

30

# Management and Public Interaction Surrounding the Massachusetts Military Reservation Installation Restoration Program

by  
Benjamin R. Jordan

B.S., Environmental Engineering Science  
Massachusetts Institute of Technology, 1995

Submitted to the  
Department of Civil & Environmental Engineering  
in Partial Fulfillment of the Requirements for the Degree of

MASTER OF ENGINEERING

at the  
Massachusetts Institute of Technology

June 7, 1996

© 1996 Benjamin Raines Jordan, all rights reserved. The author hereby grants MIT permission to reproduce and to distribute publicly paper and electronic copies of this thesis document in whole or in part.

Signature of Author

\_\_\_\_\_

~~Department of Civil & Environmental Engineering  
Massachusetts Institute of Technology  
May 10, 1996~~

Certified by

\_\_\_\_\_

\_\_\_\_\_  
Professor David H. Marks  
James Mason Crafts Professor of Civil & Environmental Engineering  
Director, Program on Environmental Engineering Education & Research  
Thesis Supervisor

Accepted by

\_\_\_\_\_

\_\_\_\_\_  
Joseph M. Sussman  
Chairman, Departmental Committee on Graduate Studies

MASSACHUSETTS INSTITUTE  
OF TECHNOLOGY

JUN 05 1996

Eng.

LIBRARIES

# **Management and Public Interaction Surrounding the Massachusetts Military Reservation Installation Restoration Program**

by  
Benjamin R. Jordan

Submitted to the Department of Civil & Environmental Engineering, May 10, 1996,  
in Partial Fulfillment of the Requirements for the Degree of Master of Engineering

## **Abstract**

The Massachusetts Military Reservation (MMR), which is located on Cape Cod, Massachusetts, is a Superfund site currently listed on the National Priorities List (NPL) by the United States Environmental Protection Agency. Since it was placed on the NPL, remediation activities have been ongoing at the MMR. This report presents the results of a project to assess the environmental impacts of the groundwater plume emanating from the MMR Main Base Landfill (LF-1). In addition, this report details an in-depth study into management and public interaction surrounding activities at the MMR Installation Restoration Program (IRP).

Public involvement in IRP activities has had a somewhat sordid history. Beginning with the first announcements of contamination on the base, public outcry and distrust for the military led to an adversarial relationship between the public and those responsible for cleanup. And while IRP officials have increased the amount of participation and input the public has in the process over the past several years, this effort has not been as successful in speeding up the remediation process as the government might have hoped. Remnants of the adversarial relationship fostered by attitudes in the early stages of the IRP, to a degree, still exist. The MMR, and the way public was mistreated and seen as a problem rather than a potential source of solutions early on in the process, has been used by other bases as a “negative model”. The individual study detailed here probes these and various other issues surrounding public involvement at the Massachusetts Military Reservation.

Thesis Supervisor: Professor David H. Marks

Title: James Mason Crafts Professor of Civil & Environmental Engineering

## Acknowledgments

There are several groups and individuals that I would like to thank--without them, this thesis effort would have gone by the wayside. I am sure that I am leaving someone out, so I will start by saying thanks to everyone who's been a part of the past year and my transition into graduate school--now that I am here, I think I like it, and maybe I'll stay for awhile. Whether or not you made a tangible effort to help me with my thesis work, you have undoubtedly contributed to it in one way or another--even if most of your time was spent keeping me away from it enough so that I could keep it in perspective.

Specific to the thesis effort, I would like to acknowledge the other members of the LF-1 research team and all their hard work (hit 150 pages yet, Karl?): Dan Alden, Kishan Amarasekera, Michael Collins, Karl Elias, Jim Hines, and Robert Lee--especially Dan, who kept the rest of us from killing each other before we realized we actually were a "team". I would also take time to thank Douglas Karson of the MMR IRP office--public affairs guru--for providing information regarding public participation at the MMR. Thanks also to Capt. Mike Wells of the California National Guard for providing further information. Professor Lynn Gelhar deserves a lot of thanks for his handling of the M.Eng. Thesis/Project Course. I also thank Prof. Gelhar for serving as my Academic Advisor this year, and Dennis LeBlanc of the USGS for putting all this risk stuff into perspective with the following quote:

*"One part per billion is the equivalent of one crouton in 500,000 pounds of lettuce."*

Along with the thesis work as well as the M.Eng. Program as a whole, I would like to thank Professor David Marks and Shawn Morrissey. Dave kept me going as my Thesis Supervisor this spring, and has been an advisor of sorts for, (uh, *one, two, three...*) four years now--for him I have only one question: "How much farther, Papa Dave?" As for Shawn (he helped with the thesis, too), I'd like to know what it is about his personality that gives off encouragement (even though he knows you are full of it), because there have been plenty of times when I walked into his office feeling frustrated and walked out feeling like I could pull this year off without a hitch. Maybe it's the whole PEEER/M.Eng./Alliance office: thanks to Jackie and Joanne for putting up with all the traffic in and out of there this year.

Outside M.Eng., but still inside the Department, thanks to all the folks in headquarters. Thanks for the financial support, but also, thanks for making the Department a nice place to be--it's even been upgraded to "fishable and swimable". Thanks also to all my ol' buddies in ASCE.

Across campus towards Sloan, but still keeping its distance, I would like to thank everyone involved in the MIT Program on Technology, Business & Environment (TB&E). To Professor John Ehrenfeld, thanks for the financial support, and thanks for trusting me with an interesting and worthwhile project when we weren't exactly sure I'd have enough time to complete it (for the record, I'm getting there!). Thanks to Jennifer Nash for everything, *...again*--all the busy work you gave me that first summer at TB&E turned into a little bit more than that, didn't it? To everyone else, especially Michael Lenox, I owe a special thanks for keeping me busy at TB&E and giving me a different perspective on environmental management (it's about a lot more than

just haz waste cleanup). Thanks also to Sandra Rothenburg, a Sloanie who's really a TB&E'er at heart.

On the non-academic side, there are several friends and relatives I must thank here. Thanks to Mom and Dad for all the encouraging phone calls and emails, and all the love and support through the years--telling me time and time again to keep my sail in the wind is finally paying off (speaking of paying off--thanks, Dad, for doing my taxes). And to my sister Jill, thanks for listening even when you didn't have time to--thank goodness for that 1-800 number at Suntrust! To the rest of the family, thanks to Aunt Betty for the pie crust recipe and all the philosophy, and to everyone else for the emails, the cards, and all the Sunday dinner conversations.

Finally, I am beginning to realize just how many people there are out there to thank. Keeping this to one page might be tough, but I have to include the friends at MIT and around Boston that were part of the reason I couldn't get away from New England last year this time--and part of the reason I am staying around once again. Many thanks go out to Jim Casey and Surekha Vajjhala for always being around, to Peter Berger for turning 21 at just the right time, to Nate Boyd, Brad Elder, and Ned Patterson for keeping the dream alive, to Marwan Kazimi for keeping my gears in check, to Noah Breslow for being a Democrat, to Peter Chatel at Coca-Cola for all the advice (and last summer!), to microbreweries for giving me a new hobby when I thought I wouldn't have time for it, to the people at SATCO, Salvation Army Nashville, and the Tinsworth Discoteque for giving me "Saturday Night Fever", to the Town of Rochester, Minnesota, for having spring-like weather for a few days in March, and to everyone else that I have forgotten, peace and love to you, and thanks for everything.



## *Words to Live By...*

**I shall be telling this with a sigh  
Somewhere ages and ages hence:  
Two roads diverged in a wood, and I--  
I took the one less traveled by,  
And that has made all the difference.**

**--Robert Frost, from *The Road Not Taken***

*If you ain't the lead dog,  
The scenery never changes...*

**--anonymous**

# Table of Contents

<b>1. INTRODUCTION .....</b>	<b>9</b>
<b>2. BACKGROUND AND SITE DESCRIPTION: CHARACTERIZATION OF THE MAIN BASE LANDFILL [LF-1] PLUME .....</b>	<b>11</b>
2.1 UPPER CAPE GEOGRAPHY AND LAND USE .....	11
2.2 CLIMATE .....	12
2.3 GEOLOGY AND GROUNDWATER .....	13
2.3.1 Geology.....	13
2.3.2 Groundwater System.....	15
2.3.2.1 Vertical Hydraulic Gradients.....	15
2.3.2.2 Horizontal Hydraulic Gradients.....	16
2.3.2.3 Seepage Velocity .....	16
2.4 THE MMR'S LISTING ON THE NATIONAL PRIORITIES LIST .....	16
2.5 PRESENT ACTIVITY .....	17
<b>3. RESULTS FROM THE LARGER LF-1 STUDY .....</b>	<b>22</b>
3.1 CHARACTERIZATION AND REMEDIATION RESULTS .....	22
3.1.1 Site Characterization.....	22
3.1.1.1 Groundwater Contamination.....	22
3.1.1.2 Hydraulic Conductivity .....	24
3.1.1.3 Summary.....	25
3.1.2 Groundwater Modeling and Particle Tracking Simulation.....	29
3.1.2.1 Objectives and Scope.....	29
3.1.2.2 DYNFLOW, DYNTRACK and DYNPLOT Systems .....	29
3.1.2.3 Study Area and Grid.....	30
3.1.2.4 Model Formulation.....	31
3.1.2.4.1 Assigned Geologic Materials.....	31
3.1.2.4.2 Source.....	31
3.1.2.4.3 Ponds.....	31
3.1.2.4.4 Hydraulic Properties.....	32
3.1.2.4.4.1 Hydraulic Conductivity.....	32
3.1.2.4.4.2 Dispersivity.....	33
3.1.2.4.4.3 Effective Porosity.....	33
3.1.2.4.5 Boundary Conditions.....	34
3.1.2.4.5.1 Saltwater-Freshwater Interface.....	34
3.1.2.4.5.2 No-Flux Boundaries.....	34
3.1.2.4.6 Recharge.....	34
3.1.2.5 Results .....	35
3.1.3 Risk Assessment & Management of Risks .....	48
3.1.3.1 Toxicology.....	48
3.1.3.2 Dose.....	49
3.1.3.3 Identification of Hazardous Materials.....	50
3.1.3.4 Review Existing Reports .....	51
3.1.3.5 Uncertainty .....	51
3.1.3.6 Results of Human Health Risk Assessment.....	52
3.1.3.7 Results of Assessment of Risk from Ingestion of Contaminated Shellfish.....	54
3.1.4 Public Perception: Management of Public Interaction at the MMR.....	56
3.1.4.1 Public Perception in Superfund Cleanup.....	56
3.1.4.2 History of Public Involvement at the MMR .....	57
3.1.4.3 Design Of Future Approaches At the MMR And Elsewhere.....	58
3.2 REMEDIAL APPROACHES .....	59

3.2.1 Source Containment.....	59
3.2.1.1 Introduction .....	59
3.2.1.2 Regulatory Review .....	60
3.2.1.3 Subgrade Layer.....	63
3.2.1.4 Gas Ventilation Layer.....	63
3.2.1.5 Hydraulic Barrier Layer.....	64
3.2.1.6 Drainage Layer .....	64
3.2.1.7 Surface Layer.....	65
3.2.1.8 Conclusions .....	66
3.2.2 Bioremediation .....	68
<b>4. DETAILED INDIVIDUAL STUDY.....</b>	<b>74</b>
4.1 METHODOLOGY FOR INDIVIDUAL STUDY .....	74
4.2 BACKGROUND ON THE CERCLA PROCESS PATH.....	74
4.3 HISTORY OF MANAGEMENT OF PUBLIC INTERACTION AT THE MMR.....	75
4.3.1 Evolution of Management Scheme for Public Involvement (Karson, 1995).....	75
4.4 CURRENT PUBLIC AFFAIRS/INVOLVEMENT ACTIVITIES AT THE MMR.....	76
4.4.1 Present Committee Make-up, Action .....	78
4.4.2 Various Public Meeting formats .....	80
4.5 ANALYSIS OF THE STATUS QUO: WHERE HAVE PAST ACTIONS TAKEN US? .....	81
4.5.1 Influence of the Public thus far.....	81
4.5.1.1 Public Meetings .....	81
4.5.1.1.1 Concerns Raised by the Public at Recent IRP Committee and Sub-committee Meetings.....	82
4.5.1.1.2 Public Relations Documents.....	83
4.5.1.1.3 Design Of Containment System.....	83
4.5.2 Media Involvement.....	84
4.5.3 Current IRP Personnel Tasking.....	84
4.6 COMPARISON WITH INSTALLATION RESTORATION PROGRAMS AT OTHER MILITARY BASES..	86
4.6.1 Los Alamitos Air National Guard Base, California (Wells, 1996) .....	86
4.6.1.1 Site Background .....	86
4.6.1.1.1 Land and Groundwater Characteristics .....	87
4.6.1.1.2 Water management in California .....	88
4.6.1.1.3 Current Extent of Contamination .....	88
4.6.1.2 Potential Implications of Contamination at Los Alamitos on Local Communities.....	89
4.6.1.3 The IRP process at Los Alamitos.....	89
4.6.1.3.1 Regulatory Agency oversight of the Los Alamitos IRP .....	94
4.6.1.3.2 Funding for the IRP at Los Alamitos .....	94
4.6.1.4 Public Participation in the IRP Process at Los Alamitos .....	95
4.6.1.4.1 Personalities and public perception .....	96
4.6.1.4.2 Media used to disseminate information about the IRP at Los Alamitos.....	96
<b>5. CONCLUSIONS PERTAINING TO INDIVIDUAL OBJECTIVES.....</b>	<b>97</b>
5.1 STALLS RESULTING FROM LEAVING PUBLIC OUT OF THE PROCESS .....	97
5.2 STALLS RESULTING FROM INVOLVING THE PUBLIC.....	98
5.3 ACHIEVING THE PROPER LEVEL OF PUBLIC INVOLVEMENT.....	99
<b>6. REFERENCES.....</b>	<b>101</b>
<b>7. APPENDICES.....</b>	<b>105</b>

# List of Figures

For the most part, the figures included in this document are attached at the end of the relevant sections. However, a few tables and figures are included in the text flow of the document.

FIGURE 2-1. SITE LOCATION MAP (ABB, 1992) .....	18
FIGURE 2-2. PHOTOGRAMMETRIC LAYOUT OF MAIN BASE LANDFILL (ABB, 1992) .....	19
FIGURE 2-3. GROUNDWATER CONTOUR MAP, WESTERN CAPE (AUTOMATED SCIENCES, 1994).....	20
FIGURE 2-4. GEOLOGIC PROFILE OF THE WESTERN CAPE (AUTOMATED SCIENCES, 1994).....	21
FIGURE 3-1. LOG-LINEAR CONTOUR OF TOTAL CONTAMINANT MASS .....	26
FIGURE 3-2. LOG-LINEAR CONTOUR OF MAX MCL NORMALIZED .....	27
FIGURE 3-3. 3-D GAUSS FILTER OF SLUG DATA .....	28
FIGURE 3-4. PLAN VIEW OF LF-1 STUDY AREA AND 3-D FINITE ELEMENT GRID.....	38
FIGURE 3-5. PLAN VIEW OF STUDY AREA WITH ASSIGNED MATERIALS .....	39
FIGURE 3-6. NORTH-SOUTH CROSS SECTION OF BUZZARDS BAY MORaine .....	40
FIGURE 3-7. EAST-WEST CROSS-SECTION OF SITE NEAR BUZZARDS BAY.....	41
FIGURE 3-8. EAST-WEST CROSS-SECTION OF STUDY AREA NEAR NANTUCKET SOUND .....	42
FIGURE 3-9. DIFFERENCES BETWEEN CALCULATED AND OBSERVED HEAD AND CALCULATED WATER TABLE CONTOURS.....	43
FIGURE 3-10. 51-YEAR SIMULATION OF A CONTINUOUS SOURCE AT LF-1 SITE.....	44
FIGURE 3-11. CROSS-SECTION OF SIMULATED 51-YEAR PLUME, ALSO SHOWING OBSERVED CONCENTRATIONS OF TOTAL VOC .....	45
FIGURE 3-12. 165-YEAR SIMULATED PLUME WITH SOURCE TURNED OFF AFTER 55 YEARS .....	46
FIGURE 3-13. NORTH-SOUTH CROSS-SECTION OF SIMULATED PLUME AT POINT OF ENTRY INTO THE BUZZARDS BAY MORaine.....	47
FIGURE 3-14. CROSS-SECTION OF PROPOSED COVER DESIGN .....	62
FIGURE 3-15. CONCEPTUAL DIAGRAM OF THE SEQUENTIAL BIOREMEDIATION SYSTEM (SKIADAS, 1996).....	73
TABLE 4-1. LIST OF PUBLIC INTEREST GROUPS INVOLVED IN THE MMR IRP PROCESS (KARSON, 1995) .....	77
TABLE 4-2. PROCESS ACTION TEAM TASK DESCRIPTIONS (IRP, 1996) .....	79
TABLE 4-3. VARIOUS PUBLIC MEETING FORMATS.....	80
TABLE 4-4. PUBLIC MEETINGS ATTENDED FOR RESEARCH PROJECT .....	82
TABLE 4-5. PERSONNEL TASKING AT THE MASS MILITARY RESERVATION INSTALLATION RESTORATION PROGRAM (THE MMR IRP, 1995).....	85

# 1. Introduction

This report summarizes findings of a research project undertaken to characterize environmental impacts of groundwater contamination emanating from the Main Base Landfill (LF-1) at the Massachusetts Military Reservation [the MMR], located at Cape Cod, Massachusetts. The United States Environmental Protection Agency placed the MMR on the Superfund National Priorities List (NPL) in 1989.

This project report was submitted in partial fulfillment of the course requirements for the Master of Engineering (M.Eng.) Program in the Department of Civil and Environmental Engineering at the Massachusetts Institute of Technology (MIT). Each individual on the project team researched a specific topic associated with the site. Individual findings were compiled as individual theses in further fulfillment of the Master of Engineering Degree requirements. This individual thesis presents the group effort undertaken to assess environmental impacts of the LF-1 plume in the form of overall project results, which are presented in Section 3. Detailed research methodology and results of the individual study to characterize management of public interaction at the MMR are presented in sections 4 and 5.

An extensive amount of data on contamination at the MMR has been collected and is maintained by the MMR Installation Restoration Program (IRP) office. The IRP acts as principal agent for the U.S. government on behalf of the MMR. Numerous reports have been generated for the IRP which include data observations and professional opinions. These reports are available for public review and are the principal source of information used for analysis in this report. A general

assumption of this project research and subsequent report and theses is that the analytical data which has been collected and reported in these documents are accurate.

The group project report both examines and offers opinions on the potential impacts of the MMR LF-1 on public health and welfare and how these effects can be mitigated. The scope of the research project includes site characterization and groundwater modeling, risk assessment, management of public interaction, study of source containment, and bioremediation technology.

The individual research presented in sections 4 and 5 attempts to answer the following questions:

- How has the management scheme for public involvement at the MMR IRP evolved over time?
- What is the current degree of public participation/involvement at the MMR?
- How have approaches to IRPs at other bases compared to that taken at the MMR, specifically regarding management of public interaction?
- What knowledge from past IRPs can be applied to the design of future approaches?

Section 4 presents individual study methodology, characterization of public involvement in the IRP process at the MMR, as well as a case study of the IRP currently ongoing at the Los Alamitos Air National Guard Base in California. Section 5 includes an analysis of the observations made during the study and discusses suggestions for future approaches to Installation Restoration Program activity.

## **2. Background and Site Description: Characterization of the Main Base Landfill [LF-1] Plume**

### ***2.1 Upper Cape Geography and Land Use***

The Massachusetts Military Reservation (MMR) is located in the northwestern portion of Cape Cod, Massachusetts, covering an area of approximately 30 square miles (ABB, 1992). See Figure 2.1 for regional and base maps. Military use of the MMR began in the early 1900's, and may generally be categorized as mechanized forces training and military aircraft operations. Since commencement of military operations, the base has seen use by several branches of the armed services, including the United States Air Force, Army, Navy, Coast Guard, and the Massachusetts Air National Guard. Operations by the Air National Guard and Coast Guard are ongoing.

The area of present study is the Main Base Landfill site, termed LF-1 by the MMR Installation Restoration Program. The landfill is about 10,000 feet from the western and southern the MMR boundaries and occupies approximately 100 acres. The landfill has operated since the early 1940's as the primary waste disposal facility at the MMR (CDM Federal, 1995). Unregulated disposal of waste at LF-1 continued until 1984, at which time disposal began to be regulated by the Air National Guard. Waste disposal operations at LF-1 took place in five distinct disposal cells and a natural kettle hole, as shown in Figure 2.2. These are termed the 1947, 1951, 1957, 1970, post-1970, and kettle hole cells. The date designations indicate the year in which disposal operations ceased at that particular cell. Accurate documentation of the wastes deposited at LF-1 does not exist. The wastes may include any or all of the following: general refuse, fuel tank

sludge, herbicides, solvents, transformer oils, fire extinguisher fluids, blank small arms ammunition, paints, paint thinners, batteries, DDT powder, hospital wastes, municipal sewage sludge, coal ash, and possibly live ordnance (ABB, 1992). Wastes were deposited in linear trenches, and covered with approximately 2 feet of native soil. Waste depth is uncertain, but estimated to be approximately 20 feet below the ground surface on average. Waste disposal at the landfill ceased in 1990. A plume of dissolved chlorinated volatile organic compounds, primarily tetrachloroethylene (PCE) and trichloroethylene (TCE), has developed in the aquifer downgradient of the landfill.

The four towns of interest on the western Cape are Bourne, Sandwich, Mashpee, and Falmouth. The total population of this area, according to 1994 census, is 67,400. The area is mostly residential, with some small industry. A significant amount of economic activity is associated with restaurants, shops, and other tourist-type industry. The total population of Cape Cod is estimated to triple in summer, when summer residents and tourists make up most of the population. The total base population has doubled in the last twenty years. Cape Cod has been one of the fastest growing areas in New England. In 1986, 27% of economic activity was attributed to retirees; tourism accounted for 26%; seasonal residents, 22%; manufacturing, 10%; and business services (fishing, agriculture, and other), 15%. The economy is currently experiencing a shift from seasonal to year-round jobs. (Cape Cod Commission, 1996).

## ***2.2 Climate***

The Cape Cod climate is categorized as a humid, continental climate. Average wind speeds range from 9 mph from July through September to 12 mph from October through March.



Precipitation is fairly evenly distributed, with an average of approximately 4 inches per month. Average annual precipitation is approximately 47 inches. There is very little surface runoff. Approximately 40% of the precipitation infiltrates the ground and enters the groundwater system (CDM Federal, 1995).

## ***2.3 Geology and Groundwater***

### **2.3.1 Geology**

The Cape Cod Basin consists of material deposited as a result of glacial action during the Wisconsinian stage between 7000 and 80,000 years ago. Advancing glaciers from the north transported rock debris gouged from the underlying bedrock until reaching the southernmost point of advance at Martha's Vineyard and Nantucket Island. The glacial action also resulted in a thin layer of basal till being deposited over the bedrock. The entire sedimentation process occurred as a sequence of glacial deposition, erosion and re-deposition. In later periods, the glaciers melted, receded, and reached a stagnation point near the western and northern shores of Cape Cod. The remaining glacial till was deposited there and formed the Buzzards Bay and Sandwich moraines. The present day Sandwich Moraine is thought to be of glacio-tectonic origin, due to pro-glacial sediments being thrust over older morainal deposits during a readvance of the Cape Cod Bay glacier (Oldale 1984).

The regional geology in the LF-1 study area can be classified into three main sedimentary types. These are the Buzzards Bay and Sandwich moraines (BBM and SM), the Mashpee Pitted Plain (MPP) and the Buzzards Bay Outwash (BBO). The geographic distribution of these materials is depicted in Figure 2.4. The MPP consists of stratified coarse to fine grained sands that were

transported from the melting Buzzards Bay and Cape Cod Bay ice sheets, and deposited over a bed of fine-grained glacio-lacustrine sediments and basal till. The general trends in the glacial outwash deposits in terms of grain size are coarsening upwards and fining north to south. The thickness of the coarse material decreases north to south, as the distance from the outwash source increases.

The morainal sediments were deposited directly as the ice-sheets melted. Thus, these deposits are not stratified like the MPP glacial outwash and are thought to occur in layers of poorly sorted sediment-flow deposits and finer till material. These sandy sediments overlie a fining sequence of sand, silt, clay and basal till. The unsorted glacial till that comprise the BBM ranges in size from boulders to fine clays. This complex heterogeneity leads to wide variations in observed hydrogeological parameters in the moraine. A general trend of fining in material size results in lower hydraulic conductivities (LeBlanc, 1986).

The Buzzards Bay Outwash (BBO) was deposited as a result of sedimentation between the retreating ice sheets and the newly deposited Buzzards Bay Moraine. BBO sediments are generally sand and gravel, and are considered to be stratified in the same manner as the MMP outwash, with a general trend of fining downwards.

The geologic structure described above lies atop a Paleozoic crystalline bedrock. The bedrock contours range in depth from 70 to 500 feet below sea level (Oldale, 1984). The bedrock is of a much lower hydraulic conductivity than the surrounding sediments, and therefore acts as an impermeable barrier to groundwater flow and thus forms the bottom boundary of the Cape Cod aquifer.

### **2.3.2 Groundwater System**

Cape Cod is underlain by a large, unconfined groundwater flow system. This phreatic aquifer has been designated a sole source aquifer by the Federal Environmental Protection Agency. The aquifer is divided into six flow cells according to the hydraulic boundaries of the flow system. The Massachusetts Military Reservation and LF-1 plume are located in the west Cape flow cell, the largest of the six flow cells. The aquifer system and water table contours in the west Cape region are depicted in Figure 2.3.

The water table in this region occurs at a depth of 40-80 feet below the ground surface. Surface water is also present in the study area as intermittent streams in drainage swales and more importantly as ponds in kettle holes on the Mashpee Pitted Plain. However, there are a few large kettle ponds that can significantly influence the flow regime near the LF-1 site and plume. Cranberry bogs can also occur at surface discharges of groundwater, but it is thought that the cranberry bogs west of the LF-1 site are underlain by localized perched water tables, and thus hydrologically disconnected from the larger aquifer system (CDM Federal, 1995). This fact, and the depth of the contaminant plume near these cranberry bogs makes it unlikely that contaminants from LF-1 will discharge into these important agricultural areas.

#### ***2.3.2.1 Vertical Hydraulic Gradients***

Vertical gradients that have been calculated for the LF-1 site are very small. Most gradients calculated in the IRP hydrologic investigations were below the survey accuracy threshold. Significant upward vertical gradients do exist where groundwater discharges into large ponds and near coastal areas where the aquifer discharges into the ocean. Small downward gradients of about  $10^{-3}$  to  $10^{-4}$  ft/ft are observed throughout the rest of the study area (CDM Federal, 1995).

Such vertical gradients generally indicate upward flow near the shoreline and surface water bodies and downward flow elsewhere.

### ***2.3.2.2 Horizontal Hydraulic Gradients***

Groundwater flow in the region is driven mostly by horizontal gradients. These can be measured by dividing a groundwater elevation contour interval by the horizontal distance between the contours. The latter value can be estimated from a contour map similar to Figure 2.3. Horizontal gradients calculated for the LF-1 study area using February 1994 water levels range from  $1.3 \times 10^{-3}$  to  $6.8 \times 10^{-3}$  ft/ft (CDM Federal, 1995). These gradients are observed to steepen from the LF-1 source area westwards.

### ***2.3.2.3 Seepage Velocity***

Calculated seepage velocities in the LF-1 study area indicate that advective contaminant transport takes place at velocities ranging from 0.10 ft/day to over 3 ft/day. Since seepage velocity is a function of hydraulic conductivity, the differential permeabilities of the various sediment types strongly influence calculation of seepage velocities at this site. An estimate of seepage velocity of contaminants made using observed LF-1 plume migration distance and time yielded an average seepage velocity of 0.9 ft/day (CDM Federal, 1995).

## ***2.4 the MMR's Listing on the National Priorities List***

the MMR is one of 1,236 sites that have been placed on the National Priority List (NPL) by the U.S. Environmental Protection Agency (EPA). NPL sites are those to which the EPA has given particularly high human health and environmental risk ranking. Rankings are determined from an evaluation of the relative risk to public health and the environment from hazardous substances

identified in the air, water and geologic surroundings local to a site. Once placed on the NPL, sites are targeted for remedial clean-up financed by the Superfund, which is the federal government's fiduciary and political device for remediating hazardous waste sites. Additional funding for cleanup is provided by potentially responsible parties (PRPs), those individuals and organizations whose activities have resulted in contamination.

### ***2.5 Present Activity***

Due to the health and environmental risks which have been attributed to activities at the MMR, federal activity is underway to further quantify and reduce, to the extent required, the risk imposed upon human health and the environment. As part of remediation operations at the MMR, several of the landfill cells have recently been secured with a final cover system. These cells include the 1970 cell, the post-1970 cell, and the kettle hole. The remaining cells (1947, 1951, and 1957) have collectively been termed the Northwest Operable Unit (NOU). Remedial investigations as to the necessity of a final closure system for these cells is ongoing. Other IRP activities associated with the LF-1 site include design of a plume containment system and further plume delineation and groundwater modeling.

Figure 2-1. Site Location Map (ABB, 1992)

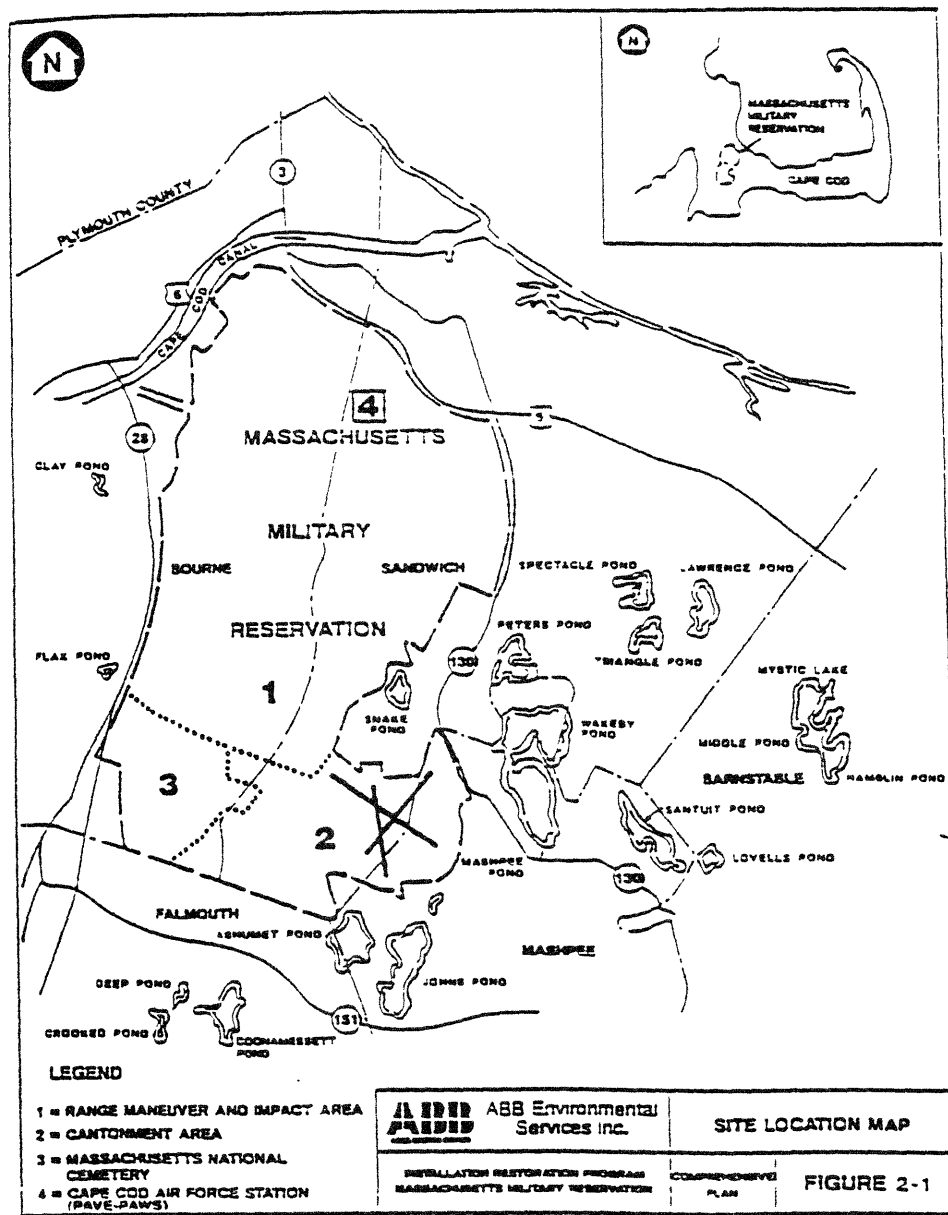


Figure 2-2. Photogrammetric Layout of Main Base Landfill (ABB, 1992)

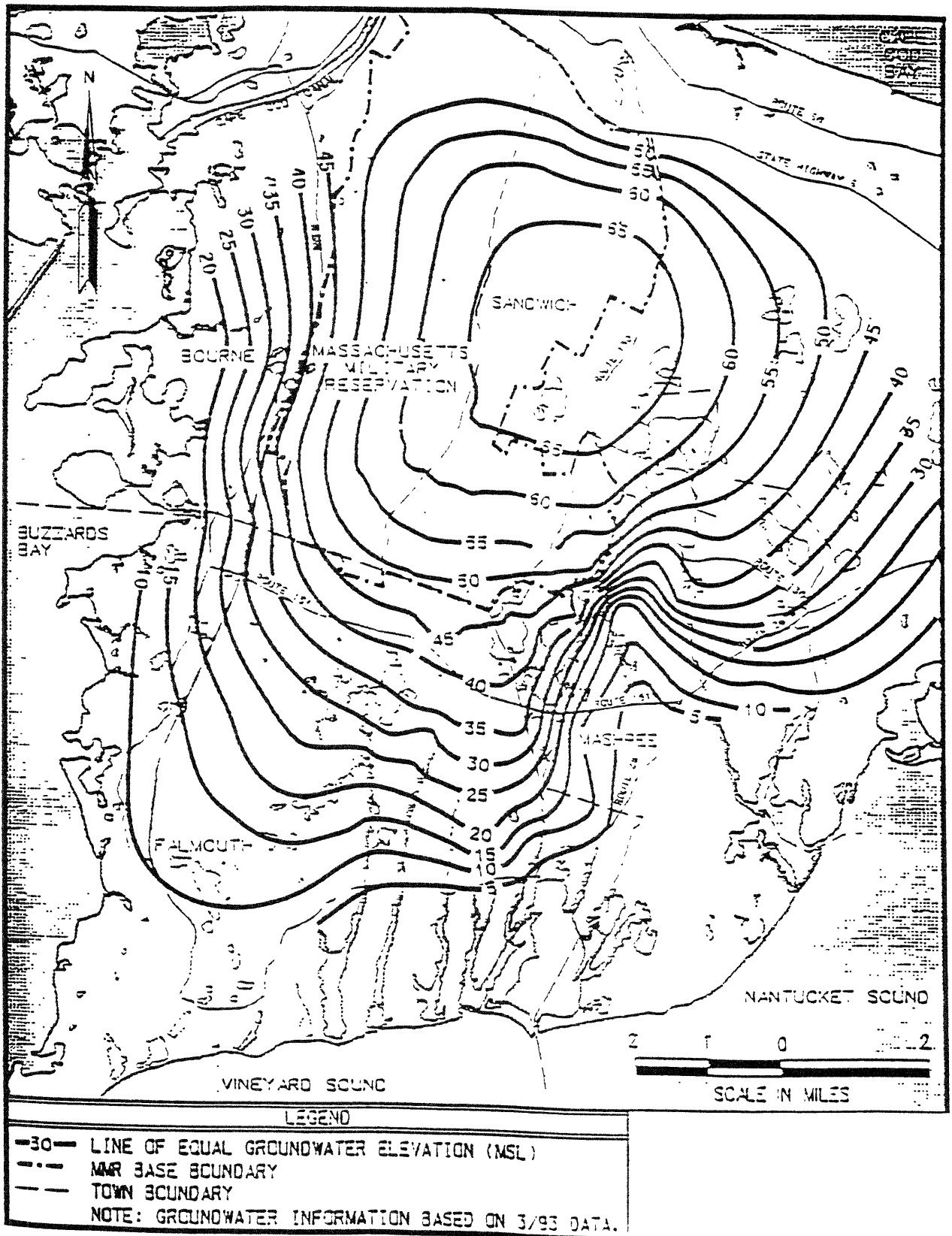


Figure 2-3. Groundwater Contour Map, Western Cape (Automated Sciences, 1994)

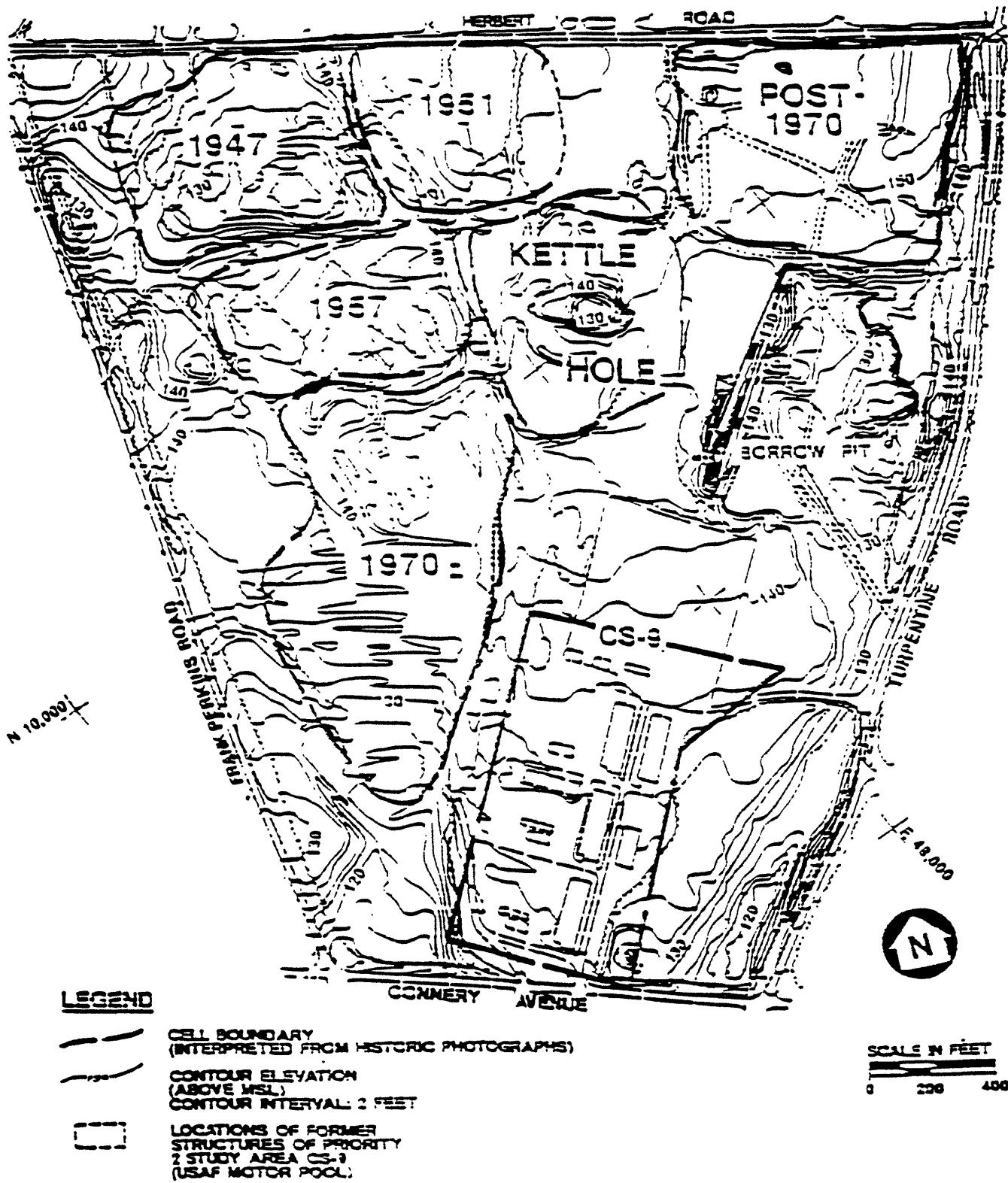
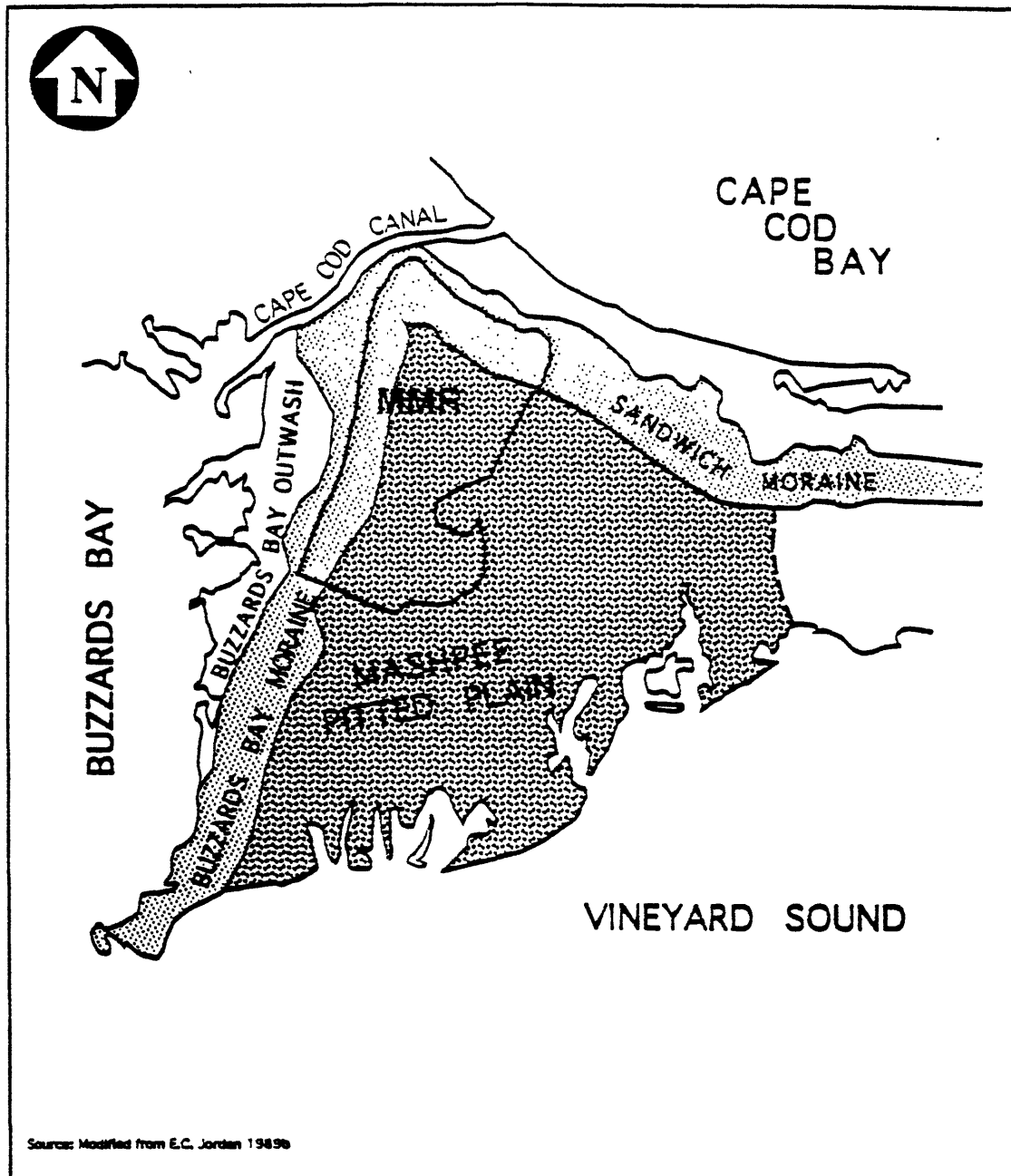




Figure 2-4. Geologic Profile of the Western Cape (Automated Sciences, 1994)



## **3. Results from the Larger LF-1 Study**

### ***3.1 Characterization and Remediation Results***

This chapter provides the results of the investigations conducted for this report. The results are divided into three sections. Section 3.1 covers site characterization, groundwater modeling, and risk analysis. Section 3.2 looks at possible source containment and bioremediation actions.

#### **3.1.1 Site Characterization**

Site characterization investigations followed two main topics with respect to this report. The first involved describing the nature and extent of the chemical contamination in the groundwater. The second involved analyzing tests for hydraulic conductivity to determine parameters that could be used for modeling contaminant migration.

##### ***3.1.1.1 Groundwater Contamination***

As part of the Superfund Remedial Investigation process, 73 wells at different locations and different depths were tested for 34 of the most likely compounds. The EPA standard for drinking water sets individual maximum contamination levels (MCLs) for most of these compounds. 28 out of the 73 wells had at least one contaminant which exceeded the MCL. 7 out of the 34 possible contaminants were at levels which exceeded the MCL. These contaminants are vinyl chloride (VC), carbon tetrachloride (CT), trichloroethylene (TCE), tetrachloroethylene (PCE), 1,4 dichlorobenzene (1,4 DCB), benzene (B), and chloroform (CF). All of these compounds have an MCL of 5 ppb, except for vinyl chloride which has an MCL of 2 ppb. The highest total of all 7 of these contaminants at any one well was 168 ppb.

The highest total of all contaminants sampled at any one well was 236 ppb. (Some of these contaminants have an MCL much higher than 5 ppb.) The highest three individual contaminant readings were CT at 60 ppb, TCE at 64 ppb, and PCE at 65 ppb. One ppb by volume is equivalent to one drop in 15,000 gallons. 168 ppb is equivalent to about 1/3 ounce per 15,000 gallons. At 60 gallons per day of individual water use, 15,000 gallons are used in 250 days. At 236 ppb, the highest total concentration sampled, this works out to about 1 drop of exposure per person per day. The risk assessment section of this report discusses the danger to humans from possible exposure.

Looking at two dimensional log-linear contours of the contamination data points and vertical section filtered contours (see Figures 3.1), a very rough estimate of the total volume of contamination can be made. This is estimated to be about 103 cubic feet or 14 - 55 gallon drums. This mass is distributed over approximately 4.5 square miles. The area where any single MCL level is exceeded is about 2 square miles.

Contamination contours show that little degradation of PCE is occurring. TCE is the degraded product of PCE. The contours show the center of PCE concentration to be downgradient from the center of TCE concentration, therefore the TCE could not be the result of PCE degradation. Instead, this indicates that TCE must be one of the originally dumped contaminants.

A comparison can be made between possible contaminant discharge to the ocean through groundwater migration versus the same discharge through a pipe from a hypothetical industrial source. If the contaminant front is considered to be 50 feet thick by 5000 feet wide and moving at a rate of 1 foot per day, this equates to an outfall pipe 2 feet in diameter with a flow rate of 1

foot per second. (A fast walk is about 5 feet per second.) In addition to drinking water standards, the EPA publishes guidelines for allowable contaminant marine discharge beyond the mean low water mark. These standards are considerably higher than those for drinking water. If the landfill plume were being discharged from a single pipe, the EPA would have to decide whether to permit such a discharge. From the given guideline values, and the known contamination levels, it is difficult to say whether a permit would be granted. However, the discharge is, in effect, put through a diffuser over an area 2500 times as large as the hypothetical pipe.

Examining cross sectional contours of contamination (see Figure 3.2), it is seen that a contamination level exceeding the MCL comes within 10 feet of the top of the aquifer. It is estimated that the withdrawal depth of a hypothetical private well pulling 1000 gallons per day to be 13 feet, given a conservative figure for hydraulic conductivity (50 ft/day) and hydraulic gradient (1/100). Therefore, it is possible that private wells located directly over the uppermost levels of contamination could draw in water exceeding the MCL levels for drinking water.

#### ***3.1.1.2 Hydraulic Conductivity***

Hydraulic conductivity (K) was determined using 140 grain size samples from 21 well locations and 79 slug test well locations. A comparison of values from these two different tests generally shows very poor correlation. However, a good correlation was seen between the Alyamani/Sen (Alyamani, et al., 1993) and Bedinger (Bradbury, et al., 1990) grain size methods. This is due to the fact that both depend on the grain size fraction  $d_{50}$ . Both grain size and slug test data were put through a 3-D gauss filtering process. The resulting data and corresponding contours exhibit

a significant correlation between the Hazen and slug methods. However, the Hazen values are much lower.

The filtered slug contours match the general geology of the area, showing a decline in conductivity from north to south and with depth. In addition, the Buzzard's Bay Moraine is clearly seen (see Figure 3.3). The contours also point out a zone of lower conductivity in a region where the contaminant plume appears to be dividing. This finding may provide part of the explanation for the observed migration path. The arithmetic mean of the unfiltered slug test data was 75 feet/day, ranging from less than 1 ft/day to 316 feet/day. The calculated horizontal conductivity from the filtered slug test data had a mean of 85 feet/day and a maximum of 272 feet/day. In addition to hydraulic conductivity, a determination of overall hydraulic anisotropy was made using the filtered slug K values. The number was approximately 3.4. It is very similar to the value of 3.2 determined by Springer for the Mashpee Pitted Plain (Springer, 1991).

### ***3.1.1.3 Summary***

In summary, a large area of groundwater has been contaminated by the MMR Main Base Landfill 1 with halogenated volatile organic compounds. The contaminant plume is heading west through the Buzzards Bay Moraine. Public and private drinking supply wells are in danger of drawing water with concentration levels exceeding EPA drinking water standards. Hydraulic conductivity trends can be ascertained using gaussian filtered slug test data. Values for horizontal and vertical hydraulic conductivity may be calculated from the filtered data. These values may be used to model migration of the plume. The next section describes the groundwater modeling process.

Figure 3-1. Log-Linear Contour of Total Contaminant Mass

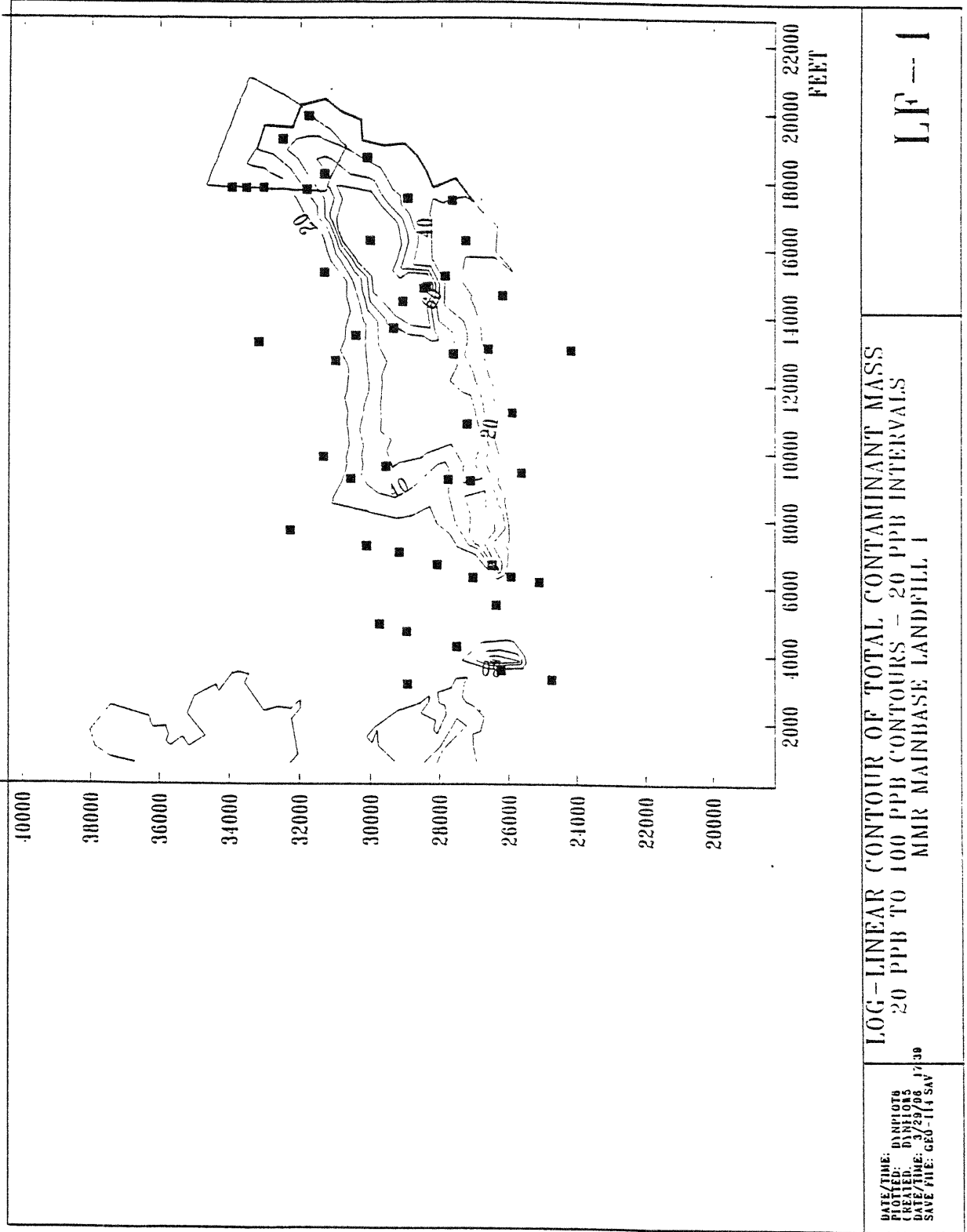


Figure 3-2. Log-Linear Contour of Max MCL Normalized

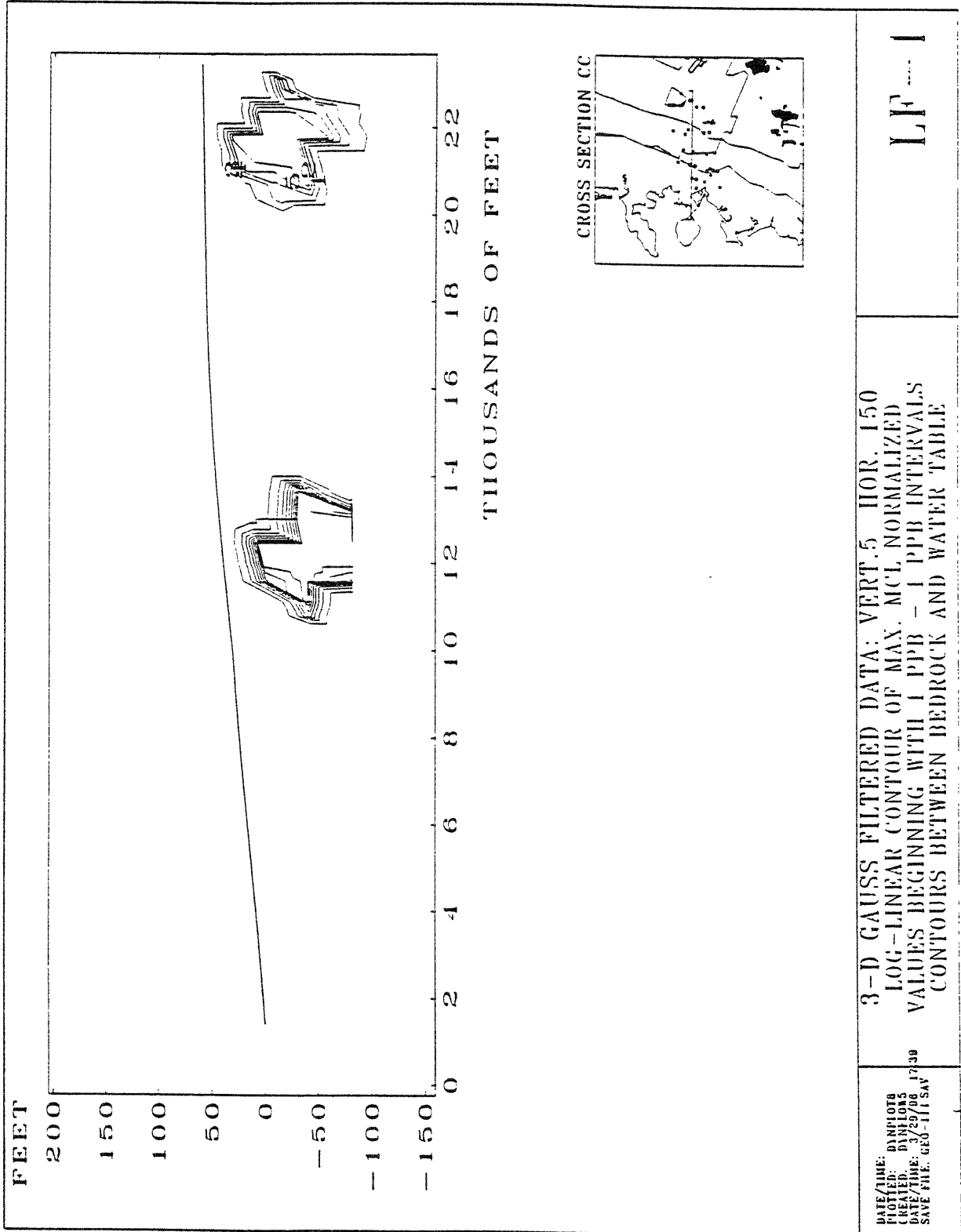
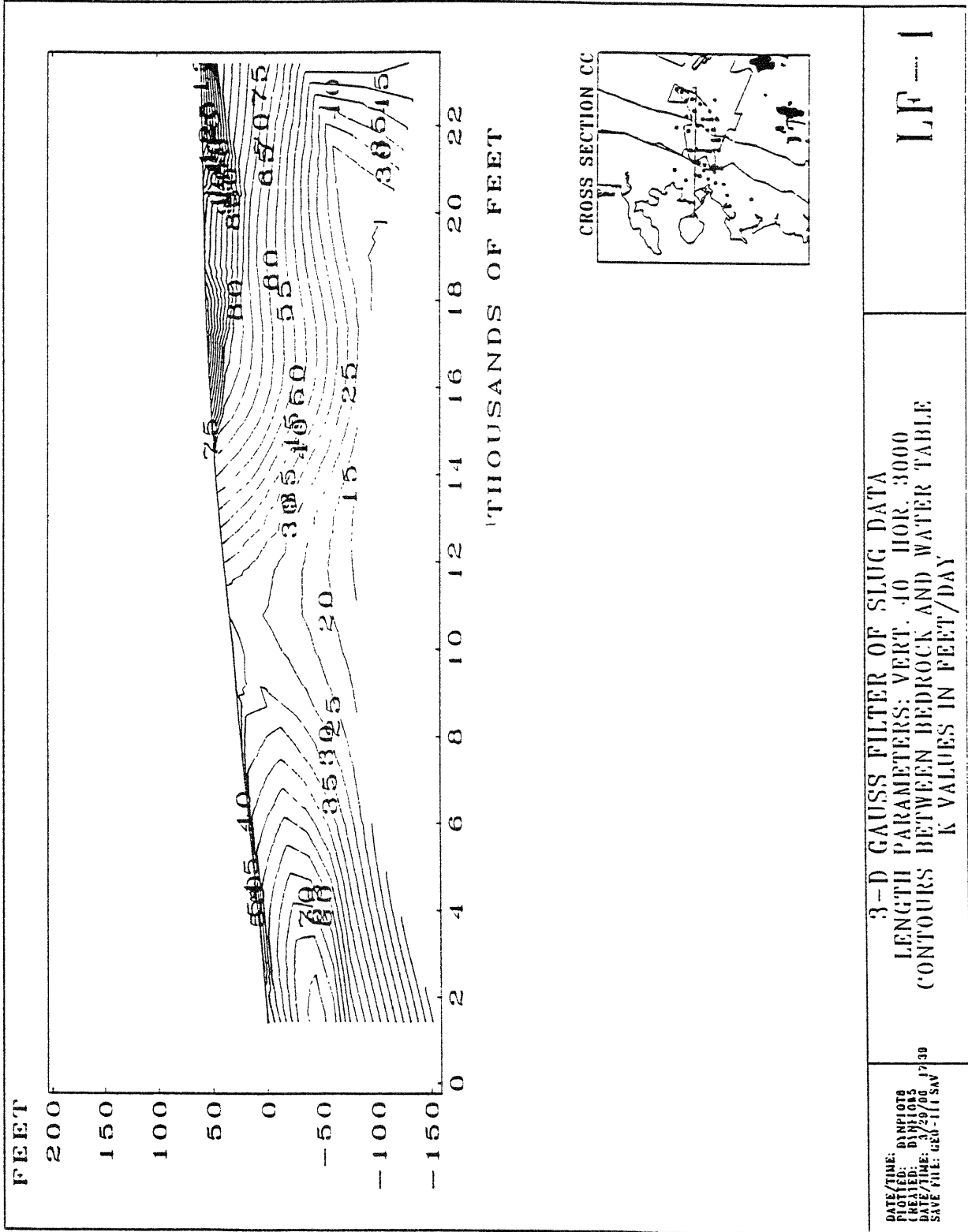


Figure 3-3. 3-D Gauss Filter of Slug Data





### **3.1.2 Groundwater Modeling and Particle Tracking Simulation**

#### **3.1.2.1 Objectives and Scope**

This section of the report describes a three dimensional groundwater model and particle tracking simulation of the portion of the aquifer that is deemed to affect the spatial characteristics and migration pathlines of the LF-1 plume. The DYNSTEM modeling package developed by CDM, Inc., is utilized for this purpose. The goals of the modeling effort are as follows:

- Develop a steady state flow model for the study area.
- Track particles released from a continuous source area and observe migration patterns.
- Determine flushing time and plume migration with source removed.
- Determine sensitivity of model results (plume migration) to the Buzzards Bay Moraine and other geologic features and characteristics of the region.
- Explore the possibility that the deep plume observed in advance of the main plume is caused by a pool of dense leachate from the landfill sinking below the source area.

#### **3.1.2.2 DYNFLOW, DYNTRACK and DYNPLOT Systems**

The groundwater flow system of the Western Cape is modeled with the DYNFLOW groundwater modeling package. DYNFLOW is a FORTRAN based program that simulates three-dimensional flow using a finite element formulation. A distinct advantage of the finite element based model over a finite difference model like MODFLOW is that the former allows the user the flexibility to use variable sized grid elements. Thus, in regions of interest, the user can obtain higher resolution without having to implement the same degree of resolution throughout the model and obtain significant advantages in terms of computational time and complexity.

DYNTRACK simulates three-dimensional contaminant mass transport and uses the same finite element grid, flow field and aquifer properties that were used in and derived from DYNFLOW. DYNTRACK models either single particle tracking or 3-d transport of conservative or first-order decay contaminants with or without adsorption and dispersion.

DYNPLOT is a graphical pre- and post-processor that can create full color displays in plan view or cross-section of observed data, DYN system calculated data and simulated results. DYNPLOT is also capable of generating the finite element grid used by the flow and tracking models.

### ***3.1.2.3 Study Area and Grid***

The roughly triangular study area of the model was chosen to be large enough to ensure that boundary effects did not unduly influence the calculated flow and head values in the area of concern. The study area is depicted in Figures 3-3, 3-4, 3-5, and 3-6. The northern and eastern boundaries of the model are streamlines (no-flux boundaries). The western part of the grid area is bounded by the ocean. The ocean-aquifer interface is of particular interest because it determines how far out at sea the LF-1 plume will discharge if it is not completely contained.

The grid covering the LF-1 study area was generated in DYNPLOT, with smaller grid elements in the sources area and presently observed plume locations and progressively coarser grid elements moving away from these locations. The study grid is composed of 3401 triangular elements and 1281 nodes. The grid discretizes the vertical dimension of the study area in 8 layers ( 9 levels). The bottom (1st) level follows the bedrock contours, while the top (9th) level approximates the surface topography.

### **3.1.2.4 Model Formulation**

#### 3.1.2.4.1 Assigned Geologic Materials

The geologic structure of the LF-1 study area was represented as depicted in Figure KA-2. The geographic locations of the material were assigned according to USGS maps of the region. The Mashpee Pitted Plain (MPP) was represented vertically as two material types and two horizontal sections. This was done to accurately represent the upward coarsening and north-south fining that is observed (LeBlanc, 1986) The Buzzards Bay Moraine (BBM) was defined vertically as four different material of increasing permeability upwards and two horizontal divisions. The Buzzards Bay Outwash (BBO) was depicted by two vertical materials, coarsening upwards. All three deposit types were underlain by a layer of Glacio-Lacustrine deposits (GLS) of varying thickness and bedrock.

#### 3.1.2.4.2 Source

The LF-1 source was represented by six distinct cells within the source area. In the particle tracking simulation, three cells were defined as being non-sources after 1994. This was done to simulate a successful capping of part of the landfill in 1994 by the IRP.

#### 3.1.2.4.3 Ponds

Ponds were modeled as a layer of material that was almost infinitely permeable horizontally and with a high vertical conductivity of the order of 500 ft/day. The pond material layer was extended to the observed depth of the each pond. These pond nodes were then assigned a rising head boundary condition. With this method, the material defined as the pond displays a consistent horizontal head and acts as a sink for groundwater upgradient of the pond and a source

of groundwater to sections of the grid downgradient. This formulation was considered to most closely approximate the behavior of ponds in the Cape Cod region.

#### 3.1.2.4.4 Hydraulic Properties

##### *3.1.2.4.4.1 Hydraulic Conductivity*

Estimates of hydraulic conductivity for the LF-1 region have been made through field investigations. Many slug tests, and laboratory tests of soil samples have been carried out for the sediments found in the Cape Cod region. The previous section on site characterization carries a full discussion of these empirical findings. For the purposes of the groundwater model, hydraulic conductivities proved to be the parameter that the flow model was most sensitive to. Hydraulic conductivity values of each sediment type were considered a variable input, and were assigned values within an empirically determined range obtained from literature in calibrating the flow model. The final values of hydraulic conductivities assigned to each geologic material are included in Table 1.

**Table 3-1. Hydraulic Conductivities and Dispersivities used in Flow and Mass Transport Models**

<b>Material</b>	<b>K<sub>x</sub>, K<sub>y</sub> ft./day</b>	<b>K<sub>z</sub> ft./day</b>	<b>Long. Disp ft.</b>	<b>Trans. Disp ft</b>	<b>Disp Ratio vert./horiz</b>
Lacustrine	15	5	90.0	3.3	0.03
Fine Sand West	80	27	90.0	3.3	0.03
Coarse Sand West	180	60	90.0	3.3	0.03
Fine Sand South	135	45	90.0	3.3	0.03
Coarse Sand South	210	70	90.0	3.3	0.03
BBM Low -N	30	10	90.0	3.3	0.03
BBM Med Low-N	110	33	90.0	3.3	0.03
BBM Med High-N	150	50	90.0	3.3	0.03
BBM High-N	170	57	90.0	3.3	0.03
BBM Low -S	15	5	90.0	3.3	0.03
BBM Med Low-S	60	20	90.0	3.3	0.03
BBM Med High-S	100	33	90.0	3.3	0.03
BBM High-S	135	45	90.0	3.3	0.03
Nant. Ice Dep	190	63	90.0	3.3	0.03
Pond Mat	10 <sup>-5</sup>	10	90.0	3.3	0.03
Fine Sand North	140	47	90.0	3.3	0.03
Coarse Sand North	270	90	90.0	3.3	0.03
Fine Lacustrine	10	3	90.0	3.3	0.03

#### 3.1.2.4.4.2 Dispersivity

Accurately characterizing the dispersivity at a field site is essential in predicting the transport and spreading of a contaminant plume. Due to natural heterogeneities in the field that cause irregular flow patterns, field-scale dispersivities are several orders of magnitude larger than laboratory scale values (Gelhar et al., 1992). In this model, a tabulation of field-scale dispersivity data is used to obtain suitable values of the dispersivity coefficients while taking into account the scale of the LF-1 source. These values are also included in Table 1.

#### 3.1.2.4.4.3 Effective Porosity

Porosity estimates for the outwash in the LF-1 study area range from less than 1% to over 30% (CDM Federal, 1995). These measurements are somewhat lower than expected. Since effective

porosity is not an easily measured quantity, it was decided that an effective porosity value of 39% will be used throughout the model.

#### 3.1.2.4.5 Boundary Conditions

##### *3.1.2.4.5.1 Saltwater-Freshwater Interface*

The saltwater-freshwater interface determines where the landfill plume, if not fully contained, will discharge in to Megansett, Red Brook and Squeteague harbors. The steepness and the distance from shore of the interface depends on the aquifer discharge and geologic characteristics of the coastal region. Available geologic information does not indicate the existence of low permeability layers above the aquifer near the shore that will force the salt-fresh interface further into the ocean. Therefore, for the purposes of this report, it is assumed that the location and shape of the salt-fresh interface along the Western Cape Cod shore are determined entirely by the discharge and hydraulic conductivity of the aquifer. The distance from the shore to the salt-fresh interface was calculated to be approximately 500 ft.

##### *3.1.2.4.5.2 No-Flux Boundaries*

No-flux boundaries are modeled in DYNFLOW by assigning all nodes on streamlines at the edge of the study area a “free head” boundary condition. It is assumed that the no-flux boundaries are far enough from the areas of the model we wish to observe that they do not influence the calculated values of head and velocity.

#### 3.1.2.4.6 Recharge

Natural recharge is the largest source of replenishment of the West Cape aquifer system. This natural recharge is composed entirely of rainfall infiltrate through the surface layer. Cape Cod on

average receives 46 inches of rainfall annually (source). Nearly half of this precipitation, or 46-50%, infiltrates to the groundwater system through the highly permeable top soil (LeBlanc et al., 1986). There is little or no surface runoff due to the permeable nature of the soils and the small topographic gradients present in this region. Artificial recharge and pumping is considered to be negligible in this region in comparison with the natural recharge.

#### ***3.1.2.5 Results***

The calibrated flow model agreed with observed water table measurements at 145 wells within 0.211 ft mean difference and 2.09 ft standard deviation. Figure 3-8 shows the calibrated model results and calculated water table contours. The calculated contours agree well with observed contours in the region.

The flow model was found to be very sensitive to the difference in permeability between the moraine and surrounding deposits. This sensitivity is highlighted by the curvature of the model calculated head contours, which in turn significantly influence the migration pathlines of a contaminant released at the LF-1 site. The sensitivity of the particle paths to head contours is enhanced by the fact that the LF-1 source area is located close to the point where north south head contours change to an east-west orientation.

The first particles released at the LF-1 site will migrate to the ocean in 50 years. Figure 3-9 shows a 51 year mass transport simulation in plan view, with particles reaching the ocean interface. Figure 3-10 is a cross section of the simulated plume. Thus, assuming that the volatile organic compounds of concern at this site were released in 1945, the predicted extent of the plume reaches the ocean discharge face by 1996. The initial discharge point is at Red Brook

Harbor. This finding is in agreement with the Op-Tech Data Gap Report which concludes that the LF-1 plume has now reached Red Brook Harbor.

If the entire landfill is successfully capped by the year 2000, and the contaminated groundwater is allowed to flush unmitigated into the ocean, the DYNTRACK simulation time of 110 additional years is required for all LF-1 derived contaminants in the aquifer to travel beyond the Buzzards Bay Moraine. This is depicted in Figure 3-11, a 165 year simulation with the source turned off in 2000. A further 55 years is required for all the contaminant particles to be discharged from the aquifer.

The predicted plume exhibits the same differential North-Lobe South-Lobe travel times observed in the field. In the model, the presence of a low-permeability layer in the moraine causes the southern part of the plume to be retarded. The northern section, by virtue of having to travel a shorter distance to the moraine, is at a higher elevation than the southern part of the plume and thus travels through a higher permeability layer of the moraine. These differential travel velocities through the moraine cause the distinct northern and southern lobes observed in the simulated plume. Figure 3-12 is a north-south cross-section of the plume at the point of entry into the moraine, showing the differential elevations of the particles from north to south.

The previous finding that the portion of the plume at a lower elevation is retarded by the presence of a lower conductivity layer of moraine deposits indicates that the deep plume observed near the shoreline cannot be simulated by a sinking source of contaminant in this model formulation. A tenable explanation for the observed deep northern plume is that the down-sloping bedrock surface near the shoreline causes the faster moving simulated northern lobe to



sink further due to infiltration as it traverses the Buzzards Bay Outwash towards the shoreline. Since the slower moving southern lobe is still in the moraine, the leading edges of the northern lobe near Red Brook Harbor now appear to be a northern plume lobe at a lower elevation.

If an extraction well system is constructed along Route 28, and it is assumed that the extraction pumping and infiltration are carried out so that the hydraulic system is relatively unchanged, the uncaptured section of the LF-1 plume will take a further 12 years to completely discharge into the ocean. This result was obtained assuming that the portion of the plume upgradient of the extraction well fence is fully captured.

In summary, the groundwater flow and particle transport model provides results that are similar to field observations. The Buzzards Bay Moraine exerts a great deal of influence on the regional hydrologic system. The geologic characteristics assigned in the flow model to the BBM defines the shape of the regional head contours and thus the travel path and velocity of the simulated plume. Therefore, it is essential that the geology of this moraine be properly identified if a flow and particle tracking model that can accurately represent the region is to be formulated. In the absence of such data, any groundwater flow model of the LF-1 region will contain a significant degree of uncertainty and error. The models developed in this study can be used to determine the effects of an extraction system to contain or capture the LF-1 plume and also as a means of designing an efficient capture system for this contaminated site. The following section addresses the risks associated with the LF-1 plume and how these risks can be managed.

Figure 3-4. Plan View of LF-1 Study Area and 3-D Finite Element Grid

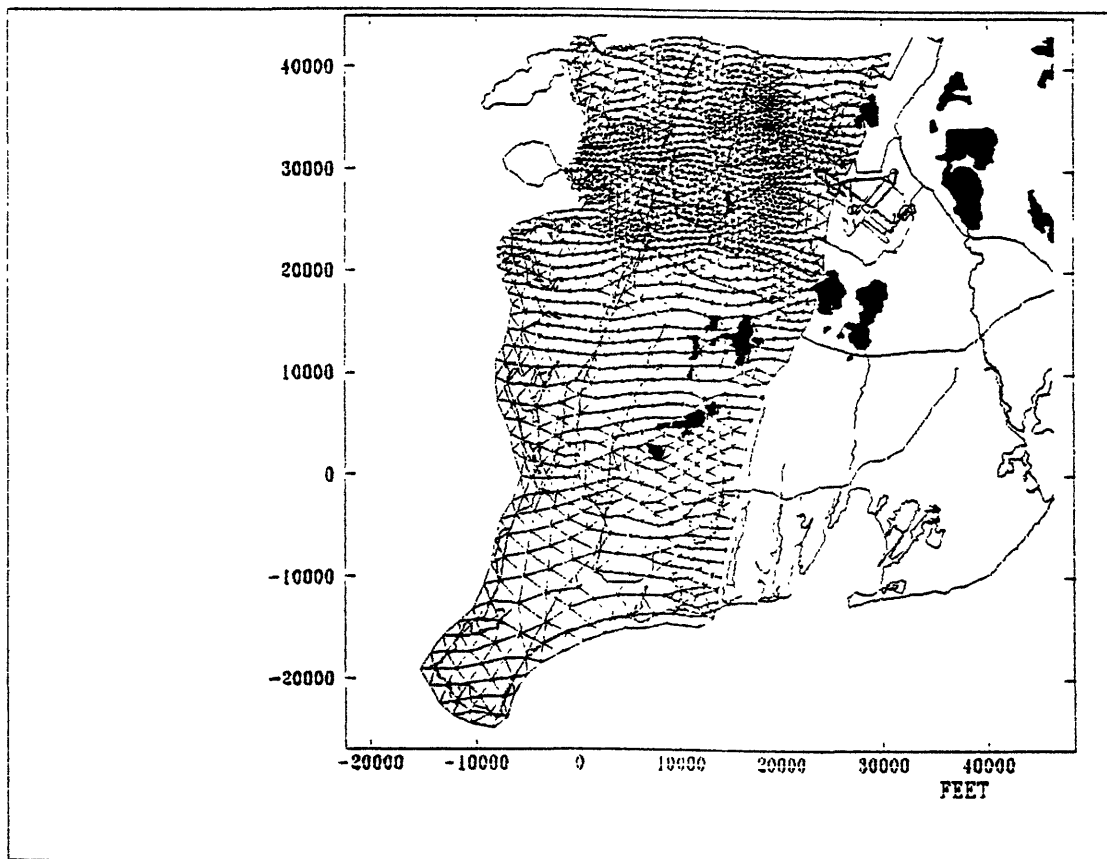


Figure 3-5. Plan View of Study Area with Assigned Materials

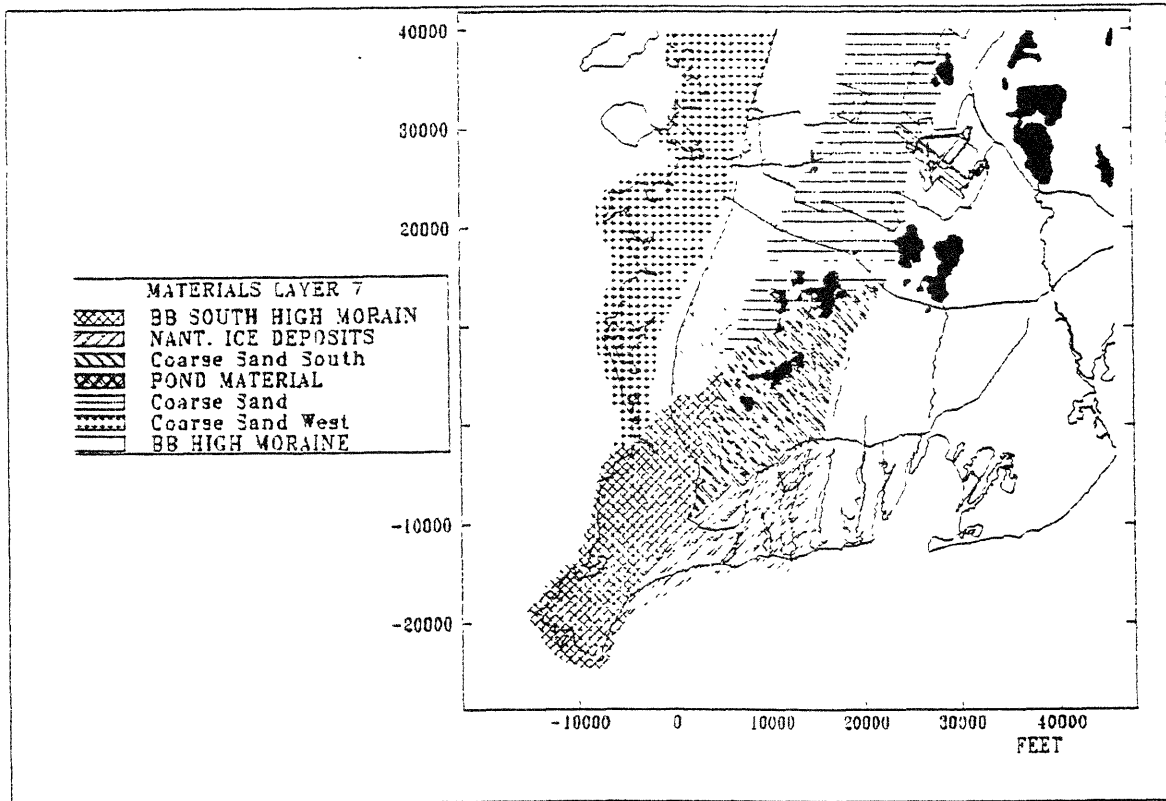


Figure 3-6. North-South Cross section of Buzzards Bay Moraine

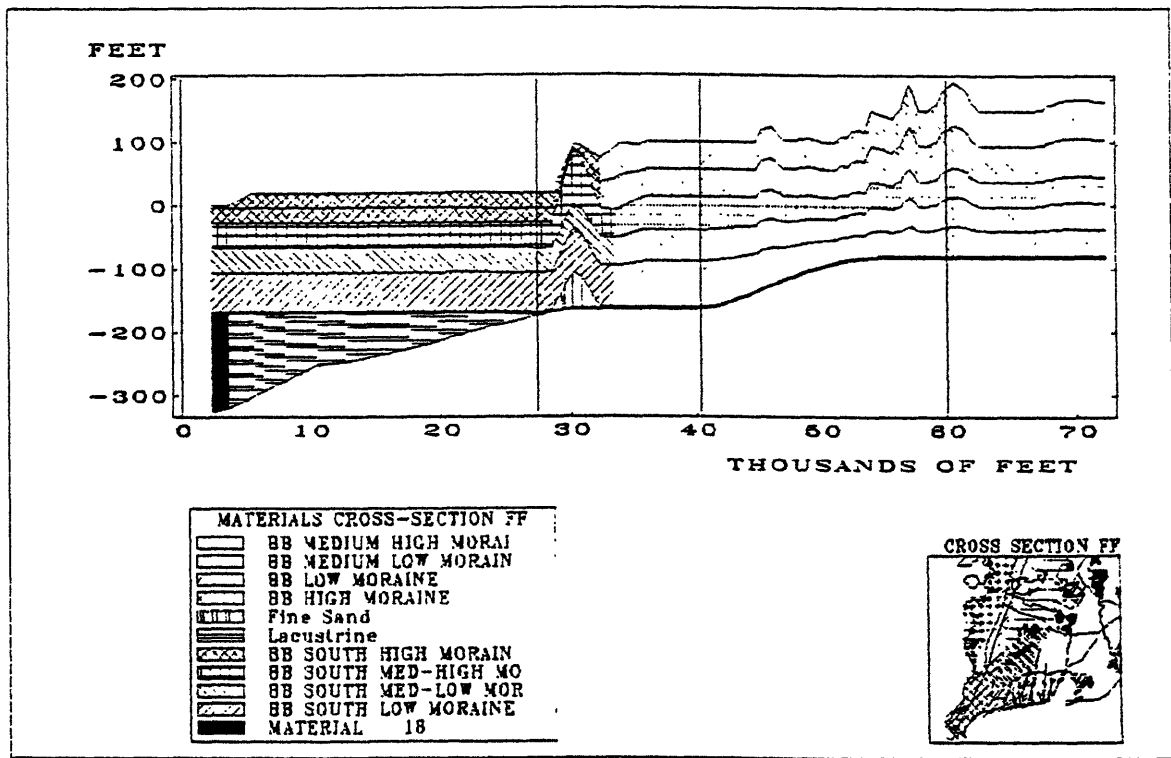


Figure 3-7. East-West Cross-section of Site Near Buzzards Bay

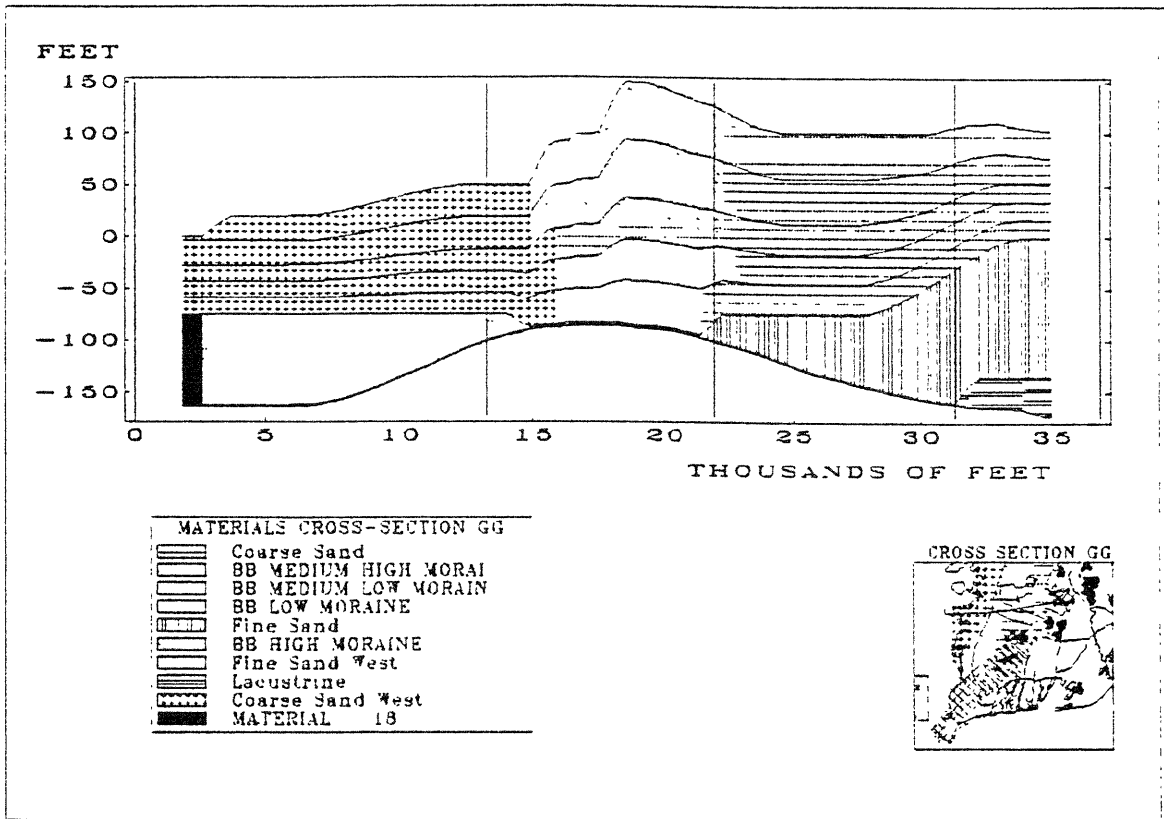


Figure 3-8. East-West Cross-section of Study Area Near Nantucket Sound

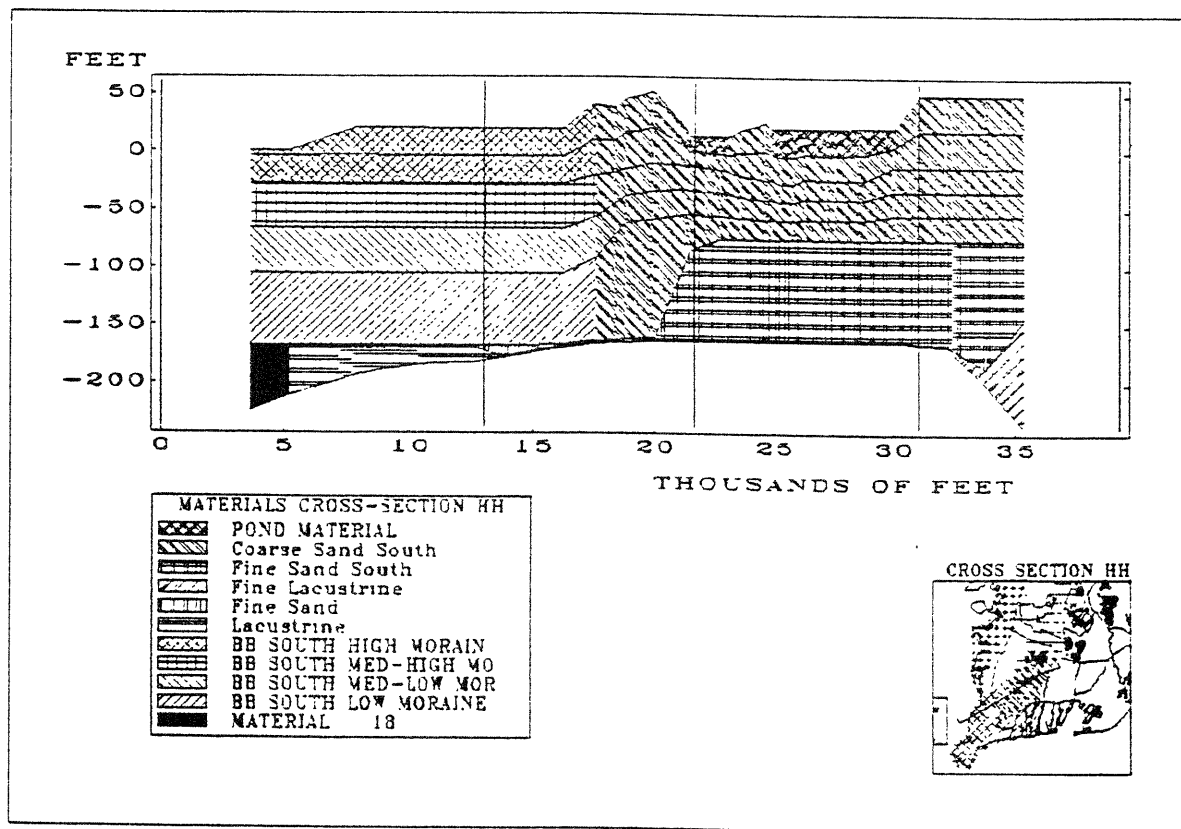


Figure 3-9. Differences Between Calculated and Observed Head and Calculated Water Table Contours

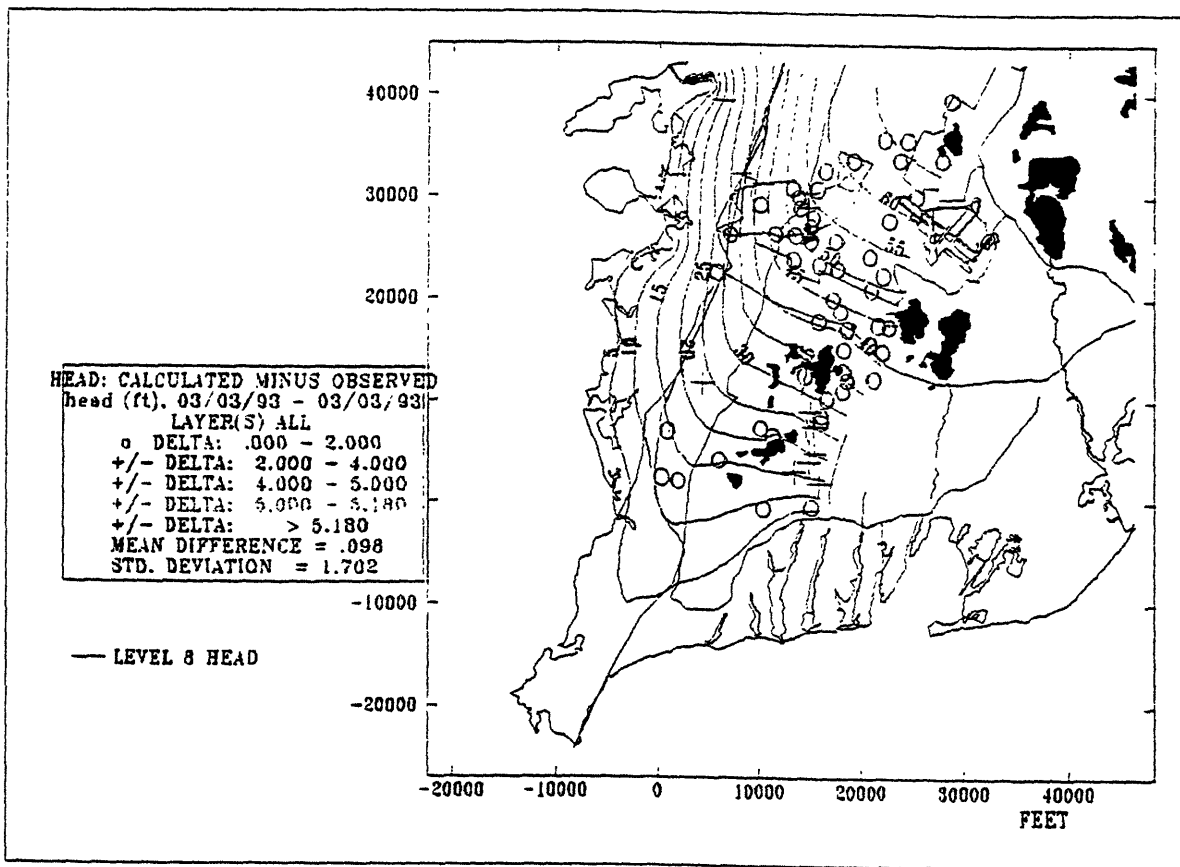


Figure 3-10. 51-Year Simulation of a Continuous Source at LF-1 Site

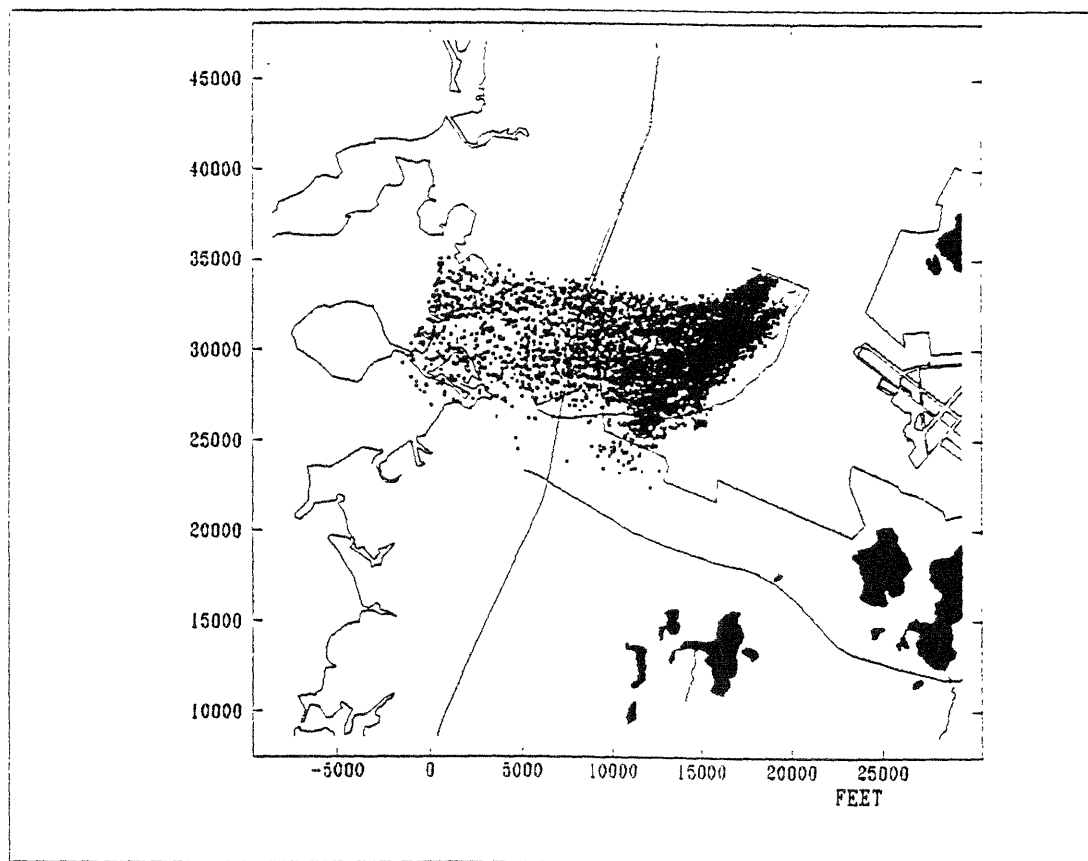




Figure 3-11. Cross-section of Simulated 51-Year Plume. Also Showing Observed Concentrations of Total VOC

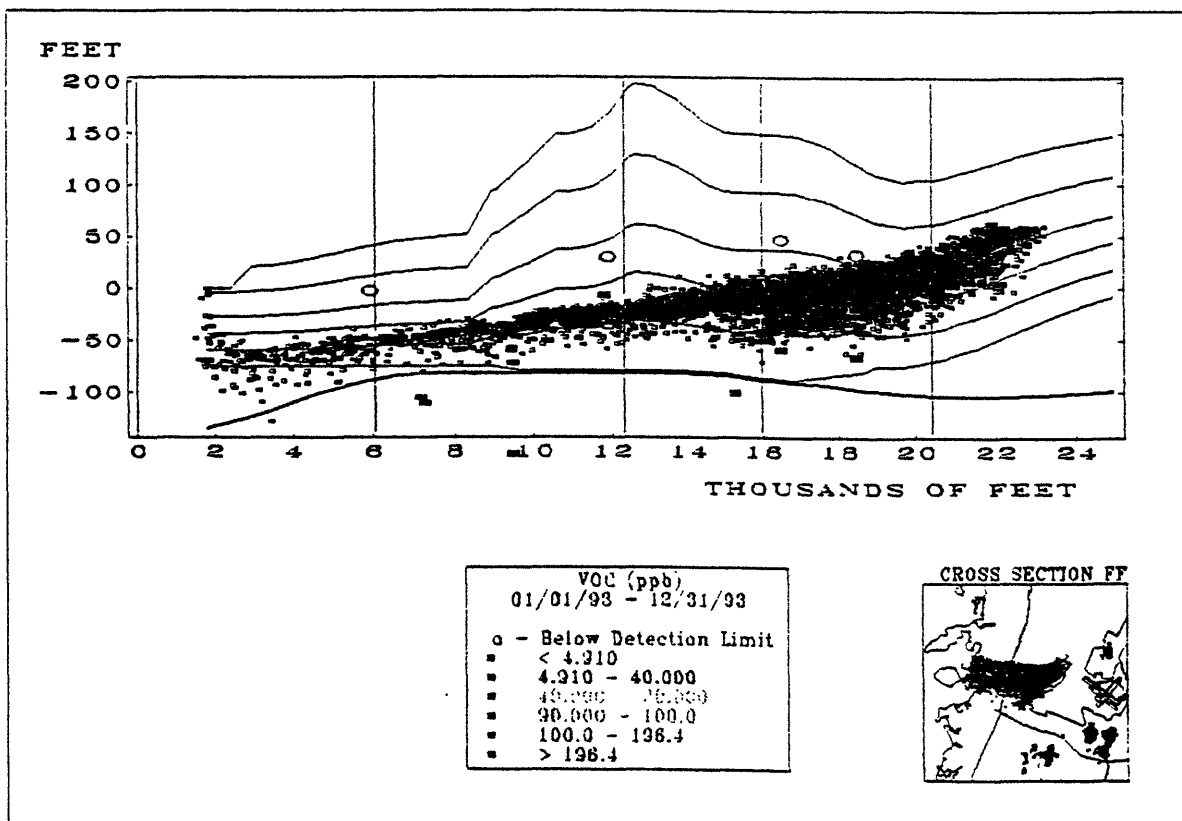


Figure 3-12. 165-Year Simulated Plume with Source Turned Off After 55 Years

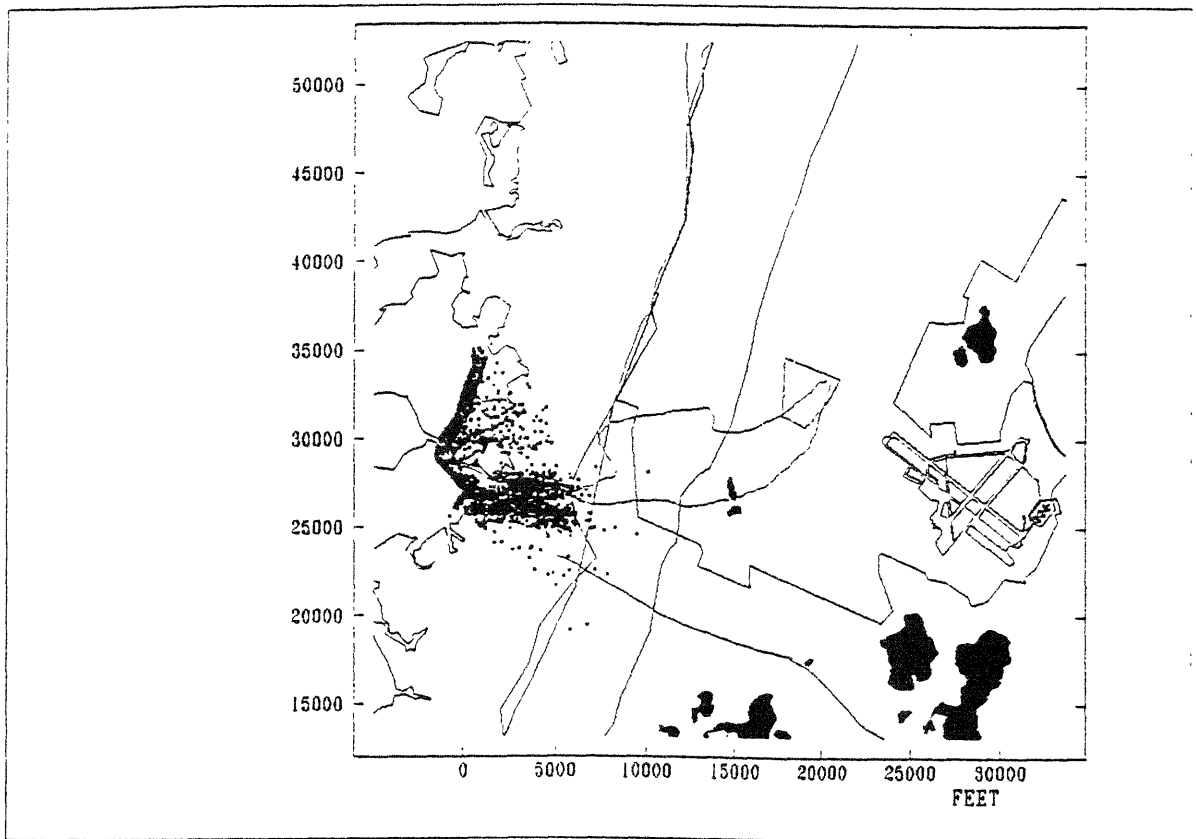
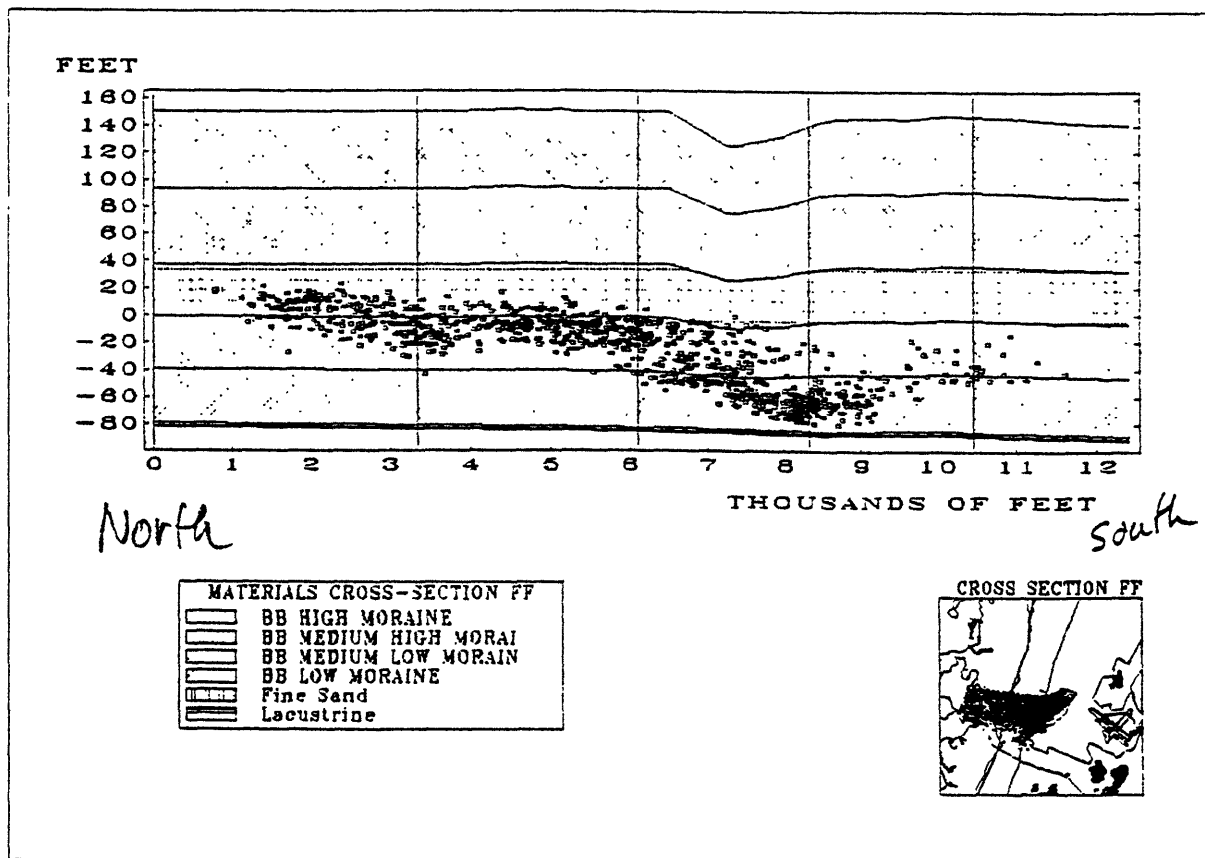


Figure 3-13. North-South Cross-section of Simulated Plume at Point of Entry into the Buzzards Bay Moraine



### **3.1.3 Risk Assessment & Management of Risks**

The IRP's Remedial Investigation (RI) Report and their Final Risk Assessment Handbook (RAH) present an evaluation of potential adverse effects to human health from materials identified in the MMR LF-1. The MMR site has been classified using EPA guidelines which were not specifically developed for the MMR site. The accuracy of the health and environmental risk scores are limited by the constraints of the EPA's deterministic risk assessment model.

Cancer risk is the statistical increase in mortality rate for a member of the local community who has been exposed to carcinogenic materials identified in the MMR LF-1 as compared to the rate for a member of the local community if the MMR LF-1 did not exist. It is the probability of an event occurring and the magnitude of the effect which an event will likely produce. More simply, cancer risk is the product of the probability of dying from cancer because of exposure to carcinogens and the probability of exposure to carcinogens.

#### ***3.1.3.1 Toxicology***

According to the EPA guidelines (cited in both the RAH, 1994 and LaGrega et. al., 1994), toxicology and dose are to be calculated by following specific protocols. In terms of toxicology, carcinogens are considered to vary greatly in their potency. "When considering lifetime cancer risk to humans, it is widely accepted that carcinogenesis works in a manner such that it is possible, however remote, that exposure to a single molecule of a genotoxic carcinogen could result in one of the two mutations necessary to initiate cancer". (LaGrega et. al., 1994, p. 277). Therefore, the calculation of carcinogenic risk from toxicology involves the use of cancer

potency factors which are basically the slopes of the dose-response curves for carcinogens which are extrapolated to zero for extremely small doses. These extrapolated slopes are commonly referred to as cancer slope factors (CSFs) and they are used for the toxicological component of the EPA's acceptable risk calculations. CSFs are maintained in the EPA's Integrated Risk Information System (IRIS) database.

Many papers have been published which comment upon the uncertainty of the EPA's CSFs. In addition, "the EPA is well aware of the problems associated with overly conservative risk estimates and has repeatedly stressed that the unit cancer risk estimate only provides a plausible upper limit for a risk that can very well be much lower. The problem is that, in reality, official EPA unit risk estimates are widely used, more or less, as absolute standards." (LaGrega et. al., 1994, p.280). Due to insufficient expertise in toxicology, this report will not offer an opinion concerning specific toxicological uncertainty of the EPA's CSFs.

### ***3.1.3.2 Dose***

In terms of dose calculations, it is important to understand the environmental pathway.

Therefore, for this cancer risk evaluation it is important to identify the following:

- carcinogens
- source of carcinogens
- release mechanisms
- transport mechanisms
- transfer mechanisms
- transformation mechanisms
- exposure paths
- exposure point concentrations
- receptors

However, it is interesting to note that in performing an EPA risk assessment, only the carcinogens and the exposure point concentrations are used to calculate risk. Although the other seven above-referenced factors are essential for developing spatially distributed exposure point concentrations, EPA protocol requires maximum detect concentrations for maximum or upper bound risk calculations. In addition, EPA protocol requires arithmetic averaging of detect concentrations for mean risk calculations. That is to say, two sites with hazardous materials at similar concentrations with entirely different hydrogeologic conditions, would have the same risk according to EPA guidelines. However, at their discretion, EPA will review risk assessments which incorporate site-specific conditions into their calculations.

### ***3.1.3.3 Identification of Hazardous Materials***

Hazardous materials are broadly defined as non-carcinogens which are known to have harmful systemic effects upon humans, and carcinogens which have a propensity to initiate and promote cancer. Both terminal and “quality of life” health problems from exposure to hazardous materials are primary human health concerns. Because of these health concerns, human exposure to hazardous materials, especially carcinogens, is a source of risk and is of primary concern for risk assessment and management. However, for this report, only the carcinogenic materials identified in the MMR LF-1 are being evaluated for potential risk; they are identified in the risk spreadsheets presented in Tables H1-H5.

According to Boston University’s School of Public Health Upper Cape Cancer Incidence Study which was prepared under contract to the Massachusetts Department of Public Health, cancer incidence rates for the MMR regional area have increased at a relative rate of approximately fifty

six (56) percent overall (BUSPH, 1992). In addition, according to the Journal of the American Medical Association cancer incident rates are increasing steadily for the United States at a relative rate of approximately forty four (44) percent overall (JAMA, Vol. 271, No. 6, 1994). Furthermore, it is generally accepted that approximately twenty five (25) percent of all annual deaths in the US are caused by cancer. When the uncertainties presented in the above-referenced reports are taken into account, both the MMR cancer rate and the US cancer rate are very similar. Since these cancer rates are so similar, it is difficult to discern if the cancer rate increase at the MMR region is caused on account of reasons which are linked to the background national cancer rate increase, or if cancer rate increase near the MMR is tied to the release of carcinogenic materials at the MMR site.

#### ***3.1.3.4 Review Existing Reports***

Part of this investigation was a comprehensive review of the RI, and the RAH which are relevant to risk assessment for the MMR LF-1. An examination of the methodology used, the consistency of the reports with respect to the EPA's regulatory guidelines, and independent spreadsheet calculations using the equations and numerical values which are cited in the above-referenced reports supplied similar results. This three part process confirmed the consistency of the reporting which has been provided to MIT to calculate risk and formulate risk opinions. Independent spreadsheet calculations are included in Tables H1-H5. As the MMR LF-1 is part of an on-going clean-up, new and updated data from the above-referenced reports has been included, as required, to present the most current EPA approved health risk connected with the MMR LF-1.

### **3.1.3.5 Uncertainty**

In all statistically intensive calculations there are uncertainties specific to the numerical model which is being used. Since the EPA's model is the requisite regulatory guideline for Superfund sites, their model is the one which is being scrutinized. The EPA's model uses mathematical conventions in their computations which are statistically conservative and consequently will tend to overestimate risk. In addition, the EPA incorporates policy into defining empirical risk. Policy considerations do not support representative risk quantification, but risk quantification that is constrained by policy constructs. Therefore, the EPA uses regulated risk assessment vice probabilistic risk assessment with regulation of risk management. "On account of point estimates, regulated risk is overestimated by several orders of magnitude beyond probabilistic risk" (Hines, 1996).

Uncertainty can be characterized more accurately by modifying the EPA's deterministic model with elements of a stochastic model. A stochastic, probabilistic *per se*, model both promotes generally accepted engineering principles and supports the EPA's need to fulfill their statutory mandates from Congress. Therefore, if the EPA can minimize inclusion of policy elements in risk assessment and maximize the incorporation of policy into risk management, they will be able to regulate environmental risk with less uncertainty.

### **3.1.3.6 Results of Human Health Risk Assessment**

CDM Federal performed a preliminary risk assessment of the LF-1 plume with no containment system in the *Remedial Investigation (RI): main base landfill and hydrogeologic region I study* (1995). The maximum cancer risk found for adult residents of the towns of Bourne and



Falmouth in Cape Cod for future exposure to contaminated groundwater is  $1.3E-03$ . This risk is interpreted as the incremental increase in probability of developing cancer above background level for each exposed resident. The United States Environmental Protection Agency (USEPA) acceptable risk standard ranges from  $1.0E-06$  to  $1.0E-04$ . The standard is set independently for each site and case. The increased risk of  $1.3E-03$  for each resident is above the highest acceptable USEPA standard. In addition, the overall maximum Hazard Index (HI) for non-cancer risk from potential exposure to the contaminated groundwater is 39.5. The USEPA's acceptable HI standard for non-cancer risk is 1.0. Calculated HI that are above the USEPA standard pose possible non-cancer deleterious health effects to exposed populations. Thus, the current LF-1 plume poses cancer and non-cancer risks to adult residents of Bourne and Falmouth above the USEPA acceptable standard.

Operational Technologies, the main design contractor to contain contaminated groundwater plumes, has recommended a row of extraction wells along Route 28 of western Cape Cod as the strategy to contain the LF-1 plume (OpTech, 1996). The fence line of wells at Route 28 is designed to capture the landfill contaminated groundwater as the plume migrates westward to Buzzards Bay of Massachusetts. Current plume data which describes the spatial distribution of the contamination indicates that the leading edge of the plume has been detected passed Route 28 (OpTech, 1996). Since the proposed containment strategy will not capture this leading edge termed the "toe" of the plume, the detached plume of contaminated groundwater is expected to continue its migration and discharge into Buzzards Bay untreated. This containment strategy of extraction wells installed along Route 28 was proposed due to potential disturbance to the

freshwater-saltwater interface along the coastline if the extraction wells are installed at the leading edge of the plume, and the possible difficulty of private property access.

Operational Technologies also performed a preliminary risk assessment of future potential effects to human health and ecological systems from this recommended plume containment system. The maximum cancer risk for adult residents in the towns of Bourne and Falmouth is 4.7E-04. This increased risk to adult residents from the detached contaminated groundwater plume is also above the USEPA acceptable standard. The overall maximum HI for non-cancer risk from exposure to the detached plume is 3.3. HI above the acceptable USEPA standard of 1.0 poses non-cancer deleterious health effects risk to exposed residents. The cancer and non-cancer risks posed by the detached plume are also above both USEPA standards.

A comparison of the preliminary risk assessment results indicate that the proposed containment system for LF-1 plume will reduce the maximum cancer and non-cancer risks posed by the contaminants of LF-1 plume, but both the cancer and non-cancer risks are still significant and above the acceptable USEPA standards. The results of the risk estimates clearly show that the containment strategy will still pose tangible risk to the potentially exposed population of western Cape Cod. Alternative containment and remediation systems need to be further investigated to reduce the risk to USEPA acceptable standards. The USEPA sets acceptable risk standards to adequately protect human health and the natural environment.

#### ***3.1.3.7 Results of Assessment of Risk from Ingestion of Contaminated Shellfish***

From the current data of the LF-1 plume, the contaminants are projected to discharge into Red Brook, Squeteague, and Megansett harbors of Buzzards Bay (OpTech, 1996, CDM Federal,

1995). The shallow tidal flats of these harbors support a rich population of local shellfish species. Soft shell clams, quahogs (hard clams), oysters, bay scallops, surf clams, mussels, and conch are harvested by local commercial and recreational fishermen. Since metals are part of the LF-1 plume contaminants and shellfish have been shown to bioaccumulate metals in their body tissue, the potential discharge of the plume into the harbors along the shoreline pose a risk to the coastal marine shellfish population as well as to human health from the consumption of tainted shellfish.

The results of maximum cancer and non-cancer risk assessment of consuming metals contaminated quahogs over a life time are calculated for two different data sets. The maximum concentration of metals detected in well samples from the LF-1 plume are derived from the Remedial Investigation Study conducted by CDM Federal (1995) and the Technical Memorandum issued by Operation Technologies (1996). The data is shown in Table 1. Using the CDM Federal (1995) data, the maximum cancer risk from consumption of tainted quahogs is  $4.2E-04$ . A maximum cancer risk of  $1.3E-04$  is calculated when maximum concentration of metals from OpTech (1996) data is used in the assessment. This cancer risk only includes the risk from beryllium since this is the only metal with a published cancer slope factor. The hazard index non-cancer risk from consumption of quahogs containing metals is 22.6 when CDM Federal (1995) data of maximum metals concentration in the plume is used and 8.18 when OpTech (1996) data is used. The cancer and non-cancer risks from contaminated shellfish are above the USEPA standards.

The risk estimates for humans from consumption of tainted shellfish are based on worst case assumptions. Thus, the risk is a conservative estimate and indicates the maximum risk posed to human health. From these results, it is recommended that a monitoring program for shellfish harvested from Red Brook, Squeteague, and Megansett harbors be implemented.

### **3.1.4 Public Perception: Management of Public Interaction at the MMR**

An analysis of the approaches used to manage public interaction at the Massachusetts Military Reservation was undertaken to characterize the evolution of public perception of risk posed by past activities at the MMR. Public meetings at the MMR between January 15 and March 31, 1996, were attended. In addition, a comparison of management approaches at other bases was carried out. This included interviewing personnel at military bases in California and Arizona. As part of the analysis, suggestions for future approaches at IRPs were explored and are discussed below.

#### ***3.1.4.1 Public Perception in Superfund Cleanup***

In any scenario where pollution is an issue, there is frequently a gap between the perceived risk to human health and the actual risk posed by contamination. Because of scientific uncertainty in risk assessment, often times, the actual risks are not known, and so the perceived level of risk results from speculation by many parties. In the siting of hazardous waste facilities, the potential threat to human health results in the NIMBY (“Not in my backyard”) syndrome. Often times this “potential threat” is a perceived one. Public interest groups have fought many a facility siting and won, not due to actual risk, but because of a perceived one. In Superfund cases, unlike potential hazardous waste facility sitings, contamination has already occurred, but there is still a

question of whether the contamination poses a real threat to public health. The gap between actual and perceived risks in this case results in the answer to the question of “how clean is clean?” becoming a policy, rather than a scientific, one. Groundwater contamination at the Massachusetts Military Reservation Superfund site is perceived to be a problem, and steps are being taken to remediate this problem to the greatest extent feasible. Public opinion has defined “the greatest extent feasible” as the level to which groundwater is treated to “non-detect” levels for contaminants that pose threats to human health. In private sector cases, economics would figure into the calculation of feasibility of cleanup, but in the case of the MMR, where an entity as large as the federal government is funding the cleanup, the public believes that “anything is affordable” and therefore feasible.

#### ***3.1.4.2 History of Public Involvement at the MMR***

The initial approach to management of public interaction surrounding the Installation Restoration at the MMR was similar to the “compliance-based” approach many companies take towards environmental regulation--the National Guard Bureau met only the minimum requirements necessary. Actions taken by the NGB were reactive rather than proactive. The NGB promulgated press releases and sent reports to local libraries, as well as holding news conferences after technical meetings, but any actions beyond that were minimal. Technical meetings concerning IRP activities were closed to the public and media, and virtually no public information meetings were held.

During 1990 and 1991, there was a modest effort to increase public involvement in the cleanup at Otis, as the IRP office at the MMR was created to manage the program locally rather than from

far away. The “Joint Public Involvement Community Relations Plan” was presented, bi-monthly public information meetings were initiated, site tours/briefings were made possible, a site mailing list was created, and the IRP office began to print quarterly fact sheets that described the IRP activities. Although these fact sheets were limited in scope, they, along with the public information meetings, represented the first real effort to inform the public about specific activities associated with the IRP.

Late-1991 marked a major change in the way public interaction was managed at the MMR. The IRP office began updating technical reports much more frequently, and progress reports were made available to all interested parties. The local IRP office began educating the public by participating on local radio/cable TV programs as well as taking part in neighborhood association meetings. An educational display was created for to be used at these meetings and at libraries, and detailed bi-monthly fact sheets were developed. In addition, all technical meetings were opened to the public and media.

The post-1991 period also has included the creation of many committees that assist the cleanup activities at the MMR. These committees, called “process action teams”, are made up of personnel from the MMR, the relevant regulatory agencies, and the public. These process action teams (or “PATs”) report to the senior management board, which was created to oversee the restoration. Presently, a total of 8 community working groups hold regular meetings (Karson, 1995). Although the public is highly involved in the IRP process at this point, how much influence the public actually has in the decisionmaking process is still a question.

### ***3.1.4.3 Design Of Future Approaches At the MMR And Elsewhere***

There are several things that should be considered before an Installation Restoration Program is initiated at a particular base or military reservation. Not the least of these is the management of public interaction surrounding the restoration. Public and public interest group opinion are very likely to polarize as soon as contamination and threat to public health are made known. Public distrust of government, especially on the federal level, compounds the fear that public health is in danger and contributes to the belief that any cleanup activities will be inadequate to alleviate the problem of contamination.

There are steps that can be taken to minimize the potential for adversarial relationships developing between all interested parties in base cleanup. Since the public has been involved in the restoration process at the MMR, the relationships between all interested parties have become less of a barrier to cleanup as all parties are seen to have input into the process. However, analysis of the approach used to manage public interaction at the MMR shows that, even though outwardly it appears that all the “right” approaches were taken, public concern is still an issue. This is due to the fact that early on in the MMR IRP process, the public was not included and was seen more as a “problem” than a potential source of solutions.

## ***3.2 Remedial Approaches***

### **3.2.1 Source Containment**

#### ***3.2.1.1 Introduction***

As part of remediation operations at the MMR, several of the cells at the Main Base Landfill have recently been secured with a final cover system. These cells include the 1970 cell, the post-

1970 cell, and the kettle hole. The remaining cells (1947, 1951, and 1957) have collectively been termed the Northwest Operable Unit (NOU). Remedial investigation as to the necessity of a final closure system for these cells is ongoing. This proposal is focused on the design of a final closure system for the 1951 cell. The landfill final closure requirements of the Resource Conservation and Recovery Act (RCRA) and Massachusetts Solid Waste Management Regulations will be examined and adapted to site specific conditions. Material and design options for the components of the cover system will be examined and choices made according to performance, availability, and relative cost, as applicable to site-specific conditions. A cross-section of the proposed cover system is provided in Figure 3-1.

### ***3.2.1.2 Regulatory Review***

Massachusetts Solid Waste Management regulations specify the following as minimum design requirements for a landfill final closure system (MA DEP, 1993):

- Subgrade layer
- Venting layer with minimum hydraulic conductivity of  $1 \times 10^{-3}$  cm/sec
- Low conductivity layer with minimum thickness of 18 inches and maximum hydraulic conductivity of  $1 \times 10^{-7}$  cm/sec, or an approved flexible membrane liner (geomembrane)
- Drainage layer with minimum thickness of 6 inches and minimum hydraulic conductivity of  $1 \times 10^{-3}$  cm/sec, or a synthetic drainage net (geonet)
- Combined vegetative support / protection layer of minimum thickness 18 inches, with at least 12 inches of soil capable of supporting vegetation.

Subparts G, K, and N of the Resource Conservation and Recovery Act (RCRA) Subtitle C

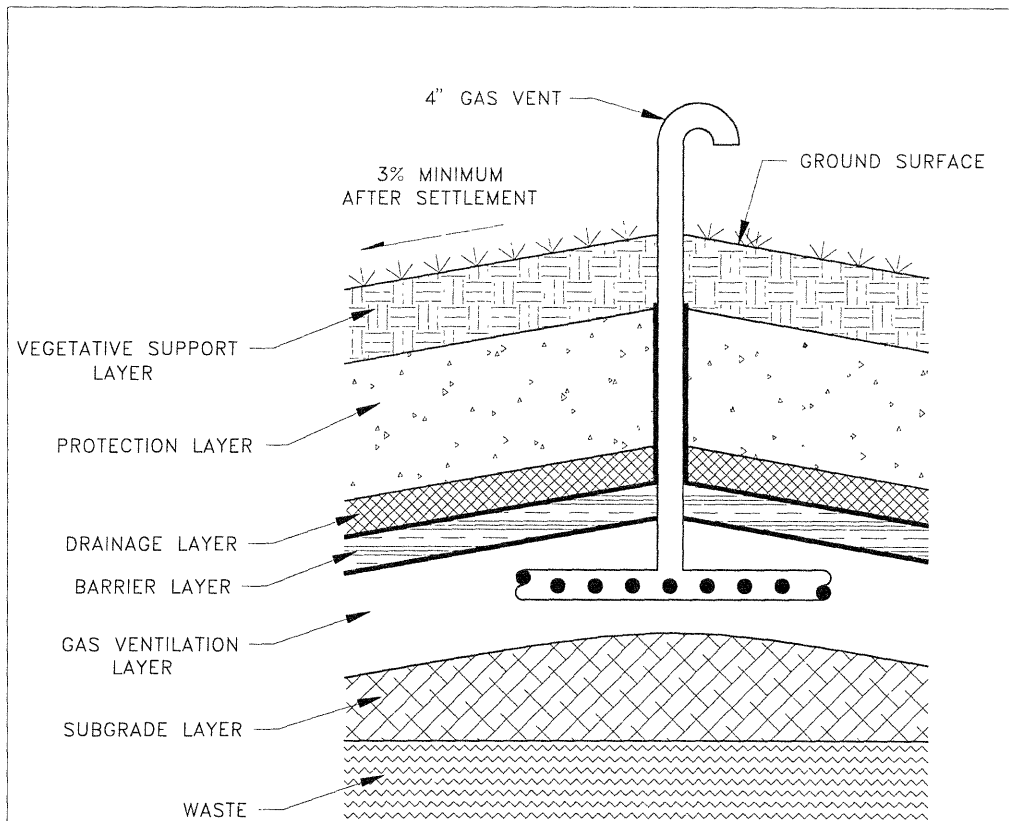
(Hazardous Waste Management) regulations dictate the requirements for hazardous and mixed



waste landfill cover systems (US EPA, 1991). The EPA recommends that a final cover system consist of the following (US EPA, 1991):

- A low hydraulic conductivity geomembrane / soil layer consisting of a 24 inch layer of compacted natural or amended soil with a hydraulic conductivity of  $1 \times 10^{-7}$  cm/sec in intimate contact with a geomembrane liner of minimum thickness 0.5 mm (20 mil).
- A drainage layer of 12 inch minimum thickness having a minimum hydraulic conductivity of  $1 \times 10^{-2}$  cm/sec, or a geosynthetic material of equal transmissivity.
- A top vegetative support / soil layer consisting of a top layer with vegetation or an armored surface, and a minimum of 24 inches of soil graded at a slope between 3 and 5 %.

The EPA does encourage design innovation, and will accept an alternative design upon a showing of equivalency.



LAYER	MATERIAL	SPECIFICATIONS
Vegetative Support	Loom	6" thickness
Protection	Borrow Soil	18" thickness
Drainage	Geonet	Transmissivity $> 3 \times 10^{-5} \text{ m}^2/\text{sec}$
Barrier	Geomembrane over Geosynthetic Clay Liner	Geomembrane 60mil VLDPE Geosynthetic Clay Liner Gynoseal with 40mil VLDPE Substrate
Gas Ventilation	Screened Borrow Soil	12" thickness Hydraulic conductivity $> 1 \times 10^{-1} \text{ cm}^2/\text{sec}$

NOT TO SCALE

Figure 3-14. Cross-section of Proposed Cover Design

### ***3.2.1.3 Subgrade Layer***

The subgrade layer acts as a foundation for the overlying layers of the cap, and it is also used as a contouring layer to create the appropriate final slope of the cover system. It is recommended that the foundation layer be placed to provide a final grade (after settlement) no greater than 5% and no less than 3%. This slope range provides sufficient grade to promote some surface water runoff while not being so steep as to produce erosion of the surficial soils. Allowance must be made for waste settlement that will occur as a result of the vertical stresses imposed by the weight of the cover materials.

Materials typically utilized for foundation layers include a variety of soils, and some acceptable wastes. At sites such as the MMR where soil borrow volumes are relatively plentiful, soil is the obvious choice for the foundation layer. Results of on-site borrow characterization tests (ABB, 1993) have revealed that this material is acceptable for use in the foundation layer. The material is classified as a fine-to-medium sand with trace-to-some fine-to coarse gravel (ABB, 1993).

This material has a relatively low fines content and has acceptable compressibility characteristics, therefore it is recommended for use in this layer. The subgrade should be placed in lifts of approximately 8 inches and compacted by 4 to 6 passes of a typical sheepsfoot roller. This placement procedure should result in compaction to approximately 90% of the maximum dry density.

### ***3.2.1.4 Gas Ventilation Layer***

The gas venting layer is a permeable layer containing piping for the collection and venting or recovery of gases produced from waste degradation. Based on the cell composition

(predominantly burn-fill), the moist, aerobic conditions provided by the intermediate cover, and the time since placement (over 40 years) it is concluded that gas generation rates at the 1951 cell will be low. Consequently, a passive gas venting system is recommended. It is recommended that material from the "lower layer" of the borrow area be utilized for the ventilation layer. The soil must be screened on a 3/8 inch sieve prior to placement, and then placed with a light machine in a single lift with no further compaction efforts. To collect the gas, PVC collector pipe is bedded in the sand and run laterally along the slope. To vent the gas to atmosphere, it is recommended that a total of ten ventilation risers be installed and spaced equidistantly. Flexible (to accommodate loading and settlement) 4 inch perforated PVC is recommended for the collector pipe, and 4 inch non-perforated rigid PVC is recommended for the risers.

#### ***3.2.1.5 Hydraulic Barrier Layer***

The barrier layer is designed to minimize the percolation of water through the cover system directly by impeding infiltration and indirectly by promoting storage and drainage of water in the overlying layers and eventual removal of water by runoff, evapotranspiration, and internal storage (Geosyntec, 1994). This design proposal recommends a composite geomembrane over geosynthetic clay liner (GCL) as the hydraulic barrier layer. The specified geomembrane is a 60 mil (1.5 mm) textured very low density polyethylene (VLDPE), and the specified GCL is a Gundseal<sup>®</sup> GCL with a 40 mil (1.0 mm) textured VLDPE substrate placed bentonite-side up.

#### ***3.2.1.6 Drainage Layer***

The drainage layer functions to remove water which infiltrates the vegetative support/protection layer. It should be designed to minimize the standing head and residence time of water on the

barrier layer in order to minimize leachate production (US EPA, 1989). The recommended drainage layer for this design is an extruded solid rib geonet with factory bonded nonwoven, heat-bonded geotextile on both faces. The composite drainage layer must have a minimum transmissivity of  $3 \times 10^{-5} \text{ m}^2/\text{sec}$ .

### ***3.2.1.7 Surface Layer***

The top layer of the cover system is actually comprised of two separate layers; the lower layer termed the protection layer and the upper layer termed the surface layer. On-site or local soil is the most commonly used and typically the most suitable material for the protection layer.

Suitable on-site materials are available for use in the protection layer. The on-site borrow materials have been classified as a fine-to-medium sand with trace-to-some fine-to coarse gravel (ABB, 1993). This material has a relatively low fines content and a low organic content, therefore it is acceptable for use in the protection layer. The borrow material should be placed to a thickness of 18 inches using a small dozer with low ground-pressure to protect the underlying cover components. Compaction beyond that which occurs during placement is not necessary.

Vegetation is specified as the surface layer cover, consequently the surface layer will be designed for vegetative support. The on-site borrow material is not well suited to supporting vegetation, therefore it is recommended that loam be imported from an off-base supplier and placed to a thickness of 6 inches. A warm season grass mix is specified as the vegetative cover. Periodic mowing and inspection of the vegetative cover are recommended as part of the Postclosure Program discussed in Elias, 1996.

### **3.2.1.8 Conclusions**

It is concluded that this cover system, if constructed with appropriate construction quality assurance / quality control, will satisfy the primary objective of containing the source of pollution, thus minimizing further contamination of groundwater by the waste fill. The composite geomembrane / geosynthetic clay liner barrier layer is theoretically nearly impermeable. Estimates of the hydraulic conductivity of VLDPE geomembranes are on the order of  $1 \times 10^{-10}$  cm/sec (Koerner, 1994), and estimates of the hydraulic conductivity of Gundseal<sup>®</sup> GCLs are on the order of  $1 \times 10^{-12}$  cm/sec (Eith et al., 1991). Essentially all infiltration that does occur through such a composite barrier is the result of defects from manufacturing and / or construction processes. Theoretical performance of the cover was evaluated using the Hydrologic Performance of Landfill Performance (HELP) computer model (Schroeder et al., 1994). HELP is a quasi-two-dimensional, deterministic, water-routing model for determining water balances (Schroeder et al., 1994). HELP predicted 0.000000 inches of annual percolation through the barrier layer. Clearly, this prediction is unrealistic as no cover is absolutely impermeable. Because the performance of the cover system is so closely linked to construction QA/QC, it is very difficult to make an accurate estimate of anticipated infiltration through the barrier layer. It is accurate to state, however, that if this proposed cover system is constructed with appropriate QA/QC, it will meet and exceed the regulatory performance specifications. To accurately monitor the performance of the cover system, it is recommended that the downgradient groundwater quality be closely monitored before and after cover construction to reveal contaminant concentration trends indicative of cover system effectiveness.

While the primary objective of the cover system is to minimize infiltration into the waste fill, there are several other significant performance criteria which must be satisfied. Given the site-specific conditions, the cover system must also:

- isolate the waste from humans, vectors and other animals, and other components of the surrounding ecosystem
- control gases generated within the waste fill
- be resistant to erosion by wind and water
- be resistant to static and seismic slope failures
- be durable, maintaining its design performance level for 30 years (regulatory) or the life of the waste fill (prudent)
- control surface water runoff and lateral drainage flow in a manner which does not promote erosion and does not adversely impact the surrounding environment

As presented in Elias, 1996, these criteria are satisfied by the proposed cover design. The waste is well isolated from the surrounding ecosystem by a total of over 5 feet of soil. Any gases produced by the waste will be vented to atmosphere to prevent explosive conditions from occurring within the waste layer. Additionally, atmospheric monitoring is included as part of the post-closure program to ensure that vented gases do not violate Clean Air Act standards and to ensure that no gas migrates off-site. The cover is designed to be erosion-resistant. The surface is graded to a moderate slope, seeded with an appropriate grass mixture, and covered with straw mulch. Surface water runoff and lateral drainage flow are handled by a network of open channels and culverts which divert flow to specified recharge areas in a controlled manner which also assists in erosion control. The cover system is also resistant to static and seismic slope failure. The minimum static factor of safety of the proposed cover system is 3.1, the minimum seismic factor of safety is 1.0. The recommended minimum factors of safety are 1.5 and 1.0 respectively. It should be noted that it is relatively rare to have a cover design satisfy the seismic stability

safety factor in a seismically active area such as Cape Cod. The issue of durability is not so clearly satisfied, in the author's opinion. Relatively little research on the long-term durability of geosynthetics in landfill covers has been performed, and since the history of geosynthetics in cover systems is fairly short, there are few, if any, case studies of sufficient length (e.g., over 30 years) to fill the data gap. However, the research that has been performed indicates that a cover system is an environment which is relatively conducive to geosynthetic survivability (Koerner et al., 1991). In a cover, the geosynthetics are not exposed to toxic chemicals, they are isolated from ultraviolet radiation, and they are fairly well protected from the effects of freeze/thaw cycles. Thus, it seems likely that the cover system will maintain its integrity well into the future.

In summary, it is contended that the proposed cover system will adequately contain the source of the LF-1 plume. If constructed with appropriate construction QA/QC, the proposed cover system design will provide a nearly impermeable barrier while also controlling lateral drainage flow, surface runoff, and decomposition gases with a stable, durable design that should maintain its integrity for decades.

### **3.2.2 Bioremediation**

Bioremediation of the LF-1 plume has been considered as a potential remedial action for the site, but a comprehensive plan has yet to be proposed (RI, 1995). Conventional enhanced bioremediation systems stimulate microbial degradation by amending groundwater from the aquifer with oxygen and nutrients and recirculating it through the contaminated area (O'Brien & Gere Engineers Inc., 1995). The immense size of the LF-1 plume would necessitate the pumping and recirculation of millions of gallons of water in order to ensure the removal of all of the



chlorinated solvents. This plan would not only be prohibitively costly, it would also be ineffective because the plume contains PCE which cannot be aerobically degraded (Pavlostathis and Zhuang, 1993).

In order to solve the technical problems associated with a traditional enhanced bioremediation action, a passive anaerobic/aerobic system can be used. This system would consist of two groups of horizontal injection wells which are driven into the aquifer at a depth just below that of the plume. The wells would be driven across the width of the plume and have thousands of small injection ports along the top of each one. The ports are used to inject gases into the aquifer in order to stimulate the microbes which will degrade the plume contaminants. Each set of wells will form a distinct biozone above it. The first biozone will be anaerobic and will treat the PCE in the plume, while the second biozone will be an aerobic treatment phase which will remove the remaining chlorinated solvents in the plume. This system has a significant advantage over traditional systems because it is a flow-through system; the gas is injected below the plume where it can rise up into the contaminated water and stimulate microbial activity as the plume flows over the treatment wells. This significantly reduces the pumping costs associated with a more traditional bioremediation system.

The part of the aquifer where the LF-1 plume is located is aerobic (RI, 1995), but the plume contains significant quantities of PCE which can only be degraded anaerobically because the bacterial monooxygenase enzyme cannot oxidize a fully chlorinated ethene molecule. Therefore, the first stage of the system must be designed to turn the system anaerobic so that anaerobic

bacteria can utilize the PCE in the plume in the process of reductive chlorination. PCE is an oxidized chemical species while organic matter is relatively reduced. Reductive dechlorinating bacteria use the PCE as a chemical oxidant in a redox reaction with organic matter in order to obtain energy to function and grow (Hollinger et al., 1993). In the process, one or more chlorines are removed from the PCE and replaced with hydrogen. This renders the PCE susceptible to aerobic attack.

In order to turn the aquifer anaerobic, methane and air are injected at the first biozone. This injection serves a threefold purpose. Methanotrophs utilize the methane for growth and deplete the oxygen in the plume as it flows past the well. In addition, the methanotrophs will also degrade some of the TCE and DCE in the plume since their monooxygenase enzymes can degrade the solvents as well as methane (Semprini, 1995). Finally, as methane is utilized by the methanotrophs for growth, biomass will be accumulated in the region above the treatment well. This biomass will then be used by methanogenic bacteria to fuel the process of reductive dechlorination of PCE within the plume.

Once the oxygen is depleted from the plume, the first biozone will be anaerobic. It will remain anaerobic since there will be little or no vertical mixing with oxygenated recharge water. Furthermore, oxygen will be depleted from the plume as it flows into the biozone by periodic injections of methane. Bacteria in this anaerobic zone will utilize the dead biomass and reductively dechlorinate the solvents in the plume. This is a slow biological process; based on laboratory batch studies and the temperature and pH of the aquifer the biozone needs to produce

at least five milligrams per liter of biomass and it should take about five hundred days to achieve extensive (greater than 99 percent) of the PCE in the plume. Given a PCE migration rate within the plume of 1.3 ft per day and a horizontal well radius of influence of two hundred feet, four six-thousand foot horizontal wells will need to be installed to create the first biozone. Some of the TCE and DCE in the plume will also be dechlorinated within this area, rendering all of the chlorinated solvents in the LF-1 plume more susceptible to treatment by aerobic degradation.

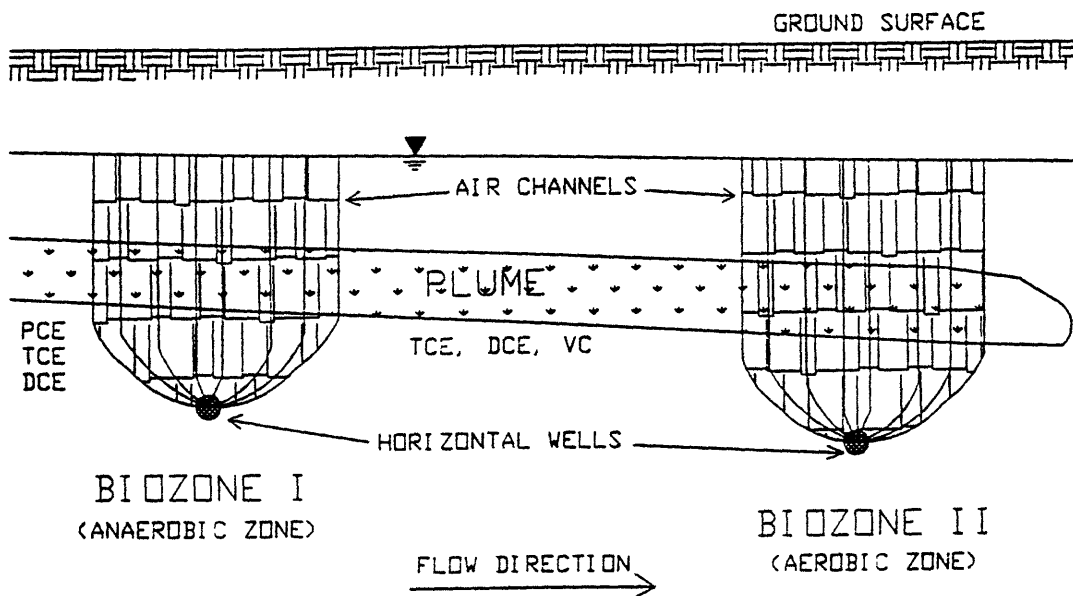
The second biozone will be an aerobic zone that will be used to degrade the bulk of the chlorinated solvents in the plume. Gaseous methane, air, nitrous oxide, and triethyl phosphate will be injected into the aquifer (Skiadas, 1996). Methanotrophs will feed on this and will also degrade the solvents in a process termed cometabolic oxidation. Two consecutive horizontal wells must be used to produce the aerobic biozone, but the system can achieve a ninety-three percent reduction in the concentration of TCE and ensure total remediation of DCE and VC.

This level of remediation is more than sufficient to ensure that federal MCLs for the pollutants in the LF-1 plume are not exceeded in private drinking wells in the path of the plume.

It is apparent that the enhanced bioremediation system proposed above has the potential to effectively remediate the chlorinated solvent plume emanating from the main base landfill at the MMR on Cape Cod. The system would be difficult to manage and expensive to emplace, but it does offer many cost advantages over other remediation or containment schemes because it does involve pumping large volumes of water or treating contaminated groundwater with granular activated carbon to remove the chlorinated organics. However, this type of system has never been used in the field so a pilot-scale study should be conducted at a smaller site to ensure that the concept works and is cost-effective. If this test produces positive results, then a sequential

anaerobic/aerobic enhanced bioremediation system of this nature could be used to clean up the LF-1 plume.

Figure 3-15. Conceptual Diagram of the Sequential Bioremediation System (Skiadas, 1996)



## **4. Detailed Individual Study**

### ***4.1 METHODOLOGY FOR INDIVIDUAL STUDY***

Research for the individual segment of the LF-1 study included here, focusing on Management and Public Interaction at the MMR IRP, included observations taken from participation in public involvement activities at the MMR between January 15, 1996, and the completion of this report. In addition to these observations, interviews of personnel at and associated with the IRP were conducted. Finally, personnel conducting Installation Restoration activities at bases in California and Arizona were contacted, so that the purpose of comparing management approaches used at other bases with the ones used at the MMR could be served.

### ***4.2 BACKGROUND ON THE CERCLA PROCESS PATH***

In order to understand the regulatory scheme under which the Installation Restoration Program at the MMR is operating, it is important to describe the typical process followed in site remediation. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or “Superfund”) is the federal government’s primary statute for dealing with contaminated sites. The CERCLA regulatory process is first triggered by the discovery that a site is contaminated. The site is then inspected, as levels of contamination are detailed. If contamination on the site meets a certain level of risk to human health and the environment, the United States Environmental Protection Agency places the site on the National Priorities List (NPL). Sites on the NPL are priority sites for cleanup, and this cleanup is partially funded by Superfund, a fund set up by the federal government to cover the costs of remediating contaminated sites in the United States.

After a site is listed on the NPL, a remedial investigation is conducted to further assess contamination on the site, risk to human health and the environment, and the degree of cleanup required to remediate the site. A feasibility study of approaches to cleanup is conducted, followed by a proposed plan for cleanup, remedy selection, and remedial design. Finally, remedial actions are taken, and if, through initial remediation and continual maintenance of remedial technologies, the site is determined to be “clean”, the site is taken off the National Priorities List.

Along the CERCLA process, remediation is generally overseen by the US EPA. However, due to the fact that the Massachusetts Department of Environmental Protection (DEP) regulations (allowable contaminant levels, etc.) are somewhat stricter than federal regulations in most cases, the DEP can be seen as the “lead” agency pushing, or overseeing, cleanup at the MMR.

### ***4.3 HISTORY OF MANAGEMENT OF PUBLIC INTERACTION AT the MMR***

#### **4.3.1 Evolution of Management Scheme for Public Involvement (Karson, 1995)**

The initial approach to management of public interaction surrounding the Installation Restoration at the MMR was similar to the “compliance-based” approach many companies take towards environmental regulation--the National Guard Bureau (NGB) met only the minimum requirements necessary to involve the public. Actions taken by the NGB were reactive rather than proactive. The NGB promulgated press releases and sent reports to local libraries, as well as holding news conferences after technical meetings, but any actions beyond that were minimal. Technical meetings concerning IRP activities were closed to the public and media, and virtually no public information meetings were held.

During 1990 and 1991, there was a modest effort to increase public involvement in the cleanup at the MMR, as the local IRP office was created on base to manage the program locally rather than from far away. The “Joint Public Involvement Community Relations Plan” was presented, bi-monthly public information meetings were initiated, site tours and briefings were made possible, a site mailing list was created, and the IRP office began to print quarterly fact sheets that described the IRP activities. Although these fact sheets were limited in scope, they, along with the public information meetings, represented the first real effort to inform the public about specific activities associated with the IRP (A copy of a recent IRP fact sheet is attached in full in Appendix B.).

Late-1991 marked a major change in the way public interaction was managed at the MMR. The IRP office began updating technical reports much more frequently, and progress reports were made available to all interested parties. The local IRP office began educating the public by participating on local radio and cable television programs as well as taking part in neighborhood association meetings. An educational display was created to be used at these meetings and at libraries, and detailed bi-monthly fact sheets were developed. In addition, all technical meetings were opened to the public and media.

#### ***4.4 CURRENT PUBLIC AFFAIRS/INVOLVEMENT ACTIVITIES AT the MMR***

Current public participation activities conducted by the Installation Restoration Program office at the MMR are detailed in the “Joint Public Involvement Community Relations Plan” (PIP/CRP). The PIP/CRP gives a background and site description of the MMR, including a list of areas of contamination. Community concerns about the site are detailed, and a plan to address these



concerns is presented, as well as a listing of the public involvement/community relations activities undertaken by the IRP office. The Table 4-1 lists the public interest groups currently maintaining involvement in the MMR Installation Restoration Program process.

Table 4-1. List of Public Interest Groups involved in the MMR IRP Process (Karson, 1995)

- Alliance for Base Cleanup
- Area Town Selectmen and Boards of Health
- Ashumet Valley Property Owners
- Association for the Preservation of Cape Cod
- Barnstable County Assembly of Delegates
- Boston Physicians for Social Responsibility
- Conservation Law Foundation
- Coonamessett Pond Association
- Johns Pond Association
- LF-1 Committee
- Mashpee/Briarwood Association
- Massachusetts Campaign to Clean Up Hazardous Waste
- National Environmental Law Center
- Otis Conversion Project
- Responsible Environmental Protection for Sandwich
- Sierra Club
- Upper Cape Concerned Citizens

Currently, there are seven committees on which public representatives serve. These include the Senior Management Board, the Technical Environmental Affairs Committee (TEAC), the Long Range Water Supply Process Action Team (PAT), the Plume Containment Team (Team 1), the Program Implementation Team (Team 2), the Innovative Technologies PAT, and the FS-12 subcommittee. These, combined together, are sometimes referred to as “community working groups”; the TEAC and Senior Management Board as “committees”, and the other groups as “subcommittees”. They all serve the same basic goal of guiding the remedial actions taken on the base.

#### **4.4.1 Present Committee Make-up, Action**

From observation of IRP activities at the MMR, it is evident that the two most active process action teams are currently the Plume Containment Team and the Program Implementation Team. This is perhaps due to the fact that most of the recent IRP activity has involved the final design of plume containment actions to be taken, and these two teams are the most relevant to the plume containment scheme, Team 1 in design of the plume containment system, and Team 2 in the implementation of and public education about it. Table 4-2 gives a listing of the tasks/roles of the two teams. The activity on the subcommittee level The TEAC and Senior Management Board are the most technically-oriented committees, and each hold meetings approximately every six weeks. The Long Range Water Supply PAT, as its name suggests, deals with water supply issues in the communities surrounding the MMR. The Innovative Technologies PAT works with the EPA, DEP and other interested parties to explore options for testing innovative remediation technologies at the MMR, as well as utilization of technologies at the MMR to serve educational purposes. Appendix A gives a detailed listing of the make-up of the various IRP committees, including a full listing of committee members.

Table 4-2. Process Action Team Task Descriptions (IRP, 1996)

Plume Containment Team	Program Implementation Team
<ul style="list-style-type: none"> <li>• Track and make recommendations on the plume containment plan, implementation schedules, methods of containment and location of containment fences/treatment facilities</li> <li>• Track milestones of the design and make recommendations on ways to expedite</li> <li>• Track and make recommendations on information data gaps and related unforeseen issues</li> <li>• Review groundwater quality data as it becomes available and provide input</li> <li>• Monitor and make recommendations in setting design performance and cleanup standards</li> <li>• Review existing cleanup efforts such as the Chemical Spill 4 Groundwater pump and treat containment system and the upcoming innovative technology demonstration of the “Reactive Wall”, and make recommendations on design analysis for the containment plan.</li> <li>• Assist the Installation Restoration Program in keeping the public informed</li> </ul>	<ul style="list-style-type: none"> <li>• Develop and implement a plan to inform the public</li> <li>• Obtain input from the public at large and act as an information conduit</li> <li>• Address issues of access in each affected neighborhood</li> <li>• Participate in public meetings</li> <li>• Maintain a liaison with the plume containment team</li> </ul> <div style="border: 1px solid black; background-color: #e0e0e0; padding: 5px;"> <p><b>Planned Public Participation Activities of the Program Implementation Team</b></p> <ol style="list-style-type: none"> <li>1. Issuance of fact sheets providing the latest information on planned construction activities associated with the plume containment project</li> <li>2. Provide information via local cable television access</li> <li>3. Coordinate speaking engagements with local homeowners associations and other interested parties</li> <li>4. Conduct periodic public meetings in the local communities as construction nears start-up and throughout construction</li> <li>5. Conduct visits in affected neighborhoods, as necessary, to provide information</li> <li>6. Provide information to local real estate agents and continue dialogue</li> <li>7. Continue with updates on the plume containment project at meetings of the Senior Management Board and Technical Environmental Affairs Committee which are open public meetings</li> </ol> </div>

#### 4.4.2 Various Public Meeting formats

The public meetings associated with the IRP process fall into three basic categories, or types: the technical briefing, the committee meeting, the team meeting, and the town hall meeting. Each of these different meeting formats is discussed below in Table 4-3.

Table 4-3. Various Public Meeting Formats

<b>Meeting</b>	<b>Audience</b>	<b>General Comments</b>	<b>Moderated?</b>
TECHNICAL BRIEFING	Large audience, usually made up of several committees, hired consultants, public, interested consultants, and other researchers.	Public participation is hindered by the fact that most information presented is highly technical. In addition, the room where the meeting takes place is usually dark, to allow for better viewing of visual aids, which actually damps participation/discussion.	Led by public affairs specialist from the IRP office.
COMMITTEE MEETING	Committee members, some public, press, outside observers made up mostly of consultants	Similar to the technical briefing, as most of the issues may be of a technical nature. Public participation/discussion is hampered by formal nature of the meetings.	Led by IRP personnel, committee chairmen.
TEAM MEETING	Team members, few outside observers, both public and consultants	Much more informal and frequent than the meetings above, this meeting format allows for much more discussion/participation by "outside" parties.	Moderated by a professional facilitator.
TOWN HALL MEETING	IRP personnel, regulatory agency personnel, hired consultants, most outside observers consisting of public, committee/sub-committee members	This meeting has the largest potential for conflict, as the large audience allows for proceedings to tend towards an adversarial nature.	Led by personnel from the IRP office.

## ***4.5 ANALYSIS OF THE STATUS QUO: Where have past actions taken us?***

### **4.5.1 Influence of the Public thus far**

There must be a distinction drawn here between public involvement and public influence. The fact that the public is “involved” in the process would lead to the belief that the public is influential. However, involvement does not necessarily translate into influence. Issues that could dampen the influence of public in the process are rooted in the fact that entities responsible for cleanup do not listen to the suggestions given by the public. A criticism throughout the IRP process at the MMR has been the accusation that the MMR IRP office has given "lip service" to the concept of public participation and involvement, without actually taking action on the suggestions and input resulting from it. And while the IRP currently involves the public to a high degree, if the public has no influence, then the public is not truly involved in the process. Instead, the public is simply a bystander, providing input and concerns that are not addressed by the relevant parties.

#### ***4.5.1.1 Public Meetings***

Committee members provide input on all aspects of IRP activities. Public meetings, the main forum provided for public input, are conducted regularly. Although public interest groups are represented on every committee, the influence of the committees and sub-committees themselves has been questioned in recent months by actual members of the working groups. Table 4-4 lists the public meetings attended as part of this thesis research.

Table 4-4. Public Meetings Attended for Research Project

<b>Meeting</b>	<b>Attendance</b>	<b>Significant Outcomes</b>
58th Technical Environmental Affairs Committee [TEAC] Meeting, January 16, 1996	Mostly Committee members and IRP personnel; some public	Plume containment design schedule, results from data gap field investigations presented.
Plume Containment Team Meeting, January 25, 1996	Committee members, some public	Committee decided to provide input "memorandum" on 60% design issues
Program Implementation Team Meeting, February 13, 1996	Committee members, some public	Team response to 60% design document discussed.
Bourne Town Hall Meeting	Committee members, consultants, public, regulatory agency personnel	60% design presented to public.
Senior Management Board Meeting, February 22, 1996	Board members, committee members, IRP personnel, hired and outside consultants, some public	60% design issues presented to SMB by various committees and subcommittees.
Innovative Technologies Process Action Team Meeting,	Committee members, outside consultants, some public	Updates on Educational efforts, Enviro-Tech Center presented
59th Technical Environmental Affairs Meeting, March 20, 1996	Committee members, consultants, some public	Further discussion of 60% plume containment design and related issues

4.5.1.1.1. Concerns Raised by the Public at Recent IRP Committee and Sub-committee Meetings

Concerns raised by the public at meetings attended as part of this research effort covered a large range of issues. At the first TEAC meeting that was attended, concerns ranged from public perception of risk to technical questions, questions about public involvement, and concerns over the placing of groundwater extraction wells on private property. At the subcommittee meetings that followed the TEAC meeting, concerns involved issues surrounding the presentation of the

60% plume containment design. These concerns dealt with the issue of “hotspots” at the MMR. Several areas identified as hotspots in earlier data reports no longer were identified as such in the 60% design. Other concerns involved the competency of design contractors and the honesty of various players responsible for cleanup.

Interesting among the various concerns raised by the public from a public interaction perspective was one sub-committee’s questioning of its actual role in the IRP process. One member of the Plume Containment Team suggested that a cost-benefit analysis be conducted to decide if the LF-1 plume should be allowed to release into Buzzards Bay. Several members were upset by this, as they stated that the purpose of the sub-committee was to contain the plumes rather than study the effects of not doing so.

#### ***4.5.1.2 Public Relations Documents***

The Program Implementation Team (Team 2) has been instrumental in the development of public informational fact sheets detailing remedial actions at the MMR IRP. This has been a significant method of communicating IRP activities to the public at-large. Involving the public on this level ensures that information is presented to the general public in the most effective manner, as opposed a way in which information is much too technical for the average public to understand.

#### ***4.5.1.3 Design Of Containment System***

The 60% design of the plume containment system for the MMR was released in document form by OpTech, the consultant hired to design the remediation scheme, in March. All committees have reviewed the 60% design and have or are making suggestions on the scheme presented by OpTech. However, due to information presented by data gap investigations in recent months, the

technical value of the 60% design has been questioned, and a peer review panel has been established to review the design scheme before the final design is presented.

#### **4.5.2 Media Involvement**

Several community newspapers and television stations on Cape Cod publicize activities taking place at the MMR. Press coverage ranges from meeting announcements to detailed meeting and IRP activity coverage. Press coverage currently serves more of an informational role rather than a role that would polarize public opinion. Involvement of the Boston media is almost non-existent (Karson, 1996).

#### **4.5.3 Current IRP Personnel Tasking**

Table 4-5 lists the personnel employed by the local IRP office at the MMR. Of the four primary individuals employed by the IRP, the percentage of time spent on public relations activities ranges from 25-35% for the Program Manager, Senior Hydrologist, and Environmental Engineer, to 100% for the Public Affairs Specialist, whose role is discussed below (Karson, 1996). This high level of time spent on public involvement translates into around half of the overall man-hours spent by the primary personnel at the MMR. This is a significant amount of time which should be realized by anyone entering into the engineering field.

the MMR IRP currently maintains one individual whose sole responsibility is working with the public as a Public Affairs Specialist. His role is to inform the public about ongoing IRP activities at the MMR. The Public Affairs specialist plans the working group meetings and publicizes them, as well as participating in the meetings. In addition, he is the principal contact for any persons--including the press--wishing to obtain information on current IRP activities.



**Table 4-5. Personnel Tasking at the Mass Military Reservation Installation Restoration Program (the MMR IRP, 1995)**

<b>Person</b>	<b>Responsibilities</b>	<b>Background</b>
Michael Minior, IRP Program Manager	Carries out all aspects of the environmental cleanup program, including investigation, remediation, public affairs, and funds management.	B.S. degree in Civil Engineering from Southeastern Massachusetts University; 20 years of engineering experience.
Edward Pesce, Environmental Engineer	Oversees all remediation projects on the MMR.	B.S. degree in Civil Engineering from Norwich University; registered professional engineer in Massachusetts and Maryland
Martin Aker, Senior Hydrologist	Heads the investigative branch which includes subsurface soil and groundwater investigations at the MMR.	Bachelor's degree in Earth Science from Salem State College; over eighteen years experience as a geologist, geophysicist and hydrologist with major petroleum companies and firms.
Douglas Karson, Public Affairs Specialist	Responsible for carrying out all of the activities outlined in the Joint Public Involvement/Community Relations Plan for the site, including running public meetings and being a spokesperson to local news media.	Bachelor's degree in Political Science from the University of Massachusetts; received the National Guard Bureau "Environmental Public Affairs Officer of the Year" award in 1991.

Douglas Karson currently fills the position of IRP Public Affairs Specialist at the MMR. Some would argue that Mr. Karson is the most influential individual at the IRP. Although he serves a non-technical role and mostly a public information role, the fact that public committees have become somewhat influential in the process makes the role of information broker a very important one. Public perception, and the types and amount of information given to the public along the way have influenced the extent to which remedial actions have taken place. And while Mr. Karson is an employee of the IRP, he actually serves as somewhat of a liaison between the IRP and the public. He comes across as being, though not "against" the IRP, on the side of the public. Nevertheless, the fact that any remedial actions have been taken at all at the MMR can be

attributed to the proactive involvement of the public by Mr. Karson. It is evident that other IRP personnel are not as congenial with the public, and therefore, are not as trusted by public interest groups as is Mr. Karson.

## ***4.6 COMPARISON WITH INSTALLATION RESTORATION PROGRAMS AT OTHER MILITARY BASES***

### **4.6.1 Los Alamitos Air National Guard Base, California (Wells, 1996)**

Captain Mike Wells is the Compliance and Restoration Chief for the California National Guard. In the role of Installation Restoration Project Manager for California, he deals with every aspect of IRP activities, from public affairs to technical specifications, contracting, and remedial project management. There are currently six California sites with IRPs in progress, with a possibility that three additional sites will be added in the near future. Three of these sites are very active; none are on the NPL. All are federal facilities regulated by CERCLA. The site in California most relevant to the study of public participation at the MMR is the Los Alamitos Air National Guard Base in northern Orange County.

#### ***4.6.1.1 Site Background***

The Los Alamitos ANG Base was originally a Naval Air Station, beginning operations in 1940-1941, just as World War II was really getting off the ground. The base served as a Naval Air Station from propellers through the jet stage, and was primarily a training facility--the West Coast equivalent of Pensacola, where naval aviators are trained. The Navy left the base in 1972-73 because of noise complaints by the nearby community, concerns associated particularly with the F-4 fighter during the Vietnam era. When the Navy left, they left very annoyed with the

public. A year later, the California Air National Guard took over the air field, and installation operations were assumed by the National Guard in 1977.

When the Navy left Los Alamitos in the early 1970s, their annoyance with the public led them to take all records kept during their stay on the base. All institutional data about activities on the base were lost. This included data on waste streams and activities that might have resulted in contamination. The lack of data made the site inspection, which would take place later due to the finding of contamination on the base, very difficult. Rather than speculate about activities that might have taken place on the base, National Guard personnel studied other bases (Naval Air Stations in particular) that carried out similar operations around the time that Los Alamitos was in its prime. They looked at Miramar, Alameda, a base in Maryland, and a site near Seattle, Washington. Los Alamitos personnel obtained copies of information from all of the sites, mostly from Miramar. Even with all of this data, there were many gaps in knowledge about what might have gone on earlier at Los Alamitos.

#### 4.6.1.1.1 Land and Groundwater Characteristics

The Guard Base at Los Alamitos covers a land area of approximately 1300 acres. Six cities surround the base, with a total population of 600,000 people. Within a 5-mile radius of the site, there are 1.5 million people; within a ten mile radius, that population more than doubles. It is an extremely heavily urbanized community. From there down to the Mexican border, there is an approximately 120-mile stretch of constant urbanization. Camp Pendleton breaks up the urban area between San Diego and the south border of Orange County.

The average groundwater depth near the Los Alamitos site is 8 feet below the ground surface, but for the last three years, it has at times been only a foot from the surface--this is an unusually high groundwater level. From 0-50 feet below the ground surface, the soil at Los Alamitos is very heavy silt and clay. From 38-50 feet, there is a change to soil and sandy gravels. There is a very thick (30-50 feet) aquaclude (relatively impermeable layer) at 167 feet below the surface.

#### 4.6.1.1.2 Water management in California

All groundwater in California is classified as “beneficial use water”. Water is managed by municipalities, and is constantly managed/monitored by water districts. A water district might draw water from 300-400 groundwater wells, reservoirs, and aqueducts. Water is drawn from all sources, monitored, then blended and distributed. If a well is bringing in water that is contaminated, the well will be continuously monitored, but water will not be drawn from it. All water is part of the California Water Management Project. Wells are constantly monitored. The Los Alamitos area, near the Pacific Coast, is an area where saltwater migration, as well as contamination from man-made sources, is an issue.

#### 4.6.1.1.3 Current Extent of Contamination

Areas of contamination at Los Alamitos include high levels of JP-4 jet fuel contamination (to be discussed below) and a former storage area for PCB transformers. Additional PCB contamination is significant around the base air field, where PCBs from an oil mixture used to control weeds are still present. The golf course on base harbors hotspots of lead (around 22,000 ppb) just below ground. Other contaminants range from TCE and benzene to jet fuels and chlorinated solvents--contaminants that are generic to the typical air station. There are DNAPL problems in 3 areas, as well as hydrocarbons and various other pollutants.

#### ***4.6.1.2 Potential Implications of Contamination at Los Alamitos on Local Communities***

The communities at the northern tip of Orange County near Los Alamitos are some of the most affluent communities in the country. The community that surrounds the base on the western and southern perimeter is built-up with 350-450,000 dollar homes. The highest levels of JP-4 contamination occurred about 100 yards from the western boundary of the base. Groundwater flow is in a westerly direction. Homes, schools, and a catholic church are all located just outside the base across from the JP-4 fuel farm.

#### ***4.6.1.3 The IRP process at Los Alamitos***

The IRP process at Los Alamitos kicked off “with a whimper” in 1988. The California National Guard was actively involved. At this point in time, Los Alamitos served as the coordinating center for emergency response in California (e.g., earthquakes, the L.A. riots, etc.). What started the ball rolling was the discovery that a fuel pipe was damaged. Maintenance crews dug up soil around the pipe and found pure JP-4 jet fuel leaking from it. Personnel covered the hole and “forgot about it”. Then, in 1990-91, there were UST permitting problems on the base. Using a tracer test to explore the possibility that the base’s 210-gallon USTs were leaking, base personnel found a crack in one of three tanks, as well as a leak in the piping leading to another. An NFA (“no further action”) decision was made after crews closed the cracked tank and repaired the leak in the piping to the other. Another leak, found elsewhere at the Los Alamitos site, led base personnel to discover a large-scale fuel leak. Pure JP-4 jet fuel was coming out of the ground in test samples. A citation was issued by the Orange County Health Care Agency, the office responsible for permitting underground storage tanks in Orange County. Repair on this leak was

initiated, at which point it was estimated that approximately 100,000 gallons of JP-4 had leaked into the ground.

An extraction well was placed at the site of JP-4 contamination, and approximately 36,000 gallons of pure jet fuel have been extracted to date. From late 1992 to April of 1994, the majority of this jet fuel was collected, around 25,000 gallons. Most of the remaining fuel (about 64,000 of the original 100,000 gallons) had already gone into the dissolved phase.

The preliminary assessment process at Los Alamitos--in the early days of the IRP--was very haphazard. A variety of reports on the data obtained on the base were proliferated, none of which were that well-coordinated. There was no real defined IRP process going forward on the base. In 1993, there was first initiated a full-scale preliminary assessment. This was driven by the military, through recognition that contamination on the base was regulated under CERCLA and would necessitate compliance. Between that and the present time, there have been two community meetings (since 1994). A Restoration Advisory Board (RAB) has been established, made up of public as well as military, federal and state agency personnel. (RABs are detailed in DOD guidance to military bases; guidance required the establishment of a RAB and set out certain criteria for determining when establishment of a RAB is necessary. Further, it details the factors that must be considered when determining when and how to establish a RAB. The purpose of the RAB is to improve relations between the installation and the community. The RAB is recommended in conjunction with EPA guidelines to provide a tool for the community to provide input into the CERCLA process. RABs were intended to give people the opportunity to comment but not to make decisions specifically)

Some of the things that were occurring around the time of the preliminary assessment at Los Alamitos began to shape the thought process of those involved in the cleanup activities, as they saw what was occurring at other bases. Stories were being told about the MMR and the contentious nature of public involvement there, for example. Captain Wells and others tried to look at those things and begin to steer the Los Alamitos IRP process away from that. There was a lot of input from the National Guard Bureau (NGB) at that point. Information was processed, and a choice was made to “create the [proper] climate” for public involvement: to give the community information as early as possible. And although there have not been a large number of “public meetings” at Los Alamitos, the RAB created was the first at a military base in the country. The creation of the RAB was earlier in the process than is suggested in the DOD guidance requiring RABs. (Guidance suggests formation of RABs after commencement of the remedial investigation phase. The RAB at Los Alamitos was created mid-way through the initial site inspection.)

There have been varying degrees of public involvement in the Los Alamitos IRP process. Overall, there have been relatively good relations with the community. But for people on the western perimeter of the base, near the JP-4 jet fuel farm, where the main base landfill is also located, there has been significant concern about issues of human health risk and potential loss of property value. These concerns led the process early on and dictated how they would be addressed.

The first public meeting surrounding the IRP at Los Alamitos was held in April of 1994. Three public meetings have been held since then, one in support of an EIS for the replacement of the

USTs with above-ground tanks. The Guard told the public in August of 1993: "Hey, we want to install these new tanks. These are the impacts they are going to have." The public had the opportunity to give comments. Before that time, no IRP activity had been announced. When the first IRP meeting was held, the IRP was coming off the heels of the preliminary assessment. The initial meeting was "somewhat shaky". One headstrong individual in the IRP program made some strategic errors in the planning of the public meeting which almost backfired. For example, it was decided that no chairs were needed for the public at the meeting, which was held at a local high school. Therefore, the meeting turned out to be more of a briefing by IRP personnel than a meeting with significant discussion. Charts, maps, areas of contamination, expected timelines were all described. Luckily, the IRP had the "good fortune" of having a good Colonel with good community instincts who came in to save the day by "diffusing the public". Because of that, the IRP "got by without an excessive amount of damage", i.e., public left this meeting with a considerable amount of trust for the process.

Once this initial meeting was held, it was decided that periodic meetings and updates would be part of the IRP process. A repository of information was established in local libraries.

Documents on the base activities and contamination were made available. In addition, some of the other things that went well were preparations with elected officials. The governor, senators, congressmen, and mayors of surrounding communities were all briefed. There was a great deal of leg work at this early stage to explain the process to the "decisionmakers" and to keep them informed throughout the process. This all worked out very well. The officials were all very supportive, and there was a good natured relationship riding on the heels of the handling of the 1993-4 L.A. riots by the National Guard.



Throughout the IRP process at Los Alamitos, the NGB and National Guard public affairs officers have constantly reminded the environmental staff, Base Commander, and Adjutant General of problems that existed at the MMR. the MMR served as somewhat of a “negative model” of things the Los Alamitos IRP “wanted to try and avoid”. And although they haven’t been 100% successful, they seem to have faired well. One of the things that was not as successful as some was something that was tried in the initial public meeting at Los Alamitos. IRP personnel decided that they would split up the people participating in the meeting for smaller site tours. Questions such as “Why are you trying to divide us?” and “Why are you trying to keep us from hearing what other people are saying?” were asked. Confrontation was brewing. The IRP decided to change the format, to open up to questions, and things went more smoothly. There were some difficult questions, some people trying to champion their individual agendas. For example, one woman was in attendance who had recently attempted to have million-dollar homes built on the southwest corner of the base. There were tough and pointed questions. The IRP succeeded by being honest and asking for patience, by making assurance that when information was obtained by the IRP, it would be immediately available. Some questions, such as, “If I eat fruit from my backyard, are you poisoning me?” and “Do I have to disclose pollution to prospective property buyers?” were still being asked at times.

“Behind-the-scenes” decisions were made after the initial public meetings that the IRP “would be as open as possible”. Partnering with regulatory agencies began to take place, as regulators saw their reputations on the line as well. When data became available, it would be given to regulatory agencies at the same time it was provided to the NGB. This did not excite the NGB,

but achieved a higher level of trust with the regulatory agencies. And once partnering took place, agencies were willing to give Los Alamitos a lot of latitude that they weren't giving other bases.

Further policy choices to aggressively pursue remediation were made. The IRP would identify problem areas and clean up as soon as possible. Sources of contamination were removed. A permanent extraction trench was put in place to prevent the groundwater plume from moving further. This extraction trench was designed with future in mind, as the system will be used eventually for an air sparging and soil vapor extraction system. All USTs were pulled and contamination remediated.

#### 4.6.1.3.1 Regulatory Agency oversight of the Los Alamitos IRP

Los Alamitos has virtually no oversight from the US EPA. The EPA delegated oversight authority to the California EPA, since California's environmental laws are very aggressive. California EPA administers CERCLA--the lead department is the California Department of Toxic Substances. The Water Quality Control Board also has some oversight responsibility, as it generally takes charge when groundwater quality is impacted. The Orange County Water District and Air Quality Management District also have roles.

#### 4.6.1.3.2 Funding for the IRP at Los Alamitos

The Los Alamitos IRP has not been getting nearly the same level of funding that similar Navy bases have been able to obtain. The Navy spent 60-70 million by the end of a site inspection at a similar base and knew no more than Los Alamitos did spending only \$650,000. Los Alamitos really had to stretch the funding it did have. (This \$650,000 tag included the cost of extracting the 36,000 gallons of JP-4). They optimized the funding crunch by being really aggressive.

Adjustments were made in sampling techniques and other technologies to make the process more efficient. Some of the changes were not only made due to economics, but also yielded more useful data. The IRP was able to take examples of this to the public and say, “We are doing it in a cost-effective way.” A lot of this aggressiveness was stimulated by learning from John Sable, the “guru of aggressive IRPs”. Sable, who leads the IRP at March AFB in California, believes that IRPs should proceed in identifying problems/concerns and remediating them as soon as possible. Regulatory agencies pointed Wells to Sable after noticing that a lot of similar things were going on at March and Los Alamitos. The one major difference was that Sable had gotten close to 100 million dollars--a “huge chunk” of Air Force money--to fund the IRP at March AFB.

#### ***4.6.1.4 Public Participation in the IRP Process at Los Alamitos***

Public interest groups actively involved in the LA IRP: There are organizations that have watch groups to monitor what is going on at Los Alamitos. Some of these groups are national, some local. Homeowners associations and other local groups have been very active. But on these local groups, people have their own “particular political agendas”. According to Capt. Wells, by creating a RAB, the IRP was able to “get these people on to the community”. They have been able to explain to the community that when contamination/problems are found, the public will get information as soon as possible.

The second Community meeting at Los Alamitos was a “180 degree turn” from the first. The IRP came through and was very clear about what had been found at Los Alamitos. It “really

turned out to be a great meeting.” Of course there were new parties with new agendas, but for the most part the meeting was very successful for the IRP.

At this point in time, the Los Alamitos IRP said, “We are going to establish a RAB; public participation is essential.” A number of people expressed interest in participating. The IRP gave personal tours with people involved. The most significant decision the IRP made was to “be honest, (to) put a premium on integrity”. The IRP made efforts to go to the public and explain what was going on rather than withholding information. This was an unusual approach. The IRP has done a lot of things that have been “somewhat risky”, but the “dividends paid off”, according to Wells.

#### 4.6.1.4.1 Personalities and public perception

According to Captain Wells of the Los Alamitos IRP, personalities have been a contributor to the reasons things have gone smoothly with the public. “Perception equals reality.” The community perceives that the IRP is being honest. That does not mean that every detail is disclosed; that can sometimes “get you into trouble”. And the way things are described is as important as the substance in them.

#### 4.6.1.4.2 Media used to disseminate information about the IRP at Los Alamitos

IRP personnel took advantage mostly of news releases in the beginning. When contamination outside the base was first identified, IRP personnel went to homeowners and explained the situation, that there would “people in white suits” sampling, as well as disseminating information about other activities.

## **5. Conclusions Pertaining to Individual Objectives**

There is ample room along the CERCLA process for conflict. Study of the MMR reveals conflict virtually throughout the entire process, especially in the early stages. Generally, there are many opportunities for public interest groups to get involved, and the potential for stalls in the process is high. Some would argue that stalls result from leaving the public out of the process, as public interest groups would eventually fight a process in which they were not allowed to take part. However, it could also be noted that increased public involvement in itself stalls the process. Therefore, the proper balance between too much and too little public participation in the process of site remediation must be reached.

### ***5.1 Stalls Resulting from Leaving Public out of the Process***

In hazardous waste facility siting, siting decisions are often fought by concerned citizens due to what has been termed the NIMBY (“Not in my backyard”) syndrome. Local citizens groups have fought many a facility siting and won due to concerns about human health and environmental risks associated with such facilities. Uncertainties in the science of risk assessment lead to the proliferation of ideas and opinions about risks associated with facilities, and often times, the public fears the worst case scenario. Uncertainty ensures that public perception is that risk associated with a particular activity is high.

While the process of hazardous waste facility siting concerns the potential for contamination, Superfund sites result from contamination that has already occurred. But while contamination is certain, the public involved in Superfund remediation deal with the same uncertainties in risk assessment as those who concern themselves with potential contamination. The question of

“What if (the public is exposed)?” is no more simple in Superfund cases than in hazardous waste facility sitings. Another question presents itself, however, as well. The question of “How clean is clean?” arises as the public, regulatory agencies, and responsible parties all struggle with the levels of remediation necessary to ensure that human health and environmental risk due to contamination is kept at a minimum. High public perception of risk necessitates that the answer to this question is a policy, rather than a scientific, one, as lawmakers and regulatory agencies responsible for remedial oversight set the levels that must be met before a site is “checked off”.

The problem of high risk perception is compounded when public interest groups and the like feel that they are not a part of the remedial process. Further, when they are not only kept away from the negotiating table, but when information is withheld from them, public perception of risk escalates. In this “worst case”, the public will fight any process in which significant buy-in to remedial approaches was not achieved proactively.

### ***5.2 Stalls Resulting from Involving the Public***

Urban planners might argue that designing “the perfect process” necessarily ensures a good result. However, in the issue of environmental contamination and human health risk, it must be remembered that the goal is not public participation; the goal is environmental restoration. A process that involves the public to a great degree can be designed--that process may achieve nothing more environmentally than a process in which concerns of the public are neglected. In the case of an Installation Restoration Program, involving the public adds significant responsibilities to the already burdensome workload of IRP personnel. Stalls in the process can result from the tremendous amount of education that must be achieved once the public is

involved. Developing and distributing education materials require time and money. And while in the case of the MMR, the public may believe that the “bottomless coffers” of the federal government are at issue (i.e., that there is enough money to achieve anything in regard to the IRP), money is, and always will be, an issue. IRPs are subject to Defense appropriations just as any other base or installation program may be.

### ***5.3 Achieving the Proper Level of Public Involvement***

How would one approach the level of public involvement that would facilitate a “speedy” remediation effort? Analysis of the Los Alamitos, CA, IRP activity would offer the idea of involving the public early on in the process as the panacea to all public perception ills. While the Los Alamitos IRP seems to be moving along without much public “opposition”, the level of contamination there is significantly lower than that on Cape Cod. The water management scheme in California, being much more complex than that in the Northeast, forces one to believe that concerns over water quality might be lessened since Californians have significant experience with water management, and, for that matter, water shortages.

Let us not, however, downplay the success of the Los Alamitos IRP in achieving public buy-in to the environmental restoration process. Getting the public involved early ensures buy-in to the process, and this should be a basic goal of any “up-and-coming” IRP. Involving the public early requires more than base tours and environmental updates; base personnel must be perceived as concerned and well-intended, but above all, as honest and truthful. Approaches currently utilized at the MMR seem to be the proper ones, though late in the process. Had they been attempted

much earlier in the process, the MMR IRP would undoubtedly be well on its way to achieving significant levels of remediation.

What, then, went wrong at the MMR? The lack of information provided to the public in the early stages of the MMR IRP resulted in a level of distrust that was certainly problematic. Further, this problem of distrust was difficult to overcome, and some would argue that it never has been sufficiently “remediated”. Recent activity on the base has included the establishment of technical review teams to assess the technical value of the plume containment designs generated to date. These teams have decided throw out the designs and to basically begin again. In addition, the Air Force has taken over the responsibility of remediating the MMR site from the Air National Guard. Personnel responsible for decisionmaking at the ANG attempted to by-pass certain technical barriers to cleanup by proceeding with designs although the technical merit of such designs was questioned. The push to go ahead with cleanup was undoubtedly due to pressure placed on decisionmakers by the public and regulatory agencies to remediate the site. The end result to such irrational decisionmaking is now further delay in the CERCLA process at the MMR. Therefore, it can be said that delays in the IRP process at the Massachusetts Military Reservation have and are resulting from both neglecting to involve the public, and also, especially in recent months, from involving the public to a high degree.



## 6. References

ABB Environmental Services, Inc., "Installation Restoration Program, Massachusetts Military Reservation, Interim Remedial Investigation, Main Base Landfill (AOC LF-1)", Portland, Maine, March 1992.

Alyamani, M.S., and Z. Sen, "Determination of Hydraulic Conductivity from Complete Grain-Size Distribution Curves", *Ground Water*, v. 31, no. 4, p. 551-555, 1993.

Aschengrau, A. And Ozonoff, D., *Upper Cape Cancer Incidence Study Final Report*, Massachusetts Department of Public Health, Boston, January 9, 1992.

Automated Sciences Group, Inc., Hazardous Waste Remedial Actions Program, and Oak Ridge National Laboratory, *Risk Assessment Handbook*, Oak Ridge, Tennessee, 1994.

Bradbury and Muldoon, "Hydraulic Conductivity Determinations in Unlithified Glacial and Fluvial Materials," ASTM STP 1053, *Ground Water and Vadose Zone Monitoring*, 1990.

Bouwer, Herman and R.C. Rice. "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers With Completely or Partially Penetrating Wells", *Water Resources Research*, v. 12, no. 3, p. 423-428, 1976.

Camp Dresser & McKee Inc., *DYNFLOW, DYNTRACK and DYNPLOT, 3-Dimensional Modeling Systems For Groundwater Studies*, Camp Dresser & McKee Inc., Boston, Massachusetts, 1984.

Cape Cod Commission, "Cape Trends, Demographic and Economic Characteristics and Trends, Barnstable County - Cape Cod", Barnstable, Massachusetts, 1996.

CDM Federal Programs Corporation, "Remedial Investigation Report Main Base Landfill (AOC LF-1) and Hydrogeological Region I Study", Boston, Massachusetts, April 1995.

Davis, D.L. et al., "Decreasing Cardiovascular Disease and Increasing Cancer Among Whites in the United States From 1973 Through 1987", *Journal of the American Medical Association*, Vol. 271, No. 6, February 9, 1994.

Domenico, Patrick A., and Franklin W. Schwartz. *Physical and Chemical Hydrogeology*, John Wiley & Sons, New York, NY, 1990.

E.C. Jordan Company, "Hydrogeologic Summary, Task 1-8, Installation Restoration Program, Massachusetts Military Reservation", Portland, Maine, April 1989.

Eith, A. W., Boschuk, J., and Koerner, R. M., "Prefabricated Bentonite Clay Liners", in *Proceedings of the 4th GRI Seminar on the Topic of Landfill Closures - Geosynthetics, Interface Friction and New Developments*, Geosynthetic Research Institute, Philadelphia, 1991.

Freeze, R.A., and J.A. Cherry, *Groundwater*, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1979.

Gelhar, L. W., C. Welty and K. R. Rehfeldt, A critical review of data on field-scale dispersion in aquifers, *Water Resources Research*, **28(7)**, 1958-1974, 1992.

Hollinger, Christof, Gosse Schraa, Alfons J. M. Stams, and Alexander J. B. Zehnder. *A Highly Purified Enrichment Culture Couples the Reductive Dechlorination of Tetrachloroethene to Growth*. Applied and Environmental Microbiology, Vol. 59, No. 9, pp. 2991-2997, 1993.

Karson, Douglas, presentation to M.Eng. Program students, M.Eng. Course: Concepts of Engineering Practice, MIT Department of Civil & Environmental Engineering, Fall 1995; and, personal communication with author, Spring 1996.

Koerner, R. M., "*Designing with Geosynthetics*", Third Edition, Prentice Hall, Englewood Cliffs, New Jersey, 1994.

LaGrega, D.M., P.L. Buckingham, and J.C. Evans, *Hazardous Waste Management*, McGraw-Hill, New York, 1994.

LeBlanc, D.R., J.H. Guswa, M.H. Frimpter, and C.J. Londquist, "Groundwater Resources of Cape Cod, Massachusetts", U.S. Dept. of the Interior, U.S. Geological Survey, Hydrologic Investigations Atlas HA-692, 1986.

Massachusetts Military Reservation Installation Restoration Program, "Our Program and our People", 1995.

Massachusetts Military Reservation Installation Restoration Program, "Plume Containment Design Fact Sheet, February, 1996.

Masterson, J. P. and P. M. Barlow, *Effects of Simulated Ground-Water Pumping and Recharge on Ground-Water Flow in Cape Cod, Martha's Vineyard, and Nantucket Island Basins, Massachusetts..* U.S. Geological Survey Open-File Report 94-316, 1994.

O'Brien & Gere Engineers Inc. *Innovative Engineering Technologies For Hazardous Waste Remediation*, Van Nostrand Reinhold, New York, NY, 1995.

Oldale, R.N., "Glaciotectonic Origin of the Massachusetts Coastal End Moraines and a Fluctuating Late Wisconsinian Ice Margin", Geological Society of America Bulletin, v. 95, 1984.

Operational Technologies Corporation, "Plume Containment Design Data Gap Field Work Technical Memorandum", San Antonio, Texas, February 1996.

Operational Technologies Corporation, "Technical Memorandum Containment of Landfill-1 Plume", San Antonio, Texas, January 1996.

Pavlostathis, Spyros G., and Zhuang, P., "Reductive Dechlorination of Chloroalkenes in Microcosms Developed with a Field Contaminated Soil", *Chemosphere*, Vol. 27, No. 4, pp. 585-595, 1993.

Schroeder, P. R., Dozier, T. S., Zappi, P. A., McEnroe, B. M., Sjostrom, J. W., and Peyton, R. L., "The Hydrologic Evaluation of Landfill Performance (HELP) Model: Engineering Documentation for Version 3", EPA/600/9-94/xxx, U.S. Environmental Protection Agency Risk Reduction Engineering Laboratory, Cincinnati, Ohio, 1994.

Semprini, L., "In-Situ Bioremediation of Chlorinated Solvents", *Environmental Health Perspectives*, Volume 103 (Suppl 5), pp. 101-105, 1995.

Skiadas, P., "Design of an In-Situ Bioremediation Scheme of Chlorinated Solvents by Reductive Dehalogenation Sequenced by Cometabolic Oxidation", M.Eng. Thesis, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1996.

Springer, R.K., "Application Of An Improved Slug Test Analysis To The Large-Scale Characterization Of Heterogeneity in a Cape Cod Aquifer", M.S. Thesis, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1991.

Thompson, K.D., "The Stochastic Characterization of Glacial Aquifers Using Geologic Information", Ph.D. Thesis Massachusetts Institute of Technology, Cambridge, Massachusetts, 1994.

U.S. Environmental Protection Agency (US EPA), "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA", Office of Solid Waste and Emergency Response, OSWER Directive 9335.3-01, March 1988.

Van Der Kamp, G., "Determining Aquifer Transmissivity by Means of Well Response Tests: The Underdamped Case", *Water Resources Research*, v. 12, no. 1, p. 71-77, 1976.

Wells, Captain Mike, California Air National Guard, personal communication with author, April 5, 1996.

Individual Theses Compiled as Part of the Larger LF-1 Study:

Alden, D.S., "Subsurface Characterization of the Massachusetts Military Reservation Main Base Landfill Superfund Site," M.Eng. Thesis, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1996.

Amarasekera, K.N., "A Groundwater Model Of The Landfill Site At The Massachusetts Military Reservation", M.Eng. Thesis, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1996.

Collins, M., "Design of a Sequential In-Situ Anaerobic/Aerobic Enhanced Bioremediation System for a Chlorinated Solvent Contaminated Plume", M.Eng. Thesis, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1996.

Elias, K.G., "Source Containment at the Massachusetts Military Reservation Main Base Landfill: Design of a Hazardous Waste Landfill Cover System," M.Eng. Thesis, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1996.

Hines, J.J., "Uncertainty of Risk to Human Health from Groundwater Impacted by the Massachusetts Military Reservation Superfund Site Landfill", M.Eng. Thesis, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1996.

Jordan, B.R., "Management and Public Interaction Surrounding the Massachusetts Military Reservation Installation Restoration Program", M.Eng. Thesis, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1996.

Lee, R.F., "Human Health and Coastal Ecosystem Risk Assessment of the Massachusetts Military Reservation Main Base Landfill Groundwater Plume", M.Eng. Thesis, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1996.

## 7. Appendices

**Appendix A.**  
**the MMR IRP Public Involvement: Present Committee**  
**Listing**

LONG-RANGE WATER SUPPLY PROCESS ACTION TEAM

MARTY AKER (Chair)  
INSTALLATION RESTORATION PROGRAM  
ANG/CEVRO, BOX 41  
322 EAST INNER ROAD  
OTIS ANG BASE, MA 02542-5028  
(508) 968-4971 FAX: (508) 968-4673

MR. LARRY DAYIAN (Co-Chair)  
MASS. DEPT. OF ENVIRONMENTAL PROTECTION  
SOUTHEAST REGION  
20 RIVERSIDE DRIVE  
LAKEVILLE, MA 02347  
(508) 946-2769 FAX: (508) 947-6557

KYMBORLEE KECKLER  
USEPA, HBT  
JFK FEDERAL BUILDING  
BOSTON, MA 02203  
(617) 573-5777  
fax: (617) 573-9662

RAY JACK  
TOWN OF FALMOUTH  
WATER DEPARTMENT  
50 TOWN HALL SQUARE  
FALMOUTH, MA 02540  
(508) 548-7611 FAX: (508) 457-2511

MR. ROBERT KREYKENBOHM  
SANDWICH WATER DISTRICT  
P.O. BOX 600  
SANDWICH, MA 02563  
(508) 888-2775 FAX: (508) 888-9675

MR. DAVID RICH  
MASHPEE WATER DISTRICT  
P.O. BOX 1543  
MASHPEE, MA 02649  
(508) 477-6767 FAX: (508) 539-0382

MR. RALPH MARKS  
BOURNE WATER DISTRICT  
P.O. BOX 1447  
POCASSET, MA 02559  
(508) 563-2294 FAX: (508) 564-4661

MR. JOHN MASTERSON  
U.S. GEOLOGICAL SURVEY  
28 LORD ROAD, SUITE 280  
MARLBOROUGH, MA 01752  
(508) 490-5028 FAX: (508) 490-5068

MR. TOM CAMBARERI  
CAPE COD COMMISSION  
3225 MAIN STREET, BOX 226  
BARNSTABLE, MA 02630  
(508) 362-3828 FAX: (508) 362-3136

MR. DICK PRINCE  
P.O. BOX 594  
MONUMENT BEACH, MA 02553  
(508) 759-3449 FAX: (508) 759-0647 (c/o Bourne Library)

**Adjunct Member:**

MS. GABRIELLE BELFIT  
CAPE COD COMMISSION  
3225 MAIN STREET, BOX 226  
BARNSTABLE, MA 02630

**Unofficial Members:**

MS. MICHELLE DRURY  
DEPT. OF ENVIRONMENTAL MANAGEMENT  
100 CAMBRIDGE STREET  
BOSTON, MA 02202  
(617) 727-3267 FAX: (617) 727-9402

MR. PETER PHIPPEN  
DEPT. OF ENVIRONMENTAL MANAGEMENT  
100 CAMBRIDGE STREET  
BOSTON, MA 02202  
(617) 727-3267 FAX: (617) 727-9402

MR. TODD GANNON  
SOUTH SAGAMORE WATER DISTRICT  
P.O. BOX 484  
SAGAMORE, MA 02561  
(508) 888-7240

BOB BURT  
102FIW/CE  
OTIS ANG BASE, MA 02542-5028  
(508) 968-4234 FAX: (508) 968-4730

c:\misc\lrws.lst



**Plume Containment Team (Team 1)**

MICHAEL MINIOR  
IRP  
968-4670

ANDREA PAPADOPOLOUS  
MA DEP/SERO  
20 RIVERSIDE DRIVE  
LAKEVILLE, MA 02347  
(508) 946-2711

LEONARD PINAUD  
MA DEP/SERO  
20 RIVERSIDE DRIVE  
LAKEVILLE, MA 02347  
(508) 946-2895  
FAX: (508) 947-6557

PAUL MARCHESSAULT  
USEPA, HAN/CAN1  
JFK FEDERAL BUILDING  
BOSTON, MA 02203  
(617) 573-5793  
FAX (617) 573-9662

SUSAN NICKERSON  
APCC  
BOX 636  
ORLEANS, MA 02653  
(508) 255-4142  
FAX (508) 255-8780

THOMAS CAMBARERI  
CAPE COD COMMISSION  
3225 MAIN STREET, BOX 226  
BARNSTABLE, MA 02630  
(508) 362-3828  
FAX (508) 362-3136

EILEEN GUNN  
COALITION FOR BUZZARDS BAY  
P.O. BOX 268  
BUZZARDS BAY, MA 02532  
(508) 759-1440  
FAX (508) 759-1444

DR. JOEL FEIGENBAUM  
UPPER CAPE CONCERNED CITIZENS  
24 POND VIEW DRIVE  
E. SANDWICH, MA 02537  
(508) 833-0144  
FAX: (508) 833-3837

JAMES KINNEY  
ALLIANCE FOR BASE CLEANUP  
P.O. BOX 227  
W. BARNSTABLE, MA 02649  
FAX: (508) 362-1510  
(508) 362-7680

JAMES J. GRAHAM  
BOX 41  
N. FALMOUTH, MA 02556  
(508) 563-5814

J. HARRY DONALD  
86 SHORE STREET  
FALMOUTH, MA 02540  
(508) 540-7572

RAY D. TAYLOR  
2 PONY LANE  
FORESTDALE, MA 02644  
(508) 539-1709

GREG YOGIS  
24 SIPPEWISSETT ROAD  
FALMOUTH, MA 02540  
(508) 540-5076

SHAUN CODY  
27 PRISCILLA BEACH ROAD  
MANOMET, MA 02381  
(617) 944-0500 ext. 2541  
(508) 224-6452

STEVE HURLEY  
SOUTHEAST WILDLIFE DISTRICT  
195 BOURNE DALE ROAD  
BUZZARDS BAY, MA 02532  
(508) 759-3406

CHARLES DESAULNIERS  
6 GOLF LINKS CIRCLE  
SANDWICH, MA 02563  
(508) 420-5715

JUAN BACIGALUPI  
162 HOOPPOLE ROAD  
MASHPEE, MA 02649  
H (508) 477-7197  
W (508) 771-4510  
FAX (508) 771-1692

GREG TAYLOR, P.E.  
MASHPEE PUBLIC WORKS DEPT.  
P.O. BOX 554  
MASHPEE, MA 02649  
(508) 539-1420

**TEAM 1 FACILITATOR**  
GREG SOBEL  
MEDIATION AND FACILITATION  
489 PEAKHAM ROAD  
SUDBURY, MA 01776  
(508) 443-8180  
FAX (508) 443-8181

**Program Implementation Team**  
**(Team 2)**

ED PESCE  
IRP  
968-4676

ALEXANDER INDORF  
17 SOUTHPOINT DRIVE  
SANDWICH, MA 02563  
(508) 428-8739

LYNNE DOTY  
MASS DEP/SERO  
20 RIVERSIDE DRIVE  
LAKEVILLE, MA 02347  
(508) 946-2886  
FAX: (508) 947-6557

SUSAN WALKER  
197 FARMERSVILLE ROAD  
SANDWICH, MA 02563  
H (508) 477-1386  
W (508) 790-9838

WILLIAM SHIMER  
22 HORNBEAM AVE  
FALMOUTH, MA 02540  
548-0896

RUTH MEUCCI  
P.O. BOX 431  
FORESTDALE, MA 02644  
(508) 477-6574

MARTINE W. MEIJERING  
12 PINECREST AVE  
MASHPEE, MA 02649  
(508) 477-2807  
FAX: (508) 539-2799

DANIEL FRAUNFELTER  
427 CURRIER ROAD  
E. FALMOUTH, MA 02536-4231  
(508) 564-5247

KATHLEEN AMATRUDO  
5651 A DOOLITTLE AVE  
OTIS ANGB, MA 02542  
H (508) 563-6301

RALPH MARKS  
BOURNE WATER DISTRICT  
P.O. BOX 1447  
POCASSET, MA 02559  
(508) 563-2294  
FAX (508) 564-4661

DAVID OSHMAN  
90 DAVIS STRAITS  
FALMOUTH, MA 02540  
(508) 548-8888  
FAX (508) 540-8616

DR. WILLIAM MCDERMOTT  
7 MANOR LANE  
FALMOUTH, MA 02536  
(508) 564-6531

JOHN LATAWIC  
P.O. BOX 239  
SALT MARSH LANE  
POCASSET, MA 02559  
H (508) 563-3295  
H FAX (508) 563-5989  
W (508) 998-2162

MS. EDYTHE COLLINS  
BOX 319  
CATAUMET, MA 02534  
(508) 563-5061

CAROL KEATING  
USEPA, HBT  
JFK FEDERAL BUILDING  
BOSTON, MA 02203  
(617) 223-5594  
FAX: (617) 573-9662

C:\MISC\TEAM1-2.LST

**INNOVATIVE TECHNOLOGIES PAT**

MR. EDWARD PESCE  
INSTALLATION RESTORATION PROGRAM  
322 E. INNER ROAD, BOX 41  
OTIS ANG BASE, MA 02542-5028  
(508) 968-4676 FAX (508) 968-4673

MR. MARK FOREST  
OFFICE OF CONGRESSMAN GERRY E. STUDDS  
146 MAIN STREET  
HYANNIS, MA 02601  
(508) 771-0666 FAX (508) 790-1959

MR. JOHN SMALDONE  
USEPA, HIO  
JFK FEDERAL BUILDING  
BOSTON, MA 02203  
(617) 223-5519  
FAX (617) 573-9662

DR. DAVID MARKS  
MASS. INSTITUTE OF TECHNOLOGY  
77 MASSACHUSETTS AVE, ROOM 1-123  
CAMBRIDGE, MA 02139  
(617) 253-1992 FAX (617) 258-6099

DR. ANDREA PAPADOPOLOUS  
DEPT. OF ENVIRONMENTAL PROTECTION  
20 RIVERSIDE DRIVE  
LAKEVILLE, MA 02347  
(508) 946-2711 FAX (508) 947-6557

MS. DEBORAH NEHODA  
CLEAN SITES, INC.  
1199 NORTH FAIRFAX STREET  
ALEXANDRIA, VA 22314  
(703) 683-8522 FAX (703) 548-8773

MR. DAN POWELL  
U.S. EPA/TIO (5102W)  
401 MAIN STREET SW  
WASHINGTON, D.C. 20460  
(703) 308-8827 FAX (703) 308-8528

MR. TOM CAMBARERI  
CAPE COD COMMISSION  
3225 MAIN STREET, BOX 226  
BARNSTABLE, MA 02630  
(508) 362-3828 FAX (508) 362-3136

MS. MELINDA HOLLAND  
CLEAN SITES, INC.  
1199 N. FAIRFAX STREET, SUITE 400  
ALEXANDRIA, VA 22314  
(703) 739-1205 FAX (703) 548-8773

MR. SHAWN MORRISSEY  
MASS. INSTITUTE OF TECHNOLOGY  
77 MASSACHUSETTS AVE, ROOM 1-123  
CAMBRIDGE, MA 02139  
(617) 253-9871 FAX (617) 258-6099



DR. TOM CURRY  
COLLEGE OF ENGINEERING  
UMASS-DARTMOUTH  
DARTMOUTH, MA 02747  
(508) 999-8539 FAX (508) 999-9137

## SENIOR MANAGEMENT BOARD

MR. DAVID VAN GASBECK (Chair)  
ANG/CEV  
3500 FETCHET AVENUE  
ANDREWS AFB, MD 20762-5157  
(301) 836-8160 FAX: (301) 836-8151

MR. HAYDON COGGESHALL (Co-Chair)  
TOWN OF BOURNE  
BOARD OF SELECTMEN  
24 PERRY AVENUE  
BUZZARDS BAY, MA 02532  
(508) 759-0600 FAX: (508) 759-8026

MAJ. GEN. RAYMOND W. VEZINA  
THE ADJUTANT GENERAL  
25 HAVERHILL STREET  
CAMP CURTIS GUILD  
READING, MA 01867-1999  
(617) 944-0500 FAX: (617) 727-5574

MS. MARY SANDERSON  
USEPA  
HAA/CAN2  
JFK FEDERAL BUILDING  
BOSTON, MA 02203  
(617) 573-5711 FAX: (617) 573-9662

MR. ED KUNCE  
DEPT. OF ENVIRONMENTAL PROTECTION  
ONE WINTER STREET  
BOSTON, MA 02108  
(617) 292-5915 FAX: (617) 574-6880

MR. EDWARD CONDON  
TOWN OF SANDWICH  
BOARD OF SELECTMEN  
P.O. BOX 600  
SANDWICH, MA 02563  
(508) 888-4910 FAX: (508) 888-8655

MS. NANCY CAFFYN  
TOWN OF MASHPEE  
BOARD OF SELECTEMEN  
16 GREAT NECK ROAD  
MASHPEE, MA 02649  
(508) 539-1400 FAX: (508) 539-1403

MS. VIRGINIA VALIELA  
TOWN OF FALMOUTH  
BOARD OF SELECTMEN  
59 TOWN HALL SQUARE  
FALMOUTH, MA 02540  
(508) 548-7611 FAX: (508) 457-2511

CAPT. LEONARD BOSMA  
USCG AIR STATION CAPE COD/CC  
OTIS ANG BASE, MA 02542  
(508) 968-6300 FAX: 968-6315

c:\misc\smb.lst

TECHNICAL ENVIRONMENTAL AFFAIRS COMMITTEE  
MEMBERSHIP/ATTENDEE LIST ADDRESSES  
MARCH 1995

Permanent Members:

Ms. Joanne Miller Buntich  
Sandwich Planning Board  
88 Boardley Rd, Sandwich, MA 02563  
Phone: 508-833-8001

Mr. Elias McQuaid, Health Agent  
Mashpee Board of Health  
16 Great Neck Road North, Mashpee, MA 02649  
Phone: 508-539-1418/Fax: 539-1403

Mr. Paul Marchessault  
USEPA - HAN/CAN1  
JFK Federal Bldg, Boston, MA 02203  
Phone: 617-573-3793/Fax: 573-9652

Mr. Thomas Cambareri  
Cape Cod Commission  
3225 Main St., Box 226  
Barnstable, MA 02630  
Phone: 508-362-3828/Fax: 362-3136

Mr. Haydon Coggeshall  
Town of Bourne - Board of Selectmen  
24 Perry Avenue, Buzzards Bay, MA 02539  
Phone: 508-759-0600/Fax: 759-8026

Mr. David Wells, Director  
VA Cemetery  
Mass. National Cemetery, Bourne, MA 02532  
Phone: 508-563-7113

Mr. Mark Forest  
Regional Representative  
Congressman Gerry Studds  
146 Main Street, Hyannis, MA 02601  
Phone: 508-771-0666/Fax: 790-1959

Ms. Virginia Valiela  
Town of Falmouth, Board of Selectmen  
59 Town Hall Square, Falmouth, MA 02540  
Phone: 508-291-2122/Fax: 291-2125

Dr. Robert Knorr  
Dept. of Public Health  
150 Tremont St., Boston, MA 02111  
Phone: 617-727-7170

LtCol Michael Washeleski  
ANG/CEV, 3500 Fetchet Avenue  
Andrews AFB, MD 20762  
Phone: 301-981-8144/DSN: 278-8144  
Fax: 301-981-8151/DSN: 278-8151

Mr. Stetson Hall  
Barnstable Cty Health Dept.  
Superior Court House - Route 6A  
Barnstable, MA 02630  
Phone: 508-362-2511, ext. 333

BG William R. LaBrie  
AASF #1 - Bldg 2816  
Otis ANG Base, MA 02542  
DSN: 557-5830

CDR William Bailey  
Facility Engineer  
Building 5215  
Air Station Cape Cod, MA 02542  
Phone: 508-968-6480/DSN: 557-6480



Temporary Members:

Mr. Christopher V.R. Dunn  
Ashumet Valley Property Owners  
55 Redlands Road, E. Falmouth, MA 02536  
Phone: 508-564-6414

Mr. Richard W. Anderson  
Water Commissioner  
Sandwich Water District  
72 Tupper Road, Box 600  
Sandwich, MA 02563  
Phone: 508-888-2775/Fax: 888-9675  
Work. 508-888-1267

Ms. Geraldine Orlando  
Wheeler Rd., Mashpee, MA 02649  
Phone: 508-477-1902

Mr. Keith A. Smith  
President, Coonamessett Pond Assoc.  
P.O. Box 1393, North Falmouth, MA 02556  
Phone: 508-564-4112

Mr. George Seaver  
LF-1 Committee  
P.O. Box 401, Cataumet, MA 02534  
Phone: 508-564-4404

\*\*\*\*\*

Support Personnel:

Ms. Beverly Cadigan  
ABB Environmental  
110 Free Street - P.O. Box 7050  
Portland, ME 04112  
Phone: 207-775-5400/Fax: 772-4762

Ms. Eleanora Babij  
Camp Curtis Guild - Bldg 43  
Haverhill Street, Reading, MA 01867  
Phone: 617-944-2525/Fax: 944-2514

Dr. Bernard Bartels  
Cape Cod Community College  
Science Department - Route 132  
W. Barnstable, MA 02668

Lt Col Paul Brogna  
102FW/DE, Otis ANGB, MA 02542  
Phone: 508-968-4231/DSN: 557-4231  
Fax: 508-968-4730/DSN: 557-4730

Mr. Robert Snyder  
SFIM-AEC-IRP - Bldg E-4480  
US Army Environmental Center  
Aberdeen Prv. Ground, MD 21010-5401  
Phone: 410-671-1541/DSN: 584-1541

Robert F. Cannon, Jr.  
Building 5215 - Env.  
Air Station Cape Cod, MA 02542  
Phone: 508-968-6487/DSN: 968-6487

\*\*\*\*\*

Mr. Ernest Keating  
Unified Env. Planning Function  
Bldg 1204, Camp Edwards, 02542  
Phone: 508-968-5824/DSN: 557-5824

Ms. Victoria Smith  
U.S. Public Health Service  
Mail Stop E-32  
1600 Clifton Road, N.E., Atlanta, GA 30333  
Phone: 404-639-6016

Mr. George Crombie, Reg. Dir.  
Dept. of Environmental Protection  
Southeast Region - 20 Riverside Dr.  
Lakeville, MA 02347  
Phone: 508-946-2707/Fax: 947-6557

Mr. Robert DiBiccaro  
Office of Regional Council  
USEPA- JFK Federal Building  
Boston, MA 02203  
Phone: 617-565-3449/Fax: 565-3335

Mr. Christopher M. Faux  
102FW/EM - Bldg 197, Otis ANGB, MA 02542  
Phone: 508-968-4233/DSN: 557-4233  
Fax: 508-968-4673/DSN: 557-4673

Mr. Scott Ferson, Regional Rep.  
Senator Edward Kennedy  
Room 409 - JFK Federal Building  
Boston, MA 02203  
Phone: 617-565-3170/Fax: 565-3183

MSgt Gerard F. Flaherty  
102FW/SG: B - Bldg 197, Otis ANGB, MA 02542  
Phone: 508-968-4078/DSN: 557-4078  
Fax: 508-968-4673/DSN: 557-4673

LtCol Everett Foster  
NGB/PAE - Park Center IV, Room 450  
4501 Ford Avenue, Alexandria, VA 22302-1454  
Phone: 703-756-5790

LtCol John R. Haddon  
102FW/SD - Bldg 158  
Otis ANGB, MA 02542-5028  
Phone: 508-968-4106/DSN: 557-4106  
Fax: 508-968-4290/DSN: 557-4290

Col Clayton Anderson  
Office of Deputy Asst. Secretary  
(Env., Safety & Occupational Health)  
SAF/MIQ - Suite 5C866  
1660 Air Force Pentagon, Washington, DC 20330  
Phone: 703-694-8458

Ms. Louise House  
ATSDR - EPA Region I  
60 Westview Street, Lexington, MA 02173  
Phone: 617-860-4300/Fax: 860-4397  
Phone: 617-223-5526

Mr. Douglas Karson  
ANG/CEVRO - Bldg 322  
Otis ANGB, MA 02542  
Phone: 508-968-4678/DSN: 557-4678  
Fax: 508-968-4673/DSN: 557-4673

Mr. Denis LeBlanc  
U.S. Geological Survey  
Water Resources Division  
28 Lord Road, Suite 280  
Marlborough, MA 01752  
Phone: 508-490-5030/Fax: 490-5068

Col Harry Mehrmann  
Bldg 3468 - Camp Edwards  
Camp Edwards, MA 02542  
Phone: 508-968-5885/DSN: 557-5885

Mr. Shawn Morrissey, Research Eng.  
MIT - Room 48-336B  
Cambridge, MA 02139  
Phone: 617-253-9871/Fax: 258-8850

Ms. Susan Nickerson  
APCC - P.O. Box 636 (169 & Rte. 6A)  
Orleans, MA 02653  
Phone: 508-255-4142/Fax: 255-8780

Ms. Mary Sanderson  
USEPA - HAN/CAN1, JFK Federal Bldg.  
Boston, MA 02203  
Phone: 617-573-5711

Mr. Michael Minior  
ANG/CEVRO - Bldg 322  
Otis ANGB, MA 02542  
Phone: 508-968-4670/Fax: 968-4673

Mr. Greg Taylor  
Director of Public Works  
P.O. Box 554, Mashpee, MA 02649  
Phone: 508-539-1420

Mr. M. Carl Wheeler  
HAZWRAP - Tri-County Mall  
831 Tri-County Boulevard  
Oliver Springs, TN 37840  
Phone: 615-435-3406/Fax: 435-3709

Ms. Sarah Woodhouse  
Senator John Kerry  
1 Bowdoin Square - 10th Floor  
Boston, MA 02114  
Phone: 617-565-8519/Fax: 248-3870

Mr. Michael Yurewicz  
U.S. Geological Survey  
28 Lord Road, Suite 280  
Marlborough, MA 01752  
Phone: 508-490-5030/Fax: 490-5068

Mr. Gary Hinkle  
ANG/CEVR  
3500 Fetchet Avenue, Andrews AFB, MD 20762  
Phone: 301-981-8146/Fax: 981-8151

Mr. Kenneth Till  
Operational Technologies Corp.  
8 Otis Park Drive, Box 960  
Pocasset, MA 02559  
Phone: 508-759-6989/Fax: 759-7576

Mr. Clifford Bell  
CH2M Hill  
322 E. Inner Road, Box 41  
Otis ANG Base, MA 02542  
Phone: 508-968-4675/Fax: 968-4673

Mr. Ralph Marks  
Bourne Water District  
P.O. Box 1447, Pocasset, MA 02559  
Phone: 508-563-2294/Fax: 564-4661

Ms. Judy Bygate  
Dept. of Public Health  
150 Tremont Street  
Boston, MA 02111  
Phone: 617-727-7170

Ms. Julia Nault  
CDM Federal Programs Corp.  
160 North Washington Street, Suite 400  
Boston, MA 02114  
Phone: 617-742-2659/Fax: 617-227-3851

TOM, THE FOLLOWING IS THE MOST CURRENT LIST OF MEMBERSHIP THAT I HAVE FOR THE FS-12 SUBCOMMITTEE. PLEASE REVIEW IT FOR ACCURACY AND PROVIDE ME WITH ANY CHANGES YOU ARE AWARE OF. PLEASE REPLACE DAN WALTZ WITH MIKE MINOR IF THAT HASN'T BEEN DONE YET. ALSO, JANE CONNET IS NO LONGER WITH ALLIANCE TECHNOLOGIES.

MR. THOMAS CAMBARERI (CHAIR)  
CAPE COD COMMISSION

MR. PAUL MARCHESSAULT  
U.S. EPA

MR. ROBERT KREYKENBOHM  
SUPERINTENDENT, SANDWICH WATER DISTRICT

MS. SUSAN NICKERSON  
EXECUTIVE DIRECTOR, APCC

MS. LOESJE F. CREEDEN  
SANDWICH BOARD OF HEALTH

MR. ROBERT HALL  
WHITMAN AND HOWARD, INC.

MR. DAN WALTZ  
ANGRC/CEVR

MR. STETSON HALL  
BARNSTABLE COUNTY DEPT. OF HEALTH, HUMAN SERVICES AND THE ENVIRONMENT

MR. JOEL FEIGENBAUM  
UPPER CAPE CONCERNED CITIZENS

MR. ~~JAMES BOLEY~~ *Lea Pinard*  
MASS. DEP

~~MS. JANE CONNET~~  
~~ALLIANCE TECHNOLOGIES~~

MS. FAITH WILLARD  
CAMP GOOD NEWS

MS. LYNNE MACDONALD  
SANDWICH

**Plume Containment Team Members**

MICHAEL MINIOR  
ANG/CEVRO  
322 E. INNER ROAD, BOX 41  
OTIS ANGB, MA 02542-5028  
(508) 968-4670 FAX (508) 968-4673

LEONARD PINAUD  
MADEP/SERO  
20 RIVERSIDE DRIVE  
LAKEVILLE, MA 02347  
(508) 946-2895 FAX (508) 947-6557

PAUL MARCHESSAULT  
USEPA, HAN/CANI  
JFK FEDERAL BUILDING  
BOSTON, MA 02203  
(617) 573-5793 FAX (617) 573-9662

SUSANNICKERSON  
APCC  
BOX 636  
ORLEANS, MA 02653  
(508) 255-4142 FAX (508) 255-8780

THOMAS CAMBARERI  
CAPE COD COMMISSION  
3225 MAIN STREET, BOX 226  
BARNSTABLE, MA 02630  
(508) 362-3828 FAX (508) 362-3136

EILEEN GUNN  
COALITION FOR BUZZARDS BAY  
P.O. BOX 268  
BUZZARDS BAY, MA 02532  
(508) 759-1440 FAX (508) 759-1444

DR. JOEL FEIGENBAUM  
UPPER CAPE CONCERNED CITIZENS  
24 POND VIEW DRIVE  
E. SANDWICH, MA 02537  
(508) 833-0144 FAX: (508) 833-3837

JAMES KINNEY  
ALLIANCE FOR BASE CLEANUP  
P.O. BOX 227  
W. BARNSTABLE, MA 02649  
(508) 362-7680 FAX: (508) 362-1510

JAMES J. GRAHAM  
BOX 41  
N. FALMOUTH, MA 02556  
(508) 563-5814

J. HARRY DONALD  
86 SHORE STREET  
FALMOUTH, MA 02540  
(508) 540-7572

RAYD. TAYLOR  
2 PONY LANE  
FORESTDALE, MA 02644  
(508) 539-1709

GREG YOGIS  
24 SIPPEWISSETT ROAD  
FALMOUTH, MA 02540  
(508) 540-5076

SHAUN CODY  
27 PRISCILLA BEACH ROAD  
MANOMET, MA 02381  
(617) 944-0500 ext. 2541

STEVE HURLEY  
SOUTHEAST WILDLIFE DISTRICT  
195 BOURNEDALE ROAD  
BUZZARDS BAY, MA 02532  
(508) 759-3406

CHARLES DESAULNIERS  
6 GOLF LINKS CIRCLE  
SANDWICH, MA 02563  
(508) 420-5715

JUAN BACIGALUPI  
162 HOOP POLE ROAD  
MASHPEE, MA 02649  
(508) 771-4510 FAX (508) 771-1692

GREG TAYLOR, P.E.  
MASHPEE PUBLIC WORKS DEPT.  
P.O. BOX 554  
MASHPEE, MA 02649  
(508) 539-1420

ELIAS MCQUAID  
HEALTH AGENT, TOWN OF MASHPEE  
16 GREAT NECK ROAD NORTH  
MASHPEE, MA 02649  
(508) 539-1418

TEAM 1 FACILITATOR  
GREG SOBEL  
MEDIATION AND FACILITATION  
489 PEAKHAM ROAD  
SUDBURY, MA 01776  
(508) 443-8180 FAX (508) 443-8181

**Program Implementation Team Members**

ED PESCE  
ANG/CEVRO  
322 E. INNER ROAD, BOX 41  
OTIS ANGB, MA 02542-5028  
(508) 968-4670  
FAX (508) 968-4673

ALEXANDER INDORF  
17 SOUTHPOINT DRIVE  
SANDWICH, MA 02563  
(508) 428-8739

LYNNE DOTY  
MASS DEP/SERO  
20 RIVERSIDE DRIVE  
LAKEVILLE, MA 02347  
(508) 946-2886  
FAX (508) 947-6557

SUSAN WALKER  
197 FARMERSVILLE ROAD  
SANDWICH, MA 02563  
H (508) 477-1386  
W (508) 790-9838

WILLIAM SHIMER  
22 HORNBEAM AVE  
FALMOUTH, MA 02540  
548-0896

RUTH MEUCCI  
P.O. BOX 431  
FORESTDALE, MA 02644  
(508) 477-6574

MARTINE W. MEIJERING  
12 PINECREST AVE  
MASHPEE, MA 02649  
(508) 477-2807  
W (508) 968-7109

DANIEL FRAUNFELTER  
427 CURRIER ROAD  
E. FALMOUTH, MA 02536-4231  
(508) 564-5247

KATHLEEN AMATRUDO  
5651 ADOOLITTLE AVE  
OTIS ANGB, MA 02542  
H (508) 563-6301

RALPH MARKS  
BOURNE WATER DISTRICT  
P.O. BOX 1447  
POCASSET, MA 02559  
(508) 563-2294  
FAX (508) 564-4661

DAVID OSHMAN  
90 DAVIS STRAITS  
FALMOUTH, MA 02540  
(508) 548-8888  
FAX (508) 540-8616

DR. WILLIAM MCDERMOTT  
7 MANOR LANE  
FALMOUTH, MA 02536  
(508) 564-6531

JOHN LATAWIC  
P.O. BOX 239  
SALT MARSH LANE  
POCASSET, MA 02559  
(508) 998-2162 FAX (508) 563-5989  
H (508) 563-3295

MS. EDYTHE COLLINS  
BOX 319  
CATAUMET, MA 02534  
(508) 563-5061

**LONG-RANGE WATER SUPPLY PROCESS ACTION TEAM**

MARTY AKER (Chair)  
INSTALLATION RESTORATION PROGRAM  
ANG/CEVRO, BOX 41  
322 EAST INNER ROAD  
OTIS ANG BASE, MA 02542-5028  
(508) 968-4971 FAX: (508) 968-4673

MR. LARRY DAYIAN (Co-Chair)  
MASS. DEPT. OF ENVIRONMENTAL PROTECTION  
SOUTHEAST REGION  
20 RIVERSIDE DRIVE  
LAKEVILLE, MA 02347  
(508) 946-2769 FAX: (508) 947-6557

RAY JAKES  
TOWN OF FALMOUTH  
WATER DEPARTMENT  
50 TOWN HALL SQUARE  
FALMOUTH, MA 02540  
(508) 548-7611 FAX: (508) 457-2511

MR. ROBERT KREYKENBOHM  
SANDWICH WATER DISTRICT  
P.O. BOX 600  
SANDWICH, MA 02563  
(508) 888-2775 FAX: (508) 888-9675

MR. DAVID RICH  
MASHPEE WATER DISTRICT  
P.O. BOX 1543  
MASHPEE, MA 02649  
(508) 477-6767 FAX: (508) 539-0382

MR. RALPH MARKS  
BOURNE WATER DISTRICT  
P.O. BOX 1447  
POCASSET, MA 02559  
(508) 563-2294 FAX: (508) 564-4661

MR. JOHN MASTERSON  
U.S. GEOLOGICAL SURVEY  
28 LORD ROAD, SUITE 280  
MARLBOROUGH, MA 01752  
(508) 490-5028 FAX: (508) 490-5068

## SENIOR MANAGEMENT BOARD

MR. DAVID VAN GASBECK (Chair)  
ANG/CEV  
3500 FETCHET AVENUE  
ANDREWS AFB, MD 20762-5157  
(301) 981-8160 FAX: (301) 981-8151

MR. HAYDON COGGESHALL (Co-Chair)  
TOWN OF BOURNE  
BOARD OF SELECTMEN  
24 PERRY AVENUE  
BUZZARDS BAY, MA 02532  
(508) 759-0660 FAX: (508) 759-8026

MAJ. GEN. RAYMOND W. VEZINA  
THE ADJUTANT GENERAL  
25 HAVERHILL STREET  
CAMP CURTIS GUILD  
READING, MA 01867-1999  
(617) 944-0500 FAX: (617) 727-5574

MS. MARY SANDERSON  
USEPA  
HAA/CAN2  
JFK FEDERAL BUILDING  
BOSTON, MA 02203  
(617) 573-5711 FAX: (617) 573-9662

MR. ED KUNCE  
DEPT. OF ENVIRONMENTAL PROTECTION  
ONE WINTER STREET  
BOSTON, MA 02108  
(617) 292-5915 FAX: (617) 574-6880

MR. EDWARD CONDON  
TOWN OF SANDWICH  
BOARD OF SELECTMEN  
P.O. BOX 600  
SANDWICH, MA 02563  
(508) 888-4910 FAX: (508) 888-8655

**Appendix B.**  
**Sample IRP Informational Fact Sheet**



# PLUME CONTAINMENT DESIGN FACT SHEET

A series of fact sheets providing updates on the project to contain groundwater plumes of solvents and/or fuels emanating from the Massachusetts Military Reservation.

Fact Sheet 96-1

February 6, 1996

## Design of containment systems to stop plumes nears completion

The design to stop six groundwater plumes of solvents and/or fuels that emanate from the Massachusetts Military Reservation (MMR) is 60 percent complete. The 60 percent design outlines nearly all activities required to stop the movement of plumes near their leading edges. The final design is due on April 22, 1996. The construction contract should be awarded by August 1, 1996.

The plumes contain solvents or fuels that have moved from a surface source area to the water table underground. The chemicals move with the flow of groundwater.

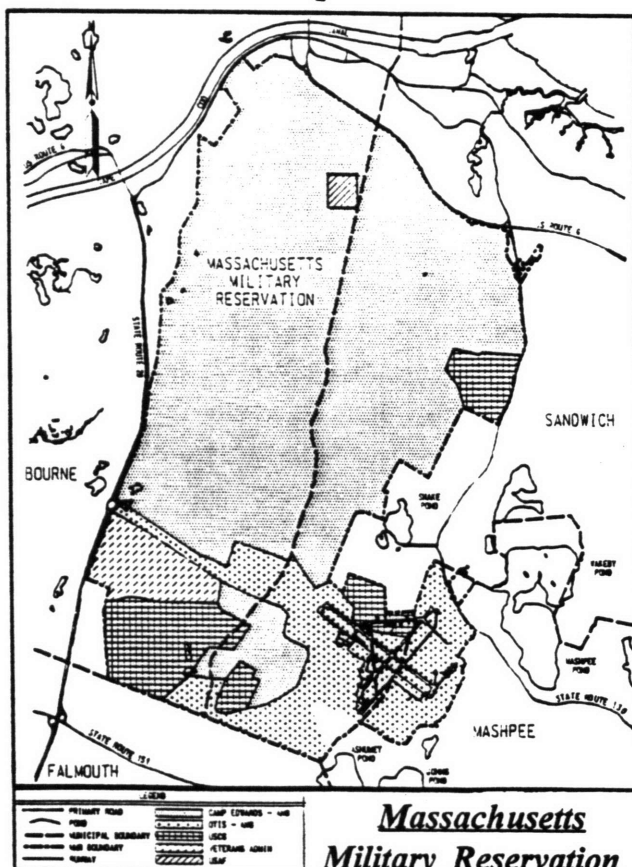
This fact sheet provides a summary of key information on the design including recommended methods of treatment, implementation schedule, permission for access, the role of the Plume Containment and Program Implementation Teams, and where to find more information.

### Background

June 15, 1994 - The Senior Management Board endorses the Plume Response Plan.

June 30 and July 1, 1994 - A detailed presentation is made to high ranking Department of Defense (DoD) officials seeking a commitment for implementation/funds.

July 1, 1994 - Ms. Sherri Wasserman Goodman, Deputy Undersecretary of Defense for Environmental Security makes a commitment on behalf of the DoD to implement the plan.



March 10, 1995 - Design contract awarded to Operational Technologies Corporation, San Antonio, Texas.

Spring 1995 - One citizen team is expanded and another is created to work on design issues. The Plume Containment Team, formerly Plume Management Process Action Team (PAT), and the Program Implementation Team are their names.

Summer 1995 - OpTech begins field-work effort to resample hundreds of wells, (See Background, Page 2)

## **Background**

*(Continued from Page 1)*

and install nearly 100 new groundwater monitoring wells to define leading edges of the plumes.

January 22, 1996 - 60 percent design document delivered to the Installation Restoration Program (IRP) and the regulatory agencies.

April 22, 1996 - Planned delivery of the final design to the IRP and regulatory agencies.

August 1, 1996 - Planned award of plume containment construction contract.

## **Why is it important to stop the plumes?**

The Plume Management PAT conducted 18 meetings in nine months to produce the Plume Response Plan, 1994. The team evaluated many important factors all of which pointed to the need to address the continued movement of the groundwater plumes that emanate from the MMR.

\* Risks to public health and the environment: Water supplies, recreational ponds and coastal bays of Upper Cape Cod are threatened by the groundwater plumes that contain known and/or suspected cancer causing agents. All of the plumes that are scheduled for containment have moved off-base. The Western Aquafarm Plume is on base but is now recommended for monitoring only based on new test information. Rapid movement of the plumes threatens the viability of water supplies. Containment of the plumes will preserve water supplies and eliminate risks to the public and the environment.

\* Unique features of the Upper Cape: Beaches, historic neighborhoods, recreational ponds, healthy air and water and a relatively mild year-round climate all contribute to the uniqueness of the area. Groundwater plumes from the MMR threaten the area in a variety of ways. For example: the Wampanoag Tribe who live in close proximity to the MMR and gain vital resources from hunting, fishing and shellfishing. The traditional lifestyle of this indigenous minority could be severely threatened if the groundwater plumes were not contained.

\* Public perception: Limited water resources are being lost on a daily basis; concerns over health appear to be affecting perceptions which may be contributing to lower property values. These concerns are reinforced by a recent Public Health Assessment by the Agency for Toxic Substances and Disease Registry (ATSDR) which concluded: "After considering the completed human exposure pathways, community health concerns, and available health outcome data, ATSDR concludes that contamination originating from several areas on the MMR is a public health hazard." Elevated cancer rates in the Upper Cape Cod area have also created concerns although not directly attributable to past MMR activities.

\* Devaluation of property: The team also reviewed scientific and statistical studies which have shown that proximity to hazardous waste sites decreases property values. Perceptions of buyers and sellers are affected by activities at the MMR regarding the cleanup program. There has been great public interest in the present status and future plans of the program in dealing with the plumes. Without an elaborate study, the effect of MMR contamination on property values can only be inferred based upon studies in other areas of the country. Regardless, studies have shown that the onset of large-scale cleanup action can reverse perceptions and downward property value trends. Another factor affected by perceptions is tourism. Tourism is the main economic influence for Cape Cod. Plume containment will help improve public perceptions about the Upper Cape.

## Plume Containment Approach

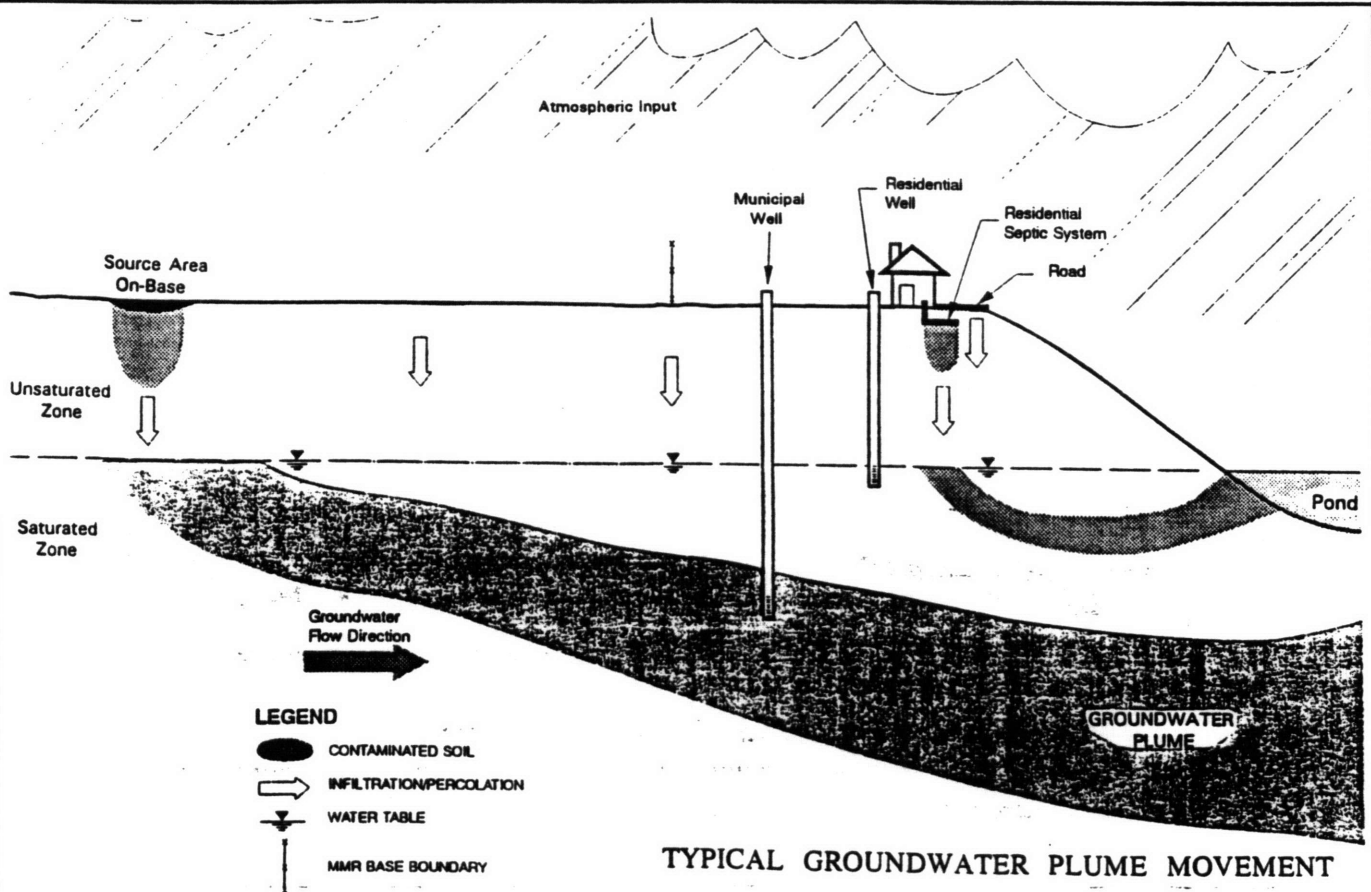
- \* Install extraction wells near the leading edges of six plumes to stop their movement.
- \* Treat extracted plume water using five separately located granular activated carbon treatment facilities.
- \* Construct infiltration galleries and/or re-injection systems to return the cleaned water, thus minimizing potential negative effects due to extraction.
- \* The cleaned water will meet state and federal drinking water standards.

### Plumes to be contained

- |  |                                   |
|--|-----------------------------------|
| * Ashumet Valley Plume (CS-16/17, FTA-1) | * Chemical Spill 10 Plume (CS-10) |
| * Main Base Landfill Plume (LF-1)        | * Fuel Spill 12 Plume (FS-12)     |
| * Storm Drain 5 Plume (SD-5)             | * Eastern Briarwood Plume         |

### Other monitored plumes

- \* Chemical Spill 4 Plume (CS-4), (Containment system in place, its effectiveness is being studied. Field-work is on-going to define extent of solvents and ethylene dibromide detected south of extraction wells.)
- \* Petroleum Fuels Storage Area Plume (PFSA), (Plume not migrating, periodic monitoring occurring).
- \* Fuel Spill One (FS-1), (Plume is localized to source area, not believed to be moving).
- \* Western Aquafarm Plume (Latest sampling shows fuel compound levels within acceptable state and federal drinking water standards. Periodic monitoring to occur.)



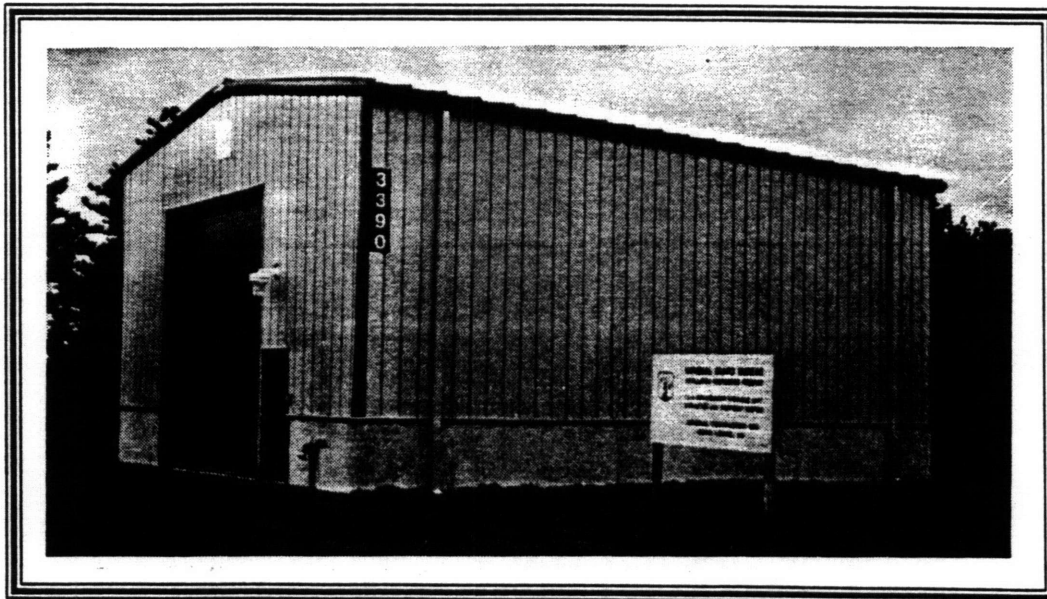
## Revised Plume Containment Implementation Schedule

<u>Plume</u>	<u>Contract Award Date</u>	<u>Construction Start Date</u>	<u>Number of Days to Construct</u>	<u>System On-Line</u>
E. Briarwood/SD-5	8/1/96	TBD*	350	TBD**
FS-12	8/1/96	8/1/96	440	10/9/97
LF-1	8/1/96	8/1/96	365	7/31/97
CS-10	8/1/96	TBD*	248	TBD**
Ashumet Valley	8/1/96	TBD*	320	TBD**

*SD = Storm Drain, FS = Fuel Spill, LF = Landfill, CS = Chemical Spill, TBD = To Be Determined*

*\* The actual construction start date cannot be determined until the funding is made available and the contracting officer issues the Notice to Proceed to the contractor.*

*\*\* This date cannot be determined until the construction start date is determined. See " \* " above.*



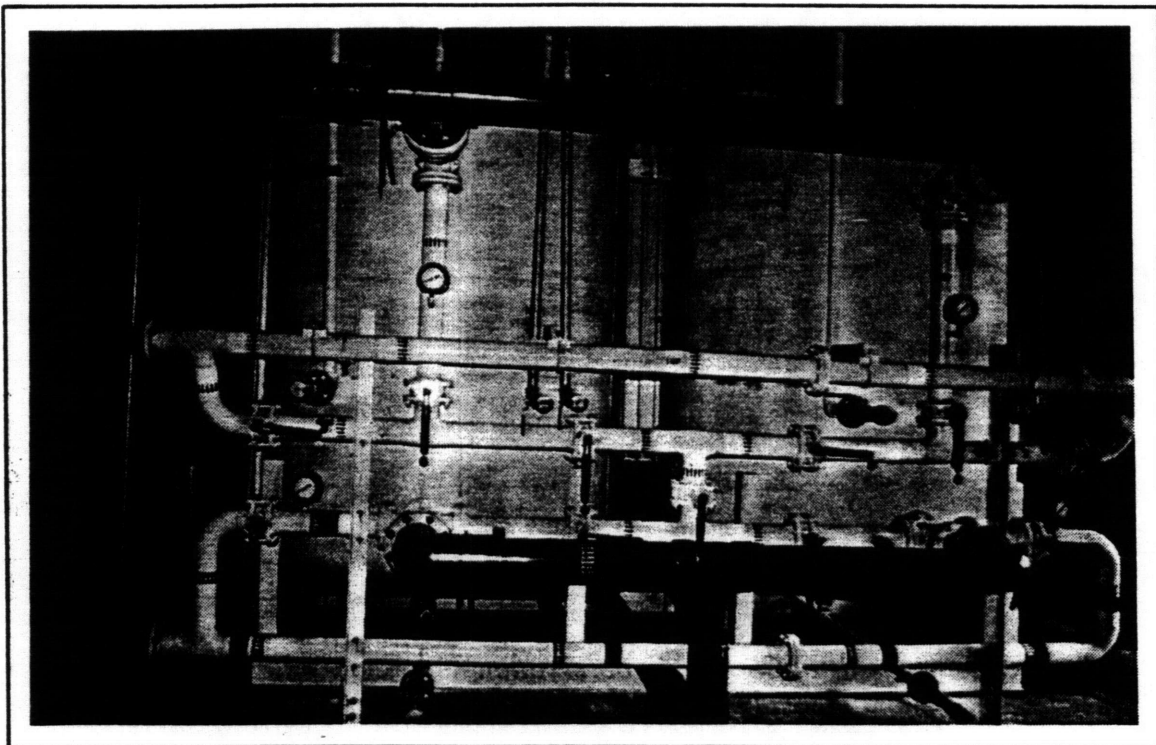
*Building 3390 on the Massachusetts Military Reservation houses two granular activated carbon vessels, a backwash holding tank and computer control panel for the Chemical Spill 4 (CS-4) groundwater plume that has had a containment system in place since November 1993.*



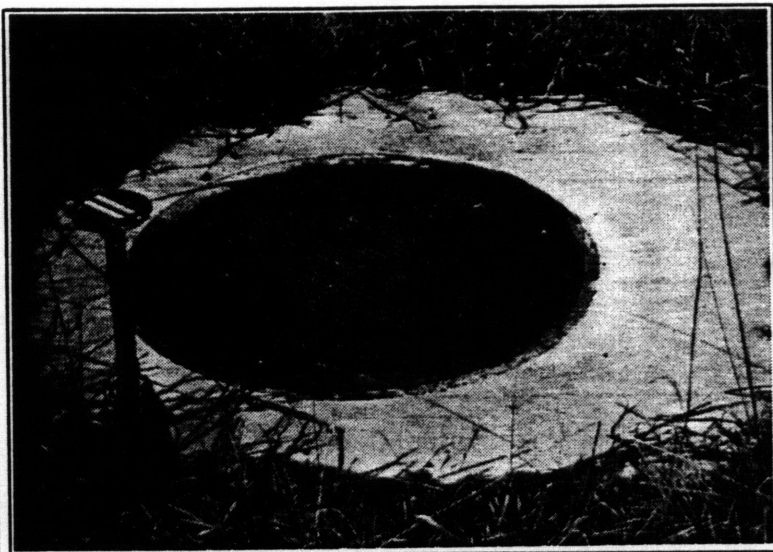
## Recommended Treatment Processes

<i>Plume</i>	<i>Extraction Rate</i>	<i>Method to Treat Metals</i>	<i>Method to Treat Solvents/Fuel</i>	<i>Treatment Unit Locations</i>
E. Briarwood and SD-5	1,320 GPM	Greensand Filtration	Activated Carbon	On-Base
FS-12	1,350 GPM	Greensand Filtration	Ultraviolet/Oxidation and Activated Carbon	On-Base
LF-1	8,970 GPM	Greensand Filtration/ Chemical Precipitation	Activated Carbon	On-Base
CS-10	5,000 GPM	None Needed	Activated Carbon	On-Base
Ashumet Valley	2,400 GPM	Greensand Filtration	Activated Carbon	Off-Base (Falmouth)

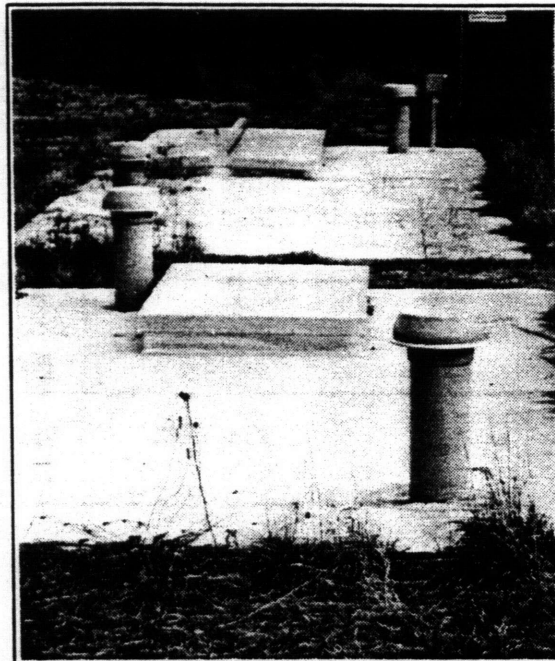
*GPM = gallons per minute*



*Granular activated carbon treatment vessels inside the CS-4 groundwater plume treatment facility. Solvents from the plume water stick to the carbon. The cleaned water is returned to the ground nearby through an infiltration gallery located just below the ground's surface. Similar systems are being designed for the six plume containment project.*



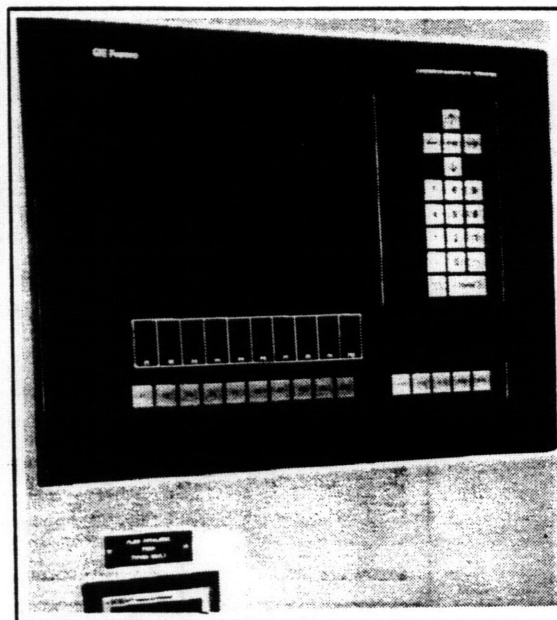
*A flush-mount groundwater extraction well located in the Crane Wildlife Management Area of Falmouth. Extracted CS-4 plume water is pumped to an underground piping vault and then through underground piping to the base for cleaning.*



*CS-4 underground piping and electrical vaults located off-base. Water flow is regulated by a series of valves in one vault while a computer console in the other monitors all aspects of the system's performance.*



*An unobstrusive data collection vault for one of the groundwater extraction wells at CS-4. An observation test well is located behind the vault and is periodically sampled to help evaluate the extraction system's performance. Such test wells can easily be installed as a flush-mount well, which will be the plan for off-base installations associated with the six plume containment project.*



*In addition to the computer control panel in one of the vaults, another is located at the CS-4 treatment facility, Building 3390.*

## Permission for access explained

Permission for access is a mutual agreement between the federal government and a property owner for the express purpose of conducting remediation related to Installation Restoration Program activities at the Mass. Military Reservation. Such permission is sought by the U.S. Army Corps of Engineers which has been delegated the responsibility for seeking permission from private, public and state property owners. Whenever possible, property will be sought such as public lands and already established rights-of-way which will minimize impacts to the local community.

There are four ways that the federal government can seek permission for access for permanent construction. The government can sign a lease with a property owner to use the land for a specified period of time. Another option is an easement that can be signed with the property owner that allows for access but is more restrictive than a lease.

The government has additional methods to gain access to properties which are not as preferable as the two methods listed in the paragraph above. One is land acquisition. In this case, the federal government buys a property that is available for sale. The final option is a taking by eminent domain. In this case, the federal government will have exhausted all options to gain access to a property and/or to relocate environmental activities, and it determines that it is in the best interest of the federal government and the community to acquire the property by eminent domain for an intended purpose. It should be noted that all four cases involve some form of compensation to the property owner for use of the property.

Property owners will be contacted in the near future regarding the siting of groundwater extraction wells and piping related to the plume containment project.

## Local libraries that maintain information on the Installation Restoration Program

### *JONATHAN BOURNE LIBRARY*

19 Sandwich Road  
Bourne, MA 02532  
(508) 759-0644

### *SANDWICH PUBLIC LIBRARY*

142 Main Street  
Sandwich, MA 02563  
(508) 888-0625

### *FALMOUTH PUBLIC LIBRARY*

123 Katherine Lee Bates Road  
Falmouth, MA 02540  
(508) 457-2555

### *MASHPEE PUBLIC LIBRARY*

Steeple Street, Mashpee Commons  
Mashpee, MA 02649  
(508) 539-1435

### *U.S. COAST GUARD LIBRARY*

Building 5202  
Otis ANG Base, MA 02542  
(508) 968-6456

## Technical Memoranda (additional project details)

**Preliminary Hydraulic Analysis of Plume Capture and Recharge.** This memorandum shows preliminary estimates of the groundwater recovery rates required for complete capture of the plumes.

**Air Stripping Evaluation and Air Stripping Evaluation Addendum.** This memorandum presents technical and cost comparisons among air stripping and granular activated carbon technologies for the removal of solvents and fuels from the extracted plume water. The evaluation concluded that granular activated carbon is a more cost-effective process.

**Analysis of Metals Treatment.** This memorandum presents the projected levels of metals for the incoming plume water for each of the plumes. Specific metals treatment requirements were based upon these projected levels.

**Evaluation of Individual/Multiple/Central Treatment Units.** This memorandum presents an evaluation of the treatment units based on land availability for off-base units, identification of primary cost differences for system alternatives and advantages and disadvantages of commingling extracted groundwater for treatment.

**Western Aquafarm Plume.** This memorandum presents information supporting the position of excluding the Western Aquafarm Plume from the set of seven groundwater plumes selected for containment. Long-term monitoring is proposed.

## Other recommended reading

- \* Plume Response Plan, June 1994
- \* Plume Response Plan Fact Sheets #'s 1-11, June 1994
- \* Record of Decision, Interim Action, Containment of Seven Groundwater Plumes, September 1995

*(All the documents listed on this page are available in local libraries or by calling (508) 968-4678.)*

***Have questions or need information?  
Want to be added to the Site Mailing List?  
Please call the Installation Restoration Program  
Public Affairs Office at (508) 968-4678.***



## **Role of the two teams**

### ***Plume Containment Team***

- \* Track and make recommendations on the plume containment plan, implementation schedules, methods of containment and location of containment fences/treatment facilities.
- \* Track milestones of the design and make recommendations on ways to expedite.
- \* Track and make recommendations on information data gaps and related unforeseen issues.
- \* Review groundwater quality data as it becomes available and provide input.
- \* Monitor and make recommendations in setting design performance and cleanup standards.
- \* Review existing cleanup efforts such as the Chemical Spill 4 Groundwater pump and treat containment system and the upcoming innovative technology demonstration of the "Reactive Wall," and make recommendations on design analysis for the containment plan.
- \* Assist the Installation Restoration Program in keeping the public informed.

### ***Program Implementation Team***

- \* Develop and implement a plan to inform the public.
- \* Obtain input from the public at large and act as an information conduit.
- \* Address issues of access in each affected neighborhood.
- \* Participate in public meetings.
- \* Maintain a liaison with the Plume Containment Team.

### **Program Implementation Team** **Planned Public Participation Activities**

- \* Issuance of fact sheets providing the latest information on planned construction activities associated with the plume containment project.
- \* Provide information via local cable television access.
- \* Coordinate speaking engagements with local homeowners associations and other interested parties.
- \* Conduct periodic public meetings in the local communities as construction nears start-up and throughout construction.
- \* Conduct visits in affected neighborhoods, as necessary, to provide information.
- \* Provide information to local real estate agents and continue dialogue.
- \* Continue with updates on the plume containment project at meetings of the Senior Management Board and Technical Environmental Affairs Committee which are open public meetings.

**Plume Containment Team Members**

Michael Minior, Team Co-Coordinator  
Installation Restoration Program  
322 E. Inner Road, Box 41  
Otis ANGB, MA 02542-5028  
(508)968-4670 FAX (508)968-4673

Leonard Pinaud, Team Co-Coordinator  
Mass. Dept. of Environmental Protection/  
Southeast Regional Office  
20 Riverside Drive  
Lakeville, MA 02347  
(508)946-2895 FAX(508)947-6557

Paul Marchessault  
U.S. Environmental Protection Agency  
HAN/CANI  
JFK Federal Building  
Boston, MA 02203  
(617)573-5793 FAX(617)573-9662

Susan Nickerson  
Association for the Preservation of Cape Cod  
Box 636  
Orleans, MA 02653  
(508)255-4142 FAX(508)255-8780

Thomas Cambareri  
Cape Cod Commission  
3225 Main Street, Box 226  
Barnstable, MA 02630  
(508)362-3828 FAX(508)362-3136

Eileen Gunn  
Coalition for Buzzards Bay  
P.O. Box 268  
Buzzards Bay, MA 02532  
(508)759-1440 FAX(508)759-1444

Dr. Joel Feigenbaum  
Upper Cape Concerned Citizens  
24 Pond View Drive  
E. Sandwich, MA 02537  
(508)833-0144 FAX: (508)833-3837

James Kinney  
Alliance for Base Cleanup  
P.O. Box 227  
W. Barnstable, MA 02649  
(508)362-7680 FAX:(508)362-1510

James J. Graham  
Box 41  
N. Falmouth, MA 02556  
(508)563-5814

J. Harry Donald  
86 Shore Street  
Falmouth, MA 02540  
(508)540-7572

Ray D. Taylor  
2 Pony Lane  
Forestdale, MA 02644  
(508)539-1709

Greg Yogis  
24 Sippewissett Road  
Falmouth, MA 02540  
(508)540-5076

Shaun Cody  
27 Priscilla Beach Road  
Manomet, MA 02381  
(617)944-0500 ext.2541

Steve Hurley  
Mass. Division of Fisheries and Wildlife  
195 Bournedale Road  
Buzzards Bay, MA 02532  
(508)759-3406

Charles Desaulniers  
6 Golf Links Circle  
Sandwich, MA 02563  
(508)420-5715

Juan Bacigalupi  
162 Hooppole Road  
Mashpee, MA 02649  
(508)771-4510 FAX(508)771-1692

Greg Taylor, P.E.  
Mashpee Public Works Department  
P.O. Box 554  
Mashpee, MA 02649  
(508)539-1420

Plume Containment Team Facilitator  
Greg Sobel  
Mediation and Facilitation  
489 Peakham Road  
Sudbury, MA 01776  
(508)443-8180 FAX(508)443-8181

## Program Implementation Team Members

Ed Pesce  
Installation Restoration Program  
322 E. Inner Road, Box 41  
Otis ANGB, MA 02542-5028  
(508) 968-4670  
FAX (508) 968-4673

Alexander Indorf  
17 Southpoint Drive  
Sandwich, MA 02563  
(508) 428-8739

Lynne Doty  
Mass. Dept. of Environmental Protection/  
Southeast Regional Office  
20 Riverside Drive  
Lakeville, MA 02347  
(508) 946-2886  
FAX (508) 947-6557

Susan Walker  
197 Farmersville Road  
Sandwich, MA 02563  
H (508) 477-1386  
W (508) 790-9838

William Shimer  
22 Hornbeam Ave.  
Falmouth, MA 02540  
548-0896

Ruth Meucci  
P.O. Box 431  
Forestdale, MA 02644  
(508) 477-6574

Martine W. Meijering  
12 Pinecrest Ave.  
Mashpee, MA 02649  
(508) 477-2807  
W (508) 968-7109

Daniel Fraunfelter  
427 Currier Road  
E. Falmouth, MA 02536-4231  
(508) 564-5247

Kathleen Amatrudo  
5651A Doolittle Ave.  
Otis ANGB, MA 02542  
H (508) 563-6301

Ralph Marks  
Bourne Water District  
P.O. Box 1447  
Pocasset, MA 02559  
(508) 563-2294  
FAX (508) 564-4661

David Oshman  
90 Davis Straits  
Falmouth, MA 02540  
(508) 548-8888  
FAX (508) 540-8616

Dr. William McDermott  
7 Manor Lane  
Falmouth, MA 02536  
(508) 564-6531

John Latawic  
P.O. Box 239  
Salt Marsh Lane  
Pocasset, MA 02559  
H (508) 563-3295  
FAX (508) 563-5989

Ms. Edythe Collins  
Box 319  
Cataumet, MA 02534  
(508) 563-5061

**PRINTED ON RECYCLED PAPER**

**To request additional copies of this fact sheet  
please call the Installation Restoration Program  
at (508) 968-4678.**

**Another Plume Containment Design Fact Sheet is  
being prepared. It will show the most up-to-date  
depictions of the groundwater plumes; and planned  
locations of groundwater extraction wells,  
underground piping and treatment units.**

**Installation Restoraton Program  
ANG/CEVRO, Box 41  
322 E. Inner Road  
Otis ANG Base, MA 02542-5028**

**FIRST CLASS MAIL  
U.S. POSTAGE PAID  
OTIS ANG BASE, MA  
PERMIT NO. 1**