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Final Report

REMEDIAL INVESTIGATION TECHNICAL REPORT

(VOLUME I)

NAVAL EDUCATION AND TRAINING CENTER
NEWPORT, RHODE ISLAND

Contract No. N62472-86-C-1282
January 1992

Prepared for:

Northern Division
Naval Facilities Engineering Command
Lester, Pennsylvania

TRC
TRC Environmental Corporation

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EXECUTIVE SUMMARY

A Remedial Investigation (RI) was conducted at the U.S. Navy Naval Education and Training Center (NETC) located in Newport, Rhode Island by TRC Environmental Consultants, Inc. (TRC). The RI was conducted by TRC under contract with the United States Navy, as part of the Department of Defense Installation Restoration (IR) Program, which is similar to the U.S. EPA's Superfund program. The NETC facility is included on the U.S. EPA National Priorities List (NPL).

This document presents the results of Phase I field activities conducted at five sites within the NETC facility, as well as the results of Human Health Evaluations conducted for the sites. The sites which were studied include the following:

- *Site 01 - McAllister Point Landfill;*
- *Site 02 - Melville North Landfill;*
- *Site 09 - Old Fire Fighting Training Area;*
- *Site 12 - Tank Farm Four; and*
- *Site 13 - Tank Farm Five.*

This Executive Summary presents general site information and an overview of the remedial investigation activities followed by a site-by-site description of the study and its results.

INTRODUCTION

PURPOSE

The RI was conducted subsequent to the completion of previous environmental investigations at the NETC. These previous investigations, and the reports generated as a result of the investigations, include the following:

- Initial Assessment Study (IAS), Envirodyne Engineers, 1983
- Confirmation Study (CS), Loureiro Engineering Associates, 1985

These initial investigations identified the five previously listed sites as areas of potential concern requiring additional study.

While specific investigation objectives were developed for each site, the general purposes of the overall investigation were to:

- Determine the presence, nature and extent of contamination resulting from historic site activities, including on-site and off-site impacts to soils, ground water, surface water, sediment and biota;
- Identify potential contaminant migration routes;
- Identify potential receptors of site contaminants; and
- Characterize related environmental impacts and potential human health risks.

This volume of the report, Volume I, describes the sites' histories, physical characteristics of the sites, the activities conducted during the Remedial Investigation, and the nature and extent of contamination at and around each site. Contaminant fate and transport and human health impacts are also summarized. The evaluation of contaminant fate and transport mechanisms, and human health assessments are presented in detail for each of the five sites in Volume II of the report.

GENERAL FACILITY DESCRIPTION AND HISTORY

The NETC site is approximately 1,063 acres in size, with portions of the facility located in Newport, Middletown, and Portsmouth, Rhode Island. The site is approximately 60 miles south of Boston and 25 miles southeast of Providence. The facility layout is long and narrow, following the shoreline of Aquidneck Island for nearly 6 miles bordering Narragansett Bay. A site location map is provided on Figure ES-1.

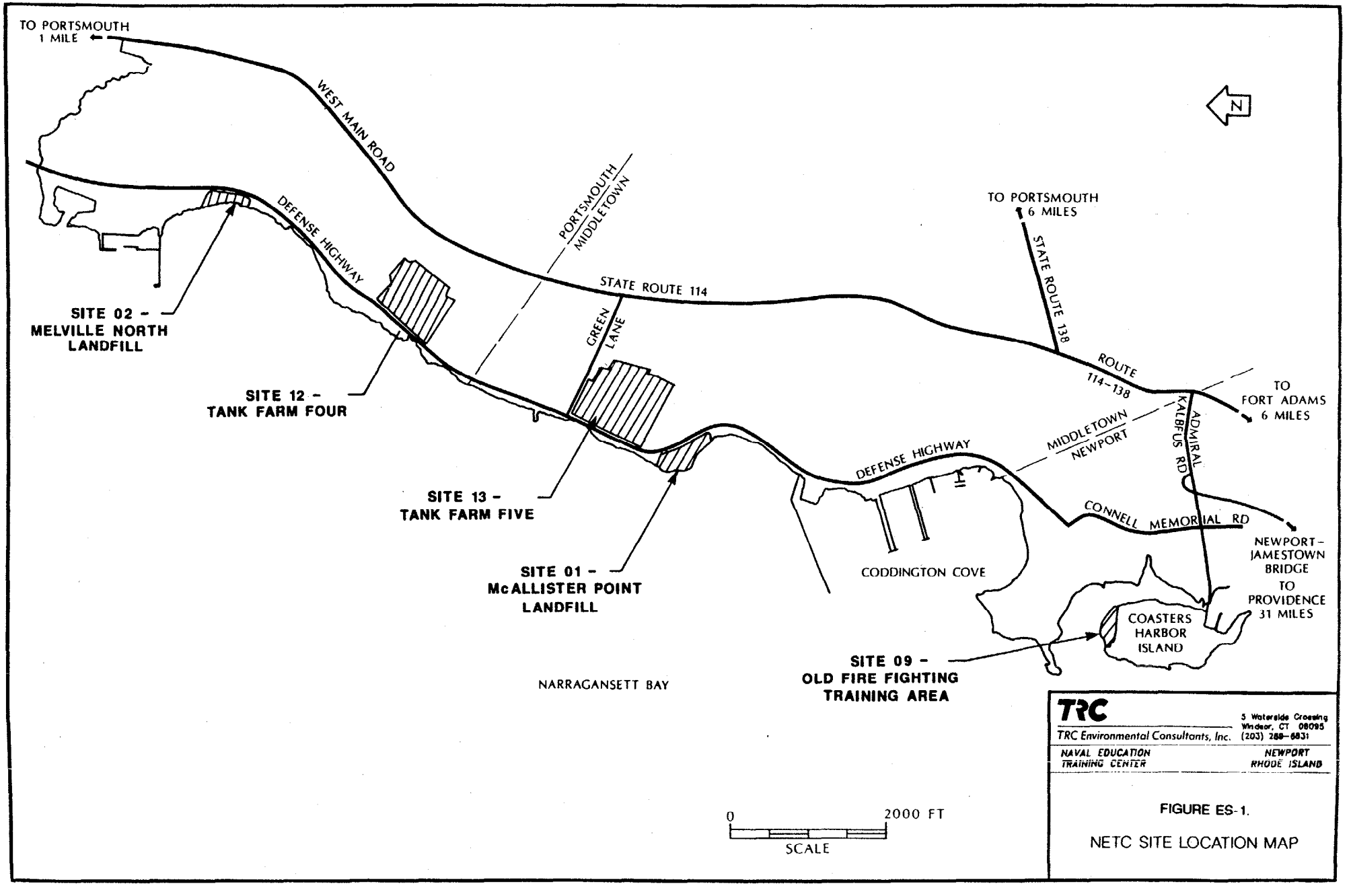


FIGURE ES-1.

NETC SITE LOCATION MAP

The NETC facility area has been used by the US Navy since the era of the Civil War. Military activities at the base significantly increased during times of war. During World Wars I and II, servicemen were housed on the base. In subsequent peacetime years, on-site facilities were slowly disestablished, until the headquarters of the Commander Cruiser-Destroyer Force Atlantic was located there in 1962. In April 1973, the Shore Establishment Realignment Program (SER) reorganized Naval forces and resulted in the disestablishment of several on-site facilities and associated reductions in Navy personnel. Subsequent to this "downsizing", the Navy excessed a significant portion of its original acreage. Other portions of the facility are currently leased by the Navy to the State of Rhode Island and Economic Development Corporation. Some of these areas are subleased to private enterprises.

Previous investigations at the NETC facility include the performance of an Initial Assessment Study (IAS) by Envirodyne Engineers, Inc. (EEI) in 1982 and 1983, and a Confirmation Study (CS), consisting of a Verification Step and Characterization Step, by Loureiro Engineering Associates (Loureiro) over the period from 1983 to 1986. The IAS, which consisted of a background investigation and site visits, was conducted at all five sites addressed within this RI. The CS, which involved environmental sample collection and analysis, was conducted for the McAllister Point and Melville North landfills and for Tank Farm Four. In addition to these comprehensive studies, a Tank Closure Plan has been prepared for Tanks 53 and 56 at Tank Farm Five. Environmental samples were collected at this site as part of these closure activities.

Individual site descriptions and histories, including results of previous environmental investigations, are presented for each of the five areas of concern in the individual site summaries which follow.

INVESTIGATION AREAS

The RI program, in addition to characterizing the site as a whole, was structured to investigate target areas of the site based on historic site use information. These areas are described in the individual site summaries which follow.

FIELD INVESTIGATION SCOPE

Key elements of the field investigation program are listed in Table ES-1. The primary goal of the field investigation program was to obtain data to:

TABLE ES-1
FIELD INVESTIGATION PROGRAM SUMMARY
NETC SITE

Ambient Air and Radiological Surveys *- Site walkovers using organic vapor analyzers, photoionization detectors, and radiation meters*

Geophysical Surveys *- Electromagnetic surveys and magnetometer surveys were conducted at Sites 01, 02 and 09 only*

Soil Gas Surveys *- Conducted at Sites 09, 12 and 13 only*

Surface Soil Sampling *- Conducted at each site*

Test Pit Operations *- Conducted at Site 02 only*

Test Borings *- Conducted at Sites 01, 02 and 09 only*

Ground Water Monitoring Well Installation *- Conducted at each site*

Ground Water Sampling *- Conducted at each site*

Surface Water/Sediment Sampling *- Conducted at Sites 02, 12 and 13 only*

Sediment and Mussel Sampling *- Originally proposed for Sites 01, 02 and 09 but abandoned due to lack of approved analytical methods for such samples*

Underground Storage Tank Investigations *- Conducted at Sites 12 and 13 only*

Structure Investigations *- Conducted at Sites 12 and 13 only*

- *Characterize the hydrogeologic regime in the study area, including hydraulic properties of overburden deposits;*
- *Characterize the type(s) of contamination present in the study area;*
- *Determine areal and vertical extent of contamination in the media sampled;*
- *Identify pathways of contaminant migration; and*
- *Characterize the nature and extent of contaminant migration.*

Field investigation activities conducted at each of the five investigation sites are summarized in the individual site summaries which follow.

SITE GEOLOGY, HYDROGEOLOGY, AND HYDROLOGY

The NETC site is located at the southeastern end of the Narragansett Basin. The rocks of the Narragansett Basin are non-marine sedimentary rocks of Pennsylvanian age. The bedrock at the NETC facility is almost entirely of the Rhode Island Formation. Within the Rhode Island Formation, there are a few areas of thick conglomerates. They consist of pebbles, cobbles, and boulders interbedded with sandstone and graywacke. Coasters Harbor Island is mostly covered with this conglomerate material. Overlying the Pennsylvanian rocks of the Narragansett Basin are surficial deposits of Pleistocene sediments. These unconsolidated, glacial sediments range in thickness from 1 to 150 feet and consist of till, sand, gravel and silt.

Many areas on Aquidneck Island, on which the NETC is located, obtain potable water supply from wells. Ground water is obtained from the unconsolidated glacial till deposits and from the underlying Pennsylvanian bedrock. The average depth to ground water is 14 feet. In the NETC area, glacial till deposits are typically less than 20 feet in thickness. Well yields in these materials range from 1 to 120 gallons per minute. Bedrock well yields range from less than 1 to as much as 55 gallons per minute and are highly dependent on the presence of joints and fractures. Most ground water is soft or moderately hard. In scattered locations, pumping has led to salt water intrusion. No wells were identified within the boundaries of NETC other than on Gould Island.

The NETC facility is located within the Narragansett Bay drainage basin. All surface water drainage from the basin is into Narragansett Bay. Throughout the majority of the facility surface drainage is toward Narragansett Bay, with drainage provided by several brooks and streams.

Individual geologic, hydrogeologic, and hydrologic descriptions for each of the sites are in the individual site summaries which follow.

FIELD INVESTIGATION SUMMARY

In conducting a preliminary evaluation of detected contaminant levels, they were compared to available regulatory action levels, background levels or contaminant-comparison levels. These levels are summarized below for each media sampled:

- *Soils and Sediments:*
  - *Volatile Organics (VOCs) - 1 ppm total*
  - *Base Neutral/Acid Extractables (BNAs) - 10 ppm total*
    - *Polynuclear Aromatic Hydrocarbons (PAHs) - 10 ppm total*
    - *Carcinogenic PAHs (caPAHs) - 1 ppm total*
  - *Pesticides - site by site basis*
  - *PCBs - 1 ppm (RIDEM action level)*
  - *Inorganics - background levels, as defined by off-site surface sample inorganics levels*

- *Ground Water:*
  - *Federal and State Maximum Contaminant Levels (MCLs), including final, proposed and tentative levels*

- *Surface Water:*
  - *Federal and State Surface Water Quality Criteria*

These levels are referenced in the subsequent site-specific field investigation summaries.

For each environmental media or potential contaminant source (e.g., oil/water separators) sampled, a discussion of the contaminant types detected, the environmental distribution of contaminants, and a comparison of detected levels to regulatory action levels is presented in the subsequent site-specific sections.

CONTAMINANT FATE AND TRANSPORT (VOLUME II)

Potential routes of migration, contaminant persistence and distribution, and observed contaminant migration were considered in evaluating the fate and transport of the identified site contaminants.

Contaminant fate and transport mechanisms were considered for each of the NETC sites evaluated. Potential migration pathways common to all five sites included the following:

- *Migration of surface soil contaminants directly via surface runoff, windblown dust, or tracking (tires, shoes, etc.);*

- *Migration of surface soil contaminants indirectly via precipitation, leaching and subsequent ground water migration, via volatilization to ambient air, or via uptake by plants or animals and subsequent human consumption;*

- *Migration of subsurface soil contaminants via precipitation, leaching and subsequent ground water migration; and*

- *Migration of ground water contaminants via ground water flow.*

Ground water is not used as a drinking water source on or downgradient of any of the sites evaluated. The presence of the various contaminant types is evaluated with respect to the existing migration pathways to provide an understanding of contaminant persistence and potential migration in the following site-specific sections.

HUMAN HEALTH EVALUATION (VOLUME II)

A baseline human health assessment was conducted to quantitatively and qualitatively assess the potential impacts of the NETC sites on human health. Both current and future land use scenarios were considered. These scenarios generally included a trespassing/current use scenario, a construction/future use scenario, an industrial/future use scenario, and a residential/future use scenario, with additional scenarios considered as applicable for a given site. The routes of exposure of most concern generally included ingestion of soil and ingestion of ground water. Inhalation of vapor phase VOCs also contributed to the risk estimates for the residential use scenarios. The chemicals of primary concern in the soil, upon which the risk estimates were based, included base neutral/acid extractable organics (PAH compounds), and inorganics (arsenic and antimony). The chemicals of primary concern in the ground water included volatile organics (chlorinated hydrocarbons), carcinogenic base neutral/acid extractable organics (PAH compounds), and inorganics (arsenic, beryllium, manganese, and others).

The primary cancer and non-cancer risks for the sites as a whole were associated with the future use of the sites as residential areas and future commercial/industrial uses of the sites, due mainly to the evaluation of ground water ingestion under these scenarios. The only current use scenario modeled for which target risk levels were exceeded was the child care scenario evaluated for the Old Fire Fighting Training Area. Only the estimated maximum cancer risk value (1.3E-04) for this scenario exceeded the target range (1E-06 to 1E-04). However, some of the data used in this estimate was qualified data, and therefore has some uncertainty associated with its use.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the Remedial Investigation, conclusions regarding the nature and extent of contamination and recommendations for future site studies can be made. These are presented individually by site in the following sections.

SITE 01 - MCALLISTER POINT LANDFILL

Site Description

The McAllister Point Landfill is located in the central portion of the NETC facility. The site is approximately 6 acres in size and is located between Defense Highway and Narragansett Bay. The site is characterized by a mounded area in the central to north-central portion of the site, with flat areas at the northern and southern ends. Along the western edge of the site, the elevation drops significantly to the shoreline. The site is covered with grass, weeds and small trees, with more mature wooded areas near the northern site border. A site map is provided on Figure ES-2.

Site History

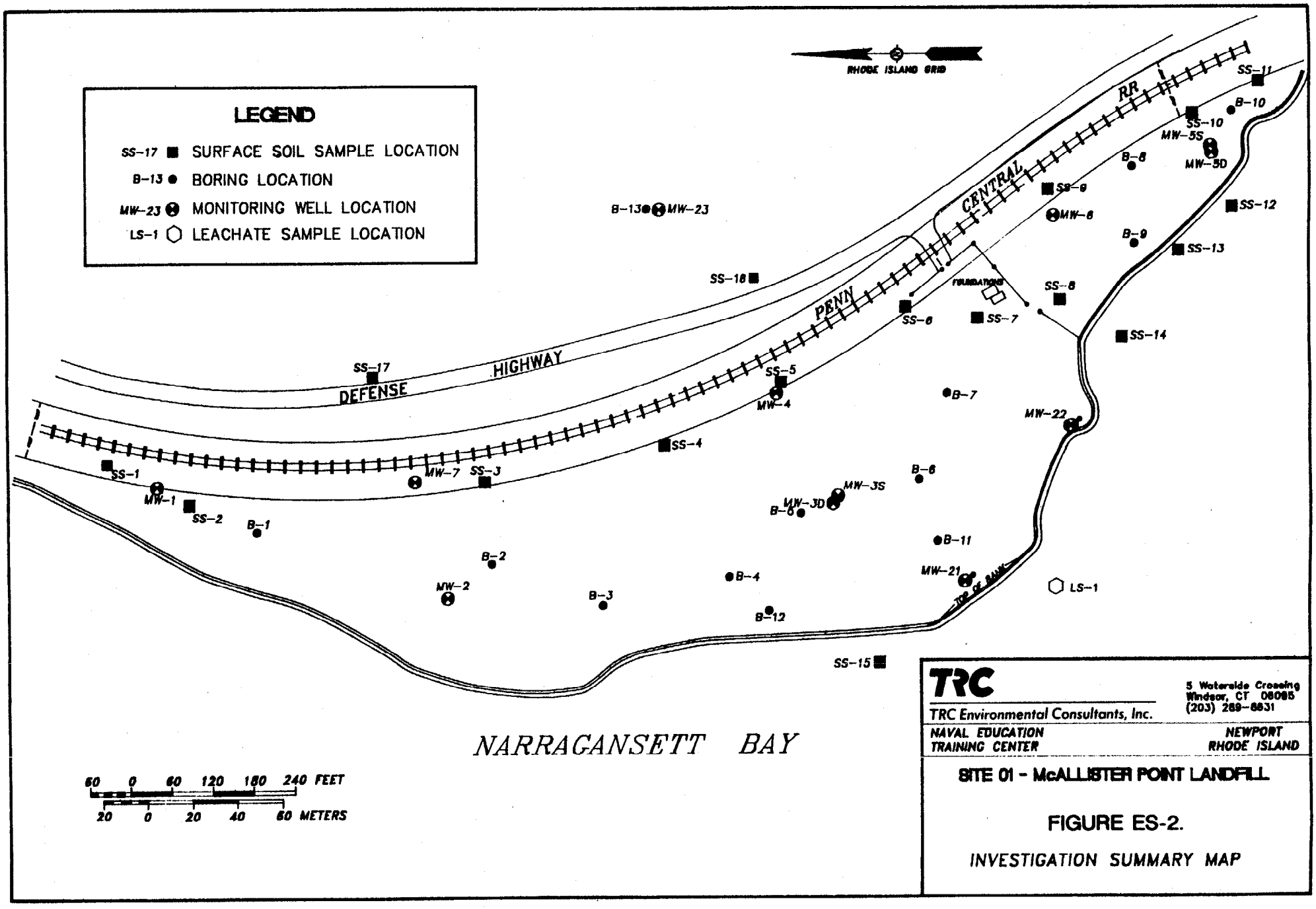
The McAllister Point Landfill was operated as a landfill over a twenty year period, from 1955 until the mid-1970's. Reportedly barrels containing liquid wastes, including paints and oils, and at least two transformers containing PCBs were disposed of at the site, along with general domestic refuse. A waste incinerator operated at the site from 1965 until the early 1970's, with ash residue disposed of on-site. The landfill was reportedly extended into Narragansett Bay, with wastes used as fill material. Following landfill closure, a three-foot thick soil cap was placed over the site.

Previous Environmental Investigations

The CS conducted at this site involved the collection and analysis of sediment, mussel, landfill leachate, surface soil and ground water samples. The surface soil samples indicated that low levels of contamination may be associated with the landfill cap material. The leachate spring samples exhibited metals, cyanide, phenol and some organic constituents. The sediment and mussel samples indicated the presence of inorganic contaminants in samples collected adjacent to the site, especially near the southern end of the landfill, with levels decreasing with distance from the site. However, PCB contamination detected in mussels samples appeared to be attributable to area-wide contamination, on the basis of background samples. Ground water samples exhibited elevated levels of metals. Screen placement in existing monitoring wells may limit detection of floating or sinking contaminants.

Field Investigation Areas and Scope

Areas of potential concern investigated at this site include the historic landfill areas, and areas of incinerator operation. Historic aerial photos also indicate that materials, potentially including aboveground storage tanks, were stored on the surface of


LEGEND
SS-17 SURFACE SOIL SAMPLE LOCATION
B-13 BORING LOCATION
MW-23 MONITORING WELL LOCATION
LS-1 LEACHATE SAMPLE LOCATION
RHODE ISLAND GRID
DEFENSE HIGHWAY
PENN CENTRAL RR
FOUNDATIONS
TOP OF BANK
NARRAGANSETT BAY
SS-1
SS-2
SS-3
SS-4
SS-5
SS-6
SS-7
SS-8
SS-9
SS-10
SS-11
SS-12
SS-13
SS-14
SS-15
SS-17
SS-18
MW-1
MW-2
MW-3D
MW-3S
MW-4
MW-5D
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SITE 01 - McALLISTER POINT LANDFILL
FIGURE ES-2.
INVESTIGATION SUMMARY MAP

the site. A summary of the field investigation program conducted at this site is provided in Table ES-2. Sample locations are shown on Figure ES-2.

Geology, Hydrogeology, and Hydrology

The overburden on this site consists of fill and glacial till deposits. The thickness of the fill material ranges from 3 feet at the edges to 24 feet in the central portion of the landfill area The fill materials consist of a wide variety of municipal and industrial wastes as well as ash materials. The fill material appears to have been placed directly on the bedrock surface over much of the site. Glacial till deposits were noted below the fill material in a few locations. A discontinuous clay-silt "cap" layer overlays many areas of the fill. Tests performed on an undisturbed till sample determined the till has an average permeability of 2.69 x 10^{-7} cm/sec. The bedrock consists of a gray-green to black, highly weathered to competent, carboniferous shale. Cores of the shale exhibited a high degree of fracturing. Depth to bedrock ranges from 4 to 24 feet.

Ground water flow direction at McAllister Point Landfill is from east to west, towards Narragansett Bay. Hydraulic conductivities determined from slug tests performed on weathered bedrock materials range from 0.07 to 0.20 ft/day. Negative vertical hydraulic gradients were measured in the two sets of nested monitoring wells on-site. Horizontal hydraulic gradients in the overburden ranged from 0.0056 to 0.038 ft/ft while deep values ranged from 0.0077 to 0.0049 ft/ft. Estimated average linear velocities for shallow ground water range from 0.0061 to 0.0417 ft/day, while for deep ground water they range from 0.0091 to 0.0057 ft/day. Tidal influences on ground water were measured during continuous water level measurements (over a three-day period) at most on-site wells. The greatest fluctuation (greater than 2 feet) was measured in a bedrock well.

Site topography generally slopes in an east-to-west direction. During periods of heavy rain, ponded water forms in a small depression in the north-central portion of the site. The western edge of the site bordering Narragansett Bay is characterized by a steep slope to the shoreline. Springs have been observed discharging from the bottom of the landfill bank into the bay.

Field Investigation Summary

Soil Assessment *- VOCs, BNAs, pesticides, PCBs and inorganics were all detected in on-site soils. The major areas of the site where contaminants were detected in the soil at elevated levels include the following:*

TABLE ES-2
FIELD INVESTIGATION PROGRAM SUMMARY
Site 01 - McAllister Point Landfill

Ambient Air and Radiological Surveys *- Site walkover using organic vapor analyzer, photoionization detector, and radiation meter*

Geophysical Survey *- Electromagnetic survey and magnetometer survey*

Surface Soil Sampling *- 15 on-site samples; 2 off-site background samples*

Test Borings *- 12 on-site test borings; 1 off-site test boring; 2 to 3 soil samples per test boring in fill area; 1 near-surface soil sample from the off-site test boring*

Ground Water Monitoring Well Installation *- 7 well borings from which 2 to 3 soil samples were collected for analysis; 4 shallow wells and 3 deep wells installed initially; 2 shallow wells installed at a later date*

Ground Water Sampling *- April 1990: 7 newly-installed wells and 3 pre-existing wells sampled; July 1990: 2 additional newly-installed wells sampled; 1 leachate spring sample collected in August 1990 from the shoreline of the landfill*

- *Northern area - CaPAHs;*
- *North-central area - BNAs, CaPAHs, and inorganics;*
- *Central landfill area - VOCs, BNAs, PCBs and inorganics;*
- *South of access road - BNAs, CaPAHs, and inorganics; and*
- *Shoreline - BNAs, CaPAHs, and inorganics.*

*Significant **VOC** contamination (i.e., greater than 1 ppm total VOCs) was detected in soils and fill in the central portion of the landfill area but VOC levels were not consistently high throughout the depth of the soil horizons sampled. **BNAs** were detected at elevated levels (i.e., greater than 10 ppm total BNAs) throughout the site, with the highest levels (i.e., greater than 100 ppm total BNAs) detected at spot locations in the central and southern portions of the site. Elevated levels of total carcinogenic PAHs (i.e., greater than 1 ppm) were also detected at locations where total BNA concentrations were less than 10 ppm. These locations were generally in the northern portion of the site, with smaller areas identified in the southern portion of the site and along the shoreline. **Pesticides** were detected at low levels (i.e., 10's of ppb) in surface soil samples across the site, while **PCBs** were detected in surface and subsurface soils. PCBs were detected in surface soils along the shoreline and in subsurface soils in the north-central and southern portions of the site. One soil boring sample exceeded the 1 ppm RIDEM PCB soil action level. **Inorganics** levels in the soils and fill were compared to off-site background surface soil levels. Inorganics were detected in soil and fill samples collected from across the site at levels exceeding background levels. The highest inorganic levels were detected in soils from the central and south-central portions of the landfill, in the northern portion of the site (ash materials), in the southern portion of the site, and along the shoreline.*

Ground Water Assessment *- VOCs, BNAs, PCBs and inorganics were all detected in ground water samples. The major areas of the site where contaminants were detected at levels exceeding action levels include the following:*

- *Northern area - inorganics;*
- *North-central area - inorganics;*
- *Central landfill area - VOCs, and inorganics; and*
- *South of access road - VOCs, PCBs, and inorganics.*

***VOC** detections, consisting mostly of petroleum-related VOCs (e.g., xylene, benzene) were limited to wells located in the central and southern portions of the site. VOCs were also detected in soil boring samples collected at the depth of the water table from the north-central to southern portions of the site, indicating the potential for ground water contamination throughout this area. Oil was observed in one well (MW-5S) in the southern portion of the site five months after it was sampled. No **BNAs** were detected above ground water action levels and no **pesticides** were detected in*

ground water samples. A PCB concentration of 150 ppb was detected in the well in the southern portion of the site (MW-5S) in which oil was subsequently observed. The highest levels of inorganic analytes were detected in wells from the north-central to southern portions of the site.

Contaminant Fate and Transport (Volume II)

General contaminant fate and transport mechanisms were discussed in the introductory section. The ground water flow direction at this site is to the west, towards Narragansett Bay. The primary migration pathway for VOCs is likely to be via ground water flow. For BNAs, which are generally persistent in the environment, contamination appears to be greatest in the surface and subsurface soils, with migration to ground water not considered a primary migration route. Pesticides and PCBs were generally detected in soils and are not anticipated to migrate from that media (with the exception of the detection of PCB in one ground water sample). Inorganics were detected at elevated levels in surface and subsurface soils/fill and in ground water samples, indicating potential migration from the soils/fill to the ground water with a potential for movement off-site within the ground water.

Human Health Assessment (Volume II)

The exposure scenarios considered in the evaluation of the McAllister Point Landfill site included a trespassing/current use scenario, a recreational/future use scenario, a construction/future use scenario, an industrial/future use scenario, and a residential/future use scenario. The estimated risks, in terms of cancer risk (carcinogenic) and hazard risk (non-carcinogenic) estimates associated with each scenario evaluated and the exposure pathway(s) driving the calculated risks are summarized below:

- ***Trespassing Scenario (Scenario 1)*** *- Total cancer risk range and total hazard index ratio range are within target values.*

- ***Recreational Use Scenario (Scenario 2)*** *- The maximum cancer risk value slightly exceeded the acceptable risk range. The mean risk value and total hazard index ratio range are within target values.*

- ***Construction Scenario (Scenario 3)*** *- The total cancer risk range and the mean hazard index ratio are within target values. The maximum hazard index ratio exceeded the target value.*

- ***Commercial/Industrial Use Scenario (Scenario 4)*** *- The total cancer risk range and the hazard index ratio range exceed target values.*

- ***Residential Use Scenario (Scenario 5)*** *- The total cancer risk range and the hazard index ratio range exceed target values for both children and adult receptors.*

For Scenarios 1, 2, and 3, the major contributing factor to the calculation of cancer risk is ingestion of caPAHs in soil. The pathway of primary concern associated with Scenarios 4 and 5 with respect to cancer risk is ingestion of ground water containing inorganics (arsenic, beryllium) and caPAHs. The primary contributor to the total hazard index ratio for Scenarios 1, 2, and 3 is ingestion of inorganics in soil. Ingestion of inorganics (antimony, arsenic, cadmium, chromium, copper, manganese, mercury and zinc) in ground water drove the total hazard index ratio for Scenarios 4 and 5.

Conclusions and Recommendations

Based on the results of the Remedial Investigation, conclusions regarding the nature of site contamination and human health risks, and recommendations for future site studies can be made.

Elevated VOC levels, an oil product and PCBs have been identified in the ground water in the southern portion of the site, and elevated VOC levels have also been detected in the ground water in the central portion of the site. Soil contamination by BNAs, caPAHs and PCBs has also been identified. Action levels for PCBs in soils, and VOCs, PCBs and inorganics in ground water were exceeded in samples collected during the Remedial Investigation. While the site does not pose excessive human health risks in its current state, the potential for future risks to human health exists if the site use is changed. Additional studies are recommended to further define the extent of ground water contamination, the source and extent of the oil product detected in well MW-5 and the significance of inorganic and pesticide contaminant levels in soil and/or ground water at this site as compared to background levels. Biota sampling and analysis of archived samples for dioxins/furans will be incorporated into any future site evaluation. Upon further definition of site contamination, a Feasibility Study is recommended to evaluate potential remedial alternatives.

SITE 02 - MELVILLE NORTH LANDFILL

Site Description

The Melville North Landfill is located at the northern end of the NETC facility. The site is approximately 10 acres in size and is located between Defense Highway and Narragansett Bay. The site is generally flat across the central to northern portions, with a ridge running along the eastern side of the southern portion of the site. An oily soil/waste pile area is located at the northern end of the site. The grade along the western edge of the site is nearly level with the shoreline. Elevations increase in the easterly direction. The site is covered with grass, weeds and small trees, with more mature wooded areas in the southern portion of the site. A marshy area lies along the northern edge of the site. A site map is provided on Figure ES-3.

Site History

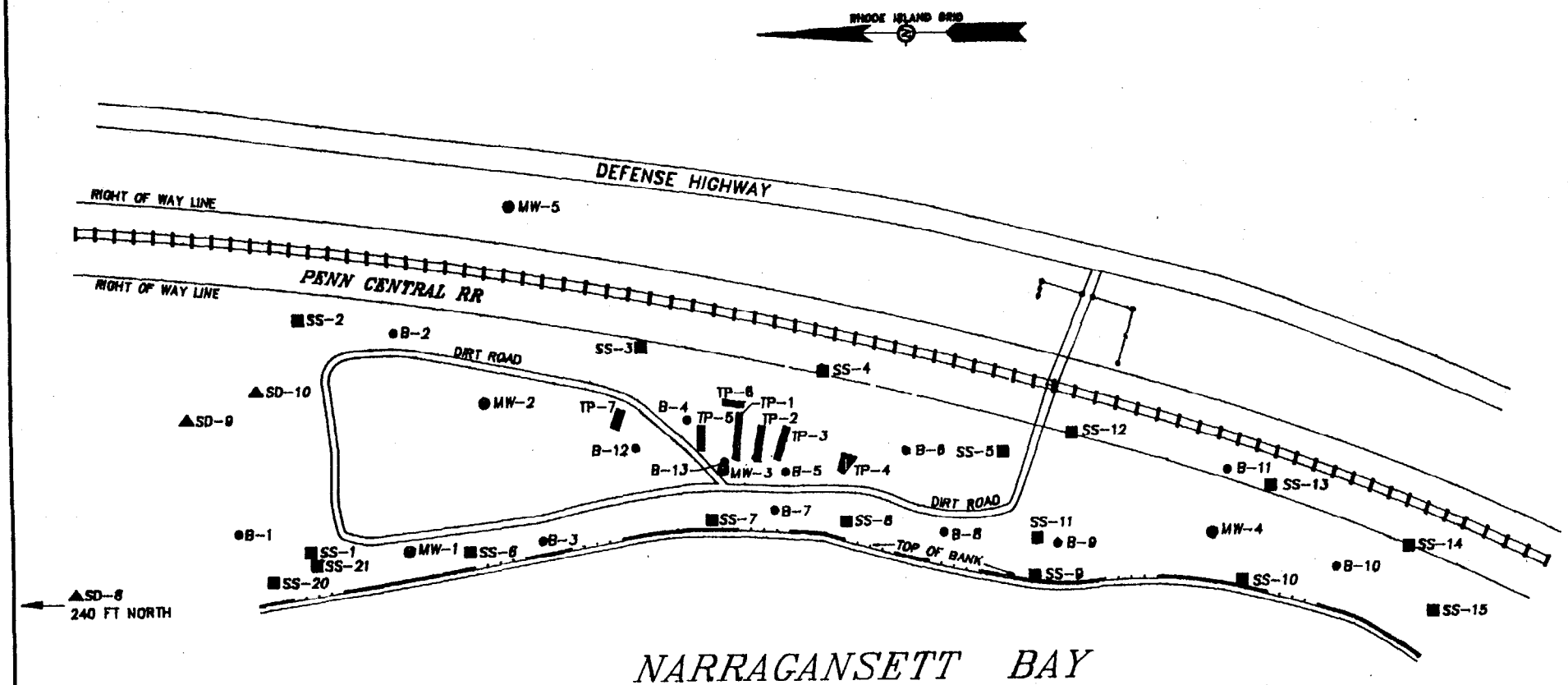
The Melville North Landfill was operated as a landfill following World War II until 1955. Reportedly wastes similar to those received at McAllister Point Landfill were disposed of at Melville North Landfill, including spent acids, paints, oils, and, potentially, PCBs. Oil-soaked soil appears to have been dumped on the surface in the northern portion of the site. The site was excessed by the Navy, and the planned future use of the site is as a marina.

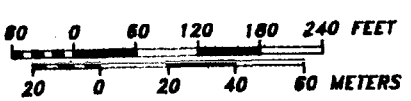
Previous Environmental Investigations

The CS at this site involved the collection of sediment and mussel samples and a composite soil sample from a mound of oil-saturated soils, and the excavation of test pits to determine the depth of oil-contaminated soils. The soil sample collected from the oily waste deposits contained over 3% petroleum hydrocarbons by weight, as well as an elevated level of lead. Based on the test pit activities, no lateral or downward migration of oil from the waste deposits is evident. Metals levels detected in sediment samples and PCB levels detected in mussel samples appeared to be similar to background levels and not attributable to site-specific contamination.

Field Investigation Areas and Scope

Areas of potential concern investigated at this site include the historic landfill areas, areas of surficial oily deposits and previous lagoon sites, as identified through historic aerial photo review. A summary of the field investigation program conducted at this site is provided in Table ES-3. Site sample locations are provided on Figure ES-3.





LEGEND

SS-6 ■	SURFACE SOIL SAMPLE LOCATION
B-7 ●	BORING LOCATION
MW-4 ●	MONITORING WELL LOCATION
SD-10 ▲	SEDIMENT SAMPLE LOCATION
TP-7 ▮	TEST PIT LOCATION

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SITE 02 - MELVILLE NORTH LANDFILL

FIGURE ES-3.

INVESTIGATION SUMMARY MAP

TABLE ES-3
FIELD INVESTIGATION PROGRAM SUMMARY
Site 02 - Melville North Landfill

Ambient Air and Radiological Surveys *- Site walkover using organic vapor analyzer, photoionization detector, and radiation meter*

Geophysical Survey *- Electromagnetic survey and magnetometer survey*

Surface Soil Sampling *- 15 on-site samples*

Test Pit Operations *- 7 test pits, with soil samples collected from 4 of the test pits*

Test Borings *- 13 test borings; 1 to 3 soil samples per test boring, depending on the presence of fill materials or visible contamination*

Ground Water Monitoring Well Installation *- 4 on-site well borings, 1 off-site well boring; 1 to 3 soil samples per well boring, depending on the presence of fill materials or visible contamination*

Ground Water Sampling *- July 1990: 4 on-site monitoring wells and 1 off-site monitoring well sampled*

Sediment Sampling *- 3 sediment samples collected from the marshy area north of the site*

Geology, Hydrogeology, and Hydrology

The overburden on this site consists of fill and glacial till deposits. The thickness of the fill material ranges from 2 feet at the edges to 10 feet in the central portion of the landfill area. The fill materials consist primarily of loose, black, medium to coarse sand and gravel with some shale fragments. Ash, wood and metal debris were also encountered, along with oily fill in the central portion of the site. Glacial till deposits were noted below the fill material throughout the site. The till consisted primarily of silt, with up to 50% fine to coarse sand in places. None of the borings penetrated bedrock, although fragments of weathered shale, which closely resembled the bedrock encountered at the McAllister Point Landfill site, were encountered at the base of many borings, possibly indicating a close proximity to the overburden/bedrock boundary.

Ground water flow direction at Melville North Landfill is from east to west, towards Narragansett Bay. Hydraulic conductivities determined from slug tests performed on till overburden and fill materials range from 0.22 to 0.45 ft/day, with the fill twice as conductive as the till materials. Vertical hydraulic gradients could not be measured due to the lack of nested monitoring wells on-site. Horizontal hydraulic gradients in the fill and overburden ranged from 0.0027 to 0.033 ft/ft. Calculated average linear velocities for shallow ground water range from 0.0053 to 0.0654 ft/day. Tidal influences on ground water were measured during continuous water level measurements (over a three-day period) at most on-site wells. The fluctuations ranged from 0 to 0.31 feet.

No distinct surface water bodies are present on the Melville North Landfill site, although a marshy area is present along the northern edge of the site. Topography generally slopes in an east-to-west direction. The western edge of the site is at an elevation that is nearly level with the adjoining shoreline of Narragansett Bay.

Field Investigation Summary

Soil Assessment *- VOCs, BNAs, pesticides, PCBs, and inorganics were all detected in on-site soils. The major areas of the site where contaminants were detected in the soils at elevated levels include the following:*

- *Northwestern area - BNAs, PCBs;*
- *Northeastern area - PCBs, inorganics;*
- *North-central area - inorganics;*
- *Central area - VOCs, BNAs, pesticides, PCBs and inorganics; and*
- *South of access road - VOCs, BNAs, PCBs, and inorganics.*

*Significant **VOC** contamination (i.e., greater than 1 ppm total VOCs) was detected in subsurface soils in the central portion of the site, in the suspected area of former lagoons, and in the southern portion of the site at well boring 4. Soil samples collected in the former lagoon area and from well boring 4 generally exhibited strong petroleum odors and/or visible oil contamination. **BNAs** were detected at elevated levels (i.e., greater than 10 ppm total BNAs) in the northwest, central and southern portions of the site. **Pesticides** were detected at low levels (i.e., 10's of ppb) in surface soil samples across the site with higher levels (100's of ppb) detected in the central portion of the site. **PCBs** were detected in surface and subsurface soils. PCBs were detected above the 1 ppm RIDEM PCB soil action level in surface soils in the northwest and northeast portions of the site, and in subsurface soils in the central and southern portions of the site. **Inorganics** were detected in soil samples collected from the northeast corner of the site to just south of the site access road at levels exceeding background levels. The highest inorganic levels were detected in subsurface soils generally collected at or below the water table from the north-central and central to south-central portions of the site.*

__Ground Water Assessment__ - VOCs, BNAs, pesticides, PCBs, and inorganics were all detected in ground water samples. The major areas of the site where contaminants were detected at levels exceeding action levels include the following:

- *North-central area - inorganics;*
- *Central area - VOCs, and inorganics; and*
- *South of access road - VOCs, BNAs and PCBs.*

***VOC** detections at concentrations exceeding ground water action levels, consisting mostly of petroleum-related VOCs (xylene, benzene), were limited to wells located in the central (MW-3) and southern (MW-4) portions of the site. Oil was identified in well MW-3. VOCs were also detected in soil boring samples collected at the depth of the water table from the central and southern portions of the site, and signs of petroleum related contamination (e.g., odors, oil) were observed during the drilling and sampling of these borings. One **BNA** compound was detected above ground water action levels in a well (MW-4) in the southern portion of the site. A **pesticide**, gamma-BHC, was detected in ground water at well MW-4. A **PCB** concentration of 40 ppb was also detected in well MW-4 (PCBs were detected in the soil from this well boring). PCBs were also detected at 0.13 ppb, less than the MCL, in MW-3 in the central portion of the site. While inorganic concentrations exceeded ground water action levels in most wells, the highest levels of **inorganic** analytes were detected in ground water in the central to north-central portions of the site.*

Sediment Sample Assessment *- VOCs, BNAs, pesticides, and inorganics were detected in sediment samples. The sediment samples were collected from the swampy area at the northern edge of the site. The contaminants detected at elevated levels in the sediment include the following:*

- *CaPAHs, pesticides and inorganics*

The maximum total ***VOC*** *concentration detected in the sediment was 11 ppb, well below the contaminant-comparison level of 1 ppm. The maximum total* ***BNA*** *concentration detected was 5.43 ppm, also below the contaminant-comparison level of 10 ppm. However, total carcinogenic PAH levels in two samples exceeded the contaminant-comparison level of 1 ppm.* ***Pesticides*** *were detected in each of the sediment samples, with 4,4'-DDE detected at each location at concentrations ranging from 7.9 to 470 ppb.* ***Inorganic*** *analytes were detected at elevated concentrations at each sample location, although different analytes exceeded background at each location.*

Contaminant Fate and Transport (Volume II)

General contaminant fate and transport mechanisms were discussed in the introductory section. The ground water flow direction at this site is to the west, towards Narragansett Bay. The primary migration pathway for VOCs is likely to be via ground water. For BNAs, which are generally persistent in the environment, contamination appears to be greatest in the surface and subsurface soils, with migration to ground water considered a potential migration route. Migration of carcinogenic PAHs to surface water is a potential migration route in the northern, swampy area. Pesticides and PCBs were both detected in surface and subsurface soil. PCBs were detected in ground water samples, suggesting potential migration in the ground water. Inorganics were detected at elevated levels in surface and subsurface soils and in ground water samples, although evaluation of ground water samples does not indicate a trend of inorganics migrating off-site.

Human Health Assessment (Volume II)

The exposure scenarios considered in the evaluation of the Melville North Landfill site included a trespassing/current use scenario, a construction/future use scenario, an industrial/future use scenario, and a residential/future use scenario. The estimated risks, in terms of cancer risk (carcinogenic) and hazard risk (non-carcinogenic) estimates associated with each scenario evaluated and the exposure pathway(s) driving the calculated risks are summarized below:

- ***Trespassing Scenario (Scenario 1)*** *- Total cancer risk range and total hazard index ratio range are within target values.*

- ***Construction Scenario (Scenario 2)*** *- The total cancer risk range and the mean hazard index ratio are within target values. The maximum hazard index ratio exceeded the target value.*

- ***Commercial/Industrial Use Scenario (Scenario 3)*** *- The total cancer risk range and the hazard index ratio range exceed target values.*

- ***Residential Use Scenario (Scenario 4)*** *- The total cancer risk range and the hazard index ratio range exceed target values for both children and adult receptors.*

For Scenarios 1 and 2, the major contributing factor to the calculation of cancer risk is ingestion of arsenic and carcinogenic PAHs in soil. The pathway of primary concern associated with Scenarios 3 and 4 with respect to cancer risk is ingestion of ground water containing chlorinated VOCs (1,1-dichloroethene, vinyl chloride and trichloroethene, which are completely based on qualified data) and inorganics (arsenic, beryllium). Ingestion of arsenic and PAHs in soil and inhalation of VOCs also are important exposure pathways in the residential use scenario with respect to cancer risks.

The primary contributor to the total hazard index ratio for Scenarios 1 and 2 is ingestion of inorganics (antimony, copper) in soil. Ingestion of inorganics (mercury, thallium) in ground water drove the total hazard index ratio for Scenarios 3 and 4. Other pathways of concern specifically applicable to exposure of children in the residential use scenario are ingestion of chemicals in soil and inhalation of vapor phase VOCs.

Conclusions and Recommendations

Based on the results of the Remedial Investigation, conclusions regarding the nature of site contamination and human health risks, and recommendations for future site studies can be made.

The major areas of contamination on-site appear to be associated with the former lagoon locations in the central portion of the site and in the southern portion of the site, in the vicinity of well MW-4. Elevated VOCs and PCBs have been identified in the ground water in the southern portion of the site and elevated VOC levels and PCBs have also been detected in the ground water in the central portion of the site. Soil contamination by VOCs, BNAs, PCBs and inorganics has also been identified in these areas. PCBs have also been identified in surface soils in the northwest and northeast portions of the site. Action levels for PCBs in soils, and VOCs, BNAs, PCBs and inorganics in ground water were exceeded in samples collected during the Remedial

Investigation. While the site does not pose excessive human health risks in its current state, the potential for future risks to human health exists if the site use changes. Additional studies are recommended to further define the extent of soil and ground water contamination in the area of the former lagoons, the extent of the soil and ground water contamination in the area surrounding well MW-4, the nature and extent of fill in the north-central portion of the site (west of MW-2), and the significance of pesticide and inorganic contaminant levels in both soil and ground water at this site as compared to background levels. Upon further definition of site contamination, a Feasibility Study is recommended to evaluate potential remedial alternatives.

SITE 09 - OLD FIRE FIGHTING TRAINING AREA

Site Description

The Old Fire Fighting Training Area site occupies approximately 5 acres at the northern end of Coasters Harbor Island. Current site uses include a child care facility, picnic area, playground and baseball field. The site is characterized by two mounds: a 15-foot high mound in the center of the site and a 6-foot high mound at the western end of the site. A site map is provided on Figure ES-4.

Site History

The Old Fire Fighting Training Area site was used for fire fighting training exercises from World War II to 1972. A historic (1943) construction drawing indicates that a water/oil mixture may have been piped to two structures referred to as "carrier compartments", where the mixture was ignited. Underground piping also led from the buildings to an oil/water separator. In 1987, geotechnical borings being completed in anticipation of an expansion of the on-site child-care facility identified the presence of oily subsurface soils at the site.

Previous Environmental Investigations

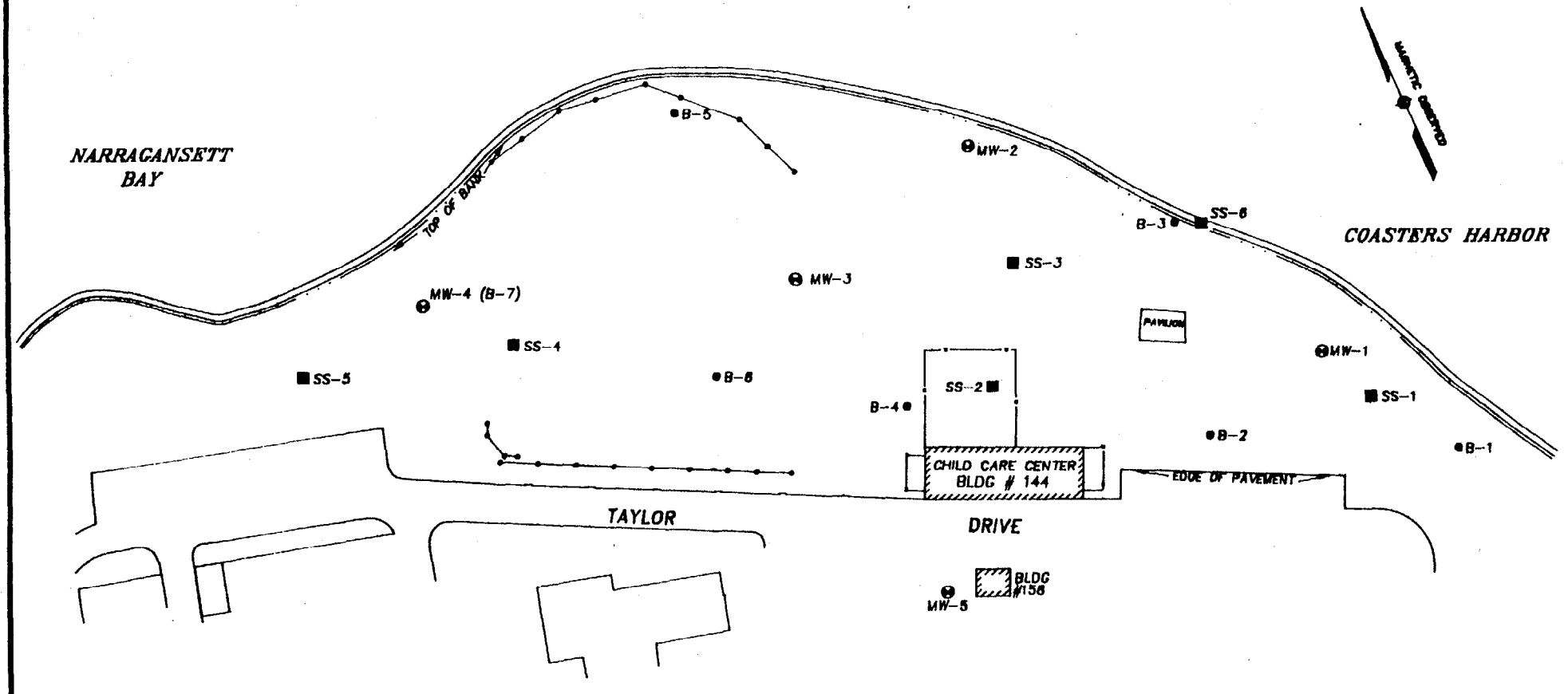
No previous environmental investigations have been conducted at this site. As discussed above, geotechnical borings identified the presence of oil at a depth of 5 feet below the surface in two of these borings.

Field Investigation Areas and Scope

Areas of potential concern include areas used for former fire fighting training, where residuals of the materials used in the training exercises may exist. Determination of the extent of subsurface contamination, as was previously identified during geotechnical borings completed on-site, was also a priority of these investigations. A summary of the field investigation program conducted at this site is provided in Table ES-4. A site map is provided on Figure ES-4.

Geology, Hydrogeology, and Hydrology

The overburden materials consist of fill over till deposits. The thickness of the fill material ranges from 0 to 4 feet across the site. The fill materials consist primarily of fine sand and silt and construction-type debris. The native overburden deposits identified at the site include a continuous very tight sand and



40 0 40 80 120 160 FEET

20 0 20 40 METERS

LEGEND

SS-5 ■ SURFACE SOIL SAMPLE LOCATION

B-6 ● BORING LOCATION

MW-5 ⊗ MONITORING WELL LOCATION

TRC

TRC Environmental Consultants, Inc.

5 Waterside Crossing
Windsor, CT 06095
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NEWPORT RHODE ISLAND

SITE 09 - OLD FIRE FIGHTING TRAINING AREA

FIGURE ES-4.

INVESTIGATION SUMMARY MAP

TABLE ES-4
FIELD INVESTIGATION PROGRAM SUMMARY
Site 09 - Old Fire Fighting Training Area

Ambient Air and Radiological Surveys - Site walkover using organic vapor analyzer, photoionization detector, and radiation meter

Geophysical Survey - Electromagnetic survey and magnetometer survey

Soil Gas Survey - Conducted over entire site, except for central soil mound area

Surface Soil Sampling - 6 on-site samples

Test Borings - 7 test borings; 1 to 3 soil samples per test boring, depending on the presence of visible contamination or depth to ground water

Ground Water Monitoring Well Installation - 4 on-site well borings, 1 off-site, upgradient well boring; 1 to 3 soil samples per well boring, depending on the presence of visible contamination or depth to ground water

Ground Water Sampling - July 1990: 4 on-site wells and 1 off-site well sampled

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gravel till, and discontinuous silt and fine sand till, and organic, swampy muck. Bedrock, composed of sandstone, was encountered at depths of 5.5 to 10.2 feet below grade in this and previous investigations.

Ground water flow direction on the Old Fire Fighting Training Area site is generally from south to north, towards Narragansett Bay. Hydraulic conductivities determined from slug tests performed on the overburden till ranged from 0.29 to 0.44 ft/day. Vertical hydraulic gradients could not be measured due to the absence of nested monitoring wells on-site. Horizontal hydraulic gradients in the overburden till ranged from 0.0040 to 0.0068 ft/ft. Calculated average linear velocities for shallow ground water range from 0.0080 to 0.014 ft/day. Tidal influences on ground water were detected during continuous water level measurements (over a three-day period) at three of the five monitoring wells. The fluctuations ranged from 0 to 0.91 feet.

The site topography slopes slightly in a south-to-north direction, with Narragansett Bay bordering the northern edge of the site. Small ponded areas were observed on-site during periods of heavy rainfall. The northern edge of the site is at an elevation slightly higher than the adjoining shoreline of Narragansett Bay.

Field Investigation Summary

Soil Assessment *- VOCs, BNAs, pesticides, PCBs and inorganics were all detected in on-site soils. The major areas where contaminants were detected in the soils at elevated levels include the following:*

- *Northern area - VOCs, BNAs, and inorganics;*
- *Central area - VOCs, and inorganics*
- *Western area - BNAs;*
- *Eastern area - BNAs, caPAHs, and inorganics; and*
- *Southern area (off-site) - BNAs.*

Significant ***VOC*** *contamination (i.e., greater than 1 ppm total VOCs) was detected in subsurface soils at the depth of the water table in the central portion of the site (B-6) and in the north central portion of the site (M-2). In the central portion of the site, detected contaminants were petroleum-related VOCs, while in the northern area, only 2-butanone was detected. Soil samples collected at both of these locations generally exhibited petroleum odors and/or visible oil contamination.* ***BNAs*** *were detected at elevated levels (i.e., greater than 10 ppm total BNAs) in the northern, western, and eastern portions of the site. The subsurface samples collected from the western portion of the site (at B-7) exhibited a strong petroleum odor. BNAs were also detected at levels greater than 10 ppm at the off-site well boring*

(M-5). Carcinogenic PAHs were detected at levels greater than 1 ppm, but total BNA concentrations were less than 10 ppm in samples collected from the eastern portion of the site. ***Pesticides*** *were detected at low levels (i.e., 10's of ppb) in surface soil samples across the site. One surface soil sample exhibited* ***PCBs*** *at 80 ppb, well below the 1 ppm RIDEM PCB soil action level.* ***Inorganics*** *were detected at levels exceeding background levels in soil samples collected throughout the central and eastern portions of the site. The highest inorganic levels were generally detected in subsurface soils collected at well location M-2, in the northern portion of the site, although background inorganic levels were also exceeded at boring B-1.*

Ground Water Assessment *- VOCs, BNAs, and inorganics were detected in ground water samples. The major areas of the site where contaminants were detected at levels exceeding action levels include the following:*

- *Northern area - BNAs and inorganics;*
- *Central area - inorganics;*
- *Western area - inorganics;*
- *Eastern area - inorganics; and*
- *Southern area (off-site) - inorganics.*

VOCs *were not detected at concentrations exceeding ground water action levels in any ground water samples. However, at well location M-4, elevated soil gas readings in the soil, petroleum odors in the soil and ground water samples, and a sheen on the ground water sample indicate a potential for subsurface VOC contamination in this area. Elevated soil gas readings, petroleum odors and/or sheens were also observed in association with other well locations at this site. Four* ***BNA*** *compounds were detected above ground water action levels in one well (MW-2) in the northern portion of the site. A strong petroleum odor and sheen were observed during ground water sampling at this well. No* ***pesticides*** *or* ***PCBs*** *were detected in ground water samples. While inorganic concentrations exceeded ground water action levels in all wells, including the background well, the highest levels of* ***inorganic*** *analytes were detected in wells in the central to northern portions of the site.*

Contaminant Fate and Transport (Volume II)

General contaminant fate and transport mechanisms were discussed in the introductory section. The ground water flow direction at this site is to the north, towards Narragansett Bay. The primary migration pathway for VOCs appears to be via ground water flow, although VOCs are not currently detected in the ground water at levels exceeding action levels. For BNAs, which are generally persistent in the environment, contamination appears to

be greatest in the surface and subsurface soils, with migration to ground water considered a potential migration route based on their presence in one on-site well. Pesticides and PCBs were both detected in surface soil, generally at low concentrations, but were not detected in subsurface soil or in the ground water. Significant migration of these compounds is not anticipated. Inorganics were detected at elevated levels in surface and subsurface soils and in ground water samples. Evaluation of ground water samples indicates inorganics may be migrating off-site.

Human Health Assessment (Volume II)

The exposure scenarios considered in the evaluation of the Fire Fighting Training Area included a child care/current use scenario, a recreation/current use scenario, a construction/future use scenario, an industrial/future use scenario, and a residential/future use scenario. The estimated risks, in terms of cancer risk (carcinogenic) and hazard risk (non-carcinogenic) estimates associated with each scenario evaluated and the exposure pathway(s) driving the calculated risks are summarized below:

- ***Child Care Scenario (Scenario 1)*** *- The mean cancer risk and the hazard index ratio range are within target values. The maximum cancer risk exceeds the target values.*

- ***Recreational Use Scenario (Scenario 2)*** *- The total cancer risk range and total hazard index ratio range are within target values.*

- ***Construction Scenario (Scenario 3)*** *- Total cancer risk range and total hazard index ratio range are within target values.*

- ***Commercial/Industrial Use Scenario (Scenario 4)*** *- The total cancer risk range and the hazard index ratio range exceed target values.*

- ***Residential Use Scenario (Scenario 5)*** *- The total cancer risk range and the hazard index ratio range exceed target values for both children and adult receptors.*

For Scenarios 1, 2 and 3, the major contributing factor to the calculation of cancer risk is ingestion of arsenic and carcinogenic PAHs in soil. The pathway of primary concern associated with Scenarios 3 and 4 with respect to cancer risk is ingestion of ground water containing carcinogenic PAHs and inorganics (arsenic). It should be noted that some of the data for both the PAHs and arsenic upon which these risks were calculated was qualified data. Ingestion of soil and house dust and/or inhalation of vapor phase VOCs also contribute to the overall cancer risk for children and

adults, while ingestion of 1,1-dichloroethene and beryllium contributes significantly to the ground water ingestion scenario for adults only.

The primary contributor to the total hazard index ratio for Scenarios 1, 2 and 3 is ingestion of soil contaminants. Ingestion of inorganics (arsenic, cadmium, copper, manganese and zinc) in ground water drove the total hazard index ratio for Scenarios 4 and 5. Other pathways of concern, specifically applicable to exposure of children in the residential use scenario, are ingestion of chemicals in soil and house dust and inhalation of vapor phase VOCs.

Conclusions and Recommendations

Based on the results of the Remedial Investigation, conclusions regarding the nature of site contamination and human health risks, and recommendations for future site studies can be made.

Elevated levels of VOCs and BNAs have been identified in subsurface soils at this site. While elevated VOC levels have not been detected in ground water samples, the identification of elevated soil gas readings, petroleum odors and/or sheens in wells and at well and boring locations indicate the presence of subsurface contamination. Action levels for BNAs and inorganics in ground water were exceeded in samples collected during the Remedial Investigation. The site may pose a potential risk to children in its current state (although the PAH compounds which drove the risk evaluation were detected along the shore area, an area to which the children are not normally exposed) and the potential for future risks to human health exists if the site use is changed. Additional studies are recommended to further define the extent of subsurface contamination at well locations M-2 and M-4, to further investigate the central soil mound area, and the significance of pesticide and inorganic contaminant levels in the soil and/or ground water at this site as compared to background levels. Upon further definition of site contamination, a Feasibility Study is recommended to evaluate potential remedial alternatives.

SITE 12 - TANK FARM FOUR

Site Description

Tank Farm Four covers approximately 80 acres in area and is located in the northern portion of the NETC facility. The site is located east of Narragansett Bay, with Defense Highway lying between the site and the bay. The site is characterized by the presence of twelve 60,000-barrel underground storage tanks (USTs) and associated pump/valve houses. A paved road provides access to the site, passing between the tank locations in a loop. Other facilities on-site include a small metal building, which was used as an electrical substation, a wooden pole barn currently used for hay storage, and a concrete structure apparently used as an oil-water separator. A brook, Normans Brook, crosses the western corner of the site. Topography generally slopes to the west. The site is vegetated with grass, brush and some trees and is used as a grazing land for cows. A site map is provided on Figure ES-5.

Site History

Diesel and fuel oil were historically stored at the site in the USTs. Tank bottom sludges totalling 100,000 to 190,000 gallons in volume were reportedly disposed of at the site.

Previous Environmental Investigations

The CS conducted at this site included the collection of a near-surface composite soil sample, a surface water sample (expected to be representative of shallow ground water quality), a stream sediment sample, ground water samples, and water samples from six of the twelve USTs. The near-surface soil sample indicated the presence of oil and grease. Petroleum hydrocarbons were detected in the surface water and sediment samples. The water samples collected from the USTs exhibited low concentrations of petroleum hydrocarbons and varied levels of total suspended solids and biochemical oxygen demand. The ground water samples indicated the presence of lead and petroleum hydrocarbons in the ground water. The monitoring wells do not appear to be located directly downgradient of the USTs. Therefore, the full impact of the tanks on ground water quality has not been defined.

Field Investigation Areas and Scope

Areas of potential concern include the areas surrounding the individual storage tanks, the oil/water separator area, and a demolished unknown structure area, referred to as the ruins. A summary of the field investigation program conducted at this site is provided in Table ES-5. Sampling locations are shown of Figure ES-5.

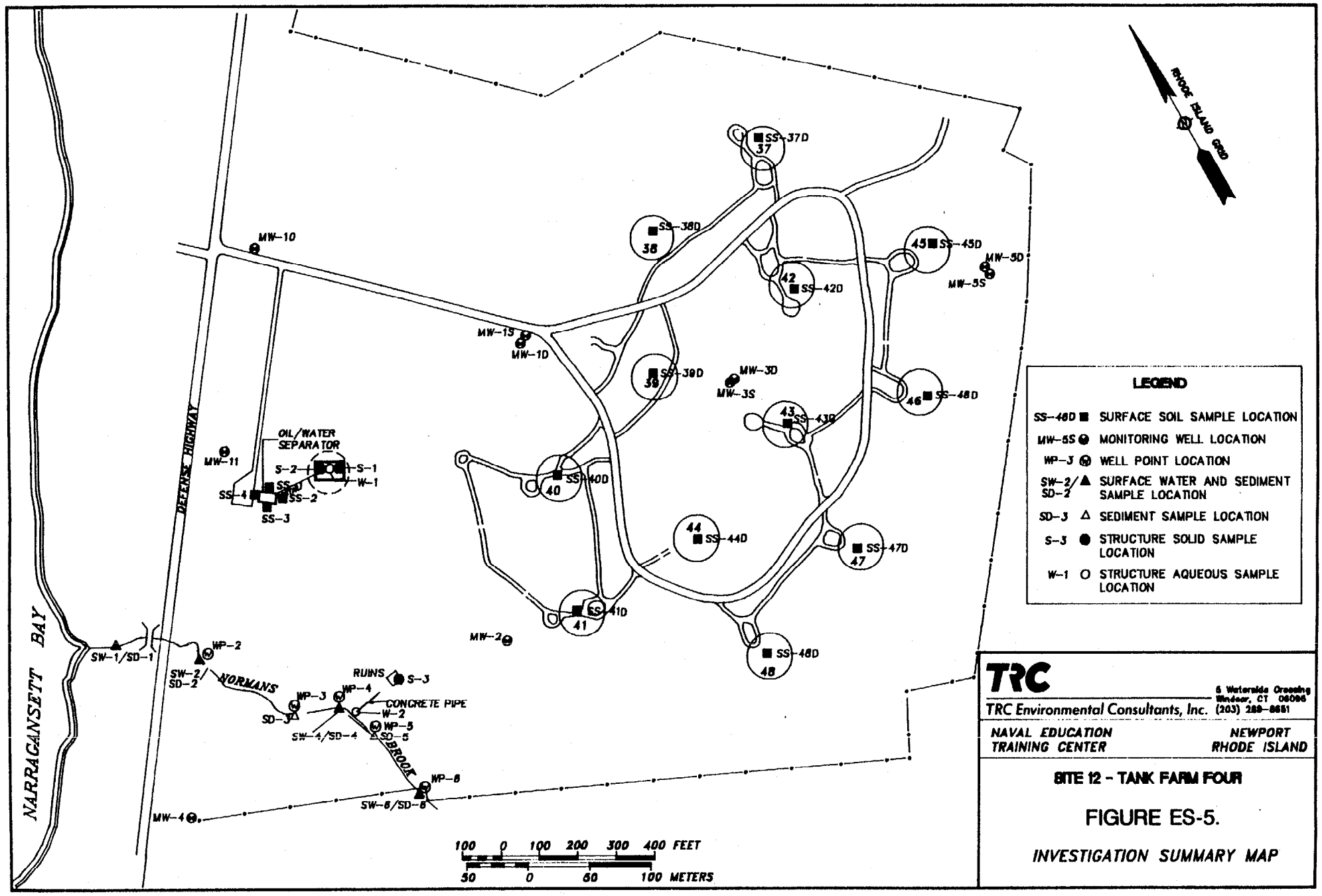
NARRAGANSETT BAY
DEFENSE HIGHWAY
NORMANS BROOK
RHODE ISLAND GRID
MW-10
MW-11
MW-15
MW-1D
MW-3D
MW-3S
MW-5D
MW-5S
MW-2
MW-4
SS-37D
37
SS-38D
38
SS-39D
39
SS-40D
40
SS-41D
41
SS-42D
42
SS-43D
43
SS-44D
44
SS-45D
45
SS-46D
46
SS-47D
47
SS-48D
48
OIL/WATER SEPARATOR
S-1
S-2
W-1
SS-1
SS-2
SS-3
SS-4
SW-1/SD-1
WP-2
SW-2/SD-2
WP-3
SD-3
WP-4
SW-4/SD-4
RUINS
S-3
CONCRETE PIPE
W-2
WP-5
SD-5
WP-6
SW-6/SD-6
100 0 100 200 300 400 FEET
50 0 50 100 METERS
LEGEND
SS-46D SURFACE SOIL SAMPLE LOCATION
MW-5S MONITORING WELL LOCATION
WP-3 WELL POINT LOCATION
SW-2/SD-2 SURFACE WATER AND SEDIMENT SAMPLE LOCATION
SD-3 SEDIMENT SAMPLE LOCATION
S-3 STRUCTURE SOLID SAMPLE LOCATION
W-1 STRUCTURE AQUEOUS SAMPLE LOCATION
TRC
TRC Environmental Consultants, Inc.
5 Waterside Crossing
Windsor, CT 06095
(203) 289-8651
NAVAL EDUCATION TRAINING CENTER
NEWPORT RHODE ISLAND
SITE 12 - TANK FARM FOUR
FIGURE ES-5.
INVESTIGATION SUMMARY MAP

TABLE ES-5
FIELD INVESTIGATION PROGRAM SUMMARY
Site 12 - Tank Farm Four

Ambient Air and Radiological Surveys - Site walkover using organic vapor analyzer, photoionization detector, and radiation meter

Soil Gas Survey - Conducted around tanks and on the basis of a 400-foot grid system over the remainder of the site

Surface Soil Sampling - 28 on-site samples

Ground Water Monitoring Well Installation - 8 well borings advanced at 5 locations; 1 soil sample collected at or near the water table per well location

Ground Water Sampling - July 1990: 5 overburden wells and 3 bedrock wells (each nested with an overburden well) sampled, two pre-existing wells sampled; all located on-site

Surface Water/Sediment Sampling - 4 on-site surface water samples collected from Normans Brook; 2 sediment samples collected at each of the surface water sample locations; 2 sediment samples collected from each of 2 additional on-site brook locations

Underground Storage Tank Investigations - 12 oil samples and 11 water samples collected from the tanks

Structure Investigation - 1 soil sample, 1 sludge sample, and 1 water sample collected from the oil/water separator structure; 1 soil sample collected from the ruins; 1 water sample collected from a 12-inch pipe which appeared to be discharging water from the structure of the ruins

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Geology, Hydrogeology and Hydrology

The overburden materials consist of a native sand and silt and glacial till. The till was encountered in all borings, ranging in thickness from 12 to 29 feet across the site. No fill materials were encountered at this site. Bedrock was encountered at all boring locations and consisted of weathered shale over competent bedrock. Rock cores indicate the bedrock is of the same unit encountered at the McAllister Point Landfill site.

Ground water flow direction for both the shallow and deep ground water at Tank Farm Four is generally to the southwest, towards Narragansett Bay. Both the shallow and the deep ground water flow directions seem to be affected by the presence of Normans Brook, a gaining stream (receives discharge from the ground water), located in the southwestern portion of the site. The hydraulic conductivity determined from slug tests performed on two wells screened in the till overburden were 0.23 ft/day. Hydraulic conductivities measured in the bedrock wells ranged from 0.029 to 0.059 ft/day. Vertical hydraulic gradients were negative at each of the three pairs of nested monitoring wells on-site, ranging from -0.059 to -0.683 ft/ft. Horizontal hydraulic gradients in the till overburden ranged from 0.041 to 0.187 ft/ft, while in the bedrock they ranged from 0.052 to 0.162 ft/ft. Estimated average linear velocities for shallow ground water range from 0.063 to 0.29 ft/day and for deep ground water range from 0.023 to 0.070 ft/day. Because this site is not located immediately adjacent to Narragansett Bay, tidal influences on the ground water were not evaluated.

Normans Brook, a perennial stream, flows across the southwestern corner of the site. Site topography generally slopes in an east-to-west direction. The central portion of the site in which the tanks are located is gradually sloping and well-drained. During periods of heavy rainfall, ponded water was observed in a ditch which runs between the site and Defense Highway and in low-lying areas in the northern corner of the site. As mentioned previously, piezometer and surface water level measurements indicate that Normans Brook is a gaining stream, receiving discharge from the ground water.

Field Investigation Summary

Soil Assessment *- VOCs, BNAs, pesticides, and inorganics were detected in on-site soils. In general, minimal soil contamination was detected at the site, with the exception of elevated TPH levels detected in surface soils adjacent to the oil/water separator and in a soil boring sample collected along the site access road.*

VOCs *were detected in three subsurface soil samples at very low levels (i.e., less than 5 ppb) and are not considered to*

represent significant subsurface VOC contamination. ***BNAs*** *were not detected at levels greater than the contaminant-comparison level (i.e., greater than 10 ppm total BNAs). Only one soil sample exhibited BNAs at a concentration greater that 1 ppm (3.3 ppm) and that concentration consisted entirely of di-n-butylphthalate. Therefore, BNA soil contamination at this site is not considered to be significant.* ***Pesticides*** *were detected at low levels (i.e., less than 10 ppb) in one surface soil and one subsurface soil sample and are not considered to be significant soil contaminants. No* ***PCBs*** *were detected in soil samples.* ***Inorganics*** *were generally detected at levels less than or slightly exceeding (1 to 7 ppm above) background levels in soil samples. Therefore, there does not appear to be significant inorganic soil contamination at this site.* ***Total petroleum hydrocarbons*** *(TPH) analysis of soil samples identified the presence of TPH across the site, ranging in concentration from 3 to 270 ppm. The highest TPH levels were detected in a subsurface soil sample collected along the site access road (boring M-1) and in a surface soil sample collected from adjacent to the oil/water separator.*

Ground Water Assessment *- BNAs, and inorganics were detected in ground water samples. Inorganics were detected at levels exceeding action levels in all wells on-site.*

VOCs *were not detected in any ground water samples, which coincides with their absence in soil samples. One* ***BNA*** *compound, bis(2-ethylhexyl)phthalate (a common laboratory contaminant) was detected in two on-site wells. No ground water action levels were exceeded for BNAs. No* ***pesticides*** *or* ***PCBs*** *were detected in ground water samples. While inorganic concentrations exceeded ground water action levels in both shallow and deep wells, including the background well, the highest levels of* ***inorganic*** *analytes were detected in wells in the northeast to southwest portions of the site.*

Surface Water and Sediment Assessment *- VOCs, BNAs pesticides and inorganics were detected in sediment samples and VOCs and inorganics were detected in surface water samples.*

One ***VOC****, carbon disulfide, was detected in one sediment sample at 21 ppb, which is not considered to be a significant level of sediment contamination. Three* ***BNAs*** *were detected in sediment samples, with a maximum total BNA concentration of 780 ppb, well below the contaminant-comparison level of 1 ppm. One* ***pesticide****, 4.4'-DDT was detected in three sediment samples at concentrations of 2.8 to 5.9 ppb. No* ***PCBs*** *were detected in sediment samples. Arsenic, cobalt and iron were the only* ***inorganic*** *analytes detected in soils at levels exceeding background. Higher inorganic concentrations were generally detected in the 0-1 foot sediment sample interval than the 1-2 foot interval.*

*Two **VOCs**, carbon disulfide and carbon tetrachloride, were detected in surface water samples. No surface water quality criteria for VOCs were exceeded. No **BNAs, pesticides or PCBs** were detected in surface water. Cadmium, lead and zinc were the only **inorganic** analytes detected at levels exceeding surface water quality criteria. The highest levels of inorganic analytes were detected in the surface water sample collected closest to the mouth of Normans Brook, as it enters Narragansett Bay.*

Structure Sample Assessment *- The distribution of contaminants within the oil/water separator and demolished unknown structure (referred to as the ruins) was as follows:*

- *Oil/water separator -*
  Soil: VOCs, BNAs, and inorganics; and
  Sludge: BNAs, PCBs and inorganics.
- *Ruins -*
  Soil/sediment: inorganics; and
  Water: inorganics.

***VOCs** were detected in the soil/sediment and sludge samples collected from the oil/water separator and from the ruins on-site, although total VOC levels were less than the contaminant-comparison level of 1 ppm. The soil/sediment sample collected from the ruins exhibited the greatest VOC concentration (680 ppb tetrachloroethene). This sample was visibly contaminated (e.g., odor, sheen). **BNAs** were detected in the soil/sediment and sludge samples. The sludge sample was the only sample with a total BNA concentration greater than the contaminant-comparison level of 10 ppm and a carcinogenic PAH concentration greater than the contaminant-comparison level of 1 ppm. No **pesticides** were detected in soil/sediment or sludge samples. A **PCB** compound was identified in the sludge sample at a concentration of 12 ppb, well below the RIDEM soil action level of 1 ppm. Cobalt and iron were the only **inorganics** detected at levels exceeding background levels and were only detected in the ruins sample.*

*No **VOCs, BNAs, pesticides, or PCBs** were detected in the surface water sample collected from the ruins. Lead and zinc were the only **inorganic** analytes which were detected in the water sample at levels exceeding surface water quality criteria.*

Tank Contents Assessment *- The distribution of contaminants within the oil and water samples collected from the on-site tanks was as follows:*

- *Oil: VOCs, BNAs, and inorganics; and*
- *Water: VOCs, BNAs, and inorganics.*

***VOCs** were detected in the oil samples collected from the on-site tanks at very elevated levels. The VOCs consisted of benzene,*

toluene, ethylbenzene, and xylene. Total VOC levels exceeded 10 ppm in a majority of the tanks. EP Toxicity extraction and analysis of oil samples detected no EP Toxicity analytes; low levels of toluene, ethylbenzene and xylene in a TCL/TAL analysis of the EP Toxicity extraction leachate from one sample. A TCL/TAL analysis of the TCLP extraction leachate from the same oil sample detected concentrations of these compounds at levels three orders of magnitude greater than the EP Toxicity results. ***BNAs*** *were detected in the oil samples and consisted primarily of PAHs. Total BNA levels in excess of 1,500 ppm were detected in four of the oil samples. Oil samples were not analyzed for* ***pesticides****. No* ***PCBs*** *were detected in the oil samples, although detection limits ranged from 12 to 24 ppm. Iron, lead and zinc were the only* ***inorganics*** *detected in greater than 50% of the oil samples. TAL metals analysis of EP Toxicity and TCLP oil leachates identified inorganic analytes. The EP Toxicity extract analyses detected silver and arsenic, analytes which were not detected in the CLP method extract. The detected arsenic level exceeds the EP Toxicity federal standard.*

VOCs *were detected in all of the tank water samples, with total VOC concentrations ranging from 13 to 346 ppb. The main VOC compounds detected included the same VOCs detected in the oil samples.* ***BNAs*** *detected in the water samples consisted of PAH compounds, phenols, phthalate esters and dibenzofuran. Total BNA concentrations ranged from 10 to 202 ppb. Tank water samples were not analyzed for* ***pesticides*** *or* ***PCBs****. The* ***inorganics*** *detected in greater than 50% of the tank water samples include barium, calcium, iron, potassium, magnesium, manganese, sodium, lead and zinc. The analyte concentrations in the water samples were typically higher than those detected in the oil samples.*

Contaminant Fate and Transport (Volume II)

General contaminant fate and transport mechanisms were discussed in the introductory section. The ground water flow direction at this site is to the southwest, towards Normans Brook. For volatile organic compounds (VOCs), detections were infrequent and at low concentrations in surface soils and subsurface soils. Therefore, the potential for migration of these compounds is not expected to be significant. For BNAs, which are generally persistent in the environment, detections were limited to soils, ground water and surface water. Extensive migration of semi-volatile compounds is not expected. Pesticides were detected in soil and sediment samples only and at low concentrations, while PCBs were not detected in any media on-site. Significant migration of pesticides is not anticipated. Inorganics were detected at slightly elevated levels in subsurface soils and at levels exceeding action levels in ground water samples. Evaluation of downgradient ground water samples indicates that significant off-site migration of inorganics has not occurred.

Human Health Assessment (Volume II)

The exposure scenarios considered in the evaluation of the Tank Farm Four included a trespassing/current use scenario, a construction/future use scenario, an industrial/future use scenario, and a residential/future use scenario. The estimated risks, in terms of cancer risk (carcinogenic) and hazard risk (non-carcinogenic) estimates associated with each scenario evaluated and the exposure pathway(s) driving the calculated risks are summarized below:

- ***Trespassing Scenario (Scenario 1)*** *- The total cancer risk range and the hazard index ratio range for both adults and children are within target values.*

- ***Construction Scenario (Scenario 2)*** *- The total cancer risk range and total hazard index ratio range are within target values.*

- ***Commercial/Industrial Use Scenario (Scenario 3)*** *- The total cancer risk range and the hazard index ratio range exceed target values.*

- ***Residential Use Scenario (Scenario 4)*** *- The total cancer risk range and the hazard index ratio range exceed target values for both children and adult receptors.*

For Scenarios 1 and 2, the major contributing factor to the calculation of cancer risk is ingestion of soil contaminants (arsenic and PAHs). The pathway of primary concern associated with Scenarios 3 and 4 with respect to cancer risk is ingestion of ground water containing arsenic and beryllium.

The primary contributor to the total hazard index ratio for Scenarios 1 and 2 is ingestion of soil contaminants (arsenic, thallium and antimony). Thallium was not actually detected in the soil but was included in the analysis on the basis of "UJ" data. Ingestion of inorganics (arsenic, thallium and manganese) in ground water drove the total hazard index ratio for Scenarios 3 and 4. As for soils, thallium was not detected in ground water but was included in the assessment due to "UJ" data.

Conclusions and Recommendations

Based on the results of the Remedial Investigation, conclusions regarding the nature of site contamination and human health risks, and recommendations for future site studies can be made.

Significant levels of contamination generally have not been detected at this site. No residual contamination associated with

the alleged on-site disposal of tank bottom sludges was identified with the exception of some elevated total petroleum hydrocarbon soil levels. Action levels were exceeded for inorganics in ground water, surface water and structure water samples. The site does not pose a potential risk to human heath in its current state but a potential for future risks to human health exists if the site use is changed. Additional studies are recommended to further define the extent of contamination associated with the ruins, characterize the sludge material in the oil/water separator further for future disposal, confirm the VOC, TPH and lead levels in on-site ground water (for comparison to previous investigations results) and determine the significance of inorganic contaminant levels in the soil and/or ground water at this site as compared to background levels. Upon further definition of site contamination, a Feasibility Study is recommended to evaluate potential remedial alternatives.

SITE 13 - TANK FARM FIVE

Site Description

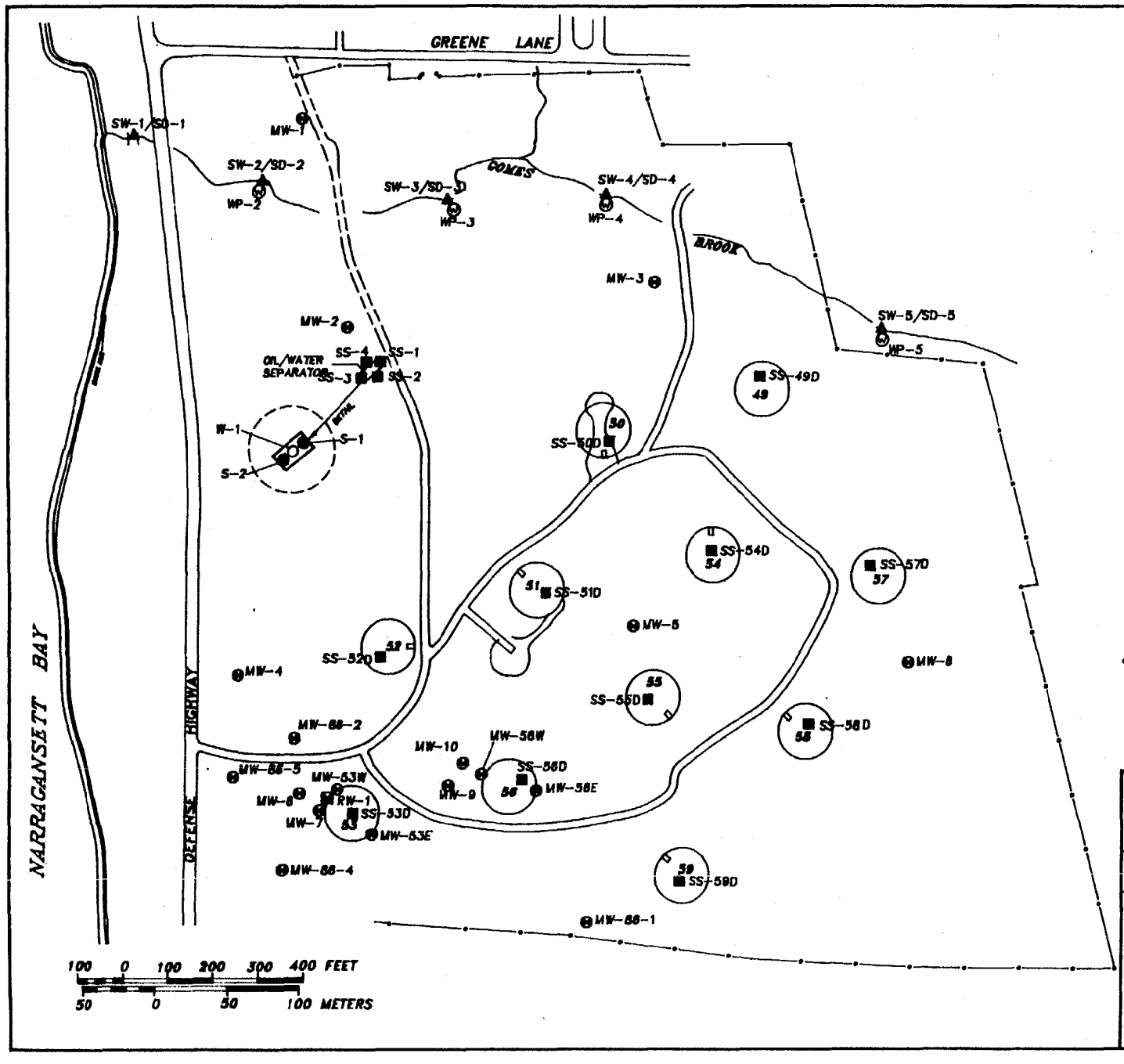
Tank Farm Five is located in the north-central portion of the facility and is approximately 80 acres in area. The site is located east of Narragansett Bay, with Defense Highway lying between the site and the bay. The site is characterized by the presence of eleven 60,000-barrel USTs and associated pump/valve houses. A paved road provides access to the site, passing between the tank locations in a loop. Other facilities on-site include the new Fire Fighting Training Area, a small metal building, which was used as an electrical substation, and a concrete structure apparently used as an oil-water separator. The Fire Fighting Training Area occupies approximately 3 acres in the northwest portion of the site and is surrounded by a chain-link fence. A brook, Gomes Brook, crosses the northeastern portion of the site. Topography generally slopes to the north. The site is vegetated with grass, brush and some trees. A site map is provided on Figure ES-6.

Site History

Diesel and fuel oil were historically stored at the site. Tank bottom sludges were reportedly burned on-site in a burning pit. In addition, oil sludge totaling 100,000 to 175,000 gallons in volume was reportedly disposed of at the site. Two of the USTs, Numbers 53 and 56, were used for waste oil storage after the other tanks at the site were taken out of service.

Previous Environmental Investigations

While a CS was not conducted at this site, studies of the contents of the USTs and ground water quality adjacent to the USTs during closure investigations provide site information. Sampling of the tank contents included the collection of water samples, surficial floating oil samples, bottom sludge samples and samples of an intervening oil-water emulsion (Tanks 53 and 56). The sample results indicated the presence of aromatic and chlorinated compounds and some metals in the oils contained within Tanks 53 and 56. The sludge samples from these two tanks also exhibited high metals levels. Water samples collected from other tanks indicated that tanks which were not used for waste oil storage also contain water contaminated with chlorinated and aromatic organic compounds, copper and zinc. Ground water samples collected from wells located adjacent to Tanks 53 and 56 indicated the presence of low levels of metals and high levels of volatile organics. Petroleum product was also identified in the ground water around Tank 53. Downgradient migration of contaminants as well as movement of chlorinated



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NEWPORT RHODE ISLAND

SITE 13 - TANK FARM FIVE

FIGURE ES-6.

INVESTIGATION SUMMARY MAP

contaminants downward through the water column is indicated by the analytical results.

Field Investigation Area and Scope

Areas of potential concern include the areas surrounding the individual storage tanks and the oil/water separator area. A summary of the field investigation program conducted at this site is provided in Table ES-6. Sample locations are shown on Figure ES-6.

Geology, Hydrogeology and Hydrology

The overburden materials consist of a native sand and silt, glacial till, like that encountered at Tank Farm Four. The till was encountered in all borings, ranging in thickness from 1 to 21 feet across the site. The till directly overlies bedrock at this site. Bedrock was encountered at all boring locations and consisted of gray, highly weathered to competent, slightly metamorphosed shale with quartz lenses. Rock cores indicate the bedrock is of the same unit encountered at the McAllister Point Landfill site. A considerable zone (up to 22 feet) of weathered bedrock overlies the competent bedrock.

Ground water flow direction for the shallow ground water at Tank Farm Five is generally to the west-northwest, towards Narragansett Bay in the southern portion of the site and to the north, towards Gomes Brook, in the northern portion of the site. Gomes Brook is a gaining stream (receives discharge from the ground water). The hydraulic conductivity determined from slug tests performed on five wells screened in the shallow, weathered bedrock (with the exception of one well screened in till overburden) ranged from 0.16 to 0.21 ft/day. Vertical hydraulic gradients could not be measured due to the lack of nested monitoring wells on-site. Horizontal hydraulic gradients in the shallow bedrock and till ranged from 0.0128 to 0.0398 ft/ft. Estimated average linear velocities for shallow ground water range from 0.017 to 0.05 ft/day. Because this site is not located immediately adjacent to Narragansett Bay, tidal influences on the ground water are not expected.

Gomes Brook, a perennial stream, flows across the northeastern portion of the site. Site topography generally slopes in a south-to-north direction. The central portion of the site in which the tanks are located is gradually sloping and well-drained. During periods of heavy rainfall, runoff from the site was observed to accumulate at the point where Defense Highway crosses Gomes Brook. Ponded water was also observed in a marshy area in the eastern corner of the site. As mentioned previously, piezometer and surface water level measurements indicate that Gomes Brook is a gaining stream, receiving discharge from the ground water.

TABLE ES-6
FIELD INVESTIGATION PROGRAM SUMMARY
Site 13 - Tank Farm Five

Ambient Air and Radiological Surveys *- Site walkover using organic vapor analyzer, photoionization detector, and radiation meter*

Geophysical Survey *- Electromagnetic survey and magnetometer survey*

Soil Gas Survey *- Conducted around tanks and on the basis of a 400-foot grid system over the remainder of the site*

Surface Soil Sampling *- 26 on-site samples*

Ground Water Monitoring Well Installation *- 6 well borings; 1 soil sample per well boring at or near the water table*

Ground Water Sampling *- July 1990: 6 newly-installed on-site overburden wells and seven previously-installed on-site overburden wells sampled*

Surface Water/Sediment Sampling *- 3 on-site surface water and sediment samples, 1 off-site upgradient surface water and sediment sample, and 1 off-site downgradient surface water and sediment sample were collected from Gomes Brook*

Underground Storage Tank Investigation *- 10 oil samples and 11 water samples were collected from the tanks*

Structure Investigation *- Two composite soil samples and one water sample were collected from the oil/water separator*

Field Investigation Summary

Soil Assessment *- VOCs, BNAs, pesticides, and inorganics were detected in on-site soils. In general, minimal soil contamination was detected at the site, with the exception of elevated TPH levels detected in surface soils adjacent to the oil/water separator and in a soil boring sample collected along the site access road.*

VOCs *were detected in surface and subsurface soil samples at very low levels (i.e., less than 10 ppb) and are not considered to represent significant subsurface VOC contamination.* ***BNAs*** *were not detected at levels greater than the contaminant-comparison level (i.e., greater than 10 ppm total BNAs). Only two soil samples exhibited BNAs at a concentration greater that 1 ppm (4.6 and 1.3 ppm) and those concentrations consisted entirely of phthalate esters and PAHs, respectively. Therefore, BNA soil contamination at this site is not considered to be significant.* ***Pesticides*** *were detected at low levels (i.e., 10's of ppb) in two surface soil and one subsurface soil sample and are not considered to be significant soil contaminants. No* ***PCBs*** *were detected in soil samples.* ***Inorganics*** *were generally detected at levels exceeding background levels in subsurface soil samples. Lead was detected above background in one surface soil sample collected from adjacent to the oil/water separator.* ***Total petroleum hydrocarbons*** *(TPH) analysis of soil samples identified the presence of TPH across the site, ranging in concentration from 4 to 60,000 ppm. The highest TPH levels were detected in visibly oily samples collected at Tank 50. Significantly elevated levels of TPH (TPH greater than 100 ppm) were detected in surface soil samples collected at Tanks 49, 50, 51 and 55.*

Ground Water Assessment *- VOCs, BNAs, and inorganics were detected in ground water samples. VOCs and inorganics were detected at levels exceeding ground water action levels.*

VOCs *were detected at levels exceeding ground water action levels in only one on-site well (MW-53W) and consisted mainly of petroleum-related VOCs. Petroleum product was also observed in wells MW-53W and MW-53E, both located in the ring drain of Tank 53. The presence of low VOC levels in downgradient well MW-4 indicates the potential migration of the ground water contamination observed adjacent to Tank 53.* ***BNAs*** *were only detected in well MW-53W and consisted entirely of PAHs. Detected levels did not exceed ground water action levels. No* ***pesticides*** *or* ***PCBs*** *were detected in ground water samples. While inorganic concentrations exceeded ground water action levels in all wells, including the background well, the highest levels of* ***inorganic*** *analytes were detected in wells in the central portion of the site.*

Surface Water and Sediment Assessment *- Lead and TPH were detected in sediment samples; no PCBs, lead or TPH were detected in surface water.*

*No **PCBs** were detected in sediment samples. **Lead** was detected in all sediment samples but at levels less than background soil levels. **TPH** was detected in sediment samples at concentrations ranging from 4 to 155 ppm, with detected levels increasing with distance downstream.*

Structure Sample Assessment *- The distribution of contaminants within the oil/water separator was as follows:*

- *Soil: VOCs, BNAs, and inorganics; and*
- *Water: inorganics.*

*One **VOC** was detected in one soil sample collected from the oil/water separator at a very low (2 ppb) level. Low levels of two **BNAs** were detected in one soil sample collected from the oil/water separator. No **pesticides or PCBs** were detected in soil samples and no **inorganics** were detected in the soil samples at levels exceeding background levels.*

*No **VOCs, BNAs, pesticides, or PCBs** were detected in the surface water sample collected from the oil/water separator. Cadmium was the only **inorganic** analyte which was detected in the water sample at levels exceeding surface water quality criteria.*

Tank Contents Assessment *- The distribution of contaminants within the oil and water samples collected from the on-site tanks was as follows:*

- *Oil: VOCs, BNAs, and inorganics; and*
- *Water: VOCs, BNAs, and inorganics.*

***VOCs** were detected in the oil samples collected from the on-site tanks at very elevated levels. The VOCs consisted of petroleum-related hydrocarbons and chlorinated hydrocarbons. Total VOC levels exceeded 100 ppm in a majority of the tanks. **BNAs** were detected in the oil samples and consisted primarily of PAHs and bis(2-ethylhexyl)phthalate. Total BNA levels in excess of 1,000 ppm were detected in six of the oil samples. Only PAHs were detected in the oil sludge sample. Oil samples were not analyzed for **pesticides**. No **PCBs** were detected in the oil samples. Iron and lead were the only **inorganics** detected in greater than 50% of the oil samples. The EP Toxicity extract analysis detected barium at a level which exceeds the EP Toxicity federal standard.*

***VOCs** were detected in all of the tank water samples, with total VOC concentrations ranging from 2 to 4,917 ppb. The main VOC compounds detected included the same VOCs detected in the oil*

*samples. **BNAs** detected in the water samples consisted of PAH compounds, phenols, and dibenzofuran. Total BNA concentrations ranged from 31 to 895 ppb. Tank water samples were not analyzed for **pesticides** or **PCBs**. The **inorganics** detected in greater than 50% of the tank water samples include barium, calcium, iron, potassium, magnesium, manganese, and sodium. The analyte concentrations in the water samples were typically higher than those detected in the oil samples.*

Contaminant Fate and Transport (Volume II)

General contaminant fate and transport mechanisms were discussed in the introductory section. The ground water flow direction at this site is to the north and west, towards Gomes Brook and Narragansett Bay. For volatile organic compounds (VOCs), detections were infrequent and at low concentrations in surface soils and subsurface soils. VOCs were detected in ground water. Based on observations in a downgradient well, off-site VOC migration does not currently appear to be a major pathway of migration. BNAs were not prevalent in the matrices sampled at this site, therefore, significant migration is not anticipated. Pesticides were detected in two surface soil samples and one subsurface soil sample only, while PCBs were not detected in any media on-site. Significant migration of pesticides is not anticipated. Inorganics were detected at elevated levels in soils and ground water samples. Evaluation of downgradient ground water samples indicates that off-site migration of inorganics may be occurring.

Human Health Assessment (Volume II)

The exposure scenarios considered in the evaluation of the Tank Farm Five included a trespassing/current use scenario, an industrial/current use scenario (based on presence of new fire fighting training area on-site), a construction/future use scenario, and a residential/future use scenario. The estimated risks, in terms of cancer risk (carcinogenic) and hazard risk (non-carcinogenic) estimates associated with each scenario evaluated and the exposure pathway(s) driving the calculated risks are summarized below:

- ***Trespassing Scenario (Scenario 1)** - The total cancer risk range and the hazard index ratio range for both adults and children are within target values.*

- ***Commercial/Industrial Use Scenario (Scenario 2)** - The total cancer risk range and the hazard index ratio range are within target values.*

- ***Construction Scenario (Scenario 3)*** *- The total cancer risk range and total hazard index ratio range are within target values.*

- ***Residential Use Scenario (Scenario 4)*** *- The total cancer risk range and the hazard index ratio range exceed target values for both children and adult receptors.*

For Scenarios 1, 2 and 3, the major contributing factor to the calculation of cancer risk is ingestion of soil contaminants (arsenic and PAHs). The pathway of primary concern associated with Scenario 4 with respect to cancer risk is ingestion of ground water containing VOCs, arsenic, and beryllium.

The primary contributor to the total hazard index ratio for Scenarios 1, 2 and 3 is ingestion of soil contaminants (thallium, arsenic, antimony and/or mercury). Thallium was not actually detected in the soil but was included in the analysis on the basis of "UJ" data, while arsenic was detected at only one location. Ingestion of inorganics (arsenic, chromium and manganese) in ground water drove the total hazard index ratio for Scenario 4. BNAs also contributed to the total hazard index but their presence was based solely on "UJ" data.

Conclusions and Recommendations

Based on the results of the Remedial Investigation, conclusions regarding the nature of site contamination and human health risks, and recommendations for future site studies can be made.

Significant levels of contamination generally have not been detected at this site. No residual contamination associated with the alleged on-site disposal of tank bottom sludges was identified with the exception of elevated total petroleum hydrocarbon soil levels. The majority of the detected subsurface contamination was detected at Tank 53, where VOCs and BNAs were detected in the ground water and where petroleum product was observed in the monitoring wells. Action levels were exceeded for inorganics in ground water and oil/water separator samples. The site does not pose a potential risk to human heath in its current state but a potential for future risks to human health exists if the site use is changed. Further definition of ground water contamination in association with Tank 53 is being provided under a separate tank closure investigation. Tanks 53 and 56 have been emptied. Additional studies are recommended to further define the extent of TPH in on-site surface soils and determine the significance of inorganic contaminant levels in the soil and/or ground water at this site as compared to background levels. Upon further definition of site contamination, a Feasibility Study is recommended to evaluate potential remedial alternatives.

1.0 INTRODUCTION

This document is the Remedial Investigation (RI) report for the environmental investigation of five sites on the U.S. Navy Naval Education and Training Center (NETC) in Newport, Rhode Island. The location of the NETC, also referred to as the Newport Naval Base, is shown on Figure 1-1. The five sites included in the investigation are the McAllister Point Landfill (Site 01), Melville North Landfill (Site 02), Old Fire Fighting Training Area (Site 09), Tank Farm Four (Site 12), and Tank Farm Five (Site 13). The locations of the sites at the NETC are shown on Figure 1-2. These sites are being studied by the Navy under the Department of Defense Installation Restoration (IR) Program, which is similar to the U.S. EPA's Superfund program authorized under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). The entire NETC was listed on the U.S. EPA National Priorities List (NPL) of abandoned or uncontrolled hazardous waste sites in November 1989. The NPL identifies those sites which pose a significant threat to public health or environment.

The RI of the five above listed NETC sites was conducted by TRC Environmental Consultants, Inc. (TRC) under a contract with the U.S. Navy. The scope of work for the RI Work Plan was specified in the subject contract between the Navy and TRC, dated March 9, 1988. The final RI Work Plan (TRC, 1989) was submitted to the Navy in March 1989. The RI Work Plan consists of the following five volumes: Background Investigation Report, Field Sampling Plan,

Quality Assurance/Quality Control Plan, Data Management Plan, and Health and Safety Plan. This RI report presents the findings and conclusions of the RI field activities conducted according to the RI Work Plan.

The RI field investigation activities were conducted between November 1989 and July 1990. Field investigation activities initially began solely on Site 01-McAllister Point Landfill in November 1989. Field investigation activities on the other four sites began in April 1990 and were completed in July 1990 along with some additional work on Site 01.

This RI report provides a summary of background information for the NETC and the five sites investigated, details on the field investigation scope and methods, and a discussion of the nature and extent of contamination at the five sites. The risk assessment portion of this RI is also being submitted as Volume II of this document.

1.1 Objectives and Scope of Investigations

The general objectives of the NETC site investigations were to determine the nature and extent of site contamination, sources of contamination, potential contaminant migration pathways, potential contaminant receptors, and associated exposure pathways. This information is necessary to determine whether, and to what extent, a threat to human health or the environment exists, and to provide the information required to develop and evaluate remedial action alternatives for each site.

The scope of the sampling effort for each site was developed to meet site-specific RI/FS objectives. As presented in the RI Work Plan, the specific investigation objectives for each site are presented as follows.

Site 01 - McAllister Point Landfill

- determine the presence and nature of surface soil contamination;
- determine the extent of fill material;
- determine the nature of fill material contamination;
- determine the nature and extent of ground water contamination; and
- determine the nature and extent of sediment and biota contamination in the adjacent bay.

Site 02 - Melville North Landfill

- determine the presence and nature of surface soil contamination;
- determine the nature and extent of contamination related to the oily deposits on a portion of the site;
- determine the location of the waste lagoons suspected to previously exist on the site;

- determine the nature of contamination related to the suspected waste lagoons;
- determine the location and extent of fill material;
- determine the nature of fill material contamination;
- determine the presence and nature of ground water contamination;
- determine the presence and nature of sediment and biota contamination in the adjacent bay;
- determine the presence and nature of sediment contamination in the wetlands adjacent to the site.

Site 09 - Old Fire Fighting Training Area

- determine the presence and nature of surface soil contamination;
- determine the nature and extent of subsurface soil contamination;
- determine the presence and nature of ground water contamination;
- determine the presence and nature of sediment and biota contamination in the adjacent bay.

Site 12 - Tank Farm Four

- determine the presence of surface soil contamination;
- determine the physical and chemical characteristics of the contents of the underground storage tanks;
- determine the locations of past sludge disposal/burning areas;
- determine the nature of contamination associated with the past sludge disposal/burning areas;
- determine the presence and nature of contamination in the oil/water separator;
- determine the nature and extent of ground water contamination; and
- determine the nature and extent of surface water and sediment contamination in the on-site brook.

Site 13 - Tank Farm Five

- determine the presence of surface soil contamination;

- determine the physical and chemical characteristics of the contents of the underground storage tanks;
- determine the locations of past sludge disposal/burning areas;
- determine the nature of contamination associated with the past sludge disposal/burning areas;
- determine the presence and nature of contamination in the burning pit;
- determine the nature and extent of ground water contamination; and
- determine the nature and extent of surface water and sediment contamination in the on-site brook.

1.2 NETC Background

1.2.1 NETC Description

The NETC is located in Newport, Rhode Island, on the west shore of Aquidneck Island, facing the east passage of Narragansett Bay. A general location map of the NETC is provided as Figure 1-1. The NETC is approximately 60 miles south of Boston and 25 miles southeast of Providence. Long Island Sound and the Atlantic Ocean are approximately 6 miles south of the naval complex.

NETC presently encompasses approximately 1,374 acres of active land, which is significantly below the 2,805 acres held prior to the 1973 Shore Establishment Realignment Program (SER) (Navy, 1986). Impacts of the SER are described in more detail in Section 1.2.2. The NETC is spread out along nearly 6 miles of shoreline of Aquidneck Island and borders Narragansett Bay. Portions of the NETC lie within the boundaries of the Towns of Newport, Middletown, and Portsmouth.

1.2.2 NETC History

Extensive information on the history of the Newport Naval Base was presented in the Initial Assessment Study (IAS) (Envirodyne Engineers, 1983), and Confirmation Study (CS) (Loureiro Engineering Associates, 1985). Therefore, text from these reports have been incorporated herein, and referenced with a "IAS" or "CS" and the appropriate reference page numbers. The following information on

the history of the Newport Naval Base was obtained from the IAS report.

> The Newport area was first used by the Navy during the Civil War when the Naval Academy was moved from Annapolis, Maryland to Newport in order to protect it from Confederate troops. The Naval Academy operated at Newport for about four years before returning to Annapolis.
>
> In 1869, the experimental Torpedo Station at Goat Island was established. This was the Navy's first permanent activity at Newport. The station was responsible for developing torpedoes and conducting experimental work on other forms of naval ordnance.
>
> In 1881, Coasters Harbor Island was acquired by the Navy from the City of Newport and used for training purposes. In 1884, the Naval War College was established on the island. A causeway and bridge linking the island to the mainland was constructed in 1892. In 1894, the USS Constellation was permanently anchored as a training ship for the Naval War College.
>
> The Melville area was established as a coaling station for the steam-powered ships in 1900. The Navy purchased 160 acres of land and constructed the Narragansett Bay Coal Depot. With the advent of ships burning liquid fuel, it became necessary to add oil tanks. Consequently, in 1910, four fuel oil tanks were added in the Melville area. These tanks are still used today.
>
> In 1913, the Navy established the Naval Hospital on the mainland of Aquidneck Island, directly adjacent to Coasters Harbor Island. At this time, the main hospital building was constructed.
>
> The outbreak of World War I caused a significant increase in military activity at Newport. Some 1,700 men were sent to Newport and housed in tents on Coddington Point and Coasters Harbor Island. A bridge was built at this time connecting Coddington Point with Coasters Harbor Island. In 1918, Coddington Point was purchased by the Navy. Much of the base organization was then transferred to Coddington Point. During the war, numerous destroyers and cruisers were fueled by the Melville coal depot and fuel tanks. By this time, a pipeline had been extended to the north fueling pier and two additional oil tanks constructed.

Following World War I, fuel oil gradually replaced the use of coal by the Navy fleet. In 1921, the Coal Depot was changed to the Navy Fuel Depot. In 1931, the coal barges and coaling equipment were sold to the highest bidder.

In 1923, some two hundred buildings, which were part of the emergency war camps established on Coddington Point, were stripped and sold for scrap. The station was put on caretaker status in 1933. The base remained relatively inactive until the onset of World War II.

Reactivation of the base occurred in the late 1930s as a result of military build-up in Europe. Just prior to the reactivation, a 1938 hurricane and tidal wave had destroyed or severely damaged over 100 buildings and much of the sea walls. In 1940, Coddington Cove was acquired for use as a supply station, and hundreds of Quonset huts were constructed throughout the base. Additional barracks were constructed on Coasters Harbor Island, increasing the base housing capacity to over 3,500 men. Power plant facilities were also constructed at this time. Coddington Point was reactivated to house thousands of recruits. The Anchorage housing complex in the Coddington Cove area was constructed in 1942. In the Melville area, additional fuel facilities were constructed along with a Motor Torpedo Squadron Boat Training Center and nets for harbor defense were constructed. Tank Farms 1 through 5 were constructed during this time period. The Fire Fighting School, Fire Control Training Building, and the Steam Engineering Building were constructed in 1944.

The Torpedo Station at Goat Island was very active during World War II and had expanded its operation to Gould Island. The Torpedo Station employed more than 13,000 people and manufactured 80 percent of all torpedoes used by our country during the war. The station was the largest single industry ever operated in Rhode Island.

Following World War II, naval activities at Newport converted to a peace time status. This resulted in a reduction of naval activity. Some 300 Quonset huts and buildings were removed, and the entire naval complex was consolidated into a single naval command designated the U.S. Naval Base in 1946.

The Naval Base adjusted to its peace time status by increasing its activities in the fields of research and development, specialized training, and preparedness for modern warfare. There was a brief period during the Korean War when some 25,000 sailors trained at Newport.

In 1951, the Torpedo Station was permanently disestablished after 83 years of service. Future manufacture of torpedoes was to be awarded to private industry. In place of the Torpedo Station, a new research and development facility, the Naval Underwater Ordnance Station, was established and given the responsibility of overseeing the private contractors. The Officer Candidate School was also established in 1951.

In 1952, the Training Station and other naval schools were disestablished, and the U.S. Naval Station and the U.S. Naval Schools Command were established.

In 1955, Pier 1 was constructed, with Pier 2 being added in 1957. Newport became the headquarters of the Commander Cruiser-Destroyer Force Atlantic in 1962. Some 55 naval warships and auxiliary craft were homeported at Newport. New housing and bachelor quarters were added in the late 50's and early 60's.

Major expansion of the Naval War College occurred during the late 50's and early 70's, transforming the college into a major university. In July of 1971, the Naval Schools Command was restructured and named the Naval Officer Training Center (NOTC).

In April of 1973, the Shore Establishment Realignment Program (SER) was announced and resulted in the largest reorganization of Naval forces in the Newport area. The fleet stationed in Newport was relocated to other naval stations on the east coast. SER resulted in the disestablishment of the Naval Communication Station and the Fleet Training Center and related activities. The Public Works Center, Naval Supply Center, Naval Station and Naval Base were absorbed by NOTC. In April of 1974, NOTC was changed to the Naval Education and Training Center (NETC).

The drastic changes which resulted from SER caused a reduction of Navy personnel, both military and civilian, in excess of 14,000. Coupled with the reductions at the Naval Construction Battalion Center at Davisville, and the closure of the Naval Air Station at Quonset Point, SER had severe economic impacts in the Narragansett Bay area.

The reorganization brought about by SER resulted in the Navy excessing some 1,629 [1,374] acres of its 2,420 [2,805] acres. Some of the land has been leased to the State of Rhode Island pending final sale of the land by the General Services Administration. Table 1-1 shows an

area by area breakdown on land holdings prior to SER and following. The Navy also leases 44 acres of land in Coddington Cove to the State of Rhode Island and Economic Development Corporation. The state has subleased this property to a private enterprise engaging in shipbuilding and repair. Also, a fish food processing operation utilizes the cold storage warehouse in Building 42 near Pier 1.

The above information on the history of the installation was obtained from the most recent Master Plan (NORTHDIV, 1980), the 1981 Annual Report of the Navy in the Rhode Island Area (NETC Public Affairs Office, 1981), and the Command Histories at the Naval History Office in Washington, DC.

(IAS, pp. 5-6 to 5-14)

1.2.3 Historic Site Map/Aerial Photo Review Summary

Historic site maps and plans for the NETC facility as well as historic aerial photos and photo prints were reviewed to identify the locations and extent of historic site activities and previous site structures and their uses. A detailed list of the photos and maps reviewed and associated descriptions is presented in Appendix B. Summaries of the information obtained from the site map and aerial photo reviews for each site are presented below.

Site 01 - McAllister Point Landfill

Aerial photos and facility maps were reviewed covering the years from 1938 to 1988. Activity on the site dates back to 1938, with a railroad spur entering the site near the current site entrance, and running north into the center of the site. Throughout the 1940's and 1950's, large open

depressions are visible, along with material storage areas and apparent tanks. From 1958 through 1970, an incinerator is visible in the north-central portion of the site. From 1965 through 1975, the shoreline of the central portion of the site changes shape, indicating filling of Narragansett Bay in this area. In 1981 and 1988 photos, the site appears to be generally inactive.

Site 02 - Melville North Landfill

Aerial photos and facility maps were reviewed for the period from 1938 through 1988. Activity on the site dates back to 1951, where lagoons and a structure which could be a building or tank are visible on the site. In a 1953 photo, a lagoon appears to be emitting smoke from its surface. Areas of ponded water are visible at various locations throughout the site from 1951 until 1975. In an undated photo estimated to have been taken between 1970 and 1975, two obviously man-made impoundments are visible along the northern spur of the site access road (see Figure 1-3).

Site 09 - Old Fire Fighting Training Area

Aerial photos and facility maps were reviewed for the period from 1939 through 1988. Activity on the site dates back to 1943, with a site map which indicated the locations of structures and site features associated with fire fighting training exercises. Based on this map and subsequent facility

maps, on-site structures included an administration building, hose house, two carrier compartments, smothering pit, separator pit, foam pit, simulated ship structures, suction pumps and oil tanks. The structure currently used as a day care center was used as "wash and dressing rooms". No significant visible site changes are noted until 1975, when all structures and facilities associated with the fire fighting training area no longer exist, with exception of the hose house and day care center structure. As of 1987, the site appears similar to its current condition, with soil mounds visible in the central and western portions of the site and a pavilion in the east-central portion of the site.

Site 12 - Tank Farm Four

Aerial photos and facility maps were reviewed for the period from 1938 through 1988. Activity on the site dates back to 1942 blackline photo prints, which show the tank farm under construction. In the early 1950's, two shedlike structures were located along the site access road (near the access road to the oil/water separator) and Norman's Brook was dammed and a reservoir formed at the point where the brook exits the site. A 1965 aerial photo identifies site features similar to the way they exist today. The access road, substation building, pole barn, and oil/water separator are all visible. The site generally remains unchanged through 1988.

Site 13 - Tank Farm Five

Aerial photos and facility maps were reviewed for the period from 1938 through 1988. Activity on the site dates back to 1942 blackline photo prints which show the tank farm under construction. In a 1963 aerial photo, the site features appear similar to the way they appear today. The tank farm is visible, along with a main access road which encircles the tanks, and two spur, which split off to the north. The oil/water separator is visible to the west of the westernmost spur. A transformer vault is present along the northern side of the main access road. No significant site changes are visible through 1988.

1.3 Site Background

This section presents a general description of the five sites addressed in this investigation, along with a review of the history of each site . Extensive information on the history of NETC sites was gathered from the IAS report (Envirodyne Engineers, 1983) and CS report (Loureiro Engineering Associates, 1985). Therefore, text has been incorporated from these reports and is referenced with a "IAS" or "CS" and the appropriate reference page numbers.

1.3.1 Site 01 - McAllister Point Landfill

The following subsections present both the general site description and history for this site.

Site Description

The McAllister Point Landfill is located in the central portion of the Newport Naval Base (see Figure 1-2). The site is approximately 6 acres in size and is situated between Defense Highway and Narragansett Bay. A set of Penn Central Railroad tracks run in a north-south direction along the eastern side of the site. Access to the site is off of Defense Highway, across the railroad tracks, through a gate in the south-central portion of the site. A map of the site is presented as Figure 1-4.

A short section of chain-link fence borders the eastern edge of the site at the site entrance and transects the south central portion of the site. An opening in the portion of the fence which

transects the site allows travel between the central and southern portions of the site. Overhead power lines run along the eastern edge of the site.

The site is characterized by a mounded area in the central to north-central portion of the site and flat areas at the northern and southern ends. Ground elevations across the main portion of the site vary between approximately 15 and 35 feet above mean low water level (mlw). Along the western edge of the site, the grade drops off quickly to the shoreline, in some areas by as much as 20 feet.

The site is vegetated with grass, weeds, and some small trees. A small, lightly wooded area is present at the northern end of the mounded area. A more mature wooded area is present just off the northeastern edge of the site between the railroad tracks and Defense Highway. Several depressions are present in the central portion of the site where standing water collects during precipitation events. The Navy routinely clears vegetation along overhead power lines which run between the edge of the site and the railroad tracks.

Site History

The McAllister Point Landfill was investigated in both the IAS and CS. The following site history information was obtained from the IAS report.

> This is the site of a sanitary landfill which was operational over a 20-year period. The site was first used in 1955 following the closure of the landfill in Melville North. The site continued to be used as a

landfill until the mid-1970's and encompasses approximately 6 acres. The site is located on land which is being excessed by the Navy.

During the years that the site was operational, it received all the wastes which were generated at the naval complex. This included wastes from all the operational areas (machine shops, ship repair, NUSC, etc.), Navy housing areas (domestic refuse), and from the 55 ships which were homeported at Newport prior to the 1973 SER action. Generally, 25 to 30 of these ships were in port at any one time. Each day, fourteen 40-cubic yard containers were emptied from the pier areas and disposed of in the landfill. The materials disposed of at this site included spent acids, paints, solvents, waste oils (diesel, lube and fuel), and PCB-contaminated transformer oil.

The operators of the landfill indicated that it was common practice for barrels filled with liquids to be brought to the landfill. These barrels contained paints, oils and other unidentifiable liquids. The barrels were crushed by the bulldozer operator before being covered. It was also discovered through interviews with base personnel that at least two transformers, each of which contained approximately 100 gallons of PCB-contaminated oil, and at least 4 or 5 capacitors were disposed of in the landfill. The Superfund notification for McAllister Point indicated that PCBs were disposed of at the site.

For the period 1955 through 1964, wastes were simply trucked to the site, spread out with a bulldozer, and then covered over. In 1965, an incinerator was built at the landfill. From 1965 through 1970-71, some 98 percent of all the wastes were burned before being disposed of in the landfill. The incinerator was closed about 1970 as a result of the air pollution it was causing. During the remaining years that the site was operational, all wastes were again disposed of directly into the landfill.

The site is located along the shoreline of Narragansett Bay as shown in Figure 1-2. Throughout the time period that the site was operational, the landfill was extended out into the bay using the wastes as fill material. The site used to be subject to periodic flooding until the elevation of the site was increased through additional filling. . . .

Operations at the site were discontinued in the mid-1970's. Following this, all wastes generated at NETC were disposed of at the City of Newport's transfer

station. A final covering of soil three feet thick was placed over the NETC landfill following its closure.

(IAS, pp. 6-25, 6-31)

The site is still planned to be excessed by the Navy. Currently, the site is zoned by the Navy as "open space" (e.g., recreational use, parking).

1.3.2 Site 02 - Melville North Landfill

The following subsections present both the general site description and history for the Melville North Landfill.

Site Description

The Melville North Landfill is located at the northern end of the Newport Naval Base (see Figure 1-2). The site is approximately 10 acres in size and is situated between Defense Highway and Narragansett Bay. A set of Penn Central Railroad tracks run in an approximate north-south direction on the eastern side of the site. Access to the site is off of Defense Highway through a small gate and along a paved entrance way. The paved entrance way leads approximately 180 feet down a small hill and across the railroad tracks to the site. A map of the site is presented on Figure 1-5.

The site is relatively flat across the central to northern portions. In the southern portion of the site a slight ridge runs along the eastern half of the site. At the northern end of the site is a waste pile area which covers approximately 6,000 square feet and is approximately 5 feet above grade at its highest point.

Ground elevations across the main portion of the site vary between approximately 10 and 20 feet above mean sea level. Along the western edge of the site, the grade of the site is nearly level with the shoreline. As you proceed from the site to Defense Highway there is an increase in elevation of approximately 40 feet.

The site is vegetated with grass, weeds, and some small trees. A strip of small trees is present along the edge of the bay in the west-central portion of the site. A small, more densely wooded area is present along the edge of the bay in the southern portion of the site. Just off of the site, a wooded area is present along the central to southern edge of the site, between the site and Defense Highway. The Navy routinely clears vegetation along the overhead power lines which run along the eastern edge of the site.

Site History

The Melville North Landfill site was investigated in both the IAS and CS. The following site history information was obtained from the IAS report.

> This site was used as a landfill for at least the period following World War II until 1955. The date that the site first began to be used as a landfill is unclear, but all indications are that it was after the war. Following its closure in 1954, wastes generated at the naval complex were disposed of at the McAllister Point Landfill. The site encompasses approximately 10 acres.
>
> The Melville North Landfill would have received wastes similar to those which were disposed of in McAllister Point Landfill, including spent acids, waste paints, solvents, waste oils (diesel, fuel, lube) and, potentially, PCBs. The quantity of these wastes disposed of in the landfill is unknown. During visual inspections of the site, areas covered with oil and oil sludge were found to be scattered throughout the site. There were

> mounds of oil-soaked soil which appeared to have been trucked to the site and dumped. These oil-contaminated mounds could be the oil sludge material obtained from the tank farms during tank cleaning operations, or the result of cleanup operations following oil spills.
>
> The site is situated in the Melville North area in a low-lying wetland type area along the shoreline of Narragansett Bay, as shown in Figure 1-2. The area is subject to periodic flooding and lies within the 100-year flood plain (NETC Master Plan, 1980). This site is located on land which is being excessed by the Navy and is pending final disposal by GSA.

(IAS, pg. 6-34)

The site was excessed by the Navy in September 1983 to the State of Rhode Island. Six months later, the site was sold to Melville Marine Industries. The planned development for the site is a marina.

1.3.3 Site 09 - Old Fire Fighting Training Area

The following subsections present both the general site description and history for the former Fire Fighting Training Area.

Site Description

The site occupies approximately 5 acres at the northern end of Coasters Harbor Island. Presently, the site contains a child care facility, picnic area, playground, and baseball field. The only unique topographic features at the site are two soil mounds: one that is approximately 15 feet high located in the center of the site, and another that is approximately 6 feet high located in the western corner of the site. A map of the site is presented on Figure 1-6.

Site History

This site was not investigated in detail during the IAS and was not studied in the CS. The site was not studied in the CS because the conclusions of the IAS stated that the site did not warrant any further action. It was decided by the Navy to investigate the site further after the discovery of oily subsurface soils during a 1987 geotechnical boring investigation related to the planned expansion of the on-site child care facility.

This site was used from World War II to 1972 as a fire fighting training area. A 1943 construction drawing for the Fire Fighting Training Area shows how it appeared when operational. The site details from the 1943 drawing are provided on Figure 1-7. It is believed that the two buildings labeled "Carrier Compartment" had a water/oil mixture injected into them which was set on fire for fire fighting practice. Underground piping carried the water/oil mixture to the buildings and from the buildings to the oil-water separator shown on the figure.

1.3.4 Site 12 - Tank Farm Four

The following subsections present the general site description and history of Tank Farm Four.

Site Description

Tank Farm 4 is located in the northern portion of the Newport Naval Base, in the town of Portsmouth. The tank farm is

approximately 80 acres in size. The site is located just east of Narragansett Bay. Defense Highway borders the western edge of the site. Wooded, undeveloped areas are located just north and south of the site. A residential development is located east of the site. A map of Tank Farm Four is presented on Figure 1-8.

Access to the site is from the west, off of Defense Highway, through a gate and along a paved entrance way which leads to the central portion of the site. The paved road continues through the site in a loop, past all of the underground storage tank locations. Adjacent to each of the UST locations are pump/valve houses for the tanks. At the western side of the tank area is a small metal building which was used as the electrical substation during the operation of the tank farm. In the northeastern corner of the site is a small dirt road which leads to a wooden pole barn currently used for the storage of hay. A concrete structure which was used as an oil-water separator is located at the end of an extension of the paved road, near the entrance to the site.

The site topography generally slopes to the west. The ground elevation generally ranges from 25 feet above mlwl in the western corner of the site to 120 feet above mlwl in the eastern corner of the site. In the vicinity of a brook (Normans Brook) which crosses the western corner of the site, the ground elevation falls to mean low water level. The brook flows off-site and into Narragansett Bay.

The site is vegetated with grass, weeds, brush, and some trees. The central portion of the site where the tanks are located

is covered with grass and weeds. This portion of the site is routinely cleared of brush for use as grazing land by cows which are kept on the site. The grazing by the cows also keeps the grass down in this area. The remaining portion of the site is covered by dense brush and some trees. The majority of the more mature pine trees are located along the eastern edge of the site.

Site History

Tank Farm Four was studied in both the IAS and the CS. The following site history information was obtained from the IAS report.

> Tank Farm Four was used for the storage of diesel and fuel oil and consists of twelve 60,000-barrel underground storage tanks. Disposal at the site was from World War II until the mid-1970's. The tank bottom sludge, obtained during cleaning operations, was disposed of directly onto the ground in the vicinity of the tank being cleaned. Between 100,000 and 190,000 gallons of oil sludge, which is a hazardous waste in Rhode Island, was disposed of at this site. The sludge is no longer evident on the surface but probably covered the entire Tank Farm. This site is located within one quarter mile of Narragansett Bay. This site is on land which is being excessed by the Navy.

(IAS, pg 2-8)

The Navy has withdrawn its plans to excess the site's land.

1.3.5 Site 13 - Tank Farm Five

The following subsections present the general site description and history of Tank Farm Five.

Site Description

Tank Farm 5 is located in the north-central portion of the Newport Naval Base in the town of Middletown. The tank farm is approximately 80 acres in size. The site is located just east of Narragansett Bay. Defense Highway borders the western edge of the site. A road (Greene Lane) borders the site to the northeast. East of the site is a residential development. To the south is a wooded area and cemetery. A map of Tank Farm Five is presented on Figure 1-9.

Access to the site is from the west, off of Defense Highway through a gate and along a paved entrance way which leads to the central portion of the site. Just inside the entrance and north of the paved road is the new Fire Fighting Training area which occupies approximately 3 acres and is surrounded by a chain link fence. The paved road continues through the site in a loop past all of the underground storage tank locations. Adjacent to each of the UST locations are pump/valve houses for the tanks. At the western side of the tank area is a small metal building which was used as the electrical substation during the operation of the tank farm. A concrete structure which was used as an oil-water separator is located at the end of an extension of the paved road, just northeast of the new Fire Fighting Training Center.

The site topography generally slopes to the north. The ground elevation generally ranges from 25 feet above mlwl in the northern corner of the site to 90 feet above mlwl at the southern edge of the site. In the vicinity of a brook (Gomes Brook) which crosses

through the northeastern portion of the site, the ground elevations fall to mean low water level. The brook flows off-site and into Narragansett Bay.

The site is vegetated with grass, weeds, brush, and some trees. Most of the site is covered by very dense brush. The area around the new Fire Fighting Training area is grassy with new sod. The majority of the more mature trees are located in the northern and southern corners of the site.

Site History

Tank Farm Five was studied during the IAS but not during the CS; however, two of the tanks at the site were examined further as part of a tank closure study conducted from 1985 to 1986. The following is a summary of the history of the site as presented in the IAS report.

> The site was used for the storage of diesel and fuel oil and consisted of eleven 60,000-barrel underground storage tanks. Disposal at this site has been from World War II until the mid-1970's. The tank bottom sludge, obtained during cleaning operations, was disposed of in a burning pit. This burning pit had steel sides and a sand bottom.
>
> The sludge was placed in the pit and burned. Between 100,000 and 175,000 gallons of oil sludge were disposed of at this site. This oil sludge is considered a hazardous waste in Rhode Island. This site is located within 1,000 feet of Narragansett Bay. With the exception of Tanks 53 and 56, this site is being excessed by the Navy.

(IAS, pg. 2-8)

The Navy has withdrawn its plans to excess all but 1.75 acres of the site's land. The 1.75 acres of land, located in the eastern

corner of the site along Green Lane, was previously sold to the town of Middletown.

1.4 Previous Environmental Investigations

This section presents a brief chronology of the interactions between the NETC and governmental agencies (e.g., RIDEM, US EPA) concerning environmental issues at the Newport Naval base. In addition, a summary of the findings of previous environmental investigations of the five sites is presented.

Chronology of Regulatory and Navy Actions

The following pre-RI chronology of NETC environmentally-related activities was obtained from the IAS report, the Draft Tank Closure Plan for Tanks 53 and 56, a review of information in RIDEM files, and other sources.

- Mid-1960's - burning of oil tank bottom sludges discontinued because of air pollution regulations.
- Unknown Date - all of NETC shoreline closed to shellfishing due to concerns about bioaccumulation of contaminants in Narragansett Bay from sites on the facility.
- September 11, 1980 - the Navy Assessment and Control of Installation Pollutants (NACIP) program was initiated. The purpose of the program is to systematically identify, assess, and control environmental contamination from past use and disposal of hazardous substances at Navy and Marine Corps installations. (Note: This study is being conducted under the Department of Defense Installation Restoration Program.)
- August 3, 1981 - NETC was designated for an Initial Assessment Study (IAS) by the Chief of Naval Operations.
- April 26, 1982 - Contract awarded to Envirodyne Engineers, Inc (EEI) to perform the IAS.
- 1982 - the RIDEM adopted hazardous waste regulations which classified waste oil as a hazardous waste.

- March 1983 - the IAS of the NETC completed by EEI.
- October 1983 - the Verification Step of the Confirmation Study for IAS sites at which further action was recommended is begun by Loureiro Engineering Associates (Loureiro).
- September 1984 - the Characterization Step of the Confirmation Study is begun by Loureiro.
- 1984 - the Navy ceased using Tanks 53 and 56 at Tank Farm Five for waste oil storage.
- 1986 - the RIDEM implemented new regulations for the operation and closure of underground storage tanks used to hold oils and hazardous materials.
- May 1986 - the Confirmation Study report for the NETC is completed by Loureiro.
- 1988 - Tank Closure Plan for Tanks 53 and 56 located at Tank Farm Five completed and closure option selected for implementation.
- July 1989 - the NETC proposed for the U.S. EPA NPL.
- November 1989 - addition of the NETC to the NPL becomes final.

Summary of Environmental Investigations

Previous investigations for the sites included either Initial Assessment Studies (IAS) and/or Confirmation Studies (CS). The IAS involves the initial environmental assessment of a site based upon site background information and a site visit. An IAS was conducted at all five of the subject sites. A CS, which involves the collection of environmental samples from a site, was conducted for three of these sites. Environmental samples were collected during the two phases of the CS (the Verification Step and the Characterization Step) for the McAllister Point and Melville North landfills and Tank Farm Four.

Although Tank Farm Five was not investigated under the CS, soil and ground water samples were collected at Tank Farm Five as part of an underground storage tank closure for two tanks on the site. An IAS was conducted for the Old Fire Fighting Training Area site; however, no CS was performed and no environmental samples have been collected from the site. The following is summary of the previous environmental investigations conducted for each of the sites.

1.4.1 Site 01 - McAllister Point Landfill

An IAS was completed for the McAllister Point Landfill in 1983. The history of waste disposal at the McAllister Point Landfill, as presented in the IAS and Section 1.3.1 of this report, directed the need for further environmental investigations at the site. The Verification and Characterization steps of environmental sampling were conducted at McAllister Point Landfill during the CS from 1984 to 1985. During the Verification Step of the CS, five sediment and five blue mussel samples were collected adjacent to the site from Narragansett Bay, along with three landfill leachate samples and one composite soil sample (collected from six locations on the landfill cover) (see Figure 1-10). In addition, background samples for the sediment and mussels were collected from Narragansett Bay. During the second phase of the CS, the Characterization Step, additional mussel and sediment samples were collected and a ground water investigation was performed at the site.

Surface Soil

One composite surface soil sample was collected from the site in the Verification Step of the CS. The surface soil sample was analyzed for the full list of priority pollutants. The locations from which the surface soil sample aliquots were collected are shown on Figure 1-10. The surface soil sample aliquots were collected along the approximate north-south central axis of the site. The sampling points were selected at places where vegetation was absent. The surface soil sample results are presented in Table 1-2.

Low concentrations of contamination were detected in the composite surface soil sample. The low levels detected in the sample included detectable concentrations for several metals (Cr, Cu, Pb, Ni, Zn), total cyanide (47 parts per billion (ppb)) and total phenol (27 ppb). No priority pollutant volatile organics, semi-volatile organics, or pesticides/PCBs were detected in the soil sample. However, given that this composite surface soil sample was reportedly collected from the capped portion of the landfill, the results for this sample are not considered representative of the surface soil quality resulting from the operation of the landfill.

Leachate Springs

The two leachate springs (Nos. 07, 08) sampled during the IAS investigation were located along the western edge of the landfill. The locations of the leachate springs are shown on Figure 1-10.

Spring number 08 was sampled twice during the investigation, once during wet weather and again during dry weather. Spring number 07 was sampled once during wet weather. Spring number 08 produced a greater flow of leachate than spring number 07. The leachate spring samples were analyzed for all of the priority pollutant compounds except the pesticides and PCBs. The leachate spring sample results are presented in Table 1-2.

All of the leachate samples contained detectable levels of cadmium (0.028 to 0.058 ppb), total cyanide (0.017 to 0.867 ppb) and total phenols (0.006 to 0.016 ppb). Spring number 08 also contained detectable levels of chromium during both the wet and dry sampling events (0.028 ppb and 0.032 ppb, respectively). The sample from spring number 07 was also found to contain two volatile organic compounds, ethylbenzene (30 ppb) and toluene (26 ppb).

The EPA has established salt water quality standards for metals under the Clean Water Act. These water quality standards apply to the homogenized water offshore from a discharge point rather than to the quality of the discharge (in this case the leachate). Although these water quality standards do not apply directly to the leachate sample results, the standards do provide a relative framework in which to evaluate the leachate sample metals results. Also note that the salt water quality standard for cyanide applies to free cyanide rather than total cyanide as measured in this study. The salt water quality standards are provided with the leachate sample data in Table 1-2.

The concentrations of metals detected in the leachate samples are significantly below any established salt water metals standards. Also the resulting concentration of the metals in the bay water offshore from the landfill would likely be well below the established salt water standards as a result of the dilution effects of the bay. The concentration of volatile organic compounds detected in one of the leachate samples would also likely be much lower, if detected at all, in the bay water as a result of the high solubility of the compounds and dilution effects of the bay. However, it is important to note that metals and some organic compounds, such as PCBs and PAHs, can accumulate in sediments and shellfish and, thereby, potentially pose a threat to human health and the environment.

Sediment and Mussels

Sediment and blue mussels were sampled from Narragansett Bay along the length of the landfill. Given that no regulatory standards exist for contaminants in sediment or mussels, sample results were compared to background sample concentrations. The background samples N-1 and N-2 were collected from Narragansett Bay; N-1 was collected from approximately 4.5 miles north of the site along the Portsmouth shoreline, and N-2 from approximately 2 miles south of the site along the eastern shoreline of Conanicut Island (see Figure 1-1).

Sediment and mussel samples were collected from five (5) locations along the landfill shoreline in the Verification Step of

the CS. The sediment samples were collected from the 0 to 4 inch depth approximately 25 feet off-shore in one to three feet of water. The mussels were collected in the intertidal zone shoreward of the sediment sampling points. The sediment and mussel samples were analyzed for metals (Cr, Cd, Pb, As, Hg, Se, Ag, Cu, Ba, Ni, Be, Sb, Sn), and total PCBs. The results of the sample analyses are presented in Table 1-3.

In general, the Verification Step sample results indicate that the concentration of several metals increases from north to south along the bay in the sediment samples collected adjacent to the site. Similarly copper, the only metal detected in the mussel samples, increases in concentration for samples collected from north to south. At the southern end of the landfill, near leachate spring number 08, sediment and mussel sample concentrations were several times greater than upstream and background levels.

The initial phases of sediment and biota data indicate that metals contamination exists in sediments and mussels in the bay adjacent to the site. However, PCBs were not detected in the sediment samples. The PCB concentrations detected in the mussel samples (0.29 to 0.38 ppm) did not vary according to location and were not significantly higher than the established background sample results (0.36 and 0.37 ppm). The PCB data suggest that the PCB levels in the mussels are likely due to general, widespread contamination in Narragansett Bay rather than from site-specific contamination.

The second phase of fieldwork, the Characterization Step, was conducted in part to further delineate the sediment and mussel metals contamination around the southern end of the landfill. Mussels were resampled at stations 12 and 13. In addition, mussel and sediment samples were collected further south of the site, from a new station (No. 14). Sediment samples were also collected from six additional sampling points located approximately 100 to 300 feet offshore. The locations of the Characterization Step mussel and sediment samples are shown on Figure 1-11. The mussel samples were analyzed for a select list of metals (lead, copper, chromium, and nickel). The sediment samples were analyzed for a select list of metals (lead, copper, chromium, and nickel), EP Toxicity metals, and cyanide. The mussel and sediment sample results are presented in Table 1-4.

The metals analytical results for the mussel samples collected during the Characterization Step differed from the prior mussel sample results in that four metals (lead, copper, chromium, and nickel) were detected in the second round as compared to just one (copper) in the first round. The change in mussel contaminant concentrations between the two sampling events may be due to seasonal variations; the Verification Step was conducted in November 1983 and the Characterization Step was conducted in September 1984. The concentration changes may also be due to the following sample analytical deficiencies: the duplicate sample results indicate a fairly low degree of precision for the second phase results, with the sample and blind duplicate concentrations

differing by as much as 50%. In either case, the mussel data indicates that contamination from McAllister Point Landfill has migrated at least as far south as Station 14 (see Figure 1-11), although concentrations for the sample collected at Station 12 (northernmost sample) exceeding those detected at Station 14.

The analytical results for the sediment samples collected during the Characterization Step show a clear pattern of decreasing metals concentrations with increasing distance from the landfill. A summary of the sediment metal concentration results for the sediment samples collected during the Characterization Step is provided in Table 1-5. This summary reflects the general trend of decreasing metals concentrations in the sediments as you proceed offshore, away from the site.

Additional sediment and mussel sampling was conducted by the U.S. Army Corps of Engineers (US ACE) in the bay adjacent to McAllister Point Landfill in January 1988. Mussel and sediment samples were collected from seven locations within the intertidal zone; six samples (numbers 1-6) were collected adjacent to the landfill and one sample (number 7) was collected 300 feet north of the site as a control sample. The US ACE sediment/mussel sample locations are shown on Figure 1-13. The samples were analyzed for metals, PCBs, and petroleum hydrocarbons. The US ACE sample results are provided in Table 1-6.

The US ACE sediment sample results indicate that the levels of metals, PCBs, and petroleum hydrocarbons detected in the sediments adjacent to the landfill were consistently at least one order of

magnitude greater than those detected in the control sample. Copper concentrations were detected in some of the mussels samples at levels above that of the control sample (not detected at a detection limit of 1.4 ppm). Chromium was detected in one of the mussel samples (No. 4) at concentrations above that of the control sample (not detected at detection limit of 2 ppm). Zinc was detected in five of the mussel samples at concentrations slightly above that of the control sample. PCBs were detected at elevated concentrations in mussel sample numbers 1 and 4. Petroleum hydrocarbons were detected at elevated concentrations (170 - 1100 ppm) in five of the seven sediment samples. The highest levels of petroleum hydrocarbons were detected in sediment sample numbers 6 (1100 ppm) and 1 (480 ppm).

In summary, the sediment and mussel data show metals, PCB, and petroleum hydrocarbon contamination in the bay near the landfill. The mussel and sediment contamination appears to be primarily localized around the southern end of the landfill. The higher contaminant levels in this area of the bay may be due to two factors: the chemical characteristics of the on-site landfill material near this portion of the bay, and the physical characteristics of the shoreline in this area. More highly contaminated waste materials may be deposited in the portion of the landfill adjacent to this area. Also, the shoreline point which protrudes into the bay at this location may provide, on its southern leeward side, protection against rapid sediment erosion allowing for the accumulation of contaminated sediments. In

addition, the longer surface water residence time on the leeward side of the point would allow more time for contamination to accumulate in sediments and mussels in this area.

Ground Water

During the Characterization Step, two wells were placed in the landfill and a third well was installed in an upgradient location off-site. The well locations are shown on Figure 1-11. The two wells installed within the landfill area, referred to as wells MW-21 and MW-22, were installed in borings of depths of 43 and 30 feet, respectively. The well installed upgradient of the site, referred to as well MW-23, was installed in a boring 40 feet deep. Boring and well logs for each of these well are provided in Appendix C. The logs indicate that each of the wells are apparently screened below the observed water table by depths of 3 to 15 feet.

Ground water samples were collected from the three wells during four different sampling events. During each sampling event, the ground water samples were analyzed for cyanide, metals (lead, copper, chromium, and nickel), chlorides, and Ph. During the third sampling event, the ground water samples were also analyzed for all priority pollutant metals, priority pollutant volatile organics, priority pollutant base neutral/acid extractable organics, cyanide, and phenols. The sample results are provided in Table 1-7.

The ground water sample results indicate that metal contamination exists in the site ground water. Elevated

concentrations of lead, copper, and total phenols were detected in the two downgradient ground water samples. Phthalates were detected in all three ground water samples; however, the greatest concentrations were detected in the upgradient well sample. No other priority pollutants were detected in any of the ground water samples. However, given that all of the wells are apparently screened at least 3 feet below the water table, light non-aqueous phase liquids (LNAPLs) may be present in the ground water at the water table (e.g., petroleum hydrocarbons), despite the evidence presented in the analytical results. There is also a possibility that dense non-aqueous phase liquids (DNAPLs) may also be present in the ground water but were not sampled or detected as a result of the placement of the well screen.

1.4.2 Site 02 - Melville North Landfill

An IAS was completed for the Melville North Landfill in 1983. The history of waste disposal at the landfill as presented in the IAS and Section 1.3.2 of this report, directed the need for further environmental investigations at the site. Verification and Characterization Steps were conducted under the Confirmation Study performed for the Melville North Landfill. The Verification Step involved collecting three sets of sediment and mussel samples adjacent to the site from Narragansett Bay and one composite soil sample from a mound of oil-saturated deposits observed at the site (see Figure 1-14). During the Characterization Step, small test

pits were dug near the mound to visually observe the extent of any oil.

Soil

The composite soil sample collected from the oil-saturated waste deposits was analyzed for lead, total PCBs, and petroleum-based hydrocarbons. The waste sample contained 60 ppm of lead, no detectable PCBs, and 32,508 ppm of petroleum-based hydrocarbons. The petroleum-based hydrocarbon concentration represents over 3% of the waste deposits by weight.

During the Characterization Step, several 3-foot deep test pits were excavated around the perimeter of the oily waste deposits at the northern end of the site. The subsurface soil was inspected in these test pits and no visual evidence of lateral or downward migration of oil from the waste deposits was observed in the area. No samples were collected from the test pits for laboratory analyses.

Sediment and Mussels

Three sediment and mussel samples were collected during the Verification Step from the bay adjacent to the site. The sediment samples were collected from the 0- to 4-inch depth approximately 25 feet off-shore in one to three feet of water. The mussel samples were collected in the intertidal zone, shoreward of the sediment sample locations. The sediment and mussel samples were analyzed

for PCBs and total metals. The detected sample concentrations are provided in Table 1-8.

The sample results indicate that metals and PCB contamination in the mussels and sediments in the bay adjacent to the site does not appear to be attributable to the site. PCBs were detected in the mussel samples but not in the sediment samples. As discussed in connection with the McAllister Point Landfill, the PCB concentrations detected in the mussel samples appear to be the result of general, area-wide bay contamination, as is evident from the similar levels observed in background samples. Similarly, the levels of metals detected in sediment samples collected adjacent to the site are similar in concentration to background samples.

Unlike the McAllister Point Landfill, the Melville North Landfill does not physically protrude into the bay. As previously stated, it is believed that this physical feature of McAllister Point protects the sediments against erosion and may enhance the bioaccumulation of metals in sediments and mussels in that area. Therefore, it is possible that the Melville North landfill is emitting contaminants into the bay; however, the currents may be transporting the contaminants and affected sediments away from the site.

1.4.3 Site 09 - Old Fire Fighting Training Area

An IAS was performed for the site in 1983. The IAS report speculates that, although waste oils were likely used at the site, there are no reports of any environmental problems resulting from the operations at the site. It was also concluded in the IAS

report that "Any oil used at the site is no longer present, and this site does not pose a threat to human health or the environment." The site was one of those sites listed in the IAS report as not requiring further action (i.e., no Confirmation Study).

Given the prior use of the site for fire fighting training exercises, and the likely use of waste oils and solvents in the exercises, a potential for petroleum hydrocarbons, chlorinated solvents, metals, and PCBs contamination exists at the site. This is based on the type of contaminants typically found at such a site and detected around the waste oil storage tanks at Tank Farm Five on the NETC. Because no environmental investigations or sampling were conducted at the site, little was known about the environmental condition of the Old Fire Fighting Training Area site. The surface soil appears visually clean but no sample analytical results existed to confirm this observation. As presented in Section 1.3.3 of this report, geotechnical soil borings drilled on the site in 1987 encountered oil approximately 5 feet below the ground surface. Figure 1-15 shows the locations of the borings. Observations during the drilling indicated that oil was encountered in borings 1 and 2.

Although an aquifer suitable for water supply probably does not exist on Coasters Harbor Island, the potential exists for the oily subsurface soil contamination to contaminate ground water and migrate into the bay. Also, given the prior use of the site as a fire fighting training area and the previous locations of these activities (see Figure 1-7) in relation to the discovered oily

soils, the potential existence of additional subsurface soil contamination is a concern. Any oily subsurface soils may also pose a future hazard to utility workers and others who may excavate in the area. Given the potential human health and environmental risks associated with this site, it was decided by the Navy to address this site through further environmental investigations.

1.4.4 Site 12 - Tank Farm Four

An IAS was completed for Tank Farm Four in 1983. It was reported in the IAS report that tank bottom sludge from the tanks on this site was disposed of onto the ground. Given the possibility of surface soil and ground water contamination at this site, it was listed as requiring further action in the IAS. The Verification and Characterization Steps of the CS were conducted at the Tank Farm Four site. The Verification Step included the collection of a near-surface composite soil sample, a surface water sample, and a stream sediment sample (see Figure 1-16). The Characterization Step involved the collection of water samples from on-site USTs and ground water samples from two on-site wells (see Figure 1-17).

Soil

One composite near-surface soil sample was collected from the site. The near-surface soil sample aliquots were collected from six locations on the site adjacent to six of the on-site underground storage tanks. The near-surface soil sample was

collected to determine the presence of residual oils from the sludge burning operations which reportedly occurred at the site. The sample aliquots were collected from a depth of three feet at each location. The composite sample was analyzed for lead and oil/grease. Lead and oil/grease were detected in the soil sample at concentrations of 3.25 ppm and 216 ppm, respectively. The sample results indicate that oil/grease soil contamination exists at Tank Farm Four, probably as a result of general site operations which occurred during the use of the tanks (e.g., tank filling, tank sludge burning).

Surface Water & Sediment

A surface water and sediment sample were collected for analysis from an on-site swale during the Verification Step of the CS. The location of the samples is shown on Figure 1-16. The sediment sample was collected from the 0- to 4-inch depth. The two samples were analyzed for lead and petroleum-based hydrocarbons.

The surface water and sediment samples both contained petroleum-based hydrocarbons, at 3.6 ppm and 478 ppm, respectively. Lead was not detected in either of the samples. The field sampling personnel observed that the source of water flowing in the swale from which the samples were collected appeared to be ground water seeping from the hillside. Therefore, this may indicate that the shallow ground water in this area of the site is contaminated with hydrocarbons.

Tanks

During the Characterization Step, water samples were collected from 6 of the 12 underground storage tanks on the site. The tank water samples were analyzed for total suspended solids (TSS), lead, pH, ammonia, biochemical oxygen demand (BOD), and petroleum-based hydrocarbons. The tank water sample analyses results are presented in Table 1-9. The tank water sample results indicate that low concentrations (4.0 to 36. 7 ppm) of petroleum-based hydrocarbons exist in the tank contents and that the levels of TSS and BOD vary throughout the six tanks.

Ground Water

During the Characterization Step, two ground water monitoring wells were installed on the site and ground water samples were collected from the wells. The locations of the wells are shown on Figure 1-17. Ground water samples were collected from the wells at four different times between November 1984 and January 1985. The ground water samples were analyzed for lead and petroleum-based hydrocarbons. The results of the ground water sample analyses are presented in Table 1-10.

The ground water samples from both monitoring wells contained detectable concentrations of lead (40-100 ppb) and petroleum-based hydrocarbons (1.9-12.3 ppm) during at least one of the sampling events. The highest levels of ground water contaminants were consistently detected in monitoring well 11.

The position of the monitoring wells is not optimal for intercepting a contaminant plume from Tank Farm Four; the land surface and the hydraulic heads measured in the two monitoring wells indicate that ground water is flowing in the west or south west direction. Thus, given the location of the probable sources of ground water contamination (i.e., the underground storage tanks), the two monitoring wells are to the side (north) of the probable contaminant pathway. In support of this interpretation, monitoring well number MW-11, which is closer to the probable plume position, showed higher contaminant concentrations during each sampling event.

1.4.5 Site 13 - Tank Farm Five

An IAS was conducted for Tank Farm Five. It was reported in the IAS report that tank bottom sludge from the tanks on this site was disposed of in a burning pit, constructed with steel sides and a sand bottom. Given the possibility of surface soil and ground water contamination at this site, it was listed as requiring further action in the IAS. Given the similarity of this site and Tank Farm Four, a CS was not conducted at Tank Farm Five. It was recommended in the IAS that the findings of the investigation of one of the other tank farms (Tank Farms One and Four were addressed in the CS) be used to direct any investigation at this tank farm. Therefore, an environmental assessment for all of Tank Farm Five is not available.

As presented previously in Section 1.3.5, two studies were completed on Tank Farm Five related to two of the underground storage tanks (USTs); a 1983 study on the contents of two of the USTs at the site, and a 1985-86 study required by the RIDEM for the closure of the same two tanks. These two tanks were used for waste oil storage after the other tanks at the site were taken out of service. The scope and findings of the tank closure investigation are presented in a report by Environmental Resource Associates, Inc. (ERA, 1988) and are summarized below.

Tanks

The 1983 ERA tank investigation involved the sampling of tank numbers 53 and 56. Samples of the floating oil layer, water, and bottom sludge were collected from each of the two tanks. Although relatively homogeneous oil was floating on the water surface and relatively oil-free water was present in the bottom 2 feet of the water column, the intervening 28 feet of water appeared to consist of an oil-water emulsion.

Samples from the tanks were collected at 1-foot intervals throughout each tank with a point sampler, which consisted of a cylinder open at both ends, which could be closed by dropping a weight down a connecting cable. It was noted in the ERA tank closure study report that the viscous nature of the floating layer may have fouled the sampler as it was lowered through the oil. It was also noted that determining the presence of oil at intermediate depths was difficult because the floating layer appeared to

interfere with the collection of the water samples. Two oil and two water samples were composited from several of the 1-foot point samples. One oil sample came from only the top floating oil layer, while the other consisted of oil retrieved from thin oil intermediate layers located within the water column. Likewise, one water sample was composited from the bottom 2 feet of the water column, while the other water sample was composited from intermediate levels of the water column. The samples were analyzed for arsenic, lead, and several volatile organic compounds. The sample results are presented in Table 1-11. In the table, the surficial oil and bottom water samples are designated with an "A", preceded by an "O" and "W", respectively, while the samples separated and composited from mixtures collected from the water column are designated with a "B".

The tank sample results indicate that chlorinated solvents are much more concentrated in the oil layer than in the water. The total volatile organic compound concentration detected in the oil samples were 100 to 1000 times greater than that detected in the water samples. This is likely due to the hydrophobic nature of these solvents.

The tank sludge samples were analyzed for eight metals, with all metals except arsenic and selenium detected in the samples. The results of the tank sludge sample analyses are presented in Table 1-12. Although the concentrations of total metals in the sludge were high, the potential for the metals to leach from the sludge and migrate with the tank water into the environment is not

known. Given that the metals would be more likely to leach from the sludge under acidic conditions, the results of the pH measurements conducted on the tank water (pH ranged from 5.6 to 8.1) tend to indicate that the metals should remain adsorbed to the solid fraction. Leachate tests were not performed on any of the sludge samples collected during the tank closure investigation.

During 1985, samples were collected from the floating oil and from two different water levels within Tanks 53 and 56. The samples were analyzed for volatile and semi-volatile organic compounds, metals, and other miscellaneous parameters. The 1985 tank sample results for Tanks 53 and 56 are presented in Table 1-13. Thousands of parts per billion of aromatic and chlorinated organic compounds were detected in the oil samples. High levels of naphthalene, a semi-volatile organic compound, were also detected in the oil samples. Copper, lead, mercury, nickel, and zinc were also detected in the oil samples at significant concentrations. Tank water samples were collected from the top and bottom of the water within each tank. Both samples collected from Tank 53 contained high levels of aromatic and chlorinated organic compounds. Low levels of semi-volatile organic compounds (naphthalene, isophrone, and 2,4-dimethylphenol) were also detected in the Tank 53 water samples. Cadmium, copper, lead, and zinc were also detected in the water samples from Tank 53. From the water samples collected at Tank 56, chloroform and 2,4-dimethylphenol were the only volatile organic / semi-volatile organic compounds

detected in either sample. Low levels of cadmium, copper, lead, nickel and zinc were also detected in both samples.

During the 1985 tank closure investigation, water samples were also collected from all but one (Tank 57) of the other tanks at Tank Farm Five. The samples were analyzed for both aromatic and chlorinated volatile organic compounds, as well as priority pollutant metals, and other miscellaneous parameters (e.g., pH, BOD, TSS). The 1985 tank water sample results are provided in Table 1-14. No organic compounds were detected in the water samples collected from three of the tanks, numbers 49, 58, and 59. Tank 54 had only 42 ppb of total volatile organics detected in its water sample and tank 56 had detectable concentrations levels of chloroform detected in its water sample. Several hundreds of parts per billion of chlorinated and aromatic organic compounds were detected in the water samples from the remaining tanks, numbers 50, 51, 52, 53, and 55. The source of chlorinated solvents in the non-waste oil tanks (all the tanks except numbers 53 and 56) is unknown. The presence of these solvents, many of which are considered potential human carcinogens, increase the potential for serious ground water contamination, if the tanks are discovered to be leaking.

All of the tank water samples contained detectable concentrations of copper (0.02 to 0.07 ppm) and zinc (0.01 to 0.12) ppm. Most tank water samples did not contain detectable concentrations of other metals, except tanks numbers 51, 53, and

56. The water samples from these tanks contained cadmium and lead at concentrations near the analytical detection limit.

Ground Water

The tank closure ground water investigation involved two phases of field work. The first phase involved the installation and sampling of two monitoring wells (wells MW-53E, MW-53W, MW-56E, and MW-56W) on the east and west side of each tank, in the fill material (ring drain) surrounding the perimeter of the tanks. The second phase further investigated whether a ground water contaminant plume was emanating from Tank 53.

The four monitoring wells were initially sampled in October 1985 and analyzed for metals and volatile organics. The results of the ground water sample analyses are presented in Table 1-15. Although the chemical analyses results show low levels of metal below established ground water standards, significant concentrations of aromatic and chlorinated hydrocarbons were detected around Tank 53 at levels above ground water standards. The ground water sample results from the four wells indicate that low level metals contamination (Cd and Hg) and high level volatile organics contamination are present in the ground water near Tanks 53 and 56.

The second phase of the tank closure investigation field work specifically addressed whether a contaminant plume is emanating from Tank 53. Six additional wells were installed under this phase of the investigation and sampled by ERA in 1986. Figure 1-18 shows

the location of all of the monitoring wells that were installed at the site during the tank closure investigation. Monitoring well number MW-86-3 was actually two nested wells in one borehole (Note: this well nest was accidently destroyed in 1989 during nearby construction activities); the two wells were screened at depths of 13 to 33 feet and 39 to 49 feet, respectively. The six additional wells were sampled during October 1986 and analyzed for volatile organic compounds. These sample results are presented in Table 1-16.

The 1986 surrounding well ground water sample concentrations are one to two orders of magnitude less than those detected in the samples from the wells completed in the tank perimeter fill materials. The deeper well at location number MW-86-3 (3D) contained higher concentrations of contaminants than the shallow well (3S) at this location. This appears to demonstrate the propensity of the chlorinated compounds to sink. The absence of any detectable volatile organic compounds in well number MW-86-5 does not necessarily indicate that the plume has not reached that far; it may have simply sunk to a depth below the bottom of the well screen (at 26 feet) at this location.

In addition, the four wells installed in the first phase of the tank closure investigation were resampled in November 1986 and analyzed for volatile organic compounds. The 1986 sample results for the four tank ring drain wells are provided in Table 1-17. Again, significant concentrations of volatile organic compounds were detected in the ground water samples, although different

compounds than those identified in 1985 were detected. During this second ground water sampling event, methylene chloride, chloroform, and 1,2-dichloroethane were not detected; toluene, 1,1-dichloroethane, 1,1-dichloroethylene and bromodichloromethane were detected in the second round but not in the first round. With the above exceptions, the concentrations and compounds detected during both events were similar. Differences in hydrogeological parameters (e.g., ground water levels, direction of flow, etc.), sampling techniques, and laboratory quality control may account for the variability in results between the two ground water sampling events.

All of the tank closure ground water investigation findings indicate that petroleum product and volatile organic compounds are present in the ground water around tank 53. The ground water findings also indicate that a plume of ground water contamination is moving downgradient of the tank.

1.5 Report Organization

This section of the report summarizes the format and contents of the remainder of the RI report, which addresses findings and conclusions for all five NETC sites. The contents of the remaining sections are summarized as follows:

Section 2.0 - Site Investigation

This section of the report presents overviews of each of the field investigation activities at each of the sites. The field activities are presented in subsections, by area of investigation as follows: ambient air and radiological, geophysical, soil gas, surface soil, test pit, subsurface soil, ground water, tank, and structures. The investigation techniques and methods used at each of the sites are presented at the beginning of each of the respective subsections. The scope of each field activity is detailed in the investigation overviews for each site. Sample location maps, boring and well logs, and sample summary tables are referenced in the discussion. Summaries of field measurements and observations are also provided for each of the sites.

Section 3.0 - Physical Characteristics

This section of the report presents the physical characteristics of each site, as determined through background and field investigations. Information presented includes site and regional physiography, meteorology, hydrology, geology, soils, and hydrogeology.

Section 4.0 - Nature and Extent of Contamination

This section of the report presents a summary of the sample results for each site for those sampling activities discussed in Section 2.0. Data summary tables, data/standard comparison tables, and contaminant concentration maps are referenced in this discussion for each site.

Section 5.0 - Summary and Conclusions

This section of the report provides a summary of the nature and extent of contamination, contaminant fate and transport, and risk assessment for each site. Conclusions regarding recommendations for future work and any remedial action objectives are also provided.

2.0 SITE INVESTIGATIONS

This section of the report provides information on the field investigation activities conducted at the five sites investigated under this Remedial Investigation. The field investigation activities were based upon the five volume RI Work Plan (TRC, 1989) which includes the following reports and plans: Volume I - Background Investigation Report, Volume II - Field Sampling Plan, Volume III - Quality Assurance/Quality Control Plan, Volume IV - Data Management Plan, and Volume V - Health and Safety Plan. The field investigation activities included ambient air and radiological surveys, geophysical surveys, soil gas surveys, surface soil sampling, test pit sampling, soil boring sampling, ground water sampling, surface water and sediment sampling, underground storage tank sampling, and other structure sampling. Survey maps showing all of the field investigation activity locations are provided for each site in Appendix A.

This section of the report provides a separate discussion for each of the above-listed field investigation activities. Within each section (not including air and radiological survey discussion) is a separate discussion on the sampling activity methods applicable to each site, followed by site-specific subsections providing an overview of the sampling activity conducted at each site investigation. Also provided in each subsection is a discussion of any field measurements and observations for that activity.

The samples were analyzed by Weston Analytics in Lionville, Pennsylvania. All sample analyses were performed according to US EPA Contract Laboratory Program (CLP) protocols. Non-CLP analyses (e.g., TCLP, EP Toxicity) were performed according to established, current EPA protocols. All of the sample analytical results are discussed in Section 4.0 of this report and presented in data summary tables ("hits tables") in Appendix M. A summary of the data validation process and findings for each site are provided in Appendix N.

2.1 Ambient Air and Radiological Investigations

Ambient air and radiological surveys were conducted at each of the sites. These surveys were conducted to locate any previously unidentified, potentially contaminated areas, so that they could be addressed in the field sampling activities, and as a health and safety precautionary measure. Ambient air monitoring was also conducted throughout site investigation activities. Although radiological surveys were conducted, there is no knowledge or record of any radioactive waste being present or disposed of at any of the sites.

The ambient air surveys consisted of general site walkovers with an organic vapor analyzer (OVA-128) and HNu photoionization detector (PI-101). The air surveys were conducted prior to any field sampling activities and primarily in areas of potential concern (e.g., debris piles, waste piles, structures). No readings above background were observed with the air monitoring instruments on any of the sites during the general site walkovers.

The radiological surveys were conducted with a Ludlum Model 19 Micro-R radiation meter. Continuous radiation readings were obtained with the Model 19 meter, which has an internally-mounted NaI scintillator to offer optimum performance in counting low-level gamma radiation. The radiological surveys consisted of general site walkover surveys on the two tank farms and the Old Fire Fighting Training Area and a gridded traverse survey on the two landfills. The radiation surveys on the two tank farms were conducted near each UST and oil/water separator on the sites. The

radiation survey on the Old Fire Fighting Training Area consisted of a walkover of the site at the locations planned for sampling activities (e.g., shoreline, soil mounds, playground, baseball field). No radiation levels above background (7-12 micro R/hour) were observed on any of the sites with the Micro R meter.

In summary, the findings of the ambient air and radiological surveys did not result in any changes in the planned sampling activities.

2.2 Geophysical Investigations

Geophysical investigations were conducted at the following three sites: the McAllister Point Landfill, the Melville North Landfill, and the Old Fire Fighting Training Area. Both electromagnetic and magnetic surveys were conducted on these sites. The geophysical surveys were conducted to aid in determining the locations of buried conductive or metallic objects (e,g,, tanks, drums) and buried conductive waste areas (e.g., former lagoon locations, oil sumps, fill). The findings of the geophysical surveys were used in determining the final locations for borings, wells, and/or test pits on the sites.

Details on the geophysical survey techniques used at the sites are provided in the following discussion. Separate subsections on the scope of the geophysical investigations conducted at each of the sites, along with a summary of the geophysical survey findings for each site follow the survey methods discussion.

Geophysical Survey Methods

Both electromagnetic (EM) and magnetic surveys were conducted on the three sites. The EM surveys were conducted continuously along surveyed traverse lines with a Geonics EM-31 electromagnetic terrain conductivity meter. The EM-31 has a fixed intercoil spacing of 3.7 meters (12 feet) and an effective depth of penetration of approximately 6 meters (20 feet). The magnetic surveys were conducted with a Geometric Model G-816 proton precession magnetometer. Magnetic readings were recorded from the

magnetometer at 50-foot intervals along the surveyed traverse lines. Both EM and magnetic readings were recorded at the same stations to allow for a comparison of the measured values. The magnetic data were used to identify areas of buried ferrous metal and to distinguish EM-31 anomalies due to ferrous metal from electrically conductive, non-ferrous objects (e.g., conductive contaminants, copper cables, scrap aluminum).

2.2.1 Site 01 - McAllister Point Landfill

Overview of Investigation

The extent of the actual landfill area on the McAllister Point Landfill site is unknown. The area over which landfilling activities occurred at the site could not be documented in the background investigation of the site. Historical aerial photographs of the site provided some information on the suspected, primary fill areas. The presence of a mounded area on the site also indicated the likely location of the landfill. Thus, the geophysical investigations were used along with this existing information to aid in determining the extent of the landfill.

An EM survey was conducted continuously along 50-foot spaced traverses in an approximate north-south direction across the site. Although EM readings were recorded at every 50-foot station on the traverses, if any significant deviations (e.g., negative values) were encountered, the EM values between the stations were also recorded.

A magnetic survey was conducted along the surveyed traverse lines. Magnetic readings were measured and recorded at stations spaced at 50-foot intervals along the surveyed traverse lines.

Findings of Geophysical Investigation

Data from the EM-31 conductivity survey were used to generate a conductivity contour map of the site (see Figure 2-1). The conductivity contour map illustrates the areas of elevated electromagnetic conductivity, as well as the areas where negative conductivity values were encountered.

The area that exhibited the highest conductivity values is located in the central portion of the landfill area (see Figure 2-1, area labelled "A"). Conductivity values in this area range from 55 to 100 mmhos/meter, in comparison to typical site reading from 20 to 40 mmhos/meter. The high conductivity readings in this area are likely due to the presence of significant amounts of conductive fill materials in this area of the site. This observation is supported by both the physical presence of an elevated mound in this area of the site and historical aerial site photos which indicate that significant landfilling occurred in this area of the site (shape of site shoreline changed in this area, see Appendix B). This is also confirmed by the fact that under a previous site investigation, fill material was encountered to a depth of 38 feet in a boring completed in this area. Other small areas of elevated conductivity (> 60 mmhos/meter) were also found just north of this area and in the southern portion of the site.

Five areas of negative conductivity values were encountered at locations along the eastern side of the site (see Figure 2-1). The negative conductivity readings at these locations were likely due to magnetic/electromagnetic interferences from the nearby railroad tracks and overhead power lines which run along that side of the site. The two northern-most negative areas, however, are larger anomalies which also extend somewhat onto the site. The source of these negative readings may in part be due to metal debris which was observed in the small wooded area located on-site between these two negative areas.

Data from the magnetometer survey were used to generate a magnetic contour map the site (see Figure 2-2). The largest area of elevated magetic values is located in the central portion of the landfill (on Figure 2-2, area labelled "A"). Much of this area corresponds with the large electromagnetic anomaly detected in this portion of the site. Magnetic values in this area are greater than 65,000 gammas, in comparison to values between 55,000 and 60,000 gammas observed over the majority of the site.

Four areas were encountered with magnetic values greater than 65,000 gammas (Figure 2-2, areas labelled "B"), but all were located within 50 feet of the railroad tracks and overhead wires. Thus, as with the negative conductivity values, these magnetic highs can likely be attributed to electromagnetic/magnetic interferences from the tracks and wires.

The conductivity and magnetic data indicate the presence of a large amount of buried metal/conductive material in the central portion of the site.

2.2.2 Site 02 - Melville North Landfill

Overview of Investigation

The extent of the actual landfill area on the Melville North Landfill site is unknown. The area over which landfilling activities occurred at the site could not be documented in the background investigation of the site. Historical aerial photographs of the site provided some information on the suspected, primary fill areas and the locations of former lagoons on the site. However, a mounded area indicative of a landfill, as is the case with the McAllister Point Landfill, is not present on this site. Thus the geophysical investigations were used along with the aerial photograph information to aid in determining the extent of the landfill.

An EM survey was conducted continuously along 50-foot spaced traverses in an approximate north-south direction across the site. Although EM readings were recorded at every 50-foot station on the traverses, if any significant deviations (e.g., negative values) were encountered, the EM values between the stations were also recorded.

A magnetic survey was also conducted along the surveyed traverse lines. Magnetic readings were measured and recorded at

stations spaced at 50-foot intervals along the surveyed traverse lines.

Findings of Geophysical Investigation

Data collected during the EM-31 survey conducted at the site were used to generate a conductivity contour map of the site (see Figure 2-3). The conductivity contour map illustrates the areas of elevated electromagnetic conductivity, as well as the areas where negative conductivity values were encountered.

A large area of high and negative conductivity were found at the site, as well as two smaller areas of negative conductivity. Areas of elevated (from 100-400 mmhos/meter) and negative conductivity values were found in the central to northern portions of the site (on Figure 2-3 labelled as "A"). The high conductivity values detected over these areas of the site were much higher than the magnetic readings of 5 to 10 mmmhos/meter measured in eastern-central and southern portions of the site. In addition, one area of negative conductivity (on Figure 2-3, labelled as "B"), at the south central portion of the site, on the site access road, is lekely due to interferences from the adjacent railroad tracks and overhead power lines.

Data collected during the magnetometer survey at the site were used to generate a magnetic contour map of the site (see Figure 2-4). A large area of increased and decreased magnetic values was found at the site (on Figure 2-4 labelled "A"). The area extends from the northern to the central portion of the site. Magnetic

values over this area of elevated readings ranged from 55,000 gammas to greater than 57,000 gammas, as compared to typical site magnetic readings of approximately 54,600 gammas.

The conductivity and magnetic data indicate the presence of a large amount of buried metal/conductive material in the central to northern portion of the site.

2.2.3 Site 09 - Old Fire Fighting Training Area

Overview of Investigation

The geophysical surveys were conducted at the Old Fire Fighter Training Area in order to aid in locating possible areas of buried waste and/or underground structures (e.g., sumps, pits) related to the past use of the site. The area over which fill had been deposited at the site, following the demolition of the former fire fighting training facility, could not be documented in the background investigation of the site. Historical Navy planning maps and aerial photographs of the facility provided some information on the suspected areas of concern (see Appendix B).

An EM survey was conducted continuously along 50-foot spaced traverses in an approximate north-south direction across the site. Although EM readings were recorded at every 50-foot station on the traverses, if any significant deviations (e.g., negative values) were encountered, the EM values between the stations were also recorded.

A magnetic survey was also conducted along the surveyed traverse lines. Magnetic readings were measured and recorded at

stations spaced at 50-foot intervals along the surveyed traverse lines.

Findings of Geophysical Investigation

Data collected from the EM-31 survey conducted at the site were used to generate a conductivity contour map of the site (see Figure 2-5). Areas of elevated conductivity (greater than 60 mmhos/meter), as well as areas of negative conductivity, were found on the site. Conductivity values ranging from 60 to 140 mmhos/meter were measured over a large area in the northern portion of the site (on Figure 2-5 labelled "A"). Small areas of elevated (60 - 100 mmhos/meter) and/or negative conductivity were also found in the south-central and western portions of the site (labelled "B" on Figure 2-5). The anomalies detected at both of these locations are likely due to buried storm sewer pipes which traverse the site at each location. Several small negative conductivity areas (labelled "C" on Figure 2-5) were also found at the eastern end of the site. These anomalies are likely due to small, buried conductive objects at each location.

Data collected during the magnetometer survey were used to generate a magnetic contour map of the site (see Figure 2-6). One distinct area of increased and decreased magnetic values was encountered in the central portion of the site (on Figure 2-6, labelled "A"). This area exhibited magnetic values ranging from 53,670 gammas to 56,160 gammas. This area also corresponds closely to a portion of the large mounded area on the site. Another nearby

of high and low magnetic values (on Figure 2-6, labelled "B"), is likely due to a buried storm sewer pipe which traverses the site at this location. Several other small areas having elevated magnetic readings (on Figure 2-6, labelled "C") were also found on the site. These are likely due to small amounts of buried metallic debris related to the demolition of the former on-site buildings. Concrete rubble with reinforced steel was observed along the shoreline of the site near these areas.

The conductivity data indicates the presence of subsurface conductive material in the north-central portion of the site. The elevated conductivity readings in this area may be related to past site uses (oily soils or ground water, subsurface stuctures) or conductive salt water intrusion from Narragansett Bay. The magnetic data indicates the presence of a large amount of buried metal in the central portion of the site, at the location of the large soil mound.

2.3 Soil Gas Investigations

Soil gas surveys were conducted at the following three sites: Old Fire Fighting Training Area, Tank Farm Four, and Tank Farm Five. The objective of the soil gas surveys was to identify the presence of volatile organic compounds (VOCs) in subsurface soil vapors and, thereby, to aid in defining the presence, nature, and extent of subsurface volatile organic contamination. The results of the soil gas survey were evaluated to determine if planned locations for borings or monitoring wells on the sites should be relocated to better investigate areas of suspected subsurface contamination.

Details on the soil gas survey techniques used at the three sites are provided in the following discussion. Separate subsections presenting the scope of the soil gas survey conducted at each of the sites, along with a summary of the soil gas survey findings for each site, follow the general survey method discussion.

Soil Gas Survey Methods

At the Old Fire Fighting Training Area site, soil gas sampling points were installed by drilling a 3/4-inch diameter hole into the soil using an electric hammer drill equipped with a 2 1/2-foot long steel drill bit. Once drilled, a 2-foot section of 1/2-inch diameter, dedicated Teflon® tubing, with the top end of the tube sealed with parafilm, was inserted into the hole. The annulus of the hole was then sealed with an inert plastic clay to prevent

ambient air from entering the hole. After allowing for gases in the hole to equilibrate, the parafilm was removed from the end of the tubing and a vacuum pump was attached to the open end.

At Tank Farms 4 and 5, the shallow soil gas sampling method was ineffective in detecting VOCs. This was likely due to the greater depths (approximately 10-20 feet) to the water table over most of the tank farm sites. Therefore, an alternate means of soil gas sample collection was implemented. Sampling points were installed using an all-terrain drill rig equipped with 3-1/4 inch, inside diameter, hollow-stem augers, which were advanced to within one to two feet of the water table. Prior to removing the augers from the ground, 1/2-inch diameter, rigid PVC pipe was inserted into the hole. The bottom two feet of the pipe was slotted to allow soil gas vapors to enter the pipe, while the remainder of the tubing was solid. When sections of PVC pipe longer then ten feet were needed (i.e., hole depth greater than ten feet), two sections were coupled together using 5/8-inch diameter tubing. Following removal of the augers, polyethylene sheeting was placed around the tubing and soil backfill was placed on top of the plastic sheeting to block the top of the borehole and minimize ambient air interference with the subsurface soil gas sample. Rigid polyethylene tubing was placed over the end of the PVC tubing and a flexible piece of chemically inert, teflon tubing was attached to the polyethylene tubing. The tubing was then reduced down to a 1/4-inch tygon tubing which was attached to the personal sampling pump used for drawing the vacuum on the hole.

For both soil gas sampling methods, soil gas was extracted from the ground using a low flow personal pump for three (3) minutes. All samples were collected with a glass syringe immediately following the three-minute purging period. To collect the sample, the glass syringe was inserted through the teflon tubing. The pump remained running during the collection of the soil gas sample.

Soil gas samples were analyzed using a portable gas chromatograph (GC), HNu Model 311, which allows for the low level (1 - 50 parts per billion) detection of several aromatic and chlorinated components. All soil gas samples were injected directly from a glass into the GC. The GC uses an EPA Model #602 packed column in conjunction with a 10.2 electron volt photoionization detector. The carrier gas utilized in the GC was ultrapure nitrogen, at a flow rate of 25 ml/minute. The GC injector/detector and oven temperatures were typically 130° to 140° Celsius and 90° to 100° Celsius, respectively.

Prior to and throughout soil gas sample analysis, several QA/QC procedures were systematically performed. The QA/QC procedures include analyses of instrument blanks, syringe blanks, and air blanks. Syringe blanks were analyzed for all syringes prior to their use in sample collection. The three types of QA/QC analyses permit the calculation of equipment and ambient air background levels. The background values, if any, were subtracted from associated measured soil gas sample concentrations. The three QA/QC procedures was performed periodically throughout the day, as

determined necessary by the GC operator (e.g., evaluation of an instrument blank after analysis of a heavily contaminated sample).

The GC was calibrated on a daily basis to benzene, toluene, xylene, and, in most cases, perchloroethylene (PCE) standards. Under the calibration, a ratio of peak height (cm) to parts per million (ppm) was calculated for each standard. Component identification was determined by matching the standard's retention time (RT) determined through calibration with the RT measured for the soil gas samples. Ratios calculated from the standards were used to calculate contaminant concentrations in the vapor samples. For unidentified compounds (components whose RTs did not match the standards' RTs), concentrations were calculated using the standard ratio for the standard with the nearest retention time to the unidentified compound. The total concentration value for all volatile organic compounds (VOC's) detected in each soil gas sample was reported in ppb.

Soil Gas Sampling Strategy and Location

Sampling grids were established at each site, encompassing areas of suspected contamination, in order to systematically characterize the soil gas conditions at each site. The soil gas sampling strategy and sampling results are discussed individually for each site below.

2.3.1 Site 09 - Old Fire Fighting Training Area

Background Information

Oily soil was encountered at a depth of approximately five feet below the ground surface during a 1987 geotechnical investigation. It is likely that this contamination is associated with past fire fighting training activities at the site. A soil gas survey was conducted to aid in determining the location of contamination sources and the extent of contamination.

Overview of Investigation

A soil gas survey was completed across the site using a 50-foot grid system. The survey was performed on April 10, 11, and 13, 1990. A total of eighty-one (81) soil gas points were installed for the measurement of soil gas. Soil gas sample points were not installed on top of the large soil mound in the central portion of the site. In some instances, soil gas samples were not collected at planned locations because heavy rain prior to the investigation resulted in ponded water at these locations. Soil gas sample depths averaged two feet.

The GC was calibrated daily to benzene, toluene, m- and p-xylenes, and o-xylene. Due to difficulties in obtaining the required gas standard for PCE, the GC was only calibrated to PCE on the last day of sampling.

Findings of Soil Gas Survey

Soil gas survey results were calculated as total volatile organic compound (VOC) values. The total VOC soil gas results are presented on Figure 2-7. VOCs were detected at most sampling points, ranging in concentration from background levels to greater than 1,120 ppb. Individual elevated VOC levels were identified in the western portion of the site, near the soil mound; in the south-central and central portions of the site, and along the eastern side of the soil mound in the central portion of the site.

Soil gas samples from 24 points, located in the central portion of the site were all collected on the first day of sampling and exhibited relatively high total VOC values (ranging from background to greater than 1,120 ppb). On the second day of sampling, two of the first day sample locations were redrilled and resampled to determine if rainy conditions on the second day of sampling impacted the soil gas sample readings. The sample location, at which the 1,120 ppb VOC level was measured on the first day of sampling, exhibited 215 ppb VOCs on the rainy second day of sampling. Also, a sample location which exhibited 80 ppb on the first day of sampling, measured 52 ppb on the second day of sampling. In general, VOC levels on the second and third days of sampling were consistently less than those measured on the first day of sampling.

On the basis of the soil gas results some of the planned well and boring locations were slightly adjusted to further investigate detected subsurface VOC soil gas levels. The planned locations of monitoring wells MW-2 and MW-3 coincided with the areas of elevated

VOC soil gas levels detected north of the child care center. The planned location of monitoring well MW-4 was slightly adjusted to coincide with a location having high VOC soil gas levels along the eastern edge of the western soil mound. The planned location of boring B-3 coincided with an area of elevated VOC soil gas levels. The location of boring B-2 was adjusted slightly south, to an area of higher VOC soil gas levels.

2.3.2 Site 12 - Tank Farm Four

Background Information

Previous investigations have documented the presence of petroleum-based hydrocarbons in the tanks on-site as well as in on-site ground water monitoring wells. A soil gas survey was conducted to aid in the determination of the nature and extent of ground water contamination at the site.

Overview of Investigation

The soil gas survey was conducted around each of the twelve underground storage tanks and on a 400-foot spaced grid over the remainder of the site. The survey was performed on May 2, 3, 4, 7, and 8, 1990. Three soil gas points were installed and sampled around each of the tanks: one on the suspected downgradient side of the tank and one on either side of the tank, longitudinal to the downgradient sample point location. These grid points located close to tank points were not included in the survey. A total of sixty-one (61) soil gas sampling points were installed across the site for soil gas measurement.

Due to the shallow ground water depth (approximately 10 to 20 ft. below grade), present over most of this site, the planned method of near-surface (2-foot depth) soil gas sampling was not employed. Therefore, soil gas points were instead drilled to a greater depth using augers. Soil gas sample point depths varied with the depth of the water table. Using nearby water level measurements, attempts were made to drill soil gas point holes to within approximately 2 feet of the water table. Thus, soil gas point depths ranged from 3.5 deep near the on-site brook to 25 feet deep in the center of the site.

Findings of Soil Gas Survey

Soil gas survey results were calculated as total VOC values. The soil gas survey results for this site are presented on Figure 2-8. VOCs were detected in the soil gas at every sample point, ranging in total VOCs concentration from background levels to 7,980 ppb. The highest soil gas level (7,980 ppb) was measured adjacent to Tank 45. Near other tanks, detected total VOC levels ranged from backgroud levels to 4,360 ppb. At the soil gas sampling points located furthest away from the tank along the western portion of the site, elevated VOC levels were still detected, ranging from 180 to 3,320 ppb. At points located hydraulically upgradient (ground water), elevated VOC levels (520 to >1,890 ppb) were also detected in the soil gas. The detected VOC soil gas levels did not indicate the presence of well-defined plumes or areas of subsurface contamination on the site. Due to the inconclusive nature of the soil gas results, none of the planned

monitoring well locations were adjusted on the basis of the results.

2.3.3 Site 13 - Tank Farm Five

Background Information

Previous investigations have documented the presence of petroleum-based hydrocarbons (aromatic and chlorinated VOCs) in tanks on-site as well as in on-site ground water monitoring wells. A soil gas survey was conducted to aid in the determination of the nature and extent of ground water contamination at the site.

Overview of Investigation

The soil gas survey was conducted on April 24, 25, 27, and 30, 1990 around each of the eleven underground storage tanks and on a 400-foot spaced grid over the remainder of the site. Three soil gas points were installed and sampled around each of the tanks: one on the suspected downgradient side of the tank and one on each side of the tank longitudinal to the downgradient sample point location. Those grid points located close to the tank points were not included in the survey. A total of fifty-one (51) sampling points were installed across the site for soil gas measurement. However, at three locations, samples could not be collected due to the presence of standing water at the surface.

Due to the greater depths to ground water present over most of the site (approximately 10 to 20 ft. below grade), the originally planned method of near-surface soil gas sampling was not employed. Therefore, soil gas points were installed to a greater depth using

augers. Using nearby water level measurements, attempts were made to drill soil gas point holes to within approximately 2 feet of the water table. Over most of the site, soil gas samples were collected from an average depth of 15 feet below grade. In the eastern portion of the site, near Tanks 49, 51, 54, 57, and 58, drilling depths were limited to 3 to 5 feet, due to the shallow depth of the ground water table in this area of the site.

Findings of Soil Gas Survey

Soil gas survey results were calculated as total VOC values. The soil gas survey results for this site are presented on Figure 2-9. VOCs were detected at every sample point, ranging in total VOCs concentration from background to 62,350 ppb. The highest soil gas levels were measured in points installed around Tank 53. Near other tanks, detected total VOC levels ranged from 210 to 6,680 ppb. At the sampling points located furthest from the tanks, elevated VOC levels were still detected, ranging from 200 to 1,170 ppb. At points located hydraulically upgradient (ground water), elevated VOCs (330 to 1,770 ppb) were also detected in the soil gas. The detected VOC levels did not indicate the presence of well-defined plumes or areas of subsurface contamination on the site. Due to the inconclusive nature of the soil gas results, none of the planned monitoring well locations were adjusted on the basis of the soil gas findings.

2.4 Surface Soil Investigations

Surface soil samples were collected from each of the five sites. Surface soil sampling activities were conducted across the sites and concentrated on those areas surrounding possible and/or known contamination sources (e.g., tanks, pits, landfills). In general, surface soil sampling was conducted to aid in determining the presence, nature, and extent of surface soil contamination at each site. Information obtained from the initial site surveys (e.g., site walkovers, soil gas, geophysics) was also used in fine tuning the final surface soil sample locations at each site.

Surface Soil Sampling Methods

All surface soil samples were collected with a dedicated stainless steel spoon. Surface soil samples to be analyzed for total petroleum hydrocarbons and volatile organic compounds (VOCs) were collected from a depth of at least 6 inches below grade. A decontaminated hand auger was used if the sampler could not reach the desired VOC sample portion depth (6-12") with a spoon. These samples were transferred directly to the appropriate sample container to minimize the loss of VOCs from the sample. All other surface soil samples were collected from the 0 to 6 inch interval.

Composite surface soil samples were collected from the tank farm sites. Each composite surface soil sample from the tank farms consisted of four aliquots collected from four adjoining quadrants of approximately equal area above each tank. The compositing of the soil sample portions for all but the VOC and TPH analyses was

performed by collecting approximately equal amount of sample from each location, placing these samples into a decontaminated stainless steel bowl, mixing them thoroughly with a dedicated stainless steel spoon, and then placing the mixed sample in the appropriate sample containers. The composite sample portions for the VOC and TPH analyses were collected by placing approximately equal amounts of each sample aliquot directly in the proper sample containers.

All sampling devices (i.e., spoons, bowls) were laboratory decontaminated prior to use according to the procedures described in the project QA/QC Plan.

Surface Soil Sample Designation

All surface soil samples were assigned a designated sample identification number, which referenced the site name, sample type, sample location number, and sample date. At the tank farm sites, an identifier was included after the sample location number to indicate if the sample was a discrete (D) or composite (C) sample. Below is an example of a surface soil sample designation:

Example: TF4-SS49D-614

where: TF4 = Tank Farm Four
SS = Surface Soil Sample
49 = Location Number (@ tank farms = tank #)
D = Identifier (D = discrete, C = composite)
614 = Sampling Date (6/14/90)

Surface Soil Sampling Strategy and Location

Limited soil sampling had been previously conducted at several of the sites being investigated. When appropriate, the results of

previous investigations were used in establishing the surface soil sampling strategy for each site. The specific surface soil sampling activities conducted at each site are presented below.

2.4.1 Site 01 - McAllister Point Landfill

The following sections present an overview of the surface soil sampling at the McAllister Point Landfill along with a summary of observations made during the field sampling activities.

Background Information

Previous surface soil sampling (conducted by others) was limited to sampling of landfill cap soils. The analytical results of the sampling indicated low level contamination may be associated with the cap soils (see Section 1.4.1).

Overview of Investigation

Surface soil samples were collected from fifteen (15) locations on-site and two locations off-site. Of the fifteen on-site samples, four were collected from along the shoreline of Narragansett Bay. The remaining eleven on-site surface soil samples were collected outside of established fill areas. All fifteen on-site surface soil samples were collected from locations outside of the reportedly capped area of the landfill. The two off-site surface soil samples were collected from areas believed to be representative of background conditions. The locations of the

surface soil samples are shown on Figure 2-10. A log of the surface soil samples collected is presented in Appendix D.

Due to the unknown nature of material deposited in the landfill and the lack of representative surface soil data from previous investigations, all of the on-site surface soil samples collected from this site were analyzed for the full list of Target Compound List (TCL) organics, target analyte list (TAL) metals, and cyanide. The surface soil samples were also archived for possible dioxin analyses. A list of the TCL and TAL parameters is provided in Table 2-1. The two off-site surface soil samples were analyzed for TAL metals to provide an indication of background metal concentrations in area soils.

Field Measurements and Observations

Of the eleven surface soil samples collected on-site (not including the shoreline samples) four samples contained debris-type fill; sample SS-02 contained pieces of roofing paper, sample SS-05 and SS-08 both contained pieces of plastic sheeting, sample SS-05 contained parts of magazines and a comb, and sample SS-11 contained asphalt pieces. The remainder of the surface soil samples all contained a topsoil-type soil (organic rich silt, trace gravel, dark brown).

Four of the surface soil samples were collected from along the beach shoreline of the site. Three of these samples (SS-12, SS-13, and SS-14) contained brown, medium to coarse sand with some shell

fragments. Sample SS-15 contained dark brown, fine to medium sand with trace gravel.

The two off site surface soil samples (SS-16 and SS-17) both consisted of organic rich, dark brown, fine to medium sand (topsoil). No visible signs of contamination (i.e., staining, odors) were observed in any of the surface soil samples collected at the McAllister Point Landfill.

2.4.2 Site 02 - Melville North Landfill

The following sections present an overview of the surface soil sampling at the Melville North Landfill along with a summary of observations made during the field sampling activities.

Background Information

As discussed in Section 1.4.2, previous surface soil sampling was conducted (by others) in and around a central area of the site containing visible oily deposits (see Figure 1-12). One composite sample previously collected from the oily deposit area was found to contain lead and very high concentrations (32,508 ppm) of petroleum-based hydrocarbons. No polychlorinated biphenyls (PCBs) were detected in the sample. A visual field investigation (via test pits) had also previously been conducted (by others) to determine the extent to which oil from the deposits may have contaminated nearby soil. On the basis of the visual field observations, it was concluded that "oily material has not migrated laterally away from the surface piles of the soil". These visual

observations were not confirmed by any soil sample laboratory chemical analyses.

The results of the previous investigations provide a gross indication of the presence of contamination in the visibly oily deposits investigated at the site. A lack of full scan chemical analyses on the waste deposit samples and any analyses on adjacent soil samples indicated the need for additional sampling and analysis in this area.

Overview of Investigation

Seventeen (17) surface soil samples were collected from across the site. The seventeen surface soil samples were collected outside of suspected fill areas. The locations of the surface soil samples are shown on Figure 2-11. A log of the surface soil samples collected is presented in Appendix D.

Due to the unknown nature of materials deposited in the landfill, fifteen surface soil samples were analyzed for the full list of TCL and TAL parameters and archived for possible dioxin analyses. The other two surface soil samples were analyzed for TCL PCB compounds.

Field Measurements and Observations

Of the seventeen surface soil samples collected at the site, only three of the samples (SS-20, SS-21, and SS-08) contained distinct fill materials.

Surface soil samples SS-20 and SS-21 consisted of a black, tar-like substance and SS-08 contained some asphalt pieces.

The remainder of the surface soil sample collected at the site primarily contained fine sand and silt. Many of the soil samples (SS-01, SS-05, SS-06, SS-07, SS-09, SS-10, SS-12, and SS-15) contained some organic material (i.e., roots, black soil). Visible signs of contamination (e.g., odors, staining, tar) were only observed in two of the surface soil samples (SS-20 and SS-21) collected from the Melville North Landfill.

2.4.3 Site 09 - Old Fire Fighting Training Area

The following presents an overview of the surface soil sampling activities conducted at the Old Fire Fighting Training Area, along with a summary of observations made during the sampling activities.

Background Information

No previous investigations of surface soil quality have been conducted at the site.

Overview of Investigation

Surface soil samples were collected from six (6) locations across the site. The samples were collected from those areas of concern with respect to human exposure (e.g., child care center, baseball field, park) and other areas which may provide an indication of areal surface soil contamination (e.g., soil mounds,

shoreline). One discrete surface soil sample was taken from each of the following areas: child care center playground, baseball field, large soil mound in the center of the site, soil mound at the western end of the site, shoreline, and the pavilion/park area. The locations for these surface soil samples are shown on Figure 2-12. A log of the surface soil samples collected is presented in Appendix D.

It is likely that the original fire training area has been covered with soil fill and revegetated to facilitate the use of the property as a park and child care center. Thus, it is possible that most of the near-surface soils now at the site are not those that were present during the site's operation. However, the six surface soil samples were collected to provide information on the existing on-site surface soil quality, as required to assess the public health risks at the site.

Given the fact that subsurface soil contamination has been documented at the site and that no chemical analyses were previously conducted on samples from the site, all of the surface soil samples were analyzed for the full list of TCL and TAL parameters and archived for possible dioxin analyses. One surface soil sample (SS-2) was also collected as a split sample with the EPA.

Field Measurements and Observations

Of the six surface soil samples collected from the Old Fire Fighter Training Area site, only one sample (SS-06) contained any

fill material. Sample SS-06, collected from along the shoreline of the site, contained some asphalt pieces along with coarse sand, pebbles and shells. The remaining five surface soil samples all consisted of brown, fine sand and silt. No visible signs of contamination (e.g., odors, staining) were observed in any of the surface soil samples collected from the Old Fire Fighting Training Area site.

2.4.4 Site 12 - Tank Farm Four

The following is an overview of the surface soil sampling activities conducted at Tank Farm Four, along with a summary of observations made during the sampling activities.

Background Information

As discussed in Section 1.4.4, previous surface soil sampling activities conducted at the site included the collection of one composite soil sample. The composite soil sample was comprised of soil collected near six of the underground storage tanks on the site. Sample analyses results indicated elevated concentrations of lead and oil/grease in the soil. Samples also previously collected from on-site sediments, ground water monitoring wells, and tanks were found to contain detectable concentrations of petroleum-based hydrocarbons. This information indicates that petroleum-based contamination does exist at the site, and thus required further investigation.

It is known that petroleum products (e.g., fuel oil, diesel) were handled and stored at the site; however, the locations of reported past tank sludge disposal/burning areas at the site are unknown. Therefore sampling was conducted to determine the presence of petroleum contamination around each tank and around the oil/water separator at the site.

Overview of Investigation

A total of twenty-eight (28) surface soil samples were collected from across the site. The surface soil samples were collected as follows: two from around each tank and four from around the oil/water separator. The two surface soil samples from around each tank consisted of one composite sample from the tank area and one discrete sample from any area observed to have signs of contamination (e.g., stains, stressed vegetation). If no area of potential contamination was visible, the discrete sample was collected from the central portion of each tank area. The four samples from around the oil/water separator were collected adjacent to the approximate center of each wall of the structure. The locations of the discrete surface soil samples are shown on Figure 2-13. A log of the surface soil samples collected is presented in Appendix D.

The surface soil samples were analyzed for the indicator analysis of total petroleum hydrocarbons (TPH) and lead. In addition, two of the composite surface soil samples were analyzed for all of TCL and TAL parameters plus total petroleum

hydrocarbons. These two samples were also split with the EPA for analyses.

Field Measurements and Observations

All of the surface soil samples collected from around the tanks at Tank Farm Four (both composite samples and discrete samples) contained topsoil-like soils. These soils consisted of brown, fine to medium sand and silt, with trace gravel. No odors or stained soils were noted in any of the composite or discrete samples collected from around the tanks. Given that no signs of contamination were noted around the tanks (stained soils or stressed vegetation), the discrete surface soil samples were collected from the central portion above each tank.

The four surface soil samples collected around the oil-water separator all contained brown, fine to medium sand and silt with trace gravel. No odors or stained soils were noted in any of the samples collected from around the oil-water separator.

2.4.5 Site 13 - Tank Farm Five

The following is an overview of the surface soil sampling conducted at the Tank Farm Five site, along with a summary of observations made during the sampling activities.

Background Information

During previous investigation activities, surface soil samples were not collected from the site for analyses; however, given the

past tank sludge disposal/burning operations which reportedly occurred at the site, potential surface soil contamination is of concern.

Petroleum products (e.g., fuel oil, diesel, and waste oils) were handled and stored in USTs at the site. During the operation of the tank farm, sludge collected from the USTs was reportedly burned in an on-site burning pit. The reported burning pit structure location is identifiable in the field. A portion of the reported burning pit structure also appeared to be an oil/water separator. It is not known if any of the tank sludge burning operations occurred near any of the tanks, as was reportedly the case at Tank Farm Four. Therefore, surface soil sampling was conducted using the same approach as done at Tank Farm Four. Sampling was conducted to determine the presence of petroleum contamination around each tank and around the burning pit structure at the site.

Overview of Investigation

A total of twenty-six (26) surface soil samples were collected from across the site. The surface soil samples were collected as follows: two from around each tank and four from around the burning pit structure. The two surface soil samples from around each tank consisted of one composite sample from the tank area and one discrete sample from any area observed to have signs of contamination (e.g., stains, stressed vegetation). If no area of potential contamination was visible, the discrete sample was

collected from the central portion of each tank area. The locations of the discrete surface soil samples are shown on Figure 2-14. A log of the surface soil samples collected is presented in Appendix D.

The surface soil samples were analyzed for the indicator analysis of total petroleum hydrocarbons (TPH) and lead. In addition, two of the composite tank surface soil samples were analyzed for all of the TCL and TAL parameters plus total petroleum hydrocarbons. These two samples were also split with the EPA for analyses.

Field Measurements and Observations

All but one of the surface soil samples collected from around the tanks at Tank Farm Five (both composite samples and discrete samples) contained topsoil-like soils. These soils consisted of brown silt with trace to little sand and trace gravel. The discrete surface soil sample collected at Tank 50 (SS-50D) was a black silt, saturated with oil and had a strong petroleum odor.

With the exception of around Tank 50, no odors or stained soils were noted in any of the composite or discrete surface soil samples collected from around the other tanks at the site. Since no signs of contamination (stained soils or stressed vegetation) were noted around the other tanks, the other discrete surface soil samples (i.e., not including those at Tank 50) were collected from the central portion above each tank.

The four surface soil samples collected around the oil-water separator at the site all contained brown silt with some fine sand. No odors or stained soils were noted in any of the samples collected from around the oil-water separator.

2.5 Test Pit Investigations

Test pit investigation and sampling activities were conducted only at the Melville North Landfill site. Test pits were excavated to visually investigate the presence and areal extent of lagoons observed on historical aerial photos of the site and to investigate areas of geophysical anomalies. The vertical extent of the contamination associated with the lagoons was also addressed during the test boring investigation as presented in Section 4.3.2 of this report. The findings of the test pit investigation were used to determine the final locations of several test borings and a ground water monitoring well at this site.

Test Pit Sampling Method

Test pit excavation activities were conducted with a backhoe. The test pits were excavated down to the ground water table (an average depth of 4 feet). The soils and fill material encountered in the test pits as well as the depth to ground water were logged and are presented in Appendix E. At the completion of any sampling and logging, the excavated soil was backfilled into its respective test pit.

The test pit samples were either collected directly from the backhoe bucket or from the sidewall of the test pit with a dedicated stainless steel spoon. All bucket samples were collected from the middle area of the bucket so as to obtain a sample which had not contacted the backhoe bucket. The depth and location from

which each sample was collected is also presented in the test pit log (see Appendix E).

Test Pit Sample Designation

All test pit samples were assigned a designated sample identification number which referenced the site name, sample type, sample location number, and sample date. Presented below is an example of a test pit sample designation:

Example: MN-TP1-425

where: MN = Melville North Landfill
TP = Test Pit Sample
1 = Test Pit Number
425 = Sampling Date (4/25/90)

Test Pit Sampling Strategy and Location

The specific test pit investigation activities at Melville North Landfill are described below.

2.5.1 Site 02 - Melville North Landfill

The following is an overview of the test pit investigation activities conducted on the Melville North Landfill site along with a summary of observations made during the sampling.

Background Information

Site background information indicates that man-made lagoons existed in the central portion of the site. As discussed in Section 1.2.3 and presented in Appendix B, Historical aerial photographs of the site shows what appears to be two lagoons in

this area of the site (see Figure 1-3). Based upon the scale of the photo, the southern-most lagoon appeared to have dimensions of approximately 40 feet by 20 feet, while the northern-most had dimensions of approximately 25 feet by 15 feet. The lagoons were separated by approximately 15 feet. Although an area of stressed vegetation is currently visible in the field in this general area, the former locations of the lagoons are not readily apparent.

Overview of Investigation

Seven test pits or trenches were excavated at the site. Five were excavated to investigate the suspected lagoon locations and two were excavated to investigate detected geophysical anomalies. The test pits were excavated to the depth of the ground water table (ranged from 3.2 to 5.5 feet below grade). The test pits/trenches were approximately 3 feet wide and ranged from 11.5 to 42 feet long. Soil samples were collected from four (4) of the test pits. A summary of the test pit samples collected is provided in Table 2-2. The locations of the test pits are shown on Figure 2-15. A log of the test pit soils is presented in Table E.

The test pit samples were analyzed for all of the TCL and TAL parameters. The test pit samples were also archived for dioxin analyses.

Field Observations and Measurements

During the test pit investigation activities, all field measurements and observations were recorded in a field notebook.

Recorded field measurements included OVA and/or HNu and LEL instrument readings. Observations which were recorded included geological soil descriptions and visual observations (e.g., debris, waste, oil, discolored soils). Information regarding the physical pit dimensions and test pit sample locations was also recorded. All of the test pit excavation measurements and observations are presented in the test pit logs in Appendix E.

Below is a summary of the test pit investigation activities and findings. All of the test pit samples were analyzed for all of the TCL and TAL parameters. The test pit samples were also archived for dioxin analysis by the laboratory.

- Test pits TP-1, TP-2, TP-3, TP-5, and TP-6 were excavated in the central portion of the site to investigate a suspected, former waste lagoon location. These test pits were also excavated in an area where geophysical anomalies were detected during the site geophysical surveys (see Figure 2-3 and 2-4). Oily soil, oily ground water, and metal debris were encountered in test pits TP-1 and TP-5. Soil samples were collected from the oily soils in test pits 1 and 5. A slight oil sheen was also observed on the ground water in test pits TP-2 and TP-6. The depth to ground water in these test pits ranged from 3 to 4 feet below grade. No oily soils or sheen were observed in test pit TP-3; however, a large amount of metal debris was encountered from 1 to 4 feet (depth of water table) below grade. The metal consisted of scrap metal (pipes, sheeting) and what appeared to be machine shop parts (bolts, gears, metal wheels).

- Test pit TP-7 was excavated just north of the other test pits to investigate the geophysical anomaly detected in this area and to further investigate the extent of the oily soils observed in test pit TP-5. A large amount of metal debris was encountered in this test pit from 2 to 5.5 feet (approx. depth of water table) below grade. A slight oil sheen was also observed on the ground water in the test pit. A soil sample was collected from the fill materials above the ground water table.

- Test pit TP-4 was excavated to investigate a geophysical anomaly detected in this area of the site. Metal and wood debris were encountered from 2 to 4 feet (depth of water

table) below grade. A 55-gallon, crushed metal drum carcass was encountered at the western end of the test pit near the on-site dirt road. A layer of what appeared to be burned paper was encountered at 2 feet below grade in the pit. A soil sample was collected from the fill materials above the ground water table.

Signs of oil contamination (e.g., oily soils, sheen) were observed in four of the test pits (TP-1, TP-2, TP-5, and TP-6). These test pits were completed over an area with covering approximately 60 feet by 180 feet (10,800 square feet). The most significant oily soil contamination was observed at the location of test pit TP-1. Metal debris was encountered in all of the test pit. Significant amounts of metal debris was observed in test pits TP-3, TP-4, and TP-7. Geophysical anomalies had been observed across this area of the site.

2.6 Subsurface Soil Boring Investigation

Subsurface test borings were completed at the McAllister Point Landfill, Melville North Landfill, and the Old Fire Fighting Training Area sites to aid in determining the nature and extent of subsurface soil contamination at each site. Information obtained from the test boring activities aided in determining final locations for the monitoring wells at the three sites. In addition, monitoring well borings were completed at all five of the sites during monitoring well installation activities.

Soil Boring Sampling Methods

Split spoon samples were collected continuously from each borehole at two-foot intervals. Test borings were sampled continuously to just beyond observed contamination or the depth of bedrock, whichever was encountered first. Well borings were sampled continuously to a maximum depth of 20 feet or to bedrock, whichever was encountered first. When it was necessary to extend well borings beyond 20 feet and bedrock was not encountered, split spoon samples were collected at every 5-foot interval or identifiable change in strata. Standard penetration tests [ASTM Standard 1586-84 (ASTM, 1990)] were conducted for every two-foot sampling interval. The physical characteristics of each soil sample were also geologically logged.

Soil boring samples submitted for laboratory analyses were transferred directly from the decontaminated split spoon to the sample container with a dedicated stainless steel spoon. In some

instances, samples were initially transferred to a ziploc bag for OVA and/or HNu headspace analyses. The headspace readings from the bagged samples were used to aid in selecting which samples to submit for laboratory analyses. Split spoon samples were also monitored with an OVA and/or HNu. All field observations were recorded in a field notebook.

A Shelby tube sample was collected from one monitoring well boring at McAllister Point Landfill. A Shelby Tube was collected from the till layer (14-16 feet depth) in the well boring of MW-5S. The Shelby Tube was collected for analysis of grain size, triaxial permeability and Atterberg Limits in order to provide information on the characteristics of the till at the site. The Shelby tube sample was collected according to ASTM Method Standard D1587-83 (ASTM, 1990).

Several of the monitoring well borings completed at McAllister Point Landfill, Tank Farm Four, and Tank Farm Five were advanced into bedrock. In instances were the bedrock was sufficiently weathered, the borings were advanced using augers. If competent bedrock was encountered, the borehole was advanced to the desired depth and a rock core collected using a double-tube Nx rock core barrel. After the rock coring was completed, the open borehole was reamed out with a 4-inch outside diameter (O.D.) tri-cone bit.

All drilling equipment (i.e., augers, drilling rods, split spoons) was decontaminated prior to each use according to the procedures described in the QA/QC Plan. Dedicated sampling spoons

and bowls were laboratory decontaminated according to procedures defined in the QA/QC Plan.

The drill cuttings from each site's soil borings were handled differently. The cuttings from the test borings at the two landfills were returned to their respective boreholes. Given the public access to the Old Fire Fighting Training Area site, special procedures were used to eliminate the potential for public exposure to contamination during and after the soil boring investigation. During all of the drilling activities at Site 09, plywood and plastic sheeting was placed around each borehole to intercept the drill cuttings and eliminate the potential for spreading contamination around the borehole. All test boring drill cuttings were backfilled into their respective boreholes. To eliminate potential future human exposure to contaminated drill cuttings, the remainder of the borehole was capped with a cement-bentonite grout. The plastic sheeting was placed in a DOT-approved 55-gallon drum for disposal. Drill cuttings from the monitoring well borings at all five of the sites were placed in DOT-approved 55 gallon drums and later transported to the drum staging area at McAllister Point Landfill.

Test Boring Sample Designation

All test boring soil samples submitted for laboratory analyses were assigned a designated field identification number which referenced the site name, sample type, sample location, sample

interval, and sampling date. Presented below is an example of a test boring soil sample designation:

Example: MN-B011-417

where:
MN = Melville North Landfill
B = Boring Soil Sample
01 = Sample Location Number
1 = Sample Interval
417 = Sampling Date (4/17/90)

Monitoring Well Boring Sample Designation

All well boring soil samples submitted for laboratory analyses were assigned a designated field identification number which referenced the site name, sample type, sample location, sample interval, and sampling date. Presented below is an example of a well boring soil sample designation:

Example: MN-M041-010990

where:
MN = Melville North Landfill
M = Monitoring Well Boring Soil Sample
04 = Sample Location Number
1 = Sample Interval
0109 = Sampling Date (01/09/90)

Soil Boring Sampling Strategy and Location

The specific soil boring activities completed for the sites are detailed in Sections 2.6.1 through 2.6.3 below.

2.6.1 Site 01 - McAllister Point Landfill

Background Information

As is discussed in Section 1.3.1 of this report, this landfill received nearly all of the wastes generated at the NETC for a period of almost twenty years. The landfill is believed to contain

spent acids, waste paints, solvents, and waste oils. The landfill also reportedly contains at least 200 gallons of PCB-contaminated oil.

Previous subsurface investigation activities at the site included the installation of two on-site monitoring wells and one off-site background monitoring well. Several landfill leachate samples were also collected from the edge of the landfill along the shoreline. The two on-site wells are located at the southwestern edge of the portion of the site where most of the landfilling activities reportedly occurred. The borings associated with the wells encountered 15 to 38 feet of fill material (e.g., bricks, wood, fabric). No samples were collected from the soil or fill material for laboratory analyses. Ground water elevation measurements from the wells indicate that the water table is within the fill material. The results of the ground water monitoring well sample analyses indicated elevated concentrations of metals in the site ground water. The analytical results of the leachate samples collected from springs emanating from the western edge of the landfill also indicated that volatile organic and metal-containing waste is present in the landfill. These findings indicated the need for determining the nature and extent of subsurface contamination at the site.

Overview of Investigation

The subsurface investigation activities initially included the drilling and sampling of ten (10) test borings and nine (9) well

borings at the site. The borings were drilled throughout the site to provide information on the site stratigraphy, soil quality, and ground water quality. One additional test boring (B-11) was added later in the investigation for the collection of additional soil samples and to aid in defining the extent of fill material in the center of the site. In addition, two monitoring well borings were converted to test borings (B-12 and B-13) when it was realized that the planned overburden ground water table monitoring wells could not be installed at these locations. The planned overburden wells were not installed at either of the locations because the ground water table was not encountered in the unconsolidated, overburden material at the locations. Soil boring B-12 was located in the western edge of the central landfill area and provides information on the depth and characteristics of the fill material in that area. Soil boring B-13, the only boring drilled off-site, was located east of the site (across Defense Highway in the cemetery property) and provides information on background subsurface soil quality. The nine (9) monitoring well borings were advanced during monitoring well installation. The well borings provided additional information on the nature and extent of the subsurface soil contamination. The locations of the test borings are shown on Figure 2-16. The location of the monitoring wells are shown on Figure 2-17.

Continuous split spoon soil sampling was conducted for all of the soil borings. All of the test borings were completed to beyond any observed fill or contamination to a minimum depth of six feet.

The well borings were completed at a depth sufficient for the installation of a ground water table monitoring well. Fill was encountered in all of the borings completed on the site.

A total of two to three samples were collected for analyses from each of the borings completed on the site. On soil sample was collected for analyses from the off-site soil boring (B-13). Summaries of the test boring and well boring soil samples collected for analysis are provided in Tables 2-3 and 2-4, respectively. All of the split spoon samples were screened with an OVA and/or HNu for signs of contamination. Downhole and near-hole LEL measurements were also made during the drilling activities. Generally, the three samples submitted for analyses from the borings included a sample from the fill material, a sample from the approximate depth of the ground water table, and a sample from the soil just beneath the fill layer. If the first two soil boring samples (i.e. the one in the fill material and the one at the water table) appeared to be of the same fill material, only the sample collected at the ground water table was submitted for analyses. The fill material sample was collected from the split spoon that appeared to be the most contaminated based upon visual observations (e.g., discolored, oily, waste) and OVA readings. The selection of which split spoon samples were to be submitted for analysis was also constrained by the amount of material recovered by each split spoon.

Soil boring samples were generally analyzed for all of the TCL and TAL parameters. Many of the boring samples collected from the fill material were also archived for dioxin analysis. One of the

fill samples (B1-4) containing some gray ash layers was also submitted for the Toxicity Characteristic Leaching Procedure (TCLP) analysis.

Field Measurements and Observations

During the soil boring drilling and sampling investigation activities, all field measurements and observations were recorded in a field notebook. Recorded field measurements included organic vapor measurements made with an OVA and/or HNu and LEL readings. Observations that were recorded in the field include geologic soil descriptions and visual signs of potential contamination (i.e., discolored soils, waste products, odors, etc.). All of the soil boring drilling measurements and observations are presented in the boring logs and well logs in Appendices F and G, respectively.

The landfill material appears to be generally separated into three broad categories of waste, consisting of domestic type refuse, industrial/construction waste, and incinerator ash. The central, mounded portion of the landfill was found to contain domestic-type refuse (i.e. plastic bags, rags, newspaper, etc.). Samples from this portion of the landfill exhibited strong "garbage-type" odors, which typically resulted in very high headspace readings (at times >1000 ppm) on the OVA. Lower volatile organic gas readings were typically measured with the HNu, indicating the likely presence of methane gas in this portion of the landfill since the HNu does not detect methane, unlike the OVA. Domestic wastes were encountered in borings B-3, B-5, B-6, B-7, B-

11, and the well boring for well MW-3S/D. This area of the site also corresponds to the area of the site which appears to be capped with a clay-silt cover material.

The remainder of the soil borings completed at the site contained waste typical of building demolition debris (i.e. wood, metal, brick, concrete, etc.). Volatile organic vapor readings from samples and borings in these areas were generally lower than those in the central portion of the site.

Incinerator ash was encountered in borings B-1, B-2, B-4, B-9, and the well boring for MW-2S. What appears to be ash deposits are also visibly present on the surface to the northeast of B-4. The ash deposits appear to be located primarily along the northwest portion of the site, although boring B-9, which was completed in the southern portion of the site, also encountered what appeared to be ash deposits. In instances where both ash waste and demolition-type debris were encountered (B-2, B-4, and B-9, and MW-2) the ash waste overlaid the demolition-type debris. The thickest deposit of ash waste was identified in boring B-1, where the ash extends from 1.5 to 8 feet below grade and was the only type of waste encountered throughout the entire boring.

2.6.2 Site 02 - Melville North Landfill

Background Information

As is discussed in Section 1.3.2 of this report, this landfill received nearly all wastes generated at the NETC for a period of almost 15 years. The landfill is believed to contain wastes

similar to the McAllister Point Landfill; spent acids, waste paints, solvents, waste oils, and PCB oil.

No previous subsurface investigation activities had been completed at this site; however, surficial sampling of oily deposits at the site indicated the presence of petroleum-based hydrocarbons and metals in on-site waste pile deposits. The unknown nature of the landfill indicated the need for determining the presence and nature of subsurface contamination at the site.

Overview of Investigation

Soil boring activities initially included the drilling and sampling of ten (10) test borings and five (5) well borings across the site. The borings were drilled throughout the site to provide information on the site stratigraphy, subsurface soil quality, and ground water quality. Twelve (12) of the borings were completed in fill material and three (3) were completed outside of any fill. One of the well borings (M-5) was completed off-site. Two of the borings (B-4 and B-5) were drilled near the suspected location of the former waste lagoons to define the vertical and horizontal extent of the contamination identified in the test pit excavations. Three additional borings (B-11, B-12, and B-13) were completed to further investigate the extent of subsurface soil contamination identified by other borings and the test pit excavations. The locations of the test borings are shown on Figure 2-18. The locations of the monitoring well borings are shown on Figure 2-19.

Continuous split spoon sampling was conducted in all of the test borings and well borings. The test borings were completed to a depth of just beyond any observed fill material or contamination. The monitoring well borings were completed to a depth sufficient for installation of a water table monitoring well. The test borings which did not encounter fill material were completed to a depth of six feet to investigate the near-surface soil in the area.

A total of two to three samples were collected for analyses from each of the soil borings completed in the fill area. Summaries of the test boring and well boring soil samples collected for analysis are provided in Tables 2-5 and 2-6, respectively. All of the split spoon samples were screened with an OVA and/or HNu for signs of contamination. The three samples that were submitted for analyses from these borings included a sample from the fill material, a sample from the ground water table, and a sample from the soil just beneath the fill material. If these first two samples (i.e., the one in the fill material and the one at the water table) appeared to be of the same fill material, only the sample at the ground water table was submitted for analyses. The fill material sample was collected from the split spoon that appeared to be the most contaminated based upon visual observations and OVA/HNu readings.

One soil sample was collected for analyses from borings which did not encounter fill material or any signs of contamination. The one soil sample was collected from the 0- to 2-foot surface

interval to investigate near-surface soil contamination in the area.

Soil boring samples were generally analyzed for all of the TCL and TAL parameters. One soil boring sample from visually contaminated fill material (B-13) was also submitted for Toxicity Characteristic Leaching Procedure (TCLP) analysis.

Field Measurements and Observations

During the test boring and well boring drilling and sampling investigation activities, all field measurements and observations were recorded in a field notebook. Recorded field measurements included organic vapor measurements taken with an OVA and/or HNu and LEL readings. Observations that were recorded in the field include geologic soil descriptions and visual signs of potential contamination (i.e., discolored soils, waste product, odors, etc.). All of the soil boring drilling measurements and observations are presented in the boring logs and well logs in Appendices F and G.

Descriptions of soil encountered in soil borings as well as observations made during test pit excavations indicate that the landfilled material consists of three general types of fill: soil and gravel fill (not native soil), scrap metal debris, and burned wood debris. The soil borings also further documented the presence of oily stained soils in the vicinity of the former waste impoundments. Large amounts of domestic type refuse, like that encountered at McAllister Point Landfill, were not observed during

the subsurface investigation activities at the Melville North Landfill.

The types of landfilled materials do not appear to be segregated into definite areas across the site. Burned wood debris was encountered in borings B-2, B-5, B-6, B-7, B-9, B-12, test pit 2, and test pit 4. Soil and gravel fill was present in borings B-1, B-4, B-5, B-6, B-7, B-12, the well borings for wells MW-2 and MW-3, and all seven of the test pits. Construction type debris was encountered in borings B-6, B-13, well boring MW-2, as well as in test pits 1 and 5. Petroleum odors were encountered during the drilling of borings B-4, B-5, B-7, B-9, B-12, B-13, and well borings for wells MW-3 and MW-4, as well as in test pits 1 and 5. Visible petroleum contamination was encountered in borings B-4, B-7, B-13, the well boring for well MW-3, and in test pits 1 and 5. Elevated volatile organic vapor readings were encountered in some of the borings surrounding the area of the former waste impoundment (B-4, MW-3) and also at the location of well MW-4. No strong "garbage-type" odors like those detected at the McAllister Point Landfill were encountered at this site.

2.6.3 Site 09 - Old Fire Fighting Training Area

Background Information

Previous subsurface investigation activities at this site included the drilling of three test borings during a 1987 geotechnical investigation. Oily soil was encountered approximately 5 feet below the surface during these investigations.

Numerous below-grade structures (e.g. sumps, pits) were used during fire fighter training operations, which were conducted at the site for nearly 30 years. It is likely that these structures and surface discharges were potential sources of the oily soil contamination encountered at the site. The previous site use and oily subsurface soil discovery indicated the need for determining the nature and extent of subsurface contamination.

Overview of Investigation

The soil boring activities included the drilling of seven (7) test borings and five (5) monitoring well borings across the site. The borings were drilled throughout the site to characterize the site stratigraphy, subsurface soil quality, and ground water quality. Findings of the soil gas survey performed at the site were used to aid in determining the final locations of several of the borings (B-6 and B-7). The locations of the test borings are shown on Figure 2-20. The locations of the monitoring wells are shown on Figure 2-21.

Continuous split spoon sampling was conducted in all of the soil borings. The test borings were completed to a depth just beyond any observed contamination. If no contamination was encountered in the boring, the boring was completed to bedrock or until refusal was encountered. The monitoring well borings were completed to a depth sufficient for installation of a ground water table monitoring well. One overburden well at the Old Fire Fighter Training Area (MW-1S) was installed by the water-rotary drilling

technique using a 4-inch tri-cone drilling bit. This method was used when the hollow stem augers could no longer advance through the dense till at the well location.

A total of one to three soil samples were collected for analysis from each soil boring. If three samples were submitted for analyses, the samples included a sample from the highest observed contamination, a sample from the approximate location of the water table, and a sample from the bottom of the boring. If the first two soil boring samples (i.e., the most visually contaminated, and the one at the water table) appeared to be similar, only the sample at the water table was submitted along with the bottom sample for analysis. If no signs of contamination were present in the boring, a sample was collected at the water table. Two samples were typically submitted for analyses from each boring. The two samples included a sample from the area of highest observed contamination (i.e, most oily, largest OVA/HNu readings) and one from the bottom of the boring. The sample intervals were also dependent upon the sample recoveries from the split spoons of each boring. Summaries of the test boring and well boring soil samples collected for analysis are provided in Tables 2-7 and 2-8, respectively. All of the split spoon samples were screened with an OVA and/or HNu for signs of contamination. The soil boring samples were generally analyzed for all of the TCL and TAL parameters.

Field Measurements and Observations

During the soil boring drilling and sampling investigation activities, all field measurements and observations were recorded in a field notebook. Recorded field measurements included organic vapor measurements made with an OVA and/or HNu and LEL readings. Observations that were recorded in the field include geologic soil descriptions and visual signs of potential contamination (i.e., discolored soils, waste product, odors, etc.). All of the soil boring drilling measurements and observations are presented in the test boring logs and well logs in Appendices F and G respectively.

Building demolition-type debris (i.e., brick, concrete, asphalt) was encountered in test borings B-2, B-4, B-6, and the well borings for wells MW-2 and MW-3. The area where these borings were completed, the center of the site, corresponds to where fire fighting structures (e.g., sumps, pits) were once located. Visibly oil-stained soils were encountered in test borings B-2, B-3, B-5, and well borings MW-2 and MW-3. In all instances, the observed petroleum contamination began at the approximate location of the ground water table. In addition, petroleum-type odors were encountered in soil borings B-6, B-7, and the well boring for well MW-5. What appeared to be a light hydrocarbon (i.e., diesel fuel) odor was encountered in soil boring B-4. No fill, odors, or visible contamination were encountered in soil boring B-1 or in the well boring for MW-1, both of which are located at the extreme southern end of the site.

The highest volatile organic vapor readings were encountered in those soil borings which exhibited visible contamination and in the central portion of the site (B-5, MW-2, MW-3). An organic muck was encountered at the bottom of boring B-5 (depth of 6-10 feet), completed at the western edge of the site near the bay. The silty muck had an odor similar to ocean bottom sediments and contained shell fragments. One sample of the organic muck exhibited an OVA measurement of >1000 ppm and an HNu measurement of 3 ppm. Given the large discrepency between the OVA and the HNu measurements, it is likely that the high OVA reading is a result of methane gas generated from decay of the organic material (the HNu cannot detect methane gas).

2.6.4 Site 12 - Tank Farm Four

Background Information

Although no previous subsurface soil sample analytical results are available, two monitoring wells were previously installed at the western edge of the site. Although the wells are not directly downgradient of the on-site underground storage tanks (UST's), the analytical results of the ground water samples from these wells indicate that metals and petroleum-based hydrocarbon contamination exist in the site ground water. Given that the well contamination is very likely attributed to the on-site petroleum storage activities, the subsurface soil and ground water quality at the site required further investigation.

No test borings were completed at Tank Farm Four, although eight monitoring well borings were completed for the installation of ground water monitoring wells at the site. The monitoring well borings were spaced throughout the site to provide information on the site stratigraphy, subsurface soil quality, and ground water quality.

Overview of Investigation

Five (5) monitoring well borings were sampled during monitoring well installation activities at the site. The monitoring well borings were spaced throughout the site to provide information on the site, stratigraphyu, subsurface soil quality, and ground water quality. The findings of the soil gas investigation performed at the site also aided in evaluating the final locations for the monitoring wells.

The locations of the monitoring wells are shown on Figure 2-22. Continuous split spoon sampling was conducted in all of the well borings to a maximum of 20 feet or to 10 feet beyond the depth of the water table. When it was necessary to extend the well borings beyond 20 feet and sufficient saturated soil had not been encountered, split spoon soil samples were collected at every 5-foot interval or identifiable change in strata. A summary of the well boring soil samples collected for analysis is provided in Table 2-9.

At three of the well locations (MW-1, MW-3, and MW-5), two monitoring wells, a shallow and a deep well, were nested together.

The deep monitoring well borings (MW-1D, MW-3D, and MW-5D) were advanced using Nx rock coring techniques into competent bedrock. The other well borings were completed in overburden or weathered bedrock to a depth sufficient for the installation of a water table monitoring well. All of the split spoon samples were screened with an OVA and/or HNu for signs of contamination. Since no signs of contamination were encountered in any of the well borings, one soil sample was collected from each monitoring well boring at or near the water table. The soil samples were generally analyzed for all of the TCL and TAL parameters. One of the samples was also analyzed for Total Petroleum Hydrocarbons. MW-1 0204 Ft. BGS 150 PPM (DUP=160 PPM)

Field Measurements and Observations

During the well boring drilling and sampling investigation activities, all field measurements and observations were recorded in a field notebook. Recorded field measurements included organic vapor measurements made with an OVA and/or HNu. Observations that were recorded in the field include geologic soil descriptions. All of the well boring drilling measurements and observations are presented in the well logs in Appendix G.

No signs of potential contamination (i.e. discolored soils, fill, odors) were encountered in any of the well borings at the site. All of the well borings encountered native overburden materials (sand and silt). The sand and silt directly overlaid bedrock in all of the deep well borings. Further details on the site geology are presented in Section 3.4 of this report. The

organic vapor measurements of the split spoon soil samples were for the most part low in all of the well boring soil samples (the highest OVA reading was 24 ppm from the 8-10 foot interval in MW-5S).

2.6.5 Site 13 - Tank Farm Five

Background Information

Ten monitoring wells were previously installed in the southwest portion of the site as a part of a tank closure investigation for two of the UST's (Tanks 53 and 56) on the site. The findings of that tank closure investigation indicated that ground water contamination is present in that portion of the site. Given the existence of additional UST's and a burning pit at the site, the subsurface soil and ground water quality around these structures required further investigation.

Overview of Investigation

Six (6) monitoring well borings were sampled during monitoring well installation activities at the site. The monitoring well borings were spaced throughout the site to provide information on the site stratigraphy, subsubsurface soil quality, and ground water quality. Findings of the soil gas investigation performed at the site aided in evaluating the final locations of the monitoring wells. The locations of the monitoring wells are shown on Figure 2-23.

Continuous split spoon sampling was conducted in all of the well borings to a maximum of 20 feet or to 10 feet beyond the depth of the water table. When it was necessary to extend the well borings beyond 20 feet and sufficient saturated soils had not been encountered, split spoon samples were collected at every 5-foot interval or identifiable change in strata. A summary of the well boring soil samples collected for analysis is provided in Table 2-10. Weathered bedrock was encountered in all of the monitoring well borings but was degraded enough to allow advancement of the borings using hollow stem auger drilling methods. All six of the monitoring well borings were completed in the degraded bedrock material. All of the split spoon samples were screened with an OVA and/or HNu for signs of contamination. Since no signs of contamination were observed in any of the well borings, one soil sample was collected from each monitoring well boring at or near the depth of the water table.

The soil samples were generally analyzed for all of the TCL and TAL parameters. One of the samples was also analyzed for Total Petroleum Hydrocarbons.

Field Measurements and Observations

During the well boring drilling and sampling investigation activities, all field measurements and observations were recorded in a field notebook. Recorded field measurements included organic vapor measurements made with an OVA and/or HNu. Observations that were recorded in the field include geologic soil descriptions. All

of the well boring drilling measurements and observations are presented in the well logs in Appendix G.

No signs of potential contamination (i.e. discolored soils, fill, odors) were encountered in any of the well borings completed on the Tank Farm Five site. All of the well borings encountered native overburden materials (sand and silt). This sand and silt was directly overlying bedrock in all of the deep well borings at the site. Further details on the site geology are presented in Section 3.4 of this report. The organic vapor measurements were for the most part low in all six of the monitoring well borings, with the highest value (22 ppm) encountered in the boring for MW-5 at a depth of 4-6 feet below grade.

2.7 Ground Water Investigation

Monitoring wells were installed at all five sites to aid in determining the presence, nature, and/or extent of ground water contamination at each site. The monitoring wells were also used to provide information on the aquifer characteristics and ground water flow directions at each site.

The following monitoring well investigation topics applicable to each of the sites are discussed below: well sampling strategy and location for each site, well construction details, well sampling methods, and the well sample designation scheme.

Well Boring, Drilling, and Sampling Methods

The boreholes for the wells constructed in the unconsolidated overburden materials were advanced to the desired depth using 4-¼" inside diameter (I.D.) hollow-stem augers. Continuous split spoon sampling was conducted in all of the well borings to a maximum of 20 feet or to 10 feet beyond the depth of the water table. When it was necessary to extend the well borings beyond 20 feet and sufficient saturated soils had not been encountered, split spoon samples were collected at every 5-foot interval or identifiable change in strata. Standard penetration tests [ASTM D 1586-67 (1974)] were conducted at every two-foot sampling interval. The physical characteristics of each soil sample were visually characterized and geologically logged.

Soil samples submitted for laboratory analyses were typically transferred from the split spoon directly to the appropriate sample

containers with a dedicated stainless steel spoon. In some instances, soil samples were first transferred to ziploc bags for headspace analysis. The headspace analysis information was used to aid in selecting which soil boring samples to submit for laboratory analyses. All split spoon samples were monitored with an OVA and/or HNu. All field observations were recorded in a field notebook.

Bedrock wells were installed at the McAllister Point Landfill and Tank Farm Four sites. The bedrock well installed at the McAllister Point Landfill (MW-1D) was advanced into the weathered bedrock according to the procedure described previously for the overburden wells. The hollow stem augers (4-¼" I.D.) were able to advance thirty feet through the weathered bedrock at this location.

The bedrock wells at Tank Farm Four (MW-1D, MW-3D, and MW-5D) were installed using a slightly different technique. Since these wells were paired with shallow wells, split spoon sampling in the deep well borings began at a depth of five feet below the last split spoon collected in the paired shallow well boring. The deep well borings were advanced with 4-¼" (I.D.) hollow stem augers, with a split spoon sample collected at every five-foot interval until competent bedrock was encountered. A roller bit was then used to ream the borehole out to the top of the competent bedrock surface. The borehole was then advanced fifteen (15) feet into competent bedrock using a double-tube Nx rock core barrel. The coring times for each one-foot interval were recorded as well as

the core recoveries. The monitoring well screen was then installed directly into the cored interval of the borehole.

At Tank Farm Four, four of the monitoring wells (MW-1S, MW-1D, MW-3, and MW-5S) were vandalized shortly after installation. Trespassers broke the protective casing locks off of all four wells, and poured cement into well MW-1D. As discussed under the well development discussion, these wells were redeveloped to assess the possible effects of the vandalism.

The final depth of all monitoring wells was determined by the TRC field geologist/engineer. Variables that were considered in establishing the wells' final depths included: materials encountered (e.g., refuse vs. clean material), observed contamination, geologic materials, depth to water table, and site sampling objectives.

All well boring drill cuttings were contained in labeled, DOT-approved 55-gallon drums at each well location. At the conclusion of all investigations the drums were transported to the designated drum staging area at McAllister Point.

All sampling equipment (i.e., augers, drilling rods, spoons) were decontaminated prior to each use according to the procedures in the project QA/QC Plan.

Well Construction Details

The drilling and well construction activities were subcontracted to Construction Drilling Services, a division of Layne-Western Company, Inc., of Chelmsford, Massachusetts. All

drilling activities were conducted under the supervision of a TRC geologist.

Construction specifications which are common to all monitoring wells installed for this project include the following:

- 6-inch diameter borehole (minimum);
- 2-inch I.D. PVC riser and screen;
- Threaded joints (no glued joints);
- Silica (quartz) sand backfill to at least 1 foot above the top of the well screen;
- 1 to 2-foot thick bentonite seal above the sand pack;
- Portland cement/bentonite slurry (approximately 6:1 ratio, respectively) in the well annulus from the top of the bentonite seal to the ground surface;
- All casing sealant and drilling fluids were mixed with potable water;
- Vented well cap; and
- Steel casing with a locking cap securely set in cement over the well casing stick up and a minimum of 3 feet below the ground surface. Note: All wells at the Old Fire Fighting Training Area were installed with curb boxes constructed at or below grade.

Typical monitoring well construction details for the surficial overburden and bedrock wells are depicted in Figures 2-24 and 2-25, respectively. A summary of the monitoring well construction details for the five sites is provided in Table 2-11. Well screen lengths varied for each well. Screen lengths for wells intercepting the water table were typically a minimum of 10 feet, when possible, with no more than five feet extending above the water table. One monitoring well (MW-4) completed at the top of

the bedrock surface at McAllister Point was restricted to 4.5 feet of screen due to the thickness of overburden material present at that location. Well riser lengths were field-determined so the top of the casing extended approximately one to two feet above the ground surface. The riser extended to just below grade for the flush mount wells at the Old Fire Fighting Training Area. The driller and TRC geologist maintained accurate written logs of the well construction details.

Well Development

Wells were developed using two methods: by the surge-block technique with a Watterra pump assembly, and by compressed air. During the surge-block technique, fine-grained material around the well screen was drawn into the well and removed by the agitation and pumping action of the Watterra pump tubing and foot valve. The Watterra pump assembly utilized dedicated ASTM-drinking water grade polyethylene tubing and a dedicated check valve. During the surging, the water was removed from the well at a low rate. During the air development technique, compressed, filtered air was injected into the monitoring wells in order to displace the well water to the surface where it was collected in drums. During which, fine grained material was dislodged from the well screen and brought to the surface along with the water.

All of the wells installed during the investigation, except the deep wells at Tank Farm Four, were initially developed using the surge-block technique. Just after installation, four of the

monitoring wells installed at Tank Farm Four (MW-1S, MW-1D, MW-3S, and MW-5S) were vandalized on the night of June 13, 1990. The locks on the protective well casing covers of all four wells were broken off. Based upon the following observations, it appeared as though one well, MW-1D, had cement poured into its casing: an empty bag of cement adjacent to the well, cement on the ground adjacent to the well, and cement between the well casing and protective casing. Within several days after the vandalism, MW-1D, MW-3D, and MW-5D were developed for the first time using the compressed air technique. During development of the three deep wells, the pH of the development water was monitored to evaluate the effects, if any, the vandalism had on well MW-1D. Development water from all three deep wells stabilized to a pH of 5.6. The three shallow monitoring wells were redeveloped within several days of the vandalism using the surge-block technique. The shallow wells were redeveloped until the pH of the water stabilized.

Generally, all of the site wells were pumped for a minimum of one hour or until the development water achieved visual clarity. Table 2-12 shows the well development data for all of the sites. All water produced during the well development was contained in 55-gallon drums.

Monitoring Well Measurements and Sampling

Prior to purging the wells for sampling, the ground water levels of all monitoring wells were measured to the nearest 0.01 foot using an electric water sensing device. Periodic water level

measurements were obtained from monitoring wells on each of the sites at several different times. The water level indicator was decontaminated before each use with a tap-water/non-phosphate detergent wash, tap water rinse, and a distilled/deionized water rinse. In instances where significant contamination was present in a well (e.g., odors, oil), the water level indicator was also decontaminated after use in that well with a hexane and methanol rinse prior to the final water rinse. An oil/water interface probe was used to measure the thickness of any oil present in a well.

In addition to the periodic water level measurements, continuous water level measurements were obtained from several of the wells at McAllister Point Landfill, Melville North Landfill, and the Old Fire Fighter Training Area. The continous water level measurements were conducted using two Enviro-Labs EL-200/SYSTEM 17 Data Loggers and five pressure transducers. Water levels in five monitoring wells at McAllister Point and in four wells at Melville North were recorded continously by the data loggers for a 72-hour period. These continous water level measurements display any effect of tidal influences upon the water levels in the monitoring wells. Details on the results of these measurements for each site are discussed int hydrogeology section of this report (section 3.5).

Piezometers (well points) were installed at both Tank Farm Four and Tank Farm Five. Five piezometers were installed along Normans Brook at Tank Farm Four and four piezometers were installed along Gomes Brook at Tank Farm Five. These piezometers consist of

a 2-inch diameter, four-foot section of carbon steel screen attached to a five foot section of steel riser. The piezometers were hand driven into the soil with a sledge hammer until the screened section intercepted the water table.

The tops of the piezometers were surveyed in and water levels within the piezometers were recorded at two different times during the investigation. These water levels along with surface water levels taken in the streams were used to determine if the streams at the Tank Farms were gaining or losing streams. Further detail on the results of these measurements is found in Section 3.6 of this report.

Just prior to the sampling of each monitoring well, the wells were purged to introduce fresh formation water into the well for sampling. A Watterra pump with dedicated ASTM drinking water grade polyethylene tubing and a foot valve was used for the purging of each well. In general, the total water quantity evacuated from the wells ranged between three and four well volumes. When the wells did not produce sufficient water for purging three well volumes, they were pumped near-dry once and allowed to recover. In some instances, dedicated teflon bailers were used to purge the wells instead of the Watterra pump.

Ground water samples were collected in dedicated teflon bailers connected to a dedicated teflon leader and polyethylene rope. The teflon bailers were decontaminated in the laboratory using the decontamination protocol specified in the QA/QC plan. The teflon bailers were wrapped in aluminum foil for transport to

the site prior to their use. During sample collection, the bailer was slowly lowered in the well to a depth of approximately five feet below the water level in the well. The bailer was then retrieved from the well and the water slowly transferred to the appropriate sample containers. The ground water samples collected from all of the wells installed during the investigation were generally analyzed for the TCL and TAL parameters. Two previously installed wells at Tank Farm Five were sampled for TCL and TAL parameters as well as TPH. Four previously installed wells at Tank Farm Five were sampled only for TPH and lead.

Well Permeability Testing

After the completion and development of the wells, a permeability test was performed at several of the wells at each site. Slug tests were used to better define the site aquifer characteristics at the sites.

The slug tests were conducted using a PVC rod, or slug. Prior to inserting the slug test rod into the well, a pressure transducer connected to a digital LCD readout was lowered into the well. The pressured transducer provides a continous readout of the amount of water (feet) that is above the transducer. The slug test rod was then lowered into the well and the water level was allowed to equilibrate. Once the water level had equilibrated, the slug test rod was rapidly removed from the well and the transducer readings were recorded at specified intervals for approximately a five minute period.

The information obtained from these tests was used to evaluate the hydrogeologic properties of the site soils. The results of the well permeability tests are discussed in Section 3.5 of this report.

Ground Water Sample Designation

All ground water samples were assigned a designated field identification number which referenced the site name, sample type, sample location number, and sampling date. Presented below are examples of a ground water sample designation:

Example: TF5-MW1-720

where:
TF5 = Tank Farm Five
MW = Monitoring Well Water Sample
1 = Well Number
720 = Sampling Date (7/20/90)

Monitoring Well Sampling Strategy and Location

Several monitoring wells were previously installed and sampled at three of the five sites. Information obtained from the existing wells was used in establishing the well network for the five sites. The monitoring well network developed for each site was also based primarily upon historical site information and the site-specific ground water monitoring objectives. Information obtained from initial site investigation activities (e.g., test borings, soil gas sampling) was, in some cases, used to make final adjustments to the well locations. The monitoring well investigation activities completed at each site are detailed below.

2.7.1 Site 01 - McAllister Point Landfill

Background Information

Two wells were previously installed on-site (wells MW-21 and MW-22) and one well off-site (well MW-23). The two on-site wells are approximately 300 feet apart along the southwestern edge of the site bordering Narragansett Bay. The off-site well is approximately 300 feet northeast and upgradient of the site. The analytical results of the water samples from these wells indicated that elevated concentrations of metals exist in the site ground water. Samples collected from leachate springs flowing from the western edge of the landfill indicate that organic and inorganic contamination is emanating from the landfill. These results, and the nature of the wastes disposed of at the landfill indicated the need for investigating the ground water at the site.

Overview of Investigation

A total of nine (9) monitoring wells were installed at the McAllister Point Landfill to investigate the ground water quality at this site. The nine wells installed at the site consist of five wells screened in the unconsolidated overburden and fill materials, and three wells screened in competent bedrock, and one well screened in weathered bedrock. The monitoring wells were installed during two different time periods. Monitoring wells MW-1D, MW-2S, MW-3S, MW-3D, MW-4S, MW-5S, and MW-5D were installed in January of 1990, while monitoring wells MW-6S and MW-7S were added in June of

1990 to provide additional information on the ground water quality at the site.

Two of the wells screened in bedrock (MW-3D and MW-5D) were nested with overburden wells. Given that the ground water table is within the bedrock at the other bedrock well location (MW-1D), an overburden well was not installed. Well MW-7S was screened in the weathered, upper zone of bedrock at the site which could be augered into easily. Wells MW-3D and MW-5D were advanced by rock coring into the competent bedrock.

The three bedrock wells were installed to aid in determining the ground water quality across the site, to define the direction of ground water flow in the bedrock, and to evaluate potential contaminant flow directions. Two of the deep monitoring wells (MW-3D and MW-5D) were installed at locations where some of the greatest visual evidence of contamination was observed (stained soils, fill, waste) during shallow well installation. The locations of all of the monitoring wells are shown on Figure 2-17.

Monitoring wells MW-1D, MW-2S, MW-3S, MW-3D, MW-4S, MW-5S, MW-5D, MW-21, MW-22, and MW-23 were sampled on April 3, 1990. Monitoring wells MW-6S and MW-7S, which were installed in June 1990, were sampled on July 18, 1990. The ground water samples were analyzed for all of the TCL and TAL parameters.

Field Measurements and Observations

Several field measurements were conducted as a part of the ground water investigation at the McAllister Point Landfill site.

These measurements included several periodic and continuous water level measurements of site wells, along with water quality parameter measurements of each ground water sample. All field measurements and notable observations made during the ground water sampling events were recorded in a field notebook and are discussed below.

Prior to ground water sampling, the ground water level for each monitoring well was measured using an electric water sensing device. All ground water level measurements are provided in Table 2-13. These ground water level measurements were used to determine site ground water flow directions and rates which are discussed in Section 3.5 of this report. In addition, continuous water elevation measurements were recorded over a 72-hour period in seven of the monitoring wells. At the same time, continuous surface water elevation measurements were measured adjacent to the site in Narragansett bay. These surface water measurements were collected under a separate research project being performed by a Navy officer. As discussed in Section 3.5 of this report, the continuous water elevation measurements were collected to evaluate the tidal effects of the bay on the site's ground water flow characteristics. The findings of this assessment are provided in Section 3.5. of this report.

Immediately after ground water sample collection, the pH, specific conductance, and temperature of each sample were measured and recorded in a field notebook; the values for each of these parameters are provided in Table 2-14. The pH of the ground water

samples ranged from 5.7 to 7.5, the temperature ranged from 11 to 14 °C, and the specific conductance of the ground water samples ranged from 140 to 3000 μmhos/cm. The two monitoring wells that were sampled in July (MW-6 and MW-7) exhibited slightly elevated temperatures which may be due to seasonal ground water temperature increases. The monitoring wells that exhibited the highest specific conductance (MW-21, MW-4S, and MW-3S) are all located within the main landfill area.

All observations concerning unusual appearance or odor of ground water during the well development, purging, and sampling were recorded in a field notebook. A summary of the recorded observations is provided in Table 2-12. The headspace of monitoring wells MW-3S and MW-5S exhibited a slight petroleum odor at the time of sampling, and the headspace of wells MW-3S, MW-3D and MW-4S exhibited a "garbage-type" odor. Well MW-2S, which was dry at the time of sampling, also exhibited a "garbage-type" odor. At the time of the water level measurements recorded on September 20, 1990, a thin oil layer was present in well MW-5S. The remaining wells did not exhibit noticeable odors at the time of sampling. This oil layer was not detected in any of the previous or subsequent dates of water level measurements.

2.7.2 Site 02 - Melville North Landfill

Background Information

No ground water investigations were previously conducted at this site.

Overview of Investigation

A total of five (5) monitoring wells were installed by TRC to investigate the presence and nature of ground water contamination at the Melville North Landfill site. Four of the wells (MW-1S, MW-2S, MW-3S, and MW-4S) are located on the site and one of the wells (MW-5S) is located upgradient and off of the site. Generally, the wells were spaced to provide information on the ground water quality across the site. Several of the wells were located in or near areas of suspected contamination based upon historical site information. Wells MW-1S and MW-2S were located in the area of the site which appeared to be a fill area based upon historical site aerial photos. Well MW-3S was located near the suspected location of a former waste impoundment shown on a historical site aerial photograph. Well MW-4S was also placed in a location where a suspected waste impoundment and disposal area had been observed on historical site aerial photos. MW-5S is an off-site upgradient well, installed to provide background information on the ground water quality upgradient of the site. The locations of the site monitoring wells are shown on Figure 2-19. All of the wells were installed in the overburden and fill materials and intercept the ground water table.

Installation and development of the monitoring wells took place in April of 1990. Sampling of the monitoring wells took place on July 18, 1990. All of the wells were sampled and analyzed for all of the TCL and TAL parameters.

Field Measurements and Observations

Several field measurements were conducted as a part of the ground water investigation at the Melville North Landfill site. These measurements included periodic and continuous ground water level measurements, along with water quality indicator measurements of each ground water sample. All field measurements and notable observations made during the ground water sampling events were recorded in a field notebook and are discussed below.

Prior to the ground water sampling and approximately once every three months after the ground water sampling event, the ground water level for each monitoring well was measured with an electric water sensing device. All ground water levels and elevations are provided in Table 2-15. These water level measurements were used to evaluate site ground water flow direction and rates, which are discussed in Section 3.5 of this report. In addition, continuous water table elevation measurements were recorded in four of the monitoring wells at the site. As discussed in Section 3.5, these continuous ground water level measurements provided information on the bay's tidal effect upon site ground water flow characteristics.

Immediately after ground water sample collection, the pH, specific conductance, and temperature of each sample were measured and recorded in a field notebook. The values for each of these parameters are provided in Table 2-14. The pH of the ground water samples ranged from 5.40 to 6.25, temperatures ranged from 14.2 to

19.3 °C, and the specific conductance of the ground water samples ranged from 190 to 250 μmhos/cm.

All observations concerning unusual appearance of ground water during the well development, purging, and sampling were recorded in a field notebook. A summary of the recorded observations is provided in Table 2-12. Petroleum odors and sheen were present in the ground water of monitoring well MW-4 during development, purging, and sampling of the well. Strong petroleum odors as well as a thin oil layer (less than one inch) was present in monitoring well MW-3 during development, purging, and sampling of the well. A sample of the oil from well MW-3 was collected and analyzed for volatile organic compounds. Oily ground water was also present during the water level measurements of September 20, 1990. At the time of the January 31, 1991 water level measurement, no measurable product was present in the well, however, a strong odor and sheen were still present. Monitoring wells MW-1, MW-2, and MW-5 did not exhibit any unusual appearance or odors.

2.7.3 Site 09 - Old Fire Fighting Training Area

Background Information

No ground water investigation were previously conducted at this site. However, a previous geotechnical investigation conducted at the site identified an oily substance which exists on a portion of the site below the ground water table.

Overview of Investigation

A total of five (5) monitoring wells were installed to investigate the nature and extent of ground water contamination at the site. Four of the wells (MW-1S, MW-2S, MW-3S, and MW-4S) were installed on the site and one of the wells (MW-5S) was installed upgradient and off of the site. All wells were installed in the overburden and fill material at the site. The off-site well (MW-5S) was installed to provide background information on the ground water quality upgradient of the site. Locations of the monitoring wells are shown on Figure 2-21.

The installation of the monitoring wells took place from April 23 to April 26, 1990. The sampling of the wells took place on July 19, 1990. The monitoring well samples were analyzed for all of the TCL and TAL parameters.

Field Measurements and Observations

Several field measurements were conducted as a part of the ground water investigation at the Old Fire Fighting Training Area site. These measurements included periodic and continuous ground water level measurements, as well as water quality indicator (pH, temperature, and conductivity) measurements of each ground water sample. All field measurements and notable observations made during the ground water sampling events were recorded in a field notebook and are discussed below.

Prior to ground water sampling and approximately once every three months after the ground water sampling event, the ground

water level for each monitoring well was measured with an electric water sensing device. All ground water levels and elevations are reported in Table 2-16. These water level measurements were used to evaluate site ground water flow directions and rates which are discussed in Section 3.5 of this report. In addition, continuous water table elevation measurements were recorded in four of the monitoring wells at the site. As discussed in Section 3.5, these ground water elevation measurements provided information on the bay's tidal effects upon ground water flow characteristics on the site.

Immediately after ground water sample collection, the pH, specific conductance, and temperature of each sample were measured and recorded in a field notebook. The values of each of these parameters are provided in Table 2-14. The pH of the ground water samples ranged from 6.2 to 7.4, the temperatures ranged from 13.1 to 17.7 °C, and the conductance of the samples ranged from 500 to 13,050 μmhos/cm. The two monitoring wells exhibiting the highest specific conductance (MW-2 (13,050 μmhos/cm) and MW-3 (2,150 μmhos/cm)) both contained visible petroleum contamination. In addition, MW-2 was installed closest to Narragansett Bay and exhibited the strongest tidal influence of the monitoring wells (see Section 3.5). Thus, it is likely that the high conductivity values measured in the ground water sample from well MW-2 are due to salt water intrusion from Narragansett Bay.

All observations concerning unusual appearance of ground water during the development, purging, and sampling of the monitoring

wells were recorded in a field notebook. A summary of the recorded observations is provided in Table 2-12. Strong petroleum odors and sheen were observed during the development, purging, and sampling of wells MW-2 and MW-3. A light petroleum odor was observed in the development, purging and sampling of MW-4. No odors or sheen was observed in monitoring wells MW-1 or MW-5 during the monitoring well investigation.

2.7.4 Site 12 - Tank Farm Four

Background Information

Two wells were previously installed on-site. The two wells are located along the western edge of the site. Although the wells are not directly downgradient of the on-site underground storage tanks (USTs), previous analytical results of the ground water samples from these wells indicated that metals and petroleum-based hydrocarbon contamination exists in the ground water. Given that the well contamination is very likely attributable to the on-site petroleum storage activities, further investigation of the site ground water was conducted.

Overview of Investigation

Eight (8) monitoring wells were installed at five locations on the site to investigate the ground water contamination. Five of the eight wells were screened in the overburden material and three wells were screened in bedrock. Each bedrock well was nested with

an overburden well. The locations of the monitoring wells are shown on Figure 2-22.

Generally, the wells were located throughout the site to provide information on the nature and extent of ground water contamination and the effect of the brook on the site hydrogeology. One well pair (MW-1S/D) was installed immediately downgradient of the USTs, the suspected sources of ground water contamination. Another well pair (MW-3S/D) was installed in the central portion of the site, in the middle of the tank area. Well pair MW-5S/D was installed in a location upgradient of the USTs to assess shallow and deep background ground water quality. Well MW-2S is located between the USTs and on the near, upgradient site of the on-site brook. Well MW-4 is located on the far side of the brook.

The installation of the monitoring wells took place during May and June of 1990. The sampling of the monitoring wells took place on July 18, 1990. The ground water samples were analyzed for all of the TCL and TAL parameters. At the time of the initial ground water sampling well MW-4S only contained sufficient ground water for the collection of a sample for volatile organic compounds. This well was later resampled for pesticides and PCB compounds.

Field Measurements and Observations

Several field measurements were conducted as a part of the ground water investigation at Tank Farm Four. These measurements included periodic water level measurements, piezometer water level measurements, along with water quality indicator measurements of

each ground water sample. All field measurements and notable observations made during the ground water sampling events were recorded in a field notebook and are discussed below.

Prior to ground water sampling the ground water level in each monitoring well was measured using an electric water sensing device. All ground water measurements are provided in Table 2-17. These ground water level measurements were used to determine site ground water flow direction and rates which are presented in Section 3.5 of this report. Water levels in the piezometers on site were recorded on two dates and provided further information on ground water flow direction at the site.

Immediately after ground water sample collection, the pH and specific conductance of each sample were measured and recorded in a field notebook. The measured values for these parameters are provided in Table 2-14. Temperature measurements of the ground water samples from this site were not recorded due to a malfunctioning temperature probe. At the time of sampling, monitoring well MW-4S did not contain sufficient water to allow for the collection of these field measurements. The pH of the ground water samples at the site ranged from 5.86 to 6.30, and the specific conductance ranged from 152 to 440 μmhos/cm.

All observations concerning unusual appearance or odor of ground water during the well development, purging, and sampling were recorded in a field notebook. A summary of the recorded observations are in provided in Table 2-12. No observable sheen or

odors were encountered during the development, purging, or sampling of the monitoring wells at the site.

2.7.5 Site 13 - Tank Farm Five

Background Information

Ten monitoring wells were previously installed in the southwest portion of the site as part of a tank closure investigation for two of the USTs (Tanks 53 and 56) at the site. The results of that investigation indicate that ground water contamination exists in the area of the tank closure. Given the existence of additional USTs, and a sludge burning pit at the site, it was necessary to further investigate the ground water quality across the site.

Overview of Investigation

Monitoring wells were installed at six locations on the site (MW-1S through MW-6S) to investigate the ground water contamination at the site. The previous well investigation data showed that ground water flow on a portion of the site appeared to be in a northwest direction, toward the bay. The monitoring well locations were used to investigate the nature and extent of ground water contamination at the site and the effect of the brook on the site ground water. All six of the newly installed wells were installed in the overburden material. The six wells were installed from 13 to 31 feet depth from ground surface. The locations of the monitoring wells are shown on Figure 2-23

Ground water samples were collected from all six of the newly installed wells at the site and analyzed for all TCL and TAL parameters. Monitoring well MW-4S only contained sufficient water for volatiles and base neutrals sample analysis. In addition, seven of the previously installed wells were sampled and analyzed during this investigation. Monitoring wells ERA-86-1, ERA-86-2, ERA-86-4, MW-53E, and MW-56E were sampled and analyzed for TPH and lead. Samples from monitoring wells MW-53W and MW-56W, which were shown previously to be heavily contaminated, were analyzed for all of the TCL and TAL parameters and TPH. The ground water samples were collected on July 20, 1990.

Field Measurements and Observations

Several field measurements were conducted as a part of the ground water investigation at Tank Farm Five. These measurements included water level measurements at each well, piezometer water level measurements, along with water quality indicator measurements of each ground water sample. All field measurements and notable observations made during the ground water sampling events were recorded in a field notebook and are discussed below.

Just prior to the ground water sampling event, the ground water level for each monitoring well was measured with an electric water sensing device. All ground water measurements are provided in Table 2-10. Water and product levels in monitoring wells MW53-E and MW53-W were measured using an oil/water interface probe. Well MW53-E contained 4.08 feet of oil in the well and well MW53-W

contained 0.81 feet of oil. The ground water level measurements were used to determine site ground water flow direction and rates which are discussed in Section 3.5 of this report. Water levels were recorded within the piezometers installed on-site at two different dates and provide further information on the ground water flow direction at the site.

Immediately after ground water sample collection, the pH, specific conductance, and temperature of each sample were measured and recorded in a field notebook. The values for each of these parameters are provided in Table 2-14. The pH of the ground water samples ranged from 5.92 to 6.40, the temperatures ranged from 11.3 to 17.7 °C, and the conductance of the samples ranged from 90 to 498 μmhos/cm.

All observations concerning unusual appearance or odor of ground water during the well development, purging, and sampling were recorded in a field notebook. A summary of the recorded observations is provided in Table 2-12. None of the newly installed wells exhibited an observable sheen or odors during development, purging, or sampling. Both of existing wells MW53-E and MW53-W contained an oil layer, very oily water, and petroleum odors. The remaining existing well samples did not exhibit any odors or sheens.

After installation and prior to sampling, four of the monitoring wells installed at Tank Farm Four (MW-1S, MW-1D, MW-3S, and MW-5S) were vandalized. The wells were vandalized on the night of June 13, 1990. The locks on the protective well casing covers

of all four wells were broken off. Based upon the following observations it appeared as though one well, MW-1D, had cement poured into its casing: an empty bag of cement adjacent to the well, cement on the ground adjacent to the well, and cement between the well casing and protective casing. All four of these wells were redeveloped within four days of the vandalism. During the redevelopment of these wells, the pH was measured to evaluate the effects, if any, the vandalism had on the wells.

2.8 Surface Water and Sediment Investigations

Surface water and/or sediment samples were collected from the Melville North Landfill, Tank Farm Four, and Tank Farm Five. The samples were collected to determine if contamination has migrated from each site into surface water adjacent to or on the site. Sediment and biota sampling was initially planned for in the bay adjacent to the McAllister Point Landfill, the Melville North Landfill, and the Old Fire Fighting Training Area sites. However, given the unavailability of EPA Region I-approved, analytical methods for biota samples, the off-shore sampling for these sites was not conducted.

Surface Water Sampling Methods

Surface water samples were collected directly into the appropriate containers. The pH, temperature, and specific conductance were measured downstream of each sampling location, just prior to sampling. The elevation of the surface water at each location was measured relative to the top of a wooden stake driven into the sediments at each location. A electronic water level sensing devise was used to measure the water levels. Surface water elevations were recorded in July 1990 and April 1991. The locations and elevations of the top of the stakes were later surveyed for use in evaluating water levels in the stream relative to the site ground water. Surface water sampling proceeded from downstream to upstream. Surface water samples were collected prior to the sediment sample at each location.

Sediment Sampling Methods

Sediment samples were collected from the brooks which flow through the tank farm sites with a hand auger sampling device. At Tank Farm Four, sediment samples were collected by driving a 4-inch diameter section of PVC pipe into the sediment and then using a hand auger to collect a sample from within the pipe. The PVC pipe was used to keep the sampling hole open while sampling the 0- to 1-foot and 1- to 2-foot sediment intervals at Tank Farm Four. At Tank Farm Five, a hand auger was used to collect the 0- to 1-foot sediment interval. The sediment sample collected in the hand auger was emptied into a decontaminated stainless steel bowl and transferred directly into appropriate sample containers with a dedicated stainless steel spoon. The sample aliquot for VOC analysis was collected first from the bowl.

Surface Water and Sediment Sample Designations

All surface water and sediment samples submitted for laboratory analyses were assigned a designated field identification number which referenced the site name, sample type, sample location, and sampling date. The sediment samples collected at Tank Farm Four were also given an additional identifier to distinguish the sediment sample intervals. Below are examples of surface water and sample designations:

Surface Water Samples:

Example: TF5-SW1-60190

where: TF5 = Tank Farm Five
SW = Surface Water Sample
1 = Sample Location Number
60190 = Sampling Date

Sediment Samples:

Example: TF4-SD12-60190

where: TF4 = Tank Farm Four
SD = Sediment Sample
1 = Sample Location Number
2 = Sediment Sample Interval (1- to 2-foot)
60190 = Sampling Date

Surface Water and Sediment Sampling Strategy and Locations

Previous surface water-related studies have been completed at several of the sites being investigated. Sediment and mussel sampling has been conducted in the bay adjacent to both of the landfill sites. Limited surface water and sediment sampling had been conducted at the Tank Farm Four site. No surface water-related sampling had been previously conducted at the Old Fire Fighting Training Area site or the Tank Farm Five site. The results of the previous site investigations were used in establishing the surface water-related sampling plan for each site. The surface water/sediment sampling activities conducted at Sites 02, 12, and 13 are presented below.

2.8.1 Site 02 - Melville North Landfill

Background Information

A previous investigation at the site included the collection of three sediment and mussel samples from the bay adjacent to the site. Several control samples were also collected from the bay for

comparison. The sample analytical results indicates that mussel PCB levels and sediment metals levels are comparable to levels detected in the control samples. In the previous site investigations no samples were collected from the wetlands area just north of the site.

Overview of Investigation

The collection of sediment and biota samples from the bay was planned for this investigation. However, unresolved issues regarding the sampling scope and biota analytical methods resulted in these activities not being completed. Although, three sediment samples were collected from the wetlands area just north of the site. The three sediment samples were collected from three locations within the wetlands; two locations adjacent to the site and one location on the northern edge of the wetlands. The locations of the sediment samples are shown on Figure 2-26.

The sediment samples were collected from the 0 to 1-foot interval. The sediment samples were collected with a dedicated stainless steel spoon and transferred directly to appropriate sample containers. The sample aliquot for VOC analysis was collected from 6 inches below the top of the sediment. The sediment samples were analyzed for all of the TCL and TAL parameters.

2.8.2 Site 12 - Tank Farm Four

Background Information

A previous investigation at the site included the collection of one sediment sample from Normans Brook and the collection of a sediment and surface water sample from swale into which ground water appeared to be seeping. The analytical results of the brook and swale samples document that petroleum-based hydrocarbon contamination exists in the sediments and surface water in the brook and swale. The swale is upgradient of the nearby brook and it is likely that the water from the swale flows into the brook. It is also possible that the brook is a "gaining stream" in that it is hydraulically connected to and receives water from the ground water. Given that the site ground water is documented as being contaminated and the likelihood that the brook is contaminated, the sediments and surface water in the brook were investigated further to determine the nature and extent of the contamination in the brook.

Overview of Investigation

Sediment and surface water samples were collected from Normans Brook which runs through the southern portion of the site and into Narragansett Bay. Four of the brook sediment sample locations were on-site, one was off-site and upstream just beyond the site fence, and one was downstream, at the mouth of the brook. Surface water samples were collected from four of the six sediment sample locations; two from on-site locations and one from each of the off-

site locations. The locations of the surface water and sediment locations are shown on Figure 2-27.

Two sediment samples were collected from each location; one from 0- to 1-foot and the other from 1- to 2-feet below the sediment surface. The surface water and sediment samples were analyzed for all of the TCL and TAL parameters.

Well points were placed on the stream bank just north of the brook, adjacent to each of the four on-site sediment sample locations and the one off-site (upstream) sample location. A stake was also driven into the brook sediments at each sample location. The elevations of these stakes were surveyed, and used as a datum from which the elevation of the surface water was measured. The elevations of the ground water in the well points and the elevations of the surface water at the stake locations were then simultaneously measured. The information from these elevation measurements was then used to determined if the stream is a "losing" or "gaining" stream. The well point and surface water elevations for Tank Farm Four are presented in Table 2-19. These data indicate that the brook is a "gaining stream", which is recharged by the site ground water.

2.8.3 Site 13 - Tank Farm Five

Background Information

A previous investigation of Tank Farm Five did not include an investigation of the Gomes Brook, which runs through the northern portion of the site and into Narragansett Bay.

Overview of Investigation

Sediment and surface water samples were collected from five locations along Gomes Brook to determine the presence of contamination, if any, in the brook. Three of the sample locations were on-site, one of the locations was off-site and upstream, and the other was off-site and downstream at the mouth of the brook. The sediment samples were collected from the 0 to 1-foot interval. The sample locations are shown on Figure 2-28. The surface water and sediment samples were analyzed for total petroleum hydrocarbons and lead. The sediment samples were also analyzed for PCBs.

Well points were placed on the stream bank just south of the brook at each of the three on-site sediment sample locations and the one upstream, off-site sample location. A wooden stake was also driven into the brook sediments at each sediment sample location. The elevations of these stakes were surveyed, and served as a datum from which the elevation of the surface water was measured. The elevations of the ground water in the well points and the elevations of the surface water at the stake locations were simultaneously measured to determine if the stream was a "losing" or "gaining" stream. The well point and surface water elevation data for Tank Farm Five are presented in Table 2-20. These data indicate that the brook is a "gaining stream" which is recharged by the site ground water.

2.9 Underground Storage Tank Investigation

Samples were collected from underground storage tanks at the two tank farm sites. The information from the sample analyses aided in characterizing the contents of the tanks and in determining if they are a source of contamination at each site. The following two subsections, which are applicable to both sites, provide details on the tank sampling methods and tank sample designations. Following those two subsections are separate discussions on the tank investigations conducted for each tank farm site.

Tank Sampling Methods

Tank sampling included the collection of three different sample media: oil, water, and sludge. Each sample was collected by different techniques, and in some instances several sampling techniques were employed to collected the same sample media at different locations. All of the tank samples were collected through a tank vent pipe opening located inside the above-ground pump house for each tank. Described below are the sampling methods used to collect the oil, water, and sludge tank samples.

The floating oil samples were collected by either the use of a peristaltic pump and tubing assembly or telescoping steel rod/sample container assembly. The peristaltic pump and tubing assembly was used to retrieve oil samples from tanks which had a shallow, light (i.e., pumpable) oil layer. The other oil sampling device consisted of a laboratory sample container attached to a

telescoping stainless steel rod. The rod and attached sample container were extended through the tank fill pipe to the floating oil layer. The dedicated sample container was submersed into the oil layer and the oil was allowed to flow into the container. The oil sample was then raised to the surface and transferred into the appropriate sample containers.

The water samples were collected by either the use of a discrete-interval liquid sampler or a teflon bailer. In each case, a section of 3" diameter, ASTM-grade PVC piping was first lowered through the oil layer to the desired water sampling depth. The lower, submerged end of the pipe was covered with parafilm to prevent the contamination of the water sampling device as it passed through the floating oil layer. The water sampling device was then lowered down through the PVC piping and pushed through the parafilm cap to the desired depth where the water sample was collected. The discrete-interval liquid sampler utilizes a ball check-valve with a plunger type inner rod that allows for the valve to be opened and closed at a discrete sampling interval. The sampler was lowered to a depth of approximately 5 feet below the floating oil layer and a water sample was collected. The sampler was then raised to the surface and the water was transferred to the appropriate sample container through the bottom dump valve on the sampler. The discrete interval liquid sampler is constructed of stainless steel and teflon and utilizes stainless steel inner rods.

When a teflon bailer was used to collect the tank water samples, the bailer was lowered on a stainless steel cable down

through the PVC piping and parafilm and into the tank water. The bailer was lowered to a depth of approximately 5 feet below the floating oil layer and the check ball set on the bailer to retain the water sample. The bailer was then raised and the water transferred into the appropriate sample containers.

One sludge sample was collected from one of the tanks sampled on the tank farms. The sludge sample was collected from Tank 50 on Tank Farm Five using a sludge sampler. The sludge sampler is a stainless steel cylinder equipped with a butterfly valve attachment which retains sludge samples. The sludge sampler is attachable to steel hand auger extensions. The sludge sample was collected by extending the sampler with the attached auger extensions to the top of the sludge layer. The sampler was pushed into the sludge layer and the sludge was collected in the sampler cylinder. The sampler was then raised to the surface and the sludge sample transferred to the appropriate sample containers.

All tank sampling equipment was decontaminated prior to each use according to the equipment decontamination procedure described in the project QA/QC plan.

Tank Sample Designations

All tank samples were assigned a designated sample identification number which referenced the site name, sample type, sample location (tank number), and sample date. Presented below are examples of the tank oil, water, and sludge sample designations:

Tank Oil Samples:

Example: TF5-O50-625

where: TF5 = Tank Farm Five
O = Oil Sample
50 = Tank 50
625 = Sampling Date (6/25/90)

Tank Water Samples:

Example: TF5-W50-625

where: TF5 = Tank Farm Five
W = Water Sample
50 = Tank 50
625 = Sampling Date (6/25/90)

Tank Sludge Sample:

Example: TF5-S50-625

where: TF5 = Tank Farm Five
S = Sludge Sample
50 = Tank 50
625 = Sampling Date (6/25/90)

Tank Sampling Strategy and Locations

Limited sampling of the tanks had previously occurred at both of the tank farm sites. The results of the previous sampling were used in establishing the tank sampling plans for each site. The specific tank sampling activities conducted at each tank farm site are presented below.

2.9.1 Site 12 - Tank Farm Four

Background Information

In a previous site investigation, water samples were collected from six of the twelve USTs at the site. The analytical results

for these samples document that the water in the tanks is contaminated with petroleum-based hydrocarbons. Given that the USTs are a possible source of subsurface contamination at the site and that the USTs' contents must be characterized to properly evaluate the USTs' closure alternatives, the contents of each tank were physically characterized and sampled.

It is known that during the operation of the tank farm, all of the USTs at this site contained either fuel oil or diesel. When the tank farm ceased to operate, all of the tanks were filled with water which served as ballast to keep the tanks from rising out of the ground. The interiors of the USTs were not cleaned and, thus, residues (e.g. bottom sludge and oil) remaining in each UST was not removed prior to filling the tanks with water. As was documented for most of the USTs at Tank Farm Five during previous investigations, this practice results in a multi-layered media in the UST, consisting of a bottom sludge layer, a middle water layer, and a floating oil layer.

Overview of Investigation

Oil samples were collected from each of the twelve USTs, and water samples were collected from all but one of the USTs (Tank 40) at the site. A water sample could not be collected from Tank 40 because the oil in Tank 40 had risen into the tank access chamber restricting access into the chamber. The oil sample from Tank 40 was collected from within the pump house itself. All of the oil samples were analyzed for all of the TCL (less pesticides) and TAL

parameters. Four of the oil samples which were very viscous (i.e., sludge-like) were also analyzed for the EP Toxicity metals. In addition, two of the oil samples were submitted for the Toxicity Characteristic Leaching Procedure (TCLP) analyses. All of the water samples were analyzed for the TCL semi-volatile organic compounds, volatile organic compounds, TAL metals, and cyanide. None of the tanks at Tank Farm Four contained sludge on the bottom of the tanks so no sludge samples were collected at this site.

Field Measurements and Observations

Several field measurements were conducted as a part of the tank sampling protocol. During the collection of the tank water samples, the pH, temperature, and specific conductance of the water were measured and recorded in a field notebook. The measured values for these parameters for each tank water sample are presented in Table 2-21. The pH of the tank water samples ranged from 7.1 to 8.4, the temperatures ranged from 11.1 to 14.0 °C, and the specific conductance ranged from 100 to 320 μmhos/cm. The tank water sample exhibiting the highest specific conductance (320 μmhos/cm) was collected from Tank 41. This tank was the only tank at Tank Farm Four which appeared to contain a light oil (e.g., diesel fuel).

Observations were made during the gauging and sampling of the tanks regarding the physical characteristics of the contents of each tank. Notes on the characteristics of the oil in each tank are provided in Table 2-22. All of the tanks at Tank Farm Four,

except Tank 41, contained a thick, black oil (bunker oil) which was floating on top of the water in the tank. The floating oil sampled in Tank 41 was a black, light oil. The oil in the tank access chamber of Tank 40 was an olive-green, black color.

The thickness of each layer was measured in each UST at the site. The volume of any oil, water, and sludge remaining in each tank was estimated knowing the diameter and depth of the USTs documented on their design plans. Table 2-22 gives the measured thicknesses of oil, water, and sludge in each tank, their estimated volumes, and physical characteristics of the oil.

2.9.2 Site 13 - Tank Farm Five

It is known that during the operation of Tank Farm Five, the USTs on the site were used to store either bunker fuel oil (No. 5-6) or diesel fuel (No. 2). When the overall use of the tank farm for the storage of fuel oil was discontinued, two of the tanks (Tanks 53 and 56) on the site were used for the storage of waste oil.

In previous tank investigations at the site, the contents of all of the eleven USTs at the site were physically characterized and sampled. A multi-layered media consisting of oil, water, and sludge layers was identified in the tanks. Sludge and oil samples were collected from the two USTs (Tanks 53 and 56) for which a tank closure investigation was conducted. Ground water monitoring wells were also installed around these two USTs and sampled. The analytical results indicate the presence of metals and VOCs in the

tank water samples, metals, VOCs, and SVOCs in tank oil samples, metals and VOCs in tank sludge samples, and metals and VOCs in ground water samples. Based on these results, the contents of all of the USTs needed to be fully investigated as possible sources of subsurface contamination at the site. The contents of the USTs also needed to be characterized to properly evaluate the closure alternatives for the tanks.

As is the case for Tank Farm Four, when decommissioned, all of the USTs at this site were filled with water for ballast without prior cleaning. A multi-layered media, typically consisting of oil, water, and sludge layers, is present in many of the USTs, as was documented in the previous tank investigations.

Overview of Investigation

Oil samples were collected from ten of the eleven USTs at the site, and water samples were collected from all eleven USTs. The layer of oil in Tank 55 was too thin (0.1 inch) to sample. A sludge sample from the bottom of Tank 50 was the only sludge sample collected from the tanks on the site. Although some sludge (less than three inches) was present in tanks 51, 52, 53, and 56, it was sufficient for the collection of a sludge sample at these tanks. The tank oil samples were analyzed for all of the TCL (less pesticides) and TAL parameters. The tank water samples were analyzed for the TCL semi-volatile organic compounds, volatile organic compounds, TAL metals, and cyanide. The sludge sample

collected from Tank 50 was analyzed for all of the TCL (less pesticides) and TAL parameters and for the EP Toxicity metals.

Field Measurements and Observations

Several field measurements were conducted as a part of the tank sampling activities. During the collection of the tank water samples, the pH, temperature, and specific conductance of the tank water was measured and recorded in a field notebook. The measured values for these water quality parameters for each tank water sample is presented in Table 2-21. The pH of the tank water samples ranged from 7.1 to 7.9, the temperatures ranged from 12.0 to 14.7 °C, and the specific conductance ranged from 140 to 3,950 μmhos/cm. The tank water sample exhibiting the highest specific conductance (3,950 μmhos/cm) was collected from Tank 52.

Observations were made during the gauging and sampling of the tanks regarding the physical characteristics of the oil remaining in each tank. Notes on the characteristics of the oil in each tank are provided in Table 2-23. All of the tanks at Tank Farm Five, with the exception of Tank 59, contained light oil (similar to No. 2 fuel oil or diesel). The oil in all of the tanks was either brown or black in color. Tank 59 contained a black oil of medium viscosity (not as thick as the oil in most of the Tank Farm Four tanks).

Based upon field measurements and tank design specifications, the quantity of the different layers in each UST was estimated. Table 2-23 summarizes the measured thicknesses of oil, water, and

sludge in each tank, their estimated volumes, and the physical characteristics of the oil.

2.10 Structure Investigation

Samples were collected from oil/water separators and burning pits on Tank Farm Four and Tank Farm Five. Observations made during the structure sampling indicate that each of the structures on the sites appear to be oil/water separators. In addition, a sample was collected from a remote, previously unidentified structure (hereafter referred to as "ruin") discovered on Tank Farm Four. A water sample was also collected from a pipe which appeared to flow from the ruin and whose outfall is into the on-site brook. As discussed in Section 2.4, surface soil samples were also collected from around each of the oil/water separator structures.

The investigations of these structures provided information necessary to evaluate if the structures are a potential source of contamination at the sites or if they contain any contaminated materials. Below is a discussion on the structure sampling methods applicable to each of the sites. Specific sampling plans and observations for each site follow the structure sampling methods discussion.

Structure Sampling Methods

Soil, waste, and/or water samples were collected from the structures on the two tank farm sites. Soil and/or waste samples were collected from the end units of each structure. The ends of the Tank Farm Five oil/water separator and one end of the Tank Farm Four oil/water separator appeared to be filled in with soil. One end of the Tank Farm Four oil/water separator was partially filled

with what appeared to be a waste, sludge-like material. Water samples were collected from the middle portion of each oil/water separator. A sediment sample was also collected from the ruin discovered on Tank Farm Four. A water sample was also collected from a pipe believed to be coming from the ruin.

The soil samples were collected from each structure using a portable, split-spoon tripod derrick rig. Split spoon samples were collected at two foot intervals until the bottom of the structure was encountered. The bottom of the structure was encountered at 3-½ feet depth at Tank Farm Four, and at 5-½ feet depth at Tank Farm Five. The split spoon soil samples collected (two for S-1 at Tank Farm Four, and three each for S-1 and S-2 at Tank Farm Five) were mixed in a stainless steel bowl for the collection of one composite sample from each location. The sample portion for VOCs analysis was collected directly from each split spoon sample prior to compositing. The waste sludge sample was collected with a dedicated stainless steel spoon and transferred directly into the appropriate sample containers. The portion for VOC analyses was collected from a depth of six inches below the surface of the oily sludge pile. The water samples were collected from what appeared to be the oil/water separator portion of the structure. The water samples were collected directly into the appropriate sample container.

The soil sample collected from the ruins discovered on Tank Farm Four was collected using a decontaminated bucket auger. The bucket auger was extended through a small opening in the ruins to

what was believed to be the bottom of the structure. The sediment sample recovered from the ruin was carefully placed into a dedicated stainless steel bowl and immediately transferred directly into the appropriate container using a dedicated stainless steel spoon.

A water sample was collected from the 12" concrete pipe located approximately 125 feet below the ruins at Tank Farm Four. The water flowing out from this pipe was collected directly into the appropriate sample containers.

Structure Sample Designations

All structure samples were assigned a designated sample identification number which referenced the site name, sample type, sample number, and sampling date. Presented below is an example of a structure sample designation:

Structure Samples:

Example: TF5-S1-621

where: TF5 = Tank Farm Five
S = Sample Type (W=water, S=soil/sediment/sludge)
1 = Sample Number
621 = Sampling Date (6/21/90)

Structure and Ruin Sampling Strategy and Locations

No previous sampling had been conducted of the structures and ruins on Tank Farm Four and the structures on Tank Farm Five. The structure and ruin sampling activities conducted at each site are presented below.

2.10.1 Site 12 - Tank Farm Four

Overview of Investigation

Samples were collected from the oil/water (o/w) separator located on the site. The location of the o/w separator is shown on the site map on Figure 2-29. The o/w separator is a four-walled concrete structure which, according to design drawings, has a concrete bottom. Previous site planning maps and design drawings tend to indicate that the o/w separator was once used as a burning pit. A 1959 base planning map indicates that a "burning chamber" existed at the location of the now present o/w separator. The o/w separator design drawings also show a pre-existing structure at the location. The o/w separator appears to have been constructed within a portion of the "burning pit". The two ends of the structure are shown on the design drawings to be backfilled with a gravel fill. The dimensions of the oil/water separator are approximately 20 feet wide by 40 feet long by 8 feet deep.

A portable, split-spoon, tripod derrick rig was used to collect split spoon samples from one of the chambers within the structure (sample S-1). This sample was collected as a composite sample of the entire interval sampled. The split spoons could not be advanced further than 3.5 feet in the chamber. The design drawings for this structure indicate that 7 feet of gravel was placed in the structure. This may account for the limited sampling depth that was achieved with the split spoon sampling device. A second sample (S-2), consisting of a black, tar-like sludge, was collected from a pile of sludge located within the chamber at the

other end of the structure. The locations of the structure samples are shown on Figure 2-29. Logs of the split spoons can be found in Appendix F. All of the structure samples were analyzed for all of the TCL and TAL parameters (less pesticides). These soil and sludge samples collected from the structure were also archived for dioxin and furan analyses.

One water sample (sample W-1) was collected from the center section of the structure. The water sample was analyzed for all of the TCL and TAL parameters less the pesticide compounds.

Ruins of an unknown structure were located at a location approximately 50 feet upstream of surface water and sediment location #4, and approximately 125 feet north of the brook (see Figure 2-29). As discussed in Appendix B, this structure had been noted on historical site maps. A 12-inch diameter concrete pipe was located on the northern bank of the brook at the point 50 feet upstream of surface water and sediment sample location #4.

The ruins appeared to be a former oil/water separator or similar structure. Nearly all of the structure at this location is buried by soil and densely overgrown with small trees and brush. Portions of the structure which are visible include several of the concrete corners of the structure's walls, a portion of one of the side walls, and what appears to be a vent pipe similar to that extending from the oil/water separator identified on the site. The ruins have approximate dimensions of 20 feet by 40 feet and are constructed of concrete. The buried structure appears to be divided into several chambers and is partially filled with water.

Orange colored water was bubbling up from within the northern end of the structure and was flowing into the southern chamber. A hand auger was used to obtain a sample of a silty soil from the bottom of the southern chamber (sample S-3) beneath the water in the structure. The concrete bottom of the structure was encountered at approximately 6 feet below grade. The sample from the structure bottom was a brown/grey silt, with trace clay. The sample had a slight petroleum odor and had a visible sheen of petroleum product on the sample.

A 12-inch diameter concrete pipe which appears to be connected to the ruins (runs in an orientation towards the ruins) is located just down grade of the ruins. At the time of the ruins sampling, water was flowing continuously from the pipe into the brook. The orange colored water flowing from the pipe was similar to that observed in the ruins. A sample of the water flowing from the concrete pipe (sample W-2) was collected for analysis. The soil sample from the ruins was analyzed for all of the TCL (less pesticides) and TAL parameters. The water sample was analyzed for all of the TCL (less pesticides/PCBs) and TAL parameters.

Field Measurements and Observations

Measurements and observations were recorded during the collection of soil and water samples from the structure and ruins at Tank Farm Four. During the sampling of soil sample S-1 from the oil-water separator at the site, no odors or stained soils were noted in the split spoons. The soil appears to be clean sand and

silt fill, with little gravel. Structure sample S-2 consisted of a black, tar-like sludge with a strong tar-like odor.

Following the collection of the water sample from the oil water separator, measurements of pH, temperature, and specific conductance of the water were taken in the field and recorded in a field notebook. The water sample had a pH of 7.1, a temperature of 19.1 °C, and a specific conductance of 70.0 μmhos/cm.

The sediment sample collected from the bottom of the ruins at Tank Farm Four consisted of 1 foot of brown gravel and silt overlying another foot of gray silt. The bottom silt layer had a visible sheen of petroleum product and a slight petroleum odor. The water sample collected at the concrete pipe at the site, was orange in color and slightly silty. No odor was detected from the water sample. The same orange color water was noted bubbling up from the ruins at the site.

2.10.2 Site 13 - Tank Farm Five

Overview of Investigation

Soil and water samples were collected from the oil/water separator structure located on the site. As presented in Appendix B, this structure was noted on historical site maps as a "burning pit"; however, it currently appears to be an oil/water separator similar to the one on Tank Farm Four. The location of the structure is shown on Figure 2-30. Based on its design drawings, the size of the structure is approximately 6 feet high by 40 feet wide by 45 feet long. The oil/water separator is a four-walled

concrete structure. The structure is equally separated into three separate sections by concrete walls. The far western section consists of an area which appears to be backfilled with soil. Small trees and shrubs grow in this area. The central section, which consists of an area of piping and baffles filled with nearly four feet of water, appears to be the main section of the oil/water separator. The far eastern section consists of a soil filled area at its southern end and a concrete pad/manhole area covering its other end. Water can be observed through a manhole at the eastern end of the concrete pad. This northeastern section of the structure appears to be connected to the center section.

A portable, split-spoon, tripod derrick rig was used within the structure to collect split spoon soil samples from two borings completed at each end of the structure. The approximate locations of the two borings within the structure are shown on Figure 2-30. Continuous split spoon sampling was conducted at two-foot intervals in the borings until refusal. Refusal was encountered in both of the borings at a depth of 5.5 feet into the soil, at what was believed to be the concrete bottom of the structure. At each boring location, one composite soil sample was collected over the entire depth of the boring (0 to 5.5 feet) (samples S-1 and S-2). Both of the composite samples were analyzed for all of the TCL and TAL parameters. The soil sample from the eastern end of the structure (sample S-2) was split with the EPA. A blind duplicate (labeled S-3) of this sample was also collected and submitted to the laboratory by TRC.

One water sample (sample W-1) was collected from the center section of the structure. The water sample was analyzed for all of the TCL and TAL parameters.

Field Measurements and Observations

Measurements and observations were recorded in the field during the sampling of the soil and water samples from the structure at the site. Soil samples S-1 and S-2 collected within the structure both contained what appears to be sand and gravel fill. No stained soils or odors were noted in either of the structure soil samples.

Following the collection of the water sample from the structure, measurements of pH, temperature, and specific conductance of the water were taken in the field and recorded in a field notebook. The water sample had a pH of 7.30, a temperature of 24.5 °C, and a specific conductance of 153 μmhos/cm. The water sample had a slight sheen at the time of sampling.

3.0 PHYSICAL CHARACTERISTICS

This section of the report presents information on the regional and site physiography, meteorology, surface water hydrology, geology, and hydrogeology. Site-specific discussions for each of the five sites are presented following the regional information.

3.1 Regional Physiography

Presented below is information on the physiography of the NETC area. The information is presented in two separate discussions , concerning terrestrial features and marine features. Much of the information was obtained from the IAS report. The appropriate IAS report page number(s) from which the information was obtained is provided after each excerpt.

Terrestrial Features

The topography of the NETC area was shaped by the bedrock geology, glaciation, and recent erosion. The bedrock geology controlled the locations of the ancient river valleys which glaciers subsequently gouged out of the bedrock. The hills are the result of bedrock highs. A mantle of till, on average 20 feet thick, was spread over the bedrock during the Wisconsin glaciation. As the glaciers melted, ocean levels rose and flooded the river valleys forming the passages of Narragansett Bay.

> Elevations at NETC range from near mean sea level to 175 feet in the Melville North area. Many areas of NETC have low elevations which are susceptible to flooding during hurricane storm surges. The 100 and 500 year tidal flood elevations for the NETC area are 12.6 feet and 15.6 feet above mean low water, respectively. Areas below these elevations are subject to flooding.
>
> Ninety percent of the land within the boundaries of NETC has slopes of from 0 to 9 percent (Master Plan, 1980). The remaining land has slopes in the categories of 10 to 25 percent and greater than 25 percent. Maps showing slopes on all NETC areas are included in the most recent Master Plan for NETC.

(IAS, pg. 5-15)

The soils in the area of NETC formed in glacial deposits of till and outwash. . . . There are also a few areas with tidal marsh soils along the shores of Narragansett Bay. These tidal marsh areas receive deposits of silt and clay during tidal inundation and from upland areas. These sediments are deposited along with the plant remains of the salt tolerant plants growing in the marshes.

(IAS, pg. 5-21)

There are five basic types of soils at the NETC: mucks, beaches, loams, sands, and urban complexes. The mucks are found in tidal flats and inland depressions which hold ponded water. Loams (mixture of sand, silt, clay, and organic matter) and sands are found in upland areas on-site and generally drain rapidly. Urban complexes are mixtures of natural soils, imported soils, and urban materials.

The flora and fauna of the NETC is strongly influenced by human activity.

The southern portion of the base is heavily industrial with machine shops and other support facility operations. The north portion of the base is divided in land usage between residential, vacant (held for expansion), tank farms, and storage-fueling facilities (industrial). There are no land areas on NETC which have not been disturbed at some time during base operations. . . .

Southern Rhode Island has relatively few forests of mature climax successional stage. Fires, logging, and the agricultural conversion of forest land prior to the Civil War have greatly reduced the extent of climax forest acreage. The predominant forest vegetation in southern Rhode Island is that of abandoned fields in early successional stages, and forests of immature hardwoods. Pure stands of mature softwoods are the least abundant. . . .

The upland vegetation within the NETC is restricted primarily to perennial weeds and grasses. The majority of trees is located near residences, drainageways and around the tank farms. The upland vegetation of NETC reflects complete management (mowing) or recent disturbance of the area.

The habitats available for lowland vegetation on the NETC are located on the waterfront along Narragansett Bay and surrounding the small impoundments and their drainages further inland. Those areas located on the waterfront

are comprised of borrow pits along the railroad tracks and abandoned disposal areas where excavation has created depressions.

The largest of these depressions is the Melville North landfill. This area was excavated during landfill operations and depressions were created. These depressions support a limited diversity of wetland flora including reeds and various shrub and grass species. Borrow pits can be found along the railroad tracks which parallel the shoreline extending from McAllister Point northward to the Melville North landfill. These are individually less than one acre in size and contain similar wetland species with a lack of diversity.

All lowlands on NETC have been artificially created and are in a disturbed condition. The potential for maintaining diversified floral species within the lowlands of NETC is poor. This area did not previously contain these habitats, and sills and drainage are not conducive to their successional development.

The fauna of the region have been affected by similar disturbances (clearing, excavation, construction) which led to the impoverishment of the flora. Field studies have indicated impoverished fauna, particularly of herptile and mammal types. Widespread habitat destruction over a period of several hundred years has caused emigration or elimination of many species. As a result, the present regional fauna consist primarily of species of wide distribution and ecological tolerances, high adaptability, and nonrestrictive habitat requirements.

No large animals such as deer, turkey, or cougar are known within the boundaries of NETC. However, red fox, raccoon, rabbit, and gray squirrel are present in the woodlands.

Mammalian forms expected to be found on base include: the Eastern chipmunk, New England cottontail rabbit, white-footed mouse, short tailed shrew, gray squirrel, and red squirrel. Several of these species inhabit the few remaining wooded areas on base slated to be excessed.

Various herptiles occupy NETC habitats. Common ones include the red backed salamander, American toad, wood frog, eastern gartersnake, northern black racer and the wood turtle.

Common herptiles of the wet areas include the American toad, spring peeper, bullfrog and northern watersnake (Natrix sipedon), along with the snapping turtle.

Avian species which may be found within the NETC upland habitats include the bobolink, meadowlark, chimney swift, kingbird, eastern phoebe (Sayorius phoebe), barn shallow, red-tailed hawk and kestrel.

In addition, game birds, such as the ring-necked pheasant, bobwhite quail and the mourning dove, are highly dependent on the plant communities on the base.

(IAS, pp. 5-37 to 5-39)

Marine Features

Narragansett Bay occupies three former river valleys which have been drowned by the advance of the Atlantic Ocean. Narragansett Bay is 20 miles long and 11 miles wide. The bay has a surface area of 102 square miles. Figure 3 shows Narragansett Bay and the surrounding areas. The shape of the former river valleys has changed little since the last glaciation. The bay is divided into an eastern and western passage by Conanicut Island. The average depth of the bay is 30 feet. In the western passage, the average depth is 25 feet, while in the eastern passage, the average depth is 50 feet. The eastern passage, which NETC fronts, allows deep water access up to the south end of Prudence Island. Channel depth exceeds 80 feet in the eastern passage from Gould Island seaward, and depths in excess of 150 feet occur near the mouth of the bay.

Freshwater flows into the bay at an average rate of 1,239 cubic feet per second from a drainage area of 1,850 square miles. This accounts for 90 percent of the annual flow of fresh water into the bay. The other 10 percent is provided by direct rainfall into the bay and sewage effluent. An average of some 43 inches per year of precipitation falls directly into the bay. The freshwater input into the bay is small compared to the large volume of saline water in the bay. The relatively small freshwater input into the bay results in the bay water being well mixed with only small salinity gradients through the bay. Salinities range from about 22 parts per thousand (ppt) in the Providence River to 32 ppt at the mouth of the bay.

Tides are semi-diurnal in Narragansett Bay with a mean range of 3.6 feet at the mouth of the bay and 4.6 feet at the head. Abut 13 percent of the volume of water in the bay is exchanged each tidal cycle (Oviatt and Nixion, 1973). This is over 250 times the mean tidal river flow into the bay during a tidal cycle. The tidal movement is the single most important factor in water circulation in the bay. Tidal currents range in velocity from 0.07 to 2.3 feet per second (Atlantic Scientific, 1982). The faster velocities occur in the east and west passages near the mouth of the bay, while slower velocities occur in the upper bay.

Non-tidal current in the bay moves slowly at an average of 0.34 feet per second (Olsen, 1980). Although the non-tidal currents are slow, they are important in the exchange of water out of the bay and into Rhode Island Sound. The amount of time needed to transport a particle of water from Providence to the mouth of the bay is some 45 to 50 days (Olsen, 1980). However, this time can vary depending on the winds. Research seems to indicate that southeast winds blowing up the bay may prevent surface waters from flowing down the bay (Olsen, 1980).

The sediments in the bay are contaminated with heavy metals, hydrocarbons, and sewage sludge (Master Plan, 1980). A survey conducted by EPA (EPA, 1975) has shown the presence of heavy metal concentrations in the sediments in interstitial waters north of the Naval Complex. The values found were 7,048 mg/l manganese, 2,351 mg/l zinc, 559 mg/l iron, 55 mg/l lead, 46 mg/l nickel, 44 mg/l copper, and less than 1 mg/l cadmium. These contaminants are the result of industrial and municipal discharges into the bay. No sediment samples have been taken in the area of the Naval Complex.

The water quality for Narragansett Bay as determined by the State of Rhode Island is shown in Figure 4. Most of the bay is Class SA, which means it suitable for direct shellfish harvesting, bathing and other water contact sports. Areas classified as SB are suitable for shellfish harvesting after depuration and for bathing and other recreational activities. Areas classified as SC are suitable for fish, shellfish, and wildlife habitat areas, but the shellfish cannot be harvested. The entire shoreline of NETC is closed to shellfishing.

(IAS, pg 5-28, 5-31)

The marine ecosystem of Narragansett Bay forms the shoreline of the base for approximately 9 miles. The bay is of great economic and aesthetic importance of the

entire southern portion of Rhode Island. It is an estuary and the fishery resources of the bay are extremely important. The annual value of the combined commercial and sport fishing is estimated at several million dollars.

In Narragansett Bay, the phytoplankton are by far the most important primary producers, synthesizing organic matter from carbon dioxide and inorganic nutrients with sunlight as the energy source. In shallower, less turbid estuaries, seaweeds and sea grasses may assume this role. . . .

The phytoplankton and zooplankton are rich and varied in Narragansett Bay. The species composition is relatively uniform from station to station indicating a good movement of the water mass within the bay. The estimated productivity figure of 84 grams of carbon per square meter per year is also indicative of good environmental conditions. . . .

Most species of finfish move in and out of Narragansett Bay following well established seasonal patterns. These migratory movements, although different for each species, provide for distinct summer and winter populations of finfish. The migrations are related primarily to temperature, and the major shifts between winter and summer populations take place when the water temperature is about 10°C (50°F).

Narragansett Bay is visited each year by a great many species of fish because it lies along the boundary between southern and northern populations. Thus, herring from Georges Bank may visit the bay at the end of their southward midwinter migrations, and species such as scup and occasional exotic tropical strays brought up by the Gulf Stream make their appearance during the summer. In all, over 100 species may appear in any given year, about half of which are occasional visitors.

In various studies during the 1970's a total of 99 species of fish have been taken from Narragansett Bay (Oviatt and Nixon, 1973; Jeffries and Johnsons, 1974; Camp, Dresser and McKee, 1978; Department of the Navy, 1978). Ten species accounted for 91 percent of the fish catch with the winter flounder, the sand dab, scup and butterfish the most commonly occurring fish taken. These four species are also of commercial importance. . . .

A year-long, bay-wide survey (excluding Mount Hope Bay and the Sakonnet River) of bottom fish made in 1972 yielded an annual minimum estimate of 117 individuals, or

28.5 pounds per acre. This translates into a standing crop of 1.9 million pounds of bottom fish. (The margin of error gives a range of 0.8 to 2.9 million pounds.) This is comparable to other estimates made using similar sampling techniques in New England estuaries and offshore fishing grounds. This bay-wide survey showed that despite the constant movement of species in and out of the bay, the total biomass of bottom fish is remarkably steady.

There are fewer species of pelagic fish than of bottom fish in the bay, but they make up for this by their numbers and their importance to fishermen. All the pelagic species are highly seasonal, with anchovies and sea herring appearing in the winter, and menhaden, bluefish, and striped bass in the summer. When schools of menhaden are present, their biomass may be far greater than that of the bottom fish. Population estimates for the bay are for as much as 16 million pounds of menhaden and 2 million pounds of bluefish and stripers. . . .

The benthic community in Narragansett Bay plays a critical role in the functioning of the ecosystem. Benthic filter feeders consume significant amounts of phytoplankton, and the bay's high primary productivity may be attributable in good part to the recycling activity of the benthos. . . .

The shellfish of Narragansett Bay include both bivalve molluscs (clams, oysters, scallops) and decapod crustaceans (crabs, shrimp, lobster). Lobster are caught both within and outside of Narragansett Bay. Lobsters are trapped in much of Narragansett Bay including the Coddington Cove area. Some lobster traps are located a short distance from Pier 2.

Bivalves harvested in the region of Narragansett Bay include the northern quahog - known as the bay quahog in Rhode Island), soft shell clam, and Atlantic bay scallop.

The quahog is the most valuable shellfish resource within the bay system. The number of people harvesting this organism for individual or commercial use is increasing. Shellfishing areas open to the public do not include the NETC shoreline.

Quahogs are the most abundant benthic animal of their size in Narragansett Bay (URI, 1980, Bulletin #40). In recent years, the total Rhode Island harvest ranged from 5 million pounds of meats in 1955 to 2 million pounds in 1978, the great majority of which are taken from the bay. . . .

Water pollution continues to take a heavy toll in the reduced numbers of quahogs available for harvesting. The primary criterion used in closing areas to shellfishing is the abundance of fecal coliforms in the water; these are an indicator of sewage and the pathogenic bacteria and viruses it may contain. A shellfish depuration plant is capable of killing harmful microorganisms that might be found within the shellfish, but none has been built in the bay area. Unfortunately, pathogenic microorganisms are only one aspect of the pollution in the upper bay. There are signs that Providence River quahogs are not healthy and may be dying off at least in some areas. Several researchers are concerned that they may be accumulating significant levels of petroleum or heavy metals, which are not removed by the usual depuration methods.

Aquaculture within the bay includes the eastern oyster and the blue mussel. Two species of clams are harvested offshore and landed at bay fishing ports. They are the Atlantic surf clam and the ocean quahog. Most of the northern areas of the bay are closed permanently or opened on a conditional basis. Most of the lower bay localities are opened. The shellfish area just south of the Newport Naval Facility is permanently closed because of municipal sewage discharge.

A small commercial fishery for squid occurs in the bay. A large squid trap is presently located in Coddington Cove (RI DEM, 1982) Sportsmen harvest squid with rod and reel throughout the spring and early summer months in the lower bay.

The blue crab and the rock crab are taken throughout the bay by recreational fishermen. Both of these species inhabit the shallow bays, sounds, and pools during the warm months and migrate to deeper water in the fall. The commercial fishing for blue crabs ended in 1938 with a severe population decline. The reason for the decline is not understood, but pollution from heavy metals and chlorinated hydrocarbons may have played an important role. [Note: The actual cause of the blue crab population decline is not documented.] At present, the population of blue crabs is increasing. The commercial use for rock crabs will be expanded with the development of new techniques for extracting the crab meat from the shells.

The Blue Gold Sea Farm, Inc. has leased five acres north of NETC for rearing the blue mussel. They suspend string from floats to which the larval stages of the mussel attach. It takes about 18 months for these mussels to

reach market size. Eastern oysters are being cultured on suspended strings in coastal ponds on Prudence Island and southwestern shores of the bay. Scallop seed is planted in the bay, and in 1978, the catch was valued at one million dollars (Rhode Island Statewide Planning Program, 1979).

(IAS, pp. 5-40 to 5-47)

3.2 Meteorology

The following information on the meteorology of the NETC area was obtained from the IAS report, and is referenced as such with page numbers which follow the excerpts.

> The climate at NETC is greatly influenced by its proximity to Narragansett Bay and Atlantic Ocean, which tend to modify the area's temperatures. Winter temperatures are somewhat higher and summer temperatures lower than more inland areas. Winters are moderately cold in the area, and summers are generally mild with many summer days cooled by sea breezes. . . .
>
> The average annual precipitation for the area is 42.75 inches, but this has varied from as little as 25.44 inches to as much as 65.06 inches. Measurable precipitation (.01 inch or greater) occurs on about one day out of every three and is evenly distributed throughout the year. Thunderstorms are responsible for much of the rainfall from May through August. These thunderstorms often produce heavy amounts of rainfall, but their duration is relatively short. Summer thunderstorms are frequently accompanied by high winds which may result in property damage, especially to small boats. The average snowfall during winter is close to 40 inches, ranging from a low of 11.3 inches to a high of 75.6 inches. February is usually the month of greatest snowfall, but January and march are close seconds. It is unusual for the ground to remain snow covered for any long period of time. . . .
>
> Severe weather from tropical cyclones (winds 39 to 73 miles per hour) and hurricanes (winds greater than 73 miles per hour) is a serious threat in the area of NETC. The probability that a tropical cyclone will invade the area is one in five in any year, while the probability of hurricane force winds invading the area is less than one in fifteen in any year (Outleasing EIS, 1977). The most damage from these severe storms results when they strike at high tide.

(IAS, pp. 5-14 to 5-15)

3.3 Surface Water Hydrology

The regional hydrology for the NETC is presented below, followed by site-specific discussions of the surface water hydrologic characteristics of the five sites studied under this investigation. Much of the regional information was obtained from the IAS report, and is referenced as such with page numbers which follow the excerpts.

Regional Surface Water Hydrology

> NETC is located within the Narragansett Bay Drainage Basin. This drainage basin covers an area of 1,850 square miles, 1,030 square miles of which are in Massachusetts and 820 square miles of which are in Rhode Island. All surface water drainage from the basin is into Narragansett Bay. Three major rivers, the Taunton, Blackstone, and Pawtucket, as well as the Providence River and a number of smaller rivers and streams, drain into Narragansett Bay. Discharge from Narragansett Bay is into the Atlantic Ocean between Point Judith and Sakonnet Point in Rhode Island.
>
> Throughout NETC, the surface drainage is westward toward Narragansett Bay with the exception of one area in Tank Farm #2 which drains eastward into Melville Reservoir. Surface drainage at NETC is provided by the Melville Ponds, Normans Brook, Lawton Brook and Reservoir, Gomes Brook, a stream and pond in the northeastern portion of NUSC, and a stream discharging into Coasters Harbor. The surface drainage for NETC is shown in Figure 7. All these streams discharge into Narragansett Bay. . . .
>
> Except for the stream and pond at NUSC and the stream which empties into Coasters Harbor, all of the other streams and ponds are on land which is being excessed by the Navy. The Melville Ponds have been disposed of by GSA and are now part of the Melville Public Fishing Area.
>
> While these streams and ponds receive drainage from many of the areas within NETC, a substantial portion of the NETC area drains directly into Narragansett Bay or infiltrates into the soil before reaching a stream or body of water. Direct runoff into Narragansett Bay would especially occur following thunderstorms. . . .

(IAS, pp. 5-26, 5-28)

> The potential for pollutant migration by surface drainage at NETC is greatly increased by its proximity to Narragansett Bay. Many of the waste disposal areas, such as the McAllister Point landfill, Melville North disposal site and Gould Island disposal site, are located right along the shoreline of Narragansett Bay. Surface drainage from these areas is directly into the bay. The NETC area is frequently subjected to thunderstorms during which intense periods of rainfall are common. Surface drainage into the bay would be greatest following these thunderstorms.
>
> Pollutants from these portions of NETC drain into the Melville Ponds, Normans Brook, Lawton Brook, Gomes Brook, and the NUSC stream and would also migrate off-site. All of the streams discharge directly into Narragansett Bay.

(IAS, pg. 5-34)

Presented below is a discussion of the surface water hydrology for each of the five sites.

Site 01 - McAllister Point Landfill

There are no surface water bodies present on the McAllister Point Landfill site. The general site topography slopes in an east to west direction (see site contour map in Appendix A). Surface water on the site (precipitation or runoff from surrounding higher elevations) either evaporates, infiltrates into the site soils, or flows overland to surrounding lower elevation areas or the adjacent Narragansett Bay. During periods of heavy rainfall, ponded water forms in a small depression located in the north-central portion of the site. The western edge of the entire site, which borders Narragansett Bay, is at an elevation approximately 10 feet higher than the beach shoreline along bay, which likely hinders surface

runoff into the bay. Springs have been observed discharging from the bottom of the landfill bank along the western edge of the site, directly into the bay.

Site 02 - Melville North Landfill

No distinct surface water bodies are present on the Melville North Landfill site. There is, however, a wetlands area present along the northern edge of the site. The general site topography slopes in an east to west direction (see site contour map in Appendix A). East of the site is a flat area (railroad track location), beyond which a very steep grade rises up to Defense Highway. Narragansett Bay borders the site along its western edge. Some topographically low areas are present on the site where water ponds during rainfall events. A small marshy area is also present in the north-central portion of the site. Surface water on the site (precipitation or runoff from higher surrounding elevations) either evaporates, infiltrates into the site soils, ponds on site or flows overland to lower surrounding elevations or Narragansett Bay. The edge of the site is at an elevation nearly level with the beach shoreline along the bay, which may allow for surface water runoff to the bay.

Site 09 - Old Fire Fighting Training Area

No surface water bodies are present on the Old Fire Fighting Training Area site. The general site topography slopes slightly in

a southern to northern direction (see site contour map in Appendix A). Narragansett Bay borders the site along its northern edge. Along the southern edge of the site is a curbed road which likely deters any surface water runoff from flowing onto the site. Surface water runoff (precipitation) from the site either evaporates, infiltrates into the site soils, ponds on-site, or flows directly into the Narragansett Bay. Small ponded areas were observed on-site during periods of heavy rainfall. The site shoreline is at an elevation slightly higher than the beach along the bay.

Site 12 - Tank Farm Four

A perennial stream, Normans Brook, flows across the southwestern corner of the site. The brook is located in a topographically low area of the site and flows into Narragansett Bay. The general site surface topography slopes in a east to west direction, with the steepest surface gradients located near the brook (see site map in Appendix A). The central, tank portion of the site is gradually sloping and well drained. Along the northwestern edge of the site is Defense Highway, beyond which is Narragansett Bay.

Surface water runoff (from precipitation) on the site either evaporates, infiltrates into site soils, ponds on the surface, or flows overland towards the brook and Defense Highway. During periods of heavy rainfall, ponded water was observed both in a small ditch which runs between the site and Defense Highway, and in

low lying areas in the northern corner of the site. During rainfall events, overland flow was observed in the western corner of the site towards Normans Brook.

Data from piezometers installed along the banks of Normans Brook, as well as surface water levels recorded in the brook, document that the brook is a "gaining" or effluent stream (i.e., ground water discharges into the stream). Ground water springs have been observed along the land slope just east of the brook. The piezometric ground water and surface water elevation data are provided in Table 2-19. As shown on the site ground water contour map (see Figure 3-25), the site ground water flow direction is strongly influenced by Normans Brook. The site ground water flow characteristics are discussed in greater detail in Section 3.5 of this report.

Site 13 - Tank Farm Five

A perennial stream, Gomes Brook, flows across the northeast side of the site. The brook is generally located in a topographically low area of the site, and flows into Narragansett Bay. The general site topography slopes in a south to north direction, with the steepest surface gradients located near the brook in the northern corner of the site (see site contour map in Appendix A). The central, tank portion of the site is gradually sloping and generally well drained. Along the northwestern edge of the site is Defense Highway, beyond which is Narragansett Bay.

Surface water runoff (from precipitation) on the site either

evaporates, infiltrates into site soils, ponds on the surface, or flows overland towards the brook and Defense Highway. The western edge of the site slopes downward to Defense Highway. During periods of heavy rainfall, runoff from the site was observed accumulating at the point where Defense Highway crosses Gomes Brook. During these events, overland flow was also observed in the northeastern portion of the site towards Gomes brook and ponded water was observed in a marshy area in the eastern corner of the site.

Data from piezometers installed along the southern bank of Gomes Brook, as well as surface water levels recorded within the brook, document that the brook is a "gaining" or effluent stream (i.e., ground water discharges into the stream). The piezometric ground water and surface water elevation data are provided in Table 2-20. As shown on the site ground water contour map (see Figure 3-27), the site ground water flow is strongly influenced by Gomes Brook. The site ground water flow characteristics are discussed in greater detail in Section 3.5 of this report.

3.4 Geology

This section presents information on the regional geology and the site-specific geology. The regional geology information was obtained directly from the IAS report and is referenced as such.

3.4.1 Regional Geology

NETC is located at the southeastern end of the Narragansett Basin. This basin is a complex synclinal mass of Pennsylvanian aged sedimentary rocks and is the most prominent geologic feature in eastern Rhode Island and adjacent Massachusetts. Narragansett Basin is an ancient north to south trending structural basin originating near Hanover, Massachusetts. The basin has a length of approximately 55 miles and varies from 15 to 25 miles wide. The western margin of the basin is in the western portion of Providence, Rhode Island, and the eastern margin runs through Fall River, Massachusetts. Exposures of older rocks on Conanicut Island and in the vicinity of Newport suggest that the southern extent of the basin is near the mouth of Narragansett Bay.

The rocks of the Narragansett Basin are non-marine sedimentary rocks of Pennsylvanian age. The rocks are chiefly conglomerates, sandstones, shales, and anthracite. Total thickness of the strata in the Narragansett Basin has been estimated at 12,000 feet. Both vertical and lateral irregularities in the lithologic character of the rock are present within the basin. Many folds and some faults occur throughout the basin, but the character and amount of the folding and faulting are not clearly known. The sedimentary rocks of the basin are believed to have been deposited in a lowland area which was surrounded by an upland area of considerable relief. The presence of coal beds within the basin also indicates that there were fairly extensive swampy areas. Figure 5 shows a general geologic map of Rhode Island.

The bedrock of the Narragansett Basin has been divided into the following five units: the Rhode Island Formation, Dighton Conglomerate, Wansulta Formation, Pondville Conglomerate, and Felsite at Diamond Hill. At NETC and most of the surrounding area, the bedrock is entirely of the Rhode Island Formation, and thus, only

this unit will be examined in detail. Figure 6 represents a detailed look at the geology at NETC and the surrounding areas.

The Rhode Island Formation is the most extensive and thickest of the Pennsylvania formations in Rhode Island. The vast majority of the Narragansett Basin is underlain by this formation. Included within the Rhode Island Formation are fine to coarse conglomerate, sandstone, lithic graywacke, graywacke, arkose, shale and a small amount of meta-anthracite and anthracite. Most of the rock is gray, dark gray, and greenish, but the shale and anthracite are often black. Crossbedding and irregular, discontinuous bedding is characteristic of the formation. Rocks of the Rhode Island Formation, which are in the northern portions of the basin, are strong and indurated but are not metamorphosed. However, those rocks in the southern portion of the basin, such as the NETC, are metamorphosed, and these rocks contain quartz-mica schist, feldspathic quartzite, garnet-stacrolite schist, and some quartz-mica-sillimanite schist. The beds of meta-anthracite and anthracite are mostly thin, but many areas within basin have been mined. Vein quartz, fibrous quartz, and pyrite are commonly associated with these coal layers, and the ash content is high.

Within the Rhode Island Formation, there are a few areas of thick conglomerates. These conglomerate layers are gray to greenish in color and are mostly very coarse. These conglomerates consist of pebbles, cobbles, and boulders (up to several feet long), interbedded with sandstone and graywacke. The stones are predominantly quartzite and have been elongated as a result of tectonic forces in the southern portion of the basin. These thick conglomerate layers are more resistant to erosion than are the surrounding rocks and thus, are topographically higher. Coasters Harbor Island is mostly covered with this conglomerate material.

Throughout the Narragansett Basin, the Pennsylvanian rocks are underlain by pre-Pennsylvanian igneous and metamorphic rocks such as Bulgarmarch granite, Metacom granite gneiss, porphyritic granite and slate and quartzite. For the most part, these basement rocks are deeply buried beneath the Pennsylvanian rocks. However, these older rocks occur north of NETC in the Bristol area and south of NETC in the Fort Adams and Newport Neck areas and on the southern tip of Conanicut Island. Rose Island and Goat Island also have older metamorphic rocks of slate and quartzite.

Overlying the Pennsylvanian rocks of the Narragansett Basin are surficial deposits of Pleistocene sediments.

> These Pleistocene sediments owe their origin to the Wisconsin glaciation which covered the area with ice several thousand feet thick. As the glaciers receded some 10,000 to 12,000 years ago, they deposited unconsolidated glacial materials of variable thicknesses throughout the Narragansett Basin area. The unconsolidated glacial material ranges from 1 to 150 feet thick, being thicker in the valleys and thinner in the uplands. The glacial material consists of till, sand, gravel, and silt. These glacial deposits were derived from shale, sandstone, conglomerate, and in a few places, coal. The glacial materials serve as the parent materials for the soils in the area. Areas where sand and gravel were deposited serve as important regional mineral sources. . . .

(IAS, pp. 5-18, 5-21)

> Over most of the bay floors, thick glacial deposits are buried beneath up to 50 feet of sediments. These sediments are predominantly sand, gravel, silt, and clay. The sediments near the mouth of the bay are more sandy than those in the upper bay which have more silt and clays. This is a reflection of the current velocities in the bay. . . .

(IAS, pg. 5-31)

> Much of the geologic information contained in this section was obtained from Geological Survey Bulletin 1295 (Quinn, 1971). . . .

(IAS, pg. 5-21)

3.4.2 Site-Specific Geology

Presented below is information on the geology of each of the five sites studied under this investigation.

Site 01 - McAllister Point Landfill

The soil boring activities performed at the site under this investigation, as well under previous subsurface investigations, provided information on the site geology. Previous subsurface investigation activities included the drilling and sampling of

three soil borings completed for the installation of three monitoring wells. The locations of the wells are shown in Figure 2-17. The logs for these wells are provided in Appendix G.

Subsurface investigation activities conducted under this investigation included the drilling and sampling of thirteen (13) test borings and seven (7) well borings. The locations of these borings and wells are shown on Figures 2-16 and 2-17, respectively. The logs for these borings and wells are provided in Appendices F and G. Using information from these logs, three geologic cross sections were developed for the site. The locations of the three cross section lines are shown on Figure 3-1. The three geologic cross sections are presented as Figures 3-2, 3-3, and 3-4. Below is a discussion of the site stratigraphy, from overburden to bedrock, as interpreted from the findings of these investigations.

The overburden on this site consists of fill and glacial till deposits. All of the soil borings except for test boring B-13 (off-site and upgradient) and all of the monitoring well borings, except for well MW-23 previously installed off-site, encountered fill material. The thickness of the fill material ranged from 3 feet (M-1) at the periphery of the site, to 24 feet (M-3) in the central portion of the landfill. The boring for well MW-21, previously installed at the western edge of the central portion of the landfill, reportedly encountered 38 feet of fill material. The fill material encountered consisted of a wide variety of municipal and industrial wastes (e.g., plastic, wood, paper, garbage, construction debris, paints), as well as what appears to be ash

from the incinerator which reportedly operated on the site. The fill material appears to have been deposited directly upon the bedrock surface across a majority of the site.

Overlying the fill material, at several locations across the landfill, is a clay-silt layer ranging in thickness from 0 to 4 feet. This layer is presumably the cover material or "cap" which was reportedly placed on-site when the landfill was closed in 1973. The cover material is discontinuous across the site, and was found primarily in the central portion of the landfill (soil borings B-3, B-4, B-5, and B-6), as indicated in Cross-Section B-B′ on Figure 3-3. A clay-silt horizon was also encountered overlying the fill material in well boring M-5 and test boring B-10, both completed at the southern end of the landfill, and in B-1, completed in the northern portion of the landfill; however, this material did not appear to be the same "cap" material encountered in the central landfill area.

Glacial till deposits were observed directly beneath the fill and overlying the bedrock at the periphery of the site (at well borings M-1 and M-5, and test boring B-10), as indicated in Cross Section A-A′ on Figure 3-2. Till was observed directly overlying the bedrock at the off-site location of soil boring B-13. Till was also encountered in boring B-4 in the central landfill area, and in B-8 in the southern portion of the site. These borings were completed within the till layer. The till encountered consisted primarily of fine to coarse sand and silt, with some horizons containing weathered shale fragments. The till varied in thickness

from 4.5 feet (B-13) to 11.5 feet (M-5). One undisturbed Shelby tube soil sample was collected from the till, at the southern end of the site (M-5). The Shelby tube was collected from 14 to 15.5 feet below grade. The undisturbed soil sample was tested by Empire Soils Investigations, Inc. for triaxial permeability, particle size, and Atterberg limits. The till sample was determined to have a permeability of 2.69×10^{-7} cm/sec (7.626×10^{-4} ft/day). Grain size analysis indicated the till sample consisted of 23.5% gravel, 44.6% sand, 13.4% silt, and 18.5% clay. According to its Atterberg limits, the soil sample was classified as "non-plastic", which is typical of till.

The bedrock encountered at the McAllister Point Landfill consists of a gray-green to black, highly weathered to competent, carboniferous shale. Cores of the shale exhibited a high degree of fracturing with quartz and iron-oxide deposits common along fractures. All but four of the soil borings were completed to the depth of the bedrock surface. The depth to bedrock at the site varied from 4 feet (at M-7) to 24 feet (at M-3). The bedrock surface exhibits a uniform, westward slope, towards Narragansett Bay. A contour map of the bedrock surface is shown on Figure 3-5.

Site 02 - Melville North Landfill

The soil boring activities performed under this investigation provided information on the site geology. The subsurface soil investigation activities included the drilling and sampling of thirteen (13) test borings and five (5) well borings across the

site. Shallow test pits were also completed in the central portion of the site. The locations of the borings, wells, and test pits are shown on Figures 2-18, 2-19, and 2-15, respectively. The soil boring logs and well logs are provided in Appendices F and G. The test pit logs are provided in Appendix D. Using information from these logs, three geologic cross sections were developed for the site. The locations of the three geologic cross section lines are shown on Figure 3-6. The three geologic cross sections are presented as Figures 3-7, 3-8, and 3-9.

The overburden material on this site consists of fill and glacial till deposits. All of the borings completed at the site, with the exception of test borings B-1, B-10, and off-site well boring M-5, encountered fill material. The thickness of fill varied from 2 feet (B-2) at the edge of the site, to 10 feet (B-5 and M-2) in the central portions. The fill material encountered consisted primarily of loose, black, medium to coarse sand and gravel, with some shale fragments. Ash, wood, and metal debris were also encountered in many of the borings as well as in the test pits. Oily fill was encountered in several borings (B-4, B-13, M-3) and test pits (TP-1 and TP-5), all located in the central portion of the site, as well as in B-9, located to the south-west.

Glacial till deposits were observed beneath the fill across the site (see Figures 3-7 to 3-9). The till encountered on this site consisted primarily of silt, with up to approximately 50% fine to coarse sand in places. The greatest thickness of till encountered at the site was 16 feet (in well boring M-4).

Although none of the soil borings completed at the site penetrated bedrock, fragments of weathered shale were encountered in the bottom of many of the borings (B-5, B-6, B-9, M-1, M-2, and M-5). Those borings may indicate a close proximity to the overburden-bedrock boundary. The shale fragments closely resembled the bedrock encountered at the McAllister Point Landfill site. Based upon these observations, it is inferred that the Melville North Landfill is underlain by the same shale unit (the Rhode Island Formation) as the McAllister Point Landfill.

Site 09 - Old Fire Fighting Training Area

A previous geotechnical study conducted on the site, along with soil boring activities completed during this investigation, provided information on the geology of the site. Previous activities included the drilling of three geotechnical borings on the site near the existing, on-site child care facility. The locations of the borings are shown on Figure 1-14.

Subsurface investigation activities conducted under this investigation included the drilling and sampling of seven (7) test borings and four (4) well borings. The locations of these borings and wells are shown on Figures 2-20 and 2-21, respectively. The logs for the borings and wells are provided in Appendices F and G. Using information from these logs, three geologic cross sections were developed for the site. The locations of the three geologic cross section lines are shown on Figure 3-10. The three geologic cross sections are presented as Figures 3-11, 3-12, and 3-13.

The overburden materials across a majority of the site consist of fill over till deposits. Fill was encountered over most of the site, generally ranging in thickness from 0 to 4 feet. The fill consists primarily of fine sand and silt and construction-type debris (i.e., brick, concrete, asphalt).

The native overburden deposits at the site can be divided into three general types: a very tight sand and gravel till (encountered across the entire site), a silt and fine sand till (similar to that encountered at McAllister Point and Melville North; present at the background well location (MW-5)), and an organic, swampy muck encountered in boring B-5, completed along the shoreline of Narragansett Bay. The sand and gravel till was present overlying the silt and fine sand layer at the location of well MW-5.

The previous investigation boring logs indicate that bedrock, composed of sandstone, was encountered at depths of 5.5 to 10.2 feet below grade. Bedrock was encountered in only one of the borings (M-1) completed under this investigation (see Cross Section C-C′ on Figure 3-13). Bedrock was present at a depth of 9 feet in this boring and consisted of brown-gray sandstone.

Site 12 - Tank Farm Four

The soil boring activities performed at the site under this investigation, as well as under previous subsurface investigations, provided information on the site geology. Previous subsurface investigation activities included the drilling and sampling of two

well borings. The locations of the wells are shown in Figure 1-16. The logs for these wells are provided in Appendix E.

The well boring logs indicate that the surficial deposits are mostly silt with sand layers. Although shale chips were recovered in the split spoon samples, neither competent nor weathered shale was encountered in either of the borings.

Subsurface investigation activities conducted under this investigation included the drilling and sampling of five (5) shallow (M-1 through M-5) and three (3) deep (M-1, M-3, and M-5) monitoring well borings. The locations of these wells are shown in Figure 2-22. The logs for these wells are provided in Appendix G. Using information from these logs, two geologic cross sections were developed for the site. The locations of the two geologic cross section lines are shown on Figure 3-14. The two geologic cross sections are presented as Figures 3-15 and 3-16.

The overburden deposits on this site consist of a native sand and silt, glacial till. The till was encountered in all of the borings, ranging in thickness from 12 feet (at M-5) to 29 feet (at M-3) (see Cross Section A-A′ on Figure 3-15). No fill was encountered at the this site.

Bedrock was encountered at all of the boring locations. The three deep monitoring wells (M-1, M-3, and M-5) were completed within competent bedrock. At the location of well boring M-3, completed in the central portion of the site, 10 feet of weathered shale was encountered on top of competent rock. Nx rock cores were

collected of competent rock from the screened interval of the three deep monitoring well borings. The rock cores indicate that the bedrock at the site consists of the same shale unit (the Rhode Island Formation) that was encountered at the McAllister Point Landfill. The bedrock is a gray-green to black, carboniferous shale, which varies from highly weathered to competent. The shale exhibits a high degree of fracturing, with quartz and iron-oxide deposits common along fractures. A bedrock contour map generated for the site (see Figure 3-17) indicates that the bedrock slopes towards the west.

Site 13 - Tank Farm Five

The soil boring activities performed at the site under this investigation, as well as under previous subsurface investigations, provided information on the site geology. Previous tank closure investigation activities included the drilling and sampling of several well borings around Tanks 53 and 56. The locations of these wells are shown on Figure 1-17. The logs for these wells are provided in Appendix E.

Six (6) monitoring wells were installed under this investigation. Five (5) additional monitoring wells were installed under tank closure investigation activities completed by TRC. The locations of these wells are shown on Figure 2-23. Two geologic cross sections were developed from the information obtained from these monitoring well borings. The locations of the two geologic cross section lines are shown on Figure 3-18. The cross sections

are presented as Figures 3-19 and 3-20. The monitoring well logs are presented in Appendix G. Presented below is a discussion of the site stratigraphy, from overburden to bedrock, as interpreted from the findings of these investigations.

The overburden deposits on this site consist of a native sand and silt, glacial till, like that encountered at Tank Farm Four. The till was encountered in all of the borings and ranged in thickness from 1 foot (M-3) to 21 feet (M-8). The till directly overlies the bedrock at the site.

The bedrock at the site consists of gray, highly weathered to competent, slightly metamorphosed, shale, with quartz lenses. All of the monitoring well borings completed at the site during this investigation encountered the bedrock surface. Depth to bedrock ranged from 1 foot (at M-3) to 33 feet (in R-1). It is believed that the depth to bedrock encountered in boring R-1 is artificially low due to its proximity to the Tank 53 excavation. The tank excavations reportedly extended into bedrock at the site. Greatest depths to bedrock were encountered at the hilltop on the southern side of the site near Tank 59. Nx rock cores were collected from several of the well borings completed on the site. The rock cores indicate that the bedrock at the site consists of the same unit (the Rhode Island Formation) which was encountered at the McAllister Point Landfill and at Tank Farm Four. As was observed at Tank Farm Four, a considerable zone of weathered bedrock overlies the competent bedrock at Tank Farm Five. Twenty-two feet of weathered shale was encountered at the location of well boring

M-10, which was installed during tank closure investigation activities. A bedrock contour map generated for the site is provided as Figure 3-21. The contour map indicates that the bedrock surface slopes to the west (to the bay) in the southwestern portion of the site (by Tanks 53 and 56), and towards the north (to the brook) in the northeastern portions of the site.

3.5 Hydrogeology

This section presents information on the regional hydrogeology and the site-specific hydrogeology. The regional hydrogeology information was obtained directly from the IAS report and is referenced as such.

3.5.1 Regional Hydrogeology

Many areas on Aquidneck Island, on which NETC is located, obtain their water supply from wells. Areas relying on ground water are mostly north of the Middletown area, but there are wells throughout the entire island. Most ground water is used for domestic needs, although some is used by small industries and businesses.

Ground water on Aquidneck Island is obtained from the unconsolidated glacial deposits of till and outwash and from the underlying Pennsylvanian bedrock. Throughout the area, depth to ground water ranges from less than one foot to about 30 feet, depending upon the topographic location, time of year, and character of subsurface deposits. The average depth to the ground water is around 14 feet on Aquidneck Island and moves from areas of high elevations to Narragansett Bay or the Sakonnet River.

Seasonal water level fluctuations are common in the area. These fluctuations range from less than 5 feet to as much as 20 feet on the hills. In the valleys and lowland areas, the fluctuations are generally less than 5 feet. During the late spring and summer, the water table usually declines as a result of evaporation and the uptake of water by plants, and rises during autumn and following winter thaws.

The unconsolidated glacial deposits range in thickness from less than one foot near the rock exposures to about 50 feet throughout Aquidneck Island. Most of the glacial deposits are till, but isolated outwash areas occur. In the NETC area, the glacial deposits are till with a thickness of less than 20 feet. Wells completed in the till are usually dug and range in depth from less than 10 feet to as much as 75 feet. The average depth for these wells is about 20 feet. These dug wells are usually 2 to 3 feet in diameter and are usually dug down to the top of the bedrock.

The yield of till wells varies considerably depending upon the type and thickness of the water-bearing deposits penetrated. Yields range from less than one to as much as 120 gallons per minute. Under normal weather conditions, till wells yield a few hundred gallons of water per day and are adequate for domestic supplies. The large diameter of dug wells also provides substantial water storage area between periods of use. Each foot of water in a 3-foot diameter well represents storage of 53 gallons. However, these wells are subject to going dry during seasonal or unusual droughts.

Bedrock wells in the area range from 14 to 1,300 feet in depth. The average depth for these bedrock wells is 135 feet. Yields from bedrock wells range from less than one to as much as 55 gallons per minute. Most wells yield less than 10 gallons per minute. The yields vary considerably in the bedrock over short distances because the joints and fractures which transmit water to the wells occur intermittently. Joints and fractures are most numerous and widest near the top of the bedrock and become fewer and narrower with depth. Bedrock wells seldom go dry, but yields can be extremely low if not enough fractures and joints occur in the area of the well.

The chemical characteristics of the ground water are similar throughout the area, and the water is generally satisfactory for most ordinary uses. Most ground water in the area is soft or only moderately hard, with ground water from till generally containing less mineral matter and being softer than ground water from bedrock. Areas where the ground water has high iron content are scattered throughout the area, being most numerous around Newport and Middletown and the northern part of Portsmouth. Wells which have a high iron content usually penetrate only rocks of Pennsylvanian age.

In scattered locations near the shoreline, over-pumping has led to salt water intrusion in some wells. Bedrock wells are not as easily contaminated with salt water as are till wells, but the chance of contamination increases as the depth of the well below sea level increases.

No wells were identified within the boundaries of NETC other than on Gould Island, although there are numerous wells in close proximity. These wells are upgradient of NETC. . . .

(IAS, pp. 5-31 to 5-34)

The ground water at NETC is very shallow, being less than 10 feet below the surface in most areas. This shallow depth makes ground water contamination at NETC very possible. Those pollutants which do find their way into the ground water would migrate to the west and discharge into Narragansett Bay. NETC extends along the western shoreline of Aquidneck Island, and

the ground water only has to migrate a short distance before discharging into Narragansett Bay.

The soils occurring at NETC have permeabilities which are moderate to moderately rapid, and they do not restrict the vertical movement of water. The glacial till, from which these soils were derived, is generally less permeable than the overlying soils but does not represent a barrier to the vertical migration of water. Therefore, it is possible that any contaminant transported in this water could contaminate the ground water. There are also isolated areas where the bedrock occurs at the surface. Contamination is possible in these areas through the cracks and fissures which commonly occur in the bedrock.

(IAS, pg. 5-34)

3.5.2 Site-Specific Hydrogeology

Site 01 - McAllister Point Landfill

Ground water levels were measured in the nine monitoring wells installed at the site in April, July, and September of 1990, and in January of 1991. This water level data is provided in Table 2-13. A representative ground water table contour map is presented as Figure 3-22. The remaining ground water table contour maps are provided in Appendix I for reference. The contour maps indicate that the site ground water is flowing from east to west, towards the bay.

Single well hydraulic conductivity tests (slug tests) were performed in four of the monitoring wells at the site (MW-1, MW-3D, MW-5D, and MW-7). All of these wells are screened within the bedrock at the site. Monitoring wells MW-1 and MW-7 are screened in the weathered upper zone of the bedrock. The results of these slug tests are provided in Appendix J. The hydraulic conductivities determined from the slug tests range from 0.07

ft/day (wells MW-7 and MW-3D) to 0.20 ft/day (well MW-5D). These hydraulic conductivity values are higher tan values normally attributed to shale (3.28×10^{-4} to 3.28×10^{-8} ft/day) (Driscoll, 1987) and probably reflect the highly weathered and fracture nature of the upper portion of the bedrock at the site. Slug tests were not conducted in monitoring wells screened in the fill material at the site, due to the shallow ground water levels (i.e., insufficient water) in the shallow wells.

Vertical Hydraulic Gradients

Vertical hydraulic gradients were determined at the two sets of nested monitoring wells at the site (MW-3S/D and MW-5S/D). Vertical hydraulic gradients are used to evaluate whether contamination can migrate downward through an aquifer. Vertical gradients were calculated for the four dates that ground water elevations were measured. The vertical hydraulic gradients calculated for the two on-site well pairs are provided in Table 3-1. A positive hydraulic gradient indicates an upward flow, and a negative gradient indicates a downward flow. An upward flow would tend to retard contaminant transport down through an aquifer, whereas a downward vertical gradient provides a means by which contamination can migrate toward the bottom of the aquifer.

On all four of the dates that water levels were measured, a downward, or negative, hydraulic gradient was observed in both of the well pairs. The calculated vertical gradients ranged from

-0.115 ft/ft (MW-3S/D on 4/3/90) to -0.242 ft/ft (MW-3S/D on 9/20/90). This indicates that ground water from above the bedrock surface (in the fill or overburden) would tend to flow downward into the bedrock at these two locations.

Horizontal Hydraulic Gradients

Horizontal hydraulic gradients were also determined from the water level measurements at the site. Horizontal gradients are used, along with the aquifer hydraulic conductivity and effective porosity, in determining horizontal ground water flow velocities, and hence the rate at which an aquifer may transport contaminant solutes. Representative average horizontal gradients calculated for several areas on the site are provided in Table 3-2. Horizontal gradients were calculated for the shallow wells (screened in the fill and overburden materials), and the three deep wells at the site (screened in bedrock) on the basis of the average of the four sets of ground water level measurements taken at the site. The horizontal gradient represents the change in head, measured in feet, per horizontal foot of travel through the medium.

Calculated shallow average horizontal hydraulic gradients ranged from 0.0056 ft/ft (MW-5S to MW-6), to 0.038 ft/ft (MW-4 to MW-3S). Deep average horizontal gradients were calculated as 0.0077 ft/ft (MW-5D to MW-3D) and 0.0049 ft/ft (MW-3D to MW-1).

Average Linear Velocities

The calculated average horizontal hydraulic gradients, along with hydraulic conductivity and effective porosity values, were used to calculate average linear ground water velocity values at the site. The linear velocities were calculated using Darcy's equation (Freeze and Cherry, 1979):

$$v = K/n \times g$$

Where:

v = linear velocity (ft/day)

K = hydraulic conductivity (ft/day)

n = effective porosity of the aquifer material (unitless)

g = horizontal hydraulic gradient (ft/ft)

Since no hydraulic conductivity values were determined for the fill at the site, a hydraulic conductivity of 0.57 ft/day was assumed for the fill (this value is given as the hydraulic conductivity of municipal waste in the "Hydrologic Evaluation of Landfill Performance (HELP)", Version 2.0 developed by the U.S. Army Corps of Engineers (USACE, 1988)). An effective porosity of 52% was assumed for the fill as obtained from the HELP Model. A hydraulic conductivity of 0.117 ft/day was used for the bedrock at the site. This value is an average of the conductivities derived from the slug tests executed at wells screened in bedrock MW-1D, MW-3D and MW-5D, and MW-7S. An effective porosity of 10% was assumed for the shale (Driscoll, 1986).

Calculated average linear velocities for the shallow ground water ranged from 0.0061 ft/day (MW-6 to MW-5S) to 0.0417 ft/day (MW-3S to MW-4). The average linear velocities of the deep ground water were calculated as 0.0091 ft/day (MW-5D to MW-3D) and 0.0057 ft/day (MW-3D to MW-1). It is important to note that the calculated average linear velocity values are lower than the "true microscopic velocities" because water particles must travel along irregular paths that are longer than the linearized paths represented by the calculated average linear velocities (Freeze and Cherry, 1979). In addition, the estimated effective porosity value of 52% for the fill at the site may be too high or low, causing the linear velocity estimates to be too low or high, respectively.

Tidal Influence

Continuous ground water level measurements were recorded in five of the monitoring wells at the site (MW-1, MW-3S, MW-3D, MW-5S, and MW-5D) for three days (August 21 to August 24, 1990). Ground water levels were recorded every 15 minutes during the three-day time period. At the same time, continuous surface water levels were recorded at a gauging station located in Narragansett Bay, adjacent to the site.

A graphical depiction of the tidal influence in the five monitoring wells is shown in Appendix K. Tidal influences were observed in each of the monitoring wells except MW-3S. The influence upon monitoring wells MW-3D and MW-5S were small enough to be considered negligible. The strongest tidal influence was

encountered in monitoring well MW-5D. The piezometric water level in MW-5D fluctuated by as much as 2.12 feet between high and low tide. The water level fluctuations in the wells paralled the six hour tidal period observed in the Narragansett Bay tidal station adjacent to the site (see Appendix K).

It is important to note that the tidal influence is much stronger in the deep wells than the shallow wells at the site. This is demonstrated at monitoring well nest MW-5S/D where the water level in well MW-5S fluctuated 0.04 feet, as compared to more than 2 feet in well MW-5D. The higher tidal influence noted in the bedrock wells is probably due to the fact that the bedrock outcrops in the bay. Salt water intrusion from the bay displaces fresh water within the fractures in the bedrock over a horizontal distance which extends into the site; the distance the bay water intrudes depends on the elevation (head) of Narragansett Bay.

Proximity of the monitoring wells to the bay also appears to have an effect upon the tidal influence observed in the well. In monitoring wells MW-1 and MW-5D, which are both are located within 100 feet of the shoreline, the strongest tidal influences were observed. Well MW-3D, which is located approximately 250 feet from the shoreline, exhibited negligible tidal effects.

The vertical gradient at well nest MW-5S/D fluctuated by approximately 2 feet due to tidal effects, with a greater downward gradient observed, as would be expected, during low tide. Contaminated ground water, therefore, could move downward into the

bedrock with greater ease at low tide than at high tide at that location.

Site 02 - Melville North Landfill

Ground water levels were measured in the five monitoring wells installed at the site in July and September of 1990, and in January of 1991. This water level data is provided in Table 2-15. A representative contour map of the ground water table elevation is presented as Figure 3-23. The remaining ground water table contour maps are provided in Appendix I for reference. The ground water contours indicate that the site ground water is flowing from east to west towards the bay.

Single well hydraulic conductivity tests (slug tests) were performed at three of the monitoring wells at the site (MW-1, MW-2, and MW-5). Monitoring wells MW-1 and MW-5 are both screened in the till overburden, and MW-2 is screened in fill. The results of these slug tests can be found in Appendix J. The hydraulic conductivities determined for the till were 0.24 ft/day (MW-1) and 0.22 ft/day (MW-5S). The hydraulic conductivity of the fill material at MW-2S was determined to be 0.45 ft/day. This indicates that the fill at the site is approximately 2 times as conductive as the till.

Vertical Hydraulic Gradients

Because no monitoring well pairs or nests were installed at the site, no vertical hydraulic gradients could be determined.

Horizontal Hydraulic Gradients

Horizontal hydraulic gradients were determined from the water level measurements at the site. Representative average horizontal gradients for several areas on the site are provided in Table 3-3. Horizontal gradients were calculated for each of the three dates on which water levels were measured. The horizontal gradients reported are averages of the three individual values. Average horizontal gradients ranged from 0.0027 ft/ft (MW-3 to MW-4) to 0.033 ft/ft (MW-5 to MW-2).

Average Linear Velocities

The calculated average horizontal hydraulic gradients, along with hydraulic conductivity and effective porosity values, were used to calculate average linear velocity values at the site. A hydraulic conductivity of 0.31 ft/day, an average of the hydraulic conductivities determined by the slug tests performed at the site, was used in the calculations. An effective porosity of 15% was assumed for the till at the site (Driscoll, 1986).

Average linear velocities of the shallow ground water ranged from 0.0053 ft/day (MW-3 to MW-4) to 0.0654 ft/day (MW-5 to MW-2). It is important to note that the above calculated average linear velocity values are lower than the "true microscopic velocities" because water particles must travel along irregular paths that are longer than the linearized paths represented by the calculated average linear velocities (Freeze and Cherry, 1979). In addition, the estimated effective porosity value of 15% for the till at the

site may be too high or low, causing the linear velocity estimates to be too low or high, respectively.

Tidal Influence

Continuous water level measurements were recorded in four of the five monitoring wells at the site (MW-1, MW-2, MW-4, and MW-5), for three days (August 14 to August 17, 1990). Water levels were recorded every 15 minutes during the three-day time period. A graphical depiction of the tidal influence in the four monitoring wells is shown in Appendix K. Tidal influences were seen in all of the monitoring wells except the most upgradient well MW-5. Monitoring wells MW-1, MW-2, and MW-4 all exhibited similar tidal influences. The maximum fluctuations of the ground water table were 0.31, 0.25, and 0.29 feet for MW-1, MW-2, and MW-4 respectively. These fluctuations were considerably smaller than those observed in some deep wells at the McAllister Point Landfill. No gauging station was constructed at Melville North to measure the tidal fluctuation in the bay during this time period. Although a six-hour tidal fluctuation is evident in the ground water elevation data plotted in Appendix K.

Site 09 - Old Fire Fighting Training Area

Ground water levels were measured in the five monitoring wells installed at the site in June and September of 1990, and in January of 1991. The water level data is provided in Table 2-16. The water level measurements indicate that ground water is flowing to

the north. A representative contour map of the ground water table elevation is presented as Figure 3-24. The remaining ground water table contour maps are provided in Appendix I for reference.

Single well hydraulic conductivity tests (slug tests) were performed at two of the monitoring wells at the site (MW-4 and MW-5). Monitoring wells MW-4 and MW-5 are both screened in the till overburden. The results of these slug tests are presented in Appendix J. The hydraulic conductivities determined for the till were 0.44 ft/day (MW-4) and 0.29 ft/day (MW-5).

Vertical Hydraulic Gradients

Because no monitoring well pairs or nests were installed at the site, no vertical hydraulic gradients could be determined.

Horizontal Hydraulic Gradients

Horizontal hydraulic gradients were determined from the water level measurements at the site. Representative average horizontal gradients for several areas on the site are provided in Table 3-4. Horizontal gradients were calculated for each of the three dates on which water levels were measured. The horizontal gradients reported are averages of the three individual values. Average horizontal gradients ranged from 0.0040 ft/ft (MW-3 to MW-4) to 0.0068 ft/ft (MW-1 to MW-2).

Average Linear Velocities

The calculated average horizontal hydraulic gradients, along with hydraulic conductivity and effective porosity values, were used to calculate average linear velocity values at the site. A hydraulic conductivity of 0.30 ft/day, an average of the hydraulic conductivities determined by the slug tests performed at the site, was used in the calculations. An effective porosity of 15% was assumed for the till at the site (Driscoll, 1986).

Average linear velocities of the shallow ground water ranged from 0.0080 ft/day (MW-3 to MW-4) to 0.014 ft/day (MW-1 to MW-2). It is important to note that the above calculated average linear velocity values are lower than the "true microscopic velocities" because water particles must travel along irregular paths that are longer than the linearized paths represented by the calculated average linear velocities (Freeze and Cherry, 1979). In addition, the estimated effective porosity value of 15% for the till at the site may be too high or low, causing the linear velocity estimates to be too low or high respectively.

Tidal Influence

Continuous water level measurements were recorded in all five of the monitoring wells at the site for three days (August 27 to August 30, 1990). Water levels were recorded every 15 minutes during the three-day time period. A graphical depiction of the tidal influence in the five monitoring wells is shown in Appendix K. Tidal influences were seen in monitoring wells MW-2 and MW-4.

No tidal effects were exhibited in wells MW-1, MW-3, or MW-5. The maximum fluctuation of the ground water table (0.91 feet) was observed in well MW-2. No gauging station was constructed at the Old Fire Fighter Training Area site to measure the tidal fluctuation in the bay during this time period. Although a six-hour tidal fluctuation is evident in the ground water elevation data plotted in Appendix K.

Site 12 - Tank Farm Four

Ground water levels were measured in the eight monitoring wells installed at the site in July and September of 1990, and in January of 1991. The water level data is provided in Table 2-17. The water level measurements indicate that the shallow and deep ground water seems is flowing to the southwest. A representative contour map of the ground water table elevation is presented as Figure 3-25. The remaining ground water table contour maps are provided in Appendix I for reference. A representative contour map of the deep piezometric surface is provided in Figure 3-26. The remaining contour maps of the deep piezometric surface are provided in Appendix I for reference.

As shown on the contour maps, the shallow and deep ground water at the site appear to be affected by the presence of Norman's Brook at the southwestern end of the site. The ground water contours also generally reflect the site topography. As discussed earlier in the surface water hydrology section, Normans Brook is a gaining stream. This means that the brook receives discharge from ground

water at the site. This fact is supported by the observation that both shallow and deep site ground water appears to flow towards the brook.

Single well hydraulic conductivity tests (slug tests) were performed at two of the shallow monitoring wells (MW-1S and MW-5S) and the three deep monitoring wells (MW-1D, MW-2D, and MW-5D) at the site. The shallow monitoring wells are all screened in the till overburden and the deep wells are all screened in competent bedrock. The results of these slug tests are provided in Appendix J. The hydraulic conductivities determined for the shallow (till) were 0.23 ft/day for both well MW-1S and MW-5S. The hydraulic conductivities determined for the deep (bedrock) wells were 0.059 ft/day (MW-1D), 0.029 ft/day (MW-3D), and 0.042 ft/day (MW-5D). These values indicate that the till is an order of magnitude more conductive than the bedrock at the site.

Vertical Hydraulic Gradients

Vertical hydraulic gradients were determined at the three sets of nested monitoring wells at the site (MW-1S/D, MW-3S/D, and MW-5S/D). Vertical hydraulic gradients are used to determine whether contamination can migrate downward through an aquifer. The vertical gradients were determined for each of the three dates on which water level measurements were taken. Table 3-5 presents the vertical hydraulic gradients at the three well pairs at the site.

For all three of the dates, a downward, or negative, hydraulic gradient was observed in all three of the well pairs. The vertical

gradients ranged from -0.059 ft/ft (MW-3S/D on 7/19/90) to -0.683 ft/ft (MW-5S/D on 9/20/90). This indicates that ground water from above the bedrock surface (in the till overburden) would tend to flow downward into the bedrock at these locations.

Horizontal Hydraulic Gradients

Horizontal hydraulic gradients were determined from the water level measurements at the site. Representative average horizontal gradients for both the shallow ground water and the deep ground water were determined for several areas on the site, and are provided in Table 3-6. Horizontal gradients were calculated for all three of the dates on which water levels were measured. The horizontal gradients reported are averages of the three individual values. Average horizontal gradients for shallow ground water ranged from 0.041 ft/ft (MW-3S to MW-1S) to 0.187 ft/ft (MW-5S to MW-3S). Deep average horizontal gradients were calculated as 0.052 ft/ft (MW-3D to MW-1D) and 0.162 ft/ft (MW-5D to MW-3D).

Average Linear Velocities

The calculated average horizontal hydraulic gradients at the site, along with hydraulic conductivity and effective porosity values, were used to caluculate average linear velocity values at the site. A hydraulic conductivity of 0.23 ft/day, an average of the hydraulic conductivities determined by the slug tests performed at the shallow wells at the site, was used in the calculations. An effective porosity of 15% was assumed for the till at the site

(Driscoll, 1986). A hydraulic conductivity of 0.043 ft/day was used for the bedrock at the site, and is an average of the hydraulic conductivities determined by the slug tests performed on the deep wells at the site. An effective porosity of 10% was assumed for the shale (bedrock) at the site (Driscoll, 1986).

Average linear velocities of the shallow ground water ranged from 0.063 ft/day (MW-3S to MW-1S) to 0.29 ft/day (MW-5S to MW-3S). The average linear velocities of the deep ground water were calculated as 0.023 ft/day (MW-3D to MW-1D) and 0.070 ft/day (MW-5D to MW-3D). It is important to note that the calculated average linear velocity values are lower than the "true microscopic velocities" because water particles must travel along irregular paths that are longer than the linearized paths represented by the calculated average linear velocities (Freeze and Cherry, 1979). In addition, the estimated effective porosity value of 15% for the till and 10% for shale at the site may be too high or low, causing the linear velocity estimates to be too low or high, respectively.

Site 13 - Tank Farm Five

Ground water levels were measured in the six, originally installed monitoring wells in July and September of 1990. Five additional monitoring wells were installed later as a part of the tank closure investigation. Water levels were then measured in all twelve of the monitoring wells in January of 1991. The water level data is provided in Table 2-18. The water level information was used to develop contour maps of the ground water table at the

site. Surface water levels and piezometer levels were also used in developing the ground water table contour map for April 30, 1991. A representative ground water table contour map for the site is presented as Figure 3-27. The remaining ground water table contour maps are provided in Appendix I for reference.

As shown in the contour maps, the shallow ground water at the site appears to be affected by the presence of Gomes Brook at the northern end of the site. The ground water contours also generally reflect the site topography. Ground water from the southern end of the site (near tanks 53, 56 and 59) appears to be flowing to the west-northwest (directly toward the bay). Ground water from the northern portion of the site becomes increasingly affected by Gomes Brook and flows to the north (toward the brook). As discussed earlier in the surface water hydrology section, Gomes Brook is a gaining stream. This means that the brook receives discharge from ground water at the site. This fact is supported by the observation that site ground water appears to flow towards the brook.

Water levels from the wells that were installed within the tank excavations (MW-7, RW-1) were not used determine the ground water table contours. These water levels were considered to be unreliable, due to the likelihood that the bedrock surface was lowered considerably by the tank excavations at these locations. Also the tanks, which have been filled with water may have been leaking and this could give erroneous water levels in adjacent wells.

Single well hydraulic conductivity tests (slug tests) were performed at five of the shallow monitoring wells (MW-1, MW-2, MW-3, MW-5, and MW-6) at the site. All of these monitoring wells were screened in weathered bedrock, except MW-6 which is screened in till (overburden).

The results of these slug tests are presented in Appendix J. The hydraulic conductivities determined for the weathered bedrock ranged from 0.16 ft/day (MW-2) to 0.21 ft/day (MW-3). The hydraulic conductivity determined for the overburden well (MW-6) was 0.25 ft/day. These values indicate that the weathered bedrock at the site is almost as conductive as the overburden at the site.

Vertical Hydraulic Gradients

Because no monitoring well pairs or nests were installed at the site, no vertical hydraulic gradients could be determined.

Horizontal Hydraulic Gradients

Horizontal hydraulic gradients were determined from the water level measurements at the site. Representative average horizontal gradients for several areas on the site are provided in Table 3-7. Horizontal gradients were calculated for three of the dates on which water levels were measured. The horizontal gradients reported are averages of the three individual values. Average horizontal gradients ranged from 0.0128 ft/ft (MW-3 to MW-2) to 0.0398 ft/ft (MW-5 to MW-3).

Average Linear Velocities

The calculated average horizontal hydraulic gradients, along with hydraulic conductivity and effective porosity values, were used to caluculate average linear velocity values at the site. A hydraulic conductivity of 0.20 ft/day, an average of the hydraulic conductivities determined by the slug tests performed at the site, was used in the calculations. An effective porosity of 15% was assumed for the till at the site (Driscoll, 1986).

Average linear velocities of the shallow ground water ranged from 0.017 ft/day (MW-3 to MW-2) to 0.05 ft/day (MW-5 to MW-4). It is important to note that the above calculated average linear velocity values are lower than the "true microscopic velocities" because water particles must travel along irregular paths that are longer than the linearized paths represented by the calculated average linear velocities (Freeze and Cherry, 1979). In addition, the estimated effective porosity value of 15% for the till at the site may be too high or low, causing the linear velocity estimates to be too low or high, respectively.

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4.0 NATURE AND EXTENT OF CONTAMINATION

This section presents a discussion on the nature and extent of contamination detected at each of the five sites at the NETC facility. Each site is addressed individually in terms of the nature and extent of contamination in the various media sampled.

4.1 Introduction

Soil and ground water samples were collected at each site. Surface water, sediment, and structure samples were also collected at various sites, based on the individual site characteristics. This section presents an overview of the sampling activities and presentation of the sampling results for each media at each site. Following this introductory section, the investigation results for all media are presented individually by site.

All of the sample results for the various media sampled are provided in data summary tables in Appendix M. The data summary tables ("hits tables") only include those compounds and analytes for which concentrations were reported by the laboratory. The "hits tables" also include any changes to the laboratory data (e.g., qualifiers, negated values) which resulted from data validation. Also included in Appendix M are listings of laboratory and data validation qualifiers, as defined under the CLP Statements of Work, and the USEPA CLP Contract Required Quantitation Limits (CRQLs) and Contract Required Detection Limits (CRDLs) for organics and inorganics. A Data Validation Summary is provided following the data tables.

Summaries of the samples collected from each site are provided in Tables 4-1 through 4-5. The locations of the site investigation activities completed at each site are shown on Figures 4-1 through 4-5. Summary tables (Tables 4-7 through 4-28) are provided for each site which indicate the sample locations where individual compounds of the various compound classes were not detected, where

they were detected and where the detected levels exceeded Federal or State criteria, contaminant-comparison levels (described in more detail in Section 4.1.1), or background levels.

The contaminant assessment discussion for the sampled media at each of the sites investigated includes a discussion of the frequency and level of detection for analytes in each of the compound classes. The discussion is generally presented in order of the following chemical compound classes: volatile organic compounds (VOCs), base neutral/acid extractable organic compounds (BNAs), pesticide and PCB compounds, and inorganic analytes.

Where applicable, the impact of data validation activities on the analytical results is discussed. For example, where data validation has resulted in the qualification of analytical results for common laboratory contaminants as undetected ("U") due to blank contamination, these analytical results are generally eliminated from further consideration in the contaminant assessments. A full discussion of the impacts of data validation on the analytical results is provided in Appendix M. The remaining detected compounds are then reviewed on the basis of detected contaminant levels and detection frequencies. For soil and sediment samples, compounds detected at low levels, detected infrequently, and not detected in other media at the site are also generally eliminated from further consideration in the contaminant assessment. The remaining detected compounds are then referred to as "key" contaminants in the data assessment.

4.1.1 Soil Assessment

Soil investigations were conducted at all five of the sites to evaluate soil quality. Soil investigations included surface soil sampling, test pit excavation and sampling, test boring drilling and sampling, and well boring drilling and sampling. Summaries of the samples collected from each site are provided in Tables 4-1 through 4-5. The locations of the soil investigation activities completed at each site are shown on Figures 4-1 through 4-5.

Surface soil sampling was conducted at all five of the sites. The surface soil samples from Sites 01, 02, 09, and 12 were analyzed for all of the TCL and TAL parameters. The surface soil samples from Site 13 were analyzed for TPH and lead; two of the surface soil samples were also analyzed for all of the TCL and TAL parameters.

Test pit excavations were completed only at Site 02. The test pit samples were analyzed for all of the TCL and TAL parameters.

Test borings were completed on Sites 01, 02, and 09. The test boring soil samples were analyzed for the all of the TCL and TAL parameters. Well borings were also completed at all five of the sites. The well boring soil samples were analyzed for all of the TCL and TAL parameters.

Many of the soil samples collected from Sites 01, 02, and 09 were also archived by the laboratory for dioxin and furan analysis according to EPA Modified Method 8280. Samples collected from the oil/water separators on Sites 12 and 13 were also to be archived by the laboratory; however, the laboratory inadvertently disposed of

the samples. The determination of which samples will be analyzed for dioxins and furans was based on the following: the list of samples actually archived by the laboratory (i.e., available for dioxin/furan analyses), the sample locations having significant soil contamination, the presence of dioxin indicator TCL compounds (2,4,5-trichlorophenol, 1,2,4-trichlorobenzene, PCBs and dibenzofurans), and other site background information (e.g., suspected waste oil disposal areas, ash disposal areas). While samples have been proposed for dioxin and furan analyses, the analyses have not yet been conducted and, therefore, are not discussed herein.

In order to evaluate the analytical soil data and identify areas of concern at each site, contaminant-comparison levels or background levels were established for volatile organic compounds (VOCs), base neutral/acid extractable organic compounds (BNAs), and inorganics. Enforceable action or clean-up levels for soil contaminants generally have not been developed by Federal or State agencies, with the exception of a 1 ppm action level for total PCBs, which has historically been enforced by the RIDEM as a soil clean-up level. This action level has been used to evaluate soil PCB levels. In order to evaluate other detected soil contaminant levels, background levels have been developed for inorganic analytes, and contaminant-comparison levels have been set for other classes of compounds (volatile and base neutral/acid extractable organic compounds). Pesticide levels are addressed on the basis of detected levels and frequency of detection. The development of

contaminant-comparison levels and background inorganic soil levels are further described in the following paragraphs.

Contaminant-comparison levels have been developed for volatile organics and base neutral/acid extractable compounds (BNAs) as a means of evaluating the relative contamination of soil samples with respect to the associated group of chemical compounds. The levels used do not necessarily reflect the risks posed by the individual compounds within the chemical class. Rather, they have been used as a general indicator of the degree of soil contamination, and as a means of identifying general locations where potential contaminant "hot spots" exist which require further compound-specific evaluation. Contaminant-comparison levels have been set at 1 ppm for total volatile organics and 10 ppm for total BNAs. For BNAs, contaminant-comparison levels have also been set for polynuclear aromatic hydrocarbons (PAHs) and carcinogenic PAHs, as a means of further evaluating the relative contamination of the soil samples with respect to the more toxic BNA components. Contaminant-comparison levels have been set at 10 ppm for total PAHs and 1 ppm for total carcinogenic PAHs.

Background levels for inorganic soil contaminants have been developed on the basis of soil quality at two background surface soil sample locations (SS-16 and SS-17) at the McAllister Point Landfill site. These background levels are summarized in Table 4-6.

Where appropriate, subsurface contaminant levels for various chemical classes have been plotted on subsurface cross-sections.

These cross-sections provide a general indication of trends in subsurface soil contamination. Soil contamination location maps are also referenced, where applicable. These maps show the areas on a site where contaminants were detected and highlight areas where contaminant-comparison, action, or background levels were exceeded. For sites where few samples exceeded these reference levels, or where no trends in the extent of contamination could be identified, soil contamination location maps are not provided.

4.1.2 Ground Water Assessment

Ground water monitoring was conducted at each of the five sites. Summaries of the samples collected from each site are provided in Tables 4-1 through 4-5. The locations of the monitoring wells are shown on Figures 4-1 through 4-5.

In order to evaluate the analytical ground water data and identify areas of concern at each site, Federal and State action levels were used. These levels generally consisted of Maximum Contaminant Levels (MCLs). Final, proposed and tentative MCLs were considered in the ground water assessment. The applicable action levels applied to detected contaminants are referenced in the ground water analytical summary tables.

Ground water contamination location maps are referenced, where applicable. These maps show the areas on a site where contaminants were detected at levels exceeding action levels and indicate other site-specific information (e.g., wells in which a petroleum product was observed on the ground water surface). For sites where few

samples exceeded reference levels, or where no trends in the extent of contamination could be identified, ground water contamination maps are not provided.

4.1.3 Surface Water and Sediment Assessment

Surface water and/or sediment samples were collected at three of the sites, Site 02, Site 12 and Site 13. At Sites 02 and 12, surface water and/or sediment samples were analyzed for all of the TCL and TAL parameters, with the exception of one surface water sample collected from Site 12 which was not analyzed for pesticides/PCBs. At Site 13, sediment samples were analyzed for PCBs. lead, and TPH, while surface water samples were analyzed for lead and TPH.

In order to evaluate sediment data and identify areas of concern at each site, contaminant-comparison, action, or background levels have been used. The identification of these levels was discussed in detail in Section 4.1.1.

4.1.4 Structure Assessment

Soil/sediment, sludge and water associated with on-site structures were sampled at two sites, Sites 12 and 13. An oil/water separator is located at each site and at Site 12, an unknown structure was identified which contained soil/sediment and water. The soil/sediment, sludge and water samples were all analyzed for all of the TCL and TAL parameters.

In order to evaluate soil/sediment and sludge data, contaminant-comparison or background levels, as described in Section 4.1.1, were used. For water samples, analytical data were compared to Federal and State surface water quality criteria.

4.2 Site 01 - McAllister Point Landfill

4.2.1 Soil Assessment

This section of the report provides an assessment of the McAllister Point Landfill soil sample analytical results and a discussion on the nature and extent of soil contamination at the site. A total of sixty-six (66) soil samples (not including duplicate samples) were collected from across the site through several field investigation techniques. Soil sample locations are indicated in Figure 4-1. The investigation techniques included surface soil sampling, subsurface soil boring sampling, and monitoring well boring sampling. A discussion of the sampling locations, the number of samples collected, and field measurements and observations made during the soil sampling activities is presented in Sections 2.4 through 2.6 of this report. A summary of the soil samples collected from the site is presented in Table 4-1. Tables containing the analytical results for all of the soil samples are presented in Appendix M.

Volatile Organic Compounds (VOCs)

Sixty-four (64) soil samples were collected from thirty-five (35) locations across the site and analyzed for TCL volatile organic compounds (VOCs). To evaluate the VOC soil sample data, the contaminant-comparison level of 1 ppm for total VOCs in soil was used. Summaries of those soil samples whose concentrations exceeded the 1 ppm total VOC level for the soil samples collected

from this site are included in Tables 4-7 through 4-9. The areal extent of volatile organic soil contamination is shown on Figure 4-6. The subsurface distribution of volatile organics is also shown on site cross-sections on Figures 4-10 through 4-12.

As discussed in Appendix M, validation of the data resulted in the assignment of data qualifiers to sample data based upon blank contamination and other data validation criteria. At this site, a majority of the detected levels of methylene chloride and acetone in the soil samples were qualified as undetected ("U" qualifier). These qualified levels are not considered in the site soils contamination assessment. Given these findings, and the absence of "real" levels of these compounds in other site media samples, methylene chloride and acetone will not be considered further in the site soils contamination assessment.

Additional review of the data was also necessary to assess the field and trip blank data as compared to actual sample data. This review indicated the low levels (ppb) of carbon disulfide, chloroform, and toluene detected in the soil samples are similar in concentration to those detected in a few of the field blanks. However, toluene was detected in a few of the soil samples at significantly higher concentrations (100's of ppb). Given the low levels, low frequency of detection, and the relative absence of carbon disulfide and chloroform in other site media samples, along with their presence in quality control blanks, these two compounds will not be considered further in the site soils contamination assessment. Toluene will be retained for further consideration

based upon its detection at relatively higher concentrations in several of the soil samples.

A total of thirty-four (34) TCL volatile organic compounds (VOCs) were analyzed for in each soil sample collected for VOC analysis. A list of the TCL VOCs is provided in Table 2-1. Of these thirty-four TCL VOCs, eighteen (18) were detected in the soil samples. Four of these VOCs are eliminated from further consideration in the site soils contamination assessment for reasons explained previously in this section. An additional five compounds, namely 1,2-dichloroethane, 2-butanone, chloroethane, 4-methyl-2-pentanone, and 2-hexanone were detected in only a few samples and at very low levels. The remaining nine VOCs which were detected in several samples, at elevated levels, and/or in other site media samples are considered "key" contaminants in the site soils contamination assessment. They include the following: 1,2-dichloroethene (1,2-DCE), 1,1,1-trichlorethane (1,1,1-TCA), trichloroethene (TCE), benzene, tetrachloroethene (PCE), toluene, chlorobenzene, ethylbenzene, and xylene.

Upon reviewing the VOC soil sample analyses results and the contaminant-comparison level summary tables, the following observations can be made concerning the occurrence of total VOCs in the soil samples collected from the site:

- VOCs were not detected in approximately 40% of the soil samples collected from the site. The areas in which VOCs were detected are shown on Figure 4-6.
- Very low levels (low ppb) of VOCs were detected at only three of the surface soil sample locations (SS-01 @ 12 ppb,

SS-04 @ 3-5 ppb (duplicates), and SS-06 @ 2 ppb). 1,1,1-TCA was the primary VOC detected in these samples.

- Three samples collected from two of the soil boring locations exceeded the 1 ppm comparison level for total volatile organic compounds in soil (B05-1 @ 2.4 ppm, B05-3 @ 21.6 ppm, and B07-2 @ 2.5 ppm).

- Very low levels (ppb) of petroleum-related VOCs (e.g., benzene, toluene, xylene, ethylbenzene, chlorobenzene) were detected in several soil samples collected from soil borings (B-3, B-5, B-7, B-8, B-9 and B-10) completed in the central and southern portions of the site.

- The VOCs detected in the three samples having the highest total VOC concentrations (B05-1, B05-3, and B07-2) consisted primarily of petroleum-related VOCs.

The concentrations of eight of the nine key VOCs specified above were the greatest at the two locations (B-5 and B-7) where the contaminant-comparison level of 1 ppm for total VOCs was exceeded (see Figure 4-6). The following observations can be made concerning the magnitude of the concentrations of the above listed nine "key" VOCs:

- The highest concentration of 1,2-DCE (340 ppb) was detected at boring 9 (sample B09-2) completed in the south-central portion of the site. However, 1,2-DCE was not detected at either of the two locations (B05 or B07) having the highest total VOCs concentrations.

- The highest concentrations for five of the nine VOCs (TCE, PCE, toluene, ethylbenzene, and xylene) were detected in soil samples collected from soil boring 5 (B05-1 and B05-3).

- The highest concentrations of benzene (75 ppb) and chlorobenzene (1,200 ppb) were detected in sample B07-2 collected from boring 7.

The above information indicates that there are two sample locations (B05 and B07) in one area on the site, the central portion of the landfill (see Figure 4-6), where total VOC levels greater than 1 ppm were detected in the soil. The three soil

samples collected from these two locations were collected from various depths within the fill material: sample B05-1 was collected from fill 6 to 8 feet below grade; sample B05-3, where the highest total VOC concentration was detected, was collected from fill 22 to 24 feet below grade, just above the bedrock surface; and sample B07-2 was collected from fill 12 to 14 feet below grade, four feet above the bedrock surface.

The findings of the VOC soil sample analyses do not indicate any consistent, area-wide pattern of VOC contamination in the subsurface soils or fill across the site. Although elevated levels of total VOCs (> 1 ppm) were detected in samples collected from fill material in the central portion of the landfill, low levels (low ppb) of total VOCs were also detected in fill samples collected from this area (e.g., at B-6 and M-3). Also, even though samples B05-1 and B05-3, which were both collected from the same sample location (B-5), contained elevated VOC levels (total VOCs > 1 ppm), sample B05-2, also collected from boring B-5 at a depth between these two samples (14 to 16 feet below grade), contained low levels (75 ppb) of VOCs. This inconsistency in vertical distribution of VOC contamination is also evident in reviewing the subsurface soil contamination cross-sections for this site (see Figures 4-10 through 4-12).

Base Neutral/Acid Extractable Organic Compounds (BNAs)

Sixty four (64) soil samples were collected from thirty-five (35) locations across the site and analyzed for TCL base

neutral/acid extractable organic compounds (BNAs). To evaluate the BNA soil data, the contaminant-comparison level of 10 ppm for total BNAs in soil was used. In addition to the contaminant-comparison level for total BNAs, contaminant-comparison levels for total polynuclear aromatic hydrocarbons (PAHs) of 10 ppm and total carcinogenic PAHs of 1 ppm were also used. Summaries of those soil samples whose concentrations exceed the established BNA and PAH contaminant-comparison levels for the soil samples are provided in Tables 4-7 through 4-9. Areas in which elevated BNAs and carcinogenic PAHs were detected are shown on Figure 4-7. The subsurface distribution of BNAs is also shown on site cross-sections, on Figures 4-10 through 4-12.

As discussed in Appendix M, the findings of the data validation indicated that very low levels of four common phthalate esters, namely di-n-butylphthalate, butylbenzylphthalate, diethylphthalate, and bis(2-ethylhexyl)phthalate, were typically detected in the laboratory method blanks and/or field and trip blanks. Therefore the associated detected concentrations for these compounds have typically been qualified as undetected ("U") or estimated ("J"). However, significantly elevated, non-qualified concentrations of these phthalate esters were detected in several of the soil samples, indicating that some of the site soils appear to contain "real" levels of these common phthalate esters. Based upon this review, all of the BNAs detected in the soil samples were retained for further consideration in the site soils contamination assessment.

A total of sixty-five (65) BNAs were analyzed for in each soil sample collected for TCL BNA analysis. A list of the TCL BNAs is provided in Table 2-1. Of the sixty-five (65) TCL BNAs, thirty-two (32) were detected in at least one of the soil samples submitted for TCL BNA analysis. One of these BNAs, n-nitrosodiphenylamine, was detected at a low concentration (200 ppb) in only one sample collected from the site. Therefore, n-nitrosodiphenylamine will not be considered further in this assessment. The remaining thirty-one (31) BNAs which were detected in several soil samples, at elevated concentrations, and/or in other site media samples are considered "key" BNAs in the soil contamination assessment for this site.

Upon comparing the established contaminant-comparison level of 10 ppm for total BNAs to the soil sample analytical results, the following observations can be made:

- Of the thirty-five (35) locations across the site from which samples were collected for TCL BNA analyses, at least one sample from nineteen (19) locations exceeded the 10 ppm total BNA level.
- Of the sixty-four (64) soil samples collected for TCL BNA analyses, fifty-eight (58) of the samples contained detectable concentrations of BNAs.
- The highest concentrations of total BNAs (greater than 100 ppm) were detected in five soil samples (B05-2, B09-1, M03-2 and M03-3, SS-06, SS-11) collected from four different locations across the site (see Figure 4-7).
- One of the samples (B09-1) having the highest levels of BNAs detected on the site had a total BNA concentration which consisted almost entirely of phthalate compounds, primarily bis(2-ethylhexyl)phthalate.
- The highest total BNA concentration of 1,943 ppm was detected in sample M03-2 collected from the central portion

of the landfill. The highest concentrations of seventeen (17) of the thirty-one "key" BNAs were detected at this location.

The BNA subgroups for which total concentration calculations have been compiled are the polynuclear aromatic hydrocarbons (PAHs) and carcinogenic PAHs. The BNAs included in each of these groups are noted on the analytical data tables in Appendix M. The total BNA and total PAH concentration values for the site samples are also provided in the data tables in Appendix M.

The following observations can be made concerning the magnitude of total and carcinogenic PAHs detected in the soil samples collected from the site:

- At least one soil sample from seventeen (17) of the thirty-five (35) soil sample locations exceeded the 10 ppm contaminant-comparison level for total PAHs in soil.
- Of the seventeen soil sample locations which exceeded the 10 ppm level for PAHs, the highest total PAH concentrations (all greater than 50 ppm) were detected in soil samples collected from seven of those locations (B-5 with B05-2 @ 105 ppm/B05-4 @ 85 ppm; M-3 with M03-1 @ 66 ppm/M03-4 @ 83 ppm, M03-2 @ 1,887 ppm, and M03-3 @ 466 ppm; SS-2 @ 71 ppm; SS-06 @ 199 ppm; SS-08 @ 73 ppm; and SS-11 @ 194 ppm).
- The highest total PAH soil concentration of 1,887 ppm was detected in sample M03-2 collected from the boring for well MW-3 in the central portion of the landfill.
- The total carcinogenic PAH concentrations were highest (ranged from 22 to 526 ppm) in the same seven soil samples having the highest total PAH concentrations.
- Locations where total carcinogenic PAH concentrations exceed 1 ppm and total BNA concentrations are less than 10 ppm are shown on Figure 4-7.
- For a majority of the soil samples, the total carcinogenic PAH concentration comprises an average of over 40% of the total PAH concentration.

As is evident from the above information, BNA soil contamination (i.e., total BNAs > 10 ppm) is present in the soils across the site. The highest levels of total BNA contamination (> 100 ppm) were mainly detected in the central portion of the site within the fill material sampled in soil boring 5, monitoring well borings 3, and surface soil sample 6. Spot locations of high total BNA contamination (> 50 ppm) can also be found in the northern (@ SS-2) and southern (@ SS-8 and SS-11) portions of the site. It should be noted that at surface soil sample locations 2 and 11, the elevated PAH concentrations may be due to the presence of asphalt pieces or tar paper which were noted in the fill material from which the samples were collected.

Pesticide and PCB Compounds

Sixty-four (64) soil samples were collected from thirty-five (35) locations across the site and analyzed for TCL pesticide and PCB compounds. A soil action level of 1 ppm total PCBs was used to evaluate the PCB soil data. This level has historically been enforced by the RIDEM as a PCB soil clean-up level. The pesticide soil sample data was assessed by reviewing the levels and frequency at which different pesticide compounds were detected in the soil samples.

Summaries of those soil samples whose PCB concentrations exceed the 1 ppm PCB soil action level are provided in Table 4-7 through 4-9. Areas in which PCBs were detected and where PCBs concentrations exceed 1 ppm are shown on Figure 4-8. Upon

reviewing the pesticide and PCB soil sample analyses results and the soil summary tables, the following observations can be made:

Pesticides:

- Of the thirty-five (35) locations across the site from which samples were collected for TCL pesticides analyses, at least one sample from twenty-six (26) of the locations contained detectable concentrations of pesticides.

- Of the twenty (20) TCL pesticide compounds analyzed for in the soil samples, seven pesticides (beta-BHC, aldrin, dieldrin, 4,4-DDE, 4,4-DDD, 4,4-DDT, and alpha-chlordane) were detected in at least one of the soil samples collected from the site.

- Pesticides were detected at very low levels (10's of ppb) in a majority of the surface soil samples collected from across the site. The highest pesticide concentrations were detected in soil samples SS-11 (4,4-DDT @ 1,800 ppb) and B05-2 (4,4-DDT @ 2,300 ppb), collected from the southern and central portions of the site, respectively.

- The pesticides detected most frequently in the site soils were 4,4-DDE, 4,4-DDD, and 4,4-DDT. The pesticides beta-BHC, aldrin, dieldrin, and alpha-chlordane were each only detected in one soil sample.

PCBs:

- Of the thirty-five (35) locations across the site from which samples were collected for TCL PCB analyses, at least one sample from seventeen (17) locations contained detectable concentrations of PCBs (see Figure 4-8).

- Of the seven TCL PCB Aroclor compounds analyzed for in the soil samples, four of the PCB Aroclors (Aroclors 1242, 1248, 1254, and 1260) were detected in at least one soil sample.

- PCBs were detected in only four of the surface soil samples (SS-12, SS-13, SS-14, and SS-15); those samples were all collected from the beach shoreline of the site.

- Of the thirty-five (35) locations across the site from which soil samples were collected for TCL PCB analyses, only one of the soil samples exceeded the established 1 ppm action level for PCBs in soil (sample B-12 @ 1.1 ppm), as shown on Figure 4-8.

- Some of the highest levels of PCBs (> 200 ppb) were detected in soil samples collected from between 8 to 24 feet below grade (B02-2 from 8-10 ft., B03-3 from 22-24 ft., B05-2/B05-4 from 14-16, B09-3 from 16-18 ft., and B10-2 from 8-10 ft., B12-1 from 10-12 ft., B12-2 from 22-24 ft., and M02-1 from 10-12 ft.).

As is evident from the information summarized above and the overall pesticide sample results, low levels (10's of ppb) of three pesticides (4,4-DDE, 4,4-DDD, and 4,4-DDT) are predominant in the soils across the site. Nearly three quarters (75%) of the soil sample locations contained detectable levels of pesticides; however, only two soil samples (B05-2 and SS-11) contained pesticide levels greater than 1 ppm.

The information summarized above and the overall PCB sample results also indicate that PCBs are primarily present in the subsurface soils across the site. Nearly half (50%) of the sample locations across the site contained detectable levels of PCBs. PCBs were detected over a range of concentrations (0.017 ppm to 1.1 ppm) in soil samples. Elevated levels (> 1 ppm) of PCBs were detected at boring B-12, completed in the central portion of the landfill. Some of the highest levels (> 200 ppb) of PCBs detected at the site were in soil samples collected from as deep as 24 feet below grade (e.g., M04-2 and B03-3).

Inorganic Analytes

Sixty-six (66) soil samples were collected from thirty-seven (37) locations across the site and analyzed for the TAL inorganic analytes (includes metals and cyanide). To evaluate the inorganic

analyte soil sample data, compound levels were compared to those levels detected in off-site background samples. The site background inorganic analyte soil levels are provided in Table 4-6.

Summaries of those soil samples whose concentrations exceeded the established background levels along with the specific inorganic analytes whose background levels were exceeded in the soil samples are provided in Tables 4-7 through 4-9. The extent of inorganic analyte contamination is shown on Figure 4-9. Upon reviewing soil sample data and the summary tables, the following observations can be made:

- Of the thirty-seven (37) locations across the site from which samples were collected for inorganic analyses, at least one sample from twenty-eight (28) locations exceeded one of the established contaminant levels for inorganic analytes in soil.

- Of the twenty-four (24) inorganic analytes analyzed for in the soil samples, the detected levels of twenty-one (21) of the inorganic analytes exceeded established background levels in at least one of the soil samples.

- The one inorganic analyte which exceeded the established background level in numerous (i.e. greater than 50%) soil samples collected was iron (55%).

- Those inorganic analytes which exceeded the established background levels in many (i.e. 10%-50%) of the soil samples collected for inorganic analyses are silver (18%), arsenic (21%), barium (15%), vanadium (35%), calcium (39%), cadmium (27%), cobalt (39%), chromium (26%), copper (35%), lead (21%), magnesium (15%), manganese (20%), sodium (24%), nickel (33%), antimony (20%), and zinc (29%).

- The inorganic analytes which exceeded the established background levels in a few (less than 10%) of the soil samples collected for inorganic analyses are aluminum (8%), beryllium (8%), mercury (8%), and selenium (2%).

- Thallium was not detected in any of the soil samples. Potassium and cyanide were detected, but not at levels which exceeded the established background levels.

As is evident from the above information, inorganic contamination is present in nearly all of the soil samples collected from the site. There are a few areas and spot locations across the site at which soil samples exhibit some of the highest levels of inorganic soil contamination (see Figure 4-9). The areas and spot locations which were found to have significantly high and/or the highest levels of inorganic soil contamination are discussed below.

- The soils located in the central and south-central portions of the landfill, as detected in subsurface soil samples B05-2, B05-3, M03-3, B12-1, B12-2, and B07-2.
- The soil located in the northern portion of the site, as detected in subsurface soil samples B02-2 and M02-2. Both of these samples were taken from an ash material.
- The soil located in the southern portion of the site as detected in soil samples B09-2, SS-08 and SS-10.
- The three surface soil samples (SS-13, SS-14 and SS-15) collected from along the shoreline contained high concentrations of cadmium, copper, nickel, lead, and zinc.

4.2.2 Ground Water Assessment

This section of the report provides an assessment of the McAllister Point Landfill ground water sample analytical results and a discussion on the nature and extent of ground water contamination at the site. Under this investigation, a total of nine (9) wells were installed at seven locations on the site (MW-1 through MW-7). Overburden and bedrock well nests were installed at two of the locations (MW-3 and MW-5). Well locations are provided on Figure 4-1. Ground water samples were collected from all wells

but well MW-2, due to the fact that it was dry on the date of ground water sampling. Three wells installed previously at the site (MW-21, MW-22, and MW-23) were also sampled under this investigation. Also addressed in this discussion is a leachate spring sample (LS-1) collected along the western edge of the site. The ground water samples, including the leachate spring sample, were analyzed for all of the TCL and TAL parameters.

As discussed in the site-specific hydrogeology section (Section 3.5) of this report, the site ground water flow is flowing from east to west, towards Narragansett Bay. Below is a discussion of the ground water sample results.

Volatile Organic Compounds

The ground water sample results indicate the presence of low level volatile organic compound (VOC) contamination in site ground water. Low concentrations (1-160 ppb) of VOCs were detected in five of the ten on-site wells (MW-3S, MW-3D, MW-4, MW-5S, and MW-21) which were sampled.

As shown in Table 4-10 and 4-13, VOCs were detected at levels exceeding established ground water action levels in three of the wells (MW-3S, MW-4, and MW-5). Petroleum-related VOCs, benzene and/or xylene were detected in the ground water samples collected from these wells. Soil samples collected from the well borings for these wells were also found to have similar types of contaminants (e.g., toluene, ethylbenzene, chlorobenzene, toluene). The highest level of VOC ground water contamination was detected in well MW-5S

(xylene = 160 ppb), located at the southern end of the site. A slight oil sheen was also observed during the development of this well, and an oil layer was present in this well five months after sampling.

As discussed in Section 4.2.1, the highest levels of subsurface soil VOC contamination were detected in test boring B-5 and B-7, both completed in the central portion of the site. Boring B-5 is located within 50 feet of well MW-3S, one of the locations where ground water action levels were exceeded. Well MW-4, where action levels were also exceeded, is located upgradient of well MW-3S. A low level (1 ppb) of only one VOC (benzene) was detected in the deep well MW-3D, nested with MW-3S. Low levels of VOCs (10's of ppb) were also found in a soil sample collected from just above the top of the MW-3D well screen (@ 22-24 feet). A very low level (2 ppb) of one VOC (xylene) was detected in well MW-21, just downgradient of well nest MW-3. Also, no VOCs were detected in the leachate spring sample (LS-1) collected from along the edge of the site, just southwest of well MW-21. At well MW-22, located just downgradient of the site location found to have the highest level of total VOC soil contamination (B-7), no VOCs were detected.

At well location MW-5, while VOCs in the shallow well exceeded action levels, no VOCs were detected in the ground water sample collected from the nested deep well, MW-5D.

VOCs were also not detected in the ground water samples collected from wells on-site wells MW-6 and MW-7, and off-site well MW-23.

The extent of VOC ground water contamination appears to be limited to two areas on the site: the central portion of the landfill (at MW-3 and MW-4), and the southern end of the site (at MW-5). A low level of one VOC was also detected in the ground water at the western edge of the central portion of the landfill (MW-21), downgradient of well location MW-3. VOC contaminated soil samples, collected from at or beyond the depth of the ground water table at several other site locations (M-2, B-2, B-3, B-5, B-6, B-7, B-8, B-9, and B-10) indicate the potential for VOC ground water contamination at these locations.

Base Neutral/Acid Extractable Organic Compounds

The ground water sample results indicate the presence of non-detectable to low levels of BNAs in the site ground water. BNAs were detected in three (MW-3S, MW-4, and MW-5S) of the eleven wells sampled. No BNAs were detected in any of the deep wells or in the leachate sample. None of the BNAs detected exceeded any ground water action levels established for BNAs.

The BNAs detected in the three ground water samples consisted primarily of PAHs and phenols. Very low levels (< 10 ppb) of phthalates, 1,4-dichlorobenzene, benzoic acid, and dibenzofuran were also detected in the ground water. The highest level of total BNAs (407 ppb) was detected in the ground water sample collected from well MW-3S, located in the central portion of the site. The BNAs detected in this well consisted almost entirely of PAHs. As presented in Section 4.2.1, the highest level of total BNAs

detected in the soil was detected in a sample collected at the depth of the ground water table in the well boring for well MW-3S. The BNAs detected in this soil sample also consisted almost entirely of PAHs. Elevated levels of BNAs were primarily detected in the soils located in the south-central to north-central portions of the site.

Low level BNA ground water contamination appears to be limited to two areas on the site: the central portion of the site (at wells MW-3 and MW-4), and the southern end of the site (at MW-5). Although BNA ground water contamination was detected at the boring location found to have the highest level of BNA soil contamination (MW-3), and at a second well boring location with elevated BNA levels (greater than the contaminant-comparison level of 10 ppm), BNAs were not detected in a ground water sample (MW-6) collected from the only other well boring location which exhibited elevated soil BNA levels. The soil samples collected from well location MW-5, the third well in which BNAs were detected, exhibited less than 10 ppm total BNAs.

Pesticide and PCB Compounds

The ground water sample results indicate the presence of PCBs in one of the ground water samples collected from the site. No pesticides were detected in any of the site ground water samples. PCBs were detected at a concentration of 0.73 ppb in the ground water sample from well MW-5S, located at the southern end of the site. This concentration exceeds the final MCL of 0.5 ppb for

PCBs. As discussed previously, an oil sheen and oil were observed in the ground water in this well.

PCBs were detected in soil samples collected from several of the well locations (MW-1, MW-2, MW-5, and MW-6). PCBs were primarily detected in soils in the north-central and southern portions of the site. The highest level of PCBs (1,110 ppb) was detected in a soil sample collected from test boring B-12, located at the western edge of the central portion of the site. A PCB concentration of 150 ppb was detected in the soil sample collected from the depth of the water table in the boring for well MW-5S.

PCB ground water contamination appears to be located only at the southern end of the site.

Inorganic Analytes

The inorganic ground water sample results indicate the presence of numerous inorganic analytes in ground water samples collected at the site. Inorganic analytes were detected in each of the twelve wells sampled as well as in the leachate sample. Table 4-10 provides a summary of the inorganic analytes whose ground water action levels were exceeded, the well locations at which the exceedances were measured, and the associated action levels. Upon reviewing the ground water inorganic data provided in Appendix M and the summary table, the following observations can be made:

- Fourteen (14) inorganic analytes were detected at levels exceeding action levels in at least one of the ground water and/or leachate spring samples.

- In the off-site, upgradient well, MW-23, the inorganics detected at levels exceeding action levels include aluminum (3,270 ppb), arsenic (54.2 ppb), beryllium (1 ppb), iron (58,800 ppb), manganese (1,140 ppb), and lead (42.8 ppb). These levels are considered to be representative of background conditions in the ground water assessment.

- Three inorganic analytes, aluminum, iron and manganese, were detected in each ground water sample (i.e., 100%) at levels exceeding action levels. These analytes were detected at levels exceeding the associated background level at the following frequencies: aluminum - 90%, iron - 60%, and manganese - 80%.

- Those inorganic analytes which exceeded the established action levels in 50-99% of the ground water samples are arsenic (55%), beryllium (64%), nickel (55%), and lead (82%). These analytes were also detected on-site at levels exceeding background levels, with the exception of nickel. The highest concentration of nickel was detected in the off-site upgradient well MW-23.

- Inorganic analytes which exceeded the established action levels in less than 50% of the ground water samples are silver (9%), cadmium (27%), chromium (18%), copper (9%), mercury (9%), and zinc (1%). None of these analytes were detected in the background sample.

The distribution of inorganics at levels exceeding background and action levels within the on-site monitoring wells can be summarized as follows:

- The highest levels of six (6) of the fourteen (14) analytes (silver, cadmium, copper, lead, antimony and zinc) detected in ground water samples at levels exceeding action and background levels were detected in monitoring well MW-3S.

- Other wells in which the greatest levels of individual inorganic analytes were detected include MW-5S (aluminum, beryllium, and iron), MW-6 (lead), MW-7 (chromium, manganese, and nickel), and MW-21 (arsenic).

- In the on-site deep wells (MW-3D and MW-5D), inorganics detected at levels exceeding action levels were limited to aluminum, iron, manganese and lead; however, these analytes were generally detected in the deep wells at levels less than the background levels.

- Other than aluminum, iron, and manganese, inorganics detected at levels exceeding 50 times their action levels were detected in wells MW-3S (lead and antimony), MW-6 (lead), and MW-7 (lead), as indicated on Figure 4-14.

- Only two inorganic analytes were detected in the leachate sample (LS-1) at levels exceeding action levels: manganese and antimony. Manganese, however, was detected in the leachate sample at a level less than the background ground water level.

Therefore, the greatest amount of inorganic ground water contamination was detected in the north-central (MW-3, MW-7) to southern (MW-6) portions of the site. Inorganics were also detected in soil samples from these areas of the site at relatively high levels. Elevated inorganic ground water levels were also detected at the southern end (MW-5) of the site, as well as in well MW-21, downgradient of MW-3. Background ground water quality does not meet all drinking water criteria and, in particular, has elevated levels of aluminum, arsenic, beryllium, iron, manganese and lead.

The deep ground water quality with respect to inorganics does not appear to be significantly impacted by the site. Also, the leachate spring sample did not exhibit significantly high inorganic levels. This may indicate that the majority of inorganics have already leached from the landfill materials and impacted ground water quality in the past, with a low amount of leaching occurring today.

4.3 Site 02 - Melville North Landfill

4.3.1 Soil Assessment

This section of the report provides an assessment of the Melville North Landfill soil sample analytical results. The assessment includes information on the nature and extent of soil contamination across the site. As discussed in Section 4.1.1, to aid in evaluating the soil data, contaminant-comparison and/or background levels were established for VOCs, BNAs, PCBs, and inorganics. These levels were used to define areas of soil contamination on the site.

A total of fifty-nine (59) soil samples (not including duplicate samples) were collected from across the site through several field investigation techniques. Sampling locations are provided on Figure 4-2. The investigation techniques included surface soil sampling, test pit sampling, subsurface soil boring sampling, and monitoring well boring sampling. A discussion of the sampling locations, the number of samples collected, and all field measurements and observations made during the soil sampling activities at the Melville North Landfill site is presented in Sections 2.4 through 2.6. A summary of the soil samples collected from the site is presented in Table 4-2. Tables containing the analytical results for all of the soil samples are presented in Appendix M.

Volatile Organic Compounds (VOCs)

Fifty-seven (57) soil samples were collected from thirty-seven (37) locations across the site and analyzed for TCL volatile organic compounds (VOCs). To evaluate the VOC soil sample data, the contaminant-comparison level of 1 ppm for total VOCs in soil was used. Summaries of those soil samples whose concentrations exceeded the 1 ppm total VOC level for the soil samples collected from this site are included in Tables 4-11 through 4-14. The extent of volatile organic soil contamination is shown on Figure 4-15. The subsurface distribution of volatile organics is also shown on site cross-sections on Figures 4-19 through 4-21.

As discussed in Appendix M, validation of the data resulted in the assignment of data qualifiers to the sample data based upon blank contamination and other data validation criteria. At this site, a majority of the detected levels of methylene chloride and acetone in the soil samples were qualified as "undetected" ("U" qualifier). These qualified levels are not considered in the site soils contamination assessment. However, it is important to note that acetone was detected in several of the soil samples at levels which were not qualified as undetected (e.g., B06-2 @ 240 ppb, B07-2 @ 1,100 ppb, and B07-3 @ 300 ppb). The levels detected in these samples are considered in this assessment.

Additional review of the data was also necessary to assess the field and trip blank data as compared to the soil sample data. This review indicated that the low levels (low ppb) of carbon disulfide and chloroform detected in several soil samples are

similar in concentration to that detected in some of the trip blanks. Therefore, given the low levels, low frequency of detection, and relative absence of these compounds in other site media, along with their presence in quality control blanks, carbon disulfide and chloroform will not be considered further in the site soils contamination assessment.

A total of thirty-four (34) TCL volatile organic compounds (VOCs) were analyzed for in each of the soil samples collected for VOC analysis. A list of TCL VOCs is provided in Table 2-1. Of these thirty-four (34) TCL VOCs, fifteen (15) were detected in the soil samples collected from the site. Three of these VOCs, methylene chloride, carbon disulfide, and chloroform, are not considered "key" VOCs in the site soils contamination assessment for reasons explained previously. Two additional VOCs, trichloroethene and tetrachloroethene, were detected in only a few soil samples and at very low concentrations (low ppb). Vinyl chloride was detected in only one sample at a very low concentration (6 ppb). The remaining nine VOCs which were detected in several samples, at elevated levels, and/or in other site media and are considered "key" VOCs in the site soils contamination assessment are the following: acetone, 2-butanone, 1,1,1-trichloroethane (1,1,1-TCA), benzene, 4-methyl-2-pentanone (4-M-2-P), toluene, chlorobenzene, ethylbenzene, and xylene.

Upon reviewing the VOC soil sample analysis results and the contaminant-comparison level summary tables, the following

observations can be made concerning the occurrence of total VOCs and "key" VOCs in the soil samples collected from this site:

- Of the thirty-seven (37) locations across the site from which soil samples were collected for TCL volatile organic compound analyses, at least one sample from five of the locations exceeded the 1 ppm contaminant-comparison level for volatile organic compounds in soil (B04-1 @ 1,073 ppb, B07-2 @ 1,187 ppb, M03-2 @1,020 ppb, M04-2 @ 15,720 ppb, and TP-5 @ 2,260 ppb).

- The highest total VOC concentrations were detected in soil samples collected from two general site locations: the central portion of the site (B07, M03, and TP-5) and the southern end of the site (M04), as indicated on Figure 4-15.

- Of the fifty-seven (57) soil samples collected for TCL volatile organic compound analyses, twenty (20) of the samples contained detectable concentrations of the "key" VOCs (see Figure 4-15).

- The highest concentrations for four of the nine "key" VOCs (2-butanone @ 1,700 ppb, toluene @ 720 ppb, ethylbenzene @ 2,300 ppb, and xylene @ 11,000 ppb) were detected in a soil sample collected from monitoring well boring 4 (M04-2) completed at the southern end of the site.

- The highest concentrations of acetone (1,100 ppb in B07-2), chlorobenzene (1,500 ppb in TP-5), and benzene (730 ppb in B12-4) were all detected in samples collected from the central portion of the site. Both 1,1,1-TCA and 4-methyl-2-pentanone were detected only in samples also collected from this portion of the site (1,1,1- TCA @ 200 ppb in TP-1 and 4-M-2-P @ 99 ppb in B04-1).

- The level of acetone detected in soil sample B07-2 (1,100 ppb) contributed to over 90% of the total volatile organic compound concentration detected in the sample.

The above information indicates that there are two areas at the site where total VOC levels greater than 1 ppm were detected in the soil: the central portion and southern end of the site, as indicated on Figure 4-15. Soil samples B04-1, B07-2, M03-2, and TP-5, which have the highest levels of total VOCs detected in the soil samples collected from the site, were all collected from the

central portion of the site, within approximately 120 feet of one another. As previously discussed, this area of the site is the suspected former location of lagoons. At each of the sample locations, strong petroleum-type odors and/or visibly oily soils were noted during the sample collection. Each of the samples at these four locations were also collected at or near the water table (as indicated on the cross-sections in Figures 4-19 through 4-21), which would indicate the likely presence of volatile organic ground water contamination.

The other location where total VOCs were detected at concentrations greater than 1 ppm was in monitoring well boring 4, completed at the southern end of the site. Well boring sample M04-2 had the highest total VOC concentration (15,720 ppb) detected in the site soil samples. During the drilling and sampling of this boring, a strong petroleum-like odor was noted in the soil. This soil sample was collected from 8 to 10 feet below grade, at the depth of the ground water table.

Base Neutral/Acid Extractable Organic Compounds (BNAs)

Fifty-seven (57) soil samples (not including duplicates) were collected from thirty-seven (37) locations across the site and analyzed for TCL base neutral/acid extractable organic compounds (BNAs). To evaluate the BNA soil data, the contaminant-comparison level of 10 ppm for total BNAs in soil was used. In addition to using this total BNA comparison level, contaminant-comparison levels of 10 ppm and 1 ppm were also used for total polynuclear

aromatic hydrocarbons (PAHs) and total carcinogenic PAHs, respectively. Summaries of those soil samples whose concentrations exceed the established BNA and PAH contaminant-comparison levels for the soil samples are provided in Tables 4-11 through 4-14. Figure 4-16 shows the extent of BNA contamination on the site, including areas where the 10 ppm total BNA contaminant-comparison level was exceeded. The subsurface distribution of base neutral/acid extractable organics is also shown on site cross-sections on Figures 4-19 through 4-21.

As discussed in Appendix M, the findings of the data validation indicated that very low levels of two common phthalate esters, di-n-butylphthalate and bis(2-ethylhexyl)phthalate, and three phenols, pentachlorophenol, 2,4-dichlorophenol and 2,4,5-trichlorophenol, were detected in laboratory method blanks and/or field and trip blanks. Therefore, the associated detected soil sample concentrations for these compounds have been qualified as undetected ("U"). In addition to these five compounds, benzoic acid was also detected in laboratory method blanks and/or field blanks, and thus a majority of the detected concentrations for this compound have also been qualified as "undetected". Given these findings, and the near absence of these compounds in other site media samples, the two phthalate esters, three phenols, and benzoic acid will not be considered "key" BNAs in the soil contamination assessment.

A total of sixty-five (65) BNAs were analyzed for in each soil sample collected for TCL BNA analysis. A list of the TCL BNAs is

provided in Table 2-1. Of the sixty-five (65) TCL BNAs, twenty-nine (29) were detected in at least one of the soil samples submitted for TCL BNA analysis. Of the twenty-nine BNAs detected, six have been eliminated from further consideration in the soil assessment for reasons explained previously. An additional four BNAs, phenol, 4-methylphenol, dimethylphthalate, and 4-nitrophenol, were each detected in only one or two soil samples and at low levels (100's of ppb). The remaining nineteen (19) BNAs which were detected in several soil samples, at elevated concentrations, and/or in other site media samples are considered "key" BNAs in the soil contamination assessment for this site.

Upon comparing the established contaminant-comparison level of 10 ppm for total BNAs to the soil sample analyses results, the following observations can made:

- Of the thirty-seven (37) locations across the site from which soil samples were collected for TCL BNA analyses, at least one sample from twelve (12) of the locations exceeded the 10 ppm total BNA level.
- Of the fifty-seven (57) soil samples collected for TCL BNA analyses, forty-five (45) of the samples contained detectable concentrations of BNAs (see Figure 4-16).
- The highest concentrations (greater than 50 ppm) of total BNAs were detected in seven (7) soil samples (B01-1, B04-1, B09-1 and B09-2, M03-2, M04-2, SS-01) collected from six (6) different sample locations.
- The highest total BNA concentration of 162 ppm was detected in soil sample M04-2 collected at the southern end of the site from the boring completed for well MW-4. The highest concentrations of nine of the twenty-three key BNAs were detected at this location.

The BNA sub-groups for which total concentration calculations have been compiled are the polynuclear aromatic hydrocarbons (PAHs)

and carcinogenic PAHs. The BNAs included under each of these groups are noted on the data tables in Appendix M. The total BNA and PAH concentration values for the site samples are also provided in the data tables in Appendix M.

The following observations can be made concerning the magnitude of total and carcinogenic PAHs detected in the soil samples collected from the site:

- At least one soil sample collected from twelve (12) soil sample locations exceeded the 10 ppm contaminant-comparison level for total PAHs in soil.
- Of the twelve soil sample locations which exceeded the 10 ppm level for total PAHs, the highest total PAH concentrations (all greater than 50 ppm) were detected in soil samples collected from six (6) of those locations (B01-1 @ 70.1 ppm, B04-1 @ 59.6 ppm, B09-1 @ 94 ppm and B09-2 @ 81.7 ppm, M03-2 @ 54.1 ppm, M04-2 @ 144.4 ppm, and SS-01 @ 101.8 ppm).
- The highest total PAH soil concentration of 144 ppm was detected in sample M04-2 collected from the boring for well MW-4 installed at the southern end of the site.
- At least one soil sample from eighteen (18) soil sample locations exceeded the 1 ppm contaminant-comparison level for total carcinogenic PAHs.
- The highest concentrations of total carcinogenic PAHs (all greater than 10 ppm) were detected in soil samples B01-1 (31 ppm), B09-1 (31.6 ppm), B09-2 (28 ppm), SS-01 (46.4 ppm), and SS-06 (15.26 ppm) collected from across the site.
- For a majority of the soil samples, the total carcinogenic PAH concentration comprises an average of over 40% of the total PAH concentration.

As is evident from the above information, BNA soil contamination is present in the soils across the site. The highest levels of BNA soil contamination were detected in three different areas of the site: the northwestern corner, the central portion,

and the southern portion. Presented below are discussions on the BNA soil contamination detected in these three different areas.

In the northwestern corner of the site, relatively high levels of total BNAs were detected in three soil samples (B01-1 @ 71 ppm, SS-01 @ 102 ppm, and SS-06 @ 39.2 ppm), as indicated on Figure 4-16. All three samples were collected from within the top two feet of soil and did not have any visible signs of contamination (e.g., staining, odors). The BNAs detected in these three soil samples consisted primarily of PAHs. Surface soil sample SS-01 also had the second highest total BNA and total PAH concentrations detected at the site, along with the highest level of total carcinogenic PAHs.

In the central portion of the site, high levels of total BNAs were detected in six subsurface soil samples (B12-2 @ 14.6 ppm, B04-1 @ 59.6 ppm, M03-2 @ 54.1 ppm, M03-3 @ 36.2 ppm, TP-1 @ 27.6 ppm, TP-5 @ 36.9 ppm) collected from five locations, as shown on Figure 4-16. All six of these soil samples were noted as having petroleum-like odors and/or as being visibly oily. Extensive oily soils were observed in test pit 1 during its excavation and sampling. Test pits were excavated in this area of the site to investigate suspected former lagoon locations (see Figure 1-3).

In the southern portion of the site, high levels of total BNAs were detected in five soil samples (SS-09 @ 13.8 ppm, SS-16 (duplicate of SS-11) @ 10.4 ppm, B09-1 @ 95.6 ppm, B09-2 @ 83.4 ppm, and M04-2 @ 162 ppm) collected from two separate areas (see Figure 4-16). Samples SS-09, SS-16, and B09-1, and B09-2 were all

collected from within 50 feet of each other in the south-central portion of the site. Soil boring samples B09-1 and B09-2 were collected from just above the ground water table (2 to 4 ft. depth) and at the water table (4 to 6 ft. depth), respectively. Both samples were noted as having a petroleum-like odor. Surface soil samples SS-09 and SS-11 were not noted as having any odor or visible signs of contamination.

The location of monitoring well MW-4 was the other area in the southern portion of the site which exhibited total BNA levels greater than 10 ppm. This well is located approximately 180 feet south of the other southern site area (near B-9 and SS-9) having high BNA soil levels. Soil boring sample M04-2 contained the highest level of total BNAs (162 ppm) and PAHs (144 ppm) detected in the soil at the site. The BNAs detected in sample M04-2 consisted primarily of PAHs but also contained several chlorinated compounds (1,3-dichlorobenzene, 1,4-dichlorobenzene and 1,2,4-trichlorobenzene). Soil sample M04-2 was collected at the approximate depth of the ground water table (8 to 10 ft. depth). Soil sample M04-2 was also noted as having a petroleum-like odor during its collection.

Pesticide and PCB Compounds

Fifty-seven (57) soil samples were collected from thirty-seven (37) locations across the site and analyzed for TCL pesticide and PCB compounds. In addition, surface soil samples were collected from two other locations for TCL PCB analysis. A soil

action level of 1 ppm total PCBs was used to evaluate the PCB soil data. This level has historically been enforced by the RIDEM as a PCB soil clean-up level. The pesticide soil sample data was assessed by reviewing the levels and frequency at which the different pesticide compounds were detected in the soil samples.

Summaries of those soil samples whose PCB concentrations exceed the established 1 ppm PCB action level are provided in Tables 4-11 through 4-14. Areas where PCBs were detected and areas where PCB concentrations exceed the 1 ppm action level are shown on Figure 4-17. Upon reviewing the pesticides/PCBs soil sample analyses results and these summary tables, the following observations can be made:

Pesticides:

- Of the thirty-seven (37) locations across the site from which samples were collected for TCL pesticides analyses, at least one sample from sixteen (16) of the locations contained detectable concentrations of pesticides.
- Of the twenty (20) TCL pesticide compounds analyzed for in the soil samples, four (aldrin, 4,4-DDE, 4,4-DDD, and 4,4-DDT) were detected in at least one soil sample collected from the site.
- Pesticides were detected at very low levels (10's of ppb) in over 60% of the surface soil samples collected from across the site. The highest pesticide concentration was detected in surface soil sample SS-07 (4,4-DDT @ 450 ppb), collected from the center portion of the site. Pesticides were detected much less frequently in subsurface soil samples.
- The pesticides detected most frequently in the site soil samples were 4,4-DDE and 4,4-DDT. In addition, 4,4-DDD was detected in two samples at very low levels (SS-06 @ 5 ppb and B08-2 @ 5.6 ppb), and aldrin was detected in only one soil sample (B07-1 @ 3.1 ppb).

PCBs:

- Of the thirty-nine (39) locations across the site from which samples were collected for TCL PCB analyses, at least one sample from seventeen (17) locations contained detectable concentrations of PCBs.

- Of the seven TCL PCB Aroclors analyzed for in the soil samples, two of the Aroclors (Aroclors 1254 and 1260) were detected in at least one soil sample.

- Of the thirty-nine (39) locations across the site from which soil samples were collected for TCL PCB analyses, six samples collected from five sample locations exceeded the 1 ppm action level for PCBs in soil (M03-2 @ 1.9 ppm, M03-3 @ 1.1 ppm, M04-2 @ 27 ppm, SS-01 @ 8 ppm, SS-02 @ 7.3 ppm, and TP-1 @ 10 ppm), as shown on Figure 4-17.

As is evident from the information summarized above and the overall pesticide sample results, low levels (10's of ppb) of two pesticides (4,4-DDE and 4,4-DDT) are predominant in the surface soils across the site. Higher levels (100's of ppb) of individual pesticides were detected at a few sample locations (SS-04, SS-05, SS-07, B-03, and B-06) in the middle of the site.

The information summarized above and the overall PCB sample results also indicated that PCBs are present in the soil across the site. PCBs were detected at a wide range of concentrations (0.043 ppm to 27 ppm) in soil samples. Elevated levels (> 1 ppm) of PCBs were detected in the soil at four different areas on the site (see Figure 4-17): at surface soil SS-01 (8 ppm) in the northwest corner of the site, at surface soil SS-02 (7.3 ppm) in the northeast corner of the site, at well boring M-3 (1.9 and 1.1 ppm) and test pit TP-1 (10 ppm) in the central portion of the site, and at well boring M-4 (27 ppm) at the southern end of the site. A

discussion of the PCB contamination detected in these areas follows.

Surface soil samples SS-01 and SS-02 were collected from the northwest corner and northeast corner of the site, respectively. Aroclor-1260 was detected in both samples at concentrations of 8 and 7.3 ppm, respectively. Neither soil sample exhibited any signs of contamination (e.g., staining, odors) when collected.

Soil samples M03-2, M03-3, and TP-1 were all collected from the central portion of the site. Each of these soil samples exhibited visible oil contamination. As discussed previously, this area of the site is the suspected former location of lagoons.

The highest PCB concentration of 27 ppm was detected in soil sample M04-2 collected from 8 to 10 feet below grade, at the depth of the ground water table.

Inorganic Analytes

Fifty-five (55) soil samples were collected from thirty-seven (37) locations across the site and analyzed for the TAL inorganic analytes (metals and cyanide). To evaluate the inorganic analyte soil sample data, analyte levels were compared to those levels detected in off-site background samples. The background inorganic soil levels used in the soil assessment are provided in Table 4-6.

Summaries of those soil samples whose concentrations exceeded the established background levels along with the specific inorganic analytes whose background levels were exceeded in the soil samples are provided in Tables 4-11 through 4-14. The extent of inorganic

contamination in on-site soils is shown on Figure 4-18. Upon reviewing the soil sample data and the summary tables, the following observations can be made concerning the occurrence of inorganics in the soil samples collected from the site:

- Of the thirty-seven (37) locations across the site from which soil samples were collected for inorganic analyses, at least one sample from twenty-seven (27) of the locations exceeded one of the inorganic compound background levels.

- Of the twenty-four (24) inorganic analytes analyzed for in the soil samples, the detected levels of twenty-two (22) of the inorganic analytes exceeded established background levels.

- The one inorganic analyte which exceeded the established background level in numerous (i.e. greater than 50%) soil samples was vanadium (53%).

- Those inorganic analytes which exceeded the established contaminant levels in many (i.e. 10%-50%) of the soil samples are silver (20%), barium (33%), calcium (36%), cadmium (40%), cobalt (38%), chromium (27%), copper (38%), iron (35%), manganese (22%), sodium (18%), nickel (29%), lead (29%), antimony (38%), and zinc (40%).

- The inorganic analytes which exceeded the established background levels in a few (less than 10%) of the soil samples collected for inorganic analyses are aluminum (2%), arsenic (5%), beryllium (7%), mercury (5%), potassium (2%), magnesium (4%), selenium (2%), and cyanide (4%).

- Thallium was not detected in any of the soil samples collected from this site.

As is evident from the above information, inorganic contamination is present in nearly all of the soil samples collected from the site. There were a few areas and spot locations across the site at which soil samples exhibit some of the highest levels of inorganic soil contamination. The areas and spot locations which were found to have significantly high and/or the highest levels of inorganic soil contamination are the following:

- The soils located in the central portion of the landfill, as detected in samples B12-1, B12-2, and TP-7. Sample B12-2 contained the highest levels of five of the metals (silver, arsenic, beryllium, antimony and zinc) detected in the soil samples collected from the site. All of these sample locations were observed to have petroleum-like odors during sample collection. All of the samples were collected at or below the depth of the ground water table.

- The soil located in the northern-central portion of the site as detected in soil samples M02-1 and M02-2. These samples were collected from fill soils. These soil samples were collected at or below the depth of the ground water table.

- The soil located in the south-central portion of the site as detected in soil samples B09-2 and B06-3. Soil sample B09-2 contained the highest levels of three of the metals (barium, cadmium and mercury) detected in the soil samples collected from the site. A strong petroleum-like was observed in this boring during drilling. This sample was collected at the depth of the water table (4 to 6 ft. depth).

4.3.2 Ground Water Assessment

This section of the report provides an assessment of the Melville North Landfill ground water sample analytical results and a discussion of the nature and extent of ground water contamination at the site. Under this investigation, a total of five (5) wells were installed at five locations across the site (MW-1 through MW-5). Shallow overburden wells were installed at each location. No bedrock wells were installed on this site. Ground water samples collected from each of the wells were analyzed for all TCL and TAL parameters.

As discussed in the site-specific hydrogeology discussion in Section 3.5 of this report, the site ground water flow is from east to west, towards Narragansett Bay. Presented below is a discussion of the ground water sample results.

Volatile Organic Compounds

The ground water sample results indicate the presence of volatile organic compound (VOC) contamination in site ground water. Low concentrations (3-110 ppb) of VOCs were detected in three (MW-1, MW-3, and MW-4) of the five wells. As shown in Table 4-15, ground water VOC action levels were exceeded in two wells. Signs of VOC-related contamination (e.g., oil, sheen) were also observed at the ground water table at several other locations on the site. Figure 4-22 shows the extent of VOC contamination detected in the wells and observed at the ground water table.

VOCs were detected in two wells (MW-3 and MW-4) at levels exceeding ground water action levels (see Table 4-15). Petroleum-related VOCs (e.g., benzene, toluene, chlorobenzene, ethylbenzene, xylene) were detected in these two wells. A low level (3 ppb) of benzene was also detected in well MW-1. Soil samples collected from the well borings completed for these wells were also found to have similar levels of VOCs. Signs of petroleum-related contamination (e.g., odors, oil) were also observed during the drilling and sampling of the well borings for MW-3 and MW-4. Although no VOCs were detected in an oil sample (MW-3-O) collected from well MW-3, this is likely due to the high dilution factor (47.6) used by the laboratory in the analysis of the oil sample.

As discussed in Section 4.3.1, the highest levels of subsurface VOC soil contamination were detected in soil samples collected from the central portion (at B-7, MW-3, and TP-5) and the southern end (at MW-4) of the site. Boring B-7 and test pit TP-5

are located within 75 feet of well MW-3, one of the locations where ground water VOC action levels were exceeded. As shown on Figure 4-22, signs of petroleum-related contamination (e.g., odors, sheen, oil) were observed at the depth of the ground water table in several borings (B-4, B-5, B-7, B-12, and B-13) and test pits (TP-1, TP-2, TP-5, and TP-7) completed around well MW-3.

A low level (1 ppb) of one VOC (benzene) was detected in the ground water at well MW-1; however, only toluene was detected in a soil sample collected at the depth of the water table in this well boring.

VOCs were not detected in the ground water samples collected from on-site well MW-2 and off-site, upgradient well MW-5. VOCs were also not detected in the soil samples collected from the borings completed for these wells.

The extent of VOC ground water contamination appears to be limited to two areas on the site: the central portion of the site (at and around MW-3), and the southern end of the site (at MW-4). A low level of one VOC was detected in well MW-1 located at the western edge of the north end of the site. Significant petroleum-related contamination (strong odors and oil) was observed in subsurface soils around well MW-3. The VOC soil and ground water contamination in this area is likely related to the former lagoons which were located in this portion of the site (see Figure 1-3).

Base Neutral/Acid Extractable Organic Compounds

The ground water sample results indicate the presence of non-detectable to low levels of BNAs in the site ground water. BNAs were detected in two of the site monitoring wells (MW-3 and MW-4). Only one of the detected BNAs, 1,4-dichlorobenzene, exceeded ground water action levels established for BNAs. It was detected in well MW-4 at a concentration of 83 ppb (MCL = 75 ppb).

The BNAs detected in the two ground water samples consisted primarily of PAHs and dichlorobenzene. Low levels of one phthalate compound were also detected in one of the samples. The highest level of total BNAs (518 ppb) was detected in the ground water sample collected from MW-4, located at the southern end of the site. The BNAs detected in this well consisted almost entirely of PAHs. As presented in Section 4.3.1, the highest level of total BNA soil contamination was detected in a soil sample collected at the depth of the water table from the boring completed from well MW-4 (M04-2). The BNAs in this soil sample consisted almost entirely of PAHs. Elevated levels of BNAs were primarily detected in soils located in the central and southern portions of the site.

Low level BNA ground water contamination appears to be limited to two areas of the site: the central portion of the site (at and around MW-3), and the southern end of the site (at MW-4). BNA ground water contamination was only observed at those site locations found to have very high levels of BNA soil contamination.

Pesticide and PCB Compounds

The ground water sample results indicate the presence of a pesticide and PCB in ground water samples collected from the site. The pesticide gamma-BHC (lindane) was detected at a concentration of 0.13 ppb in well MW-4, located at the southern end of the site. PCBs were detected at a concentration of 40 ppb in well MW-4 and at 0.22 ppb in well MW-3, located in the central portion of the site. The PCB concentration in well MW-4 exceeds the MCL of 0.5 ppb for PCBs in ground water.

As discussed in Section 4.3.1, PCBs were detected in soils across the site. The highest PCB soil levels were found at the northern end of the site (at SS-1 and SS-2), the central portion of the site (at MW-3 and TP-1), and the southern end of the site (at MW-4). The highest level of PCBs (27 ppm) was detected in a soil sample collected at the depth of the water table from the well boring completed for well MW-4 (M04-2). Elevated levels of PCBs were also detected in soil samples from the well boring completed for well MW-3 and from the nearby, upgradient test pit TP-1.

PCB ground water contamination appears to be located in the southern and central portions of the site. Low levels of pesticides were also detected in ground water at the southern end of the site.

Inorganic Analytes

The inorganic ground water sample results indicate the presence of numerous inorganic analytes in ground water samples

collected from the site. Inorganic analytes were detected in ground water samples collected from each of the five site wells. Table 4-15 provides a summary of the inorganic analyte, ground water sample concentrations which exceeded established ground water action levels. Upon reviewing the ground water sample data and the summary table, the following observations can be made:

- Eight (8) inorganic analytes were detected at levels exceeding action levels in at least one of the ground water samples.

- In the off-site, upgradient well, MW-5, the inorganic analytes detected at levels exceeding action levels include aluminum (93,200 ppb), beryllium (3.8 ppb), chromium (121 ppb), iron (208,000), manganese (3,660 ppb), nickel (221 ppb), and lead (28.5 ppb). These levels are considered to be representative of background conditions in the ground water assessment.

- Four (4) inorganic analytes, aluminum, iron, manganese, and lead were detected in each ground water sample (i.e., 100%) at levels exceeding action levels. The highest levels of aluminum and iron were detected in the off-site, upgradient well MW-5. Only well MW-4 had higher level of manganese than that detected in well MW-5. The levels of lead detected in wells MW-2 and MW-3 greatly exceeded (> 50x's) lead action levels (see Figure 4-23).

- Inorganic analytes which exceeded the established action levels in 50 to 99% of the ground water samples are beryllium (60%), chromium (60%), and nickel (60%).

- Cadmium exceeded the established action levels in less than 50% of the ground water samples (2 of the 5).

The distribution of inorganics exceeding action levels and background levels (i.e., MW-5) within the on-site monitoring wells can be summarized as follows:

- The highest levels of two of the analytes, cadmium and lead, were detected in well MW-2, located in the north-central portion of the site.

- Lead was detected in all on-site wells, except for MW-4, at concentrations exceeding action levels and background.
- Other wells having analytes exceeding action levels and background include MW-3 (cadmium) and MW-4 (manganese).

The above information indicates that the greatest amount of inorganic ground water contamination was detected in the north-central (MW-2) to central portions (MW-3) of the site. The inorganics detected in soil samples from locations in this area (at MW-2, TP-7, B-12) also exhibited high inorganic analyte levels.

4.3.3 Sediment Sample Assessment

This section of the report provides an assessment of the Melville North sediment sample analytical results. The assessment includes information on the nature and extent of sediment contamination within the wetlands in the northern portion of the site. As discussed in Section 4.1, to aid in evaluating the data, contaminant-comparison and/or background levels were established for VOCs, BNAs, PCBs, and inorganics.

A total of three (3) sediment samples were collected from three locations in the wetlands. At each sediment sample location, one sample was collected from the 0-1 foot interval. All of the sediment samples were analyzed for all of the TCL and TAL parameters. A discussion of the sample locations and the field measurements and observations made during the sediment sampling activities is presented in Section 2.8.1. Tables containing the analytical results for the sediment and surface water samples are presented in Appendix M.

Volatile Organic Compounds (VOCs)

All of the sediment samples were analyzed for TCL volatile organic compounds (VOCs). To evaluate the sediment sample VOC data, the contaminant-comparison level of 1 ppm for total volatile organic compounds in soil was used.

As discussed in the Data Validation Summary presented in Appendix M, the validation of the data resulted in the qualification of sediment sample data based upon laboratory blank contamination and other data quality control criteria. At this site, the detected levels of methylene chloride and acetone in the sediment and surface water samples were qualified as undetected ("U" qualifier). These qualified levels are not considered in the site sediment and surface water contamination assessment.

A total of thirty-four (34) TCL VOCs were analyzed for in each of the sediment samples. Three of the thirty-four VOCs were detected in the sediment samples. Toluene was detected in sediment samples SD-8 and SD-9 at an estimated value ("J" qualifier) of 2 ppb. Carbon disulfide was detected in sediment sample SD-8 at an estimated value of 9 ppb, and 2-hexanone was detected in sediment sample SD-9 at an estimated value of 3 ppb. No VOCs were detected in sediment sample SD-10. As shown in Table 4-16, none of the total VOCs levels detected in the site sediment samples exceeded the 1 ppm total VOC soil comparison level. The sediment sample exhibiting the highest total VOC concentration (11 ppb) was sample SD-8 located approximately 450 feet north of the landfill, at the far end of the wetlands.

Base Neutral/Acid Extractable Organic Compounds (BNAs)

All of the sediment samples were analyzed for TCL BNA compounds. To evaluate the sediment sample BNA data, the contaminant-comparison level of 10 ppm for total BNA in soil was used. In addition to using the contaminant-comparison level for total BNAs, the contaminant-comparison levels of 10 ppm and 1 ppm for total polynuclear aromatic hydrocarbons (PAHs) and total carcinogenic PAHs, respectively, were used.

A total of sixty-five (65) BNAs were analyzed for in each sediment sample collected for TCL BNA analysis. Of the sixty-five TCL BNAs, thirteen (13) were detected in the sediment samples.

Upon comparing the established soil contaminant-comparison level of 10 ppm for total BNAs to the sediment sample results, none of the sediment samples had detected concentrations of total BNAs greater than the 10 ppm. The sample with the highest total BNA concentration was SD-10 at a concentration of 5.43 ppm. Sediment sample SD-10 is located on the edge of the wetlands, closest to the landfill. The total BNA concentration detected in this sample consisted entirely of PAH compounds. Carcinogenic PAHs comprised 2.64 ppm of the total PAHs, a level which is above the associated contaminant-comparison level of 1 ppm. Sediment sample SD-8, which had a total BNA concentration of 1.95 ppm, also consisted entirely of PAH compounds. Of the 1.95 ppm total PAHs detected in this sample, 1.03 ppm were carcinogenic PAHs, just above the contaminant-comparison level of 1 ppm. Sediment sample SD-9 primarily consisted of PAHs but also contained low levels of

phenol, di-n-butylphthalate, and bis(2-ethylhexyl)phthalate. The total concentration of carcinogenic PAHs (0.753 ppm) was below the 1 ppm contaminant-comparison level.

Pesticide and PCB Compounds

All of the sediment samples collected were analyzed for TCL pesticides and PCB compounds. No PCBs were detected in any of the sediment samples. Four pesticides were detected in the three site sediment samples.

The pesticide 4,4'-DDE was detected in each of the sediment samples, ranging in concentration from 7.9 to 470 ppb. The highest level of 4,4'-DDE was detected in sediment sample SD-10. The pesticides 4,4'-DDD and 4,4'-DDT were detected in both samples SD-8 (460 ppb 4,4'-DDD & 7.9 ppb 4,4'-DDT) and SD-10 (34 ppb 4,4'-DDD & 740 ppb 4,4'-DDT). The pesticide alpha-chlordane was detected in sediment sample SD-9 at a concentration of 7.9 ppb. The concentrations for each of these samples were reported as estimated ("J" qualifier) by the laboratory.

Inorganic Analytes

All of the sediment samples collected from the site were analyzed for the TAL inorganic analytes (including metals and cyanide). To evaluate the sediment sample inorganic analyte data, detected analyte levels were compared to analyte levels detected in background soil samples. The background inorganic analyte soil levels used in the soil assessment are provided in Table 4-6.

Summaries of those sediment samples whose inorganic analyte concentrations exceeded the established background levels, along with those inorganic analytes that were exceeded in the sediment samples are included in Table 4-16. Upon reviewing the summary tables and sediment sample analyses results, the following observations can be made:

- Of the three (3) locations within the wetlands from which a sediment sample was collected for TAL inorganic analyses, at least one of the established background analyte levels was exceeded at all three locations.
- Of the twenty-four (24) inorganic TAL analytes, twenty (20) were detected in sediment samples collected from the wetlands, and seven (7) (calcium, cobalt, chromium, copper, sodium, nickel, and zinc) were detected at levels greater than background.
- When an inorganic analyte was detected above the background level, it was detected in only one of the three sediment samples.

The above information indicates that inorganic analytes detected above the established background levels were dispersed throughout the three separate sample locations. At sediment sample SD-8, sodium was the only inorganic analyte detected above background levels. At sediment sample SD-9, cobalt was the only inorganic analyte detected above background levels. Chromium, copper, nickel, and zinc were all detected at sediment sample SD-10 above the established background levels. Sample SD-10 generally had the highest concentration for each of the inorganic analytes.

4.4 Site 09 - Old Fire Fighting Training Area

4.4.1 Soil Assessment

This section of the report provides an assessment of the Old Fire Fighting Training Area soil sample analytical results. The assessment includes information on the nature and extent of soil contamination across the site. As discussed in the introduction to Section 4.0, to aid in evaluating the soil data, contaminant-comparison and/or background levels were established for VOCs, BNAs, PCBs, and inorganics.

A total of twenty-seven (27) soil samples were collected from across the site through several field investigation techniques. Soil sample locations are shown on Figure 4-3. The investigation techniques included surface soil sampling, subsurface soil boring sampling, and monitoring well boring sampling. A discussion of the sampling locations, the number of samples collected, and field measurements and observations made during the soil sampling activities at the site is presented in Sections 2.4 through 2.6. A summary of the soil samples collected from this site is presented in Table 4-3. Tables containing the analytical results for the soil samples are presented in Appendix M.

Volatile Organic Compounds (VOCs)

Twenty-seven (27) soil samples were collected from sixteen (16) locations across the site and analyzed for TCL volatile

organic compounds (VOCs). To evaluate the VOC soil sample data, a contaminant-comparison level of 1 ppm for total VOCs in soil was established. Summaries of those soil samples whose concentrations exceeded the 1 ppm total VOC level are provided in Tables 4-17 through 4-19. The extent of volatile organic compounds in on-site soils and those areas where total VOC concentrations exceed 1 ppm are shown on Figure 4-24. The subsurface distribution of volatile organics is also shown on site cross-sections on Figures 4-27 through 4-29.

As discussed in Appendix M, validation of the data resulted in the qualification of sample data based upon laboratory blank contamination and other quality control criteria. At this site, a majority of the detected levels of methylene chloride and acetone in the soil samples were qualified as "undetected" ("U" qualifier). These qualified levels are not considered in the site soils contamination assessment. Therefore, these compounds will not be considered further in the site soils contamination assessment.

Additional review of the data was also necessary to assess the field and trip blank data as compared to the soil sample data. This review indicated that low levels (low ppb) of chloroform were detected in one of the trip blanks. However, chloroform was not detected in any of the soil samples collected from the site. Therefore, chloroform will not be considered further in the site soils contamination assessment.

A total of thirty-four (34) TCL volatile organic compounds (VOCs) were analyzed for in each of the soil samples collected for VOC analysis. A list of the TCL VOCs is provided in Table 2-1. Of these thirty-four (34) TCL VOCs, nine (9) were detected in soil samples collected from this site. Three of these VOCs, methylene chloride, acetone, and chloroform, are not considered "key" VOCs in the site soils contamination assessment for reasons explained previously. Two additional VOCs, carbon disulfide and tetrachloroethene, were detected in only a few soil samples and at very low concentrations (low ppb). The remaining four VOCs which were detected in the soil samples and are considered "key" VOCs in the site soils contamination assessment are the following: 2-butanone, toluene, ethylbenzene, and xylene.

Upon reviewing the VOC soil sample analysis results and the contaminant-comparison level summary tables, the following observations can be made concerning the occurrences of total VOCs and "key" VOCs in the soil samples collected from this site:

- Of the sixteen (16) locations across the site from which soil samples were collected for TCL VOC analyses, at least one sample from two (2) of the locations exceeded the 1 ppm contaminant-comparison level for VOCs in soil (M02-1 @ 1,100 ppm and B06-1 @ 1,356 ppm), as shown on Figure 4-24.

- Of the twenty-seven (27) soil samples collected for TCL VOC analyses, six (6) of the soil samples contained detectable concentrations of the four "key" VOCs.

- The detected concentrations of the four "key" VOCs were greatest at the two locations where the contaminant-comparison level of 1 ppm for total VOCs was exceeded (@ M-2 and B-6).

- The highest concentration of 2-butanone (1,100 ppb) was detected in a soil sample collected from monitoring well boring 2 (M02-1). This was the only VOC detected in the two soil samples collected from this boring.

- The highest concentrations detected for three of the four "key" VOCs (toluene @ 67 ppb, ethylbenzene @ 89 ppb, and xylene @ 1,200 ppb) were detected in soil sample B06-1 collected from test boring 6.

The above information indicates that there are two separate locations on the site (at B-6 and M-2) where total VOC levels greater than 1 ppm were detected in the soil. The highest concentration of total VOCs (1,356 ppb) was detected in soil sample B06-1 collected from boring B-6, located in the central portion of the site, just west of the large soil mound on-site (see Figure 4-24). Soil sample B06-1 was collected from the depth of the ground water table (4 to 6 ft. depth). The soil sample was noted as having a light petroleum-like odor. Petroleum-related VOCs (toluene, ethylbenzene, and xylene) were detected in this sample. The other soil sample (M02-1) having a total VOC level greater than 1 ppm was collected from well boring M-2, located in the north-central portion of the site along the shoreline. This sample was also collected from the depth of the water table (6 to 8 ft. depth), where a strong petroleum-like odor and visibly oily soils were noted. 2-Butanone was the only VOC detected in this soil sample.

Base Neutral/Acid Extractable Organic Compounds (BNAs)

Twenty-seven (27) soil samples were collected from sixteen (16) locations across the site and analyzed for TCL base neutral/acid extractable organic compounds (BNAs). To evaluate the BNA soil data, the contaminant-comparison level of 10 ppm for total BNAs in soil was used. In addition to using the contaminant-comparison level for total BNAs, contaminant-comparison levels of 10 ppm and 1 ppm were used for total polynuclear aromatic hydrocarbons (PAHs) and total carcinogenic PAHs. Summaries of those soil samples whose concentrations exceeded the established BNA and PAH contaminant-comparison levels for the soil samples are provided in Tables 4-17 through 4-19. The extent of BNA contamination in on-site soils, including areas where BNA and carcinogenic PAH contaminant-comparison levels are exceeded, is shown on Figure 4-25. The subsurface distribution of base neutral/acid extractable compounds is also shown on site cross-sections on Figures 4-27 through 4-29.

As discussed in Appendix M, the findings of the data validation indicated that very low levels of two common phthalate esters, di-n-butylphthalate and bis(2-ethylhexyl)phthalate, were detected in laboratory method blanks and/or field and trip blanks. Therefore, the associated detected soil sample concentrations for these compounds have been qualified as undetected ("U"). However, a detected, elevated concentration (1,400 ppb) of di-n-butylphthalate was detected in one soil sample (B03-3), indicating

that some of the site soils appear to contain "real" levels of this phthalate compound. The compound bis(2-ethylhexyl)phthalate was also detected at an elevated concentration in one soil sample (SS-1) and a ground water sample from the site. Based on these findings, both of these phthalate compounds are considered "key" BNAs in the site soils contamination assessment.

A total of sixty-five (65) BNAs were analyzed for in each soil sample collected for TCL BNA analysis. A list of the TCL BNAs is provided in Table 2-1. Of the sixty-five (65) TCL BNAs, twenty-three (23) were detected in the soil samples submitted for TCL BNA analysis. All twenty-three (23) BNAs were detected in several soil samples, at elevated concentrations, and/or in other site media and are considered "key" BNAs in the soil contamination assessment for this site.

Upon comparing the established contaminant-comparison level of 10 ppm for total BNAs to the soil sample analyses results, the following observations can be made:

- Of the sixteen (16) locations across the site from which samples were collected for TCL BNA analyses, at least one sample from four (4) locations (SS-06, B-7, M-2, and M-5) exceeded the 10 ppm total BNA level, as shown on Figure 4-25.

- Of the twenty-seven (27) soil samples collected for TCL BNA analyses, twenty-five (25) of the samples contained detectable concentrations of BNAs.

- The highest total BNA concentration of 40 ppm was detected in surface soil sample SS-6 collected from the northeast portion of the site along the shoreline. The highest concentrations of twelve (12) of the twenty (23) "key" BNAs were detected in this sample.

The BNA subgroups for which total concentration calculations have been compiled are the polynuclear aromatic hydrocarbons (PAHs) and carcinogenic PAHs. The BNAs included under each of these groups are noted on the data tables and listed in Table 2-1. The total BNA and PAH concentration values for the site samples are provided in the data tables in Appendix M.

The following observations can be made concerning the magnitude of total and carcinogenic PAHs detected in the soil samples collected from the site:

- Six (6) soil samples collected from four (4) soil sample locations exceeded the established 10 ppm contaminant-comparison level for total PAHs in soil (SS-06, B07-1 and B07-2, M02-1 and M02-2, and M05-1). These four locations are the same locations where the highest total BNA concentrations were detected (see Figure 4-25).

- The highest total PAH concentration of nearly 40 ppm was detected in surface soil sample SS-6 collected from the northeastern portion of the site.

- Eight (8) soil samples collected from six (6) soil sample locations exceeded the established 1 ppm contaminant-comparison level for total carcinogenic PAHs in soil (M02-1, M05-1, B01-1, B03-1 and B03-2, B07-1 and B07-2, and SS-6), as shown on Figure 4-25.

- For the soil samples, the total carcinogenic PAH concentration comprised an average of over 30% of the total PAH concentration.

As is evident from the above information, BNA soil contamination is present in the soils across the site. The highest levels of BNA soil contamination were detected in the northeast portion of the site at surface soil sample 6. This sample was taken from along the shoreline in the loose sand and shells. Soil descriptions from this sample location indicated that trace amounts

of asphalt were found, which could potentially account for the high BNA concentrations detected.

Spot locations of high BNA soil contamination can also be found across the northern and western portions of the site. In the northern portion of the site along the shoreline, samples M02-1 and M02-2 contained high levels of total BNAs, total PAHs and total carcinogenic PAHs, while samples B03-1 and B03-2 contained high levels of total carcinogenic PAHs. The samples collected from both locations were noted as having a strong petroleum odor and visible contamination. In the western portions of the site, samples B07-1 and B07-2 contained high levels of total BNAs, total PAHs, and total carcinogenic PAHs. The two samples were collected from depths of 4-6 and 6-8 feet, respectively. Each sample was noted as having a strong petroleum odor.

Soil samples collected from an off-site location, monitoring well 5 just south of the site, also contained high levels of total BNAs, PAHs, and carcinogenic PAHs. Sample M05-1 was collected from the 8-10 foot interval, with no odor or visible contamination observed during sampling.

Pesticide and PCB Compounds

Twenty-seven (27) soil samples were collected from sixteen (16) locations across the site and analyzed for TCL pesticide and PCB compounds. A soil action level of 1 ppm total PCBs was used to evaluate the PCB soil data. This level has historically been

enforced by the RIDEM as a PCB soil clean-up level. The pesticide soil sample data was assessed by reviewing the levels and frequency at which the different pesticide compounds were detected in the soil samples.

Summaries of those soil samples whose PCB concentrations exceed the established 1 ppm PCB action level are provided in Tables 4-17 through 4-19. Upon reviewing the pesticides/PCBs soil sample analyses results and these summary tables, the following observations can be made:

Pesticides:

- Of the twenty (20) TCL pesticide compounds analyzed for in the soil samples, two pesticides (4,4-DDE and 4,4-DDT) were detected in at least one of the soil samples.
- Of the sixteen (16) locations across the site from which samples were collected for TCL pesticides analyses, at least one sample from six (6) of the locations contained detectable concentrations of pesticides.
- Pesticides were only detected in surface soil samples collected from the site.

PCBs:

- Of the sixteen (16) locations across the site from which samples were collected for TCL PCB analyses, only one sample (SS-01) contained a detectable concentration (16 ppb) of PCBs.
- Of the seven TCL PCB Aroclors analyzed for in the soil samples, one (Aroclor 1254) was detected in one of the soil samples.
- Of the sixteen (16) locations across the site from which samples were collected for TCL PCB analyses, none of the samples exceeded the established 1 ppm action level for PCBs in soil.

The preceding information and pesticide sample results indicate that low levels (low ppb) of pesticides were detected in the surface soil across the site. Similar levels of two pesticide compounds were detected in nearly all of the surface soil samples. The highest total pesticide concentration was found in sample SS-02 at 16 ppb.

The PCB sample results indicate that only one of twenty-seven soil samples collected from the site contained detectable concentrations of PCBs. Surface soil sample SS-01, collected from the eastern end of the site, contained 80 ppb of PCB Aroclor-1254.

Inorganic Analytes

Twenty-five (25) soil samples were collected from sixteen (16) locations across the site and analyzed for the TAL inorganic analytes (metals and cyanide). To evaluate the inorganic analyte soil sample data, analyte levels were compared to levels detected in background soil samples. The background inorganic analyte soil levels used in the soil assessment are provided in Table 4-6.

Summaries of those soil samples whose concentrations exceeded the established background levels along with those inorganic analytes which were exceeded in the soil samples are provided in Tables 4-17 through 4-19. The extent of inorganic contamination in on-site soils is shown on Figure 4-26. Upon reviewing the soil sample data and the summary tables, the following observations can be made:

- Of the sixteen (16) locations across the site from which samples were collected for inorganic analyses, at least one sample from fourteen (14) locations exceeded one of the established background levels for inorganic analytes in soil.

- Of the twenty-three (23) inorganic analytes analyzed for in the soil samples, the detected levels exceeded the background levels for twelve of the analytes.

- No inorganic analytes exceeded the established background levels in greater than 50% of the soil samples collected from the site.

- Those inorganic analytes which exceeded the established contaminant levels in many (i.e. 10%-50%) of the soil samples collected for inorganic analyses are calcium (28%), cobalt (24%), copper (12%), iron (28%), manganese (20%), sodium (40%), and lead (12%).

- The inorganic analytes which exceeded the established contaminant levels in a few (less than 10%) of the soil samples collected for inorganic analyses are barium (4%), cadmium (8%), magnesium (8%), selenium (8%), and zinc (8%).

As is evident from the above information, inorganic contamination is present in nearly all of the soil samples collected from the site. The highest levels of inorganic soil contamination were detected at monitoring well boring 2 in soil samples M02-1 and M02-2, as shown on Figure 4-26. As noted previously, petroleum-like odors and oily soils were present in this boring. The highest concentration of seven of the inorganic analytes analyzed for in the soil samples were detected at this location, including six analytes (barium, cadmium, copper, iron, lead, and zinc) which exceeded background levels. Elevated levels of calcium, sodium, and lead were also detected in soil boring 1 completed at the eastern edge of the site.

4.4.2 Ground Water Assessment

This section of the report provides an assessment of the Old Fire Fighting Training Area ground water sample analytical results and a discussion on the nature and extent of ground water contamination at the site. Under this investigation, a total of five (5) wells were installed at five locations on the site (MW-1 through MW-5). All wells were screened within the overburden till materials. Well locations are provided on Figure 2-21. The ground water samples were analyzed for all of the TCL and TAL parameters.

As discussed in the site-specific hydrogeology section (Section 3.5) of this report, the site ground water flow is generally flowing from south to north, towards Narragansett Bay. Below is a discussion of the ground water sample results.

Volatile Organic Compounds

The ground water sample results indicate the relative absence of volatile organic compound (VOC) contamination in site ground water. The presence of methylene chloride and acetone in the samples was qualified as undetected ("U") and therefore, these compounds are not considered in this assessment. Only one volatile organic compound, chloroform, was detected in only one of the four on-site wells (MW-1). No VOCs were detected in the upgradient, off-site well (MW-5).

The level of chloroform detected in well MW-1 did not exceed any ground water action levels. Chloroform was not detected in any

of the soil samples collected at the site, although it was detected in a trip blank associated with the soil samples.

VOC analyses of ground water samples do not indicate the presence of significant VOC contamination in the ground water. The potential for ground water contamination, as indicated by the exceedance of the VOC contaminant-comparison level, was identified in only one monitoring well soil boring sample, collected from the well boring for monitoring well MW-2. Soil gas readings at this general location were also elevated. The ground water sample collected from well MW-2 exhibited a petroleum odor and sheen; however, the sample exhibited no detectable levels of VOCs. Elevated soil gas readings, petroleum odors, and/or sheens were also observed in association with soil and/or ground water samples collected at other well locations on the site. Some of these characteristics are discussed further in the discussion presented below.

Base Neutral/Acid Extractable Organic Compounds

The ground water sample results indicate the presence of non-detectable to low levels of BNAs in the site ground water. BNAs were detected in two (MW-2 and MW-3) of the five wells sampled. No BNAs were detected in the upgradient, off-site well (MW-5). Four of the BNAs detected exceeded ground water action levels established for BNAs.

The highest level of total BNAs (877 ppb) was detected in the ground water sample collected from well MW-2, located in the north-central portion of the site, and consisted primarily of bis(2-ethylhexyl)phthalate (740 ppb). A very low level (1 ppb) of dibenzofuran and relatively low levels (1 to 44 ppb) of PAHs were also detected in this sample. Benzo(a)anthracene, chrysene, benzo(b)fluoranthene, and benzo(a)pyrene were detected at levels exceeding action levels. Detected levels ranged from 1 to 4 ppb, while action levels (tentative Maximum Contaminant Levels) ranged from 0.1 to 0.2 ppb, as presented in Table 4-20. A strong petroleum odor and sheen were observed during ground water sample collection at this well.

BNAs were also detected in well MW-3 at a total concentration of 4 ppb. The BNAs detected in this well consisted almost entirely of PAHs. No BNAs were detected at levels exceeding action levels in MW-3. A strong petroleum odor and sheen were observed during ground water sample collection at this well.

A slight petroleum odor was also observed during ground water sample collection at well MW-4. No BNAs were detected in the ground water sample collected at this location. A strong petroleum odor was also observed during the collection of subsurface soil samples at this location (B-7).

In comparing the ground water BNA results to the soil quality at this site, as discussed in Section 4.4.1, the levels of total BNAs detected in the two soil samples collected from the soil

boring for MW-2 both exceeded the contaminant-comparison level of 10 ppm. The soil samples were collected at the water table and 6-8 feet beneath it and exhibited visible oil contamination. The BNAs detected in these soil samples consisted almost entirely of PAHs. Bis(2-ethylhexyl)phthalate and dibenzofuran were not detected in the soil samples. At the soil boring for MW-3, the other well in which BNAs were detected in the ground water, total BNA levels in the soil samples exhibited less than 5 ppm total BNAs.

Low level BNA ground water contamination appears to be limited to the central and north-central portion of the site (at wells MW-2 and MW-3). Other evidence of potential ground water contamination (e.g., petroleum odors and/or sheens) exists at these two wells and at a third well, MW-4 located in the western portion of the site, where no BNA contamination was detected.

Pesticide and PCB Compounds

No pesticide or PCB compounds were detected in the ground water samples collected at the Old Fire Fighting Training Area.

Inorganic Analytes

The inorganic ground water sample results indicate the presence of numerous inorganic analytes in ground water samples collected at the site. Inorganic analytes were detected in each of the five wells sampled. Table 4-10 provides a summary of the inorganic analytes whose ground water action levels were exceeded,

the well locations at which the exceedances were measured, and the associated action levels. Upon reviewing the ground water inorganic data provided in Appendix M and the summary table, the following observations can be made:

- Nine (9) inorganic analytes were detected at levels exceeding action levels in at least one of the ground water samples.

- In the off-site, upgradient well, MW-5, the inorganics detected at levels exceeding action levels include aluminum (14,500 ppb), iron (41,700 ppb), manganese (6,140 ppb), and lead (11.7 ppb). These levels are considered to be representative of background conditions in the ground water assessment.

- Four inorganic analytes, aluminum, iron, manganese and lead, were detected in each ground water sample (i.e., 100%) at levels exceeding action levels (see Figure 4-30). These analytes were detected at levels exceeding the associated background level at the following frequencies: aluminum - 75%, iron - 75%, manganese - 25% and lead - 100%.

- The remaining inorganic analytes exceeded the established action levels in only one of the five ground water samples (i.e., 20%) and include beryllium (MW-3), cadmium (MW-2), mercury (MW-2), antimony (MW-2), and zinc (MW-2). As indicated, these analytes were not detected in the background well (MW-5S).

The distribution of inorganics within the on-site monitoring wells can be summarized as follows:

- The highest levels of five (5) of the nine (9) analytes (cadmium, mercury, lead, antimony and zinc) detected in ground water samples at levels exceeding action and background levels were detected in monitoring well MW-2.

- Other wells in which the greatest levels of individual inorganic analytes were detected include MW-3 (aluminum, beryllium, and iron), and MW-4 (manganese).

- Monitoring wells MW-2 and MW-3 each contained lead at levels greater than 10 times the action level (see Figure 4-30). Detected levels of aluminum, iron, and manganese exceeded 10

times their associated action levels in all five monitoring wells.

Therefore, the greatest amount of inorganic ground water contamination was detected in the north-central (MW-2) and central (MW-3) portions of the site (see Figure 4-30). The inorganics detected in soil samples from the soil boring at MW-2 were also detected at the highest inorganic soil levels for soil samples collected at the site. Background ground water quality does not meet all drinking water criteria and, in particular, has elevated levels of aluminum, iron manganese and lead.

4.5 Site 12 - Tank Farm Four

4.5.1 Soil Assessment

This section of the report provides an assessment of the Tank Farm Four soil sample analytical results. The assessment includes information on the nature and extent of soil contamination across the site. As discussed in Section 4.1.1, to aid in evaluating the soil data, contaminant-comparison and/or background levels were established for VOCs, BNAs, PCBs, and inorganic analytes.

A total of forty-six (46) soil samples were collected from across the site through several field investigation techniques. Soil sample locations are shown on Figure 4-4. The investigation techniques included surface soil sampling and monitoring well boring sampling. The majority of the soil samples collected were surface soil samples which were typically analyzed for total petroleum hydrocarbons (TPH) and lead. A discussion of the sampling locations, the number of samples collected, and field measurements and observations made during all of the soil sampling activities at the site is presented in Sections 2.4 through 2.6. A summary of the soil samples collected from this site is provided in Table 4-4. Tables containing the analytical results for the soil samples are presented in Appendix M.

Volatile Organic Compounds (VOCs)

Seven (7) soil samples were collected from seven (7) locations across the site and analyzed for TCL volatile organic compounds

(VOCs). To evaluate the VOC soil sample data, the contaminant-comparison level of 1 ppm for total volatile organic compounds in soil was used.

As discussed in the Data Validation Summary presented in Appendix M, validation of the data resulted in the qualification of soil sample data based upon laboratory blank contamination and other data quality control criteria. At this site, the detected levels of methylene chloride and acetone in the soil samples were qualified as undetected ("U" qualifier). These qualified levels are not considered in the site soils contamination assessment.

A total of thirty-four (34) TCL VOCs were analyzed for in each of the soil samples collected for VOC analysis. A list of the TCL VOCs is provided in Table 2-1. Only two of these VOCs, tetrachloroethene (PCE) and toluene, were detected in soil samples collected from the site. One or both of these VOCs were detected in three subsurface soil samples. No VOCs were detected in the two surface soil samples analyzed for VOCs. PCE was detected at a very low concentration (2 ppb) in one of the soil boring samples. Toluene was detected at very low concentrations (1-2 ppb) in three of the soil boring samples. All three samples were collected from the depth of the ground water table. As shown in Tables 4-21 and 4-22, none of the total VOCs levels detected in the site soil samples exceeded the 1 ppm total VOC comparison level.

The significance of the low VOC levels detected in the three subsurface soil samples is diminished when other factors are considered. No odors or visible signs of contamination (e.g.,

staining, oil) were observed during the drilling and sampling of these borings. Boring M-4, from which the soil sample exhibiting the highest total VOC concentration (4 ppb) was collected, was drilled in the far western corner of the site. Also, although toluene was not detected in any of the blanks associated with this site, low levels of this common laboratory contaminant were detected in blanks associated with other sites. Furthermore, similar levels of both of these VOCs were also detected in Tank Farm Five soil sample M02-1, which was analyzed in the same laboratory batch as these samples. The reported concentrations for both of these VOCs were reported as estimated ("J" qualifier) at levels below the detection limit (6 ppb) reported for the other site soil samples. Given these observations and the fact that both toluene and PCE were detected at very low levels in the soil samples and at locations (i.e., at M-4) far from any likely contamination source, the reported concentrations for these VOCs are considered questionable.

Base Neutral/Acid Extractable Organic Compounds (BNAs)

Seven (7) soil samples (not including duplicate samples) were collected from seven (7) locations across the site and analyzed for TCL base neutral/acid extractable organic compounds (BNAs). To evaluate the BNA soil data, the contaminant-comparison level of 10 ppm for total BNAs in soil was used. In addition to using the contaminant-comparison level for total BNAs, contaminant-comparison

levels of 10 ppm and 1 ppm were used for total polynuclear aromatic hydrocarbons (PAHs) and total carcinogenic PAHs, respectively.

As discussed in Appendix M, the findings of the data validation indicated that very low levels of bis(2-ethylhexyl)phthalate and pentachlorophenol were detected in the laboratory method blanks. Therefore, the associated detected soil sample concentrations for these compounds have been qualified as undetected ("U"). Detected levels of pyrene were also qualified as undetected ("U") on the basis of holding time criteria. Based on these findings, these compounds will not be considered in the site soil contamination assessment.

A total of sixty-five (65) BNAs were analyzed for in each soil sample collected for TCL BNA analysis. A list of the TCL BNAs is provided in Table 2-1. Of the sixty-five TCL BNAs, ten (10) were detected in the soil samples submitted for TCL BNA analysis. Of the ten, three were eliminated from further consideration in the soil assessment for reasons explained previously. The remaining seven (7) BNAs which were detected in several samples, at elevated concentrations, and/or in other site media are considered "key" BNAs in the soil contamination assessment for this site.

Upon comparing the established soil contaminant-comparison level of 10 ppm for total BNAs to the soil sample analytical results, none of the soil samples collected from this site had detected concentrations of total BNAs greater than the 10 ppm. Only one soil sample (M4-1) had a concentration of total BNAs greater than 1 ppm (3.3 ppm). The total BNA concentration detected

in this sample consisted entirely of di-n-butylphthalate. This soil sample (M04-1) was collected from a well boring completed in the far western corner of the site.

Pesticide and PCB Compounds

Seven (7) soil samples were collected from seven (7) locations across the site and analyzed for TCL pesticide and PCB compounds. No PCBs were detected in any of the site soil samples. Two pesticides were detected at very low levels in two of the site soil samples.

The pesticides 4,4′-DDE and 4,4′-DDT were each solely detected in soil samples SS-44D (4,4′-DDE @ 4.5 ppb) and M05-1 (4,4′-DDE @ 5.6 ppb) at very low levels. Sample SS-44D was a surface soil sample collected above Tank 44 in the south-central portion of the site. Subsurface soil M05-1 was collected from 16 to 18 feet below grade at the depth of the water table from boring M-5 drilled in the eastern corner of the site. The concentrations of both of these pesticides were reported as estimated ("J" qualifier) by the laboratory.

Inorganic Analytes

Seven (7) soil samples were collected from seven (7) locations across the site and analyzed for the TAL inorganic analytes (includes metals and cyanide). Another twenty-six (26) surface soil samples were collected from sixteen (16) locations and analyzed for lead. To evaluate the inorganic compound soil sample

data, analyte levels were compared to analyte levels detected in background soil samples. The background inorganic analyte soil levels used in the soil assessment are provided in Table 4-6.

Summaries of those soil samples whose inorganic analyte concentrations exceeded the established background levels along with the specific inorganic analytes whose background levels were exceeded in the soil samples are included in Tables 4-21 and 4-22. Upon reviewing the summary tables and the soil sample analyses results, the following observations can be made:

- Of the seven (7) locations across the site from which a soil sample was collected for TAL inorganic analyses, at least one of the established background analyte levels was exceeded at five (5) of the locations. All five of these locations were subsurface soil sample locations.

- Of the twenty-four (24) inorganic TAL analytes, nineteen (19) were detected in soil samples collected from the site, and six (6) (arsenic, cobalt, iron, manganese, nickel, and antimony) were detected at levels greater than background.

- Of the sixteen (16) locations across the site from which surface soil samples were collected and analyzed for lead, none had lead levels detected above the established soil background level of 315 ppm. The highest lead level detected in the soil was 68 ppm.

- Those inorganic analytes which exceeded the established background soil levels in numerous (i.e. greater than 50%) soil samples collected for inorganic analyses are cobalt (57%), iron (57%), and antimony (71%).

- Those inorganic analytes which exceeded the established background soil levels in many (i.e. 10%-50%) of the soil samples collected for inorganic analyses are arsenic (43%), manganese (14%), and nickel (43%).

The above information indicates that inorganic analytes above established background levels were detected in several of the site soil samples. However, most of those analytes were detected at

concentrations only slightly above (1 to 7 ppm) the established background levels. The concentrations reported for some of these analytes (arsenic, cobalt, and antimony) were also estimated values ("J" qualifier) below the sample quantitation limit but greater than zero. Iron was the only analyte detected at concentrations significantly above the established background level of 29,400 ppm. All of the soil samples (including all twenty-six surface soil samples) contained lead levels (ranging from 4 to 68 ppm) significantly below the established soil background level of 315 ppm. No signs of contamination (e.g., staining, odors) were observed in surface soil sample SS-2, which had the highest lead level (68 ppm), or in any of the other soil samples collected from the site. Given these observations, there does not appear to be significant inorganic analyte contamination of the soils on the site.

Total Petroleum Hydrocarbons (TPH)

Twenty-nine (29) soil samples (not including duplicate samples) were collected from seventeen (17) location across the site and analyzed for total petroleum hydrocarbons (TPH). Levels of TPH were detected in all but one of the soil samples. The detected TPH levels ranged from 3 ppm to 270 ppm. The highest TPH concentrations were detected in the duplicate sample of subsurface soil sample M01-1 (160 ppm), collected from 2 to 4 feet below grade at the depth of the ground water table, and surface soil sample SS-2 (270 ppm) collected adjacent to the on-site oil/water separator.

Not including the TPH concentrations detected in these two soil samples, the average TPH concentration detected in the soil samples was approximately 26 ppm. No signs of contamination (e.g., odors, stains) were observed during the collection of these samples or any other of the site soil samples. Sample locations at which TPH concentrations exceeded 50 ppm are shown on Figure 4-31.

4.5.2 Ground Water Assessment

This section of the report provides an assessment of the Tank Farm Four ground water sample analytical results and a discussion on the nature and extent of ground water contamination at the site. Under this investigation, a total of eight (8) wells were installed at five locations on the site (MW-1 through MW-5). Overburden and bedrock well nests were installed at three of the locations (MW-1, MW-3 and MW-5). Well locations are provided on Figure 2-22. Ground water samples were collected from each of the wells. Two wells installed previously at the site (MW-10, and MW-11) were also sampled under this investigation. The ground water samples were analyzed for all of the TCL and TAL parameters, with the exception of the sample from well MW-4S, which was only analyzed for TCL organics and pesticides/PCBs.

As discussed in the site-specific hydrogeology section (Section 3.5) of this report, the site ground water flow is flowing to the southwest, towards Normans Brook. Below is a discussion of the ground water sample results.

Volatile Organic Compounds (VOCs)

The ground water sample results indicate the absence of volatile organic compound (VOC) contamination in site ground water. The presence of methylene chloride and acetone in the samples was qualified as undetected ("U") and, therefore, these compounds are not considered in this assessment. No other VOCs were detected in the ten wells sampled. As discussed in Section 4.5.1, soil VOC contamination was also relatively absent at this site, with only two VOCs detected at levels less than or equal to 2 ppb in soil samples collected at the water table.

Base Neutral/Acid Extractable Organic Compounds (BNAs)

The ground water sample results also indicate the relative absence of BNAs in the site ground water. BNAs were detected in two (MW-2S, and MW-5D) of the nine well samples analyzed for BNAs. None of the BNAs detected exceeded any ground water action levels established for BNAs.

The BNAs detected in the two ground water samples consisted entirely of bis(2-ethylhexyl)phthalate. Bis(2-ethylhexyl)phthalate is a common laboratory contaminant but it was not detected in the laboratory blanks associated with these samples. As discussed in the Data Validation Summary in Appendix M, it is reported at estimated ("J") concentrations due to the fact that these two samples were re-extracted outside of holding times. The highest level of bis(2-ethylhexyl)phthalate (30 ppb) was detected in the ground water sample collected from well MW-2S, located in the

southwestern portion of the site. It was detected at 18 ppb in the ground water sample from well MW-5D.

As presented in Section 4.5.1, the highest level of total BNAs detected in the soil was detected in a sample collected from the well boring for well MW-4. The BNAs detected in this soil sample consisted entirely of di-n-butylphthalate. Bis(2-ethylhexyl)phthalate was detected in the laboratory blanks associated with the soil samples and, therefore, it was qualified as undetected ("U") in subsurface soil samples. No BNAs were detected in soil samples collected from the well borings for wells MW-2 or MW-5. While BNAs generally were not detected in soil samples, total petroleum hydrocarbons were extensively detected in surface and near surface soil samples (see Section 4.5.1).

Low level BNA ground water contamination appears to be limited to the presence of bis(2-ethylhexyl)phthalate in two wells (MW-2S and MW-5D) on the site. Soil boring sample analytical results and the fact that this compound is a common laboratory contaminant bring into question the actual presence of this compound in the ground water.

Pesticide and PCB Compounds

The ground water sample results indicate the absence of pesticides and PCBs in the ground water at this site. No pesticides or PCBs were detected in any of the site ground water samples.

Inorganic Analytes

The inorganic ground water sample results indicate the presence of numerous inorganic analytes in ground water samples collected at the site. Inorganic analytes were detected in each of the well samples analyzed for inorganics. Table 4-23 provides a summary of the inorganic analytes whose ground water action levels were exceeded, the well locations at which the exceedances were measured, and the associated action levels. Upon reviewing the ground water inorganic data provided in Appendix M and the summary table, the following observations can be made:

- Nine (9) inorganic analytes were detected at levels exceeding action levels in at least one of the ground water samples.
- In the on-site, upgradient shallow well (MW-5S), the inorganics detected at levels exceeding action levels include aluminum (57,900 ppb), beryllium (7.2 ppb), cadmium (8.5 ppb), chromium (213 ppb), iron (87,900 ppb), manganese (11,500 ppb), nickel (447 ppb), and lead (136 ppb).
- In the on-site, upgradient deep well (MW-5D), the inorganics detected at levels exceeding action levels include iron (19,000 ppb), and manganese (1,200 ppb).
- One inorganic analyte, manganese, was detected in each ground water sample (i.e., 100%) at levels exceeding action levels. It was not detected at levels exceeding the associated shallow ground water background level in any of the five shallow ground water samples. The deep background level was exceeded in each of the other deep monitoring wells (1,570 ppb at MW-1D, 2,260 ppb at MW-3D).
- Those inorganic analytes which exceeded the established action levels in 50-99% of the ground water samples are aluminum (78%), iron (89%), and lead (56%). Aluminum and iron were detected at levels exceeding action levels in deep ground water samples as well as in shallow samples.
- Those inorganic analytes which exceeded the established action levels in less than 50% of the ground water samples

are arsenic (22%), beryllium (33%), cadmium (22%), chromium (33%), and nickel (33%).

The distribution of inorganics at levels exceeding action and background levels within the on-site monitoring wells can be summarized as follows:

- The highest levels of the nine (9) analytes detected in ground water samples at levels exceeding background levels (MW-5S) were detected in monitoring wells MW-2 and MW-3S. Wells MW-2, MW-3S and background well MW-5S all contained lead at levels greater than 10 times action levels (see Figure 4-32).

- In the on-site deep wells (MW-1D and MW-3D), inorganics detected at levels exceeding background levels (MW-5D) were limited to aluminum and/or manganese (see Figure 4-33). The level of iron detected in well MW-5D was not exceeded in any other deep well.

Therefore, the greatest amount of shallow inorganic ground water contamination was detected east to west (MW-5 to MW-3 to MW-2), along the central portion of the site. In the deep ground water, inorganic contamination was not extensive but aluminum, iron and manganese were consistently detected at levels exceeding action levels in all three deep wells and may be indicative of general water quality in the area. Significant inorganic soil contamination was not detected in soil samples from Tank Farm Four, as discussed in Section 4.5.1. Background ground water quality, as indicated by ground water quality in wells MW-5S and MW-5D, does not meet all drinking water criteria and, in particular, has elevated levels of aluminum (MW-5S), beryllium (MW-5S), cadmium (MW-5S), chromium (MW-5S), iron (MW-5S and MW-5D), manganese (MW-5S and MW-5D), nickel (MW-5S) and lead (MW-5S).

4.5.3 Surface Water and Sediment Assessment

This section of the report provides an assessment of the Tank Farm Four sediment and surface water sample analytical results. The assessment includes information on the nature and extent of sediment and surface water contamination within Normans Brook which traverses through the southwestern corner of the site. As discussed in the introduction to Section 4.0, to aid in evaluating the data, contaminant-comparison and/or background levels were established for VOCs, BNAs, PCBs, and inorganics in soil/sediment samples. State and Federal surface water quality criteria were used to evaluate surface water contaminant levels.

A total of twelve (12) sediment samples were collected from six locations within Normans Brook. At each sediment sample location, two samples were collected. One sample was collected from the 0-1 foot interval, while the second sample was collected from the 1-2 foot interval. A total of four (4) surface water samples were collected from Normans Brook. The surface water samples were collected prior to the collection of any sediment samples. A surface water sample (W-2) was also collected from an outfall pipe which appeared to drain from the ruins which were investigated at this site (see Section 2-10). All of the sediment samples and surface water samples were analyzed for all of the TCL and TAL parameters, except for surface water sample W-2, which was not analyzed for pesticides/PCBs. A discussion of the sample locations and the field measurements and observations made during the sediment and surface water sampling activities is presented in

Section 2.8.2. Tables containing the analytical results for the sediment and surface water samples are presented in Appendix M.

Volatile Organic Compounds (VOCs)

All of the sediment samples and surface water samples were analyzed for TCL volatile organic compounds (VOCs). To evaluate the sediment sample VOC data, the contaminant-comparison level of 1 ppm for total volatile organic compounds in soil was used. To evaluate the surface water sample VOC data, State and Federal surface water quality criteria was used.

As discussed in the Data Validation Summary presented in Appendix M, the validation of the data resulted in the qualification of sediment and surface water sample data based upon laboratory blank contamination and other data quality control criteria. At this site, the detected levels of methylene chloride and acetone in the sediment and surface water samples were qualified as undetected ("U" qualifier). These qualified levels are not considered in the site sediment and surface water contamination assessment. Also, most of the detected levels of carbon disulfide were qualified as "U" due to blank contamination. In surface water samples SW-1 and W-2 and in sediment samples SD3-2, however,the concentrations of carbon disulfide were considered to be real.

A total of thirty-four (34) TCL VOCs were analyzed for in each of the sediment and surface water samples. Only one of these VOCs, carbon disulfide, was detected in one sediment sample, while two

VOCs, carbon disulfide and carbon tetrachloride, were detected in surface water samples. Carbon disulfide was detected in sediment sample SD3-2, collected from the 1-2 foot interval, at 21 ppb. As shown in Table 4-25, none of the total VOCs levels detected in the site sediment samples exceeded the 1 ppm total VOC comparison level. Three of the surface water samples contained detectable levels of VOCs. Carbon disulfide was detected in surface water samples SW-1 and W-2 at concentrations of 26 ppb and 4 ppb, respectively. Carbon tetrachloride was detected in surface water sample SW-4 at a concentration of 3 ppb. The concentrations of both of these VOCs detected in the surface water samples were reported as estimated ("J" qualifier) based on data validation. Carbon disulfide was also detected in the laboratory blank associated with the surface water and sediment samples, but at a level too low to negate these results. The concentration of carbon tetrachloride detected at SW-4 is well below the water quality criteria chronic guideline of 30 ppb established by the RIDEM. No guidelines have been established for carbon disulfide.

Base Neutral/Acid Extractable Organic Compounds (BNAs)

All of the sediment and surface water samples were analyzed for TCL BNA compounds. To evaluate the sediment sample BNA data, the contaminant-comparison level of 10 ppm for total BNAs in soil was used. In addition to using the contaminant-comparison level for total BNAs, the contaminant-comparison levels of 10 ppm and 1 ppm were used for total polynuclear aromatic hydrocarbons (PAHs)

and total carcinogenic PAHs, respectively. To evaluate the surface water sample BNA data, State and Federal surface water quality criteria was used.

As discussed in Appendix M, the findings of the data validation indicated that very low levels of bis(2-ethylhexyl)phthalate was detected in the laboratory method blanks. Therefore, the associated detected sediment and surface water sample concentrations for this compound have been qualified as undetected ("U"). Based on these findings, this compound will not be considered in the site sediment and surface water contamination assessment.

A total of sixty-five (65) BNAs were analyzed for in each sediment and surface water sample collected for TCL BNA analysis. Of the sixty-five TCL BNAs, three (3) were detected in sediment samples while none were detected in the surface water samples. Benzoic acid was detected in three sediment samples (SD1-2, SD7-1 (which is a duplicate of SD2-1), and SD4-2) at estimated ("J" qualifier) concentrations ranging from 110 to 250 ppb. 1,2-dichlorobenzene was detected in one sediment sample (SD4-2) at an estimated ("J" qualifier) concentration of 270 ppb. Di-n-butylphthalate, which was not present in the trip or field blanks, was detected in one sediment sample (SD7-1, duplicate of SD2-1) at a concentration of 670 ppb.

Upon comparing the established soil contaminant-comparison level of 10 ppm for total BNAs to the sediment sample results, none of the sediment samples had detected concentrations of total BNAs

greater than the 10 ppm. The sample with the highest total BNA concentration was SD7-1 at a concentration of 780 ppb, well below the established soil contaminant-comparison level. Sample SD7-1 is a duplicate of sediment sample SD2-1, which contained no detectable levels of BNA compounds.

Pesticide and PCB Compounds

All of the sediment and surface water samples collected (except for surface water sample W-2) were analyzed for TCL pesticides and PCB compounds. No PCBs were detected in any of the sediment of surface water samples. One pesticide was detected at very low levels in three of the site sediment samples, while no pesticides were detected in the surface water samples.

The pesticide 4,4'-DDT was detected in sediment sample SD3-2 at 5.9 ppb, SD4-1 at 2.8 ppb, and SD4-2 at 5.3 ppb. The concentrations for each of these samples were reported as estimated ("J" qualifier) by the laboratory.

Inorganic Analytes

All of the sediment and surface water samples collected from the site were analyzed for the TAL inorganic analytes (including metals and cyanide). To evaluate the sediment sample inorganic analyte data, detected analyte levels were compared to analyte levels detected in background soil samples. The background inorganic analyte soil levels used in the soil assessment are provided in Table 4-6. To evaluate the surface water sample

inorganic analyte data, State and Federal surface water quality criteria was used.

Summaries of those sediment samples whose inorganic analyte concentrations exceeded the established background levels along with the specific inorganic analytes whose background levels were exceeded in the sediment samples are included in Table 4-25. Upon reviewing the summary tables and sediment sample analyses results, the following observations can be made:

- Of the six (6) locations within Normans Brook from which a sediment sample was collected for TAL inorganic analyses, at least one of the established background analyte levels was exceeded at four (4) locations.
- Of the twenty-four (24) inorganic TAL analytes, sixteen (16) were detected in sediment samples collected from the brook, and three (3) (arsenic, cobalt, and iron) were detected at levels greater than background.
- Arsenic was detected above established background soil levels in 17% of the sediment samples, cobalt was detected above established background soil levels in 42% of the sediment samples and iron was detected above established background soil levels in 42% of the sediment samples.
- In general, higher concentrations of inorganic analytes were detected in the 0-1 foot sediment sample interval than the 1-2 foot interval.

The above information indicates that a few inorganic analytes were detected above established background levels in several of the sediment samples collected from the brook. However, the detected levels of arsenic and cobalt were only slightly above (1 to 10 ppm) the established soil background levels. The concentrations reported for these two analytes were also estimated values ("J" qualifier) below the sample quantitation limit but greater than zero. Iron was the only analyte detected at concentrations

significantly above the established background level of 29,400 ppm. The only observable trend of inorganic contamination in sediment samples collected at Tank Farm Four is that higher concentrations were generally detected in the 0-1 foot sample interval than in the 1-2 foot interval.

Summaries of those surface water samples whose inorganic analyte concentrations exceeded the established State or Federal ambient water quality criteria, along with the specific inorganic analytes whose water quality criteria were exceeded in the surface water samples are included in Table 4-24. Both acute and chronic surface water quality criteria are provided in the table. Some of the criteria are based on the hardness of the surface water; therefore, for a number of the inorganic analytes detected in the surface water, the acute and chronic criteria were calculated using an assumed hardness value for the surface water of 100 ppm as $CaCO_3$.

Upon a review of Table 4-24, only three of the detected inorganic analytes exceeded established ambient water quality criteria. Both cadmium and lead were detected at levels which only exceeded the chronic criteria, while zinc exceeded both the acute and chronic criteria. Cadmium was detected above the established water quality criteria in surface water sample SW-4, at an estimated ("J" qualifier) concentration of 3.3 ppb. Surface water sample SW-4 is located directly downstream of an outfall pipe, although no cadmium was detected in the sample (W-2) collected from this outfall. No inorganic analytes were detected at levels

exceeding water quality criteria in sample W-2. Both lead and zinc were detected above the ambient water quality criteria in surface water sample SW-1 located furthest downstream and off-site, near Narragansett Bay. For those inorganic analytes detected in surface water samples in Normans Brook, the highest levels were detected in surface water sample SW-1, with the exception of cadmium, chromium, and selenium. Given that this sample location is at the mouth of the brook as it enters Narragansett Bay and is tidally influenced, the elevated inorganic analytes may be related to a source in the bay and not the Tank Farm. At the time that surface water sample SW-1 was collected, the water in the brook was at a relatively low flow period at the sampling location due to the change of tide. The lowest levels of inorganic analytes were detected in surface water sample SW-6, located furthest upstream and off-site. The two surface water samples collected on-site contained relatively similar concentrations of inorganic analytes.

4.5.4 Structure Assessment

This section of the report provides an assessment of the Tank Farm Four structure sample analytical results. The assessment includes information on the nature of contamination detected in the soil/sediment, sludge and/or water samples collected from the oil/water (o/w) separator and the ruins of an unknown structure identified on-site. As discussed in the introduction to Section 4.0, to aid in evaluating the data, contaminant-comparison and/or background levels were established for VOCs, BNAs, PCBs, and

inorganics. Federal and State surface water quality criteria were used to evaluate water sample data, where appropriate.

One (1) soil sample, one (1) sludge sample, and one (1) water sample were collected from within the o/w separator located at Tank Farm Four. Sample S-1 was a composite soil sample collected from the fill material sampled over the 0-3.5 foot interval within the western-most chamber of the o/w separator, while sample S-2 was a discrete sample of a black, tar-like sludge material collected from the opposite end of the o/w separator. The one (1) water sample was collected from the center section of the o/w separator. One (1) sediment/soil sample and one (1) water sample were also collected from the on-site ruins. The soil/sediment sample (S-3) was collected from beneath water in the southern chamber of the ruins structure. The water sample (W-2) was collected from a pipe which appeared to be connected to the ruins. This sample is addressed in the sediment and surface water contamination assessment (Section 4.4.4) since the water discharging from the pipe flows into Normans Brook. The soil/sediment, sludge and water samples were analyzed for all of the TCL and TAL parameters. A discussion of the sample locations and the field measurements and observations made during the structure sampling activities is presented in Section 2.10.1. Tables containing the analytical results for the soil/sediment, sludge, and water samples are presented in Appendix M.

Volatile Organic Compounds (VOCs)

All of the soil/sediment, sludge and water samples were analyzed for TCL volatile organic compounds (VOCs). To evaluate the soil/sediment and sludge sample VOC data, the contaminant-comparison level of 1 ppm for total volatile organic compounds soil was used.

As discussed in the Data Validation Summary presented in Appendix M, the validation of the data resulted in the qualification of soil/sediment, sludge, and water sample data based upon laboratory blank contamination and other data quality control criteria. At this site, the detected levels of methylene chloride and acetone in the soil/sediment, sludge, and water samples were qualified as undetected ("U" qualifier). These qualified levels are not considered in the site soil/sediment, sludge, and water contamination assessment.

A total of thirty-four (34) TCL VOCs were analyzed for in each of the soil, sludge, and water samples. Only three of these VOCs, toluene, tetrachloroethene, and carbon disulfide, were detected in soil/sediment and sludge samples. No VOCs were detected in the water sample. The soil sample collected from the o/w separator (S-1) contained a detectable level (1 ppb) of carbon disulfide, while the sludge sample (S-2) contained toluene at 6 ppb, both at estimated ("J) levels. The soil/sediment sample from the ruins contained 680 ppb tetrachloroethene. This sample had visible signs of petroleum-related contamination (e.g., odor, sheen). None of

the total VOCs levels detected in the soil/sediment or sludge samples exceeded the 1 ppm total VOC comparison level.

Base Neutral/Acid Extractable Organic Compounds (BNAs)

All of the soil/sediment, sludge, and water samples were analyzed for TCL BNA compounds. To evaluate the BNA data, the contaminant-comparison level of 10 ppm for total BNA in soil was used. In addition to using a contaminant-comparison level for total BNAs, contaminant-comparison levels of 10 ppm and 1 ppm were used for total polynuclear aromatic hydrocarbons (PAHs) and total carcinogenic PAHs, respectively.

As discussed in Appendix M, the finding of the data validation indicated that bis(2-ethylhexyl)phthalate and di-n-butylphthalate were detected in the laboratory method blanks associated with the ruins sample only. Therefore, the associated detected soil/sediment sample concentrations in S-3 have been qualified as undetected ("U"). Detected levels of these compounds in soil and sludge samples S-1 and S-2, however, are considered real and will be considered in this assessment.

A total of sixty-five (65) BNAs were analyzed for in each soil/sediment, sludge, and water sample collected for TCL BNA analysis. Of the sixty-five TCL BNAs, thirteen (13) were detected in soil/sediment or sludge samples, while none were detected in the water sample. Phenol and di-n-butylphthalate were the only BNA compounds detected in the soil sample (S-1) from the o/w separator. Four BNA compounds, including bis(2-ethylhexyl)phthalate,

phenanthrene, pyrene, and chrysene, were detected in the sludge sample (S-2). Eleven BNA compounds were detected in the soil/sediment sample collected from the ruins structure.

Upon comparing the established soil contaminant-comparison level of 10 ppm for total BNAs to the soil/sediment and sludge sample results, the sludge sample was the only sample with detected concentrations of total BNAs (29.7 ppm) greater than the 10 ppm. The total BNA concentration consisted of 22.9 ppm total PAHs. The total carcinogenic PAH level for this sample was 9.6 ppm, exceeding the contaminant-comparison level of 1 ppm. The soil/sediment sample collected from the ruins had a total BNA concentration (2.2 ppm) greater than 1 ppm, with the majority of that concentration consisting of PAHs (2.1 ppm). Soil sample S-1 had less than 1 ppm total BNAs and no detectable level of PAHs.

Pesticide and PCB Compounds

All of the soil/sediment, sludge and water samples collected were analyzed for TCL pesticides and PCB compounds. No pesticides were detected in any of the soil/sediment or water samples. The presence of Aroclor 1260, a PCB compound, was qualified in sludge sample S-2 on the basis of data validation. During validation, it was determined that the chromatogram for the Aroclor 1260 standard did not match the sample chromatogram and, therefore, the reported concentration was qualified as undetected ("U"). Aroclor 1260 was detected in soil sample collected from the o/w separator (S-1) at 12 ppb. This value is well below the associated action level of 1

ppm. No PCBs were detected in the structure water sample or ruins soil/sediment sample (S-3).

Inorganic Analytes

All of the soil/sediment, sludge and water samples collected from the site were analyzed for the TAL inorganic analytes (metals and cyanide). To evaluate the soil/sediment and sludge sample inorganic analyte data, detected analyte levels were compared to analyte levels detected in background soil samples. The background inorganic analyte soil levels used in the soil assessment are provided in Table 4-6. To evaluate the surface water sample inorganic analyte data, State and Federal surface water quality criteria were used.

As discussed in the Data Validation Summary presented in Appendix M, the validation of the data resulted in the qualification of soil/sediment and sludge sample data based upon laboratory blank contamination and other data quality control criteria. At this site, the detected levels of arsenic, barium, cobalt, chromium, copper, sodium, nickel, silver, vanadium and zinc in the soil and sludge samples from the o/w separator and detected levels of antimony, barium, cobalt, copper, potassium, sodium, nickel, vanadium and zinc in the soil/sediment sample from the ruins were qualified as undetected ("U" qualifier). These qualified levels are not considered in the site soil/sediment and sludge contamination assessment.

Upon reviewing the soil/sediment and sludge sample analytical results, the following observations can be made:

- Of the three (3) soil/sediment and sludge samples collected for TAL inorganic analyses, the established background analyte levels were exceeded at only one (1) location (S-3), the soil/sediment sample location at the ruins structure.
- Of the twenty-four (24) inorganic TAL analytes, fifteen (15) were detected in the soil/sediment and sludge samples collected and two (cobalt and iron) were detected at levels greater than background (only in the ruins soil/sediment sample S-3).

The above information indicates that two inorganic analytes were detected above established background levels and only in the soil/sediment sample collected from the ruins. The detected level of cobalt was only slightly (4.3 ppm) above the established background level. The concentration reported for this analyte was also estimated ("J" qualifier) below the sample quantitation limit but greater than zero. Iron was the only analyte detected at concentrations significantly above the established background level of 29,400 ppm.

Both acute and chronic surface water quality criteria are provided in Table 4-24. For a number of the inorganic analytes, the acute and chronic criteria were calculated using an assumed hardness value for the surface water of 100 ppm as $CaCO_3$. Upon review of the water sample analytical data, only two inorganic analytes exceeded established ambient water quality criteria. Lead was detected in the water sample at a level which only exceeded the chronic criteria, while zinc exceeded both the acute and chronic criteria. Lead was detected above the established water quality

criteria in water sample W-1 at a concentration of 3.8 ppb, while zinc was detected at a level of 1,190 ppb.

4.5.5 Underground Storage Tank Assessment

This section of the report provides an assessment of the Tank Farm Four underground storage tank sample analytical results. Under this investigation, samples were collected from the twelve (12) USTs located on the site. The locations of the tanks are shown on Figure 1-18. The field observations and measurements relating to the tank sampling are provided in Section 2.9.1. The physical characteristics of the tank contents are provided in Table 2-22. All of the tank oil samples were analyzed for the TCL (less pesticides) and TAL parameters. The tank water samples were analyzed for the TCL (less pesticides/PCBs) and TAL parameters. Several of the oil samples were also analyzed for EP Toxicity and by the TCLP. Tables containing the analytical results for the tank samples are provided in Appendix M.

Volatile Organic Compounds (VOCs)

The tank sample results indicate the presence of volatile organic compounds (VOCs) in the tanks contents. The presence of methylene chloride and acetone in the oil and water samples was qualified as undetected ("U") as a result of laboratory blank contamination and therefore, these compounds are not considered in this assessment. Other VOCs detected in the oil sample from tank 39 were rejected in data validation on the basis of GC/MS tuning

criteria. Several VOCs were detected in the oil samples at very elevated levels. Those VOCs detected in the oil samples include benzene, toluene, ethylbenzene, and xylene. VOCs were also detected in tank water sample at high levels. The VOCs detected in the water samples included those detected in the oil samples and several others.

VOCs were detected at total VOC levels greater than 10 ppm in the oil samples collected from Tanks 37, 38, 40, 41, 43, 44, 47, and 48. The reason VOCs were not detected in the oil samples from Tanks 42, 45, and 46, is likely due to the fact that these samples had higher analytical detection limits (42 to 50 ppm) for the individual VOCs (benzene, toluene, ethylbenzene, and xylene) than the other oil samples. The oil samples collected from Tanks 38, 40, and 44 had total VOC levels greater than 100 ppm. The highest total VOC level (288 ppm) was detected in the oil sample collected from Tank 40. The Tank 40 sample was collected from oil which had flowed up into the pump house; the oil had a olive-green black color, different from the black oil sampled in the other tanks.

VOCs were detected in all of the water samples. Detected total VOC concentrations ranged from 13 to 346 ppb in the water samples. The primary VOCs detected in the water samples included the same VOCs detected in the oil samples (i.e., benzene, toluene, ethylbenzene, and xylene). VOCs were detected at total VOC levels greater than 100 ppb in the water samples collected from Tanks 38, 39, 43, 44, 47, and 48. The highest total VOC level (346 ppb) was detected in the water sample from Tank 38; the total VOC

concentration consisted mainly of xylene. The oil sample collected from this tank had one of the highest total VOC and xylene levels detected in the tank oil samples.

EP Toxicity and TCLP extractions and analyses were also performed on several of the oil samples. The EP Toxicity tests for metals, pesticides, and herbicides were performed on oil samples from Tanks 43, 44, 47, and 48. None of the EP Toxicity compounds were detected in any of these oil samples. A TCL/TAL analysis was performed on the TCLP extraction leachate of the oil sample from Tank 44. The results of this analysis show low levels of toluene (44 ppb), ethylbenzene (15 ppb), and xylene (75 ppb). These VOC levels were generally lower than those detected in the water sample from this tank. A TCL/TAL analysis of the TCLP extraction leachate of the oil sample from Tank 40 showed similar concentrations for toluene (57 ppb), ethylbenzene (21 ppb), and xylene (90 ppb). Benzene was also detected in this sample at 24 ppb.

Base Neutral and Acid Extractable Organic Compounds (BNAs)

BNAs were detected in all of the oil and water samples collected from the tanks. The BNAs consisted primarily of PAHs. Those PAHs frequently detected in the oil samples include naphthalene, 2-methylnaphthalene, fluorene, and phenanthrene. The highest total BNA levels (all > 1,500 ppm) were detected in oil samples from tanks 38, 39, 40, and 44. The highest total BNA concentration (4,380 ppm) was detected in the oil sample collected from Tank 40. The TCLP leachate TCL analyses results show the same

PAHs that were detected in the oil sample, but at much lower concentrations (2 - 36 ppb). Several phenolic compounds were also detected in the oil sample having the TCLP extraction.

The BNAs detected in the water samples included the same PAHs detected in the oil samples and several other additional compounds. The additional compounds included several phenols (those detected in the TCLP oil leachate), dibenzofuran, and phthalate esters. The BNAs detected at the highest levels in the water samples were those same PAHs (naphthalene and 2-methylnaphthalene) typically detected at the highest levels in the oil samples. Those water samples having the highest total PAH concentrations (all > 150 ppb) were collected from Tanks 37, 38, 43, 44, and 47. The water sample having the highest total BNA concentration (202 ppb) was collected from Tank 43. A water sample could not be collected from Tank 40, the tank from which the oil sample with the highest total BNA level was collected.

Pesticide and PCB Compounds

No PCBs were detected in any of the oil samples. The PCB Aroclor detection limits for the oil samples ranged from 12 to 24 ppm. The oil samples were not analyzed for pesticides. The water samples were not analyzed for pesticides or PCBs.

Inorganic Analytes

Inorganic analytes were detected in all of the tank oil and water samples. More analytes were detected in the water samples

than the oil samples. The inorganic analytes detected in a majority (at least 50%) of the oil samples were iron, lead, and zinc. The inorganic analytes detected in a majority (at least 50%) of the water samples were barium, calcium, iron, potassium, magnesium, manganese, sodium, lead, and zinc. The analytes detected in the oil samples but not the water samples were silver, arsenic, nickel, and vanadium. Analytes detected in the water samples and not the oil samples were aluminum, beryllium (1 sample), cadmium (1 sample), and cyanide (1 sample). The analyte concentrations detected in the water samples were typically higher than those detected in the oil samples.

The TCLP extraction procedure was also performed on oil samples collected from Tanks 40 and 44, and the resulting leachates were analyzed for TAL metals. Those leachate sample results are presented next to the CLP method extract analysis results in the data tables in Appendix M. The inorganic levels in the TCLP leachate extract were much lower than those detected in the CLP method extract. Many inorganic analytes were detected in these leachate samples at low concentrations (ppb). Those inorganic analytes detected in the TCLP extracts of the oil sample from Tank 44 which were not detected in the CLP method extracts include silver (0.007 ppm) and arsenic (12 ppm). The detected arsenic level (12 ppm) exceeds the federal maximum concentration for characterizing the oil as a hazardous waste (40 CFR, Part 261 Subpart C). Neither arsenic or silver were detected in any of the tank water samples.

4.6 Site 13 - Tank Farm Five

4.6.1 Soil Assessment

This section of the report provides an assessment of the Tank Farm Five soil sample analytical results. The assessment includes information on the nature and extent of soil contamination across the site. As discussed in the introduction to Section 4.0, to aid in evaluating the soil data, contaminant-comparison and/or background levels were established for the VOCs, BNAs, PCBs, and inorganic analytes.

A total of thirty-two (32) soil samples were collected from across the site through several field investigation techniques. Soil sample locations are shown on Figure 4-5. The investigation techniques included surface soil sampling and monitoring well boring sampling. The majority of the soil samples collected were surface soil samples which were analyzed for only total petroleum hydrocarbons and lead. A discussion of the sampling locations, the number of samples collected, and field measurements and observations made during all of the soil sampling activities is presented in Section 2.4 through 2.6. A summary of the soil samples collected from this site is provided in Table 4-5. Tables containing the analytical results for the soil samples are presented in Appendix M.

Volatile Organic Compounds (VOCs)

Of the thirty-two (32) soil samples collected for analyses at Tank Farm 5, only eight (8) soil samples were collected from eight locations across the site and analyzed for TCL volatile organic compounds. Volatile organic analyses were limited to the six monitoring well borings and two of the surface soil samples. To evaluate the volatile organic compound soil sample data, a contaminant-comparison level of 1 ppm for total volatile organic compounds in soil was established.

As discussed in the Data Validation Summary presented in Appendix M, validation of the data resulted in the qualification of soil sample data based upon laboratory blank contamination and other quality control criteria. At this site, the detected levels of methylene chloride and acetone in the soil samples were qualified as undetected ("U" qualifier). These qualified levels are not considered in the site soils contamination assessment.

A total of thirty-four (34) TCL VOCs were analyzed for in each of the soil samples collected for VOC analysis. A list of the TCL VOCs is provided in Table 2-1. Only three of these VOCs, tetrachloroethene (PCE), toluene, and xylene, were detected in soil samples collected from the site. One or all of these VOCs were detected in three soil samples (SS-56, SS-57, and M02-1). PCE was detected at very low concentrations (1 to 5 ppb) in all three of the soil samples. Toluene was detected at very low levels (2 and 3 ppb) in two of the soil samples. Xylene was detected at a very low concentration (2 ppb) in one of the soil samples. Two of the

samples were surface soil samples (SS-56 and SS-57) and one was a subsurface soil sample (M02-1) collected from 10 to 12 feet below grade at the depth of the ground water table. As shown in Tables 4-26 and 4-27, none of the total VOC levels detected in the site soil samples exceeded the 1 ppm total VOC comparison level. The highest level of total VOCs detected in the soil samples was 9 ppb in surface soil sample SS-57.

The significance of the trace VOC levels (low ppb) detected in the three soil samples is diminished even further when other factors are considered. All concentrations for PCE, toluene and xylene were reported as estimated ("J" qualifier) at levels below the detection limit (6 ppb). No odors or visible signs of contamination (e.g., staining, oil) were observed during sample collection. Toluene and PCE were each detected in a minimum of one field or trip blank collected at this site, although the blanks in which they were detected are not associated with these particular samples. Similar levels of both PCE and toluene were also detected in Tank Farm Four soil sample M04-1, which was analyzed in the same laboratory batch as Tank Farm Five sample M02-1, and the presence of these compounds is also considered suspect in that sample. Given consideration of these factors and the detected contaminant levels, these compounds are not considered to be significant contaminants in on-site soils.

Base Neutral/Acid Extractable Organic Compounds (BNAs)

Eight (8) soil samples were collected from eight locations across the site and analyzed for TCL base neutral/acid extractable organic compounds (BNAs). To evaluate the BNA soil data, a contaminant-comparison level of 10 ppm for total BNAs in soil was established. In addition to establishing a contaminant-comparison level for total BNAs, contaminant-comparison levels of 10 ppm and 1 ppm were established for total polynuclear aromatic hydrocarbons (PAHs) and total carcinogenic PAHs, respectively.

As discussed in Appendix M, the findings of the data validation indicated that very low levels of bis(2-ethylhexyl)phthalate were detected in laboratory method blanks. Therefore, the associated detected soil sample concentrations for this compound have been qualified as undetected ("U" qualifier). Based upon these findings, this compound will not be considered in the site soil contamination assessment.

A total of sixty-five (65) BNAs were analyzed for in each soil sample collected for TCL BNA analysis. A list of the TCL BNAs is provided in Table 2-1. Of the sixty-five TCL BNAs, twelve (12) were detected in the soil samples submitted for TCL BNA analysis. Of the twelve, one was eliminated from further consideration in the soil assessment for reasons explained previously. The remaining ten (10) BNAs which were detected in several samples, at elevated concentrations, and/or in other site media are considered "key" BNAs in the soil contamination assessment for this site.

Upon comparing the established contaminant-comparison level of 10 ppm for total BNAs to the soil sample analyses results, none of the soil samples had detected concentrations of total BNAs greater than 10 ppm. Only two samples (SS-56 and M05-1) had a concentration of total BNAs greater than 1 ppm. The total BNA concentration detected in sample M05-1 consisted entirely of phthalate esters (di-n-butylphthalate and butylbenzylphthalate) at a concentration of 4.6 ppm. Soil sample M05-1 was collected from well boring M-5 completed in the central portion of the tank farm between Tanks 51, 54, 55, and 56. The BNAs detected in soil sample SS-56 consisted of almost entirely of PAHs at a total BNA concentration of 1.3 ppm. Surface soil sample SS-56 was collected from above Tank 56 located in the west-central portion of the site.

Pesticide and PCB Compounds

Eight (8) soil samples were collected from eight locations across the site and analyzed for TCL pesticide and PCB compounds. No PCBs were detected in any of the site soil samples. Two pesticides were detected at low levels (10's of ppb) in three of the site soil samples.

The pesticides 4,4'-DDE and 4,4'-DDT were each detected in soil samples SS-56, SS-57, and M03-1 at low levels. Samples SS-56 and SS-57 are surface soil samples collected above Tanks 56 and 57 in the west-central and east-central portions of the site. Subsurface soil sample M03-1 was collected from 6 to 8 feet below grade (at the depth of the water table) from well boring M-3

completed in the northeastern area of the site. The concentrations of both of the pesticides were reported as estimated ("J" qualifier) in all but sample SS-56, where the 4,4'-DDT concentration (74 ppb) was not qualified.

Inorganic Analytes

Eight (8) soil samples were collected from eight locations across the site and analyzed for the TAL inorganic analytes (includes metals and cyanide). Another twenty-four (24) surface soil samples were collected from fifteen (15) locations and analyzed for lead. To evaluate the inorganic analyte soil sample data, detected analyte levels were compared to analyte levels detected in background soil samples. The background inorganic analyte soil levels used in this soil assessment are provided in Table 4-6.

Summaries of those soil samples whose inorganic analyte concentrations exceeded the established background levels along with the specific inorganic analytes whose background levels were exceeded in the soil samples are provided in Tables 4-26 and 4-27. Upon reviewing the summary tables and the soil sample analyses results, the following observations can be made:

- Of the eight (8) locations across the site from which samples were collected for TAL inorganic analyses, at least one of the established background analyte levels was exceeded at seven (7) of the sample locations.
- Of the twenty-four (24) inorganic TAL analytes, twenty-two (22) were detected in soil samples collected from the site, and ten (10) were detected at levels greater than background.

- Of the fifteen (15) locations across the site from which soil samples were collected and analyzed for lead, only the surface soil sample SS-01 collected adjacent to the oil/water separator had a lead level (370 ppm) greater than background (315 ppm).

- The only inorganic analyte which exceeded the established background soil levels in numerous (i.e., greater than 50%) soil samples collected for inorganic analyses is cobalt (63%).

- Those inorganic analytes which exceeded the established background levels in many (i.e., 10%-50%) of the soil samples collected for inorganic analyses are silver (13%), arsenic (38%), calcium (13%), iron (25%), mercury (25%), magnesium (13%), manganese (25%), nickel (13%), and antimony (25%).

The above information indicates that inorganic analytes above established background levels were detected in several of the site soil samples. Cobalt was detected most frequently in the soil samples at levels greater than background. The background level for cobalt (15 ppm) was exceeded in four subsurface soil samples and one surface soil sample. The highest level of cobalt (43 ppm) was detected in subsurface soil sample M03-1 collected from 6 to 8 feet below grade, at the depth of the water table. A level of cobalt greater than background was also detected in subsurface soil sample M01-1 collected from well boring M-1, completed in the far northern corner of the site. Arsenic was detected at levels greater than background (15 ppm) in three subsurface soil samples (M02-1 @ 23 ppm, M03-1 @ 24 ppm, and M04-1 @ 31 ppm). All three of these samples were collected at the depth of the water table. Mercury was detected at levels greater than background (1 ppm) in surface soil samples SS-56 (54 ppm) and SS-57 (2 ppm). Iron was detected at levels significantly above background in soil samples

M04-1 and M05-1. Lead was detected above background in surface soil sample SS-01 collected adjacent to the on-site oil/water separator.

Generally, most of those analytes detected above background were in the subsurface soil samples collected from the depth of the ground water table. Only mercury and/or cobalt were detected above background in the two surface soil samples analyzed for the TAL. None of the soil samples with analyte levels greater than background exhibited any signs of contamination (e.g., odors, staining). Only surface soil samples SS-50 (and its duplicate SS-60) and SS-50D, with levels of lead (29 to 61 ppm) below background, were visibly oily and/or had strong petroleum-like odors. These two surface soil samples were not analyzed for any other TAL analytes.

Total Petroleum Hydrocarbons (TPH)

Twenty-six (26) soil samples were collected from fifteen (15) locations across the site and analyzed for total petroleum hydrocarbons (TPH). Levels of TPH were detected in all but two of the soil samples. The detected TPH levels ranged from 4 ppm to 60,000 ppm. The highest TPH concentrations were detected in surface soil samples SS-50/SS-60 (duplicates at 14,000 ppm and 15,000 ppm, respectively) and SS-50D (60,000 ppm) collected from above Tank 50. Discrete surface soil sample SS-50D was collected from very oily soils, while sample SS-50 was a composite sample collected from in and around the visibly oily soils above this

tank. Significantly elevated levels (at or above 100 ppm) of TPH were also detected in surface soil samples SS-49, SS-51, and SS-55. None of these soil samples had visible signs of contamination (e.g., odor, stains, oil). Elevated levels (96 ppm) of TPH were also detected in one of the soil samples (SS-02) collected adjacent to the on-site oil/water separator. Sample locations where TPH concentrations exceeded 50 ppm are shown on Figure 4-34.

4.6.2 Ground Water Assessment

This section of the report provides an assessment of the Tank Farm Five ground water sample analytical results and a discussion on the nature and extent of ground water contamination at the site. Under this investigation, a total of six (6) wells were installed at six locations on the site (MW-1 through MW-6). All wells are screened in weathered bedrock, except for well MW-6 which is screened in till (overburden). Well locations are provided on Figure 2-23. Ground water samples were collected from each of the wells. Seven wells installed previously at the site (MW-53E, MW-53W, MW-56E, MW-56W, MW-86-1, MW-86-2 and MW-86-4) were also sampled under this investigation. All newly installed wells were sampled and analyzed for all of the TCL and TAL parameters, with the exceptions of the samples from well MW-4 (no pesticide/PCB or inorganic analyses) and well MW-5 (no pesticides/PCB analyses). The ground water samples collected from wells MW-53W and MW-56W were analyzed for all of the TCL and TAL parameters and total petroleum hydrocarbons (TPH), while the samples collected from

wells MW-53E, MW-56E, MW-86-1, MW-86-2, and MW-86-4 were analyzed only for TPH and lead.

As discussed in the site-specific hydrogeology section (Section 3.5) of this report, the site ground water flow varies across the site: in the southern end of the site, ground water is flowing to the west-northwest (directly towards Narragansett Bay), while in the northern portion of the site ground water is flowing towards Gomes Brook, which crosses the northern portion of the site. Below is a discussion of the ground water sample results.

Volatile Organic Compounds (VOCs)

The ground water sample results indicate the presence of volatile organic compounds (VOCs) in site ground water. The presence of methylene chloride and acetone in the samples was qualified as undetected ("U") and, therefore, these compounds are not considered in this assessment. Other volatile organic compounds were detected at low concentrations (3 to 17 ppb) in two of the newly installed wells. Higher concentrations of individual VOCs (ranging from 7 to 630 ppb) were detected in the ground water sample collected from pre-existing well MW-53W.

As shown in Table 4-28, VOCs were detected at levels exceeding established ground water action levels in only one of the on-site wells, MW-53W. Petroleum-related VOCs and chlorinated hydrocarbons were the main VOCs detected in this well, with 1,2-dichloroethane, 1,2-dichloroethene, trichloroethene (TCE), tetrachloroethene (PCE), ethylbenzene and xylene all detected at levels exceeding ground

water action levels. Chlorinated compounds were also detected in well MW-4, but at concentrations which were less than ground water action levels. Chloroform was the only VOC detected at well MW-5 and its concentration did not exceed any action levels. Figure 4-35 shows the extent of volatile organic compounds detected in the ground water, and also identifies the wells in which a petroleum product was observed (monitoring wells MW-53E and MW-53W).

As discussed in Section 4.6.1, VOCs were also relatively absent from the soil samples collected at Tank Farm Five. VOCs were detected in two surface soil samples and a subsurface soil sample collected from the boring for well MW-2. All detected VOC levels ranged from 1 to 5 ppb. No VOCs were detected in the soil sample collected from the boring for monitoring well MW-4. Elevated TPH levels were limited to surface soil samples.

The extent of VOC ground water contamination appears to be limited to the area near Tank 53, with petroleum product identified in both wells located adjacent to the tank. The presence of low levels of chlorinated hydrocarbons in downgradient well MW-4 indicates potential downgradient migration of the contamination associated with Tank 53.

Base Neutral/Acid Extractable Organic Compounds (BNAs)

The ground water sample results also indicate the relative absence of BNAs in the newly installed on-site wells, while 206 ppb total BNAs were detected in pre-existing well MW-53W. As described in the Data Validation Summary in Appendix M, detected levels of

bis(2-ethylhexyl)phthalate and di-n-butylphthalate were qualified as undetected ("U") and were not considered in this assessment. BNAs were not detected at levels exceeding ground water action levels in well MW-53W. The total BNA concentration consisted entirely of PAHs, with no carcinogenic PAHs detected.

As discussed in Section 4.6.1, BNAs were also relatively absent from the soil samples collected at Tank Farm Five. BNAs were detected at levels exceeding 1 ppm only in one surface soil sample and one subsurface soil sample collected from the boring for well MW-5.

The extent of BNA contamination appears to be limited to the area near Tank 53, where a petroleum product was identified in both MW-53W and MW-53E.

Pesticide and PCB Compounds

The ground water sample results indicate the absence of pesticides and PCBs in the ground water at this site. No pesticides or PCBs were detected in any of the site ground water samples analyzed for these compounds.

Inorganic Analytes

The inorganic ground water sample results indicate the presence of numerous inorganic analytes in ground water samples collected at the site. Inorganic analytes were detected in each of the well samples analyzed for inorganics. Table 4-28 provides a summary of the inorganic analytes whose ground water action levels

were exceeded, the well locations at which the exceedances were measured, and the associated action levels. Upon reviewing the ground water inorganic data provided in Appendix M and the summary table, the following observations can be made:

- Ten (10) inorganic analytes were detected at levels exceeding action levels in at least one of the ground water samples.

- In the on-site, upgradient well (MW-6), the inorganics detected at levels exceeding action levels include aluminum (88,000 ppb), beryllium (5.5 ppb), chromium (116 ppb), copper (297 ppb), iron (288,000 ppb), manganese (7,650 ppb), and lead (108 ppb). These levels are considered to be representative of background conditions in this assessment.

- Three inorganic analytes, aluminum, iron, and manganese, were detected in each ground water sample (i.e., 100%) at levels exceeding action levels. These analytes were detected at levels exceeding the associated background level at the following frequencies: aluminum - 50%, iron - 50%, and manganese - 33%.

- Those inorganic analytes which exceeded the established action levels in 50-99% of the ground water samples are beryllium (71%), chromium (57%), copper (86%), nickel (71%), and lead (92%). These analytes were also generally detected at levels exceeding background levels, with the exception of lead and copper which were detected at several locations at levels less than the background levels.

- Those inorganic analytes which exceeded the established action levels in less than 50% of the ground water samples are arsenic (43%), and cadmium (14%, 1 sample). Cadmium was not detected in the background sample.

The distribution of inorganics at levels exceeding action and background levels within the on-site monitoring wells can be summarized as follows:

- The highest levels of the ten (10) analytes detected in ground water samples at levels exceeding background levels (MW-6) were detected in monitoring wells MW-2, MW-3 and MW-5. Wells MW-2, MW-3 and/or MW-5 contained copper, nickel and/or lead at levels greater than 100 times action levels (see Figure 4-36).

Therefore, the greatest amount of shallow inorganic ground water contamination was detected in the central portion of the site, bounded by wells MW-2, MW-3 and MW-5, as indicated in Figure 4-36. Inorganic soil contaminants were detected at levels exceeding background levels in soil samples from Tank Farm Four, as discussed in Section 4.5.1, but the contamination was generally limited to cobalt, arsenic, and iron. Background ground water quality, as indicated by ground water quality in well MW-6 does not meet all drinking water criteria and, in particular, has elevated levels of aluminum, beryllium, chromium, copper, iron, manganese, and lead.

4.6.3 Surface Water and Sediment Assessment

This section of the report provides an assessment of the Tank Farm Five surface water and sediment sample analytical results. The assessment includes information on the nature and extent of sediment and surface water contamination within Gomes Brook which traverses through the northern portion of the site. As discussed in the introduction to Section 4.0, to aid in evaluating the data, contaminant-comparison and/or background levels were established for PCBs and inorganics.

A total of five (5) sediment samples and five (5) surface water samples were collected from Gomes Brook. The surface water samples were collected prior to the collection of any sediment samples. All five sediment samples were collected from the 0-1 foot interval and analyzed for PCBs, lead, and TPH. The five

surface water samples were also collected and analyzed for lead and TPH. A discussion of the sample locations and the field measurements and observations made during the sediment and surface water sampling activities is presented in Section 2.8.3. Tables containing the analytical results for the sediment and surface water samples are presented in Appendix M.

PCBs

All five of the sediment samples collected from Gomes Brook were analyzed for PCB compounds. No PCBs were detected in any of the site sediment samples. Detection limits for the PCBs ranged from 120 ppb to 730 ppb. None of the surface water samples were analyzed for PCBs.

Lead

All five of the sediment and surface water samples collected from Gomes Brook were analyzed for lead. To evaluate the sediment sample lead data, detected lead levels were compared to lead levels detected in background soil samples (see Table 4-6). A background level of 315 ppm has been established for lead in soil. All of the sediment samples contained lead levels (ranging from 4.2 to 155 ppm) significantly below the established soil background level of 315 ppm. The highest lead concentration was detected in the furthest upstream sediment sample (SD-5) located off-site. The highest lead concentration detected in an on-site sediment samples was at SD-4 (25.8 ppm), the furthest upstream sediment sample

location on-site. These results would indicate lead contamination in Gomes Brook may be attributable to an off-site source upstream. None of the surface water samples contained lead concentrations above the detection limit. A detection limit of 3 ppb for lead was reported for the five surface water samples.

No signs of contamination (e.g., odors, sheen) were observed in any of the sediment or surface water samples collected from the site. Given these observations, there does not appear to be significant lead contamination of the sediments or the surface water within Gomes Brook.

Total Petroleum Hydrocarbons (TPH)

All of the sediment and surface water samples were analyzed for total petroleum hydrocarbons (TPH). Levels of TPH were detected in all five of the sediment samples ranging from 13 to 220 ppm. The highest TPH concentrations were detected in the furthest downstream sediment sample (SD-1 at 220 ppm), located off-site, and at the furthest upstream sediment sample (SD-5 at 110 ppm), also located off-site. The average TPH concentrations at the remaining three sediment sample locations was approximately 28 ppm.

Review of the three on-site sediment sample results indicates that the concentration of TPH increases with distance downstream. The levels detected on-site were very similar to those detected in on-site surface soils (see Section 4.6.1). The lowest TPH concentration was detected at sediment sample SD-4 (13 ppm), while the highest on-site TPH concentration (41 ppm) was detected at

sediment sample SD-2. Evaluation of these samples alone could indicate that the site may be acting as a source of TPH contamination to Gomes Brook; however, the presence of 110 ppm in the upstream, off-site sediment sample (SD-5) suggests an off-site source. The elevated TPH level detected in the downstream, off-site sediment sample (SD-1) may be attributable to runoff from Defense Highway or the railroad tracks. The sample was collected directly beneath a railroad bridge and approximately 40 feet downstream of Defense Highway. Given that this sample location is located at the mouth of the brook as it enters Narragansett Bay and is tidally influenced, the elevated level of TPH may also be related to a current or historic source in the bay (e.g., oil spill, boating).

None of the surface water samples contained levels of TPH above the detection limit. A detection limit of 1 ppm TPH was reported for the five surface water samples.

4.6.4 Structure Assessment

This section of the report provides an assessment of the Tank Farm Five structure sample analytical results. The assessment includes information on the nature of contamination detected in the soil and water samples collected from the oil/water (o/w) separator identified on-site. As discussed in the introduction to Section 4.0, to aid in evaluating the data, contaminant-comparison and/or background levels were established for VOCs, BNAs, PCBs, and

inorganics. Federal and State surface water quality criteria were used to evaluate water sample data, where appropriate.

Two (2) soil samples and one (1) water sample were collected from within the o/w separator located at Tank Farm Five. Samples S-1 and S-2 were composite soil samples collected from the 0-5.5 foot interval within the chambers of the o/w separator. A duplicate of sample S-2 was collected and identified as S-3. The one (1) water sample was collected from the center section of the o/w separator. The soil and water samples were analyzed for all of the TCL and TAL parameters. A discussion of the sample locations and the field measurements and observations made during the structure sampling activities is presented in Section 2.10.2. Tables containing the analytical results for the soil and water samples are presented in Appendix M.

Volatile Organic Compounds (VOCs)

All of the soil and water samples were analyzed for TCL volatile organic compounds (VOCs). To evaluate the soil sample VOC data, the contaminant-comparison level of 1 ppm for total volatile organic compounds soil was used.

As discussed in the Data Validation Summary presented in Appendix M, the validation of the data resulted in the qualification of soil and water sample data based upon laboratory blank contamination and other data quality control criteria. At this site, the detected levels of methylene chloride and acetone in the soil and water samples were qualified as undetected ("U"

qualifier). These qualified levels are not considered in the site soil and water contamination assessment.

A total of thirty-four (34) TCL VOCs were analyzed for in each of the soil and water samples. Only one of these VOCs, tetrachloroethene, was detected in the soil samples. No VOCs were detected in the water sample. Soil sample S-2 from the o/w separator contained a detectable level (2 ppb) of tetrachloroethene, at an estimated ("J) level. Soil samples S-1 and S-3 (duplicate of S-2) contained no detectable levels of VOCs. The total VOC levels detected in the soil samples did not exceed the 1 ppm total VOC comparison level.

Base Neutral/Acid Extractable Organic Compounds (BNAs)

All of the soil and water samples were analyzed for TCL BNA compounds. To evaluate the BNA data, the contaminant-comparison level of 10 ppm for total BNA in soil was used. In addition to using a contaminant-comparison level for total BNAs, contaminant-comparison levels of 10 ppm and 1 ppm were used for total polynuclear aromatic hydrocarbons (PAHs) and total carcinogenic PAHs, respectively.

As discussed in Appendix M, the finding of the data validation indicated that di-n-butylphthalate was detected in the laboratory method blanks. Therefore, the associated detected soil sample concentrations have been qualified as undetected ("U") and these qualified levels will not be considered further in this assessment. Bis(2-ethylhexyl)phthalate was not detected in the laboratory blank

but was qualified as estimated ("J") on the basis of surrogate spike recovery criteria. It will be retained for further consideration in this assessment.

A total of sixty-five (65) BNAs were analyzed for in each soil and water sample collected for TCL BNA analysis. Of the sixty-five TCL BNAs, two (2) were detected in soil samples, while none were detected in the water sample. Bis(2-ethylhexyl)phthalate and benzo(a)pyrene were the only BNA compounds detected in soil sample (S-1) from the o/w separator. No BNA compounds were detected in soil sample S-2 or its duplicate, S-3.

Upon comparing the established soil contaminant-comparison level of 10 ppm for total BNAs to the soil sample results, the total BNA level detected in sample S-1 (0.22 ppm) was well below the contaminant-comparison level of 10 ppm. The total PAH and carcinogenic PAHs levels in this sample were also well below the associated contaminant-comparison levels of 10 ppm and 1 ppm, respectively.

Pesticide and PCB Compounds

All of the soil and water samples collected were analyzed for TCL pesticides and PCB compounds. No pesticides or PCBs were detected in any of the soil or water samples.

Inorganic Analytes

All of the soil and water samples collected from the site were analyzed for the TAL inorganic analytes (metals and cyanide). To

evaluate the soil sample inorganic analyte data, detected analyte levels were compared to analyte levels detected in background soil samples. The background inorganic analyte soil levels used in the soil assessment are provided in Table __. To evaluate the surface water sample inorganic analyte data, State and Federal surface water quality criteria were used.

As discussed in the Data Validation Summary presented in Appendix M, the validation of the data resulted in the qualification of soil sample data based upon laboratory blank contamination and other data quality control criteria. At this site, the detected levels of arsenic, copper, sodium, nickel and vanadium in the soil samples were qualified as undetected ("U" qualifier) due to blank contamination. These qualified levels are not considered in the site soil contamination assessment.

Upon reviewing the soil sample analytical results, the following observations can be made:

- Of the two (2) soil samples collected for TAL inorganic analyses, the established background analyte levels were not exceeded at any location.
- Of the twenty-four (24) inorganic TAL analytes, twelve (12) were detected in the soil samples.

The above information indicates that no inorganic analytes were detected above established background levels.

Both acute and chronic surface water quality criteria are provided in Table 4-24. For a number of the inorganic analytes, the acute and chronic criteria were calculated using an assumed hardness value for the surface water of 100 ppm as $CaCO_3$. No

detected levels of inorganic analytes in water samples were qualified as undetected ("U") on the basis of data validation.

Upon review of the water sample analytical data, only one inorganic analyte exceeded established ambient water quality criteria. Cadmium was detected in the water sample at a level (3.3 ppb) which exceeded only the chronic criteria (1.13 ppb).

4.6.5 Underground Storage Tank Assessment

This section of the report provides an assessment of the Tank Farm Five underground storage tank sample analytical results. Under this investigation, oil and water samples were collected from the eleven (11) USTs located on the site. The locations of the tanks are shown on Figure 1-19. The field observations and measurements relating to the tank sampling are provided in Section 2.9.2. The physical characteristics of the tank contents are provided in Table 2-23. All of the tank oil samples were analyzed for the TCL (less pesticides) and TAL parameters. The tank water samples were analyzed for the TCL (less pesticides/PCBs), and TAL parameters. A sludge sample was also collected from one of the USTs (Tank 50) and analyzed for the TCL (less pesticides), TAL and EP Toxicity parameters. The EP Toxicity tests for metals, pesticides, and herbicides were performed. The results are discussed with the inorganics discussion below. Tables containing the analytical results for the tank samples are provided in Appendix M.

Volatile Organic Compounds

The tank sample results indicate the presence of volatile organic compounds (VOCs) in the tanks' contents. The presence of methylene chloride and acetone in the oil samples and the presence of methylene chloride, acetone and carbon disulfide in the water samples was qualified as undetected ("U") and therefore, these compounds are not considered in this assessment (see Appendix M data validation discussion). The concentrations of acetone in two of the water samples are considered "real" and these will be retained for further consideration.

Several other VOCs were detected in the oil samples at very elevated levels. Those VOCs detected in the oil samples include chlorinated hydrocarbons (e.g., 1,2-dichloroethene, 1,1,1-trichloroethane, trichloroethene and tetrachloroethene) and petroleum-related hydrocarbons (e.g., benzene, toluene, ethylbenzene, and xylene). VOCs were also detected in tank water samples at high levels. The VOCs detected in the sludge sample included only toluene, ethylbenzene and xylene.

VOCs were detected at total VOC levels greater than 100 ppm in the oil samples collected from Tanks 50, 51, 52, 53, 56, and 59. VOCs were not detected in the oil samples from Tanks 49, 54, 57 and 58. The highest total VOC level (1,920 ppm) was detected in the oil sample collected from Tank 53. Tank 53 was used to store waste oils.

VOCs were detected in all of the water samples. Detected total VOC concentrations ranged from 2 to 4,917 ppb in the water

samples. The primary VOCs detected in the water samples included the same VOCs detected in the oil samples (i.e., petroleum-related compounds and chlorinated compounds). VOCs detected in the water samples which were not detected in the tank samples include vinyl chloride, acetone, carbon disulfide, 1,2-dichloroethane, and 4-methyl-2-pentanone. VOCs were detected at total VOC levels greater than 100 ppb in the water samples collected from Tanks 50, 51, 52, 53, and 56. The highest total VOC level (4,063/4,917 ppb) was detected in the water sample/duplicate from Tank 53; the total VOC concentration consisted mainly of toluene (2,200/2,600 ppb). The oil sample collected from this tank had the highest total VOC and toluene levels detected in the tank oil samples. The second highest total VOC level (3,994) was detected in the water sample from Tank 51 and consisted mainly of 1,2-dichloroethene (3,000 ppb). The oil sample from Tank 51 was the only sample in which 1,2-dichloroethene was detected.

Base Neutral/Acid Extractable Organic Compounds

The tank sample results indicate the presence of base neutral/acid extractable compounds (BNAs) in the tanks' contents. Those BNAs detected in the oil samples at high levels include polynuclear aromatic hydrocarbons (PAHs) and bis(2-ethylhexyl)phthalate. BNAs were also detected in tank water samples at high levels. The BNAs detected in the sludge sample included only two of the four PAHs detected in the oil sample from that tank.

BNAs were detected in oil samples from every tank at total BNA levels greater than 100 ppm; they were detected at total BNA levels greater than 1000 ppm in the oil samples collected from Tanks 50, 51, 52, 53, 56, and 57. The highest total BNA level (4,260 ppm) was detected in the oil sample collected from Tank 52. While the total BNA level was comprised almost entirely of PAHs, no carcinogenic PAHs were detected in any oil sample. In the sludge sample, only naphthalene and 2-methylnaphthalene were detected, at a total concentration of 640 ppm.

BNAs were detected in all of the water samples. Detected total BNA concentrations ranged from 31 to 895 ppb in the water samples. The primary BNAs detected in the water samples included the same BNAs detected in the oil samples (i.e., PAHs), as well as phenols and dibenzofuran. BNAs were detected at total BNA levels greater than 100 ppb in the water samples collected from Tanks 50, 51, 52, 53, and 56. These are the same tanks in which total VOC levels greater than 100 ppb were detected. The highest total BNA level (895 ppb) was detected in the water sample from Tank 51; the total VOC concentration consisted mainly of phenol, 2-methylphenol and 4-methylphenol. No carcinogenic PAHs were detected in the water samples.

Pesticide and PCB Compounds

No PCBs were detected in the oil samples or sludge sample. The detection limits for the PCB compounds analyzed for in the oil

samples ranged from 12-24 ppm. The water samples were not analyzed for PCBs. None of the samples were analyzed for pesticides.

Inorganic Analytes

The tank sample results indicate the presence of inorganic analytes in the tanks' contents. The presence of arsenic, barium, calcium, chromium, copper, magnesium, manganese, nickel, sodium, vanadium, and zinc in the oil samples was qualified as either undetected ("U") or estimated ("J"), based on the detected level of the analyte. Analytes qualified as undetected are not considered in this assessment (see Appendix M data validation discussion). Similar qualifiers were assigned to inorganics in water samples.

Eleven inorganic analytes were detected in the oil samples. The inorganics were not consistently detected in every tank and the highest detected levels for the various inorganic analytes were distributed throughout the oil samples. The oil sludge sample generally had higher levels of inorganic analytes (e.g., aluminum, cobalt, copper, iron and zinc) than the oil samples. The inorganic analytes detected in a majority (at least 50%) of the oil samples were iron and lead. The EP Toxicity compounds were not detected in the sludge sample, with the exception of barium at 0.24 ppm, which was less than the EP Toxicity limit of 100 ppm.

Eleven inorganic analytes were detected in the tank water samples. Detections of the inorganic analytes in the tank water samples were more consistent than in the oil samples and the highest detected levels for several of the various inorganic

analytes were detected in water samples from Tanks 52 or 53. Inorganics levels in Tanks 49, 54, 55, 57, 58 and 59 were generally less than those detected in other tanks. The inorganics detected in a majority (at least 50%) of the water samples were barium, calcium, iron, potassium, magnesium, manganese, and sodium.

5.0 SUMMARY AND CONCLUSIONS

This section of the report provides a brief summary of the nature and extent of contamination detected at each of the five sites as presented in Section 4.0. Contaminant fate and transport mechanisms for each site are discussed in Volume II. Conclusions regarding recommendations for future work and suggested remedial action objectives are also provided.

5.1 Site 01 - McAllister Point Landfill

5.1.1 Nature and Extent of Contamination

Soil Assessment - VOCs, BNAs, pesticides/PCBs and inorganics were all detected in on-site soils. The major areas of the site where contaminants were detected in the soil at elevated levels include the following:

- Northern area - Carcinogenic PAHs;
- North-central area - BNAs, carcinogenic PAHs, and inorganics;
- Central landfill area - VOCs, BNAs, PCBs and inorganics;
- South of access road - BNAs, carcinogenic PAHs, and inorganics; and
- Shoreline - BNAs, carcinogenic PAHs, and inorganics.

Significant VOC contamination (i.e., greater than 1 ppm total VOCs) was detected in soils and fill in the central portion of the landfill area but VOC levels were not consistently high throughout the depth of the soil horizons sampled. BNAs were detected at elevated levels (i.e., greater than 10 ppm total BNAs) throughout the site, with the highest levels (i.e., greater than 100 ppm total BNAs) detected at spot locations in the central and southern portions of the site. Elevated levels of total carcinogenic PAHs (i.e., greater than 1 ppm) were also detected at locations where total BNA concentrations were less than 10 ppm. These locations were generally in the northern portion of the site, with smaller areas identified in the southern portion of the site and along the shoreline. Pesticides were detected at low levels (i.e., 10's of ppb) in surface soil samples across the site, while PCBs were

detected in surface and subsurface soils. PCBs were detected in surface soils along the shoreline and in subsurface soils in the north-central and southern portions of the site. One soil boring sample exceeded the 1 ppm RIDEM PCB soil action level. Inorganics levels in the soils and fill were compared to off-site background surface soil levels. Inorganics were detected in soil and fill samples collected from across the site at levels exceeding background levels. The highest inorganic levels were detected in soils from the central and south-central portions of the landfill, in the northern portion of the site (ash materials), in the southern portion of the site, and along the shoreline.

Ground Water Assessment - VOCs, BNAs, PCBs and inorganics were all detected in ground water samples. The major areas of the site where contaminants were detected at levels exceeding action levels include the following:

- Northern area - inorganics;
- North-central area - inorganics;
- Central landfill area - VOCs, and inorganics; and
- South of access road - VOCs, PCBs, and inorganics.

VOC detections, consisting mostly of petroleum-related VOCs (e.g., xylene, benzene) were limited to wells located in the central and southern portions of the site. VOCs were also detected in soil boring samples collected at the depth of the water table from the north-central to southern portions of the site, indicating the potential for ground water contamination throughout this area. Oil was observed in one well (MW-5S) in the southern portion of the site five months after it was sampled. No BNAs were detected above

ground water action levels and no pesticides were detected in ground water samples. A PCB concentration of 150 ppb was detected in the well in the southern portion of the site (MW-5S) in which oil was subsequently observed. The highest levels of inorganic analytes were detected in wells from the north-central to southern portions of the site.

5.1.2 Conclusions, Data Limitations and Recommendations for Future Work

Elevated VOC levels, an oil product and PCBs have been identified in the ground water in the southern portion of the site, and elevated VOC levels have also been detected in the ground water in the central portion of the site. Soil contamination by BNAs, carcinogenic PAHs and PCBs has also been identified. Action levels for PCBs in soils, and VOCs, PCBs and inorganics in ground water were exceeded in samples collected during the Remedial Investigation. While the site does not pose excessive human health risks in its current state, the potential for future risks to human health exists if the site use is changed. Additional studies are recommended to further define the extent of ground water contamination, the source and extent of the oil product detected in well MW-5 and the significance of inorganic and pesticide contaminant levels in soil and/or ground water at this site as compared to background levels. Biota sampling and analysis of archived samples for dioxins/furans will be incorporated into any future site evaluation. Upon further definition of site contamination, a Feasibility Study is recommended to evaluate

potential remedial alternatives.

5.1.3 Recommended Remedial Action Objectives

Preliminary remedial action objectives would include the following:

- Prevent migration of contaminants from existing sources (e.g., subsurface petroleum products) and subsequent impacts on soil and ground water quality.
- Prevent exposures to BNAs, carcinogenic BNAs, and PCBs in site soils at levels exceeding acceptable risk-based cleanup levels or regulatory action levels and prevent migration of contaminants that could result in ground water contamination.
- Prevent exposures to VOCs, PCBs, and inorganics in site ground water at levels exceeding acceptable risk-based cleanup levels or regulatory action levels.

5.2 Site 02 - Melville North Landfill

5.2.1 Nature and Extent of Contamination

Soil Assessment - VOCs, BNAs, pesticides, PCBs, and inorganics were all detected in on-site soils. The major areas of the site where contaminants were detected in the soils at elevated levels include the following:

- Northwestern area - BNAs, PCBs;
- Northeastern area - PCBs, inorganics;
- North-central area - inorganics;
- Central area - VOCs, BNAs, pesticides, PCBs and inorganics; and
- South of access road - VOCs, BNAs, PCBs, and inorganics.

Significant VOC contamination (i.e., greater than 1 ppm total VOCs) was detected in subsurface soils in the central portion of the site, in the suspected area of former lagoons, and in the southern portion of the site at well boring 4. Soil samples collected in the former lagoon area and from well boring 4 generally exhibited strong petroleum odors and/or visible oil contamination. BNAs were detected at elevated levels (i.e., greater than 10 ppm total BNAs) in the northwest, central and southern portions of the site. Pesticides were detected at low levels (i.e., 10's of ppb) in surface soil samples across the site with higher levels (100's of ppb) detected in the central portion of the site. PCBs were detected in surface and subsurface soils. PCBs were detected above the 1 ppm RIDEM PCB soil action level in surface soils in the northwest and northeast portions of the site, and in subsurface soils in the central and southern portions of the

site. Inorganics were detected in soil samples collected from the northeast corner of the site to just south of the site access road at levels exceeding background levels. The highest inorganic levels were detected in subsurface soils generally collected at or below the water table from the north-central and central to south-central portions of the site.

Ground Water Assessment - VOCs, BNAs, pesticides, PCBs, and inorganics were all detected in ground water samples. The major areas of the site where contaminants were detected at levels exceeding action levels include the following:

- North-central area - inorganics;
- Central area - VOCs, and inorganics; and
- South of access road - VOCs, BNAs and PCBs.

VOC detections at concentrations exceeding ground water action levels, consisting mostly of petroleum-related VOCs (xylene, benzene), were limited to wells located in the central (MW-3) and southern (MW-4) portions of the site. Oil was identified in well MW-3. VOCs were also detected in soil boring samples collected at the depth of the water table from the central and southern portions of the site, and signs of petroleum related contamination (e.g., odors, oil) were observed during the drilling and sampling of these borings. One BNA compound was detected above ground water action levels in a well (MW-4) in the southern portion of the site. A pesticide, gamma-BHC, was detected in ground water at well MW-4. A PCB concentration of 40 ppb was also detected in well MW-4 (PCBs were detected in the soil from this well boring). PCBs were also

detected at 0.13 ppb, less than the MCL, in MW-3 in the central portion of the site. While inorganic concentrations exceeded ground water action levels in most wells, the highest levels of inorganic analytes were detected in ground water in the central to north-central portions of the site.

Sediment Sample Assessment - VOCs, BNAs, pesticides, and inorganics were detected in sediment samples. The sediment samples were collected from the swampy area at the northern edge of the site. The contaminants detected at elevated levels in the sediment include the following:

- Carcinogenic PAHs, pesticides and inorganics

The maximum total VOC concentration detected in the sediment was 11 ppb, well below the contaminant-comparison level of 1 ppm. The maximum total BNA concentration detected was 5.43 ppm, also below the contaminant-comparison level of 10 ppm. However, total carcinogenic PAH levels in two samples exceeded the contaminant-comparison level of 1 ppm. Pesticides were detected in each of the sediment samples, with 4,4'-DDE detected at each location at concentrations ranging from 7.9 to 470 ppb. Inorganic analytes were detected at elevated concentrations at each sample location, although different analytes exceeded background at each location.

5.2.2 Conclusions, Data Limitations and Recommendations for Future Work

The major areas of contamination on-site appear to be associated with the former lagoon locations in the central portion

of the site and in the southern portion of the site, in the vicinity of well MW-4. Elevated VOCs and PCBs have been identified in the ground water in the southern portion of the site and elevated VOC levels and PCBs have also been detected in the ground water in the central portion of the site. Soil contamination by VOCs, BNAs, PCBs and inorganics has also been identified in these areas. PCBs have also been identified in surface soils in the northwest and northeast portions of the site. Action levels for PCBs in soils, and VOCs, BNAs, PCBs and inorganics in ground water were exceeded in samples collected during the Remedial Investigation. While the site does not pose excessive human health risks in its current state, the potential for future risks to human health exists if the site use changes.

Additional studies are recommended to further define the extent of soil and ground water contamination in the area of the former lagoons, the extent of the soil and ground water contamination in the area surrounding well MW-4, the nature and extent of fill in the north-central portion of the site (west of MW-2), and the significance of pesticide and inorganic contaminant levels in both soil and ground water at this site as compared to background levels. Upon further definition of site contamination, a Feasibility Study is recommended to evaluate potential remedial alternatives.

5.2.3 Recommended Remedial Action Objectives

Preliminary remedial action objectives would include the following:

- Prevent migration of contaminants from existing sources (e.g., former lagoons) and subsequent impacts on soil and ground water quality.

- Prevent exposures to VOCs, BNAs, PCBs and inorganics in site soils at levels exceeding acceptable risk-based cleanup levels or regulatory action levels and prevent migration of contaminants that could result in ground water contamination.

- Prevent exposures to VOCs, BNAs, PCBs and inorganics in site ground water at levels exceeding acceptable risk-based cleanup levels or regulatory action levels.

5.3 Site 09 - Old Fire Fighting Training Area

5.3.1 Nature and Extent of Contamination

Soil Assessment - VOCs, BNAs, pesticides, PCBs and inorganics were all detected in on-site soils. The major areas where contaminants were detected in the soils at elevated levels include the following:

- Northern area - VOCs, BNAs, and inorganics;
- Central area - VOCs, and inorganics
- Western area - BNAs;
- Eastern area - BNAs, carcinogenic PAHs, and inorganics; and
- Southern area (off-site) - BNAs.

Significant VOC contamination (i.e., greater than 1 ppm total VOCs) was detected in subsurface soils at the depth of the water table in the central portion of the site (B-6) and in the north central portion of the site (M-2). In the central portion of the site, detected contaminants were petroleum-related VOCs, while in the northern area, only 2-butanone was detected. Soil samples collected at both of these locations generally exhibited petroleum odors and/or visible oil contamination. BNAs were detected at elevated levels (i.e., greater than 10 ppm total BNAs) in the northern, western, and eastern portions of the site. The subsurface samples collected from the western portion of the site (at B-7) exhibited a strong petroleum odor. BNAs were also detected at levels greater than 10 ppm at the off-site well boring (M-5). Carcinogenic PAHs were detected at levels greater than 1 ppm, but total BNA concentrations were less than 10 ppm in samples collected from the eastern portion of the site. Pesticides were

detected at low levels (i.e., 10's of ppb) in surface soil samples across the site. One surface soil sample exhibited PCBs at 80 ppb, well below the 1 ppm RIDEM PCB soil action level. Inorganics were detected at levels exceeding background levels in soil samples collected throughout the central and eastern portions of the site. The highest inorganic levels were generally detected in subsurface soils collected at well location M-2, in the northern portion of the site, although background inorganic levels were also exceeded at boring B-1.

Ground Water Assessment - VOCs, BNAs, and inorganics were detected in ground water samples. The major areas of the site where contaminants were detected at levels exceeding action levels include the following:

- Northern area - BNAs and inorganics;
- Central area - inorganics;
- Western area - inorganics;
- Eastern area - inorganics; and
- Southern area (off-site) - inorganics.

VOCs were not detected at concentrations exceeding ground water action levels in any ground water samples. However, at well location M-4, elevated soil gas readings in the soil, petroleum odors in the soil and ground water samples, and a sheen on the ground water sample indicate a potential for subsurface VOC contamination in this area. Elevated soil gas readings, petroleum odors and/or sheens were also observed in association with other well locations at this site. Four BNA compounds were detected above ground water action levels in one well (MW-2) in the northern

portion of the site. A strong petroleum odor and sheen were observed during ground water sampling at this well. No pesticides or PCBs were detected in ground water samples. While inorganic concentrations exceeded ground water action levels in all wells, including the background well, the highest levels of inorganic analytes were detected in wells in the central to northern portions of the site.

5.3.2 Conclusions, Data Limitations and Recommendations for Future Work

Elevated levels of VOCs and BNAs have been identified in subsurface soils at this site. While elevated VOC levels have not been detected in ground water samples, the identification of elevated soil gas readings, petroleum odors and/or sheens in wells and at well and boring locations indicate the presence of subsurface contamination. Action levels for BNAs and inorganics in ground water were exceeded in samples collected during the Remedial Investigation. The site may pose a potential risk to children in its current state (although the PAH compounds which drove the risk evaluation were detected along the shore area, an area to which the children are not normally exposed) and the potential for future risks to human health exists if the site use is changed.

Additional studies are recommended to further define the extent and source of subsurface contamination at well locations M-2 and M-4, to characterize the nature of the soil mound (especially the geophysical anomaly) in the central portion of the site, and the significance of pesticide and inorganic contaminant levels in

the soil and/or ground water at this site as compared to background levels. Upon further definition of site contamination, a Feasibility Study is recommended to evaluate potential remedial alternatives.

5.3.3 Recommended Remedial Action Objectives

Preliminary remedial action objectives would include the following:

- Prevent migration of contaminants from existing sources (e.g., subsurface oil wastes) and subsequent impacts on soil and ground water quality.
- Prevent exposures to VOCs and BNAs in site soils at levels exceeding acceptable risk-based cleanup levels and prevent migration of contaminants that could result in ground water contamination.
- Prevent exposures to BNAs and inorganics in site ground water at levels exceeding acceptable risk-based cleanup levels or regulatory action levels.

5.4 Site 12 - Tank Farm Four

5.4.1 Nature and Extent of Contamination

Soil Assessment - VOCs, BNAs, pesticides, and inorganics were detected in on-site soils. In general, minimal soil contamination was detected at the site, with the exception of elevated TPH levels detected in surface soils adjacent to the oil/water separator and in a soil boring sample collected along the site access road.

VOCs were detected in three subsurface soil samples at very low levels (i.e., less than 5 ppb) and are not considered to represent significant subsurface VOC contamination. BNAs were not detected at levels greater than the contaminant-comparison level (i.e., greater than 10 ppm total BNAs). Only one soil sample exhibited BNAs at a concentration greater that 1 ppm (3.3 ppm) and that concentration consisted entirely of di-n-butylphthalate. Therefore, BNA soil contamination at this site is not considered to be significant. Pesticides were detected at low levels (i.e., less than 10 ppb) in one surface soil and one subsurface soil sample and are not considered to be significant soil contaminants. No PCBs were detected in soil samples. Inorganics were generally detected at levels less than or slightly exceeding (1 to 7 ppm above) background levels in soil samples. Therefore, there does not appear to be significant inorganic soil contamination at this site. Total petroleum hydrocarbons (TPH) analysis of soil samples identified the presence of TPH across the site, ranging in concentration from 3 to 270 ppm. The highest TPH levels were

detected in a subsurface soil sample collected along the site access road (boring M-1) and in a surface soil sample collected from adjacent to the oil/water separator.

Ground Water Assessment - BNAs, and inorganics were detected in ground water samples. Inorganics were detected at levels exceeding action levels in all wells on-site.

VOCs were not detected in any ground water samples, which coincides with their absence in soil samples. One BNA compound, bis(2-ethylhexyl)phthalate (a common laboratory contaminant) was detected in two on-site wells. No ground water action levels were exceeded for BNAs. No pesticides or PCBs were detected in ground water samples. While inorganic concentrations exceeded ground water action levels in both shallow and deep wells, including the background well, the highest levels of inorganic analytes were detected in wells in the northeast to southwest portions of the site.

Surface Water and Sediment Assessment - VOCs, BNAs pesticides and inorganics were detected in sediment samples and VOCs and inorganics were detected in surface water samples.

One VOC, carbon disulfide, was detected in one sediment sample at 21 ppb, which is not considered to be a significant level of sediment contamination. Three BNAs were detected in sediment samples, with a maximum total BNA concentration of 780 ppb, well below the contaminant-comparison level of 1 ppm. One pesticide,

4.4'-DDT was detected in three sediment samples at concentrations of 2.8 to 5.9 ppb. No PCBs were detected in sediment samples. Arsenic, cobalt and iron were the only inorganic analytes detected in soils at levels exceeding background. Higher inorganic concentrations were generally detected in the 0-1 foot sediment sample interval than the 1-2 foot interval.

Two VOCs, carbon disulfide and carbon tetrachloride, were detected in surface water samples. No surface water quality criteria for VOCs were exceeded. No BNAs, pesticides or PCBs were detected in surface water. Cadmium, lead and zinc were the only inorganic analytes detected at levels exceeding surface water quality criteria. The highest levels of inorganic analytes were detected in the surface water sample collected closest to the mouth of Normans Brook, as it enters Narragansett Bay.

Structure Sample Assessment - The distribution of contaminants within the oil/water separator and demolished unknown structure (referred to as the ruins) was as follows:

- Oil/water separator -
  Soil: VOCs, BNAs, and inorganics; and
  Sludge: BNAs, PCBs and inorganics.
- Ruins -
  Soil/sediment: inorganics; and
  Water: inorganics.

VOCs were detected in the soil/sediment and sludge samples collected from the oil/water separator and from the ruins on-site, although total VOC levels were less than the contaminant-comparison level of 1 ppm. The soil/sediment sample collected from the ruins exhibited the greatest VOC concentration (680 ppb tetrachloro-

ethene). This sample was visibly contaminated (e.g., odor, sheen). BNAs were detected in the soil/sediment and sludge samples. The sludge sample was the only sample with a total BNA concentration greater than the contaminant-comparison level of 10 ppm and a carcinogenic PAH concentration greater than the contaminant-comparison level of 1 ppm. No pesticides were detected in soil/sediment or sludge samples. A PCB compound was identified in the sludge sample at a concentration of 12 ppb, well below the RIDEM soil action level of 1 ppm. Cobalt and iron were the only inorganics detected at levels exceeding background levels and were only detected in the ruins sample.

No VOCs, BNAs, pesticides, or PCBs were detected in the surface water sample collected from the ruins. Lead and zinc were the only inorganic analytes which were detected in the water sample at levels exceeding surface water quality criteria.

Tank Contents Assessment - The distribution of contaminants within the oil and water samples collected from the on-site tanks was as follows:

- Oil: VOCs, BNAs, and inorganics; and
- Water: VOCs, BNAs, and inorganics.

VOCs were detected in the oil samples collected from the on-site tanks at very elevated levels. The VOCs consisted of benzene, toluene, ethylbenzene, and xylene. Total VOC levels exceeded 10 ppm in a majority of the tanks. EP Toxicity extraction and analysis of oil samples detected no EP Toxicity analytes; low levels of toluene, ethylbenzene and xylene in a TCL/TAL analysis of

the EP Toxicity extraction leachate from one sample. A TCL/TAL analysis of the TCLP extraction leachate from the same oil sample detected concentrations of these compounds at levels three orders of magnitude greater than the EP Toxicity results. BNAs were detected in the oil samples and consisted primarily of PAHs. Total BNA levels in excess of 1,500 ppm were detected in four of the oil samples. Oil samples were not analyzed for pesticides. No PCBs were detected in the oil samples, although detection limits ranged from 12 to 24 ppm. Iron, lead and zinc were the only inorganics detected in greater than 50% of the oil samples. TAL metals analysis of EP Toxicity and TCLP oil leachates identified inorganic analytes. The EP Toxicity extract analyses detected silver and arsenic, analytes which were not detected in the CLP method extract. The detected arsenic level exceeds the EP Toxicity federal standard for arsenic.

VOCs were detected in all of the tank water samples, with total VOC concentrations ranging from 13 to 346 ppb. The main VOC compounds detected included the same VOCs detected in the oil samples. BNAs detected in the water samples consisted of PAH compounds, phenols, phthalate esters and dibenzofuran. Total BNA concentrations ranged from 10 to 202 ppb. Tank water samples were not analyzed for pesticides or PCBs. The inorganics detected in greater than 50% of the tank water samples include barium, calcium, iron, potassium, magnesium, manganese, sodium, lead and zinc. The analyte concentrations in the water samples were typically higher than those detected in the oil samples.

5.4.2 Conclusions, Data Limitations and Recommendations for Future Work

Significant levels of contamination generally have not been detected at this site. No residual contamination associated with the alleged on-site disposal of tank bottom sludges was identified with the exception of some elevated total petroleum hydrocarbon soil levels. Action levels were exceeded for inorganics in ground water, surface water and structure water samples. The site does not pose a potential risk to human heath in its current state but a potential for future risks to human health exists if the site use is changed.

Additional studies are recommended to further define the extent of contamination associated with the ruins, characterize the sludge material in the oil/water separator further for future disposal, confirm the VOC, TPH and lead levels in on-site ground water (for comparison to previous investigations results) and determine the significance of inorganic contaminant levels in the soil and/or ground water at this site as compared to background levels. Upon further definition of site contamination, a Feasibility Study is recommended to evaluate potential remedial alternatives.

5.4.3 Recommended Remedial Action Objectives

Preliminary remedial action objectives would include the following:

- Prevent exposures to inorganics in site ground water at levels exceeding acceptable risk-based cleanup levels or regulatory action levels.

5.5 Site 13 - Tank Farm Five

5.5.1 Nature and Extent of Contamination

Soil Assessment - VOCs, BNAs, pesticides, and inorganics were detected in on-site soils. In general, minimal soil contamination was detected at the site, with the exception of elevated TPH levels detected in surface soils adjacent to the oil/water separator and in a soil boring sample collected along the site access road.

VOCs were detected in surface and subsurface soil samples at very low levels (i.e., less than 10 ppb) and are not considered to represent significant subsurface VOC contamination. BNAs were not detected at levels greater than the contaminant-comparison level (i.e., greater than 10 ppm total BNAs). Only two soil samples exhibited BNAs at a concentration greater that 1 ppm (4.6 and 1.3 ppm) and those concentrations consisted entirely of phthalate esters and PAHs, respectively. Therefore, BNA soil contamination at this site is not considered to be significant. Pesticides were detected at low levels (i.e., 10's of ppb) in two surface soil and one subsurface soil sample and are not considered to be significant soil contaminants. No PCBs were detected in soil samples. Inorganics were generally detected at levels exceeding background levels in subsurface soil samples. Lead was detected above background in one surface soil sample collected from adjacent to the oil/water separator. Total petroleum hydrocarbons (TPH) analysis of soil samples identified the presence of TPH across the

site, ranging in concentration from 4 to 60,000 ppm. The highest TPH levels were detected in visibly oily samples collected at Tank 50. Significantly elevated levels of TPH (TPH greater than 100 ppm) were detected in surface soil samples collected at Tanks 49, 50, 51 and 55.

Ground Water Assessment - VOCs, BNAs, and inorganics were detected in ground water samples. VOCs and inorganics were detected at levels exceeding ground water action levels.

VOCs were detected at levels exceeding ground water action levels in only one on-site well (MW-53W) and consisted mainly of petroleum-related VOCs. Petroleum product was also observed in wells MW-53W and MW-53E, both located in the ring drain of Tank 53. The presence of low VOC levels in downgradient well MW-4 indicates the potential migration of the ground water contamination observed adjacent to Tank 53. BNAs were only detected in well MW-53W and consisted entirely of PAHs. Detected levels did not exceed ground water action levels. No pesticides or PCBs were detected in ground water samples. While inorganic concentrations exceeded ground water action levels in all wells, including the background well, the highest levels of inorganic analytes were detected in wells in the central portion of the site.

Surface Water and Sediment Assessment - Lead and TPH were detected in sediment samples; no PCBs, lead or TPH were detected in surface water.

No PCBs were detected in sediment samples. Lead was detected in all sediment samples but at levels less than background soil levels. TPH was detected in sediment samples at concentrations ranging from 4 to 155 ppm, with detected levels increasing with distance downstream.

Structure Sample Assessment - The distribution of contaminants within the oil/water separator was as follows:

- Soil: VOCs, BNAs, and inorganics; and
- Water: inorganics.

One VOC was detected in one soil sample collected from the oil/water separator at a very low (2 ppb) level. Low levels of two BNAs were detected in one soil sample collected from the oil/water separator. No pesticides or PCBs were detected in soil samples and no inorganics were detected in the soil samples at levels exceeding background levels.

No VOCs, BNAs, pesticides, or PCBs were detected in the surface water sample collected from the oil/water separator. Cadmium was the only inorganic analyte which was detected in the water sample at levels exceeding surface water quality criteria.

Tank Contents Assessment - The distribution of contaminants within the oil and water samples collected from the on-site tanks was as follows:

- Oil: VOCs, BNAs, and inorganics; and
- Water: VOCs, BNAs, and inorganics.

VOCs were detected in the oil samples collected from the on-

site tanks at very elevated levels. The VOCs consisted of petroleum-related hydrocarbons and chlorinated hydrocarbons. Total VOC levels exceeded 100 ppm in a majority of the tanks. BNAs were detected in the oil samples and consisted primarily of PAHs and bis(2-ethylhexyl)phthalate. Total BNA levels in excess of 1,000 ppm were detected in six of the oil samples. Only PAHs were detected in the oil sludge sample. Oil samples were not analyzed for pesticides. No PCBs were detected in the oil samples. Iron and lead were the only inorganics detected in greater than 50% of the oil samples. The EP Toxicity extract analysis detected barium at a level which exceeds the EP Toxicity federal standard.

VOCs were detected in all of the tank water samples, with total VOC concentrations ranging from 2 to 4,917 ppb. The main VOC compounds detected included the same VOCs detected in the oil samples. BNAs detected in the water samples consisted of PAH compounds, phenols, and dibenzofuran. Total BNA concentrations ranged from 31 to 895 ppb. Tank water samples were not analyzed for pesticides or PCBs. The inorganics detected in greater than 50% of the tank water samples include barium, calcium, iron, potassium, magnesium, manganese, and sodium. The analyte concentrations in the water samples were typically higher than those detected in the oil samples.

5.5.2 Conclusions, Data Limitations and Recommendations for Future Work

Significant levels of contamination generally have not been detected at this site. No residual contamination associated with

the alleged on-site disposal of tank bottom sludges was identified with the exception of elevated total petroleum hydrocarbon soil levels. The majority of the detected subsurface contamination was detected at Tank 53, where VOCs and BNAs were detected in the ground water and where petroleum product was observed in the monitoring wells. Action levels were exceeded for inorganics in ground water and oil/water separator samples. The site does not pose a potential risk to human heath in its current state but a potential for future risks to human health exists if the site use is changed.

Further definition of ground water contamination in association with Tank 53 is being provided under a separate tank closure investigation. Tanks 53 and 56 have been emptied.

Additional studies are recommended to further define the extent of TPH in on-site surface soils (i.e., through additional full scan TCL/TAL analyses) and determine the significance of inorganic contaminant levels in the soil and/or ground water at this site as compared to background levels. Upon further definition of site contamination, a Feasibility Study is recommended to evaluate potential remedial alternatives.

5.5.3 Recommended Remedial Action Objectives

Preliminary remedial action objectives would include the following:

- Prevent migration of contaminants from existing sources (e.g., petroleum product in tank areas) and subsequent impacts on soil and ground water quality.

- Prevent exposures to TPH-related compounds in site soils at levels exceeding acceptable risk-based cleanup levels and prevent migration of contaminants that could result in ground water contamination.

- Prevent exposures to inorganics in site ground water at levels exceeding acceptable risk-based cleanup levels or regulatory action levels.

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