Massachusetts Military Reservation

PLUME RESPONSE PROGRAM

Final Record of Decision for Landfill-1 Source Area and Groundwater

September 2007

Prepared for:
AFCEE/MMR
Installation Restoration Program
322 E. Inner Road
Otis ANGB, MA 02542

Prepared by:
Jacobs Engineering Group Inc.

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JACOBS

6 Otis Park Drive
Bourne, Massachusetts 02532-3870 U.S.A.
1.508.743.0214 Fax 1.508.743.9177

05 October 2007

Mr. Jonathan S. Davis
Remediation Program Manager
HQ AFCEE/MMR
322 East Inner Road
Otis ANG Base, MA 02542

SUBJECT: Contract F41624-03-D-8605
MMR Plume Response Program
TO 0002 DCN/PROJECT # A4P-J23-35BC02VA-M26-0007
Final Record of Decision for Landfill-1 Source Area and Groundwater

Dear Mr. Davis:

As directed by the Air Force Center for Engineering and the Environment (AFCEE), Jacobs is providing six bound copies, one unbound copy, and eight electronic copies of the above-referenced document. Copies are also being sent to the appropriate agencies.

Please feel free to contact me at (508) 743-0214, extension 236, or Anita Rigassio Smith at extension 265, if you have any questions or comments. Mr. Mike Minior is the Air Force point of contact for this project and may be reached at (508) 968-4670, extension 4672.

Sincerely,

Jeff Carman, CPG
Program Manager

JC/aw

Enclosures: Document (6 bound, original, & 8 CDs)

c: Rose Forbes, AFCEE/MMR (1)
Melvin Alli, HQ AFCEE/ISA (1 CD)
HQ AFCEE/ACB (w/o attach)
HQ AFCEE/MSCD (w/o attach)
Paul Marchessault, EPA (1, 1 CD)
Jim Murphy, EPA (w/o attach)
Leonard Pinaud, MassDEP (1, 1 CD)
Ellie Grillo, MassDEP (w/o attach)
Col. William Fitzpatrick E&RC (c/o IRP, 1 CD)
Hopeton D. Brown, SFIM-AEC-CDP (1 CD)
Rachel Marino, USCG (1 CD)
Denis LeBlanc, USGS (1)
Peter Golonka, GF (1, 1 CD)
James Quin, EEG (1)
Heidi Marsella, Bourne Consv. (1)
Cynthia Coffin, Bourne LBH (1)
Mark Kasprzyk, Falmouth Consv. (1)
David Carignan, LBH, Falmouth (1)
George Seaver, CCA (1)
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Anita Rigassio Smith, Jacobs (1)
Katie Thomas, Jacobs (1)
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ACRONYMS AND ABBREVIATIONS

AFCEE	Air Force Center for Engineering and the Environment
ANGI	Air National Guard Instruction
AOC	area of concern
ARAR	applicable or relevant and appropriate requirement
BOH	Board of Health
CCl_4	carbon tetrachloride
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CFR	Code of Federal Regulations
CS	Chemical Spill
cis-1,2-DCE	cis-1,2-dichloroethene
COC	contaminant of concern
COPC	chemical of potential concern
DAD	dermally absorbed dose
DCM	decision criteria matrix
DOD	U.S. Department of Defense
EDB	ethylene dibromide
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ETI	extraction, treatment, infiltration
ETR	extraction, treatment, reinjection
FFA	Federal Facility Agreement

ACRONYMS AND ABBREVIATIONS

FS	feasibility study
FS-29	Fuel Spill-29
ft msl	feet mean sea level
GAC	granular activated carbon
gpm	gallons per minute
HEAST	Health Effect Assessment Summary Table
HI	hazard index
HQ	hazard quotient
IRIS	Integrated Risk Information System
IROD	Record of Decision for Interim Action
IRP	Installation Restoration Program
lb	pounds
LF-1	Landfill-1
LTM	long-term monitoring
LUC	land use control
M	million
MassDEP	Massachusetts Department of Environmental Protection
MCL	maximum contaminant level
mg/kg-day	milligrams per kilogram per day
MMR	Massachusetts Military Reservation
MMCL	Massachusetts maximum contaminant level
MPP	Mashpee Pitted Plain
NCP	National Oil and Hazardous Substances Contingency Plan
NGB	National Guard Bureau
NPL	National Priorities List

ACRONYMS AND ABBREVIATIONS

NWOU	Northwest Operable Unit
O&M	operations and maintenance
OU	operable unit
PCE	tetrachloroethene
PCM	post-closure monitoring
PCT	Plume Cleanup Team
PP	Proposed Plan
PRG	preliminary remediation goal
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI	remedial investigation
RME	reasonable maximum exposure
ROD	Record of Decision
SF	slope factor
SPEIM	system performance and ecological impact monitoring
TCE	trichloroethene
1,1,2,2-TeCA	1,1,2,2-tetrachloroethane
TRET	Technical Review and Evaluation Team
UCL_{95}	95 percent upper confidence limit
USCG	U.S. Coast Guard
VOC	volatile organic compound
µg/L	micrograms per liter

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1.0 DECLARATION

1.1 SITE NAME AND LOCATION

The Massachusetts Military Reservation (MMR) on Cape Cod Massachusetts is located within the boundaries of the towns of Bourne, Mashpee, Sandwich, and Falmouth. This site is listed on the National Priorities List (NPL) as Otis Air National Guard/Camp Edwards in Falmouth, Massachusetts. This Record of Decision (ROD) addresses part of the Landfill-1 (LF-1) source area, specifically the 1970 Cell, the Post-1970 Cell, and the Kettle Hole, and the LF-1 groundwater. The Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) number for the MMR site is MA2570024487.

1.2 STATEMENT OF BASIS AND PURPOSE

This ROD presents the selected remedy for a portion of the LF-1 source area, specifically the 1970 Cell, the Post-1970 Cell, and the Kettle Hole, and the LF-1 groundwater, which was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act, and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based on the Administrative Record for this site. The northwest part of the LF-1 source area (the 1947, 1951, and 1957 cells) will be addressed in a future decision document.

The U.S. Department of Defense (DOD) (U.S. Air Force) is the lead agency for CERCLA remedial actions at the MMR. The U.S. Environmental Protection Agency (EPA), the U.S. Air Force, and the National Guard Bureau (NGB) are parties to the Federal Facility Agreement (FFA) (EPA et al. 2002) for this site. They, along with the Massachusetts Department of Environmental Protection (MassDEP), concur with the selected remedy.

1.3 ASSESSMENT OF THE SITE

The response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

1.4 DESCRIPTION OF SELECTED REMEDY

The selected remedy for the LF-1 source area (the 1970-Cell, Post-1970 Cell, and the Kettle Hole) provides for continued monitoring and maintenance of the existing landfill cover system. The objective of the remedy is to maintain the integrity of the landfill cover system to retard leaching of contamination that would cause downgradient groundwater to be unusable and implement land use controls (LUCs) to prevent exposure to landfill waste.

The selected remedy for the LF-1 groundwater provides for continued active treatment of the LF-1 plume with the existing extraction, treatment, and infiltration (ETI) system with an expansion of the system to improve capture of the southern lobe at the base boundary. The system expansion involved installation of a sixth extraction well in the LF-1 plume (27EW0006), from which water is processed at the Hunter Avenue Treatment Facility and returned to the aquifer through infiltration. The objective of this remedy is to continue to operate, maintain, and optimize the existing, expanded ETI system to expedite aquifer restoration, maintain containment of the plume upgradient of a point approximately 800 feet west of the base boundary, and implement LUCs to reduce residential exposure to the LF-1 plume. The ETI system consists of ETI of groundwater following federal and state standards for the tetrachloroethene (PCE), trichloroethene (TCE), carbon tetrachloride (CCl_4), 1,4-dichlorobenzene, vinyl chloride, and 1,1,2,2-tetrachloroethane (1,1,2,2-TeCA) as stipulated in the current Operations and Maintenance (O&M) Plan. The remedy leaves open the possibility of modifying the treatment system to optimize the cleanup time frame and maintain containment of the plume upgradient of a point approximately 800 feet west of the base boundary. Most likely, modifications will be implemented using the existing extraction wells and infiltration trenches and

gallery, and could involve well packering (decreasing the effective length of the well screen through installation of a well packer), turning on or off existing extraction wells and infiltration trenches or galleries, or adjusting flow rates. This remedy, however, does not exclude the possibility of adding system components, such as additional extraction wells, if deemed necessary. Modifications will be made for the purpose of improving treatment system operation, expediting plume cleanup, and maintaining containment of the plume upgradient of a point approximately 800 feet west of the base boundary. This remedy will also provide for chemical and hydraulic monitoring of the plume as long as active remediation continued. After active ETI becomes no longer effective at expediting plume cleanup, the Air Force Center for Engineering and the Environment (AFCEE), with regulatory agency input, will cease operation of the ETI system and will continue to monitor the residual plume contamination until the remedial action objectives (RAOs) have been met. The monitoring of the plume will be conducted as part of the system performance and ecological impact monitoring (SPEIM) program. This remedy provides the flexibility of modifying the monitoring network as necessary to adequately monitor the LF-1 plume and optimize system performance. LUCs will reduce potential human exposure to contaminated groundwater. Five-year reviews will be performed to determine if the remedy is still appropriate and protective. A residual risk assessment and/or evaluation of the technical and economic feasibility of additional remediation to approach background concentrations will be performed if necessary.

1.5 STATUTORY DETERMINATIONS

The selected LF-1 source area (the 1970-Cell, Post-1970 Cell, and the Kettle Hole) remedy and the LF-1 groundwater remedy are protective of human health and the environment, comply with federal and Commonwealth of Massachusetts requirements that are applicable or relevant and appropriate requirements (ARARs) for the remedial action, utilize permanent solutions to the maximum extent possible, and are cost-effective. The remedies also satisfy the statutory preference for treatment as a principal element of the remedy (i.e., reduces the toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants, as a principal element through treatment). Because hazardous substances are expected to remain in the source area and in the

aquifer for a number of years above levels that allow for unlimited use and unrestricted exposure, five-year reviews will be conducted to ensure that the remedies continue to be protective of human health and the environment.

1.6 DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary (Section 2.0) section of this ROD. Additional information can be found in the Administrative Record for this site.

Data Item	Location in Document
Contaminants of Concern (COCs) and their respective concentrations.	Section 2.7.5
Baseline risk represented by the COCs.	Section 2.7
Cleanup levels established for the COCs and the basis for these levels.	Section 2.8
How source materials constituting principal threats will be addressed.	Section 2.2
Current and reasonable anticipated future land use assumptions and current and potential future beneficial use of groundwater used in the baseline risk assessment and the ROD.	Section 2.6
Potential land and groundwater use that will be available at the site as a result of the selected remedy.	Section 2.8
Estimated annual and total present value costs, discount rate, and the number of years over which the remedy cost estimate is projected.	Sections 2.11.3 (LF-1 source area) and 2.13.3 (LF-1 groundwater)
Key factor(s) that led to selecting the remedy.	Sections 2.10.2, 2.12 (LF-1 source area) and Sections 2.10.3, 2.14 (LF-1 groundwater)

1.7 AUTHORIZING SIGNATURES

The foregoing represents the decision for remedial action for a portion of the LF-1 source area, specifically the 1970 Cell, the Post-1970 Cell, and the Kettle Hole, and the LF-1 groundwater by AFCEE and the EPA, with the concurrence of the MassDEP.

Approve and recommend for immediate implementation.

AIR FORCE CENTER FOR ENGINEERING AND THE ENVIRONMENT

By: _____ Date: 24 Sep 2007

Paul A. Parker, SES
Director

U.S. ENVIRONMENTAL PROTECTION AGENCY

By: _____ Date: 9-28-07

James T. Owens III
Director, Office of Site Remediation and Restoration

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2.0 DECISION SUMMARY

The following sections describe the setting, potential risks, RAOs, and alternative evaluation for remediation of the LF-1 source area (the 1970 Cell, Post-1970 Cell, and the Kettle Hole) and the LF-1 groundwater.

2.1 SITE NAME, LOCATION, AND BRIEF DESCRIPTION

The MMR is listed on the NPL as Otis Air National Guard/Camp Edwards in Falmouth, Massachusetts. The CERCLIS number for the MMR site is MA2570024487. In accordance with Executive Order 12580, the DOD is the lead agency for remedial actions at the MMR. The MMR was formally added to the NPL in 1989. The FFA for the MMR site was signed in 1991 by the DOD, the EPA, and the U.S. Coast Guard (USCG)/Department of Transportation[1] (EPA et al 2002). The Commonwealth of Massachusetts chose not to be a signatory to the FFA. In 1995, the FFA was amended to add the U.S. Air Force as the lead agent for the cleanup at MMR. The FFA, as amended, requires the U.S. Air Force to implement CERCLA requirements at the MMR (EPA et al. 2002).

The MMR occupies approximately 22,000 acres on Cape Cod (Figure 2-1) and consists of several operating command units: the Air National Guard, the Army National Guard, the Air Force, the USCG, and the Veterans Administration. Military training and maneuvers, military aircraft operations, and maintenance and support activities have resulted in past releases of hazardous materials at the MMR. LF-1 is located on the west-southwest side of the MMR (Figures 2-1 and 2-2). The LF-1 source area was identified as OU ID 07 BASE LANDFILL (LF-1)/CAP, and the groundwater plume was identified as OU ID 016, OU 01D - LANDFILL 1 GW PLUME in the EPA database.

[1] In 2000, the FFA was amended to remove the USCG/U.S. Department of Transportation as a signatory to the FFA.

2.2 SITE HISTORY AND ENFORCEMENT ACTIVITIES

Military use at the MMR began in 1911. The most intense periods of activity occurred from 1940 to 1946 and 1955 to 1970. Sources of contamination and chemical spills resulting from a variety of military operations include motor pools, landfills, fire training areas, and drainage structures such as dry wells and drainage swales.

The MMR history consists of a series of complex interactions between various federal agencies and the Commonwealth of Massachusetts. In 1940, the U.S. Army signed a 99-year lease with the Commonwealth of Massachusetts for the use of the MMR. The Army transferred this lease to the Air Force in 1953 for the Otis Air Force Base portion of the military reservation, and the Army maintained a sublease for the 14,000-acre area on the base known as Camp Edwards. In 1974, the Air Force licensed the Massachusetts Air National Guard to use Otis Air Force Base, and in 1975, the U.S. Army licensed the Massachusetts Army National Guard to use and occupy Camp Edwards. On 05 March 2002, a law was enacted to designate the northern 15,000 acres of the MMR as protected conservation land dedicated for the purposes of water supply and wildlife habitat, at the same time allowing military training compatible with the environmental protection of the land. In 2003, the Commonwealth of Massachusetts extended the lease with the National Guard until 2052.

Activities resulting in CERCLA actions are summarized below. In 1982, the DOD initiated the Installation Restoration Program (IRP) at the Otis Air National Guard Base area of the MMR. The IRP at the MMR is funded by the Defense Environmental Restoration Account. The NGB was responsible for implementing the IRP at the MMR. In 1986, the IRP was expanded to include all potential hazardous waste sites at the MMR. In 1989, the MMR was formally added to the NPL. An FFA among the NGB, the EPA, and the USCG was signed in 1991 and has since been amended (EPA et al. 2002). The FFA provides a framework for EPA oversight and enforcement of the MMR investigations and cleanup activities and identifies a schedule for cleanup activities. A Community Relations plan is included as an attachment to the FFA. In 1996, the regulatory agencies requested that the DOD provide a new management structure for the

MMR IRP. In response to that request, the U.S. Air Force assumed the lead role in the execution of the IRP and assigned AFCEE to manage the program. Under Amendment 2, additional enforceable milestones and the Plume Response Decision Criteria and Schedule were added to the FFA. More recently, the USCG has been removed from its status as a party to the FFA because the USCG has not played an active role in implementing cleanup obligations under the FFA (Amendment 3 to the FFA). Amendment 4 added Section 7003 of the Resource Conservation and Recovery Act (RCRA) to the FFA in order to address contamination caused solely by petroleum releases that fall within the scope of the CERCLA "petroleum exclusion" described in the last sentence of CERCLA Section 101(14). In June 2002, Amendment 5 was signed and removed the Chemical Spill (CS)-13 site from the list of Study Areas and Areas of Contamination contained in Section 5.24 of the FFA. After investigation of the historical usage of the CS-13 site, it was removed based on a lack of evidence to indicate that any military component currently is or had been either an owner or operator of the site (i.e., real property comprising CS-13) as defined under CERCLA and the NCP.

In 1941, the landfill began operating as the primary solid waste disposal facility at MMR. Waste was reportedly disposed at the landfill in five distinct cells and a natural Kettle Hole. The cells are designated by the year representing the approximate last date of waste disposal. The five cells are 1947, 1951, 1957, 1970, and Post-1970 (Figure 2-3). The 1947, 1951, and 1957 cells occupy approximately 40 acres, while the 1970 and Post-1970 and Kettle Hole occupy approximately 50 acres. The depth of waste burial is estimated to be approximately 20 feet below ground surface; for the 1970 and Post-1970 cells, the depth of waste in the Kettle Hole is unknown (E.C. Jordan *1990b*, *1988*).

In 1983, a records search identified the landfill as a potential source for the volatile organic compounds (VOCs) detected in June 1979 in a base water supply well approximately 6,000 feet downgradient of the landfill (ANG 1983). In 1985, an initial site investigation of the landfill was conducted (ANG 1985) and indicated there was minor evidence of landfill-derived leachate based on the presence of VOCs detected during monitoring well installation and sampling. Magnetic anomalies and the disposal

boundaries were delineated through magnetometer and radar surveys of the landfill (E.C. Jordan 1990b). Soil gas data indicated that waste buried in the landfill emitted a wide variety of VOCs and that landfill gases related to the degradation of organic material (including methane) were being released to the atmosphere (E.C. Jordan 1990b). These investigations confirmed that contamination leaching from LF-1 was contributing to groundwater contamination.

From 1987 to 1989, an interim remedial investigation (RI) was performed to further quantify the impact to groundwater downgradient of each landfill cell, to estimate the potential for each cell to be a continuing source of groundwater contamination, and to characterize the initial conceptual model of the plume (E.C. Jordan 1990a). Groundwater data collected during 1989-90 (ANG 1993a) indicated that significant contamination was not emanating from the older Northwest Operable Unit (NWOU) cells (1947, 1951, and 1957). An environmental justification report indicated that the NWOU was not a source of contamination and that it did not pose a public health risk or environmental hazard (ANG 1991). Hence, recommendations were made for no additional action (i.e., landfill cover) at the NWOU. A risk assessment of the landfill area of concern (AOC) (all six disposal areas) indicated there was a potential for human health risks as a result of exposure to source area groundwater and that remedial action should be performed at the landfill to reduce contaminants leaching to groundwater (ABB 1992).

From 1992 through 1994, the LF-1 RI was conducted and was intended to complete the characterization of the extent of subsurface contamination by defining the downgradient (horizontal and vertical) extent of the chlorinated solvent plume, and evaluating the stratigraphy and geology of the region (AFCEE 1996b). The data from installation and sampling of monitoring wells indicated that the plume had well defined northern and southern lobes, and that concentrations of PCE, TCE and CCl_4 exceeded maximum contaminant levels (MCLs). The RI identified that natural anaerobic degradation of chlorinated hydrocarbons was occurring, based on the presence of cis-1,2-dichloroethene (cis-1,2-DCE) and vinyl chloride, and that this degradation was probably contributing to plume remediation. The human health risk assessment that was conducted as part of the

RI indicated that future groundwater use posed a potential risk. The RI recommendations included additional data gap investigation work and work to be conducted as part of feasibility study (FS) activities.

2.2.1 LF-1 Source Area Remedial Actions

A preliminary risk assessment for the landfill indicated that through residential exposure to source area groundwater there was risk that exceeded the EPA and MassDEP criteria for cancer and non-cancer target risk levels. Based on the results of the risk assessment, a focused FS for the AOC LF-1 identified a number of potential remedial alternatives for the landfill to reduce contaminants leaching to the groundwater (ABB 1992). Following an evaluation of alternatives that will protect human and environmental health and comply with ARARs, an interim remedy was selected. The interim remedial action for the landfill (ANG 1993b) consisted of the following actions:

1. Leaving NWOU wastes in place beneath the soil and vegetative cover and installing downgradient groundwater monitoring wells to assess any impacts from the older cells and to determine if the interim remedial action is an appropriate long-term remedial action. Monitoring wells were selected for sampling on a regular basis.
2. Construction of a landfill cover system on the 1970 and Post-1970 cells and the Kettle Hole.
3. Preparation of a post-closure monitoring (PCM) plan for the 1970 cell, the Post-1970 cell, and the Kettle Hole.

Closure activities at the landfill, including capping three cells and instituting PCM, were completed in December 1995 [details of the closure activities are provided in *Closure Plan for Study Area LF-1 1970 Cell, Post-1970 Cell, and Kettle Hole Technical Specifications (90 Percent Design)*, ANG 1992]. Landfill caps on the three most recently used cells (1970, Kettle Hole, and Post-1970) were constructed because these cells were the apparent sources of groundwater contamination. The primary purpose of the landfill cover and associated drainage structures is to minimize the amount of precipitation that infiltrates the landfill and produces leachate (water containing contaminants, nutrients, and microorganisms) that drains into the aquifer. It is expected that with a properly functioning cover, landfill drainage will become negligible once moisture in excess of the

waste's field capacity has drained. The LF-1 cover system is composed of low permeability caps built on top of the three cells, an associated drainage system, and 70 gas vents designed to release gas from the interior of the landfill. Gas probes are located around the perimeter of the caps to monitor subsurface vapor. A perimeter fence already existed around the entire landfill (capped cells and NWOU) at the time of capping.

The *Post-Closure Plan for Main Base Landfill (AOC LF-1)* (ANG 1993a) outlined the following actions:

1. Post-closure maintenance and monitoring of the cover system is to be conducted for a minimum of 30 years after the completion of cap construction. To verify that the cap maintains its structural integrity, it is inspected for animal burrows, erosion rills, settlement depressions, intrusive vegetation, seeps, and sedimentation in ditches and culverts. Post-closure maintenance is performed any time a loss of integrity is noticed; landfill surveys are performed regularly.
2. Landfill gas and groundwater quality at the landfill are to be monitored as appropriate. The landfill interim remedial action will allow time to further evaluate the environmental impact of the 1947, 1951, and 1957 cells on groundwater quality.
3. The performance evaluation of the interim remedial action occurs regularly.

In 1996, the EPA and MassDEP approved the closure report for the landfill site (AFCEE 1996a), thus initiating the long-term monitoring (LTM) program (actions listed above) as defined in the PCM plan (ANG 1993a). Ongoing PCM investigations were eventually combined with the SPEIM program for the interim groundwater remedial action (Section 1.2.2). The SPEIM program was implemented to evaluate the performance of the groundwater remedial action and evaluate the fate and transport of the plume.

2.2.2 LF-1 Groundwater Remedial Actions

In the *Final Record of Decision for Interim Action, Containment of Seven Groundwater Plumes at Massachusetts Military Reservation, Cape Cod, Massachusetts* (ANG 1995) (referred to as the IROD), the selected remedy for the LF-1 plume included extraction of contaminated groundwater and discharge of treated water to groundwater (and/or other beneficial use) and institutional controls. At the time of the IROD, the COCs for LF-1

included TCE, PCE, and CCl_4. Maximum contaminant level (MCL) exceedances of these three contaminants defined the physical extent of the plume. Other contaminants (i.e., metals and other VOCs) in the LF-1 plume exceeded respective MCLs, but detections were relatively sporadic and did not justify independent delineation (i.e., contouring and other detailed conceptualization). The interim remedial action for LF-1 (ANG 1995) was conceptually designed to intercept contaminated groundwater and prevent further downgradient movement of contamination. The IROD states that extraction and treatment will continue until the final remedy for the site is chosen. In summary, the interim remedy as outlined in the IROD provides for:

- extracting contaminated groundwater at the leading edge of contaminant plumes and potentially extracting groundwater from hot spot areas;
- pumping and conveying the extracted groundwater to a treatment system to remove contaminants;
- discharging the treated water back to the groundwater and/or other beneficial uses;
- installing monitoring wells, measuring water levels, and sampling groundwater to monitor the performance of the extraction system;
- sampling the influent and effluent of the treatment system to monitor its performance;
- restricting groundwater use within the areas contained by the extraction, treatment, reinjection (ETR) system through imposition of institutional controls; and
- conducting regular reviews of operation to ensure the remedy provides adequate protection of human health and environment.

The Technical Review and Evaluation Team (TRET), established in 1996 as part of the new IROD management process, reviewed wellfield designs and determined that the 60-percent design for containment of several of the IROD plumes would cause negative ecological impacts (TRET 1996). The remedy for LF-1 was revised through a decision criteria matrix (DCM) process, which included public participation. The process used decision criteria that focused on protection of human health and the environment, regulatory requirements, effectiveness of treatment technologies, and community acceptance.

Numerous remedial alternatives considered during the DCM process included alternatives that consisted of ETR, recirculation, and monitored natural attenuation. Numerous public comments were received. Commenters from the affected neighborhoods expressed strong opposition to the construction of a remediation system in the village of Cataumet and other densely populated areas. Some commenters observed that the low concentration levels in the plume did not merit the cost or environmental impacts of active treatment. Commenters did not tend to express a preference between types of treatment technologies, but rather, focused on the location of remediation treatment systems. Concerns were expressed about impacts on property values from the plume, as well as potential impacts on property values from active remediation systems. Concerns were also expressed about the potential impacts from letting any or all of the plume go, and the need to coordinate with scientific organizations about any potential effects on marine environments.

Through the DCM process, Alternative 3E was determined to be the best option for aquifer restoration downgradient of the MMR western boundary (AFCEE 1997). The objective of this alternative was restoration (i.e., reduce groundwater concentrations to below the 5 micrograms per liter [µg/L] MCL for each COC) of the aquifer between the MMR western boundary and Route 28 within 20 years. This objective was to be accomplished by an ETR system located along the base boundary, by natural attenuation in the central part of the plume, and by the return of treated groundwater into the aquifer directly upgradient of the Bourne public water supply wells. In addition, as part of the interim remedy, the Air Force agreed to complete a study to estimate the extent of natural resources injury; to work with the Natural Resources Trustees and regulators to develop the scope, schedule, oversight and review of this natural resources study; to replace Bourne Water District Wells 2 and 5; and to connect residents using private wells within the footprint or path of the plume to public water.

The interim remedial design consisted of five extraction wells placed along the MMR western boundary, monitored natural attenuation in the central part of the plume, and infiltration of treated groundwater (AFCEE 1999). Although most of the previous design

alternatives for the LF-1 treatment system considered an ETR system, modeling evaluations indicated that the ETI system presented in the wellfield design report was the most appropriate design (AFCEE 1999). Downgradient of the base boundary, the plume will naturally attenuate and/or discharge to Red Brook or Squeteague harbors.

The groundwater ETI system, located approximately 10,000 feet downgradient of the landfill at the western boundary of the MMR, was designed to remove contaminated groundwater from the northern and southern lobes of the LF-1 plume. In the central lobe and the uncaptured portions of the plumes, contaminants were expected to decrease in mass and concentration through naturally occurring processes to attenuate the migrations of COCs (i.e., advection, dispersion, and degradation). Factors to determine if natural attenuation was occurring were monitored through groundwater sampling and analysis. On 26 August 1999, the ETI system began operation. These five extraction wells (27EW0001 through 27EW0005) (Figure 2-4) were designed to capture the higher COC concentrations within the southern and northern lobes at a combined design extraction rate of 700 gallons per minute (gpm). The influent is processed through a granular activated carbon (GAC) treatment plant that also includes a sodium hypochlorite injection system to reduce biofouling. The extracted groundwater is treated and released to an infiltration gallery and two infiltration trenches located near the MMR boundary within a relatively clean groundwater zone, situated between the northern and southern lobes of the LF-1 plume. The infiltration system was located in this area to protect the downgradient water supply wells by recharging the zone of contribution to the downgradient water supply wells with treated water.

There have been some minor changes to the operation of the system since it began operation. The original design extraction rate was 700 gpm; the current optimized design extraction rate is 1195 gpm (AFCEE 2007). Data collected after the ETI system began operation indicated that part of the southern plume would escape capture of the ETI system and migrate off-base to such a degree as to not meet the interim RAOs (restoring the aquifer between the MMR western base boundary and Route 28 within 20 years of remedial system start-up in 1999) (AFCEE 2005). AFCEE agreed to modify the system

by adding an extraction well (27EW0006) south of 27EW0002 for the purpose of meeting the interim RAOs (Figure 2-4). The extracted groundwater will be piped to the Hunter Avenue Treatment Facility, which was constructed as part of the remedial action for the CS-4, CS-20, CS-21, and Fuel Spill-29 (FS-29) plumes. The CS-4, CS-20, CS-21, and FS-29 remedial system became fully operational in September 2006. The Hunter Avenue Treatment Facility is designed to remove VOCs and ethylene dibromide (EDB) from extracted groundwater by filtration through GAC, and was built with additional treatment capacity for water extracted from the LF-1 and CS-23 plumes. After treatment, the LF-1 and CS-23 treated water will be returned to the aquifer through infiltration trenches. The expansion of the LF-1 remedial system and the CS-23 remedial system become operational in December 2006.

In addition to treatment, other actions have been taken to reduce potential risk of the LF-1 plume through reducing exposure to contaminated groundwater. LUCs have been implemented to reduce exposure to groundwater impacted by the LF-1 plume and to protect the integrity of the landfill cap. For the area on-base, all base housing has been connected to base supplied water. In the area of the LF-1 plume off-base, AFCEE has provided public water supply connections to all residences that were not already connected, and the towns of Bourne and Falmouth have established regulations that prevent installation of private wells for human consumption or irrigation in areas of known plume contamination or in the direct path of an advancing plume. The towns' regulations do not apply to use of existing drinking water wells and irrigation wells. The IRP has committed funds for replacement of lost capacity from the Bourne public water supply wells PWS-2 and PWS-5 due to the proximity of the plume to the wells. A portion of the funds have already been spent on pipeline construction, a pump house, and hydrogeologic studies for replacement of potential lost municipal water production capacity due to potential migration of LF-1 contamination into the public water supply wells.

In support of reaching a final ROD for LF-1, a risk assessment was performed (AFCEE 2006b) using data collected from the ongoing SPEIM program to characterize the current

plume and assess potential risks from exposure to the groundwater in the LF-1 plume area. Based on the risk assessment, RAOs were established, which formed the basis of a FS. The FS evaluated a range of remedial alternatives; the proposed remedies were presented in the Proposed Plan (PP) and were selected as the final remedy (AFCEE 2006a). The ROD is the documentation of the selected remedy and considers information from all previous investigation and decision documentation.

2.3 COMMUNITY PARTICIPATION

The MMR IRP has a community involvement program that provides many opportunities for the public to become involved in the investigation and decision-making process. Public meetings and poster board sessions are held, display ads and notices are placed in newspapers to announce significant events, public comment periods and meetings, news releases are issued, tours of the sites and treatment facilities are conducted, and neighborhood notices are distributed to notify people of events impacting their neighborhoods.

In addition, several citizen teams have been formed over the years to advise the IRP and the regulatory agencies. Currently the Senior Management Board and the Plume Cleanup Team (PCT) are the two teams that continue to meet. They are made up of citizen volunteers and government representatives working together to resolve problems and advise on the cleanup process. All citizen team meetings are open to the public. Assumptions about reasonably anticipated future land use and potential beneficial uses of groundwater and surface water are regularly discussed.

The public has been kept up-to-date on the progress of the LF-1 site through various public and citizen team meetings and public notices. The following updates on the IROD to ROD process for sites addressed in this ROD were presented to the PCT:

- 11 February 2004: Overview of the *Final Work Plan for the Process Leading to Final Groundwater Decisions for Ashumet Valley and Landfill-1* (AFCEE 2004b).
- 11 August 2004: Overview of the human health risk assessment for LF-1.

- 08 September 2004: Overview of the initial LF-1 remedial alternatives for the FS.
- 04 December 2004: Overview of the screening of LF-1 remedial alternatives and list of alternatives that were carried forward to the detailed analysis.
- 11 May 2005: Overview of the LF-1 FS results.
- 14 June 2006: PP for LF-1 Source Area and Groundwater (AFCEE 2006a).
- 12 July 2006: PCT input on PP for LF-1 Source Area and Groundwater.

On 14 June 2006, a presentation of the LF-1 PP was made to the PCT; on 12 July 2006, the team discussed their preferred alternative. On 22 June 2006, AFCEE held a public meeting at Handy Hall, Cataumet United Methodist Church to present the PP. From 23 June to 22 July 2006, AFCEE held a 30-day comment period to obtain public comments on the remedy presented in the PP for the LF-1 source area (the 1970 Cell, the Post-1970 Cell, and the Kettle Hole) and groundwater. Before the public comment period, the PP was delivered to the town libraries of Bourne, Sandwich, Falmouth, and Mashpee, and an electronic copy was posted on the IRP website. On 20 July 2006, AFCEE held a public hearing at the Handy Hall, Cataumet United Methodist Church to accept formal public comments on the PP. A transcript of the public hearing is provided in Appendix B. No verbal comments were provided at the meeting. AFCEE's response to written comments received during the public comment period is included in the Responsiveness Summary, which is Section 3.0 of this ROD.

AFCEE published display advertisements for the public information meeting, public comment period, and the public hearing on 16 June 2006 for the LF-1 PP in the *Falmouth, Mashpee, Bourne,* and *Sandwich Enterprises* and in the *Cape Cod Times.* AFCEE also circulated news releases for the public information meeting, public comment period, and public hearing on 13 June 2006. The PP was made available for public review at the main public libraries in Bourne, Falmouth, Mashpee, and Sandwich, Massachusetts and on the MMR website. The PP has also been made part of the Administrative Record available for public review at the AFCEE IRP office at the MMR and on the MMR website, http://www.mmr.org.

2.4 SCOPE AND ROLE OF OPERABLE UNIT

The LF-1 site was organized into separate operable units (OU), focusing on source area and groundwater. This ROD addresses a portion of the source area, specifically the 1970 Cell, the Post-1970 Cell, and the Kettle Hole (Figure 2-3), and the groundwater OU (Figure 2-5).

The LF-1 area is located along the west-southwest edge of the MMR where, through the IRP, AFCEE is responsible for the cleanup of contamination from past military practices. The NGB is actively investigating and remediating soil and groundwater contamination in the northern portion of the base (north of the LF-1 site) as part of the Impact Area Groundwater Study Program.

2.5 SITE CHARACTERISTICS

As described in Section 2.2, environmental data have been collected from the LF-1 area since 1985. The following overview of site characteristics will focus on the current site conditions.

The LF-1 source area is located in the south-central portion of the MMR, within the town of Bourne (Figure 2-1). The landfill, occupying approximately 100 acres of open to heavily wooded terrain, is bounded by Turpentine and Frank Perkins roads to the east and west and Herbert Road and Connery Avenue to the north and south (Figure 2-3).

The eastern portion of the LF-1 plume is primarily located within the Mashpee Pitted Plain (MPP), and the western portion of the plume is within and beneath the Buzzards Bay Moraine and the Buzzards Bay Outwash (Figure 2-1). The MPP is a broad, flat, gently southward-sloping glacial outwash plain. The MPP consists of stratified outwash sand underlain by silty glaciolacustrine sediment. Some sections have remnants of gravel and basal till that overlie bedrock. The topography of the MPP gradually slopes from 140 feet mean sea level (ft msl) in the north to 70 ft msl in the south and is pocked with numerous kettle ponds. The Buzzards Bay Moraine is present as a veneer of bouldery glacial till overlying stratified sands and silty glaciolacustrine sediment. A few kettles

are located within the Buzzards Bay Moraine. Beneath these sediments, a variable thickness of glacial till overlies the bedrock.

The single groundwater flow system that underlies western Cape Cod, including the MMR, is known as the Sagamore Lens. This sole-source aquifer is primarily unconfined and recharged by infiltration of precipitation. Groundwater flow is generally radial from the recharge area toward the ocean, which forms the lateral boundary of the aquifer on three sides; the Bass River in Yarmouth forms the eastern boundary of the Sagamore Lens. Flow direction within the aquifer is generally horizontal with stronger vertical gradients near surface water bodies. Ponds are generally an expression of the water table and are hydraulically connected with the aquifer. Groundwater enters the upgradient portion of the pond, flows through the pond, and exits on the downgradient portion of the pond. Water table elevations fluctuate from 1 to 4 feet per year. The elevation of the water table is approximately 55 ft msl near the source area and 20 ft msl in the downgradient portion of the plume. The aquifer thickness varies from 170 to 220 feet in the LF-1 area depending on the elevation of the bedrock surface, which forms the bottom of the aquifer.

2.5.1 Conceptual Site Model

The LF-1 plume originated at the landfill source area on-base, and monitoring data indicate that a small portion of the plume above cleanup levels is beneath the landfill and most of the plume is now disconnected from the source. The conceptual site model assumes that the landfill is not a continuing source. The leached contamination mixed with groundwater at the water table and was transported to the west under the influence of prevailing hydraulic gradients (Figures 2-6 and 2-7). The area overlying the LF-1 plume on-base consists primarily of a housing area operated by the USCG and a cemetery operated by the Veterans Affairs (Figure 2-2). West of the housing area to Route 28 (off-base), the area is characterized by undeveloped woodlands. The area west of Route 28 is primarily residential, with smaller areas characterized as recreational, conservational, and commercial.

LF-1 plume contaminants dissolved in the groundwater are transported downgradient with groundwater flow. Natural attenuation processes for this contamination include sorption, dispersion, and biodegradation. The contaminants are migrating through the aquifer with little volatilization. Most of the plume upgradient of the existing ETI system migrates to the fence and is extracted, treated, and infiltrated. There is a small portion that migrates approximately 800 feet downgradient of the extraction wells. The portion of the plume downgradient of the existing ETI system continues to migrate and naturally attenuate or discharge under Red Brook and Squeteague harbors. As the plume discharges to the harbors, the contaminant concentrations are almost immediately reduced to nondetectable levels through mixing with the surface water. In areas where organic material is present at the sediment/surface water interface, some of the contaminants may be anaerobically degraded as a result of biological activity in this setting.

The LF-1 plume is defined by TCE, PCE, and CCl_4 concentrations greater than the MCL (5 µg/L for TCE, PCE, and CCl_4). The other LF-1 plume COCs are essentially co-located with TCE, PCE, or CCl_4 and the other COCs are relatively sporadic and do not justify independent delineation (i.e., contouring and other detailed conceptualization). The plume varies in thickness from 40 to 140 feet. The top of the plume varies between 30 to 60 feet below the top of the water table and is found on top of bedrock in some places. Three distinct lobes of the LF-1 plume are apparent from the analysis of LTM data (Figure 2-5). PCE exists in a broad area throughout the southern and central lobes. TCE exists in all three of the lobes with the area of the highest concentrations in the upgradient portion of the southern lobe referred to as the "warm spot" (Figure 2-5). CCl_4 comprises a relatively small zone of contamination along the southern boundary of the southern lobe.

Southern Lobe

The southern plume lobe is detached from the source area and extends approximately 16,000 feet downgradient from the boundary of the landfill. It is the largest of the three LF-1 plume lobes and contains the highest mass and highest concentrations of TCE

(64.8 µg/L), PCE (38 µg/L), and CCl_4 (34.7 µg/L) (AFCEE 2006b). CCl_4 occurs in the core of the southern lobe, but is most common along the southern periphery of the southern lobe. Most of the contaminant mass located upgradient of the MMR boundary in the southern plume lobe is being removed and treated by the four southern extraction wells.

The core of the southern plume lobe is characterized by elevated levels of PCE and TCE, methane, elevated specific conductance, and detections of vinyl chloride. Anoxia, high methane concentrations, and elevated specific conductance are indicative of the landfill signature in the core of this lobe, largely resulting from the biodegradation of organic compounds. Data have indicated that reductive dechlorination of TCE, PCE, and CCl_4 is prevalent in the core and that it will have an important role in the long-term remediation of the southern lobe of the plume. The zone of significant reductive dechlorination is limited to the area of high contaminant concentrations in the southern lobe, upgradient of the extraction system (Figure 2-6).

The southern lobe has reached Squeteague Harbor. Low concentrations (i.e., less than 2.0 µg/L) of PCE and TCE have been detected in seep samples in Squeteague Harbor, indicating discharge of the southern lobe. Seeps are areas where groundwater (fresh water) is discharging to the harbor. The contaminant concentrations will be reduced almost immediately to nondetectable levels through mixing with the harbor water; PCE, TCE, CCl_4, 1,4-dichlorobenzene, vinyl chloride, and 1,1,2,2-TeCA have not been detected at concentrations above the respective reporting limit.

Northern Lobe

The northern plume lobe consists primarily of TCE, and it contains a shallow section upgradient of extraction well 27EW0005 and a deep section downgradient of 27EW0005. Compared to other areas of the plume, minimal biological reduction of contamination is occurring in this lobe. The deep, downgradient section located to the west of the MMR base boundary consists of TCE at relatively low concentrations (20-30 µg/L), and is discharging under Red Brook Harbor (Figure 2-7). Analysis of samples and groundwater

modeling indicate that the LF-1 plume is discharging approximately 500 feet offshore under Red Brook Harbor (McCobb and LeBlanc 2002; AFCEE 2003). TCE has been detected at concentrations below the MCL in groundwater beneath the harbor bottom (McCobb and LeBlanc 2002). In the area of plume discharge, the harbor bottom is comprised of soft, highly organic-rich sediments, which form oxygen-depleted, strongly reducing conditions. In strong reducing conditions, reductive dechlorination will convert TCE to less toxic compounds such as cis-1,2-DCE and ultimately to nonhazardous compounds (ethane and ethene). The organic-rich sediments have a high sorption potential and retard the migration of contaminants, thereby increasing the time contaminants are exposed to the highly reducing conditions and, thus, increasing the conversion of contaminants by reductive dechlorination. If contaminants migrate through the organic rich sediments, the concentrations will be reduced almost immediately to nondetectable levels through mixing with surface water. Therefore, it is unlikely that TCE from the deep plume will ever discharge to the surface water of the harbor at concentrations above the MCL due to (1) the low concentrations of TCE that may discharge to the harbor, (2) dilution of contaminants through mixing with surface water, and (3) conversion of contaminants through reductive dechlorination in the highly organic rich sediments on the harbor bottom.

Central Lobe

The central plume lobe has historically been defined as the zone of landfill-impacted groundwater located between the TCE-dominated northern lobe and the mixed VOC southern lobe. Groundwater chemistry data collected since system start-up (AFCEE 2001, 2002, 2003, 2004a) indicate that natural attenuation plays a minor role in the central plume lobe. The smaller mass of contaminants associated with the central plume lobe is a result of source and flow path characteristics (AFCEE 2004a). Although microbial processes are insignificant in reducing the concentrations of PCE in this region, other natural attenuation processes (e.g., dispersion) are also effective (Figure 2-7).

2.5.2 Sampling Strategy

Groundwater samples have been collected in the LF-1 area at prescribed frequencies (minimum annual frequency) as part of the SPEIM program, which was initiated before the operation of the LF-1 ETI system in 1999. A total of 335 monitoring wells have been installed in support of monitoring the LF-1 plume, and since 1996, a total of 3,179 samples have been collected. The sampling program was initiated as part of the interim remedy for LF-1 groundwater and, thus, is ongoing.

2.6 CURRENT AND POTENTIAL FUTURE SITE AND RESOURCE USES

This section discusses the current and reasonably anticipated future land uses and current and potential beneficial groundwater uses at the LF-1 source area and in the vicinity of LF-1 contaminated groundwater, and presents the basis for future land use and groundwater use assumptions.

2.6.1 Land Use

The LF-1 source area (1970 Cell, Post-1970 Cell, and the Kettle Hole) is currently being maintained as a capped landfill. It is anticipated that the land use in the source area will not change significantly over time. Source area controls, in the form of environmental land use restrictions, are in place that protect human health by limiting exposure to the landfill source areas and preventing intrusive activities on the landfill.

The on-base area of LF-1 groundwater contamination includes the inactive landfill (i.e., the source area), portions of a housing area operated by the USCG, part of the Massachusetts National Cemetery operated by the U.S. Department of Veterans Affairs, and undeveloped woodlands. The off-base area west of the MMR boundary to Route 28 is characterized by undeveloped woodlands, and the area west of Route 28 is primarily residential, with smaller areas characterized as recreational, conservational and commercial (Figure 2-2). It is anticipated that the land use in the LF-1 area will not change significantly over time.

2.6.2 Water Resource Use

The LF-1 plume extends from the landfill on MMR to Red Brook and Squeteague harbors. The aquifer in this area and throughout the upper Cape Cod, known as the Sagamore Lens, is generally a highly transmissive and productive aquifer, and designated by the MassDEP and EPA as a sole source aquifer (defined as the sole or principal source of drinking water for a given area). Two Bourne public water supply wells, PWS-2 and PWS-5, are located within the LF-1 plume area.

Surface water bodies in the vicinity of the LF-1 plume (e.g., Osborn Pond, Long Pond, Cuffs Pond) are fed by groundwater and provide recreational use such as fishing swimming and boating. Red Brook and Squeteague harbors are located at the western end of the LF-1 plume and provide for the same recreational uses.

AFCEE has developed a working relationship with the water commissioners of the four towns that surround MMR to ensure that future development of the groundwater resource is coordinated with groundwater monitoring and remediation at the MMR. The groundwater in the vicinity of the LF-1 plume is expected to be utilized in approximately 40 to 50 years.

2.7 SUMMARY OF SITE RISKS

The risk assessment estimated the potential future risks posed by the LF-1 groundwater contamination (AFCEE 2006b). It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed. The technical approach of the risk assessment is detailed in the *Final Work Plan for the Process Leading to Final Remedial Decisions Ashumet Valley and Landfill-1* (AFCEE 2004b). The risk assessment evaluated the human health risks from exposure to contaminated groundwater in the LF-1 area. An ecological baseline risk assessment was not conducted for LF-1 because previous evaluations of ecological risk (AFCEE 1996b) as well as evaluation of contaminant body burdens in shellfish and sediment pore water (TRET 2001; ATSDR 2002) have indicated that no significant exposures will be expected in these surface water

bodies (AFCEE 2004b). Consequently, ecological exposures to surface water and sediment in Buzzards Bay, including Red Brook Harbor and Squeteague Harbor were not re-evaluated.

Soil exposure pathways at the source area were not considered due to installation of a landfill cap and fence, which minimizes exposure to contamination. Also, the nature of the proposed cover system was deemed sufficient to prevent receptors from contacting contaminated soils (ABB 1992). In addition, soil in non-source areas is not impacted by groundwater contamination.

Inhalation of vapors from the landfill was not evaluated in the risk assessment. Based on the PCM results, total VOC readings are zero and the regulatory limit for landfill gas (25 percent of the lower explosive limit at the assigned boundary) is not currently being exceeded at LF-1 (AFCEE 2003 and 2004a). Based on the PCM results, the regulatory limit is unlikely to be exceeded in the future. This conclusion is based on the relatively high porosity of the soil and the great horizontal distance the landfill gas would have to travel to reach the base boundary (approximately three miles away) (AFCEE 2004b).

This section of the ROD summarizes the results of the human health risk assessment for LF-1 groundwater, surface water, and sediment and COC selection for LF-1 groundwater (AFCEE 2006b). A complete description of the methods and results of the baseline human health risk assessment for LF-1 is presented in Appendix A of the *Final Landfill-1 Source Area and Groundwater Feasibility Study* (AFCEE 2006b).

2.7.1 Identification of Chemicals of Potential Concern

The selection of chemicals of potential concern (COPC) for inclusion in the quantitative human health risk calculations was typically based on three screening criteria:

- Frequency of detection,
- Compound concentration and toxicity, as compared to conservative risk and/or hazard-based concentrations, and
- Essential nutrient status.

The concentration-toxicity screen was conducted by comparing site data with a series of federal and Massachusetts risk-based criteria. The maximum detected concentration was used in the concentration-toxicity screen.

For groundwater, the following screening criteria were used:

- EPA Region IX preliminary remediation goals (PRGs) for residential tap water (EPA 1999a),
- EPA MCLs, and
- Massachusetts drinking water standards and guidelines.

For surface water, the screening criteria were the EPA recommended water quality criteria for human health consumption of water and organisms. The groundwater screening criteria were used as conservative surrogate values when EPA water quality criteria were not available. For sediment, the EPA Region IX PRGs for residential soil were used.

PRGs for noncarcinogens were modified (PRG was multiplied by 0.1) such that the PRGs were based on a non-cancer hazard quotient (HQ) of 0.1 (EPA 1995). PRGs for carcinogens were based on a cancer risk level of 1×10^{-6} and were not modified for the screening. When more than one criterion was available for a chemical (PRG, MCL, state standard, or guideline), the lowest of the available criteria was used in the concentration-toxicity screen.

Groundwater in the LF-1 risk assessment was evaluated separately in subsets, based on the influence of the existing remedial system, and different environmental media: LF-1 groundwater within the capture zone[2] and LF-1 groundwater outside the capture zone. Surface water and sediment in Buzzards Bay were also evaluated. The tables presenting the screening process for identifying COPCs in each area are listed below:

[2] Capture zone defined by Scenario 15 (AFCEE 2003).

- LF-1 Groundwater Within the Capture Zone (Table 2-1),
- LF-1 Groundwater Outside the Capture Zone (Table 2-2),
- Surface Water in Buzzards Bay (Table 2-3), and
- Sediment in Buzzards Bay (Table 2-4).

Tables 2-1 through 2-4 present the occurrence and distribution of compounds detected in the LF-1 areas listed above. For each detected chemical, these tables include the minimum and maximum detected concentration, the data qualifiers associated with these concentrations, the location of the maximum detected concentration, the frequency of detection, and the range of detection limits. The "J" qualifier indicates estimated concentrations. Analytical data results for sediment were all less than the screening criteria (Table 2-4). Therefore, risk from exposure to Buzzards Bay sediment was not evaluated.

2.7.2 Exposure Assessment

Several exposure pathways were eliminated from the assessment based on the likely absence of site-related contamination. Soil exposure pathways at the source area were not considered due to installation of a landfill cap and fence, which minimizes exposure to contamination. In addition, soil in non-source areas is not impacted by groundwater contamination. Also based on the PCM results, the inhalation of vapors from the landfill was not evaluated in the risk assessment.

There is currently no exposure to the LF-1 plume on the MMR (although there are residences in the area overlying the plume on-base, all are connected to the public water system). For LF-1 groundwater, all constituent concentrations exceeding MCLs are located at depths of 100 feet or more below ground surface and therefore an evaluation of the vapor intrusion to an indoor air pathway was not necessary. No off-base residents are currently exposed to groundwater in close proximity to the LF-1 plume. Residences located off-base are connected to a municipal water supply. However, potential future exposure to LF-1 groundwater was evaluated since it was assumed that residential use of groundwater could occur anywhere on or off the base in the future. Exposures were

evaluated separately for receptors potentially exposed to groundwater within the capture zone and groundwater outside the capture zone. Since household water use was the exposure pathway with the highest exposure potential, other potential future exposure pathways were not evaluated. Potential exposure routes for these individuals are ingestion, dermal contact, and inhalation of vapors released during household use of groundwater.

LF-1 groundwater discharges to Buzzards Bay. Human receptors of concern evaluated for Buzzards Bay were recreational swimmers (adult and child) and adult fish/shellfish consumers. Exposure of adult fish/shellfish consumers was evaluated for ingestion of recreationally caught fish/shellfish impacted by the bioaccumulation of contaminants from surface water. Only adults were considered to ingest recreationally caught fish/shellfish since children ages 1 to 6 were not expected to ingest much locally caught fish/shellfish.

The human health conceptual exposure model for the LF-1 area is illustrated in Figure 2-8. After identifying which human receptors will be evaluated in the risk assessment, the exposure point concentrations (EPCs) for each receptor were determined. A representative EPC was calculated for each COPC.

For groundwater, the EPCs for the reasonable maximum exposure (RME) condition were the maximum concentrations. For surface water, the RME condition was the 95 percent upper confidence limit on the mean (UCL_{95}) unless the UCL_{95} exceeded the maximum concentration. When this was the case, the RME EPC was the maximum concentration. For the metals that were selected based on both dissolved and total concentrations, the EPCs were selected as the higher of the total or dissolved concentration for the RME exposure scenario.

The EPCs for each area and media are presented in the tables listed below:

- LF-1 Groundwater Within the Capture Zone (Table 2-5),
- LF-1 Groundwater Outside the Capture Zone (Table 2-6), and
- LF-1 Impacted Surface Water (Table 2-7).

To quantitatively assess the potential carcinogenic risks and health hazards, daily intakes of the COPCs were calculated. These exposure parameters are site-specific and chemical-specific, and vary depending on the time frame, exposure medium, exposure point, and receptor population and age. Exposure assumptions and other parameters used in the chronic daily intake (CDI) or dermal absorbed dose algorithms are presented for each receptor and exposure medium in the tables listed below:

- Future Adult Resident and Child Resident, Groundwater (Table 2-8),
- Future Adult Recreational Fisherman/Shellfisher, Surface Water (Table 2-9), and
- Future Adult Swimmer and Child Swimmer, Surface Water (Table 2-10).

All of the parameters used in the CDI and daily absorbed dose calculations are presented in these tables, except for some chemical-specific parameters (e.g., bioaccumulation factors for fish, dermal absorption factors, and other calculated parameters used in the daily absorbed dose calculations), which are presented in Appendix A of the *Final Landfill-1 Source Area and Groundwater Feasibility Study* (AFCEE 2006b).

2.7.3 Toxicity Assessment

The purpose of the toxicity assessment is to identify the types of adverse health effects that a COPC may potentially cause and to define the relationship between the dose of a compound and the likelihood and magnitude of an adverse effect (i.e., response). Adverse effects are characterized by EPA as carcinogenic or noncarcinogenic. Dose-response relationships are defined by the EPA for oral and inhalation exposures. For the LF-1 risk assessment, oral dose-response values were also used to evaluate dermal exposure.

At the time each risk assessment was prepared, EPA's most current toxicity values were obtained from the following hierarchy of sources: (1) EPA's on-line Integrated Risk Information System (IRIS) (EPA 2004), (2) EPA's Health Effect Assessment Summary Tables (HEAST) (EPA 1997), (3) memoranda from the EPA's National Center for Environmental Assessment, and (4) dose-response values recommended by EPA. Cancer

and non-cancer toxicity factors for each of the COPCs evaluated in the LF-1 risk assessment are presented in the tables listed below:

- LF-1 Oral/Dermal Non-Cancer Toxicity Data (Table 2-11),
- LF-1 Inhalation Non-Cancer Toxicity Data (Table 2-12),
- LF-1 Oral/Dermal Cancer Toxicity Data (Table 2-13), and
- LF-1 Inhalation Cancer Toxicity Data (Table 2-14).

2.7.4 Risk Characterization

Risk characterization integrates the results of the exposure and toxicity assessments to derive quantitative and qualitative estimates of the potential cancer risk and non-cancer hazards that may occur due to exposure to site-related contaminants.

For carcinogens, risks are generally expressed as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the carcinogen. Excess lifetime cancer risk is calculated from the following equation:

$$\text{Risk} = (\text{CDI or DAD}) \times \text{SF}$$

Where

Risk = a unitless probability of an individual's developing cancer
CDI = chronic daily intake (milligrams per kilogram per day [mg/kg-day])
DAD = dermally absorbed dose (mg/kg-day)
SF = slope factor $(\text{mg/kg-day})^{-1}$

Carcinogenic risks are probabilities that usually are expressed in scientific notation (e.g., 1E-06). An excess lifetime cancer risk of 1E-06 indicates that an individual experiencing the RME theoretically has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an excess lifetime cancer risk because it will be in addition to the risk of cancer an individual faces from other causes such as exposure to too much solar radiation or radon. The chance of an individual developing cancer from all other causes has been estimated to be as high as one in three. EPA's target risk

range for site-related exposures is E-04 to E-06 (EPA 1991). Separate assumptions were used to calculate doses for adult and child residents, and then cancer risks for the adult and child were combined to represent total risks to residents for a 30-year exposure period.

The potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified time period (e.g., lifetime) with a reference dose (RfD) derived for a similar exposure period. An RfD represents a level to which an individual may be exposed that is not expected to cause any deleterious effect. The ratio of exposure to toxicity, which is called an HQ, is calculated as follows:

Non-cancer HQ= (CDI or DAD) / (RfD)

Where

CDI = chronic daily intake (mg/kg-day)

DAD = dermally absorbed dose (mg/kg-day)

RfD = reference dose (mg/kg-day)

The hazard index (HI) is calculated by adding the HQs for all COCs that affect the same target organ (e.g., prostate) within a medium or across all media to which a given individual may reasonably be exposed. An HI less than 1 indicates that, based on all of the different contaminants and exposure routes, toxic noncarcinogenic effects are unlikely (EPA 1991). An HI greater than 1 indicates that site-related exposures may present a hazard to human health.

The tables listed below are the risk assessment tables that summarize the cancer and non-cancer risks to each receptor under the RME exposure scenarios. Cancer and non-cancer risks that appear in these tables are limited to those for the COPCs that produced cancer or non-cancer risks at or near regulatory thresholds. Risks associated with COPCs that produced excess lifetime cancer risks less than 1E-06 or HQs less than 0.1 do not appear in these tables.

- Future Adult Resident, LF-1 GW Within the Capture Zone (Table 2-15),
- Future Child Resident, LF-1 GW Within the Capture Zone (Table 2-16),
- Future Adult Resident, LF-1 GW Outside the Capture Zone (Table 2-17),
- Future Child Resident, LF-1 GW Outside the Capture Zone (Table 2-18),
- Future Adult Swimmer, Buzzards Bay Surface Water (Table 2-19),
- Future Child Swimmer, Buzzards Bay Surface Water (Table 2-20), and
- Future Adult Fish Eater, Buzzards Bay Surface Water (Table 2-21).

The cancer risk calculations indicated that future residential exposure to LF-1 groundwater within the capture zone and LF-1 groundwater outside the capture zone may present an excess lifetime cancer risk greater than the acceptable federal range of E-04 to E-06. The potential RME carcinogenic risk levels for the future residential exposure pathways are 4E-03 for LF-1 groundwater within the capture zone and 2E-03 for LF-1 groundwater outside the capture zone. The non-cancer hazard calculations indicated that residential exposure to LF-1 groundwater within the capture zone and LF-1 groundwater outside the capture zone may present an unacceptable non-cancer hazard.

The cancer risk calculation indicated that current and future exposure to LF-1 impacted surface water through recreational swimming and recreational fish consumption are within and lower than the EPA acceptable risk range, and there is no potential unacceptable carcinogenic health risk associated with LF-1 impacted surface water. The non-cancer hazard calculations indicated that potential exposure pathways for recreational swimming and recreational fish consumption are less than unity and there is no concern for potential noncarcinogenic health effects.

2.7.5 Uncertainty Analysis and Human Health Risk Assessment Conclusions

There are uncertainties involved in the process of quantifying the risk for human receptors, and overall they make the risk assessment very conservative. Exposure assumptions, slope factors, and oral-to-dermal adjustment factors are all very conservative. In the RME groundwater assumptions, the maximum concentrations of contaminants detected in groundwater were conservatively assumed to be present in all

groundwater throughout the area for the entire 30-year period (neglecting contaminant degradation or plume movement). The assumption was also made that human exposure remains constant over the lifetime of an individual, when in fact, lifestyle changes due to age and actual time in residence will alter the projected exposure duration. Even the assumption that the groundwater in these areas would be used for household purposes is a conservative assumption. In light of the conservatism that was built into many of the factors used in the risk assessment approach, the results should be considered to be significant overestimates of actual risk.

COPCs for which an RME were calculated result in an excess lifetime cancer risk greater than one in a million or an HI greater than 1 are presented in Table 2-22. From this list, the COCs were identified based on a range of criteria. Several COPCs were eliminated from inclusion as COCs because they met one or more of the following criteria:

- The COPC is present at the site at concentrations similar to background concentrations.
- The COPC is present only at concentrations below state and federal drinking water standards.

In consideration of these criteria and based on discussions with the EPA and MassDEP, the following COCs were selected for the entire LF-1 plume (the contaminant-specific evaluations are presented in the risk assessment [AFCEE 2006b]):

- CCl_4,
- 1,4-dichlorobenzene,
- EDB,
- 1,1,2,2-TeCA,
- PCE,
- TCE,
- vinyl chloride, and
- manganese.

Some of more significant COPCs associated with potential risks as discussed below.

The LF-1 risk assessment identified cis-1,2-DCE as a potential health risk based on a concentration of 73.5 µg/L. The 2005 and 2006 maximum monitoring well concentrations of cis-1,2-DCE in LF-1 groundwater are below the MCL of 70 µg/L. Due to the low risk (HI below 1 for child and adult) calculated during the LF-1 risk assessment associated with cis-1,2-DCE in LF-1 groundwater and the current concentrations below 70 µg/L, cis-1,2-DCE is not an LF-1 COC.

The LF-1 risk assessment also identified perchlorate as a potential health risk based on a concentration of 17.7 µg/L. Perchlorate was detected during borewater screening at one location in 2005 at concentrations above the Massachusetts maximum contaminant level (MMCL) of 2 µg/L for approximately 20 vertical feet (2.6 and 3.7 µg/L). In 2006 perchlorate was detected in monitoring wells below the reporting limit. Since perchlorate distribution in LF-1 groundwater is sporadic, no contiguous area of groundwater contamination with perchlorate has been defined and perchlorate concentrations in groundwater have decreased since the risk assessment was conducted, perchlorate is not considered a COC for LF-1 groundwater. However, the AFCEE will conduct chemical monitoring of the limited extent of perchlorate in LF-1 groundwaters.

2.8 REMEDIAL ACTION OBJECTIVES

Results of the human health risk assessment for LF-1 groundwater were considered in conjunction with expected current and future use of the aquifer to develop RAOs. Exposure to groundwater was the only viable exposure pathway for the LF-1 plume. The following RAOs for the LF-1 source area and groundwater FS, agreed upon by AFCEE, the EPA, and the MassDEP, were developed to evaluate the alternatives with respect to protecting human health:

- Prevent the leaching from the source area of landfill contamination that would cause groundwater downgradient from the landfill to be unusable.
- Prevent risks to human health and the environment (if any) posed by the landfill.

- Prevent residential exposure to LF-1 groundwater with TCE concentrations greater than the MCL of 5 µg/L.
- Prevent residential exposure to LF-1 groundwater with PCE concentrations greater than the MCL of 5 µg/L.
- Prevent residential exposure to LF-1 groundwater with CCl_4 concentrations greater than the MCL of 5 µg/L.
- Prevent residential exposure to LF-1 groundwater with 1,1,2,2-TeCA concentrations greater than the Massachusetts GW-1 standard of 2 µg/L.
- Prevent residential exposure to LF-1 groundwater with vinyl chloride concentrations greater than the MCL of 2 µg/L.
- Prevent residential exposure to LF-1 groundwater with EDB concentrations greater than the MMCL of 0.02 µg/L.
- Prevent residential exposure to LF-1 groundwater with 1,4-dichlorobenzene concentrations greater than the MMCL of 5 µg/L.
- Prevent residential exposure to LF-1 groundwater with manganese concentrations greater than the Health Advisory of 300 µg/L.
- Return useable groundwaters to their beneficial uses wherever practicable, within a time frame that is reasonable given the particular circumstances of the site.
- Prevent exposure to LF-1 groundwater for human receptors under non-residential use scenarios (including dermal contact, ingestion, and inhalation), unless shown, pursuant to Section 2.11.2, that such use does not present a carcinogenic risk in excess of the EPA target risk range of 10^{-4} to 10^{-6} or present a non-carcinogenic hazard index greater than 1.0.

The remedial alternatives were developed to satisfy these RAOs. The groundwater cleanup levels as specified in the RAOs are the MCLs for TCE (5 µg/L), PCE (5 µg/L), CCl_4 (5 µg/L), and vinyl chloride (2 µg/L), the MMCLs for EDB (0.02 µg/L) and 1,4-dichlorobenzene (5 µg/L), and the Massachusetts GW-1 standard for 1,1,2,2-TeCA (2 µg/L).

2.8.1 Basis and Rationale for Remedial Action Objectives

For human health concerns, the only media/exposure pathway that presents a cancer risk and/or a non-cancer HI above the target values is the future potential residential exposure to groundwater. A summary of the human health total non-cancer HIs and cancer risks for the LF-1 study area indicates that CCl_4, 1,4-dichlorobenzene, EDB, 1,1,2,2-TeCA,

PCE, TCE, and vinyl chloride increase risk and hazards associated with exposure to groundwater.

2.8.2 Steps to Achieving Remedial Action Objectives

MMR groundwater plumes, including the LF-1 plume, are located within the Cape Cod sole-source aquifer. Therefore, AFCEE has agreed that for all active remedies selected, it will undertake a three-step process in achieving RAOs. This three-step process will be implemented in the following manner:

(1) **During the period that treatment systems are remediating the aquifer to federal and state drinking water standards or other risk-based cleanup levels, AFCEE will monitor the plume in accordance with an approved system performance monitoring plan.** The performance monitoring program will collect data for evaluating (a) whether the system is performing as designed, (b) whether the system is impacting ecologically sensitive areas, (c) the potential for short-term health effects due to exposures during active remediation, and (d) when the selected remedy will attain the remediation goals in the ROD.

(2) **In accordance with applicable EPA guidance, a residual risk assessment(s) will be performed to determine if unacceptable ecological and/or human health risks are present, system operation will continue, and/or additional measures pursued as required to achieve acceptable risks.** AFCEE shall conduct a residual risk assessment of all contaminants remaining in the aquifer associated with LF-1 to determine whether the groundwater contamination continues to pose unacceptable ecological and/or human health risks. This risk determination shall be made jointly by AFCEE and EPA, in consultation with the MassDEP, and may result in aquifer cleanup that is more protective than the NCP point-of-departure risk of 10^{-6} [40 Code of Federal Regulations (CFR) Part 300.430 (e)(2)], if justified, based on the following site-specific factors: cumulative effects of multiple contaminants, the potential for exposure from other pathways of exposure at the site, population, sensitivities, potential impacts on environmental receptors, and cross-media impacts (NCP Preamble, page 8717).

(3) ***Once acceptable risk levels have been achieved, the technical and economic feasibility of additional remediation to approach or achieve background concentrations will be evaluated.*** AFCEE shall proceed with a technical and economic feasibility analysis of approaching or achieving background concentrations in the aquifer. The feasibility of approaching or achieving background will be determined in accordance with the following criteria:

(a) Technological – Not feasible if

i. the existing technologies or modification cannot remediate to a level of no significant risk, or to levels that approach or achieve background; or

ii. the reliability of the identified alternative has not been sufficiently proven and a substantial uncertainty exists as to whether it will effectively reduce risk; or

iii. the remedy does not or cannot be modified to meet other regulatory requirements.

(b) Economic – The benefits of implementing a remedy and reducing the concentrations of contaminants in the environment to levels that approach or achieve background justifies related costs unless

i. the incremental cost for the remedy is substantial and disproportional to the increased reduction of risk, environmental restoration and monetary and non-monetary values; or

ii. the risk of harm to health/safety/public welfare/environment by the remedy cannot be adequately controlled.

AFCEE and EPA with input from MassDEP have also agreed that in the event that implementation of this process leads to a mutual decision to undertake additional cleanup and such decision results in a significant or fundamental change to the remedial approach, cleanup levels and/or costs documented in this final ROD, AFCEE will execute an Explanation of Significant Differences (with public comment) or ROD Amendment, as appropriate. Whether any such additional cleanup actions result in a significant or fundamental change to this final ROD shall be determined jointly by AFCEE and EPA in consultation with MassDEP in accordance with the criteria set forth in EPA's *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and other Remedy Selection Decision Documents* (EPA 1999b). In this manner, such changes will be subject to regulatory review and stakeholder involvement through issuance of a new PP and/or conduct of a public comment period. In the event that a dispute arises regarding any of the determinations to be jointly reached under the process outlined above, such dispute shall be resolved under the dispute resolution procedure of the MMR FFA.

2.9 DESCRIPTION OF LF-1 SOURCE AREA AND GROUNDWATER ALTERNATIVES

The alternatives evaluated in the FS were developed with input from the EPA, the MassDEP, and the PCT. Alternatives were created to address the source area separately from the groundwater; as a result, the selected remedy for the source area and groundwater will consist of two alternatives: a source area alternative and a groundwater alternative. Following an initial screening of alternatives (AFCEE 2006b), two (of four) source area and nine (of eighteen) groundwater alternatives were eliminated from further consideration due to concerns with effectiveness, implementation and/or cost. Therefore, two source area alternatives and nine groundwater alternatives were retained and considered for detailed evaluation for the LF-1 source area and groundwater actions.

Components common to most of the alternatives are LUCs. Several LUCs protect area residents from exposure to LF-1 refuse and groundwater contaminants. Source area controls that protect humans from exposure to the landfill source area include environmental land use restrictions for the site. The safety of all public water supplies within Massachusetts is currently regulated by the Commonwealth. Residents and workers on the MMR receive their water from the base water supply system that has wellhead treatment. All off-base residences within the LF-1 plume area are currently connected to municipal water supplies. The off-base LUCs include the towns of Bourne and Falmouth regulating installation of private wells to reduce potential residential exposure to contaminated groundwater. Neither the Falmouth Board of Health (BOH) Water Well Regulations nor the Bourne BOH Well Regulations applies to use of existing drinking water and irrigation wells.

2.9.1 Source Area Remedial Alternatives

The following sections present an overview of the two LF-1 source area remedial alternatives that were retained for detailed analysis.

2.9.1.1 Alternative 1 – No Action

The NCP requires that a no-action alternative be considered for all media (40 CFR 300.430[e][6]). This no-action alternative leaves the landfill cap and fence in place, but ceases the monitoring and maintenance of the landfill cap and fence. The landfill cap, associated fence, gas vents, and drainage system would not be altered or maintained. The cap, fence, vents, and drainage system are all passive systems and would function for some time, but would not function properly in the long term due to lack of maintenance. AFCEE would not check the adherence to LUCs under Alternative 1.

2.9.1.2 Alternative 2 – Status Quo of the Landfill with Land Use Controls

The existing landfill cover system over the 1970 Cell, Post-1970 Cell, and Kettle Hole would not be altered. Site monitoring, settlement monitoring, and periodic maintenance would continue until waste left in place no longer poses a risk to human health and the environment. This alternative provides for LUCs to prevent human exposure to the landfill waste and five-year CERCLA reviews throughout the lifetime of the alternative.

2.9.2 Groundwater Remedial Alternatives

The following sections present an overview of the nine LF-1 groundwater remedial alternatives that were retained for detailed analysis (Figures 2-9 and 2-10).

2.9.2.1 Alternative 1 – No Action

The no-action alternative is required by the NCP (40 CFR 300.430[e][6]) to provide a baseline condition if no remedial action is taken. This no-action alternative would mean that current active remediation would cease when the ROD is signed. Hydraulic and chemical monitoring of the plume would not continue. Due to the proximity of the plume to public water supply wells PWS-2 and PWS-5, the IRP has previously committed funds to the Bourne Water District to replace water from PWS-2 and PWS-5 (Bourne water provision). This alternative would take away the continued commitment of funds to the Bourne Water District. AFCEE would not check adherence to LUCs under Alternative 1.

2.9.2.2 Alternative 3 – Long-Term Monitoring with Land Use Controls and Bourne Water Provision

Alternative 3 is a limited-action alternative. Remediation via active treatment of the LF-1 plume would cease. This alternative would provide for chemical monitoring of groundwater via existing wells. Continued monitoring and reporting would be implemented to assess the attenuation of the LF-1 plume and determine when COC concentrations have reached cleanup levels. This alternative also includes LUCs that reduce the risk of future human exposure to the LF-1 plume.

Water supply wells PWS-2 and PWS-5 are downgradient and crossgradient of the LF-1 plume, and due to the proximity of the plume to the wells, this alternative includes a commitment for IRP funding for the Bourne Water District to replace water from the public water supply wells PWS-2 and PWS-5. The Bourne Water District would decide how the monies were spent, which may include one or more of the following options: wellhead protection for wells PWS-2 and PWS-5, replacement well(s), or replacement water. This commitment, hereafter referred to as the Bourne water provision, is also included in the subsequent groundwater alternatives.

A CERCLA review would be performed every five years throughout the lifetime of the alternative. AFCEE will conduct a residual risk assessment if deemed necessary and would likely include additional data collection and analysis.

2.9.2.3 Alternative 5 – Base Boundary ETI System with Southern Expansion, Land Use Controls and Bourne Water Provision

Alternative 5 provides for continued operation of the current LF-1 treatment system and the LF-1 SPEIM program, LUCs, and the Bourne water provision. In addition, extracting groundwater south of 27EW0002 through one additional extraction well (27EW0006) increases capture of the southern portion of the LF-1 plume. The water would be pumped to the Hunter Avenue Treatment Facility for treatment and infiltration/reinjection. The alternative includes SPEIM and LTM. A CERCLA review would be performed every

five years throughout the lifetime of the alternative. A residual risk assessment would be performed, if necessary, and would likely include additional data collection and analysis.

2.9.2.4 Alternative 9 – Total Containment at the Base Boundary, Land Use Controls and Bourne Water Provision

Alternative 9 provides for total containment of the LF-1 plume (defined by COCs at concentrations above the cleanup level) at the MMR boundary, LUCs, and the Bourne water provision. Alternative 9 requires an increase to the operational flow rate of the existing ETI system plus the addition of extraction wells. The extracted water would be treated at an expanded LF-1 treatment facility and the Hunter Avenue Treatment Facility. The treated water would be discharged via an expanded LF-1 infiltration gallery/trenches and/or new reinjection wells and/or infiltration gallery/trenches. The alternative includes SPEIM and LTM. A CERCLA review would be performed every five years throughout the lifetime of the alternative. A residual risk assessment would be performed, if necessary, and would likely include additional data collection and analysis.

2.9.2.5 Alternative 12 – Base Boundary ETI System with Southern Expansion, Remediation of the Northern and Southern Lobes West of Route 28, Land Use Controls and Bourne Water Provision

Alternative 12 provides for continued operation of the current LF-1 treatment system with southern expansion and the LF-1 SPEIM program, LTM, LUCs, and the Bourne water provision. Water from the additional extraction well (27EW0006) located south of 27EW0002, would be pumped to the Hunter Avenue Treatment Facility for treatment and infiltration/reinjection. Additionally, one stand-alone ETI system located west of Route 28 in the northern lobe and two stand-alone ETI systems located west of Route 28 in the southern lobe would be constructed. The systems west of Route 28 would prevent contamination at concentrations above the cleanup levels from moving downgradient of the ETI systems and would decrease the aquifer restoration time frame in some parts of the northern and southern plumes west of Route 28. The stand-alone ETI systems would not be located at the most downgradient extent of the northern or southern lobes; therefore, some of the plume would not be captured. The alternative also includes five-

year CERCLA reviews throughout the lifetime of the alternative, and a residual risk assessment if deemed necessary.

2.9.2.6 Alternative 15 – Base Boundary ETI System with Southern Expansion, Remediation of the Northern and Southern Lobes West of Route 28, Warm Spot Remediation, Land Use Controls and Bourne Water Provision

Alternative 15 includes the provisions of Alternative 12 (LF-1 ETI system status quo with southern expansion, remediation of the northern and southern lobes west of Route 28, LUCs, and the Bourne water provision) with the addition of warm-spot remediation. An extraction well would be placed to intercept the warm spot, and water would be pumped to the Hunter Avenue Treatment Facility for treatment and infiltration/reinjection. The alternative includes SPEIM and LTM, five-year CERCLA reviews throughout the lifetime of the alternative, and a residual risk assessment if deemed necessary.

2.9.2.7 Alternative 16 – Total Containment at the Base Boundary, Remediation of the Northern and Southern Lobes West of Route 28, Warm Spot Remediation, Land Use Controls and Bourne Water Provision

Alternative 16 provides for total containment at the base boundary, warm-spot remediation, remediation of the northern and southern lobes west of Route 28, LUCs, and the Bourne water provision. The alternative includes SPEIM and LTM, five-year CERCLA reviews throughout the lifetime of the alternative, and a residual risk assessment if deemed necessary.

2.9.2.8 Alternative 17 – Total Containment at the Base Boundary, Warm Spot Remediation, Land Use Controls and Bourne Water Provision

Alternative 17 includes total containment at the base boundary, warm-spot remediation, LUCs, and the Bourne water provision. The alternative includes SPEIM and LTM, five-year CERCLA reviews throughout the lifetime of the alternative, and a residual risk assessment if deemed necessary.

2.9.2.9 Alternative 18 – Base Boundary ETI System with Southern Expansion, Warm Spot Remediation, Land Use Controls and Bourne Water Provision

Alternative 18 consists of the LF-1 ETI system status quo with southern expansion, warm-spot remediation, LUCs, and the Bourne water provision. The alternative includes SPEIM and LTM, five-year CERCLA reviews throughout the lifetime of the alternative, and a residual risk assessment if deemed necessary.

2.9.3 Common Elements and Distinguishing Features of Alternatives

Two source area alternatives and nine groundwater alternatives were evaluated in detail. Common elements and distinguishing features of these alternatives are summarized below.

LF-1 Source Area Alternatives – Two source area alternatives were evaluated as part of the FS: the no-action alternative (Alternative 1) and a status quo alternative (Alternative 2), which includes LUCs and monitoring and maintenance activities. Alternative 1 leaves the source area as-is, provides no action or LUCs to limit exposure to residual risk, would not be compliant with ARARs, and has no costs associated with it. Alternative 2 affords continuation of monitoring and maintenance of the existing landfill cover system and implementation of LUCs, which is protective of human health and the environment; meets all ARARs; and has an approximate present value cost of $0.8 million (M). The ARAR tables for the selected alternative (Alternative 2) are listed in Tables 2-23, 2-24, and 2-25.

LF-1 Groundwater Alternatives – Nine groundwater alternatives were evaluated as part of the FS: a no-action alternative (Alternative 1), a limited-action alternative (Alternative 3), and seven active treatment alternatives (Alternatives 5, 9, 12, 15, 16, 17, and 18). The seven active treatment alternatives include varying degrees of increased plume remediation through the installation of additional extraction wells and increased pumping rates of existing extraction wells. All of the alternatives, except the no action alternative (Alternative 1), include LUCs, LTM, the Bourne Water Provision, CERCLA reporting, and a residual risk assessment if deemed necessary.

Alternative 1 provides no action and would mean that the current treatment system would shut down, chemical and hydraulic monitoring would cease, and funding for the Bourne Water Provision would end. Alternative 1 would not include LUCs that limit exposure to the LF-1 plume and would not actively reduce the toxicity, mobility, or volume of the contaminants. The plume would naturally attenuate, but there would be no monitoring to document that it was occurring. Alternative 3 is similar to the no-action alternative in that the current treatment system would shut down. However, under Alternative 3, LTM of the plume would continue, LUCs would be implemented, and the Bourne Water Provision would remain in effect. Under Alternatives 1 and 3, the plume is not expected to naturally attenuate until approximately 2054.

Alternatives 5, 9, 12, 15, 16, 17, and 18 all provide for active treatment in addition to the existing treatment system. The additional active treatment alternatives include various combinations of the following:

- Southern Expansion – one additional extraction well (27EW0006, installed in 2006) located along the base boundary south of existing well 27EW0002;
- Total Containment – the likely addition of more than one extraction well along the base boundary, increased flow rates of the existing extraction wells, and expansion of the LF-1 treatment facility;
- Remediation of the Northern and Southern Lobes West of Route 28 – includes the addition of one stand-alone ETI system located west of Route 28 in the Northern Lobe, and two additional stand-alone ETI systems in the Southern Lobe west of Route 28; and
- Warm Spot Remediation – one extraction well would be placed in a location to intercept the portion of the LF-1 plume identified as the "warm spot."

The seven active treatment alternatives include various combinations of the options listed above. Table 2-26 presents a summary of the evaluation of the groundwater alternatives, and Table 2-27 presents the model-predicted mass removed, time to cleanup each area of the plume, and present value cost for each alternative. Refer to the *Final Landfill-1 Source Area and Groundwater Feasibility Study* (AFCEE 2006b) for further analysis including a complete listing of ARARs for each alternative and how individual

alternatives would comply with them. ARARs for the selected alternative (Alternative 5) are listed in Tables 2-28, 2-29, and 2-30.

2.9.4 Expected Outcomes of the Alternatives

LF-1 Source Area Alternatives – Two source area alternatives were evaluated as part of the FS: the no-action alternative (Alternative 1) and a status quo alternative (Alternative 2). The no-action alternative leaves the landfill cap and fence in place, but ceases the monitoring and maintenance of the landfill cap, fence and associated gas vents, and drainage system. The cap, fence, vents, and drainage system are all passive systems and would function for some time, but would not function properly in the long term due to lack of maintenance, and AFCEE would not check the adherence to LUCs. Alternative 1 offers no assurance that residents and workers will not be exposed to source area contaminants or that leaching of source area contaminants would resume. Alternative 2 affords continuation of monitoring and maintenance of the existing landfill cover system, which is protective of human health and the environment, and offers additional assurance that residents and workers will not be exposed to the LF-1 source area through the implementation and monitoring of LUCs.

LF-1 Groundwater Alternatives – Groundwater modeling indicates that under Alternatives 1 and 3 the plume moves west at concentrations higher than the cleanup standards as it migrates downgradient and discharges to Red Brook and Squeteague harbors. The plume eventually attenuates to concentrations below cleanup levels by approximately 2054. Modeling indicates plume cleanup time frames for the remaining seven active treatment alternatives (Alternatives 5, 9, 12, 15, 16, 17, and 18), presented in Table 2-27, range from approximately 2036 to 2045; time frames varying depending on the number of extraction wells and extraction well flow rates.

Based on current and reasonably anticipated future land use, human health risks are acceptable under all of the alternatives. The existing Bourne and Falmouth BOHs regulations reduce the risk of exposure of residents to contaminated groundwater. The Bourne and Falmouth BOHs well regulations do not apply to use of existing drinking

water wells and irrigation wells. However, Alternatives 3, 5, 9, 12, 15, 16, 17, and 18 offer additional assurances that residents and workers will not be exposed to the LF-1 plume through implementation and monitoring of LUCs.

2.10 COMPARATIVE ANALYSIS OF LF-1 SOURCE AREA AND GROUNDWATER ALTERNATIVES

The following sections summarize the comparative analysis of the two LF-1 source area and nine LF-1 groundwater alternatives presented in the *Final Landfill-1 Source Area and Groundwater Feasibility Study* (AFCEE 2006b).

2.10.1 Criteria For Detailed Analysis of Alternatives

The NCP (40 CFR, Part 300) presents nine criteria for analyzing the acceptability of a given alternative. These nine criteria are categorized as threshold criteria, primary balancing criteria, and modifying criteria. The performance of the nine LF-1 groundwater alternatives with respect to the threshold and primary balancing criteria are summarized in Table 2-26.

2.10.1.1 Threshold Criteria

There are two threshold criteria: overall protection of human health and the environment, and compliance with ARARs. Threshold criteria represent the minimum requirements that each alternative must meet to be eligible for selection.

Overall Protection of Human Health and the Environment This criterion assesses the overall effectiveness of an alternative and focuses on whether that alternative achieves *adequate protection and risk reduction, elimination, or control. The assessment of* overall protection draws on assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

Compliance with ARARs Each alternative is assessed to determine whether it complies with ARARs under federal and state laws. Section 121(d) of CERCLA requires that remedial actions at CERCLA sites attain legally applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations, unless such ARARs are waived under CERCLA Section 121(d)(4). Appendix E of the *Final Landfill-1 Source Area and Groundwater Feasibility Study* (AFCEE 2006b) outlines ARARs for all the LF-1 alternatives. ARARs for the selected alternatives are listed in Tables 2-23, 2-24, 2-25 (Source Area Alternative 2), and 2-28, 2-29, and 2-30 (Groundwater Alternative 5).

2.10.1.2 Primary Balancing Criteria

The five primary balancing criteria are (1) long-term effectiveness and permanence, (2) reduction of toxicity, mobility, or volume through treatment, (3) short-term effectiveness, (4) implementability, and (5) cost. Primary balancing criteria form the basis for comparing alternatives in light of site-specific conditions.

Long-Term Effectiveness and Permanence Each alternative is assessed for its long-term effectiveness and the permanence of the solution. This criterion assesses the magnitude of residual risks remaining at the conclusion of remedial activities and the adequacy and reliability of controls to be used to manage residual risk.

Reduction of Toxicity, Mobility, or Volume Through Treatment Section 121 (Cleanup Standards) of CERCLA states a preference for remedial actions that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of contaminants as the primary element of the action. This criterion addresses the capacity of the alternative to reduce the principle risks through destruction of contaminants, reduction in the total mass of contaminants, irreversible reduction in contaminant mobility, or reduction in the total volume of contaminated media.

Short-Term Effectiveness This criterion addresses the effects of the alternative during construction and operational phases until remedial objectives are met. Each alternative is evaluated with respect to its (potentially negative) effects on community health, worker

safety, and environmental quality during the course of remedial actions. This criterion also addresses the time required by each alternative until remedial objectives are achieved.

Implementability The implementability criterion is used to assess the technical and administrative feasibility of implementing an alternative. Technical issues include the reliability of the technology under consideration, potential construction difficulties, and the availability of required services, materials, and equipment (preferably from multiple sources). Administrative issues include permitting and access for construction and monitoring.

Cost Costs associated with carrying out an alternative are based on current (present day) information escalated at a rate of 5 percent until year zero; after year zero, costs are discounted at a rate of 3.5 percent (per Office of Management and Budget Circular A-94 [OMB 2004]). Cost estimates included in this document are intended for comparative purposes only. The accuracy of the estimates are between –30 and +50 percent.

2.10.1.3 Modifying Criteria

There are two modifying criteria: state acceptance and community acceptance.

State Acceptance The MassDEP has expressed its support for Alternative 2 for the LF-1 source area, and Alternative 5 for the LF-1 groundwater plume.

Community Acceptance The PCT unanimously supports Alternative 2 for the LF-1 source area, and Alternative 5 for the LF-1 groundwater plume.

2.10.2 Comparison of LF-1 Source Area Alternatives

Two source area alternatives were evaluated as part of the FS: the no-action alternative *(Alternative 1) and a status quo alternative (Alternative 2), which includes* LUCs and monitoring and maintenance activities. Alternative 2 affords continuation of monitoring

and maintenance of the existing landfill cover system and LUCs, which are protective of human health and the environment; meets ARARs; poses low-level risk to workers, the community, and the environment; and has an approximate present value cost of $0.8M. Alternatives 1 and 2 were evaluated against the nine NCP criteria. The following sections present the evaluation.

2.10.2.1 Overall Protection of Human Health and the Environment

Both alternatives provide short-term effectiveness through the existing cap, but Alternative 2 provides long-term protection of human health and the environment through maintenance of the existing landfill cover system.

2.10.2.2 Compliance with ARARs

Alternative 1 is not compliant with chemical-specific ARARs as deterioration of the existing landfill cover system may allow landfill leachate to contaminate the groundwater. Alternative 2 is compliant with chemical-specific ARARs through maintenance of the exiting landfill cover system. All monitoring and maintenance activities will be performed in accordance with action-specific ARARs.

2.10.2.3 Long-Term Effectiveness and Permanence

Alternative 1 does not have LUCs; therefore, there is no exposure control in place to limit exposure to residual risk. Through Alternative 2, LUCs provide long-term protection to human health.

2.10.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 1 does not reduce the toxicity, mobility, or volume of contamination. Alternative 2 reduces the mobility of the contaminants in the landfill by monitoring and maintaining the landfill cover system, which prevents landfill contamination to leach to the groundwater. Alternative 2 provides no reduction in the toxicity or volume of contamination.

2.10.2.5 Short-Term Effectiveness

Both alternatives are effective in the short-term due to the existing cover system.

2.10.2.6 Implementability

There are no technical or administrative implementability concerns with respect to either of the alternatives.

2.10.2.7 Cost

Alternative 1 has no cost, and the present value cost for Alternative 2 is approximately $0.8 M.

2.10.2.8 State Acceptance

The MassDEP has expressed its support for Alternative 2.

2.10.2.9 Community Acceptance

The PCT unanimously supports Alternative 2.

2.10.3 Comparison of LF-1 Groundwater Plume Alternatives

Nine groundwater alternatives were evaluated in the FS, a no-action alternative (Alternative 1), a limited-action alternative (LTM and Bourne water provision) (Alternative 3), and seven alternatives that consist of various active treatment scenarios (Alternatives 5, 9, 12, 15, 16, 17, and 18). All of the alternatives (except for the no-action Alternative 1) are protective of human health and the environment and comply with ARARs. All active remediation alternatives use proven technologies, will permanently remove contaminants, and pose low risk to workers, the community and the environment (alternatives with greater construction have greater risk and more impact to the community and the environment). The alternatives differ in the amount of plume volume reduction and mass removed, time frames to reach cleanup levels in different areas of the plume, degree of inconveniences and disturbance that will be generated by

construction and long-term activities, and costs. Alternatives 1, 3, 5, 9, 12, 15, 16, 17, and 18 were evaluated against the nine NCP criteria. The following sections present the evaluation.

2.10.3.1 Overall Protection of Human Health and the Environment

AFCEE has already ensured protection of human health by providing municipal water supply hook-ups for all on-base and off-base residences impacted by the LF-1 plume. Additional protection of human health is afforded by on-base LUCs and the Falmouth BOH Water Well Regulations, and the Bourne BOH Well Regulations which prevent the installation of private wells for water consumption or irrigation in areas of groundwater contamination. Neither the Falmouth BOH Water Well Regulations nor the Bourne BOH Well Regulations apply to use of exiting drinking water wells and irrigation wells. Therefore, for continuation of the current use of the aquifer, the risk to human health and the environment is the same for all alternatives, except for Alternative 1 (no action).

2.10.3.2 Compliance with ARARs

The point at which chemical-specific ARARs are met would not be known under Alternative 1 since monitoring would not be performed. All construction, treatment, and monitoring activities will be performed in accordance with location-specific and action-specific ARARs.

2.10.3.3 Long-Term Effectiveness and Permanence

The magnitude of residual risks and the adequacy and reliability of controls are similar for Alternatives 3, 5, 9, 12, 15, 16, 17, and 18: low residual risk because there are no untreated waste or treatment residuals. Reliability of controls is good for all alternatives because AFCEE has provided water supply connections to all on-base and off-base residences impacted by the LF-1 plume.

All of the active treatment alternatives use proven and reliable technology as an integral part of the treatment train. For the ETI systems, spent carbon is removed from the site

and regenerated, thus, permanently destroying contaminants. At the conclusion of the remedy, groundwater concentrations will be below RAOs and, thus, pose minimal risk.

2.10.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternatives 1 and 3 do not remove contaminants from the aquifer. All active treatment alternatives (5, 9, 12, 15, 16, 17, and 18) satisfy the statutory preference that active treatment be a principal element in site remediation. Contaminants are permanently removed from the aquifer. The active treatment alternatives address varying portions of the entire LF-1 plume. Alternative 5 captures approximately 750 pounds (lb) of TCE and PCE (2006 to 2045), which is the smallest amount of mass removed from the eastern area; and when paired with warm-spot remediation, it removes an approximate additional 110 lb (approximately 860 lb, Alternative 18, 2006 to 2042). Modeling predicts that an expansion of Alternative 5 to a total containment system at the base boundary (Alternative 9) results in an increase of approximately 220 lb captured (approximately 970 lb, Alternative 9, 2006 to 2043), which when paired with an upgradient extraction well would only increase the mass capture by approximately 44 lb (approximately 1014 lb, Alternative 17, 2006 to 2036). The alternatives that have stand-alone ETI systems located west of Route 28 have the largest amounts of mass capture (approximately 1014 lb from 2006 to 2045, Alternative 12; approximately 1102 lb from 2006 to 2042, Alternative 15; approximately 1235 lb 2006 to 2036, Alternative 16). There is uncertainty in the model predictions of mass capture estimates and cleanup times. The uncertainty in the model is related to estimates of the hydraulic conductivity field, the three-dimensional representation of the plume, and the contaminant transport model parameters.

2.10.3.5 Short-Term Effectiveness

Alternatives 1, 3, and 5 have the least impact on workers, the community, and the environment since they do not require any new construction activities. Alternative 16 has the greatest impact since, based on the conceptualization of the alternative, it would involve the most construction (new wells and treatment plant) of any of the proposed

alternatives. Alternatives 9, 12, 15, 16, 17, and 18 feature active remediation in addition to the existing LF-1 ETI system and would require site clearing, road grading, excavation, well installation, treatment system construction in some cases, and routine maintenance and monitoring of the treatment systems.

Alternatives 12, 15, and 16 have stand-alone ETI systems located west of Route 28 in areas of residential development and potentially in conservation areas. These alternatives carry additional short-term risks to the community, including increased vehicle traffic during construction and O&M, and hazards associated with an active construction site. The risks to the community associated with increased traffic can be addressed through safe driving practices. Hazards associated with the construction of the treatment system can be controlled by coordinating activities with the fire department and police department, school districts, using police details where necessary, and fencing the property. There are no known risks to the community that cannot be controlled.

Risks to workers include hazards associated with drilling and construction (injury) and O&M of the treatment systems (injury and exposure). Risks to workers can be addressed through training, safety procedures, and medical monitoring. There are no known risks to workers that cannot be controlled.

Environmental impacts include the following: site preparation (clearing and grading) for the extraction, reinjection, and monitoring wells; infiltration gallery expansion, treatment plant construction; excavation for the well vaults; additional vehicle traffic in the neighborhood and at the site; increased sound levels associated with operation of the system; and increased electrical demand. Environmental impacts will be addressed by working with the Natural Heritage and Endangered Species Program to identify threatened and endangered species at the site and appropriate mitigation procedures; conducting cultural surveys as necessary; minimizing the area to be cleared, excavated and graded; and reducing sound levels as much as possible. Environmental impacts that cannot be avoided include additional vehicle traffic; clearing, excavating and grading; and increased electrical consumption during operation of the systems.

Time frames to reach cleanup levels vary depending on the amount of active remediation used in parts of the plume and the strategy of the active remediation at the base boundary (total containment at the base boundary or status quo with southern expansion at the base boundary). Natural attenuation processes under Alternative 3 would eventually cause contaminant concentrations to fall below the cleanup levels, but this would not occur until approximately 2054, based on model predictions. Modeling predicts that Alternatives 5 and 12 provide a decrease in the cleanup time frame of approximately nine years (2045) for the entire plume. Alternatives 9, 15, and 18 decrease the cleanup time an additional two to three years (2042-2043). Alternatives 16 and 17 offer the shortest cleanup time with the entire plume reaching cleanup levels in 2036, a nine-year decrease in cleanup time in comparison to Alternatives 5 and 12.

Both Alternative 5 and Alternative 9 consist of extraction at the base boundary. Contamination downgradient of the base boundary would decrease to below cleanup levels through natural attenuation. Based on modeling predictions, in comparison to Alternative 5, Alternative 9 would clean up the entire plume approximately two years earlier and, specifically, the eastern area (upgradient of the existing extraction wells) two years earlier, the northwestern area (the northern lobe downgradient of the existing extraction wells) four years earlier, and only one year earlier in the southwestern area (the southern lobe downgradient of the existing extraction wells). The results indicate that the greater hydraulic stress applied by total containment at the base boundary decreases the cleanup time in the eastern area by approximately two years. The one-year difference in cleanup time in the southeastern area indicates that Alternative 5 is capturing most of the on-base contamination in the southern area. The four-year difference in cleanup time for the northwestern area indicate that total containment at the base boundary (Alternative 9) is better than Alternative 5 at capturing mass before it migrates off-base in the northern portion of the plume; however, there is uncertainty in the migration of contamination in this area, and the actual differences in alternative performance may not be as great as predicted.

The comparison of Alternatives 5 and 12 indicates that a four-year difference in cleanup time in the southwestern area is attributed to the two stand-alone ETI systems located west of Route 28 in the southern plume. The stand-alone ETI system in the northern lobe west of Route 28 is ineffective in reducing the cleanup time frame in the northwestern area in Alternative 12 because the base boundary ETI system is ineffective in preventing upgradient mass from moving into the northwestern area. Again, there is uncertainty in the migration of contamination in this area, and the stand-alone ETI system may be more effective than modeling indicates. The simulation of total containment at the base boundary paired with remediation west of Route 28 (Alternative 16) is effective at reducing the cleanup time and has the shortest cleanup time for the northwestern area.

Comparison of modeling results from Alternatives 5 and 18 indicates that extraction upgradient of the existing ETI system reduces the amount of mass that may migrate north of the infiltration trench, escape capture, and migrate to the northwestern area. The results also indicate that the warm-spot remedy is effective in decreasing the operational time frame of the ETI system based on TCE contamination, but is less effective with respect to PCE contamination. The PCE concentrations are lower than the TCE concentrations, but the PCE contamination covers a broader area. The cleanup time frame for the eastern area is only three years sooner for Alternative 18 (2042) compared to Alternative 5 (2045). The shortest cleanup time frame (2036) for the eastern area is for Alternatives 16 and 17, which both pair total containment at the base boundary with warm-spot remediation. The greater extraction stress of Alternatives 16 and 17 at the base boundary is effective at remediating PCE contamination close to the base boundary, resulting in shorter cleanup times and shorter operational times in the eastern area.

2.10.3.6 Implementability

For Alternatives 5, 9, 12, 15, 16, 17, and 18, the GAC carbon technology is considered reliable and is currently being used in the existing LF-1 treatment system. Also, the implementation of no action, continued treatment, LTM, and additional active treatment are all technically feasible. The willingness of the Town of Bourne, the Commonwealth of Massachusetts, and private landowners to accommodate the remedial system on their

property and the amount of site preparation required are unknown at this time. Access or terrain issues could potentially delay or even prevent active treatment in some areas. These access or terrain issues may negatively affect implementability for the active remediation alternatives proportionally to the amount of construction required for each alternative.

Administrative implementation for all alternatives (except Alternative 1, no action) will include coordination with the towns of Bourne and Falmouth (implementation of LUCs) and other agencies for technical update meetings, remedial program manager meetings, and active communication on all issues of concern. Long-term access agreements with private landowners and well permits are an administrative implementability concern for all alternatives.

2.10.3.7 Cost

Alternative 3 is the lowest cost groundwater alternative ($9 M) because it does not have any costs associated with active treatment of the plume. The most significant costs are associated with construction of additional treatment components (e.g., extraction and reinjection wells, stand-alone ETI systems, etc.), and aggressive remediation can also result in high O&M costs. The costs of Alternatives 5 and 18 are similar—$44 M and $49 M, respectively—and represent the lowest costs with active treatment. There are no additional construction costs associated with Alternative 5. The higher construction costs of Alternative 18 are compensated for by the lower costs due to a shorter operational time for the existing LF-1 ETI system. Alternatives 9, 12, 15, and 17 are all comparable ($66 M, $70 M, $73 M, and $68 M, respectively). The most expensive is Alternative 16 ($95 M), which is a result of the additional cost of construction of numerous treatment components and the high extraction rate estimated for alternative comparison, resulting in relatively high O&M costs. The additional costs for construction and O&M for Alternative 16 are not compensated for by the O&M costs saved due to a shorter operational time frame.

2.10.3.8 State Acceptance

The MassDEP has expressed its support for Alternative 5.

2.10.3.9 Community Acceptance

The PCT unanimously supports Alternative 5.

2.11 SELECTED REMEDY FOR THE LF-1 SOURCE AREA OPERABLE UNIT

Based on the Administrative Record for the LF-1 site and the evaluation of comments received by interested parties during the public comment period, AFCEE has selected Alternative 2 as the remedy for the LF-1 source area, specifically the 1970 Cell, Post-1970 Cell, and Kettle Hole.

2.11.1 Summary of the Rationale for the Selected Remedy

AFCEE's preferred remedial alternative for the LF-1 source area (the 1970 Cell, Post-1970 Cell, and Kettle Hole) is Alternative 2—Status Quo of the Landfill with Land Use Controls. The *Final Landfill-1 Source Area and Groundwater Feasibility Study* (AFCEE 2006b) evaluated both remedial alternatives according to the threshold and balancing criteria. Alternative 2 meets the threshold criteria (complies with applicable requirements and is protective of human health and the environment). AFCEE believes Alternative 2 provides the best balance of tradeoffs between the two alternatives with respect to the balancing criteria.

Risks to human health that are related to the landfill source area have already been controlled. The IRP constructed a landfill cover system, including a perimeter fence that prevents contact with the landfill waste. The existing landfill cover system prevents the formation of leachate that would cause groundwater downgradient to be unusable. The following discussion summarizes the comparison of LF-1 source area remedial alternatives in the context of the threshold criteria (overall protection of human health and the environment, and compliance with ARARs and balancing criteria (long-term

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

2.11.2 Detailed Description of Selected Remedy

Under the selected remedy, the existing landfill cover system (low permeability landfill cap, associated fence [installed around the entire landfill], gas vents, and drainage system) over the 1970 Cell, Post-1970 Cell, and Kettle Hole would not be altered (Figure 2-3). Site-condition monitoring, site-settlement monitoring, and periodic maintenance will continue until waste left in place no longer poses a risk to human health and the environment. CERCLA five-year reviews will be performed to evaluate remedy appropriateness and site status until the waste left in place no longer poses a risk to human health and the environment. The northwest part of the LF-1 source area (the 1947, 1951, and 1957 cells) will be addressed in a future decision document.

Site monitoring (visual inspections) and reporting documents the physical condition of the landfill cover system including the perimeter fence around the entire landfill and the vegetative cover, monitoring wells, gas probes, gas vents, and the drainage system while identifying maintenance needs of the cover system over the 1970 Cell, Post-1970 Cell, and Kettle Hole. Monitoring of concentrations of landfill gas by gas probes located at the perimeter of the landfill will be performed. Settlement monitoring will be performed to verify the slopes are maintained to shed precipitation from the cap and to verify that the cap thickness is adequate to retard leaching of contaminants. Periodic maintenance will be performed to retain the integrity of the landfill cover system. Maintenance activities performed at the landfill include mowing the cover system once per year, clearing drainage culverts, and repairing areas damaged by erosion. Monitoring results would be provided in formal reports.

The following text describes the LUCs that will be implemented for both the LF-1 source area selected remedy and the LF-1 groundwater selected remedy discussed in Section 2.13 of this report. Exposure to the waste beneath the LF-1 landfill cover system could pose an unacceptable risk to human health. The LF-1 contaminated groundwater

currently poses an unacceptable risk to human health if used for household purposes (i.e., ingestion, dermal contact, and inhalation of vapors released during household use of water).

The LF-1 source area is located in the middle of the cantonment area. The LF-1 contaminated groundwater is located in the western part of the MMR cantonment area, and a portion of the contaminated groundwater has migrated past the MMR boundary into the neighboring towns of Bourne and Falmouth. Therefore, administrative and/or legal controls that minimize the potential for human exposure to contamination by limiting land or resource use, known as "LUCs," must be established for the LF-1 source area and groundwater to avoid the risk of exposure to the LF-1 source area and LF-1 groundwater. These LUCs are needed both on-base and off-base, within the towns of Bourne and Falmouth, until the LF-1 source area and contaminated groundwater no longer poses an unacceptable risk.

The performance objectives of the LUCs are to

- Prevent access to waste and soils beneath the LF-1 cover system until the waste and soils no longer pose an unacceptable risk,
- Prevent or reduce access to or use of the groundwater from the LF-1 contaminated groundwater until the groundwater no longer poses an unacceptable risk, and
- Maintain the integrity of the current or future remedial or monitoring system such as the landfill cover system, the treatment systems, and monitoring wells.

The LUCs will encompass the area including the LF-1 source area and contaminated groundwater and surrounding areas to reduce the risk from exposure to contaminated groundwater (Figure 2-11). The on-base area of concern is controlled and operated by the USCG and the Air Force, who lease this land from the Commonwealth of Massachusetts. It is expected that these entities (USCG and U.S. Air Force) will control the area of concern and the surrounding area for the duration of this ROD. As a result, the Air Force will coordinate with the Commonwealth of Massachusetts as the Air Force fulfills its responsibility to establish, monitor, maintain, and report on the LUCs for this site.

Each LUC will be maintained until either (1) the concentrations of COCs in the groundwater are at such levels as to allow unrestricted use and exposure and the landfill waste and soils no longer pose an unacceptable risk, or (2) the Air Force, with the prior approval of the EPA and MassDEP, modifies or terminates the LUC in question.

The Air Force is responsible for ensuring that the following three LUCs are established, monitored, maintained, and reported on as part of this final remedy to ensure protection of human health and the environment in accordance with CERCLA and the NCP for the duration of the final remedy selected in this ROD. The Commonwealth of Massachusetts only has enforcement authority regarding the third LUC. In the event that the Town of Bourne fails to promptly enforce the first LUC and/or the Town of Falmouth fails to promptly enforce the second LUC or the Commonwealth of Massachusetts fails to promptly enforce the third LUC, the Air Force will act in accordance with the third to last paragraph in this section. For purposes of the preceding sentence, "promptly enforce" means if the violation or potential violation is imminent or on-going, enforce to prevent or terminate the violation within 10 days from the enforcing agency's (i.e., the Town or the Commonwealth) discovery of the violation or potential violation; otherwise, enforce as soon as possible.

(1) On 24 September 2003, to better protect the public health and welfare of its citizens, the Bourne BOH, voted to amend the private well construction regulations originally adopted on 23 February 2000. The BOH will not approve construction of a well intended for human water consumption or irrigation if the well is known to be over a plume of contamination or in the direct path of an advancing plume of contamination. The Bourne BOH Well Regulations do not apply to use of existing drinking water wells and irrigation wells. The regulations are reproduced in Appendix C. To assist the Bourne BOH in the implementation of this LUC, the Air Force will meet with the BOH on an annual basis, or more frequently if needed, to provide and discuss plume maps that document the current and projected location of the LF-1 contaminated groundwater within the town of Bourne. While Figure 2-11 shows the current area of LUCs in the town, the Bourne BOH may modify the areas subject to the moratorium, and this LUC will apply to such areas even if they differ from the area shown in Figure 2-11.

(2) The Falmouth BOH requires a permit for the installation and use of all wells, including drinking water wells, irrigation wells, and monitoring wells. If a permit to install a drinking water well is approved, the Falmouth BOH will not approve the use of that well until its water has been tested and the BOH has determined that the water

is potable. The Falmouth BOH Water Well Regulations do not apply to use of existing drinking water wells and irrigation wells. The regulations, which are reproduced in Appendix D, cover documented and anticipated areas of contamination from the LF-1 plume. To assist the Town of Falmouth in the implementation of this LUC, the Air Force will meet with the BOH on an annual basis, or more frequently if needed, to provide and discuss plume maps that document the current and projected location of the LF-1 plume within the town of Falmouth. While Figure 2-11 shows the current area of LUCs in the town, the Falmouth BOH may modify the areas where well use is excluded, and this LUC will apply to such areas even if they differ from the area shown in Figure 2-11.

(3) In addition to the towns of Bourne and Falmouth BOH regulations, which generally applies to small water supply wells, existing LUCs also prevent the possible creation of a large potable water supply well. The MassDEP administers a permitting process for any new drinking water supply wells in Massachusetts that propose to service more than 25 customers or exceed a withdrawal rate of 100,000 gallons per day. This permitting process, which serves to regulate the use of the LF-1 contaminated groundwater for any withdrawals of groundwater for drinking water purposes, constitutes an additional LUC for this final remedy. This LUC applies to both on-base and off-base portions of LF-1.

The Air Force has provided municipal water supply hook-ups for all residences in areas of current or anticipated groundwater contamination. In conjunction with the Bourne BOH Well Regulations and the Falmouth BOH Water Well Regulations, the municipal water supply hook-ups significantly reduce the likelihood of exposure to contaminated groundwater from existing wells and from any future wells installed in areas of anticipated contamination. Additionally, the Air Force is responsible for ensuring that the following LUCs are established, monitored, maintained, reported on, and enforced as part of this final remedy to ensure protection of human health and the environment in accordance with CERCLA and the NCP for the duration of this final remedy selected in this ROD.

(1) For the on-base area of concern, a prohibition on new drinking water wells serving 25 or fewer customers has been established and placed on file with the planning and facilities offices for the Massachusetts Air and Army National Guard and USCG (major tenants at the MMR). The prohibition will be applied to future land use planning per Air National Guard Instruction (ANGI) 32-1003, Facilities Board, Army National Guard Regulation 210-20, Real Property Development Planning for the Army National Guard, and Commandant Instruction Manual 11010.14, Shore Facility Project Development Manual.

(2) For the on-base area of concern, the Air National Guard has administrative processes and procedures that require approval for all projects involving construction or digging/subsurface soil disturbance, currently set forth in ANGI 32-1001, Operations Management. This procedure is a requirement of the Army National Guard and the USCG by the Air National Guard through Installation Support Agreements. The Air National Guard requires a completed AF Form 103, Base Civil Engineer Work Clearance Request (also known as the base digging permit), prior to allowing any construction, digging or subsurface soil disturbance activity. All such permits are forwarded to the IRP for concurrence before issuance. An AF Form 103 will not be processed without a Dig Safe permit number (see next paragraph).

(3) The Dig Safe program implemented in Massachusetts provides an added layer of protection to prevent the installation of water supply wells in the LF-1 source and groundwater areas and to protect monitoring wells and the treatment system's infrastructure. This program requires, by law, anyone conducting digging activities (e.g., well drilling) to request clearance through the Dig Safe network. The Air Force at the MMR is a member utility of Dig Safe. The LF-1 source area and groundwater plume are encompassed by a geographical area identified by the Air Force as a notification region within the Dig Safe program. Through the Dig Safe process, the Air Force will be electronically notified at least 72 hours prior to any digging within this area. The notification will include the name of the party contemplating, and the nature of, the digging activity. The Air Force will review each notification and if the digging activity is intended to provide a well, which has not been approved via the procedures above, the Air Force will immediately notify the project sponsor (of the well drilling), the EPA, the Bourne BOH or the Falmouth BOH, and the MassDEP in order to curtail the digging activity. If the Dig Safe notification indicates proposed work near monitoring wells or the treatment system infrastructure, the Air Force will mark its components to prevent damage due to excavation. This LUC applies to both on-base and off-base portions of the LF-1 source area and plume. The extent of the Air Force's enforcement of this LUC does not address off-base parties failing to file a Dig Safe request nor Dig Safe improperly processing a notification, but if incidents do occur, the Air Force is responsible for ensuring remedy integrity and, if necessary, repairing damage cause by third parties to the remedial system infrastructure or monitoring wells.

The LUCs are intended to prevent exposure to groundwater impacted by the LF-1 plume; however, to insure that the LUCs obtain the LUC performance objectives the Air Force will take the following action.

Within three years of the signing of the ROD, the Air Force shall:

a. Document all private wells (i.e. non-decommissioned wells, including wells not currently in use) that are above or within the projected path of the LF-1 plume.

b. Demonstrate and document that the private well is not capable of drawing contaminated groundwater originating from the LF-1 plume, or test the private well for contamination and demonstrate the private well to be safe for human use. The Air Force will continue such testing, on an appropriate frequency as determined in coordination with the EPA, until the plume no longer presents a threat to that well as determined in coordination with EPA.

c. If the Air Force identifies a well containing COCs, the Air Force shall assess the risk current and potential future non-drinking uses of such a well pose to human health. The Air Force shall submit a draft version of any such risk assessment to EPA for review and approval.

d. If neither b nor c is able to confirm that the identified well is safe for human use, the Air Force will offer the owner decommissioning of the well. If accepted, the Air Force will document such action with the appropriate BOH. If the decommissioning is not accepted, the Air Force will take other steps to insure protectiveness to include, but not be limited to, requesting assistance from the appropriate BOH to issue health warnings to the property owner and any other person with access to the well (such as a lessee or licensee), offering bottled water (if well is used for drinking), or installing treatment systems on affected wells. In each instance, the Air Force shall submit a schedule subject to EPA approval, outlining and including time limitations for the completion of steps sufficient to prevent exposure to concentrations of contaminated groundwater from the LF-1 plume having carcinogens in excess of ARARs (i.e., MCLs, non-zero MCLGs), and prevent exposure to groundwater from the LF-1 plume that poses a cancer risk in excess of the EPA target risk range of 10^{-4} to 10^{-6} or which presents a non-carcinogenic hazard index greater than one.

Monitoring of the environmental use restrictions and controls will be conducted annually by the Air Force. The monitoring results will be included in a separate report or as a section of another environmental report, if appropriate, and provided to the EPA and MassDEP for informational purposes. The annual monitoring reports will be used in preparation of the five-year review to evaluate the effectiveness of the final remedy.

The annual monitoring report, submitted to the regulatory agencies by the Air Force, will evaluate the status of the LUCs and how any LUC deficiencies or inconsistent uses have been addressed. The annual evaluation will address (i) whether the use restrictions and controls referenced above were effectively communicated, (ii) whether the operator,

owner, and state and local agencies were notified of the use restrictions and controls affecting the property, and (iii) whether use of the property has conformed with such restrictions and controls and, in the event of any violations, summarize what actions have been taken to address the violations.

The Air Force shall notify the EPA and MassDEP 45 days in advance of any proposed land changes that would be inconsistent with the LUC objectives or the final remedy. If the Air Force discovers a proposed or ongoing activity that would be or is inconsistent with the LUC objectives or use restrictions, or any other action (or failure to act) that may interfere with the effectiveness of the LUCs, it will address this activity or action as soon as practicable, but in no case will the process be initiated later than 10 days after the Air Force becomes aware of this breach. The Air Force will notify the EPA and MassDEP as soon as practicable, but no later than 10 days after the discovery of any activity that is inconsistent with the LUC objectives or use restrictions, or any other action that may interfere with the effectiveness of the LUCs. The Air Force will notify the EPA and MassDEP regarding how the Air Force has addressed or will address the breach within 10 days of sending the EPA and MassDEP notification of the breach.

The Air Force will provide notice to the EPA and MassDEP at least six months prior to relinquishing the lease to the LF-1 source area and the LF-1 groundwater area so the EPA and MassDEP can be involved in discussions to ensure that appropriate provisions are included in the transfer terms or conveyance documents to maintain effective LUCs. If it is not possible for the Air Force to notify the EPA and MassDEP at least six months prior to any transfer or sale, then the Air Force will notify the EPA and MassDEP as soon as possible, but no later than 60 days prior to the transfer or sale of any property, subject to LUCs.

The Air Force shall not modify or terminate LUCs, implementation actions, or modify land use without approval by the EPA and MassDEP. The Air Force, in coordination with other agencies using or controlling the LF-1 source area and LF-1 plume area, shall seek prior concurrence before taking any anticipated action that may disrupt the

effectiveness of the LUCs or any action that may alter or negate the need for LUCs. The Air Force will provide EPA and MassDEP 30 days' notice of any changes to the internal procedures for maintaining LUCs which may affect LF-1.

2.11.3 Cost Estimate for the Selected Remedy

The cost estimate for source area Alternative 2 is provided in Tables 2-31 and 2-32. Costs for monitoring and maintenance of the existing landfill cover system and perimeter fence were estimated from June 2006 to 2025; additional costs include visual inspections, settlement monitoring, gas probe monitoring, air monitoring/analysis, and periodic reporting. The present value of the remedy is an estimated $0.8 M. This is an order-of-magnitude engineering cost estimate that is expected to be within +50 to –30 percent of the actual project cost.

2.11.4 Expected Outcomes of the Selected Remedy

Alternative 2 provides for protection of human health and the environment through the continued monitoring and maintenance of the existing landfill cover system and the implementation of LUCs. The existing cover prevents exposure to landfill waste and prevents/reduces contaminants leaching to groundwater.

2.12 STATUTORY DETERMINATIONS FOR THE LF-1 SOURCE AREA OPERABLE UNIT

Under CERCLA Section 121, selected remedies must be protective of human health and the environment, comply with ARARs (unless a waiver is justified), be cost-effective, and use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as a principal element. The following sections discuss how the selected remedy meets these statutory requirements.

2.12.1 Protection of Human Health and the Environment

The existing landfill cover system prevents human and ecological exposure to landfill refuse. The existing cover system also reduces leaching of contaminants from the source area to the aquifer, which would cause groundwater downgradient of the landfill to be unusable. Maintenance of the existing cover system would provide long-term protection of human and environmental health. Monitoring and maintenance activities and implementation of LUCs would ensure long-term protection of human health and the environment. There are no short-term threats associated with the selected remedy that cannot be readily controlled.

2.12.2 Compliance with Applicable or Relevant and Appropriate Requirements

Since installation, the landfill cover system has reduced the leaching of landfill contaminants to the groundwater. The selected groundwater alternative, Alternative 5, includes LTM of the groundwater downgradient of the landfill to ensure that the chemical-specific ARARs with respect to the source area are met.

Location-specific ARARs address state requirements that aim to protect wildlife habitats. Due to the extensive modification of the surface of the source area, there are no historical resources or vital waterways at the source area. Action-specific ARARs address the wastes generated as a result of monitoring and maintenance activities, and under this alternative, the current practices would continue to ensure these ARARs are met. Refer to Tables 2-23, 2-24, and 2-25 for a listing of these ARARs.

2.12.3 Cost-Effectiveness

In AFCEE's judgment, the selected remedy for the LF-1 source area is cost-effective. The overall effectiveness of the selected remedy was determined to be proportional to its costs and, hence, to represent a reasonable value for the money to be spent.

2.12.4 Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

The selected remedy for the LF-1 source area provides the best balance of trade-offs among the alternatives considered in the FS. AFCEE finds Alternative 2 to be the most appropriate solution for the LF-1 source area. The maintenance, monitoring and reporting will demonstrate compliance with ARARs and protectiveness of human health and the environment. The existing cover system also reduces leaching of contaminants from the source area to the aquifer. The selected remedy does not present any significant short-term risks. There are no special implementability issues that make the selected remedy unacceptable.

2.12.5 Preference for Treatment as a Principal Element

The selected remedy for the LF-1 source area does not involve treatment. The mobility of contaminants is reduced by the existing cap, which prevents precipitation coming in contact with landfill refuse and leaching to the groundwater. Alternative 2 provides no reduction in toxicity or volume of contamination.

2.12.6 Five-Year Review Requirements

Five-year statutory reviews will be performed for the LF-1 source area, according to Section 121(c) of CERCLA and NCP Section 300.430(f)(4)(ii), which requires such reviews in those instances where the remedy results in any hazardous substances, pollutants, or contaminants remaining at the site in excess of levels that allow for unlimited use and unrestricted exposure. The purpose of the five-year reviews is to revisit the appropriateness of the remedy in providing adequate protection of human health and the environment. The five-year reviews for the LF-1 source area OU will be part of the five-year reviews conducted for the CERCLA IRP sites on the MMR.

2.13 SELECTED REMEDY FOR THE LF-1 GROUNDWATER OPERABLE UNIT

Based on the Administrative Record for the LF-1 site and the evaluation of comments received by interested parties during the public comment period, AFCEE has selected Alternative 5 as the remedy for the LF-1 groundwater OU.

2.13.1 Summary of the Rationale for the Selected Remedy

The selected remedy is Alternative 5, which consists of continued operation of the current LF-1 treatment system and the LF-1 SPEIM program, the installation of one additional extraction well (27EW0006) south of 27EW0002 to increase capture of the southern portion of the LF-1 plume, LUCs, and the Bourne Water Provision. The water from the additional extraction well will be pumped to the Hunter Avenue Treatment Facility for treatment and infiltration/reinjection. The selected remedy is protective of human health through implementation of LUCs, complies with ARARs, does not have any significant implementability concerns, and has minor impacts on worker safety, the community, and the environment. The preferred remedy was selected over the other alternatives because it is expected to achieve the RAOs in a reasonable time frame and is cost-effective.

2.13.2 Detailed Description of Selected Remedy

The selected remedy is Alternative 5, which consists of the existing LF-1 ETI system (five extraction wells and an associated infiltration trench) with the system expanded to the south (one extraction well, 27EW0006) (Figure 2-4) to improve capture of the plume in that area. A portion of the treatment plant effluent is to be diverted seasonally (April through October) away from the infiltration gallery to be used for irrigation purposes by Veterans Affairs at the Massachusetts National Cemetery. The additional flow from 27EW0006 is treated at the Hunter Avenue Treatment Facility and infiltrated at two new galleries located close to the Hunter Avenue Treatment Facility.

The ETI system consists of ETI of groundwater following federal and state standards for PCE, TCE, CCl_4, 1,4-dichlorobenzene, vinyl chloride, and 1,1,2,2-TeCA as stipulated in

the current O&M plan. The alternative has the flexibility of modifying the treatment system to optimize the cleanup time frame and to insure it continues to meet performance objectives. Most likely, modifications would be executed with the existing extraction wells and infiltration trenches and galleries, and could involve the use of packers to reduce the effective vertical extent of the extraction screen, or adjusting flow rates. However, the alternative does not exclude the possibility of adding additional system components, if deemed necessary. Modifications would be made for the purpose of improving treatment system operation, expediting the plume cleanup, and maintaining containment of the plume upgradient of a point approximately 800 feet west of the base boundary.

After the FS was conducted the LF-1 groundwater model and plume shells were revised. The groundwater model predictions with the revised model and plume shells are improved over what was prepared for the LF-1 FS because the more recent model predictions more accurately reflect the current and future groundwater flow patterns. In early 2006 the LF-1 Alternative 5 performance objective language was developed based on review of these updated modeling animations. A summary of the modeling and development of the performance objectives are presented in a Project Note: LF-1 Alternative 5 Performance Objectives (Jacobs 2007).

The LF-1 six-well ETI system's (Alternative 5) performance objective is to provide for containment of the groundwater plume upgradient of a point approximately 800 feet west of the base boundary and to achieve cleanup levels for COCs in the portion of the plume downgradient from the same point through the natural attenuation processes of dilution and dispersion. Achievement of this objective will be measured by the following three metrics:

1. The LF-1 plume is expected to separate at a point approximately 800 feet downgradient of the base boundary by approximately 2013.
2. The LF-1 groundwater between a point approximately 800 feet downgradient of the base boundary and Route 28 is expected to be below cleanup levels for plume COCs by approximately 2023.

3. All LF-1 groundwater downgradient of the extraction wells is expected to be below cleanup levels for plume COCs by approximately 2027.

In order to measure achievement of these metrics, the Air Force will use a combination of monitoring wells and groundwater modeling. If the ETI system does not meet its performance objective, the Air Force, with concurrence with the regulatory agencies, will evaluate and make, as necessary, system improvements.

As part of the remedy, a groundwater monitoring plan, based on EPA guidance and subject to regulatory agency approval, will be developed and made a part of the existing Comprehensive Long-Term Monitoring Plan. The groundwater monitoring plan will specify how AFCEE will monitor the plume downgradient of the extraction wells (i.e., off-base property) using the technique of monitored natural attenuation.

This alternative would provide for chemical and hydraulic monitoring of the plume, as long as active remediation continues, and chemical monitoring of the plume until the RAOs are met. Chemical monitoring of the limited extent of perchlorate will also be conducted. Monitoring data would aid in ongoing optimization and could prompt additional action if COC concentrations did not decrease as expected. Monitoring results will be periodically reported in formal reports. CERCLA reviews would be performed every five years throughout the lifetime of the alternative. A residual risk assessment and/or an evaluation of the technical and economic feasibility of additional remediation to approach background concentrations would be performed if deemed necessary. The selected remedy also includes implementation of LUCs, and the Bourne water provision. Further discussion of the LUCs is provided in Section 2.11.2 of this report.

2.13.3 Cost Estimate for the Selected Remedy

The cost estimate for LF-1 groundwater OU Alternative 5 is provided in Tables 2-33 and 2-34. The information for the cost estimate is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements may occur based on alterations in operation of the LF-1 ETI system and the monitoring

program. This is an order-of-magnitude engineering cost estimate that is expected to be within +50 to –30 percent of the actual project cost. The cost comes from the O&M of the LF-1 ETI system, the SPEIM program, periodic CERCLA reporting, and the residual risk assessment.

O&M costs would be incurred for the operation of the LF-1 treatment plant and part of the Hunter Avenue Treatment Facility from the date the ROD is signed[3] to 2043, when the treatment system is expected to cease operation. O&M costs have been estimated using actual costs realized for the previous operation of the existing LF-1 treatment system and projected costs for operation of a portion of the Hunter Avenue Treatment Facility. Previous costs have been adjusted for the expected future reductions in the total pumping rate and influent concentrations under the future operating conditions assumed for the purposes of this ROD.

Costs related to monitoring well maintenance, hydraulic measurement, sample collection, and groundwater analysis also would be incurred during this time. Groundwater monitoring could continue after the cleanup levels are met to ensure the aquifer had been restored. It is assumed (for cost-estimating purposes) that monitoring would continue for the entire plume for two years after the cleanup levels are met, making the total lifetime of this alternative 40 years. It is assumed that the number of monitoring points and frequency of testing would both continue to decrease with plume collapse, as has been the case under most SPEIM programs at the MMR to date. Monitoring costs include periodic reporting of results in technical update meetings and in formal reports.

Costs did not include those associated with potential LUCs because they were not determined until after the FS was completed. Additionally, no costs were included for negotiating and compensating for legal access to off-base property (for new monitoring wells). These omissions are anticipated to have a small impact on the overall net present value.

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[3] When cost estimates were prepared, the ROD was scheduled to be signed in June 2006.

Costs associated with CERCLA reporting and a final risk assessment are also included in this alternative. The present value of this alternative is estimated to be $44 M.

Capital, annual and periodic costs generated in the cost estimates and used in the present value calculations were assumed to start at the projected date of the ROD approval (June 2006). Cost estimates also included actuals from 2003, 2004, and 2004.5 and were escalated to the start of the base year (June 2006); thus, escalation of 1.5, 2, and 3 years at a rate of 5 percent has been used. A discount rate of 3.5 percent was used for all present value calculations per EPA guidance (EPA 2000) and Office of Management and Budget Circular A-94, revised February 2004 (OMB 2004).

2.13.4 Expected Outcomes of the Selected Remedy

Alternative 5 provides for protection of human health through implementation of LUCs. The groundwater model indicates that cleanup levels will be met by approximately 2027 downgradient of the extraction wells and by approximately 2045 for the entire plume, at which time the groundwater will be useable as a source of drinking water.

2.14 STATUTORY DETERMINATIONS FOR THE LF-1 GROUNDWATER OPERABLE UNIT

Under CERCLA Section 121, selected remedies must be protective of human health and the environment, comply with ARARs (unless a waiver is justified), be cost-effective, and use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as a principal element. The following sections discuss how the selected remedy meets these statutory requirements.

2.14.1 Protection of Human Health and the Environment

The selected remedy will protect human health and the environment through LUCs and monitoring of the groundwater plume to ensure contaminant concentrations are

dissipating to below cleanup levels, as predicted by the groundwater model. Monitoring and LUCs, on- and off-base, reduce exposure to groundwater from the LF-1 plume. Human health is adequately protected currently by municipal water provided to residences overlying or in the immediate vicinity of the LF-1 plume. The Bourne water provision provides for replacement of water from two public water supply wells. There are no short-term threats associated with the selected remedy that cannot be readily controlled.

2.14.2 Compliance with Applicable or Relevant and Appropriate Requirements

Operation of the LF-1 ETI system with southern expansion would remediate part of the plume, and the remainder of the plume contaminants would naturally attenuate to concentrations below the cleanup levels; therefore, Alternative 5 would meet the chemical-specific ARARs.

Location-specific ARARs address federal and state regulations that aim to protect wildlife habitats, historical resources, and vital waterways. These areas have already been addressed during implementation of the existing ETI system.

For this alternative, action-specific ARARs apply to the discharge (reinjection/infiltration) of treated groundwater and the management of spent carbon and contaminated groundwater generated from sampling of wells or treatment plant maintenance. Because these same activities have been occurring for existing remedial actions at LF-1, appropriate procedures are already in place for the proper handling of these materials. It is expected that these practices would continue, and all action-specific ARARs would be met. Refer to Tables 2-28, 2-29, and 2-30 for a listing of these ARARs.

2.14.3 Cost-Effectiveness

In AFCEE's judgment, the selected remedy for LF-1 groundwater is cost-effective. The overall effectiveness of the selected remedy was determined to be proportional to its costs and, hence, to represent a reasonable value for the money to be spent.

The cost-effectiveness for the LF-1 remedy was evaluated based on the data currently available for the LF-1 plume and the following considerations: (1) cleanup levels will be met by approximately 2045, (2) the model predicted approximately 750 lb of TCE and PCE will be removed from the aquifer, (3) contaminants are permanently destroyed, (4) risks to workers, the community, and the environment would be easily controlled, and (5) there is a high degree of confidence that the existing controls can adequately handle potential problems.

2.14.4 Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

The selected remedy for the LF-1 plume provides the best balance of trade-offs among the alternatives considered in the FS. Alternative 5 represents the maximum extent to which permanent solutions and treatment can be practicably utilized at the site because Alternatives 1 (no action) and 3 (LTM) would not expedite aquifer restoration and the plume would migrate towards Bourne water supply wells, and Red Brook and Squeteague harbors. Alternative 5 is preferable to Alternative 3 because it restricts further migration and expansion of the plume past the MMR boundary, thus decreasing the amount of time it will take for the aquifer west of the treatment system to become useable again as a drinking water supply. Under Alternative 5, AFCEE will continue to operate, maintain, and monitor the performance of the LF-1 ETI system with LUCs and the Bourne water provision. Groundwater modeling predicts that expansion of the LF-1 ETI system from five to six extraction wells will capture most of the LF-1 plume that is located upgradient (east) of the base boundary. Modeling predicts that after the LF-1 system modification, there will not be enough contaminant mass passing around or through the LF-1 ETI system to be a continuing source for a downgradient plume, and that by 2013 the plume located downgradient (west) of the ETI system will become detached from the upgradient plume. Incremental improvements to the aquifer restoration time frame and risk reduction in areas west of Route 28 (Alternatives 12, 15, and 16) are not commensurate with the additional costs of active remediation west of Route 28. The warm-spot remediation offered by Alternatives 15 and 16 is not cost-effective because it does not reduce the operational time frame of the base boundary

system to offset the additional construction and operation costs. Lastly, the predicted performance of Alternative 5 is not very different from the performance of Alternative 9, while the construction and operation costs are substantially different. Based on the evaluation criteria and the statutory mandates, AFCEE finds Alternative 5 to be the most appropriate solution for the LF-1 plume. The treatment, monitoring, and controls included in Alternative 5 will demonstrate compliance with ARARs and protectiveness of human health and the environment. The contaminants removed from the aquifer are destroyed through active treatment and contamination remaining in the aquifer is reduced to acceptable levels through natural attenuation. The selected remedy does not present any significant short-term risks. There are no special implementability issues that make the selected remedy unacceptable.

2.14.5 Preference for Treatment as a Principal Element

The selected remedy treats the contamination present in the LF-1 plume. The contaminated groundwater is removed from the aquifer through extraction wells and piped to the treatment plants. Contaminants are removed from the groundwater through GAC filtration. The treated groundwater is returned to the aquifer via an infiltration gallery.

2.14.6 Five-Year Review Requirements

Five-year statutory reviews will be performed for the LF-1 plume, according to Section 121(c) of CERCLA and NCP Section 300.430(f)(4)(ii), which requires such reviews in those instances where the remedy results in any hazardous substances, pollutants, or contaminants remaining at the site in excess of levels that allow for unlimited use and unrestricted exposure. The purpose of the five-year reviews is to revisit the appropriateness of the remedy in providing adequate protection of human health and the environment. The five-year reviews for the LF-1 groundwater OU will be part of the five-year reviews conducted for the CERCLA IRP sites on the MMR. The next five-year review covering the period 01 November 2002 through 31 October 2007 will be published in the spring of 2008.

2.15 DOCUMENTATION OF CHANGES

The PP for the LF-1 Source Area and Groundwater was released for public comment in June 2006. The PP identified Alternative 2 as AFCEE's preferred LF-1 source area alternative and Alternative 5 as AFCEE's preferred LF-1 groundwater alternative.

AFCEE, the EPA, and the MassDEP reviewed all written and verbal comments submitted during the public comment period. A transcript of the public hearing is provided in Appendix B. Upon review of these comments, it was determined that no significant changes to the remedy, as it was originally identified in the PP, were necessary.

During review of the selected remedy, after the PP public comment period, AFCEE agreed to add manganese as a COC. The addition of manganese as a COC does not change the selected remedy. Manganese concentrations within the plume will be monitored as part of the chemical monitoring component of the selected remedy. Manganese concentrations are predicted to decrease below cleanup levels before the modeled LF-1 plume COCs (PCE and TCE). The addition of manganese to the chemical monitoring program has a minor impact on the costs and the present value cost of the selected remedy would remain unchanged at $44 M.

Following the PP public comment period, AFCEE agreed to add an RAO in response to EPA's request that the RAOs be protective of potential exposure other than residential pathways:

- Prevent exposure to LF-1 groundwater for human receptors under non-residential use scenarios (including dermal contact, ingestion, and inhalation), unless shown, pursuant to Section 2.11.2, that such use does not present a carcinogenic risk in excess of the EPA target risk range of 10^{-4} to 10^{-6} or present a non-carcinogenic hazard index greater than 1.0.

The addition of the RAO does not alter the evaluation of the alternatives or the selection of the final remedy.

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3.0 RESPONSIVENESS SUMMARY

The Responsiveness Summary is on the following page.

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MASSACHUSETTS MILITARY RESERVATION

Installation Restoration Program

APRIL 2007

RESPONSIVENESS SUMMARY
for Landfill-1 Source Area and Groundwater

INTRODUCTION

The purpose of this *Responsiveness Summary* is to provide written responses to the comments received during the public comment period for the Proposed Plan for Landfill-1 Source Area and Groundwater.

COMMENTS RESPONSES

Comments from the PCT:	Responses:
• The team recommends Alternative 2 for the Landfill source area.	• AFCEE agrees that Alternative 2 is the preferred alternative for the LF-1 source area.
• The team recommends Alternative 5 for the LF-1 plume.	
o The team assumes that a sixth extraction well will be installed as part of the Interim ROD SPEIM program.	• The sixth extraction well has been installed.
o AFCEE will maintain their commitment to provide the Bourne Water District with replacement wells for Bourne wells 2 and 5.	• The Air Force will maintain their commitment to provide the Bourne Water District with replacement well(s) for Bourne wells 2 and 5.

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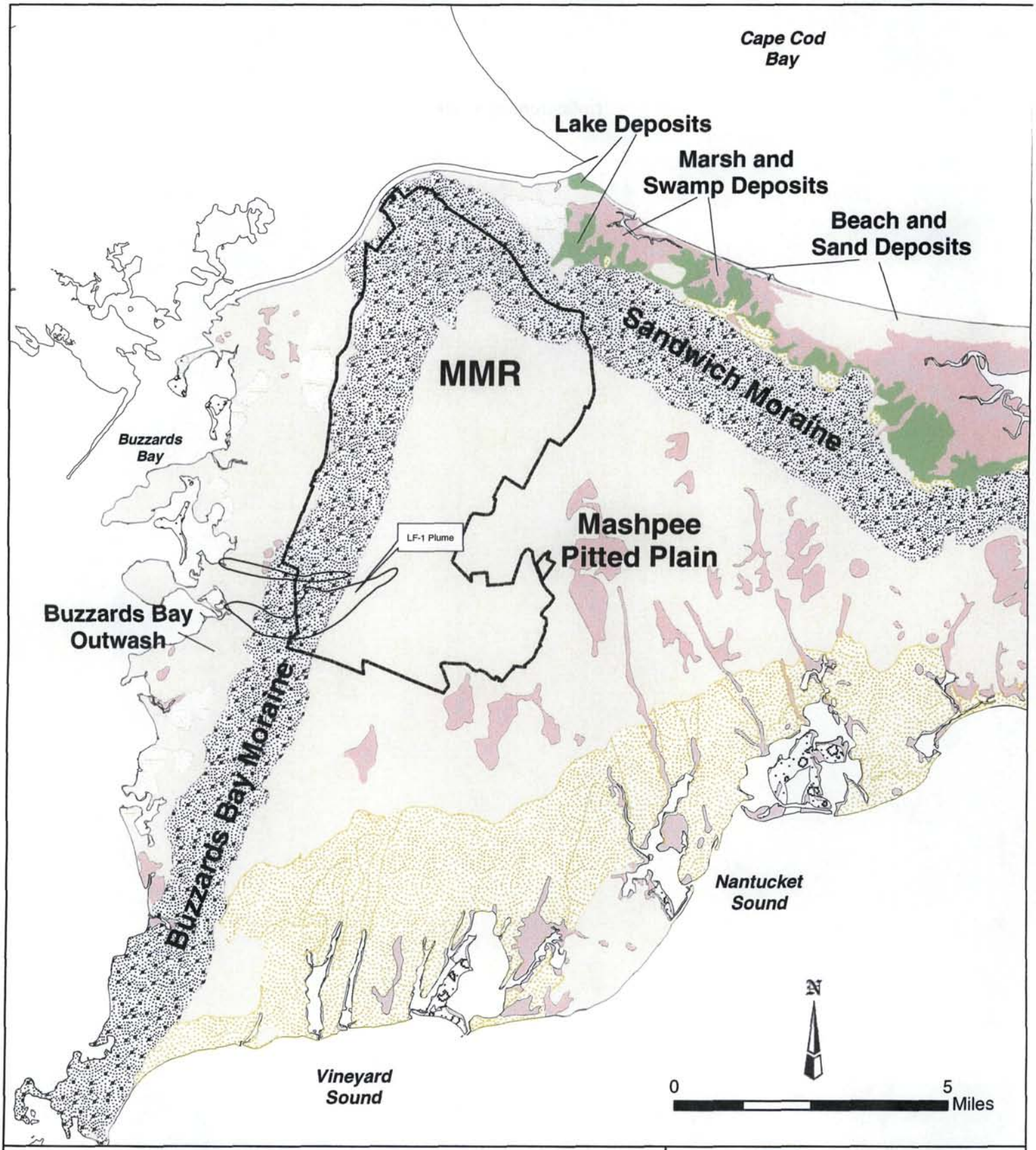
FIGURES



LEGEND

- MMR Boundary
- Surficial Geology Units
  - end moraines
  - fine-grained deposits
  - floodplain alluvium
  - large sand deposits
  - sand and gravel deposits
  - sandy till over sand
  - till or bedrock

JE JACOBS

Regional Surficial Geology Map and the Massachusetts Military Reservation

Massachusetts Military Reservation
Cape Cod, Massachusetts

NAME: jpiccuito DATE: 9/13/2007

Figure 2-1

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Red Brook Harbor
Red Brook Pond
Long Pond
Cuffs Pond
Squeteague Harbor
Route 28
Route 28A
MMR Boundary
LF-1 Plume
PWS2
PWS5
Connery Avenue
Veterans Cemetary
Bourne
Falmouth
Sandwich
U.S. Coast Guard Housing
Osborn Pond
Edmunds Pond
Land Use Legend
Crop Land/Pasture
Forest
Wetland
Mining
Open Land
Industrial
Recreation
Residential
Commercial
Urban
Transportation
Waste Disposal
Water
Water-based Recreation
Legend
Town of Bourne Public Water Supply Well
MMR Boundary
Town Boundary
LF-1 Plume (dashed where inferred)
N
0
2,000 Feet
Scale 1:24,000
JACOBS
LF-1 Area Land Use
Massachusetts Military Reservation
Cape Cod, Massachusetts
Figure 2-2

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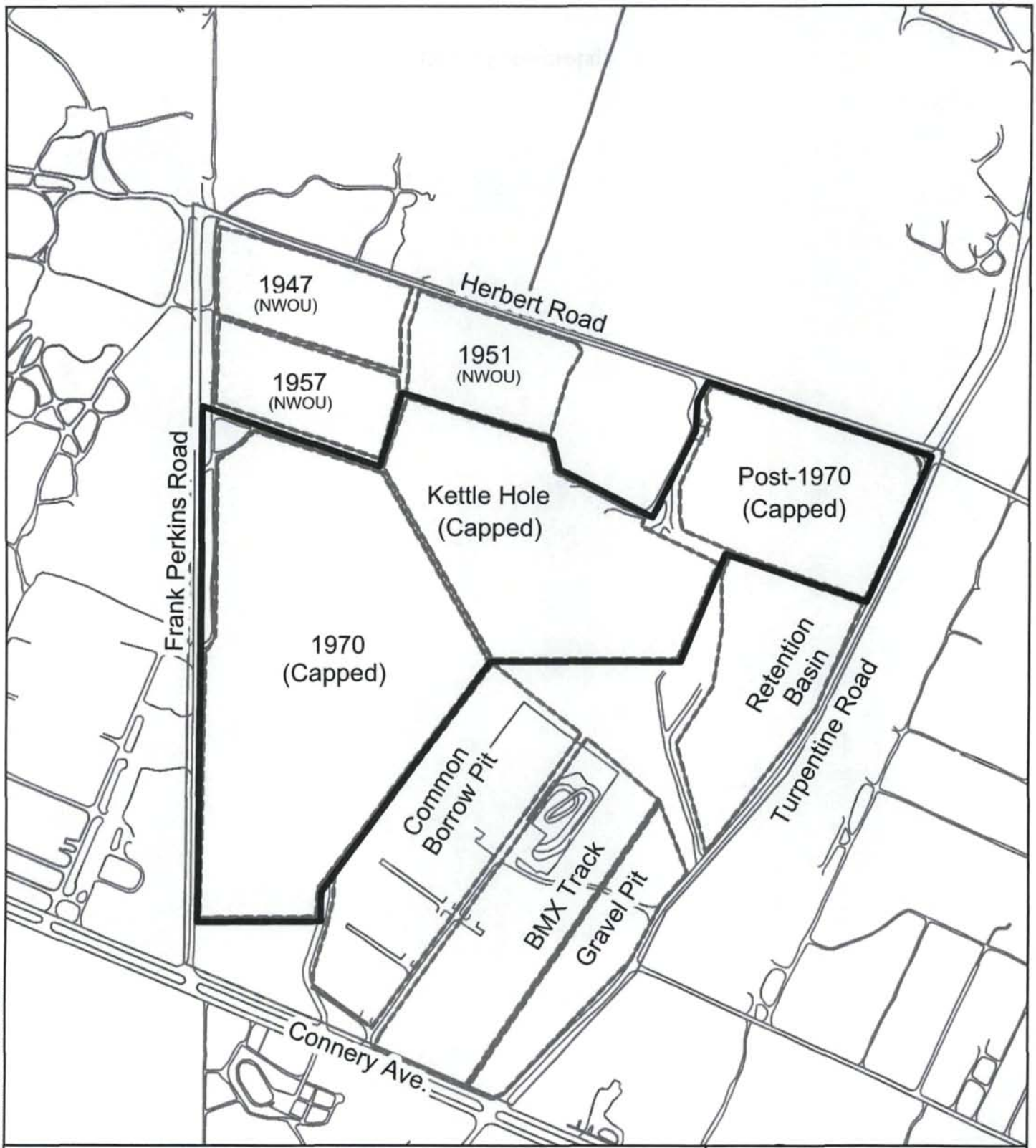

Legend

NWOU Northwest Operable Unit

LF-1 Source Area addressed in this ROD.

N

0 600 Feet

Scale 1:7,200

JACOBS

Landfill-1
Source Area

Massachusetts Military Reservation
Cape Cod, Massachusetts

NAME: jpiccuito DATE: 10/3/2006

Figure 2-3

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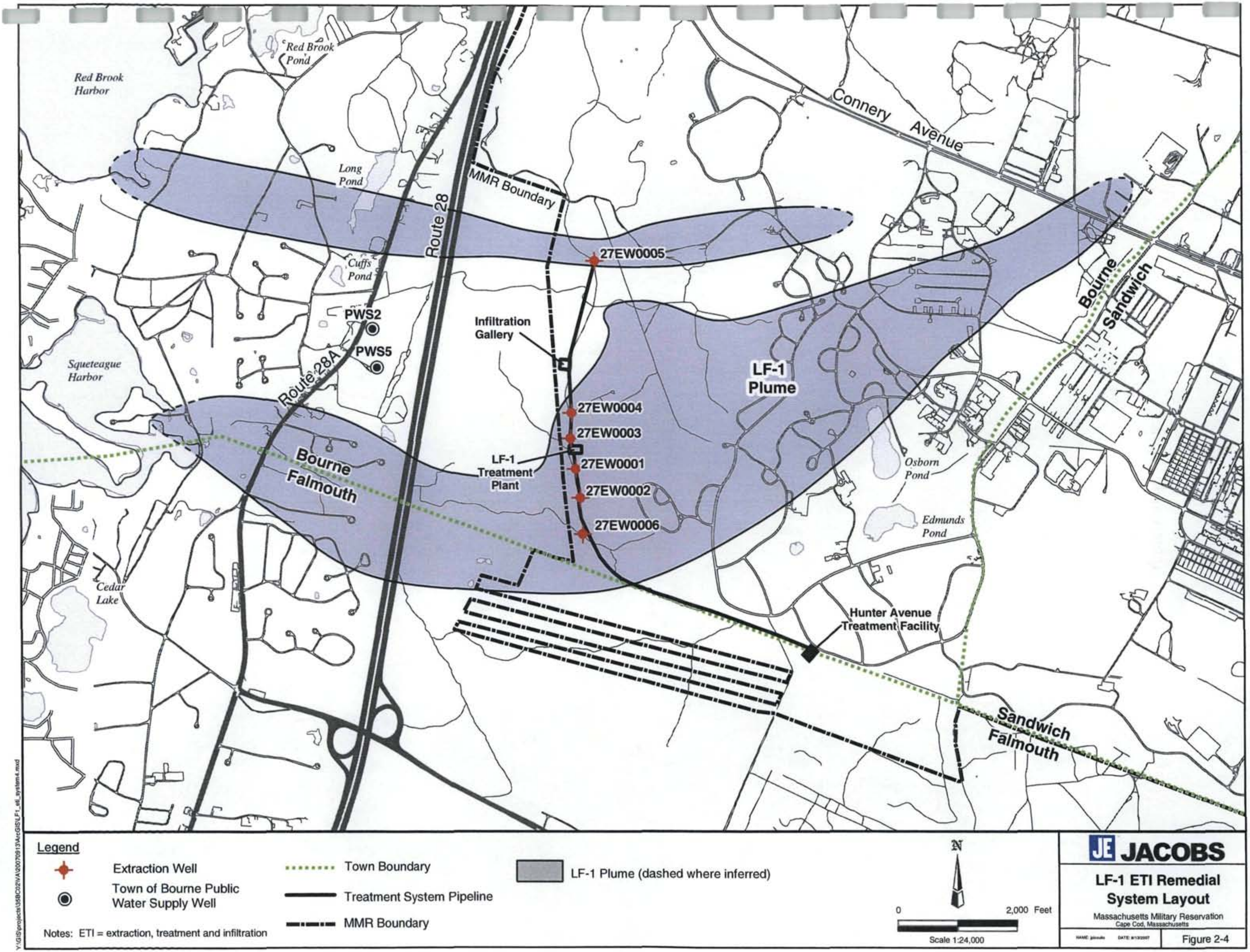

Red Brook Pond
Red Brook Harbor
Long Pond
Cuffs Pond
Squeteague Harbor
Cedar Lake
Osborn Pond
Edmunds Pond
Connery Avenue
MMR Boundary
Route 28
Route 28A
PWS2
PWS5
27EW0005
Infiltration Gallery
LF-1 Plume
27EW0004
27EW0003
LF-1 Treatment Plant
27EW0001
27EW0002
27EW0006
Bourne
Falmouth
Bourne
Sandwich
Hunter Avenue Treatment Facility
Sandwich
Falmouth
Legend
Extraction Well
Town of Bourne Public Water Supply Well
Town Boundary
Treatment System Pipeline
MMR Boundary
LF-1 Plume (dashed where inferred)
Notes: ETI = extraction, treatment and infiltration
0
2,000 Feet
Scale 1:24,000
JACOBS
LF-1 ETI Remedial System Layout
Massachusetts Military Reservation
Cape Cod, Massachusetts
Figure 2-4

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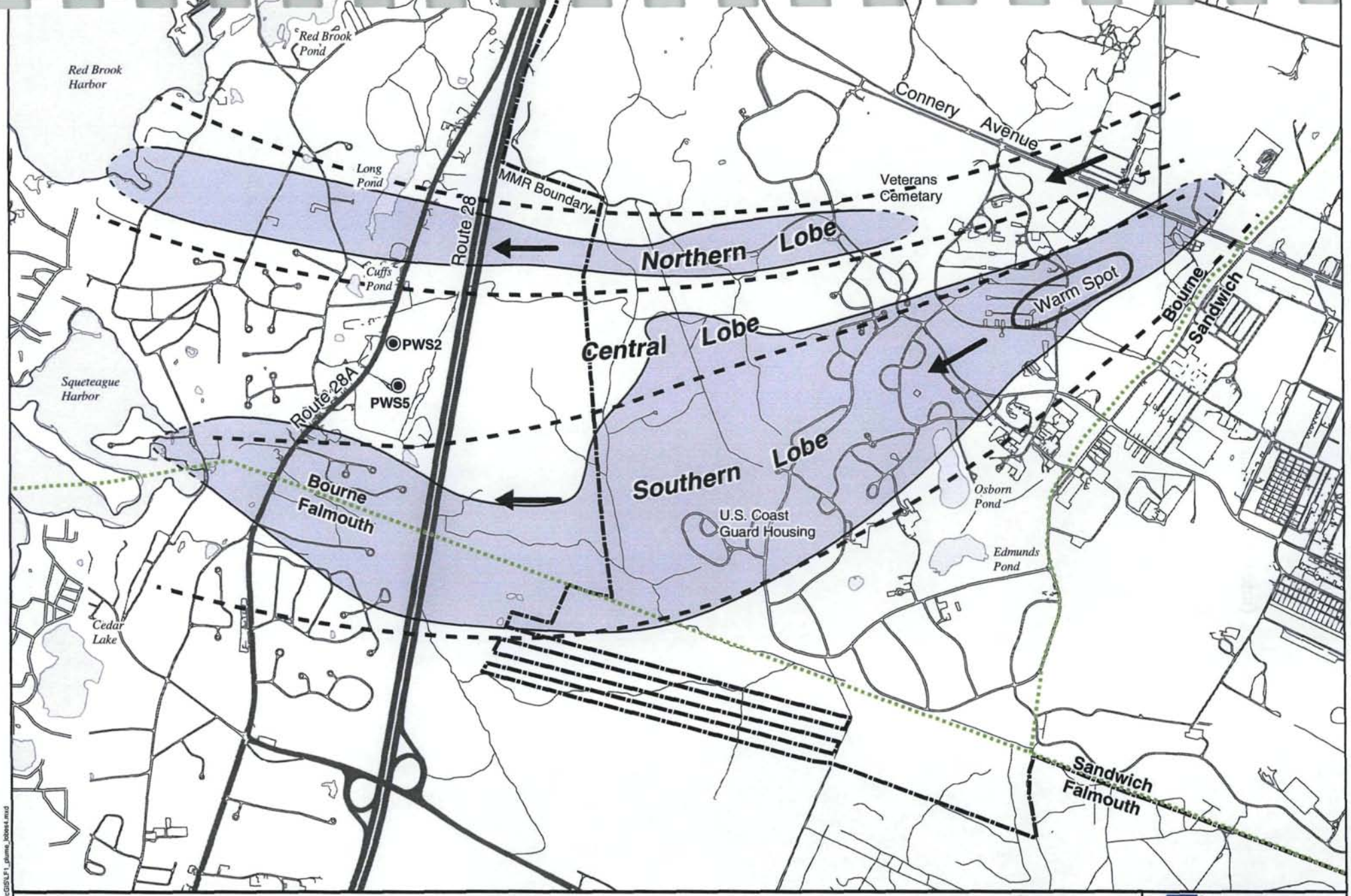
Red Brook Harbor
Red Brook Pond
Connery Avenue
Long Pond
MMR Boundary
Veterans Cemetary
Route 28
Northern Lobe
Cuffs Pond
Warm Spot
Bourne
Sandwich
PWS2
Central Lobe
Squeteague Harbor
PWS5
Route 28A
Bourne
Falmouth
Southern Lobe
U.S. Coast Guard Housing
Osborn Pond
Edmunds Pond
Cedar Lake
Sandwich
Falmouth
Legend
Town of Bourne Public Water Supply Well
MMR Boundary
LF-1 Plume Lobe Boundary
Town Boundary
LF-1 Plume (dashed where inferred)
Warm Spot
Groundwater Flow Direction
N
0
2,000 Feet
Scale 1:24,000
JE JACOBS
LF-1 Plume
Massachusetts Military Reservation
Cape Cod, Massachusetts
Figure 2-5

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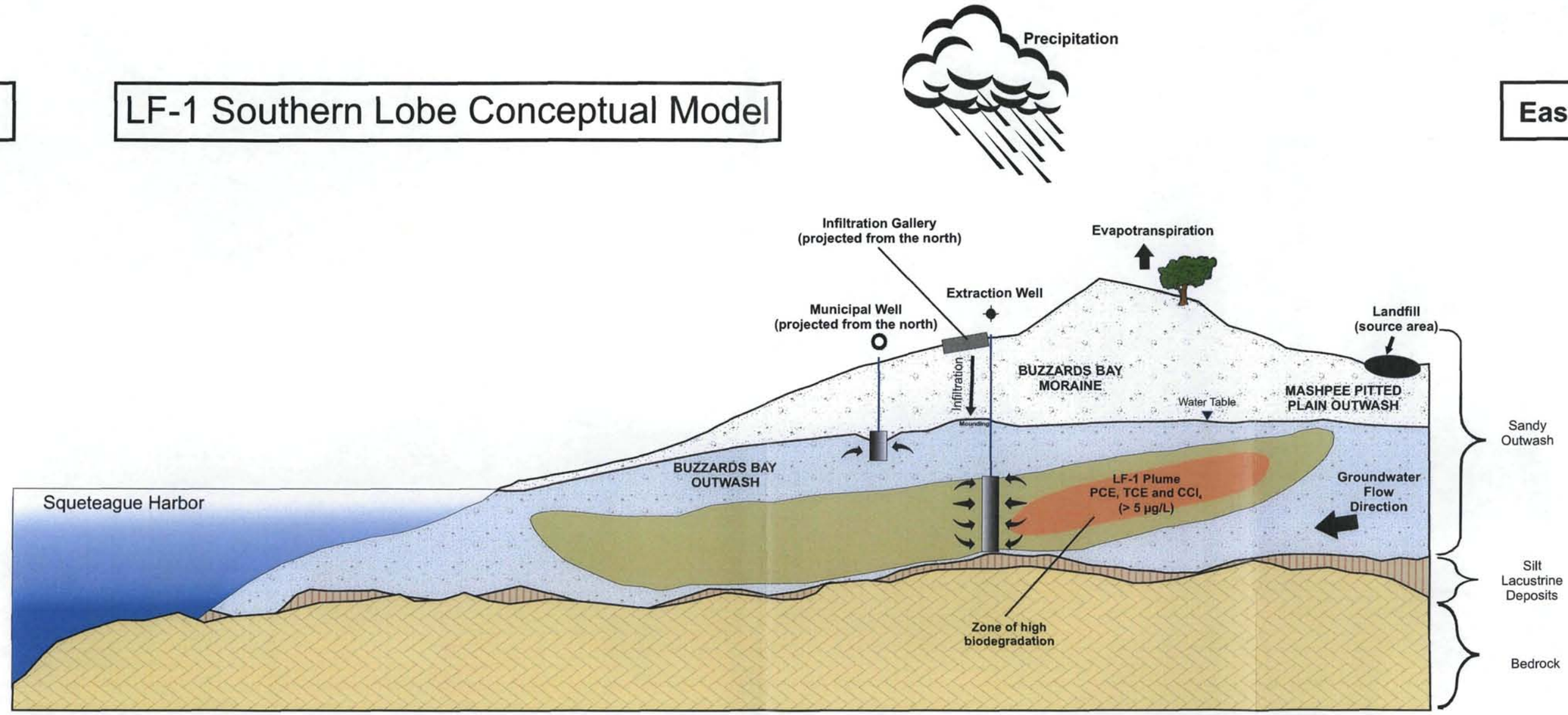
West

LF-1 Southern Lobe Conceptual Model

East



Legend

Arrows

Extraction Well

Notes:
- µg/L = micrograms per liter
- CCl_4 = Carbon Tetrachloride
- PCE = Tetrachloroethene
- TCE = Trichloroethene

JE JACOBS

LF-1 Site
Conceptual Model for
Southern Lobe
Massachusetts Military Reservation
Cape Cod, Massachusetts

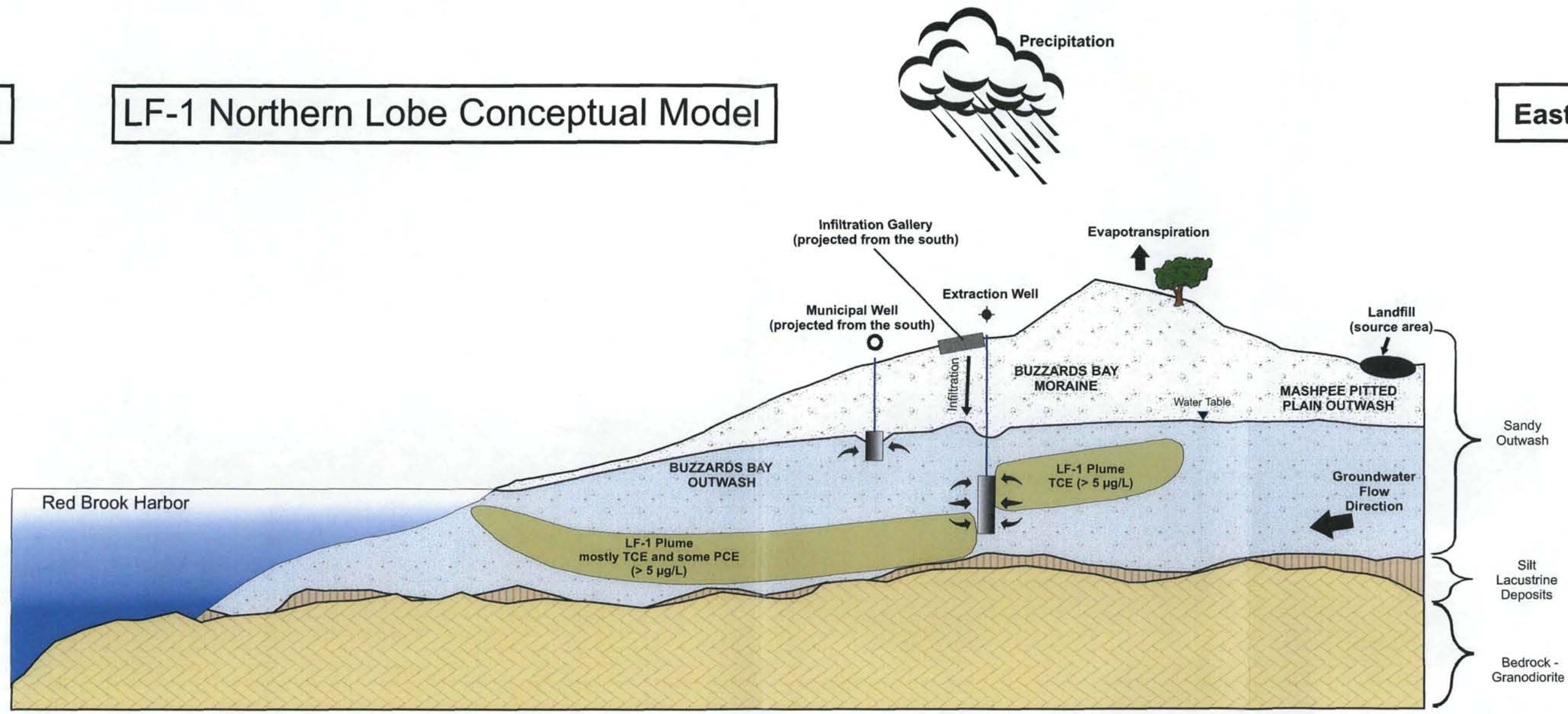
10/3/06 jpiccuito | Figure 2-6

Y:\GIS\projects\35BC02\VA\20061003\Corel\LF-1_conceptual model_S1a.cdr

West

LF-1 Northern Lobe Conceptual Model

East



Legend

Arrows

Extraction Well

Notes: µg/L = micrograms per liter
PCE = Tetrachloroethene
TCE = Trichloroethene

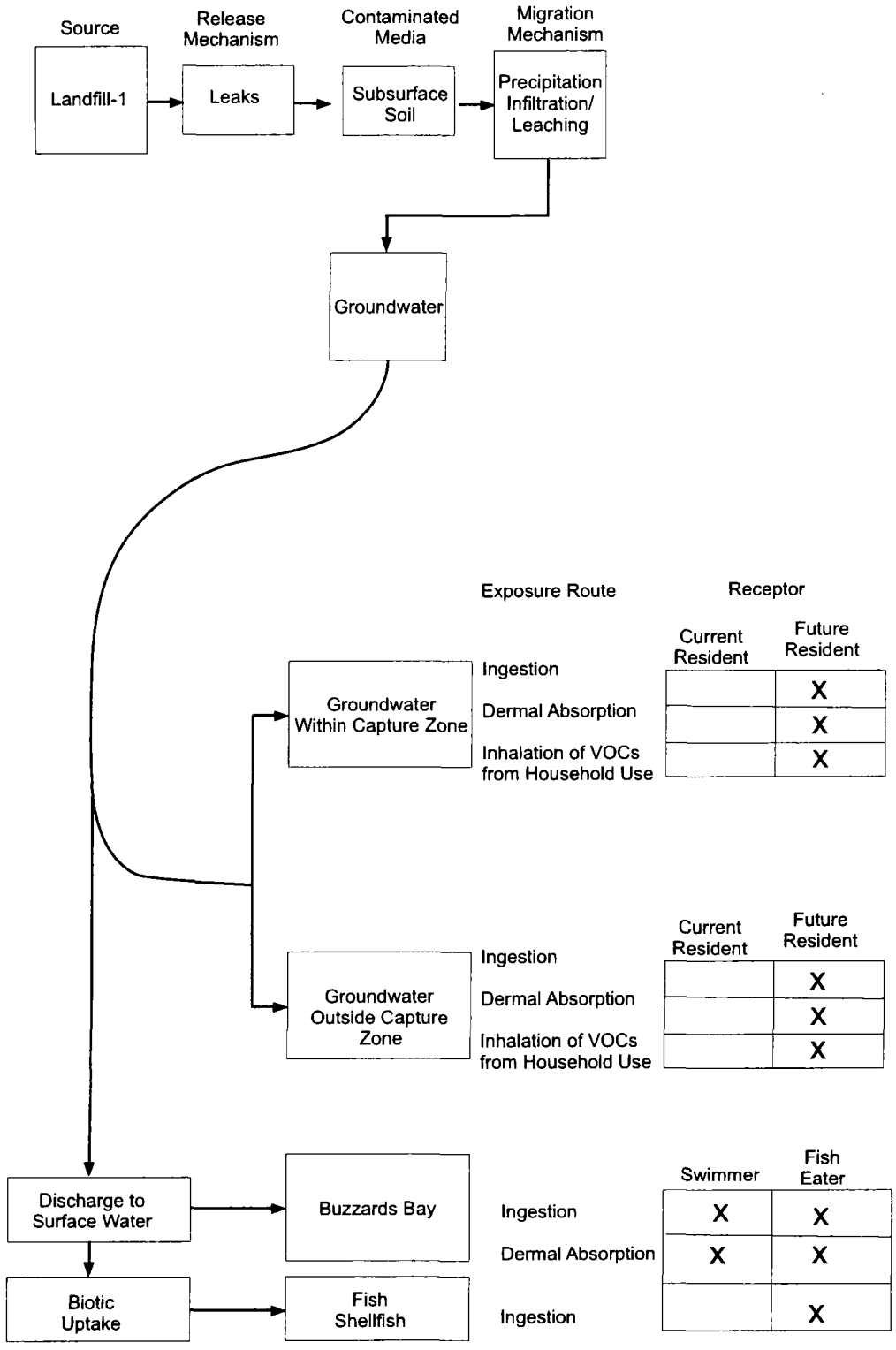
JACOBS

LF-1 Site
Conceptual Model for
Northern Lobe and Central Lobe
Massachusetts Military Reservation
Cape Cod, Massachusetts

10/3/06 jpiccuito

Figure 2-7

Y:\GIS\projects\35BC02\VA\20061003\Corel\LF-1_conceptual model_N1a.cdr



Legend

VOC volatile organic compound

JACOBS

Human Health
Conceptual Exposure Model
LF-1

Massachusetts Military Reservation
Cape Cod, Massachusetts

9/13/06 JP File...LF1_HHCEM2_8.cdr

Figure 2-8

Y:\GIS\projects\35BC02\VA\20060913\CorelLF-1_HHCEM2_8.cdr

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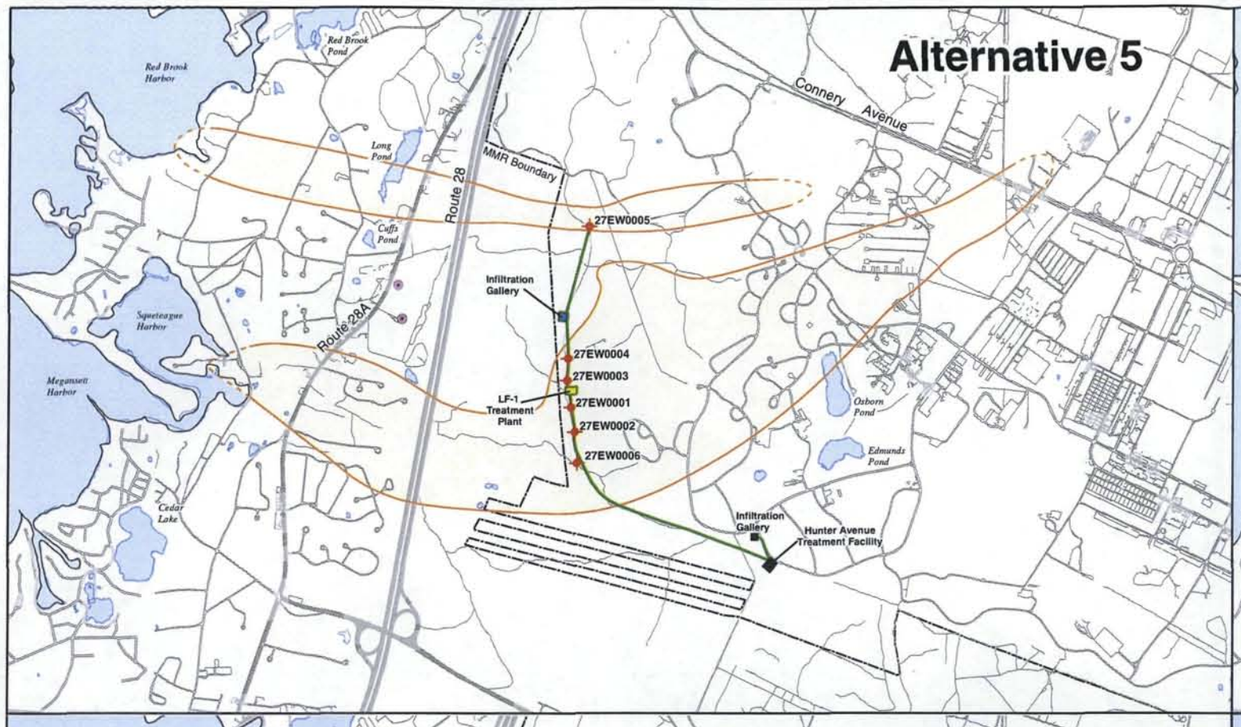
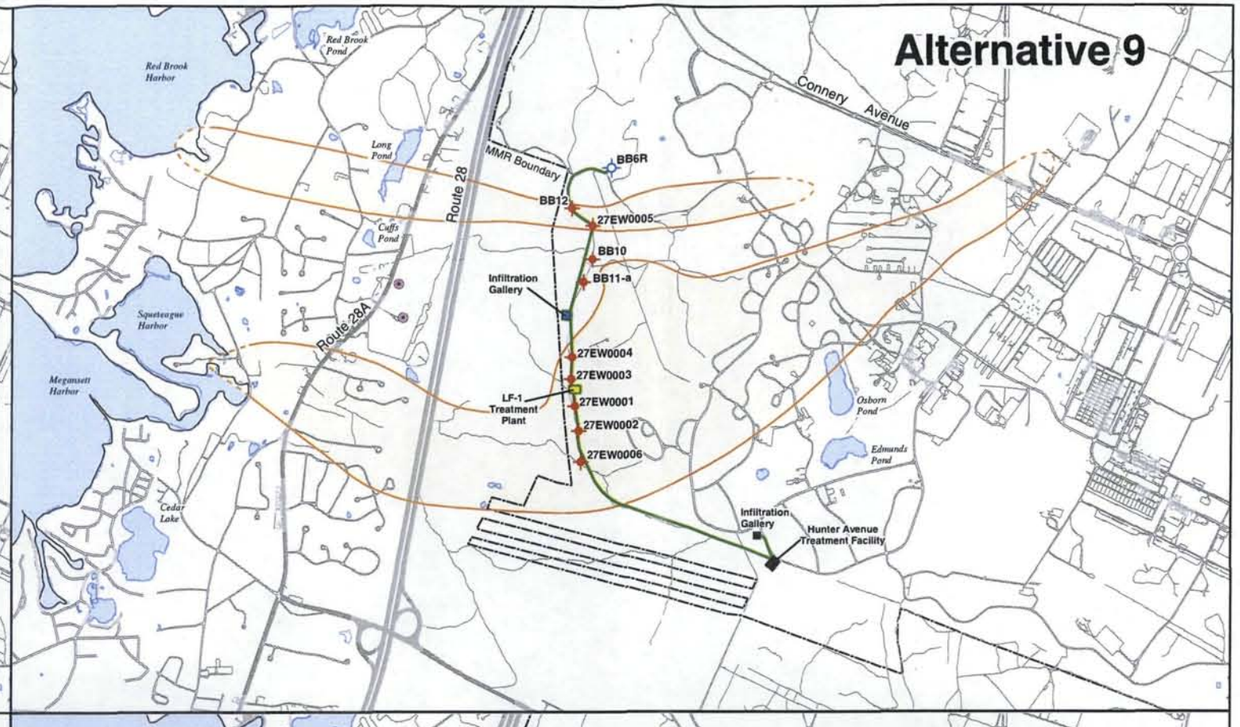
Alternative 5



Alternative 9



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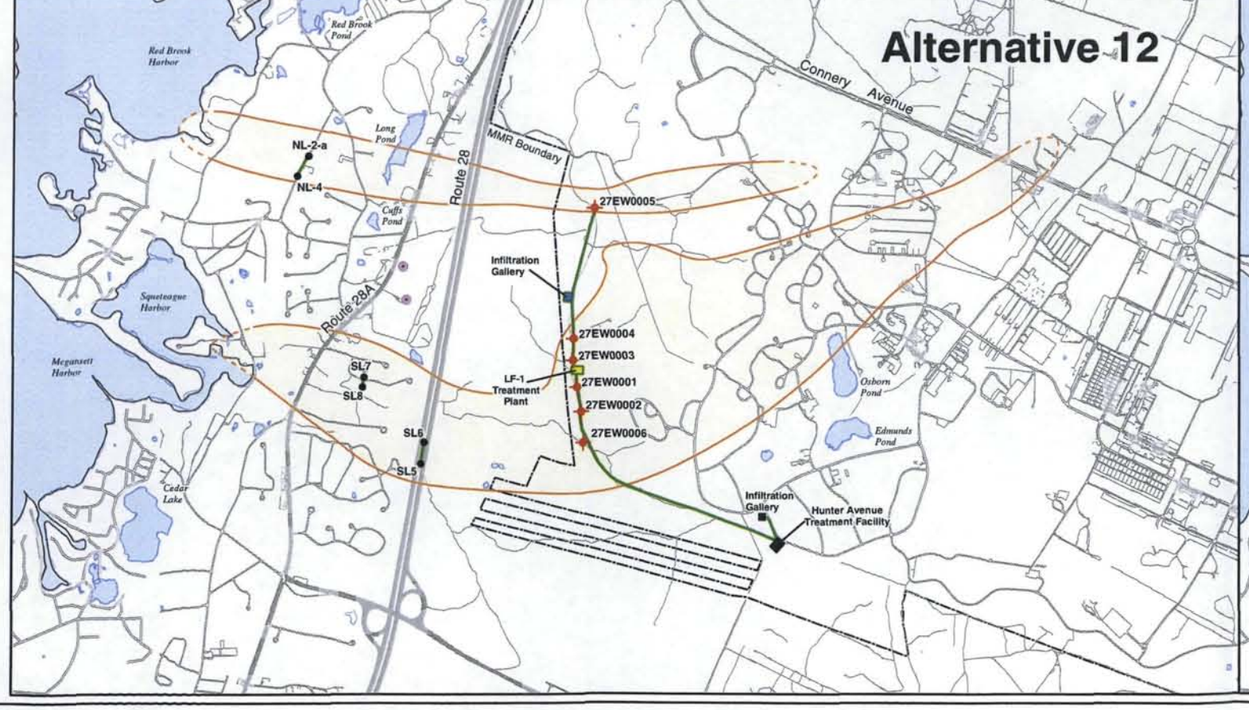
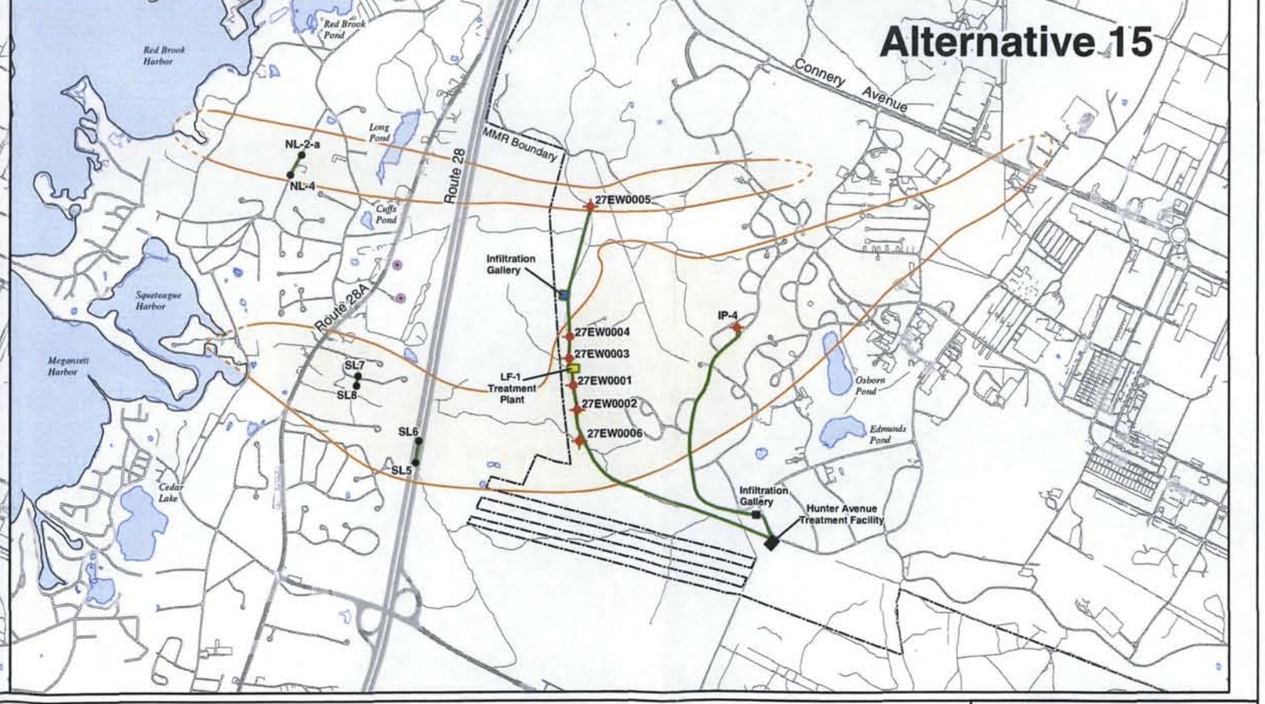


Alternative 15



Legend

- Co-located Extraction and Reinjection Well
- Extraction Well
- Reinjection Well
- Town of Bourne Public Water Supply Well
- Treatment System Pipeline
- MMR Boundary
- LF-1 Plume (dashed where inferred)

N

0 3,000 Feet

Scale 1:36,000

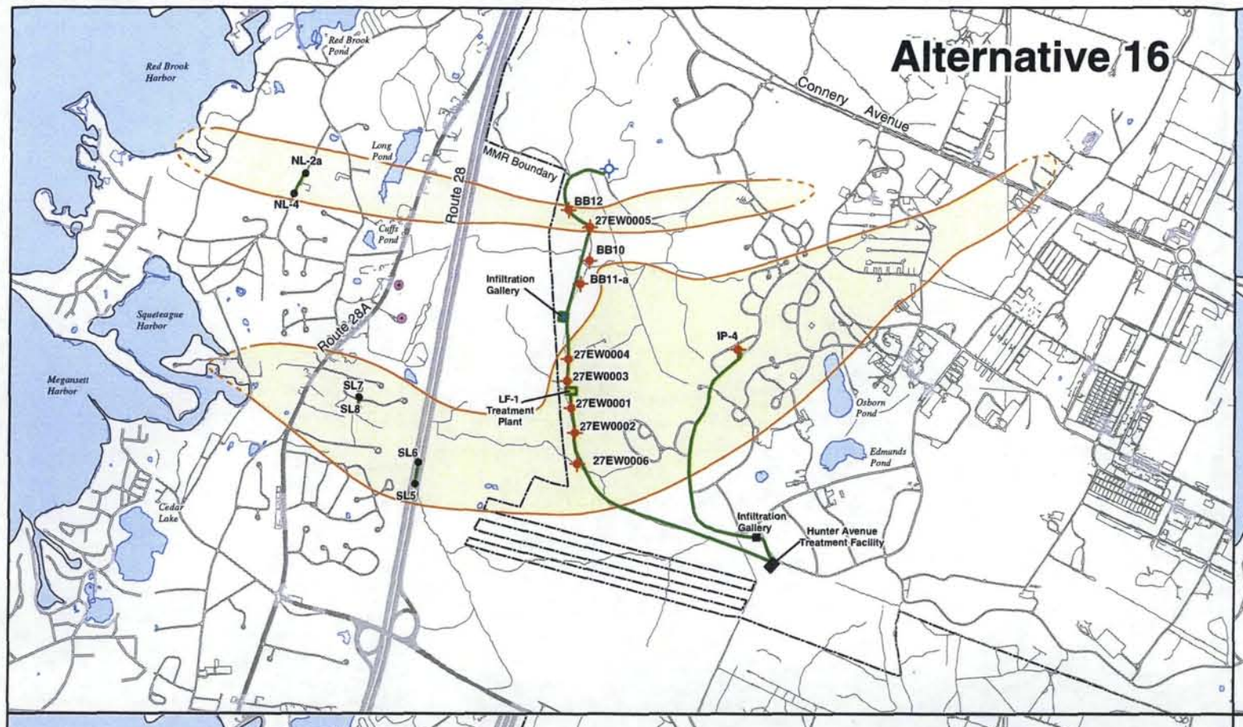
JE JACOBS

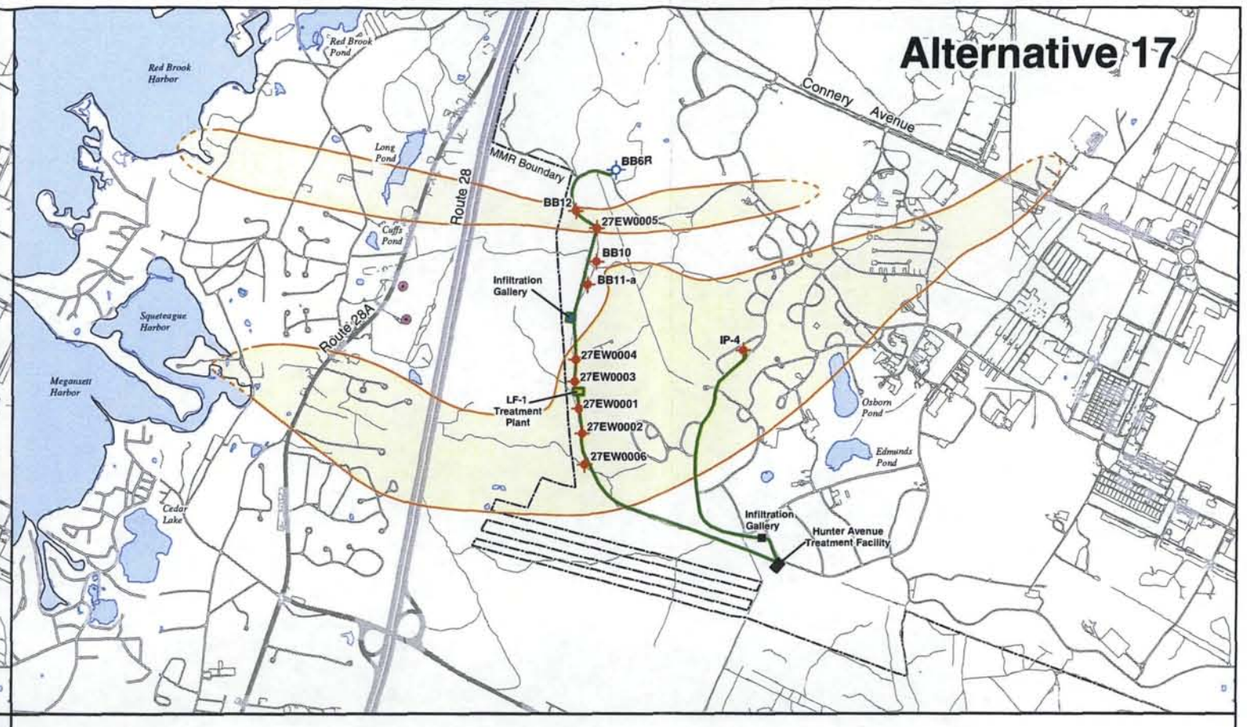
LF-1 Groundwater Remedial Alternatives 5, 9, 12, 15

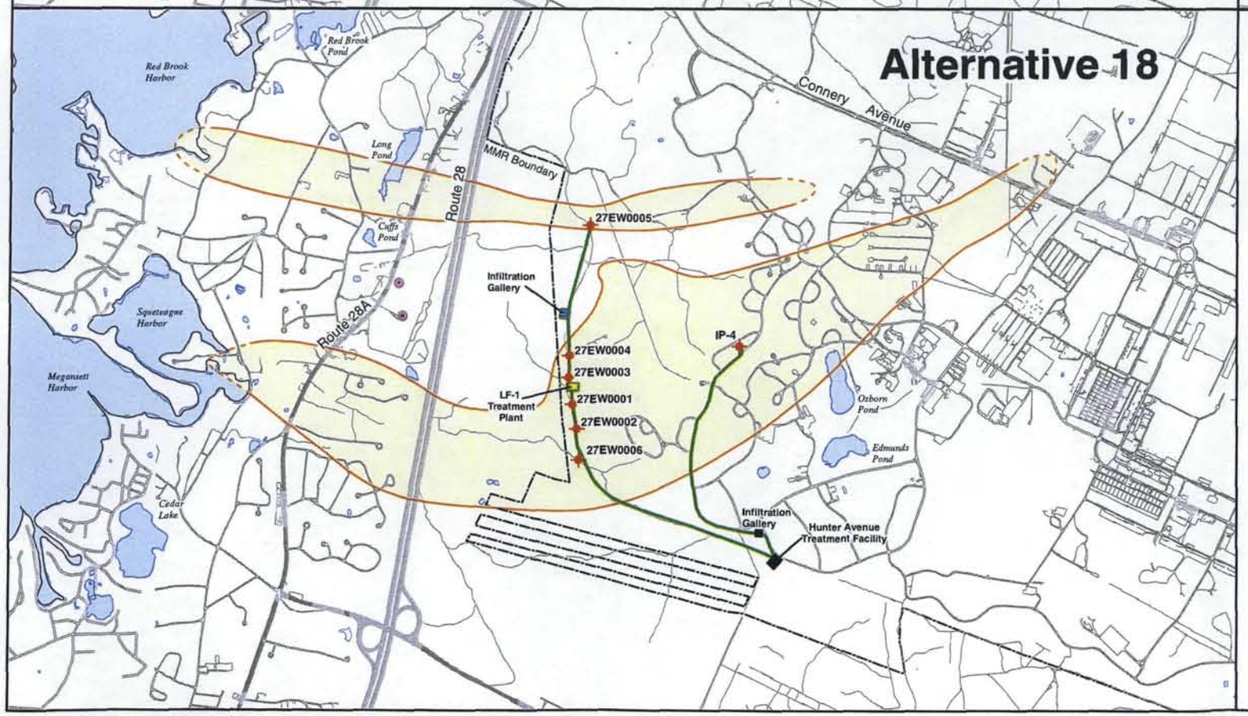
Massachusetts Military Reservation
Cape Cod, Massachusetts

NAME: jpiscitto DATE: 6/13/2007

Figure 2-9







Legend

- Co-located Extraction and Reinjection Well
- Extraction Well
- Reinjection Well
- Town of Bourne Public Water Supply Well
- Treatment System Pipeline
- MMR Boundary
- LF-1 Plume (dashed where inferred)

N

0 3,000 Feet

Scale 1:36,000

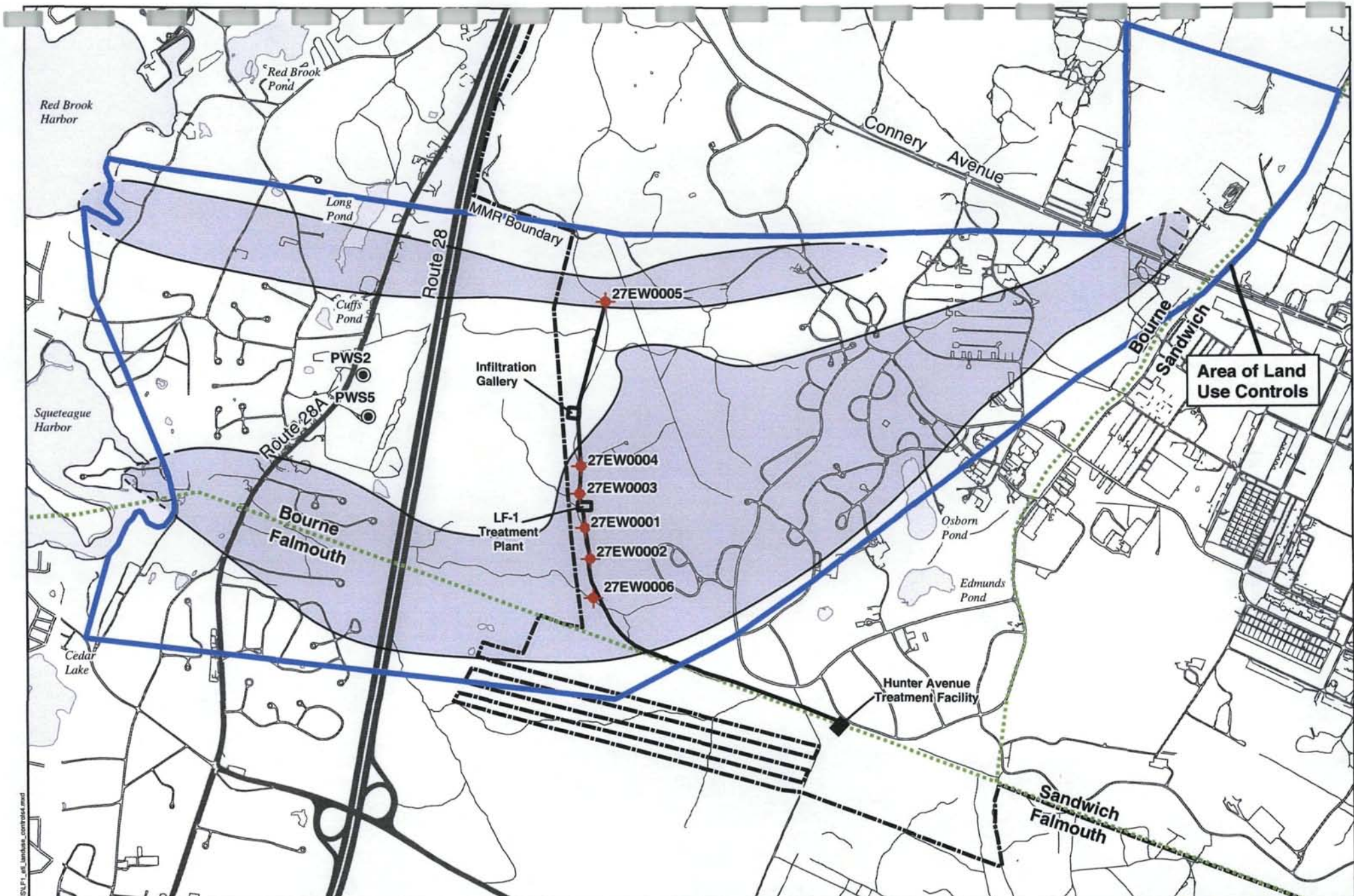
JACOBS

LF-1 Groundwater Remedial Alternatives 16, 17, 18

Massachusetts Military Reservation
Cape Cod, Massachusetts

NAME: pdroulin DATE: 8/19/2007

Figure 2-10


Red Brook Pond
Red Brook Harbor
Connery Avenue
Long Pond
MMR Boundary
Route 28
27EW0005
Cuffs Pond
PWS2
PWS5
Route 28A
Infiltration Gallery
Squeteague Harbor
Bourne
Sandwich
Area of Land Use Controls
27EW0004
27EW0003
LF-1 Treatment Plant
27EW0001
27EW0002
27EW0006
Bourne
Falmouth
Osborn Pond
Edmunds Pond
Cedar Lake
Hunter Avenue Treatment Facility
Sandwich
Falmouth
Legend
Extraction Well
Town of Bourne Public Water Supply Well
LF-1 Plume (dashed where inferred)
Town Boundary
Treatment System Pipeline
MMR Boundary
Area of Land Use Controls
N
0
2,000 Feet
Scale 1:24,000
JE JACOBS
Area of Land Use Controls in the LF-1 Area
Massachusetts Military Reservation
Cape Cod, Massachusetts
Figure 2-11

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TABLES

Table 2-1
Occurrence, Distribution, and Selection of Chemicals of Potential Concern
Landfill-1 Groundwater Within the Capture Zone

Scenario Timeframe:	future
Medium:	groundwater
Exposure Medium:	groundwater

Exposure Point	CAS Number	Chemical	Minimum Concentration	Maximum Concentration	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (N/C) (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
Landfill-1 Within the Capture Zone		**Volatile Organic Compounds**													
	71-43-2	Benzene	0.4 (J)	1.04	µg/L	27MW0022A	16/51	0.131 - 0.284	1.04		0.34 C	5	MCL	Y	ASL
	56-23-5	Carbon Tetrachloride	0.24 (J)	23.3	µg/L	27MW0026B	20/51	0.185 - 0.618	23.3		0.17 C	5	MCL	Y	ASL
	108-90-7	Chlorobenzene	0.33 (J)	0.39 (J)	µg/L	27MW0102A	2/51	0.158 - 0.34	0.39		11 N	100	MCL	N	BSL, IFD
	67-66-3	Chloroform	0.26 (J)	12.2	µg/L	27MW0026B	43/51	0.105 - 0.439	12.2		0.62 N/C	80	MCL	Y	ASL
	156-59-2	cis-1,2-Dichloroethene	0.63 (J)	51 (J)	µg/L	27MW2136A	42/51	0.144 - 0.347	51		6.1 N	70	MCL	Y	ASL
	75-34-3	1,1-Dichloroethane	0.41 (J)	3.9 (J)	µg/L	27MW2136A	37/51	0.133 - 0.277	3.9		81 N	70	ORSG	N	BSL
	75-35-4	1,1-Dichloroethene	0.32 (J)	2.68	µg/L	27MW2120A	25/51	0.226 - 0.464	2.68		34 N	7	MCL	N	BSL
	107-06-2	1,2-Dichloroethane	0.82 (J)	3.21	µg/L	27MW2136A	12/51	0.236 - 0.441	3.21		0.12 C	5	MCL	Y	ASL
	95-50-1	1,2-Dichlorobenzene	0.22 (J)	0.81 (J)	µg/L	27MW0022A	5/51	0.173 - 0.311	0.81		37 N	600	MCL	N	BSL
	106-46-7	1,4 Dichlorobenzene	0.67 (J)	13.7	µg/L	27MW0022A	20/51	0.238 - 0.428	13.7		0.5 C	5	MMCL	Y	ASL
	106-93-4	Ethylene Dibromide	0.059	0.53 (J)	µg/L	27MW0026B	2/23	0.035 - 0.047	0.53		0.00076 C	0.02	MMCL	Y	ASL
	75-09-2	Methylene Chloride	0.33 (J)	1.19 (J)	µg/L	27MW0102A	10/51	0.187 - 0.468	1.19		4.3 C	5	MCL	N	BSL
	127-18-4	Tetrachloroethene (PCE)	0.68 (J)	26.2	µg/L	27MW0026B	49/51	0.137 - 0.758	26.2		0.66 C	5	MCL	Y	ASL
	79-34-5	1,1,2,2-Tetrachloroethane	0.29 (J)	5.91	µg/L	27MW0108A	15/51	0.168 - 0.477	5.91		0.055 C	2	MGW-1	Y	ASL
	79-01-6	Trichloroethene (TCE)	0.36 (J)	68	µg/L	27MW0031A	49/51	0.138 - 0.434	68		0.028 C	5	MCL	Y	ASL
	71-55-6	1,1,1-Trichloroethane	0.23 (J)	5.24	µg/L	27MW2120A	27/51	0.196 - 0.528	5.24		320 C	200	MCL	N	BSL
	108-88-3	Toluene	0.29 (J)	0.29 (J)	µg/L	27MW0089	1/51	0.164 - 0.295	0.29		72 N	1000	MCL	N	BSL, IFD
	156-60-5	trans-1,2-Dichloroethene	0.2 (J)	0.68 (J)	µg/L	27MW0022	10/51	0.197 - 0.547	0.68		12 N	100	MCL	N	BSL
	75-01-4	Vinyl Chloride	0.67 (J)	4.95	µg/L	27MW0022A	24/51	0.125 - 0.413	4.95		0.02 C	2	MCL	Y	ASL
		Explosives													
	121-82-4	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	1.3 N(J)	1.3 N (J)	µg/L	27MW0108A	1/52	0.0281 - 0.25	1.3		0.61 C	2	HA	N	IFD
		Inorganics													
	7601-90-3	Perchlorate	2.1	17.7	µg/L	27MW0031B	8/43	0.32 - 1.8	17.7		0.36 N/C	4	PCL	Y	ASL
	7429-90-5	Aluminum (dissolved)	19 (J)	305 (J)	µg/L	27MW0110A	11/20	18 - 33.2	305		3600 N	50 to 200	SMCL	N	BSL
	7429-90-5	Aluminum (total)	54 (J)	431	µg/L	27MW0031A	5/5	21.1 - 23.9	431		3600 N	50 to 200	SMCL	N	BSL
	7440-38-2	Arsenic (dissolved)	6.6	6.6	µg/L	27MW0102A	1/20	1 - 2.3	6.6		0.045 C	10	MCL	N	IFD
	7440-39-3	Barium (dissolved)	4 (J)	35.1	µg/L	27MW0102A	19/20	0.2 - 1.8	35.1		260 N	2000	MCL	N	BSL
	7440-39-3	Barium (total)	4.8 (J)	9.5	µg/L	27MW0031B	5/5	0.5 - 1.8	9.5		260 N	2000	MCL	N	BSL
	7440-70-2	Calcium (dissolved)	5790	26,500	µg/L	27MW0102A	20/20	5.7 - 68.6	26,500		NA	NA	NA	N	NUT
	7440-70-2	Calcium (total)	12,300	26,700	µg/L	27MW0031B	5/5	21.4 - 68.6	26,700		NA	NA	NA	N	NUT
	7440-47-3	Chromium (dissolved)	1.6 (J)	4.1 (J)	µg/L	27MW0031B	2/20	0.65 - 5.6	4.1		11 N	100	MCL	N	BSL
	7440-47-3	Chromium (total)	3.3 (J)	11.2	µg/L	27MW0031A	3/5	0.6 - 3.2	11.2		11 N	100	MCL	Y	ASL
	7440-48-4	Cobalt (dissolved)	1.6 (J)	17.3	µg/L	27MW0102A	13/20	1.6 - 3.7	17.3		73 N	NA	NA	N	BSL
	7440-48-4	Cobalt (total)	1.5 (J)	5.9	µg/L	27MW0031A	3/5	1.2 - 2.6	5.9		73 N	NA	NA	N	BSL

Table 2-1
Occurrence, Distribution, and Selection of Chemicals of Potential Concern
Landfill-1 Groundwater Within the Capture Zone

Scenario Timeframe:	future
Medium	groundwater
Exposure Medium:	groundwater

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (NC) (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
	7440-50-8	Copper (dissolved)	3.5 (J)	104	µg/L	27MW0031B	2/20	0.6 - 1.7	104		150 N	1000	SMCL	N	BSL
	7439-89-6	Iron (dissolved)	0.3 (J)	21,600	µg/L	27MW2136A	84/175	5.3 - 319	21,600		1100 N	300	SMCL	N	NUT
	7439-89-6	Iron (total)	154	17,900	µg/L	27MW2136A	16/32	5.3 - 262	17,900		1100 N	300	SMCL	N	NUT
	7439-95-4	Magnesium (dissolved)	1290	10,500	µg/L	27MW0031B	20/20	15.1 - 59.1	10,500		NA	NA	NA	N	NUT, NSL
	7439-95-4	Magnesium (total)	5470	10,800	µg/L	27MW0031B	5/5	59.1 - 59.1	10,800		NA	NA	NA	N	NUT, NSL
	7439-96-5	Manganese (dissolved)	0.81 (J)	2160	µg/L	27MW2136A	53/74	0.3 - 13.3	2160		88 N	50	SMCL	Y	ASL
	7439-96-5	Manganese (total)	2.2 (J)	1560	µg/L	27MW2136A	19/26	0.3 - 27.7	1560		88 N	50	SMCL	Y	ASL
	7439-97-6	Mercury (dissolved)	0.037 (J)	2.3 (J)	µg/L	27MW0031B	4/20	0.03 - 0.1	2.3		1.1 N	2	MCL	Y	ASL
	7440-02-0	Nickel (total)	1.1 (J)	7 (J)	µg/L	27MW0031A	3/5	1.1 - 4.7	7		73 N	100	ORSG	N	BSL
	7440-02-0	Nickel (dissolved)	1.5 (J)	4.4 (J)	µg/L	27MW0102B	10/20	1.1 - 4.7	4.4		73 N	100	ORSG	N	BSL
	7440-09-7	Potassium (dissolved)	904 (J)	5450	µg/L	27MW0102A	16/20	750 - 1500	5450		NA	NA	NA	N	NUT, NSL
	7440-09-7	Potassium (total)	1250	2040	µg/L	27MW0031A	5/5	33.7 - 45.7	2040		NA	NA	NA	N	NUT, NSL
	7782-49-2	Selenium (dissolved)	1.1 (J)	1.1 (J)	µg/L	27MW0031B	1/20	1 - 2.7	1.1		18 N	50	MCL	N	BSL, IFD
	7440-21-3	Silicon (dissolved)	6460	7990 (J)	µg/L	27MW0031A	5/5	7.9 - 7.9	7990		NA	NA	NA	N	CC, NSL
	7440-21-3	Silicon (total)	6680 (J)	8400 (J)	µg/L	27MW0031A	5/5	7.9 - 7.9	8400		NA	NA	NA	N	CC, NSL
	7440-23-5	Sodium (dissolved)	8080	18,100	µg/L	27MW0105B	20/20	25.8 - 37.8	18,100		NA	NA	NA	N	NUT, NSL
	7440-23-5	Sodium (total)	10,300	14,900	µg/L	27MW0031A	5/5	28.4 - 37.8	14,900		NA	NA	NA	N	NUT, NSL
	7440-66-6	Zinc (dissolved)	10.4	43.4	µg/L	27MW0031B	5/20	0.4 - 12.6	43.4		1100 N	5000	SMCL	N	BSL
	7440-66-6	Zinc (total)	4.6 (J)	4.6 (J)	µg/L	27MW0031A	1/5	1.5 - 4.6	4.6		1100 N	5000	SMCL	N	BSL

Data Source: AFCEE, 17 January 2004 AFCEE-MMR Data Warehouse

(1) Minimum/maximum detected concentration.

(2) Maximum detected compound

(3) Refer to Appendix A of the *Final Landfill-1 Source Area and Groundwater Feasibility Study, AFCEE 2006,* text for information on background
N = one-tenth of the EPA Region IX PRG based on noncarcinogenic effects
N/C = one-tenth of the EPA Region IX PRG based on noncarcinogenic effects (also protective of carcinogenic effects)

(4) C = EPA Region IX PRG based on carcinogenic effects (at a risk of 1E-06)

(5) Rationale Codes.
Common Cation (CC)
Above Screening Levels (ASL)
Infrequent Detection (IFD)
No Screening Level (NSL)
Essential Nutrient (NUT)
Below Screening Level (BSL)

Definitions

ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
C = Carcinogenic
CAS = Chemical Abstracts Service
COPC = Chemical of Potential Concern
J = Estimated Value
EPA = U.S. Environmental Protection Agency
HA = health advisory
MCL = Federal Maximum Contaminant Level
MGW-1 = Massachusetts Groundwater 1 standard
MMCL = Massachusetts Maximum Contaminant Level
N = Noncarcinogenic
NA = Not Available
ORSG = Office of Research and Standards Guidelines
PCL = EPA Proposed Cleanup Level
PRG = Preliminary Remediation Goal
SMCL = Secondary Maximum Contaminant Level
µg/L = micrograms per liter

Table 2-2
Occurrence, Distribution, and Selection of Chemicals of Potential Concern
Landfill-1 Groundwater Outside the Capture Zone

Scenario Timeframe	future
Medium:	groundwater
Exposure Medium	groundwater

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (N/C) (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
Landfill-1 Outside the Capture Zone		**VOCs**													
	71-43-2	Benzene	0.48 (J)	0.98 (J)	µg/L	27MW0705	12/207	0.0943 - 0.216	0.98		0.34 C	5	MCL	Y	ASL
	74-97-5	Bromochloromethane	0.36 (J)	0.36 (J)	µg/L	27MW2061	1/207	0.0495 - 0.239	0.36					N	IFD
	56-23-5	Carbon Tetrachloride	0.26 (J)	31	µg/L	27MW2134B	36/207	0.0439 - 0.618	31		0.17 C	5	MCL	Y	ASL
	75-00-3	Chloroethane	1.24	1.24	µg/L	27MW0018A	1/207	0.151 - 0.646	1.24		4.6 C			N	BSL, IFD
	67-66-3	Chloroform	0.18 (J)	4.3	µg/L	27MW2071	153/207	0.0427 - 0.336	4.3		0.62 N/C	80	MCL	Y	ASL
	106-46-7	1,4-Dichlorobenzene	0.6 (J)	7.08	µg/L	27MW0020Z	12/207	0.0406 - 0.38	7.08		0.5 C	5	MMCL	Y	ASL
	156-59-2	cis-1,2-Dichloroethene	0.18 (J)	73.5	µg/L	27MW2134A	51/207	0.0578 - 0.347	73.5		6.1 N	70	MCL	Y	ASL
	75-34-3	1,1-Dichloroethane	0.25 (J)	3.61	µg/L	27MW2134A	22/207	0.055 - 0.156	3.61		81 N	70	ORSG	N	BSL
	75-35-4	1,1-Dichloroethene	0.25 (J)	3.91	µg/L	27MW3132A	21/207	0.0412 - 0.258	3.91		34 N	7	MCL	N	BSL
	95-50-1	1,2-Dichlorobenzene	0.31 (J)	1.89	µg/L	27MW0024A	3/207	0.044 - 0.305	1.89		37 N	600	MCL	N	BSL, IFD
	107-06-2	1,2-Dichloroethane	0.61 (J)	1.14	µg/L	27MW2132A	4/207	0.0513 - 0.382	1.14		0.12 C	5	MCL	N	IFD
	75-71-8	Dichlorodifluoromethane	0.2 (J)	1.9	µg/L	27MW0093	7/47	0.0352 - 0.13	1.9		39 N	1.4	ORSG	N	BSL
	75-09-2	Methylene Chloride	0.58 (J)	0.58 (J)	µg/L	27MW0024A	1/207	0.123 - 0.429	0.58		4.3 C	5	MCL	N	BSL, IFD
	79-34-5	1,1,2,2-Tetrachloroethane	0.5 (J)	8.69	µg/L	27MW0048	29/207	0.0915 - 0.477	8.69		0.055 C	2	MGW-1	Y	ASL
	127-18-4	Tetrachloroethene (PCE)	0.16 (J)	22.2	µg/L	27MW2134B	131/207	0.113 - 0.5	22.2		0.66 C	5	MCL	Y	ASL
	79-01-6	Trichloroethene (TCE)	0.29 (J)	29.3	µg/L	27MW0048	109/207	0.0358 - 0.241	29.3		0.028 C	5	MCL	Y	ASL
	71-55-6	1,1,1-Trichloroethane	0.24 (J)	9.31	µg/L	27MW2132A	32/207	0.0293 - 0.528	9.31		320 C	200	MCL	N	BSL
	79-00-5	1,1,2-Trichloroethane	0.41 (J)	0.5 (J)	µg/L	27MW00372	2/207	0.0713 - 0.4	0.5		0.2 C	5	MCL	N	IFD
	108-88-3	Toluene	0.72 (J)	1.3	µg/L	BOMW0007	2/207	0.0378 - 0.271	1.3		72 N	1000	MCL	N	BSL, IFD
	156-60-5	trans-1,2-Dichloroethene	0.22 (J)	1.5	µg/L	27MW00372	7/207	0.0956 - 0.304	1.5		12 N	100	MCL	N	BSL, IFD
	1634-04-4	Methyl-tert-butyl-ether	3.01	3.08	µg/L	BOMW0007	2/207	0.0394 - 0.42	3.08		13 C	70	ORSG	N	BSL, IFD
	75-01-4	Vinyl Chloride	0.71 (J)	3.91	µg/L	27MW0024A	9/207	0.101 - 0.413	3.91		0.02 C	2	MCL	Y	IFD
		SVOCs													
	117-81-7	bis (2-ethylhexyl) phthalate	1 (J)	4 (J)	µg/L	27MW0020Z	4/23	0.8 - 5	4		4.8 C	6	MCL	N	BSL
	84-66-2	Diethyl phthalate	2 (J)	4 (J)	µg/L	27MW0017A	2/22	0.5 - 2.5	4		2900 N			N	BSL
	108-95-2	Phenol	2 (J)	2 (J)	µg/L	ECPZVP502	1/23	0.5 - 2.5	2		220 N			N	BSL, IFD
		Explosives													
	99-65-0	1,3-Dinitrobenzene	0.8	1.7	µg/L	27MW0018A	5/169	0.0023 - 0.93	1.7		0.36 N			N	IFD
	6629-29-4	2,4-Diamino-6-nitrotoluene	0.5 (J)	0.5 (J)	µg/L	27MW0017A	1/120	0.0426 - 1.4	0.5					N	IFD
	121-14-2	2,4-Dinitrotoluene	0.5	0.5	µg/L	27MW0016B	1/169	0.028 - 0.25	0.5		0.099 C			N	IFD
	121-82-4	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	0.34 (J)	0.34 (J)	µg/L	27MW0015C	1/168	0.0281 - 0.25	0.34		0.61 C	2	HA	N	BSL, IFD
	98-95-3	Nitrobenzene	0.31	0.31	µg/L	27MW0024A	1/175	0.0038 - 0.25	0.31		0.34 N			N	BSL, IFD
	55-63-0	Nitroglycerin	42 (J)	110 (J)	µg/L	27MW0016B	3/121	0.25 - 4.21	110		4.8 C			N	IFD
		Inorganics													
	7601-90-3	Perchlorate	1.6	1.6	µg/L	27MW2134A	1/105	0.32 - 1.8	1.6		0.36 N/C	4	PCL	N	IFD

Table 2-2
Occurrence, Distribution, and Selection of Chemicals of Potential Concern
Landfill-1 Groundwater Outside the Capture Zone

Scenario Timeframe:	future
Medium:	groundwater
Exposure Medium:	groundwater

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (2)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (N/C) (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
	7440-38-2	Arsenic (total)	13.1 (J)	23.7	µg/L	27MW0016C	6/46	0.796 - 32.9	23.7		0.045 C	10	MCL	Y	ASL
	7440-39-3	Barium (total)	1.8 (J)	40.2 (J)	µg/L	27MW0017B	46/46	0.2 - 2.5	40.2		260 N	2000	MCL	N	BSL
	7440-70-2	Calcium (total)	1420 (J)	36,200	µg/L	27MW2082	46/46	12 - 100	36,200		NA	NA	NA	N	NUT, NSL
	7440-47-3	Chromium (total)	1.1 (J)	8.7 (J)	µg/L	27MW2081	16/46	0.6 - 5	8.7		11 N	100	MCL	N	BSL
	7440-48-4	Cobalt (total)	1.5 (J)	18 (J)	µg/L	27MW0017A	13/46	0.5 - 3.0	18		7.3 N	NA	NA	N	BSL
	7440-50-8	Copper (total)	3 (J)	3 (J)	µg/L	27MW0044	1/46	0.6 - 5	3		150 N	1000	SMCL	N	BSL, IFD
	7439-89-6	Iron (dissolved)	8 (J)	18,700	µg/L	27MW2134A	28/72	10.4 - 10.6	18,700		1100 N	300	SMCL	N	NUT
	7439-89-6	Iron (total)	36.8 (J)	101,000	µg/L	27MW0017A	25/65	6.07 - 125	101,000		1100 N	300	SMCL	N	NUT
	7439-92-1	Lead (total)	1.4 (J)	1.49 (J)	µg/L	27MW0048	2/47	1.17 - 2.7	1.49		NA	15	AL	N	BAL, IFD
	7439-95-4	Magnesium (total)	802 (J)	18,900	µg/L	27MW0020A	46/46	18.3 - 100	18,900		NA	NA	NA	N	NUT
	7439-96-5	Manganese (dissolved)	8.5 (J)	983	µg/L	27MW2134A	17/39	0.5 - 10.2	983		88 N	50	SMCL	Y	ASL
	7439-96-5	Manganese (total)	1.45 (J)	7080	µg/L	27MW0018B	46/65	0.5 - 14.8	7080		88 N	50	SMCL	Y	ASL
	7439-97-6	Mercury (total)	0.2	0.13 (J)	µg/L	27MW0020A	2/46	0.052 - 0.1	0.13		1.1 N	2	MCL	N	BSL, IFD
	7440-02-0	Nickel (total)	0.96 (J)	4.2 (J)	µg/L	27MW0044	21/46	0.9 - 5	4.2		73 N	100	ORSG	N	BSL
	7440-09-7	Potassium (total)	442 (J)	6100	µg/L	27MW0017A	44/46	30 - 613	6100		NA	NA	NA	N	NUT
	7440-23-5	Sodium (total)	5,580	18,200	µg/L	27MW0018A	47/47	100 - 790	18,200		NA	NA	NA	N	NUT
	7440-28-0	Thallium (total)	0.133 (J)	0.133 (J)	µg/L	27MW0048	1/46	0.1 - 1.8	0.133		0.24 N	2	MCL	N	BSL, IFD
	7440-66-6	Zinc (total)	6.2 (J)	16.3 (J)	µg/L	27MW2081	7/46	0.4 - 31.2	16.3		1100 N	5000	SMCL	N	BSL

Data Source: AFCEE, 17 January 2004, AFCEE-MMR Data Warehouse

(1) Minimum/maximum detected concentration.

(2) Maximum detected concentration

(3) Refer to Appendix A of the *Final Landfill-1 Source Area and Groundwater Feasibilty Study*, AFCEE 2006, text for information on background

(4) N = one-tenth of the EPA Region IX PRG based on noncarcinogenic effects
N/C = one-tenth of the EPA Region IX PRG based on noncarcinogenic effects (also protective of carcinogenic effects)
C = EPA Region IX PRG based on carcinogenic effects (at a risk of 1E-06)

(5) Rationale Codes:
Above Screening Levels (ASL)
Infrequent Detection (IFD)
No Screening Level (NSL)
Below Action Level (BAL)
Essential Nutrient (NUT)
Below Screening Level (BSL)

Definitions

AL = Action Level
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
C = Carcinogenic
CAS = Chemical Abstracts Service
COPC = Chemical of Potential Concern
EPA = U.S. Environmental Protection Agency
J = Estimated Value
MCL = Federal Maximum Contaminant Level
MGW-1 = Massachusetts Groundwater 1 standard
MMCL = Massachusetts Maximum Contaminant Level
N = Noncarcinogenic
NA = Not Available
ORSG = Office of Research and Standards Guidelines
PCL = EPA Proposed Cleanup Level
PRG = Preliminary Remediation Goal
SMCL = Secondary Maximum Contaminant Level
µg/L = micrograms per liter

Table 2-3
Occurrence, Distribution, and Selection of Chemicals of Potential Concern
Landfill-1 Surface Water

Scenario Timeframe:	current/future
Medium:	surface water
Exposure Medium:	surface water

Exposure Point	CAS Number	Chemical	Minimum Concentration (1)	Maximum Concentration (2)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Background Value	Screening Toxicity Value (N/C) (3)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (4)
Buzzards Bay	67-66-3	Chloroform	0.46 (J)	1.6	µg/L	27SW0006	17/17	0.105 - 0.336	1.6		0.62 N/C	5	ORSG	Y	ASL
	156-59-2	cis-1,2-Dichloroethene	0.22 (J)	0.3 (J)	µg/L	27SW0006	2/17	0.14 - 0.347	0.3		6.1 N	70	MCL	N	BSL
	1634-04-4	Methyl-tert-butyl-ether (MTBE)	1.1	1.1	µg/L	27SW0006	1/17	0.18 - 0.42	1.1		13 C	70	ORSG	N	BSL
	127-18-4	Tetrachloroethene (PCE)	0.26 (J)	0.7 (J)	µg/L	27SW0007	12/17	0.13 - 0.421	0.7		0.66 C	0.69	WQC	Y	ASL
	108-88-3	Toluene	0.3 (J)	0.3 (J)	µg/L	27SW0009	1/17	0.12 - 0.271	0.3		72 N	1000	MCL	N	BSL
	79-01-6	Trichloroethene (TCE)	0.29 (J)	0.9 (J)	µg/L	27SW0006	10/17	0.138 - 0.241	0.9		0.028 C	2.5	WQC	Y	ASL
	117-81-7	Bis(2-ethylhexyl)phthalate	1.5 (J)	4.25 (J)	µg/L	ECRBH01	3/5	0.439 - 4.48	4.25		1.2 WQC	6	MCL	Y	ASL

Data Source: AFCEE, 19 December 2003, AFCEE-MMR Data Warehouse.

(1) Minimum/maximum detected concentration.
(2) Maximum detected concentration.
(3) N = one-tenth of the EPA Region IX PRG based on noncarcinogenic effects
C = EPA Region IX PRG based on carcinogenic effects (at a risk of 1E-06)
WQC = EPA Water Quality Criteria for protection of human health due to ingestion of water and organisms [EPA. 2002 (July). *Ambient Water Quality Criteria National Recommended Water Quality Criteria*. Office of Water, Washington, DC. (40CFR131.36)].
(4) Rationale Codes:
Above Screening Levels (ASL)
Below Screening Level (BSL)

Definitions: ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
CAS = Chemical Abstracts Service
C = Carcinogenic
COPC = Chemical of Potential Concern
EPA = U.S. Environmental Protection Agency
J = Estimated Value
MCL = Federal Maximum Contaminant Level
N = Noncarcinogenic
ORSG = Office of Research and Standards Guidelines
PRG = Preliminary Remediation Goal
WQC = Water Quality Criteria
µg/L = micrograms per liter

Table 2-4
Occurrence, Distribution, and Selection of Chemicals of Potential Concern
Landfill-1 Sediment

Scenario Timeframe:	current/future
Medium:	sediment
Exposure Medium:	sediment

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Background Value	Screening Toxicity Value (N/C) (3)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (4)
Buzzards Bay	67-64-1	Acetone	248 (J)	248 (J)	µg/kg	ECRBH01	1/5	8.52 - 26.4	248		160000 N	NA	NA	N	BSL
	78-93-3	Methyl Ethyl Ketone (2-Butanone)	65.2 (J)	65.2 (J)	µg/kg	ECRBH01	1/5	10.5 - 33	65.2		71000 N	NA	NA	N	BSL
	117-81-7	BEHP [Bis(2-ethylhexyl)phthalate]	56.4 (J)	56.4 (J)	µg/kg	ECRBH04	1/5	16.3 - 338	56.4		35000 C	NA	NA	N	BSL

Data Source: AFCEE, 17 December 2003, AFCEE-MMR Data Warehouse.

(1) Minimum/maximum detected concentration.

(2) Maximum detected concentration.

(3) N = one-tenth of EPA Region IX PRG based on noncarcinogenic effects
C = EPA Region IX PRG based on carcinogenic effects (at a risk of 1E-06)

(4) Rationale Codes:
Below Screening Level (BSL)

Definitions: ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
C = Carcinogenic
CAS = Chemical Abstracts Service
COPC = Chemical of Potential Concern
EPA = U.S. Environmental Protection Agency
J = Estimated Value
N = Noncarcinogenic
NA = Not Available
PRG = Preliminary Remediation Goal
µg/kg = micrograms per kilogram

Table 2-5
Exposure Point Concentrations, Reasonable Maximum Exposure
Landfill-1 Groundwater Within the Capture Zone

Scenario Timeframe: future
Medium: groundwater
Exposure Medium: groundwater

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic	Rationale
Within the Capture Zone	**Volatile Organic Compounds**								
	Benzene	µg/L	N/A	N/A	1.06	1.06	µg/L	Maximum	EPA Region I Guidance
	Carbon Tetrachloride	µg/L	N/A	N/A	23.3	23.3	µg/L	Maximum	EPA Region I Guidance
	Chloroform	µg/L	N/A	N/A	12.2	12.2	µg/L	Maximum	EPA Region I Guidance
	cis-1,2-Dichloroethene	µg/L	N/A	N/A	50.5 (J)	50.5	µg/L	Maximum	EPA Region I Guidance
	1,2-Dichloroethane	µg/L	N/A	N/A	3.21	3.21	µg/L	Maximum	EPA Region I Guidance
	1,4-Dichlorobenzene	µg/L	N/A	N/A	13.7	13.7	µg/L	Maximum	EPA Region I Guidance
	Ethylene Dibromide	µg/L	N/A	N/A	0.53 (J)	0.53	µg/L	Maximum	EPA Region I Guidance
	1,1,2,2-Tetrachloroethane	µg/L	N/A	N/A	5.91	5.91	µg/L	Maximum	EPA Region I Guidance
	Tetrachloroethene (PCE)	µg/L	N/A	N/A	26.2	26.2	µg/L	Maximum	EPA Region I Guidance
	Trichloroethene (TCE)	µg/L	N/A	N/A	68	68	µg/L	Maximum	EPA Region I Guidance
	Vinyl chloride	µg/L	N/A	N/A	4.95	4.95	µg/L	Maximum	EPA Region I Guidance
	Inorganics								
	Perchlorate	µg/L	N/A	N/A	17.7	17.7	µg/L	Maximum	EPA Region I Guidance
	Chromium (total)	µg/L	N/A	N/A		11.2	µg/L	Maximum	EPA Region I Guidance
	Manganese (total)	µg/L	N/A	N/A	1540	1540	µg/L	Maximum	EPA Region I Guidance
	Manganese (dissolved)	µg/L	N/A	N/A	2160	2160	µg/L	Maximum	EPA Region I Guidance
	Mercury (dissolved)	µg/L	N/A	N/A	1.175 (J)	1.2	µg/L	Maximum	EPA Region I Guidance

Notes:
EPA = U.S. Environmental Protection Agency
J = estimated value
N/A = not applicable
UCL = upper confidence limit
µg/L = microgams per liter

Table 2-6
Exposure Point Concentrations, Reasonable Maximum Exposure
Landfill-1 Groundwater Outside the Capture Zone

Scenario Timeframe: future
Medium: groundwater
Exposure Medium: groundwater

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic	Rationale
Outside	**Volatile Organic Compounds**								
the Capture	Benzene	µg/L	N/A	N/A	0.98 (J)	0.98	µg/L	Maximum	EPA Region I Guidance
Zone	Carbon Tetrachloride	µg/L	N/A	N/A	31 (J)	31	µg/L	Maximum	EPA Region I Guidance
	Chloroform	µg/L	N/A	N/A	4.3	4.3	µg/L	Maximum	EPA Region I Guidance
	1,4-Dichlorobenzene	µg/L	N/A	N/A	7.08	7.08	µg/L	Maximum	EPA Region I Guidance
	cis-1,2-Dichloroethene	µg/L	N/A	N/A	73.5	73.5	µg/L	Maximum	EPA Region I Guidance
	1,1,2,2-Tetrachloroethane	µg/L	N/A	N/A	8.69	8.69	µg/L	Maximum	EPA Region I Guidance
	Tetrachloroethene (PCE)	µg/L	N/A	N/A	22.2	22.2	µg/L	Maximum	EPA Region I Guidance
	Trichloroethene (TCE)	µg/L	N/A	N/A	29.3	29.3	µg/L	Maximum	EPA Region I Guidance
	Vinyl Chloride	µg/L	N/A	N/A	3.9	3.91	µg/L	Maximum	EPA Region I Guidance
	Metals								
	Arsenic (total)	µg/L	N/A	N/A	23.7	23.7	µg/L	Maximum	EPA Region I Guidance
	Manganese (total)	µg/L	N/A	N/A	7080	7080	µg/L	Maximum	EPA Region I Guidance
	Manganese (dissolved)	µg/L	N/A	N/A	983	983	µg/L	Maximum	EPA Region I Guidance

Notes:
EPA = U.S. Environmental Protection Agency
J = estimated value
N/A = not applicable
UCL = upper confidence limit
µg/L = microgams per liter

Table 2-7
Exposure Point Concentrations, Reasonable Maximum Exposure
Landfill-1 Surface Water

Scenario Timeframe: current/future
Medium: surface water
Exposure Medium: surface water

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic	Rationale
Buzzards Bay	**Volatile Organic Compounds**								
	Chloroform	µg/L	0.88	1.1	1.6	1.6	µg/L	95% UCL-LN	SW-Test (1)
	Tetrachloroethene (PCE)	µg/L	0.3	N/A	0.7 (J)	0.7	µg/L	Max	SW-Test (2)
	Trichloroethene (TCE)	µg/L	0.3	N/A	0.765 (J)	0.8	µg/L	Max	SW-Test (2)
	Semivolatile Organic Compounds								
	BEHP [Bis(2-ethylhexyl)phthalate]	µg/L	2.33	3.40	4.25 (J)	4.25	µg/L	95% UCL-N	SW-Test (3)

Notes:
J = estimated value
LN = log-normally
N = normally
N/A = Not applicable
RME = reasonable maximum exposure
UCL = upper confidence limit
µg/L = micrograms per liter

For non-detects, 1/2 sample detection limit was used as a proxy concentration in the calculation of means and UCLs.
Statistics: 95% upper confidence limit determined from normally-distributed data (95% UCL-N), maximum detected value (Max), arithmetic mean (Mean).

(1) Shapiro-Wilk (SW) test indicates that the data are log-normally distributed.
(2) Shapiro-Wilk test indicates that the data are neither normally nor log-normally distributed so regulatory guidance indicates use max for RME.
(3) Shapiro-Wilk test indicates that the data are normally distributed.

Table 2-8
Values Used for Daily Intake Calculations, Reasonable Maximum Exposure
Landfill-1 Groundwater - Adult and Child Resident

Scenario Timeframe	Future
Medium:	Groundwater
Exposure Medium:	Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Resident	Adult	Aquifer - Tap Water	CW	Chemical Concentration in Water	Chem.-specific Maximum	µg/L	-	Chronic Daily Intake (CDI) (mg/kg/day) = CW x IRW x EF x ED x CF1 x 1/BW x 1/AT
				IRW	Ingestion Rate of Water	2	L/day	EPA 1995	
				EF	Exposure Frequency	350	days/yr	Site specific	
				ED	Exposure Duration	24	yrs	EPA 1991a	
				CF1	Conversion Factor	0.001	mg/µg	-	
				BW	Body Weight	70	kg	EPA 1989	
				AT-NC	Averaging Time (noncancer)	8760	days	EPA 1989	AT-NC = ED*365
				AT- C	Averaging Time (cancer)	25,550	days	EPA 1989	AT-C = 70*365
Dermal				CW	Chemical Concentration in Water	Chem.-specific Maximum	µg/L	-	Dermal Absorbed Dose (DAD) (mg/kg/day) = DA_{event} x SA x EV x EF x ED x 1/BW x 1/AT
				DAevent	Dose absorbed per unit area per event	Chem.-specific	mg/cm²-event	EPA 2001	Where DA_{event} (mg/cm²-event) is calculated in accordance
				SA	Skin surface area available for contact	18000	cm²	EPA 2001	with EPA Superfund Dermal Risk Guidance (EPA 2001)
				ET	Exposure Time	0.58	hr/day	EPA 2001	
				EV	Event	1	event/day	EPA 2001	
				EF	Exposure Frequency	350	days/yr	Site-specific	
				ED	Exposure Duration	24	yrs	EPA 1991a	
				BW	Body Weight	70	kg	EPA 1989	
				AT-NC	Averaging Time (noncancer)	8760	days	EPA 1989	AT-NC = ED*365
				AT- C	Averaging Time (cancer)	25,550	days	EPA 1989	AT-C = 70*365
Inhalation				CA	Chemical Concentration in Air	Chem.-specific	mg/m³	EPA 2002	Lifetime Average Air Concentration (LAAC) =
				CW	Chemical Concentration in Water	Chem.-specific Maximum	µg/L	-	CA x ET x EF x ED x CF1 x 1/AT Based on EPA 1994
				VF	Volatilization Factor[4]	0.5	L/m³	EPA 1991b	For vapors associated with household use of groundwater, CA
				ET	Exposure Time	24	hr/day	-	is estimated by CW x VF
				EF	Exposure Frequency	350	days/yr	Site-specific	For vapors associated with the groundwater vapor intrusion
				ED	Exposure Duration	30	yrs	EPA 1989	pathway, CA is estimated by the Johnson and Ettinger Model
				CF1	Conversion Factor	0.001	mg/µg	-	(1991) in accordance with EPA (2002)
				AT-NC	Averaging Time (noncancer)	262,800	hours	EPA 1989	AT-NC = 24*ED*365
				AT- C	Averaging Time (cancer)	613,200	hours	EPA 1989	AT-C = 24*70*365

Table 2-8
Values Used for Daily Intake Calculations, Reasonable Maximum Exposure
Landfill-1 Groundwater - Adult and Child Resident

Scenario Timeframe:	Future
Medium:	Groundwater
Exposure Medium:	Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Resident	Child	Aquifer - Tap Water	CW	Chemical Concentration in Water	Chem.-specific Maximum	µg/L	-	Chronic Daily Intake (CDI) (mg/kg/day) = CW x IRW x EF x ED x CF1 x 1/BW x 1/AT
				IRW	Ingestion Rate of Water	1	L/day	EPA 1995	
				EF	Exposure Frequency	350	days/yr	Site-specific	
				ED	Exposure Duration	6	yrs	EPA 1991a	
				CF1	Conversion Factor	0.001	mg/µg	-	
				BW	Body Weight	15	kg	EPA 1989	
				AT-NC	*Averaging Time (noncancer)*	2190	days	EPA 1989	*AT-NC = ED*365*
				AT-C	Averaging Time (cancer)	25,550	days	EPA 1989	AT-C = 70*365
Dermal				CW	Chemical Concentration in Water	Chem.-specific Maximum	µg/L	-	Dermal Absorbed Dose (DAD) (mg/kg/day) = DA_{event} x SA x EV x EF x ED x 1/BW x 1/AT
				DAevent	Dose absorbed per unit area per event	Chem.-specific	mg/cm^2-event	EPA 2001	Where DA_{event} (mg/cm^2-event) is calculated in accordance
				SA	Skin surface area available for contact	6600	cm^2	EPA 2001	with EPA Superfund Dermal Risk Guidance (EPA 2001)
				ET	Exposure Time	1	hr/day	EPA 2001	
				EV	Event	1	event/day	EPA 2001	
				EF	Exposure Frequency	350	days/yr	Site-specific	
				ED	Exposure Duration	6	yrs	EPA 1991a	
				BW	Body Weight	15	kg	EPA 1989	
				AT-NC	Averaging Time (noncancer)	2190	days	EPA 1989	AT-NC = ED*365
				AT-C	Averaging Time (cancer)	25,550	days	EPA 1989	AT-C = 70*365

Notes:

*Vapor from household use of groundwater

EPA. 2002 (July) *Ambient Water Quality Criteria National Recommended Water Quality Criteria*. Office of Water, Washington, DC. (40CFR131.36).

EPA. 2001 (December). *Risk Assessment Guidance for Superfund (RAGS): Volume I; Human Health Evaluation Manual.* (Part E, Supplemental Guidance for Dermal Risk Assessment). Interim Guidance. EPA/540/R/99/005.

EPA. 1995 (August). EPA Region I Risk Update No. 3.

EPA 1991a. *Risk Assessment Guidance For Superfund Volume I. Human Health Evaluation Manual Supplemental Guidance "Standard Default Exposure Factors"* Interim Final OSWER Directive 9285.6-03

EPA. 1991b (October). *Risk Assessment Guidance for Superfund (RAGS). Volume I - Human Health Evaluation Manual (HHEM)* (Part B, Development of Risk-Based Preliminary Remedial Goals). Office of Emergency and Remedial Response, Washington. DC. EPA/540/R-92/003. OSWER Directive 9285.7-01B. NTIS PB92-963333.

EPA. 1989. *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual* (Part A, Baseline Risk Assessment). Office of Emergency and Remedial Response. Washington, DC.

Chem. = chemical
cm2 = square centimeter
EPA = U S Environmental Protection Agency
hr = hour
kg = kilogram
L = liter
mg = milligram
m^3 = cubic meter
RME = reasonable maximum exposure
yr = year
µg = microgram

Table 2-9
Values Used for Daily Intake Calculations, Reasonable Maximum Exposure
Landfill-1 Surface Water - Adult Recreational Fisherman/Shellfisher

Scenario Timeframe:	Current/Future
Medium	Surface Water
Exposure Medium:	Fish/Shellfish Tissue

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Recreational Fisherman/Shellfisher	Adult	Aquifer - Tap Water	Csw	Chemical Concentration in Surface Water	Chem.-specific Maximum	mg/L	-	Chronic Daily Intake (CDI) (mg/kg/day) = Csw x BAF x IRf x FI x EF x ED x CF1 x 1/BW x 1/AT
				BAF	Bioaccumulation Factor	Chem.-specific	L/kg		
				IRf	Ingestion Rate Fish	26	g/day	AFCEE 2003	
				FI	Fraction Ingested	1	dimensionless	Assumption	
				EF	Exposure Frequency	350	days/yr	EPA 1991	
				ED	Exposure Duration	30	yrs	EPA 1989	
				CF1	Conversion Factor	0.001	kg/g	-	
				BW	Body Weight	70	kg	EPA 1989	
				AT-NC	Averaging Time (noncancer)	10,950	days	EPA 1989	AT-NC = ED*365
				AT- C	Averaging Time (cancer)	25,550	days	EPA 1989	AT-C = 70*365

Notes:
AFCEE 2003 (September). *Final Landfill-1 2002 Annual System Performance and Ecological Impact Monitoring Report.* ENR-J23-35Z15609-M31-0005. Prepared by Jacobs Engineering Group Inc. for AFCEE/MMR Installation Restoration Program, Otis Air National Guard Base, MA
EPA 1991. *Human Health Exposure Manual. Supplemental Guidance Standard Default Exposure Factors.* OSWER Directive 9285.6-03 Washington, DC.
EPA (1989). *Risk Assessment Guidance for Superfund Volume I - Human Health Evaluation Manual (Part A, Baseline Risk Assessment)* Office of Emergency and Remedial Response Washington DC

AFCEE = Air Force Center for Environmental Excellence
Chem = chemical
EPA = U.S. Environmental Protection Agency
g = gram
kg = kilogram
L = liter
mg = milligram
RME = reasonable maximum exposure

Table 2-10
Values Used for Daily Intake Calculations, Reasonable Maximum Exposure
Landfill-1 Surface Water - Adult and Child Swimmer

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Swimmer	Adult	Buzzards Bay	Csw	Chemical Concentration in Surface Water	max or 95% UCL of mean	µg/L	Site-specific	Chronic Daily Intake (CDI) (mg/kg/day) = Csw x IRsw x ET x EF x ED x CF1 x 1/BW x 1/AT
				IRsw	Ingestion Rate of Surface Water	0.05	L/hr	EPA 1989	
				ET	Exposure Time	2.6	hr/day	EPA 1998	
				EF	Exposure Frequency	60	days/yr	EPA 1998	
				ED	Exposure Duration	24	yrs	EPA 1991	
				CF1	Conversion Factor	0.001	mg/µg	-	
				BW	Body Weight	70	kg	EPA 1989	
				AT-NC	Averaging Time (noncancer)	8,760	days	EPA 1989	AT-NC = ED*365
				AT- C	Averaging Time (cancer)	25,550	days	EPA 1989	AT-C = 70*365
Dermal				Csw	Chemical Concentration in Surface Water	max or 95% UCL of mean	µg/L	Site-specific	Dermal Absorbed Dose (DAD) (mg/kg/day) = DA_{event} x SAw x EV x EF x ED x 1/BW x 1/AT
				DA_{event}	Dose absorbed per unit area per event	Chem.-specific	mg/cm^2-event	EPA 2001	Where DA_{event} (mg/cm^2-event) is calculated in accordance
				SAw	Skin surface area available for contact	18,000	cm^2	EPA 2001	with Draft EPA Superfund Dermal Risk Guidance (EPA 2001)
				ET	Exposure Time	2.6	hr/day	EPA 1998	
				EV	Event	1	event/day	EPA 2001	
				EF	Exposure Frequency	60	days/yr	EPA 1998	
				ED	Exposure Duration	24	yrs	EPA 1991	
				BW	Body Weight	70	kg	EPA 1989	
				AT-NC	Averaging Time (noncancer)	8,760	days	EPA 1989	AT-NC = ED*365
				AT- C	Averaging Time (cancer)	25,550	days	EPA 1989	AT-C = 70*365
Ingestion	Swimmer	Child	Buzzards Bay	Csw	Chemical Concentration in Surface Water	max or 95% UCL of mean	µg/L	Site-specific	Chronic Daily Intake (CDI) (mg/kg/day) = CW x IRW x EF x ED x CF1 x 1/BW x 1/AT
				IRsw	Ingestion Rate of Surface Water	0.05	L/hr	EPA 1989	
				ET	Exposure Time	2.6	hr/day	EPA 1998	
				EF	Exposure Frequency	60	days/yr	EPA 1998	
				ED	Exposure Duration	6	yrs	EPA 1995	
				CF1	Conversion Factor	0.001	mg/µg	-	
				BW	Body Weight	15	kg	EPA 1995	
				AT-NC	Averaging Time (noncancer)	2,190	days	EPA 1995	AT-NC = ED*365
				AT- C	Averaging Time (cancer)	25,550	days	EPA 1995	AT-C = 70*365
Dermal				Csw	Chemical Concentration in Surface Water	max or 95% UCL of mean	µg/L	Site-specific	Dermal Absorbed Dose (DAD) (mg/kg/day) = DA_{event} x SA x EV x EF x ED x 1/BW x 1/AT
				DA_{event}	Dose absorbed per unit area per event	Chem.-specific	mg/cm^2-event	EPA 2001	Where DA_{event} (mg/cm^2-event) is calculated in accordance

Table 2-10
Values Used for Daily Intake Calculations, Reasonable Maximum Exposure
Landfill-1 Surface Water - Adult and Child Swimmer

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Swimmer	Child	Buzzards Bay	SAw	Skin surface area available for contact	6,600	cm^2	EPA 2001	with EPA Superfund Dermal Risk Guidance (EPA 2001)
				ET	Exposure Time	2.6	hr/day	EPA 1998	
				EV	Event	1	event/day	EPA 2001	
				EF	Exposure Frequency	60	days/yr	EPA 1998	
				ED	Exposure Duration	6	yrs	EPA 1991	
				BW	Body Weight	15	kg	EPA 1989	
				AT-NC	Averaging Time (noncancer)	2,190	days	EPA 1989	AT-NC = ED*365
				AT- C	Averaging Time (cancer)	25,550	days	EPA 1989	AT-C = 70*365
Ingestion	Swimmer	Child	Backus River	Csw	Chemical Concentration in Surface Water	max or 95% UCL of mean	µg/L	Site-specific	Chronic Daily Intake (CDI) (mg/kg/day) = CW x IRW x EF x ED x CF1 x 1/BW x 1/AT
				IRsw	Ingestion Rate of Surface Water	0.05	L/hr	EPA 1989	
				ET	Exposure Time	2.6	hr/day	EPA 1998	
				EF	Exposure Frequency	60	days/yr	EPA 1998	
				ED	Exposure Duration	6	yrs	EPA 1995	
				CF1	Conversion Factor	0.001	mg/µg	-	
				BW	Body Weight	15	kg	EPA 1991	
				AT-NC	Averaging Time (noncancer)	2,190	days	EPA 1989	AT-NC = ED*365
				AT- C	Averaging Time (cancer)	25,550	days	EPA 1989	AT-C = 70*365
Dermal				Csw	Chemical Concentration in Surface Water	max or 95% UCL of mean	µg/L	Site-specific	Dermal Absorbed Dose (DAD) (mg/kg/day) = DA_{event} x SA x EV x EF x ED x 1/BW x 1/AT
				DA_{event}	Dose absorbed per unit area per event	Chem.-specific	mg/cm^2-event	EPA 2001	Where DA_{event} (mg/cm^2-event) is calculated in accordance with EPA Superfund Dermal Risk Guidance (EPA 2001)
				SAw	Skin surface area available for contact	6,600	cm^2	EPA 2001	
				ET	Exposure Time	2.6	hr/day	EPA 1998	
				EV	Event	1	event/day	EPA 2001	
				EF	Exposure Frequency	60	days/yr	EPA 1998	
				ED	Exposure Duration	6	yrs	EPA 1991	
				BW	Body Weight	15	kg	EPA 1989	
				AT-NC	Averaging Time (noncancer)	2,190	days	EPA 1989	AT-NC = ED*365
				AT- C	Averaging Time (cancer)	25,550	days	EPA 1989	AT-C = 70*365

Notes:

EPA. 2001 (December) *Risk Assessment Guidance for Superfund (RAGS). Volume I: Human Health Evaluation Manual.* (Part E, Supplemental Guidance for Dermal Risk Assessment). Interim Guidance. EPA/540/R/99/005.

EPA. 1998 (August). EPA Comments on Draft Exposure Assessment for SWOU RI/FS. Memorandum from Robert Lim, EPA Region I.

EPA. 1995 (August). EPA Region I Risk Update. No. 3.

EPA 1991 *Risk Assessment Guidance For Superfund Volume I: Human Health Evaluation Manual Supplemental Guidance "Standard Default Exposure Factors"* Interim Final OSWER Directive 9285.6-03.

EPA. 1989. *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual* (Part A, Baseline Risk Assessment). Office of Emergency and Remedial Response. Washington, DC.

Chem. = chemical
cm^2 = square centimeter
EPA = U.S. Environmental Protection Agency
hr = hour
kg = kilogram
L = liter
max = maximum
mg = milligram
RME = reasonable maximum exposure
UCL = Upper Confidence Level
yr = year
µg = microgram

Table 2-11
Non-Cancer Toxicity Data - Oral/Dermal
Landfill-1

Chemical of Potential Concern	Perchlorate			Oral Absorption Efficiency for Dermal (1)	Absorbed RfD for Dermal		Primary Target Organ(s)	Combined Uncertainty/ Modifying Factors	RfD:Target Organ(s)	
					Value	Units			Source(s)	Date(s) (MM/DD/YY)
Bis(2-ethylhexyl)phthalate (BEHP)	Chronic	2.0E-02	mg/kg/day	none	2.0E-02	mg/kg/day	Liver	1000	IRIS	10/29/03
1,1,2,2-Tetrachloroethane	Chronic	6.0E-02	mg/kg/day	none	6.0E-02	mg/kg/day	NA	NA	NCEA	10/01/02
1,2-Dichloroethane	Chronic	NA	mg/kg/day	none	NA	mg/kg/day	NA	NA	IRIS	02/13/04
1,4-Dichlorobenzene	Chronic	3.0E-02	mg/kg/day	none	3.0E-02	mg/kg/day	NA	NA	NCEA	10/01/02
Benzene	Chronic	4.0E-03	mg/kg/day	none	4.0E-03	mg/kg/day	Lymph	300	IRIS	04/17/03
Carbon Tetrachloride	Chronic	7.0E-04	mg/kg/day	none	7.0E-04	mg/kg/day	Liver	1000	IRIS	06/01/91
Chloroform	Chronic	1.0E-02	mg/kg/day	none	1.0E-02	mg/kg/day	Liver	1000	IRIS	10/19/01
cis-1,2-Dichloroethene	Chronic	1.0E-02	mg/kg/day	none	1.0E-02	mg/kg/day	NA	NA	HEAST	7/97
Ethylene Dibromide (EDB)	Chronic	NA	mg/kg/day	none	NA	mg/kg/day	NA	NA	IRIS	02/13/04
Tetrachloroethene (PCE)	Chronic	1.0E-02	mg/kg/day	none	1.0E-02	mg/kg/day	Liver	1000	IRIS	03/01/98
Trichloroethene (TCE)	Chronic	3.0E-04	mg/kg/day	none	3.0E-04	mg/kg/day	Liver	NA	NCEA	10/01/02
Vinyl chloride	Chronic	3.0E-03	mg/kg/day	none	3.0E-03	mg/kg/day	Liver	30	IRIS	08/07/00
Arsenic	Chronic	3.0E-04	mg/kg/day	none	3.0E-04	mg/kg/day	Skin	3	IRIS	02/01/93
Chromium	Chronic	3.0E-03	mg/kg/day	2.5E-02	7.5E-05	mg/kg/day	None	900	IRIS	09/03/98
Manganese	Chronic	2.4E-02	mg/kg/day	4.0E-02	9.6E-04	mg/kg/day	CNS	1	EPA 1999	11/96
Mercury (dissolved)	Chronic	3.0E-04	mg/kg/day	7.0E-02	2.1E-05	mg/kg/day	Immune	1000	IRIS	05/01/95
Perchlorate	Chronic	1.0E-04	mg/kg/day	none	1.0E-04	mg/kg/day	Thyroid	NA	EPA 2003	07/26/01

Notes:

Derivation of the Absorbed Cancer Slope Factor for Dermal exposure is presented in Section 3.3.2.

EPA 2003 (January). EPA Memorandum: Status of EPA's Interim Assessment Guidance for Perchlorate.

(1) EPA 2001 (September). *Risk Assessment Guidance for Superfund (RAGS): Volume I: Human Health Evaluation Manual.* (Part E, Supplemental Guidance for Dermal Risk Assessment). Interim Guidance. EPA/540/R/99/005.

EPA 1999 (September). Region I, Risk Update. Number 5.

CNS = central nervous system

EPA = U.S. Environmental Protection Agency

HEAST=Health Effects Assessment Summary Tables

IRIS =Integrated Risk Information System. Online database. Accessed 02/13/2004 EPA 2004. Integrated Risk Information System (IRIS). Environmental Criteria and Assessment Office, Cincinnati, OH. (Online) Available: http://www.epa.gov/iris/

mg/kg/day = milligrams per kilogram per day

NA = not available

NCEA = National Center for Environmental Assessment, values taken from EPA 2002 (October). EPA Region 9 Preliminary Remediation Goals (PRGs). (Online) Available: http://www.epa.gov/region09/waste/sfund/prg/whatsnew.htm

ND = not determined

RfD = reference dose

Table 2-12
Non-Cancer Toxicity Data - Inhalation
Landfill-1

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC		Extrapolated RfD		Primary Target Organ(s)	Combined Uncertainty/ Modifying Factors	RfC : Target Organ(s)	
		Values	Units	Value	Units			Source(s)	Date(s) (MM/DD/YY)
Bis(2-ethylhexyl)phthalate (BEHP)	Chronic	NA	mg/m^3	NA	mg/m^3	NA	NA	IRIS	10/29/03
1,1,2,2-Tetrachloroethane	Chronic	NA	mg/m^3	ND	mg/m^3	NA	NA	IRIS	02/13/04
1,2-Dichloroethane	Chronic	NA	mg/m^3	ND	mg/m^3	NA	NA	IRIS	02/13/04
1,4-Dichlorobenzene	Chronic	8.0E-01	mg/m^3	2E-01	mg/m^3	Liver	100	IRIS	11/01/96
Benzene	Chronic	3.0E-02	mg/m^3	9E-03	mg/m^3	Lymph	300	IRIS	04/17/03
Carbon Tetrachloride	Chronic	NA	mg/m^3	ND	mg/m^3	NA	NA	IRIS	02/13/04
Chloroform	Chronic	3.0E-03	mg/m^3	9E-04	mg/m^3	NA	NA	NCEA	10/29/03
cis-1,2-Dichloroethene	Chronic	NA	mg/m^3	ND	mg/m^3	NA	NA	IRIS	02/13/04
Ethylene Dibromide (EDB)	Chronic	2.0E-04	mg/m^3	6E-05	mg/m^3	Reproductive	NA	HEAST	7/97
Tetrachloroethene (PCE)	Chronic	6.0E-01	mg/m^3	2E-01	mg/m^3	NA	NA	NCEA	10/29/03
Trichloroethene (TCE)	Chronic	4.0E-02	mg/m^3	1E-02	mg/m^3	CNS, Liver, ES	NA	EPA 2003	10/01/02
Vinyl chloride	Chronic	1.0E-01	mg/m^3	3E-02	mg/m^3	Liver	30	IRIS	08/07/00
Arsenic	--	--	--	--	--	--	--	--	--
Chromium	--	--	--	--	--	--	--	--	--
Manganese	--	--	--	--	--	--	--	--	--
Mercury (dissolved)	--	--	--	--	--	--	--	--	--
Perchlorate	--	--	--	--	--	--	--	--	--

Notes:

Inhalation RfD extrapolated from the inhalation RfC by multiplying the RfC by 20 m^3/day x 1/70 kg.

-- = Inorganic compounds will not volatilize from water; therefore, these analytes are not evaluated for the inhalation pathway.

CNS = central nervous system

EPA 2003 (October). EPA Comments on the *Draft Work Plan for the Process Leading to Final Remedial Decisions for Ashumet Valley and Landfill-1*.

ES = endocrine system

HEAST = Health Effects Assessment Summary Tables

IRIS =Integrated Risk Information System. Online database. Accessed 02/13/04. EPA. 2004. Integrated Risk Information System (IRIS). Environmental Criteria and Assessment Office, Cincinnati, OH. (Online) Available: http://www.epa.gov/iris/

mg/m^3= milligrams per cubic meter

NA = not available

NCEA = National Center for Environmental Assessment, values taken from EPA 2002 (October). EPA Region 9 Preliminary Remediation Goals (PRGs). (Online) Available: http://www.epa.gov/region09/waste/sfund/prg/whatsnew.htm.

ND = not determined

RfC = reference concentration

RfD = reference dose

Table 2-13
Cancer Toxicity Data - Oral/Dermal
Landfill-1

Chemical of Potential Concern	Oral Cancer Slope Factor		Weight of Evidence/Cancer Guideline Description	Oral Cancer Slope Factor		Weight of Evidence/Cancer Guideline Description	Oral Cancer Slope Factor	
	Value	Units		Value	Units		Source(s)	Date(s) (MM/DD/YY)
Bis(2-ethylhexyl)phthalate (BEHP)	1.4E-02	$(mg/kg/day)^{-1}$	none	1.4E-02	$(mg/kg/day)^{-1}$	B2	IRIS	02/01/93
1,1,2,2-Tetrachloroethane	2.0E-01	$(mg/kg/day)^{-1}$	none	2.0E-01	$(mg/kg/day)^{-1}$	C	IRIS	02/01/94
1,2-Dichloroethane	9.1E-02	$(mg/kg/day)^{-1}$	none	9.1E-02	$(mg/kg/day)^{-1}$	B2	IRIS	01/01/91
1,4-Dichlorobenzene	2.4E-02	$(mg/kg/day)^{-1}$	none	2.4E-02	$(mg/kg/day)^{-1}$	ND	HEAST	7/97
Benzene	5.5E-02	$(mg/kg/day)^{-1}$	none	5.5E-02	$(mg/kg/day)^{-1}$	A	IRIS	01/09/00
Carbon Tetrachloride	1.3E-01	$(mg/kg/day)^{-1}$	none	1.3E-01	$(mg/kg/day)^{-1}$	B2	IRIS	06/01/91
Chloroform	NA	$(mg/kg/day)^{-1}$	ND	ND	$(mg/kg/day)^{-1}$	B2	IRIS	10/19/01
cis-1,2-Dichloroethene	NA	$(mg/kg/day)^{-1}$	ND	ND	$(mg/kg/day)^{-1}$	D	IRIS	02/01/95
Ethylene Dibromide (EDB)	8.5E+01	$(mg/kg/day)^{-1}$	none	8.5E+01	$(mg/kg/day)^{-1}$	B2	IRIS	07/01/97
Tetrachloroethene (PCE)	5.4E-01	$(mg/kg/day)^{-1}$	none	5.4E-01	$(mg/kg/day)^{-1}$	NA	EPA 2003	06/12/03
Trichloroethene (TCE)	4.0E-01	$(mg/kg/day)^{-1}$	none	4.0E-01	$(mg/kg/day)^{-1}$	NA	EPA 2002	10/01/02
Vinyl chloride	7.5E-01	$(mg/kg/day)^{-1}$	none	7.5E-01	$(mg/kg/day)^{-1}$	A	IRIS	08/07/00
Arsenic	1.5E+00	$(mg/kg/day)^{-1}$	none	1.5E+00	$(mg/kg/day)^{-1}$	A	IRIS	04/10/98
Chromium	NA	$(mg/kg/day)^{-1}$	ND	ND	$(mg/kg/day)^{-1}$	D	IRIS	02/13/04
Manganese	NA	$(mg/kg/day)^{-1}$	ND	ND	$(mg/kg/day)^{-1}$	D	IRIS	12/01/96
Mercury (dissolved)	NA	$(mg/kg/day)^{-1}$	ND	ND	$(mg/kg/day)^{-1}$	C	IRIS	06/01/96
Perchlorate	NA	$(mg/kg/day)^{-1}$	ND	ND	$(mg/kg/day)^{-1}$	ND	NA	NA

Notes:

Derivation of the Absorbed Cancer Slope Factor for Dermal exposure is presented in Section 3.3.2.

(1) EPA 2001 (September). *Risk Assessment Guidance for Superfund (RAGS): Volume I: Human Health Evaluation Manual.* (Part E, Supplemental Guidance for Dermal Risk Assessment). Interim Guidance. EPA/540/R/99/005.

EPA 2003 (October). EPA Comments on the *Draft Work Plan for the Process Leading to Final Remedial Decisions for Ashumet Valley and Landfill-1*.

EPA 2002 (October). EPA Region 9 Preliminary Remediation Goals (PRGs) Table 2002 Update. (Online). Available: http://www.epa.gov/region09/waste/sfund/prg/whatsnew.htm

HEAST - Toxicity values were obtained from Health Effects Assessment Summary Tables (HEAST) Annual FY-1997. EPA. 1997. Health Effects Assessment Summary Tables (HEAST). Annual 1997. Office of Research and Development. EPA 540-R-94-020.

IRIS =Integrated Risk Information System. Online database. Accessed 02/13/04 EPA 2004. Integrated Risk Information System (IRIS). Environmental Criteria and Assessment Office, Cincinnati, OH. (Online) Available: http://www.epa.gov/iris/

mg/kg/day = milligrams per kilogram per day

NA = not available

ND = not determined

EPA Weight of Evidence Classification:

A - Human carcinogen

B1 - Probable human carcinogen - indicates that limited human data are available

B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans

C - Possible human carcinogen

D - Not classifiable as a human carcinogen

Table 2-14
Cancer Toxicity Data - Inhalation
Landfill-1

Chemical of Potential Concern	Unit Risk		Inhalation Cancer Slope Factor		Weight of Evidence/Cancer Guideline Description	Unit Risk ; Inhalation Cancer Slope Factor	
	Value	Units	Value	Units		Source(s)	Date(s) (MM/DD/YY)
Bis(2-ethylhexyl)phthalate (BEHP)	NA	$(mg/m^3)^{-1}$	ND	$(mg/m^3)^{-1}$	B2	IRIS	02/13/04
1,1,2,2-Tetrachloroethane	5.8E-02	$(mg/m^3)^{-1}$	2.0E-01	$(mg/m^3)^{-1}$	C	IRIS	02/01/94
1,2-Dichloroethane	2.6E-02	$(mg/m^3)^{-1}$	9.1E-02	$(mg/m^3)^{-1}$	B2	IRIS	01/01/91
1,4-Dichlorobenzene	NA	$(mg/m^3)^{-1}$	ND	$(mg/m^3)^{-1}$	NA	IRIS	02/13/04
Benzene	7.8E-03	$(mg/m^3)^{-1}$	2.7E-02	$(mg/m^3)^{-1}$	A	IRIS	01/09/00
Carbon Tetrachloride	1.5E-02	$(mg/m^3)^{-1}$	5.3E-02	$(mg/m^3)^{-1}$	B2	IRIS	06/01/96
Chloroform	2.3E-02	$(mg/m^3)^{-1}$	8.1E-02	$(mg/m^3)^{-1}$	B2	IRIS	02/13/04
cis-1,2-Dichloroethene	NA	$(mg/m^3)^{-1}$	ND	$(mg/m^3)^{-1}$	D	IRIS	02/01/95
Ethylene Dibromide (EDB)	2.2E-01	$(mg/m^3)^{-1}$	7.7E-01	$(mg/m^3)^{-1}$	B2	IRIS	07/01/97
Tetrachloroethene (PCE)	5.9E-03	$(mg/m^3)^{-1}$	2.1E-02	$(mg/m^3)^{-1}$	NA	EPA 2003	06/12/03
Trichloroethene (TCE)	1.1E-01	$(mg/m^3)^{-1}$	3.9E-01	$(mg/m^3)^{-1}$	NA	EPA 2003	06/12/03
Vinyl chloride	4.4E-03	$(mg/m^3)^{-1}$	1.5E-02	$(mg/m^3)^{-1}$	A	IRIS	08/07/00
Arsenic	--	--	--	--	--	--	--
Chromium	--	--	--	--	--	--	--
Manganese	--	--	--	--	--	--	--
Mercury (dissolved)	--	--	--	--	--	--	--
Perchlorate	--	--	--	--	--	--	--

Notes:

-- = Inorganic compounds will not volatilize from water; therefore, these analytes are not evaluated for the inhalation pathway.

EPA 2003 (October). EPA Comments on the *Draft Work Plan for the Process Leading to Final Remedial Decisions for Ashumet Valley and Landfill-1* .

HEAST - Toxicity values were obtained from EPA 1997. Health Effects Assessment Summary Tables (HEAST) Annual 1997. Office of Research and Development. EPA 540-R-94-020.

IRIS =Integrated Risk Information System. Online database. Accessed 02/13/04 EPA 2004. Integrated Risk Information System (IRIS). Environmental Criteria and Assessment Cincinnati, OH. (Online) Available: http://www.epa.gov/iris/

mg/m^3 = milligrams per cubic meter

NA = not available

ND = not determined

EPA Weight of Evidence Classification:

A - Human carcinogen

B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans

B1 - Probable human carcinogen - indicates that limited human data are available

C - Possible human carcinogen

D - Not classifiable as a human carcinogen

Table 2-15

Risk Summary, Reasonable Maximum Exposure

Landfill-1 Groundwater, Within the Capture Zone, Adult

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk				Noncarcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Within the Capture Zone Tap Water	Benzene	5.5E-07	NA	8.6E-08	6.4E-07					
			Carbon Tetrachloride	2.9E-05	NA	8.1E-06	3.7E-05	Liver	9.1E-01	NA	2.6E-01	1.2E+00
			Chloroform	NA	NA	NA	NA	Liver	3.3E-02	NA	3.2E-03	3.7E-02
			cis-1,2-Dichloroethene					NA	1.4E-01	NA	1.3E-02	1.5E-01
			1,2-Dichloroethane	2.7E-06	NA	1.4E-07	2.9E-06					
			1,4-Dichlorobenzene	3.1E-06	NA	2.2E-06	5.3E-06					
			Ethylene Dibromide	4.2E-04	NA	2.5E-05	4.5E-04	NA	NA	NA	NA	NA
			1,1,2,2-Tetrachloroethane	1.1E-05	NA	1.5E-06	1.3E-05					
			Tetrachloroethene	1.3E-04	NA	8.5E-05	2.2E-04	Liver	7.2E-02	NA	4.6E-02	1.2E-01
			Trichloroethene	2.6E-04	NA	4.5E-05	3.0E-04	Liver	6.2E+00	NA	1.1E+00	7.3E+00
			Vinyl chloride	3.5E-05	NA	1.9E-06	3.7E-05					
			Perchlorate					Thyroid	4.8E+00	NA	9.7E-06	4.8E+00
			Chromium (total)					None	1.0E-01	NA	4.3E-02	1.5E-01
			Manganese (dissolved)					CNS	2.5E+00	NA	3.2E-01	2.8E+00
			Mercury (dissolved)					Immune	1.1E-01	NA	8.2E-03	1.2E-01
			Chemical Total	8.9E-04	NA	1.7E-04	1.1E-03		1.5E+01	NA	1.8E+00	1.7E+01
		Exposure Point Total					1.1E-03					1.7E+01
	Groundwater	Within the Capture Zone Vapor	Benzene	NA	1.7E-06	NA	1.7E-06					
			Carbon Tetrachloride	NA	7.2E-05	NA	7.2E-05	Liver	NA	NA	NA	NA
			Chloroform	NA	5.8E-05	NA	5.8E-05	Liver	NA	1.9E+00	NA	1.9E+00
			cis-1,2-Dichloroethene					NA	NA	NA	NA	NA
			1,2-Dichloroethane	NA	1.7E-05	NA	1.7E-05					

Table 2-15

Risk Summary, Reasonable Maximum Exposure

Landfill-1 Groundwater, Within the Capture Zone, Adult

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Noncarcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Within the Capture Zone Vapor	1,4-Dichlorobenzene	NA	NA	NA	NA					
			Ethylene Dibromide	NA	2.4E-05	NA	2.4E-05	NA	NA	1.3E+00	NA	1.3E+00
			1,1,2,2-Tetrachloroethane	NA	7.0E-05	NA	7.0E-05					
			Tetrachloroethene	NA	3.2E-05	NA	3.2E-05	Liver	NA	2.1E-02	NA	2.1E-02
			Trichloroethene	NA	1.5E-03	NA	1.5E-03	Liver	NA	8.2E-01	NA	8.2E-01
			Vinyl chloride	NA	4.5E-06	NA	4.5E-06					
			Chemical Total	NA	1.8E-03	NA	1.8E-03		NA	4.1E+00	NA	4.1E+00
		Exposure Point Total					1.8E-03					4.1E+00
	Exposure Medium Total						2.9E-03					2.1E+01
Medium Total							2.9E-03					2.1E+01
Receptor Total							2.9E-03				Receptor HI Total	2.1E+01

Total HI Across All Media	Thyroid	4.8E+00
Total HI Across All Media	Liver	1.1E+01
Total HI Across All Media	Lymph	0.0E+00
Total HI Across All Media	CNS	2.8E+00
Total HI Across All Media	Immune	1.2E-01

Notes

CNS = central nervous system

HI = hazard index

NA = not available

Table 2-16

Risk Summary, Reasonable Maximum Exposure

Landfill-1 Groundwater, Within the Capture Zone, Child

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Noncarcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Within the Capture Zone Tap Water	Carbon Tetrachloride	1.7E-05	NA	4.5E-06	2.1E-05	Liver	2.1E+00	NA	5.8E-01	2.7E+00
			cis-1,2-Dichloroethene					NA	3.2E-01	NA	2.9E-02	3.5E-01
			1,2-Dichloroethane	1.6E-06	NA	8.0E-08	1.7E-06					
			1,4-Dichlorobenzene	1.8E-06	NA	1.2E-06	3.0E-06					
			Ethylene Dibromide	2.5E-04	NA	1.4E-05	2.6E-04					
			1,1,2,2-Tetrachloroethane	6.5E-06	NA	8.2E-07	7.3E-06					
			Tetrachloroethene	7.8E-05	NA	4.7E-05	1.3E-04	Liver	1.7E-01	NA	1.0E-01	2.7E-01
			Trichloroethene	1.5E-04	NA	2.5E-05	1.7E-04	Liver	1.4E+01	NA	2.4E+00	1.7E+01
			Vinyl chloride	2.0E-05	NA	1.1E-06	2.2E-05	Liver	1.1E-01	NA	5.9E-03	1.1E-01
			Perchlorate					Thyroid	1.1E+01	NA	2.8E-05	1.1E+01
			Chromium (total)					None	2.4E-01	NA	1.3E-01	3.6E-01
			Manganese (dissolved)					CNS	5.8E+00	NA	9.5E-01	6.7E+00
			Mercury (dissolved)					Immune	2.5E-01	NA	2.4E-02	2.7E-01
			Chemical Total	5.2E-04	NA	9.4E-05	6.2E-04		3.5E+01	NA	4.3E+00	3.9E+01
		Exposure Point Total					6.2E-04					3.9E+01
	Exposure Medium Total											
	Groundwater	Within the Capture Zone Vapor	Vinyl chloride	NA	1.1E-05	NA	1.1E-05					
			Chemical Total	NA	1.1E-05	NA	1.1E-05		NA	NA	NA	0.0E+00
		Exposure Point Total					1.1E-05					0.0E+00
	Exposure Medium Total						6.3E-04					3.9E+01
Medium Total							6.3E-04					3.9E+01
Receptor Total							6.3E-04				Receptor HI Total	3.9E+01

Total HI Across All Media	Thyroid	1.1E+01
Total HI Across All Media	Liver	2.0E+01
Total HI Across All Media	Lymph	0.0E+00
Total HI Across All Media	CNS	6.7E+00
Total HI Across All Media	Immune	2.7E-01

Notes:

CNS = central nervous system

HI = hazard index

NA = not available

Table 2-17

Risk Summary, Reasonable Maximum Exposure

Landfill-1 Groundwater, Outside the Capture Zone, Adult

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Noncarcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Outside the Capture Zone - Tap Water	Benzene	5.1E-07	NA	8.0E-08	5.9E-07					
			Carbon Tetrachloride	3.8E-05	NA	1.1E-05	4.9E-05	Liver	1.2E+00	NA	3.5E-01	1.6E+00
			Chloroform	NA	NA	NA	NA	Liver	1.2E-02	NA	1.1E-03	1.3E-02
			1,4-Dichlorobenzene	1.6E-06	NA	1.1E-06	2.7E-06					
			cis-1,2-Dichloroethene	NA	NA	NA	NA	NA	2.0E-01	NA	1.9E-02	2.2E-01
			1,1,2,2-Tetrachloroethane	1.6E-05	NA	2.2E-06	1.9E-05					
			Tetrachloroethene (PCE)	1.1E-04	NA	7.2E-05	1.8E-04	Liver	6.1E-02	NA	3.9E-02	1.0E-01
			Trichloroethene (TCE)	1.1E-04	NA	1.9E-05	1.3E-04	Liver	2.7E+00	NA	4.7E-01	3.1E+00
			Vinyl chloride	2.8E-05	NA	1.5E-06	2.9E-05					
			Arsenic (total)	3.3E-04	NA	1.8E-06	3.4E-04	Skin	2.2E+00	NA	1.1E-02	2.2E+00
			Manganese (total)					CNS	8.1E+00	NA	1.1E+00	9.1E+00
			Chemical Total	6.4E-04	NA	1.1E-04	7.5E-04		1.4E+01	NA	1.9E+00	1.6E+01
		Exposure Point Total					7.5E-04					1.6E+01
	Groundwater	Outside the Capture Zone - Vapor	Benzene	NA	1.6E-06	NA	1.6E-06					
			Carbon Tetrachloride	NA	9.6E-05	NA	9.6E-05	Liver	NA	NA	NA	NA
			Chloroform	NA	2.0E-05	NA	2.0E-05	Liver	NA	6.8E-01	NA	6.9E-01
			1,4-Dichlorobenzene	NA	NA	NA	NA					
			cis-1,2-Dichloroethene	NA	NA	NA	NA	NA	NA	NA	NA	NA
			1,1,2,2-Tetrachloroethane	NA	1.0E-04	NA	1.0E-04					
			Tetrachloroethene (PCE)	NA	2.7E-05	NA	2.7E-05	NA	NA	1.8E-02	NA	1.8E-02
			Trichloroethene (TCE)	NA	6.6E-04	NA	6.6E-04	NA	NA	3.5E-01	NA	3.5E-01
			Vinyl chloride	NA	3.5E-06	NA	3.5E-06					
			Chemical Total	NA	9.1E-04	NA	9.1E-04		NA	1.1E+00	NA	1.1E+00
		Exposure Point Total					9.1E-04					1.1E+00
	Exposure Medium Total						1.7E-03					1.7E+01
Medium Total							1.7E-03					1.7E+01
Receptor Total							1.7E-03				Receptor HI Total	1.7E+01

Total HI Across All Media	Skin	2.2E+00
Total HI Across All Media	Liver	5.5E+00
Total HI Across All Media	Lymph	0.0E+00
Total HI Across All Media	CNS	9.1E+00

Notes:

CNS = central nervous system

HI = hazard index

NA = not available

Table 2-18

Risk Summary, Reasonable Maximum Exposure

Landfill-1 Groundwater, Outside the Capture Zone, Child

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Child

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk				Noncarcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Outside the Capture Zone - Tap Water	Carbon Tetrachloride	2.2E-05	NA	6.0E-06	2.8E-05	Liver	2.8E+00	NA	7.8E-01	3.6E+00
			1,4-Dichlorobenzene	9.3E-07	NA	6.3E-07	1.6E-06					
			cis-1,2-Dichloroethene	NA	NA	NA	NA	NA	4.7E-01	NA	4.3E-02	5.1E-01
			1,1,2,2-Tetrachloroethane	9.5E-06	NA	1.2E-06	1.1E-05					
			Tetrachloroethene (PCE)	6.6E-05	NA	4.0E-05	1.1E-04	Liver	1.4E-01	NA	8.7E-02	2.3E-01
			Trichloroethene (TCE)	6.4E-05	NA	1.1E-05	7.5E-05	Liver	6.2E+00	NA	1.0E+00	7.3E+00
			Vinyl chloride	1.6E-05	NA	8.9E-07	1.7E-05					
			Arsenic (total)	2.0E-04	NA	1.3E-06	2.0E-04	Skin	5.1E+00	NA	3.3E-02	5.1E+00
			Manganese (total)					CNS	1.9E+01	NA	3.1E+00	2.2E+01
			Chemical Total	3.7E-04	NA	6.1E-05	4.4E-04		3.4E+01	NA	5.1E+00	3.9E+01
		Exposure Point Total					4.4E-04					3.9E+01
	Groundwater	Outside the Capture Zone - Vapor	Vinyl chloride	NA	8.6E-06	NA	8.6E-06					
			Chemical Total	NA	8.6E-06	NA	8.6E-06		NA	NA	NA	0.0E+00
		Exposure Point Total					8.6E-06					0.0E+00
	Exposure Medium Total						4.4E-04					3.9E+01
Medium Total							4.4E-04					3.9E+01
Receptor Total							4.4E-04				Receptor HI Total	3.9E+01

Total HI Across All Media	Skin	5.1E+00
Total HI Across All Media	Liver	1.1E+01
Total HI Across All Media	Lymph	0.0E+00
Total HI Across All Media	CNS	2.2E+01

Notes:

CNS = central nervous system

HI = hazard index

NA = not available

Table 2-19

Risk Summary, Reasonable Maximum Exposure

Landfill-1 Buzzards Bay Surface Water, Adult

Scenario Timeframe:	Current/Future
Receptor Population:	Swimmer
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Noncarcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water	Surface Water	Buzzards Bay Surface Water										
			Chemical Total	NA	NA	NA	0.0E+00		NA	NA	NA	0.0E+00
		Exposure Point Total					0.0E+00					0.0E+00
	Exposure Medium Total						0.0E+00					0.0E+00
Medium Total							0.0E+00					0.0E+00
Receptor Total							0.0E+00				Receptor HI Total	0.0E+00

Total HI Across All Media Liver 0.0E+00

Notes

HI = hazard index

NA = not available

Table 2-20

Risk Summary, Reasonable Maximum Exposure

Landfill-1 Buzzards Bay Surface Water, Child

Scenario Timeframe:	Current/Future
Receptor Population:	Swimmer
Receptor Age:	Child

Medium	[illegible]	[illegible]	[illegible]	Carcinogenic Risk				Noncarcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water	Surface Water	Buzzards Bay Surface Water										
			Chemical Total	NA	NA	NA	0.0E+00		NA	NA	NA	0.0E+00
		Exposure Point Total					0.0E+00					0.0E+00
	Exposure Medium Total						0.0E+00					0.0E+00
Medium Total							0.0E+00					0.0E+00
Receptor Total							0.0E+00				Receptor HI Total	0.0E+00

Total HI Across All Media Liver 0.0E+00

Notes:

HI = hazard index

NA = not available

Table 2-21

Risk Summary, Reasonable Maximum Exposure

Landfill-1 Buzzards Bay Surface Water, Adult Fish Consumer

Scenario Timeframe:	Current/Future
Receptor Population:	Fish Eater
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Noncarcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water	Fish/Shellfish	Buzzards Bay Surface Water	Tetrachloroethene (PCE)	2.9E-06	NA	NA	2.9E-06					
			Trichloroethene (TCE)	1.9E-06	NA	NA	1.9E-06					
			BEHP [Bis(2-ethylhexyl)phthalate]	2.6E-06	NA	NA	2.6E-06					
			Chemical Total	7.5E-06	NA	NA	7.5E-06		NA	NA	NA	0.0E+00
		Exposure Point Total					7.5E-06					0.0E+00
	Exposure Medium Total						7.5E-06					0.0E+00
Medium Total							7.5E-06					0.0E+00
Receptor Total							7.5E-06				Receptor HI Total	0.0E+00

Total HI Across All Media Liver 0.0E+00

Notes:

HI = hazard index

NA = not available

Table 2-22
Identification of Contaminants of Concern for LF-1

Area	COPC	RME EPC (µg/L)	(M)MCL (µg/L)	Total Adult HI	Total Child HI	ELCR	COC (Yes/No)	Comments
Within the Capture Zone								
	Benzene	1.06	5	0.03	0.02	3E-06	No	low risk, below MCL
	Carbon Tetrachloride	23.3	5	1.2	2.7	1E-04	**Yes**	
	Chloroform	12.2	80	2.0	0.09	6E-05	No	equivalent to background, below MCL
	cis-1,2-Dichloroethene	50.5	70	0.15	0.35	NA	No	low risk, below MCL
	1,2-Dichloroethane	3.21	70	NA	NA	2E-05	No	note 1, below MCL
	1,4-Dichlorobenzene	13.7	5	0.03	0.05	8E-06	**Yes**	exceeded MMCL of 5 µg/L
	Ethylene Dibromide	0.53	0.02	1.3	NA	7E-04	**Yes**	
	1,1,2,2-Tetrachloroethane	5.91		0.003	0.007	9E-05	**Yes**	
	Tetrachloroethene (PCE)	26.2	5	0.14	0.27	4E-04	**Yes**	
	Trichloroethene (TCE)	68	5	8.1	16.9	2E-03	**Yes**	
	Vinyl chloride	4.95	2	0.07	0.11	7E-05	**Yes**	
	Perchlorate	17.7	2	4.8	11.3	NA	No	note 2
	Chromium (total)	11.2	100	0.15	0.36	NA	No	low risk, below MCL
	Manganese (dissolved)	2160		2.8	6.7	NA	**Yes**	
	Mercury (dissolved)	1.18	2	0.12	0.27	NA	No	low risk, below MCL
Outside the Capture Zone								
	Benzene	0.98	5	0.02	0.02	3E-06	No	low risk, below MCL
	Carbon Tetrachloride	31	5	1.6	3.6	2E-04	**Yes**	
	Chloroform	4.3	80	0.7	0.03	2E-05	No	equivalent to background, below MCL
	1,4-Dichlorobenzene	7.08	5	0.02	0.03	4E-06	**Yes**	exceeded MMCL of 5 µg/L
	cis-1,2-Dichloroethene	73.5	70	0.2	0.5	NA	No	low risk
	1,1,2,2-Tetrachloroethane	8.69		0.004	0.01	1E-04	**Yes**	
	Tetrachloroethene (PCE)	22.2	5	0.1	0.2	3E-04	**Yes**	
	Trichloroethene (TCE)	29.3	5	3.5	7.3	9E-04	**Yes**	
	Vinyl chloride	3.91	2	0.1	0.1	6E-05	**Yes**	
	Arsenic (total)	23.7	10	2.2	5.1	5E-04	No	equivalent to background, note 3
	Manganese (total)	7080		9.1	22.0	NA	**Yes**	

Notes:

(1) Maximum concentration greater than GW-1 standard; detected in 2 locations; risk within EPA acceptable range.

(2) Perchlorate is only detected in one well (27MW0031B), and concentrations of perchlorate measured in this well have dropped steadily since the sample containing the maximum detection was collected. The January 2006 concentration was 0.53 µg/L.

(3) A detailed discussion of arsenic concentrations and associated risk in LF-1 and background groundwater is presented in the LF-1 risk assessment (Appendix A of the *Final Landfill-1 Source Area and Groundwater Feasibility Study*, AFCEE 2006b).

COC = contaminant of concern
COPC = contaminant of potential concern
ELCR = excess lifetime cancer risk
EPA = U.S. Environmental Protection Agency
EPC = exposure point concentration
HI = hazard index
MCL = Federal maximum contaminant level
MMCL = Massachusetts maximum contaminant level
NA = not applicable
RME = reasonable maximum exposure
µg/L = micrograms per liter

Table 2-23
Chemical-Specific ARARs for Source Action Alternative 2
Status Quo of Landfill and Land Use Controls, LF-1

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Soil	FEDERAL – EPA Risk Reference Doses	RfDs are considered the levels unlikely to cause significant adverse health effects associated with a threshold mechanism of action in human exposure for a lifetime.	This alternative will meet this standard by capping potential noncarcinogenic hazards and maintaining and monitoring the cap.	TBC
Soil	FEDERAL – EPA Carcinogen Assessment Group, Cancer Slope Factors	CSFs represent the most-up-to-date information on cancer risk from EPA's Carcinogen Assessment Group.	This alternative will meet this standard by capping potential noncarcinogenic hazards and maintaining and monitoring the cap.	TBC

ARAR applicable or relevant and appropriate requirement
CSF cancer slope factor
EPA U.S. Environmental Protection Agency
LF-1 Landfill-1
RfD reference dose
TBC to be considered (guidance)

Table 2-24
Location-Specific ARARs for Source Action Alternative 2
Status Quo of Landfill and Land Use Controls, LF-1

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Endangered and threatened species and their habitats	STATE – MA Endangered Species Act (321 CMR 10.00 et seq.)	Actions that jeopardize state-listed endangered or threatened species or species of special concern or their habitats that have been identified on the MMR must be avoided, or appropriate mitigation measures must be taken.	Monitoring and maintenance activities for the current landfill caps has the potential to impact certain moth and other species identified as state-listed species on the MMR that could potentially wander onto the landfill areas. Activities will be designed and implemented to minimize such effects. The Camp Edwards Natural Resource Office (http://www.eandrc.org/rarespecies.htm) continues to search for, identify, and map locations of rare species on the MMR and provides this information to the Massachusetts Division of Fisheries and Wildlife.	Applicable

ARAR	applicable or relevant and appropriate requirement
CMR	*Code of Massachusetts Regulations*
LF-1	Landfill 1
MA	Massachusetts
MMR	Massachusetts Military Reservation

Table 2-25
Action-Specific ARARs for Source Action Alternative 2
Status Quo of Landfill and Land Use Controls, LF-1

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Air	STATE – MassDEP Air Pollution Control Regulations (310 CMR 7.06, 7.08 – 7.10, 7.14, and 7.18 – 7.24)	Establishes the standards and requirements for air pollution control in the Commonwealth. Potentially relevant sections include those pertaining to: visible emissions (7.06); dust, odor, construction and demolition (7.09); and noise (7.10). The regulations also contain air pollutant emission standards for, among other things, hazardous waste incinerators, organic materials, and VOCs.	Dust, noise, and visible emissions will be managed to meet these state requirements during monitoring and maintenance activities. No construction or demolition will take place, and any air emissions from the gas vents are expected to be at levels well below the levels that would trigger the hazardous waste incinerator or major source standards for organic materials or VOCs.	Applicable
Hazardous waste	FEDERAL – RCRA Subtitle C Standards for Hazardous Waste TSDFs: Closure and Postclosure Care of Landfills [40 CFR 264.310(a) and (b)(1), (b)(4) through (b)(6)]	Establishes requirements to: (a) cover the landfill with a final cover designed and constructed to: • provide long-term minimization of migration of liquids through the closed landfill; • function with minimum maintenance; • promote drainage and minimize erosion or abrasion of the cover; • accommodate settling and subsidence so that the cover's integrity is maintained; and • have a permeability less than or equal to permeability of natural subsoils present; and (b) maintain the integrity and effectiveness of the final cover, prevent run-on and run-off from damaging the final cover, and protect and maintain surveyed benchmarks. Maintain and monitor a groundwater monitoring system that complies with 40 CFR 264 Subpart F.	This alternative will meet the closure and postclosure standards to prevent human contact and migration of contaminants to surface and groundwater. The previously constructed landfill cover meets the requirements for final covers. The approved groundwater monitoring plan meets the requirements as an alternative monitoring program under 40 CFR 264 Subpart F.	Relevant and Appropriate

Table 2-25
Action-Specific ARARs for Source Action Alternative 2
Status Quo of Landfill and Land Use Controls, LF-1

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Hazardous waste	FEDERAL – RCRA Subtitle C Standards for Hazardous Waste TSDFs: Postclosure Care and Use of Property [40 CFR 264.117(a) and (c)]	Must maintain and monitor the waste containment systems and restrict postclosure use of property as necessary to prevent damage to the final cover or components of the containment system or the function of the facility's monitoring systems. Postclosure care must begin after completion of closure and continue for a period of 30 years.	This alternative will meet the postclosure standards to prevent human contact and migration of contaminants to surface and groundwater.	Relevant and Appropriate
Solid waste	FEDERAL – RCRA Subtitle D Criteria for Municipal Solid Waste Landfills (40 CFR 258)	Establishes minimal national criteria under RCRA for the management of solid waste at all municipal solid waste landfill units to ensure the protection of human health and the environment.	If any solid wastes are generated during monitoring and maintenance activities, they will be managed in accordance with these regulations and disposed of appropriately. This alternative will meet the closure/postclosure standards to prevent human contact and migration of contaminants to surface and groundwater.	Applicable for disposal; Relevant and appropriate for postclosure
Hazardous waste	STATE – RCRA Subtitle C Standards for Hazardous Waste TSDFs: Postclosure Care of Landfills [310 CMR 30.633(1) and (2)(a), and (d) through (h)]	Establishes requirements to: (1) cover the landfill with a final cover designed and constructed to: • provide long-term minimization of migration of liquids through the closed landfill; • function with minimum maintenance; • promote drainage and minimize erosion or abrasion of the cover; • accommodate settling and subsidence so that the cover's integrity is maintained; and (2) maintain the integrity and effectiveness of the final cover, maintain and monitor the groundwater monitoring system, prevent run-on and run-off from damaging the final cover, maintain access roads, maintain gas collection and control systems, and protect and maintain surveyed benchmarks.	This alternative will meet the closure and postclosure standards to prevent human contact and migration of contaminants to surface and groundwater. The previously constructed landfill cover meets the requirements for final covers. The approved groundwater monitoring plan meets the requirements as an alternative monitoring program under 310 CMR 30.660.	Relevant and Appropriate

Table 2-25
Action-Specific ARARs for Source Action Alternative 2
Status Quo of Landfill and Land Use Controls, LF-1

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Hazardous waste	STATE – RCRA Subtitle C Standards for Hazardous Waste TSDFs: Postclosure Care and Use of Property [310 CMR 30.592(5)]	Must maintain and monitor the waste containment systems and restrict postclosure use of property as necessary to prevent damage to the final cover or components of the containment system, or the function of the facility's monitoring systems. Postclosure care must begin after completion of closure and continue for a period of 30 years.	This alternative will meet the postclosure standards to prevent human contact and migration of contaminants to surface and groundwater.	Relevant and Appropriate
Solid waste	STATE – MassDEP RCRA Subtitle D Solid Waste Management Facilities Regulations (310 CMR 19.000 *et seq.*)	If a waste is determined to be a solid waste, it must be managed and disposed of in accordance with these requirements	If any solid wastes are generated during monitoring and maintenance activities, they will be managed in accordance with these regulations and disposed of appropriately. This alternative will meet the closure/postclosure standards to prevent human contact and migration of contaminants to surface and groundwater.	Applicable
Solid waste	STATE – MassDEP Landfill Technical Guidance Manual (May 1997)	Provides a standard reference for and guidance on landfill design, construction, and QA/QC procedures, as well as closure/postclosure, in accordance with 310 CMR 19.000.	This alternative will meet the closure/postclosure standards to prevent human contact and migration of contaminants to surface and groundwater.	TBC

ARAR	applicable or relevant and appropriate requirement	QA/QC	quality assurance/quality control
CFR	*Code of Federal Regulations*	RCRA	Resource Conservation and Recovery Act
CMR	*Code of Massachusetts Regulations*	TBC	to be considered (guidance)
LF-1	Landfill 1	TSDF	treatment, storage, and disposal facility
MassDEP	Massachusetts Department of Environmental Protection	VOC	volatile organic compound

Table 2-26
Evaluation of LF-1 Groundwater Alternatives

Alternative/Remedy Option	Overall Protection	ARARs	Long-Term Effectiveness	Short-Term Effectiveness	Reduction of Toxicity, etc.	Implement-ability	Cost[1]
1 No Action	Not Protective	No ARARs	Good	Poor	Poor	Good	$0 M
3 Long-Term Monitoring with Land Use Controls and Bourne Water Provision	Protective	Yes	Good	Poor	Poor	Good	$9 M
5 LF-1 ETI System with Southern Expansion, Land Use Controls, and Bourne Water Provision	**Protective**	**Yes**	**Good**	**Good**	**Moderate**	**Good**	**$44 M**
9 Total Containment at the Base Boundary, Land Use Controls, and Bourne Water Provision	Protective	Yes	Good	Moderate	Good	Moderate	$66 M
12 LF-1 ETI System with Southern Expansion, Remediation of the Northern and Southern Lobes West of Route 28, Land Use Controls, and Bourne Water Provision	Protective	Yes	Good	Poor	Good	Moderate	$70 M
15 LF-1 ETI System with Southern Expansion, Remediation of the Northern and Southern Lobes West of Route 28, Warm Spot Remediation, Land Use Controls, and Bourne Water Provision	Protective	Yes	Good	Moderate	Good	Moderate	$73M
16 Total Containment at the Base Boundary, Remediation of the Northern and Southern Lobes West of Route 28, Warm Spot Remediation, Land Use Controls, and Bourne Water Provision	Protective	Yes	Good	Moderate	Good	Moderate	$95 M
17 Total Containment at the Base Boundary, Warm Spot Remediation, Land Use Controls, and Bourne Water Provision	Protective	Yes	Good	Moderate	Good	Moderate	$70 M
18 LF-1 ETI System with Southern Expansion, Warm Spot Remediation, Land Use Controls, and Bourne Water Provision	Protective	Yes	Good	Moderate	Moderate	Good	$49 M

Notes:
[1] Present Value costs do not include those for interim remedial action taken prior to the signing of the final Record of Decision.
Bold text indicates the selected remedy.
ARAR = applicable or relevant and appropriate requirement
ETI = extraction, treatment, and infiltration
M = million

Table 2-27
Model-Predicted Cleanup Years and Mass Removal Estimates for LF-1 Groundwater Alternatives

Alternative	Eastern Area		Northwestern Area		Southwestern Area		All Areas		Present Value Cost
	Cleanup Year	Mass Removed (lb)	Cleanup Year	Mass Removed (lb)	Cleanup Year	Mass Removed (lb)	Cleanup Year	Mass Removed (lb)	
Alternative 1	2052	--	2034	--	2054	--	2054	--	$0 M
Alternative 3	2052	--	2034	--	2054	--	2054	--	$9 M
Alternative 5	2045	750	2034	--	2030	--	2045	750	$44 M
Alternative 9	2043	970	2030	--	2029	--	2043	970	$66 M
Alternative 12	2045	750	2034	90	2026	163	2045	1014	$70 M
Alternative 15	2042	860	2031	84	2026	163	2042	1102	$73 M
Alternative 16	2036	1014	2020	55	2027	157	2036	1235	$95 M
Alternative 17	2036	1014	2030	--	2029	--	2036	1014	$68 M
Alternative 18	2042	860	2031	--	2030	--	2042	926	$49 M

Notes:
Mass removed is an estimated of total mass of TCE (trichloroethene) and PCE (tetrachloroethene) from 2006 to the date indicated.
The estimated total mass (TCE and PCE) removal from 2004 to 2006 is 30 lb.
lb = pounds
M = million

Table 2-28
Chemical-Specific ARARs for LF-1 Groundwater Alternative 5

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Groundwater	FEDERAL – SDWA MCLs (40 CFR 141.61-141.63)	MCLs have been promulgated for organic and inorganic contaminants. These levels regulate the concentration of contaminants in public drinking water supplies, but are also considered relevant and appropriate for CERCLA groundwater response actions where the groundwater aquifer is used or classified for use as drinking water.	These standards will be used as cleanup standards to be met through cleanup of the LF-1 plume, unless a more stringent state standard has been promulgated, in which case the more stringent standard will be met. SPEIM will determine when these cleanup standards are met.	Relevant and Appropriate
Groundwater	FEDERAL – SDWA Non-Zero MCLGs (40 CFR 141.50-141.51)	Non-zero MCLGs are nonenforceable health goals for public water systems set at levels that would result in no known or expected adverse health effects with an adequate margin of safety. Non-zero MCLGs are also considered relevant and appropriate for CERCLA groundwater response actions where the groundwater aquifer is used or classified for use as drinking water.	These standards will be used as cleanup standards to be met through cleanup of the LF-1 plume, unless a more stringent state standard has been promulgated, in which case the more stringent standard will be met. SPEIM will determine when these cleanup standards are met.	Relevant and Appropriate
Groundwater	STATE – MA Drinking Water Standards (310 CMR 22. 05-22.09)	These standards establish MCLs for public drinking water systems, but are also considered relevant and appropriate for CERCLA groundwater contamination response actions. When state MCLs are more stringent than federal levels, state levels must be used.	These standards will be used as cleanup standards to be met through cleanup of the LF-1 plume if these standards are more stringent than federal drinking water standards. SPEIM will determine when these cleanup standards are met.	Relevant and Appropriate
Groundwater	STATE – MA Groundwater Quality Standards (314 CMR 6.06)	These standards limit the concentration of certain materials allowed in classified Massachusetts waters. The groundwater beneath MMR has been classified as a Class I water or fresh groundwater found in the saturated zone of unconsolidated deposits and is designated as a source of potable water. The standards for Class I groundwater are the same as the state's MCLs.	These standards will be used as cleanup standards to be met through cleanup of the LF-1 plume if these standards are more stringent than federal or state drinking water standards. SPEIM will determine when these cleanup standards are met.	Applicable

ARAR	applicable or relevant and appropriate requirement	MCL	maximum contaminant level
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act	MCLG	maximum contaminant level goal
CFR	*Code of Federal Regulations*	MMR	Massachusetts Military Reservation
CMR	*Code of Massachusetts Regulations*	SDWA	Safe Drinking Water Act
LF-1	Landfill 1	SPEIM	system performance and ecological impact monitoring
MA	Massachusetts		

Table 2-29
Location-Specific ARARs for LF-1 Groundwater Alternative 5

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Endangered and threatened species and their habitats	STATE – MA Endangered Species Act (321 CMR 10.00 et seq.)	Actions that jeopardize state-listed endangered or threatened species or species of special concern or their habitats must be avoided, or appropriate mitigation measures must be taken.	The response action will be designed and implemented to minimize effects to endangered or threatened species on the MMR. Several state-listed species have been identified on the MMR. The Camp Edwards Natural Resource Office (http://www.eandrc.org/rarespecies.htm) continues to search for, identify, and map locations of rare species on the MMR and provides this information to the Massachusetts Division of Fisheries and Wildlife.	Applicable
Historic, archeological, and Native American artifacts and resources	FEDERAL – NHPA (16 USCA 470 et seq.; 36 CFR 800); AHPA (16 USCA 469a-c); ARPA (16 USC 470aa-ll; 43 CFR 7); NAGPRA (25 USCA 3001-3013; 43 CFR 10)	These statutes and regulations provide for the protection of historical, archaeological, and Native American burial sites, artifacts, and objects that might be lost as a result of a federal construction project. If a discovery is made, all activity in the area must stop and reasonable effort must be made to secure and protect the objects discovered.	After consultation with the Wampanoag Indian Tribes and the SHPO, the parties may determine that a cultural resources survey is needed to discover and identify objects and artifacts in the response action area, particularly Native American artifacts of the Wampanoag Indian Tribes. All such resources discovered during a survey or inadvertently discovered during on-site remedial activities will be secured and protected as required by law and in accordance with the consulting parties' memorandum of agreement.	Applicable

Table 2-29
Location-Specific ARARs for LF-1 Groundwater Alternative 5

Media	Requirement	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Historic, archeological, and Native American artifacts and resources	STATE – MA Historic Preservation Act (MGL Ch. 9 Sections 26-27C; MGL Ch. 7, Section 38A; MGL Ch. 38 Sections 6B-6C; and 950 CMR 70-71)	The MHC is the state historic preservation office and is authorized by Massachusetts law to identify, evaluate and protect the Commonwealth's important historic and archaeological resources. The MHC administers state and federal preservation programs, including planning, review and compliance.	After consultation with the Wampanoag Indian Tribes and the SHPO, the parties may determine that a cultural resources survey is needed to discover and identify objects and artifacts in the response action area, particularly Native American artifacts of the Wampanoag Indian Tribes. All such resources discovered during a survey or inadvertently discovered during on-site remedial activities will be secured and protected as required by law and in accordance with the consulting parties memorandum of agreement.	Applicable
Wetlands	FEDERAL – Protection of Wetlands (EO 11990, 40 CFR 6, Appendix A)	Under this order, federal agencies are required to minimize the destruction, loss, or degradation of wetlands, and preserve beneficial values of wetlands. Appendix A requires that no remedial alternatives adversely affect a wetland if another practicable alternative is available. If no alternative is available, effects from implementing the alternative must be mitigated.	The response action will be designed and implemented to minimize adverse effects to any wetlands that could potentially be impacted by the groundwater actions.	Applicable
Wetlands	FEDERAL – CWA Section 404 (40 CFR 230; 33 CFR Parts 320-323)	No activity that adversely affects a wetland shall be permitted if a practicable alternative with fewer effects is available. If no practicable alternative exists, impacts must be mitigated.	If the design and operation of the response action may adversely affect nearby wetlands, such potential impacts will be mitigated to comply with CWA 404 requirements.	Applicable

Table 2-29
Location-Specific ARARs for LF-1 Groundwater Alternative 5

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Wetlands	STATE – MassDEP Wetlands Protection Act (MGL Ch. 131, Section 40) and regulations (310 CMR 10.00)	This regulation outlines performance standards that must be met to work within 100 feet of a coastal or inland wetland and within 200 feet of a river. It governs all work involving the filling, dredging, or alteration of wetlands, banks, land under water bodies, waterways, land subject to flooding and riverfront areas.	The response action will be designed and implemented to meet the performance standards in 310 CMR 10.21 through 10.60 to minimize adverse effects to any wetlands that could potentially be impacted by the groundwater actions.	Applicable
Wetlands	FEDERAL – Fish and Wildlife Coordination Act (40 CFR 6.302; 16 USC 661 et seq.)	This act and regulations require federal agencies to take into consideration the effect that water-related projects would have on fish and wildlife, and to consult with the U.S. Fish and Wildlife Service and the state to develop measures to prevent, mitigate, or compensate for project-related losses to fish and wildlife.	The response action will be designed and implemented to minimize adverse effects to fish and wildlife in any wetland areas. Relevant federal and state agencies will be contacted, if indicated, to help analyze the effects of the response action on fish and wildlife in wetlands in and around the site.	Applicable
Floodplains	FEDERAL – Protection of Floodplains (EO 11988, 40 CFR 6, Appendix A)	Requires federal agencies to minimize potential harm to or within floodplains and avoid the long- and short-term adverse impacts with modifications to floodplains. Appendix A requires that no remedial alternatives adversely affect a floodplain if another practicable alternative is available. If no alternative is available, effects from implementing the alternative must be mitigated.	These requirements will be complied with if the response action will take place within or affect a floodplain.	Applicable
Floodplains	STATE – MassDEP Wetland Protection Act (MGL Ch. 131, Section 40) and regulations (310 CMR 10.00)	Governs work proposed within land subject to flooding (100-year floodplain) and coastal storm flow. Compensatory flood storage is required for any loss of floodplain area.	These requirements will be complied with if the response action will take place within or affect a floodplain.	Applicable

Table 2-29
Location-Specific ARARs for LF-1 Groundwater Alternatives 5

AHPA	Archaeological and Historic Preservation Act
ARAR	applicable or relevant and appropriate requirement
ARPA	Archaeological Resources Protection Act
CFR	*Code of Federal Regulations*
Ch.	chapter
CMR	*Code of Massachusetts Regulations*
CWA	Clean Water Act
EO	Executive Order
MA	Massachusetts
MassDEP	Massachusetts Department of Environmental Protection
MGL	Massachusetts General Law
MHC	Massachusetts Historic Commission
MMR	Massachusetts Military Reservation
NAGPRA	Native American Graves Protection and Repatriation Act
NHPA	National Historic Preservation Act
SHPO	State Historic Preservation Officer
USC	*United States Code*
USCA	*United States Code, Annotated*

Table 2-30
Action-Specific ARARs for LF-1 Groundwater Alternative 5

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Groundwater	FEDERAL – Underground Injection Control Program (40 CFR 144-148)	These regulations outline minimum program and performance standards for underground injection wells and prohibit any injection that may cause a violation of any primary drinking water regulation under 40 CFR 142 in the aquifer. This program has been delegated to the state and takes effect through the state requirements listed below.	Extracted groundwater will be treated to levels at or below the federal and state primary drinking water standards to ensure that discharges to the aquifer via reinjection wells and/or infiltration galleries will not cause any violation of drinking water standards in the receiving aquifer. SPEIM will be conducted to determine when groundwater contaminant levels are at or below these standards.	Relevant and Appropriate
Groundwater	STATE – MA Underground Water Source Protection (310 CMR 27.00 *et seq.*)	These regulations prohibit the injection of fluid containing any pollutant into underground sources of drinking water where such pollutant will or is likely to cause a violation of any state drinking water regulations under 310 CMR 22.00 or adversely affect the health of persons.	Extracted groundwater will be treated to levels at or below the federal and state primary drinking water standards to ensure that discharges to the aquifer via reinjection wells and/or infiltration galleries will not cause any violation of drinking water standards in the receiving aquifer. SPEIM will be conducted to determine when groundwater contaminant levels are at or below these standards.	Relevant and Appropriate
Air	STATE – MA Air Pollution Control Regulations (310 CMR 7.06, 7.08 – 7.10, 7.14, and 7.18 – 7.24)	Establishes the standards and requirements for air pollution control in the Commonwealth. Potentially relevant sections include those pertaining to: visible emissions (7.06); dust, odor, construction and demolition (7.09); and noise (7.10). The regulations also contain air pollutant emission standards for, among other things, hazardous waste incinerators, organic materials, and VOCs.	Dust, noise, and visible emissions will be managed to meet the state requirements during response activities. Site remedial work and water treatment operations will be managed and performed in accordance with these regulations. Air emissions from the treatment systems will not be at a level high enough to trigger the standards for hazardous waste incinerators, organic materials, or VOCs.	Applicable

Table 2-30
Action-Specific ARARs for LF-1 Groundwater Alternative 5

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Stormwater runoff	FEDERAL – CWA NPDES Stormwater Discharge Requirements (40 CFR 122.26)	Establishes requirements for stormwater discharges associated with construction activities that create a land disturbance of equal to or greater than one acre of land. The requirements include good construction management techniques; phasing of construction projects; minimal clearing; and sediment, erosion, structural, and vegetative controls to be implemented to mitigate stormwater run-on and runoff.	If stormwater runoff associated with remedial action construction, operation, and maintenance activities discharges to a surface water body, including wetlands, and the area of disturbance is greater than one acre of land, it will be controlled in accordance with these requirements.	Applicable
Stormwater runoff	STATE – Stormwater Discharge Requirements (314 CMR 3.04 and 314 CMR 3.19)	Requires that stormwater discharges associated with construction activities be managed in accordance with the general permit conditions of 314 CMR 3.19 so as not to cause a violation of Massachusetts surface water quality standards in the receiving surface water body (including wetlands).	If stormwater runoff associated with remedial action construction, operation and maintenance activities discharges to a surface water body, including wetlands, and the area of disturbance is greater than one acre of land, it will be controlled in accordance with these requirements.	Applicable
Stormwater runoff	STATE – Stormwater Management Program Policy (18 November 1996)	Provides policies and guidance on complying with the state's stormwater discharge requirements.	If stormwater runoff associated with remedial action construction, operation and maintenance activities discharges to a surface water body, including wetlands, it will be controlled in accordance with this policy.	TBC
Soil	STATE – MA Erosion and Sediment Control Guidelines for Urban and Suburban Areas (May 2003)	Provides guidance and best management practices regarding erosion and sediment control.	Construction, operation, and maintenance of the remedial system components will be performed in accordance with this guidance as appropriate.	TBC

Table 2-30
Action-Specific ARARs for LF-1 Groundwater Alternative 5

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Hazardous waste	FEDERAL – Subtitle C Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR 264 *et seq.*)	These requirements establish minimum national standards that define the acceptable management of hazardous waste.	Because Massachusetts has been authorized to run the RCRA base program, hazardous materials will be managed according to the state requirements listed below.	Applicable
Hazardous waste	FEDERAL – RCRA Subtitle C Standards for Identification and Listing of Hazardous Wastes (40 CFR 261.24)	These requirements identify the maximum concentrations of contaminants at which the waste would be considered characteristically hazardous waste.	Spent activated carbon, soil generated during well installations, groundwater samples and other potentially hazardous materials will be analyzed according to the TCLP. If TCLP results exceed the standards in 261.24, the material will be disposed of off-site in a RCRA-permitted treatment, storage and disposal facility.	Applicable
Hazardous waste	STATE – MA HWMR Requirements for Generators of Hazardous Waste (310 CMR 30.300 – 30.305)	A generator of solid waste must determine whether that waste is hazardous using various methods, including the TCLP method, or application of knowledge of hazardous characteristics of the waste. If waste is determined to be hazardous, it must be managed in accordance with the applicable Massachusetts generator requirements, which require management in accordance with 310 CMR 30.000 *et seq.*	If RCRA-characteristic hazardous wastes are generated, the material will be managed in accordance with these requirements.	Applicable

Table 2-30
Action-Specific ARARs for LF-1 Groundwater Alternative 5

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Hazardous waste	STATE – MA HWMR Standards for the Identification and Listing of Hazardous Waste: Toxicity Characteristic (310 CMR 30.125)	These requirements identify the maximum concentrations of contaminants at which the waste would be considered characteristically hazardous waste.	Spent activated carbon, soil generated during well installations, groundwater samples and other potentially hazardous materials will be analyzed according to the TCLP. If TCLP results exceed the standards in 261.24, the material will be disposed of off-site in a RCRA-permitted treatment, storage and disposal facility.	Applicable

ARAR applicable or relevant and appropriate requirement
CFR *Code of Federal Regulations*
CMR *Code of Massachusetts Regulations*
CWA Clean Water Act
HWMR Hazardous Waste Management Regulation
MA Massachusetts
NPDES National Pollutant Discharge Elimination System
RCRA Resource Conservation and Recovery Act
SPEIM system performance and ecological impact monitoring
TBC to be considered [guidance]
TCLP Toxicity Characteristic Leaching Procedure
VOC volatile organic compound

Table 2-31
Present Value Calculation for LF-1 Source Area Operable Unit Alternative 2

Year	Annual Landfill Monitoring	Periodic Costs	Total Cost (0% Discount)	Discount Factor (for 3.5%)	Total Present Value Cost at 3.5%	Calendar Year
0	$ 52,647	$ -	$ 52,647	1.0000	$ 52,647	2006
1	$ 52,647	$ -	$ 52,647	0.9662	$ 50,866	2007
2	$ 52,647	$ -	$ 52,647	0.9335	$ 49,146	2008
3	$ 52,647	$ -	$ 52,647	0.9019	$ 47,484	2009
4	$ 52,647	$ -	$ 52,647	0.8714	$ 45,878	2010
5	$ 52,647	$ 2,810	$ 55,457	0.8420	$ 46,693	2011
6	$ 52,647	$ -	$ 52,647	0.8135	$ 42,828	2012
7	$ 52,647	$ -	$ 52,647	0.7860	$ 41,380	2013
8	$ 52,647	$ -	$ 52,647	0.7594	$ 39,980	2014
9	$ 52,647	$ -	$ 52,647	0.7337	$ 38,628	2015
10	$ 52,647	$ 2,810	$ 55,457	0.7089	$ 39,314	2016
11	$ 52,647	$ -	$ 52,647	0.6849	$ 36,060	2017
12	$ 52,647	$ -	$ 52,647	0.6618	$ 34,841	2018
13	$ 52,647	$ -	$ 52,647	0.6394	$ 33,662	2019
14	$ 52,647	$ -	$ 52,647	0.6178	$ 32,524	2020
15	$ 52,647	$ 2,810	$ 55,457	0.5969	$ 33,102	2021
16	$ 52,647	$ -	$ 52,647	0.5767	$ 30,362	2022
17	$ 52,647	$ -	$ 52,647	0.5572	$ 29,335	2023
18	$ 52,647	$ -	$ 52,647	0.5384	$ 28,343	2024
19	$ 52,647	$ -	$ 52,647	0.5202	$ 27,384	2025
TOTAL	$ 1,052,932	$ 8,430	$ 1,061,362		$ 780,458	

Table 2-32
Cost Estimate Basis for LF-1 Source Area Operable Unit Alternative 2

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL	SUBTOTAL	COMMENTS	ASSUMPTIONS
LANDFILL MONITORING							
ANNUAL COSTS						Based on actual costs with ongoing monitoring at LF-1. Includes equipment, personnel, laboratory analyses, IDM, maintenance, data interpretation, and reporting. Actual costs also include overhead and support.	
Visual Inspections	1	YR	$ 2,000	$ 2,000			
Settlement Monitoring	1	YR	$ 29,000	$ 29,000		via survey	
Gas Probe Monitoring	10	SAMP	$ 100	$ 1,000		summa cannister for VOCs	2 samplers for 1 hour each sample
Air Monitoring/Analysis	10	SAMP	$ 425	$ 4,250		offsite analysis	includes data validation
Reporting	1	YR	$ 5,000	$ 5,000			
TOTAL				$ 41,250		Overhead and support costs are included in the actual costs used to derive monitoring costs.	
TOTAL ESCALATED					$ 52,647	Based on actual costs from 2001	
CERCLA 5-YEAR REPORTING							
PERIODIC COSTS							
Report Preparation and Submittal	1	EA	$ 2,000	$ 2,000			Report is part of a larger review of all sources and systems at MMR.
OVERHEAD & SUPPORT				$ 580			
TOTAL					$ 2,580		
TOTAL ESCALATED					$ 2,810		

Notes:
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
EA = each
IDM = investigation-derived material
MMR = Massachusetts Military Reservation
SAMP = sample
VOCs = volatile organic compounds
YR = year

Table 2-33
Present Value Calculation for LF-1 Groundwater Operable Unit Alternative 5

Year	Annual O&M	Annual Chemical Monitoring	Annual Hydraulic Monitoring	Bourne Water Provision	Periodic Costs	Total Cost (0% Discount)	Discount Factor (for 3.5%)	Total Present Value Cost at 3.5%	Calendar Year
0	$ 752,687	$ 354,129	$ 1,062,387	$ 2,500,000	$ -	$ 4,669,204	1.0000	$ 4,669,204	2006
1	$ 752,687	$ 354,129	$ 1,062,387	$ -	$ -	$ 2,169,204	0.9662	$ 2,095,849	2007
2	$ 752,687	$ 354,129	$ 1,062,387	$ -	$ -	$ 2,169,204	0.9335	$ 2,024,975	2008
3	$ 752,687	$ 354,129	$ 1,062,387	$ -	$ -	$ 2,169,204	0.9019	$ 1,956,497	2009
4	$ 752,687	$ 354,129	$ 1,062,387	$ -	$ -	$ 2,169,204	0.8714	$ 1,890,336	2010
5	$ 752,687	$ 318,716	$ 1,062,387	$ -	$ 2,776	$ 2,136,567	0.8420	$ 1,798,932	2011
6	$ 752,687	$ 318,716	$ 1,062,387	$ -	$ -	$ 2,133,791	0.8135	$ 1,735,840	2012
7	$ 752,687	$ 318,716	$ 1,062,387	$ -	$ -	$ 2,133,791	0.7860	$ 1,677,140	2013
8	$ 752,687	$ 318,716	$ 1,062,387	$ -	$ -	$ 2,133,791	0.7594	$ 1,620,425	2014
9	$ 752,687	$ 318,716	$ 1,062,387	$ -	$ -	$ 2,133,791	0.7337	$ 1,565,628	2015
10	$ 752,687	$ 286,845	$ 1,062,387	$ -	$ 2,776	$ 2,104,695	0.7089	$ 1,492,058	2016
11	$ 752,687	$ 286,845	$ 1,062,387	$ -	$ -	$ 2,101,919	0.6849	$ 1,439,700	2017
12	$ 752,687	$ 286,845	$ 1,062,387	$ -	$ -	$ 2,101,919	0.6618	$ 1,391,015	2018
13	$ 752,687	$ 286,845	$ 1,062,387	$ -	$ -	$ 2,101,919	0.6394	$ 1,343,976	2019
14	$ 752,687	$ 286,845	$ 1,062,387	$ -	$ -	$ 2,101,919	0.6178	$ 1,298,527	2020
15	$ 752,687	$ 258,160	$ 1,062,387	$ -	$ 2,776	$ 2,076,011	0.5969	$ 1,239,151	2021
16	$ 752,687	$ 258,160	$ 1,062,387	$ -	$ -	$ 2,073,235	0.5767	$ 1,195,647	2022
17	$ 752,687	$ 258,160	$ 1,062,387	$ -	$ -	$ 2,073,235	0.5572	$ 1,155,214	2023
18	$ 752,687	$ 258,160	$ 1,062,387	$ -	$ -	$ 2,073,235	0.5384	$ 1,116,149	2024
19	$ 752,687	$ 258,160	$ 1,062,387	$ -	$ -	$ 2,073,235	0.5202	$ 1,078,405	2025
20	$ 752,687	$ 232,344	$ 1,062,387	$ -	$ 2,776	$ 2,050,195	0.5026	$ 1,030,358	2026
21	$ 752,687	$ 232,344	$ 1,062,387	$ -	$ -	$ 2,047,419	0.4856	$ 994,167	2027
22	$ 752,687	$ 232,344	$ 1,062,387	$ -	$ -	$ 2,047,419	0.4692	$ 960,548	2028
23	$ 752,687	$ 232,344	$ 1,062,387	$ -	$ -	$ 2,047,419	0.4533	$ 928,065	2029
24	$ 752,687	$ 232,344	$ 1,062,387	$ -	$ -	$ 2,047,419	0.4380	$ 896,682	2030
25	$ 752,687	$ 209,110	$ 1,062,387	$ -	$ 2,776	$ 2,026,960	0.4231	$ 857,702	2031
26	$ 376,344	$ 209,110	$ 531,194	$ -	$ -	$ 1,116,647	0.4088	$ 456,527	2032
27	$ 376,344	$ 209,110	$ 531,194	$ -	$ -	$ 1,116,647	0.3950	$ 441,089	2033
28	$ 376,344	$ 209,110	$ 531,194	$ -	$ -	$ 1,116,647	0.3817	$ 426,173	2034
29	$ 376,344	$ 209,110	$ 531,194	$ -	$ -	$ 1,116,647	0.3687	$ 411,761	2035
30	$ 376,344	$ 188,199	$ 531,194	$ -	$ 2,776	$ 1,098,512	0.3563	$ 391,376	2036
31	$ 376,344	$ 188,199	$ 531,194	$ -	$ -	$ 1,095,736	0.3442	$ 377,186	2037
32	$ 376,344	$ 188,199	$ 531,194	$ -	$ -	$ 1,095,736	0.3326	$ 364,431	2038
33	$ 376,344	$ 188,199	$ 531,194	$ -	$ -	$ 1,095,736	0.3213	$ 352,107	2039
34	$ 376,344	$ 188,199	$ 531,194	$ -	$ -	$ 1,095,736	0.3105	$ 340,200	2040
35	$ 376,344	$ 169,379	$ 531,194	$ -	$ 2,776	$ 1,079,692	0.3000	$ 323,883	2041
36	$ 376,344	$ 169,379	$ 531,194	$ -	$ -	$ 1,076,916	0.2898	$ 312,126	2042
37	$ -	$ 169,379	$ -	$ -	$ -	$ 169,379	0.2800	$ 47,431	2043
38	$ -	$ 169,379	$ -	$ -	$ -	$ 169,379	0.2706	$ 45,827	2044
39	$ -	$ 169,379	$ -	$ -	$ -	$ 169,379	0.2614	$ 44,278	2045
40	$ -	$ 169,379	$ -	$ -	$ 72,173	$ 241,552	0.2526	$ 61,009	2046
TOTAL	$ 23,709,651	$ 10,253,785	$ 33,465,197	$ 2,500,000	$ 91,605	$ 70,020,237		$ 43,847,594	

Table 2-34
Cost Estimate Basis for LF-1 Groundwater Operable Unit Alternative 5

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL	SUBTOTAL	COMMENTS	ASSUMPTIONS
TREATMENT SYSTEM O&M							
ANNUAL COSTS							
Hunter Avenue Treatment System							
Labor	1	YR	$ 20,000	$ 20,000			
Carbon	1	YR	$ 60,900	$ 60,900			
Sludge Disposal	1	YR	$ 2,000	$ 2,000			
Well Maintenance	1	WELL	$ 15,500	$ 15,500			
Spare Parts	1	WELL	$ 5,200	$ 5,200			
Utilities	1	YR	$ 51,240	$ 51,240			
Analytical, data management	36	SAMP	$ 150	$ 5,400			3 samples/month; off-site analysis; includes data validation
SUBTOTAL					$ 160,240		
OVERHEAD & SUPPORT				$ 46,470			
HA SYSTEM TOTAL					$ 206,710		
HA SYSTEM ESCALATED					$ 227,897		
Existing LF-1 Treatment System	1	YR	$ 476,000	$ 476,000		Actuals from 2004 include overhead and support	Operating at current conditions
EXISTING TOTAL					$ 476,000		
EXISTING ESCALATED					$ 524,790		
ANNUAL GROUNDWATER MONITORING							
ANNUAL COSTS							
Hydraulic Monitoring and Reporting						Based on actual costs under the LF-1 SPEIM program. Includes equipment, personnel, laboratory analyses, IDM, equipment maintenance, data interpretation, and reporting. Actual costs also include overhead and support.	
Existing Wellfield (EW01-EW05)	1	LS	$ 891,000	$ 891,000			
Escalated-Existing					$ 1,031,444		
EW06 Well	1	LS	$ 26,730	$ 26,730		Annual hydraulic monitoring costs of new extraction well and PME well	Assume 4 new monitoring locations for new extraction well.
Escalated-EW06 Well					$ 30,943		
TOTAL				$ 917,730		Overhead and support costs are included in the actual costs used to derive monitoring costs.	
TOTAL ESCALATED					$ 1,062,387		

Table 2-34
Cost Estimate Basis for LF-1 Groundwater Operable Unit Alternative 5

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL	SUBTOTAL	COMMENTS	ASSUMPTIONS
Chemical Monitoring and Reporting						Based on actual costs under the LF-1 SPEIM program. Includes equipment, personnel, laboratory analyses, IDM, equipment maintenance, data interpretation, and reporting. Actual costs also include overhead and support.	
Existing Wellfield (EW01-EW05)	1	LS	$ 297,000	$ 297,000			
Escalated-Existing					$ 343,815		
EW06 Well	1	LS	$ 8,910	$ 8,910			Assume 4 new monitoring locations for new extraction well.
Escalated-EW06 Well					$ 10,314		
TOTAL				$ 305,910			
TOTAL ESCALATED					$ 354,129	*Actual costs escalated from 2003.*	
CERCLA 5-YEAR REPORTING							
PERIODIC COSTS							
Report Preparation and Submittal	1	EA	$ 2,000	$ 2,000			Report is part of a larger review of all sources and systems at MMR.
OVERHEAD & SUPPORT				$ 580			
TOTAL					$ 2,580		
TOTAL ESCALATED					$ 2,776		
RESIDUAL RISK ASSESSMENT							
DIRECT COSTS							
Report Preparation and Submittal	1	EA	$ 50,000	$ 50,000			
OVERHEAD & SUPPORT				$ 14,500			
TOTAL					$ 64,500		
TOTAL ESCALATED					$ 69,397		
BOURNE WATER PROVISION							
Water Supply Cost	1	LS	$ 2,500,000	$2,500,000			Based on 1.8 mgd provided by AFCEE

Notes:
AFCEE = Air Force Center for Environmental Excellence
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
EA = each
HA = Hunter Avenue
IDM = investigation-derived materials
LS = lump sum
mgd = million gallons per day
MMR = Massachusetts Military Reservation
O&M = operations and maintenance
PME = performance evaluation monitoring
SAMP = sample
SPEIM = system performance and ecological impact monitoring
YR = year

APPENDIX A

MassDEP Concurrence Letter

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY & ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
SOUTHEAST REGIONAL OFFICE
20 RIVERSIDE DRIVE, LAKEVILLE, MA 02347 508-946-2700

DEVAL L. PATRICK
Governor

TIMOTHY P. MURRAY
Lieutenant Governor

IAN A. BOWLES
Secretary

LAURIE BURT
Commissioner

September 27, 2007

Mr. James T. Owens III, Director
Office of Site Remediation and Restoration
U.S. Environmental Protection Agency,
New England Office
One Congress Street, Suite 1100
Boston, MA 02114-2023

RE: BOURNE—BWSC-4-0037
Massachusetts Military Reservation (MMR),
Final Record of Decision for Landfill-1 Source Area and Groundwater, Concurrence

Dear Mr. Owens;

The Massachusetts Department of Environmental Protection (MassDEP) has received the document entitled **"Final Record of Decision for Landfill-1 Source Area and Groundwater "** (the "LF-1 ROD"), dated September 2007. The LF-1 ROD presents the selected remedy for a portion of the LF-1 source area, specifically the 1970 cell, the Post-1970 Cell and the Kettle Hole, and for the LF-1 groundwater, which was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The northwest part of the LF-1 source area (the 1947, 1951 and 1957 cells) will be addressed in a future decision document. The U.S. Air Force is the lead agency for CERCLA remedial actions at the MMR. The MassDEP concurs with the AFCEE's selected remedies identified in the LF-1 ROD.

The LF-1 source area is a landfill that occupies approximately 100 acres on the MMR. Wastes were disposed of in the landfill in five distinct cells that are designated by the approximate last date of waste disposal in the cell and include: 1947 cell, 1951 cell, 1957 cell, 1970 cell and Post-1970 cell. Wastes that may have been disposed of at the landfill include general refuse, fuel tank sludge, herbicides, solvents, transformer oils, fire extinguisher fluids, small arms ammunition, paints, paint thinners, batteries, pesticides powder, hospital wastes, municipal sewer sludge, coal fly ash, and possibly live ordnance. Dissolved contaminants leached from some of the waste in the landfill into the underlying groundwater resulting in the formation of the LF-1 groundwater plume. The LF-1 groundwater plume extends from the landfill to Red Brook Harbor located to the west of the MMR. The primary contaminants in the LF-1 plume are chlorinated solvents including tetrachloroethene (PCE), trichloroethene (TCE), and carbon tertrachloride (CCl_4). Other contaminants of concern (COCs) present in the LF-1

plume to a lesser extent include 1,1,2,2- tetrachloroethane (TeCA), ethylene dibromide (EDB), 1,4-dichlorobenzene (DCB) and vinyl chloride (VC). Perchlorate has also been detected sporadically in groundwater within the LF-1 plume area. Although not a COC, the AFCEE has agreed to monitor for perchlorate in the LF-1 plume to track concentrations and migration.

In 1993, the Department of Defense and the EPA, with concurrence from the MassDEP, agreed to implement an interim remedy for the LF-1 source area. The interim remedy was presented in the *Record of Decision for Interim Remedial Action Main Base Landfill (AOC LF-1) Source Area Operable Unit* (referred to as the Interim Record of Decision or IROD). The interim remedy consisted of 1) downgradient groundwater monitoring of the Northwest Operable Unit (NWOU) cells (1947, 1951, and 1957), 2) construction of a landfill cover system on the 1970 cell, Post-1970 cell and the Kettle Hole, and 3) post-closure monitoring for the 1970 cell, Post-1970 cell and the Kettle Hole. The construction of the landfill cover system and associated drainage system, gas vents, and the landfill perimeter fence was completed in 1995. A low-permeability cap was placed on the 1970 cell, Post-1970 cell and the Kettle Hole. The NWOU cells were covered with native soils.

In 1995, the Department of Defense and the EPA, with concurrence from the MassDEP, agreed to implement an interim remedy for the LF-1 groundwater plume. The proposed LF-1 plume interim remedy consisting of plume containment through groundwater extraction, treatment, and discharge was presented in the *Final Record of Decision for Interim Action, Containment of Seven Groundwater Plumes at Massachusetts Military Reservation, Cape Cod, Massachusetts*. The interim remedy for the LF-1 groundwater plume was implemented in August 1999 and consisted of an extraction, treatment and infiltration system (ETI) consisting of 5 extraction wells, an infiltration trench and gallery, and a granular activated carbon (GAC) treatment plant. The extraction wells were aligned across the plume to provide containment of the plume at the western base boundary. Monitored natural attenuation (MNA) was selected as the remedy for portions of the LF-1 plume upgradient and downgradient of the base boundary that were not captured by the LF-1 ETI system. An additional extraction well was installed in 2006 to improve mass capture along the southern boundary of the LF-1 plume. Groundwater use within those areas impacted by the LF-1 plume was restricted by institutional controls.

The Final LF-1 Source Area and Groundwater Feasibility Study (FS), issued in May 2006 as part of the IROD to ROD process, evaluated four response action alternatives for the LF-1 source area. Two alternatives were retained for further evaluation, 1) No Action (as required by the National Contingency Plan), and 2) Status Quo with Institutional Controls. The AFCEE's preferred response action is Alternative 2. Under this alternative, the existing landfill cover system would be maintained. Site monitoring, settlement monitoring, gas vent monitoring, and periodic maintenance would continue until 2025 (30 years after construction of the landfill cover system in 1995). Institutional controls will be used to prevent or reduce human exposure to the landfill wastes. This remedy only addresses the capped portion of the landfill. The final remedy for the uncapped NWOU is still being evaluated. The FS also evaluated eighteen remedial alternatives for the LF-1 groundwater plume, ranging from a no-action scenario to numerous alternatives involving additional active remediation in several parts of the plume. Nine remedial alternatives were retained for detailed analysis and evaluation, including a no-action scenario, a long-term monitoring scenario with ICs, a status quo scenario, and six remedial scenarios

involving the installation of additional remedial components for portions of the plume that are not currently being addressed by the existing LF-1 ETI system. The AFCEE issued a Proposed Plan in December 2005, which identified Alternative 5 (Status Quo - continued operation and monitoring of the existing ETI system (with the installation of a sixth extraction well along the *southern plume boundary) with institutional controls and the Bourne Water provision)* as the AFCEE's preferred remedial alternative.

The MassDEP concurs with the LF-1 ROD. The MassDEP's concurrence with the LF-1 ROD is based upon representations made to the MassDEP by the AFCEE and assumes that all information provided is substantially complete and accurate. Without limitation, if the MassDEP determines that any material omissions or misstatements exist, if new information becomes available, or if conditions within the LF-1 source area and/or groundwater plume change, resulting in potential or actual human exposure or threats to the environment, the MassDEP reserves its authority under M.G.L. c. 21E, and the MCP, 310 CMR 40.0000 et seq., and any other applicable law or regulation to require further response actions.

Please incorporate this letter into the Administrative Record for the LF-1 source area and groundwater plume. If you have any questions regarding this matter, please contact Leonard J. Pinaud, Chief of Federal Facilities Remediation Section, at (508) 946-2871 or Millie Garcia-Serrano, Deputy Regional Director of the Bureau of Waste Site Cleanup at (508) 946-2727.

Sincerely,

Laurie Burt
Commissioner
Massachusetts Department of Environmental Protection

LB/ljp

LF-1 ROD Concurrence.doc

Cc: DEP - SERO
Attn: Gary S. Moran, Regional Director
Millie Garcia-Serrano, Deputy Regional Director
Leonard J. Pinaud, Chief Federal Facilities Remediation Section
David B. Ellis, Chief Solid Waste Management Section

Distributions: SERO
SMB
Plume Cleanup Team (IRP)
Boards of Selectmen
Boards of Health
Mark Begley, Environmental Management Commission

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APPENDIX B

Transcript of Public Hearing

MASSACHUSETTS MILITARY RESERVATION

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

IN RE:
PROPOSED PLAN FOR
LANDFILL 1 SOURCE AREA AND GROUNDWATER
and
CHEMICAL SPILL 23 GROUNDWATER

PUBLIC HEARING

Handy Hall
Cataumet United Methodist Church
1093 County Road
Cataumet, Massachusetts

HEARING OFFICER: Douglas Karson, AFCEE

Thursday, July 20, 2006
6:00 p.m.

Carol P. Tinkham
Professional Court Reporter
321 Head of the Bay Road
Buzzards Bay, MA 02532
caroltinkham@gmail.com

A T T E N D E E S:

Mike Minter - AFCEE

Katherine Kowalski - Jacobs Engineering

Leonard Eklund - Massachusetts DEP

Paul Marchessault - EPA

P R O C E E D I N G S

MR. KARSON: The official record is now open. We are starting the public hearing for the Proposed Plan for Landfill 1 Source Area and Groundwater and Chemical Spill 23 Groundwater, Fact Sheet 2006-01, June 2006. My name is Douglas Karson, Community Involvement Lead for the Installation Restoration Program at the Massachusetts Military Reservation. I am the hearing officer for tonight.

The floor is now open for public comment. Are there any comments to be offered at this time?

[No response.]

MR. KARSON: Seeing that there are no comments tonight, I shall now close the public hearing for the Proposed Plan for Landfill 1 Source Area and Groundwater and Chemical Spill 23 Groundwater, Fact Sheet 2006-01, June, 2006. The record is now closed. Thank you for coming and have a good evening.

[Whereupon, this matter adjourned.]

C E R T I F I C A T E

COMMONWEALTH OF MASSACHUSETTS

COUNTY OF BARNSTABLE

I, Carol P. Tinkham, a Professional Court Reporter and Notary Public in and for the Commonwealth of Massachusetts, do hereby certify that the foregoing transcript represents a complete, true and accurate transcription of my audiographic recordings taken in the matter of Massachusetts Military Reservation AFCEE Public Hearing on Landfill One Source Area and Groundwater and Chemical Spill 23 Groundwater, heard at Handy Hall on Thursday, July 20, 2006.

Carol P. Tinkham
Notary Public
My Commission Expires
May 14, 2010

PLEASE NOTE: THE FOREGOING CERTIFICATION OF THIS TRANSCRIPT DOES NOT APPLY TO ANY REPRODUCTION OF THE SAME BY ANY MEANS UNLESS UNDER THE DIRECT CONTROL AND/OR DIRECTION OF THE CERTIFYING REPORTER.

APPENDIX C

Bourne Board of Health Well Regulations

TOWN OF BOURNE
BOARD OF HEALTH
24 Perry Avenue
Buzzards Bay, MA 02532

Cynthia A. Coffin
Health Agent

BOURNE BOARD OF HEALTH --- WELL REGULATIONS

Pursuant to Chapter 111, Section 31 of the Massachusetts General Laws, the Bourne Board of Health, at its regular meeting on September 24, 2003, voted to amend the well regulation originally adopted on February 23, 2000, as follows:

1.0 Purpose and Authority

These regulations are intended to protect the public health and general welfare by ensuring that private wells are constructed in a manner which will protect the quality of the groundwater derived from private wells. These regulations are promulgated under Massachusetts General Laws, Chapter 111, Section 31 and supersede all previous regulations adopted by the Board of Health relative to construction of private well.

2.0 Definitions

Agent: Any person designated and authorized by the Bourne Board of Health to execute these regulations. The agent shall have all the authority of the appointing Board and shall be directly responsible to the Board and under its direction and control.

Applicant: Any person who intends to have a private well constructed.

Aquifer: A water bearing geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Agricultural land: Refers to agricultural and horticultural use land as defined in Massachusetts General Laws, Chapter 61A, as follows:

Land shall be deemed to be in agricultural use when primarily and directly used in raising animals, including, but not limited to, dairy cattle, beef cattle, poultry, sheep, swine, horses, ponies, mules, goats, bees and fur-bearing animals, for the purpose of selling such animals or a product derived from such animals in the regular course of business; or when primarily and directly used in a related manner which is incidental thereto and represents a customary and necessary use in raising such animals and preparing them or the products derived therefrom for market.

Land shall be deemed to be in horticultural use when primarily and directly used in raising fruits, vegetables, berries, nuts and other foods for human consumption, feed for animals, tobacco, flowers, sod, trees, nursery or greenhouse products, and ornamental plants and shrubs for the purpose of selling such products in the regular course of business; or when primarily and directly used in raising forest products under a program certified by the state forester to be a planned program to improve the quantity and quality of a continuous crop for the purpose of selling such products in the regular course of business; or when primarily and directly used in a

related manner which is incidental thereto and represents a customary and necessary use in raising such products and preparing them for market.

Bentonite Grout: A mixture of bentonite (API Standard 13A) and water in a ratio of not less than one pound of bentonite per gallon of water.

Casing: Impervious durable pipe placed in a boring to prevent the walls from caving and to serve as a vertical conduit for water in a well.

Certified Laboratory: Any laboratory currently certified by the Department of Environmental Protection for drinking water analysis.

Irrigation Well: Well used for the sole purpose of watering or irrigation. These shall not be connected at any point in time to a dwelling or a building unless they meet the requirements of a Private Drinking Water Well and have the Board's written approval.

Person: An individual, corporation, association, trust, or partnership.

Potable Water Supply: A water supply of sufficient quantity and pressure to meet the needs of the occupants of the dwelling, lot or building, connected with a public water supply or with any other source that the Board of agent has determined, by requiring the water to be tested, does not endanger the health of any potential user and is fit for human consumption.

Private Well: Any dug, driven, or drilled hole, with a depth greater than its largest surface diameter developed to supply water intended and/or used for human consumption and not subject to regulation by 310 CMR 22.00.

Pumping Test: A procedure used to determine the characteristics of a well and adjacent aquifer by installing and operating a pump.

Registered Well Driller: Any person registered with the Department of Environmental Management/Office of Water Resources to dig or drill wells in the Commonwealth of Massachusetts.
Static Water Level: The level of water in a well under non-pumping conditions.

3.0 WELL CONSTRUCTION PERMIT

The property owner or his designated representative shall obtain a permit from the Board of Health prior to the commencement of construction of a private well.

Each permit application to construct a well shall include the following:

1) the property owner's name and address, and mailing address, if different.
2) the well driller's name and proof of valid state registration
3) a plan with a specified scale, signed by a registered surveyor or engineer, showing the location of the proposed well in relation to existing structures, with setbacks to any existing leaching facilities, septic tanks, cesspools. Said plan is also to include lot lines, roadways, underground storage tanks, surface and subsurface drains, landfills within 400 feet, and any agricultural use land which may contain the storage of animal waste.
4) a permit fee of $20.00

Each permit shall expire one year from the date of issuance unless revoked. Well construction permits are not transferable.

4.0 WATER SUPPLY CERTIFICATE

The issuance of a Water Supply Certificate by the Board of Health shall certify that the private well may be used as a drinking water supply. A Water Supply Certificate must be issued for the use of a private well prior the issuance of an occupancy permit for any new structure, or for the continued occupancy of an existing structure when a replacement well is installed.

The following shall be submitted to the Board of Health to obtain a Water Supply Certificate:

1) a well construction permit
2) a copy of the Water Well Completion Report, as required by the DEM Office of Water Resources (313 CMR 3.00)
3) a copy of the Pumping Test Report required pursuant to Section 6 of these regulations
4) a copy of the Water Quality Report required pursuant to Section 7 of these regulations.

5.0 WELL LOCATION AND SETBACK REQUIREMENTS

In establishing the location of a new well, the design engineer and/or well drill shall identify in writing on the plan as known sources of potential contamination (e.g. agricultural fields, animal feed lots, active or closed landfills, any establishments handling hazardous materials within 400 feet of the proposed well.

The following minimum lateral distances from potential contamination sources shall apply:

Potential Source of Contamination	Minimum Lateral Distance(feet)
leaching facility, cesspool	100
septic tank	50
sewer line	50
property line	25
public or private way, common drive	25
active or closed landfill	400
hazardous waste spill site	400
underground storage tank(outside dwelling)	200
stable/ manure storage	100
storm drains, leaching catch basins	50
dwelling unit	25

2) No well will be allowed to be constructed, for human consumption or irrigation, if its placement is known to be over a know plume of contamination or in the direct path of an advancing plume of contamination.

3) No well, private or public, will be allowed to be constructed, for human consumption, if its placement is hydraulically down-gradient of the Bourne Integrated Solid Waste

Management Facility consisting of approximately 103 acres located at 201 MacArthur Boulevard, Bourne, as delineated on the Town of Bourne Assessor's maps as map 28, parcel 13 and map 32, parcel 9. Said down-gradient area shall be delineated by the particle tracking maps created by the United States Geological Survey (USGS) on file with the Board of Health office.

4) The Board of Health reserves the right to impose minimum lateral distance requirements from other potential sources of contamination not listed above. The Board of Health may grant a variance to the minimum lateral distance requirements. See Section 11 on Variances.

6. WATER QUANTITY REQUIREMENTS

The applicant shall submit to the Board for review and approval a Pumping Test Report. The Pumping Test Report shall include the name and address of the well owner, well location referenced to at least two permanent structures or landmarks, date the pumping test was performed, depth at which the pump was set for the test, location for the discharge line, static water level immediately before pumping commenced, discharge rate and, if applicable, the time the discharge rate changed, pumping water levels and respective times after pumping commenced, maximum drawdown during the test, duration of the test, including both the pumping time and the recovery time during which measurements were taken, recovery water levels and respective times after cessation of pumping, and reference point for all measurements. In order to demonstrate the capacity of the well to provide the Required Volume of water, a pumping test shall be conducted in the following manner:

1) The volume of water necessary to support the household's daily need shall be determined using the following equation:(number of bedrooms plus one bedroom) x (110 gallons per bedroom) x (a safety factor of 2) = number of gallons needed daily.

2) The storage capacity of the well shall be determined using the measured static water level and the depth and radius of the drillhole or casing.

3) The Required Volume shall be calculated by adding the volumes of water in (1) and (2) above. It is this volume of water that must be pumped from the well within a 24 hour period. The pumping test may be performed at whatever rate is desired. Following the pumping test, the water level in the well must be shown to recover to within eighty-five (85) percent of the prepumped static water level within a twenty-four (24) hour period.

7.0 WATER QUALITY TESTING REQUIREMENTS

After the well has been completed and disinfected, and prior to using it as a drinking water supply, a water quality test shall be conducted.

A water sample shall be collected either after purging three well volumes or following the stabilization of the pH, temperature and specific conductance in the pumped well. the water sample to be tested shall be collected at the pump discharge or from a disinfected tap in the pump discharge line. In no event shall a water treatment device be installed prior to sampling.

The water quality test, utilizing an applicable US EPA approved method for drinking water testing shall be conducted by an EPA or Massachusetts certified laboratory and shall include

analysis for the following parameters and the results shall not exceed Massachusetts drinking water standards for public water supplies:

Ammonia	Manganese
Chlorine	Nitrate
Coliform Bacteria	Nitrite
Color	Odor
Conductivity	pH
Copper	Potassium
Hardness	Sodium
Iron	Sulfate
Lead	Total Dissolved Solids
Magnesium	Zinc

A copy of the certified laboratory's test results must be submitted to the Board of Health. The report should include the name of the individual who performed the sampling and where in the system the sample was obtained.

The Board of Health reserves the right to require retesting of the above parameters, or testing for additional parameters when, in the opinion of the Board, it is necessary due to local conditions or for the protection of the public health, safety, and welfare. All costs and laboratory arrangements for the water testing are the responsibility of the applicant.

The Board recommends that testing for coliform, nitrites, nitrates, and lead be conducted annually and that testing for all other compounds be done every ten years or sooner if there are compelling reasons.

8. WELL CONSTRUCTION REQUIREMENTS

Pursuant to 313 CMR 3.0, no person in the business of digging or drilling shall construct a well unless registered with the Department of Environmental Management/Office of Water Resources.

A physical connection is not permitted between a water supply which satisfies the requirements of these regulations and another water supply that does not meet the requirements of these regulations without prior approval of the Board.

All private water supply wells shall be designed such that the materials used for the permanent construction are durable in the specific hydrogeologic environment that occurs at the well site. No unsealed opening will be left around the well that could conduct surface water or contaminated groundwater vertically to the intake portion of the well or transfer water from one formation to another. During any time that the well in unattended, the contractor shall secure the well in a way as to prevent either tampering with the well or the introduction of foreign material into the well.

All water used for drilling, well development, or to mix a drilling fluid shall be obtained from a source which will not result in contamination of the well or the water bearing zones penetrated by the well. All drilling fluids shall be non-toxic.

The construction of injection wells for liquid waste disposal shall be prohibited.

9. DISINFECTION

All private wells shall be disinfected following construction, rehabilitation, and well or pump repair before the well is placed in service. The well shall be pumped to waste until the water is clear as possible. Thereafter, the well and the pumping equipment shall be disinfected with a solution containing at least 50 parts per million of chlorine. The well shall remain in contact with the chlorine solution for a minimum of 24 hours (DEP reg stated two hours) before the well is pumped to waste and the water is found to be free of chlorine.

10. DECOMMISSIONING REQUIREMENTS

Abandoned wells, test holes, and borings shall be decommissioned so as to prevent the well, including the annular space outside the casing, from being a channel allowing the vertical movement of water. A Certificate of Destruction shall be issued and kept on file by the Board of Health.

Abandoned wells, test holes, or borings shall be either sealed with non-hazardous, impervious materials which shall be permanently in place with all exposed casing materials, pumping equipment, and distribution lines removed with the excavation returned to the existing grade of the surrounding land or sealed with a welded cap so as to prevent surface water or contaminants from entering the well.

The following information shall be submitted with each well destruction application, prior to issuance of a well destruction permit:

The location of the well to be destroyed shown on a plot plan, the design and construction of the well to be destroyed, and a written statement from the property owner that the well is abandoned.

Within 30 days after the destruction of any well, the well driller shall submit to the Board of Health a report containing the following information:

The date of destruction of the well, the name and address of the owner of the well, the address of the property served, the method of sealing and materials used, and the person/persons sealing the well.

The well driller shall sign this report and this report will constitute a statement of compliance with all requirements of these regulations. This signed report will satisfy the requirements of the Certificate of Destruction.

11. VARIANCES

The Board may grant a variance to the application of these regulations with respect to any particular case when, in its opinion, the enforcement thereof would do manifest injustice, and the applicant has proven that the same degree of public health and environmental protection required under these regulations can be achieved without strict application of a particular provision.

Variance requests shall be in writing to the Board and shall include all the information/reasons and proposed measures necessary to assure the protection of the public health and environment.

Notice of the hearing shall be given by the applicant at least 10 days prior to the hearing date by certified mail to all abutters of the property upon which the private well is to be located. The variance request will appear on the agenda of the next regularly scheduled meeting of the Board. Any grant or denial of a variance shall be in writing and shall contain a brief statement of the variance sought and the reasons thereof.

12. PENALTIES

Any person who violates any provision of these regulations, or who fails to comply with any Order by the Board, for which a penalty is not otherwise provided in any of the General Laws shall be subject to a fine of not less than $25.00 nor more than $250.00. Each day's failure to comply with an Order shall constitute a separate violation.

13. SEVERABILITY

If any provision of this regulation is declared invalid by a court of competent jurisdiction, such invalidity shall not affect any remaining provisions of this regulation. Any part of these regulations subsequently invalidated by a new state law or modification of an existing state law shall automatically be brought into conformity with the new or amended law and shall be deemed to be effective immediately.

14. DISCLAIMER

The issuance of a well permit shall not be construed as a guarantee by the Board of its agents that the water system will function satisfactorily nor that the water supply will be of sufficient quality or quantity for its intended use.

Bourne Board of Health,

Steven A. MacNally, Chairman
Michael S. Giancola, Vice-Chairman
Bob Collett, Secretary
Joseph Gordon
Galon Barlow, Jr.

Effective date: April 13, 2000

Amended date: September 24, 2003

Amended by,

Steven A. MacNally, Chairman
Joseph Gordon, Vice-Chairman
Kathleen Peterson, Secretary
Donald Uitti

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APPENDIX D

Falmouth Board of Health Water Well Regulations

Falmouth Board of Health

Water Well Regulations

Purpose

The Falmouth Board of Health recognizes that certain areas of the groundwater aquifer beneath Falmouth have been contaminated by activities associated with the Massachusetts Military Reservation and others, and that not all areas of groundwater contamination have been identified. There are risks associated with exposure to these contaminants through direct ingestion, dermal contact, inhalation, irrigation of food crops, or watering of animals that are later to be consumed.

In order to protect the public from exposure to potentially contaminated groundwater, the Falmouth Board of Health adopts the following regulations for the permitting, installation and use of water wells, under the authority of Massachusetts General Laws Chapter 111, Section 30.

The testing requirements herein reflect prudent means of minimizing, but not eliminating the risk from exposure to groundwater contamination. Persons withdrawing water for drinking or irrigation are encouraged to stay informed about newly identified contaminants that may be contained in the groundwater they use, and to exercise prudence in all aspects of water withdrawal.

Section 1. Definitions:

A. Drinking Water Well - Any private source of groundwater for human use, including but not limited to, a source approved for such by the Falmouth Board of Health or Massachusetts Department of Environmental Protection (DEP) in accordance with MGL 11 sec 122A or 310 CMR 22.00.

B. Irrigation Well - Any water supply well not approved as a drinking water supply used for the watering of plants and livestock or for commercial or industrial use.

C. Monitoring Well - A well installed for the expressed purpose of monitoring water quality or water level in an area. Excluded from these requirements are wells less than twenty feet deep used for purposes of determining groundwater elevations associated

with the installation of a septic system and which are removed at the time of septic system installation or when they are no longer needed.

D. Volatile Organic Compounds - The class of organic compounds detected and quantified using United States Environmental Protection Agency (EPA) Methods 502.2, 502.4, 624.0, and 625 and 504 (modified for the analysis of Ethylene Dibromide (EBD) to a detection limits of 0.02 ug/l or 2.0 parts per billion).

Section 2. Permits Required:

A permit from the Board of Health shall be required for the installation and use of all wells, including Drinking Water Wells, Irrigation Wells, and Monitoring Wells within the Town of Falmouth. A permit granted under these regulations will that is not exercised within one year may be renewed annually for up to two additional years.

A) Drinking Water Well - A permit application for a Drinking Water Well shall include: a plan of the lot on which the Drinking Water Well is to be located showing the location of any septic systems within 150 ft of the proposed well, the location of the house or any permanent structures (existing or proposed), and a description of the proposed well that includes the location, construction material, anticipated depth of the well, and the maximum anticipated withdrawal rate in gallons per minute. The application shall also include proof that all abutters within 100 feet of the property line have been notified by receipted mail using a form of letter approved by the Board of Health. In the case of new construction, well location and description may be shown on the same plan submitted under the requirements for the Board of Health approval of the septic system. Replacement of a Drinking Water Well within 5 feet of the original location shall not require a permit under these regulations.

B) Irrigation Well - A permit application for an Irrigation Well shall include a plan of the lot on which the Irrigation Well is to be located that shows the location of any septic systems or water supply wells within 150 ft of the proposed Irrigation Well, the location of the house or any permanent structure(s) (existing or proposed), and a description of the proposed well that includes the location, construction material, anticipated depth of the well, an the maximum anticipated withdrawal rate in gallons per minute and all proposed faucets and discharge points. This permit does not relieve the applicant from being

required to secure any and all additional permits that may be required by the State under the Water Management Act or any other pertinent regulation.

C) Monitoring Well - A permit for a Monitoring Well shall include an exact location at which the Monitoring Well is to be located in degrees latitude and longitude, a description of the Monitoring Well that includes the construction material and depth, a statement of purpose for which the Monitoring Well is being installed and its proposed length of service. The name, address, and telephone number of a contact person shall be included in the application. Permits for monitoring wells shall be granted for a period requested or any period deemed appropriate by the Board of Health.

Section 3. Requirements for use.

A. Drinking Water Wells - All Drinking Water Wells shall be located: 1) to maintain a minimum lateral distance from the well to the nearest septic system of 100 ft., 2) to provide minimum risk of exposure to contamination from any known or suspected source, and 3) so that they do not infringe upon the ability of adjacent property owners to locate septic systems. No Drinking Water Well shall be physically connected with a public water supply line. A Drinking Water Well must tested for coliform, nitrate-nitrogen, and volatile organic compounds and found to be within potable water limits as defined in 310 CMR 22.000 Drinking Water Regulations and must not exceed the Commonwealth of Massachusetts' Maximum Contaminant Levels. The Board of Health, by this regulation reserves the right to require more extensive testing in areas of known or suspected contamination. A Drinking Water Well shall not be used until an as-built plan and the results of all required testing have been submitted and approved by the Board of Health.

B) Irrigation Wells - Irrigation Wells shall be located: 1) to maintain a minimum lateral distance from the well to the nearest septic system of 50 ft, 2) a minimum of 50 ft. from a lot line, and 3) to provide minimum risk of exposure to contamination from any known or suspected source. No irrigation well shall be physically cross-connected with the plumbing of either a drinking water well or a public water supply line. All irrigation well spigots shall be placarded with a notice that reads "Irrigation Well - Not for Drinking Water Purposes". Spigots for Irrigation Wells shall not be attached to a residence. An Irrigation Well shall not be used until: 1) an as-built plan and the results of all required testing have been submitted and approved by the Board of Health, and 2) A notice of the

existence and location of an irrigation well shall be recorded with the Barnstable County Registry of Deeds. In areas of known or suspected contamination, such as exist in certain areas near the Massachusetts Military Reservation, initial tests of Irrigation Wells for volatile organic compounds shall be required prior to use. Irrigation Wells must not exceed the Maximum Contaminant Levels set forth in 310 CMR 22.00 for volatile organic compounds referred to in section 1D.

C) Monitoring Wells - All Monitoring Wells shall have a locking cap or other device or structure to prevent unlawful use or entry. Caps shall be secure at all times when the well is not in use.

Section 4. Conversion of Irrigation Wells:

Water from an Irrigation Well shall not be used as a drinking water well until it is demonstrated that: 1) the water meets all the requirements of potability (Section 3A) ; 2) the well meets all the requirements of a Drinking Water Well relative to setbacks from septic systems and other potential sources of contamination; 3) the use of a well for such purposes shall not infringe upon the rights of all adjacent property owners to construct or replace their septic systems, and; 4) the well is permitted as a Drinking Water Well.

Section 5. Abandonment of Wells

A) Drinking Water Wells - A Drinking Water Well may be abandoned by: 1) Downgrading it to the classification of an Irrigation Well, or 2) Permanently taking it out of service by disconnecting it from the residential drinking water system and sealing it with concrete followed by notice and inspection by the Falmouth Board of Health. Downgrading a Drinking Water Well to an Irrigation Well requires that the well meet all the requirements denoted in Section 3 B.(Irrigation Wells).

B) Irrigation Well - An Irrigation Well may be abandoned by filling the entire pipe volume with concrete, followed by a notice and inspection by the Falmouth Board of Health and recording said abandonment with the Registry of Deeds.

C) Monitoring Well - A Monitoring Well may be abandoned by filling the entire pipe volume with concrete, followed by a notice and inspection by the Falmouth Board of Health, or removal of the entire length of pipe from the ground.

Section 6. Enforcement

This regulation will be enforced by the Board of Health under the authority granted it under MGL Chapter 111, Section 30.

These regulations are adopted on September 13, 1999 and become effective on the date of publication:

Dr. Albert Price, Chairman

Robert Chausse

Robert Chausse

George Heufelder

Arthur Vidal III

John Waterbury

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