Massachusetts Military Reservation

PLUME RESPONSE PROGRAM

Final Record of Decision for Chemical Spill-23 Groundwater

September 2007

Prepared for:
AFCEE/MMR
Installation Restoration Program
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Otis ANGB, MA 02542

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05 October 2007

Mr. Jonathan S. Davis
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HQ AFCEE/MMR
322 East Inner Road
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SUBJECT: Contract F41624-03-D-8605
MMR Plume Response Program
TO 0002 DCN/PROJECT # A4P-J23-35BC02VA-M26-0008
Final Record of Decision for Chemical Spill-23 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)

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ACRONYMS AND ABBREVIATIONS

AFCEE	Air Force Center for Engineering and the Environment
ANGI	Air National Guard Instruction
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
CS	Chemical Spill
CFR	Code of Federal Regulations
COC	contaminant of concern
COPC	chemical of potential concern
DAD	dermally absorbed dose
DOD	U.S. Department of Defense
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ETI	extraction, treatment, infiltration
FFA	Federal Facility Agreement
FS	feasibility study
ft msl	feet mean sea level
GAC	granular activated carbon
HEAST	Health Effect Assessment Summary Table
HI	hazard index

ACRONYMS AND ABBREVIATIONS

HQ	hazard quotient
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
lb	pound
LF-1	Landfill-1
LUC	land use control
LTM	long-term monitoring
M	million
MassDEP	Massachusetts Department of Environmental Protection
MCL	maximum contaminant level
mg/kg-day	milligrams per kilogram per day
MMR	Massachusetts Military Reservation
MPP	Mashpee Pitted Plain
NCP	National Oil and Hazardous Substances Contingency Plan
NGB	National Guard Bureau
NPL	National Priorities List
O&M	operations and maintenance
OU	operable unit
PCT	Plume Cleanup Team
PP	Proposed Plan
PRG	preliminary remediation goal
RAO	remedial action objective
RfD	reference dose
RI	remedial investigation
RME	reasonable maximum exposure

ACRONYMS AND ABBREVIATIONS

ROD	Record of Decision
SF	slope factor
SPEIM	system performance and ecological impact monitoring
TCE	trichloroethene
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, and Sandwich, and abuts the town of Falmouth. The MMR is listed on the National Priorities List (NPL) as Otis Air National Guard/Camp Edwards in Falmouth, Massachusetts. This Record of Decision (ROD) addresses groundwater contamination associated with Chemical Spill (CS)-23. 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 CS-23 groundwater contamination, which was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act, and to the extent practicable, the National Oil and Hazardous Substances Contingency Plan (NCP). This decision is based on the Administrative Record for this site. The CS-23 groundwater contaminant plume is detached from its source; several investigations of upgradient areas did not identify a source for the plume (AFCEE 2005). Therefore, this ROD will only address groundwater contamination.

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 and welfare and/or the environment from actual or threatened releases of hazardous substances into the environment.

1.4 DESCRIPTION OF SELECTED REMEDY

The selected remedy for CS-23 groundwater contamination provides for active treatment of the plume with an extraction, treatment, and infiltration (ETI) system. The objective of this remedy is to operate, maintain, and optimize the existing ETI system to expedite aquifer restoration. The Air Force Center for Engineering and the Environment (AFCEE) began designing a remediation system to prevent further off-base migration of the CS-23 plume concurrently with the feasibility study (FS). In December 2006, the ETI system began operation. Land use controls (LUCs) will be implemented as part of the remedy to reduce potential residential exposure to the CS-23 plume.

The ETI process consists of extraction, treatment, and infiltration of contaminated groundwater in accordance with federal and state standards for the CS-23 contaminants of concern (COCs) and the remedial action objectives (RAOs) outlined in the *Final Chemical Spill-23 Plume Feasibility Study* (AFCEE 2006c). The remedy leaves open the possibility of modifying the treatment system to optimize the achievement of the RAOs. If required, modifications would most likely be implemented using existing extraction wells, and could involve modification of the extraction screen interval using isolated packers, or adjusting flow rates. The possibility of adding system components, such as additional extraction wells, will also be considered should system performance assessment indicate the need for additional points of extraction. Modifications would be made for the purpose of improving treatment system operation and expediting plume cleanup.

This remedy would also provide for chemical and hydraulic monitoring of the plume as long as active remediation continued. After the benefits of active ETI operation have

been realized relative to expediting plume cleanup, AFCEE, with regulatory input, will cease operation of the ETI system and will continue to monitor residual contamination until the RAOs have been met. Monitoring of the plume will be conducted as part of the system performance and ecological impact monitoring (SPEIM) program. This remedy provides flexibility to modify the monitoring network to adequately monitor the CS-23 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 an evaluation of the technical and economic feasibility of additional remediation to approach background concentrations will be performed if deemed necessary.

1.5 STATUTORY DETERMINATIONS

The selected CS-23 groundwater remedy is protective of human health and the environment, complies with federal and Commonwealth of Massachusetts requirements that are applicable or relevant and appropriate requirements (ARARs) for the remedial action, utilizes permanent solutions to the maximum extent possible, and is cost-effective. The remedy also satisfies 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 aquifer for a number of years at levels above those allowed for unlimited use and unrestricted exposure, five-year reviews will be conducted to ensure that the remedy continues 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.	Sections 2.5.1, 2.7.5, and Table 2-1
Baseline risk represented by the COCs.	Section 2.7
Cleanup level established for the COC and the basis for this level.	Section 2.8
How source materials constituting principal threats have been addressed.	Not Applicable – Source Area Undefined (see Sections 2.4 and 2.5.1)
Current and reasonably 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.	Sections 2.8, 2.11.4
Estimated annual and total present value costs, discount rate, and the number of years over which the remedy cost estimate is projected.	Section 2.11.3 Tables 2-17 and 2-18
Key factor(s) that led to selecting the remedy.	Sections 2.10.2, 2.12

1.7 AUTHORIZING SIGNATURES

The foregoing represents the decision for remedial action for CS-23 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

2.0 DECISION SUMMARY

The following sections describe the setting, potential risks, remedial action objectives, and alternative evaluation for remediation of the CS-23 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. CS-23 is located on the west-southwest side of the MMR (Figures 2-1 and 2-2). The CS-23 groundwater plume was identified as Operable Unit (OU) 25, Chemical Spill-23 in the EPA database.

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

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

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, 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 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 the CS-13 site was removed 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.

Wide varieties of investigations, removal actions, and remedial actions have been and are currently being conducted at the MMR.

The contamination that initially indicated the presence of a groundwater contaminant plume in the CS-23 area (Figure 2-3) (between the CS-21 and the Landfill-1 [LF-1] plumes) was detected during the CS-4, CS-20, CS-21, and Fuel Spill-29 pre-design investigation (AFCEE 2003b). Monitoring well 69MW1531 was sampled in September 2000 and January 2001; 17 micrograms per liter (µg/L) and 13 µg/L of trichloroethene (TCE), respectively (AFCEE 2003a), which is above the TCE maximum contaminant level (MCL) of 5 µg/L, were found in the groundwater samples from 69MW1531. Based on these results, an investigation of the TCE detections at 69MW1531 (AFCEE 2002), which is outside the delineations of the adjacent plumes (LF-1, CS-10, CS-21), was conducted in 2001 and 2002 and included additional drilling and groundwater sampling. The results of the investigation indicated that the pattern of TCE detections in groundwater outside the adjacent plumes originated from an on-base source located somewhere between the eastern side of the LF-1 plume and the western side of the CS-10 plume (AFCEE 2002). It was also determined that the TCE detections above the MCL in the groundwater were not related to adjacent groundwater plumes LF-1 and CS-21.

TCE was discovered at 69MW1701 in 2001, and as a result, a drilling and groundwater sampling investigation was planned and conducted in 2002. The results indicated a mappable area of TCE concentrations above the MCL. This area was identified as a plume and named the CS-23 plume. The investigation determined that the CS-23 plume is a separate body of contamination distinct from the CS-10, LF-1 and CS-21 plumes based on available contaminant data and the known hydrogeological regime (AFCEE 2003c). Based on the results of the CS-23 plume investigation, a remedial investigation (RI) was performed (AFCEE 2005).

The CS-23 RI field work, conducted in 2003 and 2004, consisted of drilling and installation of monitoring wells at eight locations. Groundwater screening was conducted at all eight locations, lithologic characterization and grain-size analyses were conducted at two drilling locations. A total of 32 monitoring wells were sampled for volatile organic compounds (VOCs), ethylene dibromide, semivolatile organic compounds, total metals, perchlorate, and explosives. Results from monitoring wells sampled for the LF-1 and CS-10 SPEIM programs, within and around the CS-23 study area were also evaluated. A synoptic water level survey, consisting of measurements taken at three staff gauges and 72 monitoring wells and piezometers, was conducted in June 2004.

As part of the CS-23 RI, the CS-23 conceptual model was refined and is presented in Section 2.5.1. The results of the contaminant fate and transport assessment and groundwater modeling indicate that if no action is taken, the bulk of the CS-23 plume will advect downgradient and disperse before reaching Buzzards Bay. In support of reaching a final ROD for CS-23, a risk assessment was performed using data collected as part of the ongoing SPEIM program to characterize the current plume and assess potential risks from exposure to the groundwater in the CS-23 plume area. The baseline human health risk assessment (summarized in Section 2.7) indicated there was potential future risk to human health due to exposure to contaminated groundwater. Based on the risk assessment, RAOs were established. Recommendations of the RI included proceeding with an FS, proceeding with a pre-design investigation, and the design and

construction of an on-base groundwater ETI system to reduce further migration of the CS-23 plume downgradient.

The CS-23 pre-design investigation for an on-base groundwater ETI system was conducted in late 2004 and early 2005. Groundwater screening and monitoring well installation was conducted at four locations; lithologic characterization and grain-size analysis was conducted at two drilling locations. The results of the investigation, including a revised plume outline and plume shell, are presented in the *Final Chemical Spill-23 Wellfield Design Report* (AFCEE 2006a).

With approval from the EPA and MassDEP, no screening of remedial technologies or screening of remedial alternatives was conducted, resulting in a streamlined approach for the CS-23 FS. The FS evaluated a short list of five remedial alternatives, which were developed with input from the EPA, MassDEP and the Plume Cleanup Team (PCT) (AFCEE 2006c). Since the FS was completed, the Air Force has designed, constructed and operated (initiated December 2006) the base boundary ETI system represented by the preferred alternative.

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, notifications are placed in local newspapers to announce significant events and meetings, news releases are issued, tours of the sites and treatment facilities are conducted, neighborhood notices are distributed to notify people of events impacting their neighborhoods, and public notices of other kinds are issued.

In addition, several citizen teams advise the IRP and the regulatory agencies about the program. They include the Senior Management Board and the PCT. These teams are made up of citizen volunteers and government representatives working together to resolve problems and complete the cleanup. 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 by these teams, in addition to regular updates on the operation and maintenance of treatment systems in place.

The public has been kept up-to-date on the progress of the CS-23 plume through various public and citizen team meetings and public notices. The following updates on the progress for CS-23 addressed in this ROD were presented to the PCT:

- 10 September 2003: Overview of the *Final Streamlined Chemical Spill-23 Plume Remedial Investigation Work Plan* (AFCEE 2003a).
- 12 January 2005: Overview of the *Final Chemical Spill-23 Remedial Investigation* (AFCEE 2005).
- 13 April 2005: Overview of the initial CS-23 remedial alternatives for the FS.
- 14 September 2005: Overview of the CS-23 FS results.
- 14 June 2006: Proposed Plan (PP) for LF-1 Source Area and Groundwater and CS-23 Groundwater (AFCEE 2006b).
- 12 July 2006: PCT input on PP for LF-1 Source Area and Groundwater and CS-23 Groundwater.

On 14 June 2006, a presentation of the combined LF-1 and CS-23 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 to the public. 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 combined LF-1 source area and groundwater and CS-23 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.

On 16 June 2006, AFCEE published notifications of the public information meeting, public comment period, and the public hearing for the CS-23 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 CS-23 site consists of one OU, focusing on groundwater. The CS-23 plume is a detached plume; the source of which has not been identified (AFCEE 2005). This ROD addresses the groundwater OU; therefore, only the contamination in the groundwater is considered.

The CS-23 area is located along the west-southwestern 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 CS-23 site) as part of the Impact Area Groundwater Study Program.

2.5 SITE CHARACTERISTICS

As described in the CS-23 RI report (AFCEE 2005), environmental data has been collected from the CS-23 area since 1998. This overview of the site characteristics will focus on current site conditions.

The CS-23 plume is located within, or adjacent to, three geomorphic domains. The northeastern portion of the CS-23 plume is primarily located within the Mashpee Pitted Plain (MPP), and the southwestern portion of the plume is within and beneath the Buzzards Bay Moraine (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. Moraines bound the MPP to the west and north. 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 till overlying stratified sands and silty glaciolacustrine sediment. A few kettle ponds are located within the Buzzards Bay Moraine. Beneath these morainal sediments, a variable thickness of till overlies the bedrock.

In the CS-23 plume area, there are silty deposits in the lower sections of the aquifer where hydraulic conductivities are lower than in the higher sections of the aquifer, and some plume contaminants are restrained. Several of these silty glaciolacustrine deposits have been identified in the downgradient portion of the mapped CS-23 plume. Below the silty lacustrine deposits, one generally finds bedrock. In some places, a poorly sorted till can be found overlying 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 generally 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 primarily horizontal with stronger vertical gradients near surface water bodies. Kettle ponds are generally an expression of the water table and are hydraulically connected with the aquifer. Groundwater enters the upgradient portion of the pond, resides in the pond as surface water, and exits as groundwater 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 generally 55 ft msl near the upgradient portion of the CS-23 plume and approximately 35 ft msl near the leading edge. Because the ground surface elevations range from 145 to 53 ft msl, depth to water throughout the area is highly variable. The aquifer thicknesses range from 160 to 230 feet due to the variability in the bedrock surface.

2.5.1 Conceptual Site Model

The CS-23 plume is assumed to be a detached plume; its source remains unidentified (AFCEE 2005). It is believed that contamination leached from the source, was dissolved in the aquifer at the water table, and was carried downgradient with the general groundwater flow in a southwesterly direction.

The area around the CS-23 plume on-base consists primarily of a housing area operated by the USCG. Southwest of the housing area, between the base boundary and Route 28, is the Crane Wildlife Management Area, which is undeveloped and is used for recreational purposes (hiking, biking, hunting, etc.). West of Route 28, the area is primarily residential. The CS-23 groundwater plume lies within the surficial geologic units identified as the Mashpee Pitted Plain (MPP) and the Buzzards Bay Moraine (Oldale 2001). The eastern portion of the CS-23 plume is primarily located within the MPP, and the western portion of the plume is within the Buzzards Bay Moraine. The sediments within the area are primarily composed of fine- to coarse-grained sands with some laterally discontinuous fine-grained units, which are generally less than 30 feet thick. The hydraulic conductivity values of the sands comprised mostly of medium- and coarse-grained sands, the largest volumetric percentage of the aquifer, vary from 50 to 110 feet per day. Beneath these sediments, till is occasionally observed overlying bedrock. The total thickness of unconsolidated deposits ranges from 180 to 300 feet. The bedrock surface, and in some places the glacial till, forms the bottom of the groundwater aquifer.

The single groundwater flow system is a sole-source aquifer and is known as the Sagamore Lens. The aquifer thickness varies from 160 to 230 feet depending on the elevation of the bedrock surface, which forms the bottom of the aquifer. The water table is present at the surface to 100 feet below ground surface, reflecting topographic relief and a gentle slope in elevation of the water table. The horizontal gradients vary from 0.0017 to 0.0036 feet per foot, with the steeper horizontal gradient observed in the leading edge of the plume. The vertical component of groundwater flow is very small within the study area. The average groundwater velocity is approximately 1 foot per day

in the aquifer. Groundwater generally flows in a southwest direction in the upgradient portion of the plume and changes to a west-southwest direction at the downgradient portion of the plume.

CS-23 plume contaminants dissolved in the groundwater are transported downgradient with groundwater flow. The CS-23 COCs (TCE and carbon tetrachloride [CCl_4]) are present in the aquifer in the dissolved phase. The TCE concentrations range up to 55 µg/L and CCl_4 concentrations range up to 7.1 µg/L. The fate and transport assessment indicates that the plume is advected and dispersed by groundwater flow, with low retardation, and no biodegradation (AFCEE 2005).

The CS-23 plume is primarily defined by concentrations greater than the TCE MCL (5 µg/L). There is a small portion of the northeastern part of the plume defined by concentrations greater than the CCl_4 MCL (5 µg/L). The plume is approximately 8,600 feet long, with a maximum width of 1,600 feet, and a maximum thickness of 140 feet. The elevation of the top of the plume ranges from 5 ft msl to –120 ft msl, and the deepest elevation of the plume is approximately –165 ft msl, where contamination extends to the bedrock surface. The depth to the top of the plume below the water table (approximately 50 feet) suggests that the plume does not discharge to nearby surface water bodies (i.e., Osborn, Edmunds, and Spit ponds).

2.5.2 Sampling Strategy

Since 2000, when the CS-23 plume was first discovered, groundwater samples have been collected in the CS-23 study area at prescribed frequencies (minimum annual frequency) as part of the SPEIM programs for CS-10, LF-1, and the Southwest plumes. In 2003 and 2004, a total of sixteen monitoring wells were installed in support of the CS-23 plume RI field investigation. Since 2000, a total of 43 wells have been sampled, and 154 samples have been collected.

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 in the vicinity of CS-23 contaminated groundwater, and presents the basis for future groundwater use assumptions.

2.6.1 Land Use

The on-base area of CS-23 groundwater contamination consists primarily of a housing area operated by the USCG. Southwest of the housing area, between the base boundary and Route 28, is the Crane Wildlife Management Area, which is undeveloped and is used for recreational purposes (hiking, biking, hunting, etc.). West of Route 28, the area is primarily residential (Figure 2-2). It is anticipated that the land use in the CS-23 area will not significantly change over time.

2.6.2 Water Resource Use

There are no current groundwater uses at the CS-23 area. All of the residences in the area are connected to the municipal water supply. The aquifer throughout upper Cape Cod, also known as the Sagamore Lens, is generally highly transmissive and is a productive aquifer. The Sagamore Lens has been designated by the MassDEP as drinking water and by the EPA as a sole source aquifer.

Surface water bodies (Edmunds Pond, Osborn Pond and Spit Pond), which are fed by groundwater, provide recreational use. Spectacle Wetland and Vernal Pool No. 651 do not provide recreational use. However, the CS-23 plume is not discharging to any surface water bodies.

AFCEE has developed a working relationship with the water commissioners of the four surrounding towns to ensure that future development of the groundwater resource is coordinated with groundwater monitoring and remediation at the MMR. Groundwater could potentially be utilized as a source of drinking water in approximately 25 to 45 years.

2.7 SUMMARY OF SITE RISKS

The risk assessment estimated the potential future risks posed by the present CS-23 groundwater contamination. 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 Chemical Spill-23 Remedial Investigation* (AFCEE 2005). The risk assessment evaluated the human health risks from exposure to contaminated groundwater in the CS-23 area. An ecological baseline risk assessment was not conducted because the CS-23 plume is not discharging to any surface water bodies.

This section of the ROD summarizes the results of the human health risk assessment and COC selection for CS-23 groundwater. A complete description of the methods and results of the baseline human health risk assessment for CS-23 is presented in the *Final Chemical Spill-23 Remedial Investigation* (AFCEE 2005).

2.7.1 Identification of Chemicals of Potential Concern

The selection of chemicals of potential concern (COPCs) 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 (i.e., iron, magnesium, calcium, potassium, and sodium).

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

PRGs for noncarcinogens were modified (i.e., 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 (PRGs, MCLs, state standards, and guidelines), the lowest of the available criteria was used in the concentration-toxicity screen.

Table 2-1 presents the occurrence and distribution of compounds detected in the CS-23 study area. For each detected chemical, this table includes 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.

2.7.2 Exposure Assessment

The exposure assessment identified potential exposure routes for the site, the pathways by which humans may be exposed to site contamination. No soil exposure pathways were evaluated because the source of the CS-23 plume has not been identified, and the soil in non-source areas is not impacted by groundwater contamination.

Currently, there is no exposure to the CS-23 groundwater plume. Residences overlying the area are connected to the base water supply. However, potential future exposure to CS-23 groundwater was evaluated since it was conservatively assumed that residential use of groundwater could occur anywhere on- or off-base in the future. Since household water use is the exposure pathway with the highest exposure potential, other potential future exposure pathways were not evaluated. Residential exposure routes for the

evaluation included groundwater ingestion, dermal contact, and inhalation of vapors released during household use of groundwater. Migration of vapor-phase VOCs from groundwater through the subsurface soil into a residential dwelling was not evaluated because concentrations of VOCs greater than the MCLs were not detected at depths less than 100 feet. Potential exposure to groundwater was evaluated for both the adult and child receptor scenarios.

The human health conceptual exposure model for the CS-23 plume is presented in Table 2-2. After identifying which human receptors would 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 reasonable maximum exposure (RME) EPCs were the maximum detected concentrations. For metals that were selected based on both dissolved and total concentrations, the EPCs were selected as the higher of the total or dissolved concentration. The EPCs for CS-23 groundwater are presented in Table 2-3.

To quantitatively assess the potential carcinogenic risks and health hazards, daily intakes of the COPCs were calculated based on receptor-specific, site-specific, and chemical-specific exposure parameters. These exposure parameters may 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 dermally absorbed dose (DAD) algorithms are presented for each potential receptor and exposure medium (i.e., adult resident-groundwater, child resident-groundwater) in Tables 2-4 and 2-5.

All of the parameters used in the CDI and DAD equations are presented in these tables, except for some chemical-specific parameters (e.g., dermal absorption factors and other calculated parameters used in the dermally absorbed dose calculations), which are presented in Appendix F of the *Final Chemical Spill-23 Remedial Investigation* (AFCEE 2005).

2.7.3 Toxicity Assessment

At the time the risk assessment was prepared, toxicity values were obtained from EPA's most current versions of the Integrated Risk Information System (IRIS) (EPA 2003) or the Health Effects Assessment Summary Table (HEAST) (EPA 1997), which are databases containing toxicity values for use in quantitative risk assessment. Cancer and non-cancer toxicity factors for each of the COPCs evaluated in the CS-23 risk assessment are presented in the tables listed below:

- Oral/Dermal Non-Cancer Toxicity Factors (Table 2-6)
- Inhalation Non-Cancer Toxicity Factors (Table 2-7)
- Oral/Dermal Cancer Toxicity Factors (Table 2-8)
- Inhalation Cancer Toxicity Factors (Table 2-9).

2.7.4 Risk Characterization

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. 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 a 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 tables from the risk assessment that summarize the cancer and non-cancer risks to each receptor under the RME exposure scenario. 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, CS-23 Groundwater (Table 2-10)
- Future Child Resident, CS-23 Groundwater (Table 2-11)

The cancer risk calculations indicated that future residential exposure to CS-23 groundwater within the plume 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 adult resident and future child resident exposure pathways for CS-23 groundwater are 1E-03 and 2E-04, respectively (Tables 2-10 and 2-11). The non-cancer hazard calculations indicated that residential exposure to CS-23 groundwater inside the plume may present an unacceptable non-cancer hazard with HIs for the future adult resident and future child resident exposure pathways of 5E+00 and 1E+01, respectively (Tables 2-10 and 2-11).

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 was calculated to result in an excess lifetime cancer risk greater than one in a million or an HI greater than 1 are presented in Table 2-12. 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 only at concentrations below state and federal drinking water standards.
- The COPC is equivalent to background.
- The COPC is a common sampling artifact.

In consideration of these criteria, for CS-23 the groundwater COCs are TCE and CCl_4. The contaminant-specific evaluations are presented in the risk assessment (AFCEE 2005).

2.8 REMEDIAL ACTION OBJECTIVES

There is no risk to ecological receptors. Therefore, results of the human health risk assessment for CS-23 groundwater were considered in conjunction with expected current and future use of the aquifer to develop RAOs for the CS-23 groundwater OU.

The following RAOs for the CS-23 groundwater FS were developed to evaluate the alternatives with respect to protecting human health:

- Prevent residential exposure to CS-23 groundwater with TCE concentrations greater than the MCL of 5 µg/L.
- Prevent residential exposure to CS-23 groundwater with CCl_4 concentrations greater than the MCL of 5 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 CS-23 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 MCL for TCE (5 µg/L) and the MCL for CCl_4 (5 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 CS-23 study area indicates that TCE and CCl_4 increase risk and hazards associated with exposure to groundwater.

2.8.2 Steps to Achieving Remedial Action Objectives

MMR groundwater plumes, including the CS-23 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, perform a residual risk assessment(s) to determine if unacceptable ecological and/or human health risks are present; continue system operation and/or pursue additional measures as required to achieve acceptable risks.** AFCEE shall conduct a residual risk assessment(s), if deemed necessary, to determine whether the COCs remaining in the aquifer continue to pose unacceptable ecological and/or human health risks. This risk determination shall be made jointly by AFCEE and the 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, evaluate the technical and economic feasibility of additional remediation to approach or achieve background concentrations.** 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 the EPA, with input from the 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 the EPA in consultation with the 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 CS-23 ALTERNATIVES

Five alternatives were considered for the CS-23 groundwater action: (1) No Action, (2) LUCs and Long-Term Monitoring (LTM), (3) Remediation at the Base Boundary, LUCs and LTM, (4) Remediation at the Base Boundary and the Leading Edge, LUCs and LTM, and (5) Remediation at the Base Boundary, the Leading Edge, and within the Upgradient Portion of the Plume, LUCs and LTM.

A component common to Alternatives 2, 3, 4, and 5 is LUCs. Several LUCs protect area residents from exposure to CS-23 groundwater contamination. 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 CS-23 plume are currently connected to town water. The off-base LUCs include the Town of Falmouth regulating installation of private wells to reduce potential residential exposure to contaminated groundwater (Appendix C). The Falmouth Board of Health (BOH) Water Well Regulations do not apply to use of existing drinking water and irrigation wells.

2.9.1 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. Under this alternative, no monitoring would be performed to assess the predicted natural attenuation of the CS-23 plume. TCE and CCl_4 concentrations would eventually reach the cleanup levels through natural attenuation processes, but there would be no monitoring data to confirm this attenuation. Human health would remain protected by virtue of existing LUCs to the degree which they were heeded. AFCEE would not check the adherence to LUCs under Alternative 1.

2.9.2 Alternative 2 – Land Use Controls and Long-Term Monitoring

No active remediation would occur with this alternative. However, unlike Alternative 1, this alternative would provide for LUCs to limit exposure, and LTM of the monitoring wells in the surrounding network. Monitoring and reporting would provide for

- tracking CS-23 plume movement and attenuation, and
- determining when COC concentrations have decreased to below the cleanup levels.

Monitoring would involve periodic testing of groundwater for TCE and CCl_4 to measure the natural attenuation of the plume. Monitoring results would be periodically reported in technical update meetings and formal reports. Groundwater monitoring would continue after the cleanup levels were met to ensure the aquifer had been restored. For cost-estimating purposes, it has been assumed that groundwater monitoring would continue for two years after the cleanup levels are met.

Under this alternative, this plume would be subject to the basewide CERCLA five-year review through the lifetime of the alternative. A residual risk assessment and/or evaluation of the technical and economic feasibility of additional remediation to approach or achieve background concentrations would be conducted, if deemed necessary, and would likely include additional data collection and analysis.

2.9.3 Alternative 3 – Remediation at the Base Boundary with Land Use Controls and Long-Term Monitoring

Alternative 3 provides for continued operation of the ETI system at the base boundary to minimize the migration of above-MCL contamination off-base, implementation of a SPEIM program for monitoring the ETI system, implementation of LTM, and implementation of LUCs (Figure 2-4). The extracted water would be pumped to the Hunter Avenue Treatment Facility for treatment using granular activated carbon (GAC) and returned to the aquifer through two infiltration trenches. Under this alternative, the leading edge of the plume would not be captured. The leading edge of the CS-23 plume underlies a portion of the Crane Wildlife Management Area that the Massachusetts

Division of Fisheries and Wildlife, the agency managing this state-owned land, prefers remain undisturbed.

Part of the SPEIM program evaluates potential optimization of the ETI system; therefore, this alternative has the flexibility of modifying pumping scenarios to optimize system performance. Most likely, modifications to the ETI system could involve the use of packers to reduce the effective vertical extent of the extraction screens, or adjusting flow rates. However, the SPEIM program 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.

This alternative would provide for chemical and hydraulic monitoring of the plume through the SPEIM program, LUCs, LTM for two years after the cleanup levels are met, CERCLA five-year reviews, and a residual risk assessment if deemed necessary.

2.9.4 Alternative 4 – Remediation at the Base Boundary and the Leading Edge with Land Use Controls and Long-Term Monitoring

This alternative builds on Alternative 3 and would provide all the components of Alternative 3 (ETI system at the base boundary, SPEIM, LTM, LUCs, CERCLA five-year reviews and a residual risk assessment), with the addition of an ETI system for the leading edge of the CS-23 plume located in the Crane Wildlife Management Area. This additional leading edge ETI system would also be piped to the existing Hunter Avenue Treatment Facility, with the extracted and treated water returned to the aquifer through the existing reinjection/infiltration system.

2.9.5 Alternative 5 – Remediation at the Base Boundary, the Leading Edge, and Within the Upgradient Portion of the Plume, with Land Use Controls and Long-Term Monitoring

This alternative builds on Alternative 4 and would provide all the components of Alternative 4 (ETI system at the base boundary, ETI system at the leading edge, SPEIM, LTM, LUCs, CERCLA five-year reviews and a residual risk assessment), with the addition of a stand-alone ETI system in the upgradient portion of the plume. This ETI

system would comprise one extraction well located in the Coast Guard housing area on the base to reduce the restoration time frame for the on-base portion of the plume. Water from this extraction well would be treated at a new stand-alone treatment facility and discharged through a new infiltration gallery somewhere on the MMR.

2.9.6 Common Elements and Distinguishing Features of Alternatives

Alternatives 1 and 2 do not actively treat the CS-23 plume. Under both Alternatives 1 and 2, cleanup levels of the CS-23 plume would be reached primarily through natural attenuation. Under Alternatives 2, 3, 4, and 5, COC concentrations within and surrounding the CS-23 plume would be routinely measured, allowing for a check on modeling assumptions and verification of natural attenuation. Alternative 3 would actively treat the CS-23 plume via the existing ETI system. Alternatives 4 and 5 build on Alternative 3. Specifically, Alternative 4 would provide additional leading edge extraction, and Alternative 5 would provide additional leading edge extraction and upgradient extraction. Existing on-base and off-base LUCs would remain under all five alternatives, but under Alternative 1 AFCEE would not enforce or check the adherence to LUCs. Based on modeling predictions, contaminant concentrations would be reduced below the cleanup level by approximately 2055 for Alternatives 1 and 2, by approximately 2048 for Alternatives 3 and 4, and by approximately 2023 for Alternative 5. The performance of the five alternatives with respect to the threshold and primary balancing criteria, and estimated costs for the alternatives are summarized in Table 2-13.

ARAR waivers would not be required with any of the CS-23 plume alternatives. Refer to the *Final Chemical Spill-23 Plume Feasibility Study* (AFCEE 2006c) for a complete listing of ARARs for each alternative and how individual alternatives would comply with them. ARARs for the selected alternative are listed in Tables 2-14, 2-15, and 2-16.

Alternatives 3, 4, and 5 rely on techniques and technologies that have been proven and employed at the MMR since 1997. However, Alternatives 4 and 5 would encounter implementability issues when attempting to gain access in the Crane Wildlife

Management Area. Significant residual risk would not remain with any of the alternatives.

2.9.7 Expected Outcomes of the Alternatives

Groundwater modeling indicates that under Alternatives 1 and 2 most of the plume continues to migrate downgradient, west of Route 28, and naturally attenuates to concentrations below the MCL by approximately 2027 before discharging to Buzzards Bay. Some TCE contamination above the MCL is predicted to persist in a low hydraulic conductivity unit on-base until natural attenuation reduces the concentrations to cleanup levels by approximately 2055. Under Alternative 3, groundwater modeling indicates the contamination downgradient of the existing ETI system will continue to migrate downgradient and naturally attenuate to below the cleanup level just east of Route 28 by approximately 2019. The model predicts that cleanup levels will be reached by 2021 for most of the plume and by approximately 2048 for the entire plume (i.e., the contamination in the upgradient low hydraulic conductivity unit) under this alternative. Under Alternative 4, groundwater modeling indicates that with the downgradient system operating, cleanup levels near the downgradient system are predicted to be reached by 2019. The model predicts that cleanup levels will be reached by 2021 for most of the plume and by approximately 2048 for the entire plume under Alternative 4 (due to contamination in the upgradient low hydraulic conductivity unit). For Alternative 5, the base boundary and leading edge ETI systems are the same as described for Alternatives 3 and 4. Alternative 5 includes the addition of upgradient groundwater extraction. The model predicts that cleanup levels will be reached by 2019 for most of the plume under Alternative 5 and for the entire plume by 2023.

Protection of current human health is afforded by existing on-base LUCs and the Falmouth BOH Water Well Regulations which restrict the installation of private wells for consumption or irrigation. The Falmouth BOH Water Well Regulations do not apply to use of existing drinking water wells and irrigation wells. As part of implementing LUCs in Alternatives 2, 3, 4, and 5, AFCEE will confirm that either the current local ordinance remains in effect or any future remedy remains protective of human health. 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). Potential long-term health risks for the site, determined as part of the risk assessment (Section 2.7), would gradually decrease in time as the plume naturally attenuates in Alternatives 1 and 2. Alternatives 3, 4, and 5 provide more rapid restoration of the aquifer through active treatment.

2.10 COMPARATIVE ANALYSIS OF CS-23 ALTERNATIVES

The following sections summarize the comparative analysis of CS-23 groundwater Alternatives 1, 2, 3, 4, and 5 presented in the *Final Chemical Spill-23 Plume Feasibility Study* (AFCEE 2006c).

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 three alternatives with respect to the threshold and primary balancing criteria is summarized in Table 2-13.

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 A of the *Final Chemical Spill-23 Plume Feasibility Study* (AFCEE 2006c) outlines ARARs for all the CS-23 alternatives. ARARs for the selected alternative are listed in Tables 2-14, 2-15, and 2-16.

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 destruction or removal of contaminants, 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 3.1 and 2.8 percent (per Office of Management and Budget Circular A-94 [OMB 2005]) based on the length of the specific alternative. 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 3.

Community Acceptance The PCT unanimously supports Alternative 3. All of the comments received during the public comment period favored Alternative 3.

2.10.2 Comparison of CS-23 Groundwater Plume Alternatives

Alternatives 1, 2, 3, 4, and 5 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

Potential long-term health risks for the site, determined as part of the risk assessment (Section 2.7), would gradually decrease in time as the plume naturally attenuates in Alternatives 1 and 2. Alternatives 3, 4, and 5 provide more rapid restoration of the aquifer through active treatment. 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 CS-23 plume. Additional protection of human health is afforded by on-base LUCs and the Falmouth BOH Water Well Regulations which prevent the installation of private wells for water consumption or irrigation in areas of groundwater contamination. The Falmouth BOH Water Well Regulations do not apply to use of existing drinking water wells and irrigation wells. Based on current and reasonably anticipated future land use, human health risks are acceptable under all of the alternatives. Therefore, for continuation of the current use of the aquifer, the risk to human health and the environment is the same for all alternatives. However, Alternatives 2, 3, 4, and 5 offer additional assurance that residents and workers will not be exposed to the CS-23 plume through the monitoring of the LUCs.

2.10.2.2 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. Monitoring would be performed under Alternatives 2, 3, 4, and 5 to determine when cleanup goals have been met. All construction, treatment, and monitoring activities would be performed in accordance with location-specific and action-specific ARARs.

2.10.2.3 Long-Term Effectiveness and Permanence

The magnitude of residual risks and the adequacy and reliability of controls are similar for Alternatives 2, 3, 4, and 5; low residual risk because there are no untreated wastes or treatment residuals. Reliability of controls is good for all alternatives.

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 the MCLs and, thus, pose minimal risk.

2.10.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternatives 3, 4, and 5 satisfy EPA's preference that active treatment be a principal element in site remediation. The model predicts that a total of 73 pounds (lb) of TCE is removed under Alternative 3, and 93 lb and 101 lb of TCE are removed under Alternatives 4 and 5, respectively. Contaminants are permanently removed from the aquifer because regeneration of the GAC ultimately destroys the contaminants. The plume volume would decrease due to the extraction and treatment. Alternatives 1 and 2 do not employ active treatment, and under these alternatives, the plume would continue to move west-southwest, the plume volume would expand for a few years, and eventually contaminant concentrations would decrease below the MCLs through natural attenuation. Table 2-13 lists the years when MCLs are expected to be met, based on the model simulations.

2.10.2.5 Short-Term Effectiveness

Alternative 1 has the least impact on workers, the community, and the environment since it does not require any monitoring, construction, or maintenance activities. Alternative 2 has limited impact on workers, the community and environment because it entails groundwater monitoring and monitoring well construction over its lifetime. Even though additional monitoring wells would be required, the risks associated with that work is considered low and would be easily controlled through training, safety procedures, and medical monitoring.

All three active treatment alternatives (Alternatives 3, 4, and 5) include installation of potential new monitoring wells, and system optimization. It is assumed that additional

monitoring wells would be required; however, the risks associated with that work is considered low and would be easily controlled.

Alternative 3 has a similar limited impact as Alternative 2 because the impact is not new; the existing system has been operating since December 2006. Since monitoring is already being conducted under the SPEIM program, there would be no new risks posed to the community, the workers, or the environment as a result of activity under Alternative 3.

Alternatives 4 and 5 have greater impact, with Alternative 5 having the greatest impact since it involves expansion of the existing ETI system (Alternative 4) plus the installation of an additional stand-alone treatment system in the upgradient portion of the plume. Alternatives 4 and 5 would include increased risk due to the installation of additional extraction wells, including additional extraction wells located in the Crane Wildlife Management Area.

2.10.2.6 Implementability

Alternative 1 would require no action. Therefore, there are no technical or administrative implementability concerns for Alternative 1. Alternative 2 would have limited technical implementability concerns because it would entail monitoring of the current groundwater network and installation of new wells with proven technologies. Alternative 3 should have no technical implementability concerns since the operation of the existing ETI system relies on proven technologies, including extraction wells, and GAC filtration, and similar treatment facilities have been operating on MMR since 1997 without significant technical difficulties. Alternatives 4 and 5, which include additional extraction wells located in the Crane Wildlife Management Area, present significant implementability concerns because the Massachusetts Division of Fisheries and Wildlife that manages this state-owned land, prefers it remain undisturbed. Additional potential implementability concerns for Alternatives 4 and 5 include terrain issues that would affect access. Alternative 5 also includes additional system components with the potential for ecological impacts (i.e., hydraulic) to a wetland (Spit Pond) located near the proposed

groundwater extraction area. Therefore, Alternative 4 is less implementable than Alternative 3, and Alternative 5 is less implementable than Alternative 4.

Administrative implementability concerns for all alternatives (except Alternative 1, no action) will include coordination with the Town of Falmouth (implementation of LUCs) and other agencies for technical update meetings, remediation 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.

2.10.2.7 Cost

Alternative 1 is the baseline scenario and, thus, no costs are associated with it. Alternative 2 includes capital costs (monitoring well construction) and periodic costs (monitoring and reporting). The present value cost of Alternative 2 is $0.8 million (M). The most significant costs are associated with construction of additional treatment components (e.g., extraction wells, stand-alone ETI systems), and aggressive remediation can also result in high operations and maintenance (O&M) costs. The costs of Alternatives 3, 4, and 5 are $12 M, $17 M, and $22 M, respectively.

For Alternatives 2, 3, 4, and 5, it is assumed that monitoring would continue for five years once the cleanup levels are met; periodic CERCLA five-year reviews and a final risk assessment are also included in the costs.

2.10.2.8 State Acceptance

The MassDEP has expressed its support for Alternative 3.

2.10.2.9 Community Acceptance

The PCT unanimously supports Alternative 3. All of the comments received during the public comment period favored Alternative 3.

2.11 SELECTED REMEDY FOR THE CS-23 GROUNDWATER OPERABLE UNIT

Based on the Administrative Record for CS-23 and the evaluation of comments received by interested parties during the public comment period, AFCEE has selected Alternative 3 as the remedy for the CS-23 groundwater OU. Since the FS was completed, the Air Force has designed, constructed, and operated (initiated December 2006) the CS-23 base boundary ETI system represented by Alternative 3.

2.11.1 Summary of the Rationale for the Selected Remedy

The selected remedy is Alternative 3, which consists of continued operation and optimization of the existing ETI system, monitoring, and LUCs. The selected remedy provides for treatment of the plume via the existing ETI system, 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 (the base boundary ETI system is estimated to operate for five years). The preferred remedy is expected to achieve RAOs within approximately 42 years for the entire plume but most of the plume will achieve RAOs well before that time. Leading edge capture was not deemed necessary because the uncaptured plume mass is expected to decrease below the MCL before migrating significantly downgradient; modeling predicts above-MCL concentrations would not migrate west of Route 28.

2.11.2 Detailed Description of Selected Remedy

The selected remedy would provide for continued active treatment of the CS-23 plume with the current ETI system, which extracts groundwater via two extraction wells, the water is then pumped to the Hunter Avenue Treatment Facility where it is treated using GAC, and then returned to the aquifer by means of two infiltration trenches. The objective of this alternative would be to continue to expedite aquifer restoration through use of the existing ETI system. The ETI system consists of extraction, treatment, and

infiltration of groundwater following federal and state standards for the CS-23 COCs, which will be stipulated in the updated O&M plan. The remedy leaves open the possibility of modifying the treatment system to optimize the cleanup time frame. Most likely, modifications would be implemented using the existing extraction and infiltration trenches and could involve well packering, turning on or off existing extraction wells, 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 could be made for the purpose of improving treatment system operation and expediting plume cleanup.

This remedy would also provide for chemical and hydraulic monitoring of the plume as long as active remediation continued and for chemical monitoring until the RAOs are met. Sensitive wetlands in the area (i.e., Vernal Pool #651, Spectacle Wetland, Spit Pond, Osborn Pond, and Edmunds Pond) (AFCEE 2006a) will be hydraulically monitored to ensure no ecological thresholds are exceeded through operation of the CS-23 ETI system. 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 will be performed every five years to evaluate remedy appropriateness and site status for as long as hazardous substances remain above unrestricted use levels in the groundwater. A residual risk assessment would be conducted, if deemed necessary, and would likely include additional data collection and analysis.

Groundwater from the CS-23 plume 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 CS-23 plume is located in the southwest part of the MMR, and a portion of the CS-23 plume has migrated past the MMR boundary into the neighboring town of Falmouth. Therefore, administrative and/or legal controls that minimize the potential for human exposure to contamination by limiting land or resource use (i.e., LUCs) have been established for this area of concern to avoid the risk of exposure to groundwater from the CS-23 area. These LUCs are needed both

on-base and off-base, within the town of Falmouth, until the groundwater from the CS-23 plume no longer poses an unacceptable risk.

The performance objectives of the LUCs are:

- Prevent access to or use of the groundwater from the CS-23 plume until the groundwater no longer poses an unacceptable risk; and
- Maintain the integrity of the current or future remedial or monitoring system such as treatment systems and monitoring wells.

The LUCs will encompass the area including the CS-23 plume (Figure 2-5) and surrounding areas to reduce potential exposure to the plume. 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 TCE and CCl_4 in the groundwater are at such a level to allow unrestricted use and exposure, 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 two 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 second LUC. In the event that the Town of Falmouth fails to promptly enforce the first LUC or the Commonwealth of Massachusetts fails to promptly enforce the second 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. The Falmouth BOH requires a permit for the installation and use of new 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 C, cover documented and anticipated areas of contamination from the CS-23 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 CS-23 plume within the town of Falmouth. While Figure 2-5 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 2-5.
2. In addition to the BOH regulations, which generally apply 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 CS-23 plume 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 CS-23.

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 Falmouth BOH 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 Guards 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 review 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 CS-23 area 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 CS-23 plume is 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 Falmouth BOH and the MassDEP, in order to curtail the digging activity. If the Dig Safe notification indicates proposed work near monitoring wells or 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 CS-23. 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 such incidents do occur, the Air Force is responsible for ensuring remedy integrity and, if necessary, repairing damage caused by third parties to the remedial system infrastructure or monitoring wells.

The LUCs are intended to prevent exposure to groundwater impacted by the CS-23 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 CS-23 plume.

b. Demonstrate and document that the private well is not capable of drawing contaminated groundwater originating from the CS-23 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 CS-23 plume having carcinogens in excess of ARARs (i.e., MCLs, non-zero maximum contaminant level goals), and prevent exposure to groundwater from the CS-23 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.

For the LUCs identified and selected for this ROD, the Air Force will provide notice to the EPA and MassDEP at least six months prior to relinquishing the lease to the CS-23 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, implement actions, or modify land use without approval by the EPA and MassDEP. The Air Force, in coordination with other agencies using or controlling the CS-23 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 CS-23.

2.11.3 Cost Estimate for the Selected Remedy

The present value cost for Alternative 3 is $12 M (see Tables 2-17 and 2-18). 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 CS-23 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 operations and maintenance of the CS-23 ETI system, the SPEIM program, periodic CERCLA reporting, and the residual risk assessment.

O&M costs would be incurred for the operation of the extraction wells and the Hunter Avenue Treatment Facility from October 2006 (system start-up) to 2011, when the extraction wells are estimated to be shut off. O&M costs have been estimated using actual costs realized for the previous operation of similar treatment systems on the MMR. Previous costs have been adjusted for the expected future reductions in 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 and will continue through 2050. 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 five years after the cleanup levels are met, making the total lifetime of this alternative 44 years. Although seven new monitoring wells are estimated to be added, 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 related to monitoring well installation and maintenance, sample collection, and groundwater analysis would be incurred throughout the project lifetime (year 2006 to year 2050).

The present value cost estimate did not include the costs of 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.

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 $12 M.

2.11.4 Expected Outcomes of the Selected Remedy

Alternative 3 provides for protection of human health through implementation of LUCs. The groundwater model indicates that cleanup levels will be met by approximately 2048, at which time the groundwater will be useable as a source of drinking water.

2.12 STATUTORY DETERMINATIONS

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 selected remedy will protect human health and the environment through LUCs, treatment of the plume, 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 will reduce potential residential exposure to the CS-23 plume. 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

The selected remedy of continuing operation of the existing CS-23 (Hunter Avenue) ETI system to remediate the CS-23 plume complies with all chemical-, location-, and action-specific ARARs. Refer to Tables 2-14, 2-15, and 2-16 for a listing of these ARARs.

2.12.3 Cost-Effectiveness

In AFCEE's judgment, the selected remedy for CS-23 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 of the CS-23 remedy was evaluated based on the data currently available for the CS-23 plume and the following considerations: (1) cleanup levels will be met by approximately 2048, (2) approximately 73 lb of TCE will be removed, (3) contaminants are permanently destroyed, (4) risks to workers, the community, and the environment would be easily controlled, (5) there is a high degree of confidence that the existing controls can adequately handle potential problems. The additional costs associated with Alternatives 4 and 5 were not justified by their time frames to reach RAOs.

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

The selected remedy for the CS-23 plume provides the best balance of trade-offs among the alternatives considered in the FS. Alternative 3 represents the maximum extent to which permanent solutions and treatment can be practicably utilized at the site because long-term monitoring (Alternative 2) would not expedite aquifer restoration and the plume would migrate to the west-southwest and under residential neighborhoods in Falmouth as it approaches Buzzards Bay. Alternatives 4 and 5 provide additional mass capture, but the added costs, including installing extraction wells in undeveloped areas of the Crane Wildlife Management Area, are not commensurate with the incremental benefit in cleanup time. Based on the evaluation criteria and the statutory mandates, AFCEE finds Alternative 3 to be the most appropriate solution for the CS-23 plume. The treatment, monitoring, and controls included in Alternative 3 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.

2.12.5 Preference for Treatment as a Principal Element

The selected remedy treats the contamination present in the CS-23 plume. The contaminated groundwater is removed from the aquifer through extraction wells and piped to the treatment plant. Contaminants are removed from the groundwater through GAC filtration. The GAC is thermally treated, destroying the contaminants. The treated groundwater is returned to the aquifer via infiltration trenches.

2.12.6 Five-Year Review Requirements

Five-year statutory reviews will be performed for the CS-23 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 additional purpose of the five-year reviews is to evaluate the protectiveness of the remedy in light of any changes in regulatory standards. The five-year reviews for the CS-23 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 1 November 2002 through 31 October 2007 will be published in the spring of 2008.

2.13 DOCUMENTATION OF CHANGES

The Proposed Plan for the Groundwater at Chemical Spill-23 was released for public comment in June 2006. The PP identified Alternative 3 as AFCEE's preferred alternative.

AFCEE, the EPA, and the MassDEP reviewed all written and verbal comments submitted during the public comment period. 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.

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 CS-23 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.

3.0 RESPONSIVENESS SUMMARY

The Responsiveness Summary is on the following page.

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MASSACHUSETTS MILITARY RESERVATION

Installation Restoration Program

JUNE 2006

RESPONSIVENESS SUMMARY
for Chemical Spill-23 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 Chemical Spill-23 Groundwater.

COMMENTS RESPONSES

Comments from the Plume Cleanup Team:	**Responses:**
• The team recommends Alternative 3 for the CS-23 plume. o The team requests a sufficient and effective monitoring plan for monitoring the leading and trailing edges of this plume, to ensure no undue additional contamination west of the extraction wells nor east as the plume "separates" from the unknown source area(s). o The team request on-going monitoring of ecological and water parameters for Spectacle Pond and vernal pools/wetlands to ensure no adverse impact due to the extraction and reinjection as well as the plume itself.	• AFCEE concurs. o AFCEE finalized a system performance and ecological impact monitoring plan that was approved by the EPA and MassDEP. The plan includes chemical monitoring east and west of the extraction wells. o One of the objectives of the approved system performance and ecological impact monitoring plan is to assess potential ecological impacts on nearby surface water bodies through operation of the combined Landfill-1/Chemical Spill-23 extraction, treatment, infiltration systems.

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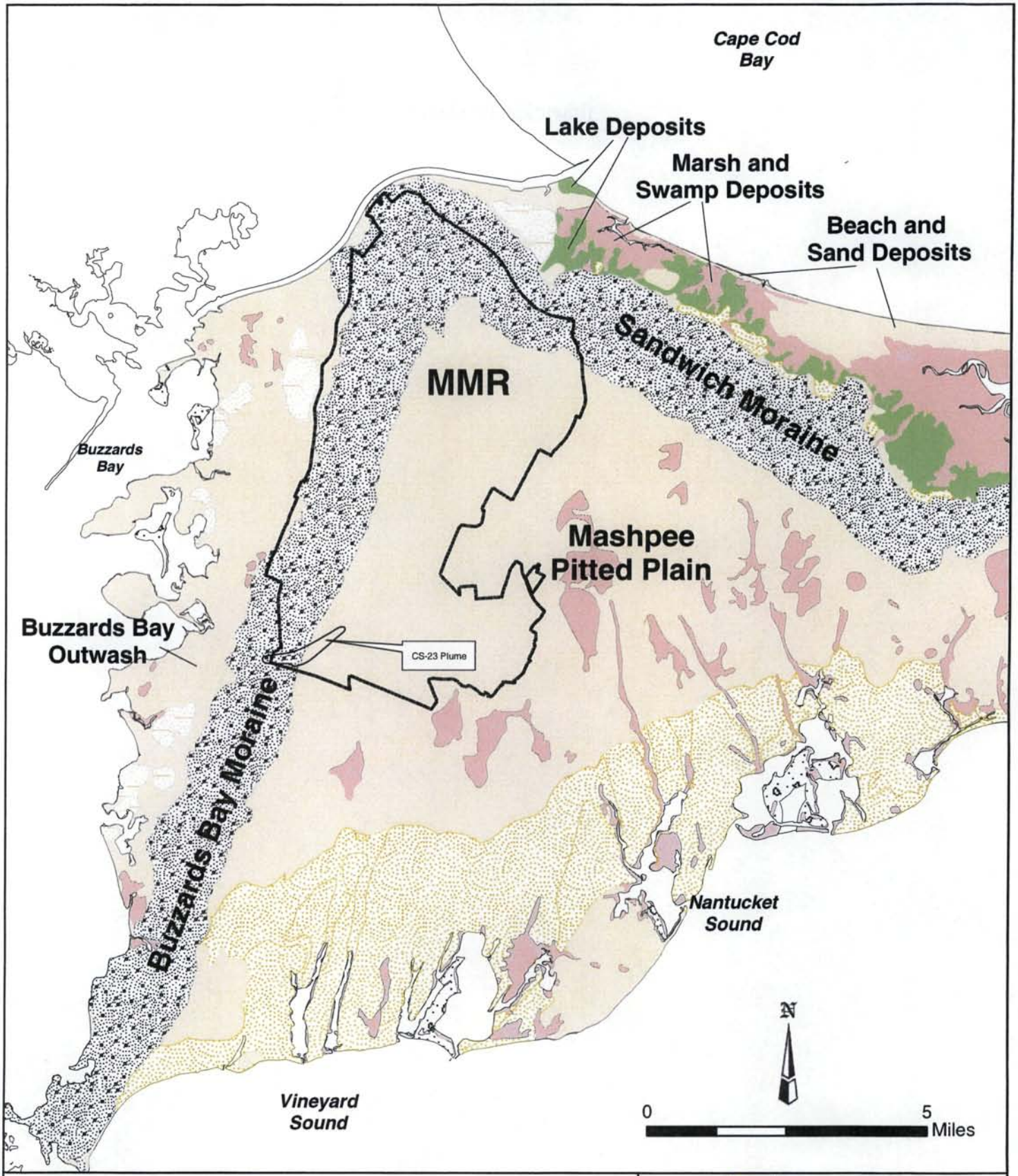
FIGURES



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

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

Y:\GIS\projects\35BC02\VA\20070913\ArcGIS\CS23_Geology_MMR2.mxd

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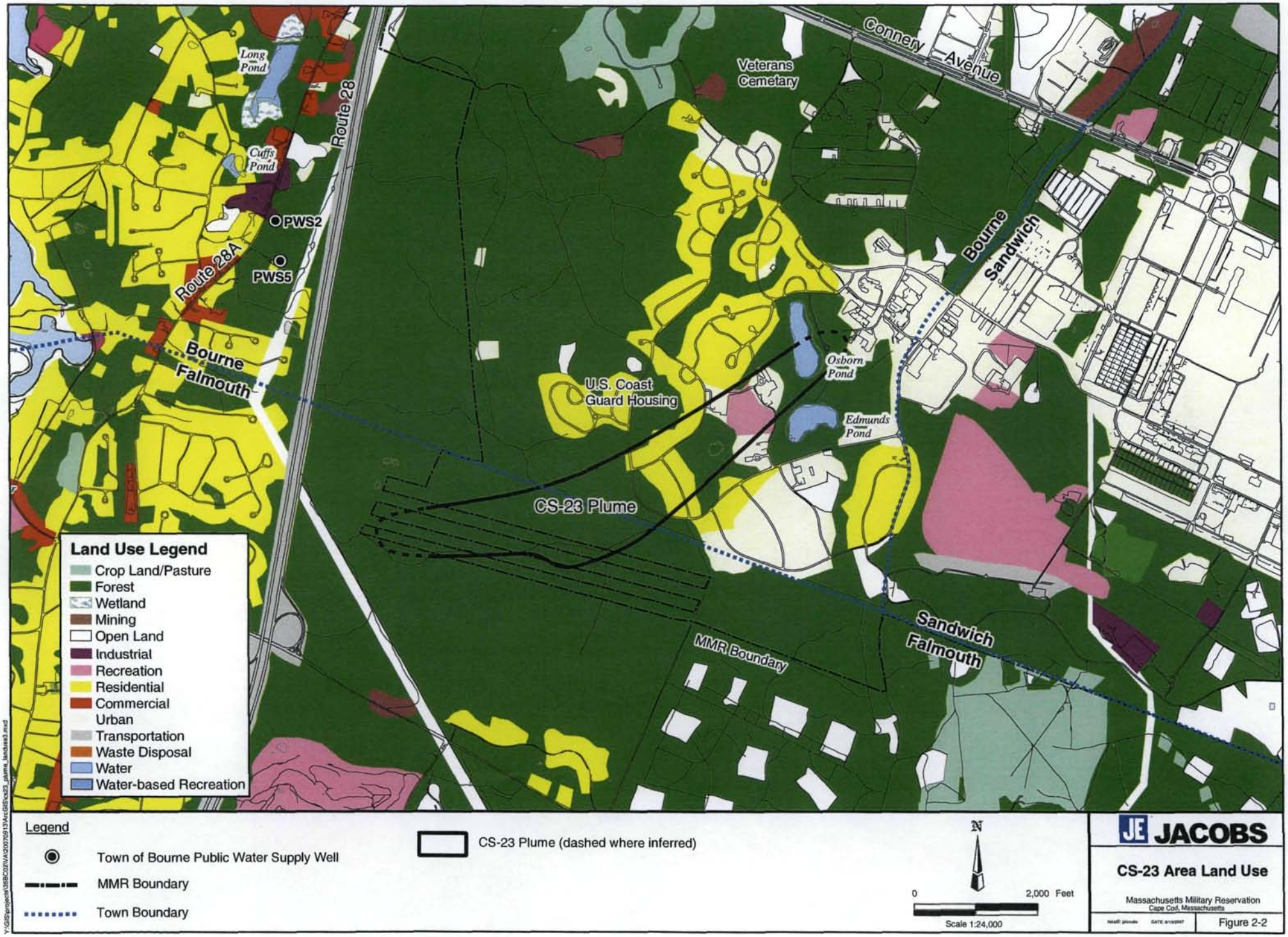
Long Pond
Cuffs Pond
Route 28
PWS2
PWS5
Route 28A
Bourne
Falmouth
Veterans Cemetary
Connery Avenue
Bourne
Sandwich
Osborn Pond
U.S. Coast Guard Housing
Edmunds Pond
CS-23 Plume
MMR Boundary
Sandwich
Falmouth
Land Use Legend
Crop Land/Pasture
Forest
Wetland
Mining
Open Land
Industrial
Recreation
Residential
Commercial
Urban
Transportation
Waste Disposal
Water
Water-based Recreation
Legend
Town of Bourne Public Water Supply Well
MMR Boundary
Town Boundary
CS-23 Plume (dashed where inferred)
N
0
2,000 Feet
Scale 1:24,000
JACOBS
CS-23 Area Land Use
Massachusetts Military Reservation
Cape Cod, Massachusetts
Figure 2-2

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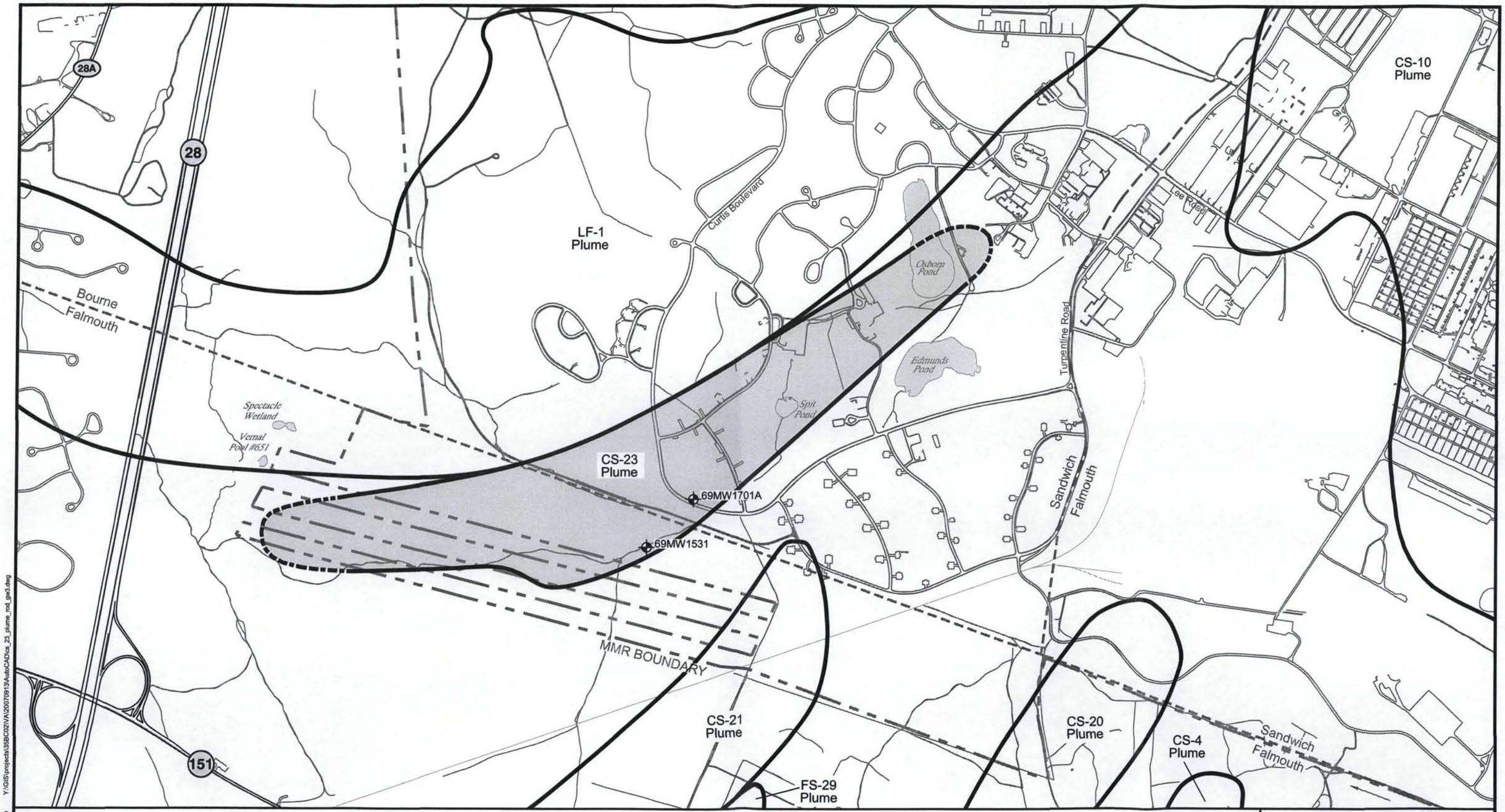


Legend

- Monitoring Well
- MMR Boundary
- Town Boundary
- Plume Contour:
- It is possible that portions of the plume in these areas are not actually there, but they are drawn with a dotted line to be conservative.

0 1000

Scale in Feet

JE JACOBS

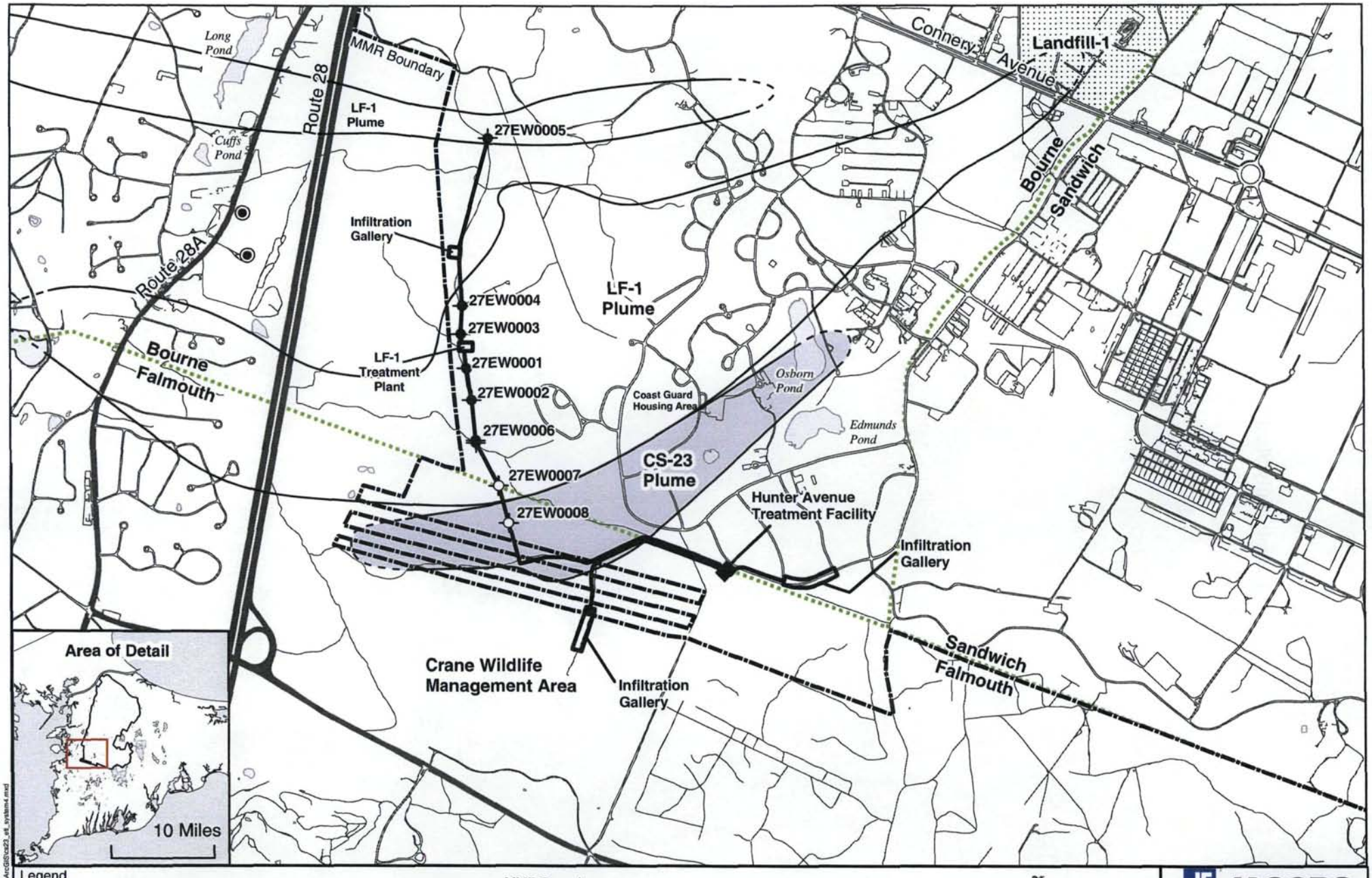
CS-23 Plume

Massachusetts Military Reservation
Cape Cod, Massachusetts

09/13/07 JP cs_23_plume_rod_gw3.dwg

Figure 2-3

last modified: 09/13/07 printed: 09/13/07 by jp Y:\GIS\projects\35BC02\VA\20070913\AutoCAD\cs_23_plume_rod_gw3.dwg


Long Pond
Route 28
MMR Boundary
LF-1 Plume
27EW0005
Cuffs Pond
Connery Avenue
Landfill-1
Bourne
Sandwich
Infiltration Gallery
Route 28A
LF-1 Plume
27EW0004
27EW0003
27EW0001
27EW0002
27EW0006
27EW0007
27EW0008
LF-1 Treatment Plant
Bourne
Falmouth
Coast Guard Housing Area
Osborn Pond
Edmunds Pond
CS-23 Plume
Hunter Avenue Treatment Facility
Infiltration Gallery
Crane Wildlife Management Area
Infiltration Gallery
Sandwich
Falmouth
Area of Detail
10 Miles
Legend
LF-1 Extraction Well
CS-23 Extraction Well
Town of Bourne Public Water Supply Well
MMR Boundary
Treatment System Pipeline
LF-1 Plume
CS-23 Plume
Town Boundary
It is possible that portions of the plume in these areas are not actually there, but they are drawn with a dotted line to be conservative.
N
0
2,000 Feet
Scale 1:24,000
Notes: ETI = extraction, treatment and infiltration
JE JACOBS
CS-23 ETI Remedial System Layout
Massachusetts Military Reservation
Cape Cod, Massachusetts
Figure 2-4

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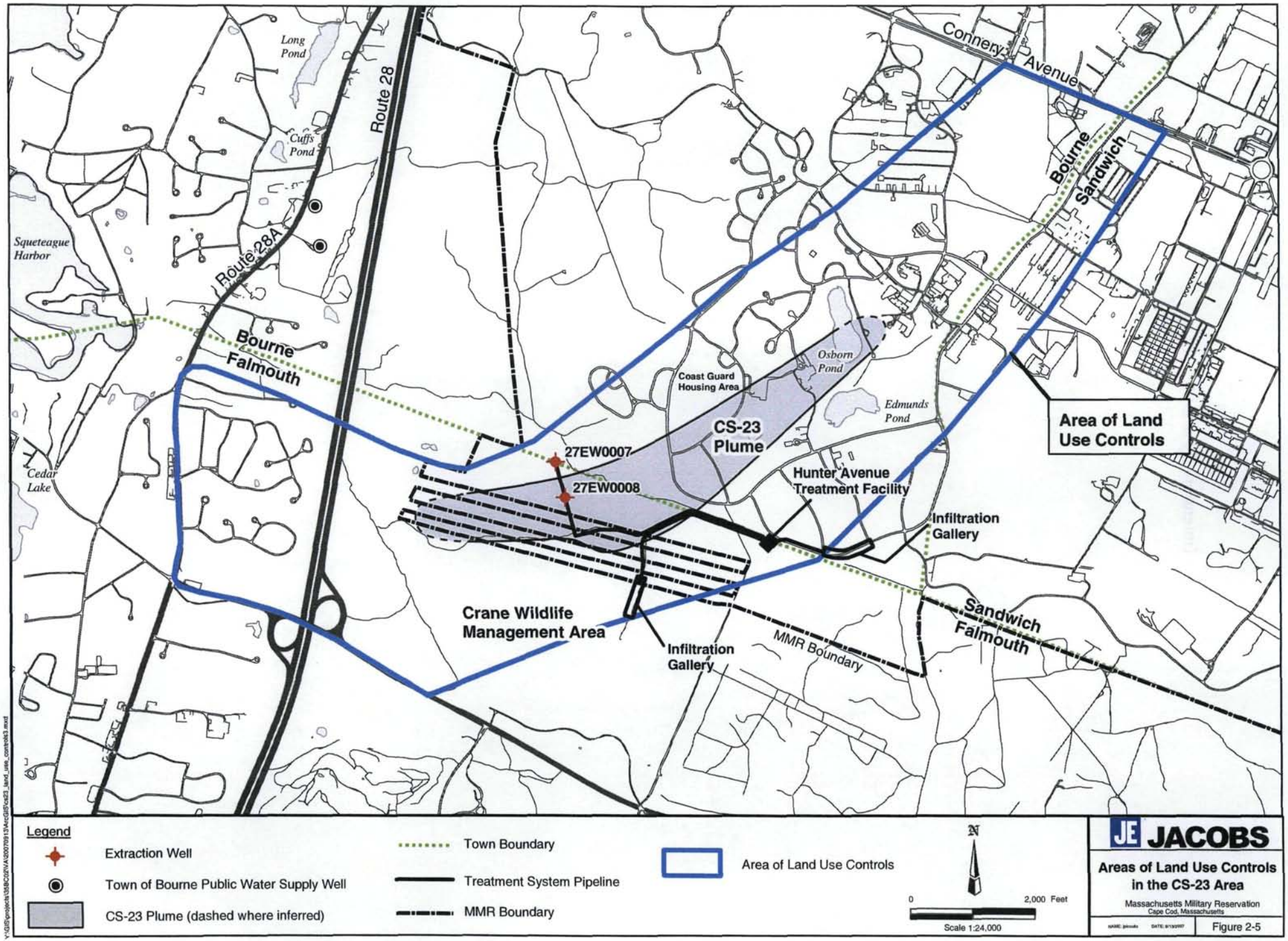

JACOBS

Areas of Land Use Controls in the CS-23 Area

Massachusetts Military Reservation
Cape Cod, Massachusetts

Figure 2-5

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TABLES

Table 2-1
Occurrence, Distribution, and Selection of Chemicals of Potential Concern
CS-23 Groundwater

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)
CS-23	79-34-5	1,1,1-Trichloroethane	0.26 (J)	1.5	µg/L	69MW1710A	14/38	0.05 - 0.205	1.5		320 N	2	MGW-1	N	BSL
	75-34-4	1,1-Dichloroethene	0.23 (J)	0.66 (J)	µg/L	69MW1710A	2/38	0.07 - 0.258	0.66		34 N	7	MCL	N	BSL
	56-23-5	Carbon Tetrachloride	0.33 (J)	7.1	µg/L	03MW0042B	14/38	0.07 - 0.238	7.1		0.17 C	5	MCL	Y	ASL
	67-66-3	Chloroform	0.25 (J)	2.5	µg/L	69MW1710B	27/38	0.05 - 0.244	2.5		6.2 C/N	80	MCL	N	BSL
	106-93-4	Ethylene Dibromide	0.014	0.014	µg/L	69MW1704A	1/31	0.0014 - 0.004	0.014		0.00076 C	0.02	MMCL	N	IFD, BMMCL
	1634-04-4	Methyl tert-butyl ether	0.04 (J)	0.93 (J)	µg/L	69MW1708B	2/38	0.04 - 0.6	0.93		13 C	70	ORSG	N	BSL
	127-18-4	Tetrachloroethene (PCE)	0.06 (J)	1.9	µg/L	69MW1715A	19/38	0.06 - 0.64	1.9		0.66 C	5	MCL	Y	ASL
	79-01-6	Trichloroethene (TCE)	0.26 (J)	44 (J)	µg/L	69MW1709B	26/38	0.05 - 1.19	44		0.028 C	5	MCL	Y	ASL
	117-81-7	bis (2-ethylhexyl) phthalate	1.4 (J)	44 (J)	µg/L	69MW1714A	10/31	0.8 - 15	44		4.8 C	6	MCL	Y	ASL
	84-66-2	Diethyl Phthalate	1.1 (J)	2.4 (J)	µg/L	69MW1710B	3/31	1 - 1.1	2.4		2900 N	30,000	HA	N	BSL
	84-74-2	Di-n-butyl Phthalate	1.8 (J)	16	µg/L	69MW1711B	7/31	0.8 - 6.2	16		360 N	4,000	HA	N	BSL
	7429-90-5	Aluminum	778	1040	µg/L	69MW1714A	3/29	7.9 - 169	1040		3600 N	50 to 200	SMCL	N	BSL
	7440-38-2	Arsenic	2.4 (J)	2.4 (J)	µg/L	69MW1708A	2/29	2.3 - 2.6	2.4		0.045 C	10	MCL	Y	ASL
	7440-39-3	Barium	3 (J)	19.5 (J)	µg/L	69MW1708B	29/29	0.26 - 0.4	19.5		260 N	2000	MCL	N	BSL
	7440-70-2	Calcium	2260 (J)	5960	µg/L	69MW1709A	29/29	8 - 32.1	5960		NA	NA	NA	N	NUT, NSL
	7440-47-3	Chromium	0.89 (J)	6.5 (J)	µg/L	69MW1714A	23/29	0.81 - 1.3	6.5		11 N	100	MCL	N	BSL
	7440-48-4	Cobalt	1.1 (J)	10.2 (J)	µg/L	82MW0002B	7/29	0.75 - 4.5	10.2		73 N	NA	NA	N	BSL
	7440-50-8	Copper	0.83 (J)	13 (J)	µg/L	69MW1708A	5/29	0.82 - 2.7	13		150 N	1000	SMCL	N	BSL
	7439-89-6	Iron	28.7 (J)	4620	µg/L	69MW1707B	18/29	18.9 - 129	4620		1100 N	300	SMCL	N	NUT
	7439-95-4	Magnesium	1640 (J)	3520 (J)	µg/L	69MW1713B	29/29	20.5 - 27.9	3520		NA	NA	NA	N	NUT, NSL
	7439-96-5	Manganese	6.6 (J)	366	µg/L	69MW1707A	23/29	0.24 - 5	366		88 N	50	SMCL	Y	ASL
	7440-02-0	Nickel	1 (J)	5.4 (J)	µg/L	69MW1708B	26/29	0.93 - 3.1	5.4		73 N	100	ORSG	N	BSL
	7440-09-7	Potassium	733 (J)	3170 (J)	µg/L	69MW1714A	29/29	40.5 - 62.3	3170		NA	NA	NA	N	NUT, NSL
	7440-22-4	Silver	1.4 (J)	1.4 (J)	µg/L	82MW0002A	1/29	0.88 - 1	1.4		18 N	100	SMCL	N	BSL, IFD
	7440-23-5	Sodium	6850	28600	µg/L	69MW1702A	29/29	428 - 654	28600		NA	20000	ORSG	N	NUT, NSL
	7440-66-6	Zinc	18 (J)	18 (J)	µg/L	69MW1715A	1/29	0.38 - 23.1	18		1100 N	5000	SMCL	N	BSL, IFD

Data Source: AFCEE, 02 August 2004, AFCEE-MMR Data Warehouse. Jacobs, 02 August 2004, Site Environmental Evaluation database.

Table 2-1
Occurrence, Distribution, and Selection of Chemicals of Potential Concern
CS-23 Groundwater

Footnotes:

(1) Maximum/minimum detected concentration

(2) Maximum detected concentration

(3) N/A - Refer to the CS-23 RI (AFCEE 2005).

(4) 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)

(5) Rationale Codes:

Common Cation (CC)

Above Screening Level (ASL)

Below Massachusetts Maximum Contaminant Level (BMMCL)

Below Screening Level (BSL)

Infrequent Detection (IFD)

Essential Nutrient (NUT)

No Screening Level (NSL)

Definitions:

ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered

CAS=Chemical Abstracts Service

COPC = Chemical of Potential Concern

J = estimated value

HA = Health Advisory

MCL = Federal Maximum Contaminant Level

MGW-1 = Massachusetts Groundwater 1 standard

N = Noncarcinogenic

NA = Not Available

N/C = Noncarcinogenic/Carcinogenic

ORSG = Office of Research and Standards Guidelines

SMCL = Secondary Maximum Contaminant Level

µg/L = micrograms per liter

Table 2-2
Selection of Exposure Pathways
CS-23 Groundwater

Scenario Time Frame	Medium	Exposure Medium	Exposure Area	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current/Future	soil	soil	source area(s)	resident/worker	adult/child	ingestion	none	The CS-23 source is unknown. The possible source areas have been addressed separately. Soil in non-source areas is not impacted by groundwater contamination.
						dermal	none	"
		dust	"	"	"	inhalation	none	"
Current	groundwater	groundwater	groundwater impacted by CS-23	resident	adult/child	ingestion	none	Currently, residences in this area are connected to the base water supply.
						dermal	none	"
		vapor	"	"	"	inhalation	none	Because there are no MCL exceedances in groundwater located less than 100 feet below ground surface, there is little potential for the groundwater vapor intrusion to indoor air pathway.
Future	groundwater	groundwater	groundwater impacted by CS-23	resident	adult/child	ingestion	quantitative	Future residents may use groundwater.
						dermal	quantitative	"
		vapor	"	"	"	inhalation	quantitative	Future residents may be exposed through household use of groundwater.
Current/Future	groundwater	groundwater	groundwater within the LF-1 plume	resident	adult/child	ingestion	none	Risks associated with human exposure to groundwater within the LF-1 plume were calculated in 2004 as part of the IROD-to-ROD project. Analytical data collected from locations within the LF-1 plume will not be used in the CS-23 risk assessment.
						dermal	none	"
		vapor	"	"	"	inhalation	none	"
Current/Future	sediment	sediment	Edmunds Pond, Spit Pond, Osborn Pond	wader or swimmer	adult/ child	ingestion	none	Edmunds, Osborn, and Spit ponds are not impacted by the CS-23 groundwater plume. Although the ponds are in hydraulic connection with the unconfined aquifer, the CS-23 contamination is deeper than the bottoms of these ponds.
						dermal	none	"
		surface water	"	wader or swimmer	adult/ child	ingestion	none	
						dermal	none	"
Current/Future	surface water	vapor	"	wader or swimmer	adult/ child	inhalation	none	"
		fish tissue	"	fish eater	adult	ingestion	none	"

Notes:
MCL = maximum contaminant level
IROD = Interim Record of Decision
ROD = Record of Decision

Table 2-3
Medium-Specific Exposure Point Concentration Summary
CS-23 Groundwater

Scenario Timeframe: future
Medium: groundwater
Exposure Medium: groundwater

Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic	Rationale
CS-23	Carbon Tetrachloride	µg/L	NA	NA	7.1	7.1	µg/L	Maximum	EPA Region I Guidance
	Tetrachloroethene (PCE)	µg/L	NA	NA	1.9	1.9	µg/L	Maximum	EPA Region I Guidance
	Trichloroethene (TCE)	µg/L	NA	NA	44 (J)	44	µg/L	Maximum	EPA Region I Guidance
	bis (2-ethylhexyl) phthalate	µg/L	NA	NA	44 (J)	44	µg/L	Maximum	EPA Region I Guidance
	Arsenic	µg/L	NA	NA	2.4 (J)	2.4	µg/L	Maximum	EPA Region I Guidance
	Manganese	µg/L	NA	NA	366	366	µg/L	Maximum	EPA Region I Guidance

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

TABLE 2-4
Values Used for Daily Intake Calculations - Adult
CS-23 Groundwater

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 1989	
				CF1	Conversion Factor	0.001	mg/µg	-	
				BW	Body Weight	70	kg	EPA 1989	
				AT-NC	Averaging Time (non-cancer)	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/cm^2-event	EPA 2001	Where DA_{event} (mg/cm^2-event) is calculated in accordance
				SA	Skin surface area available for contact	18000	cm^2	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 1989	
				BW	Body Weight	70	kg	EPA 1989	
				AT-NC	Averaging Time (non-cancer)	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	µg/m^3	EPA 2003	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*	0.5	L/m^3	EPA 1991	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 (non-cancer)	262,800	hours	EPA 1989	AT-NC = ED*365
				AT- C	Averaging Time (cancer)	613,200	hours	EPA 1989	AT-C = 70*365

Notes:

EPA (U.S. Environmental Protection Agency). 2003 (October). EPA Comments on the Draft Work Plan for the Process Leading to Final Remedial Decisions for Ashumet Valley and Landfill-1. October 16, 2003.

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

———. 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.

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

———. 1994 (August). EPA Region I Risk Update. No. 2.

———. 1991. Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions. Don R. Clay, Assistant Administrator. OSWER Directive 9355.0-30.

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

* = vapor from household use of groundwater
cm^2 = square centimeters
g = grams
hr = hours
kg = kilograms
L = liters
m^3 = cubic meter
mg = milligrams
yrs = years
µg = micrograms

TABLE 2-5

Values Used for Daily Intake Calculations - Child

CS-23 Groundwater

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 1989	
				CF1	Conversion Factor	0.001	mg/µg	-	
				BW	Body Weight	15	kg	EPA 1989	
				AT-NC	Averaging Time (non-cancer)	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 1989	
				BW	Body Weight	15	kg	EPA 1989	
				AT-NC	Averaging Time (non-cancer)	2190	days	EPA 1989	AT-NC = ED*365
				AT- C	Averaging Time (cancer)	25,550	days	EPA 1989	AT-C = 70*365

Notes:

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

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

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

cm^2 = square centimeters

g = grams

hr = hours

kg = kilograms

L = liters

mg = milligrams

yrs = years

µg = micrograms

Table 2-6
Non-Cancer Chronic Toxicity Data - Oral/Dermal
CS-23 Groundwater

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal RfD (1)	Units	Primary Target Organ	Combined Uncertainty/ Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ (MM/DD/YY)
bis (2-ethylhexyl) phthalate	Chronic	2.0E-02	mg/kg/day	none	2.0E-02	mg/kg/day	Liver	1000	IRIS	05/01/91
Carbon Tetrachloride	Chronic	7.0E-04	mg/kg/day	none	7.0E-04	mg/kg/day	Liver	1000	IRIS	06/01/91
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
Arsenic	Chronic	3.0E-04	mg/kg/day	none	3.0E-04	mg/kg/day	Skin	3	IRIS	02/01/93
Manganese	Chronic	2.4E-02	mg/kg/day	4.0E-02	9.6E-04	mg/kg/day	CNS	1	IRIS/EPA Region 1	11/96

Notes:

(1) EPA 2001b (September). Risk Assessment Guidance for Superfund (RAGS): Volume I: Human Health Evaluation Manual. (Part E, Supplemental Guidance for Dermal Risk Assessment). Interim Guidance.

CNS = central nervous system

IRIS =Integrated Risk Information System. Online database. Accessed 08/12/2004 EPA 2004.

mg/kg/day = milligrams per kilogram per day

NA = not available

NCEA = National Center for Environmental Assessment

RfD = reference dose

Table 2-7
Non-Cancer Toxicity Data - Inhalation
CS-23 Groundwater

Chemical of Potential Concern	Chronic/ Subchronic	Value Inhalation RfC	Units	Adjusted (1) Inhalation RfD	Units	Primary Target Organ	Combined Uncertainty/ Modifying Factors	Sources of RfD: Target Organ	Dates (MM/DD/YY)
bis (2-ethylhexyl) phthalate	Chronic	NA	mg/m^3	NA	mg/kg/day	NA	NA	IRIS	10/29/03
Carbon Tetrachloride	Chronic	NA	mg/m^3	NA	mg/kg/day	NA	NA	IRIS	
Tetrachloroethene (PCE)	Chronic	3.50E-02	mg/m^3	1.0E-02	mg/kg/day	NA	NA	CAL EPA 2002/EPA 2003	08/12/03
Trichloroethene (TCE)	Chronic	4.0E-02	mg/m^3	1.1E-02	mg/kg/day	CNS, Liver, ES	NA	EPA 2001	10/01/02
Arsenic	--	--	--	--	--	--	--	--	--
Manganese	--	--	--	--	--	--	--	--	--

Notes:

(1) Adjustment factor applied to inhalation RfC to calculate inhalation RfD = 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.

CAL EPA 2002. *Technical Support Document for Describing Available Cancer Potency Factors.* California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, December 2002.

CNS = central nervous system

EPA 2001. *Trichloroethylene Health Risk Assessment: Synthesis and Characterization* U.S. EPA Office of Research and Development. EPA/600/P-01/002A. August 2001 External Review Draft.

EPA 2003. U S. EPA Region 1 Comments on the *Draft Work Plan for the Process Leading to Final Remedial Decisions for Ashumet Valley and Landfill-1* . October 16, 2003.

ES = endocrine system

IRIS =Integrated Risk Information System Online database. Accessed 08/12/04 EPA 2004.

mg/kg/day = milligrams per kilogram per day

mg/m^3 = milligrams per cubic meter

NA = not available

RfC = reference concentration

RfD = reference dose

Table 2-8
Cancer Toxicity Data - Oral/Dermal
CS-23 Groundwater

Chemical of Potential Concern	Oral Cancer Slope Factor	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal Cancer Slope Factor (1)	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (MM/DD/YY)
bis (2-ethylhexyl) phthalate	1.4E-02	none	1.4E-02	$(mg/kg/day)^{-1}$	B2	IRIS	02/01/93
Carbon tetrachloride	1.3E-01	none	1.3E-01	$(mg/kg/day)^{-1}$	B2	IRIS	06/01/91
Tetrachloroethene (PCE)	5.4E-01	none	5.4E-01	$(mg/kg/day)^{-1}$	NA	CAL EPA 2002, EPA 2003	06/12/03
Trichloroethene (TCE)	4.0E-01	none	4.0E-01	$(mg/kg/day)^{-1}$	NA	EPA 2002	10/01/02
Arsenic	1.5E+00	none	1.5E+00	$(mg/kg/day)^{-1}$	A	IRIS	04/10/98
Manganese	NA	ND	ND	(mg/kg/day)-1	D	IRIS	12/01/96

Notes:

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

CAL EPA 2002. *Technical Support Document for Describing Available Cancer Potency Factors.* California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, December 2002.

EPA 2002. U.S. EPA Region 9 PRGs Table. 2002 Update, October 1, 2002.

EPA 2003. U.S. EPA Region 1 Comments on the *Draft Work Plan for the Process Leading to Final Remedial Decisions for Ashumet Valley and Landfill-1*. October 16, 2003.

IRIS = Integrated Risk Information System. Online database. Accessed 08/12/04 EPA 2004.

mg/kg/day = milligrams per kilogram per day

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

C - Possible human carcinogen

D - Not classifiable as a human carcinogen

Table 2-9
Cancer Toxicity Data - Inhalation
CS-23 Groundwater

Chemical of Potential Concern	Unit Risk	Units	Adjustment (1)	Inhalation Cancer Slope Factor (1)	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (MM/DD/YY)
bis (2-ethylhexyl) phthalate	NA	$(mg/m^3)^{-1}$	3.5E+00	NA	$(mg/kg/day)^{-1}$	B2	IRIS	02/13/04
Carbon tetrachloride	1.0E-02	$(mg/m^3)^{-1}$	3.5E+00	3.5E-02	$(mg/kg/day)^{-1}$	B2	IRIS	06/01/91
Tetrachloroethene (PCE)	5.9E-03	$(mg/m^3)^{-1}$	3.5E+00	2.1E-02	$(mg/kg/day)^{-1}$	NA	CAL EPA 2002, EPA 2003	06/12/03
Trichloroethene (TCE)	1.1E-01	$(mg/m^3)^{-1}$	3.5E+00	3.9E-01	$(mg/kg/day)^{-1}$	NA	EPA 2003	06/12/03
Arsenic	--	--	--	--	--	--	--	--
Manganese	--	--	--	--	--	--	--	--

Notes:

(1) Adjustment factor applied to Unit Risk to calculate Inhalation Slope Factor = 70 kg x 1/20 m^3/day

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

CAL EPA 2002. *Technical Support Document for Describing Available Cancer Potency Factors.* California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, December 2002.

EPA 2003. U.S. EPA Region 1 Comments on the *Draft Work Plan for the Process Leading to Final Remedial Decisions for Ashumet Valley and Landfill-1*. October 16, 2003.

IRIS = Integrated Risk Information System. Online database. Accessed 08/12/04. EPA 2004.

mg/kg/day = milligrams per kilogram per day

mg/m^3 = milligrams per cubic meter

NA = not available

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 2-10
Risk Assessment Summary
CS-23 Groundwater, 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	CS-23 - Tap Water	Carbon Tetrachloride	8.7E-06	NA	2.5E-06	1.1E-05	Liver	2.8E-01	NA	7.9E-02	3.6E-01
			Tetrachloroethene (PCE)	9.7E-06	NA	6.1E-06	1.6E-05					
			Trichloroethene (TCE)	1.7E-04	NA	2.9E-05	1.9E-04	Liver	4.0E+00	NA	7.0E-01	4.7E+00
			bis (2-ethylhexyl) phthalate	5.8E-06	NA	9.6E-06	1.5E-05	Liver	6.0E-02	NA	1.0E-01	1.6E-01
			Arsenic	3.4E-05	NA	1.8E-07	3.4E-05	Skin	2.2E-01	NA	1.2E-03	2.2E-01
			Manganese					CNS	4.2E-01	NA	5.5E-02	4.7E-01
			Chemical Total	2.2E-04	NA	4.7E-05	2.7E-04		5.0E+00	NA	9.4E-01	5.9E+00
		Exposure Point Total					2.7E-04					5.9E+00
	Groundwater	CS-23 - Vapor	Carbon Tetrachloride	NA	1.5E-05	NA	1.5E-05	NA	NA	NA	NA	NA
			Tetrachloroethene (PCE)	NA	2.3E-06	NA	2.3E-06					
			Trichloroethene (TCE)	NA	9.9E-04	NA	9.9E-04	CNS, Liver, ES	NA	5.3E-01	NA	5.3E-01
			bis (2-ethylhexyl) phthalate	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Chemical Total	NA	1.0E-03	NA	1.0E-03		NA	5.3E-01	NA	5.3E-01
		Exposure Point Total					1.0E-03					5.3E-01
	Exposure Medium Total						1.3E-03					6.5E+00
Medium Total							1.3E-03					6.5E+00
Receptor Total							1.3E-03				Receptor HI Total	6.5E+00

Notes:

CNS = central nervous system

ES = endocrine system

HI = hazard index

NA = not available

Total HI Across All Media	Skin	2.2E-01
Total HI Across All Media	Liver	5.2E+00
Total HI Across All Media	CNS	4.7E-01
Total HI Across All Media	CNS, Liver, ES	5.3E-01

Table 2-11
Risk Assessment Summary
CS-23 Groundwater, 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	CS-23 - Tap Water	Carbon Tetrachloride	5.1E-06	NA	1.4E-06	6.5E-06	Liver	6.5E-01	NA	1.8E-01	8.3E-01
			Tetrachloroethene (PCE)	5.6E-06	NA	3.4E-06	9.1E-06					
			Trichloroethene (TCE)	9.7E-05	NA	1.6E-05	1.1E-04	Liver	9.4E+00	NA	1.6E+00	1.1E+01
			bis (2-ethylhexyl) phthalate	3.4E-06	NA	5.4E-06	8.8E-06	Liver	1.4E-01	NA	2.2E-01	3.7E-01
			Arsenic	2.0E-05	NA	1.3E-07	2.0E-05	Skin	5.1E-01	NA	3.4E-03	5.1E-01
			Manganese					CNS	9.7E-01	NA	1.6E-01	1.1E+00
			Chemical Total	1.3E-04	NA	2.7E-05	1.6E-04		1.2E+01	NA	2.1E+00	1.4E+01
		Exposure Point Total					1.6E-04					1.4E+01
	Groundwater	CS-23 Groundwater - Vapor		Refer to Table 10.1 RME for the inhalation risks and hazards for the lifetime resident.								
	Exposure Medium Total											
Medium Total							1.6E-04					1.4E+01
Receptor Total							1.6E-04				Receptor HI Total	1.4E+01

Notes:

CNS = central nervous system

HI = hazard index

NA = not available

RME = reasonable maximum exposure

Total HI Across All Media	Skin	5.1E-01
Total HI Across All Media	Liver	1.2E+01
Total HI Across All Media	CNS	1.1E+00

Table 2-12
Summary of Human Health Risk Drivers
CS-23 Groundwater

COPC	RME EPC (µg/L)	Total Adult HI	Total Child HI	ELCR	COC (Yes/No)	Comments
Carbon Tetrachloride	7.1	4E-01	8E-01	3E-05	**Yes**	
Tetrachloroethene	1.9	8E-03	2E-02	3E-05	No	concentrations below the maximum contaminant level of 5 µg/L
Trichloroethene	44	5E+00	1E+01	1E-03	**Yes**	
bis- (2-ethylhexyl) phthalate	44	2E-01	4E-01	2E-05	No	common sampling artifact
Arsenic	2.4	2E-01	5E-01	5E-05	No	equivalent to background
Manganese	366	5E-01	1E+00	NA	No	equivalent to background

Notes:
COC = contaminant of concern
COPC = contaminant of potential concern
ELCR = excess lifetime cancer risk
EPC = exposure point concentration
HI = hazard index
NA = not applicable
RME = reasonable maximum exposure
µg/L = micrograms per liter
Bold indicates compound is a COC.

Table 2-13
CS-23 Feasibility Study Comparison of Alternatives

Alternative	Description	Threshold Criteria	Primary Balancing Criteria
Alternative 1: No Action	• No activity at the site	• Not protective of human health and environment • RAOs reached in 2055	• Baseline scenario • $0
Alternative 2: Land Use Controls and Long-Term Monitoring	• No active treatment • Land use controls • Chemical monitoring of plume and periphery	• Protective of human health through land use controls • Long-term monitoring will enable confirmation of natural attenuation and achievement of RAOs • RAOs reached in 2055	• Alternative to active treatment that is protective of human health • $0.8 M
Alternative 3: Operation, Maintenance, and Monitoring of the Existing ETI System (i.e., Remediation at Base Boundary), with LUCs and LTM	• Active remediation with existing treatment system • Land use controls • Chemical and hydraulic monitoring of the treatment system and plume to allow for optimization	• Protective of human health through land use controls • Long-term monitoring will enable confirmation of natural attenuation and achievement of RAOs • Decrease cleanup time of CS-23 plume; RAOs reached in 2048	• Active treatment; permanent removal of contaminants • 73 lb of TCE mass removed[1] • $12 M

Table 2-13
CS-23 Feasibility Study Comparison of Alternatives

Alternative	Description	Threshold Criteria	Primary Balancing Criteria
Alternative 4: Operation, Maintenance, and Monitoring of the Existing ETI System, with Additional Remediation at Leading Edge, LUCs and LTM	• Existing treatment system with additional extraction wells and piping for the leading edge • Land use controls • Chemical and hydraulic monitoring of the treatment system and plume to allow for optimization	• Protective of human health through land use controls • Long-term monitoring will enable confirmation of natural attenuation and achievement of RAOs • Decrease cleanup time of CS-23 plume; RAOs reached in 2048	• Active treatment; permanent removal of contaminants • 93 lb of TCE mass removed[1] • $17 M
Alternative 5: Operation, Maintenance, and Monitoring of the Existing ETI System, with Additional Remediation at Leading Edge and at Trailing Edge, LUCs and LTM	• Existing treatment system with additional extraction wells and piping for the leading edge, plus a new stand-alone treatment system, extraction well, piping and infiltration trench for the trailing edge (upgradient) treatment • Land use controls • Chemical and hydraulic monitoring of the treatment systems and plume to allow for optimization	• Protective of human health through land use controls • Long-term monitoring will enable confirmation of natural attenuation and achievement of RAOs • Further Decrease in cleanup time; RAOs reached in 2023	• Active treatment; permanent removal of contaminants • 101 lb of TCE mass removed[1] • $22 M

Notes:
[1]Mass removed is an estimate of total mass of TCE removed by extraction wells during predicted system(s) operation.
ETI = extraction, treatment, and infiltration
lb = pounds
LTM = long-term monitoring
LUC = land use control
M = million
RAO = remedial action objective
TCE = trichloroethene

Table 2-14
Chemical-Specific ARARs
CS-23 Groundwater Operable Unit Remedy Alternative 3

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 CS-23 plume. Both the state and federal MCL for TCE and CCl_4 is 5 µg/L. LTM will determine when these cleanup standards are met, unless a more stringent state standard has been promulgated, in which case the more stringent state standard must be 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. MCLGs are 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 for any contaminants that do not have promulgated state or federal MCLs.	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 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 CS-23 plume. Both the state and federal MCL for TCE and CCl_4 is 5 µg/L. LTM will determine when the cleanup standards are met, unless a more stringent state standard has been promulgated, in which case the more stringent state standard must be met.	Relevant and Appropriate

Table 2-14
Chemical-Specific ARARs
CS-23 Groundwater Operable Unit Remedy Alternative 3

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
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.	LTM will determine when these cleanup standards are met, unless a more stringent state standard has been promulgated, in which case the more stringent state standard must be met.	Applicable

ARAR	applicable or relevant and appropriate requirement	MA	Massachusetts
CCl_4	carbon tetrachloride	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
CS-23	Chemical Spill-23	TCE	trichloroethene
LTM	long-term monitoring	µg/L	micrograms per liter

Table 2-15
Location-Specific ARARs
CS-23 Groundwater Operable Unit Remedy Alternative 3

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, particularly Native American artifacts of the Wampanoag Indian Tribes. If LTM or remedial system components need to be sited in areas that may have such resources, 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 2-15
Location-Specific ARARs
CS-23 Groundwater Operable Unit Remedy Alternative 3

Media	Requirements	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, particularly Native American artifacts of the Wampanoag Indian Tribes. If LTM or remedial system components need to be sited in areas that may have such resources, 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.	If the construction, and operation and maintenance of the remedial system and/or LTM well system is needed and would adversely affect nearby wetlands, such potential impacts will be minimized to comply with these requirements.	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 construction, and operation and maintenance of the remedial system and/or LTM well system is needed and would adversely affect nearby wetlands, such potential impacts will be mitigated to comply with CWA 404 requirements.	Applicable

Table 2-15
Location-Specific ARARs
CS-23 Groundwater Operable Unit Remedy Alternative 3

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 construction, and operation and maintenance of the remedial system and/or LTM well system, if needed, will be designed and implemented to meet the performance standards in 310 CMR 10.21 through 10.60 to minimize adverse effects to any nearby wetlands.	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 are ARARs only if new wells are needed and are sited in floodplains. If the placement of any such well is needed, these requirements will be complied with if the location is within or will affect a floodplain.	Applicable

Table 2-15
Location-Specific ARARs
CS-23 Groundwater Operable Unit Remedy Alternative 3

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Floodplains	STATE – MassDEP Wetland Protection Act (MGL Ch. 131, Section 40, and 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 are ARARs only if new wells are needed and are sited in floodplains. If the placement of any such well is needed, these requirements will be complied with if the location is within or will affect a floodplain.	Applicable

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
LTM	long-term monitoring
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 2-16
Action-Specific ARARs
CS-23 Groundwater Operable Unit Remedy Alternative 3

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 most stringent 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 most stringent 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 2-16
Action-Specific ARARs
CS-23 Groundwater Operable Unit Remedy Alternative 3

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 result in 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 (November 18, 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 these requirements.	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, and operation and maintenance of the remedial system components and of any new LTM wells (if needed) will be performed in accordance with this guidance as appropriate.	TBC

Table 2-16
Action-Specific ARARs
CS-23 Groundwater Operable Unit Remedy Alternative 3

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 – 30.353)	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 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
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

Table 2-16
Action-Specific ARARs
CS-23 Groundwater Operable Unit Remedy Alternative 3

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
LTM	long-term monitoring
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
TCLP	Toxicity Characteristic Leaching Procedure
VOC	volatile organic compound

Table 2-17

Present Value Calculation for CS-23 Groundwater Operable Unit Alternative 3

Year	Treatment System Design, Construction and Start-up Costs	Baseline Monitoring Costs	Annual Hunter Avenue O&M	Annual System Performance	Long-Term Monitoring	Periodic Costs	Total Cost (0% Discount)	Discount Factor (for 3.1%)	Total Present Value Cost at 3.1%	Calendar Year
0	$ 4,447,962	$ 121,634	$ 629,335	$ 463,050	$ -	$ -	$ 5,661,980	1.0000	$ 5,661,980	2006
1	$ -	$ -	$ 629,335	$ 463,050	$ -	$ -	$ 1,092,385	0.9699	$ 1,059,539	2007
2	$ -	$ -	$ 534,934	$ 393,593	$ -	$ -	$ 928,527	0.9408	$ 873,529	2008
3	$ -	$ -	$ 534,934	$ 393,593	$ -	$ -	$ 928,527	0.9125	$ 847,263	2009
4	$ -	$ -	$ 460,044	$ 334,554	$ -	$ -	$ 794,597	0.8850	$ 703,254	2010
5	$ -	$ -	$ 460,044	$ 334,554	$ -	$ 2,776	$ 797,373	0.8584	$ 684,492	2011
6	$ -	$ -	$ 391,037	$ 284,371	$ -	$ -	$ 675,408	0.8326	$ 562,359	2012
7	$ -	$ -	$ 391,037	$ 284,371	$ -	$ -	$ 675,408	0.8076	$ 545,450	2013
8	$ -	$ -	$ 332,381	$ 241,715	$ -	$ -	$ 574,096	0.7833	$ 449,692	2014
9	$ -	$ -	$ 332,381	$ 241,715	$ -	$ -	$ 574,096	0.7598	$ 436,171	2015
10	$ -	$ -	$ -	$ -	$ 32,816	$ 2,776	$ 35,592	0.7369	$ 26,228	2016
11	$ -	$ -	$ -	$ -	$ 32,816	$ -	$ 32,816	0.7148	$ 23,455	2017
12	$ -	$ -	$ -	$ -	$ 31,503	$ -	$ 31,503	0.6933	$ 21,840	2018
13	$ -	$ -	$ -	$ -	$ 31,503	$ -	$ 31,503	0.6724	$ 21,183	2019
14	$ -	$ -	$ -	$ -	$ 30,243	$ -	$ 30,243	0.6522	$ 19,724	2020
15	$ -	$ -	$ -	$ -	$ 30,243	$ 2,776	$ 33,019	0.6326	$ 20,887	2021
16	$ -	$ -	$ -	$ -	$ 29,033	$ -	$ 29,033	0.6136	$ 17,814	2022
17	$ -	$ -	$ -	$ -	$ 29,033	$ -	$ 29,033	0.5951	$ 17,278	2023
18	$ -	$ -	$ -	$ -	$ 27,872	$ -	$ 27,872	0.5772	$ 16,088	2024
19	$ -	$ -	$ -	$ -	$ 27,872	$ -	$ 27,872	0.5599	$ 15,605	2025
20	$ -	$ -	$ -	$ -	$ 26,757	$ 2,776	$ 29,533	0.5430	$ 16,037	2026
21	$ -	$ -	$ -	$ -	$ 26,757	$ -	$ 26,757	0.5267	$ 14,093	2027
39	$ -	$ -	$ -	$ -	$ 25,687	$ -	$ 25,687	0.3040	$ 7,810	2045
40	$ -	$ -	$ -	$ -	$ 25,687	$ -	$ 25,687	0.2949	$ 7,575	2046
41	$ -	$ -	$ -	$ -	$ 24,659	$ -	$ 24,659	0.2860	$ 7,053	2047
42	$ -	$ -	$ -	$ -	$ 24,659	$ 2,776	$ 27,435	0.2774	$ 7,611	2048
43	$ -	$ -	$ -	$ -	$ 23,673	$ -	$ 23,673	0.2691	$ 6,370	2049
44	$ -	$ -	$ -	$ -	$ 23,673	$69,397	$ 93,070	0.2610	$ 24,290	2050
TOTAL	$ 4,447,962	$ 121,634	$ 4,695,462	$ 3,434,563	$ 504,488	$83,277	$ 13,287,386		$ 12,114,673	

Table 2-18
Cost Estimate Basis for CS-23 Groundwater Operable Unit Alternative 3

ITEM	QTY.	UNITS	UNIT COST	TOTAL	SUBTOTAL	COMMENTS	ASSUMPTIONS
BASE BOUNDARY TREATMENT SYSTEM DESIGN, CONSTRUCTION, AND START-UP COSTS							
CAPITAL COSTS							
Mobilization							
Cultural Resource Survey	1	LS	$ 15,500	$ 15,500		Based on similar studies performed historically at MMR.	1 area
Property Access Support	150	HR	$ 48	$ 7,200		Based on similar studies performed historically at MMR, 50 hours/EW on-base.	3 on-base EWs
Chemical and Hydraulic Study	1	LS	$ 290,000	$ 290,000		Includes drilling and oversight, data collection, analysis, data management and interpretation of physical and chemical samples.	1 area
Engineering						All engineering costs are based on historical experience with similar projects on the MMR site.	
Modeling/Design	1	LS	$ 185,000	$ 185,000			1 area of study
System Engineering Design	1	LS	$ 100,000	$ 100,000		Includes engineering design for the system and pipeline, site engineering, and start-up engineering.	
ETR Wellfield Construction							
Site Prep/Restoration-Well Area	3	WELL	$ 7,500	$ 22,500		For each EW and RIW	
Pilot Boring	3	WELL	$ 31,000	$ 93,000		One per extraction well	
EW Drilling and Installation	3	EA	$ 274,000	$ 822,000			
IDM	6	WELL	$ 8,000	$ 48,000		1 EW, 1 pilot boring per new EW	
Analytical, Data Management	105	SAMP	$ 150	$ 15,750		Assume 35 samples per EW.	
EW Pump, Motor and Assoc. Materials	3	WELL	$ 5,100	$ 15,300			Pump capacity = 300 gpm
Vault, Vault Piping	3	WELL	$ 11,500	$ 34,500		EW	Similar to vault for 81EW0003
Piping EW and Trench to Treatment Facility	7100	LS	$ 105	$ 745,500		Includes labor and restoration or repaving costs.	
Electric, Communications	3	WELL	$ 75,000	$ 225,000		Includes instrumentation and in-line delivery, control system delivery, service connection, and E&I, including grounding and surge protection.	
Power	3	WELL	$ 4,400	$ 13,200			EWs only. Assume 3,000 feet electrical line.
General Items and Construction Support	3	WELL	$ 80,000	$ 240,000		See General Assumptions for description.	
Infiltration Trench	1	LS	$ 243,000	$ 243,000		Based on historical experience with similar projects on the MMR site. Includes headers, boxes, and valves.	Used 2 linear ft of trench for every 1 gpm. 860 gpm, therefore 1700 ft of trench.
SPEIM Well Installation							
Well Drilling	3	EA	$ 26,000	$ 78,000		1 SPEIM well per new EW, set in pilot boring	
Analytical, Data Management	75	SAMP	$ 150	$ 11,250		Assume 25 samples per EW for associated SPEIM wells.	
SUBTOTAL					$ 3,204,700		
OVERHEAD AND SUPPORT				$ 929,363		Based on historical experience with similar projects at the MMR site.	
TOTAL					$ 4,134,063		
TOTAL ESCALATED					$ 4,447,962		

Table 2-18
Cost Estimate Basis for CS-23 Groundwater Operable Unit Alternative 3

ITEM	QTY	UNITS	UNIT COST	TOTAL	SUBTOTAL	COMMENTS	ASSUMPTIONS
TREATMENT SYSTEM OPERATIONS AND MAINTENANCE							
ANNUAL COSTS							
Hunter Avenue Treatment System							
Labor	1	YR	$ 15,000	$ 15,000			
Carbon	1	YR	$ 252,000	$ 252,000			
Sludge Disposal	1	YR	$ 2,000	$ 2,000			1 year/facility area
Well Maintenance	3	WELL	$ 15,500	$ 46,500			
Spare Parts	3	WELL	$ 5,200	$ 15,600			
Utilities	1	YR	$ 106,000	$ 106,000			
Analytical, Data Management	36	SAMP	$ 150	$ 5,400			3 samples/month; off-site analysis; includes data validation
SUBTOTAL					$ 442,500		
OVERHEAD AND SUPPORT				$ 128,325			
HUNTER AVENUE SYSTEM TOTAL					$ 570,825		
HUNTER AVENUE SYSTEM ESCALATED					$ 629,335		
BASELINE GROUNDWATER MONITORING							
CAPITAL COSTS							
Baseline Performance and Environmental Sampling							
Base Boundary Wellfield	2	LS	$ 15,036	$ 30,072		Two events collected prior to and after system start-up.	Hydraulic measurements only. Baseline sampling assumed to be for 10 monitoring points related to each new EW and associated wellfield only.
Baseline Report	1	LS	$ 75,000	$ 75,000		Based on historical experience with similar reports for the MMR project.	
TOTAL					$ 105,072		
TOTAL ESCALATED					$ 121,634		
ANNUAL GROUNDWATER MONITORING							
ANNUAL COSTS							
System Performance Monitoring and Reporting						Includes equipment, personnel, laboratory analyses, IDM, equipment maintenance, data interpretation, and reporting. Costs also include overhead and support.	
Base Boundary Wellfield	1	LS	$ 400,000	$ 400,000			
Escalated					$ 463,050		
Chemical Long-Term Monitoring and Reporting						Includes equipment, personnel, laboratory analyses, IDM, equipment maintenance, data interpretation, and reporting. Actual costs also include overhead and support.	7 monitoring wells and annual report.
Wellfield	1	LS	$ 30,500	$ 30,500			
TOTAL				$ 30,500			
TOTAL ESCALATED					$ 32,816		

Table 2-18
Cost Estimate Basis for CS-23 Groundwater Operable Unit Alternative 3

ITEM	QTY	UNITS	UNIT COST	TOTAL	SUBTOTAL	COMMENTS	ASSUMPTIONS
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 AND 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 AND SUPPORT				$ 14,500			
TOTAL					$ 64,500		
TOTAL ESCALATED					$ 69,397		

Notes:
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
EA = each
E&I = electrical and instrumentation
EW = extraction well
ft = feet
gpm = gallons per minute
HR = hour
IDM = investigation-derived waste
LS = lump sum
MMR = Massachusetts Military Reservation
QTY = quantity
RIW = reinjection well
SAMP = sample
SPEIM = system performance and ecological impact monitoring
YR = year

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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 Chemical Spill-23 Groundwater, Concurrence

Dear Mr. Owens;

The Massachusetts Department of Environmental Protection (MassDEP) has received the document entitled **"Final Record of Decision for Chemical Spill-23Groundwater "** (the "CS-23 ROD"), dated September, 2007. The CS-23 ROD presents the selected remedy for the CS-23 groundwater, which was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The U.S. Air Force is the lead agency for CERCLA remedial actions at the MMR. The MassDEP concurs with the AFCEE's selected remedy identified in the CS-23 ROD.

The CS-23 groundwater plume is located in Bourne and is approximately 8,600 feet long and 1,600 feet wide with a maximum thickness of 140 feet. The CS-23 plume was initially detected in September 2000 when groundwater sampling performed relative to the Southwest Operable Unit Pre-design Investigation detected trichloroethylene (TCE) above the Maximum Contaminant Level (MCL) of 5 ug/L in a monitoring well not associated with any known MMR plume at the time. The primary contaminants in the CS-23 plume are chlorinated solvents including TCE and carbon tetrachloride (CCl_4). The CS-23 plume is detached from its source area and likely originated from spills of chemical solvents on the southern part of the MMR, although no specific source area has been identified.

A CS-23 remedial investigation (RI) conducted during 2003 and 2004 concluded that future groundwater use within the area impacted by the CS-23 plume could pose an unacceptable risk to human health if used for residential purposes. The CS-23 plume does not represent a current ecological risk since it does not presently discharge into any surface waters. The CS-23

RI recommended that a Feasibility Study (FS) be performed and that a remediation system be installed to prevent further migration of the CS-23 plume beyond the base boundary. The FS was conducted in 2005 and an extraction, treatment and infiltration (ETI) system for the CS-23 plume began operating in 2006. The CS-23 ETI system consists of two extraction wells installed along the MMR boundary and two infiltration trenches. Extracted groundwater is pumped to the Hunter Avenue treatment plant located on the MMR. The Hunter Avenue facility is a granular activated carbon (GAC) treatment plant that treats multiple groundwater plumes associated with the MMR.

A streamlined approach was used for the CS-23 FS used to minimize the screening of remedial technologies and remedial alternatives. The streamlined approach, which was approved by the regulatory agencies, was used to expedite the selection of a final remedy for the CS-23 and was developed based upon extensive experience gained through the cleanup of other MMR plumes that were nearly identical to the CS-23 plume. Consequently, only five remedial alternatives were evaluated for the CS-23 groundwater plume in the FS. These remedial alternatives included a no-action scenario, a long-term monitoring scenario with Institutional Controls (ICs), and three active remedial alternatives involving groundwater extraction at the base boundary and ICs.

Alternative 3 involves the use of the existing ETI system constructed in 2006. Alternative 4 entails the use of the existing CS-23 ETI system with the installation of an additional extraction well(s) at the CS-23 leading edge (currently undefined), while Alternative 5 involves the use of the existing CS-23 ETI system with the installation of additional extraction wells at the leading edge and in areas of the plume upgradient of the base boundary. The AFCEE issued a Proposed Plan in December 2005, which identified Alternative 3 (continued operation and monitoring of the existing ETI system with ICs) as the AFCEE's preferred remedial alternative.

The MassDEP concurs with the CS-23 ROD. The MassDEP's concurrence with the CS-23 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 CS-23 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 CS-23 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

CS-23 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

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 Minior - AFCEE

Katherine Kowalski - Jacobs Engineering

Leonard Pinaud - 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

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

George Heufelder

Arthur Vidal III

John Waterbury

John Waterbury

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