the dietary RfD for manganese is also medium.

It is again emphasized that this oral RfD is based on a total dietary intake of manganese and is not intended to be applied directly to drinking water situation. Because of the greater bioavailability of manganese from water, a separate RfD for water is proposed. This is based on the Greek epidemiologic study by Kondakis et al. (1989). The major advantage of this study is that it examined a sensitive subpopulation of humans exposed to varying concentrations of manganese in the drinking water for a lifetime. A significant weakness of this study is that the actual manganese content in the diet was not measured. The author did indicate, however, that the people in the three areas were age-matched and had similar social, economic and educational backgrounds, and that the food consumed by these subjects was purchased at the marketplace and was not expected to vary much in manganese content. The confidence in the critical study can be considered low-to-medium. It is not higher primarily because of the lack of data on dietary manganese in the three populations under study. Also, many of the endpoints scored in the neurological exam are not specific for manganese poisoning and are, in fact, associated with the normal process of aging. Confidence in the data base also can be considered medium-to-low. The Greek study is supported by the more severe effects occurring at higher levels in the Japanese study (Kawamura et al., 1941) and the study in rhesus monkeys (Gupta et al., 1980). Overall confidence in the drinking water RfD can be considered medium-to-low. While the RfD process involves the determination of a single point estimate of an oral intake, it must be recognized that this estimate is associated with several sources of uncertainty. Available data indicate that numerous factors, both environmental factors (e.g., the presence of high or low levels of other inorganics in drinking water) and biological or host factors (e.g., age, alcohol consumption, and nutritional status, particularly anemia) can significantly influence the uptake of manganese by an individual. The determination of a single concentration of manganese in drinking water, then, must be recognized as a process that is limited in its ability to reflect the variable nature of manganese toxicity.

___I.A.6. EPA DOCUMENTATION AND REVIEW OF THE ORAL RfD

Source Document -- U.S. EPA, 1993

The Drinking Water Criteria Document for Manganese has received Agency review.

Other EPA Documentation -- U.S. EPA, 1984

Agency Work Group Review -- 05/17/90, 06/21/90, 06/24/92, 09/22/92, 03/31/93,

BENZENE

GENERAL BACKGROUND INFORMATION

Benzene is a clear, volatile, highly flammable, aromatic hydrocarbon which exists naturally and is produced by volcanoes and forest fires. Benzene is also a very common industrial solvent, produced from petroleum. It is used as a solvent for fats, inks, paints, plastics, rubber, in the extraction of oils from seeds and nuts, in photogravure printing, as a chemical intermediate and in the manufacture of detergents, explosives, pharmaceuticals and dyestuffs. It is also a component of gasoline and other petroleum-based fuels. Exposure to benzene can occur via inhalation, ingestion, especially of contaminated drinking water, and dermal contact (as in contact with liquid benzene found in gasoline.) (Sittig, 1981; ATSDR, 1989)

PHARMACOKINETICS

Benzene is readily absorbed through ingestion, moderately absorbed through inhalation and poorly absorbed through intact skin (see section on Relative Absorption Factors). Once in the bloodstream, benzene is distributed throughout the body, with the concentration in any one compartment dependent on the degree of perfusion of tissues by blood. Since benzene is lipid-soluble, it accumulates in fat, but the rate of accumulation is slow since fat is poorly perfused. The metabolites of benzene are responsible for its toxic effects. These include phenol (which is either formed via an unstable benzene oxide precursor or directly from benzene), catechol, hydroquinone and conjugated phenolic compounds. The primary site of benzene metabolism is the liver via the cytochrome P450 mixed function oxidase system. Some benzene metabolism may also occurs in the bone marrow via the same enzyme system. Benzene is excreted either unchanged from the lungs or as metabolites in the urine (ATSDR, 1989).

HUMAN TOXICOLOGICAL PROFILE

Benzene targets its effects on the hemopoietic, immune and nervous systems (ATSDR, 1989). Exposure to benzene has produced irritation of the skin, eyes and upper respiratory tract. Acute exposure has produced central nervous system depression, headache, dizziness, nausea, convulsions, coma and death at extremely high concentrations (Sittig, 1981). Health effects in humans have been reported starting as low as 50 ppm via inhalation. Twenty-five ppm for 6 hrs had no obvious effects though benzene was detected in blood (Sandmeyer, 1981). Early autopsy reports found benzene-induced hemorrhages of the brain, pericardium, urinary tract, mucous membranes and skin (Sittig, 1981). Chronic exposure to benzene produces blood changes involving an initial increase in levels of erythrocytes, leukocytes and

thrombocytes, followed by aplastic anemia indicated by anemia, leukopenia and thrombocytopenia (Sittig, 1981).

MAMMALIAN TOXICOLOGICAL PROFILE

The following effects have been produced experimentally in laboratory animals, following exposure to benzene: decreased leukocyte and/or erythrocyte counts, reduction in cellular immunity and bone marrow depression (reduced number of granulopoietic stem cells). Animal studies do not indicate that benzene is teratogenic, but the following fetotoxic effects have been found: reduced fetal weight, altered fetal hematopoiesis, fetal skeletal variations and increased resorptions in pregnant exposed animals. In addition, benzene has produced histopathological changes in ovaries and testes of test animals (ATSDR, 1989).

GENOTOXICITY

Benzene and its metabolites have been shown to be mutagenic in a number of in vitro and in vivo studies. Genotoxic effects produced experimentally include structural and numerical chromosome aberrations in humans, animals and cell cultures, and sister chromatid exchanges and micronuclei in in vivo animal studies. Benzene exposure has been found to produce an increase in the number of chromosome aberrations associated with myelotoxicity (Sittig, 1981). In addition, sperm head abnormalities, inhibition of DNA and RNA synthesis, DNA binding and interference with cell cycle progression have been shown in in vitro studies (ATSDR, 1989). The epidemiologic data indicate that benzene is leukemogenic. The evidence is most convincing for acute myelogenous and acute erythroleukemia, although a correlation has also been found with chronic leukemia. Benzene has been designated a group A human carcinogen (leukemogen) by inhalation. Although data are insufficient to validate the carcinogenicity of benzene via ingestion, it would not be unreasonable that benzene is carcinogenic via this route as well if present in sufficient quantities. The carcinogenicity of benzene via dermal exposure is considered to be lower since benzene is absorbed poorly through the skin (ATSDR, 1989).

REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR) (1989) Toxicological profile for benzene. U.S. Public Health Service.

Sandmeyer, E.E. (1981) *Aromatic hydrocarbons*. In: Patty's Industrial Hygiene and Toxicology, Vol. 2, 3rd ed., Clayton G.D., Clayton F.E., eds. New York. Interscience Publishers. pp. 3253-3283.

Sittig, M. (1981) Handbook of Toxic and Hazardous Chemicals. Noyes Publications.

TRICHLOROETHYLENE

GENERAL BACKGROUND INFORMATION

Trichloroethylene (TCE) is widely used as an industrial solvent, particularly in metal degreasing, which consumes about 90% of TCE produced annually in the U.S. TCE is also used for dry-cleaning, as a low-temperature heat exchange fluid, as a fumigant, as a diluent in paints and adhesives, in aerospace operations, and in textile processing. Previously, TCE was used as an extractant in food-processing. These uses were discontinued in 1975 due to evidence of possible carcinogenic activity. Its earlier use in anesthetics was also discontinued (IRP, 1985).

PHARMACOKINETICS

Absorption of TCE from the gastrointestinal and respiratory tracts is extensive. TCE is extensively metabolized in humans to trichloroethanol, trichloroethanol glucuronide, and trichloroacetic acid. Although the liver is the primary site of TCE metabolism, there is evidence for extrahepatic metabolism in the lungs and kidneys (ATSDR, 1988).

HUMAN TOXICOLOGICAL PROFILE

TCE is assumed to be responsible for the deaths of four men employed at degreasing operations using TCE as the solvent (Kleinfeld and Tabershaw, 1954). Toxicological analysis revealed TCE in varying concentrations in various tissues. Kleinfeld and Tabershaw (1954) reported that, despite treatment, a man died 11 days after he accidentally drank an unknown quantity of TCE. TCE has been shown to affect the central nervous system. Short-term exposure to high concentrations of TCE caused dizziness, headache, nausea, confusion, facial numbness, blurred vision, and, at very high levels, unconsciousness. Longer exposures cause ataxia, decreased appetite, sleep disturbances, and trigeminal neuropathy (U.S. EPA, 1985). Information regarding hepatotoxicity in humans is limited and derived from acute overexposures. U.S. EPA (1985) has concluded that it is unlikely that chronic exposure to trichloroethylene at concentrations found or expected in ambient air would result in liver damage.

MAMMALIAN TOXICOLOGICAL PROFILE

In laboratory animals, the acute toxicity of trichloroethylene is low. Oral LD_{50} values of 4920 mg/kg in the rat, 3200 mg/kg in the mouse and 2800 mg/kg in the dog have been reported. In a study by Baker (1958), several dogs died within 20 minutes of being exposed to TCE at 30,000 ppm. Rats exposed to 20,000 ppm for 5 hours died (Adams, 1951). A 2-year study

in rats conducted by the NTP (1986a) showed decreased survival due to TCE treatment. Deaths were attributed to toxic nephrosis. Behavioral changes were observed in rats at TCE vapor concentrations as low as 100 ppm (Silverman and Williams, 1975). Liver enlargement is the most commonly observed hepatic effect seen in TCE-exposed animals (Kjellstrand et al., 1983). Mice, especially males, appear to be particularly sensitive to the hepatotoxic effects of TCE. The only reproductive effects observed were reduced testis and epididymis weights in rats exposed to dietary TCE (NTP, 1986b). There were no effects of reproductive system histology, fertility, or other reproductive performance parameters in treated males or females in these studies.

GENOTOXICITY

Perocco and Prodi (1981) found positive results for unscheduled DNA synthesis both with and without metabolic activation in human lymphocytes in vivo. Another study reported a significant increase in sister chromatid exchange in six workers exposed to TCE (Gu et al., 1981). In vitro mutagenicity tests in bacteria, yeasts, and molds demonstrated weak positive responses. Most of these tests required metabolic activation of the compound (Crebelli et al., 1985). TCE has been shown to be carcinogenic in animals. Inhalation and oral exposure produced liver and lung tumors in mice and kidney adenocarcinomas, testicular Leydig cell tumors, and possibly leukemia in rats. These studies are deemed sufficient to place TCE in CAG classification B2, probable human carcinogen (U.S. EPA, 1987). Further support that TCE is a probable human carcinogen comes from studies that indicate that metabolism is qualitatively similar in humans and test animals (U.S. EPA, 1987). The available carcinogenicity studies indicate that mice are more susceptible to TCE carcinogenicity than the rat. Factors contributing to this difference may be an increased rate of metabolic conversion to trichloracetic acid in mice, and the more pronounced trichloroacetic acid-mediated peroxisomal proliferation and cell proliferation in mice (Elcombe et al., 1985). The peroxisomal proliferation may lead to an increase in the reactive oxygen species and DNA damage, which may lead to hepatocellular carcinoma.

REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR) (1988) Toxicological profile for trichloroethylene. U.S. Public Health Service.

Adams, E.M., Spencer, H.C., Rowe, V.K., McCollister, D.D. and Irish, D.D. (1951) *Vapor toxicity of trichloroethylene determined by experiments on laboratory animals*. **Arch. Ind. Hyg. Occup. Med.** 4:469-481.

Baker, A.B. (1958) *The nervous system in trichloroethylene. An experimental study*. **J. Neuropath. Exp. Med.** 17:649-655.

Crebelli, R., Conti, G., Conti, L. and Caurere, A. (1985) *Mutagenicity of trichloroethylene, trichloroethanol, and chloral hydrate in Aspergillus nidulans*. **Mutat. Res.** 155:105-111.

Elcombe, C.R., Rose, M.S. and Pratt, I.S. (1985) *Biochemical, histological and ultrastructural changes in rat and mouse liver following the administration of trichloroethylene: Possible relevance to species differences in hepatocarcinogenicity.* **Toxicol. Appl. Pharmacol.** 79:365-376.

Gu, Z.W., Sele, B. and Jalbert, P. (1981) *Induction d'echanges entre les chromatides soeurs (SCE) par le trichloroethylene et ses metabolites.* **Toxicol. Eur. Res.** 3:63-67.

The Installation Restoration Program Toxicology Guide (IRP). 1985. Vol. 1. Arthur D. Little, Inc., Cambridge, MA.

Kjellstrand, P., Holmquist, B., Alm, P., Kanje, M., Romare, S., Jonsson, I., Mannson, L. and Bjerkamo, M. (1983) *Trichloroethylene: Further studies of the effects on body and organ weights and plasma butyryl cholinesterase activity in mice.* **Acta Pharmacol. Toxicol.** 53:375-384.

Kleinfeld, M. and Tabershaw, I.R. (1954) *Trichloroethene toxicity. Report of five fatal cases.* **AMA: Arch. Ind. Hyg. Occup. Med.** 10:134-141.

National Toxicology Program (NTP) (1986a) Toxicology and carcinogenesis studies of trichloroethylene in F344/N rats and B6C3F1 mice. NTP TR 243.

National Toxicology Program (NTP). (1986b) Trichloroethylene: Reproduction and fertility assessment in F344 rats when administered in the feed. Final Report. NTP-86-085.

Perocco, P. and Prodi, G. (1981) *DNA damage by haloalkanes in human lymphocytes cultured in vitro.* **Cancer Lett.** 13:213-218.

Silverman, A.P. and Williams, H. (1975) *Behaviour of rats exposed to trichloroethylene vapors.* **Br. J. Ind. Med.** 32:308-315.

U.S. Environmental Protection Agency (U.S. EPA) (1985) Health assessment document for trichloroethylene, Final Report. Washington, DC. NTIS PB85-249696.

U.S. Environmental Protection Agency (U.S. EPA) (1987) Addendum to the health assessment document for trichloroethylene: Update carcinogenicity assessment for trichloroethylene. EPA/600/8-82/006FA.

LEAD

GENERAL BACKGROUND INFORMATION

Lead is used extensively in the manufacture of storage batteries and was used in gasoline and paint. Lead is also a natural constituent of many soils, for which concentrations normally range from 10 to 30 mg lead per kilogram of soil (U.S. EPA, 1980).

PHARMACOKINETICS

Lead can be absorbed by the oral, inhalation or dermal exposure routes (see section on Relative Absorption Factors). Gastrointestinal absorption of lead varies considerably depending upon chemical form, dietary intake, and age (Forbes and Reina, 1974; Barltrop and Meek, 1975). The deposition and absorption of inhaled lead depends upon particle size, chemical form and the rate and depth of breathing (Randall et al., 1975; Nozaki, 1966; Chamberlain et al., 1975). Once absorbed, lead is distributed to the various organs of the body, with most distribution occurring into mineralized tissues (ATSDR, 1990). Placental transfer to the developing fetus is possible (Bellinger et al., 1987). Inorganic lead is not known to be biotransformed within the body. Absorbed lead is excreted via the urinary or fecal routes (ATSDR, 1990)

HUMAN TOXICOLOGICAL PROFILE

Cases of acute lead poisoning in humans are not common and have not been studied in experimental animals as thoroughly as chronic lead poisoning. Symptoms of acute lead poisoning from deliberate ingestion by humans may include vomiting, abdominal pain, hemolysis, liver damage, and reversible tubular necrosis (U.S. EPA, 1984). Subacute exposures in humans reportedly may produce a variety of neurological effects including dullness, restlessness, irritability, poor attention span, headaches, muscular tremor, hallucinations, and loss of memory. Nortier et al., (1980) report encephalopathy and renal damage to be the most serious complications of chronic toxicity in man and the hematopoietic system to be the most sensitive. For this reason, most data on the effects of lead exposure in humans are based upon blood lead levels. The effects of lead on the formation of hemoglobin and other hemoproteins, causing decreased levels, are reportedly detectable at lower levels of lead exposure than in any other organ system (Betts et al., 1973). Peripheral nerve dysfunction is observed in adults at levels of 30 to 50 μg/dL-blood. Children's nervous systems are reported to be affected at levels of 15 μg/dL-blood and higher (Benignus et al., 1981). In high doses, lead compounds may potentially cause abortions, premature delivery, and early membrane rupture (Rom, 1976).

MAMMALIAN TOXICOLOGICAL PROFILE

Acute oral lethal doses of lead in animals depend upon chemical form, but generally range from 500 to 30,000 mg/kg. Several reproduction studies on the effects of subchronic oral exposure to lead in rats have been conducted (Kimmel et al., 1976; Grant et al., 1980; Fowler et al., 1980). These studies report that lead acetate administered in drinking water at various concentrations caused depressed body weights at 50 and 250 mg-Pb/L water, histological changes in the kidneys of offspring, cytokaryomegaly of the tubular epithelial cells of the inner cortex at concentrations greater than or equal to 25 mg/L and postnatal developmental delays at 50 to 250 mg/L. Higher oral doses of lead may result in decreased fertility and fetotoxic effects in a variety of species (Hilderbrand et al., 1973). A reduction in the number of offspring of rats and mice exposed to 25 mg Pb/L drinking water with a chromium deficient diet was reported by Schroeder et al. (1970). Chronic oral exposure of female Long-Evans rats to lead (5 mg/PB/L-water) reportedly resulted in slight effects on tissue excitability, systolic blood pressure, and cardiac ATP concentrations (Kopp et al., 1980a,b).

GENOTOXICITY

Results of *in vitro* studies with human lymphocyte cultures using lead acetate were nearly equally positive and negative. Results of in vivo tests are also contradictory but suggest that lead may have an effect on chromosomes (sister chromatid exchange).
Results for gene mutations, DNA modification, and recombinations in various microorganisms using lead acetate, lead nitrate and lead chloride were consistently negative with or without metabolic activation. Lead chloride has been reported to inhibit both DNA and RNA synthesis. In *in vitro* mammalian test systems, lead acetate gave conflicting results.

No epidemiological data regarding the oral carcinogenic potential of lead could be located in the available literature. Chronic inhalation may result in a statistically significant increase in deaths due to tumors in the digestive organs and respiratory systems in lead smelter workers and battery plant workers (Kang et al., 1980). Several studies have reported tumor formation in experimental animals orally administered specific lead salts, not normally ingested by humans (Zawirska and Medras, 1972; Boyland et al., 1962; Ito, 1973). The carcinogenicity of inhaled lead in experimental animals could not be located in the available literature. The U.S. EPA has classified lead and lead compounds as Group B2 - Probable Human Carcinogens.

REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR) (1990) Toxicological profile for lead. U.S. Public Health Service.

Barltrop, D. and Meek, F. (1975) *Absorption of different lead compounds*. **Postgrad. Med. J.** 51:805-809.

Bellinger, D.C., Leviton, A., Waternaux, C., Needleman, H. and Rabinowitz, M. (1987) *Longitudinal analyses of prenatal and postnatal lead exposure and early cognitive development*. **N. Engl. J. Med.** 316:1037-1043.

Benignus, V.A., Otto, D.A., Muller, K.E. and Seiple, K.J. (1981) *Effects of age and body lead burden on CNS function in young children. II: EEG spectra*. **Electroencephalograph. Clin. Neurophysiol.** 52:240-248.

Betts, P.R., Astley, R. and Raine, R.N. (1973) *Lead intoxication in children in Birmingham*. **Br. Med. J.** 1:402-406.

Boyland, E., Dukes, C.E., Grover, P.L. and Mitchley, B.C.V. (1962) *The induction of renal tumors by feeding lead acetate to rats*. **Br. J. Cancer** 16:283-288.

Chamberlain, D. et al. (1975) *Uptake of lead by inhalation of motor exhaust*. **Proc. Roy. Soc. London B.** 192:77-110.

Forbes, G.B. and Reina, J.C. (1974) *Effect of age on gastrointestinal absorption (Fe, Sr, Pb) in the rat*. **J. Nutr.** 102:647-652.

Fowler, B.A. et al. (1980) *Chronic low level lead toxicity in the rat: III. An integrated assessment of long-term toxicity with special reference to the kidney*. **Toxicol. Appl. Pharmacol.** 56:59-77.

Grant, L.D. et al. (1980) *Chronic low-level lead toxicity in the rat: II. Effects on postnatal physical and behavioral development*. **Toxicol. Appl. Pharmacol.** 56:42-58.

Hilderbrand, D.C. et al. (1973) *Effect of lead acetate on reproduction*. **Am. J. Obstet. Gynecol.** 115:1058-1065.

Ito, N. (1973) *Experimental studies on tumors on the urinary system of rats induced by chemical carcinogens*. **Acta. Pathol.** (Jap.) 23:87-109.

Kang, H.D. et al. (1980) *Occupational lead exposure and cancer: Letter to the Editor*. **Science** 207:935.

Kopp, L. et al. (1980a) *Altered metabolism and function of rat heart following chronic low level cadmium/lead feeding*. **J. Mol. Cell. Cardiol.** 12:1407-1425.

Kopp, L. et al. (1980b) *Cardiac physiological-metabolic changes after chronic low-level heavy metal feeding*. **Am. J. Physiol.** 239:H22-H30.

Nortier, J.W., Sangster, B. and Van Kestern, R.G. (1980) *Acute lead poisoning with hemolysis and liver toxicity after ingestion of red lead*. **Vet. Hum. Toxicol.** 22:145-147.

Nozaki, K. (1966) *Method for studies on inhaled particles in human respiratory system and retention of lead fume*. **Ind. Health** (Jap.) 4:118-128.

Randall, K. et al. (1975) *The effect of particle size on absorption of inhaled lead*. **J. Am. Ind. Hyg. Assoc.** 36:207-213.

Rom, W.N. (1976) *Effects of lead on female reproduction: A review*. **Mt. Sinai J. Med.** 43:542-552.

Schroeder, P. et al. (1970) *Zirconium, niobium, tin, vanadium, and lead in rats: Lifeterm studies*. **J. Nutr.** 100:59-68.

U.S. Environmental Protection Agency (U.S. EPA) (1980) Ambient water quality criteria document for lead. Office of Regulations and Standards.

U.S. Environmental Protection Agency (U.S. EPA) (1984) Drinking water criteria document on lead (Quantification of toxicological effects section) Office of Drinking Water.

Zawirska, B. and Medras, K. (1972) *The role of the kidneys in disorders of porphyrin metabolism during carcinogenesis induced with lead acetate*. Arch. Immunol. Ther. Exp. 20:257-272.

NICKEL

GENERAL BACKGROUND INFORMATION

Nickel in the ambient atmosphere typically exists as a constituent of suspended particulate matter (U.S. EPA, 1985). The greatest volume of nickel emitted into the atmosphere is the result of fossil fuel combustion. Other sources of nickel emissions are primary production, incinerators, metallurgy, chemical manufacturing, cement manufacturing, coke ovens, nickel recovery, asbestos mining/milling and cooling towers.

PHARMACOKINETICS

Studies of nickel absorption have shown that it is absorbed by all routes of exposure to varying degrees, primarily dependent on the chemical form (see section on Relative Absorption Factors). Absorbed nickel is bound to serum components and distributed to body organs, reaching highest concentrations in kidney and lung tissue (Whanger, 1973). Nickel is not known to be biotransformed. Excretion of absorbed nickel is primarily through urine, with minor excretory routes through hair and sweat (ATSDR, 1988).

HUMAN TOXICOLOGICAL PROFILE

Nickel carbonyl $Ni(CO)_4$ is a particularly toxic form of nickel upon inhalation and causes chest pain, dry coughing, hyperpnea, cyanosis, occasional gastrointestinal symptoms, sweating, visual disturbances and severe weakness. This is often followed by pulmonary hemorrhage, edema and cellular derangement. Survivors may be left with pulmonary fibrosis. In the workplace, nickel dermatitis may result at high nickel concentrations. At lower concentrations some susceptible individuals develop eczema-like lesions. The threshold for these health effects is much greater than exposures which occur in the ambient environment. The major adverse effects of nickel in man are dermatitis, chemical pneumonitis, and lung and nasal cancers.

MAMMALIAN TOXICOLOGICAL PROFILE

Deaths occurred in rats and mice at concentrations greater than 3.3 and 1.7 mg/m^3 nickel, respectively, upon extended inhalation exposure to $NiSO_4$ (Dunnick et al., 1987). Mice exposed to Ni_3S_2 died due to necrotizing pneumonia at 7.3 mg/m^3 nickel (Benson et al., 1987). Prolonged exposure of hamsters to nickel oxide at 41.7 mg/m^3 resulted in decreased survival due to emphysema (Wehner et al., 1975). Oral LD_{50}s in rats vary depending upon the nickel-containing compound to which the rats were exposed. These range from 355 mg compound/kg (118 mg Ni/kg) for nickel acetate (Haro, 1968) to greater than 5000 mg

compound/kg for nickel oxide, nickel sulfide, and nickel subsulfide (Mastromatteo, 1986). Rats fed diets containing nickel sulfate hexahydrate at 0, 250, 500 and 1000 ppm nickel showed no adverse effects over three generations in fertility, gestation, viability or lactation.

GENOTOXICITY

Weak evidence exists for the mutagenicity of nickel in bacterial and mammalian cells. Nickel appears to induce chromosomal aberrations in cultured mammalian cells (Larramendy et al., 1981), but not in vivo (Waksvik and Boysen, 1982). Occupational studies of human exposure indicate that certain nickel compounds appear to be carcinogenic via inhalation. However, there is no evidence of carcinogenicity in mammals through ingestion or dermal exposure (U.S. EPA, 1985). Nickel subsulfide has been found to be carcinogenic via the inhalation route in rats (Ottolenghi et al., 1974). Studies on nickel exposure via the oral route are inadequate to reach conclusions on carcinogenicity (ATSDR, 1988).

REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR) (1988) Toxicological profile for nickel. U.S. Public Health Service.

Ambrose, A.M., Larson, P.S., Borzelleca, J.R. and Henningan, G.R. (1976) *Long-term toxicologic assessment of nickel in rats and dogs*. **J. Food Sci. Technol.** 13:181-187.

Benson, J.M., Burt, D.G. and Carpenter, R.L. (1987) *Comparative inhalation toxicity of nickel sulfate to F344/N rats and B6C3F1 mice exposed for twelve days*. **Fund. Appl. Toxicol.** 10:164-178.

Dunnick, J.K., Hobbs, C.H. and Benson, J.M. (1987) *Comparative toxicity of nickel oxide, nickel sulfate, and nickel subsulfide in the F344/N rat and B6C3F1 mouse*. **Toxicology** 7:789.

Haro, R.T., Furst, A. and Falk, H. (1968) *Studies on the acute toxicity of nickelocene*. **Proc. West Pharmacol. Soc.** 11:39-42.

Larramendy, M.L., Popescu, N.C. and DiPaolo, J.A. (1981) *Induction by inorganic metal salts of sister chromatid exchanges and chromosome aberrations in human and Syrian hamster cell strands*. **Environ. Mutagen.** 3:597-606.

Mastromatteo, D. (1986) *Lant Memorial Lecture: Nickel*. **Am. Ind. Hyg. Assoc. J.** 47:589-601.

Ottolenghi, A.D., Haseman, J.K., Payne, W.W., Falk, H.L. and MacFarland, H.N. (1974) *Inhalation studies of nickel sulfide in pulmonary carcinogenesis of rats*. **J. Natl. Cancer Inst.** 54:1165-1172.

U.S. Environmental Protection Agency (U.S. EPA) (1985) Health effect assessment document for nickel. Office of Research and Development. Office of Emergency and Remedial Response.

Waksvik, H. and Boysen, V. (1982) *Cytogenic analysis of lymphocytes from workers in a nickel refinery*. **Mutat. Res.** 103:185-190.

Wehner, A.P., Busch, R.H., Olson, R.J. and Craig, D.K. (1975) *Chronic inhalation of nickel oxide and cigarette smoke by hamsters*. **Am. Ind. Hyg. Assoc. J.** 36:801-809.

Whanger, P.D. (1973) *Effects of dietary nickel on enzyme activities and mineral content in rats*. **Toxicol. Appl. Pharmacol.** 25:323-331.

THALLIUM

GENERAL BACKGROUND INFORMATION

Pure thallium is a soft bluish-white metal that is widely distributed in trace amount in the earth's crust. It is used in the manufacture of electronic devices, switches, and closures. It is also used to a limited extent in the manufacture of special glasses and for medical procedures that evaluate heart disease. Up until 1972, thallium was also used as a rat poison (ATSDR, 1991).

PHARMACOKINETICS

Thallium appears to be nearly completely absorbed from the gastrointestinal tract. No information was located on absorption following inhalation or dermal exposure. However, animal studies following intratracheal administration suggested that uptake through respiratory epithelium was rapid and complete. There is little information on the distribution of thallium in humans. Analysis of human tissues indicates that thallium is distributed throughout the body. The highest levels were found in the scalp hair, kidney, heart, bone, and spleen. In animals, the highest levels are found in the kidneys and liver. Excretion of thallium occurs by both the urinary and fecal routes (ATSDR, 1991).

HUMAN TOXICOLOGICAL PROFILE

Thallium is acutely lethal to humans following oral exposure at doses of 54-110 mg thallium/kg of body weight as thallium sulfate (Davis et al., 1981). The estimated lethal dose is approximately 14-15 mg/kg (Gosselin et al., 1984). Thallium compounds can affect the respiratory, cardiovascular, and gastrointestinal systems, the liver, kidneys and the male reproductive system. Alopecia (hair loss) and changes in the nervous system are characteristic of thallium exposure. A retrospective study was conducted which compared the incidence of congenital abnormalities in children born to mothers who had been exposed to thallium during pregnancy (Dolgner et al., 1983). The number of anomalies in the exposed group did not exceed the number of expected birth defects in the general population.

MAMMALIAN TOXICOLOGICAL PROFILE

In animals, the lowest doses showing lethality for a brief exposure period ranged from 5 to 30 mg/kg body weight for several species (Downs et al., 1960). Exposure to low doses (1.4 mg thallium as thallium sulfate/kg body weight/day) for longer durations (40-240 days) also cause death (Manzo et al., 1983). Electromyographic abnormalities without changes in

the myocardium are seem following a single oral dose (56 mg thallium/kg as thallium sulfate) in rabbits (Grunfeld et al., 1963). Parenteral injection in animals has been observed to cause liver effects. Thallium did not cause renal effects in rats following oral exposure, but parenteral exposure studies demonstrated that thallium affects the kidneys following subcutaneous administration. Rats exposed prenatally to 0.08 mg thallium/kg/day or greater during gestation evidenced impairment of learning. These effects occurred at dose levels below those at which other neurological effects (e.g structural and functional alterations of peripheral nerves) have been observed. Cultured rat embryos exposed to thallium at concentrations of 10, 30, or 100 ug/ml showed dose-related growth retardation at all levels showing embyrotoxic effects (Anschutz et al., 1981). Administration by intraperitoneal injection to pregnant rats at a dose of 2.0 mg thallium/kg/day (as thallium sulfate) during gestation days 8-10 resulted in reduced fetal body weights, hydronephrosis, and the absence of vertebral bodies (Gibson and Becker, 1970).

GENOTOXICITY

Animal and bacterial assays suggest than thallium is genotoxic. Thallium-induced dominant lethal mutations in male rats in vivo. The overall embryonic mortality increased at doses of 0.04 ug thallium/kg day or greater as thallium carbonate. In vitro DNA damage tests employing rat embryo cells were positive (Zasukhina et al., 1983). Thallium enhanced viral-induced transformations in Syrian hamster embryo cells (Casto et al., 1979) and was positive in bacterial assays (Kanematsu et al., 1980). No studies are available on the carcinogenic effects of inhalation, oral or dermal exposure to thallium.

REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR) (1991) Toxicological profile for thallium. U.S. Public Health Service.

Anschutz, M., Herken, R. and Neubert, D. (1981) *Studies on embryotoxic effects of thallium using the whole embryo culture technique*. In: Neubert D., Merker H.J., eds. Culture Techniques: Applicability for Studies on Prenatal Differentiation and Toxicity: 5th Symposium on Prenatal Development, Berlin, W. Germany. pp. 57-66.

Casto, B.C., Meyers, J. and DiPaolo, J.A. (1979) *Enhancement of viral transformation for evaluation of the carcinogenic or mutagenic potential of inorganic metal salts*. **Cancer Res.** 39:193-198.

Davis, L.E., Standefer, J.C., and Kornfeld, M. (1981) *Acute thallium poisoning: Toxicological and morphological studies of the nervous system*. **Ann. Neurol.** 10:38-44.

Dolgner R., Brockhaus, A. and Ewers, U. (1983) *Repeated surveillance of exposure to thallium in a population living in the vicinity of a cement plant emitting dust containing thallium*. **Int. Arch. Occup. Environ. Health** 52:79-94.

Downs, W.L., Scott, J.K. and Steadman, L.T. (1960) *Acute and sub-acute toxicity studies of thallium compounds*. **Am. Ind. Hyg. Assoc. J.** 21:399-406.

Gibson, J.E. and Becker, B.A. (1970) *Placental transfer, embryotoxicity and teratogenicity of thallium sulfate in normal and potassium-deficient rats*. **Toxicol. Appl. Pharmacol.** 16:120-132.

Gosselin, R.E., Smith, R.P. and Hodge, H.C. (1984) Clinical Toxicology of Commercial Products. 5th ed. Baltimore, MD; Williams and Wilkins, II-139, III-379-383.

Grunfeld, O., Battilana, G. and Aldana, L. (1963) *Electrocardiographic changes in experimental thallium poisoning*. **Am. J. Vet. Res.** 24:1291-1296.

Kanematsu, N., Hara, M. and Dada, T. (1980) *Rec assay and mutagenicity studies on metal compounds*. **Mutat. Res.** 77:109-116.

Manzo, L., Scelsi, R. and Moglia, A. (1983) *Long-term toxicity of thallium in the rat*. In: Chemical Toxicology and Clinical Chemistry of Metals. London, England. Academic Press, pp. 401-405.

Zasukhina, G.D., Vasilyeva, I.M. and Sdirkova, N.I. (1983) *Mutagenic effect of thallium and mercury salts on rodent cells with different repair activities*. **Mutat. Res.** 124:163-173.